A Performance Measurement Model for a Service Partnership

by
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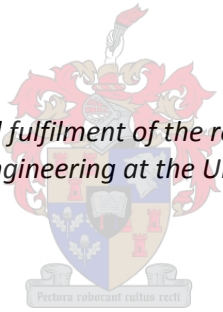

Thesis presented in partial fulfilment of the requirements for the degree Master of Science in Engineering at the University of Stellenbosch

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March 2010

Declaration

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Synopsis

The problem with which many organisations struggle in the current economical environment is that of focus. They are trapped in a situation where limited resources or lack of inherent knowledge withhold them from increasing shareholder value.

This research focuses on the strategy which an organisation pursues when outsourcing those business functions which are outside their core competencies. The outcome of this decision involves them entering into a partnership with a service organisation (or consultancy).

The duration of the relationship between these parties is dependent on the value (actual plus perceived) which the service organisation contributes to its customer. Pragma (a service organisation in the physical asset management (PAM) environment) is, due to the current economic turmoil, in a situation where they need to indicate the value created through the acquirement of their service. This leads to a search for a model which would provide them with the required justification.

A study was conducted on current available frameworks but none of those identified suited this type of measurement. This led to the development of a unique model (based on the principles of the Balanced Scorecard) called the performance measurement value index (PMVI) which identifies the generic elements required to measure the value of a service partnership. These elements are:

1. financial perspective;
2. customer engagement;
3. risk management; and
4. internal business processes.

These elements are weighted (using the analytical hierarchical process) to represent the change in value, as contributed by the elements, and is then represented as a single value (ten is used as this arbitrary value in this research).

The PMVI is introduced into the PAM environment which then produces the asset management value index (AMVI). The four elements of the PMVI are broken down into five elements required for the AMVI. These elements are:

1. cost reduction;
2. asset performance improvement;

3. customer satisfaction;
4. risk reduction; and
5. asset management maturity.

The model was applied to three of Pragma's customers. The type of application (within this environment) is dependent on the nature of both the customer and service. The first two customers are both from a manufacturing environment but they differ in the type of service (ACC@Pragma vs ACC@Client) rendered. The third customer operates within the utilities and facilities environment and receives an ACC@Client service. The period over which the model was applied varies due to the use and availability of historical data of these customers.

An increase in value was noted for the two ACC@Client customers (from 7.68 to 8.51 and 4.54 to 7.73 respectively), where the service partnership is still in its early stages (one to three years old). However, the ACC@Pragma customer reflected a stagnating value (6.62 to 6.59) where the service partnership is older than ten years.

These results reflect the expectations which Pragma had at the beginning of the study and consequently proves that they do add value to their customers.

Opsomming

Die huidige ekonomiese omgewing veroorsaak dat baie ondernemings sukkel om te fokus. Hulle word vasgevang in ‘n situasie waar ‘n beperking in hulpbronne of ‘n tekort aan nodige kennis hulle verhoed om waarde te verskaf aan hulle aandeelhouers.

Hierdie navorsing ondersoek daardie strategie van ‘n onderneming wat daartoe lei dat hulle sekere besigheids funksies, wat hulle nie beskou as hul eie sterktepunte nie, uitkontrakteer en gevolglik kan fokus op hul sterktepunte. Die gevolg van hierdie besluit verg dat die onderneming ‘n ooreenkoms aangaan met ‘n dienste onderneming.

Die tydperk van hierdie verhouding word bepaal deur die waarde (beide werklik en aangevoelde) wat die dienste onderneming toevoeg tot hul klient. Pragma (‘n dienste onderneming in die fisiese bates bestuur bedryf) word huidiglik gekonfronteer met die situasie waar hulle die waarde wat, weens die lewering van hul diens, toegevoeg word tot die klient. Dit lei tot die soeke na ‘n model om die lewering van hulle diens te valideer.

‘n Studie was uitgevoer op die huidige beskikbare modele wat doeltreffendheid in ‘n onderneming meet, maar geen van die geïdentifiseerdes was toepaslik op hiersie situasie nie. Dit het gelei tot die ontwikkeling van ‘n unieke model (gebaseer op die beginsels van die Balanced Scorecard) genaamd die Performance Measurement Value Index (PMVI) wat die nodige elemente vir die meting van hierdie tipe doeltreffenheid identifiseer. Hierdie elemente sluit in die:

- finansiële perspektief;
- kliënte interaksie;
- risiko bestuur; en
- interne besigheids prosesse.

Die geweegde uikomste van hierdie elemente (soos bepaal deur die Analytical Hierarchical Process) word gebruik om ‘n verandering in waarde aan te dui as ‘n enkele waarde (tien in die geval van hierdie studie).

Die PMVI word aangepas vir gebruik in die fisiese bate bestuur omgewing en die gevolge hiervan is die skepping van die Asset Management Value Index (AMVI). Die vier elemente, soos gebruik in die PMVI, word aangepas na vyf elemente in die AMVI. Hierdie elemente sluit in die:

- verlaging van uitgawes;
- bate doeltreffenheid verhoging;
- kliënt tevredenheid;
- risiko verlaging; en
- bate bestuur verbetering (verbetering in die interne besigheids funksies van bate bestuur).

Die model was toegepas op drie van Pragma se kliente. Die tipe van toepassing (binne hierdie omgewing) is afhanklik van beide die kliënt en dienste gelewer. Die eerste twee kliënte is beide afkomstig van ‘n hoofsaaklik vervaardigings-omgewing, maar die dienste gelewer aan die kliënte verskil (ACC@Pragma vs ACC@Client). Die ander klient is afkomstig vanuit ‘n dienste en geboue omgewing en ontvang die dienste van ‘n ACC@Client. Die tydperk waaroor die AMVI toegepas is verskil weens die toepaslikheid en beskikbaarheid van historiese inligting.

‘n Toename in waarde is bevind by beide van die ACC@Client kliënte (vanaf 7.68 na 8.51 en 4.54 na 7.73 onderskeidelik). Dit kan toeskryf word aan die vroeë fase waarin hierdie diens ooreenkoms funksioneer (vanaf een tot drie jaar). Die uitkomste van die ACC@Pragma, aan die anderkant, dui op stagnerende waarde (6.62 na 6.59) vir die kliënt waar die diens ooreenkoms alreeds ouer as tien jaar is.

Die uitkomste van hierdie studie bewys die verwagtinge wat Pragma aan die begin van hierdie studie gehad het en bewys gevolglik dat hulle wel waarde toevoeg tot hul kliënte.

Acknowledgements

I would firstly like to thank our heavenly Father for providing me with the opportunities in life, and life itself, which I am blessed with on a daily basis.

I would like to thank Lize for her understanding and moral support throughout the year, as well as my family (especially my father and mother) without whom I would not have been able to complete my studies.

To Arnold, I would like to extend my appreciation for being my mentor, study leader and friend during the year past. I would like to thank oom Adriaan Scheeres for giving me the opportunity to conduct my study at Pragma.

Last, but not least, I would like to thank prof. Neels Fourie for helping me during the difficulties and pleasantries of the year and provided me with valuable inputs so as to complete my thesis.

"*Dream as if you'll live forever, live as if you'll die today*"

- James Dean

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Glossary

ACC	-	Asset Care Centre
ACC@Client	-	An Asset Care Centre which Pragma deliver on site at the customer
ACC@Pragma	-	An Asset Care Centre service which Pragma deliver on an ad hoc basis
AHP	-	Analytical Hierarchical Process
AMIP	-	Asset Management Improvement Plan
AMVI	-	Asset Management Value Index
BSC	-	Balanced Scorecard
CMMS	-	Computerised Maintenance Management System
CROI	-	Customer Return on Investment
EMM	-	Engineering Management Model
KPI	-	Key Performance Indicator
MCDA	-	Multi-Criteria Decision Analysis
OEE	-	Overall Equipment Effectiveness
PAM	-	Physical Asset Management
PAS55	-	Public Available Specification 55
PMS	-	Performance Measurement System
PMVI	-	Performance Measurement Value Index
SHE	-	Safety, Health and Environment
SLA	-	Service Level Agreement
VI	-	Value Index

1 Introduction

"Never regard study as a duty, but as the enviable opportunity to learn to know the liberating influence of beauty in the realm of the spirit for your own personal joy and to the profit of the community to which your later work belongs"

- *Albert Einstein (1879 - 1955)*

The purpose of this chapter is to introduce the need for the research and outline the approach taken to conclude this study.

1.1 Background to Problem Definition

Organisations throughout the course of history have been confronted with strategic decisions which alter their nature and change the way they do business. This is due to the fluctuation in either the external environment or a change in the internal resources of the organisation.

The view of an organisation as a system, constituting of a complex network of interacting processes is vital in the drive for a competitive advantage [**1**]. Ackoff [**2**] acknowledges this when he states that one must understand the system (or organisation) in its entirety before attempting to analyse, and thus improve, individual aspects.

The process of analysing an organisation as a system can be defined as strategic management. Grant [**3**], Pearce and Robinson [**4**] and Moll [**5**] all propose strategic management methodologies (or life cycles) that enable an organisation to manage and embrace change. These methodologies ensure that the organisation is aware of its position in the market and aid them in developing and attaining an end-state vision.

This systemic approach enables an organisation to adopt a strategy and see the effects thereof in the performance of their operations. The measurement of this change is essential in enabling decision makers to either adapt their current strategy or to adopt an entirely different strategy. This strategic life cycle drives continuous improvement of organisational performance.

A specific scenario arises when the organisation is confronted with sub-standard performance of a business function and a change in strategy is due. Barnard [**6**] and Porter [12] defines a set of grand

strategies which can be adopted by an organisation which include the formation of a consortia and strategic alliances. The organisation can opt for such a strategy and undertake a partnership with a service organisation or a consultancy.

The service level agreement (SLA) between the two parties determines the scope of the service and the required level of performance for that business function. The organisation is confronted with the process of measuring the contribution of the partner to again verify the success of this strategy.

The partner, on the other hand, must illustrate the benefits of its service to the organisation in order to maintain a healthy business relationship and to ensure a continued need for its service.

This consensual need for a measurement of value added to the business function due to the service partnership creates the opportunity to develop a model for just this purpose. The performance measurement models currently deployed at organisations (Balanced Scorecard [**7**], Performance Prism [**8**], etc.) are sufficient in the environment under which they are proposed for use but have certain shortcomings from the perspective of the use for measuring a service partnership's performance.

Some of these shortcomings are:

- Measurements which are reflective of the synergy existing within the partnership;
- the risks which are mitigated as a consequence of the service rendered; and
- the representation of performance as a single value through which the organisation as an entity can be measured.

This thesis presents a generic model which aim is to measure the factors determining the performance of a service partnership.

1.2 Problem Definition

Pragma (Pty) Ltd (further just referred to as Pragma) is an organisation which delivers a physical asset management (PAM) service to its customers through the combination of a computerised maintenance management system (CMMS) and a related consulting service. The customer obtains Pragma's service in order to improve their PAM business function and consequently improve their operational and ultimately organisational performance.

In the past two years, the global environment of organisations has been affected by an economic meltdown. This had detrimental effects on the services industry as it became increasingly difficult to obtain and maintain a service partnership from the consultancies' perspective. This can be attributed to the fact that organisations tend to dispose of external resources prior to their internal resources. This is problematic for Pragma due to their dependency on customers for revenue.

The background to the problem identifies that the performance of a consultancy must be quantified in order to indicate their value to the customer. This develops the need for the introduction of a performance measurement model which would indicate this value in order to sustain their service. The effective reflection of this value will enable Pragma to:

- attain current customers;
- broaden their customer base through a historic comparison of related industries; and
- increase their cost of service should an incline in value be experienced.

1.3 Research Problem

This section defines the hypothesis and the contributing research questions of the thesis.

1.3.1 Hypothesis

H_0:

"Pragma's physical asset management service increases the value of an organisation's related business function."

1.3.2 Research Questions

The research questions contributing to the Hypothesis, as stated above, are:

- How do you measure the value of a service partnership?
- Which factors or elements needs measurement to obtain a true picture of the partnership value?
- How does one combine the performance measures obtained from both tangible and non-tangible into a meaningful singular output?
- Has the strategic decision to employ Pragma's services led to an improvement of a customer's PAM function?
- What is the effect of Pragma's PAM service on their customers?
- Does the value of Pragma's service differ depending on the type of service and client?

1.4 Research Objectives

The objectives in the completion of this thesis include:

- a literature review on the strategic life-cycle in an organisation (referred to as an engineering management model) with performance measurement as focal point;
- to create an understanding of the influences of a consultancy on an organisation;
- the definition of a generic performance measurement model for implementation in a service partnership;
- the implementation of this model in Pragma; and
- an analysis of the value which Pragma creates for its customers.

These objectives are answered by the structuring of this document, as seen in Figure 3.

1.5 Delimitations and limitations

This section outlines the scope of the thesis through the definition of contributing (delimitations) and confining (limitations) elements.

1.5.1 Delimitations

- the focus of this research is on both the direct and indirect effects which a consultancy has on an organisation;

- the research verifies that value have been added throughout the period of service but only through the recollection of historical data;
- the change in performance due to the service is not solely based on the service of the consultancy but due to the service partnership formed by the consultancy and the customer;
- in some circumstances, sustainability is awarded due to the fact that a removal of the service would cause a deterioration of the business function.

1.5.2 Limitations

Theoretical Limitations:

- it is recognised throughout this research that the performance of the service partnership is ultimately part of organisational performance but the results of these measurement does not necessarily align;
- this model does not attempt to address all of the value related issues of a consultancy and, even though a generic model is proposed, is constructed for a specific scenario;

Practical Limitations:

- the nature of a consultancy tend to be informative and it is difficult to attribute any indirect effect of the service as value contributed by the consultancy;
- non-tangible benefits may outweigh the tangible benefits and these are difficult to quantify;
- due to time limitations, the model is not applied as a continuous measurement;
- informational discrepancies may exist in the collection of data due to the fact that the required measures are not yet part of the customer's service.

1.6 Research Design & Methodology

The research design in this thesis, as referred to by Mouton [**9**] in Figure 1, is of empirical nature due to the complexity of performance measurement in this given scenario. The reasoning behind this will become clear in the following section.

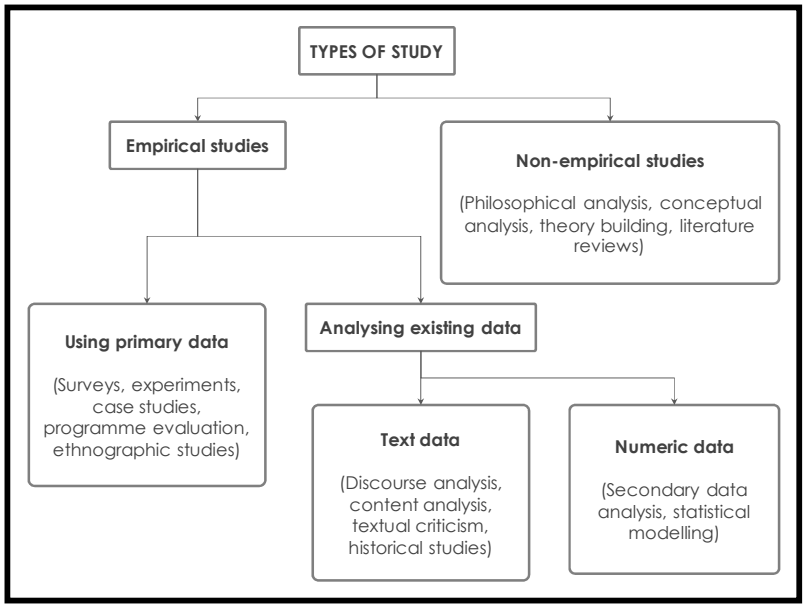


Figure 1 - Research Design Types, adopted from Mouton [9]

The nature of the required data is of both quantitative and qualitative nature and the collection thereof is not confined to a single source (of that indicated in Figure 1). This stems the need for a variety of data collection techniques and methodologies.

The first of these techniques measures the synergy of the service partnership and it uses primary data in the form of a structured interview or questionnaire. This is the only measurement which makes use of primary data from the initiation of service and is produced through the interaction between the conductor of the research and Pragma's customer's.

The analysis of other KPI's requires that a change in value be reflected from the initiation of the service and consequently requires an analysis of pre-service data. This necessitates the use historical data during the early phases of application which will migrate to the use of primary data once real-time data is available. This migration effect is attributable to the short memory of measurement where only two periods worth of data is used to indicate change.

A substantial amount of the required data is found on the Pragma database (dependant on the level of service supplied) and historical data can thus be easily obtained. The customer participates in the questionnaire and, in some cases, supplies additional required information which Pragma does not possess.

Empirical studies consist of a broad array of sub-designs (see Figure 2) depending on the nature of the problem as well as the solution.

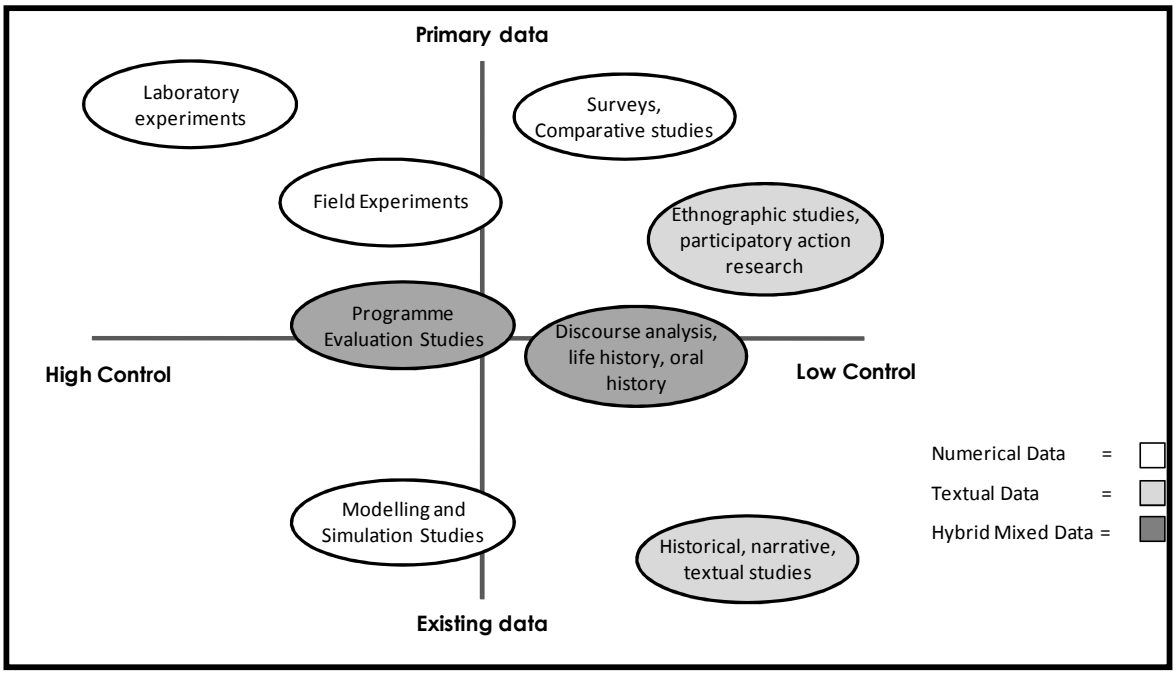


Figure 2 - Empirical Study Designs, adopted from Mouton [9]

The research in this study is situated on the zero intersect of the y-axis (due to the methodology of data acquirement) and more to the "high control" side of the x-axis (due to the use of predominantly numerical data). It is consequently identified as "Programme Evaluation Studies" and more specifically an implementation evaluation. Mouton [**9**] defines this type of study as the measurement of the success of an intervention through the use of both numerical and textual data (a hybrid).

The design methodology can be seen as the plan of the thesis providing structure to prove the hypothesis [**9**]. It is now known which type of study this is and which type of data is to be used but a sample must be identified on which the model can be applied. The sample of Pragma's customer's is selected by management in order to represent the entire spectrum of service and industries and is thus seen as a random sample.

Welman and Kruger [**10**] summarises this type of research as a situation where independent variables (the customer) is influenced by dependant variables (the consultancy) and that the operationally defined variables (KPI's) of the respective parties influences one another to ultimately prove the hypothesis.

1.7 Thesis Outline

This section defines the structure of the thesis (see Figure 3) and indicates the logical flow of contributing elements. Figure 3 is presented at the beginning of each chapter to indicate the current progression of the thesis as well as the prior and subsequent chapters.

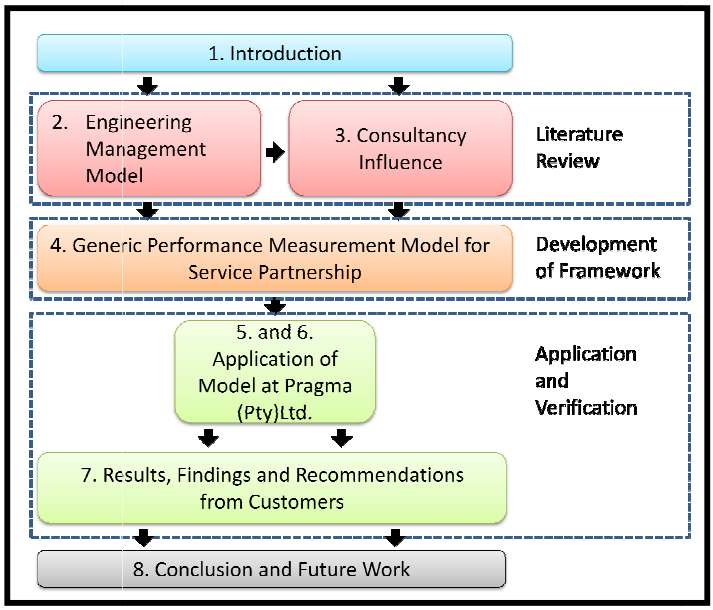


Figure 3 - Thesis Structure

Chapter 1: Introduction – This chapter introduces the reader to the thesis and contains the following contributing factors:

- definition of the problem;
- research problem;
- research objectives;
- delimitations and limitations; and
- the research design and methodology.

Chapters 2 and 3: Literature Review – This segment outlines the literature reviewed for the development of the thesis which includes:

- a strategic life-cycle model for organisations (the engineering management model or EMM) with a focus on performance measurement;
- additional contributing fundamentals which support the elements of the performance measurement model; and

- a description of the influence which a consultancy has on an organisation and the consequences thereof.

Chapter 4: Development of Framework – The development of a generic performance measurement model with the purpose of measuring the value of a service partnership. This includes:

- academic justification in the development of the model;
- the definition of a value index (VI);
- the definition of the performance measurement value index (PMVI) and its elements; and
- the measurement techniques that enables the user to quantify changes in the measurement of the key performance indicators (KPI's).

Chapters 5, 6, 7 and 8: Application and Verification – This segment is concerned with the application of the generic PMVI model at Pragma and their respective customers. This segment includes:

- the definition of the asset management value index (AMVI) and its elements;
- the in-depth look at each of the elements as well as their weighted contribution to the AMVI;
- a sensitivity analysis to indicate the stability and versatility of the AMVI;
- an application of the AMVI at a set amount of Pragma's customers and the results of this endeavour; and
- the analysis of the results and recommendations in this regard.

Chapter 9: Conclusion and Future Work – This segment reflects on the study and includes:

- a cyclical review of the thesis and the findings with regard to the hypothesis and research questions;
- the requirements and changes required to adopt the PMVI in another industry; and
- the future work in this field of research which would enable the user to relate the activities of change with the measured change due to the service partnership.

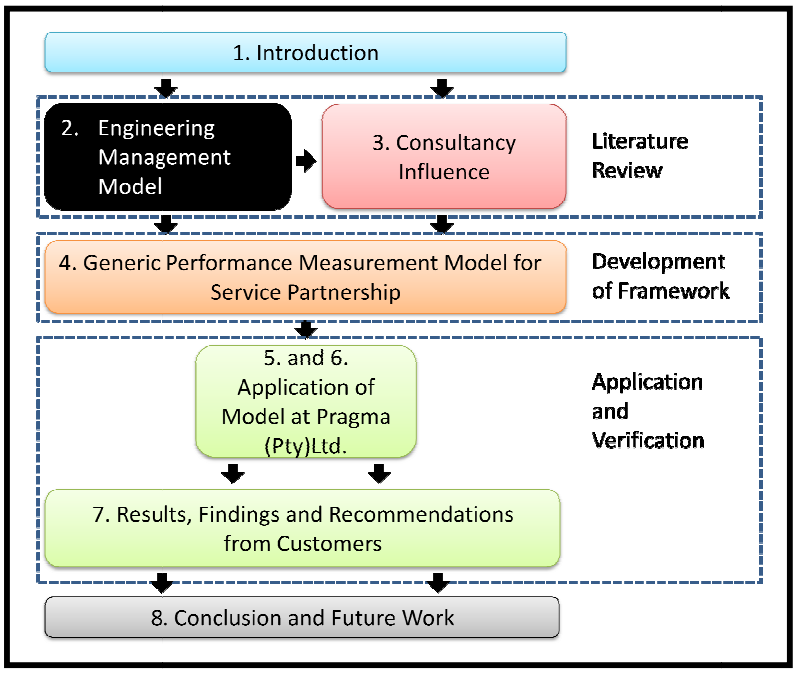
1.8 Chapter Conclusion

This chapter introduced the reader to the reasoning behind the research of the thesis. The following chapters systematically introduce the topics raised in this chapter and present the reader with a proposed solution.

2 Fundamentals

"Only those things are beautiful which are inspired by madness and written by reason."

- Andre Gide (1869 – 1951)



It is imperative to start a study with the relevant and applicable literature which enables the reader to obtain an extensive overview of the study to be undertaken. This chapter defines the different fields of research necessary for the development of this thesis.

This chapter introduces a value driven approach to the strategic management life-cycle of an organisation (referred to as the engineering management model or EMM) to ensure sustainability in the competitive business environment.

This includes the formulation of the organisational strategy, the operational execution of these strategies, the measurement of the performance due to the change in strategy and ultimately a feedback to determine if the strategy should be changed or rather improved.

An emphasis is placed on the aspect of performance measurement as the purpose of the thesis is to develop a model that would measure the performance of a service partnership.

The additional contributing fundamentals conclude this chapter and include the required fields of research in the development of the performance measurement model and a background of the field of application.

Objectives

- *create an understanding of the concept of Engineering Management and a systemic approach towards this discipline;*
- *to gain an understanding of the effects of a strategic decision on the organisation is illustrated and the fundamentals associated is created;*
- *introduce the reader to the requirements in the development of a performance measurement model and become aware of the models already developed in this field; and*
- *to supply additional information of research areas with regard to the development of the PMVI model.*

2.1 A Value Driven approach towards Engineering Management

The emphasis of this chapter is to define a strategic process which creates value for both the organisations and the customer. The EMM (see section 2.3) is defined for this purpose and a closer look is taken at the elements associated with this model.

In order to continue with this section, it is deemed necessary to firstly define some of the concepts which would create a better understanding of a value driven approach.

The first of these definitions is that of value. There are numerous definitions for value due to its universal application. Melnyk and Denzler [**11**] states that operational value should be based on the subjective perspective of the customer, adjusted for cost, of how well a product or service meets or exceeds expectations.

Porter [**12**] states that economic value is created when customers are willing to pay a price for a product or service that exceeds the cost of producing it.

These definitions enable the formation of value as a mathematical notation:

$$\boldsymbol{Value} = {}^{\boldsymbol{Functional\ Performance}}/_{\boldsymbol{Cost}} \qquad \text{...Equation 1}$$

A value added service is defined as those processes which contribute to the overall value of the output (being a service or a product) of the organisation. [**5**]

The concept of value is important as this serves as a support structure and backbone in the definition of the EMM and ultimately the development of the performance measurement value index (PMVI, see chapter 4).

2.2 Systems Approach

The EMM is a systems approach towards the strategic management process which ensures that a change in strategy is reflected in the outputs of the organisation. This induces an environment of continuous organisational improvement. This invokes a brief discussion on the principles of systemic thinking.

Franklin [**13**] defines that in a feedback control system, a variable being controlled is measured by a sensor and that the measured output is fed back to the controller to determine influence on the variable. This process is illustrated in Figure 4, where R(s) indicates the variable fed into the system (strategy). G_1 is the change imposed on the system (the application of the strategy as operations) which leads to the output variable Y(s). The feedback loop, G_2, ensures that the process reaches equilibrium (or continues to increase or decrease) as a result of the input variable.

A change in the input variable, R(s), is thus reflected in the change of the output, Y(s).

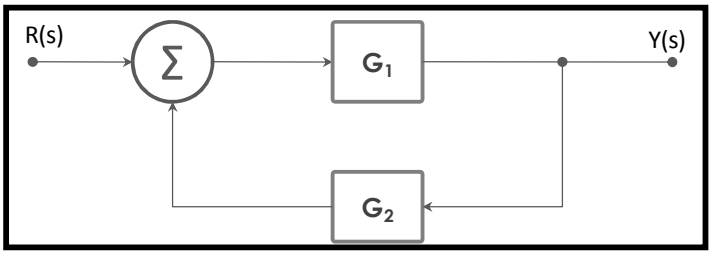


Figure 4 - Systems Thinking

This logic is used as foundation in the development of the EMM as presented in the following section.

2.3 Engineering Management Model

The engineering management model (EMM) presented in this section is used as a framework and a guide for the research undertaken in this study. The areas of research are linked into on single model

which serves as a "map" for the reader so as to indicate where every piece of the literature puzzle fits in. The model is developed from a managerial perspective (or a systems approach) so as to ensure an outcome which considers the system (or organisation) as an integrated whole.

2.3.1 Definition of Engineering Management

The construction of an EMM necessitates a thorough definition of this hybrid discipline. A definition is derived through the isolation and definition of the respective disciplines and then combining them meaningfully.

Engineering is derived from the Latin word "*ingenium"* [**14**] which means "*to create*" and is formally defined by the Encyclopedia Britannica [**15**] as *the* application of mathematics and science to the optimum conversion of the resources of nature to the uses of humankind.

Management originates from the French word "*mesnagement*" [**14**] and is formally defined in the Oxford English Dictionary as the governing body of an organization or business, regarded collectively; the group of employees which administers and controls a business or industry, as opposed to the labour force.

Moll [**16**] provides an appropriate definition for the combination of these to two disciplines when he defines engineering management as a discipline being aimed at planning, organising, leading and controlling (management) all efforts to achieve the most favourable business outcome through the use of innovative, scientific and systematic methods (engineering).

2.3.2 Introduction to Engineering Management Model

Having a clear understanding of the reasoning behind this discipline, one can move on to the definition of the framework to be used (seen in Figure 5) in this thesis.

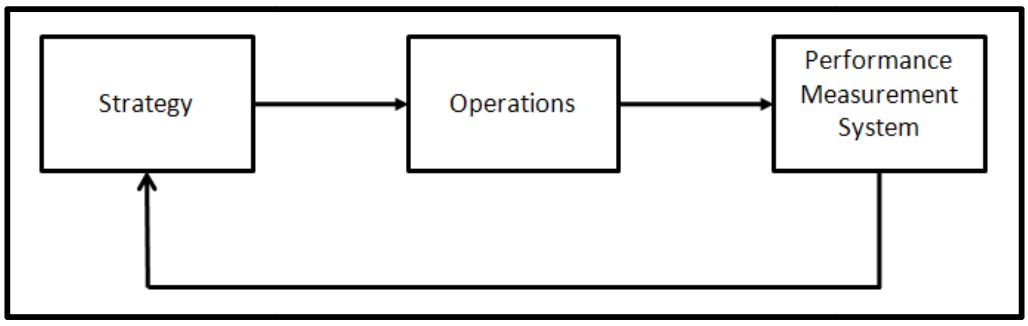


Figure 5 - The Engineering Management Model

This organisational strategic life-cycle starts with the definition of a desired strategic end-state. This determines the focus and direction of the organisation and the planning concerned with the long-term goals set during this phase.

The operational phase is aligned with the strategy and includes the required short term planning and the day-to-day activities.

A performance measurement system (PMS) measures the extent of the change introduced by the strategy and the execution of this strategy through operations on a continuous basis.

Once these measurements are completed and the effectiveness of the organisation's operations (and strategy) is determined, a process of improvement follows. This coincides with the feedback loop and decision point of a control system and leads to one of the following decisions:

- continuous improvement – the imposed strategy is satisfactory and improvement thereof occurs in a small and incremental way; and
- value engineering – the external environment or unsuccessful outcomes from a previous strategy introduces a change in strategy which changes the entire outlook of the organisation.

The use of this feedback system structures the model and provides the necessary flow of information through the organisation. Heylighen [**17**] defines this type of model as being cybernetic. This is a model (of an organisation) which continuously improves upon itself through the process of self-learning.

The foundation of the EMM, as defined in this section, is further explored in the subsequent sections to validate the concept of a strategic organisational life-cycle.

2.4 Engineering Management Model: Strategy

This section gives a brief overview of the strategic management process of the EMM and how it fits into this framework.

2.4.1 The Origins of Strategy: Militaristic Strategy

The field of strategy has been around for centuries. Sun Tzu (4th century BC) was one of the first authors on the field of strategy with his book "The Art of War". The focus of this book is on the application of strategy within a militaristic environment. He made the analogy that "*…to conquer the enemy without*

resorting to war is the most desirable. The highest form of generalship is to conquer the enemy by strategy" meaning that avoidance by use of strategy is better than engagement [**18**].

Sun Tzu was followed by other influential military strategists, such as Machiavelli with "The Prince" and von Clausewitz with "On War". These militaristic writers followed an approach towards strategy in which they developed a plan for the victory over their enemies given a certain set of circumstances and constraints.

The business environment has found a correlation with the systemic methodologies as described by these militaristic strategists and the principles have been widely adopted for use in current day organisations.

Hence, one can say that the field of strategy evolved from being strictly militaristic based to its use in business today.

2.4.2 Strategic Management

Barnard [**6**] defines strategic management is an activity which is focused on leading the organisation to achieve its strategic objectives. Strategic management is a long-term decision making process which ensures a sustainable competitive advantage for an organisation within its environment.

The strategic management process, according to Pearce and Robinson [**4**] and Grant [**3**] (also see Figure 6), is initiated through a process in which the organisational environment is analysed. This enables the organisation to synthesis the appropriate plans and make decisions which would take them from a current state to an intended future state. The requirements for this shift in organisational state are determined which would facilitate the process of change. The strategy is implemented and the effects of this strategic direction are reflected in the operational phase of the organisation.

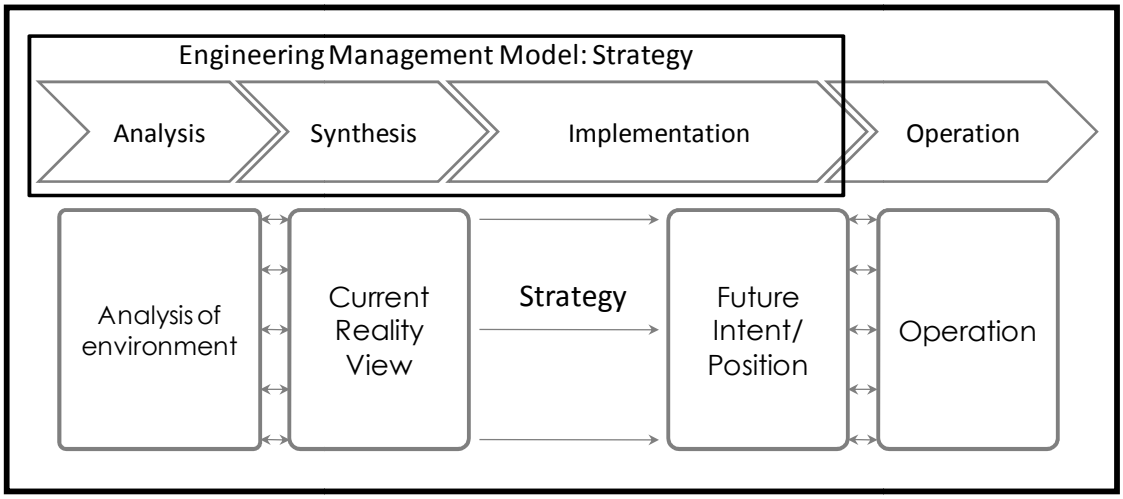


Figure 6 - Strategic Management Framework

The following sections provide the reader with a brief insight into the conception and execution of each of these phases.

2.4.2.1 *Analysis*

Mintzberg *et al.* [**19**] emphasise the importance of an external environment analysis in an organisation when he notes that it is not some kind of pear to be plucked from a tree but rather a major unpredictable force to be reckoned with. A change in the environment (depicted in figure 3) of the organisation may have detrimental effects as it can nullify a strategy and force the conception of an alternative counter strategy. The environment can be of such a (unstable) nature that it is impossible to conceive a strategy.

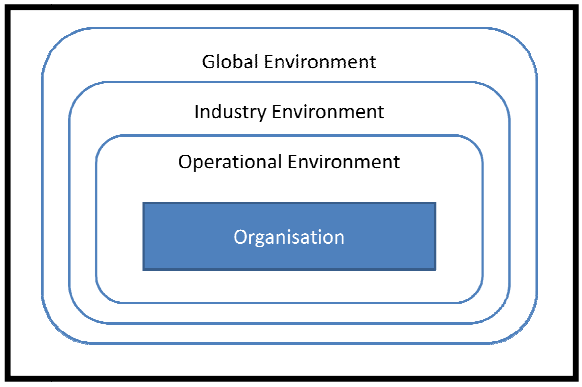


Figure 7 - Strategic Organisational Environments, adopted from [3]

The external environment of the organisation can be divided into three distinct domains, as seen in Figure 7.

The global environment (or international market) is constituted of those external factors which influence the strategic decisions of an industry. A PEST (political, economical, social and technological) analysis is conducted to envision these aspects. Note should be taken that none of the elements of a PEST analysis can be seen in isolation but that they should rather be seen as an interrelated network of dependant variables.

The organisation should always be aware of the global issues with which they are confronted to mitigate the effects of adopting an ill-conceived strategy.

The organisation is further confronted with the industry in which it operates and the state of the marketplace. Porter [**20**,**21**], as part of his model of competitive analysis, defines five forces which are the competitive forces to which an organisation is subjected and consequently forges its strategies (see Figure 8). Tracy and Wiersma [**22**] add a sixth force of compliments which represents the additional leverage which could be obtained through a mutual beneficial agreement between two organisations with supplementary products or services.

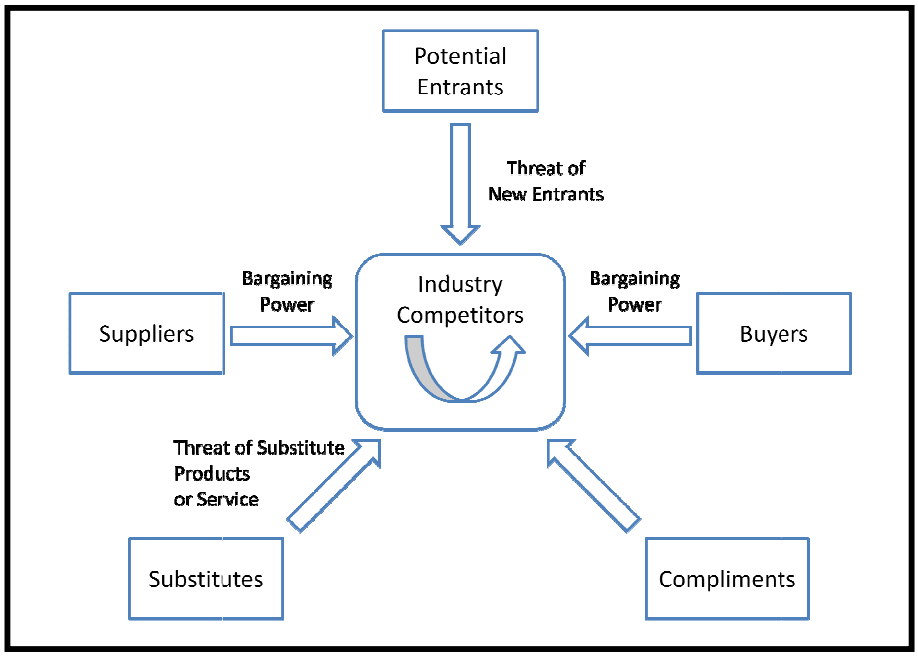


Figure 8 - Six Forces Analysis, adopted from Tracy and Wiersma [22]

A SWOT (strength, weakness, opportunities and threats) analysis enables the organisation to create a match, or fit, between its internal capabilities and the external possibilities represented in this phase of analysis [**19**].

The operational environment on the other hand is the interaction between the organisation and its stakeholders.

Prahalad and Hamel [**23**] developed the concept of core competencies which is a contrast to the external environment analysis. The methodology is initiated by the creation of a strategic intent which determines the desired end-state of the strategic decision. The resources of the organisation is analysed and the misfit between the resources and aspirations (known as "stretch") are determined. The fundamental issue of this methodology is that an organisation learns how to *leverage* its limited resource base. [**19**]

The following methodologies are used as supplements to the environmental analysis process:

- scenario planning – the examination of alternative strategies to ensure appropriate capabilities which counteracts dynamic uncertainties (as with risk management) of the organisational environment [**24**,**3**];
- sensitivity analysis – the variability found in the output of the system (or strategy) due to different inputs; and
- risk analysis – the factors which could influence or threaten the outcome of the strategies must be determined to determine mitigation actions.

2.4.2.2 Synthesis

The analysis phase of strategic management enables the organisation to determine the state of its environment and possible scenario's with which it is confronted. This implies that the organisation is aware of the current situation in which it finds itself. The synthesis phase produces a formulated strategy with long term plans and objectives so as to emulate a desired end-state (see Figure 6).

Prescott [**25**] defines the grand strategy of an organisation as the general plan of major actions by which an organisation intends to achieve its long term objective. The grand strategy focuses on what the organisation wants to do and how it is going to achieve it. Barnard [**6**] defines a series of fourteen core strategies which can be integrated when defining such a strategy. These are:

- concentrated growth;
- market development;
- product development;
- innovation;

- horizontal integration;
- vertical integration;
- concentric diversification;
- conglomerate diversification;
- turn-around;
- divesting;
- liquidation;
- joint-ventures;
- consortia; and
- strategic alliances.

Porter [**20**] defines generic strategies which impose the vision created through the grand strategy and he states that an organisation can focus on only one of these strategies to avoid mediocrity. These strategies are: [**19**]

- cost leadership – aim at being the lowest cost producer in the industry;
- differentiation – the development of unique products or services; and
- focus – serving narrow market segments.

Tracy and Wiersma [**22**] add a fourth strategy of customer intimacy. This is when an organisation delivers a service which creates a long-lasting relationship with the customer.

The diversification strategy, proposed by Grant [**3**], is in contradiction of Porters generic strategies in emphasising a focus on exploiting various industries of operations. Grant [**3**] identifies the motives of this strategy as growth, risk reduction and profitability.

The outcome of this phase in the strategic management process is a focus on a specific generic strategy with regards to the grand strategy deployed. The development of long term plans to facilitate the implementation of these strategies is completed at this stage.

2.4.2.3 Implementation

The implementation phase involves the alignment of the current organisational structure with the structure required to implement the proposed strategy. This necessitates that support structures within the organisation are adequate to facilitate this change.

Pearce and Robinson [**4**] identify the following supporting pillars on which the implementation relies:

- resources – the budgetary allocations should be sufficient to avoid any discrepancies;
- structure – the organisational structure and the matching of the correct individuals is vital to support the implementation of a strategy and it should be adapted accordingly [**3**];
- leadership – a top-down approach towards leadership is essential in indicating that top management supports to the newly adopted strategy;
- culture – a culture within the organisation should be established to embrace change and to adopt accordingly; and
- remuneration and rewards – the benefits involved with successful implementation should be stressed to serve as motivation for the individual.

The proficient management of these supporting functions serves as basis for a successful implementation. This phase is completed with the completion of short-term planning and the definition of objectives which is sub-sets of the long-term plan and grand strategies.

2.4.3 Strategic Management in Context

The strategic management process, as defined in this section (see Figure 4), is the first of the building blocks in the EMM. The outcome of this process serves as the input variable (R(s)) of the feedback loop system which is the EMM. The following section is concerned with process of executing (or G_1) this input (strategy) in order to implement the proposed change.

2.5 Engineering Management Model: Operations

"It is not good enough for things to be planned - they still have to be done; for the intention to become a reality, energy has to be launched into operation."

- Walt Kelly

This section illustrates the alignment between the strategic management process and the physical implementation of the proposed change into the operations of the organisation.

2.5.1 Operational Nature of Change

The implementation and operational phases of the EMM consists of two distinctly different approaches, which are project management and standardised operations. Berry *et al* [**26**] indicate that projects and

an operation differ primarily in the sense that operations are ongoing and repetitive, while projects are temporary and unique.

The initial implementation process is of a project nature. Kerzner [**27**] defines project management as the planning, organising, directing, and controlling of company resources for a relatively short-term objective which has been established to complete specific goals and objectives. This ensures that the organisation implements the strategy within a specific time frame and that the measurement of results can be compared with targets.

Desirable results as a consequence of this change leads to the integration of the strategy into the structure of the organisation. This is reflected in the operations of the organisation. Jacobs *et al* [**28**] define operations and supply chain management as the design, operation, improvement of the systems which create and deliver the organisations primary products and services.

This process ensures that continuous improvement is instilled into the structure of the organisation once a strategic change have been successfully implemented or that a new project is launched if desirable results is not obtained.

2.5.2 Operations in Context

The operational aspect of an organisation is a pretty straight forward topic as it is the strategies which require an extensive amount of research and thought. The constant, G_1 or G_2, of the feedback loop (see Figure 4) is defined and the output can be determined. The measurement of the output (Y(s)) determines the success of the change in strategy or the sustainability of continuous improvement. This aspect is tackled in the following section.

2.6 Engineering management Model: Performance Measurement

"However beautiful the strategy, you should occasionally look at the results"

- Sir Winston Churchill (1874 - 1965)

Performance measurement is that part of the EMM which indicates if a strategy does create value for the organisation and if the continuous application thereof would be beneficial to the organisation.

The section serves a dual purpose in the sense that it defines the concept of performance measurement in the context of the EMM and it serves as literary foundation for the development of the PMVI model.

The aspects of performance measurement defined in this section include:

- the definition and historical development of the discipline;
- performance measurement system (PMS) life-cycles;
- the available frameworks; and
- in depth look at those frameworks on which the research is based.

2.6.1 Definition of Performance Measurement

The research team at Cranfield School of Management [**29**] notes that performance measurement is a subset of performance management and that the latter must be defined to understand the concept of the former.

Treasury [**30**] elaborates on this and states that performance management is not only concerned with the measurement of organisational performance, systems and processes (as is the case with performance measurement) but also with the way people operate and interact within this context.

Neely *et al* [**31**] define performance measurement in its strictest sense as the process of quantifying the efficiency and effectiveness of action. He then states that it is a multidimensional process which requires a number of tangible and non-tangible measures.

2.6.2 Evolution of Performance Measurement

Throughout the course of history, performance measures have been used as a measure of success in a business [**32**]. The origin of the modern accounting framework dates back as far as the Middle Ages and since that time, performance assessments where predominantly based on a financial criteria [**33**]. Sometime later the double-entry system we know today where developed to avoid conflict between traders [**34**].

It was only after World War I when organisations such as Du Pont (an adapted representation of this model can be seen in Figure 11 on page 28), General Motors and Sears Roebuck saw the need for a further development of the current, margin based, accounting system [**35**]. This led to the notion of measuring return on investment as an indicator of the manager's performance [**34**].

Research and development in the field of performance measurement went through a quiet period up to the 1980's. It was during this period that the deficiencies of the traditional (backward looking) accounting systems used for performance measurement were recognised and subsequently identified. These criticisms include:

- encouraging of short-termism;
- encouraging minimisation of variance rather than continuous improvement;
- lacking strategic focus;
- lagging indicators;
- encouraging local optimisation; and
- not being externally focused.

The focus shifted from a purely financial (persisting of primarily lagging indicators) performance measurement perspective to one where various non-financial measures (leading performance measurement indicators) were incorporated into the system [**32**]. Bearing this in mind, Tangen [**36**] states that a performance measurement system (PMS) should include:

- measures derived from strategic objectives to ensure that employee behaviour is consistent with corporate goals;
- measures that provide timely, relevant and accurate feedback, from both a long-term and short-term perspective;
- limited number of performance measures that consist of both financial and non-financial measures; and
- measures which stimulate continuous improvement rather than simply monitor [**37**].

Mintzberg *et al.* [**38**] and Pun [**39**] elaborate on the topic of strategic alignment, with performance measures, and states that the key to competitiveness is not in the application of previously successful strategies or in the emulation of successful competitor's strategies. This emphasises the need for leading indicators and constant change of strategy (as indicated in the EMM).

The shortcomings of traditional accounting in combination with the growing need for organisations to reflect their true competitive position provided the necessary fuel to fire the explosion of the research in performance measurement [**32**]. Subsequently, a variety of "balanced" or "multi-dimensional" [**40**] PMS's evolved in the form of Keegan *et al*'s [**41**] supportive performance measurement matrix, the

SMART pyramid [**42**], the Results/Determinants Matrix [**43**,**44**], the Balanced Scorecard [**45**], the Performance Pyramid [**8**], and various others discussed later in this section.

2.6.3 Performance Measurement System Life Cycle

The preceding sections gave us a brief overview of what performance measurement is and how it developed through the years. This section is concerned with the life cycle of a PMS as this is the methodology used in the development of the PMVI model.

Neely [**40**] formally defines this process as comprising of four distinct phases (see Figure 9). These stages are:

- the design of the performance measures;
- the implementation of the performance measures;
- the use of the performance measures; and
- a continuous review cycle.

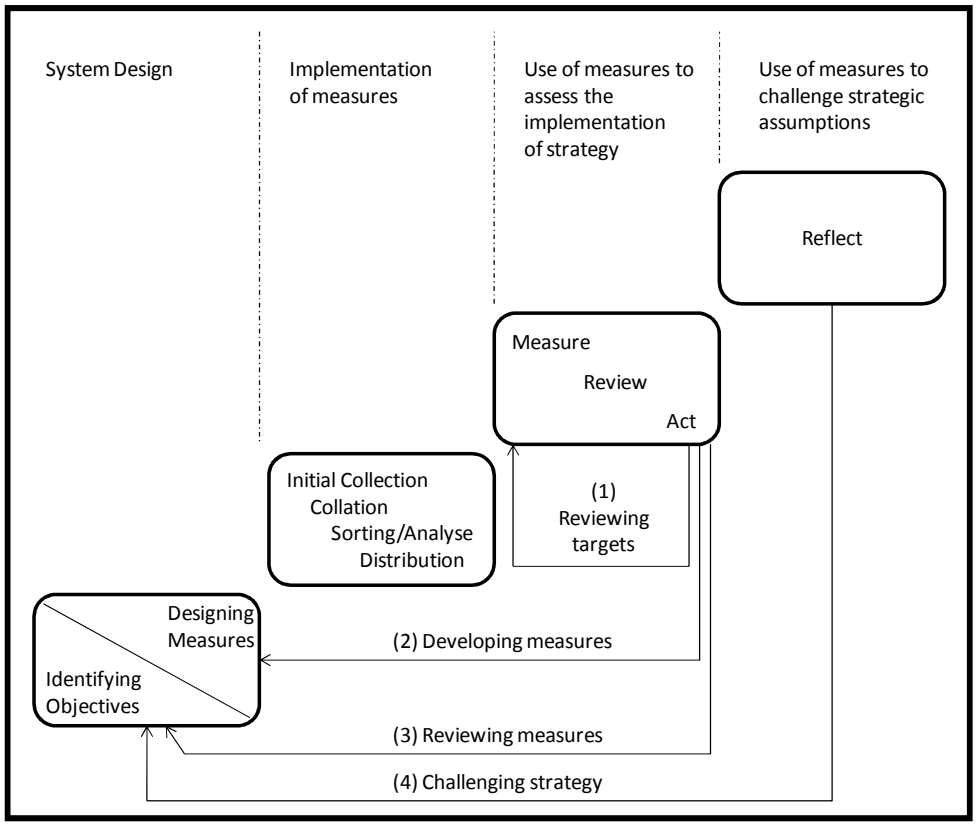


Figure 9 - Cambridge Performance Measurement Process adopted from Neely *et al* [40]

The following sections introduce these phases and provide the reader with a brief overview.

2.6.3.1 Performance Measurement System: Design

The design of the PMS is the most important part of the process as the organisation needs to define the focal areas of measurement and the associated supportive structures.

De Toni and Tonchia [**46**] state that there are two essential questions which must be answered in the design of a PMS. These questions are:

- What should be measured (key objectives)?
- How should we measure this?

In recognising this, Neely [**47**] went on to identify the activities required to measure performance by defining a PMS as consisting of three inter-related elements:

- individual measures which quantify the efficiency and effectiveness of actions;
- a set of measures which combine to assess the performance of an organisation as a whole; and
- a supporting infrastructure which enables data to be acquired, collated, sorted, analysed, interpreted and disseminated.

Kaplan and Norton [**7**] are adamant that these measures should be derived from the organisational strategy. This aligns with the notion of a strategic organisational life-cycle in the development of the EMM.

2.6.3.2 Performance Measurement System: Implementation

This is the phase where the measures and pre-defined structure of the PMS is implemented into the organisational structure. Proficient change and information management ensure that the PMS is adopted seamlessly into the organisational structure.

The change management process is required to facilitate the adoption of the infrastructural change required to adopt the newly defined PMS [**32**]. The idea is to align the proposed structure with the existing one as far as possible in order to reduce the risk of rejection from the respective parties.

The procedural requirements for the acquirement of information and the structure thereof should be established prior to implementing the PMS in the organisation. The information management system is concerned with the collection, collation, sorting and distribution of data of the selected individual performance measures.

The data can be obtained through online, oral or manual processes. Neely *et al* [**40**] prefer manual data collection for the individual measures and note that software packages should be used to facilitate an integrative PMS.

Pun and White [**48**] find that the implementation and use phases are not separated in the industry but they occur concurrently.

2.6.3.3 *Performance Measurement System: Use*

The implementation of the individual measures does not create a PMS [**40**]. The measurement of the KPI's is only one part of the process. The information gathered from these entities are converted into a desirable form and then used to make managerial decisions. This ultimately enables the decision makers to evaluate the organisational strategy and align it accordingly.

2.6.3.1 *Performance Measurement System: Review*

A review phase is incorporated in the use of the PMS. This ensures that the system adapts to the organisations ever changing environment [**49**]. Neely and Kennerly [**49**] identifies two issues (Figure 10) which influence this process. These issues are:

- drivers of change – those factors that cause change to be necessary; and
- barriers to change – those factors that must be overcome if change is to be effective.

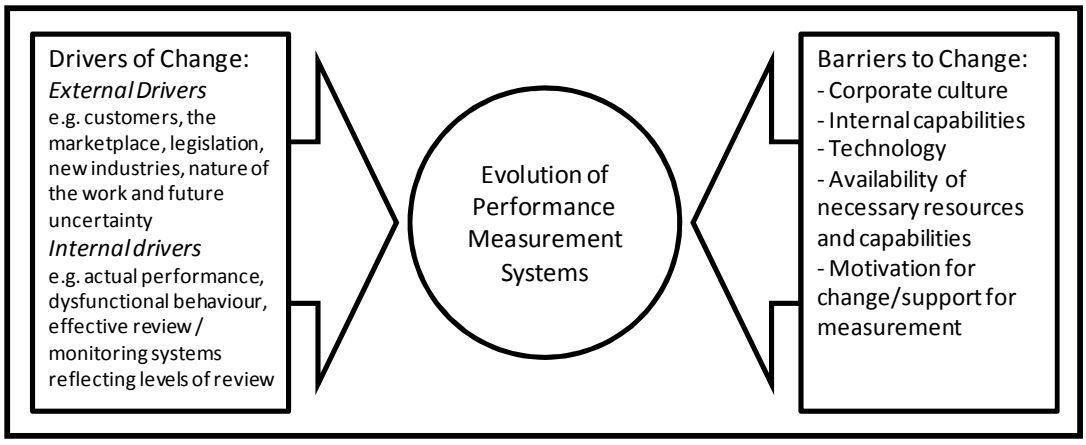


Figure 10 - Evolution of PMS, adopted from Neely and Kennerly [49]

The characteristics of these issues are inherent in any organisation and this invokes the constant need for change in the PMS.

This cyclical approach to developing and maintaining a PMS coincides with the development of the EMM as the PMS may change to accommodate a change in organisational strategy.

This section introduced a generic format for the development of a PMS. The following section introduces a set of unique, but focussed, frameworks which is commonly used by organisations when developing a PMS.

2.6.4 Performance Measurement Frameworks

Folan and Browne [**50**] argue that there are two types of performance measurement frameworks:

- structural frameworks which provide definite instructions on the measures to be used; and
- procedural frameworks which have a pre-defined set of steps to be taken to implement a PMS.

They also state that there are models that attempt to integrate these views but that these efforts have come up short in the past.

The frameworks in the rest of this section is categorised according to this criteria. There are a large variety of frameworks available for measuring an organisations performance in literature but only those used in the development of the PMVI model is presented in this section.

2.6.5 Structural Frameworks

The frameworks represented in this section provide the necessary structure for a PMS, even though they vary in functionality. The frameworks that are of this nature include: [**50**]

- traditional management accounting;
- Results and Determinants framework;
- Supportive Performance Measurement Matrix;
- Performance (SMART) Pyramid;
- Balanced Scorecard;
- EFQM' Business Excellence model; and
- Performance Prism.

2.6.5.1 Traditional Management Accounting

In 1903, three cousins decided to consolidate their separate organisations into one business called Du Pont. They revolutionised the chemical explosives industry through rational management and developed a financial model (Figure 11) for the measurement of organisational performance [**51**].

The Du Pont pyramid of financial ratios incorporate a wide range of financial ratios to ultimately measure the return on investment. This is accomplished through the use of a hierarchical structure which links measures at different levels of disaggregation. The great strength of this model is the fact that it uses explicit "levers" which management can pull as they seek to influence performance [**52**]. Grant [**3**] elaborate on the model and indicates that one can accurately calculate the value created for the shareholders by taking economic profit into account.

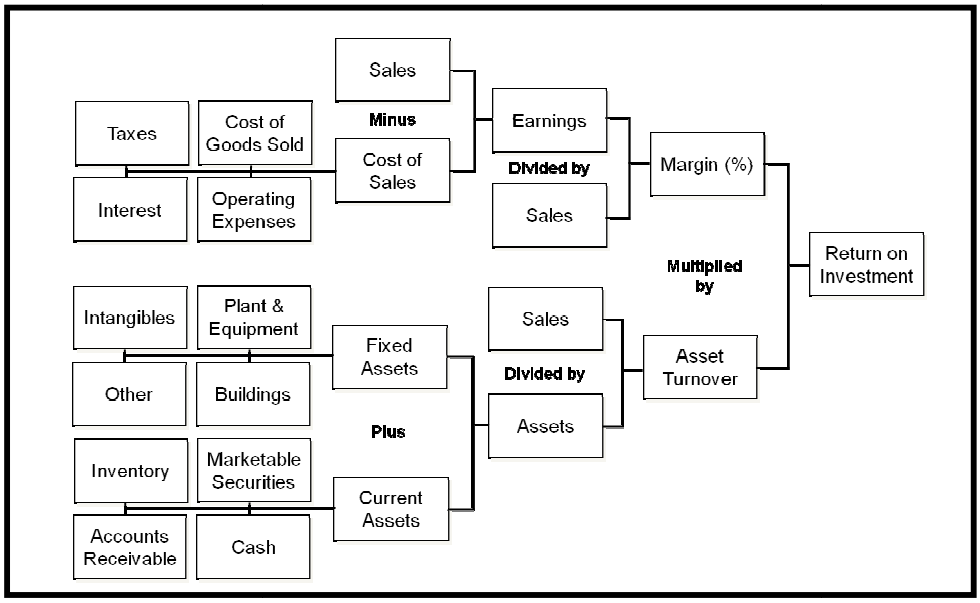


Figure 11 - Du Pont's Pyramid of Financial Ratio's, adopted from Chandler [51] and Johnson and Kaplan [53]

Kueng [**54**] points out the fact that, even though the method is heavily criticised, Du Pont's method is still widely used and taught. This can be attributed to the fact that a variety of modern day performance measurement frameworks incorporate various non-financial and financial measures which creates systemic control. Unahabhoka *et al* [**55**] continues this argument and states that financial (also called lagging or controlling) indicators are being used to indicate whether the results obtained from the leading indicators are desirable.

The measurement of financial performance has changed face over the course of the 20th century with the development of a number of alternative models. These include, but are not limited to:

- Discounted Cash Flow (DCF) – a model, articulated by John B. Williams in 1938, which discounts future payments and returns to present value (at a pre-determined discount rate) in order to determine whether a project is feasible or not [**56**].

- Economic Value Added (EVA) – a financial analysis model, develop by Stern Stewart & Co., to determine the value created, above the required return, for the shareholders of a company [**57**]. In other words, EVA quantifies the surplus return earned by the firm [**58**].

2.6.5.2 Balanced Scorecard

Kaplan and Norton introduced the Balanced Scorecard (BSC), considered by many as the most frequently used and important performance measurement framework [**59**], in a series of articles in 1992 and then formally published this dynamic, well "balanced" framework in 1996 in the book "The Balanced Scorecard".

The focus of the BSC is to link different types of measures including: (1) financial and non-financial; (2) external (financial and customer) and internal (critical business processes, innovation, and learning and growth); (3) inputs/ drivers and outcomes/ results; and (4) objective, easily quantifiable and subjective measures [**60**]. The emphasis of this model is to link organisational strategy with the performance measurement process to reflect changes and to indicate improvements of the organisational whole.

Kaplan and Norton [**61**,**60**,**62**,**7**] define the four quadrants of the BSC (Figure 12) necessary to obtain these types of measures and to obtain an integrated view into the performance of an organisation as:

- the financial perspective;
- the customer perspective;
- the internal business processes; and
- the learning and growth perspective.

These four perspectives of the scorecard permit a balance between short-term and long-term objectives, between desired outcomes and the performance drivers of those outcomes, and between hard objective measures and softer, more subjective measures. [**62**]

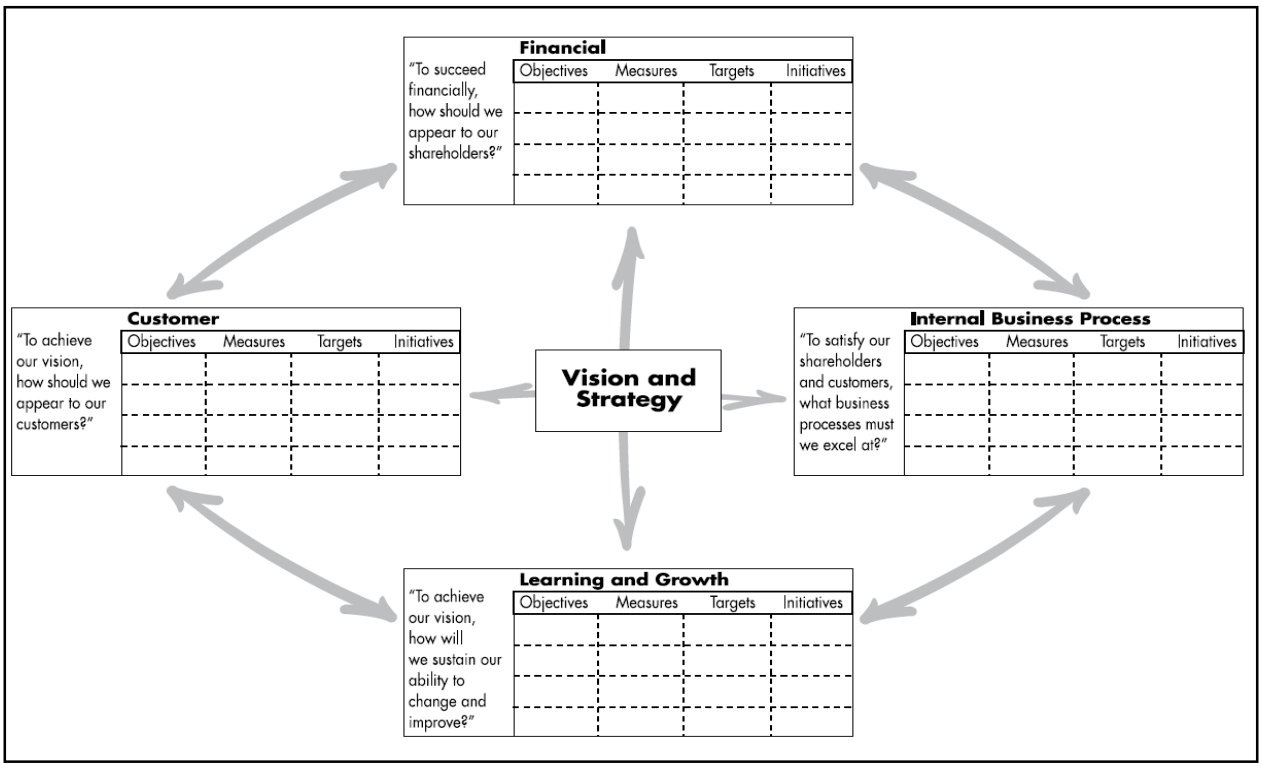


Figure 12 - Balanced Scorecard, adopted from Kaplan and Norton [63]

Financial Perspective

The financial performance measures define the long-run objectives of the organisation. Other measures may be used, but profitability objectives remain most common in organisations. There are three stages in which an organisation may find themselves which dictates the type of measures to be used. These stages are: [**62**]

- rapid growth – organisations that is still in the early stages of their life cycle. They require large investments in research and development of products and services, infra-structure, etc. The objectives in this stage will emphasis sales growth, sales from new products and services and sales in new markets and to new customers;
- sustain – these organisations still attract investment and reinvestments, but they are required to earn excellent returns on this invested capital. They are required to maintain their market share and to grow from year-to-year. The objectives in this stage will emphasis traditional financial measurements, such as return on capital employed, operating income and gross margin; and
- harvest – this is when organisations are in the mature stage of their life cycle. They would want to cash in on the investments of the previous two stages. The no longer warrant new investments-

only enough to maintain equipment and capabilities. The objectives in this stage will emphasis cash flows. Any investments must have immediate and certain cash paybacks.

Kaplan and Norton [**62**] found that organisations typically use (1) Revenue Growth or Mix, (2) Cost Reduction/ Productivity Improvement or (3) Asset Utilisation/ Investment Strategy to help achieve their business strategy.

Customer Perspective

The organisation identifies customer and market segments in which they want to compete and measures their performance according to these targeted segments [**60**]. The customer perspective includes generic outcome measures which include customer satisfaction, customer retention, new customer acquisition, customer profitability, and market and account share. Kaplan and Norton [**62**] define these measures as follows:

- customer satisfaction – drives customer retention and customer acquisition. Provides feedback on how well the organisation from the customers' perspective;
- customer retention – Maintaining and increasing market share in targeted customer segments and measuring customer loyalty in percentage growth of existing customers;
- customer acquisition – Measured as the number of new customers or the total sales to new customers;
- customer profitability – Organisations will not only measure the extent of their business with customers but the profitability of these targeted market segments. Activity-based cost (ABC) allows organisations to measure individual and aggregate customer profitability; and
- market and account share – This is a measure of how well an organisation has penetrated a desired market.

Kaplan and Norton [**62**] argue that the organisation provides the customer with a certain value proposition through certain attributes of their products and services to create loyalty and satisfaction from their targeted customer segments. These attributes are organised into three categories:

- product / service attributes – functionality, price and quality of service or product;
- customer relationship – delivery of product or service to customers and customer experience; and
- image and reputation – the way in which an organisation pro-actively defines itself to the customer.

Internal Business Processes

This perspective necessitates the identification of internal processes in which it must excel. Kaplan and Norton [**62**] implicate that these are the business processes which enables the organisation to:

1 deliver on the value propositions of customers in targeted market segments; and
2 satisfy shareholder expectations of superior financial returns.

The measures should be focused on the business processes which have greatest impact on the customer satisfaction and financial objectives of the organisation [**60**].

The BSC not only focus on the improvement of existing business processes (focus of traditional PMS's) but it also helps the organisation to identify new business processes which are of strategic importance to the organisation.

Learning and Growth

Kaplan and Norton [**60**,**62**] add this fourth perspective of the BSC for the purpose of future growth and development. Where the customer and internal business process perspectives identify the factors most crucial for current and future success, learning and growth identifies the infrastructure in terms of technologies and capabilities necessary for this success.

The other perspectives may typically identify gaps in the three principle sources (people, systems and organisational procedures). The learning and growth perspective will then identify where re-skilling, re-investment, enhancement of information technology, etc. are required for an organisation to retain its competitive advantage.

Strategy Maps

Kaplan and Norton [**64**] develop strategy maps as a tool which is used alongside the BSC to ensure that the measurements identified in the BSC are supported with a set of strategic objectives. One of the critical aspects for integrating a measurement system (such as the BSC) as a strategic tool is to ensure that intangible assets are incorporated along with the tangible assets [**61**]. Bearing this in mind, Kaplan and Norton [**64**] note that causal paths from all measures (tangible or intangible) on a BSC should invariably be linked to financial objectives (seen in Figure 13).

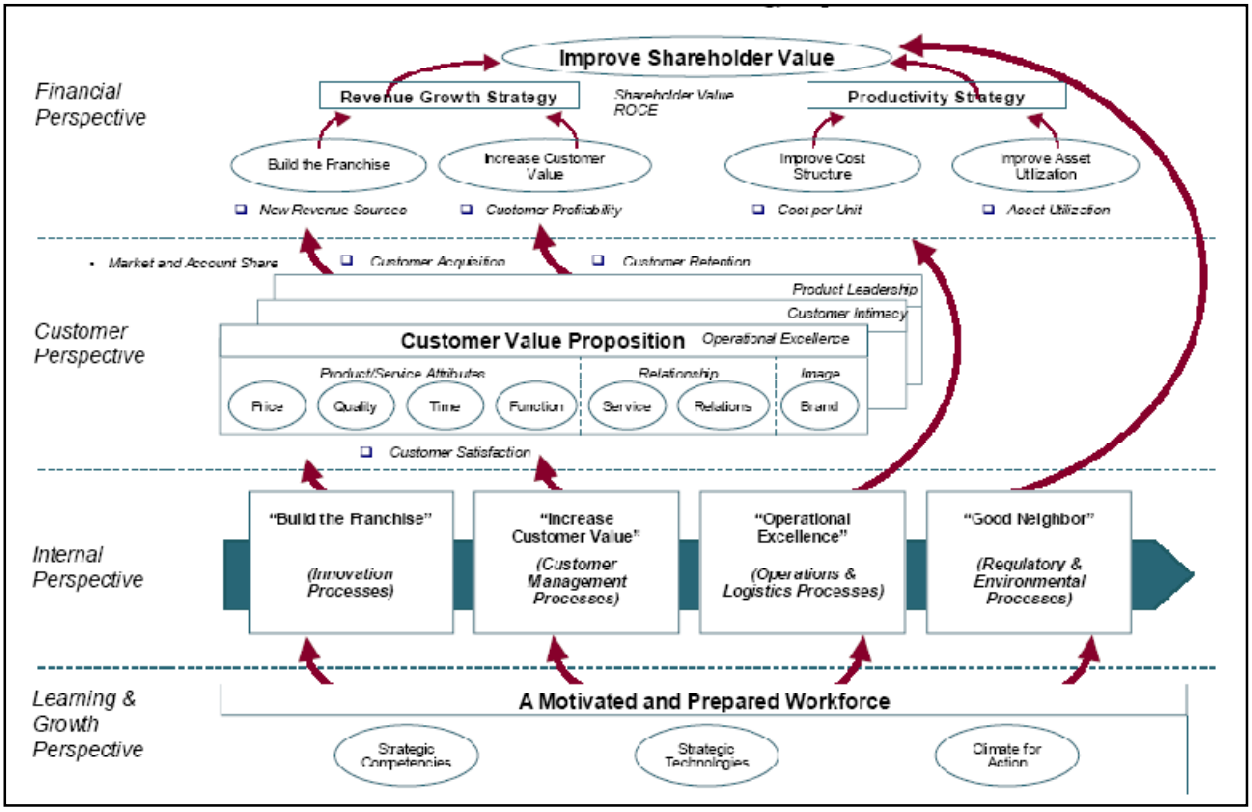


Figure 13 - Balanced Scorecard Strategy Map, adopted from Kaplan and Norton [61]

A strategy map can have one of four underlying themes, dependant on the strategy of the organisation. These themes include: [**64**]

- best total cost;
- product leadership;
- complete customer solutions; and
- system lock-in.

The chosen theme is promoted by the organisational strategy and drives the operations of the organisation.

2.6.6 Procedural Frameworks

The use of procedural frameworks simplifies the process of implementation of a PMS in an organisation. The procedural processes are used as guidelines as to the implementation of the structured performance measurement frameworks. The following frameworks are considered to be of this nature:

- Value Mapping [**65**]
- Integrated Performance Measurement Framework [**40**]

- Neely's Record Sheet [**59**]
- Fraunhofer Approach [**66**]
- Ten Step Model [**42**]
- Sink and Tuttle's framework [**67**]
- Kaydo's Framework [**68**]
- Performance Measurement Questionnaire [**59**]

The drawback of the structural framework is that it lacks the procedural aspect and that it is difficult to implement. The procedural frameworks on the other hand lacks in definitive structure. Folan and Browne [**50**] note that these frameworks are often developed in isolation and are then only combined in PMS's.

2.6.7 Performance Measurement in Context

Performance measurement is essential in determining the validity of a strategy. The output of the operational process (Y(s), as seen in Figure 4) is measured and indicates whether or not the adopted strategy delivers sufficient value.

This section provides the background for the development of a PMS in Chapter 4. The models discussed are evaluated and adopted to serve the intended purpose of measuring the performance of a service partnership.

2.7 Supplementary Fundamental Factors

The literature investigated thus far is concerned with the development of a strategic life cycle model for an organisation. The objective of this section is to define all of the methodologies and tools used in later chapters which are supplementary to the development of the PMVI.

The following fields are included in this literature:

- physical asset management (PAM);
- multi-criteria decision analysis (MCDA); and
- risk management.

The principia defined in this section is used in both the development of a performance measurement model (in chapter 4) and in the application thereof (in Chapters 6 & 7).

2.7.1 Physical Asset Management

The Institute of Asset Management [**65**] defines PAM as the systematic and coordinated activities and practices through which an organisation optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organisational strategic plan.

The research on PAM is not required as part of the development of the performance measurement model in Chapter 4 but rather due to the industry of application of this model in Chapters 6 & 7. The model is applied on Pragma (Pty) Ltd. whom is a services organisation operational in the PAM environment. The understanding of the necessary principles and methodologies, especially with regards to asset performance, of this discipline is required for the successful application of the PMVI model.

2.7.1.1 History of Asset Management

People have managed assets since the beginning of time. The caveman even kept his tools sharp in order for it to be ready during the next hunt. The armies in the middle ages relied heavily on their human assets (soldiers) to conquer their enemy and this required a different approach to manage their assets.

Moubray [**66**] describes the development of the field of modern day asset management as consisting of three phases (or generations) (Figure 14). He defines the first period as the time leading up to World War II. Machinery was over designed and easily maintainable and managers saw maintenance as a low priority.

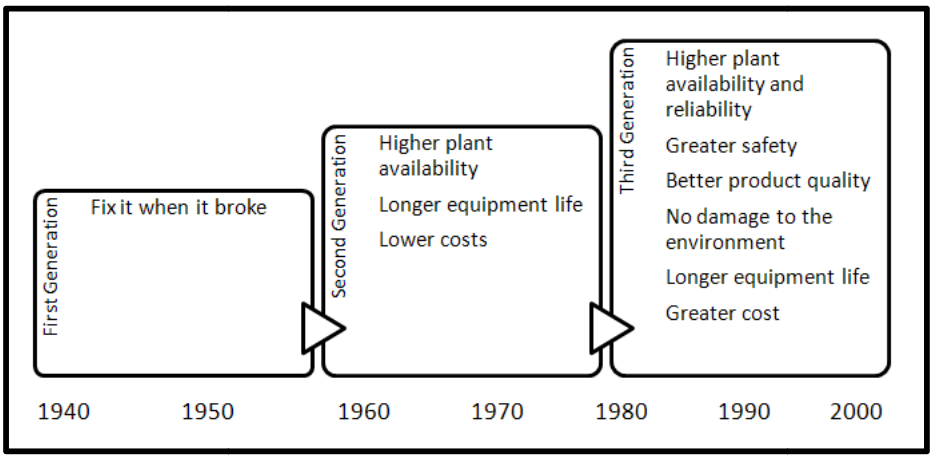


Figure 14 - Development of Asset Management, adopted from Moubray [66]

The second period started during World War II, when demand rose and the manpower available declined which led to the mechanisation of manufacturing. The dependence on uptime from the machinery led to the development of preventive maintenance to maximise the output of production.

The third period started in the 1970's, when the concept of maintenance spread from traditional physical asset intensive industries (mining, manufacturing, etc.) to more diverse sectors (health care, telecommunications, etc.). These industries all started to recognise the importance of asset management as driver for the improvement of operations. The quality of products started to play a role, as well as other factors like safety and the environment. [**66**]

Asset management is a field of research which is ever evolving and current research includes new maintenance techniques, failure modes, etc.

2.7.1.2 Public Available Specification 55

BSI British Standards is the UK's national standards organisation which produces standards and information products that promotes and shares best practice. They identified a need for the development of a set of standards for the field of asset management. The product of this endeavour is a two part publication called PAS 55: Asset Management.

The use of PAS 55 as reference to the practices of PAM in this study does not implicate that the author does not recognise other existing frameworks (Wireman's Asset Management Pyramid [**67**]), but rather that PAS 55 is the framework of choice.
The remainder of this section contains a brief overview of PAS 55, the performance measures involved in PAM and the related principles.

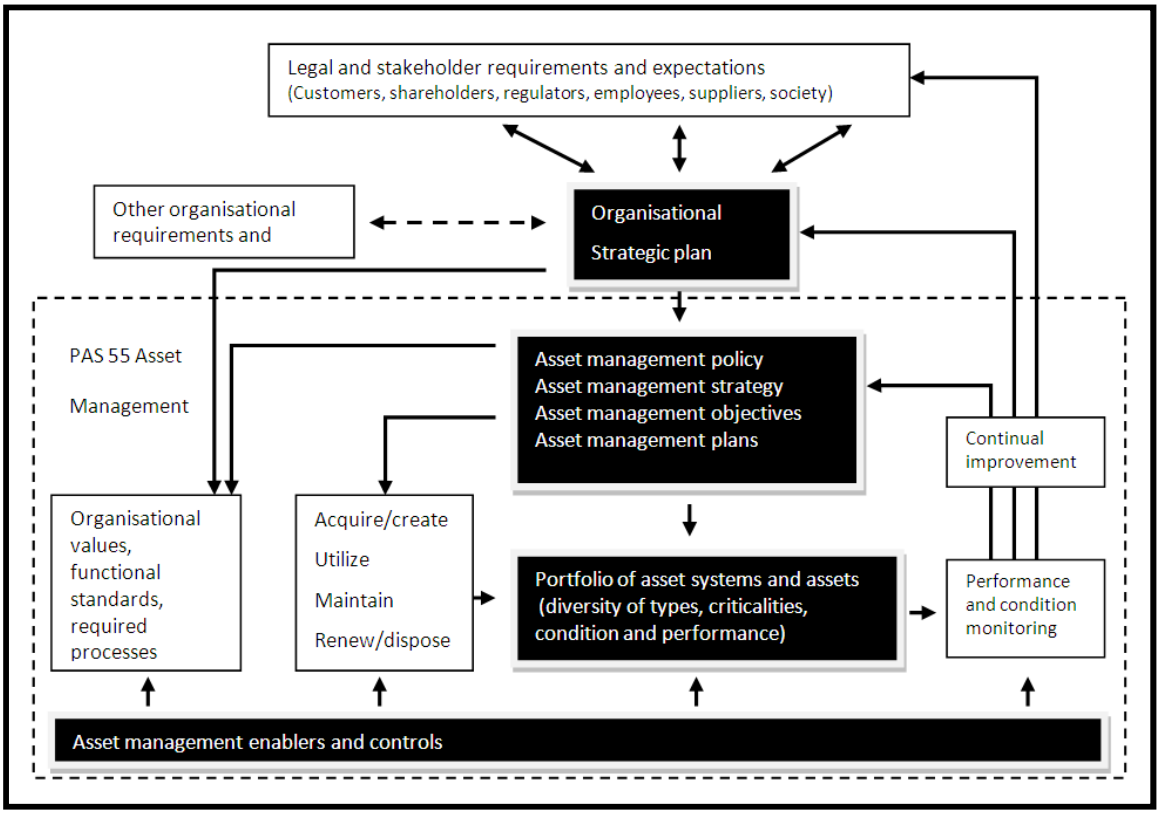


Figure 15 - PAS 55 Asset Management Structure, adopted from PAS 55 [68]

The structure of PAS 55 (represented in Figure 15) is similar to that of the EMM due to the cyclical improvement and constant review of the existing system.

The process is initiated with the strategic planning (as defined in Appendix 0) of the organisation and BSI [**65**] states that the strategy with regards to asset management should align with the overall direction of the organisation.

The conception of a strategic direction in asset management enables the effective associated activities to be formalised and installed in the organisational structure. BSI [**68**] includes the following activities in the PAS 55 structure: (see Figure 14)

- an asset management policy, strategy, objectives and plans;
- the asset management life cycle activities;
- required standards and processes;
- the asset management life cycle;
- the management of the asset portfolio;
- performance management; (see section 2.7.1.3)

- continuous improvement planning; and
- the enablers and controls which is required to be successful.

A broad definition of the discipline was given in this section (see Appendix A for an expanded version of PAM) and the purpose of the rest of this section is to highlight the relation of PAM to performance.

2.7.1.3 Asset Management Metrics

This section defines the main performance related metrics within PAM. This is fundamental in the development of the AMVI model in Chapter 6 and includes:

- overall equipment effectiveness (OEE);
- overall plant effectiveness (OPE);
- total effective equipment performance (TEEP); and
- asset utilization (AU).

The following sections give a brief overview of each of these measures.

Overall Equipment Effectiveness

OEE is a single measure which represents the organisational equipment performance from an individual level up to the overall value chain [**69**]. There are various ways in which OEE can be calculated; of which Nakajima's Time-Based method are the most common. [**70**]

The following section represents the calculation for OEE as defined by Seiichi Nakajima in his book *"Introduction to TPM: Total Productive Maintenance"*.

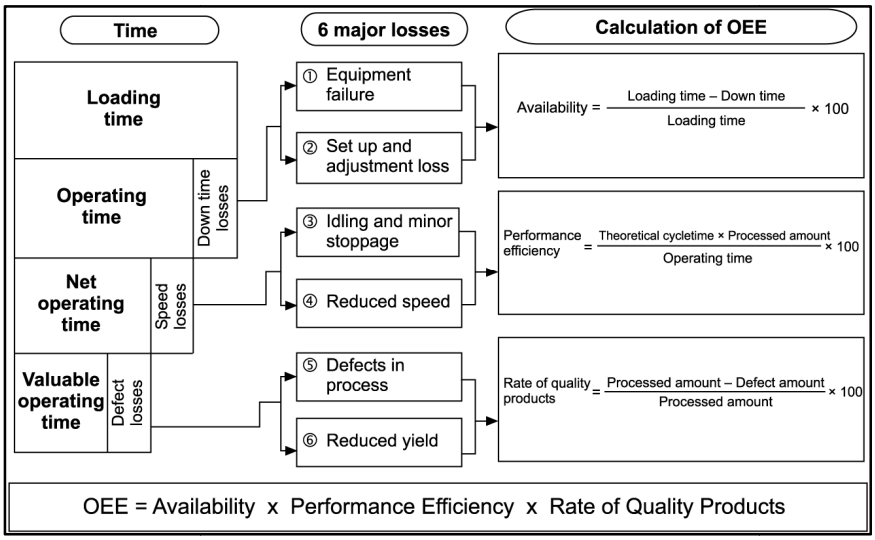


Figure 16 - Overall Equipment Effectiveness, adopted from Ahuja and Khamba [71]

The value of OEE is calculated with the use of the three KPI's: [**72**]

- availability (also used as a measure of uptime [**73**]);
- process rate; and
- quality rate.

OEE is the output of the product of these three KPI's: [**74**]

$$OEE = Availability\ x\ Process\ Rate\ x\ Quality\ Rate \quad \text{...Equation 2}$$

Availability is a measure of uptime (as well as downtime) and is calculated accordingly: [**73**]

$$Availability = \frac{Scheduled\ Time - Downtime}{Scheduled\ Time} \quad \text{...Equation 3}$$

The scheduled time of a physical asset is the time that an asset is available for production minus planned downtime (breaks, meetings, public holidays and schedule lapses). The downtime is the time that the asset is physically down for repairs. [**74**]

Process (Performance/Production) rate is a measure of the ability to produce at a standard product quality and is calculated as follows: [**74**] [**73**]

$$Process\ Rate = \frac{Ideal\ Cycle\ Time}{Actual\ Cycle\ Time} \quad or \quad \frac{Design\ Cycle\ Time\ x\ Output}{Operating\ Time} \quad \text{...Equation 4}$$

The design cycle time is a unit of production and the output is the total output for a given time period. The operating time is the time calculated from the availability in the previous calculation. This measure is ideal for calculating capacity reduction breakdowns. [**74**]

Quality rate is a measure of the ability to produce to a standard product quality. [**73**]

$$Quality\ Rate = \frac{Quality\ Product}{Total\ Product\ Produced} \quad or \quad \frac{Product\ Input - Quality\ Defects}{Product\ Inputs} \quad \text{...Equation 5}$$

The quality defects are the amount of products produced which is below the quality standard of the organisation.

Nakajima [**75**] identifies the six big losses according to this calculation of production output (Figure 16). Blom Consultancy [**76**] further categorises this six big losses into the three categories indicated in the following:

- downtime – time when should be running but stands still;
  - equipment failures; and
  - setup and adjustments.

- speed losses - the equipment is running, but it is not running at its maximum designed speed; and
    - idling and minor stoppages; and
    - reduced speed operation.
- defect losses - the equipment is producing products which do not fully meet the specified quality characteristics.
    - scrap and rework; and
    - startup losses.

Tangen [**36**] and Pomorski [**77**] state that the measurement of OEE alone is not adequate to support improvement programs, but that its power is in the linkage of OEE data with the identification of major equipment losses.

Shortcoming of OEE

The calculation of OEE, as indicated in Equation 2, rests on the assumption that all three of the contributing factors contribute equally to the measure. Williamson [**78**] argues that this may not be the case if the effects of availability and quality are considered with reference to the return on investment of an organisation.

Overall Plant Effectiveness

OPE measures the current levels of maintenance effectiveness and equipment performance and compares this to "world-class" standards. [**78**]

The effectiveness of individual physical assets is combined to produce a single measure of equipment effectiveness for an entire plant. This enables management to compare two plants from a strategic point of view. [**78**] OPE is calculated as:

$$\boldsymbol{Overall\ Plant\ Effectiveness} = \sum_{i=1}^{n} \boldsymbol{Weighted\ Importance\ of\ Asset_i\ x\ OEE_i} \quad \text{...Equation 6}$$

The difficulty in using this metric is that the weighted importance of an asset may have various contributing factors (like dependency of output on production capability) and the rating of the assets may prove to be difficult.

Total Effective Equipment Performance

TEEP is similar to OEE in the fact that it measures the effectiveness of a single piece of equipment. The main difference between these measures is that OEE measures the effectiveness of planned production schedules and TEEP measures OEE relative to every minute on the clock, or calendar time. [**79**]

Asset Utilisation

Mitchell [**80**] defines AU as the percentage of time a plant is in operation at Maximum Demonstrated Production Rate, perfect quality and defined yield.

AU is a lower level metric than OEE and can be used in conjunction with yield and the cost of poor quality (COPQ) to derive OEE. Where COPQ (derived in Six Sigma) is calculated by yield affected, multiplied by price per unit of product. [**80**]

2.7.1.4 Asset Management Key Performance Indicators

Wireman [**67**] develops a multi-level structure of integrated asset management KPI's where the emphasis is placed on linking the KPI's with the long-term corporate business objectives (see Figure 17).

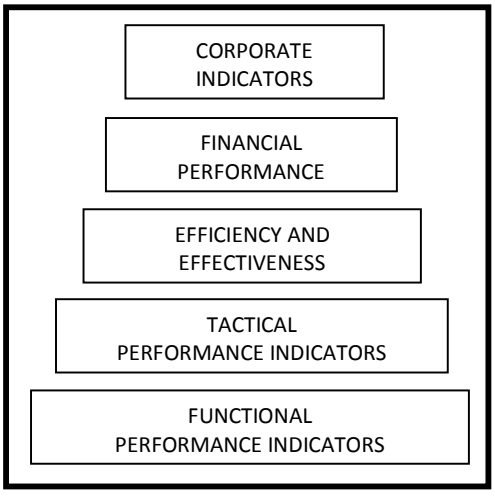


Figure 17 – Performance Indicator Pyramid, adopted from Wireman [67]

This structure serves as a table of reference for underperforming KPI's. The timeframe and strategic importance of KPI's used with respect to this pyramid declines from top to bottom. This insinuates that each level of measures supports a higher level KPI, (functional measures supports tactical measures) but ultimately they all support the corporate indicators. [**67**]

A more extensive definition of the types of KPI's can be found in Teddy Wireman's Book: "Developing Performance Indicators in Managing Maintenance".

2.7.2 Multi Criteria Decision Analysis

A problem is said to be of multi criteria nature when the solution thereof is not a function of the optimisation of a single parameter. Pohekar and Ramachandran [**81**] states that it is rather a function of different, conflicting criteria where a weighted contribution provides an outcome which is truly reflective of the problem. Multi-criteria decision analysis (MCDA) therefore acknowledges that problems are multi-dimensional and that it cannot be reduced to a single dimension. [**82**]

Drechsler [**82**] verifies that the core function of MCDA is to eliminate the subjectivity element from the decision making process.

MCDA involves making decisions when multiple conflicting criteria are present and is concerned with the following characteristics [**83**]:

- multiple attributes/objectives: in the case of a selection problem where many attributes are to be considered, or in a design problem where many objectives are the case;
- conflict among criteria: when multiple criteria are in conflict, where a particular option may score a high criterion value in one category but a low value for another criterion;
- incommensurable units: each criterion has different unit measurements, which complicates the direct comparison between criteria values; and
- design / selection: solutions to these problems are either to design the best alternative, or to select the 'best' among a finite number of alternatives.

There are a variety of methodologies related to this field of research which attempts (with varying degrees of success) to resolve such a problem. The methodologies representing this field of research are: [**81**]

- the weighted sum method;
- the weighted product method;
- the preference ranking organization method for enrichment evaluation (PROMETHEE);
- the analytical hierarchical process (AHP);
- the elimination and choice translation reality (ELECTRE);
- the technique for order preference by similarity to ideal solutions (TOPSIS);

- compromise programming (CP); and
- the multi-attribute utility theory (MAUT).

These methodologies do not form part of the development of this thesis and will consequently not be elaborated on. The model of concern in this research is AHP and the next section stipulates the theory involved in this methodology as well as the use thereof.

2.7.2.1 Analytical Hierarchical Process

Saaty [**84**,**85**] developed AHP as a basic supporting tool for support decision making. The foundation of the Analytic Hierarchy Process (AHP) is a set of axioms that carefully delimits the scope of the problem environment [**86**].

The AHP methodology compares criteria, or alternatives with respect to a criterion, of a given problem in a natural, pairwise mode using a fundamental scale of absolute numbers (see Figure 19) as input variables. The fundamental scale captures individual preferences with respect to quantitative and qualitative attributes [**87**,**88**]. It converts individual preferences into ratio scale weights which can be combined into a linear additive weight *w(a)* for each alternative *a*. The resultant *w(a)* can be used to compare and rank the alternatives and, hence, assist the decision maker in making a choice [**89**].

The three basic functions of AHP derived in addition to the fundamental scale are: [**88**,**89**]

- Decomposition - to structure a complex problem into a hierarchy with goal (objective) at the top of the hierarchy, criterions and sub-criterions at levels and sub-levels of the hierarchy, and decision alternatives at the bottom of the hierarchy (Figure 18); [**81**]
- Comparative judgments - construct pairwise comparisons of all combinations of elements in a cluster with respect to the parent of the cluster; and
- Hierarchic composition - is applied to multiply the local priorities of the elements in a cluster by the 'global' priority of the parent element, producing global priorities throughout the hierarchy.

The decomposition of a problem is complete if each element of each level depends on all the elements of the upper level. [**90**]

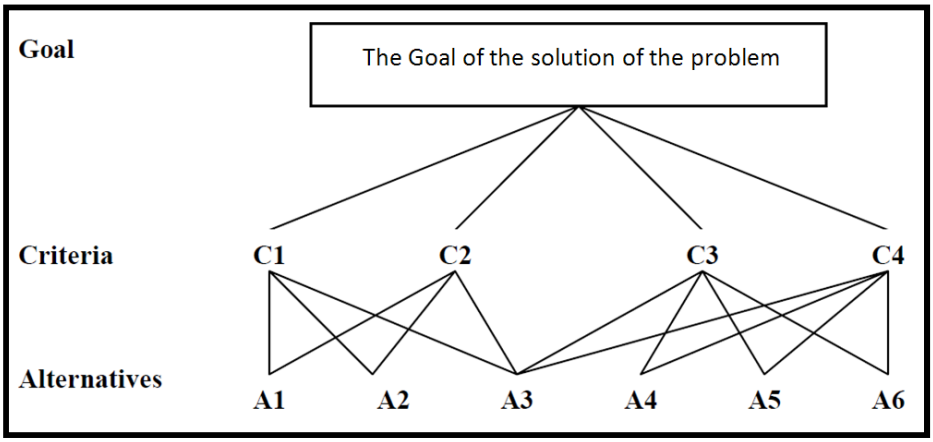


Figure 18 - AHP: Hierarchical Decomposition of Problem, adopted from Berritela et al [90]

Saaty [**91**] derived a comparative scale, which he called the Fundamental Scale of Absolute Numbers (see Figure 19), in order to compare the children (criteria) with its higher level parent (goal) on a pairwise basis.

This method is used to obtain a contribution value for the individual measure (child) relative to its parent. AHP advocates the conversion of qualitative judgements into numerical values and quantitative outputs. [**84**]

Intensity of Importance	*Definition*	*Explanation*
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate Importance	Experience and Judgement slightly favor one activity over another
4	Moderate Plus	
5	Strong Importance	Experience and Judgement strongly favor one activity over another
6	Strong Plus	
7	Very Strong or Demonstrated Importance	An activity is favored very strongly over another; it's dominance demonstrated in practice
8	Very, Very Strong	
9	Extreme Importance	The evidence favoring one activity over another is of the highest possible order of affirmation
1.1 - 1.9	When activities are very close a decimal is added to 1 to show their difference as appropriate	A better alternative way to assigning the small decimals is to compare two close activities with other widely contrasting ones, favoring the larger one a little over the smaller onewhen using the 1-9 values
Reciprocals of above	If activity *i* has one of the nonzero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A logical assumption
Measurement from ratio scales		When it is desired to use such numbers in physical applications. Alternatively, often one estimates the ratios of such magnitudes by using judgement

Figure 19 - AHP: Fundamental Scale of Absolute Numbers, adopted from [84]

The outcome of these comparisons is a pairwise judgement matrix (*A*, see Figure 20) which illustrates the relations between the children relative to the parent.

$$
\begin{array}{c} \\ A \\ B \\ C \\ D \\ E \end{array}
\begin{array}{c}
\begin{array}{ccccc} A & B & C & D & E \end{array} \\
\begin{bmatrix}
1 & a_{AB} & a_{AC} & a_{AD} & a_{AE} \\
1/a_{AB} & 1 & a_{BC} & a_{BD} & a_{BE} \\
1/a_{AC} & 1/a_{BC} & 1 & a_{CD} & a_{CE} \\
1/a_{AD} & 1/a_{BD} & 1/a_{CD} & 1 & a_{DE} \\
1/a_{AE} & 1/a_{BE} & 1/a_{CE} & 1/a_{DE} & 1
\end{bmatrix}
\end{array}
\begin{array}{c}
\text{Priority Vector} \\
\begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \end{bmatrix}
\end{array}
$$

Figure 20 - AHP: Pairwise Judgement Matrix and its Eigenvector

The eigenvector of this matrix (see Figure 20), or priority vector (w), establishes the relative weight (or priority) of the children on their contribution towards the parent element. [**84**,**87**]

After obtaining the weight vector, it is then multiplied with the weight coefficient of the element at a higher level (that was used as criterion for pairwise comparisons). The procedure is repeated upward for each level of disaggregation, until the top of the hierarchy is reached. The overall weight coefficient, with respect to the goal for each decision alternative is obtained. The alternative with the highest weight coefficient value should be taken as the best alternative. [**81**]

These pairwise comparison exercises is conducted on a subjective manner by using qualitative techniques (Delphi, brainstorming and questionnaires [**92**]) which establishes a requirement to test the consistency of the information received.

Pohekar and Ramachandran [**81**] states that a major benefit of AHP is that it calculates an inconsistency index as a ratio of the decision maker's inconsistency and randomly generated index. This index is important for the decision maker to assure him that his judgments were consistent and to indicate that the most appropriate decision is made. The inconsistency index should be lower than 0.10 to provide the desired outcome. Although a higher value of inconsistency index requires re-evaluation of pairwise comparisons, decisions obtained in certain cases could also be taken as the best alternative.

The calculation of the related variables can be found in T.L. Saaty's book: Analytical Hierarchical Process [**87**].

2.7.2.2 Use of Analytical Hierarchical Process

The application of AHP in this research is not in the traditional format, as discussed in the sections above, but rather as a tool to weigh the different elements of the PMVI model in Chapter 4. This requires that the model is adapted to accommodate only the initial weighting of sub-cluster and criteria with reference to the goal of the PMVI model which is to measure the value of the service partnership.

2.7.3 Risk Management

Risk is a challenging concept to define, understand and ultimately to manage. This is primarily because risk often means different things to different people. Historically, risk is defined as the possibility that the actual input variables and the outcomes may vary from those originally estimated [**93**,**94**].

Vose [**95**] defines the latter as a risk due to variability and he adds that there is another type of risk, uncertainty, which is the lack of ability of the assessor. He then defines that each risk constitutes of a scenario, its probability of occurrence and the size of the impact of the risk should it occur.

The need for a formal approach (or framework) to analyse risk in an organisation led to the development of risk management as a discipline. McGaughey *et al.* [**96**] defines risk management as the science and art of recognising the existence of threats, determining their consequences on resources, and applying modifying factors cost effectively to keep adverse consequences within bounds.

The framework consists of a risk management lifecycle (Figure 21), which is a continuous loop of interrelated activities to ensure that an organisation is coherent in this regard.

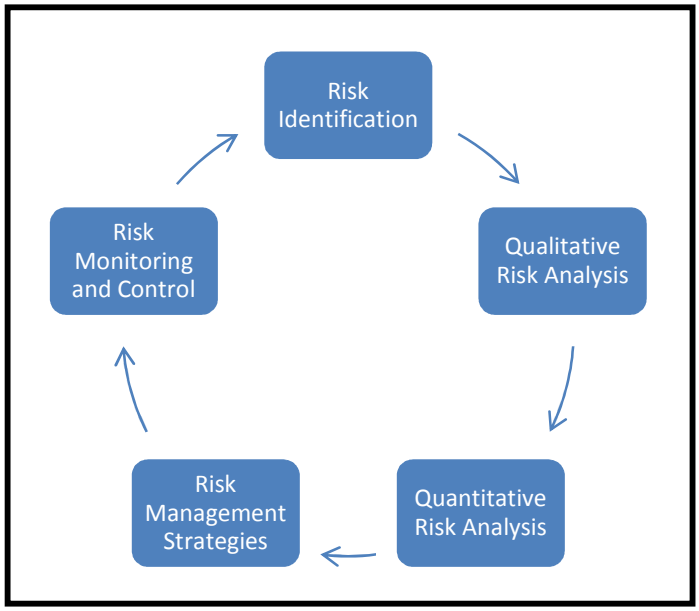


Figure 21 - Risk Analysis Process

The following sections contain a brief description of the various risk management life cycle activities.

2.7.3.1 Risk Identification

The identification of risks is the informative part of the entire risk analysis process [**95**]. It is therefore important that an environment is created where all participants can express themselves freely.

There are a variety of ways to facilitate the identification process of which structured interviews, the Delphi methodology and Brainstorming [**97**,**98**] are the most prominent. The identified risks are integrated into more comprehensive risks and categorised according to their nature. These risks are documented in the risks register which contains all of the information relevant to that specific risk.

The difference, in nature, between projects and operations (as highlighted in section 2.5) are reflected in the risk identification process due to non-similar environments. The risks in a project environment are

mainly focussed on four constraints which are costs, scope, schedule and quality [**99**,**100**] whereas organisational risk spans over a more diverse environment (see Equation 7) [**101**].

$$\boldsymbol{Organisational\ Risk} = \boldsymbol{f}\{\boldsymbol{B};\ \boldsymbol{F};\ \boldsymbol{C};\ \boldsymbol{S};\ \boldsymbol{T};\ \boldsymbol{H}\} \qquad \text{...Equation 7}$$

where B = business risk, F = financial risk, C = culture risk, S = structure risk,
T = technology risk and H = human risk.

Once the risks are defined and categorised, they are migrated into a risk register which stipulates their nature and qualities (obtained from the following sections).

2.7.3.2 *Qualitative Risk Analysis*

PMI [**97**] stipulates that in order to create a risk profile for a project (or an organisation) a proper evaluation of the individual risks must be completed.

A qualitative risk assessment requires that the individual risks are normalised into a comparative scale which enables the user to obtain a true picture of the severity [**95**].

This requires that the user define both the probability and impact of a risk and thus producing a viable severity as outcome. The scale on which the risks are compared (in both probability and impact) is typically non-linear in its application and the range on which the values are situated can differ by some order (Figure 22). Simon *et al* [**98**] propose a five point scale in which a value for each risk can be calculated by multiplying its probability with its associated impact using a weighting for each point on the scale. The values, from 1-5 (or very low to very high), is adopted by each of the scaled values in Figure 22 and the severities is calculated accordingly.

Category	Probability (%)	Impacts (Cost: Rk)
Very High	10 - 50	> 1000
High	5 - 10	300 - 1000
Medium	2 - 5	100 - 300
Low	1 - 2	20 - 100
Very Low	< 1	< 20

Figure 22 - Risk Probability and Impacts (Non-linear), adopted from [95]

This provides the normalisation required to compare the risks and thus provide consistency in the process. These values are plotted on the risk severity matrix (see Figure 23) for a visual representation in which the risk profile of an organisation can be identified without trouble.

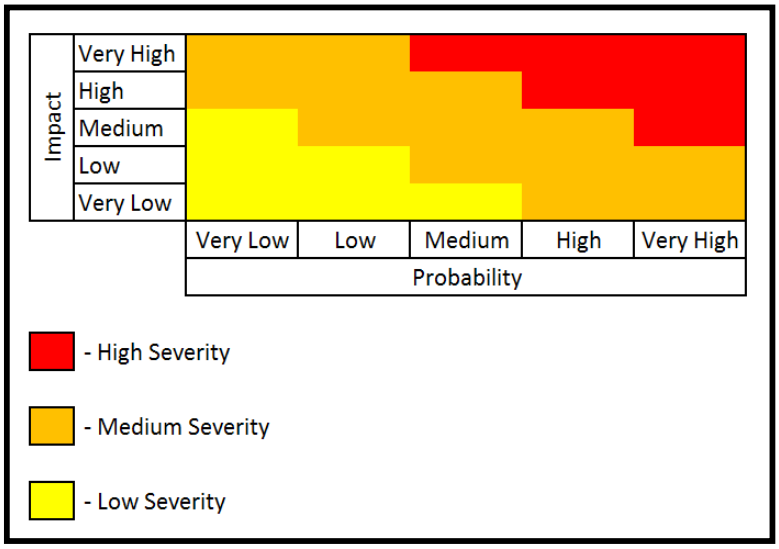


Figure 23 - Risk Severity Matrix, adopted from Vose [95]

The Delphi technique, Brainstorming and interviews are mainly used as source when conducting a qualitative risk analysis [**97**,**98**].

The outcome of this exercise is the prioritisation of the risks in the risk register. The high priority risks (threshold of risk tolerance determined by the organisation) which are further analysed on a quantitative basis are identified through this process.

It should be emphasised that the scores which are achieved have no absolute meaning; they are simply a method of indicating the relative seriousness of individual risks. [**102**]

2.7.3.3 Quantitative Risk Analysis

Heldman [**103**] defines a quantitative risk analysis is a numerical assessment of the probability and impact of the identified risks which enables the user to obtain an organisational risk score.

This process delivers the user with a measure of the variability of the probability and frequency of occurrence of the associated risk. The main requirement of this process is correct and sufficient data on which a statistical analysis of sort is completed. [**104**]

The following techniques are some of those used when conducting a quantitative risk analysis (see Vose [**95**] for the detailed description):

- monte carlo simulation;
- statistical analysis methodologies;

- discrete event simulation; and
- event – and decision tree analysis.

There are numerous software programs which enable the user to conduct these analysis methodologies with relative ease. The output of these techniques is a risk profile for the organisation in terms of a predetermined criterion (costs, for example).

The outcome of the quantitative risk analysis is a detailed analysis of high profile risks in the risk register for which appropriate actions must be determined.

2.7.3.4 Risk Management Strategies

The person responsible for managing risks in the organisation is confronted with the decision on how to mitigate the risks as prioritised in the risk register. This determines how the internal resources of the organisation are allocated. The strategies which can be followed are (see Figure 24 for an example of the output of such an exercise): [**95**]

- increase the risk – this is if the organisation is overcautious and the benefits from increasing the risk overcompensates for the increase in occurrence;
- do nothing – to take action would be to expensive;
- collect more data – better understanding of the risk;
- add a contingency – increase a dependant variable to reduce probability of occurrence;
- reduce – build in redundancy;
- share – outsource the risk to an external partner (see Chapter 6 for application);
- transfer – insure against occurrence; and
- eliminate – avoid the risk all together.

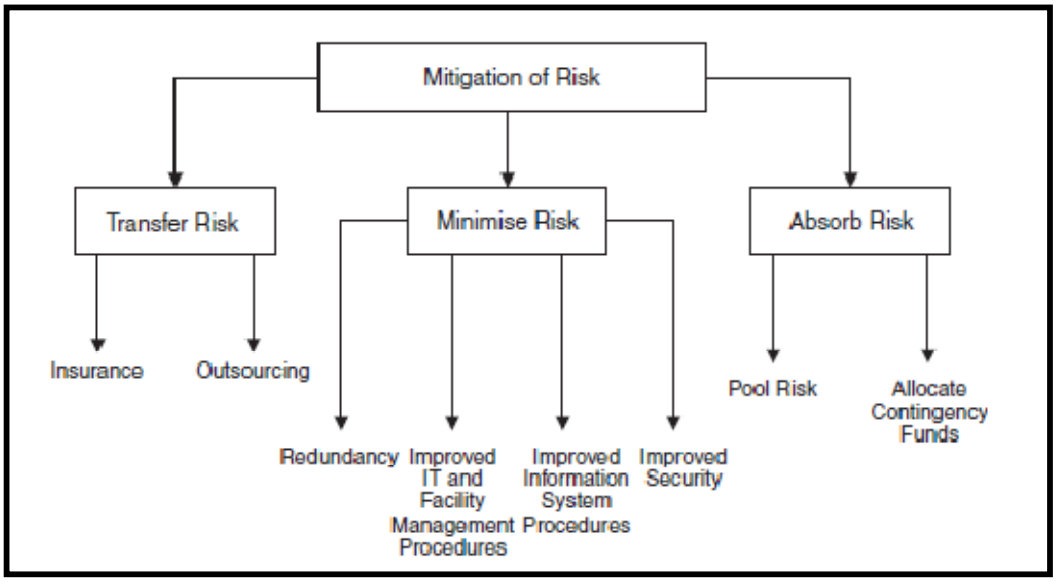


Figure 24 - Risk Management Strategies, adopted from Gibb and Buchanan [102]

The decision made per risk is dependent on the risk appetite of the organisation as well as the severity of the risk.

2.7.3.5 *Risk Monitoring and Control*

This is the process of continuously identifying, analysing, and planning for newly arising risks, keeping track of identified risks and those on the watchlist, reanalysing existing risks, monitoring trigger conditions for contingency plans, monitoring residual risks, and reviewing the execution of risk responses while evaluating their effectiveness. [**97**]

Berry *et al* [**26**] emphasise the need for mechanisms which monitor and report on the actions selected to address the risks. The effectiveness of responses should be evaluated and documented to improve organisational memory.

Risks should be reassessed and new risks must continuously be identified.

The outcomes of the reassessments, risk audits, and periodic risk reviews should be updated. All of the elements, including the probability, impact, priority, response plans and ownership, should be kept up to date in the risk register.

2.7.3.6 *Use of Risk Management*

Gibb and Buchanan [**102**] elaborates on this and states that the main theme of risk management is to ensure that a common set of tools and methodologies is selected in order to adequately compare risks

across the enterprise. The author recognises that this issue and emphasise that this is a mere overview of the discipline of risk management. The purpose of this section is to establish a framework for risk management in an organisation as this is an element of measurement in the performance measurement model of Chapter 4.

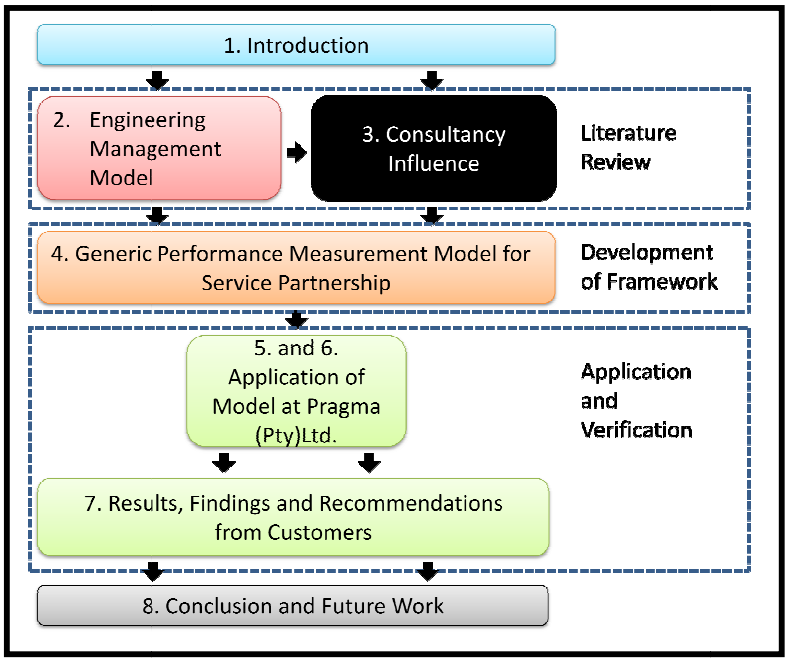
Further information on project risk management can be found in the project management institutes (PMI) handbook: “Project Management Body of Knowledge” [**97**] and an extensive overview of the quantitative aspect of this discipline can be found in D. Vose’s book: “Risk Analysis: A Quantitative Guide” [**95**].

2.8 Chapter Conclusion

The EMM is a life-cycle through which organisation evolve in the search for continual improvement and thus to gain a competitive advantage above its competitors. The supplementary fundamentals provide the reader with an insight into those elements needed in the development of the PMVI (in Chapter 4) as well as providing the techniques and models which enables the application of the model in the respective environment (Chapter 5).

The following chapter introduces the use of a specific strategy and explains the consequences thereof within an organisation.

3 Setting the Scene



The research on fundamentals (Chapter 2: Fundamentals) sought for the development of an EMM. This model illustrates the improvement (and sustainment) life cycle of an organisation in order to obtain and sustain a competitive advantage.

This chapter discusses the consequences of the decision to adapt a specific type of strategy where the organisation focus on their core competencies and outsource a business function in which they do not have sufficient resources. This discussion is expanded to include the effects of a service organisation (or consultancy) on the operations and performance of the organisation.

Objectives

- *give a brief background on the type of services which a consultancy render;*
- *reflect on the change and knowledge management required for the consultancy to be truly effective;*
- *provide insights into the influence of the services of a consultancy on the EMM discussed in Chapter 2; and*
- *provide the reader with a clear and distinct understanding of the way forward.*

3.1 Consulting Organisations

The purpose of a consultancy is to provide a specialised service in a specific area of an organisation [**105**]. The service rendered varies from one organisation to another in both the depth of penetration and the span of influence.

The depth of penetration is a measure of the extent to which an organisation requires the service on the focal area. This is a function of both the extent of services rendered by the consultancy and the services required by the organisation.

The span of influence is a function of the integration of the service rendered, and the control which the consultancy have on the other functional areas of the organisation required successfully implement its expertise.

The following section is concerned with the value (and necessity) of change and knowledge management in the partnership between the consultancy and the organisation.

3.2 Change Management

The concept of change within an organisational context is a very delicate subject and should be treated accordingly. The acquirement of a service organisations services is one such scenario when change can be detrimental if the approach and integration is not handled suitably.

The service organisation is initially required to “win over” management for employment purposes. They are required to indicate (be it on historical experiences) the value which they are going to add to the function and thus improve the organisation to successfully do this.

This is followed by the implementation of the required change at the organisation. The employees with whom the service organisation is in direct contact must be made to understand the purpose of the acquirement of service and the effects on their immediate environment.

The reluctance of people to change is not something new and may be easier said than done. The consultancy requires the complete backing of management as well as a sufficient introductory and training program to be successful in this aspect.

This process may seem to be elementary and logical, but for a consultancy to be truly effective, they need to be able to win the trust of all of the employees of the organisation prior to the implementation of their proposed systems and/or processes.

The following section defines the management of knowledge within the service partnership.

3.3 Information Management

The interaction between the two entities within the service partnership is mainly based on the flow of information. Rayport and Sviokla [**106**] developed a virtual value chain for an environment where organisations are not mainly based on production but where information is the product (see Figure 25).

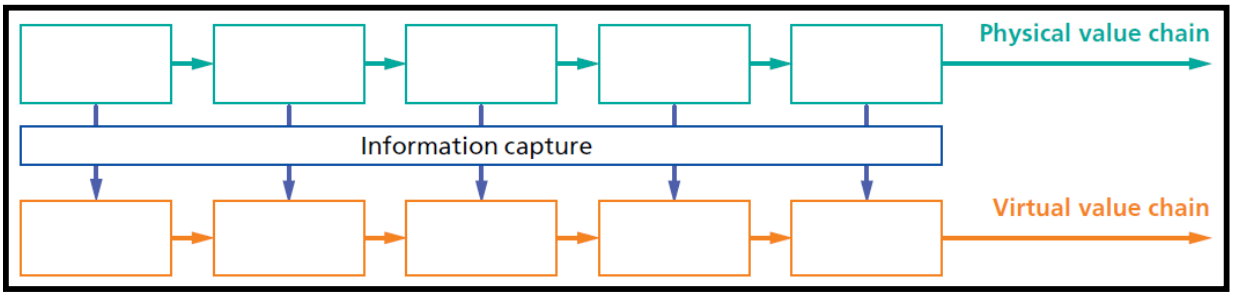


Figure 25 - Virtual Value Chain, adopted from Rayport and Sviokla [106]

They argue that an organisation's value chain should not only be confined to the marketplace, but that it should also include the marketspace. The marketspace is defined as the virtual space where products and services are rendered through information-based channels.

The physical activities of an organisation are confined to the typical representation of the value chain as Porter intended it, but information is not regarded as a support activity. The value-adding activities of information from a virtual point of view is realised and the value in the use of this information is capitalised on. [**106**]

Rayport and Sviokla [**106**] define five value-adding steps for utilising information in the virtual value chain (VVC). These steps are:

- gathering;
- organizing;
- selecting;
- synthesizing; and
- distributing information.

Porter [**20**,**21**], on the other end of the spectrum, indicates that his traditional depiction of the value chain (see Figure 26) links the various activities in the organisation to indicate their inter-relatedness. Kaplinsky and Morris [**107**] expand on the notion and states that a systemic approach must be taken to incorporate the inter-relatedness of stakeholders within the value chain. This approach enables the organisation to focus on its core competencies whilst the outsourced linkages are in effective operation.

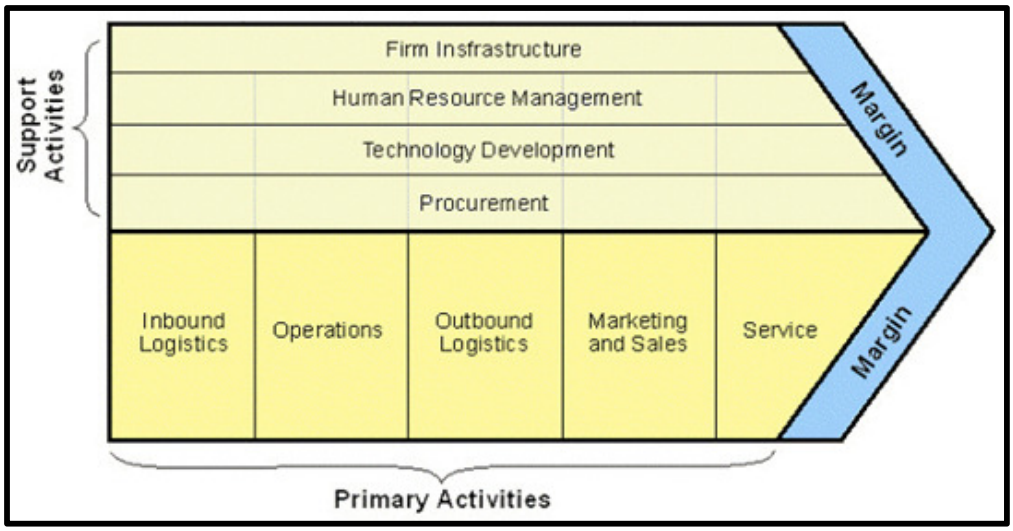


Figure 26 - Porters' Value Chain, adopted from Porter [21]

The combination of the physical and virtual value chain is essential in the service partnership for sustainability of service and to ensure the improvement of the business function.

Information management is a key element of systemic competitiveness and relates to the informational requirements to the respective organisations. The flow of information in the service partnership is depicted in Figure 27, where the information barrier is defined as the area where the required data from the respective sources are obtained and distributed.

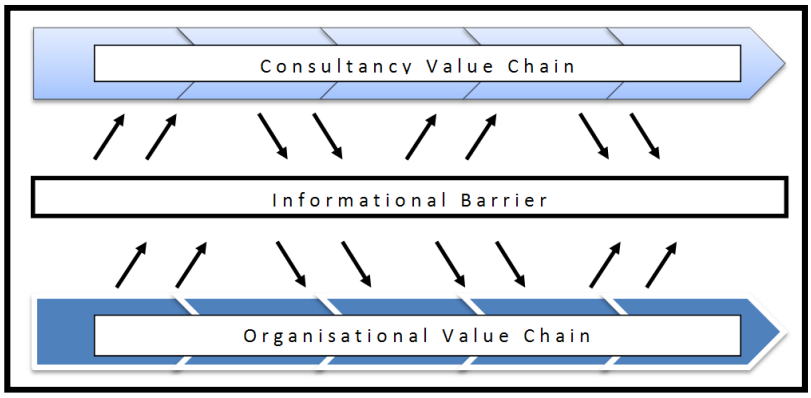


Figure 27 - Consultancy Value Chain

This concludes the section on information management in the service partnership and the effect of the outsourcing decision is discussed in the following section.

3.4 Engineering Management Model: Consultant Influence

Chapter 2 discusses the EMM and how organisations formulate, execute and improve the different strategies required to obtain and maintain a competitive advantage.

This section investigates the business decision to outsource a certain aspect of the organisation to ensure optimal value. The decision can be attributed to one of the following reasons:

- lack of knowledge or expertise in the specific focus area;
- confining the organisation to its core competencies; and
- poor performance by a specific business unit.

The decision to outsource a business function is followed by the engagement of the organisation with a consultancy to stipulate the required service. The outcome of this process is an agreement on the depth of penetration and span of influence of the service as well as the associated costs of the consultancy.

The depth of penetration (illustrated by the number of organisational functions included) and span of influence (illustrated by the percentage of each function included) is indicated in Figure 28, where the black is an indication of the control and responsibility of the consultancy.

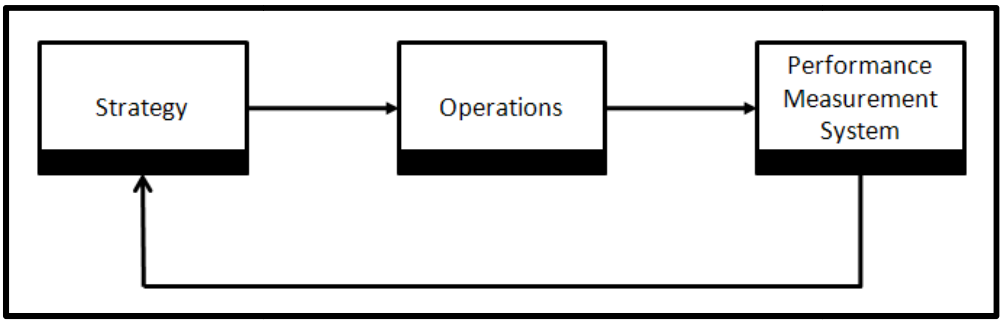


Figure 28 - Consultant Influence on EMM

One of these two factors can be predominant in the partnership between the parties. This is evident in an organisation where only strategic consulting is required and no operational support is rendered. This is often the case with management consultancies where the span of influence on strategy is extensive, but the depth of penetration is limited.

The other end of the spectrum is where the consultancy has full control of the strategic management and operations of the business function and integrate their service with other required functional areas. This is the case with a service organisation of which the service is of a purely outsourced nature and change management, as discussed in the previous section, is of utmost importance. Successful implementation of this type of service may cause that the service organisation become indispensable as the business function will deteriorate with discontinuance of service.

The SLA in such a service partnership may exist anywhere on the continuum between these two extremes.

The influence and type of service rendered, as discussed above, may have a predominant effect on the outsourcing decision of the organisation but it has no influence on the measurement of performance in the EMM (and that of the consultancy). The initial agreement between the organisations includes a set of goals and required compliancy issues. The consultancy must comply with these goals in order to maintain the relationship and to ensure future business with the organisation.

The performance measurement with reference to the organisation can be seen from two different perspectives. These are:

- the measurement of the success of the decision to outsource the business function relative to the organisational performance; and
- the performance of the consultancy with regard to their influence on the organisation and the predetermined goals.

These are two different measures with completely different criteria and it should be approached accordingly. The following section stipulates this difference and discusses the way forward within the context of the thesis.

3.5 Chapter Conclusion

Chapter 2 illustrated the life cycle of an organisation from its strategic inputs through to the measured outputs of this strategic decision.

This chapter is concerned with the consulting influence, as a strategy, on the EMM. The different types of services and influences of consultancies on an organisation are discussed and the issue of performance measurement arises as being of dual nature (in Section 3.4). This thesis is only concerned

with the second type of performance measurement as the measurement of the strategic decision would incorporate various other functions within the organisation.

The measurement of the success of a consultancy is a debatable issue. This is attributed to the direct and indirect nature of the influence and the contribution of the respective parties. The aim of this research is thus to measure the value of the service partnership and not strictly those elements which can be attributed to the consultancy. The measurement of performance is a driver of the continuous delivery of service and must be proven to a certain extent.

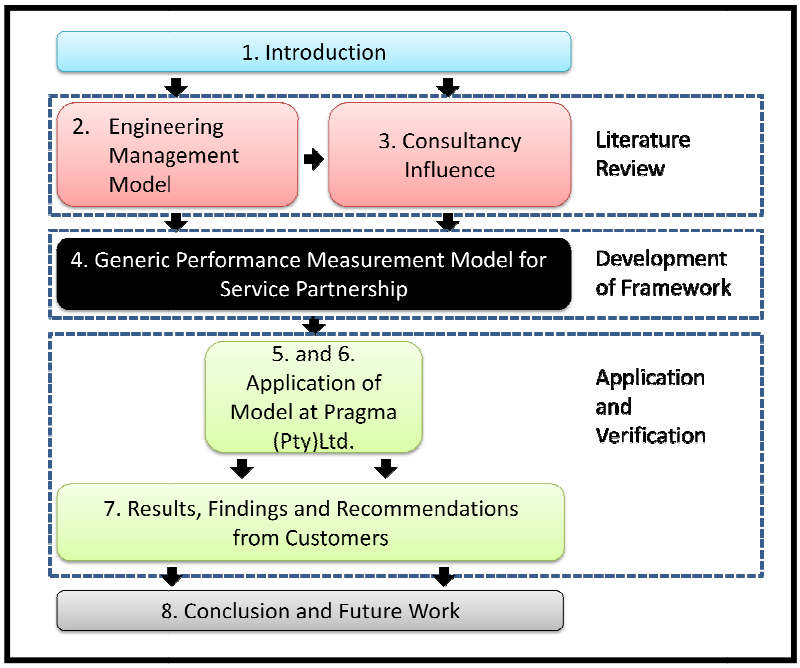
The measurement of the true value of a service cannot be based on a purely financial perspective (as various authors have indicated, see Section 2.6). This establishes the need for a multi-dimensional model measuring different perspectives of both tangible and intangible nature. The next chapter defines such a model in the PMVI and discusses the use thereof.

4 A Performance Measurement Model for the Consulting Industry

"The thing about performance, even if it's only an illusion, is that it is a celebration of the fact that we do contain within ourselves infinite possibilities"

- Sydney Smith (1771 – 1845)

The document thus far has contained the elements required to justify the development of a performance measurement model for the service partnership between a consultancy and an organisation.



The research on fundamentals (Chapter 2: Fundamentals) sought for the development of an EMM. This model illustrates the improvement (and sustainment) life cycle of an organisation in order to obtain and sustain a competitive advantage.

The chapter thereafter (Chapter 3: Setting the Scene) illustrates the effects of the strategy to focus on core competencies and to outsource a business function to a consultancy. This strategy is reflected in the performance of the organisation and the required targets to ensure that a mutually beneficial relationship is established.

This chapter is concerned with the development of a model to measure the service levels of a consultancy relative to the predetermined goals and levels of compliancy.

Objectives

- *academic justification for the use of the proposed model;*
- *a definition of the concept of a Value Index;*
- *a brief explanation of the key concepts and perspectives of the Performance Measurement Value Index;*
- *the introduction of a model to weigh each of the perspectives of the model;*
- *an elaborate look at the development of each perspective and the application thereof;*
- *the definition of the factors contributing to the type of measurement to be used; and*
- *recommendations regarding the application with different industries and for different consultancies.*

4.1 Academic Justification

The focus is shifted from the EMM and the consultancies influence in order to measure the performance of the outsourcing decision. This section describes the logic behind the development of PMVI model throughout this chapter.

The development of performance measurement models (Section 2.6.2) up to the 1980's were based either solely on financial measures (Du Pont [**35**], etc.) or on productivity measures (Taylor [**108**]). During the 1980's, academics recognised the need for development of models which incorporate a variety of tangible and intangible measures to get a better, more comprehensive picture of the performance of an organisation. [**32**]

The incorporation of tangible and intangible measures to create multi-dimensional performance measurement model is important within the consulting industry. This is attributed to the variety of aspects inherent in the service rendered to the customer. The two major aspects involved in the service of a consultancy are the people and the product and/or service delivered. The consequence of this is a broad range of measures which can be used to develop a performance measurement model for a service partnership.

The acknowledgement of this unique partnership and research of a variety of performance measurement models leads to the conclusion that there are indeed models with proficient criteria to measure this specific type of performance.

The BSC (see Section 2.6.5.2) is identified as being of such a nature. Kaplan and Norton [**61**,**60**,**62**,**7**] developed the BSC to link organisational strategy with the performance measurement process in order to reflect changes or improvements of the organisational whole. The outsourcing strategy investigated in this study (as discussed in Chapter 3) requires that the BSC be adjusted for measurement purposes.

The adjustments to the four perspectives, the development of the new model, the weighting of the newly defined perspectives and the outcome of this performance measurement model are discussed in the remainder of this chapter.

4.2 Industry Application: Introspective Analysis

The goal of the PMVI, as stipulated in the beginning of this chapter, is to measure the performance of the consultancy service partnership. A procedural approach towards the design of the model, as represented in this section, ensures that the model is applicable within a variety of industries and for different service organisations.

The key to a successful application is the understanding of the business and services of the consultancy and the value which they contribute to a customer. It is important to spend time within the consultancy itself and with a number of their customers prior to the design and application of this model.

4.3 Value Index

The first step in defining the concept of a value index (VI) is to define an index in the context of this study.

index, index number, indicant, indicator (noun) [**109**]

- a numerical scale used to compare variables with one another or with some reference number; or
- a number or ratio (a value on a scale of measurement) derived from a series of observed facts; can reveal relative changes as a function of time.

We can now define a VI as follows:
"A value index is an index or numerical scale which measures the performance of the partnership between a consultancy and their customer through the comparison of a variable set of measures over a given period of time."

The VI is coupled to a scale of reference (a single number) which enables the user to compare the outputs of a single organisation over a period of time or of a service at different organisations. The comparison of the VI across different industries is used to indicate ultimate value growth or deterioration due to the consultancies service. This is, however, not a basis for the direct comparison of relative organisational performance (cross sectional studies are used to indicate growth patterns in similar industries).

The VI is the outcome of the PMVI and is used to measure a change in performance at selected area's over a period of time. This model is balanced (containing both tangible and intangible measures) and consists of a combination of four variables (which are referred to as elements) to obtain a true picture of the partnership performance.

The VI, being of numerical nature, can be represented as either a positive or a negative value. A positive value indicates that value is being added and a negative value indicates a deterioration of value.

Both members of the partnership should continuously monitor the VI for either a inclining or declining value. An inclining value indicates that, irrespective of the current state of the VI, more value is being added than in the previous period and a decline indicates a deterioration of value.

4.4 Performance Measurement Value Index Model

The previous section describes the necessity of a relative measure to compare service delivery. This section defines the PMVI, which is a performance measurement model developed for measuring the change in value experienced due to the institution of a service partnership.
This model is based, as stated earlier, primarily on the BSC and consists of the following (see Figure 29):

- financial;
- customer engagement;
- risk management; and
- internal business processes.

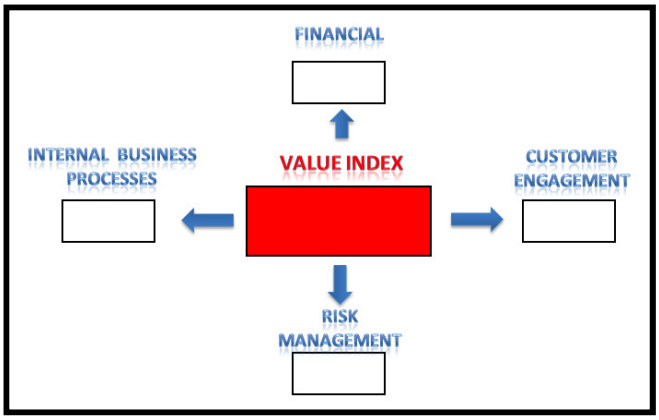


Figure 29 - Value Index

The remainder of this chapter illustrates the weighting of these elements towards the obtainment of the VI. This is followed by the design of the PMVI, which integrates these elements into a generic PMS.

4.4.1 Issues in the Design of the PMVI model

The PMVI model is a simplistic model which indicates whether a consultancy adds value to their customer. The key to simplicity lies in the definition of the KPI's and the amount of KPI's used. It is therefore preferred that the amount of KPI's should be confined to 20 in order to reduce the amount of information and time required to provide an outcome.

This constraint in the design of the PMVI model can inhibit the comprehensiveness of industry specific solutions and it is necessary to emphasise that the use of this model is not to represent the value of the service as a precise monetary value. The PMVI model is a mere indication of an increase or decrease in value and serves as a starting point for problem solving and further investigation.

4.4.2 Justification of PMVI Elements

The different elements of the model are inherently different but the factors contributing to their inputs and outputs may seem to be of similar nature at times. It is for this reason that a brief insight into the logic behind the choice of elements is supplied.

Financial Element

Goldratt [**110**] states that the goal of an organisation is to make money. The financial element is in direct correlation with this statement as the customer would like an indication of any monetary gains as a consequence of the service provided.

The institution of a financial element in a performance measurement model is thus a necessity as is the case in the PMVI model represented in this research.

Customer Engagement Element

The interaction between the customer and the consultancy is a determining factor in the delivery of a service. The service package of the consultancy is redundant if the synergy between the customer and the consultancy lacking. This element is used as a starting point for the investigation when considering customer retention.

Risk Management Element

The consultancy is burdened with the risks which the customer faces in the outsourced business function. The risks associated with the business function could be the reason for employment or the mitigation of certain risks can be an inherent benefit of the service. The outcomes of the financial element can be indicative of the reduction in financial risk but this element also includes other, non tangible, risks which are crucial to the customer.

Internal Business Processes

The business processes superimposed on those of the customer is a function of the service rendered by the consultancy. The implemented changes should be measured to indicate if it is improving the operational efficiency of the customer and whether the changes are sustainable.

4.4.3 Weighting of Model Perspectives

The weighted contribution of each element towards the PMVI model is determined by using analytical hierarchical process (AHP, see section 2.7.2). This MCDA methodology uses the qualitative input from the industry of application and the relative importance of the elements to the service partnership to obtain weightings for the elements.

Saaty [**87**,**88**] defines the three basic functions of AHP as decomposition, comparative judgments and hierarchic composition. Decomposition is the structuring of a complex problem into a hierarchy of clusters. The problem (leading to the definition of the goal of the system) identified in this research is: "What value is generated through the service partnership between a consultancy and an organisation?" (This is adapted in Chapter 6 to determine the value contributed by the service partnership between Pragma and its customer).

The goal of the PMVI is identified as measuring the value contributed by the service partnership to an organisation (see Figure 30). The elements of the model are the objectives through which this measurement is realised. The KPI's of each element are seen as the clustered subset of the element to which they contribute. The output of the decomposition process is a visual representation of the problem and the contributing factors of the solution (see Figure 30). This is not the traditional use of AHP but Suwignjo [**92**] , Tsenga *et* al [**111**] and Poyhonen and Hamalainen [**112**] all used AHP to develop PMS's where weightings are attributed to KPI's to measure contributed to the ultimate performance.

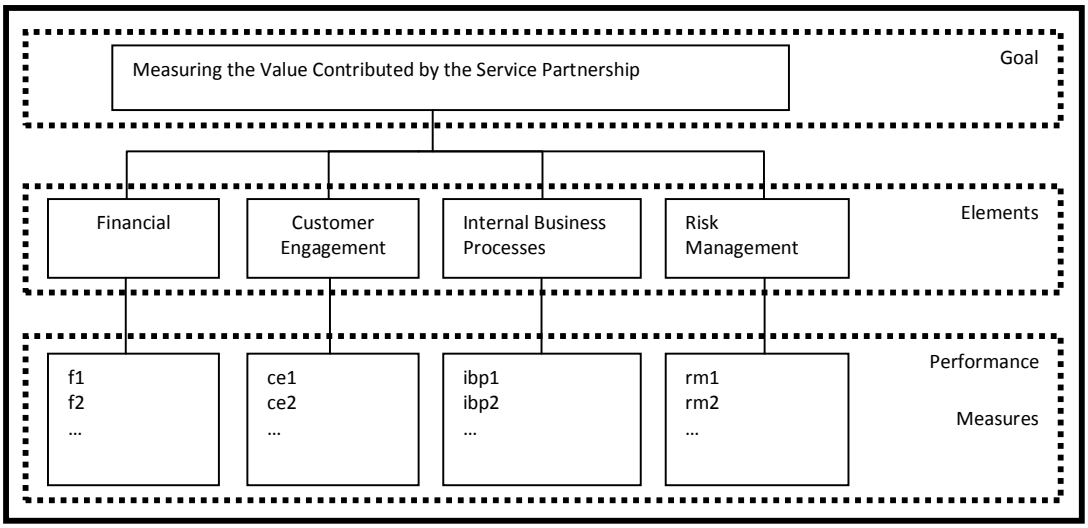


Figure 30 - PMVI Weighting: Decomposed Structure

The next step of AHP is comparative judgments (pairwise comparison). This is where, firstly the elements are compared with reference to the goal and then the KPI's are compared to determine their contribution to the respective elements.

The scale of absolute numbers (see Figure 19 in section 2.7.2) is used as reference for input into the comparative judgment matrix where the relative importance of each contributor of the respective cluster is entered (see Figure 31).

		A	B	C	D	Priority Vector
A	Financial	1				0.25
B	Customer Engagement		1			0.25
C	Risk Management			1		0.25
D	Internal Business Processes				1	0.25

Figure 31 - Comparative Judgment Matrix

The output of this process is the weighted contribution of each individual element towards the PMVI and the contribution of each KPI to their respective element. These values are obtained from the priority vector and are represented as a percentage out of 100% (see Figure 31 for representation of the PMVI elements contribution).

The objectivity of this exercise is measured through the consistency ratio (CR, as discussed in section 2.7.2). If the CR < 0.1, then the person conducting this exercise is consistent in awarding relative importance to the various pairings of elements and if CR > 0.1 the person conducting the exercise is inconsistent and the resulting output cannot be used.

The hierarchical composition function defines the global effects which each contributor (element and KPI) in the AHP framework has on the goal. This is merely the product of the KPI's contribution to the element and the contribution of the element towards the accomplishment of the goal.

The output of this section is a visual representation of the solution of the identified problem and the weighted contribution of each individual element/KPI in their respective cluster.

The following sections stipulate the inputs, outputs, methodology and how the respective elements contribute to the PMVI.

4.4.4 Financial Perspective

The first element of the PMVI model is the financial perspective. The purpose of this element is to measure the financial contribution of the service partnership and to indicate the customer return on investment (CROI) with respect to the rates charged for the services rendered.

The financial element is largely dependent on the nature of the consultancy. The identification of KPI's is a combined effort between the customer and the consultancy and is a function of the depth of penetration and the span of influence (see section 3.4) of the consultancy.

No more than five KPI's should be identified to avoid complexity in the PMVI system but the chosen KPI's (depicted as f1, f2, etc. in Figure 30) should be an accurate reflection of the consultancies service. These KPI's reflects changes in certain areas and these changes can be tracked on the Du Pont's Pyramid of Financial Ratio's (see Figure 11) to determine the effects thereof on the return on investment (ROI).

The measurement of this elements contribution towards the PMVI can be completed in a number of different ways introduced in the following paragraphs.

The cluster can be seen as constituting out of different entities (the KPI's) contributing to a singular purpose (the element). The KPI's, in this scenario, is weighted according to the AHP and each KPI's savings is seen as an individual contribution, resulting in a weighted saving, towards the financial element. The calculation of the financial elements contribution to the PMVI is the sum of the contributions of the individual KPI's.

A second scenario is when the total savings from the combined KPI's is taken and the accumulated value is used to calculate the financial element's weighted contribution towards the PMVI model.

The first scenario necessitates that the cost of service be allocated as a separate KPI contributing to the PMVI whereas the second scenario can discount the costs of service against the savings obtained due to the service rendered.

The second scenario, as used in Chapter 6 & 7, delivers a tangible output for this element (to be used in Chapter 6) which is reflected in the measurement of CROI. This is the improvement of the customers cost structure relative to the cost of the service rendered.

Both of these scenario's presents methods for converting savings into a quantitative output which is used in the PMVI.

It should be noticed that the chosen KPI's must be incorporated into the customers' measurements to ensure accurate outcomes.

4.4.5 Customer Engagement

The second element represented in the PMVI model is the engagement between the personnel of the customer and the consultants allocated to provide the service. The purpose of this section is to convert the qualitative input measurement regarding the synergy of the service partnership into a quantitative output which enables a comparative measurement in the PMVI model.

The objective is to measure the change in the environment of the customer with regard to the consultancies inputs. The successful outcome of this element serves as a driver for customer retention and acquisition. [**62**]

The consultancy must determine a certain set of KPI's through which they are to measure the level of engagement of their personnel (and the service or product they render) at the customer.

The first KPI must measure whether the customer recognise or experience the changes brought about by the service. This typically measures the high-level qualitative feel of the customer with regards to the quantitative outputs of the other PMVI elements.

The second measure is an indication whether the customer is satisfied with the consultants (and the supportive role of the consultancy) entrusted upon them and whether they contribute towards the delivery of the service.

A third KPI measures the customer's satisfaction with reference to the product which is delivered (dependant on the type of consulting service) in addition to the service. The effectiveness and efficiency of the product (and the support thereof) is measured according to the requirements set by the customer and their perception of the obtainment thereof.

The fourth KPI measures the ability of the service organisation to retain their customers. These KPI's serves as an early warning system of wavering customers.

Other industry and organisational specific KPI's should be added (if deemed necessary) but it must contribute to the measurement of the customer engagement.

Each of these KPI's is represented through a set of carefully compiled questions enabling the user to obtain an adequate measurement. The answers to these questions must be deterministic in nature (preferably 1 - 5 or "very bad" to "very good") and the conductor must avoid any open-endedness, since this will complicate the obtainment of a quantitative outcome.

The questionnaire should typically be comprised out of several operational and managerial level questions to ensure that the output is a true representation of the customer satisfaction. The initial measurement process of this element is in the form of a structured interview. This ensures that the customer understands the scope of each of the questions and the applicability thereof. An online or manual survey can be used for the remainder of the period of service and measurement.

The division of questions into KPI's enables the user to conduct both cross-sectional and longitudinal studies. In a cross-sectional study [**113**] one reviews the consultancies performance with reference to a

single KPI over its entire customer. It should be noted that a sample which are representative of the entire population is required in order to make universal conclusions regarding the engagement and satisfaction of the customer valid. The outcome of a cross-sectional study serves as a tool for management to identify problems within specific areas of their service and enables them to take corrective actions.

A longitudinal study [**114**] is the measurement of all of the KPI's at a single customer over time. This enables the conductor to see a change in satisfaction at the customer due to the service rendered.

The outcome of the questionnaire (as a percentage) is used as input of the customer engagement element into the PMVI model. These KPI's are weighted according to the AHP and contributes to the element as a weighted cluster.

4.4.6 Risk Management

The third element of the PMVI element is risk management. The purpose of this element is to measure the extent of influence which the consultancy has on the risks identified by the customer as being inherent to the outsourced business function.

The initial strategic process of obtaining the services of a consultancy to improve a business function of the organisation is an indication that the organisation deems the services of the consultancy as a mitigating factor for a specific set of risks. The type of risks is a function of the nature of the business and the industry within which the customer operate.

The consultancy is not part of the initial identification and mitigation planning of the risks as this is the reason for employment. They are, however, well aware of the type of risks which their services mitigate within different industries of application.

This brings us to the first step of the risk management element. This is the consolidation of risks which can be mitigated as a consequence of the service partnership. This is followed by a determination of the exposure of the customer to these risks. Once this is completed, the probability and impact of occurrence of these risks is to be calculated.

The impact is determined by subjecting the risk to a scale of impact (dependant on its nature, see Figure 32 - Risk Impact Calculation Chart) as determined by the customer. This scale must relate the impact to a fundamental scale of between 0-1 which enables the comparison of risks of a different nature. An

impact of 0 indicates that there is no risk present and 1 indicates that the customer would suffer severe consequences if the event (represented by the risk) should occur.

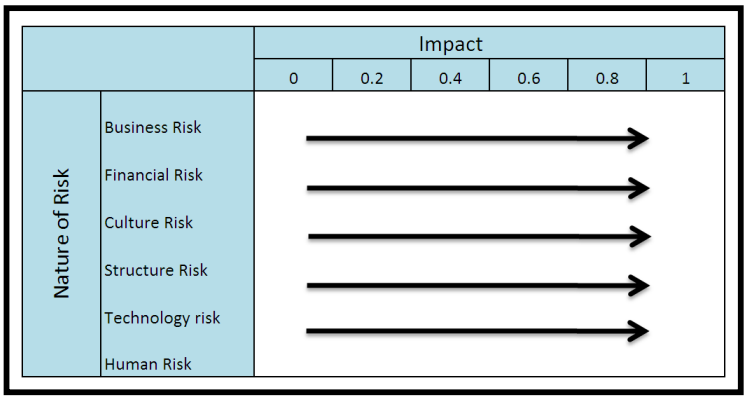


Figure 32 - Risk Impact Calculation Chart

The probability of occurrence can be calculated in one of two ways. The first is using analytic simulation techniques (Monte Carlo) to model the probabilities. The second method relies on the experience of the people involved in the process of risk management. The output of a series of brainstorming sessions and/or a Delphi analysis is used as input into the probability of the respective risks.

The severity (or criticality) of the risks (as plotted on a probability-impact matrix) are calculated as:

$$\boldsymbol{Severity = Probability\ x\ Impact} \qquad \text{...Equation 8}$$

This concludes the initial process of risk management prior to the initiation of the service of the consultancy. The continuous monitoring and improvement (or sustainment) of the risks over the time of service indicates the value being added as a function of the service partnership. The migration of severities (see Figure 33) indicates that value is being added.

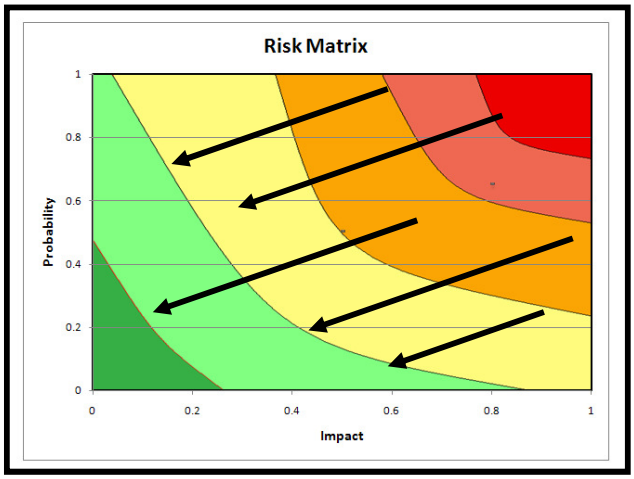


Figure 33 - Risk Management: Criticality Migration

The input of this element into the PMVI is a function of the attainment of the target reduction in severity. The SLA between the parties is revised on a periodical basis to update the targets of risk reduction.

4.4.7 Internal Business Processes

The fourth element contributing to the PMVI model is internal business processes. The purpose of this element is for the consultancy to indicate the degree of improvement in the business processes of the customer as consequence of their service.

The customer employs the consultancy as part of an effort to improve the functionality of a specific business function. The consultancy, on the other hand, has a specific set of standards and methodologies which it deploys at the customer which improves business processes and eliminates waste.

The consultancy instates their own KPI's which measures the effectiveness and efficiency of their service within their customers' organisation. The type, generic nature and extent of KPI's used are a function of the span of service and the depth of penetration as well as the nature of the consultancy. The measurement of internal business processes is a measure of the performance which the consultancy superimposes on the existing business processes of the customer.

The imposed change is a function of a variety of measures but those KPI's (no more than five) representing the essence of the service should be measured to attain a input for this element into the PMVI model.

The KPI's is weighted to determine their contribution to the PMVI model. A periodical measurement of these KPI's provides the necessary input required to obtain a value for the output of this element.

The improvement of internal business processes is a function of the attainment of targets set in the definition of the service.

4.5 Types of Measurement Techniques

The output of each element is weighted and in the measurement thereof one has to obtain a single value which represents the elements contribution to the PMVI. There are a number of different ways to calculate this contribution and the following two methods (see Figure 34) is proposed if an absolute measurement cannot be obtained:

- delta measurement – this method only uses the values from the previous and current period. The value obtained in the current period is measured against a target set with reference to the previous period. This type of measurement encourages an environment of continuous improvement; and
- baseline measurement – an initial measurement provides the user with a point of reference for future measurements. The periodical target setting serves as a definition of the range on which the KPI is measured (percentage attainment with reference of the initial measurement). This type of measurement encourages an environment of sustainability.

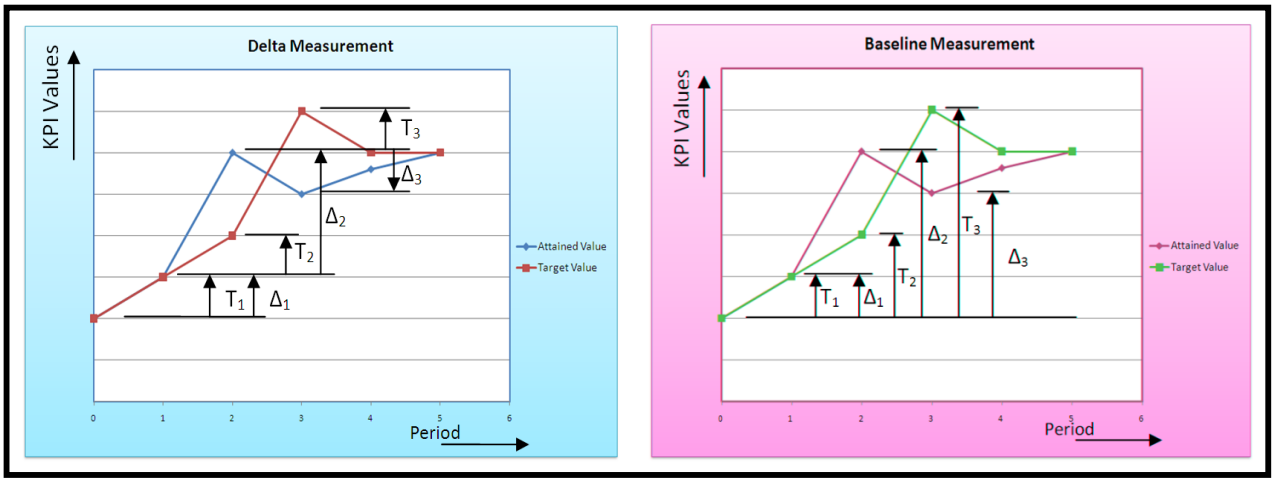


Figure 34 - Delta and Baseline Measurements

The targets in either case can be static (in which a benchmark value is used to indicate industry standards) or dynamic where a culture of continuous improvement is nurtured.

The percentage attainment of the element is calculated according to the delta and baseline methodologies and contributes to the PMVI accordingly.

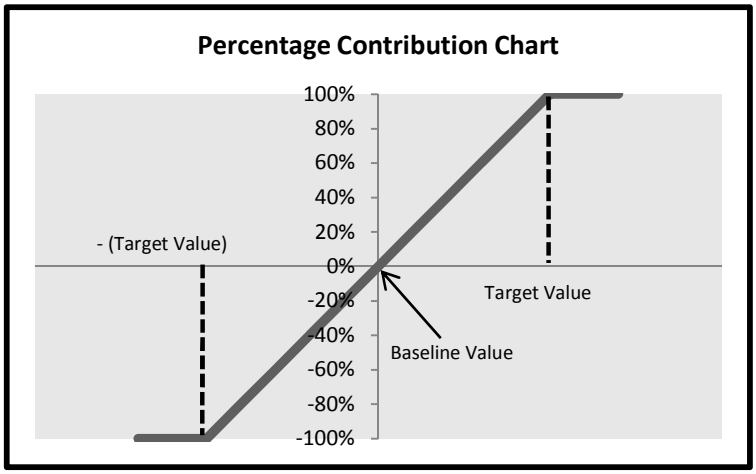


Figure 35 - Weighted Contribution Chart

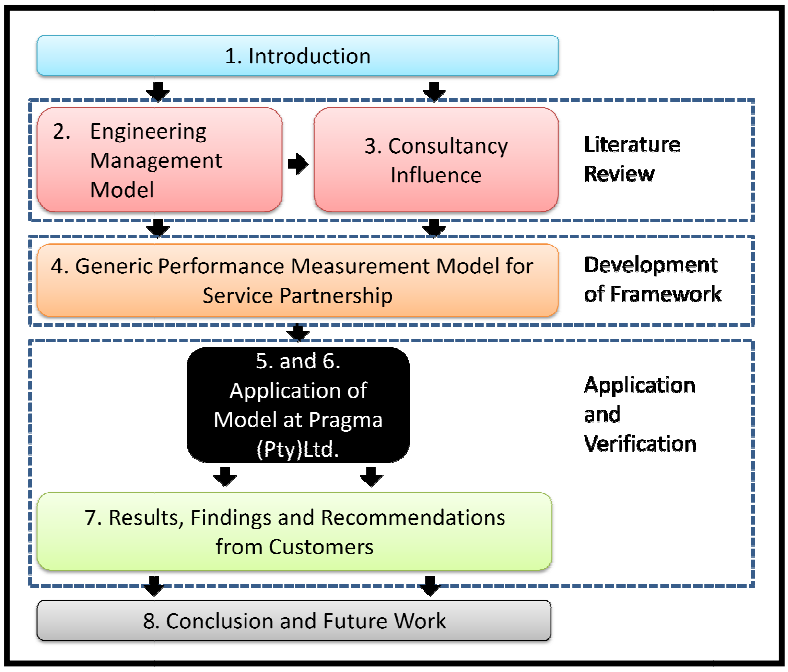
The baseline value (0%), in Figure 35, can be either the initial pre-service value or the value at the beginning of each period with its respective target (100%). The percentage attainment is the value obtained on this newly defined array which ranges from an extreme minimum (contributing -100% of elements weighting) to the target value (contributing 100% of elements weighting).

4.6 Chapter Conclusion

This chapter provides the reader with a broad definition of the PMVI model created to measure a service partnerships' value. The elements, their weighting and the establishment of measurement techniques are defined to enable the user to develop a PMVI model for a given situation.

The next chapter defines the industry of application in this thesis and Chapter 6 uses this generically defined PMVI model to develop the asset management value index (AMVI).

5 Pragma (Pty) Ltd.



The research on fundamentals (Chapter 2: Fundamentals) sought for the development of an EMM. This model illustrates the improvement (and sustainment) life cycle of an organisation in order to obtain and sustain a competitive advantage.

The chapter thereafter (Chapter 3: Setting the Scene) illustrates the effects of the strategy to focus on core competencies and to outsource a business function to a consultancy. This strategy is reflected in the performance of the organisation and the required targets to ensure that a mutually beneficial relationship is established.

The next chapter develops the performance measurement value index (PMVI, Chapter 4: Performance Measurement Model for the Consulting Industry). The PMVI is a generic performance measurement model which measures the value added through the service partnership and thus provides a true reflection of the contribution of the consultancy to the customer.

This chapter defines the service organisation (Pragma) on whom this study was conducted. This involves the application of the model on them and their customers to measure the value added through their service.

Objective:

- *provide a brief insight into Pragma (the industry of applications); and*
- *define their services, products as well as the ACC service and the AMIP methodology.*

5.1 Company Background

Pragma was initially found as a South African Maintenance Management Consultancy in the early 90's by four entrepreneurs. The name Pragma originated from the word "Pragmatic" which stands for "*dealing with matters with regard to their practical requirements or consequences*".

The organisation as it is known today, Pragma (Pty) Ltd., only officially started doing business on the 1st of April 1996. The initial service included the use of an in-house developed Enterprise Asset Management System, called On-Key, and an associated consulting service. ON KEY grew into a stronger, more focused product in the late 90's and development is currently underway of its fifth version.

In the early parts of the 21st century, Pragma evolved into three separate entities. These organisations are:

Pragma Holdings

- a holding entity which consists of two operating organisations, which are Pragma Africa and Pragma Products,
- responsible for the internal services of all Pragma employees, such as finances, administration, office support staff, corporate communications, information technology and the management of the Pragma group.

Pragma Africa

- that part of the organisation which delivers the Asset Care Centre (ACC) service to the various customers in Africa;
- jointly owned by a Black Economical Empowerment (BEE) organisation called Ukhamba Holdings (making the organisation BEE compliant);
- different fields of operation within the petrochemical, manufacturing and utilities and facilities environments;
- involved in the Pragma Academy (an asset management training facility);
- headquarters in Johannesburg with regional offices in Cape Town, Durban and Port Elizabeth.

Pragma Products

- responsible for the packaging of the PAM service solution and concurrently improving its processes;
- aligning Pragma's service with its global strategy and thus ensuring correlation between the services rendered and the methodologies developed for use.

These organisations operate as separate business entities, but they all align to the Pragma vision: "*For the world to manage physical assets the Pragma Way*".

The founders of Pragma saw it fit to establish a Pragma Property Trust. This trust is the board of directors who is responsible for the strategic decision making process.

In late 2005 Pragma Products became a value added re-seller to a Brazilian organisation called PCM. Further negotiations lead to a partnership agreement between Pragma and PCM.

The year 2007 saw a new change of pace when Pragma Holdings acquired a major stake in the operation of PCM. This in turn led to the founding of Pragma Brazil which was a beneficial transaction for both parties. PCM is now associated with a larger enterprise and enjoys the security of an already successful organisation and Pragma, on the other hand, took its first step towards its vision of globalisation and increasing their "footprint".

Today Pragma is a market leader in PAM and employs approximately 250 personnel. Its turnover grew with almost 400% in the last four years and with such a positive growth curve one can only imagine what will happen in the next decade.

5.2 Products and Services

Pragma developed their first version of ON KEY, a Computerised Maintenance Management System (CMMS), in 1993. The fifth version, as mentioned in section 5.1, is currently under development and is to be released in 2010.

This software delivers a multitude of functions to the customer enabling them to effectively and efficiently maintain their assets and improve the performance of these assets. ON KEY constitutes the software part of the ACC service which Pragma renders to its customers. There are three variations of this service which are:

ACC@Client

An asset care engineer (AC Engineer), from Pragma, is permanently on-site and coordinates asset care needs and the asset management improvement planning on a real-time basis.

The duties of the AC Engineer include:

- maintaining a up-to-date Asset Register;
- managing the PAM business processes; and
- managing work execution to service requirements.

ACC@Pragma

The service associated with the ACC@Pragma incorporates the asset care needs and planning of the customer but on an ad-hoc basis. The time and resources of the AC Engineer is divided between several customers and he only conducts site visits on a weekly, bi-weekly or monthly routine. This type of service is not as comprehensive as that of the ACC@Client and consequently provides a lower level of income to Pragma.

Pragma Shell

The Shell application of an ACC is unique in the sense that it delivers a hands-on approach to PAM. Pragma operates a call centre which services the operational division of Shell. A number of AC Engineers are on-site as in the case of ACC@Client and they receive real-time information from both the call centre, as well as Shell employees in order to facilitate the asset management process.

These are the types of services which Pragma render to its customers. The tendency is to move away from ACC@Pragma and more to ACC@Client as this is a more comprehensive service and would ultimately increase revenue.

As stated in the company background, Pragma is currently packaging their service in order to empower their international affiliates to deliver the same service of the same quality. Part of this process is the development of the business processes associated with the ACC service. These business processes currently include:

5.2.1 Asset Management Improvement Plan

Pragma's asset management improvement plan (AMiP) serves as the foundation of ACC service. The goal of AMIP is to determine the "maturity" and growth of a client's PAM business function.

This methodology includes 17 key performance areas (KPA, referred to as performance in Figure 36) each of which consisting of several best practices (referred to as practices in Figure 36) to which the PAM business function of the customer is subjected. The best practices are a measurement of the internal business processes of the customer and the KPA's is the correlating change in performance due to this change.

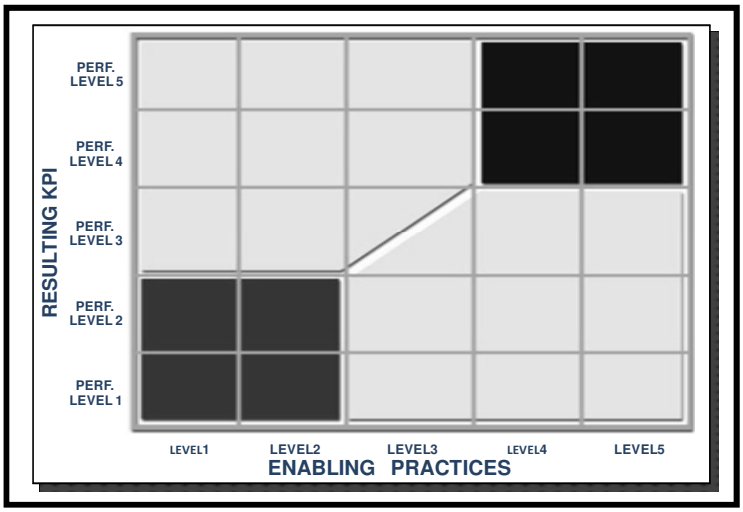


Figure 36 - Performance vs. Practice, adopted from Botha [115]

These two parameters are measured on a numerical scale from 1 to 5 (dependant on the current state of the customer). The range of the measurements are from a stage 1 (fire fighting), meaning that the function is not behaving desirably; to a stage 5 (optimising) where that business function could not be further improved.

The zero state maturity of the customer is determined at the initiation of service and a periodical measurement indicates change in the PAM business function due to the ACC service.

5.2.2 ACC Framework

The ACC Framework includes all of the business processes which fulfil the master data requirements of the downstream processes, such as Work, Planning and Control, Asset Register Administration (ARA) and Asset Identification and Verification.

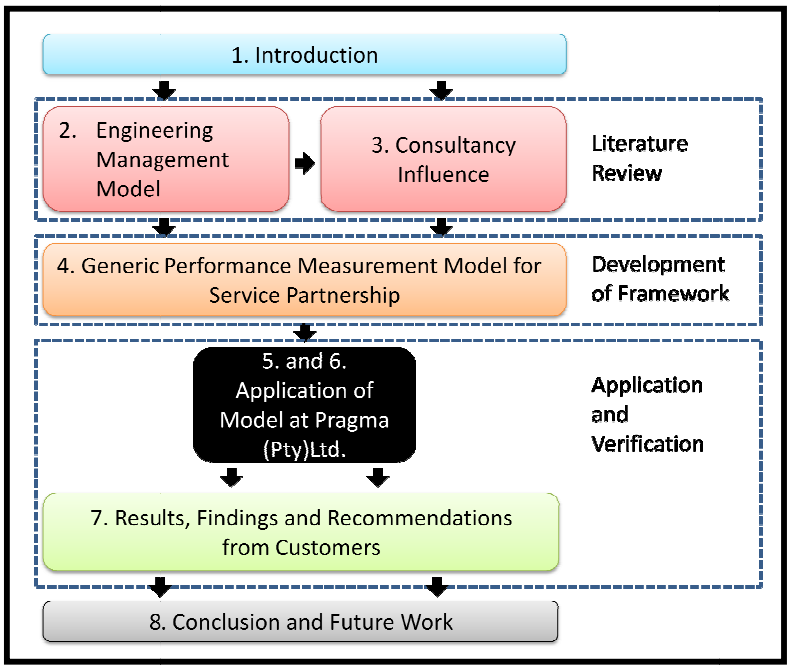
5.3 Chapter Conclusion

This brief introduction into the business, products and services of Pragma supplies the reader with sufficient background of the industry to which the PMVI model is applied in the following chapter.

6 Application of Model

"All meanings, we know, depend on the key of interpretation"

- George Eliot (1819 – 1880)



The previous chapters in this document outlined the literature and approach to develop the PMVI model and thus obtaining a measurement of the value that a consultancy adds to the specific business function of a customer.

The research on fundamentals (Chapter 2: Fundamentals) sought for the development of an EMM. This model illustrates the improvement (and sustainment) life cycle of an organisation in order to obtain and sustain a competitive advantage.

The chapter thereafter (Chapter 3: Setting the Scene) illustrates the effects of the strategy to focus on core competencies and to outsource a business function to a consultancy. This strategy is reflected in the performance of the organisation and the required targets to ensure that a mutually beneficial relationship is established.

The next chapter develops the performance measurement value index (PMVI, Chapter 4: Performance Measurement Model for the Consulting Industry). The PMVI is a generic performance measurement

model which measures the value added through the service partnership and thus provides a true reflection of the contribution of the consultancy to the customer.

The application of the model requires a definition of the industry in question (Chapter 5: Pragma (Pty) ltd.) and their respective services and products.

This chapter applies the PMVI model to the asset management industry, hence the renaming to the Asset Management Value Index (AMVI), to measure the value created through the partnership between the ACC of Pragma and their customers.

Objectives

- *defining the AMVI and indicating the specific solution with regards to the PMVI;*
- *weighting the elements of the AMVI;*
- *defining the elements of the AMVI and their respective KPI's, contribution measurements and logic; and*
- *investigate the rigor of the model at the hands of a sensitivity analysis.*

6.1 Asset Management Value Index

The PMVI, as defined in Chapter 4, is a generic model which is applied to a specific industry or service provider, in this instance the PAM environment, for the measurement of performance.

The AMVI is a model which measures the improvement of a customer's physical asset related performance due to the influence of a consultancy in this industry over time. An increase (or incline) in the AMVI is indicative of growth (or sustainability) in the customer's PAM business function and a decrease in the AMVI indicates a deterioration of value.

The concept of a VI has been defined in Chapter 4 and it has been indicated that a relative scale must be defined to substantiate the measurement process. It is for this reason that the maximum relative value of the AMVI is selected to be ten and the weighted contributions of the elements is awarded accordingly (see Figure 37).

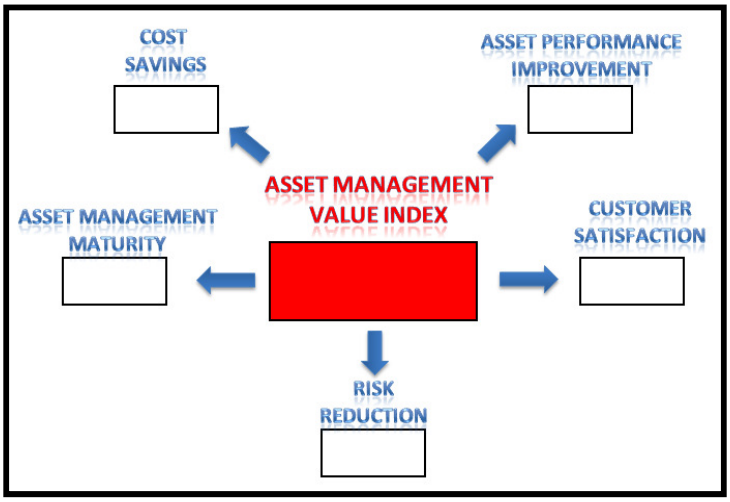


Figure 37 - Asset Management Value Index

The following sections define the elements of the AMVI as well as the reasoning and calculation of contributions.

6.1.1 Asset Management Value Index: Elements

The elements, as defined in the generic PMVI, are adapted to the environment and industry of application. The following changes in names correspond with the adoption of the PMVI model to become the AMVI model (see Figure 37):

- Financial → Cost Reduction and Asset Performance Improvement (to be explained);
- Customer Engagement → Customer Satisfaction;
- Risk Management → Risk Reduction; and
- Internal Business Processes → Asset Management Maturity.

The financial element is divided into cost reduction and asset performance improvement. This is attributed to the diversity and non-conformity with regards to the definition of physical asset related performance and the extent of its impact on associated costs.

6.1.2 Asset Management Value Index: Element Weighting

The weighting of the respective elements of the AMVI is completed according to the method described in section 4.4.3.

The values used in the pairwise comparison are obtained through the experience of senior management. The model was briefly explained and the required inputs of this AHP model stipulated. This is followed by a brainstorming session to establish a broad understanding of the importance of each element to the different departments. A Delphi questionnaire, used to gain an average consensus amongst the individuals, concluded the collection of the required data for the weighting process. The outcome of this exercise is fairly consistent and serves as weightings of the respective elements in the AMVI model (see Figure 38).

Pairwise Comparison Judgement Matrix

		A	B	C	D	E	Priority Vector
A	Cost Savings	1	2.5	5.5	3	2	0.40
B	Asset Performance Improvement	0.4	1	3	3	3	0.26
C	Customer Satisfaction	0.182	0.333	1	3	1.4	0.13
D	Risk Reduction	0.333	0.333	0.333	1	0.5	0.08
E	Asset Management Maturity	0.5	0.333	0.714	2	1	0.13

Confidence Ratio =	0.09

Figure 38 - AMVI Weighted Contributions

The decision is made to keep the weights of the elements constant across all of the consultancy's customers since this creates a basis for comparison between different types of applications (cross-sectional studies).

The outcome of the weighting process represents the input of each individual element in to the AMVI model and is as follows: (see Figure 38)

- cost reduction - 40%;
- asset performance improvement - 26%;
- customer satisfaction - 13%;
- risk reduction - 8%; and
- asset management maturity - 13%.

These values are instrumental in the calculations of the following sections.

6.1.3 Asset Management Value Index: Cost Reduction

The first element of the AMVI represents of the financial savings which the customer incurs due to the service of the PAM consultancy. The identification of no more than five KPI's is allowed to define the

core savings of the customer but the client specific savings would only be used in isolated circumstances and is not defined as a standard KPI. The savings of the customer represented through these KPI's is measured relative to the cost of service which then delivers the CROI as an output.

Inputs

The following KPI's are identified to measure the financial savings:

- Fixed Labour Costs;
- Contractor Costs;
- Overtime Costs;
- Spares Cost;
- Working Capital Costs; and
- Client Specific Savings.

The periodical values of the respective KPI's are entered into the cost table (see Figure 39) which enables a comparison of values relative to time.

Financial & Performance Index - Input

	Cost of PRAGMA Service	Availability	Maintenance Costs	Fixed Labour Costs	Contractors Costs	Overtime Costs	Spares Costs	Capital Investment in Spares Inventory	Costs of Working Capital	Savings: Client Specific	Comments
Baseline											
Jan-00											
Feb-00											
Mar-00											
Apr-00											
May-00											
Jun-00											
Jul-00											
Aug-00											
Sep-00											
Oct-00											
Nov-00											
Dec-00											
Jan-01											
Feb-01											
Mar-01											
Apr-01											
May-01											
Jun-01											
Jul-01											
Aug-01											
Sep-01											
Oct-01											
Nov-01											
Dec-01											
Jan-02											
Feb-02											
Mar-02											
Apr-02											
May-02											
Jun-02											
Jul-02											
Aug-02											
Sep-02											
Oct-02											
Nov-02											
Dec-02											

Figure 39 - Financial and Performance Elements - Input

Any form of additional savings incurred at a customer must be entered into the "Client Specific Savings" column. These values are incorporated in the calculation of this element and the recurrence of a specific saving can be instated as a KPI for that specific customer.

Formula's and Logic

The calculation of this element's weighted contribution to the AMVI model can be broken down into six distinctive steps. The first step is the calculation of maintenance costs (see Equation 9).

$$\boldsymbol{Maintenance\ Cost = Fixed\ Labour\ Costs + Contractor\ Costs + Overtime\ Costs + Spares\ Costs} \quad \text{...Equation 9}$$

Secondly, the cost of working capital is calculated. These are all of the costs associated with the capital investment required for maintenance purposes (for example, the holding costs associated with maintenance spares). This amount is approximated to be between 20% - 40% of the required annual investment [**116**](see Equation 10) and, for the purpose of this model, the average value of 30% is used.

$$\boldsymbol{Costs\ of\ Working\ Capital = Investment\ in\ Working\ Capital\ x\ 30\%} \quad \text{...Equation 10}$$

The third of the six calculations is the cost of the service to the customer (see Equation 11). The value which the service adds is a function of the additional cost premium a customer incur on PAM due to the services of the consultancy in contrast with the costs which they would have incurred in the absence of the service rendered. The consultancy is only responsible for an improvement which is equal to the "*value-adding premium*" which they charge for their service. This rests on the assumption that the customer would remain at a constant rate of performance in the absence of the consultancy.

$$\boldsymbol{True\ Cost\ of\ Consultancies\ Service = Cost\ of\ Service\ to\ Customer\ x\ 30\%} \quad \text{...Equation 11}$$

CROI is the parameter, calculated according to the incremental delta method (see section 4.5), used to reflect the weighted change in the cost reduction element of the AMVI and it is a function of the savings in costs which the customer incur over a period of time and the true costs associated with these savings (see Equation 12 and Figure 40).

$$\boldsymbol{CROI = \frac{Maintenance\ Cost, Costs\ of\ Working\ Capital_{(t_{n-1}-t_n)} + Customer\ Specific\ Savings_{(t_n)}}{True\ Cost\ of\ Consultancies\ Service_{t_n}}} \quad \text{...Equation 12}$$

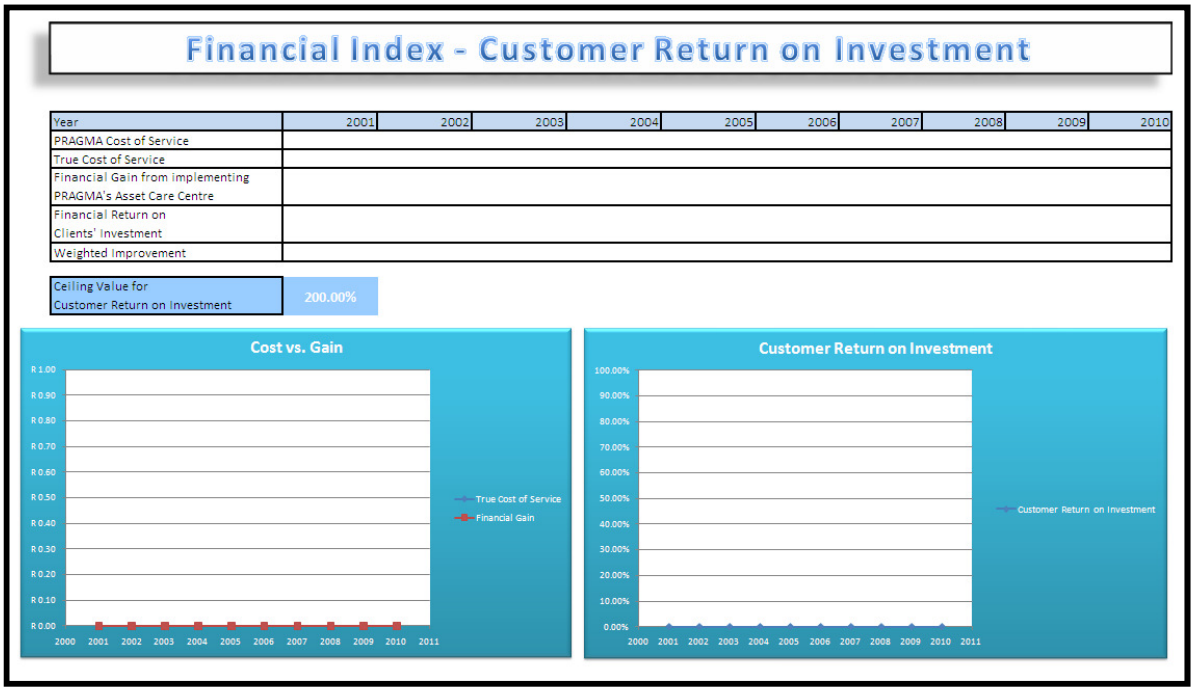


Figure 40 - Customer Return on Investment

CROI represents the percentage return on investment which the customer receives as a function of the "*value adding premium*" of the consultancies service.

A CROI value larger than 100% indicates that the consultancies service is delivering positive growth in the savings which the customer enjoys (see Figure 40). A CROI value smaller than 100% indicates a deterioration in value added to the customer and the "*value adding premium*" is not sufficiently covered in savings. A negative CROI indicates that PAM as an expenditure of the customer has grown and that the consultancies service is not beneficial to the customer.

It must be noted that inflation, leading to an escalation in the costs of the PAM activities of the customer is accounted for in the calculation of the periods cost of service and is for this reason not included in the calculation of the CROI.

The final step in this element is the conversion of the CROI to a quantitative value which is used as input for the AMVI model (see Equation 13). The calculation is a function of the weight (from section 6.1.2) and the CROI (see Equation 12).

$$\boldsymbol{AMVI(cost\ reduction)} = \boldsymbol{Customer Return\ on\ Investment\ x\ Weighted\ Score} \quad \text{...Equation 13}$$

A maximum value is required against which the contribution of the element can be measured, albeit a benchmark. This serves as motivation for the instatement of a "*ceiling value*" which would automatically be award a weighted contribution of 100% to the cost reduction element (40%) of the AMVI model if an equal or larger CROI is achieved. This value is set at a fixed CROI value of 200% (see Figure 40).

The opposite, of the statement above, is true and if the consultancy's service delivers a CROI of -200% an amount of -100% of this element's weighted contribution is reflected in the AMVI (see Figure 35 in section 4.5 for a visual representation of this logic).

6.1.4 Asset Management Value Index: Asset Performance Improvement

Asset performance improvement is the second element of the AMVI model. The purpose of this element is to measure the availability of the assets of the customer relative to a benchmark. The outcome is a measurement of the improvement or sustainability of the availability of the customer's assets.

Inputs

The inputs of the asset performance improvement element include:

- initial availability/baseline availability (see Figure 39);
- periodical measurement of availability (see Figure 41); and
- target value of availability (see Figure 41).

The baseline availability is the measure taken prior to the initiation of the consultancies service. The continuous periodical measurements and corresponding targets of availability is used as input for this element (Figure 39 & 41).

Formula's and Logic

This element is measured according to the baseline methodology (see section 4.5) but with a slight variation on the traditional methodology. This can be attributed to the variable value which the target value can adopt. The allowance for this is made due to factors such as a change in capacity or planned downtime.

This element has four scenarios in which the calculation of the weighted contribution of the element differs.

The first scenario is when the actual measured availability is higher than the baseline value but lower than the target value (see Equation 14). The calculation of the percentage attainment of this element is completed according to the baseline methodology (see section 4.5). The percentage attainment is thus a function of the range between the baseline and target availabilities (see Equation 14).

if baseline < availability < target **or** extreme minimum < availability < baseline,

$$\boldsymbol{Asset\ Performance}_{\%\ attained} = \left[\frac{Availability_{achieved} - Availability_{baseline}}{Availability_{target} - Availability_{baseline}}\right] \quad \text{...Equation 14}$$

The second scenario, represented by Equation 14, is when the availability is less than the baseline value. The target value (now the extreme minimum) is inversed around the baseline value and is the same distance (between the baseline and the initial target value) from the baseline value but on the negative axis (see Figure 42). This results in an area between the baseline value and the extreme minimum value on which the obtained availability is distributed. The outcome of this scenario is a negative percentage attainment due to the decline in availability from its initial state.

The third scenario, represented in Equation 15, occurs when the availability is lower than the extreme minimum (see Figure 42).

if availability < extreme minimum,

$$\boldsymbol{Asset\ Performance}_{\%\ attained} = -\mathbf{100}\% \quad \text{...Equation 15}$$

A value of -100% is attributed to the percentage attained and this in turn reflects on this elements contribution to the AMVI model.

The fourth scenario is when the attained availability is larger than both the target and baseline values.

if availability > target > baseline:

$$\boldsymbol{Asset\ Performance}_{\%\ attained} = \mathbf{100}\% \quad \text{...Equation 16}$$

This result in a 100% weighted contribution to the AMVI model (see Equation 16 and Figure 42).

Figure 41 - Asset Performance Improvement

The contribution of this element to the AMVI model is a function of the percentage attainment (from Equations 14 – 16) and the weight assigned to it (see Equation 17).

$$\boldsymbol{AMVI(asset\ performance)} =$$

$$\boldsymbol{Asset\ Performance_{\%\ attained}\ x\ Weighted\ Score} \qquad \text{...Equation 17}$$

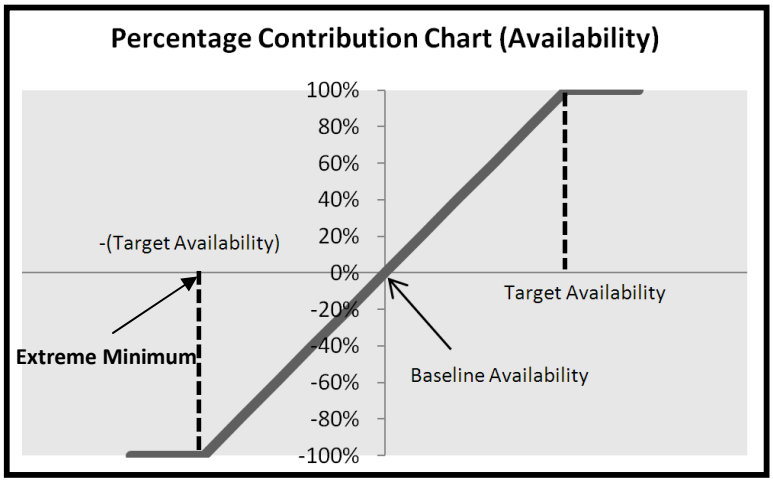


Figure 42 - AMVI: Availability Weighted Contribution

This method of measurement rewards the consultancies service for a sustained level of availability due to the adjustable target values.

6.1.5 Asset Management Value Index: Customer Satisfaction

Customer satisfaction is the third element of the AMVI model. The purpose of this element is to highlight the satisfaction of the customer with respect to the tangible and intangible aspects of the consultancy's service and it should reflect the results obtained from the other four elements.

Inputs

The input of this element is the completion of a 25 question survey. The answers of the customer is confined to "Strongly Disagree", "Disagree", "Agree", "Strongly Agree" or "N/A" and is marked with an "x". The "N/A" is primarily for a customer which uses software other than ON KEY.

The survey can be conducted in one of two ways. First is the manual completion of the survey. This process requires that the consultant (or manager) participate in the answering of the questionnaire (in an informative manner) and enter the outcome thereof into the database. The second technique is to use software to distribute and complete the survey. The consultancy of concern has already acquired software of this nature (Survey Monkey) to conduct various online surveys in an anonymous manner. This requires that the participating customers' e-mail addresses must be entered and the survey is completed anonymously. This software enables the user to focus the specific results and filter the outcome into a variety of scenarios.

Formula's and Logic

The 25 questions of the questionnaire are broken down into a set of 10 management level and 15 operational level questions. The consultant identifies the respective personnel required to answer the questionnaire and, on a periodical basis, ensure that the answered questionnaire is entered into the database.

The set of 25 questions is spread across four KPI's (as recommended in the PMVI, Chapter 4) to reflect the value which our customers perceive. The four aspects measured in the survey are:

- people and capabilities - measurement of the effectiveness of the consultancies personnel assigned to the customer;

- business processes and best practices – measurement of the perceived improvement of the customers business processes and the implementation of best practices;
- tools and technology- measurement of ON KEY and its functionalities; and
- performance and results – measurement of the customer's satisfaction with respect to the other elements of the AMVI model as well as consultancies service as a whole.

The completion of the survey does not allow for a neutral answer and forces the customer to be decisive in its answering by neglecting a neutral answer. The "N/A" excludes that specific question and/or section from the survey and does not take it into account when calculating the overall satisfaction of the customer.

The outcome of each individual KPI contributes to the final outcome of this element in a weighted manner. The weights for the KPI's are equal in this scenario and the outcome of this is that an average of the KPI's is used as outcome (see Figure 43).

Customer Satisfaction - Score

Area of Influence	Key Performance Indicators	%
People and Capabilities	% of Satisfaction with ACC Team and Pragma	0.00
Business Processes and Best Practices	% Satisfaction with the PRAGMA Business Processes	0.00
Tools and Technology	% Satisfaction with Pragma's Tools and Technology	0.00
Performance and Results	% Satisfaction with Pragma's ACC Service	0.00
	Total Weighted Average of Customer Satisfaction	**0.00%**

Figure 43 - Customer Satisfaction - Output

The nature of measurement of this element distinguishes it from the rest of the elements in the AMVI (either delta or baseline methods). The percentage satisfaction (0% - 100%) is used

directly as an input into the AMVI model (see Equation 18) according to its weight. The result of this is that the element's contribution cannot be negative.

$$\boldsymbol{AMVI(Customer\ Satisfaction) = Survey\ Outcome_{percentage}\ x\ Weighted\ Score} \quad \text{...Equation 18}$$

The outcome of this element helps the consultancy to identify aspects of their service which require attention and areas in which they excel. A decline in the AMVI should be reflected by a decline in the customer satisfaction and this could ultimately lead to a negative AMVI value.

6.1.6 Asset Management Value Index: Risk Reduction

Risk reduction is the fourth element of the AMVI model. The purpose of this element is to determine the effects of the consultancies service on the respective risks associated with the customer's physical assets. The outcome of this element is an indication of the extent to which the consultancy aids the customer in the mitigation of the identified risks.

Inputs

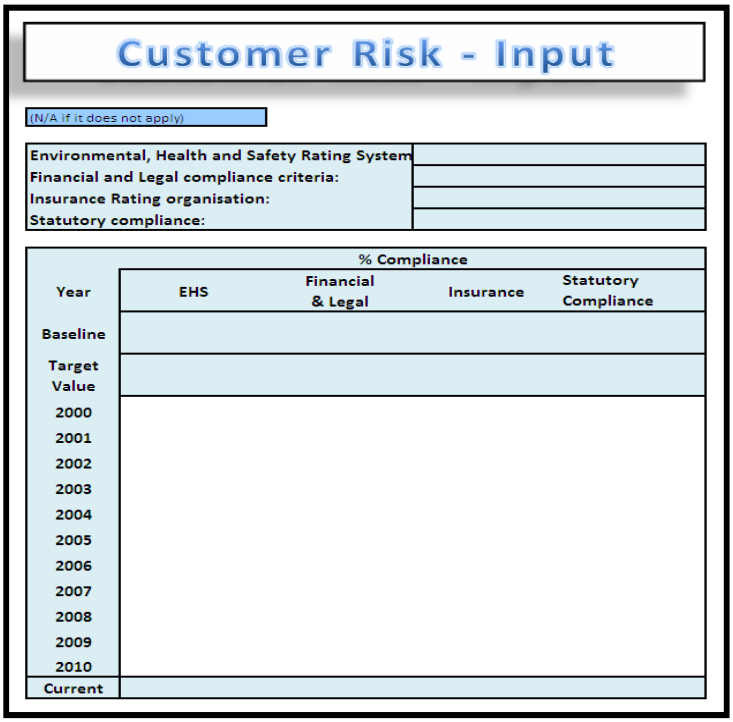
The risks identified within the consultancies environment (as seen at the top of Figure 44) are the following:

- safety, health and environment (SHE);
- financial and legal compliance;
- insurance; and
- statutory compliance.

The consultant must identify the measurements of the customer associated with the respective risks. The system or standards used to assess the compliance of the customer to the associated risk must be identified and entered on the input sheet (see Figure 44).

The customer may not be affected by the risks which the consultancy mitigates as a function of its service. This implies that there is no measurement for that specific risk and a "N/A" must be entered into the systems or standards field of the input sheet. The consequence of this is the exclusion of this risk from the calculation of the elements weighted contribution to the AMVI model.

The risk reduction element's contribution to the AMVI model is calculated according to the baseline methodology (see section 4.5) and the initial risk compliance of the customer (prior to the consultancy's service) is used as the baseline value from which the improvement (or deterioration) of value with regard to the specific risk can be tracked.



Customer Risk - Input

(N/A if it does not apply)

Environmental, Health and Safety Rating System	
Financial and Legal compliance criteria:	
Insurance Rating organisation:	
Statutory compliance:	

Year	% Compliance			
	EHS	Financial & Legal	Insurance	Statutory Compliance
Baseline				
Target Value				
2000				
2001				
2002				
2003				
2004				
2005				
2006				
2007				
2008				
2009				
2010				
Current				

Figure 44 - Risk Reduction - Input

The service partnership decides on an appropriate target (a benchmark) for the compliance of the respective risks at the beginning of the service period and the attainment of this target is measured accordingly.

Formula's and Logic

The calculation of the weighted average risk reduction occurs in two distinctive steps. The first step is the calculation of the percentage attainment of each individual risk. This value is a function of four different scenarios, represented in Equations 19, 20 and 21.

if baseline < achieved < target **or** extreme minimum < achieved < baseline,

$$\boldsymbol{Risk\ Reduction}_{individual\ in\ \%} = \frac{Compliance_{Achieved} - Compliance_{Baseline}}{Compliance_{Benchmark} - Compliance_{Baseline}} \quad \text{...Equation 19}$$

The calculation of these two scenarios is similar to that of Equation 14 but the availability is substituted with level of compliance of the risks. In Equation 19, the baseline value is set to be 0% and the target is set to 100% and the area between these values is a linearly distributed range (similar to Equation 14 and Figure 42). The percentage compliance of the risk corresponds with the associated value on the defined range.

Equation 19 represents another scenario where the compliance of the risk is worse than when the service was commenced. The outcome of this scenario is a negative contribution of the individual risk to the overall risk reduction element.

If baseline < target < achieved,

$$\boldsymbol{Risk\ Reduction_{individual\ in\ \%}} = \mathbf{100}\% \qquad \text{...Equation 20}$$

Equation 20 indicates that an achieved value which is larger than the target value automatically results in a maximum (100%) contribution towards the weighted score of the element (see Figure 45).

If achieved < extreme minimum,

$$\boldsymbol{Risk\ Reduction_{individual\ in\ \%}} = -\mathbf{100}\% \qquad \text{...Equation 21}$$

Equation 21 recognises that there is an extreme minimum value to which the element is subjected. The minimum attainable percentage (-100%) is automatically attributed to this element if a value equal or smaller than the extreme minimum is obtained and the effects of this is reflected on the AMVI model.

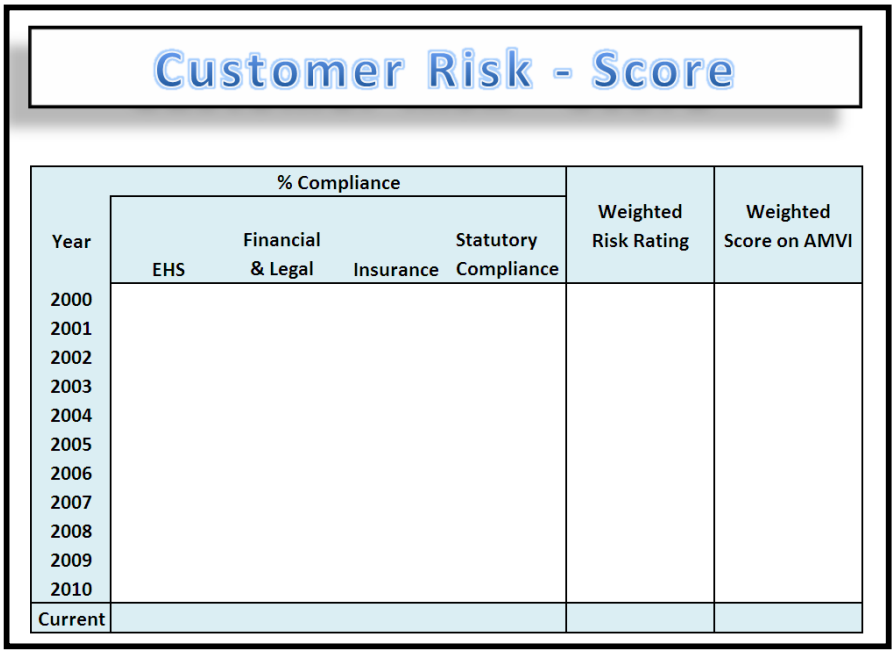


Figure 45 - Risk Reduction - Output

The second step in the process is to calculate the weighted contribution of this element towards the AMVI model. This includes the calculation of the average percentage compliance of the combined risk portfolio and the weighting of the obtained result (see Equation 22).

$$\boldsymbol{AMVI(Risk\ Reduction)} =$$

$$\boldsymbol{Total\ Compliance_{average\ of\ individual\ risks}\ x\ Weighted\ Contribution} \quad \text{...Equation 22}$$

The sustainability of compliance is rewarded in the calculation of this elements contribution due to the fact that continuous improvement is not required and the measurement is subjected to an adjustable benchmark value.

The representation of the risks on the criticality matrix is not applied in this instance due to the fact that only the probabilities are reduced in the mitigation action.

6.1.7 Asset Management Value Index: Asset Management Maturity

Asset Management Maturity is the fifth and final element of the AMVI model. The purpose of this element is to measure the level of maturity, and improvement thereof, over the period of

the service partnership. The outcome provides both the customer and Pragma with an indication of the maturity of their asset related activities and the associated best practices.

Inputs

The input of this element is the current year's asset management improvement plans (AMIP, as defined in section 5.2.1) score and the target for the next period (see Figure 46).

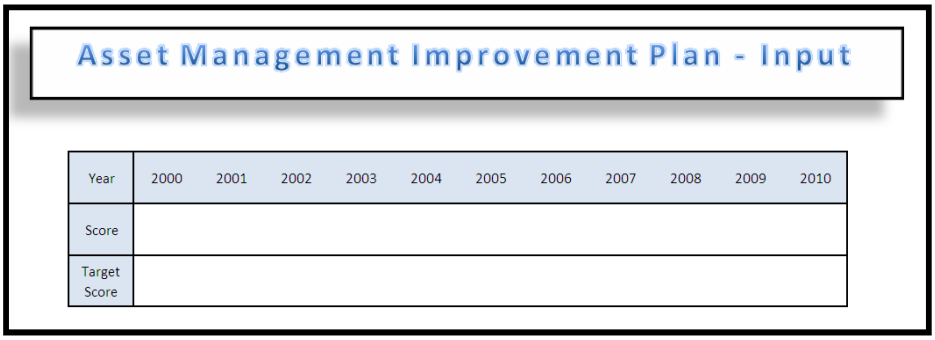


Figure 46 - Asset Management Maturity - Input

Formula's and Logic

An AMIP assessment is an extensive measurement of the customer's business processes according to 17 key performance areas and it derives a single value as output to indicate the maturity of the customer's PAM business function.

The AMIP assessment output obtained from measurements are used to determine the percentage attainment relative to the target value set at the beginning of the period. This element's weighted contribution towards the AMVI is calculated according to the delta methodology (see Figure 34 in section 4.5). This is due to the comparison of the obtained AMIP value to the previous period's result instead of a measurement against the initial, baseline value.

The previous AMIP assessment value (n-1) is used as the baseline for the current period (n) and it is measured against the current period's targeted value.

Equations 23, 24 and 25 indicate the four possible scenarios which can occur as a consequence of the consultancies service.

If $AMIP_{(n-1)} < AMIP_{(n)} <$ target or $AMIP_{(extreme\ minimum)} < AMIP_{(n)} < AMIP_{(n-1)}$,

$$\boldsymbol{Asset\ Management\ Maturity}_{\%\ attainment} = \frac{\boldsymbol{AMIP_{current} - AMIP_{previous}}}{\boldsymbol{AMIP_{target} - AMIP_{previous}}} \quad \text{...Equation 23}$$

The first scenario is when the attained AMIP value is larger than that of the previous period but the target is still not met. The percentage attained (see Figure 47) is the percentage of the target which is realised during the period of measurement.

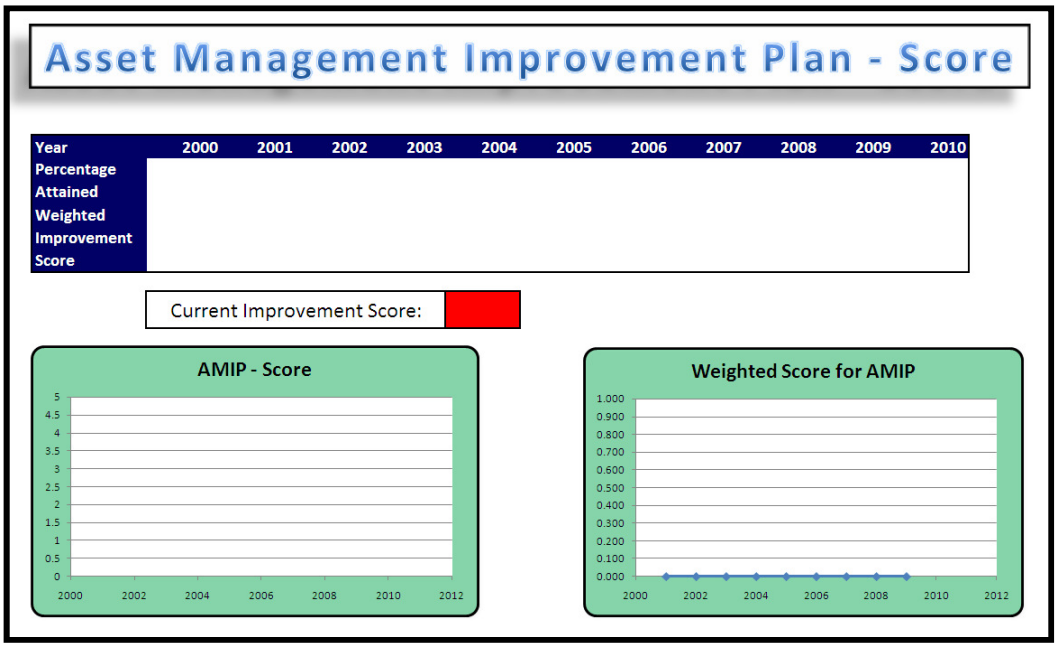


Figure 47 - Asset Management Maturity - Output

The second scenario occurs when the AMIP value is less than that of the previous period but still larger than the extreme minimum (similar to that of Figure 42). This scenario indicates a deterioration of the customer's asset management practices and a decline in the service level of the ACC.

The scenario in Equation 24 indicates a superior improvement in the maturity of the customer's PAM business function. The target value is exceeded and this contributes to a 100% percentage attainment.

If $AMIP_{(n-1)} < target < AMIP_{(n)}$,

$$\boldsymbol{Asset\ Management\ Maturity}_{\%\ attained} = \mathbf{100}\% \qquad \text{...Equation 24}$$

In Equation 25, the AMIP assessment indicates a serious deterioration in customer asset management maturity. The current value is lower than the extreme minimum (see Figure 41) and this results in a -100% contribution to the weighted AMVI model.

If $AMIP_{(n)} < AMIP_{(n-1)} - (target - AMIP_{(n-1)})$,

$$\boldsymbol{Asset\ Management\ Maturity}_{\%\ attained} = -\mathbf{100}\% \qquad \text{...Equation 25}$$

The overall contribution of asset management maturity to the AMVI model (Equation 26) is simply the product of the percentage attained and the weighted contribution of this element to the AMVI model.

$$\boldsymbol{AMVI}(\boldsymbol{Asset\ Management\ Maturity}) =$$

$$\boldsymbol{Percentage\ Attainment\ x\ Weighted\ Contribution} \qquad \text{...Equation 26}$$

The sustainability of the consultancies service is rewarded (as is the case with asset performance improvement and risk reduction) if the target does not change and it is reached continuously (as is the case with a compliance client).

6.2 Sensitivity Analysis

The basic principles and measurement techniques of the AMVI model are defined in the previous sections. The Online Business Dictionary defines a sensitivity analysis as a simulation analysis in which key quantitative assumptions and computations (underlying a decision, estimate, or project) are changed systematically to assess their effect on the final outcome.

This necessitates that the rigidity of AMVI is tested through the testing of each individual element in isolation.

The inputs from all elements a varied to validate their individual outcome and to see whether they react as intended in given circumstances. Extreme values on both ends of the spectrum are tested (see Appendix B for a representation of the individual elements) and it can be seen that the model holds true to the defined parameters.

The AMVI output of this exercise (see Figure 48) is representative of the different scenarios and holds true to the defined parameters. This enables the application of the model at customers, is the following chapter, with confidence in the validity of the model itself.

Asset Management Value Index

Year	2000	2001	2002	2003	2004	2005
AMVI	-0.64	8.10	6.00	-3.53	-1.59	6.50
Cost Savings: Score		3.99	3.02	-1.33	-3.99	2.77
Asset Performance Improvement: Score	-2.60	2.60	1.42	-0.95	1.42	1.42
Customer Satisfaction: Score	1.18	1.01	0.60	0.40	1.14	1.20
Risk Reduction: Score	0.78	-0.78	0.31	-0.37	0.27	0.59
Asset Management Maturity: Score		1.28	0.64	-1.28	-0.43	0.51
Cost Savings: %		100.00%	75.76%	-33.33%	-100.00%	69.44%
Asset Performance Improvement: %	-100.00%	100.00%	54.55%	-36.36%	54.55%	100.00%
Customer Satisfaction: %	88.00%	75.00%	45.00%	30.00%	85.00%	89.61%
Risk Reduction: %	100.00%	-100.00%	39.52%	-47.62%	34.52%	75.48%
Asset Management Maturity: %		100.00%	50.00%	-100.00%	-33.33%	40.00%

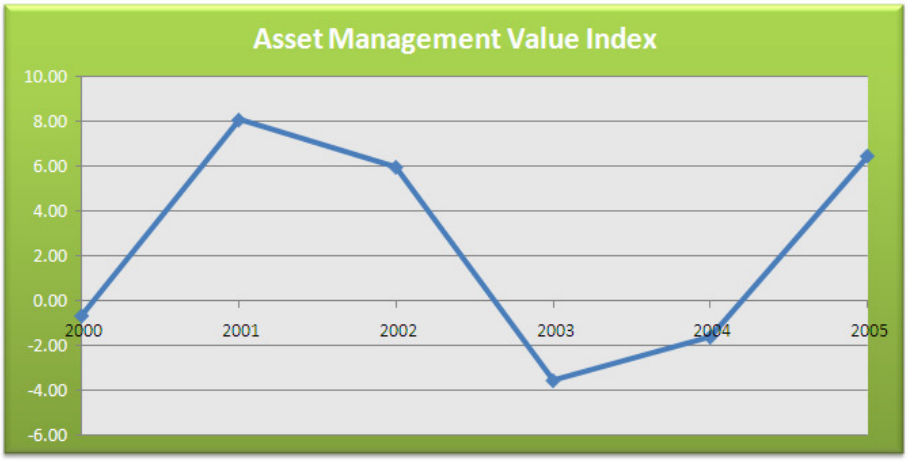


Figure 48 - AMVI: Sensitivity Analysis

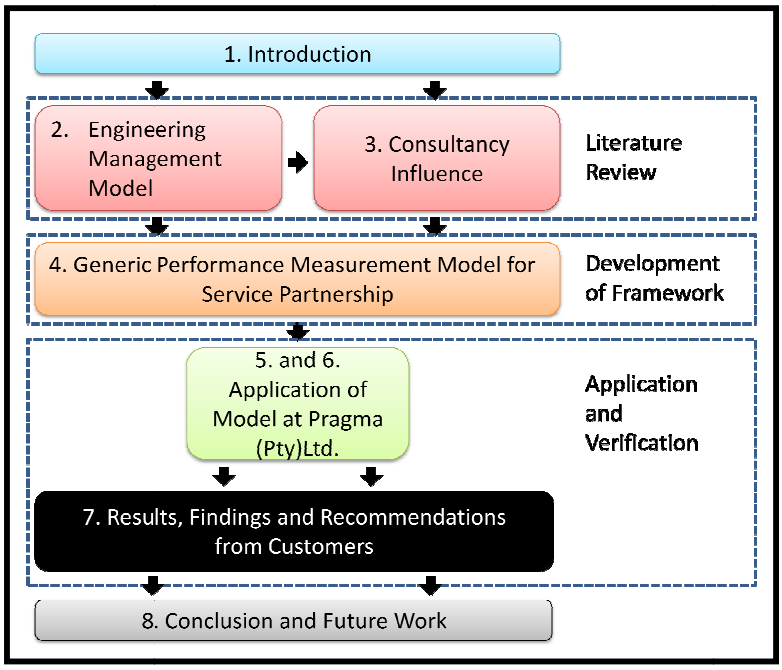
It should however be pointed out that the figures displayed in the graphs is artificially generated and does not represent the performance of any specified customer.

6.3 Chapter Conclusion

This chapter applies the generic PMVI (Chapter 4) to the environment of Pragma (Chapter 5) to determine the value of the service partnership between Pragma and their customers.

The application of the AMVI on Pragma customers and the outcome of this endeavour are presented in the following chapter. This is followed by recommendations for the use of the model in this specific environment.

7 Verification and Results



The previous chapters in this document provide the required literature and established the environment for the development of the PMVI. The AMVI is developed to measure the value of the service partnership in the PAM environment.

The research on fundamentals (Chapter 2: Fundamentals) sought for the development of an EMM. This model illustrates the improvement (and sustainment) life cycle of an organisation in order to obtain and sustain a competitive advantage.

The chapter thereafter (Chapter 3: Setting the Scene) illustrates the effects of the strategy to focus on core competencies and to outsource a business function to a consultancy. This strategy is reflected in the performance of the organisation and the required targets to ensure that a mutually beneficial relationship is established.

The next chapter develops the performance measurement value index (PMVI, Chapter 4: Performance Measurement Model for the Consulting Industry). The PMVI is a generic performance measurement model which measures the value added through the service partnership and thus provides a true reflection of the contribution of the consultancy to the customer.

The application of the model requires the definition of the industry in question (Chapter 5: Pragma (Pty) ltd.) and its respective services and products.

The model is applied to the PAM environment (Chapter 6: Application of Model) and has the AMVI as outcome.

The application and results obtained from customers is essential in proving the hypothesis of this research. This chapter provides the outputs from a selected clientele of Pragma and the results of the application of the AMVI.

Objectives

- *the reasoning behind the selection of the customer to be used in the study;*
- *to illustrate the required changes in the AMVI for each individual customer;*
- *to provide the outcomes of each case with a clarification for the AMVI value obtained; and*
- *to prove the hypothesis as being correct.*

7.1 Customer Selection

The selection of the customers on whom the AMVI is to be applied is an important factor when the value of the service partnership is measured. This necessitates that customers from every walk of life be sampled to ensure that there is no error when accepting or rejecting the hypothesis.

The type of services (see Chapter 5) which Pragma render differs in both depth of penetration and span of service (as defined in Chapter 3). The customers on who the model is applied represents both the ACC@Client and ACC@Pragma applications. These applications are from both the manufacturing and utilities and facilities environments. An investigation of this diverse nature would represent a true reflection of Pragma's services at its customers.

The application of the AMVI at the three chosen customers requires a certain degree of customisation to the model. The following sections provide the reader with the predominant issues regarding the implementation of the AMVI at the customers. The representation of the outcomes of the individual elements, as referred to in this chapter, can be found in Appendix C.

This allows for the further investigation of the AMVI and provides a more comprehensive overview of the respective elements.

7.2 Customer A: Juice Manufacturer

Customer A is a juice manufacturer in the fast moving consumer goods (FMCG) environment who service's both a local and international market. They have a global footprint spanning over five continents and have world-class manufacturing facilities to provide its diverse range of customers with their produce. The service partnership, established in 1999, requires that Pragma administer the management activities associated with the PAM business function of the customer.

7.2.1 Type of Service

The current nature of the service partnership is an ACC@Pragma where the service rendered by Pragma is administered on an ad-hoc basis. This is the minimum type of service rendered and incorporates the customer's PAM function with the planning and interpretation of results of Pragma.

7.2.2 Customer Specific Application

The AMVI was initially designed to measure performance of the service partnership in a strictly manufacturing environment. The sector in which this customer operates is manufacturing and packaging. The application of the AMVI, as a consequence of this, does not require a substantial amount of adapting to facilitate the measurement process.

The timeline of application is only from 2007 to 2009 due to changes in the nature of the ACC service and the development of the AMIP methodology. The results from this period can be seen in Figure 49.

Year	2007	2008	2009
AMVI	2.23	6.62	6.59
Cost Savings: Score		3.99	3.99
Asset Performance Improvement: Score	0.40	0.64	0.61
Customer Satisfaction: Score	1.05	1.05	1.05
Risk Reduction: Score	0.78	0.78	0.78
Asset Management Maturity: Score		0.16	0.16
Cost Savings: %		100.00%	100.00%
Asset Performance Improvement: %	15.20%	24.51%	23.53%
Customer Satisfaction: %	78.32%	78.32%	78.32%
Risk Reduction: %	100.00%	100.00%	100.00%
Asset Management Maturity: %		12.50%	12.50%

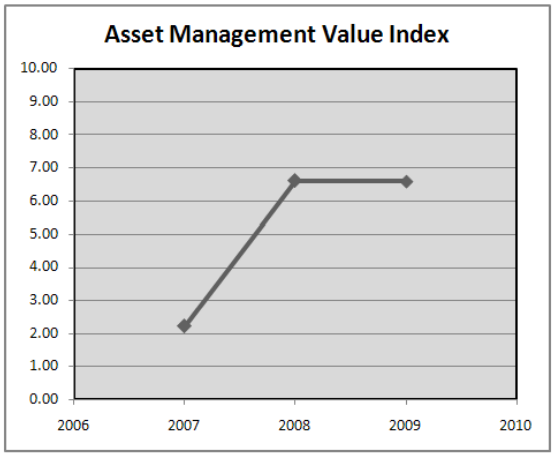


Figure 49 - AMVI Output - Customer A

The lack of informational structure for the AMVI, due to the use of historical data, subdues the measurement of all of the required KPI's.

The following section describes the application of each element.

Cost Reduction

The Cost Reduction element is not reflected on the AMVI in 2007. This can be attributed to the nature of measurement, where historical, or pre-service, data is required to obtain an accurate measurement.

The following changes, omissions and additions are made to this element:

- Spares costs are omitted from the calculation of the CROI due to its inclusion as a KPI in only October 2008. The inclusion thereof will have detrimental effects on the CROI and ultimately the AMVI. The change in this KPI should be tracked in the continuous measurement of the service partnership for at least another cycle and will only then reflect value.
- The investment in spares is not yet tracked as a KPI at the customer. The current value is used as a reference but only used as a constant and will not reflect any change in value.

Irrespective of the issues regarding this element, a CROI of 600% is obtained in 2008 which grows to 670% in 2009. These high values can be attributed to two factors. These are the reduction in the overtime of the maintenance personnel and the low costs of the service

rendered to the customer. The result of this is a full contribution of this element (3.99) to the AMVI in both 2008 and 2009.

Asset Performance Improvement

There is nothing out of the ordinary with regard to this element. The baseline availability of 68% is relatively high or rather close to the periodical values achieved during the service partnership. The service partnership has been around for 10 years and one would expect that saturation in this value would occur.

The target value is set by the customer to be a world-class standard (85%) and have not yet been obtained. This is reflected in the relatively low values of the contribution of this element to the AMVI (15% in 2007, 24% in 2008 and 25% in 2009).

Customer Satisfaction

The identification of the relevant personnel for the completion of the questionnaire was made according to the prescription in the development of the AMVI. The questionnaire was completed in the form of a structured interview to ensure that the context of all of the questions was understood.

The nature of the service partnership (ACC@Pragma) does not allow the customer to use ON KEY and the questions regarding this function was deemed not applicable (N/A). The outcome of the questionnaire cannot be extrapolated to gain a historical value and this instigates the use of the current outcome as a sensitivity measure throughout the period of measurement.

The outcome of the questionnaire indicates a 78% satisfaction (contributing a value of 1.05 to the AMVI) which the customer experience as a function of the synergy in the service partnership.

Risk Reduction

The risks which forms part of the service partnership are:

- safety, health and environmental (SHE) as measured by NOSA; and
- an industry specific food safety regulation as measured by the Hazard Analysis and Critical Control Points (HACCP).

Both of these risks are compliancy based and require that the customer adhere to the standards set by the regulatory and legislative authorities. The SHE compliancy has not changed since the initiation of the service partnership (4 stars) and this is reflected in the 100% compliancy value throughout the period of measurement. The measurement of critical points as required by HACCP standards is incorporated in the work planning and control business process and has been completed to satisfaction under this system. This attributes a 100% contribution of this risk to the AMVI throughout the period of measurement.

The combined outcome of this element is a 100% contribution to the AMVI. This is attributed to the fact that both measurements are fully compliant to the respective regulations.

Asset Management Maturity

The first AMIP assessment facilitated at this customer was in 2007. The value obtained was 2.6 (out of the possible 5) and a target was set at 3. It should be noted that this is a compliance customer and that the type of service rendered is restricted to the obtainment of a level 3 maturity (as indicated in the SLA). The following measurement was only made in 2009 with an outcome of 2.65. The contribution of this element to the AMVI is thus 12.5% of its weighted contribution which amounts to 0.16.

The lack of periodical measurement of this element (measured by incremental change) complicates the process of awarding a value to the AMVI. The value obtained in 2009 is taken for both 2008 and 2009 and, since the improvement occurred over the entire period, it cannot be attributed to any of these periods with certainty.

7.2.3 Customer Specific Findings

The AMVI values for this customer (see Figure 49) represent the expected pattern for a stagnating service partnership from a Pragma point of view. This is attributed to the requirement of only a basic (and constant) level of service from the customer. This hinders the prospects of expansion of value from Pragma's perspective.

The initial improvement (or low hanging fruit) usually creates superior value for the customer but Pragma have been employed since 1999. The period of measurement is from 2007 to 2009

and the indication, from the AMVI, is that the current activities are still performed sufficiently but that no more improvement occurs and thus no extra value is created.
The AMVI value of 2.23 in 2007 cannot be taken into account due to the lack of contribution from the cost reduction and asset management maturity elements. The values of 2008 (6.62) and 2009 (6.59) are very close to one another (see Figure 49) and indicates a solid, but not improving, level of value creation.

7.3 Customer B: Cable Manufacturer

Customer B is a leading African manufacturer of cables with five manufacturing sites, in three South African provinces, and offshore operations in Mozambique, Portugal and Spain. The customer's clientele includes power supply authorities, railway and transport organisations, municipalities, and companies in industries such as petrochemical, mining, wholesale, industrial, construction and domestic building. The customer manufactures and sells a wide range of state of the art products with different applications, design capabilities and a full technical back-up service. This is once again a mainly manufacturing application suited for the AMVI.

7.3.1 Type of Service

The service partnership is of ACC@Client nature. This implies that Pragma has employees who, on a daily basis, are on-site and operate the management activities regarding the customer's PAM business function. The service involves multi-site locations and only the Johannesburg branch of this customer are investigated in this research. The service at this site includes Pragma personnel in the form of an ACC Manager, two planners and an administrator.

7.3.2 Customer Specific Application

The main difference between the ACC@Pragma and ACC@Client is the obtainment of information. The ACC@Client is integrated into the structure of the customer and consequently has access to the required information for the AMVI where the ACC@Pragma depends on the customer for a large portion of the required information.

The unique nature of each application is reflected in this application. The entire organisation operates on a single information system which does not allow for the incorporation of ON KEY

into their PAM business function. The type of service compensates for this discrepancy through the degree of access and knowledge of the Pragma personnel to the system.

The period of application is once again determined by the periods between AMIP assessments. The service partnership was initiated in 2005 but only really started its operation in the beginning of 2007. This implies that 2007 is the baseline period used in this application. The financial KPI's are not readily available during the course of the year and is only calculated at year end for this organisation. The combination of these issues only allows for the application from 2007 to 2008. The outcome of the AMVI application can be seen in Figure 50.

Year	2007	2008
AMVI	7.68	8.51
Cost Savings: Score	3.99	3.99
Asset Performance Improvement: Score	1.28	2.12
Customer Satisfaction: Score	1.02	1.02
Risk Reduction: Score	0.78	0.78
Asset Management Maturity: Score	0.61	0.61
Cost Savings: %	100.00%	100.00%
Asset Performance Improvement: %	49.18%	81.23%
Customer Satisfaction: %	75.96%	75.96%
Risk Reduction: %	100.00%	100.00%
Asset Management Maturity: %	47.41%	47.41%

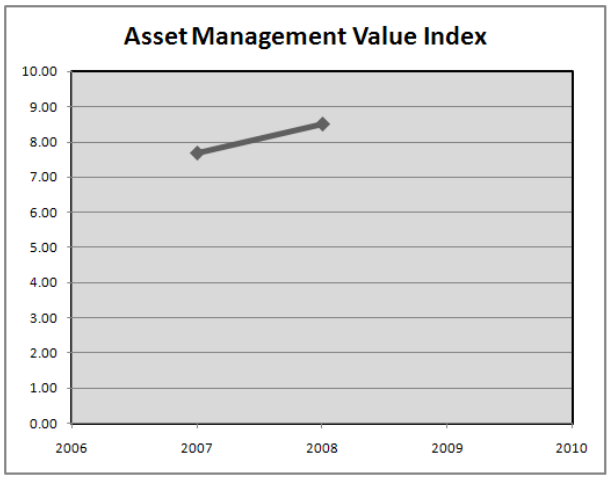


Figure 50 - AMVI Output - Customer B

The subsequent sections provide the reader with the insight necessary for the obtainment of these values.

Cost Reduction

The measurement of cost reduction does not reflect the changes in the following KPI's:

- Fixed Labour Costs – this is attributed to the level of consistency of the measurement and the multi-skilling of the labourers; and
- Contractors Costs – the cost centre associated with contractors does not allow an attribution of costs to a specific business function. It is therefore difficult to estimate the costs attributable to the PAM business function.

The spares costs incorporate the value for spares used during a shut down period in December 2008. Due to the non-occurrence of this event in 2007, the decision is made to remove the effects of this event and take the average value of 2008 for this month. Future measurements must incorporate this value to reflect the effects of this cyclical shutdown process on the AMVI.

The CROI of the customer in 2008 was 350% which leads to a fully contributable value of 3.99 on the AMVI. Due to the lack of historical data, the outcome of this measurement is made sensitive for the years 2007 and 2008. The implication of this is that no difference in cost reduction is noticed and only those elements which change during the period will reflect changes in the AMVI.

Asset Performance Improvement

The measurement of total availability in this situation does not reflect the effects of the service partnership on the PAM business function. This is due to scheduled production, shutdowns, etc. which would influence the outcome of the measurement. The measurement of engineering availability, as used in this element, is based primarily on the time which production must occur versus the downtime experienced in this time.

A baseline value of 94.5% is obtained in the beginning of 2007 and a target value of 98% is set in correlation with the customer's standards. The average engineering availability in the year of 2007 is 96.4% which provides an outcome percentage attainment of 49.2% (or value of 1.28 on the AMVI). The availability improves in 2008 with an average of 97.4% leading to the improvement of percentage attainment to 81.23% (or value of 2.12 on the AMVI).

It is evident that the engineering availability of the customer has improved in the past year. This is attributed to the implementation of visual management techniques, thus encouraging the employees to improve their productivity.

Customer Satisfaction

The questionnaire was not conducted as a structured interview, as with Customer A, but the customer's employees completing it was in contact with the conductor if any unclear issues arose. The customer, as indicated earlier, does not make use of ON KEY and marked that part of the questionnaire as "N/A".

The completion of the remainder of the questionnaire indicates a satisfaction of 75.96% (or a contribution of 1.02 to the AMVI). This value, as with all customer satisfaction elements of the research, is taken as a constant throughout the period of application due to the lack of simulation of previous satisfaction.

Risk Reduction

The only risk in which the service partnership is actively measured is that of the SHE policies. The customer has an internal measurement system for this risk, which enables it to adhere to the statutory and regulatory SHE requirements.

The work planning and control business process imposed on the already existing structure of the customer ensures that this policy is successfully complied to.

The outcome of this measurement, during 2008, equates to a 100% compliance (contributing 0.78 to the AMVI) of the risk. This value is taken to as a constant for the years 2007 and 2008 due to the lack of information available prior to implementation to remove the effects of value deterioration on the AMVI.

Asset Management Maturity

The initial AMIP assessment, completed in 2005, indicated that the maturity of the customer's PAM business function was at a 1.84 out of 5. The decision is made to use this as the base value for the service due to the fact that the active implementation of the Pragma ACC service only occurred in 2007. The assumption here is that the customer's asset management maturity did not improve from the initial AMIP assessment until 2007.The service partnership agreed upon a target value of three for the measurement in the following period.

The AMIP assessment in 2009 indicates a value of 2.39 which represents an improvement of the customer's maturity of 0.55. This is reflected in the percentage attainment of the target (47.41%) and ultimately the contribution of this element to the AMVI (0.61).

This element, as with the other elements (except for asset performance improvement), reflects only a single value on the AMVI. This value (from 2008) is taken to be sensitive to enable the user to see a change in the other elements of the AMVI.

7.3.3 Customer Specific Findings

The only value on which a change over two periods can be measured is that of asset performance. The percentage attainment thereof has increased from 2007 to 2008 which indicates value being added by the service partnership. This improvement is evident in the increase of the AMVI (7.68 to 8.51) since all of the other values achieved in 2008 are used in 2007 to enable the user to see this change.

The single output measurement for four of the five elements does not reflect the change in value desired by the AMVI. The measurements are mostly of an incremental change nature and the high values obtained indicate that the service partnership is adding value to the customer from the initiation of service.

The high values obtained initially may be attributed to low hanging fruit, where small changes can have a large impact on the business function. The difficult task for Pragma is now to sustain (or even improve) the high value currently created by the service partnership.

7.4 Customer C: State Hospital

Customer C is a state hospital which is part of the current hospital rejuvenation process being undertaken in the Western Cape. They deliver free medical care to the citizens of South Africa and are the responsibility of the Department of Health. Pragma forms part of the service partnership with several of these hospitals and provides them with the required structure within the PAM business function.

7.4.1 Type of Service

The nature of this service partnership is also an ACC@Client. The personnel of Pragma situated at the customer include an ACC Manager, planners and administrators. The ACC Manager is currently responsible for two sites and divides his attention accordingly. The multi-site nature of the customer is not considered in this research as the attention is focussed on the service partnership at a single hospital.

7.4.2 Customer Specific Application

The customer operates within the utilities and facilities sector and the approach followed with the manufacturing sector cannot be used in this application. The main difference between the manufacturing and utilities and facilities environments are the influence of PAM on the output of the customer. The direct effects of downtime can be articulated within the manufacturing environment (as with the previous two applications) but the type of service which Pragma render at this customer does not have a direct effect on the amount of people treated at the hospital. The machinery required for human critical operations is maintained by the providers and not a responsibility of Pragma. Pragma is responsible for the PAM activities relating to the structures and non-critical assets (such as the air condition system).

The period of application is predetermined due to the time of initiation of service. The service partnership only formed in late 2007 thus providing two periods over which a change in value can be indicated (see Figure 51). The period of measurement spans from October 2007 until October 2009 and the calculation is broken down into two twelve month cycles.

Year	2008	2009
AMVI	4.54	7.73
Manpower Utilisation: Score	1.81	3.97
Schedule Attainment: Score	1.03	2.05
Customer Satisfaction: Score	1.05	1.05
Risk Reduction: Score		
Asset Management Maturity: Score	0.65	0.65
Manpower Utilisation: %	45.35%	87.84%
Schedule Attainment: %	39.67%	78.67%
Customer Satisfaction: %	78.40%	78.40%
Risk Reduction: %		
Asset Management Maturity: %	50.70%	50.70%

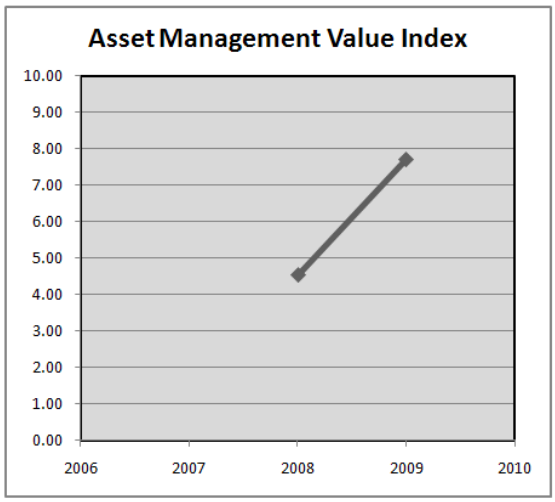


Figure 51 - AMVI Output - Customer C

The AMVI has to adapt to this alternative type of application. This approach see' s the decomposition of the current elements into lower level contributors which would ultimately produce a similar output.

The following changes are made regarding the elements of the AMVI:

- Cost Reduction is substituted by Manpower Utilisation; and
- Asset Performance Improvement is substituted by Schedule Attainment.

The concepts, reasoning and measurement techniques of these elements is portrayed in the following sections.

Manpower Utilisation

The cost reduction element is substituted with manpower utilisation due to the nature of the service. The hospitals receive a fixed budget from the government of which a percentage is made available for the PAM function. The value of these budgets has to be exhausted during each period in order to sustain cash flows from the government. There is thus no benefit in proving that Pragma's service improves the cost structure of the PAM function.

The costs associated to fixed labour remains constant over the period of measurement but the utilisation of the manpower associated with this cost is dependent on the rate of work completed by the personnel. The measurement of the manpower utilised can thus be seen as the indirect utilisation of the capital invested in the personnel and serves as a measurement on the AMVI.

The calculation of manpower utilisation is similar to that of availability (see section 6.1.4) where a baseline value is instated at the initiation of service and a target utilisation is set. The percentage attainment of this KPI is then reflected on the AMVI. This type of measurement promotes sustainable levels of workforce utilisation.

The utilisation at the initiation of service (October 2007) was at 30% and increased during the first period of measurement (from November 2007 to October 2008) to an average of 47.5%. The percentage attainment of this period is 45.4% and this equates to a contribution of 1.81 on the AMVI. The average manpower utilisation obtained during the second period (November 2008 to October 2009) increases to 68%. This, in turn, results in an 88% percentage attainment which is reflected on the AMVI as a contribution value of 3.97.

The improvement of this element is directly attributable to the implementation of the work planning and control business process. This imposes a structured approach on the existing PAM business function which enables the capturing of working hours for employees.

The low base value for this element may be due to the lack of structure in the capturing of working hours. The value created through the service partnership is evident in the increase in this element from the first to the second period (irrespective of the low base value).

Schedule Attainment

The second element of the AMVI which is measured by the utilisation of a subset measurement is that of schedule attainment. This element replaces asset performance improvement due to the lack of an availability measurement. The type of service, as discussed earlier, is not performed on production or patient critical equipment (which may be a measurement of availability) but rather on the other assets of which the hospital constitute.

The argument in the replacement of the measurement is that, when schedule attainment of preventive related tasks rise, the availability of equipment would rise. The increasing amount of non-preventive tasks completed would increase the time available to be spent on preventive tasks in periods to follow. This ultimately increases the availability of equipment and labourers and is deemed a relevant element for the AMVI.

The amount of non-preventive tasks completed within a period is closely related to the measurement of manpower utilisation and is thus removed from the schedule attainment measurement. The amount of preventive tasks completed, on the other hand, reflects the combined availability of the employees and the assets. The completion of the scheduled tasks as a percentage of total tasks planned is used as a measurement of this element.

The average attainment of scheduled preventive tasks during the 2008 period is 40%. This represents a 1.03 contribution on the AMVI. This attainment improves during the 2009 period to 79%, which represents a value of 2.05 on the AMVI.

The improvement of manpower utilisation and consequently a higher non-preventive schedule attainment, leads to the higher availability of employees. This in turn enables a positive change in the amount of preventive tasks completed as well as the amount scheduled for completion.

Customer Satisfaction

The measurement of customer satisfaction is once again completed without direct assistance from the conductor. The customer was able to direct any questions regarding the questionnaire to the conductor should there be any confusion in this regard.

The outcome of the questionnaire, and thus the satisfaction of the customer with the service partnership, is 78.4% (or a contribution of 1.05 to the AMVI). The effects of the higher values for synergy related KPI's is reduced by a 66% satisfaction of ON KEY and technology related issues.

The value is once again taken as a constant over the two periods to indicate a change in the other elements of the AMVI.

Risk Reduction

There are no risk related issues measured at this customer which are reduced due to the effects of the service partnership.

Asset Management Maturity

The maturity of this customers asset management practices are measured at the initiation of service thus enabling Pragma to determine this value in their absence. The outcome of this pre-service partnership, as of the year ending 2007, was a measurement of 1.9. The target value of 3 set at this time indicates the potential improvement capacity which Pragma see in the customer.

The measurement of the change in the maturity of the PAM function, as a consequence of the service partnership, conducted in the year 2009 indicates an improvement to a value of 2.5. This represents a percentage attainment of the target value of 50.7% and thus a value of 0.65 on the AMVI.

The value of 0.65 is used for the year of 2008 and 2009 since there are no intermediate measurements within this period and it is assumed that the improvement occurred during the entirety of this period.

7.4.3 Customer Specific Findings

The first and foremost issue with this customer is the obvious changes made to the initially proposed AMVI. This is merely an effect of the type of service and industry of application. It is

recommended that the outcome of this type of customer must not be compared to that of a manufacturing customer for a lack of similarity.

The change in value of the AMVI (from 4.54 to 7.71) indicates that, irrespective of the constant values of asset management maturity and customer satisfaction during the two periods, the service partnership improved the PAM business function of the customer. A significant improvement in the utilisation of manpower as well as the higher percentage attainment of the preventive task schedules leads to an increase in the AMVI.

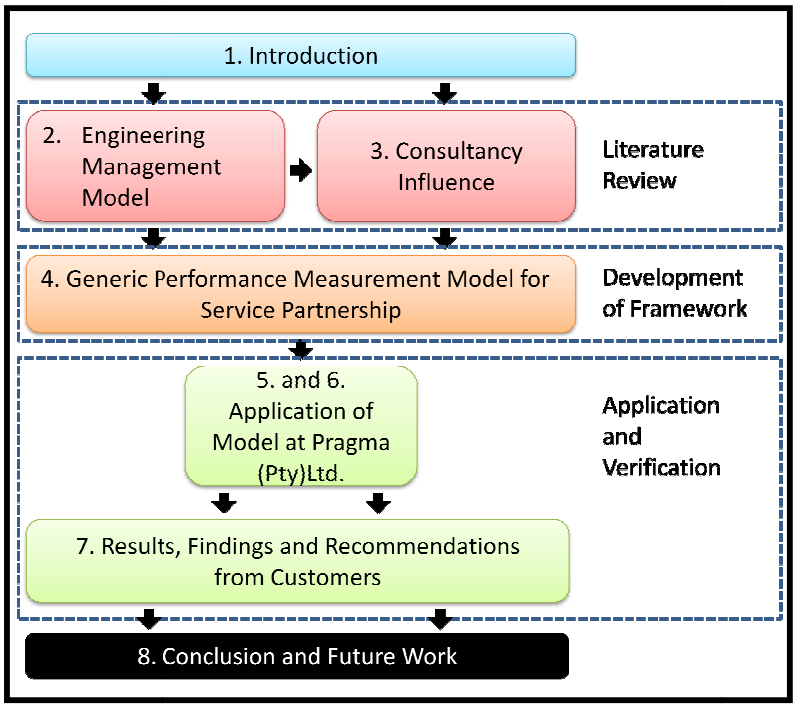
These high values of the AMVI indicate that superior value is created through the service partnership.

7.5 Chapter Conclusion

The application of the AMVI at the three selected customers produces outcomes which enable an extensive analysis of Pragma's service and the effects thereof on its customers. The theme of value represented throughout this research remains is evident during the application of the AMVI as the customer's on whom the model is applied fosters a degree of value as a consequence of the service partnership.

A reflection on the AMVI and the application thereof on Pragma's service partnerships are represented in Chapter 8, where this forms part of the thesis conclusion.

8 Recommendations, Conclusion and Future Work



The previous chapters in this document provide the required literature and establish the environment for the development of the PMVI. The AMVI is developed to measure the value of the service partnership in the PAM environment.

The research on fundamentals (Chapter 2: Fundamentals) sought for the development of an EMM. This model illustrates the improvement (and sustainment) life cycle of an organisation in order to obtain and sustain a competitive advantage.

The chapter thereafter (Chapter 3: Setting the Scene) illustrates the effects of the strategy to focus on core competencies and to outsource a business function to a consultancy. This strategy is reflected in the performance of the organisation and the required targets to ensure that a mutually beneficial relationship is established.

The next chapter develops the performance measurement value index (PMVI, Chapter 4: Performance Measurement Model for the Consulting Industry). The PMVI is a generic performance measurement model which measures the value added through the service partnership and thus provides a true reflection of the contribution of the consultancy to the customer.

The application of the model requires the definition of the industry in question (Chapter 5: Pragma (Pty) ltd.) and its respective services and products.

The model is applied to the PAM environment (Chapter 6: Application of Model) and has the AMVI as outcome.

The results obtained from customers is received and interpreted (Chapter 7: Verification and Results) to validate the application of the AMVI at the customers of Pragma.

This final chapter of the document concludes the research with an interpretation of the thesis as a whole and provides recommendations as well as intended future work for further expansion in this field of research.

Objectives

- *to conclude the research with a cyclical approach to determine the outcome with regards to the hypothesis;*
- *to make recommendations about the application of PMVI within the industry; and*
- *to propose an expansion of this current research this would provide a correlation between practice and performance.*

8.1 Recommendations

The concluding remarks and recommendations of this thesis contain general issues with regards to the application of a performance measurement model at an organisation with specific reference to Pragma and the AMVI.

The first concluding remark involves the type and format of data used. The structural requirements for obtaining the correct format of information are not currently in place. It is expected in the application of a newly developed model that a phase of change is required to standardise the informational structure for the model. This effect is removed with a continuous application of the AMVI model but current application uses historical data which at times are difficult to adapt for use. The application of the model in the future would require consistency in the practices of Pragma to enable a reflective outcome (conducting annual AMIP assessments, etc. to construct a basis for the measurement of change).

The second concluding remark concerns the field of risk management. During the development of the model, it was apparent that the service partnership does mitigate a certain set of risks within the customer's organisation. This is, however, not reflected in the measurement process of the AMVI and requires further investigation if this element is to be successfully implemented. The customer's merely indicated that the standards of certain compliancy risks are maintained but no reduction in the risks identified occurs. It is thus recommended that Pragma either apply the risk reduction element at selected customers where measurable changes for this element can be found or they should remove this element from the AMVI all together.

The third concluding remark involves the application of the model within different industries, as seen in Chapter 7. The AMVI's origins stem from a mainly manufacturing environment. A change in this environment is easier to quantify than a change within the utilities and facilities environment. This is attributed to the direct correlation of the manufacturing environments PAM function and measurable output versus the lack of this distinct correlation between the PAM function and the utilities and facilities environment. The AMVI is adapted to measure the change in the amount of work being completed which is seen as a substitute for a financial and availability measurement. The type of service, within these environments, is furthermore expected to generate different proportions of value of which the effects can be nullified through the scaling of the AMVI.

The fourth concluding remark concerns the issue of true value. During the application of the AMVI (or PMVI for that matter) it is recognised that a true reflection of value would only be represented if the service is discontinued and the business function in consideration deteriorates in value.

The last remark involves the comparison of outcomes from customers, especially within the same industry. A cross-sectional investigation or comparison of customers within the same environment cannot be completed on a one-to-one basis. This is due to the unique nature of each application and differences between organisations. It is recommended that a longitudinal study of each customer be completed of which the outcome is used for sustaining the current service partnership as well as acquiring new customers by indicating the grand total improvement over all customers.

8.2 Conclusion

The main hypothesis, as stated in Section 1.3.1, was that: “Pragma’s physical asset management service increases the value of an organisation’s related business function.”

With this in mind, a research methodology was used where a model was developed, enabling the researcher to collect and analyse data from various customers. This analysis enabled the researcher to validate the effect of Pragma’s service in practice.

During the research, development, application and analysis of this model, the respective research questions, as stated in Section 1.3.2, were answered to varying degrees. The collective answer from the research questions, in turn, provided the researcher (and reader) with the required output. This output is the acceptance (or rejection) of the hypothesis.

The conclusion drawn from the research is that Pragma does add value to their customers and this consequently proves that the hypothesis is accepted.

8.3 Future Work

This section proposes the expansion of the current study into two inseparable (but different) directions.

The first of these areas involves the testing and further application of the PMVI on other service partnerships. This will indicate whether this model is truly of a generic nature and if it reflects a change in value created by service organisations. The successful outcome of this hypothesis entails the implementation and continuous measurement of performance (according to the PMVI) of various organisations within different industries.

The second phase of research elaborates on the notion of a systemic strategic cycle. The structural changes induced by the service organisation on its customers must be tracked in order to critically assess the value being created versus the instated practices. This enables the service organisation to determine those aspects of their service which is predominant in their offering. The linkage with this thesis is the measurement of these instated practices during the assessment phase through the use of the PMVI.

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A. Appendix 1: Fundamentals

The fundamentals contained within this document are deemed sufficient to provide the reader with the necessary background on the respective subjects. Appendix A is a mere expansion on the theory regarding physical asset management (PAM) to provide insight into the field of application of the AMVI.

1 Physical Asset Management

This section provides the reader with the life cycle of PAM (see Figure 15) which coincides with that of the EMM. The preferred methodology within the industry for the PAM function is PAS 55. This section elaborates on this methodology, as well as on total productive maintenance (TPM) and reliability-centered maintenance (RCM) to introduce the predominant methodologies used in the industry.

1.1 PAS 55

BSI British Standards [**65**]is the UK's national standards organisation that produces standards and information products that promote and share best practice. They identified a need for the development of a set of standards for the field of asset management. The Institute of Asset Management (IAM) was to compile the set of standards, in collaboration with BSI and other organisation and individuals, which would govern this field of interest. The product of this endeavour is a two part publication called PAS 55: Asset Management.

The use of PAS 55 as reference to the practices of PAM in this study does not implicate that the author does not recognise other existing frameworks (Wiremans Asset Management Pyramid [**67**], Figure 52), but rather that PAS 55 is the framework of choice.

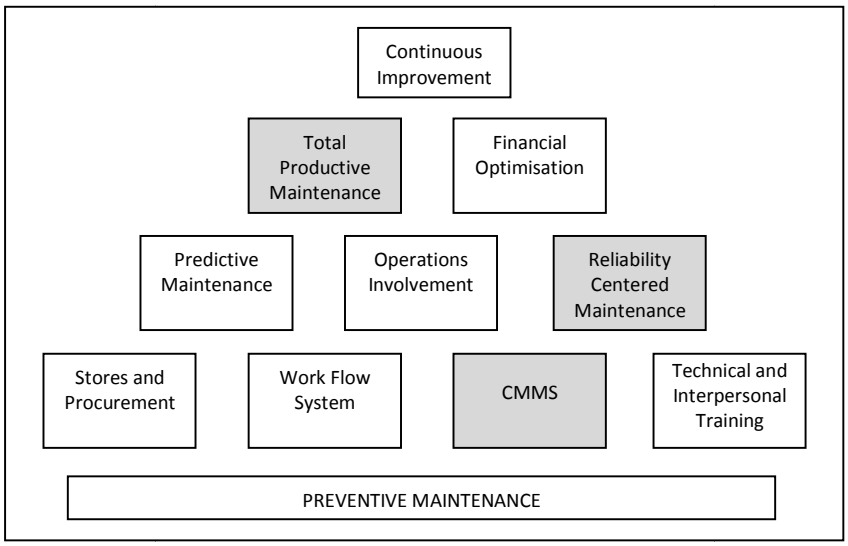


Figure 52 - Wireman's Asset Management Pyramid, adopted from Wireman [67]

The following section contains a brief overview of PAS 55 and the principles on which it is based.

Types of Assets

BSI British Standards [**68**] argues that physical assets are but one of the types of assets within an integrated network of assets that contained in an organisations. The other groups are human, financial, information and intangible assets (see Figure 53). The entire array of interlinked assets has to be managed holistically in order to achieve the strategic objectives of the organisation.

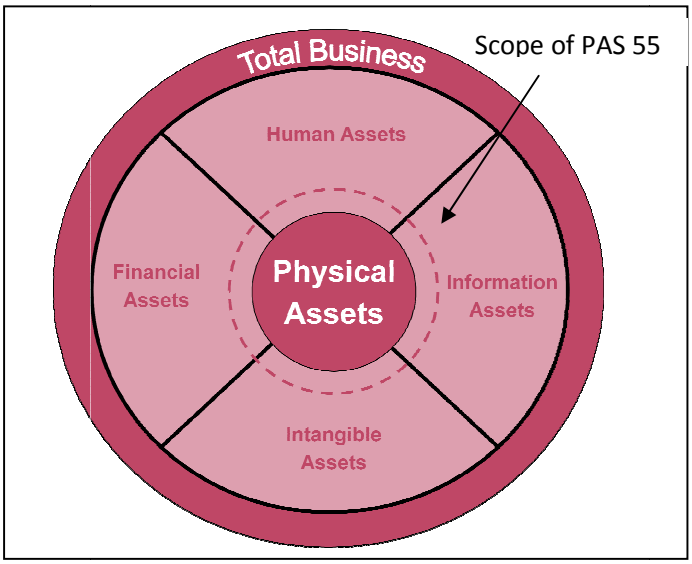


Figure 53 - Type of Assets, adopted from PAS 55 [65]

The depth of the interface between the different assets vary dependant on the infrastructure of the organisation.

Organisational Strategic Planning

Strategic planning is an integral part of the organisations existence (as defined in section 2.4) and determines the direction of the organisation. The asset management strategy should align directly with the organisational strategic plan as asset management incorporates various aspects of an organisation (as seen in Figure 15). [**65**]

Davis [**117**] and Visier [**118**] state that the effective management of organisational assets can lead to a reduction of up to 50% in maintenance costs as well as a 15% - 20% increase in real capacity, without any further capital investment in production equipment. The level of sophistication and type of industry influence the asset management is determined prior to strategic planning to evaluate influence. [**119**]

The completion of this planning process leads to the establishment of an asset management framework (see Figure 15 for PAS 55 asset management framework).

Asset Management Policy

IAM [**65**] defines the asset management policy as the principles and mandated requirements derived from, and consistent with, the strategic plan, providing a framework for the development and implementation of the asset management strategy and the setting of the asset management objectives.

Asset Management Strategy

IAM [**65**] defines the asset management strategy as a long-term optimized approach to the management of assets, derived from, and consistent with the organisational strategic plan and the asset management policy.

The first step towards the development of an asset management strategy is to determine where the organisation currently finds itself in terms of asset management. The organisation then creates a future vision of where it wants to be at a certain time and place. A gap analysis concludes the process with a definition of the organisations asset management strategy. [**119**]

Asset Management Objectives

IAM [**65**] defines the asset management objectives as the specific and measureable outcome or achievement required of asset system(s) in order to implement the asset management policy and asset management strategy.

These objectives should be SMART (Specific, Measureable, Achievable, Realistic and Time-based) since this enable the setting of clear goals and simplifies alignment with the strategy and policy. [**68**]

Asset Management Plan

IAM [**65**] defines the asset management plan as the document specifying activities and resources, responsibilities and timescales for implementing the asset management strategy and delivering the asset management objectives.

A critical part of the planning phase is risk management and contingency planning. This ensures that the organisation can readily identify unforeseen events and mitigate them (or set up a contingency plan) or capitalise on opportunities. [**68**]

The costs of implementing alternative asset management structures are calculated in this planning phase prior to implementation.

Asset Management Enablers and Controls

IAM [**65**] defines enablers as supportive systems, procedures, processes, activities and resources that enable an organisation to operate its asset management system efficiently and effectively.

IAM [**68**] identifies the following enabling procedures that ensure that the asset management process is executed effectively:

- appoint a member of management as driving force of the asset management activities, enabling employees through effective communication and allocation of resources;
- ensure that asset management system is well documented;
- the procedures and documents regarding outsourcing should be in place;
- sufficient training is provided to ensure that all parties involved the asset management function is adequately equipped;

- informational needs must be determined with regard to implementation and performance measurement;
- establish and maintain an effective risk management program);
- the organisation should determine the regulatory and legal requirements with respect to the asset management system; and
- when existing structures are revised that could influence the asset management system, the organisation should have measures in place to manage the process efficiently.

Implementation of Asset Management Plans

The implementation processes ensure that the asset management policy, strategy, objectives and plans are executed, in a controlled fashion, during the day-to-day activities. This process includes the life-cycle management of the assets as well as acquiring and ensuring that the necessary tools, facilities and equipment are available when needed. [**120**]

Asset Management Life Cycle

The Association of Local Government Engineering New Zealand Inc (INGENIUM) [**119**] defines the life cycle of an asset as: "*The time interval that commences with the identification of the need for an asset and terminates with the decommissioning of the asset or any liabilities thereafter*".

Life cycle activities include: [**119**]

- asset planning;
- asset acquisition/creation;
- financial management;
- asset operations and maintenance;
- asset condition/performance;
- asset rehabilitation/replacement;
- asset disposal/rationalisation;
- asset management audit/review.

The life cycle of an asset plays an important part in the decision making process of an organisation, especially if the organisation has capital intensive assets.

There are two fundamental methodologies (total productive maintenance (TPM) and reliability-centered maintenance (RCM)) regarding the activities of the asset management life cycle, and more specifically the maintenance aspect thereof. These methodologies are presented in the following sections.

Performance Assessment and Improvement

The literature on performance assessment is represented in the performance measurement section in the EMM. The models and metrics applicable only on asset management are done separately in this section to avoid duplication.

Asset Management Key Performance Indicators

This section defines the indicators as defined in section 2.7.1.4.

Corporate Indicators

These are the indicators that relate to the long-term strategic objectives of an organisation. The period for the planning involved with this type of indicator is typically 3 – 5 years. [**67**]

Financial Indicators

These indicators determine if the strategic objectives of the organisation are met in accordance with the annual financial figures. [**67**]

Efficiency and Effectiveness Performance Indicators

The efficiency measures compare the quantity of service provided to the resources expended. The focus of these measures is on how well a given task is completed, irrespective of the correctness of the task itself. [**67**]

The effectiveness measures on the other hand emphasis the degree to which a department or the organisation meets is targets or goals. It is often described as the quality of the service, from the customer's perspective. [**67**]

Tactical Performance Indicators

These indicators measure the performance of the functional indicators on a longer-term basis of three months or bi-annually. This allows the organisation to see trends developing due to the changes being made in the organisation.

Functional Performance Indicators

These indicators evaluate the performance of the various functions within the organisation used to support the tactical performance indicators. [**67**]

Audits

An audit is conducted periodically that determines if the asset management system conforms to the planned arrangements, if the system is successfully implemented and maintained and if the system aligns with the organisations asset management strategy, policy and objectives. [**68**]

Records

The organisation maintains an effective recording system of documents that are legible, identifiable and traceable.

Management Review

The top management of the organisation reviews the asset management system at predetermined intervals, varying according to its complexity, to ensure that the operation of the system is continuing suitably, adequately and effectively. The need for change may arise at these reviews and this may include the change of the asset management policy, strategy and objectives.

1.2 Computerised Maintenance Management Systems

Kelly [**121**] states that the utilisation of information is crucial in creating a competitive advantage in the current business environment. He further states that the mere ownership of the latest technology serves as only the entry level qualification and that the best-performing manufacturing organisations make use of computing to perform high quality processes.

CMMS's is one of the outcomes of this need for an organisation to expand its informational dimension. Wireman [**67**] argues that there is a sufficient flow of data in any organisation to justify the use of a computerised system. A CMMS is used to aid the asset management function of an organisation in the collection, processing and the analysis of maintenance data.

The improvement of these systems is a continuous process and the business functions of a CMMS are digitalising most of the information and decisions previously taken by operators.

1.3 Total Productive Management

Tsuchiya [**122**]define total productive maintenance (TPM) as a system that is designed to maximize equipment effectiveness improving overall efficiency by establishing a comprehensive productive-maintenance system covering the entire life of the equipment, spanning all equipment-related fields (planning, use, maintenance, etc.) and, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small-group activities.

TPM is synonymous with the concept of JISHU HOZEN (or autonomous maintenance) [**123**,**124**]. Scheller [**124**] regards this as the smaller, more routine, maintenance activities which the operator himself can perform to improve equipment performance. In embracing this concept, the maintenance personnel have more time to focus on activities that adds value to the operations of the organisation.

Seiichi Nakajima [**125**], widely known as the father of TPM [**126**], teaches the principles of TPM according to five pillars:

1. Adopt improvement activities designed to increase the OEE by attacking the six losses;
2. Improve existing planned and predictive maintenance systems;
3. Establish a level of self-maintenance and clearing carried out by highly trained operators;
4. Increase the skills and motivation of operators and engineers by individual and group development; and
5. Initiate maintenance prevention techniques including improved design and procurement.

The result of implementing these five pillars is a set of company-wide performance standards that is world class. Nakajima [**127**] notes that the TPM output measures are based on the production, quality, cost, delivery, safety (health and environment) and morale (PQCDSM) of the organisation. The fundamental measure of improvement according to TPM is that of OEE. [**127**] OEE is discussed in section 2.7.1.3 along with other asset related performance metrics.

Venkatesh [**128**], in further research, produces a set of fundamental pillars (as seen in Figure 54 to illustrate the principles of TPM.

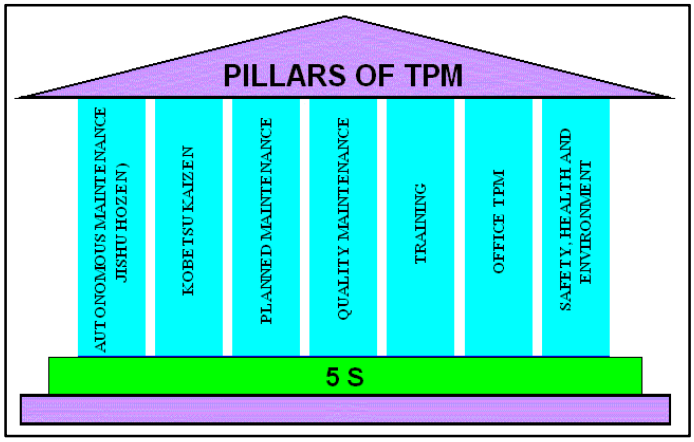


Figure 54 - TPM Fundamentals, adopted from Venkatesh [128]

Venkatesh [**128**] states that the TPM pillars rest on the foundation of the 5-s principles of housekeeping (see Figure 55) and that these practices should be in place before attempting to implement TPM.

Japanese Term	**English Translation**	**Equivalent 'S' term**
Seiri	Organisation	Sort
Seiton	Tidiness	Systematise
Seiso	Cleaning	Sweep
Seiketsu	Standardisation	Standardise
Shitsuke	Discipline	Self - Discipline

Figure 55 - 5-s Principles of Housekeeping, adopted from Wilmott [69]

The fundamental pillars include: [**128**]

- Jishu Hozen – defined earlier;
- Kobetsu Kaizen – a process of continuous improvement;
- planned maintenance – the scheduling of maintenance activities to ensure trouble free equipment;
- quality maintenance – a systematic approach towards a zero defect environment; [**129**]
- training – ensuring multiple- and highly skilled personnel with high moral;
- office TPM – improve productivity and efficiency in the administrative functions and aids in the identification and elimination of waste;
- safety, health and environment – nullify any opportunities that personnel may get hurt and abolish environmental risks.

The implementation of these principles ensures that an organisation remains focussed on continuously improving its operations of their asset structure.

1.4 Reliability-Centered Maintenance

Moubray [**66**] defines RCM as a process used to determine what must be done to ensure that any physical asset continues to do what its users wants it to do in its present operating context.

RCM establishes a rigorous framework within the maintenance capacity of an organisation for the anticipation, identification, and development of pro-active work processes directed at the maintenance of the full system functions. [**80**]

The RCM process involves the asking of the following seven questions (also called the seven essential elements) about the asset or system under review: [**66**,**80**,**73**]

1. Define assets, systems and required functions. Identify desired standards of performance of the asset in its operating context;
2. what ways can the asset fail to perform its required function;
3. what causes each functional failure;
4. what happens when each failure occurs;
5. what are the failure consequences;
6. what can be done to predict or prevent each failure; and
7. what should be done if appropriate pro-active action is not found.

A brief collaboration of the underlying principles of these questions is made in the following sections.

Functions and Performance Standards

The first step in the development of a RCM environment is to determine what exactly is required of the system. This includes: [**66**]

- primary - the purpose for the existence of the asset;
- secondary - safety, control, containment, structural, etc.;
- protective [**73**] - predetermined devices allocated to an asset that warns operators of errors and requirements; and
- capability – the ability of the asset to perform the required tasks.

Conducted correctly, this process would take approximately a third of the time required for the RCM analysis. [**66**]

Failure Modes, Effects, and Criticality Analysis

Formerly known as failure modes and effects analysis (FMEA) [**130**] the failure modes, effects, and criticality analysis (FMECA) is a pre-failure analysis to identify, prioritise, and implement corrective action to prevent reliability problems that could potentially threaten operation. [**80**]

The only occurrence that could stop an asset from performing at its required level is a failure. In order to avoid a failure, the user should be aware of the circumstances that amount to a failure as well as the events that could lead to a failure. A failure mode is what happens as opposed to what caused it to happen and the effects are what would happen should the asset fail. [**73**]

The only problem with RCM is that it found to be too time consuming and expensive [**120**]. This led to the development of streamlined-RCM, which uses the Pareto principle (20/80) [**80**] for analysis purposes and provides a risk priority number (RPN) calculated as follows:

$$\boldsymbol{Risk\ Prioirity\ Number} = \boldsymbol{detectability}\ (\boldsymbol{D})\ \boldsymbol{x}\ \boldsymbol{severity}\ (\boldsymbol{S})\ \boldsymbol{x}\ \boldsymbol{occurrence}\ (\boldsymbol{O}) \quad \text{... Equation 27}$$

Pro-active Tasks

The assets identified through the RPN method that require privilege from a maintenance perspective are subjected to the following pro-active (similar to preventive maintenance) tasks:

- scheduled restoration tasks;
- scheduled discard tasks ; and
- scheduled on-condition tasks.

The completion of the scheduling activities enables the organisation to effectively commence the required activities for the RCM process.

This concludes the additional informational required on this subject and thus the literature required in this thesis.

B. Appendix 2: Sensitivity Analysis

Appendix B provides the outcomes of the sensitivity analysis conducted to test the rigidity of the AMVI. Each of the elements is tested, in isolation, for the maximum, minimum and expected values to ensure that the outcomes from customers (in Chapter 7) are representative of the associated inputs.

2.1 AMVI Element: Cost Reduction

The AMVI is tested for the CROI's of the following situations: (see Figure 56)

- 2001 – the CROI (488.89%) exceeds the ceiling value and is awarded a maximum contribution to the AMVI of 3.99;
- 2002 – the CROI (151.52%) is larger than 0 but smaller than the ceiling value of 200% which leads to a contribution of 3.02 to the AMVI;
- 2003 – the CROI (-66.67%) is smaller than 0 but still larger than the extreme minimum and is represented by a value of -1.33 on the AMVI; and
- 2004 – the CROI (-222.22%) is smaller than the extreme minimum (-200%) and is represented by a value of -3.99 on the AMVI.

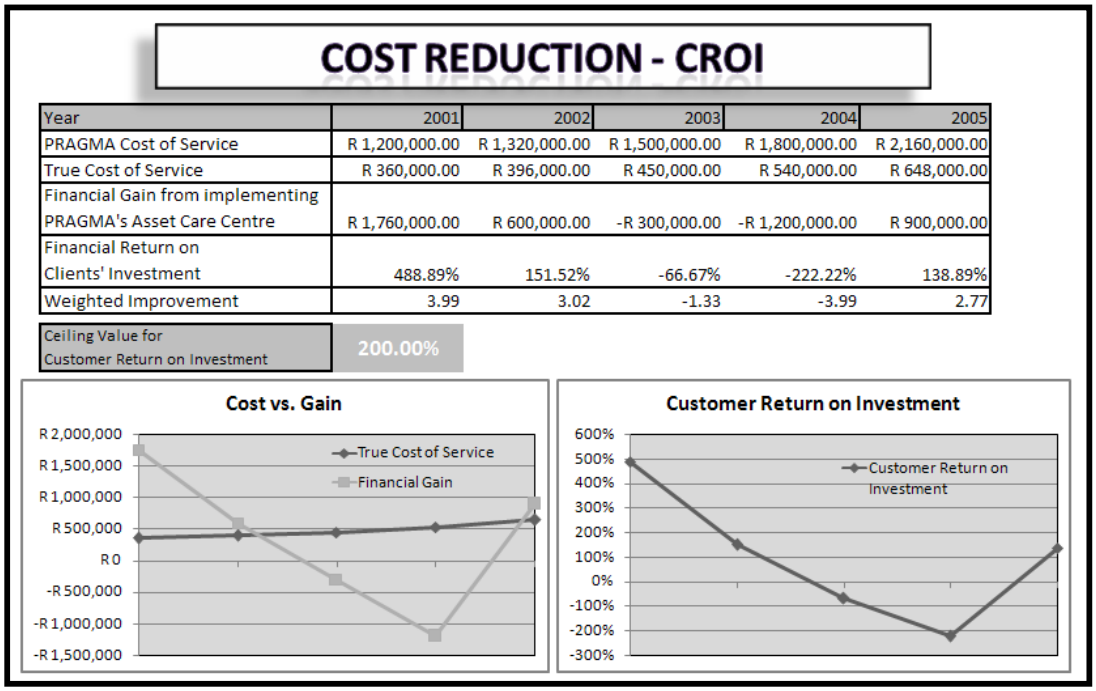


Figure 56 - Sensitivity Analysis: Cost Reduction

2.2 Asset Performance Improvement

The asset performance improvement element is tested under the following circumstances: (see Figure 57)

- The baseline value is set at 54% and the target values are at a constant value of 65% except for 2001;
- 2000 – the achieved value (54%) is similar to the baseline value, resulting in a 0% (or 0)contribution to the AMVI;
- 2001 – the achieved value (68%) exceeds the target value (60%) which results in a contribution of 100% (or 2.6) to the AMVI;
- 2002 – the achieved value (60%) is less than the target value (65%) but more than the baseline value. This equates to a weighted change of 54.55% (or contribution of 1.42) to the AMVI; and
- 2003 – the achieved value (50%) is less than the baseline value but larger than the extreme minimum (43%), resulting in a weighted change of -36.36% (or contribution of -0.95 to the AMVI).

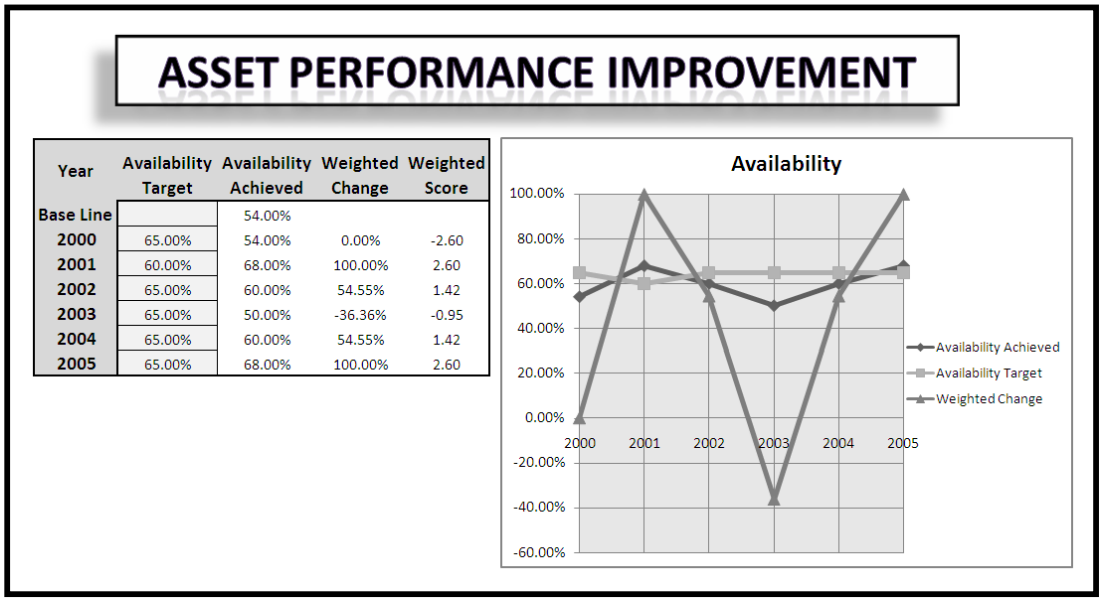


Figure 57 - Sensitivity Analysis: Asset Performance Improvement

2.3 AMVI Element: Customer Satisfaction

The customer satisfaction element cannot adopt values which are above 100% and below 0%. The contribution of the element is dependent directly on the outcome of the questionnaire. The only variation on the normal is if a KPI is neglected from the calculations, as is the case for tools and technology in the example (see Figure 58).

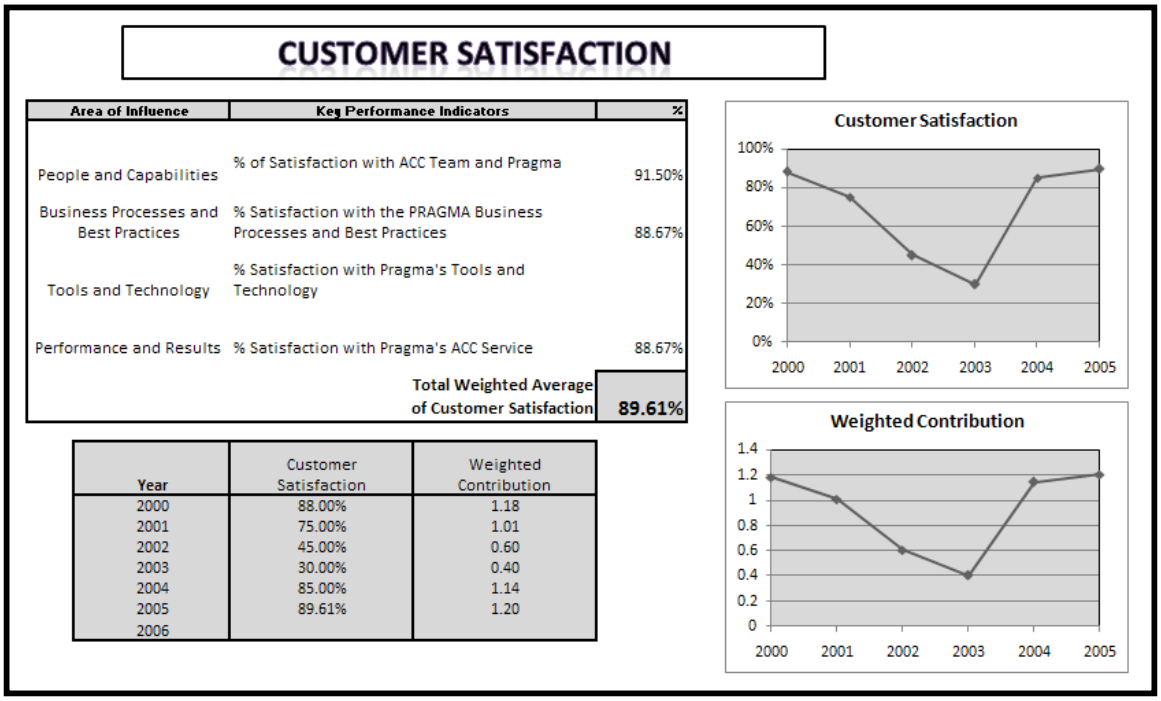


Figure 58 - Sensitivity Analysis: Customer Satisfaction

2.4 AMVI Element: Asset Management Maturity

The asset management maturity element of the AMVI is tested in this section. Different values are fed into the model to see whether a feasible output is obtained. The values and corresponding outputs are presented in the following: (see Figure 59)

- 2000 – 2001: the baseline value of 1.2 is used with a target set at 1.8. The obtained value is chosen to be 2 which provides a 100% attainment and a value of 1.284 to the AMVI;
- 2001 – 2002: the baseline value (the obtained value from the previous period) is 1.8 and the target is set at 2.4. A value of 2.2 is obtained represented by a 50% percentage attainment and a value of 0.642 on the AMVI;
- 2002-2003: the baseline value is 2.2 and the target value is set at 2.5. A value of 1.8 is obtained which is smaller than the baseline and extreme minimum value (1.9) equating to a percentage attainment of -100% and a contribution of -1.284 to the AMVI; and
- 2003-2004: the baseline value is 1.8 and the target is set at 2.1. A value of 1.7 is obtained which is smaller than the baseline value but larger than the extreme minimum

value (1.5). This results in a percentage attainment of -33.33% and a contribution of -0.428 to the AMVI.

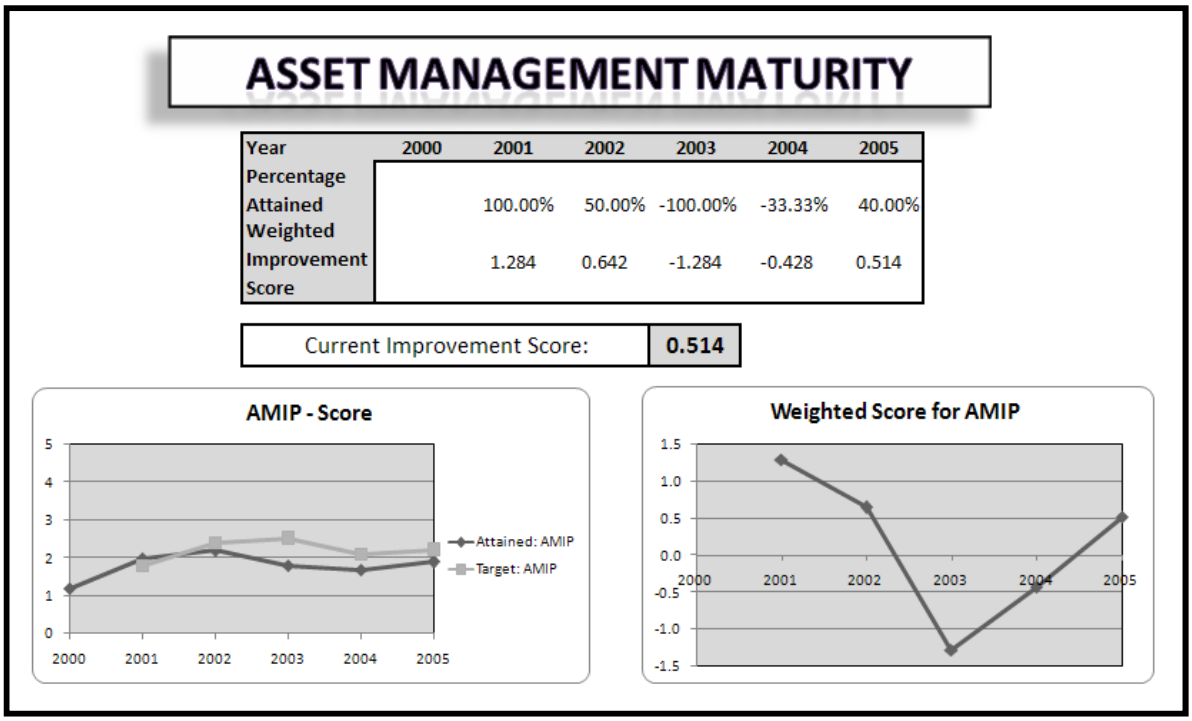


Figure 59 - Sensitivity Analysis: Asset Management Maturity

2.5 AMVI Element: Risk Reduction

This element is subjected to both the reduction of KPI's (due to the applicability of the risks identified) and changes in values (see Figure 60). These constraints are tested under the following circumstances:

- The insurance risk is marked as "N/A" and does not appear on the outcome of this exercise;
- The baseline values for the SHE, financial and legal and statutory risks are 76%, 80% and 88% and the target values are 80%, 90% and 95% respectively; and
- Figure 60 illustrates the different values which each of these risks can obtain and then provides a combined outcome in the "Weighted Risk Rating" column.

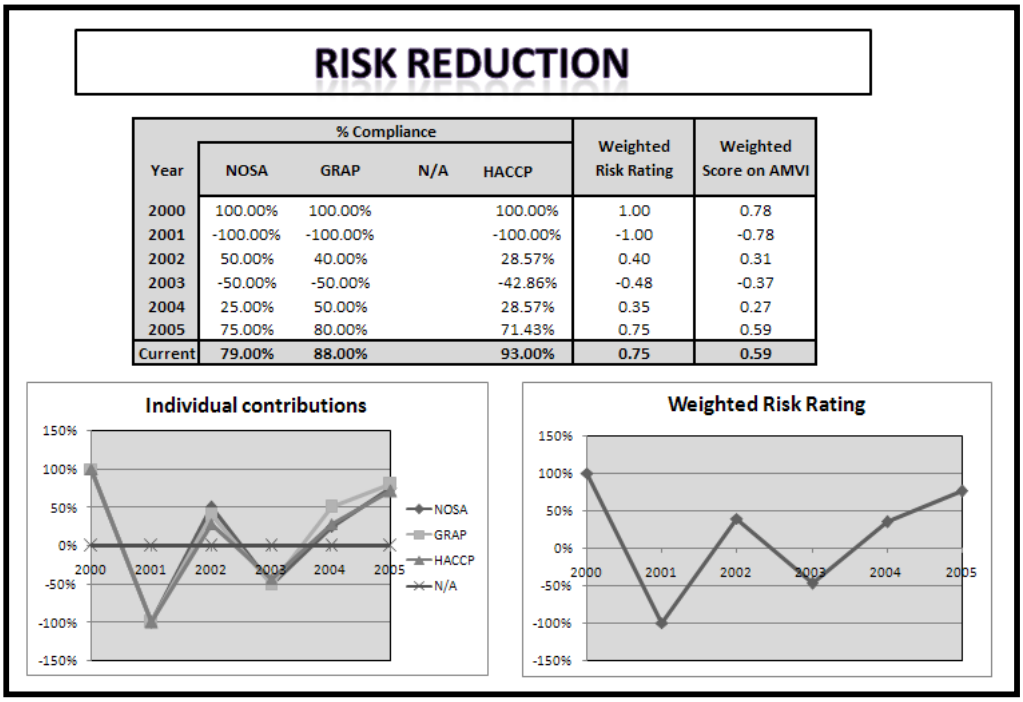


Figure 60 - Sensitivity Analysis: Risk Reduction

C. Appendix 3: Customer Results

Appendix C represents the elements of each of the customers of Pragma on whom the AMVI is applied (see Chapter 7).

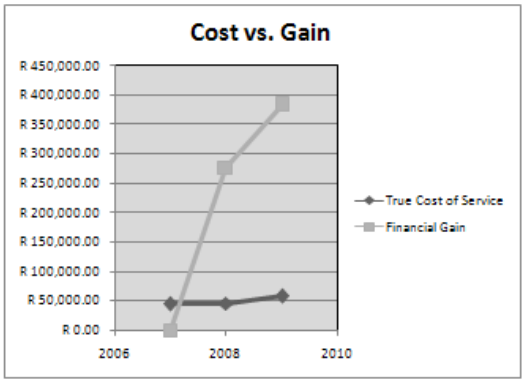
3.1 Customer A: Juice Manufacturer

3.1.1 Cost Reduction

COST REDUCTION

Year	2006	2007	2008	2009	2010
PRAGMA Cost of Service		R 148,051.74	R 153,376.92	R 190,257.19	
True Cost of Service		R 44,415.52	R 46,013.08	R 57,077.16	
Financial Gain from implementing PRAGMA's Asset Care Centre			R 277,291.84	R 382,890.94	
Financial Return on Clients' Investment			602.64%	670.83%	
Weighted Improvement			3.99	3.99	

Ceiling Value for Customer Return on Investment	200.00%



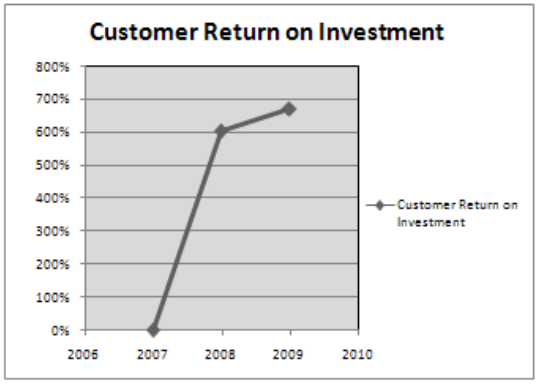
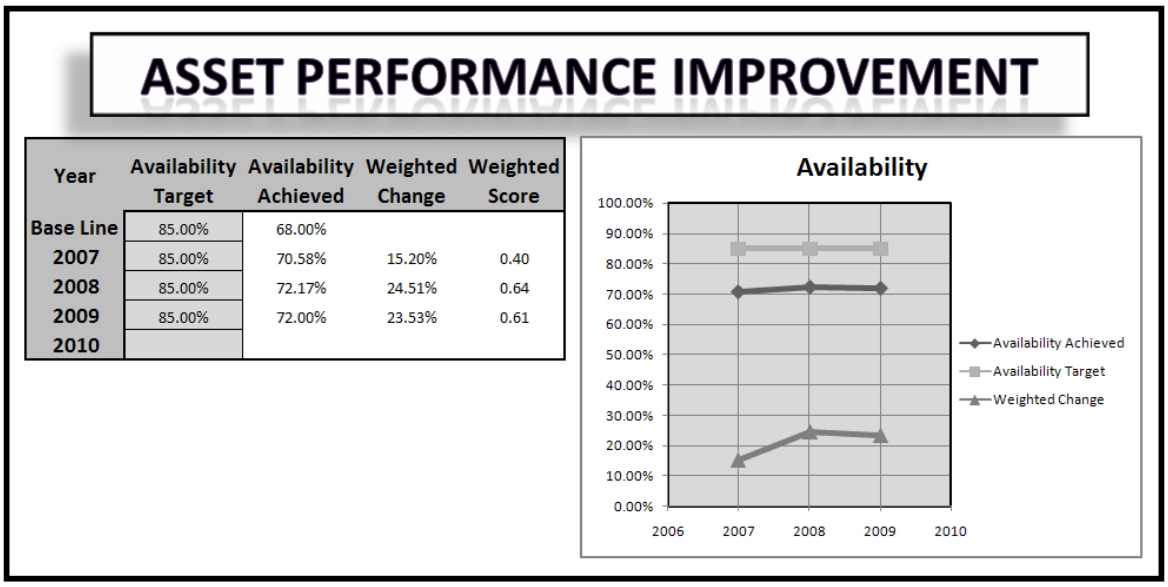


Figure 61 - Customer A: Cost Reduction

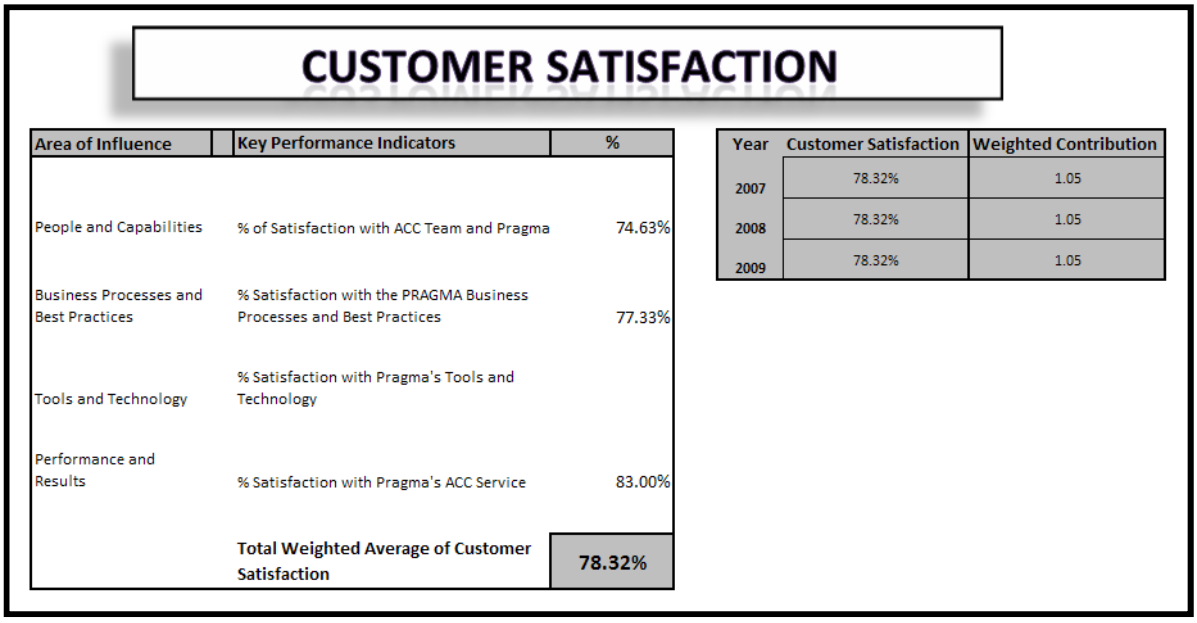
3.1.2 Asset Performance Improvement



Year	Availability Target	Availability Achieved	Weighted Change	Weighted Score
Base Line	85.00%	68.00%		
2007	85.00%	70.58%	15.20%	0.40
2008	85.00%	72.17%	24.51%	0.64
2009	85.00%	72.00%	23.53%	0.61
2010				

Figure 62 - Customer A: Asset Performance Improvement

3.1.3 Customer Satisfaction



Area of Influence	Key Performance Indicators	%
People and Capabilities	% of Satisfaction with ACC Team and Pragma	74.63%
Business Processes and Best Practices	% Satisfaction with the PRAGMA Business Processes and Best Practices	77.33%
Tools and Technology	% Satisfaction with Pragma's Tools and Technology	
Performance and Results	% Satisfaction with Pragma's ACC Service	83.00%
	Total Weighted Average of Customer Satisfaction	**78.32%**

Year	Customer Satisfaction	Weighted Contribution
2007	78.32%	1.05
2008	78.32%	1.05
2009	78.32%	1.05

Figure 63 - Customer A: Customer Satisfaction

3.1.4 Asset Management Maturity

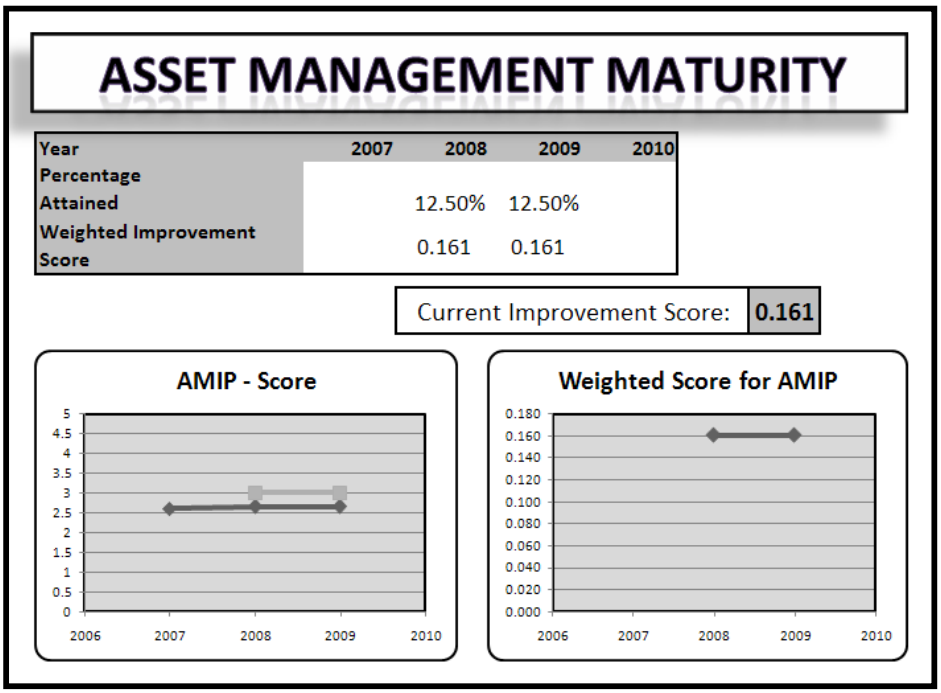


Figure 64 - Customer A: Asset Management Maturity

3.1.5 Risk Reduction

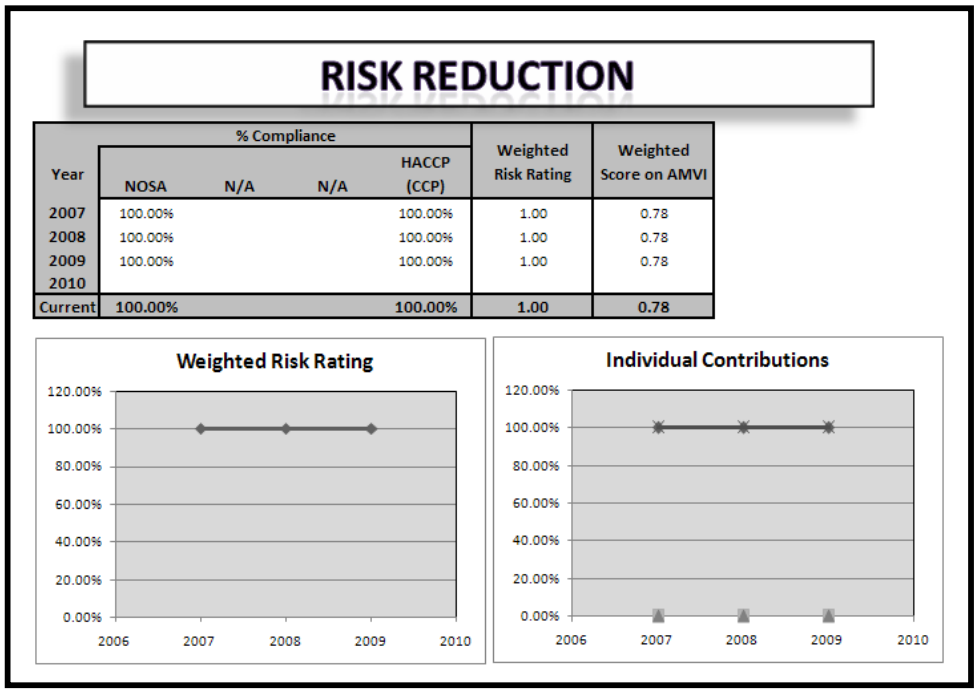


Figure 65 - Customer A: Risk Reduction

3.2 Customer B: Cable Manufacturer

3.2.1 Cost Reduction

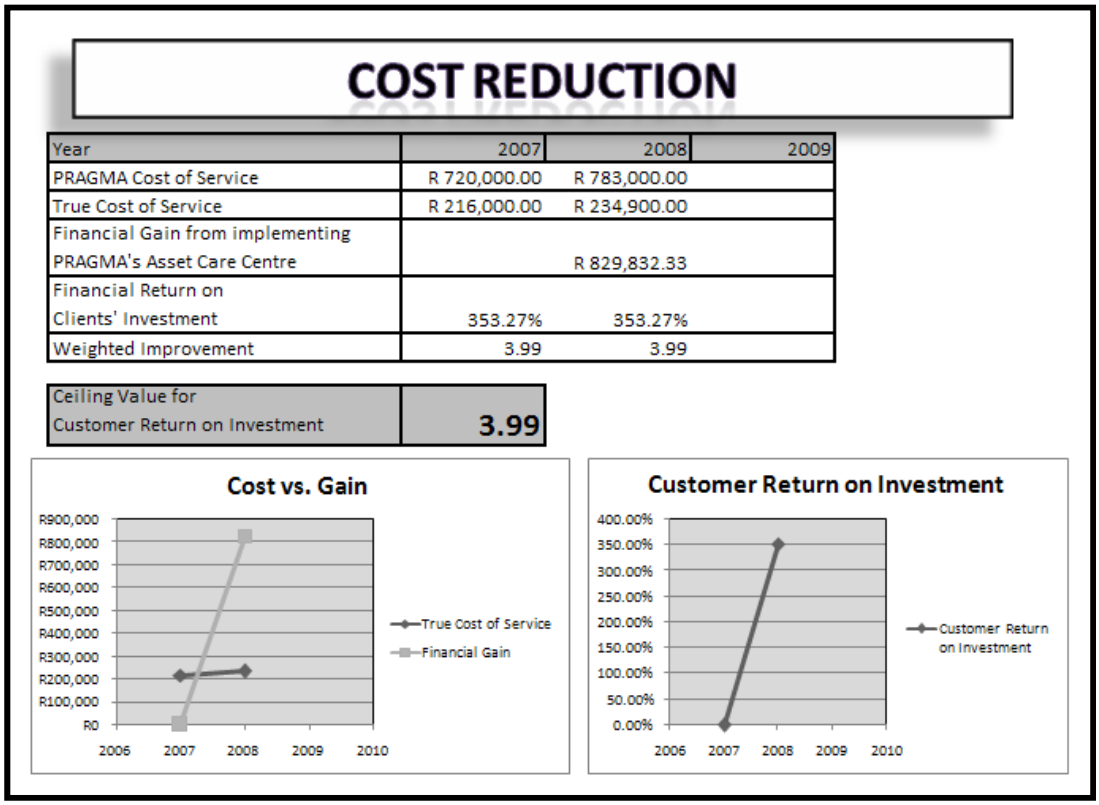


Figure 66 - Customer B: Cost Reduction

3.2.2 Asset Performance Improvement

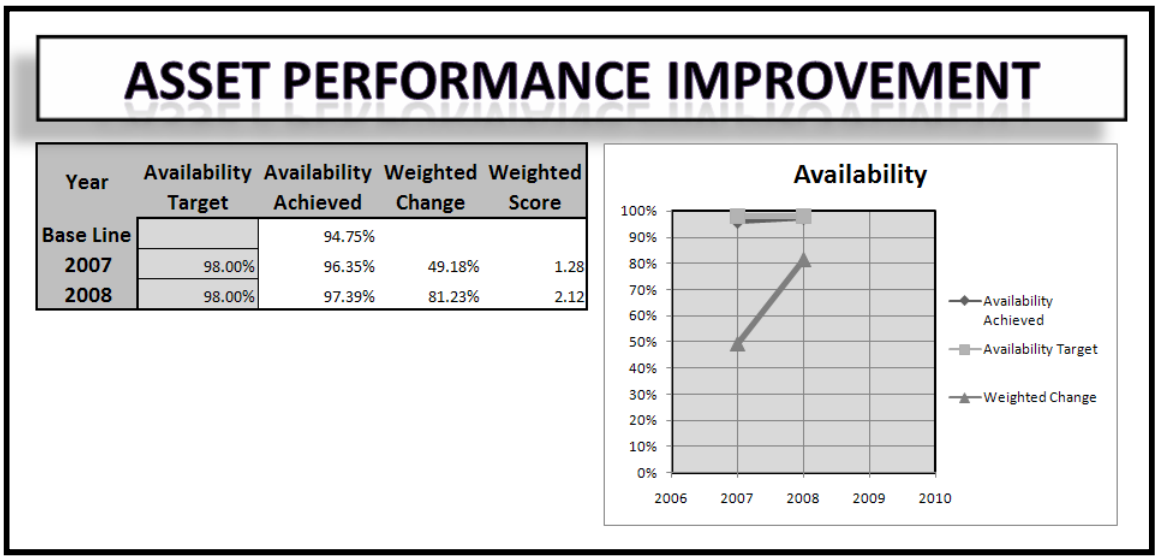


Figure 67 - Customer B: Asset Performance Improvement

3.2.3 Customer Satisfaction

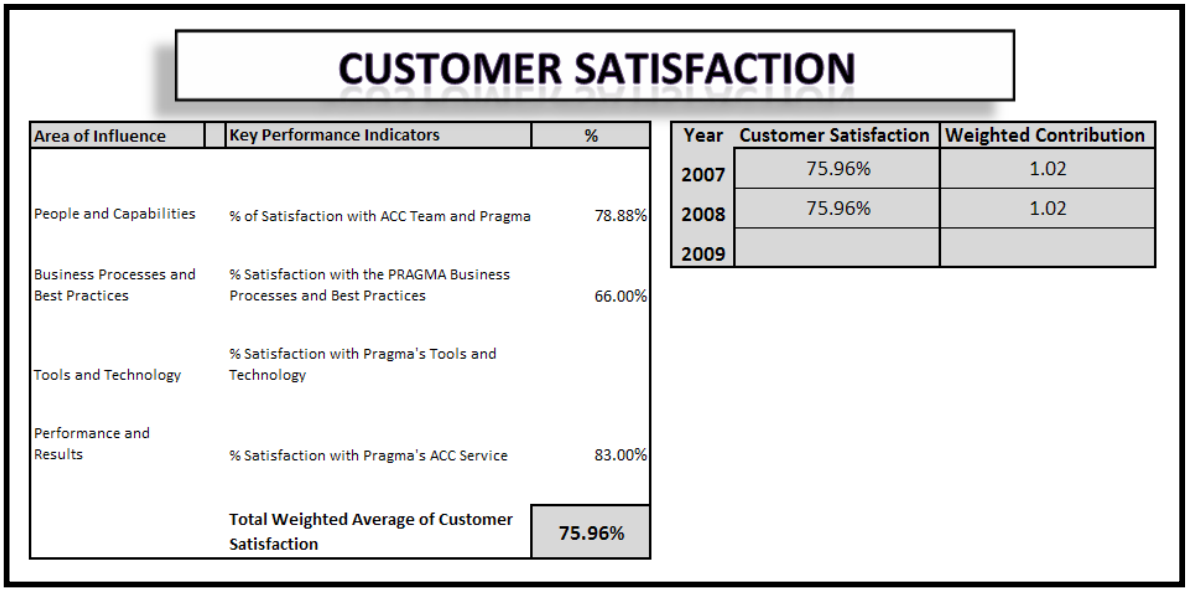


Figure 68 - Customer B: Customer Satisfaction

3.2.4 Asset Management Maturity

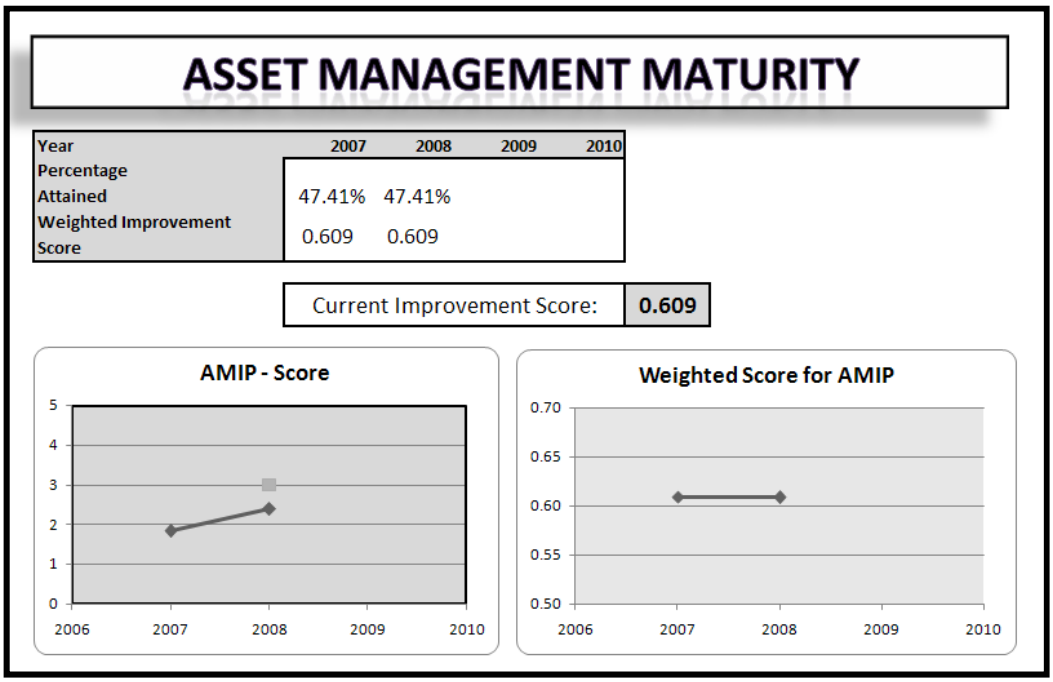


Figure 69 - Customer B: Asset Management Maturity

3.2.5 Risk Reduction

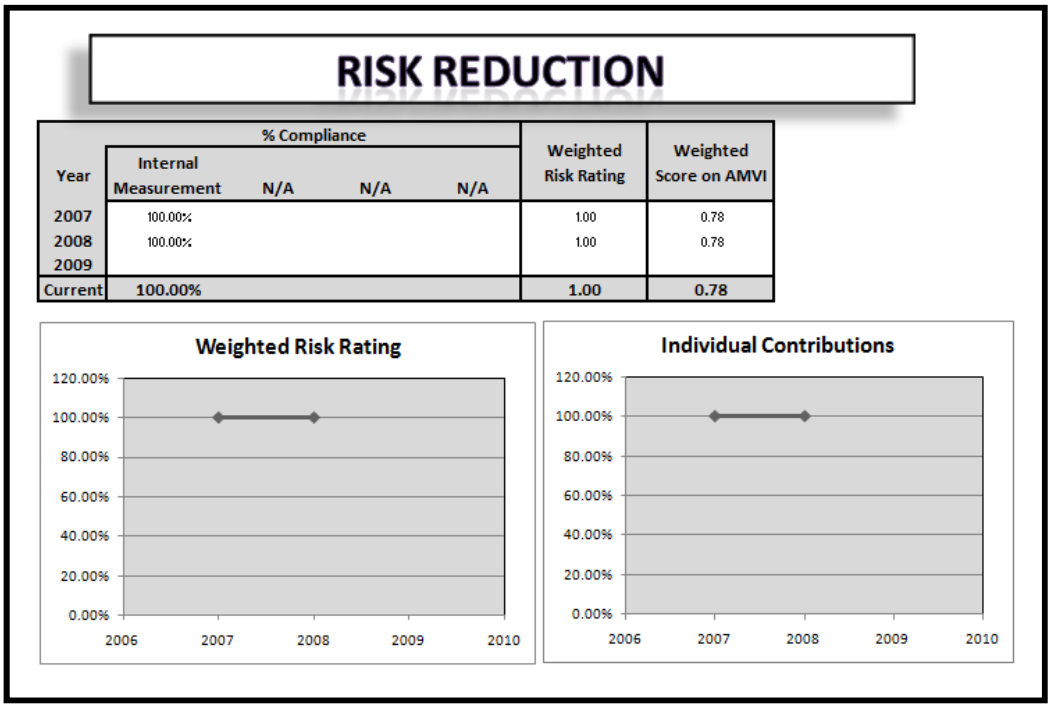


Figure 70 - Customer B: Risk Reduction

3.3 Customer C: State Hospital

3.3.1 Manpower Utilisation

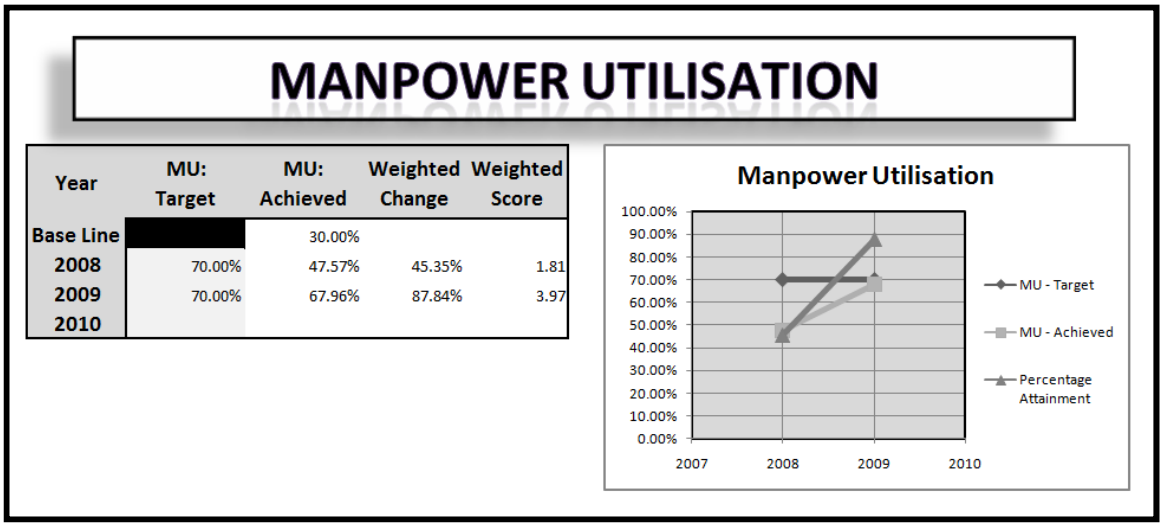


Figure 71 - Customer C: Manpower Utilisation

3.3.2 Schedule Attainment

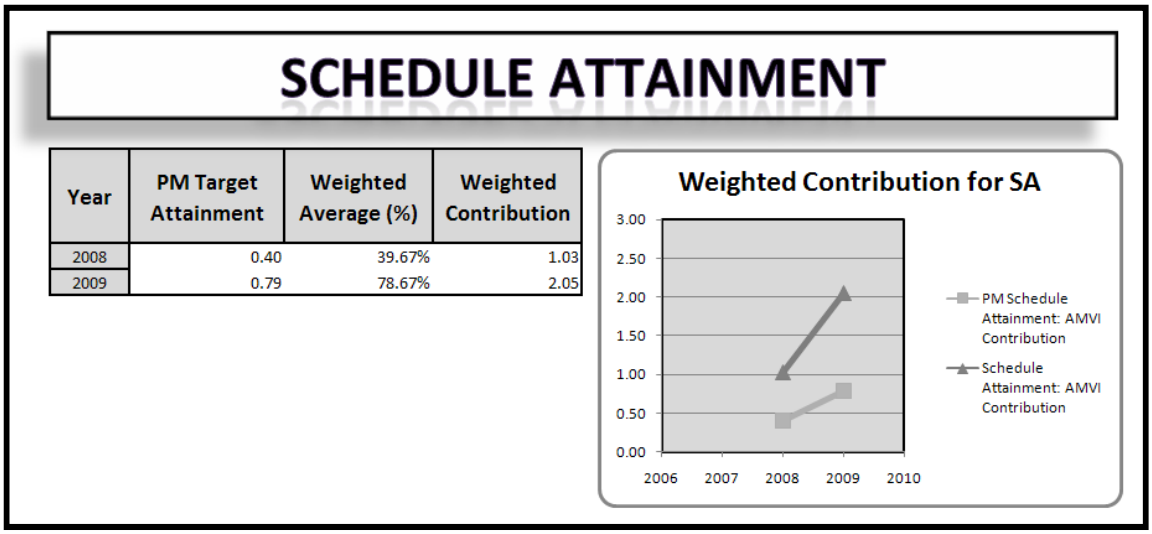


Figure 72 - Customer C: Schedule Attainment

3.3.3 Customer Satisfaction

CUSTOMER SATISFACTION

Area of Influence	Key Performance Indicators	%
People and Capabilities	% of Satisfaction with ACC Team and Pragma	87.25%
Business Processes and Best Practices	% Satisfaction with the PRAGMA Business Processes and Best Practices	77.33%
Tools and Technology	% Satisfaction with Pragma's Tools and Technology	66.00%
Performance and Results	% Satisfaction with Pragma's ACC Service	83.00%
	Total Weighted Average of Customer Satisfaction	**78.40%**

Year	Customer Satisfaction	Weighted Contribution
2008	78.40%	1.05
2009	78.40%	1.05

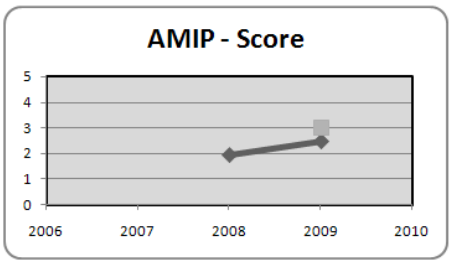
Figure 73 - Customer C: Customer Satisfaction

3.3.4 Asset Management Maturity

ASSET MANAGEMENT MATURITY

Year	2007	2008	2009
Percentage Attained		50.70%	50.70%
Weighted Improvement Score		0.650	0.651

Current Improvement Score:	0.651



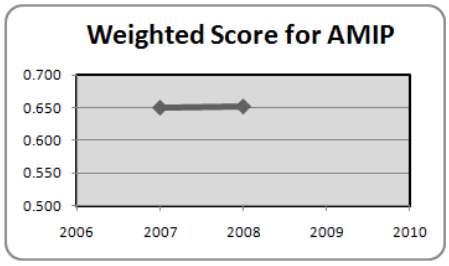


Figure 74 - Customer C: Asset Management Maturity

3.3.5 Risk Reduction

Not Applicable