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The Functional Design of a Project Management Information System: Case Study with South African Breweries Ltd

By

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the degree of Bachelors of Industrial Engineering
at Stellenbosch University.

Study leader: Prof. Corné Schutte

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Declaration

I, the undersigned, hereby declare that the work contained in this final year project is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Ek, die ondergetekende verklaar hiermee dat die werk in hierdie finalejaar projek vervat, my eie oorspronklike werk is en dat ek dit nog nie vantevore in die geheel of gedeeltelik by enige universiteit ter verkryging van 'n graad voorgelê het nie.

Sign on the dotted line:

…………………………….......... ……………………..

Anna Ju-Maré Bester Date

ECSA Exit level outcomes references

The following table include references to sections in this report where ECSA exit level outcomes are addressed.

Exit level outcome	Section(s)	Relevant Outcomes
1. Problem solving	1.1-1.3 3.1-3.13 6.1-6.5 7.1-7.7 Appendix A, G - Q	1. Analyze and define the currents problems with regard PMIS 2. Identify the criteria and desirable features for an acceptable solution. 3. Identify necessary information and applicable engineering and other knowledge and skills. 4. Generate and formulate possible approaches to the solution of the problem with regard a general PMIS and Case Study. 5. Analyze possible solution(s) in Case Study/ 6. Evaluate possible solutions and selects best solution. 7. Formulate and present the solution in an appropriate form of discussions and tables in appendixes.
5. Engineering methods, skills & tools, incl. IT	6.3.1 7.3-7.7 Appendix A-Q	1. Discipline-specific tools, processes or procedures like Root Cause Analysis, χ^2 Test 2. Information handling of literature and in analysis of questionnaire results. 3. Computers and networks and information infrastructures for accessing, processing, managing, and storing information - Excel Tools and Functions.
6. Professional & technical communication	Figures, Tables, Table of Context, Appendixes	1. Uses appropriate structure, style and language for purpose and audience. Uses effective graphical support (tables and figures) 2. Applies methods of providing information for use by others involved in engineering activity. 3. Meets the requirements of the target audience and SAB Ltd
9. Independent Learning ability	3.1-3.13 7.1-7.7 8.1	1. Reflects on own learning and determines learning requirements and strategies 2. Sources and evaluates information 3. Accesses, comprehends and applies knowledge acquired outside formal instruction. (Statistical Consultation) 4. Critically challenging assumptions and embracing new thinking
10. Engineering Professionalism	1.1-1.3 6.1-6.5 7.1-7.7 Appendix A-Q	1. Awareness of requirements to maintain continued competence. 2. Accepts responsibility for own actions especially with regard to Case Study. 3. Displays judgment in decision making during problem solving and design

Abstract

Globalization and the internationalization of markets have increased competitive pressures on business enterprises. This has led companies to engage in projects that are vital to their performance, if not their survival. These projects need to be managed, that is, they need to be planned, staffed, organized, monitored, controlled, and evaluated. In order to succeed, companies must deliver projects on time and within budget, and meet specifications while managing project risks. While large amounts of time, resources are dedicated to selecting and designing projects, it remains of supreme importance that projects be adequately managed in organizations if they are to achieve their performance objectives.

Thus, to provide a tool for the successful management of project, this final year project presents a project management information system (PMIS). The value of a PMIS and a description of a PMIS as well as the essential elements and components of a PMIS are offered. Furthermore, the information- and system requirements are provided. The final year project also describes how to use a PMIS within the management of a project. A description of PMIS hardware and software is suggested together with the desirable features of a PMIS to aid project managers to choose and design a specific PMIS that meets the requirements and needs for a specific project.

In order to validate and verify the information gathered from literature and experience, a research test model is presented to prove that a PMIS is the correct model to use within project management as well as to prove that the model is defined and described correctly.

An altered information audit and Pareto analysis is used with the aim of measuring and evaluating the current PMIS within South African Breweries Ltd against the essential information- and system requirements found. Conclusions and case specific recommendations are made to provide SAB Ltd with concrete solutions that will improve productivity and project success rate. This in turn will have a positive influence on SAB Ltd on their road towards meeting their company goals.

Opsomming

Globalisering en die internasionalisering van markte is tans besig om drasties toe te neem en plaas mededingende druk op sake-ondernemings. Gevolglik raak maatskappye betrokke in projekte wat noodsaaklik is vir hul prestasie, indien nie vir hul oorlewing nie. Hierdie projekte moet bestuur word, dit wil sê hulle moet beplan, beman, georganiseer, gemonitor, beheer, en geëvalueer word. Om suksesvol te wees, moet maatskappye projekte binne tyd en begroting lewer. Hierdie projekte moet voldoen aan gestelde spesifikasies en moet risiko bestuur ook in ag neem. Terwyl baie tyd en hulpbronne toegewy word aan die selektering en ontwerp van projekte, bly dit van uiterste belang dat die projekte genoegsaam bestuur moet word as organisasies hul prestasie doelwitte wil bereik.

Die finale jaar projek bied ’n projek bestuur inligting stelsel (PBIS) aan. ’n PBIS is ’n hulpmiddel vir die suksesvolle bestuur van projekte. Die waarde van die PBIS en 'n beskrywing van ’n PBIS asook die noodsaaklike elemente en komponente van 'n PBIS word aangebied. Verder word die inligting- en stelsel vereistes voorsien. Die finale jaar projek beskryf ook hoe om die PBIS te gebruik in die bestuur van 'n projek en dui aan hoe projek inligting gedeel kan word met behulp van 'n PBIS. 'n Beskrywing van die PBIS hardeware en sagteware is saam met die gewenste eienskappe van 'n PBIS voorsien. Dit sal projek bestuurders help om 'n spesifieke PBIS te selekteer en te ontwerp wat aan die vereistes en behoeftes vir ’n spesifieke projek voldoen.

Om te valideer en te verifieer dat die inligting wat versamel is uit literatuur en ervaring korrek is, is 'n navorsings-toets model aangebied om te bewys dat die PBIS die korrekte model is om te gebruik in die bestuur van ’n projek sowel as om te bewys dat die model wat gedefinieer is, korrek beskryf word.

'n Informasie oudit en Pareto analise word gebruik om die huidige PBIS binne die Suid-Afrikaanse Broueryе Bpk., te meet en te evalueer teen die noodsaaklike inligting en stelsel wat gevind is. Sodoende kan die huidige inligting en stelsel gapings geïdentifiseer word. Gevolgtrekkings en spesifieke aanbevelings word gemaak om SAB Bpk. te voorsien met konkrete oplossings wat produktiwiteit en projek sukseskoers sal verbeter. Dit is voordelig vir SAB Bpk. en kan help om die maatskappy se doelwitte te bereik.

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Glossary

PMIS	Project Management Information System
SAB Ltd	South African Breweries Limited
PMI	The Project Management Institute
HR	Human Resources
ERP	Enterprise Resource Planning
EKP	Enterprise Knowledge Portal
WBS	Work Breakdown Structure
M&E	Monitoring and Evaluating
CO	Central Office
PERT	Programme Evaluation Review Technique
CPM	Critical Path Method
ISSM	Information System Success Model
TAM	Technology Acceptance Model
IS	Information System
PLS	Partial Least Square Method
χ^2–Test	Chi-Square Test

1. Introduction

This report presents the functional design of a Project Management Information System (PMIS) with a case study a South African Breweries Limited. The project forms part of a research area of Industrial Engineering applied in the project management field and the information requirements within project management. The background of these fields and the motivation for the problem statement is discussed in this section. The reader is provided with a brief discussion regarding the problem identified along with a roadmap to the rest of the document.

The need of a Project Management Information System (PMIS) together with the reasons for existence is firstly identified. After this a thorough investigation of the system is conducted, the informational needs of the system are analysed and the essential requirements and elements of a PMIS are provided. A validation and verification ensures that the PMIS is the correct model to use within project management as well as to ensure that the model is defined correctly. An information audit and Pareto analysis is used with the aim of measuring and evaluating the current PMIS within South African Breweries Ltd against is the essential information- and system requirements found with the aim of identifying the information- and system gaps.

1.1 Problem Statement

Globalization and the internationalization of markets have increased competitive pressures on business enterprises. This has led companies to engage in projects that are vital to their performance, if not their survival. These projects need to be managed, that is, they need to be planned, staffed, organized, monitored, controlled, and evaluated (Liberatore, Pollack-Johnson 2004). In order to succeed, companies must deliver projects on time, within budget and meet specifications while managing project risks. While large amounts of time and resources are dedicated to selecting and designing projects, it remains of supreme importance that projects be adequately managed in organizations if they are to achieve their performance objectives.

Even in the 1980's, Peters identified that project management has long been considered an important characteristic of successful companies (Peters, Waterman 1982) and is more than ever necessary to efficiently and effectively manage these projects and to support project managers in their decision-making.

Cleland states that project managers necessitate accurate and timely information for the management of a project. Project planning, organizational design, motivation of project stakeholders, and meaningful project reviews simply cannot be carried out without information on the project together with how it relates to the larger organizational context in which the project is found. (Cleland 2004b)

An accurate and complete project management information system (PMIS) must exist to provide the basis for performance of the project. The project manager simply cannot make and execute meaningful decisions without relevant and timely information (Cleland 2004b).

1.2 Project Objectives

In this report, a project management information system (PMIS) is presented. The value of the PMIS and a description of a PMIS as well the essential elements and components of a PMIS are offered. How to use the PMIS in the management of a project is described, along with how project information can be shared. A description of PMIS hardware and software is suggested, that aids project managers to choose and design a specific PMIS that meets the requirements and needs for a specific project.

The goal of the report is to investigate and validate the functional design of a project management information system (PMIS). The goal of the case study is to measure and evaluate the current PMIS within South African Breweries Ltd against the essential information- and system requirements found to identify the information- and system gaps present. Conclusions and case specific recommendations can provide SAB Ltd with concrete solutions that will improve productivity and their project success rate.

1.3 Project Methodology

During June/July 2010 and June/July 2011, South African Breweries Limited offered vacation work with the aim to explore the business processes. The student seized this opportunity and during the 2010 working period, it could be confirmed that a sufficient opportunity for a final year project existed. This was clarified with Prof. C. Schutte in the Department of Industrial Engineering, who agreed to provide guidance.

Figure 1 illustrates the methodology process approached to complete the final year project. This project can broadly be divided into four phases namely the Literature Study Phase, the Validation and Verification Phase, the Information Gathering Phase and the Problem Solving Phase.

The first step of the project consists of a literature study in order to obtain the background needed to complete this project. In this phase a PMIS is defined. The reasons why a PMIS is needed is identified together with the appropriate information and system requirements is identified. To ensure that the PMIS meets the specified requirements, the desirable features and functions of a PMIS is identified.

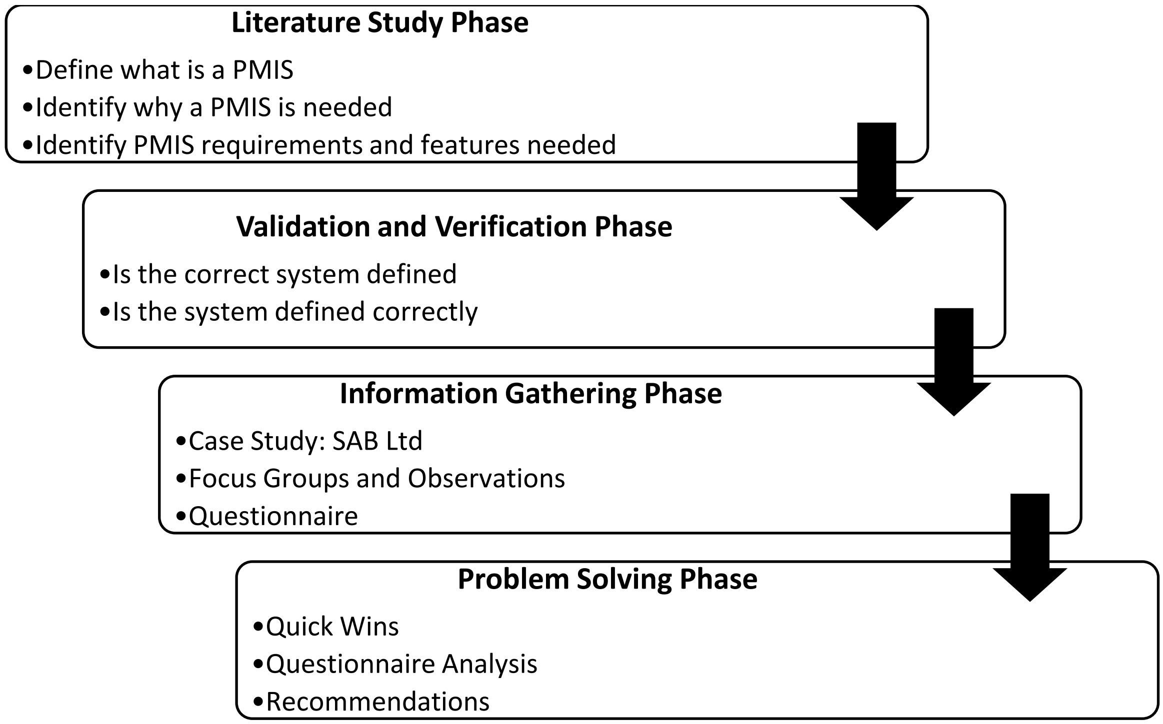

Figure 1: Project Methodology

The second phase of the project is to validate that the PMIS is correctly defined as well as to verify that the system is defined correctly. This is achieved by comparing the identified requirements against literature. Furthermore, an empirical study of the impact of a PMIS on project managers and project success by Raymond and Bergeron is presented and evaluated.

The information gathering phase is undergone at SAB Ltd during the June/July vacation work period in 2011. The business processes as well as the current systems are observed. Through focus group discussions and observations, a number of problems are identified. A questionnaire is constructed and distributed with the aim to gather data with regard to the current PMIS used within SAB Ltd.

During the problem solving phase, possible causes together with 'quick wins' are identified and documented. The questionnaire data is analysed to identify system and information gaps. Recommendations are made to improve the success rate of projects undertaken.

This chapter discusses the final year project problem statement, project objectives and the project methodology. The next chapter presents a description of a PMIS together with its monitoring and evaluating purposes.

2. Defining a PMIS

The previous chapter discussed the final year project problem statement, project objectives and project methodology. This chapter presents a description of a PMIS together with its monitoring and evaluating purposes.

2.1 Description of a PMIS

An information system is essential to project managers in support of their planning, organizing, control, reporting, and decision-making tasks. As defined by Cleland and King, the basic function of a PMIS is to provide managers with ''essential information on the cost-time performance parameters of a project and on the interrelationship of these parameters''. The nature and role of a PMIS within a project management system, as presented in Figure 2, have been characterized as fundamentally ''subservient to the attainment of project goals and the implementation of project strategies'' (Raymond 1987). Figure 2: The PMIS within the Project Mananagemnet System (Raymond 1987) illustrates how the PMIS uses project data in the different phase in a project life cycle. Figure 2 also illustrates organizational or environmental data to aid in decision-making (with regard to planning, organizing, control and monitoring, evaluating and reporting) by the project manager to meet project specifications and deadlines.

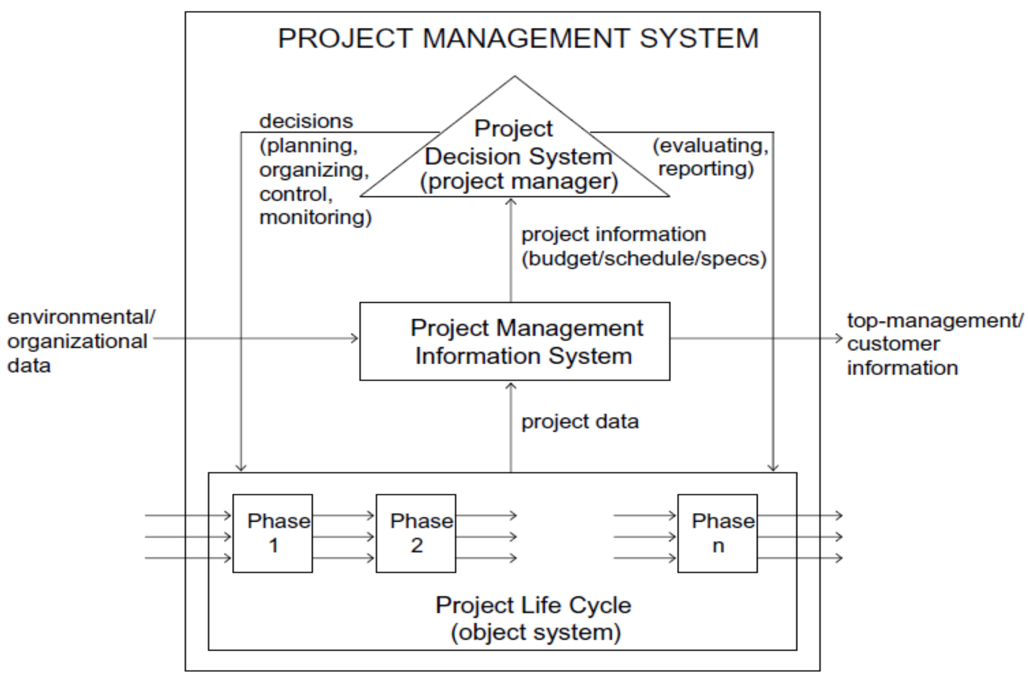

Figure 2: The PMIS within the Project Mananagemnet System (Raymond 1987)

The Project Management Institute (PMI), (PMI 2004) has shown that Project Management Information System is system tools and techniques used in project management to distribute information. Project managers use the techniques and tools to collect, combine and distribute information through electronic and manual means. Project Management Information System is used by upper and lower management to communicate with each other. The PMIS help plan, execute and close project management goals. During the planning process, project managers use PMIS for budget framework such as estimating costs. The PMIS is also used to create a specific schedule and define the scope baseline. At the execution of the project management goals, the project management team collects information into one database. The PMIS is used to compare the baseline with the actual accomplishment of each activity, manage materials, collect financial data, and keep a record for reporting purposes. During the close of the project, the Project Management Information System is used to re-evaluate the goals to ensure that the tasks were accomplished. Then, it is used to create a final report of the project close.

2.2 Purpose of a PMIS

A PMIS is mainly a monitoring and evaluating tool used throughout the progress of a project. A PMIS is used for collecting data from across various functions analysing and presenting those data in a form suitable for all parties involved in a project using monitoring and evaluation functions (Turner 1999).

2.2.1 Monitoring

Monitoring is the process of regularly collecting, storing, analysing and reporting project information that is utilized to make decisions for project management. Monitoring supply project management and project stakeholders the information necessary to evaluate the progress of the project, identify trends, patterns or deviations, keep project schedule and measure progress towards the expected goals. Monitoring information permits decisions regarding the use of project resources (human, material and financial) to enhance its effectiveness. Meridith and Mantel argues that when the right information is available at the right time and to the right people it can support decisions, like changes in the implementation strategies, that can help the project reduce costs and increase its outputs (Meridith, Mantel 2008).

Project monitoring is the continuous assessment of project implementation in relation to the agreed plans and the agreed prerequisite of services to project beneficiaries. As such, project monitoring supplies priceless information to managers and other project stakeholders with regard to the progress of the project. Further, it fortunately identifies potential successes or problems to assist timely adjustments to project operations (Meridith, Mantel 2008).

2.2.2 Evaluation

Evaluation is the periodic assessment of a project's relevance, performance, efficiency, and impact (both expected and unexpected) in relation to the stated project objectives and specifications. Evaluation profits from the process of information gathering to facilitate the assessment of the extend at which the project is achieving or has achieved its expected goals. Its results permit project managers, beneficiaries, partners, donors and all project stakeholders to learn from the experience and improve future interventions. Meredith and Mantel states that qualitative and quantitative information are critical components of an evaluation. Without it, it is almost impossible to identify how project interventions are contributing (or not) to the project goals (Meridith, Mantel 2008).

This chapter presented a description of a PMIS together with its monitoring and evaluating purposes. The next chapter discusses the need for a PMIS.

3. The Need for a PMIS

The previous chapter presented a description of a PMIS together with its monitoring and evaluating tools. This chapter discusses the need for a PMIS with regard to project success, the value of information, data management, system integration and taking stakeholders into consideration. A flow chart is presented to indicate how quality information is shared via a PMIS and how it has a direct correlation on improved performance.

Information is a valuable resource for project managers. Information costs money and needs to be acquired, secured, retrieved, stored, maintained and managed. Despite the fact that we know this, project managers often fail to deliver the types of information needed to ensure project success.

Consequently, this chapter discusses the reasons why a system for collecting, formatting, monitoring, evaluation and distributing information is needed for the organization and each project to address critical project information needs (Sifri 2002).

3.1 Project Success

According to Baccarini, project success consists of two separate components, namely project management success and project product success (Baccarini 1999). He distinguishes between them as follows:

- **Project management success** focuses on the project management process and in particular on the successful accomplishment of the project with regards to cost, time and quality. These three dimensions indicate the degree of the 'efficiency of project execution' (Pinkerton 2003).
- **Project product success** focuses on the effects of the project's end-product. Even though project product success is distinguishable from project management success, the successful outcomes both of them are inseparably linked. 'If the venture is not a success, neither is the project' (Pinkerton 2003).

According to Baccarini, project success can be summarized as:

Project success = Project Management Success + Project Product Success

Furthermore, Danie van der Westhuizen and Edmond P Fitzgerald investigated the related concepts of software project success, software project management success and software project product success and proposed a set of dimensions for defining and measuring software project success (van der Westhuizen, Fitzgerald 2004). An extension of the DeLone and Mclean model is proposed as a base model for software project success (DeLone, McLean 2003).

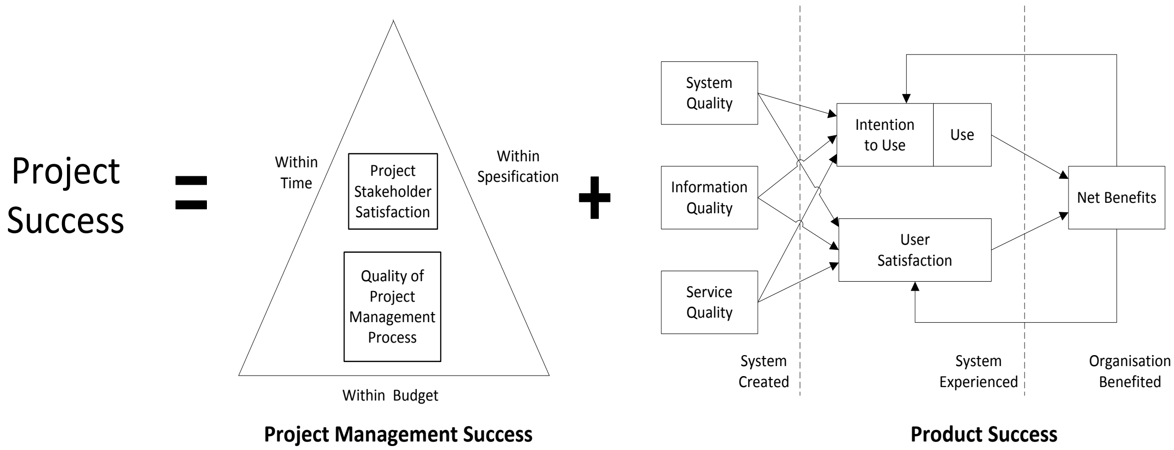

Figure 3: Adding project management success to the DeLone and McLean success model
(DeLone, McLean 2003)

Figure 3: Adding project management success to the DeLone and McLean success model (DeLone, McLean 2003) illustrates the components and requirements within the project management success (within time, specification and budget) and product success (system quality, information quality, service quality, information usage, user satisfaction, individual impact, and organizational impact).

Consequently, it is clear that a Project Management Information System is the golden midway for project management towards project success. This is illustrated below in Figure 4: Adapted Common dimensions in project management success and project product success with PMIS overlap (van der Westhuizen, Fitzgerald 2004).

As depicted in Appendix A: Validation of Success Dimensions against Literature, the success dimensions in this model satisfy the requirements of project success definitions found in literature, thus indicating the validity of this model.

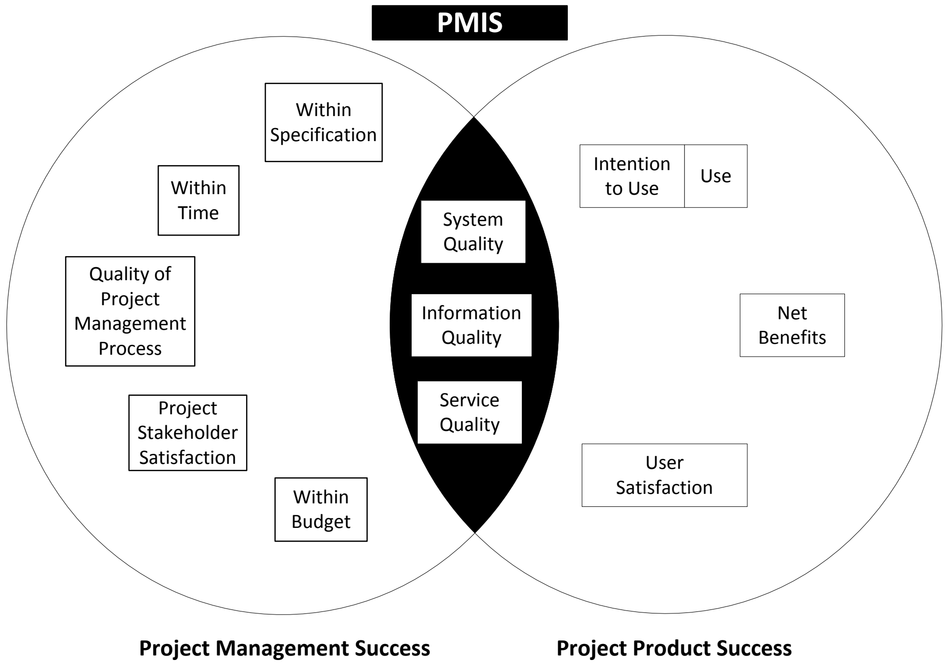

Figure 4: Adapted Common dimensions in project management success and project product success with PMIS overlap (van der Westhuizen, Fitzgerald 2004)

3.2 The Value of Information in Project

Information provides the intelligence for managing the project. Information must be processed so that decisions can be made and executed with a high degree of assurance so that the results will contribute to the project's success. In the project planning role, information provides the basis for generating project action plans, schedules, network diagrams, projections, and other elements of planning. Information is essential to promote understanding; establish project objectives, goals, and strategies; develop mechanisms for controls; communicate status; forecast future performance and resources; recognize changes; and reinforce project strategies. Matthew argues the project planning function establishes a structure and a methodology for managing the information resources, which encompass defining, structuring, and organizing project information, anticipating its flow, reviewing information quality, controlling its use and source, and providing a focal point for the project's information policies (Matthews 2004).

Information is a valuable resource to be developed, refined, and managed by the project principals: project managers, functional managers, work package managers, project professionals, and the project owner. Project information is as much an essential resource as people, materials, and equipment. Information is also a key tool which facilitates the project management process. Information is needed to prepare and use the project plans, develop and use budgets, create and use schedules, and lead the project team to a successful conclusion of the project. Information, then, becomes both a key resource to the project stakeholders and a tool for all concerned to do their job.

3.2.1 Technical Data Management and Documentation

A complex project generates a large amount of technical information. These data can be overwhelming and come in many forms such as text, graphics, large-scale drawings, correspondence, requirements and specifications, and others. If these data are not organized and managed, the project team will soon be lost in mounds of paper and information that are not readily retrievable (Eisner 2002).

3.2.2 The Quantity and Quality of the Information in a Project

Tuman agrees that analysed information provides the project team with the knowledge of where it has been in preceding periods, where it is today, and the direction the project is heading in. The proper amount of project information will support these goals, whereas too little information will not give the clear picture. To overcome the shortage of information, managers can create organizations within the corporate organization that leads to duplication and waste of time, money, and effort. Too much information has the tendency to overload the project team with information that must be filtered to properly view the past, present, and future situations. Senior managers also need the proper amount of pertinent information with which to make sound decisions on the project's future (Tuman 1988). Therefore the quality of the project relates to the quantity and quality of the information.

3.2.3 Integration and Synchronization of the Project Systems

Tuman argues that information is needed to design, produce, market, and provide after-sales support to the products and services that are offered to customers. In large organizations the flow of information can be incomplete and sequential. Traditionally, engineers and project managers do not communicate the project status adequately with upper managements and functional departments. They believe that projects are their responsibility and they have the authority to deliver them. Furthermore, functional departments are often reluctant or do not have time to provide information to project engineers (Tuman 1988).

Consequently this causes that information does not arrive at the people who need the information for their work in time to make the best decisions. Information may be found "lying" around in organizations waiting for someone who has the authority to make a decision. Cleland agrees that the best information loses its value if it is not available to people who need it to make decisions and direct actions (Cleland 2004b). These circumstances often lead to late, over budget, and low quality projects. Subsequently, information enables integration and synchronization of the project systems.

3.2.4 Stakeholders Need Information on the Project

In addition to the immediate participants to a project, there is a need to consider all stakeholders. A project manager might characterize the PMIS as being able to provide information that he or she needs to do the job and information that the bosses need. Typically, stakeholders have various information needs that can often be satisfied through the information stored in the PMIS. Appendix B: Stakeholder Information Needs provides some of the stakeholders' information needs on a routine basis. Those individuals with real or perceived information needs about the project soon become disenchanted when inadequate or inaccurate information is provided. No stakeholder likes surprises that reflect a change to the project plan or anticipated progress. Surprises quickly erode confidence in the project manager's capability to manage the work and keep key stakeholders fully informed on progress (Cleland 2004a).

3.2.5 Information is a Prerequisite for Collaboration

Collaboration requires a common understanding of purpose and the relevant fundamentals like budget, schedules and scope. Providing the same information to everyone involved, brings cohesion to the team. Information's real value is when it is used effectively in the management of the project. Information does not automatically lead to effective management of project but lack of information can contribute to project failure. Information may be in varying degrees of completeness when the PMIS is not properly populated; both on a timely basis and an accuracy basis. Partial information can be misleading and inaccurate information can lead to the wrong decision (Cleland 2004a).

3.3 Affordable and Most Reliable means to Document and Communicate Information

A PMIS reduces the costs of data collection. The data that is collected is usually repeated by several organizations. With a PMIS, the collection job is shared by the project manager, the corporate managers, etc., and then shared by all.

Without a standardized PMIS, the same data will be recorded multiple times by multiple people in multiple cabinets and computers. Thomsen agrees that this leads to inefficient and costly collection of data that is inconsistent and unreliable (Thomsen 2011). With the aid of a PMIS, only one on-line filing cabinet is presented. Responsibility for data entry is assigned to the appropriate people and those who need and use that information may access it, review it or download it. The PMIS presents a very efficient approach that helps save money because the project documentation process is clearly defined and there is less duplication of effort in implementation.

3.4 Armour for Defence against Political or Legal Attack

Projects can experience conflicts from stakeholders. For example, a lawyer may be searching for evidence to support a claim, a user can be mad or upset with the director of facilities or the media could want information for a story. An abundance of uncontrolled and conflicting documentation provides a target-rich environment for those searching for evidence to support a biases point of view (Thomsen 2011).

Gido advises that hard project facts are the arsenal of defence. Defined project goals that are consistently maintained with current data, provides owners and the facilities team with good and enough ammunition for support. In the case of a legal challenge, a PMIS provides the owner with centralized electronic documents that also results in lower discovery costs and reduces the time required for executives to assemble exhibits (Clements, Gido 2006).

3.5 A Window into the Project

According to Thomsen, it is difficult to understand progress toward a goal, to know what caused problems and what contributed to success. A PMIS informs leaders about current progress so they can operate the levers of control. A PMIS is a management tool for control and collaboration. Control systems require feedback to measure progress so adjustments can be made to stay on track (Thomsen 2011).

Before computers existed, managers had to work with human layers of reporting. A layered reporting structure has common flaws: reports may be slow, idiosyncratic, filtered, inconsistent or biased. When a program-wide roll-up report is needed, the data needs to be reviewed for consistency at each layer and then consolidated and perplexing formats for each new report is invented.

3.5.1 Centralized, Web-Accessible Management of Information

A PMIS makes layers of management more transparent. Managers can open their laptop and view the reports desired. According to Thomsen, the PMIS increases the velocity of information flow. As information passes through layers in the organization, it gets distorted (Thomsen 2011). The one-step process of storing information in a central database reduces the chance for it to be corrupted.

3.5.2 Standard Formats and Definitions

Individually designed reports on design and construction projects can create inefficiency and misunderstanding. A spreadsheet will have cryptic column headings understood only by the originator. Thomsen advises to use a PMIS which standardizes formats and definitions that everyone learns to understand at a glance which increases understanding and simultaneously saves time (Thomsen 2011).

3.5.3 Security levels

A well-defined security system is important to protect the integrity of the data. A system with defined security levels of password protection that control permissions to access, input or change information is necessary in projects (Thomsen 2011).

3.6 PMIS Improves Performance

The performance of a project needs to be measured to improve performance. For instance, a project can be viewed as a network of commitments to deliver work products that meets the requirements at a given time and cost (Thomsen 2011). These commitments need to be recorded and displayed in a periodic status report to reveal how people meet their commitments and to inform project leaders. With this information, the firm can work to improve their own performance. A PMIS will be replete with metrics that report progress against the objectives. Scorecards reveal the relationship between the current working estimate and the budget, etc.

3.7 Knowledge and Experience

Project history furnishes comprehensive facts that educate the project leadership with comprehensive understanding instead of half-truths supported by biased selections of information (Thomsen 2011). Without systematic presentation, people may act (or fail to act) on the wrong information. A PMIS is necessary for better projects and better managers because PMIS furnishes comprehensive facts about project and project history.

Valuable experience comes from learning from previous projects and anticipating that similar events might occur. To learn these lessons, leaders must have accurate reports about what has happened. Peters argues that a PMIS is crucial to enhance judgment by a clear presentation of project activity: the cause and effect of project results.

Every project presents an unplanned, unpredictable and unique event that requires a non-traditional approach. Good and complete data from multiple projects helps reveal the outliers for special attention (Cleland 2004b).

A project involves so many people, is so complex and has so many events that selective information can support different points of view and produce false conclusions. The PMIS will transfer some of the knowledge and experience from the brains of the project teams into a database (Peters, Waterman 1982). As people inevitably leave, get promoted, transfer to another department or go on vacation, they leave knowledge in the database for the benefit of the people who remain.

A PMIS won’t eliminate biased viewpoints and self-interest, but it helps define the goals, measure progress, document events, and present the final result with standard, objective facts.

3.8 PMIS Flow Diagram

PMIS supports information sharing and cooperative work among various business entities (headquarter/ field/ customer/ architect/ supervisor/ constructor/ affiliates) and provides management information to managers during projects. Figure 5: PMIS Flow Chart as adapted from the PMIS used within Hyundai (Korea) illustrates how information flows from and to the PMIS.

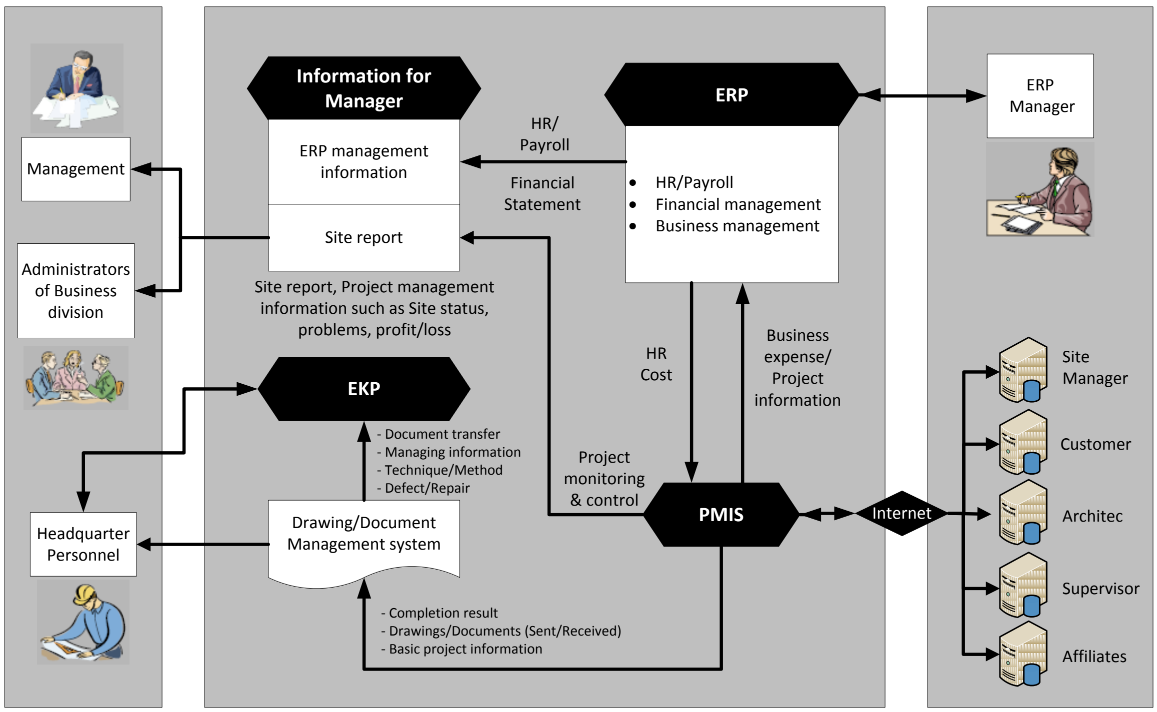

Figure 5: PMIS Flow Chart

This chapter discussed the need for a PMIS with regard to project success, the value of information, data management, system integration and taking stakeholders into consideration. A flow chart is presented to indicate how quality information is shared via a PMIS. The next chapter presents the information- and system requirement of a PMIS.

4. Requirement Analysis of a PMIS

The previous chapter discussed the need for a PMIS. This chapter presents the information and system requirement of a PMIS together with the proposed characteristics of an effective PMIS.

Requirements analysis is the process of analysing the information needs of the end users, the organizational environment, and any system presently being used, developing the functional requirements of a system that can meet the needs of the users. The requirements documentation should be referred to throughout the rest of the system development process to ensure the developing project aligns with user needs and requirements.

4.1 Research Methodology of Requirement Analysis of a PMIS

Literature is evaluated to indicate the validity the of the various information- and system requirements of a PMIS and is depicted in Appendix C: Validating the Information- and System Requirements against Literature.

4.2 Information Requirements

The information requirements of a PMIS are presented in Figure 6 below. According to Cleland, the information should be at a level of detail that permits easy translation to the current project. Too much detail masks the purpose and too little detail is not supportive of the project team (Cleland 2004b). A complete database can be sorted and filtered to provide the desired information of specific tasks or resources if needed. The use of graphics, pictures, and illustrations can convey information more quickly than narrative text. These items can be supplemented with textual descriptions or highlights. Mathematics and numbers are a precise means of providing information. These are especially good to use for performance measures or product performance requirements.

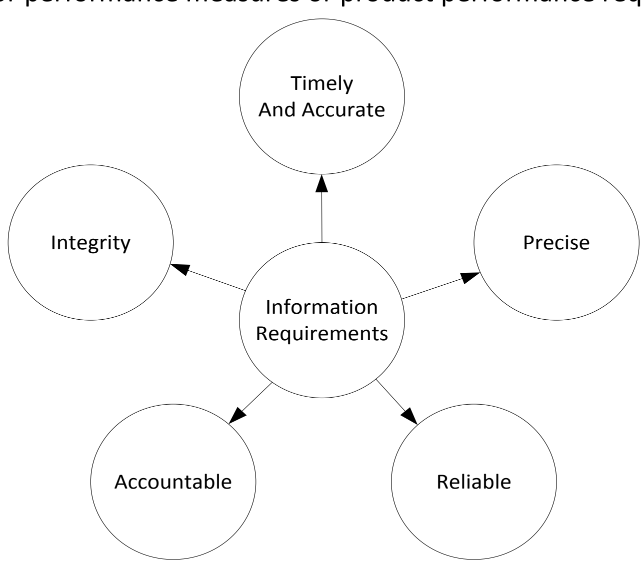

Figure 6: Information Requirements of a PMIS

4.2.1 Timely and Accurate

Information in the PMIS should be timely and accurate and represent the situation. Erroneous information can lead to wrong decisions and failed projects. Accurate information provides the best chance for managing by fact (Cleland 2004b). Furthermore, a project is responsible to meet the needs of management, donors and other projects stakeholders who need the right information at the right time.

4.2.2 Precise

Information can be perishable. Managing a project requires planning, organizing, and controlling of resources on a moving target as the project evolves through its life cycle. Information on a project at a particular point in that life cycle can change quickly as new project problems and opportunities emerge. Aged information will provide a distorted picture for the decision maker as well as give undue confidence in the decision. Only current and precise information gives the best picture of the situation and allows decisions based on facts (Cleland 2004a).

The precision of the information needs to be only to the level of granularity dictated by the project decisions. For example, there is typically no need to estimate project labour-hours to less than an hour. It is a special case where labour estimates are to the nearest minute or nearest 10 minutes (Eisner 2002).

4.2.3 Reliable

The information must be derived from a source that gives confidence that it is real and representative of the situation. Information from an unknown source or stated in terms that permit more than one interpretation should be labelled "questionable." Information with a detail structure adds to the project's value as well as that of the parent organization. Analysed and structured project management data become information that is summarized for ease of reading and understanding. This analysed information is disseminated up to senior managers of the organization and used within the project for measuring results. Reliable information has an audit trail from its source through the analysis process to the dissemination points (Gilbreath 1986).

4.2.4 Accountable

A project is responsible for safeguarding and controlling the information entrusted to its care and is answerable to proper authority for the loss or misuse of that information. The project has to inform donors and project stakeholders of the manner in which project information is used and the information provided should be traceable back to the original data collected (Caldwell 2004).

4.2.5 Integrity

The primary purpose for the collection and use of project information is to benefit beneficiaries by improving the project interventions. Integrity provides verification that the original contents of information have not been altered or corrupted and that managers can be confident on the quality of the information to make decisions on the project. A project will make reasonable effort to ensure that all information is accurate and up-to-date and that procedures are in place to dispose of records once they are of no further use (Caldwell 2004).

4.3 Project Management Information System Requirements

The information requirements for all stakeholders drive the design and development of the PMIS's contents and requirements. The PMIS requirements are presented in Figure 7: PMIS Requirements below. The project manager and project team will be the primary users of the PMIS, but will need to consider stakeholders such as senior management, customers, and functional managers.

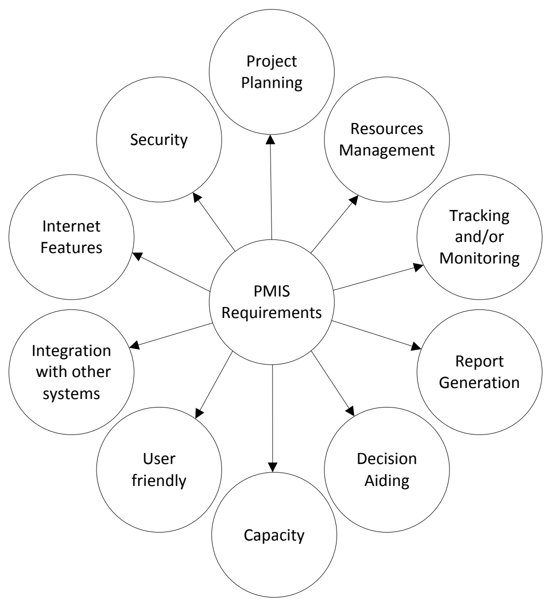

Figure 7: PMIS Requirements

4.3.1 Project Planning

Enterprise guidance and project background information form the basis for planning the project. This information should be a part of the PMIS. The PMIS supports the full range of the project life cycle to include pre-project analysis and post project reviews (Turner 1999).

The PMIS should interface with larger organizational information systems to permit smooth, efficient interchange of information in support of organizational and project objectives and goals (Thomsen 2011). Planning for a PMIS requires that information be selectively included and irrelevant information omitted to preclude an overabundance of data and little relevant information.

4.3.2 Resources Management

Information is needed to manage the project, which is to plan, organize, evaluate, and control the use of resources on the project. The PMIS should be able to apply algorithms such as resources levelling and smoothing to manage the project. The PMIS should be able to check for and help resolve over allocation of resources (Clements, Gido 2006).

4.3.3 Tracking and/or Monitoring

An important purpose served by a PMIS is that it can track at the work package level for early identification of schedule slippage or significant cost overruns on detailed work areas. Early identification of small problems permits the attention to detail before there are major impacts on higher-order work. This is especially important on large projects or projects that have a very rigorous schedule to meet the enterprise's or customer's goals. The PMIS should be prospective and capable of providing intelligence on both the current and probable future progress and status of the project (Thomsen 2011).

Information provides the basis for continuation of the project in the absence of the project manager. The project team can monitor the progress of the project and compare it to the project plan to assure that work is progressing satisfactorily. An effective PMIS provides the information that demonstrates when the project is on track or when it has exceeded the allowable limits of performance.

A PMIS should be able to track the progress of:

1. Tasks,
2. Durations,
3. Costs, committed or spend, and
4. Resources

4.3.4 Report Generation

Information to manage a project comes from a wide variety of sources, including formal reports, informal sources, observation, project review meetings, and questioning which is aided by formal evaluation and analysis as to what the information says about the status of the project (Thomsen 2011).

Reporting capabilities are given a high priority, because the ability to produce extensive and power reports is a feature that most users and stakeholders rate very highly (Clements, Gido 2006). The PMIS should be able to provide reports on the following:

1. The project's status and progress.
2. Planning
3. Scheduling
4. Individual tasks
5. Resources

6. Actual costs
7. Committed costs

4.3.5 Decision Aiding

The quality of management decisions in the project is related to the accuracy, currency, and reliability of the information on the project. According to Cleland, information establishes the basis for all project decisions and commitment of resources (Cleland 2004b). The PMIS is the repository of much of this information and reflects the user’s needs for making and executing decisions in the managing of project resources.

PERT analysis allows the user to see the effects of various scenarios in a project to aid project managers in their decision making process. Clements states that conducting a PERT analysis without the PMIS software is extremely time-consuming. The PMIS helps the project manager to prepare and plan for certain contingencies and to assess consequences (Clements, Gido 2006).

4.3.6 Capacity

Gido argues that a PMIS should be able to handle the number of tasks expect to be performed, the number of resources possibly needed, and the number expected projects to be managed simultaneously (Clements, Gido 2006).

4.3.7 User Friendly

The system should have a good and user friendly “look” and “feel” considering the menu structure, available short-cut keys, colour displays, the amount of information in each display, the ease with which data can be modified, the ease with which reports can be generated, the quality of the printouts that are produced, the consistency among the screens, and the amount of learning required to become proficient with the system (Liberatore, Pollack-Johnson 2004).

4.3.8 Integration with other Systems

The PMIS should provide integration with distributed databases, spread sheets, and even object-orientated databases. Furthermore, the system should be able to import and export information to and from word processing and graphics packages (Clements, Gido 2006). The system should also do this through e-mail.

4.3.9 Internet Features

Depending on the type of project undertaken, it might be necessary and important that the project team communicate via e-mail regarding numerous tasks. In addition, the PMIS should allow project information to be posted directly to the Web (Tuman 1988).

4.3.10 Security

A project must ensure that information is not disclosed to unauthorized persons, processes, or agencies. The PMIS is responsible for the protection of sensitive information from unauthorized disclosure to third parties. Information should be seen as private and not for distribution beyond specifically identified individuals or organizations as defined by the project stakeholders. Personal beneficiary information must be treated with respect and only used within the objectives of the project (Caldwell 2004).

4.4 Summary of the Characteristics of a PMIS

Each PMIS is tailored to project situations to meet specific requirements for managing the project (Cleland 2004b). General characteristics that should be in a PMIS include the following:

1. Must be adaptable to differing customer requirements.
2. Must be consistent with organizational and project policies, procedures, and guidelines.
3. Should minimize the chances that managers will be surprised by project developments.
4. Should provide essential information on the cost-time-performance parameters of a project and on the interrelationships of these parameters, as well as the strategic fit of the project.
5. Should provide information in standardized form to enhance its usefulness to all managers.
6. Must be decision oriented, in that information reported should be focused towards the decisions required of the managers.
7. Must be exception oriented, in that it focuses the manager’s attention on those critical areas requiring attention rather than simply reporting on all areas and requiring the managers to devote attention to each.
8. Must be a collaborative effort between users and analysts. The PMIS should be executed by a multidisciplinary team that views the design, development, and implementation of the information system as a project itself, amenable to project management approaches.

This chapter presents the information- and system requirement of a PMIS. The next chapter presents the functional design of a PMIS.

5. Functional Design of a PMIS

The previous chapter presents the information- and system requirement of a PMIS together with the proposed characteristics of an effective PMIS. This chapter discusses the functional design of a PMIS by presenting the desired features of a PMIS. A concept model together with an information architecture procedure is presented together with the different levels of technology of a PMIS.

The design of the PMIS must be sound, and it must at least satisfy all the requirements for the system as set forth by the user or customer. By following a systematic and repeatable "systems" process of developing goals into more specific functions and operations of the system, the developer maximizes the chances that this will be the case.

In this chapter, specific desirable features and functions are discussed to ensure that the system is designed in such a way to meet all the system and information requirements discussed in the previous chapter (4.2 Information Requirements and 4.3 Project Management Information System Requirements)

5.1 Desirable Features and Functions of a PMIS

5.1.1 Budgeting and Cost Control Features

In every project it is necessary to associate cost information with each activity and each resource in a project. An individual's pay can be defined in hourly rates, overtime rates, or one-time only rates. Dates when payments are due can also be specified (Clements, Gido 2006). On-time-only or on-going costs for materials can be defined, and accounting and budgeting codes can be set up that are associated with each type of material. In addition, user-defined formulas can be developed to manage cost functions.

This information is used to calculate projected costs of the project and track actual costs during the project. At any time during the project, actual costs can be compared with budgeted costs for individual resources, for groups of resources, or for the entire project. Cleland agrees that this information can be used not only for planning purposes but also for reporting purposes. The PMIS allows the user to display and print the costs for each task, for each resource (person, machine, etc.), or for the entire project, at any time during the project (Cleland 2004b).

5.1.2 Calendars

Base calendars can be used to define working days and hours for each individual resource or group of resources on a project. These calendars are used in calculating the schedule for the project. The system provides a default for the standard working period such as Monday through Friday from 8.00 a.m. to 17.00 p.m., with an hour for lunch. These calendars can be modified for each individual resource or group of resources (Clements, Gido 2006). For example, work hours can be modified, company hours can be modified, company holidays can be entered as nonworking days, various shifts (daytime, night-time) can be entered, and vacation days can included, as well as variable scales (hour, day, week).

The calendars can be used for reporting purposes and can be printed by day, week, or month for each individual resource or in the form of a full, possibly wall-size, and complete project plan in calendar form.

5.1.3 Internet Capabilities

Project information can be directly posted to a web site to facilitate communication with team members and customers. In addition, project information can be shared through e-mail instead of to the screen or printer. Project team members can be notified of important changes through email such as updated project plans or schedules. Team members can be informed about the current project status, can be sent various charts, and can even be notified of upcoming deadlines, all through e-mail (Liberatore, Pollack-Johnson 2004).

5.1.4 Graphics

A PMIS has the ability to generate easily and quickly a variety of charts, including Gantt charts and network diagrams, based on current data. Once the baseline plan has been created, any modifications to the plan can easily be entered into the system, and the charts will automatically reflect those changes. A PMIS allows tasks in Gantt charts to be linked together so that the precedence activities can be shown. The user is allowed to jump back and forth between the Gantt chart and network diagrams displays with a single command. According to Liberatore (Liberatore, Pollack-Johnson 2004), graphic and charting capabilities allow the user to:

1. Perform interactive manipulations of tasks and relationships, such as changing activity durations by stretching out the activity duration display or changing precedence relationships by graphically linking tasks together.
2. Customization of the displayed format, such as headings, column sizes, colours, fonts, and placements of text.
3. Show baseline-versus-actual charts for tasks or costs.
4. Highlight the critical path and show the slack of each activity.
5. Reduce or magnify (zoom in and zoom out) displays.

5.1.5 Importing/Exporting Data

A PMIS allow the user to import from other applications, such as word processing, spread sheet, and database applications. For example, instead of retyping cost related information on resources (people or machines) from a spread sheet into the system, the user can simply import that spread sheet information as desired. Similarly, it is possible to export information from the system to those applications (Clements, Gido 2006). For example, a schedule report for a specific contractor can be exported to a word processing memo. The PMIS should allow the transfer of information in standard ASCII text, from the MS Windows Clipboard, and to SQL databases, Lotus, MS Excel, MS Project Exchange, etc.

Importing and exporting information avoids possible entering conflicting and erroneous data. This feature satisfies the requirements discussed in 4.2 and 4.3

5.1.6 Handling of Multiple Projects and Subprojects

A PMIS can store multiple projects in separate files with connecting links between the files, store multiple projects in the same file. Furthermore, it can handle several projects at the same time, and create Gantt charts and network diagrams for multiple projects (Clements, Gido 2006).

5.1.7 Report Generation

A PMIS has extensive reporting capabilities. Among the reports a PMIS can generate are the following:

1. Reports on the project as a whole.
2. Reports on the milestones of the project.
3. Reports that provide a variety of information with respect to a date range, such as tasks that have been completed within that range, tasks that are in progress, and tasks that will start within that range (Clements, Gido 2006).
4. Financial reports including budgets for all tasks as well as the entire project, tasks and resources that are over budget, cumulative budgeted costs, actual costs, and committed costs.
5. Resources allocation reports for each resource or group of resources involved in a project.
6. Customizable standard reports, cross-tabs, and baseline-to-actual variance reports.

The PMIS should provide page setup settings that allow the user to choose a page size and a page preview before printing reports.

5.1.8 Resource Management

A PMIS can maintain a resource list consisting of resource names, the maximum amount of time available, standard and overtime rates for resources are available, accrual methods, and textual descriptions of the resources. A unique code can be assigned to each resource, as well as an individual personalized calendar. Constraints can be assigned to each resource, such as the amount of time they are available for work (Liberatore, Pollack-Johnson 2004). The user of the system can also keep memos and notes on each resource, assign resources to a percentage of a task, set priority levels for resource assignments, assign more than one resource to the same task. The system will highlight and help correct over allocation and perform resource levelling and resource smoothing (Clements, Gido 2006).

5.1.9 Planning

The PMIS allows the user to define the activities that need to be performed. The system allows an activity or task list to be maintained. For each task, the user can provide a title, a start date, a finish date, comments, and estimated durations (including optimistic, most likely and pessimistic estimates in various time scales). The PMIS can also specify any precedential relationships with other tasks as well as the person(s) responsible. In addition, the system allows the user to create a work breakdown structure (WBS) to aid in the planning process (Clements, Gido 2006).

5.1.10 Project Monitoring and Tracking

Tracking progress, actual costs, and actual resources used is one of the fundamental components of the PMIS. The user is allowed to define a baseline plan and compare actual progress and costs with those in the baseline plan (Clements, Gido 2006). The PMIS can track tasks in progress, completed tasks, associated costs, time expected, start and finish dates, actual costs committed or spend and resources used, as well as remaining duration, resources, and expenses. There are numerous report formats associated with these monitoring and tracking features. (See 4.3.3)

5.1.11 Scheduling

A PMIS builds Gantt charts and network diagrams based on the task and resource list and all of their associated information. Any modifications to these lists will automatically be reflected in the schedules. In addition, users can schedule recurring tasks, set priorities for scheduled tasks, perform reverse scheduling (from the end date backward to the beginning), define work shifts, schedule tasks to start as late as possible or as soon as possible, and specify a must-start-by or must-finish-by date or a no-earlier-than or no-later-than date (Clements, Gido 2006).

5.1.12 Security

A PMIS provides password access to individual project files, and password access to specific data. Some people have access to information on their project only, others have input and read-only privileges, others may modify documents, etc. (Clements, Gido 2006).

5.1.13 Sorting and Filtering

Sorting allows the user to view information in a desired order, such as pay rates from highest to lowest, resource names in alphabetic order, or task names in alphabetic order. A PMIS allow multiple levels of sorting (for example, by last name and then by first name). Filtering enables the user to select only certain data that meet some specified criteria (Clements, Gido 2006). For example, if the user wants information on just the tasks that require a certain resource, a simple request tells the software to ignore tasks that don’t use that resource and display only tasks that do use that resource.

5.1.14 PERT Analysis

One very important feature of a PMIS is the ability to perform PERT analysis. This feature allows the user to explore the effects of various scenarios (Liberatore, Pollack-Johnson 2004). At some point in a project, the user might ask "what if a specific task was to be delayed by a week?" The effects of the delay on the entire project would automatically be calculated, and the results would be presented. For example, to explore what would happen if lumber rates went up by 1.5 percent during a construction project, a contractor could enter this change into the system and all associated costs would be projected. Almost any variable (people, pay rates, costs) in a project can be tested to see the effects of certain occurrences. This type of analysis enables the manager to better control any risks associated with the project.

5.2 Information Architecture

An Information Architecture is a set of models, definitions, rules, and standards that gives structure and order to a project's information so that information needs can be matched with information resources. According to Caldwell, an Information Architecture is also the structure and organization of information within a framework that describes the principles, standards and processes for managing information as a resource (Caldwell 2004).

An Information Architecture defines:

- What types of information exists in the project.
- Where the information can be found.
- Who the creators and owners of the information are.
- How the information is to be distributed and used.

An Information Architecture may contain several of the following:

- A model of main information entities and processes.
- A taxonomy or categorization scheme.
- Standards, definitions and interpretations of terms.
- Directories, inventories, resource maps and description frameworks.
- Designs for developing information systems, products, services.

An Information Architecture helps the project by first identifying all the possible sources for information that the project will need, it will locate information that already exists within and outside the organization. It helps the project by saving resources and time by locating information already available and thus avoids creating the same information again. Thus, an Information Architecture reduces the time and cost of collecting, storing and processing project information. Caldwell advises to use tools like information flowcharts, information maps and project organigraphs can be used to model and draw up an Information Architecture (Caldwell 2004).

5.3 Conceptual Design of a PMIS

A concept model of a PMIS is presented in Figure 8 as adopted from Hyundai in Korea. The PMIS server resides at the headquarter office while each site accesses the server to process the tasks of each site. The various outputs or reports are stored in the server, and these will be used for management information. Employees at each site can download the drawings from the server for immediate use, so that information sharing is available among headquarter/ site/ affiliate/ customer.

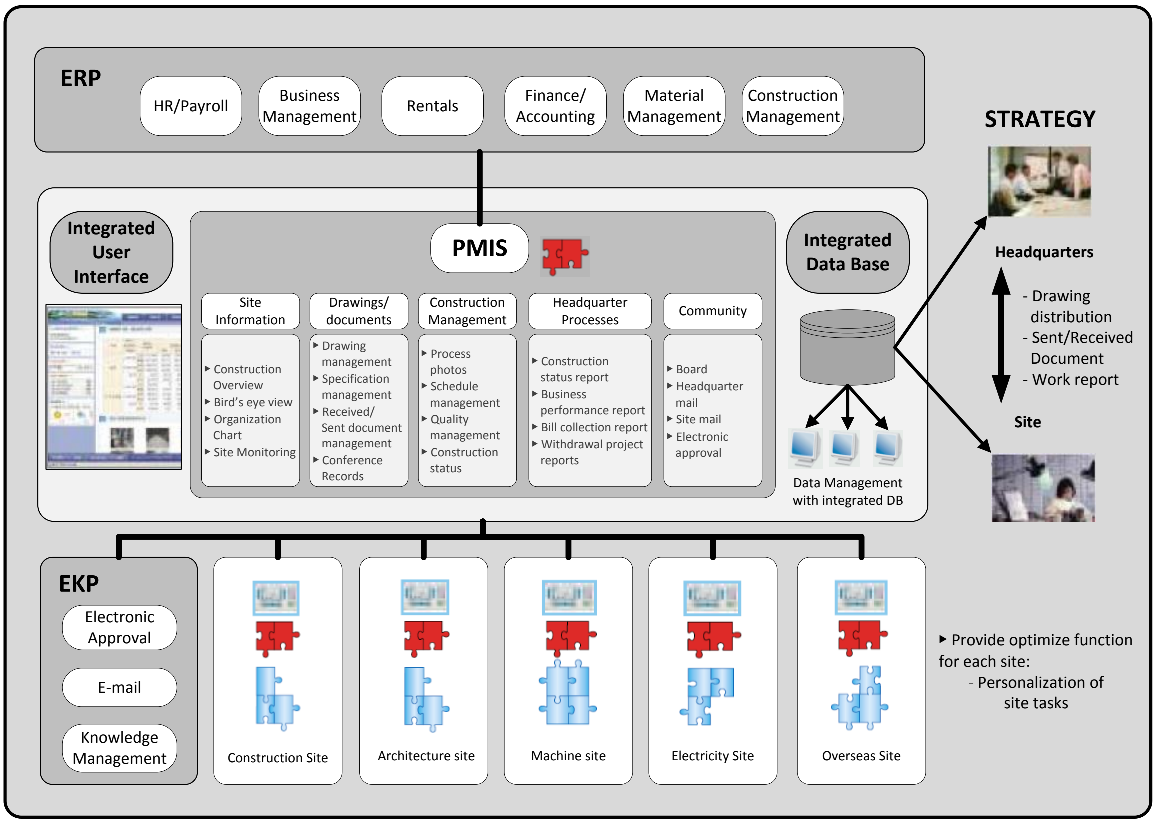

Figure 8: Concept model of PMIS used within a construction project

5.4 PMIS Levels of Technology

Caldwell suggests that a PMIS does not necessarily mean a state-of-the-art technology tool that provides features for every project because every project has different information needs both in quality and in quantity. Every project requires different levels of technologies to satisfy its basic information management needs, a small project with small needs will suffice with simple technologies, but large projects with large information needs can benefit from more extensive technological solutions (Caldwell 2004). It is very advantageous to use a specialized PMIS for it provides the project team and manager to use to correct amount and thus quality information.

Figure 9: PMIS Levels of Technology (Caldwell 2004) illustrates how the four levels help define the technology required based on the information requirements of a project:

1. Level one is a paper based information system for small projects were use of technology is not required or not available.
2. Level two requires the use of basic computer applications to manage project information.
3. Level three identifies the use of databases to manage the increased volume of information.
4. Level four will require a fully integrated PMIS.

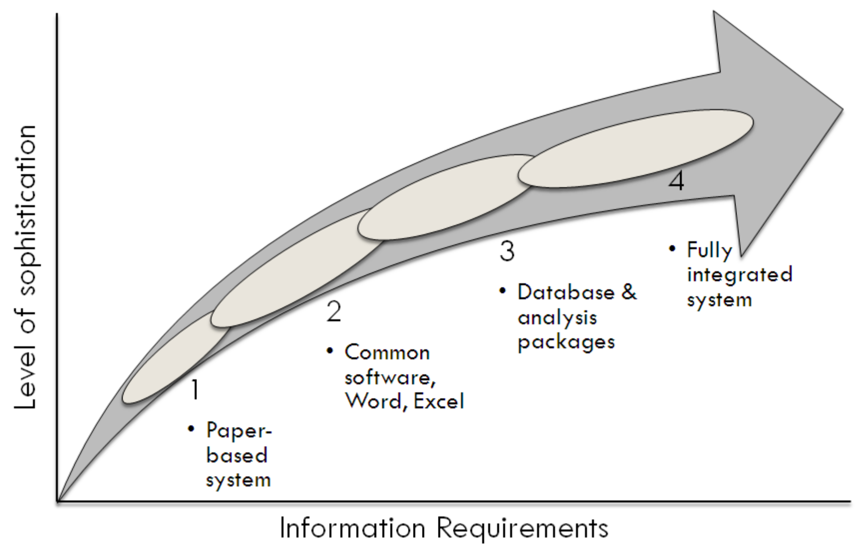

Figure 9: PMIS Levels of Technology (Caldwell 2004)

The ovals 1-4 represent the four levels progressively from low sophistication (level 1) to the higher level of sophistication (level 4). The overlapping ovals denote the occurrence of simultaneous characteristics among two levels. The upward-slanting arrow (from left to right) - represents the rising technical and resource requirements for setting up an increasingly automated information system and the ever greater complexity of the system itself as a project shifts from level 1 toward level 4.

This classification of levels is for guiding projects in assessing their location on the range of lower to more sophisticated information systems. During the life of a project the levels may alter, while on the other hand, a project manager with several projects, programs, and sectors may have each one at a different location on the range (Caldwell 2004).

The use of complex technology not necessarily means efficiency. A small project with little information needs will not benefit from a complex integrated system. On the contrary, Caldwell argues that managing the system can even be less efficient than a simple manual solution (Caldwell 2004). A project needs to determine its information requirements and match it with the appropriate technology. Figure 10: Efficiency of PMIS (Caldwell 2004) below shows the relationship between the volume of information and the quality of a PMIS comparing the four different levels shown in Figure 9: PMIS Levels of Technology (Caldwell 2004). Each level drops in its efficiency as the volume of information grows thus projects need to identify when to move to the next level.

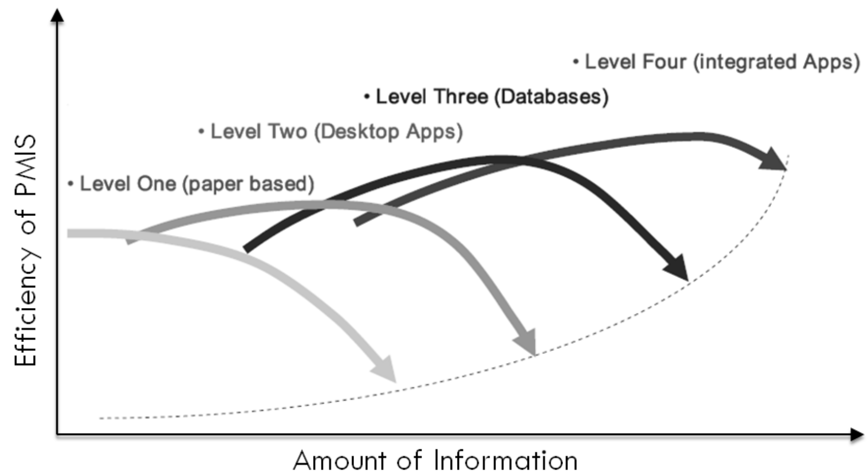

Figure 10: Efficiency of PMIS (Caldwell 2004)

Figure 10: Efficiency of PMIS (Caldwell 2004) illustrates how the amount of information increases for a given level, the efficiency in the use of a PMIS tends to decrease due to the time it takes to process, analyse and report the additional information. For example a level two system decreases in efficiency as the volume of information increases. This does not necessarily indicate that a level 4 is the principle, quite the opposite, a level 4 demonstrates a low efficiency when the volume of information is small (Caldwell 2004).

This can be seen when using a complex system to track small amounts of information, the effort to setup, manage and use the system, and all its associated costs, make a level 4 system less efficient compared with simpler solutions.

Meridith indicates that the selection process of a PMIS should be based on the following list (Meridith, Mantel 2008):

1. Establish a comprehensive set of selection criteria (what activities/ processes should it undertake?)
2. Prioritize the criteria (separate the needs from the musts)
3. Conduct a preliminary evaluation (pre-qualify tenders)
4. Evaluate the packages individually
5. Negotiate on price and aspects of value adding

Together with Meridith's selection process and Table 1, that presents the levels of information systems complexity and suggested management and software support, the most applicable software can be used for any unique project.

Table 1: Complexity, Requirements and outcomes of the four levels of technology (Caldwell 2004)

	Levels of techology			
	1	2	3	4
Complexity	No software necessary (may use), electronic calculator or 'paper & pencil'	Word processor, Excel	Software examples: Arc view, GIS, SPSS, Strata, MapInfo, GK, EPI-Info (software for nutritional data analysis), LAN	Software (as before) plus server software and computer that can support at global organization level
Requirements	Simple file organization,	Safety, backup, storage, retrieval, access, security, flexibility	Software specifically designed for project needs, ability to export/import to/from other systems	Open architecture software (for interface with HQ and CI plus other permitted users); all standard safety features.
Some expected outcomes	Sum, average, (calculations by hand)	Texts, simple charts/figures	More complex analysis, charts, maps and analysis, correlation etc.	All sorts of required analysis and presentations. Internet

This chapter discusses the functional design of a PMIS by presenting the desired features of a PMIS. A concept model together with an information architecture procedure is presented as well as the levels of technology of a PMIS. The next chapter presents the validation and verification of the literature reviewed to ensure that the correct model is discussed as well as the model is discussed correctly.

6. Validation and Verification

The previous chapter discussed the functional design of a PMIS while this chapter presents the validation and verification of the literature reviewed to ensure that the correct model is discussed as well as the model is discussed correctly.

To prove the validity and to verify the requirements and desired features of a PMIS discussed and presented in Chapter 4.1, Chapter 4.2 and Chapter 5; an empirical study by Raymond and Bergeron in 2007 (Raymond, Bergeron 2007) is presented in this chapter. The purpose of this study is to assess the quality of the PMIS presently used in organizations and to examine their impact on project managers and project performance, based on a PMIS success model.

This model is composed of five constructs: the quality of the PMIS, the quality of the PMIS information output, the use of the PMIS, the individual impacts of the PMIS and the impacts of the PMIS on project success. Analysis of questionnaire data obtained from 39 project managers confirms the significant contribution of PMIS to successful project management. Improvements in effectiveness and efficiency in managerial tasks were examined here in terms of improved project planning, scheduling, monitoring, and control. Improvements were also observed in terms of decision-making duration time. Advantages gained from PMIS use are not restricted to individual performance but also include project performance. These systems were establish to have direct impacts on project success, as they contribute to improving budget control and meeting project deadlines as well as satisfying technical specifications.

6.1 Research Background and Model

According to Raymond, (Raymond, Bergeron 2007) an IS-based conceptualisation and definition of project management software facilitates the import of knowledge from the IS field or discipline, knowledge that can provide a deeper understanding of the PMIS usage phenomenon and help in answering questions on the factors that explain the use and non-use of PMIS, and on the actual impacts of these systems on project managers and project performance. This study is thus established on the recurrent constructs of antecedents and consequences of IS use developed in DeLone and McLean's (DeLone, McLean 2003) Information System Success Model (ISSM) and in Davis (Davis, Bagozzi & Warshaw 1989) Technology Acceptance Model (TAM). Schematics of the ISSM and TAM are presented in Appendix D: Information System Success Model (ISSM) and Technology Acceptance Model (TAM). These models is notable by the continuance of their constructs, after a review of theories and models of IS use that focused on their chronological examination and their cross-influences and convergences. The ISSM incorporates information quality and system quality as antecedents of IS use, leading to individual IS impacts, that is, on users and their work (e.g., in regard to their effectiveness), and in turn to organizational impacts (e.g., in regard to business strategy and performance)

(Raymond, Bergeron 2007). While the TAM explains IS use in a similar manner by the system's perceived usefulness and perceived ease of use. Both the ISSM and the TAM offer widely accepted and validated representations and explanations of the IS use phenomenon. This is supported by studies done by Larsen, Lee and Rai (Larsen 2003, Lee, Kozar & Larsen 2003, Rai, Lang & Welker 2002).

The objectives of the study, by Raymond and Bergeron, is thus to improve the understanding of the impacts of PMIS on project managers and on project performance. More specifically, it intends to determine the success of these systems, i.e., their level of use by project managers, as determined by the quality of PMIS and of the information they provide. The study also establish to what extent PMIS contribute to the successful completion of projects through their individual and organizational impacts. Indeed, the study aims to verify if the use of a PMIS is related to efficiency, productivity and effectiveness of a project manager, and to the performance of the project itself (Raymond, Bergeron 2007).

Given the research, an adaption to –and specification for- project management of the ISSM and the TAM was deemed to be most appropriate. As presented in Figure 11, the model as adapted and specified is composed of five constructs, namely the quality of the PMIS, the quality of the PMIS information output, the use of the PMIS, the individual impacts of the PMIS and the impacts of the PMIS on project success, linked through research hypotheses presented in Table 1 below.

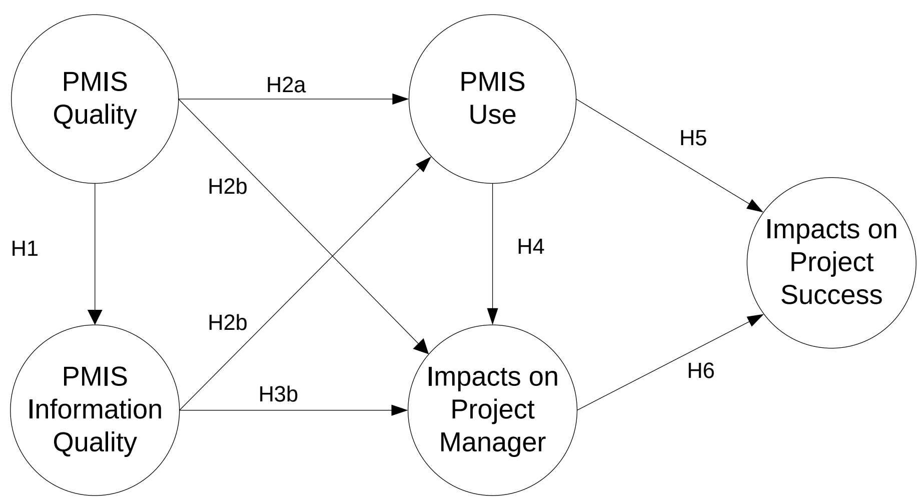

Figure 11: Research model on project management information system success (Raymond, Bergeron 2007)

Table 2: Hypotheses of Research on PMIS Success lists and describes the hypotheses 1 to 6 presented in Figure 11: Research model on project management information system success (Raymond, Bergeron 2007). A cross reference is also provided to validate the hypotheses against literature.

Table 2: Hypotheses of Research on PMIS Success

Hypotheses	Description	Cross Reference
H1	Greater PMIS quality is associated to greater quality of information output by the system. This first hypothesis is based on empirical evidence linking the technical and service aspects of an information system (e.g., ease of use, response time) to the user's satisfaction with the information output by the system (e.g., perceived usefulness, timeliness of the information).	(Igbaria, Iivari & Maragahh 1995)
H2	Greater PMIS quality is associated to greater system use (H2a) and greater system impacts on the project manager (H2b). In applying IS theory and results to project management, one finds that previous empirical tests of the ISSM and the TAM have shown system quality to positively influence system use and positively affect individual user performance in terms of job effectiveness, quality of work and decision-making.	(Bergeron et al. 1995), (Taylor, Todd 1995), (Weill, Vitale 1999)
H3	Greater quality of the information output by the PMIS is associated to greater system use (H3a) and greater system impacts on the project manager (H3b). The third hypothesis extends to project management the notion that the managers' use of IT-based information systems and their performance are dependent upon the quality of information provided to them by these systems.	(Bergeron et al. 1995), (Etezadi-Amoli, Farhoomand 1996),
H4	Greater use of the PMIS is associated to greater system impacts on the project manager. A number of IS studies have demonstrated that the depth and breadth of IS use (e.g., usage dependency, pattern, and frequency), if voluntary and appropriate to the task, has positive impacts on users in terms of job performance and decision-making performance.	(Igbaria, Tan 1997), (Seddon, Kiew 1994)
H5	Greater use of the PMIS is associated to greater impacts of the PMIS on project success. A number of IS researchers believe that the quality and intensity of information system use, and the ''full functionality'' of this use in particular, are essential to the achievement of desired organizational results or to the realization of anticipated organizational benefits.	(DeLone, McLean 2003), (van der Meijden et al. 2003)
H6	Greater impacts of the PMIS on the project manager are associated to greater impacts of the PMIS on project success. This last hypothesis is based on IS theory and evidence that the organizational impacts results not only from IS use but also from the individual impacts of the system i.e., that projects led by more efficient and effective managers, due to their use of a PMIS, tend to be more successful in terms of meeting project schedules, budgets, and specifications.	(Teo, Wong 1998, Jurison 1996)

6.2 Research Methodology of the Study done by Raymond and Bergeron

To test the research model, a survey of 224 project managers and project management consultants was conducted, identified from a list of participants to a project management national conference held in Canada. Forty five questionnaires were received, out of which 39 were considered valid, thus a 17.4% final response rate. The information quality, system quality and system use constructs were measured by adapting to the specific PMIS context instruments previously developed and validated in a general IS context (Bergeron et al. 1995).

The quality of the PMIS was measured on a five-point scale varying from 1 (low quality) to 5 (high quality) with the following eight items: Accessibility, Response time, Flexibility, Ease of use, Querying ease, Learning ease, Systems integration, Multi-project capability. (Raymond, Bergeron 2007)

The quality of information was measured on a five-point scale varying from 1 (low quality) to 5 (high quality) with the following six items: Availability, Relevance, Reliability, Precision, Comprehensiveness, and Security (Raymond, Bergeron 2007).

The use of the PMIS was measured by establishing the extent to which various system functions and their associated tools were actually used by project managers (Raymond, Bergeron 2007). The PMIS functions were divided into five categories:

1. The planning function tools aim at preparing the overall project plan; they include: Work breakdown structure, Resource estimation, Overall schedule, Gantt, PERT, CPM.
2. The monitoring function tools are used to regularly assess project progress; they are used for: progress reports and curves, to update operational reports such as completed tasks, percent project completed, effective schedule, remaining tasks and remaining days to complete.
3. The controlling function tools are used to make specific changes to the project; they allow the project manager to: fine-tune forecasts, modify tasks, reassign resources to lower the costs, cancel tasks and modifying the cost of resources.
4. The evaluating function tools are targeted toward project auditing; these tools allow the identification of cost and schedule variations, tracking the use of resources.
5. The reporting function tools give information on the most basic aspects of the project; they include: overview of the project, reports on work-in-progress, budget overruns task and schedule slippages.

Raymond obtained a score for each category was by averaging the project managers' use of specific tools. The five categories and their specific number of tools are: planning (6), monitoring (7), controlling (6), evaluating (2), and reporting (9). Five-point scales were employed: 1 (never used), 2 (rarely used), 3 (occasionally used), 4 (often used), and 5 (very often used) (Raymond, Bergeron 2007).

Raymond measured the Impacts on the project managers by using a five-point Likert scale, varying from 1 (completely disagree) to 5 (completely agree), to measure the perceived effect of the PMIS on the following 10 items: improvement of productivity at work, Increase in the quality of decisions, reduction of the time required for decision-making, reduction of the time required to complete a task, improved control of activity costs, better management of budgets, improved planning of activities, better monitoring of activities, more efficient resource allocation, better monitoring of the project schedule (Raymond, Bergeron 2007).

Raymond also based the impacts of the PMIS on project success on the perceived contribution, using a five-point scale varying from 1 (null contribution) to 5 (very high contribution), of the PMIS with regard to three performance criteria: respecting deadlines, respecting budgets, respecting quality specifications (Raymond, Bergeron 2007).

6.3 Results and Discussions of the Study done by Raymond and Bergeron

Descriptive results on the antecedents, consequences and nature of PMIS use by the respondents are presented in Appendix E: Characterization of Respondents. The measurement mentioned in Chapter 6.2 is given a unique identification code throughout the study and is presented in Appendix F: Measurement Codes.

6.3.1 Test of the Measurement Model

To test the multivariate relationships hypothesised by the research model, structural equation modelling was used. The partial-least-squares (PLS) method was selected for its robustness as it does not call for a large sample or normally distributed multivariate data in comparison to covariance structure methods such as LISREL and EQS (Fornell, Larcker 1981). Figure 12: Results of evaluating research model with PLS (n = 39) (Raymond, Bergeron 2007) summarizes the results gained. The PLS method simultaneously assesses the theoretical propositions and the properties of the underlying measurement model. Note that PLS does not provide goodness-of-fit indices; model fit is rather assessed by the reliability of each construct, the significance of the path coefficients, and the percentage of variance explained (**R^2**) for each dependent construct (Gefen, Straub & Boudreau 2000).

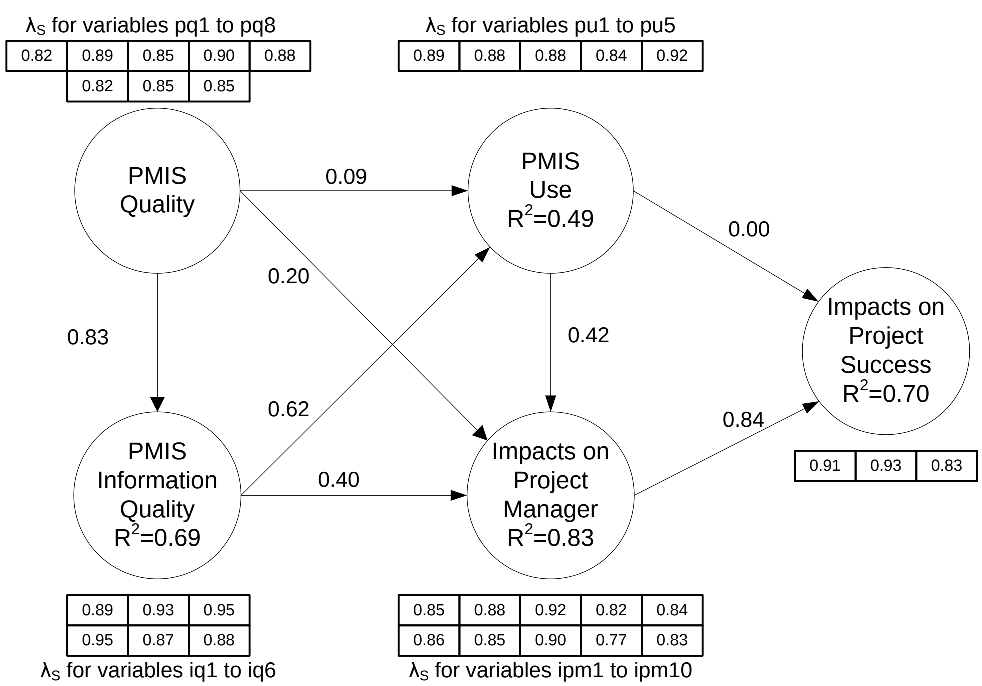

Figure 12: Results of evaluating research model with PLS (n = 39) (Raymond, Bergeron 2007)

Internal consistency of measures, i.e., their unidimensionality and their reliability must be verified first. The observable variables measuring a non-observable construct (or latent variable) must be unidimensional to be considered unique values. Unidimensionality is usually satisfied by retaining variables whose loadings (λ) are above 0.5, indicating that they share sufficient variance with their related construct. The unidimensionality criteria are thus met. Reliability can be verified by considering the value of the rho (ρ) coefficient, defined as the ratio between the square of the sum of the loadings plus the sum of the errors due to construct variance. A ρ greater than 0.7 indicates that the variance of a given construct explains at least 70% of the variance of the corresponding measure, as is the case in Table 3: Reliability, convergent validity, and discriminant validity of the research constructs (Raymond, Bergeron 2007), for all constructs in the research model. There is also evidence in Table 3: Reliability, convergent validity, and discriminant validity of the research constructs **(Raymond, Bergeron 2007)** of the convergent validity of the constructs, as their average variance extracted ranges from 0.72 to 0.83 in value. The last property to be verified is discriminant validity. It shows the extent to which each construct in the research model is unique and different from the others. The shared variance between a construct and other constructs (i.e., the squared correlation between two constructs) must be less than the average variance extracted (i.e., the average variance shared between a construct and its measures). Table 3: Reliability, convergent validity, and discriminant validity of the research constructs (Raymond, Bergeron 2007), shows this to be the case for all constructs.

Table 3: Reliability, convergent validity, and discriminant validity of the research constructs
(Raymond, Bergeron 2007)

Variable	ρ[a]	**1**	**2**	**3**	**4**	**5**
PMIS quality	0.96	0.74[b]				
PMIS information quality	0.97	0.69	0.83			
PMIS use	0.95	0.37	0.49	0.77		
Impacts on project manager	0.96	0.71	0.72	0.66	0.72	
Impacts on project success	0.92	0.46	0.41	0.48	0.71	0.79

$$\text{Re } liability \quad Coeffiecie \ nt = \frac{\left(\sum \lambda_i\right)^2}{\left[\left(\sum \lambda_i\right)^2 + \sum\left(1-\lambda_i^2\right)\right]} \qquad \text{....a}$$

$$Diagonal \ : avg \ \text{var} \ ience \ \ extracted = \frac{\sum \lambda_i^2}{n}$$

$$Sub - diagonals \ : shared \ \ \text{var} \ iance = \left(correlatio \ \ n\right)^2 \qquad \text{....b}$$

6.3.2 Test of the Theoretical Model

The research hypotheses are tested by analysing the direction, the value and the level of significance of the path coefficients **(γ)** estimated by the PLS method, as presented in Figure 12: Results of evaluating research model with PLS (n = 39) (Raymond, Bergeron 2007). The high percentage of variance explained in each dependent construct, varying from 0.49 to 0.83, is indicative of model fit.

H1– A positive and highly significant path coefficient (γ = 0.83) confirms that the quality of information output by a PMIS is strongly associated to the technical and service aspects of the system, that is, to system quality. From the project manager's point of view, the PMIS cannot be deemed merely as a ''black box'' but must be assessed for its level of sophistication and support provided by the organization's IS function and by the system providers, whether they are inside or outside the organization.

H2 – The second hypothesis could not be confirmed. PMIS quality was not found to directly influence the use of the system (γ = 0.09), nor its impacts on the project manager (γ = 0.20). There are however a significant indirect effect of system quality on system use (equal to 0.83 x 0.62 = 0.51) and on impacts on the project manager (equal to 0.83 x 0.40 = 0.12), that is, through the mediating influence of information quality.

H3 – The third hypothesis, presuming a positive influence of the quality of information provided by the PMIS upon the use of the system and its impacts on the project manager is confirmed. Indeed, the quality of information output is significantly related to the use of the PMIS by project managers (H3a, γ = 0.62). Path analysis also confirms the existence of a significant relation between the quality of information output and the system's impacts on project managers (H3b, γ = 0.40). Hence a PMIS must provide information on project costs, resources and milestones that is perceived to be relevant, reliable and accurate by project managers if they are to use these systems in their planning, controlling, monitoring and reporting tasks and if they are to be more efficient and effective in accomplishing these tasks.

H4 – Testing the fourth hypothesis confirmed that the use of a PMIS is positively related to its impacts on the project manager (γ = 0.42). In other words, the use of a PMIS by project managers increases their productivity, effectiveness and efficiency in decision-making due to the quality of the information output by the PMIS. Therefore, using project management software tools that enhance their capacity to plan, control, monitor, audit, and report provides tangible benefits to project managers and improves the quality of their work.

H5 – The fifth hypothesis could not be confirmed as no direct relationship was found between PMIS use and the system's impacts on project success (γ = 0.00). Significant improvements in project performance in terms of meeting deadlines, respecting budgets and meeting specifications can be obtained indirectly however, through the system's impacts on project managers.

H6 – Results confirmed the positive association between the impact of PMIS on the project manager and the impact of PMIS on project success (γ = 0.84).

Hence, the more project managers perceive their task to be positively impacted by their use of project management software, greater is their belief in the positive contribution of this software to the attainment of their projects' performance objectives.

6.4 Final Discussion of the Study done by Raymond and Bergeron

The objective of this research is to have a better understanding of the elements that contribute to the impact of a PMIS on project success. The study results are discussed in terms of direct and indirect effects on PMIS project success. To ease the discussion, the elements are grouped in three dimensions: technical (PMIS quality and quality of information), managerial (PMIS use and impact on project manager), and organizational (PMIS impact on project success).

At the technical level, the first element indirectly influencing the impact of a PMIS on project success is PMIS quality. The system's ease of use, flexibility, response time, learning ease and system integration play an important role in producing quality information, as perceived by the project manager. Indeed, PMIS quality is a strong predictor of the quality of information to be obtained from the system. In the case of a higher-quality PMIS, the information output is more available, reliable, precise, comprehensive, and secure. Conversely, a PMIS that produces information of poor quality would be a system that is more difficult to use, less flexible, and less integrated to other organizational information systems used by the project manager and other managers or employees. This means that project information quality requires sophisticated, well-serviced information systems.

The quality of information is directly and strongly related to PMIS use and to the system's impacts on the project manager. Information quality is not an end by itself however, as it leads only indirectly to project success. At the managerial level, it is only through the actual use of the PMIS by – and the system's impacts on – the project manager that the quality of information can influence project success. Better quality of information output increases the opportunity of the PMIS being used, which in turn allows the system to have a positive impact on the project manager. As such, the quality of information output by the PMIS leverages the project manager's work as a professional. The latter will feel more professional at work if he or she has access to project information of high quality and uses the system more intensively and more extensively for the planning, control, monitoring, and reporting activities. This combination of quality information and extensive use of the system allows the project manager to feel more productive at work and provides improved support for decision-making.

This leads Raymond to the final relationship, at the organizational level, specifically the impacts of the PMIS on project success. First, the PMIS itself has no direct influence upon project success; it is only through higher-quality information, extensive use of the system, and individual impacts on the project manager that the system has an effect on project success. While a positive impact on managerial work is essential to project success, greater use of a PMIS does not lead per se to greater impacts on project performance. It is only indirectly, through its contribution to managerial work that this use contributes to project success. In summary, if it is to make a significant contribution to the attainment of project objectives, i.e., to make an impact in terms of project budget, schedule, and specifications, a PMIS must first be sufficiently sophisticated and serviced and produce information of sufficient quality. It must then be used with sufficient depth and breadth by project managers and it must have a sufficiently beneficial impact on their work.

Raymond noted that among the managers who participated in the study, a number indicated strong impacts of the PMIS upon the successful completion of their projects, while others did not (Raymond, Bergeron 2007). The results indicate that, in general, the latter depended upon a PMIS of lower quality that produced lower quality information; hence they used their system less and were less supported in their project management task. Whereas generally speaking, the former were those for whom the sufficient conditions were met, that is, PMIS quality, information output quality, PMIS use and positive impacts on managerial work (Raymond, Bergeron 2007).

Raymond made additional comments in explaining these relationships. First, it is worth noting that a reverse or ‘‘feedback’’ relationship is possible between individual impacts of a PMIS and its use (DeLone, McLean 2003). As project managers perceive the PMIS to be beneficial to them, it is likely that they will increase their use of the system. Second, other dimensions of project management, related to the organizational environment, evidently play a role in explaining project performance; thus the managers’ authority on project activities, their involvement in project design, and their accountability in meeting project objectives are potential success factors other than the PMIS (Bergeron 1986). Third, another interesting aspect to consider is the possible reluctance of project managers to report ‘‘bad news’’ on a project, and the subsequent effect it could have on the accuracy of project reports and on the assessment of project success. Finally, as suggested by Shenhar et al. ,future studies of PMIS success could evaluate project success or performance from the client’s perspective, that is, evaluate if the impacts of the PMIS on project outcomes provide an adequate solution to the client’s problem, bring true advantages to the organization in terms of quality of product/services offered, greater output volume, quicker delivery, and better strategic positioning, and provide tangible benefits such as increased sales and revenues (Shenhar, Levy & Dvir 1997).

6.5 Conclusion of Empirical Study done by Raymond and Bergeron

The research aim of this study done by Raymond and Bergeron was to determine the actual impacts of IT-based project management information systems upon project managers and project performance. More specifically, one objective was to identify the main determinants of PMIS and determine the extent to which these systems assist project managers in terms of increased efficiency, productivity and efficiency. Another objective was to get a better understanding of the contribution of these systems to the success of projects.

Following the conclusions of previous research that PMIS success models should continue to be validated and challenged, the results of this research show that the use of a project management information system is in fact advantageous to project managers. Improvements in effectiveness and efficiency in managerial tasks were observed here in terms of better project planning, scheduling, monitoring, and control. Improvements in productivity were also observed in terms of timelier decision-making. Advantages obtained from PMIS use are not limited to individual performance but also include project performance. These systems were found to have direct impacts on project success, as they contribute to improving budget control and meeting project deadlines as well as fulfilling technical specifications. One can therefore conclude that PMIS make a significant contribution to project success and should continue to be the object of project management research.

This chapter presents the validation and verification of the literature reviewed to ensure that the correct model is discussed as well as the model is discussed correctly. The next chapter presents the case study with South African Breweries Limited that measures and evaluates the current PMIS used within the company as a whole.

7. Case Study: South African Breweries Ltd

In the previous chapter presented the validation and verification of the literature reviewed to ensure that the correct model is discussed as well as the model is discussed correctly. This chapter introduces the case study with South African Breweries Limited (SAB Ltd) that measures and evaluates the current PMIS used within the company as a whole.

7.1 Introduction

With knowledge obtained from Chapter 2, through to Chapter 6, a case study is executed with South African Breweries Limited to investigate their current project management policy and procedures. To fully understand or depict SAB Ltd experiences with a PMIS, a comprehensive examination is achieved by conducting a furrow information audit which includes focus group discussions and a questionnaire. The questionnaire is based on the requirements and constructs evaluated in Chapter 6 by Raymond and Bergeron. The fundamentals of an information audit approach guide the investigation process. Through this investigation, the current system features are determined, as well as which is missing and what features can be improved. With the results of the altered information audit, recommendations are made regarding the desired system requirements in order to meet the organizations needs and how it can be successfully implemented by presenting quick wins for the possible causes of problems.

7.2 Overview of South African Breweries Limited

South African Breweries Limited is South Africa's leading producer and distributor of alcoholic and non-alcoholic beverages and one of the nation's largest manufacturing firms. The company operates seven breweries and 40 depots in South Africa with an annual brewing capacity of 3.1 billion litres. Its portfolio of beer brands meets the needs of a wide range of consumers and includes five of the country's top six most popular beer brands – namely Carling Black Label, Hansa Pilsener, Castle Lager, Castle Lite and Castle Milk Stout.

Through its various corporate social responsibility programs, SAB Ltd actively invests in community partnerships, socio-economic and enterprise development initiatives to build a stronger South Africa. To strive towards their vision to be the most admired company in South Africa, a partner of choice, an investment of choice and an employer of choice, they conduct a large range on projects.

SAB Ltd has 5 strategic thrusts which include: Ensure Key Brands Resonate, Shape Superior Route to Market, Engage the Competitor, Stabilize the Foundation and lastly Restore Societal Leadership. Each strategic thrust has an influence on various departments that work together. This calls for a good integrated project management information system.

7.3 Research Methodology of Case Study with SAB Ltd

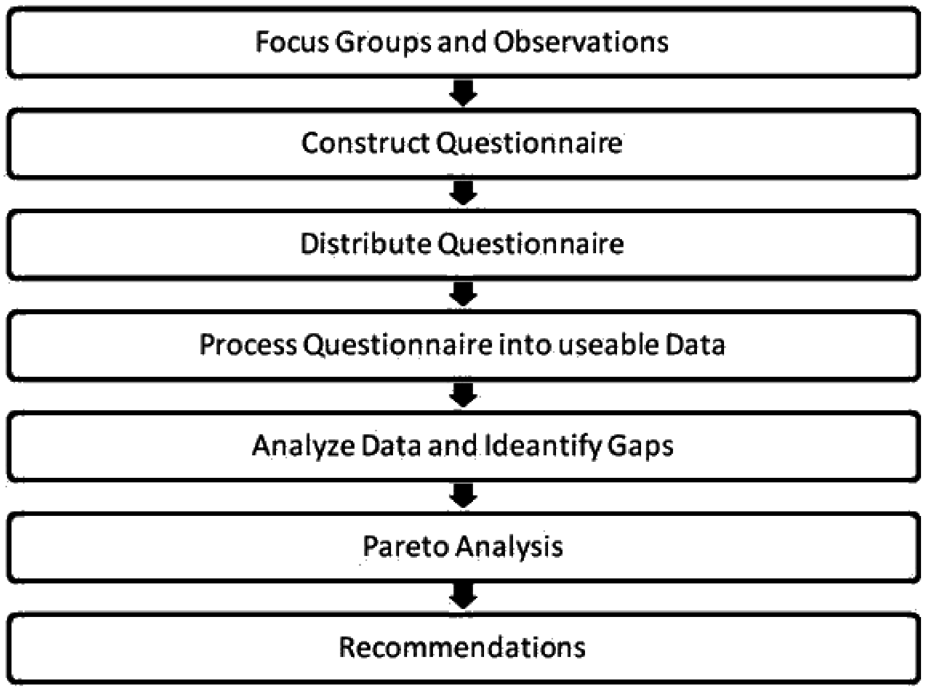

Figure 13: Methodology of the Case Study with SAB Ltd

Figure 13 presents the methodology process used to complete the case study with SAB Ltd. To understand the key issues and business processes, an altered information- and system audit approach is perused. The audit reflects on the organization and how it functions. It reviews the different business processes within the organization, exploring what information is needed in the process as well as what information is generated by the process. It requires a top-down as well as a bottom up approach by looking at all the information flows, barriers, and inefficiencies.

To achieve all the objectives of the information audit, to gather all the data, and to develop practical proposals, focus groups are observation of the system is firstly undergone. Then a questionnaire is constructed and distributed to personnel in 'central' positions. The detailed questionnaire draws out specific information and appropriate data. The measurement characteristics are based on the validation test model done by Raymond and Bergeron in the previous chapter. After the questionnaires are tallied, they are processed into useable data. The data is then analyzed to identify information- and system gaps. A Pareto analysis is employed to highlight problem areas that need to improve. Lastly, the necessary recommendations are made.

7.4 Focus Groups and Observations

By conducting focus groups discussions and sitting in on meetings with project managers and their teams in various departments (including Marketing, Operations, Fleet, etc.) that manages on-going projects, key issues and business processes (regarding their information collecting and sharing) are identified. Observations of discussion groups identified particular issues and challenges. To get an initial overview of the information- and system gaps, an altered Root Cause Analysis is done. Appendix G: Focus and Discussion Group Quick Wins for Possible Causes of Problems lists problem areas/items with possible causes as well as relevant principles or practices that serve as quick wins to the problems identified.

7.5 Questionnaire

7.5.1 Questionnaire Methodology

A detailed questionnaire is created to test the quality level of the information and the system currently used within South African Breweries Ltd. A total of 22 employees in 'central' project management positions were invited to participate in the questionnaire. These employees are situated across the whole company, thus the study is not barricaded to a certain region or department of the company. This is done to obtain an overview of the current PMIS used within the company. Take note that the data gathered is perceived data from the employees. External factors (like the scale of the project, the scale of the budget and the scale of the project team) may have played a role in the data gathered. To compensate for these external factors the standard deviation, median and range of the data are evaluated to ensure the soundness of the data.

From the 22 questionnaire released, 18 valid questionnaires were received, thus an 81.8% final response rate. The information quality, system quality and system use constructs were measured by adapting to the specific PMIS context instruments previously developed and validated in a the previous chapter (Bergeron et al. 1995). The questionnaire template is presented in Appendix H: South African Breweries Limited Questionnaire and the measurements with their unique codes are presented in Appendix F: Measurement Codes.

7.5.2 Questionnaire Analysis

The Centre of Statistical Consultation from the University of Stellenbosch was approached to verify that the data from the questionnaire is analysed correctly. Prof. Daan Nel, from the Centre of Statistical Consultation, suggested that a χ^2-test should be fitted to the data with the goal to reject or not to reject the null Hypothesis (H_0). The null Hypothesis (H_0) is where $p_j = p_{j0}$ for j=1, 2, 3, ..., n; where 'n' is the number of items measured. If the p-value is greater than 0.05, then H_0 is not rejected and vice versa.

The estimated or expected values for the measurements are developed within discussion groups with SAB head project managers. The expected and observed data is compared to analyse the differences between the targets set and actual results. A traffic light range is fitted, with a 95% confidence level, to these differences to indicate the danger and critical improvement items (red), items to take notice of and to be aware of the danger (orange) and lastly items that are considered within target (green). Furthermore, an altered Pareto analysis is used to specify the elements that need to be improved with regard to the expected targets.

7.6 Results and Discussions

The χ^2-test resulted in a positive outcome for it specified that there is no reason or not enough evidence to reject the data. Thus, valid conclusions and recommendations can be made from the data gathered from the questionnaire from SAB Limited.

7.6.1 Quality of the PMIS

Figure 14 presents the results obtained from the data analysis of the perceived and observed quality level as well as the expected quality level of the current PMIS within SAB Ltd. The complete data analysis and χ^2-test is presented in Appendix I: Quality of the PMIS Data Analysis.

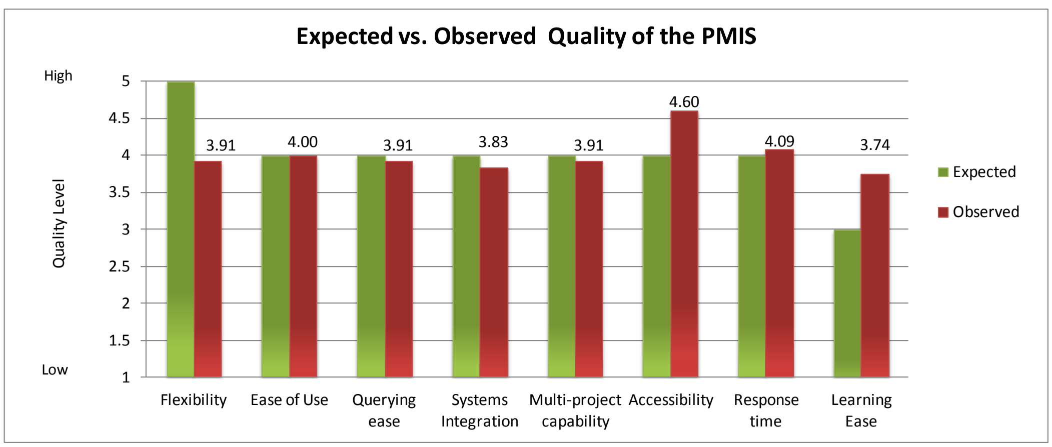

Figure 14: Expected vs. Observed Quality Level of the PMIS

From Figure 14: Expected vs. Observed Quality Level of the PMIS, it is clear that there is a huge difference in quality level with regard to flexibility of the system. The respondents perceive that the system is easy to use and have a good response time, but lacks in quality with regard to the systems querying ease, the system integration and the systems multi-project capability. However, the system meets criteria with regard to accessibility and learning ease.

Furthermore the results of the data analysis with regard to flexibility and system integration, presented in Appendix I: Quality of the PMIS Data Analysis, prove to have a range of 1. This means that most of the respondents agree with the quality level of the system's flexibility and integration functions. Moreover, the results with regard to the systems multi-project capability and querying ease, proves to have a range of 2. This means that there is a larger standard deviation perceived from the respondents, but according to Prof. Daan Nel, from the Centre of Statistical Consultation, this range value of two is small enough to accept that the respondents are still in agreement.

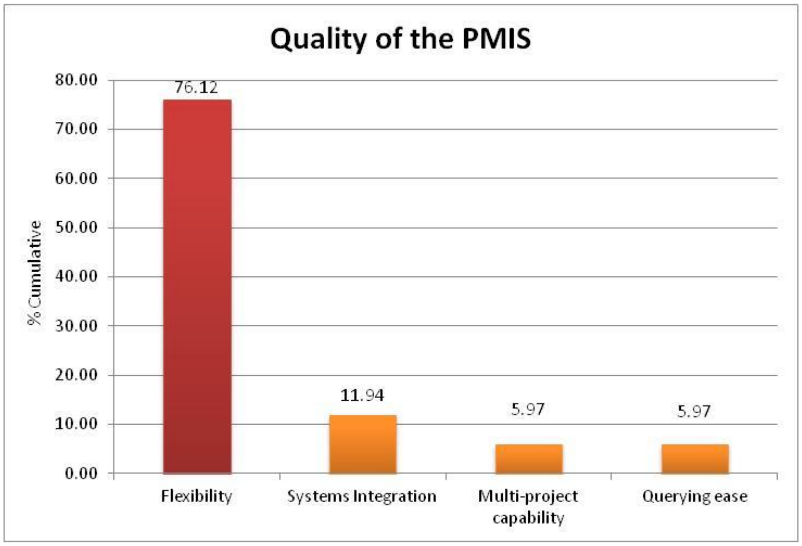

Figure 15: Pareto Analysis of the items influencing the quality level of the PMIS most

After identifying the elements that does not meet the expected quality level, a Pareto analysis is performed. The results are presented in Appendix I and in Figure 15 above. Consequently, the results from the Pareto analysis clearly indicate that the systems flexibility needs the most improvement. Thereafter the system integration functions, as well as the systems multi-project capability and querying ease.

7.6.2 Quality of the Information

Figure 16 presents the results obtained from the data analysis of the perceived and observed quality level within SAB Ltd as well as the expected quality level of the information within the PMIS. The complete data analysis and χ^2-test is presented in Appendix J: Quality of the Information Data Analysis

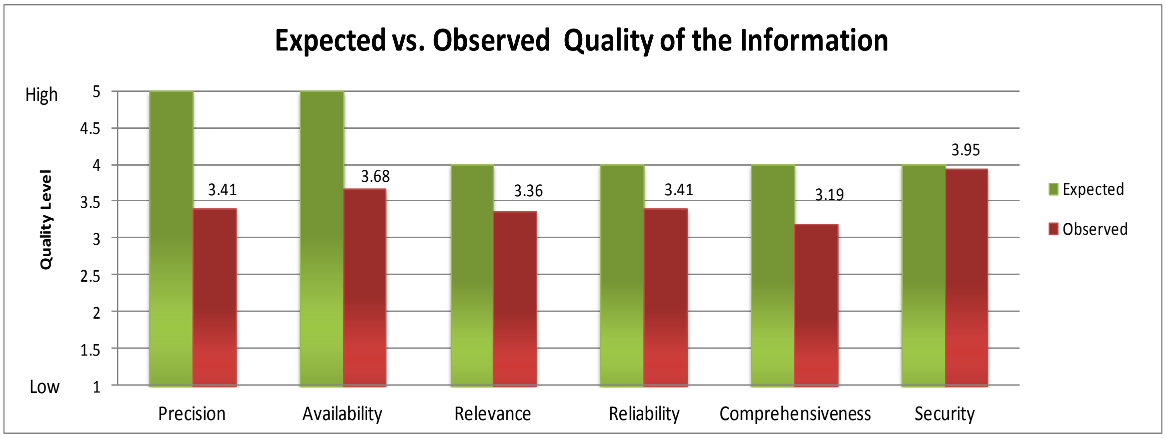

Figure 16: Expected vs. Observed Quality Level of the Information within the PMIS

From Figure 16: Expected vs. Observed Quality Level of the Information within the PMIS, it is clear that there is a huge difference in quality level with regard to the precision, availability, relevance, reliability and comprehensiveness of the information. The only element with a perceived quality level that nearly meets the expected quality level is the security of the information.

Furthermore, the results of the data analysis as presented in Appendix J: Quality of the Information Data Analysis, prove to have a range value of 3 for all the constructs. Even though the range value is high, the data is still valid according to Prof. Daan Nel because the constructs all have an equal range value.

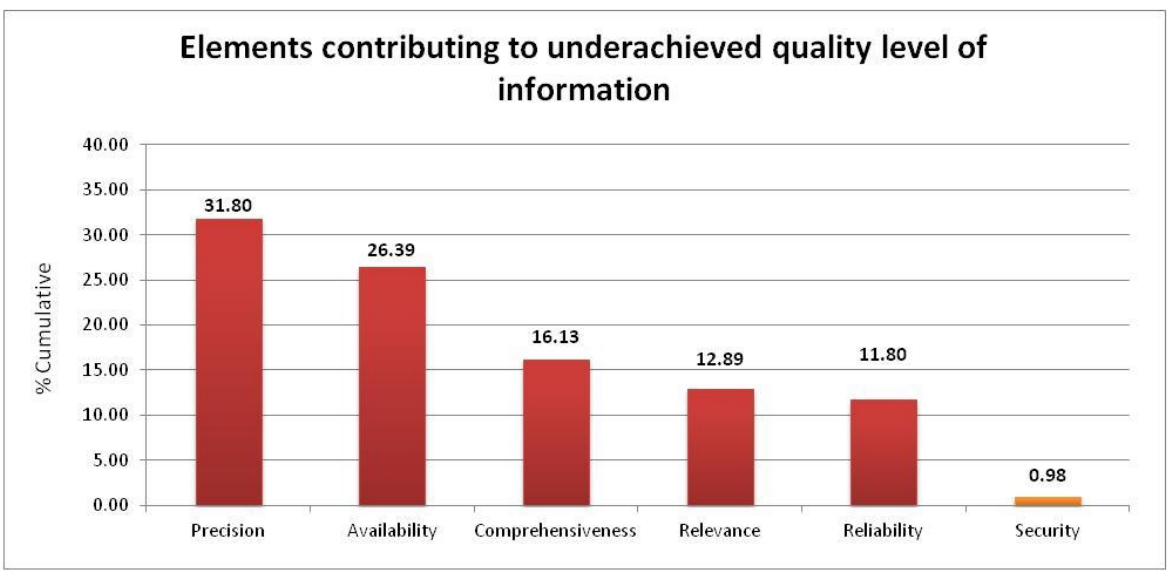

Figure 17: Pareto Analysis of the Items Influencing the Quality Level of the Information Most

After identifying the elements that does not meet the expected quality level, a Pareto analysis is performed. The results are presented in Appendix J and in Figure 17 above. Consequently, the results from the Pareto analysis clearly indicate that the precision of the information needs the most improvement. Thereafter the information availability needs to be improved, as well as the comprehensiveness, relevance and reliability of the information. Security can also improve to meet the specified requirements.

All these constructs are necessary for a high quality level of information. This is way all the constructs quality level does not meet the expected quality level, for the one reflects and influences the other.

7.6.3 Use of the PMIS

The use of the PMIS was measured by establishing the degree to which various system functions and their associated tools were actually used by project managers (Raymond, Bergeron 2007). The PMIS functions were divided into five categories: planning function tools, monitoring function tools, controlling function tools, evaluating function tools and reporting function tools.

7.6.3.1 Planning Function Tools

Figure 18 presents the results obtained from the data analysis of the perceived usage by respondents of planning function tools within SAB Ltd as well as the expected usage of the planning function tools within the PMIS. The complete data analysis and χ^2-test is presented in Appendix K: Usage of Planning Function Tools Data Analysis.

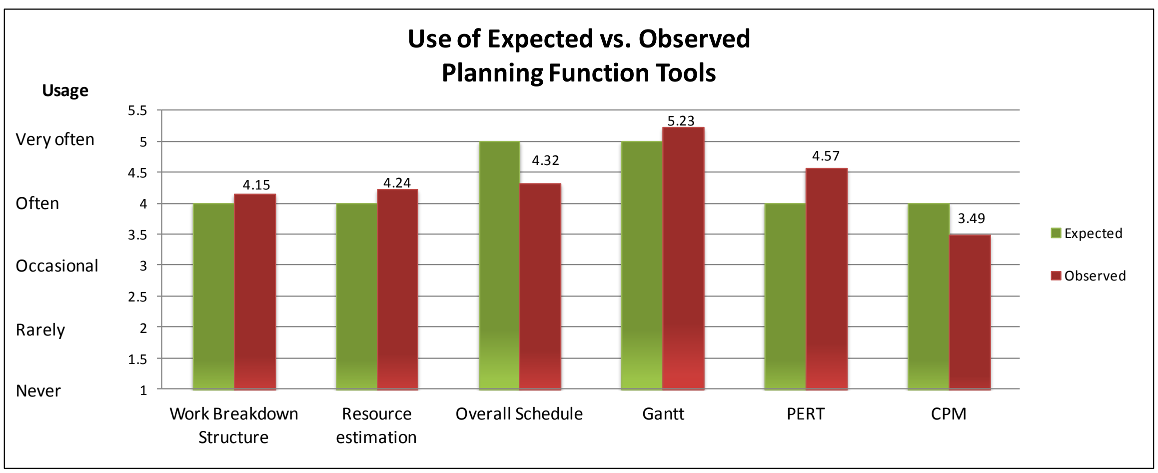

Figure 18: Use of Expected vs. Observed Planning Function Tools

Figure 18: Use of Expected vs. Observed Planning Function Tools, indicates that there is a huge difference in the perceived usage of CPM (Critical Path Method) than expected. Furthermore, there is also a difference with regard to the overall schedule planning function. The respondents perceived usage of a work breakdown structure, resource estimation, Gantt chart and PERT function tools, are used more than is expected. Overall schedule and CPM function tools have both a range value of 2 and can be accepted according to Prof. Daan Nel as previously stated.

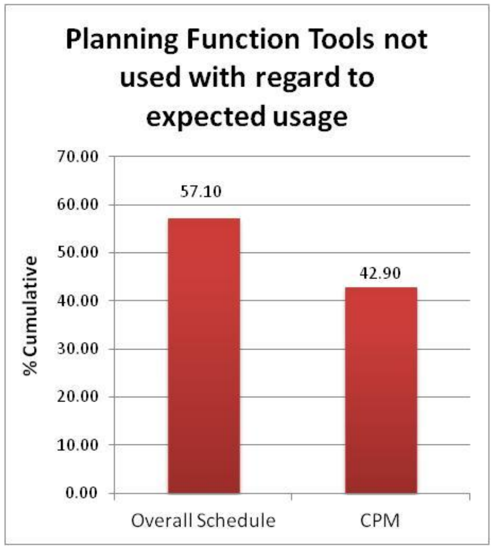

Figure 19: Pareto Analysis of the Planning Function Tools not used as expected

After identifying the elements that does not meet the expected levels of usage, a Pareto analysis is performed. The results are presented in Appendix K and Figure 19 above. As a result from the Pareto analysis it is clear that an overall schedule should be more used as a planning tool. The increased usage of the CPM will also assist using the overall schedule.

7.6.3.2 Monitoring Function Tools

Figure 20 presents the results attained from the data analysis of the perceived usage by respondents of monitoring function tools within SAB Ltd as well as the expected usage of the monitoring function tools within the PMIS. The complete data analysis and χ^2-test is presented in Appendix L: Usage of Monitoring Function Tools Data Analysis.

Figure 20: Use of Expected vs. Observed Monitoring Function Tools indicates that there is a slight difference in the perceived monitoring of overall project reports. Moreover, there is a huge difference between the expected and perceived usage of monitoring tools which includes percentage of the project completed which is indicated as only used occasionally, as well as monitoring of an effective schedule. Nevertheless, monitoring tools like completed tasks, remaining tasks and remaining days to complete is used often to very often by the respondents.

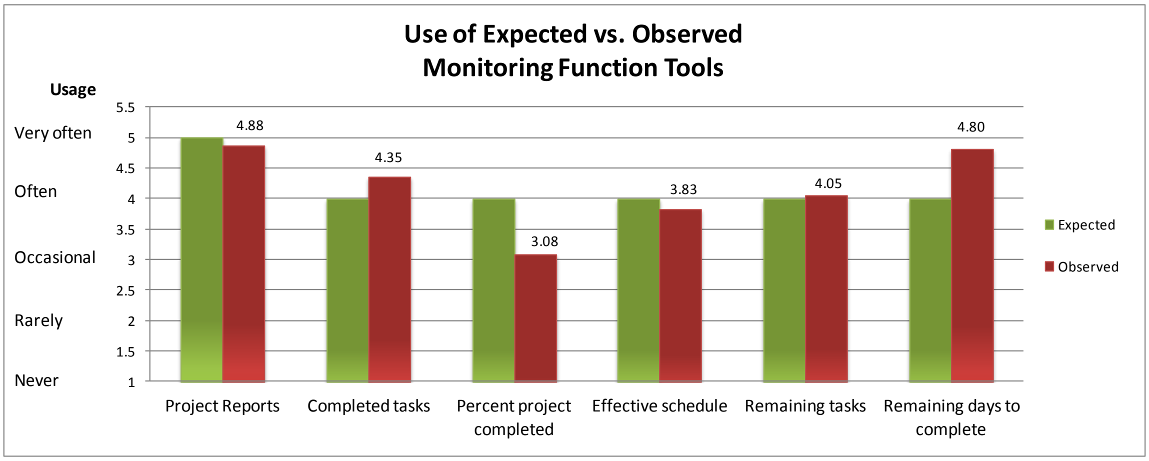

Figure 20: Use of Expected vs. Observed Monitoring Function Tools

A Pareto analysis, presented in Appendix L, is performed after the elements that does not meet the expected levels of usage, is identified. Form Figure 21 it is evident that the monitoring function tool that needs to increase its usage the most, is percentage of the project completed. It needs to increase usage form occasional too more often.

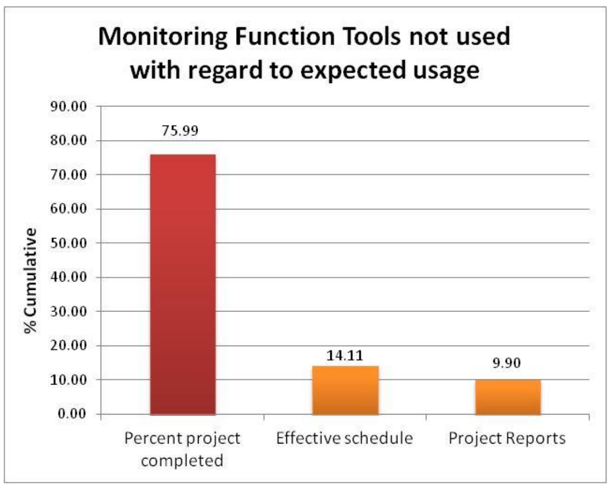

Figure 21: Pareto Analysis of Monitoring Function Tools not used as expected

Furthermore, Figure 21 suggests that the monitoring function tool effective schedule needs to be used more often and the monitor of overall projects needs to be used very often.

7.6.3.3 Controlling Function Tools

Figure 22 presents the results obtained from the data analysis of the perceived usage by respondents of controlling function tools within SAB Ltd as well as the expected usage of the controlling function tools within the PMIS. The complete data analysis and χ^2-test is presented in Appendix M: Usage of Controlling Function Tools Data Analysis.

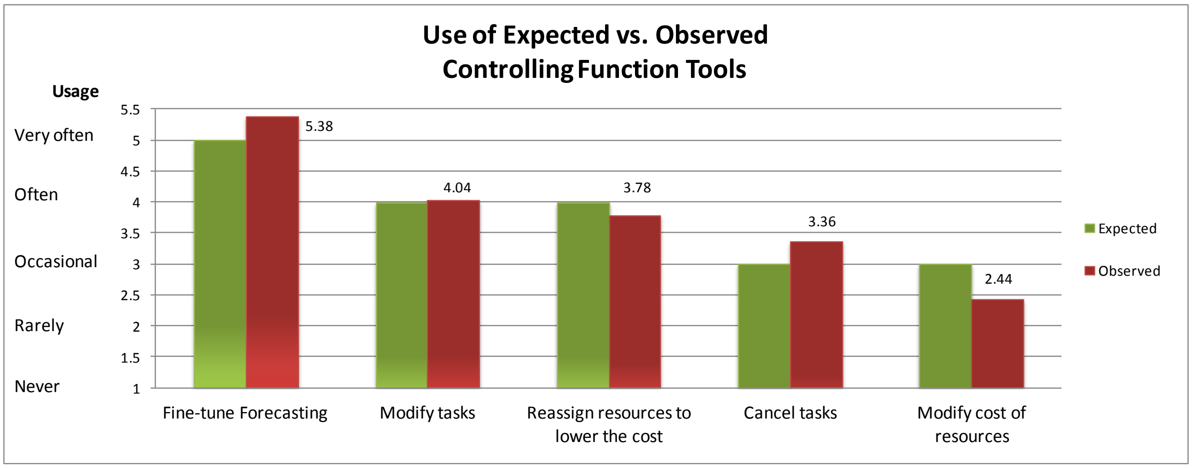

Figure 22: Use of Expected vs. Observed Controlling Function Tools

Figure 22: Use of Expected vs. Observed Controlling Function Tools, indicates that there is a slight difference in the perceived controlling task of reassigning resources to lower the cost. Furthermore, there is a larger difference in the perceived controlling function tool of modifying the cost of resources. In contrast, controlling function tools like fine-tune forecasting are used very often, modifying tasks are used often enough and cancelling tasks are used more than occasionally.

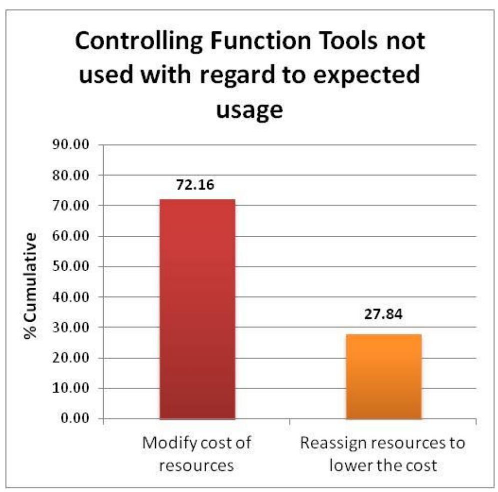

Figure 23: Pareto Analysis of Controlling Function Tools not used as expected

The Pareto analysis results, presented in Figure 23 and in Appendix M, specifies that controlling tool of reassigning resources to lower the cost needs to be used more often and modifying the cost of resources needs to be used more occasionally. Take note that not all of the respondents may have access to SAP to change these costs, which is why these controlling function tools are used less than expected. On the other hand, these function tools are still important to use by the project manager to ensure the budget is not over- or under run as well as to pay resources an appropriate salary.

7.6.3.4 Evaluating Function Tools

Figure 24 presents the results obtained from the data analysis of the perceived usage by respondents of evaluating function tools within SAB Ltd as well as the expected usage of the evaluating function tools within the PMIS. The complete data analysis and χ^2-test is presented in Appendix N: Usage of Evaluating Function Tools Data Analysis.

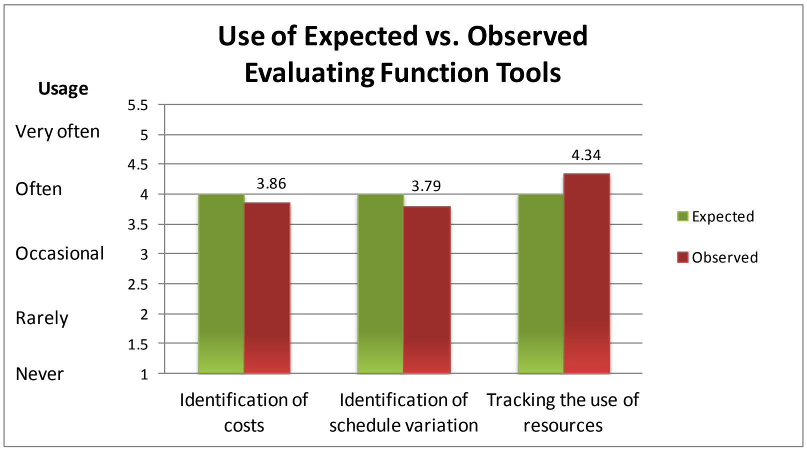

Figure 24: Use of Expected vs. Observed Evaluating Function Tools

Figure 24: Use of Expected vs. Observed Evaluating Function Tools, indicates that there is a slight difference in the perceived evaluating function tools of identifying costs together with identification of schedule variation. On the other hand, the usages of resources are tracked.

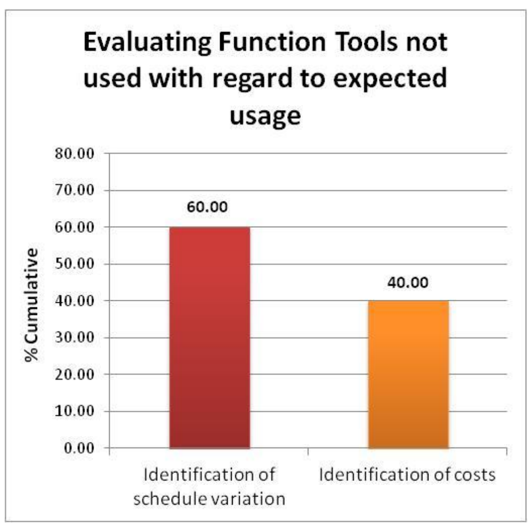

Figure 25: Pareto Analysis of Evaluating Function Tools not used as expected

After identifying the elements that does not meet the expected levels of usage, a Pareto analysis is performed. The results are presented in Appendix N and in Figure 25 above. As a result from the Pareto analysis it is clear that schedule variation should be more identified and evaluated. The increased usage of the CPM (discussed in 7.6.3.1) will assist the evaluation of schedule variation and the identification of costs.

7.6.3.5 Reporting Function Tools

Figure 26 presents the results obtained from the data analysis of the perceived usage by respondents of reporting function tools within SAB Ltd as well as the expected usage of the reporting function tools within the PMIS. The complete data analysis and χ^2-test is presented in Appendix O: Usage of Reporting Function Tools Data Analysis.

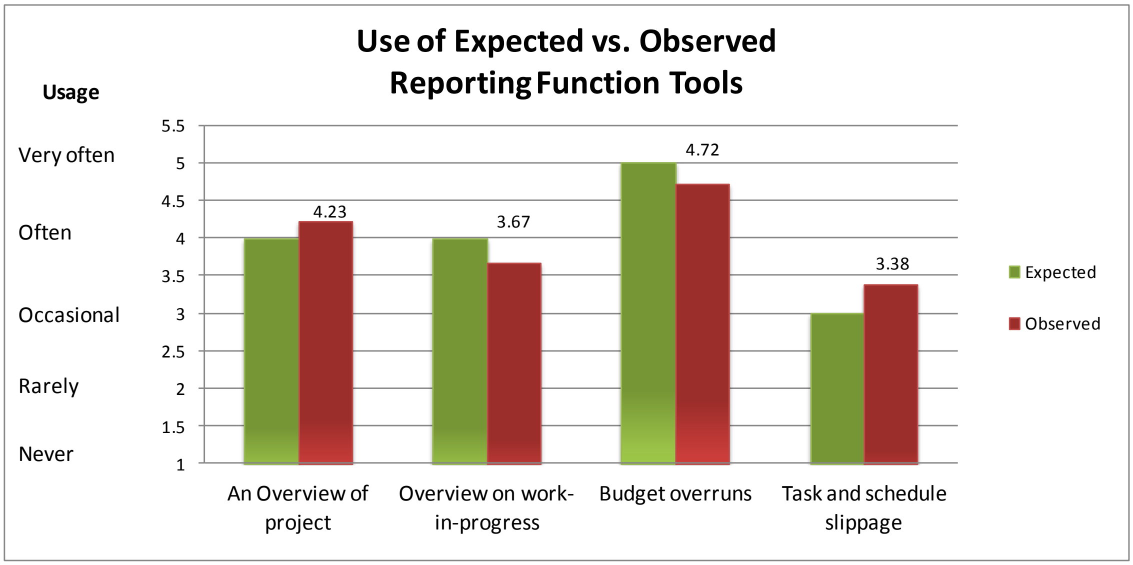

Figure 26: Use of Expected vs. Observed Reporting Function Tools

Figure 26: Use of Expected vs. Observed Reporting Function Tools, indicates that the reporting function tool of budget overruns is used often but not used enough. Furthermore, the reporting function tool for providing an overview on work-in-progress needs to be used more often. While on the other hand, the reporting tool to get an overview of the project is used often. Moreover, task and schedule slippage are used more than expected.

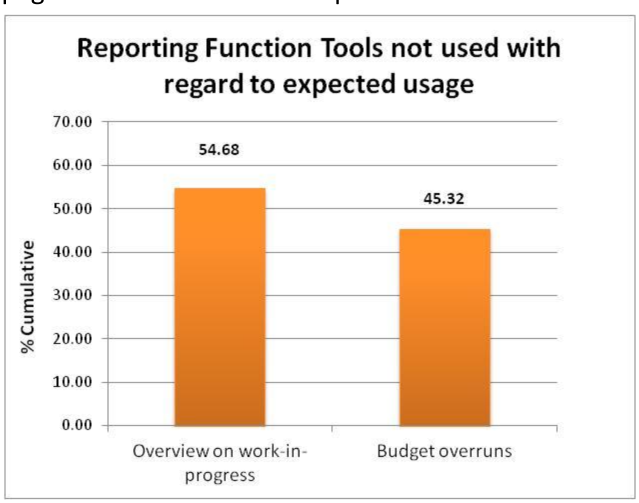

Figure 27: Pareto Analysis of Reporting Function Tools not used as expected

The Pareto analysis results, presented in Figure 27 and in Appendix O, specifies that an increase usage of the reporting tools work-in-progress overview and budget overruns needs to be increased.

7.6.3.6 Impacts on the Project Manager

Figure 28 presents the results obtained from the data analysis of the perceived contribution of the impacts on the project manager within SAB Ltd as well as the expected contribution of the impacts on the project manager. The complete data analysis and χ^2-test is presented in Appendix P: Data Analysis of the Impacts on the project manager.

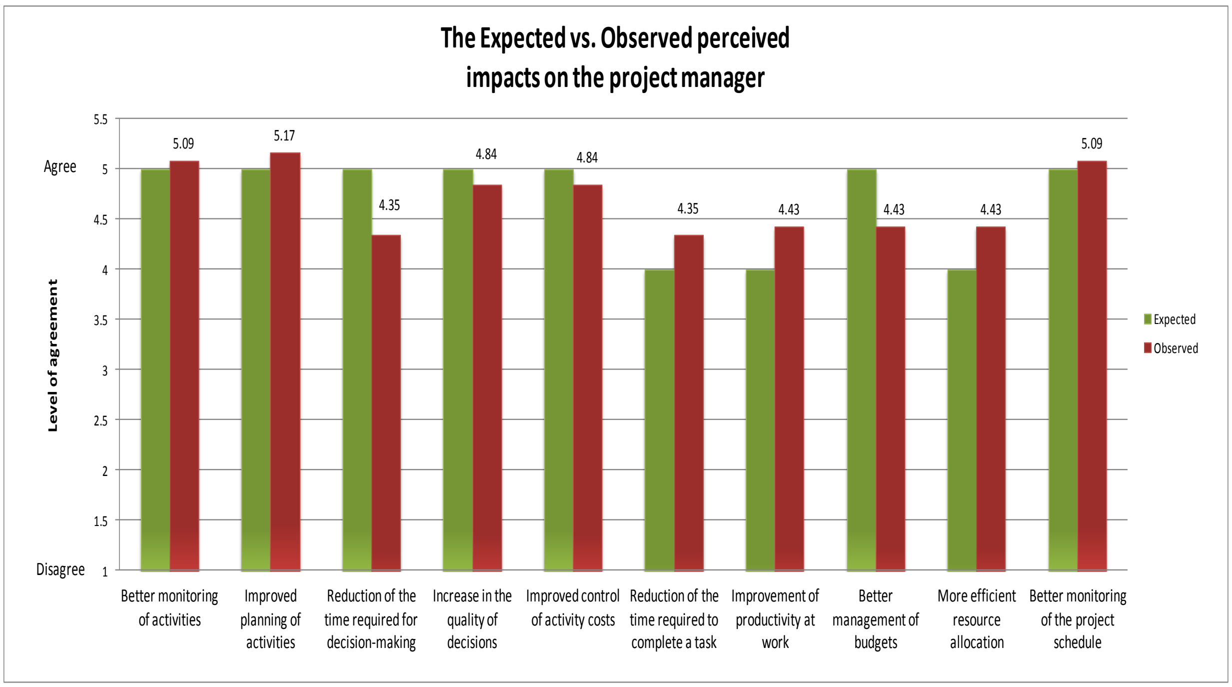

Figure 28: Expected vs. Observed perceived impacts on the project manager

By investigating Figure 28: Expected vs. Observed perceived impacts on the project manager, it is evident that respondents do not fully agree that the PMIS aids the reduction of the time required for decision-making and increases the quality of decisions. Furthermore, the respondents don't fully agree that the PMIS improves the control of activity costs and manages the budget better. The range of the perceived contribution all have a value of 2 and can be accepted according to Prof Daan Nel.

However, the respondents agree the use of a PMIS improves better monitoring of activities, better planning activities. The respondents also agree the use of a PMIS reduces the time required to complete tasks, improves productivity at work with more efficient resource allocation and better monitoring of the project schedule.

Figure 29: Pareto Analysis of Impacts on the Project Manager that doesn't meet expectations

By conducting a Pareto analysis, presented in Figure 29 and Appendix P, the contribution of the impacts that needs to improve the most is the reduction of the time required for decision-making and better management of budgets. From previous discussions in 7.6.3, the function tools regarding decision-making and budget management is not used often enough. Thus, the results of the Pareto analysis of the impacts on the project manager are perceived and subjective to the function tools used by the respondents. These results does not mean that the PMIS does not contribute to better decision making and better budget management, the contrary is true. However, these results indicate that there is a gap in usage of the systems function tools.

7.6.4 Impact on Project Success

Figure 30 presents the results obtained from the data analysis of the perceived contribution of the impacts on project success within SAB Ltd as well as the expected contribution of the impacts on project success. The complete data analysis and χ^2-test is presented in Appendix Q: Data Analysis of the Indicators of Project Success.

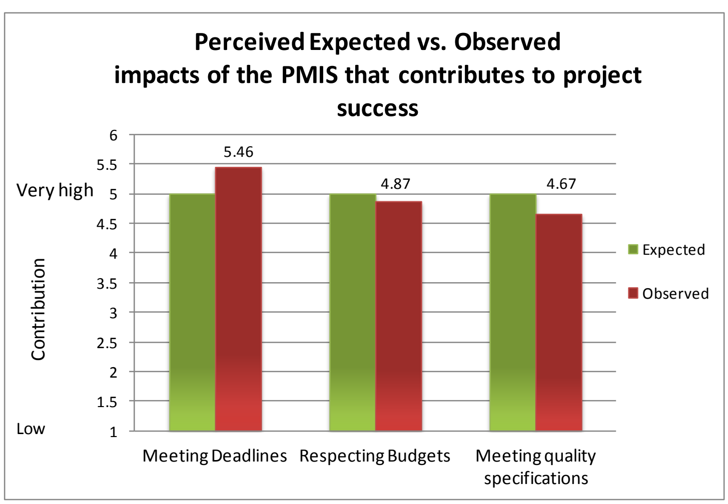

Figure 30: Expected vs. Observed impacts of the PMIS that contributes to project success

By investigating Figure 30: Expected vs. Observed impacts of the PMIS that contributes to project success, it is evident that respondents perceives that meeting deadlines is considered very high with regard to project success and considers respecting budgets and quality specifications of the project not that high with regard to project success. Evidently, project will be completed within time at the cost of a budget that is overrun and projects that does not meet all the required specifications.

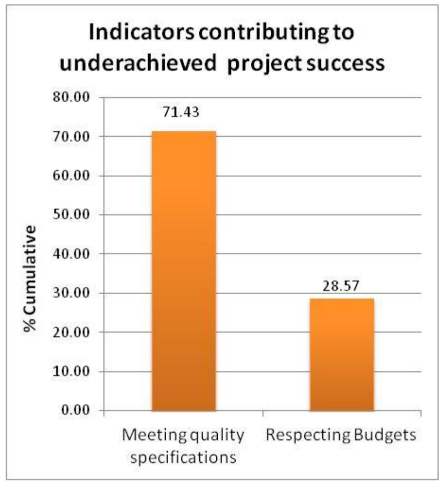

Figure 31: Pareto Analysis of Indicators Contributing to Underachieved Project Success

The Pareto analysis, presented in Figure 31 and Appendix Q, indicates that the most important element to improve is meeting quality specification and then respecting the budget of a project.

7.7 Recommendations

The aim of the case study with SAB Ltd was to identify the system and information gaps to improve the impacts on the project manager as well as project success to ensure that the company successfully works towards achieving their 5 strategic thrust.

Firstly, it is found that the systems flexibility needs the most improvement to create a fully integrated and multi-project capable system for an easy and efficiently changer over between different projects. The precision, availability and the reliability of the information needs to be improved. All these constructs are necessary for a high quality level of information. This is why all the constructs quality level does not meet the expected quality level, for the one reflects and influences the other. As such, the quality of information output by the PMIS leverages the project manager's work as a professional. The latter will feel more professional at work if he or she has access to project information of high quality and uses the system more thoroughly and more extensively for the planning, control, monitoring, evaluating and reporting activities. Hence, the more project managers perceive their task to be positively impacted by their use of project management software, greater is their belief in the positive contribution of this software to the attainment of their projects' performance objectives.

Thus, SAB Ltd needs to use planning tools like CPM more often to be able to obtain a good overview of the whole schedule. This will improve monitoring the efficiency of the schedule as well as monitoring the percentage of the project completed. The project costs needs to be controlled more thoroughly which will enable the evaluation and identification of project costs as well as how the schedule variation is influenced by the cost of the project. This will facilitate enhanced reporting of the budget overruns and provide an improved overview of work-in-progress. This combination of quality information and extensive use of the system permits the project manager to experience more productivity at work and presents improved support for decision-making.

Furthermore, SAB Ltd will respect project deadlines without compromising quality of the scope or the budget. Hence a PMIS must provide information on project costs, resources and milestones that is perceived to be relevant, reliable and accurate by project managers if they are to use these systems in their planning, controlling, monitoring and reporting tasks and if they are to be more efficient and effective in accomplishing these tasks.

This chapter discussed the case study with South African Breweries Limited, the research methodology of the case study as well and the results obtained from the study and applicable recommendation. The next chapter discusses the final conclusive remarks of the report.

8. Conclusion

The previous chapter presents a case study with South African Breweries Limited that measured and evaluated the current PMIS used within the company as a whole. This chapter presents final conclusive remarks as well as a reflection on the process followed and experienced gained from the final year project.

8.1 Reflection on Process Followed

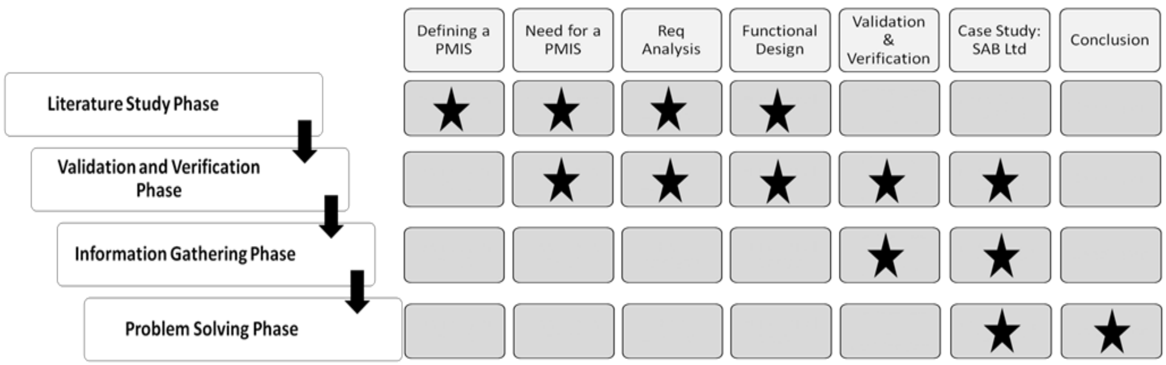

Figure 32: Reflection and Execution of the Methodology followed

Figure 32 illustrates how the methodology presented in Figure 1 and discussed in section 1.3 is executed. A star indicates where in the report a methodology phase is implemented. It is clear in Figure 32 that phases overlapped in order to achieve the project objectives.

The information gathering phase can be approached differently by dividing the questionnaire participation between departments and regions to compare the results of different sectors of the company. These results can be used to identify where more training is needed for personnel. Moreover, the different departments can provide assistance to underperforming departments. Furthermore, a monitoring and evaluating plan could have been developed to further provide assistance in selecting and improving the PMIS for any specific project.

8.2 Experience Gained from the Final Year Project

The execution of this final year project required professional together with interpersonal skills and served as an academic play field which presented an opportunity of experimenting with different tools and methods. The actual visits and work experience with the organization, to be able to get to know their processes, to identify current problems and to unravel these problems in order to find a suitable solution; was a very rewarding experience.

A personal style of professional civility is developed throughout the working period at South African Breweries Limited. This is a very valuable skill for prospect ventures and provides the student with the benefit to be independent on a professional level. Through the writing of this report, professionalism in written communication is gained as well.

Time management played a huge role throughout this project. To deal with other modules, tests as well as other group projects management of time was fundamental to reserve the required time for this individual project. The importance of consistent documentation of work completed is also grasped. Documentation eased the phases of the project and guaranteed that repetition is avoided. Furthermore, the significance of careful planning was grasped. Planning saved a lot of time throughout the project.

As an industrial engineering student, the student is attentive that the implementation of this project may have a positive and constructive impact on the organization by improving the usage of a PMIS. By the use of a Root Cause Analysis approach for effective problem solving identifies the root causes of the information- and system problems, not just the symptoms. Although it is a small contribution, every small change contributes towards a bigger result.

One of the most important lessons learnt is to take ownership of a project that is entirely one's own, to be autonomous and independent and to embrace the uncertainties as a challenge rather than a threat. Furthermore, to be focus orientated on the result in order to deliver an accurate solution in a professional and satisfied manner.

8.3 General Conclusion

The research aim of this study was to investigate the functional design of a project management information system. More specifically, one objective was to identify the main determinants of PMIS.

Following the conclusions of previous research that PMIS success models should continue to be validated and challenged, the results of this research show that the use of a project management information system is in fact advantageous to project managers. Improvements in effectiveness and efficiency in managerial tasks were observed here in terms of better project planning, scheduling, monitoring, and control. Improvements in productivity were also observed in terms of timelier decision-making. Advantages obtained from PMIS use are not limited to individual performance but also include project performance. These systems were found to have direct impacts on project success, as they contribute to improving budget control and meeting project deadlines as well as fulfilling technical specifications. One can therefore conclude that PMIS make a significant contribution to project success and should continue to be the object of project management research.

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Appendix A: Validation of Success Dimensions against Literature

As depicted in Appendix A: Validation of Success Dimensions against Literature, the success dimensions of the model specified in Figure 4: Adapted Common dimensions in project management success and project product success with PMIS overlap (van der Westhuizen, Fitzgerald 2004), satisfy the requirements of project success definitions found in literature, thus indicating the validity of the model discussed in 3.1 Project Success.

	(Baccarini 1999)	(Booch 1996, p. 22)	(Kerzner 2002, p. 6)	(Marchewka 2003, p. 30)	(Thomsett 2002, pp. 71-4)	(Wateridge 1998, p. 62)
Quality of Project management process	√		√	√		
Within time	√	√	√	√	√	√
Within budget	√	√	√	√	√	√
Specified system quality	√	√	√	√	√	√
Specified information quality	√	√	√	√	√	√
Specified service quality	√		√			√
Project stakeholder satisfaction	√		√	√	√	√
Use		√				√
User satisfaction	√	√	√	√	√	√
Net benefits	√			√	√	√

Appendix B: Stakeholder Information Needs

Stakeholders have various information needs that can often be satisfied through the information stored in the PMIS. Appendix B provides some of the stakeholders' information needs on a routine basis.

Stakeholder	Type of information needed (examples)
Customer	• Status and progress of project • Significant changes to cost, schedule, or anticipated technical performance • Any difficulty in converging on the project's objectives and goals
Senior management	• Status and progress of project • Significant changes to cost, schedule, or anticipated technical performance • Changes to resource requirements • Any difficulty in converging on the project's objectives and goals
Project manager	• Status and progress of project • Significant changes to cost, schedule, or anticipated performance • Changes to resource requirements • New project requirements or changes to specification or statement of work • Issue resolution or delay in critical decision
Functional manager	• Status and progress for their respective project elements • Changes to design or specification for their respective area of responsibility • Requirement for additional resources from their respective area of responsibility
Project team member	• Status and progress of project • Changes to project goals or objectives • New requirements for the project • Issue resolution • Change to work assignment

Appendix C: Validating the Information- and System Requirements against Literature

Appendix C: Validating the Information- and System Requirements against Literature depicts how Literature is used to indicate the validity the of the various information- and system requirements of a PMIS.

		(Cleland, 2004)	(Eisner, 2002)	(PMI, 2004)	(Gilbreath, 1986)	(Caldwell, 2004)	(Turner, 1999)	(Thomsen, 2011)	(Clements, Gido, 2006)	(Liberatore, Pollack-Johnson, 2004)	(Tuman, 1988)	(Sifiri, 2008)	(Meridith, Mantel, 2008)	(Baccarini, 1999)
Information Requirements	Timely and Accurate	√	√	√	√	√	√	√	√	√	√	√	√	√
	Precise	√	√	√	√	√				√	√	√	√	√
	Reliable	√	√	√	√	√	√	√	√	√		√	√	√
	Accountable	√	√	√	√	√				√	√		√	
	Integrity	√		√	√	√								
Project Management Information System Requirements	Project Planning	√	√	√	√	√	√	√	√	√	√	√	√	√
	Resources Management		√	√	√	√	√	√	√	√	√	√	√	√
	Tracking and/or Monitoring	√	√	√	√	√	√	√		√	√	√	√	√
	Report Generation		√	√		√		√	√		√	√	√	√
	Decision Aiding	√	√	√	√	√	√	√			√	√	√	√
	PERT Analysis		√	√		√	√	√	√	√	√			√
	Capacity					√	√		√					
	User friendly		√							√	√			
	Integration with other systems	√	√	√	√	√	√	√	√	√	√	√		
	Internet Features					√	√	√			√	√		
	Security					√		√				√		

Appendix D: Information System Success Model (ISSM) and Technology Acceptance Model (TAM)

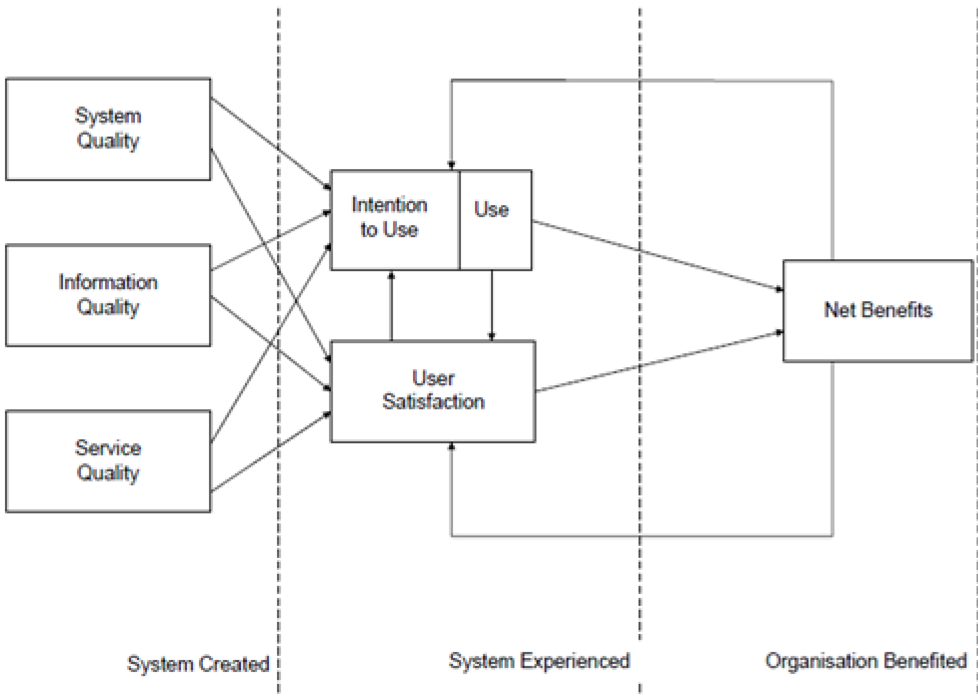

Figure D.1: The Updated Information System Success Model (ISSM) (DeLone, McLean 2003)

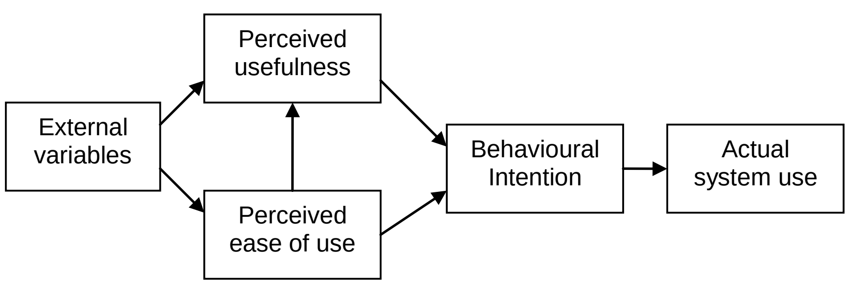

Figure D.2: The Technology Acceptance Model (TAM) (Davis, Bagozzi & Warshaw 1989)

Appendix E: Characterization of Respondents of the Raymond and Bergeron Study

Appendix E presents the descriptive results on the antecedents, consequences and nature of PMIS use by the respondents of the empirical study of Raymond and Bergeron.

Characterization of the respondents (n = 39)	**% of sample**
Experience in the use of PMIS	
More than 6 years	36
3–6 years	54
1–3 years	8
Less than 1 year	2
Most important indicator of PMIS quality	
Ease of use	33
Flexibility	23
Accessibility	23
Learning capability	28
Satisfaction with PMIS quality	
Very high	13
High	48
Project manager work indicator most impacted by PMIS	
Better monitoring of activities	46
Better planning of activities	41
Increase in productivity at work	39
Improvement in the quality of decisions	20
Better control of activity costs	18
Better allocation of resources	15
Project phase in which PMIS is highly used	
Initiation	36
Planning	72
Realization	67
Termination	28
Most important indicator of information quality	
Reliability	44
Relevance	21
Accuracy	18
Availability	18
Satisfaction with information quality	
Very high	18
High	48
Impact of PMIS on project manager's work	
Very high	13
High	51
Project success indicator most impacted by PMIS	
Meeting deadlines	59
Respecting budgets	41
Meeting project specifications	10

Appendix F: Measurement Codes of the Raymond and Bergeron- and South African Breweries Ltd Case Study

The measurements discussed in Chapter 6.2, in the empirical study of Raymond and Bergeron, are given a unique identification code throughout the study. These same measurement codes are also used within the case study with SAB Ltd.

Code	Measurement item
Quality of PMIS (pq)	
pq1	Accessibility
pq2	Response time
pq3	Flexibility
pq4	Ease of Use
pq5	Querying ease
pq6	Learning Ease
pq7	Systems Integration
pq8	Multi-project capability
Quality of Information (iq)	
iq1	Availability
iq2	Relevance
iq3	Reliability
iq4	Precision
iq5	Comprehensiveness
iq6	Security
PMIS Use (pu)	
pu1	Planning Function Tools
pu1_1	Work Breakdown Structure
pu1_2	Resource estimation
pu1_3	Overall Schedule
pu1_4	Gantt
pu1_5	PERT
pu1_6	CPM
pu2	Monitoring Function Tools
pu2_1	Project Reports
pu2_2	Completed tasks
pu2_3	Percent project completed
pu2_4	Effective schedule
pu2_5	Remaining tasks
pu2_6	Remaining day to complete

Code	Measurement item
pu3	Controlling Function Tools
pu3_1	Fine-tune Forecasting
pu3_2	Modify tasks
pu3_3	Reassign resources to lower the cost
pu3_4	Cancel tasks
pu3_5	Modify cost of resources
pu4	Evaluating Function Tools
pu4_1	Identification of costs
pu4_2	Identification of schedule variation
pu4_3	Tracking the use of resources
pu5	Reporting Function Tools
pu5_1	An Overview of project
pu5_2	Overview on work-in-progress
pu5_3	Budget overruns
pu5_4	Task and schedule slippage
Impacts of the project managers (ipm)	
ipm1	Improvement of productivity at work
ipm2	Increase in the quality of decisions
ipm3	Reduction of the time required for decision-making
ipm4	Reduction of the time required to complete a task
ipm5	Improved control of activity costs
ipm6	Better management of budgets
ipm7	Improved planning of activities
ipm8	Better monitoring of activities
ipm9	More efficient resource allocation
ipm10	Better monitoring of the project schedule
Impacts of PMIS on Project Success (ips)	
ips1	Meeting Deadlines
ips2	Respecting Budgets
ips3	Meeting quality specifications

Appendix G: Focus and Discussion Group Quick Wins for Possible Causes of Problems

To obtain an initial overview of the information- and system gaps, an altered Root Cause Analysis is done. Appendix G: Focus and Discussion Group Quick Wins for Possible Causes of Problems, lists problem areas/ items with possible causes as well as relevant principles or practices that serve as quick wins to the problems identified.

	Item/ Problem	Possible Causes	Quick Wins
Indicators	Use of indicators	* Poorly used or no use of indicators for information gatherers and/or beneficiaries who did not participate in their selection * Indicators formulated by external consultant prior to proposal submission	~ For a participatory project design, allowing the development of two levels of indicators,one at beneficiary level ~ M&E planning at project start-up to review indicators with stakeholders
Indicators	Validity of indicators	* Indicators not a good measure of the goals to be achieved * No review done of indicators to check for reliability, validity at project start	~ For a participatory project design, allowing the development of two levels of indicators,one at beneficiary level ~ M&E planning at project start-up to review indicators with stakeholders
Information Gatherers	Motivation of information gatherers or sources of info	* Lack of trust by sources of info * No sense of ownership by information gatherers in information * No participation of information collectors in analysis * Information gathering perceived as an add-on reporting requirement; implementation considered more important	~ Trust building with beneficiaries ~ Involvement of staff in M&E planning ~ Involvement of staff (information collectors) in analysis ~ Intermittent opportunities for reflection among project team ~ Estimation of M&E resource requirements for project budget ~ Sharing of results with all levels of project
Information Gatherers	Skill level of information gatherers or sources of info	* Poor quality, inadequate, or no training given * No understanding of the purpose of the information * Insufficient importance attached to quality monitoring by project management	~ Proper training with adequate timeline at project start ~ Involvement of all stakeholders in M&E planning ~ CO organizational culture that emphasizes quality PMIS and impact
Information Gatherers	Bias of information gatherers	~ Belongs to community and fears local power structure ~ Belongs to local culture and does not see own biases ~ External to culture and has pre-conceived views ~ No proper check of information/info collected for researcher bias	~ Design of information collection methods to minimize potential for bias ~ Systematic check for researcher bias when information is received ~ Recruitment procedures for enumerators that checks for any apparent biases
Info Interpretation	Rumor and/or anecdotal info vs. Facts	* A lackadaisical attitude towards information collection * Entrenched work habits that accept poor quality * Easier to rely on rumor or anecdotes * Inability to distinguish between rumor and fact	~ Staff performance reviews ~ Involvement of staff in M&E planning ~ Project management focus on quality ~ Scrutiny of consistently, highly favorable assessments from staff ~ Reference source of info
Info Interpretation	Information interpretation	* Use of qualitative methods with little experience in the synthesis of the information * Left up to one person (information entry person) who did not participate in the collection * Poor coding	~ Training of staff in use of qualitative methods (especialy focus group discussions) ~ Team work on information compilation and review ~ Multiple quality check mechanisms between preparation for fieldwork and information entry

	Item/ Problem	Possible Causes	Quick Wins
Information Characteristics	Accuracy of information	* Exaggeration, upwards or downwards, by beneficiaries * Poor methods for information collection * "Conversational" info gathering	~ An Monitoring & Evaluating (M&E) plan for staff to collect information ~ Involvement of beneficiaries in design of M&E system ~ Careful selection of methods ~ Trust building with beneficiaries
	Completeness of information	* Competency of information gatherer in administering information collection technique * Monitoring not a shared responsibility * Not enough staff to cover entire region * Poor sampling techniques * Poor quality record keeping by stakeholders or partners * Different methods and/or styles used by different enumerators	~ Training and coaching of staff in information collection and sampling, inc. refresher training ~ Clear identification of methods and communication styles ~ Involvement of stakeholders in M&E planning ~ Estimation of M&E resources for project budget ~ M&E planning to assign roles in M&E
	Excessive information	* No link between information collection and project indicators * No clear understanding of purpose of information	~ M&E planning at project start up, linking information needs with indicators ~ Involvement of project stakeholders in M&E planning
	Representativeness of information	* Beneficiary or respondent availability and/or cooperation * Sampling technique * Information collector bias * Survey instrument	~ M&E planning at project start up, linking information needs with indicators ~ Involvement of project stakeholders in M&E planning
Quality Control	Means of measurement used at field level	* Inaccurate measuring device, method, or estimation done by beneficiaries or local field staff * Different measures by different beneficiaries	~ Spot checking with beneficiaries (rather than relying only on key sources of info) ~ Coordination with the field on use of measuring techniques
	Adequacy of means of verification	* Cross-checking and triangulation not being done – lack of staff skill, poor planning, lack of appreciation for cross-checking * Only one method or one source being used for information collection	~ Training and coaching of staff, inc. refresher training
	Quality of information recording	* No sense of ownership by stakeholders in recording information * Stakeholders have no appreciation for value of information recording * Not enough resources * No standardized forms	~ Prior design of standardized forms and review with stakeholders ~ Estimation of M&E resource requirements for project budget ~ Involvement of stakeholders in M&E planning
	Appropriateness of method(s)	* Methods chosen based on staff experience, not only assessment of methods * Staff preference of quantitative vs. Qualitative * Inappropriate to culture resulting in resistance, poor quality answers, etc.	~ Exposure of staff to qualitative and quantitative methods ~ Proper training of staff, once methods are identified ~ Criteria for selection of best methods, inc. socio-cultural
	Quality of information instruments	* Time constraints in proper design of instruments * No pre-testing of instruments * No reflection and check with information gatherers * Poorly worded questions * No clarity in the broader questions being posed by project	~ Realistic planning of startup activities ~ Pre-testing of survey instruments ~ Ample opportunities to involve information gatherers in reflecting on information ~ Quality check of information instruments ~ Link instruments to indicators and precise information needs (part of M&E planning)
	Quality control of information collected	* Time constraints * No one assigned this role * Over confidence of staff in quality * Lack of skill in what to look for	~ Realistic planning ~ A conscious effort to assign responsibility for quality control to competent person ~ Staff training and learning lessons (from failures and duplicative effort)

Appendix H: South African Breweries Limited Questionnaire Template

Questionnaire Nr.

The current Project Management Information System used within SAB Ltd.

Please mark with a CROSS (X) in the applicable box with regard to the current PMIS used daily

Page 1

Quality of PMIS Quality:	low		medium		high
	1	**2**	**3**	**4**	**5**
Accessibility					
Response time					
Flexibility					
Ease of Use					
Querying ease					
Learning Ease					
Systems Integration					
Multi-project capability					

Quality of Information Quality:	low		medium		high
	1	**2**	**3**	**4**	**5**
Availability					
Relevance					
Reliability					
Precision					
Comprehensiveness					
Security					

PMIS Use

5 categories:

Planning Function Tools: **Used:**	never	rarely	occasionally	often	very often
	1	**2**	**3**	**4**	**5**
Work Breakdown Structure					
Resource estimation					
Overall Schedule					
Gantt					
PERT					
CPM					

Monitoring Function Tools: **Used:**	never	rarely	occasionally	often	very often
	1	**2**	**3**	**4**	**5**
Project Reports					
Update operational reports:					
Completed tasks					
Percent project completed					
Effective schedule					
Remaining tasks					
Remaining day to complete					

Page 2

Controlling Function Tool:	Used: never	rarely	occasionally	often	very often
	1	2	3	4	5
Fine-tune Forecasting					
Modify tasks					
Reassign resources to lower the cost					
Cancel tasks					
Modify cost of resources					

Evaluating Function Tools:	Used: never	rarely	occasionally	often	very often
	1	2	3	4	5
Identification of costs					
Identification of schedule variation					
Tracking the use of resources					

Reporting Function Tools:	Used: never	rarely	occasionally	often	very often
	1	2	3	4	5
An Overview of project					
Overview on work-in-progress					
Budget overruns					
Task and schedule slippage					

Impacts of the project managers	Completely Disagree				Completely Agree
	1	2	3	4	5
Improvement of productivity at work					
Increase in the quality of decisions					
Reduction of the time required for decision-making					
Reduction of the time required to complete a task					
Improved control of activity costs					
Better management of budgets					
Improved planning of activities					
Better monitoring of activities					
More efficient resource allocation					
Better monitoring of the project schedule					

Impacts of PMIS on Project Success	Low Contribution				Very High Contribution
	1	2	3	4	5
Meeting Deadlines					
Respecting Budgets					
Meeting quality specifications					

Thank you very much for your time and participation!!

Appendix I: Quality of the PMIS Data Analysis

Appendix I presents the complete data analysis of the quality of the PMIS. The frequency, median, range and standard deviation is illustrated.

Quality of the PMIS		Frequency					Median	Range	Stdev
	Quality:	low		med		high			
		1	2	3	4	5			
Accessibility	pq1	6%	22%	39%	33%	0%	3	3	0.907
Response time	pq2	0%	39%	56%	6%	0%	3	2	0.594
Flexibility	pq3	0%	44%	56%	0%	0%	3	1	0.511
Ease of Use	pq4	0%	50%	39%	11%	0%	2.5	2	0.698
Querying ease	pq5	0%	56%	33%	11%	0%	2	2	0.705
Learning Ease	pq6	6%	56%	28%	11%	0%	2	3	0.784
Systems Integration	pq7	0%	50%	50%	0%	0%	2.5	1	0.514
Multi-project capability	pq8	0%	56%	33%	11%	0%	2	2	0.705

Data analysis of the perceived and observed quality level as well as the expected quality level of the current PMIS within SAB Ltd with a χ^2 test fitted to the data gathered.

χ^2-Test:

		Estimate		Observed			Difference		TEST
Quality of the PMIS	**Item**	**Expected**	**Expected%**	**Data %**	**Weight n%**	**Observed**	**E-O**		χ^2
Flexibility	pq3	5	16%	51%	12.2%	3.915	-1.085		0.235
Ease of Use	pq4	4	13%	52%	12.5%	4.000	0.000		0.000
Querying ease	pq5	4	13%	51%	12.2%	3.915	-0.085		0.002
Systems Integration	pq7	4	13%	50%	12.0%	3.830	-0.170		0.007
Multi-project capability	pq8	4	13%	51%	12.2%	3.915	-0.085		0.002
Accessibility	pq1	4	13%	60%	14.4%	4.596	0.596		0.089
Response time	pq2	4	13%	53%	12.8%	4.085	0.085		0.002
Learning Ease	pq6	3	9%	49%	11.7%	3.745	0.745		0.185
	Total	32	100%	418%	100%			χ^2_{calc}=	0.522
								df=	7
								p-value	0.99936
								Conclusion:	Do not reject
								where	Ho: pj=pj0 for j=1,2,3,4,5,6,7,8

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Red indicates the danger and critical improvement items and orange indicates items to take notice of and to be aware of.

Pareto Analysis:

		Difference	% Cum
Quality of the PMIS	**Item**	**E-O**	
Flexibility	pq3	-1.085	76.12
Systems Integration	pq7	-0.170	11.94
Multi-project capability	pq8	-0.085	5.97
Querying ease	pq5	-0.085	5.97

Appendix J: Quality of the Information Data Analysis

Appendix J presents the complete data analysis of the quality level of the information within the PMIS. The frequency, median, range and standard deviation is illustrated.

Information Quality	Quality:	low 1	2	med 3	4	high 5	Median	Range	Stdev
Availability	iq1	0%	6%	39%	28%	28%	4	3	0.943
Relevance	iq2	0%	11%	44%	33%	11%	3	3	0.856
Reliability	iq3	0%	11%	44%	28%	17%	3	3	0.924
Precision	iq4	0%	17%	33%	33%	17%	3.5	3	0.985
Comprehensiveness	iq5	0%	17%	56%	11%	17%	3	3	0.958
Security	iq6	0%	6%	17%	44%	33%	4	3	0.873

Data analysis of the perceived and observed quality level as well as the expected quality level of the current of the information within the PMIS with a χ^2 test fitted to the data gathered.

χ^2-Test:

		Estimate		Observed			Difference	TEST
Information Quality	**Item**	**Expected**	**Expected%**	**Data %**	**Weight n%**	**Observed**	**E-O**	**χ^2**
Precision	iq4	5	19%	70%	16.24%	3.410	-1.590	0.506
Availability	iq1	5	19%	76%	17.53%	3.680	-1.320	0.348
Relevance	iq2	4	15%	69%	15.98%	3.356	-0.644	0.541
Reliability	iq3	4	15%	70%	16.24%	3.410	-0.590	0.506
Comprehensiveness	iq5	4	15%	66%	15.21%	3.193	-0.807	0.653
Security	iq6	4	15%	81%	18.81%	3.951	-0.049	0.220
	Total	26	100%	431%	100%			

χ^2_{calc} =	2.773
df=	5
p-value =	0.734867
Conclusion:	Do not reject
where	Ho: pj=pj0 for j=1,2,3,4,5,6

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Red indicates the danger and critical improvement items and orange indicates items to take notice of and to be aware of.

Pareto Analysis:

Information Quality	Item	Difference E-O	% Cum
Precision	iq4	-1.590	31.80
Availability	iq1	-1.320	26.39
Comprehensiveness	iq5	-0.807	16.13
Relevance	iq2	-0.644	12.89
Reliability	iq3	-0.590	11.80
Security	iq6	-0.049	0.98

Appendix K: Usage of Planning Function Tools Data Analysis

Appendix K presents the complete data analysis of the planning function tools. The frequency, median, range and standard deviation is illustrated.

PMIS Use										
Planning Function Tools		Frequency					Median	Range	Stdev
	Used:	never	rarely	occasional	often	very often			
		1	2	3	4	5			
Work Breakdown Structure	pu1_1	17%	11%	39%	33%	0%	3	3	1.079
Resource estimation	pu1_2	0%	28%	61%	11%	0%	3	2	0.618
Overall Schedule	pu1_3	0%	33%	56%	11%	0%	3	2	0.647
Gantt	pu1_4	0%	0%	50%	50%	0%	3.5	1	0.514
PERT	pu1_5	6%	0%	78%	17%	0%	3	3	0.639
CPM	pu1_6	0%	72%	22%	6%	0%	2	2	0.594

Data analysis of the perceived usage by respondents of planning function tools within SAB Ltd as well as the expected usage of the planning function tools within the PMIS together with a χ^2 test fitted to the data gathered.

χ^2-Test:

PMIS Use		Estimate		Observed			Difference	TEST
Planning Function Tools	**Item**	**Expected**	**Expected%**	**Data %**	**Weight n%**	**Observed**	**E-O**	χ^2
Work Breakdown Structure	pu1_3	4	15%	56%	16%	4.15	0.153	0.01
Resource estimation	pu1_2	4	15%	57%	16%	4.24	0.236	0.01
Overall Schedule	pu1_1	5	19%	58%	17%	4.32	-0.681	0.09
Gantt	pu1_4	5	19%	70%	20%	5.23	0.233	0.01
PERT	pu1_5	4	15%	61%	18%	4.57	0.569	0.08
CPM	pu1_6	4	15%	47%	13%	3.49	-0.511	0.07
	Total	26	100%	348%	100%		χ^2_{calc} =	0.270
							df=	5
							p-value =	0.998177
							Conclusion:	Do not reject
							where	Ho: pj=pj0 for j=1,2,3,4,5,6

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Red indicates the danger and critical improvement items.

Pareto Analysis:

PMIS Use		Difference	% Cum
Planning Function Tools	**Item**	**E-O**	
Overall Schedule	pu1_1	-0.681	57.10
CPM	pu1_6	-0.511	42.90

Appendix L: Usage of Monitoring Function Tools Data Analysis

Appendix L presents the complete data analysis of the monitoring function tools. The frequency, median, range and standard deviation is illustrated.

PMIS Use									
Monitoring Funtion Tools		Frequency					Median	Range	Stdev
	Used:	never	rarely	occasional	often	very often			
		1	2	3	4	5			
Project Reports	pu2_1	0%	17%	6%	78%	0%	4	2	0.778
Completed tasks	pu2_2	6%	17%	50%	28%	0%	3	3	0.840
Percent project completed	pu2_3	11%	22%	39%	28%	0%	3	3	0.985
Effective schedule	pu2_4	22%	33%	39%	6%	0%	2	3	0.895
Remaining tasks	pu2_5	6%	17%	28%	50%	0%	3.5	3	0.943
Remaining day to complete	pu2_6	0%	17%	22%	50%	11%	4	3	0.922

Data analysis of the perceived usage by respondents of monitoring function tools within SAB Ltd as well as the expected usage of the monitoring function tools within the PMIS together with a χ^2 test fitted to the data gathered.

χ^2-Test:

PMIS Use		Estimate		Observed			Difference		TEST
Monitoring Funtion Tools	Item	Expected	Expected%	Data %	Weight n%	Observed	E-O		χ^2
Project Reports	pu2_1	5	20%	72%	20%	4.88	-0.120		0.00
Completed tasks	pu2_5	4	16%	64%	17%	4.35	0.354		0.03
Percent project completed	pu2_4	4	16%	46%	12%	3.08	-0.922		0.21
Effective schedule	pu2_3	4	16%	57%	15%	3.83	-0.171		0.01
Remaining tasks	pu2_2	4	16%	60%	16%	4.05	0.054		0.00
Remaining days to complete	pu2_6	4	16%	71%	19%	4.80	0.805		0.16
	Total	25	100%	370%	100%			χ^2_{calc} =	0.417
								df=	5
								p-value =	0.994856
								Conclusion:	Do not reject
								where	Ho: pj=pj0 for j=1,2,3,4,5,6

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Red indicates the danger and critical improvement items and orange indicates items to take notice of and to be aware of.

Pareto Analysis:

PMIS Use		Difference	% Cum
Monitoring Funtion Tools	Item	E-O	
Percent project completed	pu2_4	-0.922	75.99
Effective schedule	pu2_3	-0.171	14.11
Project Reports	pu2_1	-0.120	9.90

Appendix M: Usage of Controlling Function Tools Data Analysis

Appendix M presents the complete data analysis of the planning function tools. The frequency, median, range and standard deviation is illustrated.

PMIS Use									
Controlling Function Tools		Frequency					Median	Range	Stdev
	Used:	never	rarely	occasional	often	very often			
		1	2	3	4	5			
Fine-tune Forecasting	pu3_1	0%	6%	33%	61%	0%	4	2	0.616
Modify tasks	pu3_2	0%	39%	56%	6%	0%	3	2	0.594
Reassign resources to lower the cost	pu3_3	22%	39%	33%	6%	0%	2	3	0.878
Cancel tasks	pu3_4	56%	28%	17%	0%	0%	1	2	0.778
Modify cost of resources	pu3_5	22%	22%	39%	17%	0%	3	3	1.043

Data analysis of the perceived usage by respondents of controlling function tools within SAB Ltd as well as the expected usage of the controlling function tools within the PMIS together with a χ^2 test fitted to the data gathered.

χ^2-Test:

PMIS Use		Estimate		Observed			Difference	TEST
Controlling Function Tools	**Item**	**Expected**	**Expected%**	**Data %**	**Weight n%**	**Observed**	**E-O**	χ^2
Fine-tune Forecasting	pu3_1	5	26%	71%	28%	5.38	0.381	0.03
Modify tasks	pu3_2	4	21%	53%	21%	4.04	0.035	0.00
Reassign resources to lower the cost	pu3_5	4	21%	50%	20%	3.78	-0.217	0.01
Cancel tasks	pu3_3	3	16%	44%	18%	3.36	0.363	0.04
Modify cost of resources	pu3_4	3	16%	32%	13%	2.44	-0.562	0.11
	Total	19	100%	251%	100%		χ^2_{calc} =	0.190
							df=	4
							p-value =	0.995756
							Conclusion:	Do not reject
							where	Ho: pj=pj0 for j=1,2,3,4,5

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Red indicates the danger and critical improvement items and orange indicates items to take notice of and to be aware of.

Pareto Analysis:

PMIS Use		Difference	% Cum
Controlling Function Tools	**Item**	**E-O**	
Modify cost of resources	pu3_4	-0.562	72.16
Reassign resources to lower the cost	pu3_5	-0.217	27.84

Appendix N: Usage of Evaluating Function Tools Data Analysis

Appendix N presents the complete data analysis of the evaluating function tools. The frequency, median, range and standard deviation is illustrated.

PMIS Use									
Evaluating Function Tools		Frequency					Median	Range	Stdev
	Used:	never	rarely	occasional	often	very often			
		1	2	3	4	5			
Identification of costs	pu4_1	0%	6%	39%	56%	0%	4	2	0.618
Identification of schedule variation	pu4_2	0%	11%	67%	22%	0%	3	2	0.583
Tracking the use of resources	pu4_3	0%	33%	28%	39%	0%	3	2	0.873

Data analysis of the perceived usage by respondents of evaluating function tools within SAB Ltd as well as the expected usage of the evaluating function tools within the PMIS together with a χ^2 test fitted to the data gathered.

χ^2-Test:

PMIS Use		Estimate		Observed			Difference	TEST
Evaluating Function Tools	**Item**	**Expected**	**Expected%**	**Data %**	**Weight n%**	**Observed**	**E-O**	**χ^2**
Identification of costs	pu4_2	4	33%	62%	32%	3.86	-0.138	0.00
Identification of schedule variation	pu4_3	4	33%	61%	32%	3.79	-0.207	0.01
Tracking the use of resources	pu4_1	4	33%	70%	36%	4.34	0.345	0.03
	Total	12	100%	193%	100%			

χ^2_{calc} =	0.045
df=	2
p-value =	0.977661
Conclusion:	Do not reject
where	Ho: pj=pj0 for j=1,2,3

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Orange indicates items to take notice of and to be aware of.

Pareto Analysis:

PMIS Use		Difference	% Cum
Evaluating Function Tools	**Item**	**E-O**	
Identification of schedule variation	pu4_3	-0.207	60.00
Identification of costs	pu4_2	-0.138	40.00

Appendix O: Usage of Reporting Function Tools Data Analysis

Appendix O presents the complete data analysis of the reporting function tools. The frequency, median, range and standard deviation is illustrated.

PMIS Use									
Reporting Function Tools		Frequency					Median	Range	Stdev
	Used:	never	rarely	occasional	often	very often			
		1	2	3	4	5			
An Overview of project	pu5_1	0%	6%	22%	67%	6%	4	3	0.669
Overview on work-in-progress	pu5_2	0%	17%	39%	39%	6%	3	3	0.840
Budget overruns	pu5_3	0%	22%	67%	11%	0%	3	2	0.583
Task and schedule slippage	pu5_4	6%	28%	61%	6%	0%	3	3	0.686

Data analysis of the perceived usage by respondents of reporting function tools within SAB Ltd as well as the expected usage of the reporting function tools within the PMIS together with a χ^2 test fitted to the data gathered.

χ^2-Test:

PMIS Use		Estimate		Observed			Difference	TEST
Reporting Function Tools	**Item**	**Expected**	**Expected%**	**Data %**	**Weight n%**	**Observed**	**E-O**	χ^2
An Overview of project	pu5_2	4	25%	67%	26%	4.23	0.229	0.01
Overview on work-in-progress	pu5_3	4	25%	58%	23%	3.67	-0.335	0.03
Budget overruns	pu5_1	5	31%	74%	30%	4.72	-0.278	0.02
Task and schedule slippage	pu5_4	3	19%	53%	21%	3.38	0.383	0.05
	Total	16	100%	252%	100%			

χ^2_{calc} =	0.106
df=	3
p-value =	0.991168
Conclusion:	Do not reject
where	Ho: pj=pj0 for j=1,2,3,4

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Orange indicates items to take notice of and to be aware of.

Pareto Analysis:

PMIS Use		Difference	% Cum
Reporting Function Tools	**Item**	**E-O**	
Overview on work-in-progress	pu5_3	-0.335	54.68
Budget overruns	pu5_1	-0.278	45.32

Appendix P: Data Analysis of the Impacts on the project manager

Appendix P presents the complete data analysis of the impacts of a PMIS on the project managers. The frequency, median, range and standard deviation is illustrated.

Impacts on the project managers		Frequency					Median	Range	Stdev
		Disagree		Bias		Agree			
		1	2	3	4	5			
Improvement of productivity at work	ipm1	0%	22%	56%	22%	0%	3	2	0.686
Increase in the quality of decisions	ipm2	0%	17%	39%	44%	0%	3	2	0.752
Reduction of the time required for decision-making	ipm3	0%	22%	61%	17%	0%	3	2	0.639
Reduction of the time required to complete a task	ipm4	6%	22%	44%	28%	0%	3	3	0.873
Improved control of activity costs	ipm5	0%	17%	39%	44%	0%	3	2	0.752
Better management of budgets	ipm6	0%	22%	56%	22%	0%	3	2	0.686
Improved planning of activities	ipm7	0%	6%	39%	56%	0%	4	2	0.618
Better monitoring of activities	ipm8	0%	11%	33%	56%	0%	4	2	0.705
More efficient resource allocation	ipm9	0%	22%	56%	22%	0%	3	2	0.686
Better monitoring of the project schedule	ipm10	0%	11%	33%	56%	0%	4	2	0.705

Data analysis of the perceived contribution of the impacts of the PMIS on the project manager within SAB Ltd as well as the expected contribution of the impacts on the project manager together with a χ^2 test fitted to the data gathered.

χ^2-Test:

		Estimate		Observed			Difference	TEST
Impacts on the project managers	**Item**	**Expected**	**Expected%**	**Data %**	**Weight n%**	**Observed**	**E-O**	**χ^2**
Better monitoring of activities	ipm8	5	11%	69%	11%	5.09	0.086	0.00
Improved planning of activities	ipm7	5	11%	70%	11%	5.17	0.168	0.01
Reduction of the time required for decision-making	ipm3	5	11%	59%	9%	4.35	-0.653	0.09
Increase in the quality of decisions	ipm2	5	11%	66%	10%	4.84	-0.161	0.01
Improved control of activity costs	ipm5	5	11%	66%	10%	4.84	-0.161	0.01
Reduction of the time required to complete a task	ipm4	4	9%	59%	9%	4.35	0.347	0.03
Improvement of productivity at work	ipm1	4	9%	60%	9%	4.43	0.429	0.05
Better management of budgets	ipm6	5	11%	60%	9%	4.43	-0.571	0.07
More efficient resource allocation	ipm9	4	9%	60%	9%	4.43	0.429	0.05
Better monitoring of the project schedule	ipm10	5	11%	69%	11%	5.09	0.086	0.00
	Total	47	100%	637%	100%			

χ^2_{calc} =	0.133
df=	9
p-value =	1.00
Conclusion:	Do not reject
where	Ho: pj=pj0 for j=1,2,3,4,5,6,7,8,9,10

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Red indicates the danger and critical improvement items and orange indicates items to take notice of and to be aware of.

Pareto Analysis:

		Difference	% Cum
Impacts on the project managers	**Item**	**E-O**	
Reduction of the time required for decision-making	ipm3	-0.653	42.26
Better management of budgets	ipm6	-0.571	36.95
Increase in the quality of decisions	ipm2	-0.161	10.40
Improved control of activity costs	ipm5	-0.161	10.40

Appendix Q: Data Analysis of the Indicators of Project Success

Appendix Q presents the complete data analysis of the indicators of project success. The frequency, median, range and standard deviation is illustrated.

Project success indicators		Frequency					Median	Range	Stdev
Contribution:		Low		Med		High			
		1	2	3	4	5			
Meeting Deadlines	ips1	0%	17%	61%	22%	0%	3	2	0.639
Respecting Budgets	ips2	0%	28%	72%	0%	0%	3	1	0.461
Meeting quality specifications	ips3	11%	28%	50%	11%	0%	3	3	0.850

Data analysis of the perceived contribution of the impacts on project success within SAB Ltd as well as the expected contribution of the impacts on project success together with a χ^2 test fitted to the data gathered.

χ^2-Test:

		Estimate		Observed			Difference	TEST
Project success indicators	Item	Expected	Expected%	Data %	Weight n%	Observed	E-O	χ^2
Meeting Deadlines	ips1	5	33%	61%	36%	5.464	0.464	0.04
Respecting Budgets	ips2	5	33%	54%	32%	4.868	-0.132	0.00
Meeting quality specifications	ips3	5	33%	52%	31%	4.669	-0.331	0.02
	Total	15	100%	168%	100%			

χ^2_{calc} =	0.068
df=	2
p-value =	0.966369
Conclusion:	Do not reject
where	Ho: pj=pj0 for j=1,2,3

Altered Pareto Analysis used to specify the elements that need to be improved with regard to the expected targets. Orange indicates items to take notice of and to be aware of.

Pareto Analysis:

Project success indicators	Item	Difference E-O	% Cum
Meeting quality specifications	ips3	-0.331	71.43
Respecting Budgets	ips2	-0.132	28.57