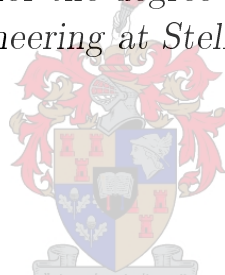


A Critical Success Factor Model for Asset Management Services

by

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December 2014

Declaration

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Date: December 2014

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Abstract

A Critical Success Factor Model for Asset Management Services

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December 2014

Business-to-business services relating to physical asset management are playing an increasingly important role in industry. This is in the midst of the current pressures which asset owning organisations are experiencing in realising optimal value from their assets. The pursuit of understanding and complying with asset management standards such as ISO 55000 as well as the potential value to be gained from successful and sustainable business relationships contributes towards the importance of these services.

The problem is that there is little or no evidence regarding the critical success factors for collaborating successfully in asset management services. The study identifies these critical success factors and demonstrates how the factors can differ between role players, industries, global regions and service types. A decision support model is developed providing the asset management community with access to the critical success factors for decision-making purposes.

Based on the synthesis from internationally conducted *Delphi*- and survey studies it is found that the continued and sustained commitment from the asset owning organisation's senior management in support of the asset management service is the most critical factor for a successful asset management service partnership. Open and effective communication is also highlighted as being critical, while it is important to have a process in place to improve the service continuously. Laboratory and field testing confirm the validity of the decision support model for facilitating the decision-making process to improve asset management services, and in addition it also formalises the commercial and contracting processes relating to these services.

Uittreksel

'n Kritiese Suksesfaktormodel vir Dienste in Batebestuur

("A Critical Success Factor Model for Asset Management Services")

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Besigheid-tot-besigheidsdienste met betrekking tot fisiese batebestuur speel 'n toenemende belangrike rol in die industrie. Dit is te midde van die druk wat batebesittende organisasies tans ondervind om optimale waarde uit hul fisiese bates te verkry. Die strewe na beter begrip en om te voldoen aan batebestuurstandaarde soos ISO 55000, asook die potensiele waarde wat verkry kan word uit suksesvolle en volhoubare besigheidheidsvennootskappe, dra by tot die belangrikheid van hierdie dienste.

Die probleem is daar bestaan min of geen bewyse rakende die kritiese suksesfaktore vir suksesvolle samewerking in batebestuurdienste. Die studie identifiseer die kritiese suksesfaktore en toon aan hoe hierdie faktore kan verskil tussen rolspelers, industrieë, wêreldstreke en dienstipes. 'n Besluitnemingsmodel is ontwikkel wat die batebestuurgemeenskap toegang gee tot die kritiese suksesfaktore vir besluitnemingsdoeleindes.

Gebaseer op die sintese van internasionale *Delphi*- en opnamestudies is daar bevind dat die mees kritieke faktor vir 'n suksesvolle vennootskap in batebestuursdienste die voortgesette en volgehoue toewyding deur die bate-besittende organisasie se senior bestuur, ter ondersteuning van die batebestuursdiens, is. Doeltreffende en openhartige kommunikasie is ook uitgewys as krities, terwyl dit belangrik is om 'n proses te volg om die diens voortdurend te verbeter. Laboratorium- en praktyk toetsing het bevestig dat die besluitnemingsmodel geldig is vir die fasilitering van die besluitnemingsproses om batebestuursdienste te verbeter asook vir die formalisering van die kommersiële en kontraktuele prosesse wat verband hou met hierdie dienste.

Dedication

Aan my ouers, Hannes en Lizan

Was du ererbt von deinen Vätern hast, erwirb es, um es zu besitzen
“Wat jy van jou vaders erf, moet jy jou eie maak, of dit bly ’n toevallige reg, en is nie joune nie”
– Johann Wolfgang von Goethe (1749-1832)

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Papers and Publications

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Acronyms

AM	Asset Management or Physical Asset Management
AMS*	Asset Management Services
ANOVA	Analysis of Variance
B2B	Business-to-Business
B2G	Business-to-Government
BSI	British Standards Authority
CMMS*	Computerised Maintenance Management System
CRINE	Cost Reduction in the New Era
CSF*	Critical Success Factors
DSM	Decision Support Model
DSMams	Decision Support Model for Asset Management Services

DSS*	Decision Support Systems
EAMS*	Enterprise Asset Management System
ERP	Enterprise Resource Planning
ESS	Electrical Support Services
GDP	Gross Domestic Product
GFAMAM	Global Forum for Maintenance and Asset Management
GIS	Geographical Information Systems
IAM	Institute of Asset Management
ICT	Information and Communication Technology
IP	Internet Protocol
IS*	Integrated Solutions
ISO	International Organisation for Standardisation
KPI*	Key Performance Indicators
OEE	Overall Equipment Effectiveness
PSS*	Product-service Systems

RCM	Reliability Centered Maintenance
RFID	Radio-frequency Identification
ROA	Return on Assets
SA	South Africa
SaaS	Software-as-a-Service
SABS	South African Bureau of Standards
SAP PM	SAP Plant Maintenance
SLA	Service Level Agreement
SOX	Sarbanes-Oxley Act of 2002
TPM	Total Productive Maintenance
UK	United Kingdom
USA	United States of America
VAS	Visual Analogue Scale

*For simplification the acronym is used for both singular and plural forms, depending on the context of its use in the text.

Glossary

Adherence

The degree to which a success factor is formally implemented (“in place”) and actively used or followed (“in use”).

Asset

An item, thing or entity that has potential or actual value to an organisation.

Asset Management Services (AMS)

The services which are provided by the service provider in support the coordinated activities of an asset owner to realise value from their assets.

Asset Owner

The organisation who contracts the service provider to provide an AMS to improve the management of the assets they own.

Asset Management or Physical Asset Management (AM)

The coordinated activity of an organisation to realise value from assets (where realisation of value involves the balancing of costs, risks, opportunities and performance benefits).

Critical Success Factors (CSF)

The characteristics, conditions or variables which, when properly sustained, maintained, or managed, can have a significant impact on the success of an intervention.

SAP Enterprise Resource Planning System

An Enterprise Resource Planning (ERP) applications system and management software suite, where SAP Plant Maintenance (SAP PM) refers to the maintenance module of the software.

Sarbanes-Oxley Act of 2002 (SOX)

An act to protect investors by improving the accuracy and reliability of corporate disclosures made pursuant to the securities laws, and for other purposes.

Service Level Agreement (SLA)

An agreement between a service provider and their client which quantifies the minimum quality of the agreed service to meet the client's business needs.

Service Provider

The organisation which provides AMS to an asset owner.

Strata

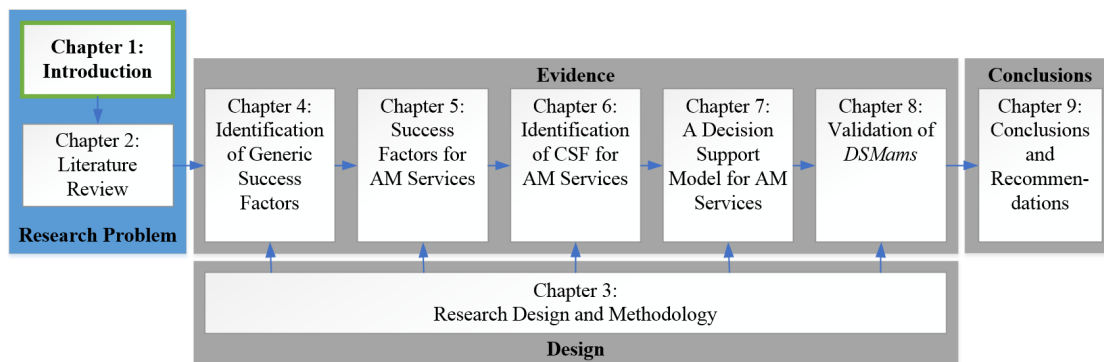
Homogeneous sub-groups of members in a population (singular: stratum).

Chapter 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 objective of this chapter is to provide an introduction to the research undertaken. The chapter commences with the background which leads to the research problem and the research questions. A general indication of the research objectives, design and methodology follows. The chapter concludes with a road map which explains the logic and outline of the remainder of the dissertation.

1.1 Theoretical Background

Industry is on the verge of a new wave in Asset productivity improvement which will be more difficult to achieve than in past initiatives. The challenge facing organisations is the necessity to maintain, and often increase, operational effectiveness, revenue and client satisfaction. Capital, operating and support costs must be reduced simultaneously (Mitchell, 2002, 1). The effective management of assets in support of these pressures is increasingly important in ensuring that business goals are achieved. Asset Management or Physical Asset Management (AM), for the purpose of the research is defined by the International Organisation for Standardisation (ISO) 55001 (International Standards Organisation, 2014a, 13) as:

the coordinated activity of an organisation to realize value from assets (where realization of value involves the balancing of costs, risks, opportunities and performance benefits).

Mitchell (2002, 2) states that opportunities for AM are substantial. Indications are that industry could recover between a third and half of annual maintenance expenditure, increase production and free capital by improving AM. Effective AM remains the single largest business improvement opportunity in the 21st century. In 2005, the size of the asset maintenance industry in the United States of America (USA) was \$1.2 trillion of which \$750 billion was as a direct cost of poor AM (Penrose, 2008, ix). The impact of poor AM is evident from examples such as the Deepwater Horizon disaster (BP [Online], 2011, 11), the Infrastructure Report Card for South Africa (SA) 2011 (South African Institution of Civil Engineering [Online], 2011, 2) and Green Drop Report (Department: Water Affairs, Republic of South Africa [Online], 2011, 8).

The potential benefits of AM are evident from an Aberdeen Group research report. The report focuses on the benefits organisations are gaining by using technology and analytics for predicting asset failures and compares the performance gains for high, average and low performing organisations (Paquin, 2014, 5). The top 20% performers measure 3.5 % unscheduled asset downtime, 89% Overall

Equipment Effectiveness (OEE), gains of 24% on Return on Assets (ROA) and a reduction of 13% in maintenance cost. Table 1.1 shows the comparison in organisations which are average performers and those who are lagging.

AM Maturity	Performance
Best-in-class (Top 20%)	3.5% unscheduled asset downtime 89% OEE +24% ROA vs. corporate plan -13% reduction in maintenance cost
Industry Average (Middle 50%)	8.3% unscheduled asset downtime 83% OEE +4% ROA vs. corporate plan -4% reduction in maintenance cost
Laggard (Bottom 30%)	16.9% unscheduled asset downtime 69% OEE -7% ROA vs. corporate plan +1% reduction in maintenance cost

Table 1.1: Top performing organisations gain high performance benefits (Adopted from Paquin (2014, 5))

The benefits which organisations are gaining from performing AM well are significant. Organisations which are not investing in their AM capabilities, potentially stand to lose ground against their counterparts who are investing in AM.

Management literature is unanimous in advocating the integration of services into core product offerings. Historically most of the value of a product was added from the production process which transformed raw material to a useful product. Today, value comes from technological improvement, styling, branding and other attributes that only services can create (Quinn *et al.* 1990, 58; Gadiesh and Gilbert 1998, 140; Wise and Baumgartner 1999, 135). Grönroos (2007, 53) defines services in general by three characteristics:

1. Services are processes consisting of activities or a series of activities.
2. Services are at least to some extent produced and consumed simultaneously.

3. The client participates as a co-producer in the service production process at least to some extent.

The importance of services is reflected in a World Economic Forum report stating that over 70% of the 137 listed countries have service sectors contributing towards more than 50% of their respective Gross Domestic Product (GDP). In South Africa services represent 66% of the GDP (Schwab, 2013, 55).

Servitisation is the term used for offering integrated packages of client-focused combinations of products, services, support, self-service and knowledge (Vandermerwe and Rada, 1988, 316). The motive for delivering services or integrating services into product offerings (servitisation) is threefold:

Economics Substantial revenue can be earned with services (T. Knecht and Weber, 1993, 1), services have higher margins than products (Economist, 2000) and services provide annuity revenue resistant to economic cycles (Oliva and Kallenberg, 2003, 160).

Services Demand The narrower definition of core competencies and the increase in technological complexity is creating a demand for more services.

Competitiveness Services are less visible and more labour-dependent, making them more difficult to imitate (Oliva and Kallenberg, 2003, 160).

The successes that some of the world's largest companies are achieving as a result of making the transition to services, instead of remaining with their traditional manufacturing business models is proof of the benefits and potential of servitisation. (White *et al.*, 1999, 63-89). The most prominent example is that of the Xerox Corporation (\$21.4 billion revenue in 2013 (Google Finance [Online], 2014)), which in 1994 moved from being a manufacturer of office equipment to a *document company* offering comprehensive document management services to their clients. Another example of successful servitisation is Rolls-Royce aerospace (£15.5 billion revenue in 2013 (Rolls Royce [Online], 2013)), which made the transition from selling engines to providing a *power by the hour* service. The service includes a fixed engine maintenance cost over an extended period and is based on a

performance-based contract, where compensation is linked to the product (engine) availability (Cohen 2007, 3; Johnstone *et al.* 2009).

Although servitisation is happening in most industries, previous research mostly focused on the manufacturing and capital goods industries (Baines *et al.*, 2009, 547). The services scholarship for other industries is sparse. Services literature in the capital goods industry reveals close similarities between capital goods services and AM activities (Oliva and Kallenberg 2003, 160; Windahl and Lakemond 2010, 1278; Holmström *et al.* 2010, 675). Traditionally, services in the field of AM were limited to transaction-based activities orientated at the asset (Campbell 1995, 19; Bertolini *et al.* 2004, 774). Industry and technological changes are leading towards more opportunities for relationship-based and AM process orientated services in the field of AM. These changes are:

- The shift from maintenance management to whole life cycle AM (Amadi-Echendu, 2004, 1156)
- The formalisation and industry acceptance of ISO 55000 (and its predecessor PAS 55) as an AM standard
- The shift from off-the-shelf software to Software-as-a-Service (SaaS) in the enterprise software industry (Cusumano, 2008, 20)
- Enterprise Resource Planning (ERP) vendors and service providers expanding their software with Computerised Maintenance Management System (CMMS) and Enterprise Asset Management System (EAMS) offerings (Hookham, 2010)

With these industrial, technological and economic pressures, service providers and asset owners are partnering or collaborating to more effectively manage the asset owner's assets and to comply with AM standards. This partnering forms part of what is referred to as Asset Management Services (AMS) in this research.

In addition to the business pressures leading to an increase in AMS, partnering has also become of interest to industry as it is recognising the potential value

from successful and sustainable relationships (Barry and Terry, 2008, 228). The purpose of such relationships is to work together in ways which add value to the involved parties (Anderson, 1995, 348). In the AMS context the potential benefits for the service provider are new business opportunities, increased sales volumes, business growth and improvement in their competitive position. The asset owner can expect to gain improved efficiency throughout the scope of their operational processes (Ojanen *et al.*, 2012, 72). A case study shows that improved operational efficiencies, as well as cost and energy savings are gained as a result of improved collaboration in maintenance management service (Ojanen *et al.*, 2010, 5).

In pursuit of gaining the potential benefits, both service providers and asset owners have a vested interest in ensuring that their AMS is successful and sustainable. It is therefore important for them to understand the underlying factors which are critical towards the success of AMS collaboration and partnerships. These so-called Critical Success Factors (CSF) need to be identified for decision-making purposes in support of sustaining successful AMS.

The *CSF approach* can be used to gain an improved understanding of these CSF. The Oxford Dictionary defines success as:

the accomplishment of an aim or purpose,

while Leidecker and Bruno (1984, 24) define CSF as:

those characteristics, conditions or variables that, when properly sustained, maintained, or managed, can have a significant impact on the success of a firm competing in a particular industry.

The CSF approach originates from information system literature (Rockart, 1979, 84), but has subsequently been successfully applied to direct strategies, manage projects and guide the execution of activities (Esteves 2004, 46; Ferguson and Dickinson 1982, 15; Munro and Wheeler 1980, 35; Boynton and Zmud 1984, 18). Goals and CSF are closely related. The advantage of CSF is that they are considered less biased than goals. Goals are usually determined subjectively based on performance or financial objectives, while CSF are effective in making the things

explicit which managers intuitively consider as important in pursuit of achieving their goals (Caralli, 2004, 15).

The success of the CSF approach is evident from case studies conducted by Akkermans and Helden (2002, 35) and Poon and Wagner (2001, 406) both who validated the success of ERP implementations against CSF previously identified by scholars for such implementations. The relevance of the CSF approach is further reflected upon in the number of publications – approximately 270 since 2000 – published on CSF in various fields¹.

1.2 Problem Statement and Research Questions

In the midst of the importance of AM in industry, asset owner tendency to employ AMS to overcome industry pressures, and the potential value to be gained from successful AMS partnerships,

the problem is that there is little or no evidence about the CSF for AMS.

To address the problem, the research focuses on identifying the CSF which are required for collaborating in a successful AMS environment. To achieve the research goal, the following research questions need to be investigated:

- 1. What are the CSF for ensuring successful AMS?**
- 2. Are these CSF different for different role, industry and service strata associated with AMS?**
- 3. What type of model and associated characteristics are required for making the CSF available to the AMS industry?**

By addressing the described problem and answering the research questions there is an unequivocal opportunity for contributing to the theory and practice of the AM and AMS scholarship.

¹Based on a Google Scholar search between 2000 and 2014 with “critical success factor” in the publication title.

1.3 Research Objectives

The dissertation builds upon a series of research objectives to answer the research questions. The objectives allow for systematically conducting the research in the form of more manageable sub-tasks. The objectives are summarised in table 1.2.

Seq.	Objective	Chapter
1.	Establish the fundamentals of AM, services and CSF	2
2.	Determine the underlying strata of AMS	
3.	Contextualise the synergy between AM, services and CSF	
4.	Devise a well-founded research methodology	3
5.	Establish a list of existing (generic) success factors through a study of relevant literature	4
6.	Derive a short list of AMS specific success factors	5
7.	Establish a set of CSF for AMS	6
8.	Contextualise the CSF findings for the different AMS strata	
9.	Construct a generalised model of CSF for AMS	7
10.	Validate the model of CSF for AMS	8
11.	Draw conclusions from the CSF for AMS, strata differences and the generalised CSF model for AMS	9

Table 1.2: Summary of research objectives

Chapter 2 pursues the first three objectives. The first objective is to establish the fundamental concepts of AM, services and CSF scholarships which form the basis of the research. A literature review of the three domains serves this purpose. The second objective is to review the scholarships, for gaining insights into the synergy between AM, services and the underlying strata for the synergy. The third objective is the contextual application of the CSF theory to the AMS synergy.

The objective covered in chapter 3 is to devise a methodical approach for the research. The approach is constructed on the findings of the aforementioned objectives and previous research in CSF to ensure a well founded design and methodology.

The four objectives of chapters 4, 5 and 6 relate to the fieldwork, data collection and analysis activities. In chapter 4 a study of the relevant literature is conducted

for identifying existing, generic success factors and this forms the foundation for the further development of AM success factors. Chapter 5 builds on these findings by eliciting a short list of success factors which are specific to AM. The remaining two objectives are covered in chapter 6. By building on the aforementioned findings, the seventh objective is to establish which of the factors identified in chapter 5 are critical towards the success of AMS. The eighth objective is to contextualise the CSF in terms of different AMS strata. The first two research questions are answered by achieving the seventh and eighth objectives.

Chapter 7 covers the penultimate objective of the research which is to generalise the findings and construct a generalised model of CSF for AMS. The aim with this objective is to answer the third research question. The model is validated in chapter 8. In chapter 9 conclusions are drawn about the contribution of the CSF of AMS, information on strata differences and the model's contribution to industry.

Achieving the objectives will lead to an improved understanding of AMS and the factors responsible for the success in such services. The understanding will firstly benefit service providers, suppliers and consultants who deliver AMS to industry and secondly, asset owners who outsource and contract in AMS. A CSF model will give service providers a decision support basis, consisting of guidelines for the effective implementation and delivery of AMS. For the asset owner it will also provide focus areas, which are important for adding value to their business. And for the service partnership, it will serve as a support framework for improved collaboration and communication.

1.4 Research Design and Methodology Overview

The research is empirical and in the form of a *mixed method exploratory sequential* study using both existing and primary data (figure 1.1). Existing textual data is analysed and used to construct a Delphi study for identifying the success factors for AMS. The outcomes from the Delphi study are used to develop a web-based survey for identifying the CSF for AMS. For the survey, data is collected by means of a web-based questionnaire from a sample of local and international AMS practi-

tioners. The survey results are used as benchmarking data to construct a decision support model of the CSF and the contextual relationships for AMS.

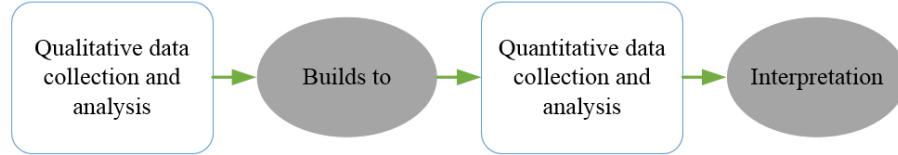


Figure 1.1: Prototypical version of the mixed method exploratory sequential research design (Adopted from Creswell (2013, 69))

1.5 Delimitations and Limitations

In exploring new areas of research it is necessary to state the delimitations and disclose the limitations. The previous sections outline the theoretical position of the dissertation. In this section the delimitations, which are the explicit boundaries for the study are set, and the limitations or conditions outside the researcher's control are stated.

This dissertation focuses specifically on identifying CSF in the field of AMS and should not be confused with CSF for AM or services in general. Furthermore, services constitutes a diverse set of activities and how such activities contribute to the value creation process differs for various services (Hytönen 2005, 16-17; Mathieu 2001, 451). For this research AMS are defined in their broadest sense and are not narrowed down to a specific definition. What is however important is to understand more about the different types of AMS. Specific AMS related strata are included during the data collection phases to study these perspectives.

The concept of *success* is complex. With reference to project management success, Dvir *et al.* (2003) states: “research into project success has not converged to a standard approach. Success means different things to different people.” Pinto and Slevin (1988, 67) corroborates: “there are few topics so frequently discussed and yet so rarely agreed upon as success.” In previous studies of CSF some researchers

quantify success (Dvir *et al.* 1998, 918; Shenhar *et al.* 2002, 166), while others define it as part of CSF (Fairchild *et al.* 2004, 64; Dexter 2010, 344; Stankovic *et al.* 2013, 1665). For the purpose of this study success is defined according to the work by Stankovic *et al.* (2013, 1665) and Dexter (2010, 349), where AMS success is based on the perception of the parties involved in the service. This will prevent unnecessary complexity and potential statistical insignificance due to the exploratory nature of this study.

This dissertation will be limited to the identification of CSF. The CSF approach according to Rockart (1981) defines sources, dimensions and hierarchies for categorising CSF for practical use in specific instances. It further refers to performance measures which should support CSF. The aim of this research is to generalise the research findings for application by the wider AMS community. Due to the diversity in AMS it would be impractical to attempt to categorise CSF and define corresponding measures for specific cases of AMS.

A web-survey method is used to collect data from AMS role players. The study aims to collect data from both local and international AMS role players. A key consideration in such an endeavor is time and cost. Although a web survey has the advantages of shorter transmitting time, lower delivery cost, more design options and less data entry time, its disadvantage is the exclusion of respondents who do not have access to the internet (Yan and Fan, 2010, 132). It is not expected that this limitation will adversely affect the study results, since most AMS role players require some form of access to the internet and email to effectively perform the activities of AMS.

An unknown factor in this study is the response rate and sample composition for the survey. Response rates for web surveys are known to be as low as 40% (Görritz, 2006, 65). Notwithstanding, it remains the preferred method for data collection due to the cost and time benefits. A required sample size with sufficient statistical *power* is calculated and specific measures are taken to ensure a sufficient sample size. The sample composition will influence the comparison of CSF for strata sub-groups. Potentially, the sample composition could be insufficient for

analysing additive and factorial effects between strata sub-group responses. This potential shortcoming is addressed as part of the data analysis following the data collection outcome.

This research begins before the AM standard, ISO 55000, is published and will conclude after its release. PAS 55 – the predecessor of ISO 55000 – serves as basis for providing the AM scholarship for the initial research phases. The dissertation content will be reviewed and updated according to the new scholarship from ISO 55000, where it is applicable and adds value to the research outcomes. It is however unknown what the effect, if any, of the ISO 55000 release will have on the perspectives of the Delphi study panel of experts and the web survey sample. Similarly, it is unknown how industry will accept the research findings (based on the scholarship of the PAS 55 era), following the release of ISO 55000 and its new contribution to the AM scholarship.

In summary, the dissertation:

- Focuses on identifying CSF for AMS.
- Does not attempt to quantify AMS success; it is based on the perception of success of the party involved in the AMS.
- Only investigates the identification of CSF.
- Excludes AMS, where stakeholders do not have access to the internet.
- Results are influenced by the survey response rate and sample composition.
- Is influenced by the release of ISO 55000, to an extent which is unknown.

1.6 Dissertation Outline

The first three chapters of the dissertation cover the introduction, background and design of the research. Chapters 4 to 6 follow with the data collection and analysis phases. A model is constructed and validated in chapters 7 and 8 and conclusions

drawn in chapter 9. Figure 1.2 illustrates the road map and chapter sequence of the dissertation.

Chapter 1 In chapter 1 the research is introduced. The theoretical background leads to the problem statement and research questions. The research objectives are stated and an overview of the research design and methodology is given. The research delimitations and limitations are stated and the chapter concludes with the dissertation outline.

Chapter 2 In chapter 2 a comprehensive literature review is done on the scholarship relevant to the research. Three predominant fields are studied in the chapter: AM, services, including servitisation and AMS, as well as the CSF approach. The areas of integration and synergies between these fields are drawn to serve as the basis for the rest of the research process.

Chapter 3 In chapter 3 the research design and methodologies are covered. The chapter begins with a high level overview about the nature of science and methodology. The research approach is described by explaining the philosophical worldview, research design and research methods which are used to study the problem. The chapter concludes with the scientific reasoning contained in the dissertation.

Chapter 4 In chapter 4 existing CSF scholarship is studied and its content analysed to identify a list of generic success factors. As part of the content analysis the relevant literature is identified, followed by thematic analysis. A list of generic success factors is the output from the chapter.

Chapter 5 In chapter 5 the generic success factors are assessed and the factors relevant to the field of AMS are extracted. This is done by conducting a three-round Delphi study. Statistical analysis is used in support of the Delphi study. The chapter concludes with the list of success factors specifically applicable to AMS.

Chapter 6 In chapter 6 the success factors applicable to AMS are rated by a sample of AMS role players to identify a short list of CSF for AMS. This is done through a web survey. The survey results are statistically analysed to

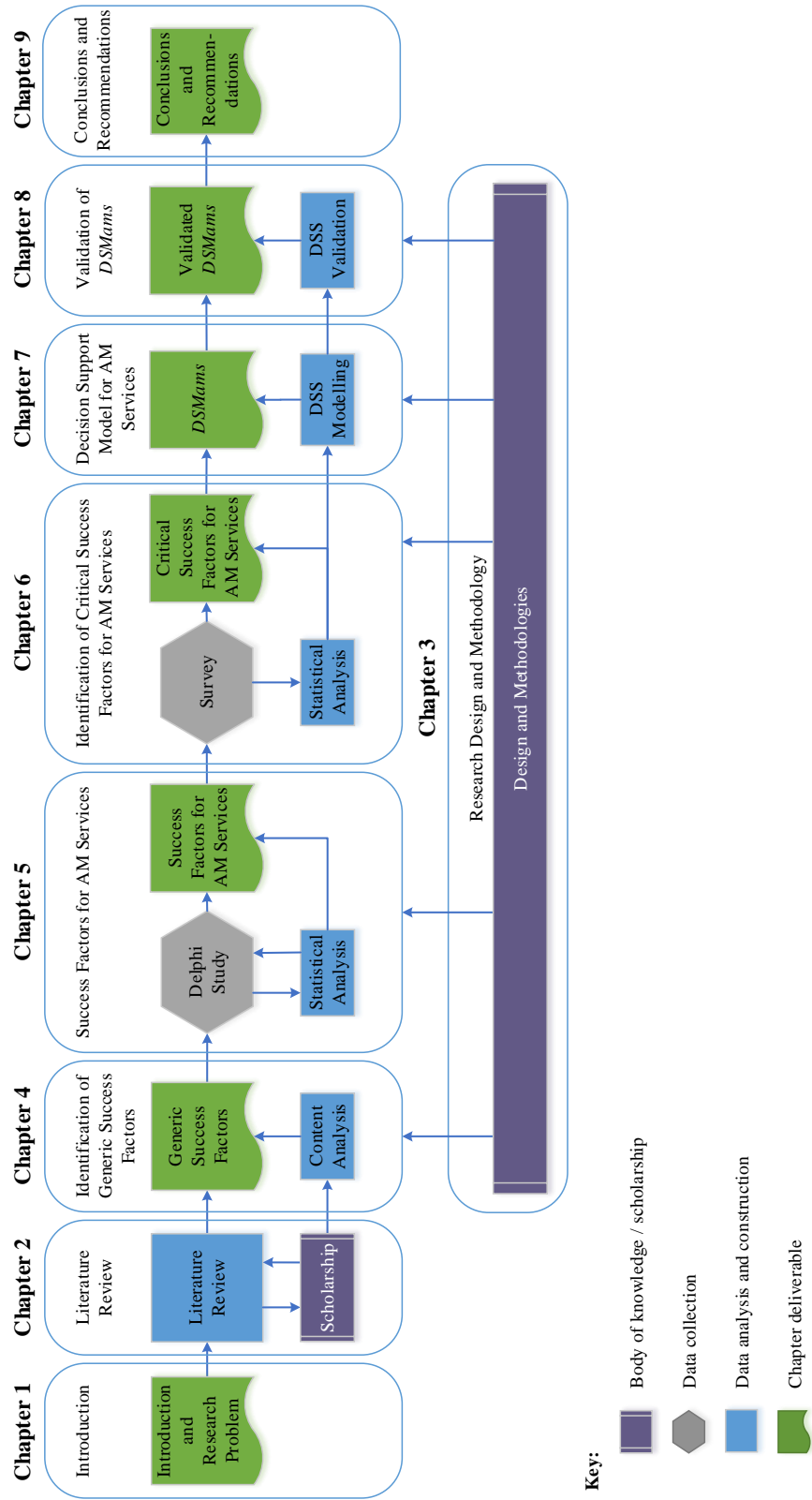


Figure 1.2: Dissertation road map

determine the rank of the success factors and to identify whether there are different perspectives between sample sub-groups about the success factors. The chapter concludes with the ranked list of the CSF for AMS.

Chapter 7 In chapter 7 a decision support model is developed to allow the AMS industry access to the results for decision-making. A modeling methodology for decision support systems is used as a foundation for constructing the decision support model for AMS, or the so-called Decision Support Model for Asset Management Services (DSMams). The model is constructed from the perspectives of the system architect, developer and user.

Chapter 8 In chapter 8 the decision support model is validated. A two-stage procedure for validating decision support systems is used as basis for the validation. The procedure consists of face-, subsystem-, predictive- and user validation in the first stage, and field testing by means of a case study in the second stage.

Chapter 9 In chapter 9 the dissertation conclusions are drawn, recommendations are made and future research opportunities are identified.

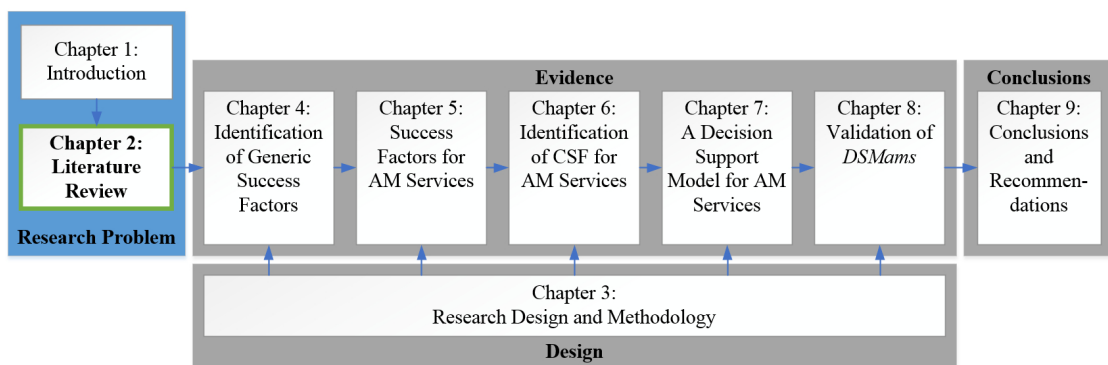
In this chapter the research is introduced and the dissertation road map outlined. The next chapter covers the literature review.

Chapter 2

Literature Review

It is easier to perceive error than to find truth, for the former lies on the surface and is easily seen, while the latter lies in the depth, where few are willing to search for it

– Johann Wolfgang von Goethe (1749-1832)



The objective of this chapter is to review the existing scholarship relating to the problem statement and objectives. The research problem lies within the synergy of the AM and services disciplines. The first part of the chapter reviews the scholarship of AM, while the second part reviews the services and AMS bodies of knowledge. The third part of the chapter concludes with a study of the CSF approach, which serves to determine the factors critical towards a successful AMS.

2.1 Asset Management

The AM scholarship forms the first foundation of the research. In this section the history of AM is presented. AM is introduced by covering concepts such as assets, asset classifications and the asset life cycle, which leads to a definition for AM. The latter subsections cover important AM characteristics, concluding with future developments which are emerging in AM.

2.1.1 An Introduction to Asset Management

The term *asset management* is plagued by ambiguity. Some of the reasons are educational and professional specialisations which caused the isolation of the various disciplines involved in the management of assets, as well as the synonymical use of AM across various industries (Hastings 2010, 2; Amadi-Echendu *et al.* 2007, 117). Mitchell (2007) and Woodhouse (2003*b*) demonstrates six different uses for the term, of which the last applies to this research:

- In the **financial services** sector AM refers to the management of stock and investment portfolios.
- **Financial directors (and boards of companies)** refer to AM in relation to mergers and acquisitions (i.e. buying and selling companies).
- **Equipment maintainers** adopted AM as a preferred term over maintenance management, to raise the profile and credibility of their activities.
- Following the equipment maintainers' example, **software vendors** have re-labelled the traditional CMMS to EAMS.
- A sub-domain of the **information systems** field interprets AM as the bar coding of computers and the tracking of their location and status.
- **Infrastructure or plant owners and operators** have adopted AM to describe the combination of investing in, exploiting and caring for appropriate physical plant and infrastructure over its life.

The origins of AM evolved from the financial services sector and the Australian and New Zealand public sectors which were brought to a head by insufficient planning and falling service levels. The North Sea oil and gas industry following the Piper Alpha disaster and the crash in the oil price was a further contributing factor (IAM 2011, 7; Woodhouse 2003a, 1). Companies were forced to review their business practices to survive. An initiative known as *Cost Reduction In The New Era (CRINE)* followed and resulted in “business units with clear lines of budget authority, performance accountability, and active encouragement to challenge the status quo, ... [creating] a sense of ownership and creativity in the workforce that had hitherto been suppressed or ignored. The ‘Asset Management Model’ which emerged during this period proved both radical and an assembly of common sense”, according to Woodhouse (2003a, 2).

As soon as the field of AM emerged, scholars argued that the field requires an interdisciplinary approach emphasising the whole life-cycle management of the asset rather than just focusing on the maintenance aspects (McGlynn and Knowlton 2011, 15; Amadi-Echendu *et al.* 2007, 117; Woodhouse 2001, 2). Short-term thinking, traditional “silo” mentality and myopic disciplinary paradigms were identified as the major threats to AM (Woodhouse 2006; Amadi-Echendu *et al.* 2007, 119) Amadi-Echendu (2004, 1156) states: “[Physical] asset management is about ensuring that the value profile, ... is enhanced in a sustainable manner through the asset’s life, [which] is a paradigm shift from the conventional cost doctrine typical to maintenance” Coetzee (1999, 280) confirms, from a maintenance perspective:

The maintenance organisation is an organism of which the various parts must function in full harmony towards the achievement of a maximum contribution towards the goals of the business, and such harmony cannot be achieved by implementing highly sophisticated (and localised) solutions to problems experienced in sub-parts of this organism. The only solution is an holistic approach that touches all the critical parts of the organisation at the same time.

Scholars from various industries started to make a case for AM. Madu (2000, 937) approaches AM from an information technology perspective and how it de-

depends on ERP systems, while Chang (1998, 86) comments that the speed and processing power of computers are spurring methodologies (i.e. RCM) in the AM domain. AM publications in the following industries followed: transport (Regina 1999; OECD 2001), construction (Vanier, 2001), electricity (Morton 1999; Hoskins *et al.* 1998; Kostic 2003), chemical engineering (Chohey and Fisher-Rosemount, 1999), irrigation (Malano *et al.*, 1999) and the built environment (Amadi-Echendu 2004; Newton and Christian 2004). As the advances and benefits gained from AM in developed countries became apparent, scholars studying asset and infrastructure improvement and sustainability in developing countries also started calling for the application of AM in these countries (Wijnia 2009, 1; Liyanage *et al.* 2009).

In the early 2000s there was a general convergence in engineering circles to view AM holistically, with emphasis on life cycle AM, the formalisation of the AM strategy, asset risk management, as well as the safety, environmental and human factors of AM (Mitchell 2007; Schuman and Brent 2005; OECD 2001). This led to the publication of the first Publicly Available Standard 55 – or PAS 55 – for AM in 2004, through the cooperation of more than 25 organisations and institutions (Woodhouse, 2006, 6). PAS 55:2008 was published containing substantial revision from the original 2004 version, with over 50 participating organisations from 15 industry sectors in 10 countries (British Standards Institution, 2008*a*, i). The widespread adoption and acceptance of PAS 55 as AM standard (especially in the utilities, transport, mining, process and manufacturing industries) served as basis for developing the ISO 55000 series of international standards for AM, which was released in 2014.

In 2010 the Global Forum for Maintenance and Asset Management (GFMAM) was established with the aim of collaborative sharing in advancements, knowledge and standards in maintenance and AM. GFMAM published the influential *Asset Management Landscape* containing 39 subjects which are core to AM and common across all its member societies (GFMAM, 2014, 11).

The difference between ISO 55000, PAS 55 and the 39 AM subjects is important. IAM (2011, 2) defines the relationship as follows:

The 39 Subjects describe the body of Asset Management knowledge as a whole, whereas PAS 55 is a requirements checklist for an organisation's management system – to direct, control and continually refine Asset Management. [The] learning about the management system standard alone does not constitute knowledge and competence across Asset Management as a whole! For anyone wanting to master the discipline, knowledge of PAS 55 and, ... ISO 55000 is important but not the whole picture – you really need to learn the whole discipline as represented by the 39 Subjects, albeit to different levels and degrees depending upon your area of responsibility or operational environment.

It is anticipated that the 39 AM subjects will play an increasingly important role in AM, especially by supplementing the ISO 55000 series of standards with practical guidelines, and for providing a learning framework.

2.1.2 The Concept of Assets, Asset Classification and Asset Life Cycle

The term *asset* is defined by the Oxford English Dictionary as (Oxford, 2010):

property owned by a person or company, regarded as having value and being available to meet debts, commitments, or legacies.

The three important aspects of the definition is that there is an object (“property”) to which a legal entity (“person or company”) attributes a value (“debt”). Per the definition, this means that an asset is more than just a physical thing. Reference is made in §2.1.1 to financial assets, while the importance of intangible and human assets in the value creation process should not be underestimated (Chareonsuk and Chansa-ngavej 2010; Ananthram *et al.* 2013).

PAS 55 expands on the objects which need to be included in the asset definition. PAS 55 defines physical assets as (British Standards Institution, 2008a, 2):

plant, machinery, property, buildings, vehicles and other items that have a distinct value to the organisation.

Similarly, Barry (2011, 2) and McGlynn and Knowlton (2011, 12) categorises physical assets into so-called *asset classes*:

Real Estate and Facilities, i.e. land, offices, warehouses, retail space, schools, housing, hospitals

Plant and Production, i.e. mining, semi-conductor, textile, chemical, petroleum, electronics, food

Mobile Assets, i.e. military, airlines, trucking, shipping, railroad, fleets

Infrastructure, i.e. railways, electricity/gas distribution, highways, telecom, water

Information Technology, i.e. computers, routers, networks, software, auto discovery, service desk

Snitkin (2003, 2) distinguishes between three asset classes; intangible, liquid and fixed or capital assets. Patents, trademarks, designs, formulas, processes and other intellectual property form part of the intangible asset class. Liquid assets consist of cash, inventory and short term securities, while fixed or capital assets correspond with the aforementioned physical assets, which includes: buildings and infrastructure, office equipment, information technology equipment, production and service equipment and fleets.

PAS 55 gives an holistic perspective of the assets forming part of AM, and defines the concept of *asset types* by stating: Physical assets represents only one of the five broad categories of asset types that have to be managed holistically in order to achieve the organisational strategic plan (figure 2.1). The scope of AM according to PAS 55 is focused on the physical assets and the interfacing areas with human, information, intangible and financial assets.

ISO 55000 is the current authority on defining assets in the context of AM. It defines an asset as a (International Standards Organisation, 2014a, 13):

item, thing or entity that has potential or actual value to an organization.

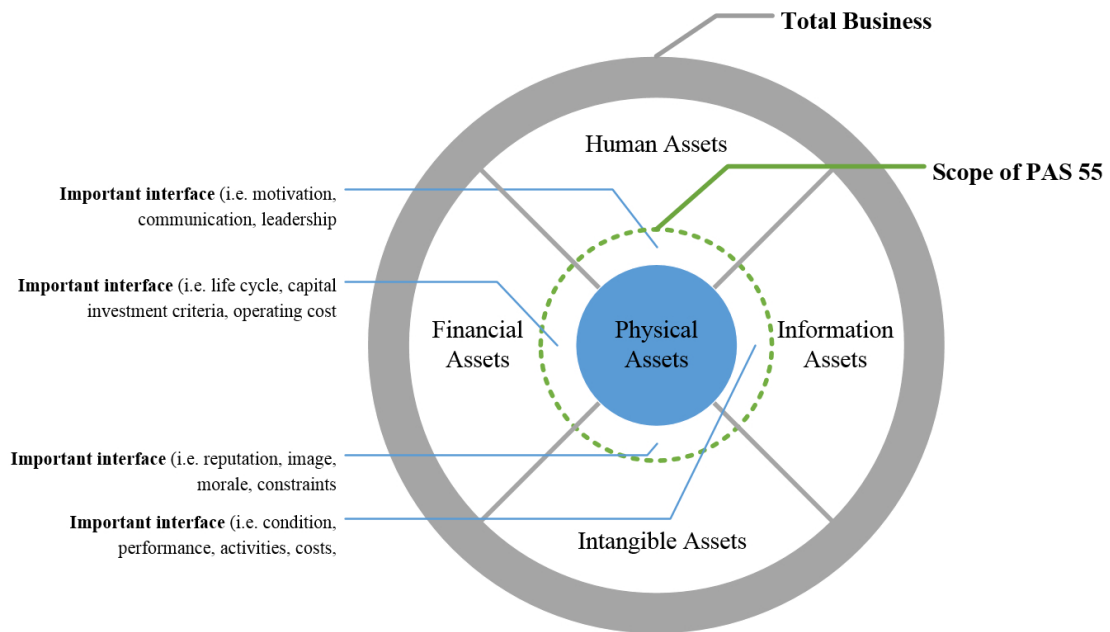


Figure 2.1: Types of assets as defined by PAS 55 (Adopted from British Standards Institution (2008a, vi))

The definition is qualified by noting:

Value can be tangible or intangible, financial or non-financial, and includes consideration of risks and liabilities. It can be positive or negative at different stages of the asset life. Physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, digital assets, use rights, licences, intellectual property rights, reputation or agreements.

ISO 55000 defines other asset related terminology which are of importance for this research (International Standards Organisation, 2014a, 13):

Asset life:

The period from asset creation to asset end-of-life.

Asset type:

The grouping of assets having common characteristics that distinguish those assets as a group or class.

Asset types are qualified by an example in ISO 55000 (International Standards Organisation, 2014a, 13) as:

physical assets, information assets, intangible assets, critical assets, enabling assets, linear assets, Information and Communication Technology (ICT) assets, infrastructure assets, moveable assets.

The asset life cycle is important for understanding AM and is well defined in the AM literature (Snitkin 2003, 2; McGlynn and Knowlton 2011, 12; IAM 2011, 10; Hastings 2010, 6; British Standards Institution 2008a, x; International Standards Organisation 2014a, 13). The asset life cycle is easy to understand at lower levels of asset granularity, however assets add value in a system context and the more complex the asset system, the more difficult it is to identify the various life cycle phases. The challenge with this lies in the difficulty to apply maintenance strategies, replacements, modifications and changing functional demands during the asset's life. (IAM, 2011, 10). The asset life cycle consists of several interdependent phases (figure 2.2).

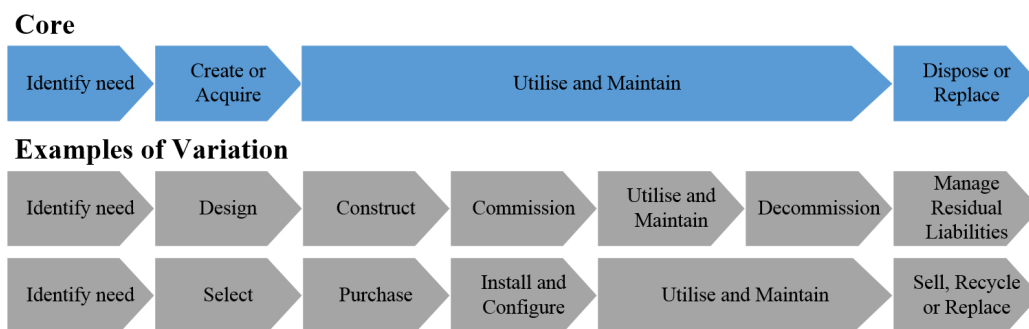


Figure 2.2: The asset life cycle phases and examples of variations (Adopted from IAM (2011, 10))

The asset life cycle begins with the identification of the need, the planning, design and selection of appropriate solutions. This is followed by an acquisition or creation process, which involves the request for proposals and comprehensive purchasing and warranty agreements. Installation, configuration and commissioning of the asset and the associated processes and systems are the next steps in the life cycle. The operation and maintenance phase of the asset is the longest. During this phase the assets create value and requires care for maintaining its performance. Traditionally this phase focusses on productivity improvement through methods such as Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM), Six Sigma and Lean manufacturing. Snitkin (2003, 7) highlights: “The need for collaboration between organisational processes affected by asset performance also peaks during this period.” The final disposal and replacement phase involves the decommissioning of equipment after its useful life and often requires safety and environmental considerations during the disposal of the asset (Snitkin 2003, 7-8; McGlynn and Knowlton 2011, 15; IAM 2011, 10; Hastings 2010, 6; British Standards Institution 2008*a*, 36).

2.1.3 Defining Asset Management

A first step in defining AM, is to define *management* in general. The Oxford English Dictionary defines management as (Oxford, 2010):

organisation, supervision, or direction; the application of skill or care in the manipulation, use, treatment, or control (of a thing or person), or in the conduct of something.

This implies management is directed at a specific purpose. However, in AM, purpose may manifest in different forms, and management may take place at various levels of the organisation (Amadi-Echendu *et al.*, 2007, 123). Definitions began acknowledging this broader perspective of AM during the early 2000s (Woodhouse 2001, 2; Amadi-Echendu *et al.* 2007, 123-124; OECD 2001, 13; Brown and Humphrey 2005, 40; INGENIUM 2006, 1.3). During this period scholars also differentiated between the management of different asset types by adding qualifying adjectives to AM; Amadi-Echendu (2004, 1157), Hastings (2010, 6), Mitchell

(2007) refers to physical AM, Snitkin (2003, 3) and Waeyenbergh and Pintelon (2002, 305) refer to capital AM, Amadi-Echendu *et al.* (2007, 117), Lin *et al.* (2006, 1) and van der Lei *et al.* (2012, 4) refer to engineering AM.

PAS 55:2008 formally defines AM as the (British Standards Institution, 2008*a*, v):

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 cycle for the purpose of achieving its organisational strategic plan.

In the influential publication, *Asset Management – an anatomy* (IAM, 2011, 5) it surfaces that as the AM discipline is maturing, there is a realisation that AM is less about “doing things to assets”, but more about “using assets to deliver value and achieve the organisation’s explicit purposes.” It further finds that the added adjectives add little value in qualifying AM, since assets have an inherent consistency across all different types, with a clear set of generic requirements which should be managed appropriately.

The compilation of the ISO 55000 series of standards brought further convergence to how the AM community defines AM. The standard defines AM as the (International Standards Organisation, 2014*a*, 14):

coordinated activity of an organization to realize value from assets.

The definition seems general. This is intentional, according to IAM (2011, 5), “as the thinking is common to the use of assets in whatever form they take. It is up to the organisation to choose *how* to manage those assets to derive best value” ISO 55000 qualifies the definition with three notes (International Standards Organisation, 2014*a*, 14):

1. Realisation of value will normally involve a balancing of costs, risks, opportunities and performance benefits.

2. Activity can also refer to the application of the elements of the asset management system.
3. The term “activity” has a broad meaning and can include, for example, the approach, the planning, the plans and their implementation.

For the purpose of this research the ISO 55000 definition for AM is used.

2.1.4 Characteristics of Asset Management

With a discipline as broad as AM it is difficult to underpin the essential elements to fully comprehend the discipline. Table 2.1 shows an analysis of the AM characteristics most often cited by scholars over the last decade. These characteristics are well represented in the definitions and previous sections and serve as an concluding summary of essential aspects which should form part of an organisation’s AM endeavors.

2.1.4.1 Asset Management Maturity

AM maturity describes the degree to which an organisation is performing AM practices and gaining corresponding benefits. AM maturity assessments are used by industry to measure the current state of AM affairs within an organisation and to use the results for identifying improvement opportunities. AM maturity is measured through assessing a selection of criteria on a maturity scale. A 5-point maturity scale is commonly used (Port *et al.* 2011, 33; IAM 2009, 2; Botha 2014, 8). There is no current standard for the assessment criteria. Criteria vary drastically and depend on the intentional use of the results. Service providers use maturity assessments as part of their sales strategy, while others use it to assess compliance with standards such as PAS 55 (IAM 2009, 2; Botha 2014, 8; Smith 2012). It is anticipated that the 39 AM subjects will provide a future basis for assessment criteria (Botha, 2014, 8).

AM maturity is of importance for this research, since different CSF could apply for levels of organisational AM maturity.

Characteristic	References
Multi-disciplinary AM crosses departmental and discipline boundaries and requires coordination, awareness, commitment and competency.	British Standards Institution (2008a, iii), IAM (2011, 8-12), Amadi-Echendu <i>et al.</i> (2007, 124)
Organisational alignment AM translates organisational objectives into decisions, plans and activities.	British Standards Institution (2008a, iii), IAM (2011, 8-12), International Standards Organisation (2014a, 3-4), Amadi-Echendu <i>et al.</i> (2007, 124), Port <i>et al.</i> (2011, 28), Stapelberg (2006, 28)
Value realisation AM does not only focus on the asset itself, but on realising the value from the asset.	IAM (2011, 8-12), International Standards Organisation (2014a, 3-4), Amadi-Echendu <i>et al.</i> (2007, 124)
Optimised decision-making AM seeks the best compromise between conflicting objectives (i.e. performance, expenditure and risk).	British Standards Institution (2008a, iii), IAM (2011, 8-12), Port <i>et al.</i> (2011, 28), Stapelberg (2006, 28)
Total life cycle management AM extends over the full life of the asset, which requires an understanding of value realisation for each phase.	IAM (2011, 8-12), Amadi-Echendu <i>et al.</i> (2007, 124), Stapelberg (2006, 28)
Integration AM activities are integrated and requires a management system to coordinate these activities in a systematic way.	IAM (2011, 8-12), Port <i>et al.</i> (2011, 28)
Strong leadership AM calls for leadership and commitment from all managerial levels.	British Standards Institution (2008a, iii), International Standards Organisation (2014a, 3-4), Port <i>et al.</i> (2011, 28), Stapelberg (2006, 28)

Table 2.1: AM characteristics most cited by scholars

2.1.4.2 Software-as-a-Service and Asset Management

Information technology has been an important enabler for maintenance and AM since the introduction of the personal computer. With the shift change to AM, leading CMMS suppliers have re-branded their system to EAMS, to distinguish themselves from the smaller CMMS. At the same time, large ERP suppliers have expanded their product offering to include EAMS modules to their enterprise system. In response, some EAMS suppliers have broadened their product lines to include client-centric and field service modules, while others have opted to include reliability-centered maintenance, bar coding, and integration with Geographical Information Systems (GIS) (Hookham, 2010, 1-3).

In addition, to the dynamics in the AM-related software sector, the overall software business has also transformed. With product sales and licence fees declining, suppliers have started moving away from pure product sales to new business models (Cusumano, 2008, 22). The most prominent is servitisation (refer to §2.2.4.1) in the enterprise software industry, with the monthly subscription fee, or the so-called *SaaS* model, being the most popular (Cusumano, 2008, 22). This shift towards software services is also affecting AM and a contributing reason for the importance of services in AM.

2.1.5 The Future of Asset Management

With the maturing of AM, new research and development in the discipline is accelerating. A key factor affecting this acceleration is the rate at which new technologies are becoming available. Some of the technologies relevant to AM are: mobile AM solutions; GIS and spatial AM solutions; Radio-Frequency Identification (RFID); the growing intelligence of assets; wireless local area technologies and assets connectivity through having Internet Protocol (IP) addresses (McGlynn and Fenhagen 2011, 392; Lampe *et al.* 2006; Emmanouilidis *et al.* 2009; Iung 2006).

Besides technological developments, other AM research trends are: the difficulty in considering the whole asset life cycle during the planning and design phases; the challenge with physical networks, such as road-, rail- and electricity, which are increasingly becoming interconnected; the interoperability and semantics of tools and methods required to operate and maintain *smart assets*; the concept of *lean data collection* which emphasises the correct choice and use of data; and the trend of maintenance management to business and society driven decision-making (van der Lei *et al.*, 2012, 169-172).

AM is further affected by the convergence between AM, product life cycle management and service life cycle management. This convergence is “adding new capability, flexibility, and new efficiencies but have changing organisational implications as well.”, McGlynn and Fenhagen (2011, 392) state. Asset owners have

realised by integrating asset- and service management they are enabled to deliver expected performance, to increase comprehension of service dependencies, and to manage the combined financial and operational risks. Asset owners are also moving towards AM as an organisational wide function, rather than a departmental discipline often relating to a specific asset system. This change is affecting the way in which organisations are managing the life cycle of their products and services.

2.1.6 Summary of Asset Management Literature

The first scholarship relevant to this research is AM. This section introduces AM with a brief history of AM. The concepts of assets and AM are defined and the section is concluded with AM characteristics relevant to this research and future trends in AM.

2.2 Services and Asset Management Services

The services scholarship forms the second foundation of the research. In this section the history of services are presented followed by the science of services and the generic characteristic of services, which differentiate them from products and tangible goods. AMS is introduced by covering concepts such as goods, products, assets and services. This is followed by aligning AMS with servitisation in the industrial product and manufacturing industries, which leads to a definition of AMS. In the latter subsections services typologies are discussed and applied to AMS and a life cycle for AMS are derived. The section is concluded with linking AMS to outsourcing, which is a common practice in AM.

2.2.1 An Introduction to Services

The history of the service domain dates back to the 1990s with publications by Berry and Parasuraman (1993), Bitner *et al.* (1993) and Swartz *et al.* (1992). Bitner *et al.* (1993) traces services back to the 1950s by defining the stages of its first evolution; the pre-1980s *crawling out*, the 1980-1985 *scurrying about* and the 1986-1992 *walking erect* stages (figure 2.3). Since the 1990s services now contributes

to more than 80% of GDP in developed countries such as the United Kingdom (UK) and the USA (Moussa and Touzani, 2010, 174). China's service sector has grown over 190% in the past 30 years (Paulson, 2006, 18). According to the World Economic Forum's global competitive index for 2012-2013 (Schwab, 2013, 55) over 70% of the 137 listed countries have services sectors contributing to more than 50% of their GDP. In South Africa services represents 66% of the country's GDP (Schwab, 2013, 55).

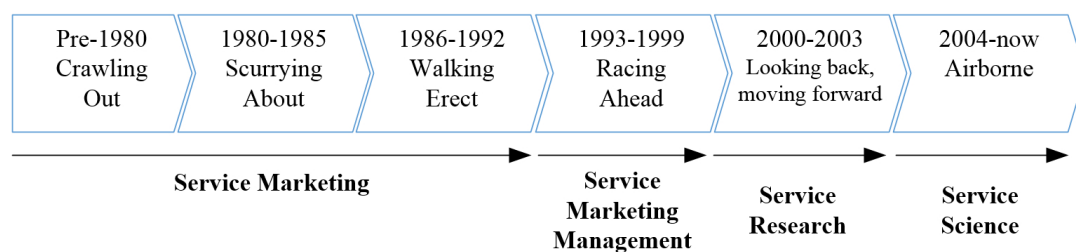


Figure 2.3: Evolution of services research (Adopted from Moussa and Touzani (2010, 177))

Traditional services industries, such as retailers, banks, and telecommunications are seeking new opportunities internationally, while manufacturers and goods-dominant companies are pursuing opportunities for growth and becoming more competitive through integrating services in their product offering (Ostrom *et al.* 2010, 4; Johansson and Olhager 2004, 309; Auramo and Ala-Risku 2005, 334). Development in the information technology and its infusion in business is also creating more opportunities within services (Bardhan *et al.* 2010, 13; Connolly and Olsen 2001, 73).

The second evolution of services covers its development since the 1990s to the 2010s (figure 2.3) (Moussa and Touzani, 2010, 177). In the *racing ahead* stage a increase was seen in the body of knowledge of services, with the main topics of focus being service quality and customer satisfaction (Furrer and Sollberger 2007, 100; Johansson and Olhager 2004, 83). By 2000 scholars realised that services

should be seen more broadly than before (Rust, 1998, 107).

In the *looking back and moving forward* stage, research came to the fore about information technology infusion in services – or e-service (Rust and Kannan 2002; Parasuraman 2000, 308) and customer equity management (Rust *et al.*, 2000). Despite requests to expand the services field to be more cross disciplinary, research was still predominantly about service marketing (Rust, 2004, 211).

The current *airborne* stage is experiencing high enthusiasm in services research. “Today the field is becoming more interdisciplinary, more cross-functional, and more international than any era before”, Moussa and Touzani (2010, 188) state. New concepts and paradigms such as the *service dominant logic* by Vargo and Lusch (2004) and the rental/access paradigm by Lovelock and Gummesson (2004) characterise this stage. Other areas showing promise are the areas of cross-cultural services (Zhang *et al.* 2008; Altenay and Roper 2007) and customer experience management (Schmitt 2003, 17; Shaw 2007; Grewal *et al.* 2009; Kwortnik and Thompson 2009; Verhoef *et al.* 2009).

2.2.2 The Science of Service

Service science involves the evolution, interaction and reciprocal co-creation of value among service systems. Service science is “an interdisciplinary field which combines organisation and human understanding with business and technological understanding to categorize and explain the many types of service systems that exist as well as how service systems interact and evolve to co-create value” (Maglio and Spohrer, 2008, 18). Service systems are “value co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information” (Maglio and Spohrer, 2008, 18). It is considered the basic unit of analysis in service science and intended as “open systems capable of improving the state of another system through sharing or applying its resources, and improving its own state by acquiring external resources” (Maglio *et al.*, 2009, 403). These systems can range in size, as explained by Maglio and Spohrer (2008, 18):

The smallest service system centers on an individual as he or she interacts with others, and the largest service system comprises the global economy. Cities, city departments, businesses, business departments, nations, and government agencies are all service systems. Every service system is both a provider and client of service that is connected by value propositions in value chains, value networks or value-creating systems (Normann, 2001, 24-25).

The function of service systems is to connect people, technology and information through value propositions with the aim of co-creating value for the service system participating in the exchange of resources within and across systems. Resource categories within these systems are: resources with rights, resources as property, physical entities and socially constructed entities. These resources exchange competence by sharing information, work, risk and goods, according to Maglio and Spohrer (2008, 19). Maglio *et al.* (2009, 400) explains the value co-creation process between service systems could be: proposing value, accepting a proposal, and realising the proposal. This implies that at least two service systems should be engaged in applying and integrating resources for a service to be realised and for value co-creation to occur.

According to Chen *et al.* (2008, 119) long term service excellence is ensured by “the *right mindset* that anchors on value co-creation. Guided by such a mindset, *right actions* that balance the innovation and commoditisation activities must be taken. Finally, *right configuration of service system resources* is critical to ensure that right actions can be taken.”

2.2.3 Characteristics of Services

The characteristics of services are defined to make the distinction between services and goods. In a meta-analysis Lovelock and Gummesson (2004, 23) state that the most frequently cited characteristics for services are; *intangibility*, *heterogeneity* or non-standardisation, *inseparability* of production and consumption or simultaneity, and *perishability* or inability to inventory. In the services literature these characteristics are referred to as *IHIP*.

Intangibility “arises from the fact that services are performances, rather than physical products and therefore cannot be seen, touched, or felt” (Hytönen, 2005, 10). Intangibility is however not an exclusive characteristic of services, since intangible goods, such as software and intellectual property also exist (Hytönen, 2005, 10). Intangibility implies that a client “cannot assess the intangible aspect of the service before the event” with the consequence that “the reputation of a service firm and its representatives [is used] to judge quality”, as stated by Dotchin and Oakland (1994, 14).

Heterogeneity is concerned with the fact that the production of a service is difficult to control and potentially has high variability (Windahl 2007, 26; Hytönen 2005, 10). Sassar *et al.* (1978, 17) confirms this by stating: “Differences exist in the outputs of firms producing the same service, and within the same firm, and even the same employee on different occasions”. A degree of standardisation can be achieved by automating services, but normally the production process of a service cannot be standardised to the extent which is possible in producing goods (Hytönen, 2005, 10).

Inseparability occurs because the client needs to be present for the service to be realised. Services cannot be transported and the production and consumption of the services happens simultaneously (Dotchin and Oakland 1994, 15; Hytönen 2005, 10). “A significant consequence of customer participation in the delivery of services is that perceptions of quality are influenced by observation of the environment, and the systems used. Service facilities, procedures and systems should be designed with the customer in mind, as well as the ‘product’ and the workforce” (Sassar *et al.*, 1978, 17).

Perishability means that services cannot be stored or inventoried. This holds different implications for the client and service provider. For the client it means that excess capacity, such as maintenance technician time and airline seats cannot be stored if not used. Perishability requires that services are produced and consumed simultaneously which supports the inseparability characteristic of services (Dotchin and Oakland, 1994, 15).

In summary, Lovelock and Gummesson (2004) provides an overarching definition for the characteristics of a service as:

the deeds, actions and efforts performed by either a person or a machine, but which exists at one point in time and cannot be stored for later use ... services are usually complex in that they are composed of different parts, some of which may or may not be employed for reasons which cannot be decided in advance, with the consequence that measuring services in their entirety can only be achieved with great difficulty.

This encapsulates the complexity of services in general, confirms the potential challenges associated with AMS and reiterates the importance of knowing what the CSF are for ensuring a successful and sustainable AMS.

2.2.4 Asset Management Services from a Servitisation Perspective

Research in the fields of servitisation and industrial services in the capital goods industry provides an unintentional, yet profound basis for AMS. In the following sections the similarities are developed and the different nuances highlighted.

2.2.4.1 Servitisation

Vandermerwe and Rada (1988) introduced the concept of *servitisation* of business by stating: “Modern corporations are increasingly offering fuller market packages or ‘bundles’ of customer-focused combinations of goods, services, support, self-service and knowledge. But services are beginning to dominate.” Since then, the adoption of servitisation as a competitive manufacturing strategy has been studied by various scholars (Baines *et al.*, 2009, 547). Wise and Baumgartner (1999) and Oliva and Kallenberg (2003) specifically sought to understand servitisation in the manufacturing and capital goods manufacturing industries. Baines *et al.* (2009) reported more than 150 publications on servitisation in 2009.

Martinez *et al.* (2010, 451) defines servitisation “as the journey or transformational process”, with figure 2.4 illustrating the client-provider interface from low to high servitisation. At low levels of servitisation the interaction between client and provider is limited to a narrow portion of the product life cycle, whereas high servitisation is associated with total solutions involving both client and provider for a broad range of activities across the product life cycle.

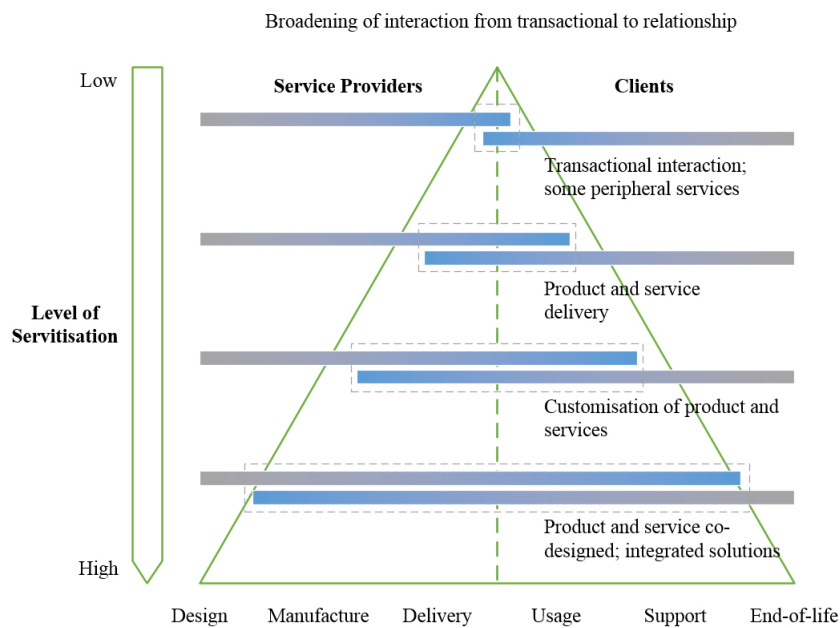


Figure 2.4: The client-provider interface in servitisation (Adopted from Martinez *et al.* (2010, 451))

Recent research indicates that servitisation is influenced by the size of the organisation and its local economic circumstances. In some cases organisations that servitise generate higher revenues, but generate lower profit than their pure manufacturing counterparts (Neely, 2008, 114). The reasons for this servitisation paradox according to literature and anecdotal evidence falls into three categories of challenges with 10 underlying factors (table 2.2).

Shifting mind sets	Of marketing – from transactional to relational marketing Of sales – from selling products to selling service contracts and capability Of customers – from wanting to own the product to be happy with the service
Timescale	Managing and delivering multi-year partnerships Managing and controlling long-term risk and exposure Modelling and understanding the cost and profitability implications of long-term partnerships
Business model and customer offering	Understanding what value means to customers and consumers, not producers and suppliers Developing the capability to design and deliver services rather than products Developing a service culture Embedding all of the above into a service organisation

Table 2.2: The challenges of servitisation (Adopted from Neely (2008, 114))

2.2.4.2 The Concepts of Goods, Products, Assets and Services

To understand AMS it is necessary to discuss the concepts of services, industrial services, goods and products, assets and AM. To achieve this we start from the broadest perspective and converge to an understanding of AMS.

According to Paloheimo *et al.* (2004, 12), Brentani (1989, 239); Normann (1991, 10) and Grönroos (1998, 336) the “difference between services and goods are often a question of degree or dimensions”. Oliva and Kallenberg (2003, 162) describes the difference on a product-service continuum supporting their work on servitisation (§2.2.4.1). The continuum model also brings about an understanding of what constitutes a *product*. In figure 2.5 the continuum shows that a product consists of both a service and a tangible goods dimension of varying proportions. A broad definition for industrial products is proposed by Mudambi *et al.* (1997, 435) as:

products used in manufacturing that are not marketed to the general consuming public. Industrial products can be process inputs, defined as products consumed in the manufacturing process, ... or product inputs, products remaining as ingredients of the final product Both goods and services are covered by the definition, as are capital goods and consumable items.

In contrast with the definition for an asset in §2.1.2 it is apparent that industrial products and assets are not mutually exclusive. Some, but not all, assets can be defined as industrial products, and vice versa. Assets, per definition, are

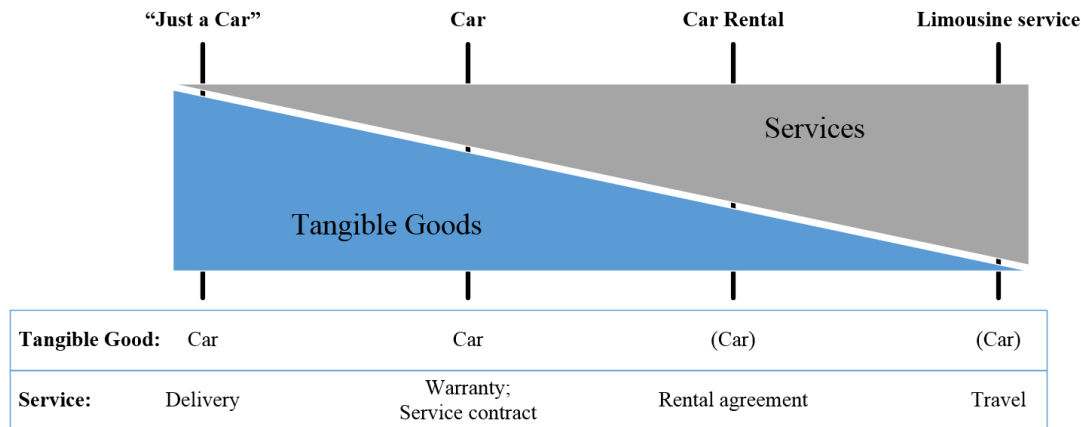


Figure 2.5: The product-service continuum (Adapted from Oliva and Kallenberg (2003, 162) and Paloheimo *et al.* (2004, 13))

a much broader concept, compared to industrial products, which are limited to manufacturing and its related processes and industries.

For defining AMS, it is necessary to define a service in general. Various definitions for a service exists and the various nuances between the definitions are noticeable. The American Marketing Association (Cook *et al.*, 1999, 319) defines a service as:

activities, benefits, or satisfactions which are offered for sale, or are provided in connection with the sale of goods.

This definition implies a service accompanies goods at no extra cost, which could be an impediment in the servitisation process (Paloheimo *et al.*, 2004, 13). A definition by Quinn *et al.* (1987, 50) for services are:

all economic activities whose output is not a physical product or construction, is generally consumed at the time it is produced, and provide added value in forms ... that are essentially intangible concerns of its first purchaser.

Quinn (1999) alludes to the fact that a service is general and is consumed at the same time of production or construction. Hill (1977, 318) proposes a definition,

which has been used as reference in various publications:

A service may be defined as a change in the condition of a person, or of a good belonging to some economic unit, which is brought about as the result of the activity of some other economic unit, with the prior agreement of the former person or economic unit.

To the contrary, Parrinelo (2004) argues that a service can also lead to a status quo, which is the case with maintenance services. A change in condition can also be the result of a traditional product. A more recent definition by Grönroos (2007, 53) is used as the norm for defining services in this research (Hytönen 2005, 9; Paloheimo *et al.* 2004, 14):

A service is an activity or series of activities of more or less intangible nature that normally, but not necessarily, take place in interactions between the client and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems.

The significance of the definitions is captured in the fact that a service is an intangible activity taking place in the interaction between the client and service provider, which is in response to the client's problem.

2.2.4.3 A Definition for Asset Management Services

Paloheimo *et al.* (2004, 18), Kosonen (2004, 13) and Hytönen (2005, 12) define the types of industrial services which facilitate the servitisation process. Literature refers to industrial services in one of three ways (Paloheimo *et al.*, 2004, 18):

1. Services targeted at optimising and supporting a client's industrial products or the production processes (Woodside and Pearce 1989, 185; Kosonen 2004, 14; Johansson and Olhager 2004, 309; Auramo and Ala-Risku 2005, 334).
2. Any business-to-business services (Gounaris and Venetis 2002, 636; Cooper and Brentani 1991, 75; Swan *et al.* 2002, 88).
3. All services provided by the service industry (Lindbergh and Wilson 2001, 67; Quinn *et al.* 1990, 58).

Paloheimo *et al.* (2004, 18) continues to define industrial services according to the first definition. Kosonen (2004, 13) concurs by defining industrial services as:

services that are targeted to optimise the use of the industrial products and to increase their value for the customer.

Kalliokoski (2003, 18) and Hytönen (2005, 12) expands on the definition by scoping industrial services according to the industrial product life cycle (figure 2.6). The product life cycle corresponds to the asset life cycle (refer to §2.1.2). While the capital goods manufacturing and servitisation literature views industrial products from the capital goods manufacturer's perspective, the AM literature views the same industrial product from the client or asset owner perspective, as assets, which should realise value for their organisation.

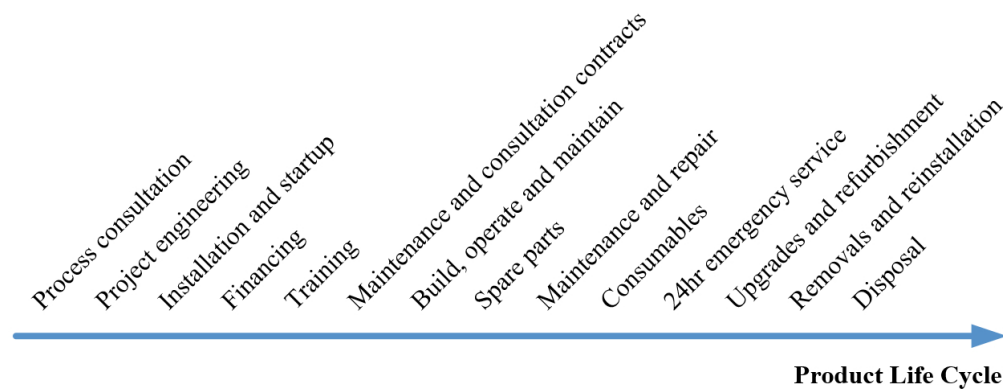


Figure 2.6: Scope of industrial services (Adopted from Kalliokoski (2003, 18))

Herein lies the connection between industrial services and AMS. The same services to optimise the use of industrial products to increase their value for the capital goods manufacturer client applies to asset owners who wish to acquire services from providers to realise the value from their own assets. A definition for AMS can be derived from the aforementioned discussion as:

services that are offered in support of the coordinated activities of an organisation to realise value from their assets.

Per the definition, AMS is not the same as industrial services. Industrial services are limited to industrial products and the production process, with bias towards manufacturing. AMS covers services relating to all assets (see definition in §2.1.2 and §2.2.4.2) and are not limited to assets in the industrial and production environments.

2.2.5 Asset Management Services from an Outsourcing Perspective

In the previous sections AMS are viewed from a services and servitisation perspective. An understanding of AMS from the perspective of outsourcing AM activities is also required.

Outsourcing is based on two premises; concentrate the organisation's resources and investments on what it does best, and; outsource other activities for which the organisation has neither a strategic need nor special capabilities (Hilmer and Quinn 1994, 43; Campbell 1995, 18). Embleton and Wright (1998, 94) define outsourcing as follows:

Outsourcing is a business strategy to develop and increase an organisation's competitive advantage.

In the domain of AM (and its predecessor maintenance management) initial publications focus on maintenance outsourcing and more specifically on the outsourcing process, reasons for outsourcing, benefits and risk of outsourcing and how to decide which activities to outsource (Campbell 1995; Bertolini *et al.* 2004; Tsang 2002; Martin 1997; Sherwin 2000). Since the paradigm shift from maintenance management to AM in the early 2000s (Amadi-Echendu 2004; Woodhouse 2001), the focus has shifted towards outsourcing as a strategy to optimise AM activities (Mather 2005, 4; Amadi-Echendu 2004, 1158). Today AM standards, such as PAS 55 and ISO 55000 include sections dedicated to outsourcing (British Standards Institution 2008*b*, 20; International Standards Organisation 2014*b*, 20).

The exchange of AM activities, as a result of the outsourcing decision can be described as AMS (also refer to definition of service in §2.2.4.2). In the next section typologies for AMS are investigated.

2.2.6 Typologies for Services

Classification schemes or typologies are important for bringing meaning and mental order to concepts under consideration (Cook *et al.*, 1999, 318). Paloheimo *et al.* (2004, 15) and University of Cambridge and IBM [Online] (2007, 6) typify services based on the entities who act as client and supplier of the service. The focus of this research is on Business-to-Business (B2B) and Business-to-Government (B2G) services. These services are similar in that the environment is invisible to most consumers and citizens, it is driven by global sourcing of skills and capabilities and based on service level agreements to ensure fulfillment of the service quality (University of Cambridge and IBM [Online], 2007, 6).

Various other services typologies have been considered by scholars. Lovelock and Gummesson (2004, 31) used a categorisation according to recipient (person or thing) and the service act (tangible or intangible), while Oliva and Kallenberg (2003, 168) distinguishes between transactional and relationship type services. In studying global trends in servitisation Neely (2007, 4) distinguish between countries, as well as organisational size (in number of employees) in presenting their study results. Cook *et al.* (1999, 325) again, included organisational ownership in their typologies to differentiate between public, private and non-profit organisations. In project success studies Shenhar *et al.* (2002, 720) study the distinction between industries and project duration (ranging from 3 months to 12 years), while Abdullah *et al.* (2010, 4179) classify organisational level and project phases.

These typologies should be considered in this research to further the understanding of AMS.

2.2.7 Product-Service Systems

Product-Service Systems (PSS) are defined as tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific client needs (Sundin, 2009, 32). Various classifications of PSS have been proposed, with most based on three categories, namely: product-orientated, use-orientated and results-orientated (Brezet *et al.* 2001, 8; Zaring *et al.* 2001, 19; Tukker 2004, 248-249). The product-orientated category is mainly concerned with the selling of a product with some extra services added. In the use-orientated category the product still remains central, but the focus of the business model is not towards selling stand alone products. The ownership of the products remains with the provider and is made available in different forms or shared among users. In the results-orientated category the provider and client agrees on a result, with no pre-determined product involved.

In the seminal work of Oliva and Kallenberg (2003, 167-168), cited in over 1000 publications, PSS are referred to as *service offerings* defined according to the focus of the client interaction and the way in which the service is priced. The 2×2 model defines four categories of services (table 2.3): basic installation, maintenance, professional and operational services. Basic installation and maintenance services are product orientated and are usually in the form of outsourcing contracts (Kumar and Kumar 2004, 314; Spring and Araujo 2009, 452). Professional services focus on product efficiency within the client's process, rather than on the product efficacy. In other words the product becomes part of the offering, rather than being the centre of the value proposition. Operational services aim to establish a fully integrated solution that assumes operating risk and also takes full responsibility for the client's process (Windahl 2007, 4; Davies *et al.* 2006, 185).

Scholars have expanded on the work of Oliva and Kallenberg (2003, 168) by aligning the service offerings to solutions business models (i.e. Kujala *et al.* (2010, 99-100) defines four business models which correspond to the categories in table 2.3, namely: basic installed base services, client support services, operations and maintenance outsourcing and life cycle solutions). This alignment brings forth the

	Product-oriented Services	End-user's Process-oriented Services
Transaction-based Services	<i>Basic Installed Base Services</i>	<i>Professional Services</i>
	Documentation	Process-orientated engineering (tests, optimisation, simulation)
	Transport to client	Process-orientated R&D
	Installation/ commissioning	Spare parts management
	Product-orientated training	Process-orientated training
	Hot line/ help desk	Business-orientated training
	Inspection/diagnosis	Process-orientated consulting
	Repairs/spare parts	Business-orientated consulting
	Product updates/upgrades	
	Refurbishing	
	Recycling/machine brokering	
	Repairs/spare parts	
Relationship-based Services	<i>Maintenance Services</i>	<i>Operational Services</i>
	Preventive maintenance	Managing maintenance function
	Condition monitoring	Managing operations
	Spare parts management	
	Full maintenance contracts	

Table 2.3: Service offering classification (Adopted from Oliva and Kallenberg (2003, 168))

interdependency between service providers and clients. Section 2.2.2 refers to the concept of co-creation between service provider and client, which forms a fundamental building block of a service. With reference to table 2.3 interdependency increases from transactional type services to relationship-based services (Penttinen and Palmer 2007, 555; Windahl and Lakemond 2010, 1283; Holmström *et al.* 2010, 682) Kujala *et al.* (2010, 99-100) expands.

2.2.8 Towards an Asset Management Services Life Cycle

It is not guaranteed that the same requirements for success applies to all aspects of a service. For example, Brentani (1989, 255) found that during the sales phase of industrial services a requirement for success is a strong external and internal marketing orientation by the service provider. In contrast, during the operational phase innovation and quality are key to success. For providing the phase dimension to AMS, its life cycle is defined from an integrated solutions perspective.

Business literature shows the leading organisations have changed their strategic focus to providing solutions rather than individual products or services (Slywotzky 1995, 229; Slywotzky *et al.* 2002, 73; Wise and Baumgartner 1999, 138; Sharma and Malloy 1999; Cornet *et al.* 2000; Foote *et al.* 2001, 86).

Integrated Solutions (IS) are traced back to the infrastructure projects in the 1980s, where “limitations on the availability of public funds led to governments to invite private sector entities to enter into long-term contractual agreements for the financing, construction, and/or operation of capital-intensive projects.” (Brady *et al.*, 2005a, 360). Brady *et al.* (2005a, 360) describe IS:

To deliver IS means the client’s needs must be met by combining products and systems with services in order to specify, design, deliver, finance, maintain, support and operate a system through its life cycle.

Miller *et al.* (2002, 3) states, there are many kinds of solutions, but fundamentally they all are:

integrated combinations of products and/or services that are unusually tailored to create outcomes desired by specific clients or types of clients.

IS involve the extension of the traditional project life cycle in the pre-project phase, as well beyond the implementation phase into an operational phase (Davies and Hobday, 2005, 244). For the purpose of this research the IS life cycle is used as the basis for AMS (figure 2.7).

The *strategic engagement phase* starts with client-facing teams engaging with existing or potential clients about their requirements, often before the client formally request assistance. (Davies and Hobday, 2005, 244).

The *value proposition phase* is concerned with the offer activities. When the client requests help or issues an invitation to tender a multi-skilled and cross-functional team representing commercial, technical, design and project members is assembled. The team should determine how to tailor products and services to

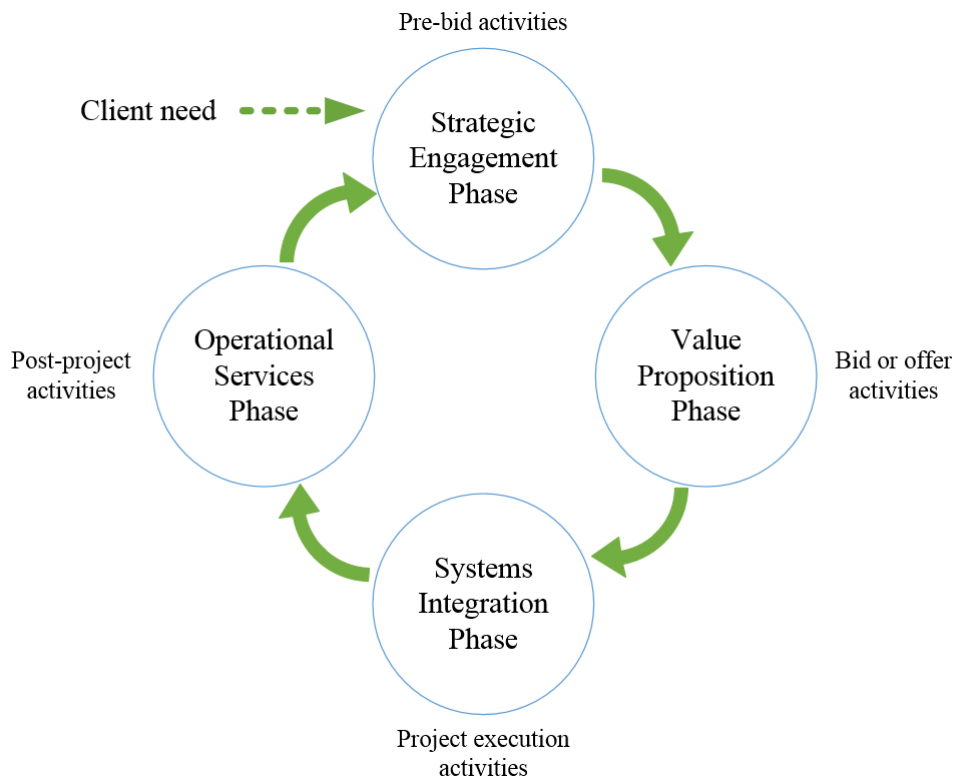


Figure 2.7: Life cycle for AMS based on the IS life cycle (Adopted from Davies and Hobday (2005, 245) and Brady *et al.* (2005a, 363))

solve the client's specific problems.

As soon as the contract has been signed the *system integration phase* follows. This involves the traditional project management activities, skills and in-depth system and process integration capabilities to design, integrate, verify and test the solution before handing it over to the client. In traditional projects the hand-over signals the end of the project. IS normally include the *operational services phase* where it is the provider's responsibility to resource, manage, support and improve the delivery of the solution in a sustainable manner, throughout its life cycle.

The life cycle phases are used for categorising themes in the further study of the success factors for AMS.

2.2.9 Summary of Services Literature

The second scholarship relevant to this research is services. This section introduces services with a brief history, an overview of service science and the universal characteristics of services. AMS are defined from a servitisation perspective and aligned to the outsourcing of AM activities. The section is concluded with an explanation of the AMS typologies and the AMS life cycle.

2.3 Critical Success Factors

The critical success factor scholarship forms the third foundation of the research. In this section the history and definition of CSF are presented followed by its importance and relevance to AMS. This is followed by the different sources and classification of CSF. The section is concluded with the methods for identifying CSF.

2.3.1 An Introduction to Critical Success Factors

In today's increasingly complex world, it is important for managers to have access to information that is relevant to their specific roles and responsibilities. The Critical Success Factor (CSF) approach identifies information needs for management control and identifies data which can be used to monitor and improve the most important business areas within an organisation.

The first reference to CSF was made by Daniel (1961, 116) who identified that: "In most industries there are ... three to six factors that determine success" and that these factors are relevant to any organisation operating within that industry. In 1972 Anthony *et al.* (1972, 155) continued the research by stating that CSF need to be tailored for both an organisation's strategic objectives and its particular managers.

In 1979 the seminal Critical Success Factor approach was developed by Rockart (1979). The CSF approach is a methodology which has been used successfully for determining precisely what business areas a manager should focus on to ensure

successful competitive performance for the organisation. From the research it is evident that the CSF approach overcomes shortcomings of traditional executive “information needs methodologies” (Amberg *et al.* 2005, 2; Rockart 1979, 85).

Today the CSF approach is well established and used widely in industry for various applications (Boynton and Zmud 1984, 18; Munro and Wheeler 1980, 27; Ferguson and Dickinson 1982, 18; Amberg *et al.* 2005, 3). It is commonly used in relation to project or improvement initiatives (i.e. CSF for the implementation of business intelligence systems). In this context, CSF can be described as the underlying principles of the effort to be considered to ensure that something is a success (Caralli, 2004, 11).

Rockart (1979, 3, 7, 12) defines CSF in the context of overall management control, in various ways as:

- the few vital areas in which favourable results are non-negotiable
- the limited number of areas in which satisfactory results will ensure successful competitive performance
- the few areas in which “things must go right” for the business to excel
- the few factors that are critical to the success of the organisation
- the areas that should receive continuous and thorough attention from management

The work by Leidecker and Bruno (1984, 24) on CSF for strategic management defines CSF as:

those characteristics, conditions or variables that, when properly sustained, maintained, or managed, can have a significant impact on the success of a firm competing in a particular industry,

while Pinto and Slevin (1987, 22) define CSF in the project management context as:

factors which, if addressed, significantly improve project implementation chances.

The various definitions and subtle differences speak to the elusive nature of CSF. Managers often recognise their, and the organisation's CSF when they see or hear them, but are not capable of clearly and concisely expressing them as the most important factors on which to focus their attention on. Even though managers are attentive to the variables which they should manage in order to succeed, these factors only become explicit when problems arise and root causes are identified (Caralli, 2004, 12). For example, suppose an organisation identifies an increase in maintenance rework. They might conclude that the increase is due to haste and bad quality workmanship when the maintenance is done the first time. As a result maintenance quality assurance might be identified as a factor that can prevent the organisation from achieving its goals. In the process they have explicitly defined a CSF for the organisation's maintenance activities.

The power of CSF is that it makes the things explicit that managers intuitively consider being important for achieving their goals. By making these CSF explicit it becomes available to the rest of the organisation to aid it in its planning process and to enhance communication in support of its mission statement.

2.3.2 The Importance of Critical Success Factors

In traditional strategic planning and management, terms such as goals and strategy are well known with clear definitions; to the contrary, defining CSF are less obvious. For this reason CSF, goals and measures are often confused. For the purpose of this research the original definitions (table 2.4) from Rockart (1981, 9) are used to explain the relationship between CSF and other organisational management terminology.

Goals and CSF are closely related. It is important for managers to clearly define their goals. Goals are very specific as to what must be achieved, by when and by whom. Closely associated with goals is the conscious, explicit definition of the basic structural variables which will most affect the failure or success in the

Term Definition	Examples
<p>Strategy Strategy is the pattern of missions, objectives, policies and plans that define what business the company is in and what kind of company it is.</p>	<ul style="list-style-type: none"> • Regional airline transportation
<p>Objectives Objectives are statements defining the general directions in which a company intends to grow their business, without specifying specific targets and/or timelines.</p>	<ul style="list-style-type: none"> • Develop profitable route structure • Change over to a more fuel efficient fleet
<p>Goals Goals are specific targets that must be achieved within a predefined timeline. A goal is thus an operational transformation of one or more objectives.</p>	<ul style="list-style-type: none"> • Eliminate routes with less than $x\%$ seat usage • Replace all type y planes with type z planes • Achieve 10% ROI by 2015
<p>Critical Success Factors (CSF) CSF are the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organisation. CSF are the few key areas where <i>things must go right</i> for the business to flourish and for the manager's goals to be attained</p>	<ul style="list-style-type: none"> • Obtain certification for higher density routes • Obtain financing for new planes
<p>Measures Measures are specific standards used to monitor the performance of each CSF, goal or objective. Measures can be categorised as quantitative or qualitative.</p>	<ul style="list-style-type: none"> • Average % seat capacity used • % of cash requirements under written equipment loan agreements with banks
<p>Problems Problems are matters arising as a result of sub-standard performance or environmental changes. Problems can affect the success of goals and/or performance of CSF.</p>	<ul style="list-style-type: none"> • Escalation of jet fuel price • Video conferencing as an alternative to air travel

Table 2.4: Comparison of basic terms with examples from an airline company (Adopted from Rockart (1981, 9))

quest to achieve the goals. These are the critical success factors (Rockart, 1981, 13).

Both, CSF and goals are required to fulfil the organisation's mission. They are interdependent and neither can be disregarded without one affecting the other. When managers define their goals they intuitively consider the factors that are required to successfully accomplish the goals. The influence CSF have on goal attainment is therefore made explicit, even if the actual CSF are not. For example, a person might set a goal to lose five kilograms in a year. In order to achieve the goal the person needs to be watchful of a few things; improve their diet and exercise regularly. Close attention to these two CSF will help the person to realise the goal of losing five kilograms. To the contrary, failing to manage these factors is likely to lead to not achieving the goal.

The example illustrates that a goal can relate to more than one CSF. Conversely, the opposite also applies in which a CSF may influence several goals. This many-to-many relationship illustrates the interdependence and importance of CSF in helping the organisation achieve its mission (Caralli, 2004, 15).

One of the advantages of using CSF is that they are considered to be less biased than goals. The process of setting goals within many organisations is subjective; typically influenced by a performance scorecard and financial objectives. Whereas goals should be set based on its contribution to the organisation's mission, it is rather set based on its achievability. The result can be that a company can fail to realise its mission, while accomplishing all of its goals (Caralli, 2004, 15).

2.3.3 Sources and Classifications of Critical Success Factors

Research indicates that CSF originate from five primary sources (Rockart, 1981; Caralli, 2004): from the nature and characteristics of the industry; the organisation's competitive position to their peers within the industry; based on specific managerial positions; from the conditions of the macro environment the organisation operates in; and temporary CSF becoming critical for certain periods of time.

Various classifications of CSF have emerged from the scholarship. Developing

a diversified list of CSF with various CSF sources and classifications ensures a balanced set of CSF. The following classifications are the most commonly identified: CSF internal to an organisation versus external CSF relating to actions outside the organisation (Donald and Enrique, 1997, 312); monitoring CSF focusing on existing situations versus building CSF relating to the future growth of the organisation (Rockart, 1981, 17); strategic CSF for identifying *which* goals must be achieved and tactical CSF describing *how* the goals should be achieved (Rockart, 1981, 17); CSF which can be temporary or ongoing (Ferguson and Khandewal, 1999); and perceived or actual CSF (Grunert and Ellegard, 1993).

CSF sources and classifications ensure balance between different types of CSF, which need be considered as part of this research.

2.3.4 Identification of Critical Success Factors

Various research methods have been used by scholars in the past for identifying CSF (table 2.5). According to Shah and Siddiqui (2002) the most frequently used method to identify success factors is through a questionnaire. Three of the research methods detailed in table 2.5 are employed during this research. A literature review and Delphi study are used in the initial research phases (chapters 4 and 5), while a questionnaire is used during the final data collection phase of the research (chapter 6).

2.4 Summary

In this chapter the scholarship of the three foundations of this research is reviewed. The first part of the chapter focuses on AM. The section shows the relevance of AM in today's industry by illustrating how the AM discipline has matured over the past two decades. The importance of AM is reiterated and underlying attributes of AM is identified for consideration during the study of AMS.

The second part of the chapter focuses on services and AMS. The section explains the importance of services and the paradigm shift towards infusing services

Research Method	Examples
Action research	Kock <i>et al.</i> (1999)
Case studies	Holland and Light (1999), Summer (1999), Shenhar <i>et al.</i> (2001)
Delphi study	MacCarthy and Atthirawong (2001), Brancheau <i>et al.</i> (1996)
Literature review	Johne and Snelson (1988), Esteves and Pastor (1999), Umble <i>et al.</i> (2003), Fairchild <i>et al.</i> (2004)
Multivariate analysis	Tishler <i>et al.</i> (1996)
Scenario analysis	Barat (1992)
Structured interviewing	Rockart (1981), Pinto and Mantel (1990), Brentani (1989), Dvir <i>et al.</i> (1998)
Questionnaires	Dvir <i>et al.</i> (1998), Dexter (2010), Shenhar <i>et al.</i> (2002), Dvir <i>et al.</i> (2003), Yu <i>et al.</i> (2006)

Table 2.5: Research methods for identifying CSF (Adapted from Amberg *et al.* (2005, 5-6) and Esteves (2004, 52))

with product offerings to gain competitive advantages. AMS is derived and defined from the basis of servitisation in the manufacturing and capital goods industries and the outsourcing of AM activities. Underlying attributes of services and AMS relevant for consideration in this study are identified and an AMS life cycle is defined.

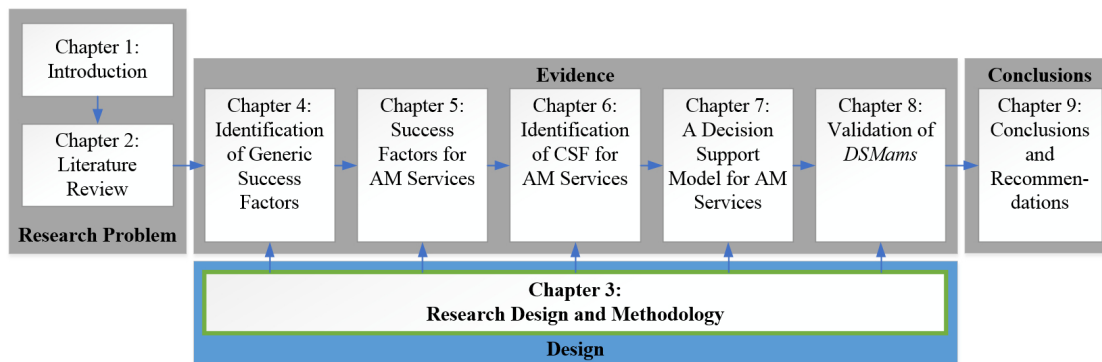
The third part of the chapter concludes with the CSF approach as an enabler for determining the factors which are critical towards a successful AMS relationship. The logic behind the approach is briefly discussed, the sources and classifications of CSF are explained and methods used by scholars for identifying CSF are highlighted.

The research design and methodologies for conducting the research follows in the next chapter.

Chapter 3

Research Design and Methodology

Well begun is half done
– Aristotle (384-322 BC)



The objective of this chapter is to discuss the research design and methodology. The chapter begins with the overview of the research approach and its philosophical foundation. A description of the research follows. The chapter concludes with the research methods employed in the dissertation.

3.1 The Nature of Science and Methodology

According to Ackoff (1999, 293) the meaning of science is not fixed, but evolving as science itself is evolving. Consequently, it is difficult to obtain an exact definition for what science is. Carey (2011, 2) advances that instead of looking at the question of *what* science is, one should observe science from a different perspective. Science can be better understood by understanding the aim of *why* scientists study the natural world, and the method with *how* scientific enquiry is conducted.

The basic aim of why any scientific research is conducted is to determine why things happen as they do. The aim of science according to Carey (2011, 2) is:

to further our understanding why things happen as they do in the natural world

The second part to the question of what science is, involves the methods of investigating nature. At the most basic level a scientific method involves three rudimentary steps: observing some aspect of nature, proposing possible explanations for not understanding some of the findings, and testing the explanations. For the purpose of this research the aim and method can be composed into a definition for what science is, according to Carey (2011, 5):

Science is that activity which aims to further our understanding of why things happen as they do in the natural world. It accomplishes this goal by applications of scientific method – the process of observing nature, isolating a facet that is now well understood and then proposing and testing possible explanations

3.2 Research Approach

Against the background of science and scientific research the research approach is defined. The research approach is the intended plan for conducting the research. Creswell (2013, 3) advances three approaches to research; qualitative, quantitative and mixed methods. The approach is determined by the philosophical assumptions, the research design and the research methods for data collection, analysis and interpretation. Further considerations for selecting an approach is the nature of the research problem, the researcher's personal experience and the audiences

for the study Creswell (2013, 5). In the following sections the research approach is presented based on the framework in figure 3.1.

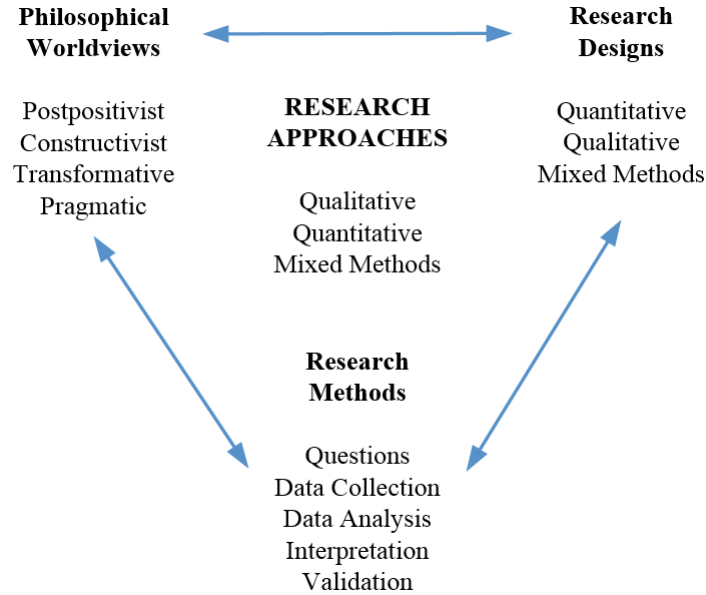


Figure 3.1: Research framework (Adopted from Creswell (2013, 5))

3.2.1 Philosophical Worldview

Researchers (Slife and Williams 1995, 4; University of Chicago 2011, 1) state that philosophers formed ideas that are now referred to as *scientific methods*. Researchers *use* science, but are often unaware of the influence of the ideas formulated by philosophers that lie hidden in scientific methods. Creswell (2013, 6) suggests the philosophical ideas rooted in the research should be explicitly stated.

The *pragmatic worldview* describes the basic set of beliefs that guides the action in this research. Pragmatism as a philosophy is derived from the work of Pierce, James, Mead and Dewey around the 1870s (Hookay, 2010). This worldview focuses on the research problem and uses all of the approaches available to understand the problem (Rossman and Wilson 1985; Cherryholmes 1992, 13). It is not committed to any one philosophy or reality; implying the use of mixed methods

research which draws from both quantitative and qualitative assumptions during the research (Creswell 2013, 11; Morgan 2007, 73; Cherryholmes 1992, 13).

The foundation of this research is based upon the pragmatic worldview. The research problem is embedded in the synergy between the AM and services domains, while the research paradigm of CSF, which originates in the management control domain, is used to better understand the synergy. Therefore, an approach is chosen which allows for the flexibility of investigating existing CSF knowledge in the respective domains: to collate and verify findings, and to collect and quantify results in the context of AMS.

This worldview is widely demonstrated in the work of other researchers in the field of CSF. (Esteves 2004, 46; Ferguson and Dickinson 1982, 15; Munro and Wheeler 1980, 35; Boynton and Zmud 1984, 18).

3.2.2 Research Design

Research design consists of selecting a type of study and selecting a strategy of inquiry within the selected type of study. The type of study to conduct can be qualitative, quantitative or mixed methods in nature. The strategy of inquiry within the three choices provides a direction for procedures within the design (Creswell 2009, 11; Creswell 2013, 4).

Dobbin and Gatowski (1999, 41) define qualitative research as a process of inquiry with the goal of understanding a social or an organisational issue from multiple perspectives within a natural setting. Qualitative research is an inductive process, where the focus is on meaning, which is descriptive in nature and concerned with the process, rather than the outcome. The researcher focuses on building abstractions, concepts, hypotheses and theories from details (Yeoh, 2008, 95). In contrast, quantitative research is an inquiry into an identified problem based on testing a theory, measured with numbers, and then analysed using statistical techniques. The goal is to determine whether the predictive generalisations of a theory hold true (Dobbin and Gatowski 1999, 41; Creswell 2013, 4). Qual-

itative and quantitative approaches should not be seen as discrete, but rather as opposites of a continuum with mixed methods in the centre (table 3.1). The

Quantitative	Mixed Methods	Qualitative
<ul style="list-style-type: none"> • Experimental designs • Non-experimental designs (i.e. surveys) 	<ul style="list-style-type: none"> • Convergent • Explanatory sequential • Exploratory sequential • Transformative, embedded, or multi-phase 	<ul style="list-style-type: none"> • Narrative research • Phenomenology • Grounded theory • Ethnographies • Case study

Table 3.1: Alternative research designs and strategies of inquiry (Adopted from Creswell (2013, 12))

mixed method design has been used by researchers to study CSF (Dexter 2010, 343; Esteves 2004, 73). This type of design allows for a predominant design (either qualitative or quantitative) which is supplemented by the research methods of the other design approach (Esteves 2004, 68; Morse 2003, 192; Tashakkori and Teddlie 2003, 11; Newman and Benz 1998, 13). Hunter and Brewer (2003, 578) state that the mixed method design overcomes each design's weaknesses and limitations by deliberately combining the different method types within the same investigation.

To answer the research questions a *mixed method* design is used. The research questions are of an exploratory and descriptive nature. The exploratory questions require qualitative research to gain a deeper understanding of the factors under investigation, while quantitative research is required for answering the descriptive research questions. This implies an exploratory sequential strategy of inquiry with a qualitative phase, followed by a quantitative phase.

Consequently, the research design will be in the form a *mixed method exploratory sequential design* (figure 1.1). Creswell and Clark (2011, 86) defines the exploratory sequential design as a two-phase sequential design whereby the researcher starts exploring a topic qualitatively before building a second quanti-

tative phase. The purpose of the design is to generalise qualitative findings based on previous research and a few individuals from the first phase, to a larger sample gathered during the second phase (Greene *et al.*, 1989, 260). The design is based on the premise that exploration is required where measures or instruments are unavailable, research variables are unknown and in the absence of a guiding framework or theory. Researchers have found exploratory sequential research particularly useful to assess and test qualitative exploratory results and to generalise the results to different groups (Morse, 2003, 227). The research problem and questions are aligned with these characteristics. CSF for AMS are currently unknown. Qualitative exploration is required to identify a basis from which CSF can be identified. Once identified, the CSF need to be generalised for use in the AMS domain.

3.2.3 Research Methodology

Against the background of the design, five research phases are used to answer the research questions. In the first phase a *qualitative content analysis* of existing literature is the starting point for the research. The purpose of the content analysis is to develop a set of statements in the form of generic success factors from available literature and to use these statements as basis in preparation for the following quantitative research phase. The software, *NVivo* (QSR International: Nvivo [Online], 2012), is used to organise and analyse the content from the literature review.

In the second phase a *modified Delphi study* is used to collect data from a panel of selected experts involved in AMS. The purpose of the study is to narrow the focus of the research by verifying the success factors applicable to AMS from the list of generic factors from the content analysis. In a modified Delphi study the traditional first round questionnaire is replaced by statement development through content analysis of existing literature (Keeney *et al.* 2011, 1556; Skulmoski *et al.* 2007, 3). This alternative approach is aligned with the research by Duffield (1993, 228) and Jenkins and Smith (1994, 416). It allows for a more efficient Delphi process that is otherwise time consuming with a likelihood of response fatigue.

The web-based survey software, *SurveyMonkey* (SurveyMonkey [Online], 2013), is used for collecting data from the Delphi study panellists. Descriptive statistics and Analysis of Variance (ANOVA) are used to analyse the data. Hypothesis testing is used to conduct sensitivity analysis. The software, *Statistica* (Statistica [Online], 2013) is used for the statistical analyses.

The third phase involves a *survey study* based on a sample of industry practitioners involved in AMS. This will allow for the answering of the first two research questions; identifying the CSF for AMS, and determining whether CSF differ for different AMS strata. Shah and Siddiqui (2002) cited by Esteves (2004, 52) states that the survey method is the most commonly used method for identifying CSF. The advantage of using a survey during this phase is that the first two phases' findings can be economically distributed to a diverse sample of AMS practitioners for final data collection. Descriptive statistics, ANOVA and hypothesis testing are used to analyse the survey data and to interpret the results for generalisation in the AMS domain. *Statistica* (Statistica [Online], 2013) is used for the statistical analyses.

Decision support modelling is used in the fourth phase to answer the final research question about making the research findings available to the AMS industry for improving decision-making. Decision support models are characterised by their ease of use for non-technical specialists, such as managers, and their ability to be used repeatedly for the same or similar decision situations (Power and Sharda, 2007, 1045). Such a model will serve the purpose of consolidating the CSF and strata results into a benchmarking database and providing a simplified and understandable representation thereof to AMS decision makers.

In the fifth and final phase a *two-stage validation procedure for decision support systems*, based on the research by Borenstein (1998), is followed for validating that the model provides a truthful representation of the results and allows acceptable support for AMS decision-making.

The selection of research methods concludes the final element of the research

framework (figure 3.1) for this dissertation. Table 3.2 summarises the research design and respective research methods, with the respective chapters which cover the research.

Phase	Approach	Process	Method	Instrument	Ch.
1.	Qualitative	Data analysis	Content analysis	<i>NVivo</i>	4
2.	Quantitative	Data collection	Delphi study	<i>SurveyMonkey</i>	5
		Data analysis	Descriptive statistics, ANOVA, hypothesis testing	<i>Statistica</i>	
3.	Quantitative	Data collection	Survey	<i>SurveyMonkey</i>	6
		Data analysis	Descriptive statistics, ANOVA, hypothesis testing	<i>Statistica</i>	
4.	Quantitative	Data analysis	Decision support modelling	<i>Microsoft Excel</i>	7
5.	Qualitative	Validation	Two-stage validation procedure	Various	8

Table 3.2: Research design and methodology summary

3.3 Reasoning Methods

Both forms of scientific reasoning are found in this research. *Deductive reasoning* is a process from one or more general statements, about what is known, to reach a logically certain conclusion (Sternberg, 2011, 507). In contrast *inductive reasoning* is a process by which observations lead to broader generalisations which seek a strong, or highly probable, conclusion (Sternberg, 2008, 513).

Deductive reasoning is used to derive the research problem and questions from the premises found in the literature review. Similar reasoning is used during the first two research phases whereby conclusions are drawn from the content analysis findings and expert panel feedback during the Delphi study. This form of reasoning is again used in the latter research phases for consolidating the generalised findings through modelling for decision-making in specific AMS.

Inductive generalisation is applied in the third phase of the research, by using a survey study to draw conclusions from the Delphi study results. The statistical insights from the survey sample of responses are generalised and inferences are made which concern the wider population of practitioners involved in AMS.

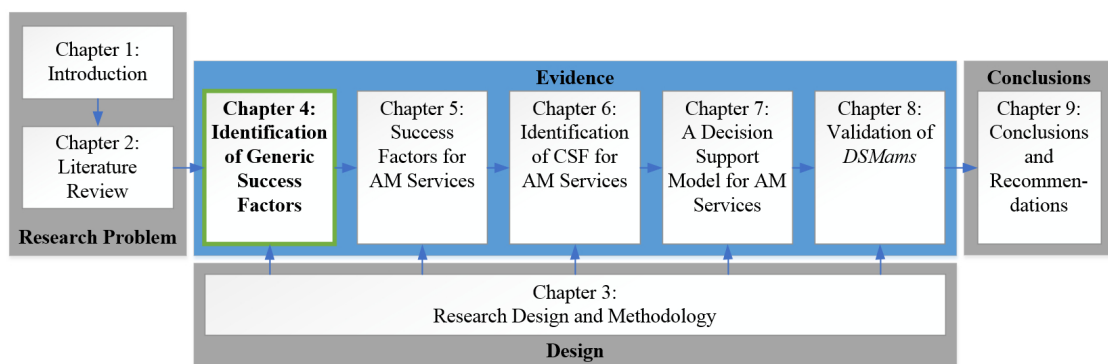
In this chapter the research approach, design, methodologies and methods of scientific reasoning for the dissertation are discussed. The next five chapters cover the five research phases.

Chapter 4

Identification of Generic Success Factors

If I have seen farther than others, it is because I was standing on the shoulders of giants

– Isaac Newton (1642-1727)



This chapter covers the content analysis and statement development of the modified Delphi study. The chapter begins with the identification of existing literature relating to generic success factors. A thematic analysis of the literature content follows. The chapter concludes with the identification of generic success factors which serve as the starting point for the Delphi study covered in chapter 5.

4.1 Introduction

Content analysis is used to group similar statements from a literature review, into categories. These categories of statements are examined for duplicates which can be collapsed into one statement (Keeney *et al.*, 2011, 1556). The aim of the content analysis is to obtain a manageable list of statements (Whitman, 1990, 36). For this research the content analysis framework of Burnard (1991, 1556) is used. The framework consists of the following activities:

1. Identification of existing literature suitable for identifying generic success factors
2. Thematic analysis by reading through the literature, noting all headings and grouping headings into categories
3. Identification of generic success factors by coding, cutting and collapsing and organising the factors under the headings

4.2 Identification of Existing Literature

For identifying generic success factors that could be further developed for AMS, the literature review focuses on fields closely related to AM. Three fields of study serve this purpose: services (including servitisation), AM (including maintenance management) and project management. Project management is of relevance because it forms part of the life cycle of services – especially more complex service solutions where system and process implementation and integration are required (refer to §2.2.8). There has been a steady output of research papers since the 1980s on the identification of success factors in these fields. Some research on success factors is also found in the fields of outsourcing, information systems and organisational development.

For identifying literature on success factors in the aforementioned fields *SUNSearch* (Stellenbosch University Library and Information Service: SUNSearch [Online], 2014) is used as the primary search engine. *SUNSearch* subscribes to the *Ex*

Libris Primo and *SFX* services which more than 2400 institutions worldwide subscribe to (including most of South Africa's universities) (Ex Libris [Online], 2014). These services give access to a comprehensive repository of local and international peer-reviewed journals.

Search requests for identifying relevant publications consist of keywords relating to success, used in combination with terminology from the three main fields of study. For example, "success", "successful", "success factors", "success and failure factors" are combined in various combinations with "services", "servitisation", "industrial services", "project(s)", "project management", "AM" and "maintenance management". No publication date, material or language filters are applied to the search criteria. Initially the search phrases are only searched for in the title of publications. The abstracts of the publications in the search results are considered, and unless thought to be inappropriate, the full publication is read. The references of these publications are used to identify the scholars who are studying success factors in the related field. Additional search requests focused on the work of these scholars to further identify relevant literature.

For the study of the literature a total of 44 relevant publications are used. The risk of the search results not being comprehensive enough is mitigated by requesting additional success factors from the expert panel as part of the Delphi study in chapter 5, §5.3.3. The distribution of the papers are (figure 4.1): 20 (45%) related to services, 11 (25%) related to AM (Waeyenbergh and Pintelon, 2002; Chan *et al.*, 2005; Brah and Chong, 2004; Aberdeen Group, 2006; Ojanen *et al.*, 2008; Ben-Daya *et al.*, 2009; Koochaki, 2009; Kellick, 2010; van der Lei *et al.*, 2012), 8 (18%) related to project management, 2 (4%) related to information system and 3 (8%) related to other relevant fields. In the first two decades following the seminal work on CSF by Rockart (1981), only a few papers were published on the identification of CSF in the fields of services and project management (Guile and Quinn, 1988; Pinto and Slevin, 1988; Pinto, 1990; Tishler *et al.*, 1996; Matthyssens and Vandembemt, 1998; Dvir *et al.*, 1998).

From 2000 a steady increase is seen in research on CSF identification, especially

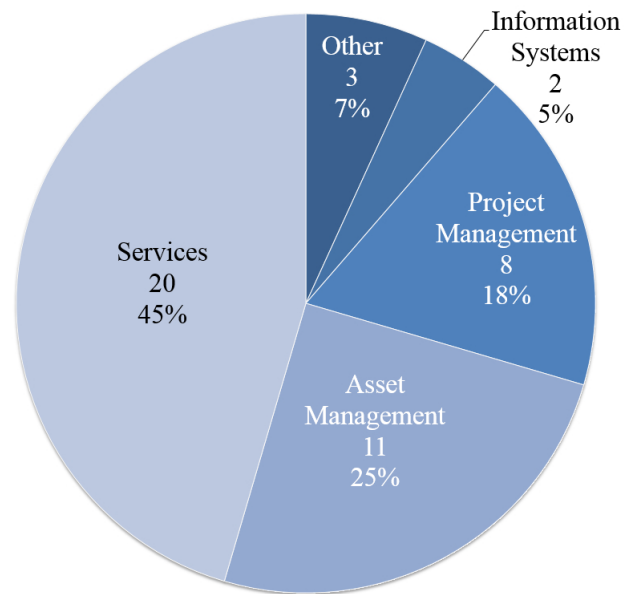


Figure 4.1: Literature study publication distribution

in the services and AM fields (figure 4.2). This supports the industry's shift towards services and the findings by Baines *et al.* (2009, 550), that more than two thirds of servitisation research papers were published from 2000 onwards. The increase in AM research also coincides with the first publication of the PAS 55 standard (British Standards Institution, 2008a) in 2004 and the renewed interest in, and importance of AM.

The origin of the research publications (figure 4.3) shows that Scandinavians are the leaders in services research, followed by Europe and North America. Research on project management CSF is lead by the Middle East, while North America and Asia lead the research in AM.

Researchers use a range of different research methods to identify CSF (figure 4.4). The majority of research is based on case studies (Esteves, 2004; Windahl and Lakemond, 2006; Dexter, 2010), interviews (Pinto, 1990; Oliva and Kallenberg, 2003; Yu *et al.*, 2006) and related qualitative analysis. Other popular methods are: expert opinion (Guile and Quinn, 1988; Deloitte, 2009; Holmström *et al.*, 2010), surveys and questionnaires (Brentani, 1989; Plant Maintenance Resource Center

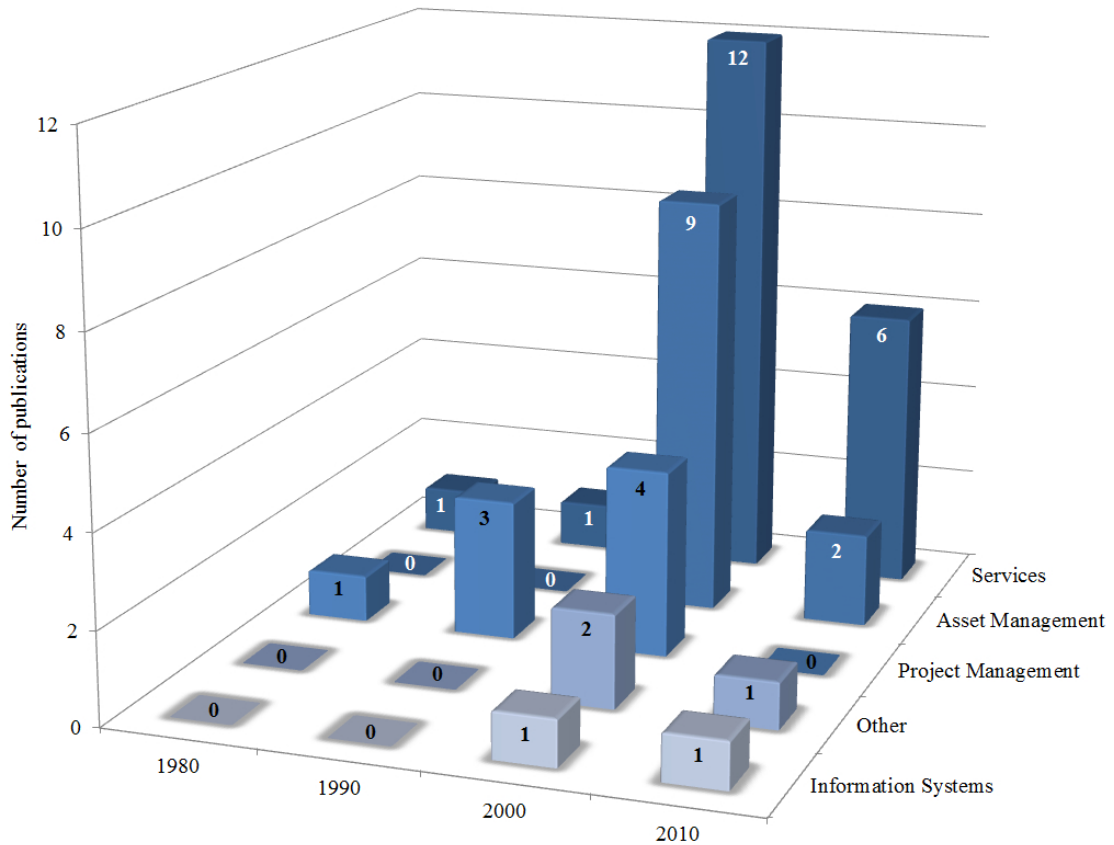


Figure 4.2: Timeline of literature study publications

[Online], 2001; Aberdeen Group, 2006), statistical analysis (Tishler *et al.*, 1996; Dvir *et al.*, 1998; Shenhar *et al.*, 2002) and literature reviews (Baines *et al.*, 2009; Velamuri *et al.*, 2011).

With services, researchers frequently make use of qualitative methods such as case studies, interviews, expert opinion and literature reviews to identify CSF (figure 4.5). With AM, researchers rely on expert opinion, while case studies and quantitative methods (such as surveys and questionnaires) are also used. With project management qualitative analysis is used. It is also the only field in the literature review in which statistical analysis is used to identify CSF.

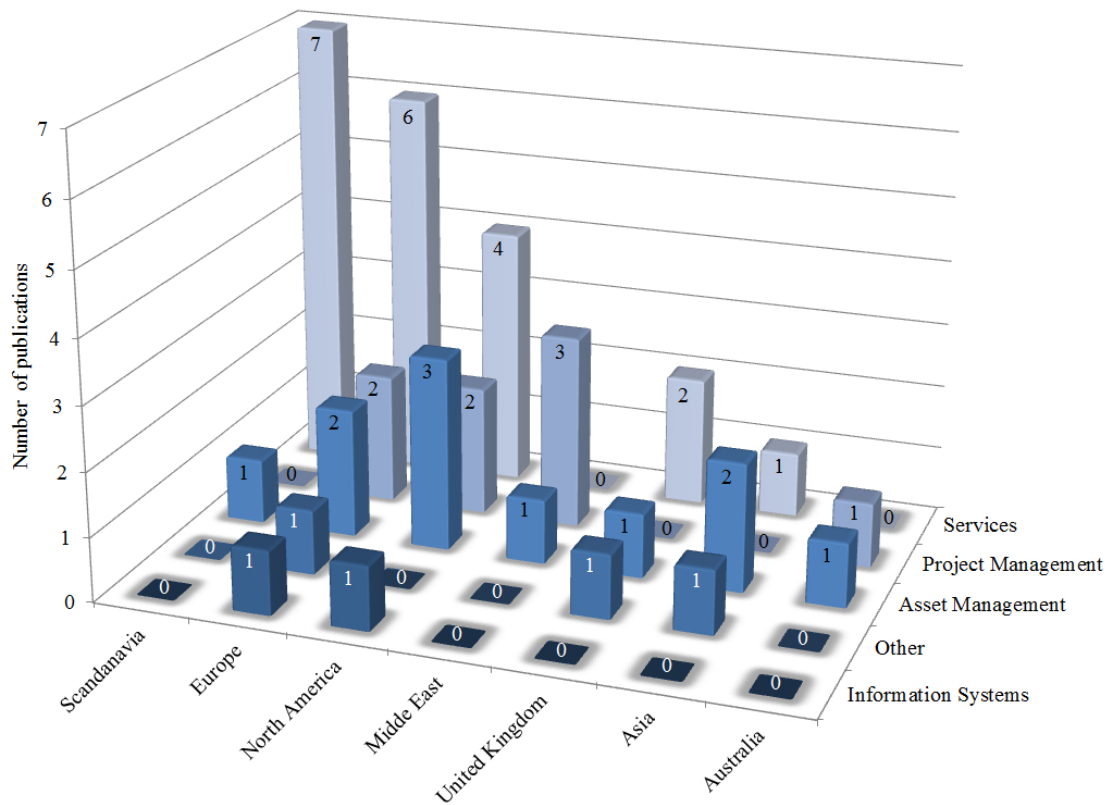


Figure 4.3: Origin of literature study publications

4.3 Thematic Analysis

The thematic analysis of the literature reveals the categorisation of publications into 20 logical sub-categories. These sub-categories are based on the main theme which is studied in the publication. The sub-categories are grouped into six main categories, which are derived from the service life cycle (refer to §2.2.8). The coverage of the publications in the the six categories and their sub-categories is shown in table 4.1.

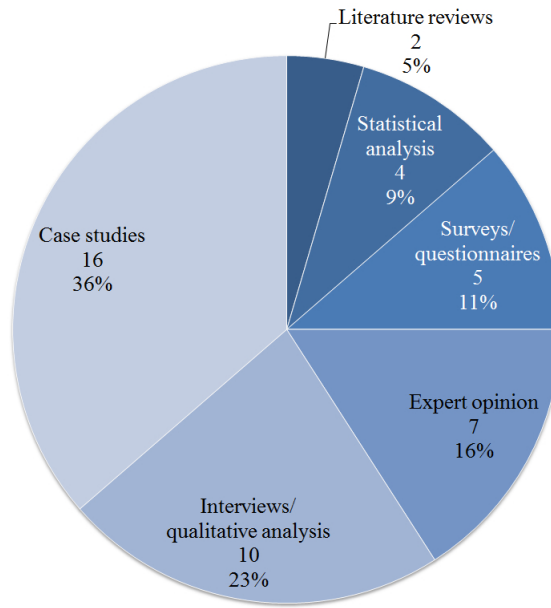


Figure 4.4: Research methods used in literature study publications

Categories and Sub-categories	Information Systems	Other	AM	Project Management	Services	Total Coverage	Percentage
1. Organisational Environment and Capabilities							
Managerial capabilities	1	3	2	4	3	13	30%
Organisational environment	1	2	4	3	11	21	48%
People	1	3	5	6	3	18	41%
2. Initiation Phase and Pre-contract Activities							
Client involvement	1	2	5	7	6	21	48%
User requirements	1	1	2	6	1	11	25%
Contracting				4		4	9%
Proposed solution		2	1	5	2	10	23%
3. Preparation and Design Processes							
Data availability during design			3			3	7%
Service design processes	1	2	2	5		10	23%
Service integration	2	2	7	4	8	23	52%

Categories and Sub-categories	Information Systems	Other	AM	Project Management	Services	Total Coverage	Percentage
System integration	1	1	2	3	3	10	23%
4. Implementation and Commissioning							
Project management	1	2	1	5	2	11	25%
Quality control	1			3		4	9%
Training and change management	2		2			4	9%
5. Control Processes							
Management of service levels			2	4	1	7	16%
Quality control			2		1	3	7%
Relationship	2	2	8	5	7	24	55%
Service improvement	1	1	3	6	2	13	30%
6. Benefits and Value-add							
Intangible benefits	1	1	1	1	1	5	11%
Quantitative benefits			2	4	4	10	23%

Table 4.1: Thematic analysis categories and sub-categories

At least half of the authors cover relationships (Plant Maintenance Resource Center [Online], 2001; Brah and Chong, 2004; Ben-Daya *et al.*, 2009) and the integration of services into existing processes (Waeyenbergh and Pintelon, 2002; Gebauer *et al.*, 2006; Kumar *et al.*, 2006). Two thirds of the authors cover the organisational environment of the service provider (Chan *et al.*, 2005; Kellick, 2010; van der Lei *et al.*, 2012), people considerations, team composition (Brentani, 1989; Shenhar *et al.*, 2002; Gebauer *et al.*, 2008) and client involvement (Fairchild *et al.*, 2004; Dörner *et al.*, 2011; Kuo *et al.*, 2010). Other themes common to all fields, but not covered as extensively by the authors, are managerial capabilities (Esteves, 2004; Deloitte, 2009; Dexter, 2010), user requirements (Pinto and Slevin, 1988; Dvir *et al.*, 2003; Ojanen *et al.*, 2008), system integration (Tishler *et al.*, 1996; Kumar *et al.*, 2006; Holmström *et al.*, 2010), project management (Matthyssens and

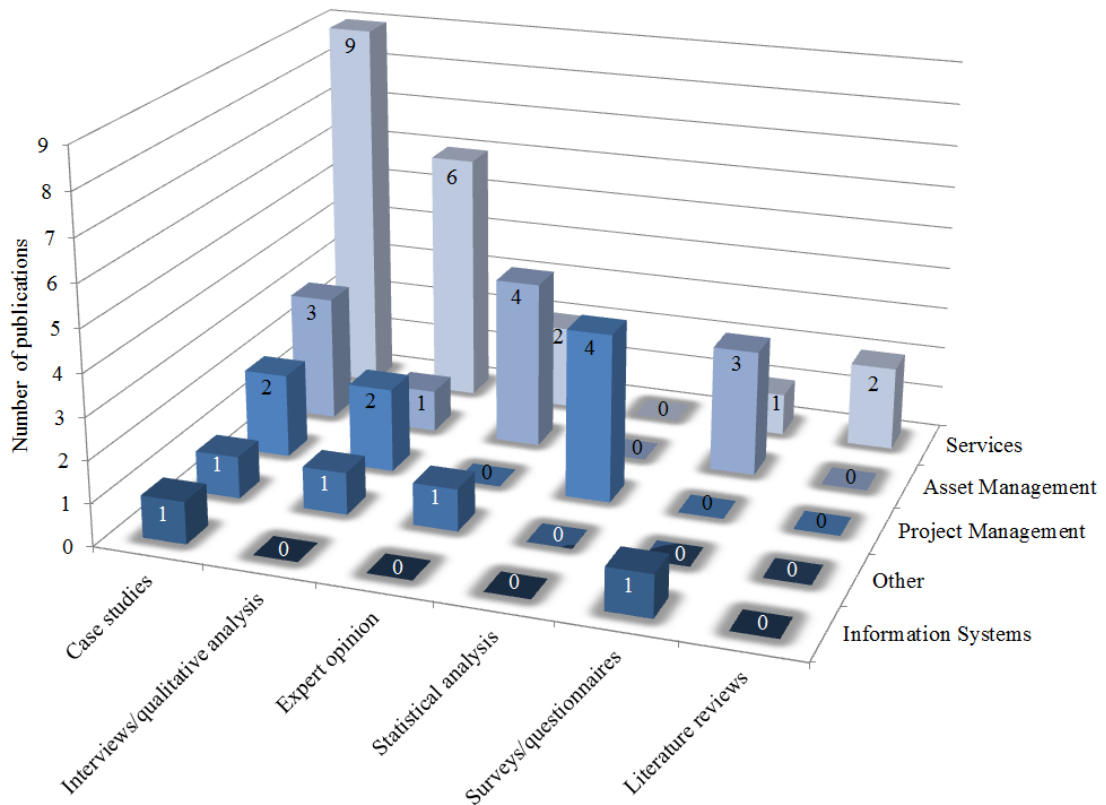


Figure 4.5: Research methods used in the different fields of study

Vandenbempt, 1998; Yu *et al.*, 2006; Aberdeen Group, 2006), service improvement (Pinto and Slevin, 1987; Dvir *et al.*, 2003; Shenhar *et al.*, 2002) and intangible benefits (Brentani, 1989; Plant Maintenance Resource Center [Online], 2001; Haider, 2007). It is interesting to note that only a few authors cover the contracting process, data availability during design, quality control and training and change management (Dvir *et al.*, 1998; Aberdeen Group, 2006; Koochaki, 2009; Fairchild *et al.*, 2004; Shenhar *et al.*, 2002; Freedman, 2011; Esteves, 2004; Ben-Daya *et al.*, 2009; Chan *et al.*, 2005).

4.4 Identification of Generic Success Factors

The *NVivo* software (QSR International: Nvivo [Online], 2012) is used for the content analysis whereby the generic success factors are identified from the liter-

ature. *NVivo* simplifies the content analysis process in §4.1. The software allows for the importing of *sources* – the publications – into its database. Within these sources, text relating to a success factor is selected and allocated to a *node*. *NVivo* refers to the selected text as *references* and to the allocation process to nodes as *coding*. Over 550 references to success factors are coded in the publications. The software allows for the easy organisation of nodes through cutting, collapsing and combining of duplicates, while retaining the reference to the source. Nodes are subsequently organised into a hierarchy with the first two tiers corresponding to the categories and sub-categories in §4.3, while the third tier represents the success factor associated with common references from the publications (see figure 4.6 for an example).

The result from the analysis is a list of 80 generic success factors. In preparation for the Delphi study, certain terminology is standardised and replaces original references in the literature:

- “AM service (AMS)” replaces all references to services, projects, product implementation, consulting intervention, etc.
- “service provider” replaces all references to the organisation which supplies or provides the “AM service”
- “client” replaces all references to the client or organisation which has a need for services and for which the “service provider” provides the “AM service”

The factors are listed with a reference to the corresponding literature¹. Each factor is assigned a unique number that is used as unique identifier for the Delphi study phase of the research.

¹Additional factors are identified, as part of the Delphi study in to chapter 5.3.3 and appendix A.5.

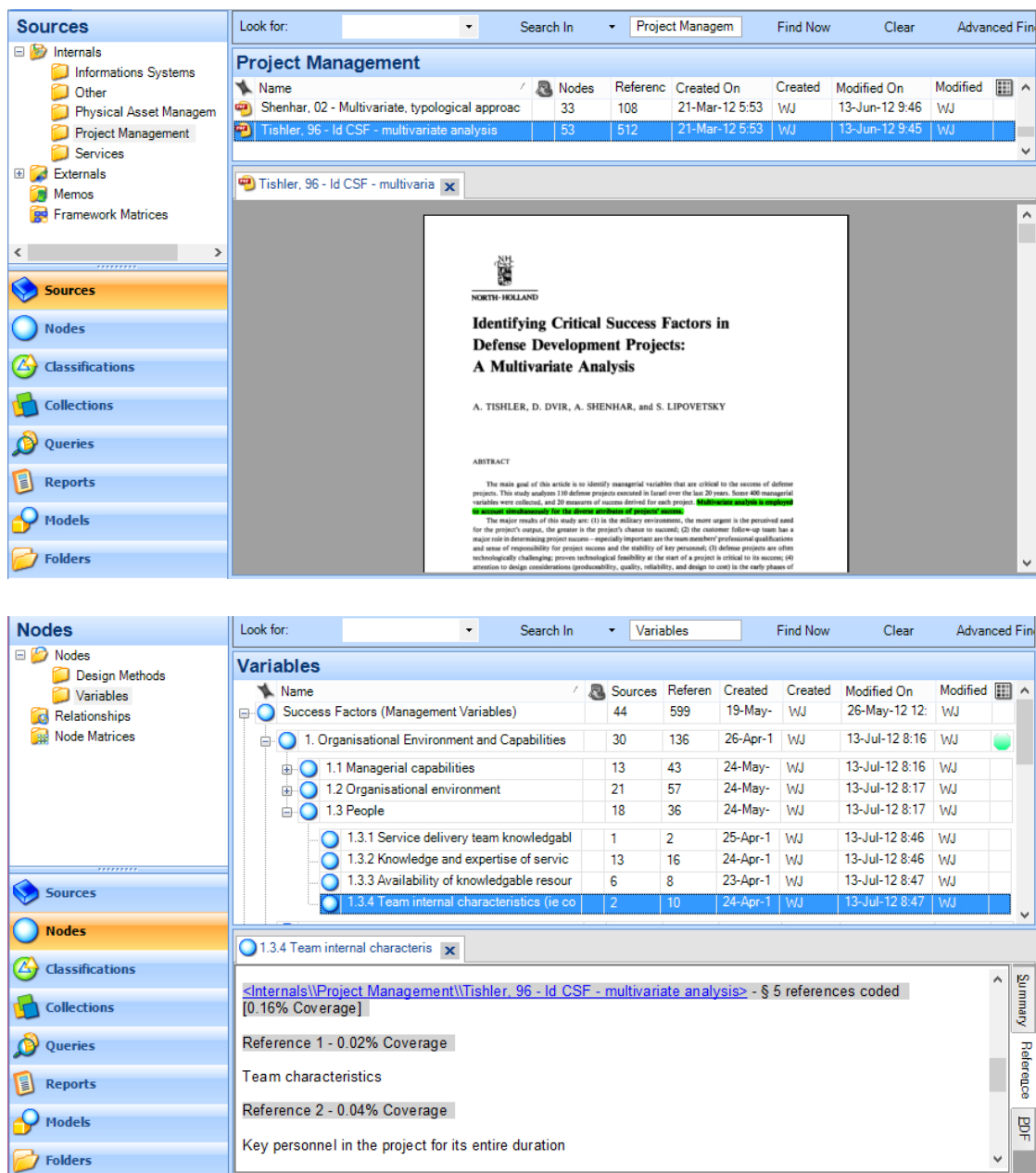


Figure 4.6: References and nodes in the NVivo software

1. Organisational Environment and Capabilities

The first set of factors relate to the organisational environment and capabilities of the service provider. The category contains 14 factors that are categorised in managerial capabilities, the organisational environment and

the capabilities and characteristics of the service provider's people.

A. Managerial Capabilities

- 1.1. A capable project manager who manages the AM service on behalf of the service provider (Esteves, 2004; Deloitte, 2009; Dexter, 2010; Yu *et al.*, 2006; Dvir *et al.*, 2003; Shenhar *et al.*, 2002; Gebauer *et al.*, 2008; Gremyr *et al.*, 2010)
- 1.2. A clear management structure and role understanding within the service provider's organisation in order not to overlap with the AM service provision process (Yu *et al.*, 2006; RCM 2006 - Reliability Centered Maintenance Manager's Forum [Online], 2006; Kellick, 2010; Dvir *et al.*, 2003; Shenhar *et al.*, 2002; Gebauer and Friedli, 2005; Gebauer *et al.*, 2008)
- 1.3. The leadership, technical and managerial styles of the AM service provider's management (i.e. their involvement in the AM service provision process, their decision-making style as well as how they motivate and supervise subordinates) (Dvir *et al.*, 1998; Tishler *et al.*, 1996)

B. Organisational Environment

- 1.4. The innovation culture of the service provider (i.e. how innovative the organisation is with their design and delivery processes) (Gebauer *et al.*, 2008; Gremyr *et al.*, 2010; Guile and Quinn, 1988)
- 1.5. A good reputation in the field or industry in which the service provider operates (Brentani, 1989)
- 1.6. A dedicated service team that only focuses on delivering a specific type of service (in contrast to a team that delivers a variety of different types of service and product-service combinations) (Esteves, 2004; Deloitte, 2009; Kellick, 2010; Baines *et al.*, 2009; Gebauer *et al.*, 2006; Kindström, 2010; Oliva and Kallenberg, 2003; Windahl and Lakemond, 2006)
- 1.7. The level of employee engagement and morale (i.e. good team morale, in contrast to a disengaged workforce) (Dvir *et al.*, 1998;

Tishler *et al.*, 1996)

- 1.8. The degree to which the service provider leverage their existing knowledge and capabilities to provide a more efficient service to their clients (Ojanen *et al.*, 2008; van der Lei *et al.*, 2012; Brentani, 1989; Gebauer *et al.*, 2008; Neu and Brown, 2005)
- 1.9. The service provider's culture towards the learning and growth of its employees (Dexter, 2010; Brah and Chong, 2004; Dvir *et al.*, 1998; Tishler *et al.*, 1996; Gebauer *et al.*, 2008; Kumar *et al.*, 2006)
- 1.10. The geographic location and distance between the operational office of the service provider and the client's operations at which the AM services are delivered (Fairchild *et al.*, 2004)

C. People

- 1.11. Degree to which the service provider's client facing team (sales representatives, project managers, service personnel) are knowledgeable in the full range of the service provider's value proposition and combination of service options available (Brentani, 1989)
- 1.12. The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants (Deloitte, 2009; Yu *et al.*, 2006; Aberdeen Group, 2006; Kellick, 2010; Ojanen *et al.*, 2008; Dvir *et al.*, 2003, 1998; Pinto, 1990; Shenhar *et al.*, 2002; Tishler *et al.*, 1996; Brentani, 1989; Gebauer and Friedli, 2005)
- 1.13. The availability of the most appropriate skilled resources for providing industry specific AM service requirements (Esteves, 2004; Deloitte, 2009; Dexter, 2010; Brah and Chong, 2004; Chan *et al.*, 2005; Gebauer *et al.*, 2008)
- 1.14. The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations) (Dvir *et al.*, 1998; Tishler *et al.*, 1996)

2. Initiation Phase and Pre-contract Activities

The second set of factors relate to the initiation phase of an AMS and to the

pre-contract activities. The category contains 15 factors that are categorised in client involvement, user requirements, contracting and a proposed solution.

A. Client Involvement

- 2.1.** The involvement of all client stakeholders in the initiation and specification of an AM service (Dexter, 2010; Yu *et al.*, 2006; Fairchild *et al.*, 2004; Gebauer *et al.*, 2008; Dörner *et al.*, 2011; Guile and Quinn, 1988; Windahl and Lakemond, 2006)
- 2.2.** Continued and sustained commitment from the client's senior management in support of the AM service (Esteves, 2004; Ben-Daya *et al.*, 2009; Brah and Chong, 2004; Chan *et al.*, 2005; RCM 2006 - Reliability Centered Maintenance Manager's Forum [Online], 2006; Kellick, 2010; Dvir *et al.*, 1998; Pinto and Slevin, 1987; Pinto, 1990; Tishler *et al.*, 1996; Gebauer *et al.*, 2008; Kuo *et al.*, 2010)
- 2.3.** The awareness and knowledge that the client's management have towards the type of AM service required by their organisation (Gebauer and Friedli, 2005)
- 2.4.** The active participation of the client personnel and their commitment towards completing the pre-contract activities (Esteves, 2004; Kellick, 2010; Dvir *et al.*, 2003, 1998; Shenhar *et al.*, 2002; Tishler *et al.*, 1996)

B. User Requirements

- 2.5.** The urgency with which the client organisation requires a solution to their AM problem (Dvir *et al.*, 1998; Tishler *et al.*, 1996; Brentani, 1989)
- 2.6.** Clear and well defined technical and operational user requirements for the AM service required (Freedman, 2011; Yu *et al.*, 2006; Ojanen *et al.*, 2008; Dvir *et al.*, 1998; Fairchild *et al.*, 2004; Pinto and Slevin, 1987; Pinto, 1990; Tishler *et al.*, 1996; Brentani, 1989)
- 2.7.** The alignment of the client organisation's AM service requirements with their overall organisational and business strategies (Brah and Chong, 2004)

- 2.8. The client organisation's acquisition process for AM and other services (i.e. evaluation of service providers, tender processes) (Yu *et al.*, 2006; Dvir *et al.*, 1998; Fairchild *et al.*, 2004; Shenhar *et al.*, 2002; Tishler *et al.*, 1996)

C. Contracting

- 2.9. Agreement on a predefined invoicing and payment plan between the service provider and client organisation (Dvir *et al.*, 1998; Tishler *et al.*, 1996)
- 2.10. Compilation and availability of formal contractual documents (Dvir *et al.*, 2003, 1998; Shenhar *et al.*, 2002; Tishler *et al.*, 1996)
- 2.11. Willingness by both the client organisation and service provider to consider new approaches (compared to preconceived ideas) to ensure an effective AM service (Dvir *et al.*, 2003; Tishler *et al.*, 1996)

D. Proposed Solution

- 2.12. A detailed project plan with milestones in place (Dexter, 2010; Dvir *et al.*, 1998; Tishler *et al.*, 1996)
- 2.13. The service provider's process for compiling a solution for the client (i.e. the understanding of the problem, evaluation of alternative solutions and consideration of various aspects such as logistics and safety considerations) (Yu *et al.*, 2006; Ojanen *et al.*, 2008; Dvir *et al.*, 1998; Fairchild *et al.*, 2004; Pinto and Slevin, 1987; Pinto, 1990; Tishler *et al.*, 1996; Maxwell *et al.*, 2006)
- 2.14. The conciseness and effectiveness of the presentation and communication of the proposed solution to the client (Dexter, 2010; Yu *et al.*, 2006; Fairchild *et al.*, 2004; Pinto and Slevin, 1987; Pinto, 1990; Maxwell *et al.*, 2006)
- 2.15. The AM service solution offering consisting of the appropriate bundling of products and services at a market related cost (in other words obtaining value from a spot-on solution) (Ojanen *et al.*, 2008; Dvir *et al.*, 1998; Fairchild *et al.*, 2004; Tishler *et al.*, 1996; Brentani, 1989)

3. Preparation and Design Processes

The third set of factors relate to the preparation and design processes. The category contains 22 factors that are categorised under data availability during design, AMS design processes, service- and system integration.

A. Data Availability During Design

- 3.1. The availability and transparency of information (for design and implementation purposes) between the service provider and client team for preparing and designing the AM service (Aberdeen Group, 2006; Koochaki, 2009; Ojanen *et al.*, 2008)
- 3.2. Design and integration of service and performance metrics for all stakeholders (service provider and client) involved in the AM service (Aberdeen Group, 2006)
- 3.3. The inter-company flow of information (between the service provider and client organisation) during the AM service design (Ojanen *et al.*, 2008)

B. Service Design Processes

- 3.4. The use of the latest methods in managing risks that could arise during the AM service (van der Lei *et al.*, 2012; Dvir *et al.*, 2003; Fairchild *et al.*, 2004; Shenhar *et al.*, 2002)
- 3.5. A formal service level agreement or policy (i.e. outlining budgets, communication, configuration control, personnel management, service provider performance requirements, client responsibilities) forming part of the design process (Dvir *et al.*, 2003, 1998; Shenhar *et al.*, 2002; Tishler *et al.*, 1996)
- 3.6. Compilation and active use of design documents (Dvir *et al.*, 2003; Tishler *et al.*, 1996)
- 3.7. Ensuring that pre-project arrangements are made for logistics, feasibility studies and changes in organisational structures that might arise from the AM service (Dvir *et al.*, 1998; Tishler *et al.*, 1996)
- 3.8. The potential of the AM service to be scalable (expandable to other business units within the client organisation) (Ojanen *et al.*, 2008)

- 3.9. Setting realistic project deadlines and budget targets (Yu *et al.*, 2006)
- 3.10. The use of a practice run or pilot projects for the designed AM service (Freedman, 2011; Dexter, 2010; Dvir *et al.*, 1998; Tishler *et al.*, 1996)

C. Service Integration

- 3.11. The degree to which the client is knowledgeable and experienced in AM and AM services (Yu *et al.*, 2006; Freedman, 2011; Waeyenbergh and Pintelon, 2002)
- 3.12. The strategic fit of the AM service with the service provider and client's current service propositions, systems and capabilities (Freedman, 2011; Dexter, 2010; Ojanen *et al.*, 2008; Brentani, 1989; Maxwell *et al.*, 2006)
- 3.13. The ability to integrate the AM service into the client's core business processes (Esteves, 2004; Ojanen *et al.*, 2008; Gebauer *et al.*, 2006; Guile and Quinn, 1988; Nordin, 2006; Velamuri *et al.*, 2011)
- 3.14. Evaluation and consideration of different AM service designs (Ben-Daya *et al.*, 2009; van der Lei *et al.*, 2012; Dvir *et al.*, 1998; Tishler *et al.*, 1996; Brentani, 1989; Kumar *et al.*, 2006; Matthyssens and Vandenbempt, 1998; Maxwell *et al.*, 2006)
- 3.15. The integration of health, safety, environmental and quality considerations as part of the AM service or to align the service to existing standards (Ojanen *et al.*, 2008; Kumar *et al.*, 2006)
- 3.16. The integration of operational excellence methodologies, such as TPM, TQM, 5S into the AM service offering or to align the service to existing standards (Dexter, 2010; Ben-Daya *et al.*, 2009; Brah and Chong, 2004; Chan *et al.*, 2005; van der Lei *et al.*, 2012; Pinto and Slevin, 1987; Pinto, 1990)

D. System Integration

- 3.17. The availability of adequate infrastructure and interfaces in support of the AM service (Esteves, 2004; Dexter, 2010)

- 3.18. An adequate information system implementation (i.e. CMMS, EAMS, ERP) strategy, including data migration (if applicable), and data quality assurance to support the AM service (Esteves, 2004; Kumar *et al.*, 2006)
- 3.19. Adequate legacy system knowledge, if such systems are required to interface with the AM service information systems (Esteves, 2004)
- 3.20. Avoidance of unnecessary customisation to existing information systems, especially ERP systems (Esteves, 2004)
- 3.21. Incorporation of the latest technology (i.e. mobility solutions) into the AM service design (Brah and Chong, 2004; Ojanen *et al.*, 2008; Dvir *et al.*, 1998)
- 3.22. The security and protection of information, relating to information systems that form part of the AM service (Fairchild *et al.*, 2004)

4. Implementation and Commissioning

The fourth set of factors relate to the implementation and commissioning processes. The category contains six factors that are categorised under project management, quality control and training and change management.

A. Project Management

- 4.1. The use of a formalised project plan or schedule for implementing the AM service (Esteves, 2004; Dexter, 2010; Yu *et al.*, 2006; Aberdeen Group, 2006; Dvir *et al.*, 2003; Pinto and Slevin, 1987; Pinto, 1990; Shenhar *et al.*, 2002; Tishler *et al.*, 1996; Dörner *et al.*, 2011; Matthyssens and Vandenbempt, 1998)
- 4.2. Good project scope management (Esteves, 2004)

B. Quality Control

- 4.3. Formal design or implementation reviews at logical stages during the implementation and commissioning phases (Dvir *et al.*, 2003; Shenhar *et al.*, 2002)
- 4.4. Formalised handover, testing and a quality control plan to ensure that the implementation is done successfully (Esteves, 2004; Fairchild *et al.*, 2004)

C. Training and Change Management

- 4.5. An adequate training programme in place for all AM service role players, both in the service provider and client teams (Esteves, 2004)
- 4.6. An effective organisational change management programme in support of the AM service (Esteves, 2004; Freedman, 2011; Ben-Daya *et al.*, 2009; Chan *et al.*, 2005)

5. Control Processes

The fifth set of factors relate to the control processes to ensure an optimal on-going AMS. The category contains 16 factors that are categorised under the management of service levels, quality control, relationships and intervention improvement.

A. Management of Service Levels

- 5.1. The active management of the roles and responsibilities of the service provider and client organisation, relating to the AM service contract (Ojanen *et al.*, 2008; van der Lei *et al.*, 2012; Dvir *et al.*, 2003, 1998; Shenhar *et al.*, 2002; Tishler *et al.*, 1996)
- 5.2. The monitoring of budgets and costs relating to the AM service (Dvir *et al.*, 1998; Tishler *et al.*, 1996)
- 5.3. Configuration control of current AM service processes and systems (Dvir *et al.*, 1998; Tishler *et al.*, 1996)
- 5.4. Management of mutual expectations between the service provider and client relating to the AM service (Velamuri *et al.*, 2011)

B. Quality Control

- 5.5. The management of quality assurance of third party suppliers (contractors), if they are used as part of the AM service (Freedman, 2011; Kumar *et al.*, 2006)
- 5.6. Periodic audits to ensure all aspects of the AM service is at the required standard per the agreement between the service provider and client (Aberdeen Group, 2006)

C. Relationship

- 5.7. The active management of the relationship between the service provider and client organisation personnel involved in the AM service (Freedman, 2011; Fairchild *et al.*, 2004; Gebauer *et al.*, 2006; Windahl and Lakemond, 2006)
- 5.8. The appreciation of diversity among inter-company teams involved in the AM service (Ben-Daya *et al.*, 2009; Brah and Chong, 2004; Chan *et al.*, 2005; RCM 2006 - Reliability Centered Maintenance Manager's Forum [Online], 2006; Ojanen *et al.*, 2008; Waeyenbergh and Pintelon, 2002; Gebauer *et al.*, 2008; Windahl and Lakemond, 2006)
- 5.9. The degree to which there is inter-company learning and collaboration between the service provider and the client organisation (Esteves, 2004; Yu *et al.*, 2006; Aberdeen Group, 2006; Ben-Daya *et al.*, 2009; Ojanen *et al.*, 2008; van der Lei *et al.*, 2012; Löfberg *et al.*, 2010)
- 5.10. Open and effective communication (Esteves, 2004; Yu *et al.*, 2006; Dvir *et al.*, 1998; Pinto and Slevin, 1987; Pinto, 1990; Tishler *et al.*, 1996; Brentani, 1989; Kumar *et al.*, 2006)
- 5.11. Mutual trust and respect between the service provider and client organisation (Esteves, 2004; Dexter, 2010; Yu *et al.*, 2006; Ojanen *et al.*, 2008; Fairchild *et al.*, 2004; Kumar *et al.*, 2006; Velamuri *et al.*, 2011)

D. Service Improvement

- 5.12. Active client participation in reporting, problem solving and improvement relating to the AM service (Shenhar *et al.*, 2002)
- 5.13. Agility (responsiveness) in responding to changes in AM service demands (Esteves, 2004; Yu *et al.*, 2006; Ojanen *et al.*, 2008; Freedman, 2011; Waeyenbergh and Pintelon, 2002; Dvir *et al.*, 1998; Pinto and Slevin, 1987; Pinto, 1990; Tishler *et al.*, 1996; Brentani, 1989)

- 5.14. Measurement and improvement of the AM service to increase the value-add and benefits (Dvir *et al.*, 2003, 1998; Shenhar *et al.*, 2002; Tishler *et al.*, 1996; Brentani, 1989; Kumar *et al.*, 2006)
- 5.15. Multi-level feedback, reviews and reporting (i.e. all hierarchical levels in the service provider and client organisations are periodically involved in improvement initiatives) (Yu *et al.*, 2006; Dvir *et al.*, 1998; Tishler *et al.*, 1996)
- 5.16. Proper priority setting of improvement actions, irrespective whether it is service or value-add related (Yu *et al.*, 2006)

6. Benefits and Value-add

The sixth set of factors relate to benefits and value-add. The category contains seven factors that are categorised under intangible (unmeasurable) benefits and quantitative (measurable) benefits.

A. Intangible Benefits

- 6.1. The consideration of intangible benefits and value creation (i.e. increased effectiveness, risk mitigation, improved decision-making capability) as a result of the AM service (Freedman, 2011)
- 6.2. Feedback and sharing of lessons learned from successful improvements made to the AM service (Freedman, 2011)
- 6.3. Formal post launch evaluations of the AM service to determine what can be improved (Brentani, 1989)
- 6.4. Proof of technological and systemic benefits and value creation as a result of the AM service (Haider, 2007)

B. Quantitative Benefits

- 6.5. Proof of operational and financial performance achievements as a result of the AM service (Kumar *et al.*, 2006)
- 6.6. The ability to measure the AM service quality and value creation (Brah and Chong, 2004; Dvir *et al.*, 2003; Shenhar *et al.*, 2002; Brentani, 1989; Matthyssens and Vandenbempt, 1998; Neu and Brown, 2004)

- 6.7.** Focused and continuous improvement to the AM service through monitoring, analysis and feedback (Aberdeen Group, 2006; Pinto and Slevin, 1987; Pinto, 1990)

In the following chapters the factors are systematically selected towards the final list of CSF for AMS. Subsequently, the list of factors are partially repeated in chapters 5 and 6 to show the progression towards the final list of CSF. The author apologises to the reader for this duplication, which is presumed preferable to the repeated referring back to this section.

In conclusion, the first part of the chapter analyses previous research on the identification of CSF related to fields closely connected to AM. A total of 44 research publications are reviewed to identify generic success factors. A list of 80 potential success factors are extracted and grouped into six categories which relate to the service life cycle phases.

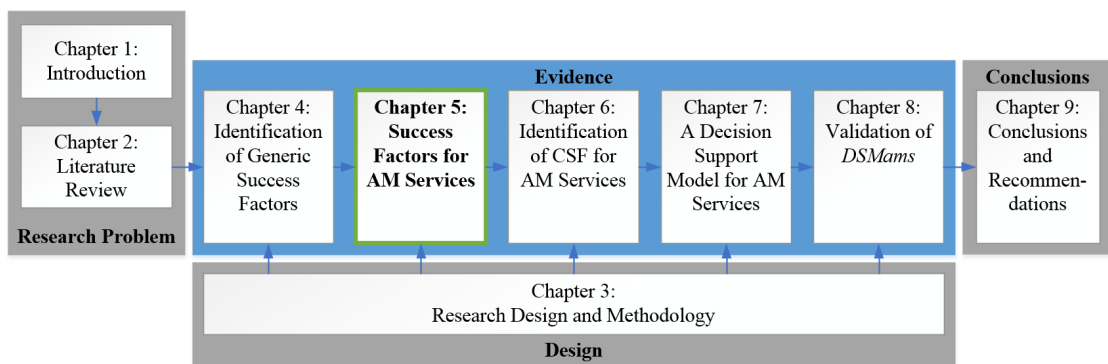
The CSF scholarship refers to three to six CSF which commonly lead to success (§2.3.1). Taking into account that the CSF for the six service life cycle phases (§2.2.8 and §4.3) might vary, there is a likelihood of a final list of 36 CSF. Eighty generic factors are a reasonable list to start from. The list is not excessive compared to an expected list of 36 factors, but large enough to allow for flexibility in selecting the most critical factors for AMS – assuming a reasonable degree of relevance to AMS. The validity of the 80 generic factors for AMS is further investigated in chapter 5.

Chapter 5

Success Factors for Asset Management Services

Exploratory data analysis can never be the whole story, but nothing else can serve as the foundation stone – as the first step

– John Tukey (1915-2000)



The objective of this chapter is to conduct a Delphi study for reaching consensus on the success factors for AMS. The chapter begins with the background and design of the Delphi study. This is followed by executing three rounds of questionnaires. For each round the responses are statistically analysed. The chapter is concluded with the final results in the form of a list of factors which are important to the success of AMS.

5.1 Introduction

The Delphi method is an established research methodology which is well suited when there is incomplete knowledge about a problem or phenomenon. It is well suited for doctoral and masters research (Skulmoski *et al.* 2007, 2; Adler and Ziglio 1996, 4). It is based on the structuring of group communication so that the process is effective; allowing a group of individuals to deal with a problem (Linstone and Turoff 2002, 3; Amos and Pearse 2008, 96). The method allows consensus to be reached amongst a panel of experts on a certain issue or topic by using multi-staged questionnaires (Keeney *et al.*, 2011, 272). The classical Delphi method consists of an open first round to facilitate idea generation and to elicit opinion. Consensus is then gained in three or more rounds of iterative questionnaires (Keeney *et al.*, 2011, 350). The results from each round are analysed to identify the statements that have gained consensus. Group and individual feedback are given in each round, allowing the panellists to revise their views in the following round. (Keeney *et al.* 2011, 442; Amos and Pearse 2008, 96; Linstone and Turoff 2002, 3).

A modified Delphi approach is followed for this research, whereby the traditional first round is replaced by statements, developed from content analysis of existing literature (Keeney *et al.* 2011, 1556; Linstone and Turoff 2002, 5). This modified approach is aligned with the work by Duffield (1993, 228) and Jenkins and Smith (1994, 416) and allows for a more efficient process which would otherwise be very time consuming with the likelihood of response fatigue. It is recognised that the content analysis of existing literature could be biased or limited in the available options. This risk is mitigated by allowing respondents the opportunity to comment and to give feedback at the end of the questionnaires (refer to §5.3.3).

According to Williams and Webb (1994, 181) and Martorella (1991, 84) the Delphi method has several advantages, many of which relate to the fact that it provides consensus from expert opinion, without the prejudice of similar techniques. Panellists remain anonymous which allows for honest opinion without peer pressure (Jenkins and Smith 1994, 413; Grobbelaar 2007, chap. 6, 2). The Delphi method works well in situations where panellists are geographically far

apart and where it is logistically impractical to use other group or conference data collection methods (Murry and Hammons 1995, 424; Grobbelaar 2007, chap. 6, 2; Jenkins and Smith 1994, 413). With Delphi, panellists are given time to consider their responses, which might not be possible in group discussions (Jenkins and Smith, 1994, 413). Grobbelaar (2007, chap. 6, 2) states the benefit of using Delphi is that judgements made from the study allow for analysis, ranking and prioritisation, while also compelling panellists to think about the future scenarios.

Nevertheless, there is criticism against the Delphi technique (Keeney *et al.*, 2011; Grobbelaar, 2007): the size of the expert panel; implications of the lack on anonymity; withdrawal of panellists and the level of consensus gained.

There is no consensus regarding the size of the panel or its composition. As a consequence, panel sizes vary from less than 15 to between 15-100. The lack of anonymity in Delphi is also criticised. Complete anonymity is difficult to ensure. Firstly because the researcher knows the panellists and their responses. Secondly, panellists often know each other, but cannot attribute responses towards one another. The withdrawal of panellists during the process is a risk to the validity of the final results. Lastly, the level of consensus is contentious, sometimes arbitrary and often stated *post hoc*.

There are differences in opinion on the methodology guidelines. Keeney *et al.* (2011, 620) states that Delphi lacks scientific and professional guidelines. Grobbelaar (2007, chap. 6, 2) however states Delphi is well-formalised which contributes to its popularity and credibility, while Linstone and Turoff (2002, 3) assert that Delphi is more an art than a science.

5.2 Delphi Design

Three aspects need to be considered in the design of the Delphi study:

- The size of the expert panel and the selection of panellists
- The level of consensus

- The development and delivery method of the questionnaire

5.2.1 Selection of Expert Panel

The reliability of results is higher for larger samples of panellists. Considering that the topic is about a specific field of study – AMS – a homogeneous sample of panellists is selected. Smaller sample sizes, such as 10-15 panellists are sufficient for homogeneous samples, as it can be inferred that the results are representative of the larger population (Skulmoski *et al.* 2007, 10; Adler and Ziglio 1996, 14). A panel size of 15-25 panellists are aimed at for this research. This is in line with similar research in other studies with homogeneous panels (Duncan 1995, 45; Grobbelaar 2007, chap. 6, 3; Lam *et al.* 1999, 88).

The panel selection is based on people who are knowledgeable in AM and specifically individuals who have experience in AMS. The experts are selected from a network of contacts and acquaintances made by the researcher over a period of ten years while being in the service of his employer Pragma (Pragma [Online], 2013). Twenty-five experts were invited to participate in the research. Nineteen indicated their willingness to participate.

Demographic information on the panellists is listed in table 5.1. Panellists are categorised according to their role – as service provider or as asset owner – and according to the major industries¹ in which they work.

In accordance with the University of Stellenbosch's ethics policy the identity of the panellists remain confidential (see appendix A.1).

¹Panellists from the five major asset intensive industries are represented; Mining & Quarrying (MQ), Manufacturing (M), Electricity Supply (ES), Water Supply (WS) and Facilities (F). The industries are aligned with the International Standard Industrial Classification of All Economic Activities (ISIC) (United Nations [Online], 2008). Some of the ISIC descriptions are shortened for simplification. *Electricity, gas, steam and air conditioning supply* is shortened to Electricity Supply, *Water supply; sewerage, waste management and remediation activities* is shortened to Water Supply and *Wholesale and retail trade; repair of motor vehicles and motorcycles and Services to buildings and landscape activities* are included in Facilities.

	Affiliation	Role	Industries
1.	AM Project Manager at Pragma (Africa)	SP	MQ, M, ES, WS, F
2.	Reliability Engineer at Fresenius Kabi (SA)	AO	M
3.	AM Services Manager for Pragma at Aberdare Cables (SA)	SP	M
4.	Global After Sales Director at Meyn Poultry Processing Technology (Netherlands)	SP	M
5.	Asset Care Manager at Pretoria Portland Cement (SA)	AO	M
6.	Maintenance Manager at Ceres Fruit Juices (SA)	AO	M
7.	ISO 55 000 working group member, AM Consultant at Pragma (Global)	SP	MQ, M, ES, WS, F
8.	Global Retail Facilities Maintenance Manager at Shell International (Global)	AO	F
9.	AM Services Manager for Pragma at Shoprite	SP	F
10.	Systems Manager at CSIR (SA)	SP	F
11.	President at P&RO Solutions (USA)	SP	MQ, M, ES, WS
12.	Head of Electrical Support Services at City of Cape Town Municipality (SA)	AO	ES, F
13.	Manager of Reliability Program Development and Master Data at Suncor Energy (Canada)	AO	MQ
14.	SAAMA Boardmember, AM Consultant at E-logics (SA)	SP	MQ, WS
15.	Chief Operating Officer at Pragma (SA)	SP	MQ, M, WS, F
16.	Chief Executive Officer at Reliabilityweb.com (USA)	SP	MQ, M, ES, WS, F
17.	Managing Director at Pragma Brasil (Brazil)	SP	MQ, M, ES
18.	AM Project Executive at eThekweni Electricity (SA)	AO	ES
19.	ISO 55 000 working group member, SAAMA President, Managing Director at Pragma (Africa)	SP	MQ, M, ES, WS, F

Table 5.1: List of Delphi study panellists

5.2.2 Level of Consensus

There is no clarity as to what the level of consensus for statements in a Delphi study should be. It is common practice to only decide on a level of consensus after the completion of the first round. The attainment of a certain level of agreement is regarded as the most common measure of consensus (Keeney *et al.*, 2011, 822), however levels can vary widely. Williams and Webb (1994, 185) used 100% agreement as consensus, Stewart *et al.* (1999, 226) used 95% , Bruininks *et al.* (1995, 553) used 80%, Keeney *et al.* (2006, 210) used 75% and Loughlin and Moore (1979, 103) used 51%. Some researchers argue that the stability of responses is a more reliable measure (Crisp *et al.* 1997, 117; Grobbelaar 2007, chap. 6, 14).

For this Delphi study the attainment of a certain level of agreement among the

panellists is used as a measure to confirm which of the generic factors are important (or unimportant) towards the success of AMS. It is unrealistic to use a 100% level of consensus as the topic being studied is new with a degree of unfamiliarity to panellists. By setting a 100% level of consensus there is a risk that none of the items will gain consensus; and a 50% level of consensus is likely to be too weak. All of the factors are important in their respective fields. At this level of consensus the risk is that all of the factors will gain consensus.

A two-thirds level of consensus is chosen. This is considered to be an appropriate level, since double the number of panellists will agree at this level, compared to those who do not agree. Since the panel is homogenous, a 66.7% consensus is deemed to be a good level to gauge the consensus amongst the group. An example of another application of this level of consensus is the required two-thirds majority from the legislature in many countries to alter constitutions.

5.2.3 Development of Questionnaires

For this study the traditional first round Delphi of eliciting information from the panellists is replaced with the results from the content analysis of the literature study in §4.4. Each questionnaire includes a participant information sheet, instructions and the list of relevant generic success factors. A 5-level Likert-type scale is used for rating the factors. This type of scale is commonly used to measure opinion on a matter (Han and Noh 1999, 31; Usoro 1999). The scale levels are; *very important (5)*, *important (4)*, *neither important or not important (3)*, *less important (2)* and *unimportant (1)*. The instruction to the panellists is to rate the factors according to how important each factor is towards the success of AMS.

No dependant variables are included in the questionnaire. Although AMS “success” could be a possible dependant variable in this context, it is not explicitly defined or included as variable in the questionnaire. This is due to the term’s broad meaning and the diversity in types of AMS in the market. Similar to Stankovic *et al.* (2013, 1665), success is based on the panellists’ perception of what a successful AMS is.

With the Delphi method the rounds of questionnaires continues until the pre-defined level of consensus is achieved, or when no new information is gained. This study consists of three rounds. In the first round all the factors identified in the content analysis are formulated into statements. The same 5-level Likert-type scale is used for all three round questionnaires. Group and individual feedback on the previous round's responses are included in rounds two and three.

The web-based survey software, *SurveyMonkey* (SurveyMonkey [Online], 2013) is used for collecting responses. The results are statistically analysed by using the statistical software, *Statistica* (Statistica [Online], 2013).

5.3 First Round Questionnaire

In the first round questionnaire demographic information is collected about the panellists. This information is used to determine if there are any sub-aggregations within the panel which could affect the responses. Panellists are also asked to provide additional success factors which they deem is missing from the list and which should be included in the study. The first round questionnaire is included in appendix A.2.

5.3.1 Questionnaire Feedback

Table 5.2 summarises the descriptive statistics for the first round responses. The response percentage – percentage of panellists who selected a particular scale level – is also shown. The factors are referenced by a unique identifying number as referred to in §4.4.

All 19 panellists completed the questionnaire. In general, there is a high occurrence of *very important* (5) and *important* (4) ratings. This is seen in the high values of the mean, median, mode and the frequency of the mode. The minimum, maximum and standard deviation values show the degree of variation between the responses of the panellists. This shows evidence that the majority of panellists have rated the factors as important, while some rated them as less important.

This tendency is confirmed by the response percentages.

Factor	Descriptive Statistics								Response Percentage (Level of Consensus)				
	Valid N	Mean	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)
1.1	19	4.263	5	5	13	1	5	1.368	68.4%	15.8%	0.0%	5.3%	10.5%
1.2	19	3.947	4	4	8	2	5	1.129	36.8%	42.1%	0.0%	21.1%	0.0%
1.3	19	4.263	5	5	10	1	5	1.098	52.6%	36.8%	0.0%	5.3%	5.3%
1.4	19	3.947	4	4	8	2	5	1.129	36.8%	42.1%	0.0%	21.1%	0.0%
1.5	19	3.947	4	4	10	1	5	1.129	31.6%	52.6%	0.0%	10.5%	5.3%
1.6	18	3.667	4	4	9	2	5	1.138	22.2%	50.0%	0.0%	27.8%	0.0%
1.7	19	4.368	5	5	10	2	5	0.831	52.6%	36.8%	5.3%	5.3%	0.0%
1.8	19	4.579	5	5	11	4	5	0.507	57.9%	42.1%	0.0%	0.0%	0.0%
1.9	19	3.947	4	4	11	2	5	0.970	26.3%	57.9%	0.0%	15.8%	0.0%
1.10	19	3.158	4	4	6	1	5	1.463	21.1%	31.6%	5.3%	26.3%	15.8%
1.11	19	4.000	4	4	12	1	5	1.000	26.3%	63.2%	0.0%	5.3%	5.3%
1.12	19	4.474	5	5	11	2	5	0.772	57.9%	36.8%	0.0%	5.3%	0.0%
1.13	19	4.105	4	4	11	2	5	0.875	31.6%	57.9%	0.0%	10.5%	0.0%
1.14	18	3.944	4	4	10	2	5	0.998	27.8%	55.6%	0.0%	16.7%	0.0%
2.1	19	4.263	4	4	11	2	5	0.733	36.8%	57.9%	0.0%	5.3%	0.0%
2.2	19	4.737	5	5	16	2	5	0.733	84.2%	10.5%	0.0%	5.3%	0.0%
2.3	19	4.053	4	4	9	2	5	1.026	36.8%	47.4%	0.0%	15.8%	0.0%
2.4	19	4.211	4	4	12	2	5	0.713	31.6%	63.2%	0.0%	5.3%	0.0%
2.5	19	3.105	2	2	9	1	5	1.370	21.1%	26.3%	0.0%	47.4%	5.3%
2.6	19	4.263	5	5	11	2	5	1.098	57.9%	26.3%	0.0%	15.8%	0.0%
2.7	19	4.579	5	5	13	2	5	0.769	68.4%	26.3%	0.0%	5.3%	0.0%
2.8	19	3.421	4	4	8	1	5	1.346	21.1%	42.1%	5.3%	21.1%	10.5%
2.9	19	3.211	3	2	9	2	5	1.273	21.1%	26.3%	5.3%	47.4%	0.0%
2.10	19	3.632	4	4	13	1	5	1.065	10.5%	68.4%	0.0%	15.8%	5.3%
2.11	19	4.474	5	5	11	2	5	0.772	57.9%	36.8%	0.0%	5.3%	0.0%
2.12	19	4.000	4	5	9	1	5	1.291	47.4%	31.6%	0.0%	15.8%	5.3%
2.13	19	4.421	5	5	10	2	5	0.769	52.6%	42.1%	0.0%	5.3%	0.0%

Factor	Descriptive Statistics								Response Percentage (Level of Consensus)				
	Valid N	Mean	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)
2.14	19	4.211	5	5	10	2	5	1.084	52.6%	31.6%	0.0%	15.8%	0.0%
2.15	19	4.000	4	4	9	1	5	1.155	36.8%	47.4%	0.0%	10.5%	5.3%
3.1	19	4.474	5	5	10	3	5	0.612	52.6%	42.1%	5.3%	0.0%	0.0%
3.2	19	4.368	4	5	9	3	5	0.684	47.4%	42.1%	10.5%	0.0%	0.0%
3.3	19	4.158	4	4	12	3	5	0.602	26.3%	63.2%	10.5%	0.0%	0.0%
3.4	19	3.526	3	3	9	1	5	0.964	15.8%	31.6%	47.4%	0.0%	5.3%
3.5	19	4.526	5	5	10	4	5	0.513	52.6%	47.4%	0.0%	0.0%	0.0%
3.6	19	3.947	4	4	12	1	5	0.911	21.1%	63.2%	10.5%	0.0%	5.3%
3.7	19	3.895	4	4	13	3	5	0.567	10.5%	68.4%	21.1%	0.0%	0.0%
3.8	19	3.842	4	4	10	1	5	0.958	21.1%	52.6%	21.1%	0.0%	5.3%
3.9	19	4.368	4	4	10	3	5	0.597	42.1%	52.6%	5.3%	0.0%	0.0%
3.10	19	4.053	4	4	10	3	5	0.705	26.3%	52.6%	21.1%	0.0%	0.0%
3.11	19	3.789	4	3	8	3	5	0.787	21.1%	36.8%	42.1%	0.0%	0.0%
3.12	19	4.105	4	4	11	3	5	0.658	26.3%	57.9%	15.8%	0.0%	0.0%
3.13	19	4.474	5	5	10	3	5	0.612	52.6%	42.1%	5.3%	0.0%	0.0%
3.14	19	4.053	4	4	8	3	5	0.780	31.6%	42.1%	26.3%	0.0%	0.0%
3.15	19	4.368	5	5	12	1	5	1.065	63.2%	21.1%	10.5%	0.0%	5.3%
3.16	19	3.895	4	4	13	1	5	0.875	15.8%	68.4%	10.5%	0.0%	5.3%
3.17	19	4.158	4	4	12	3	5	0.602	26.3%	63.2%	10.5%	0.0%	0.0%
3.18	19	4.474	5	5	11	3	5	0.697	57.9%	31.6%	10.5%	0.0%	0.0%
3.19	19	3.789	4	3	8	3	5	0.787	21.1%	36.8%	42.1%	0.0%	0.0%
3.20	19	3.947	4	4	8	3	5	0.780	26.3%	42.1%	31.6%	0.0%	0.0%
3.21	19	3.526	4	3	7	1	5	1.172	21.1%	31.6%	36.8%	0.0%	10.5%
3.22	19	3.895	4	4	9	3	5	0.737	21.1%	47.4%	31.6%	0.0%	0.0%
4.1	19	4.421	5	5	12	2	5	0.961	63.2%	26.3%	0.0%	10.5%	0.0%
4.2	19	4.526	5	5	10	4	5	0.513	52.6%	47.4%	0.0%	0.0%	0.0%
4.3	19	4.421	5	5	10	2	5	0.769	52.6%	42.1%	0.0%	5.3%	0.0%
4.4	19	4.368	4	Mult.	9	2	5	0.761	47.4%	47.4%	0.0%	5.3%	0.0%
4.5	19	4.789	5	5	15	4	5	0.419	78.9%	21.1%	0.0%	0.0%	0.0%
4.6	19	4.737	5	5	14	4	5	0.452	73.7%	26.3%	0.0%	0.0%	0.0%
5.1	19	4.316	4	4	10	2	5	0.749	42.1%	52.6%	0.0%	5.3%	0.0%

Factor	Descriptive Statistics								Response Percentage (Level of Consensus)				
	Valid N	Mean	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)
5.2	19	3.737	4	4	12	2	5	0.991	15.8%	63.2%	0.0%	21.1%	0.0%
5.3	19	4.000	4	4	10	2	5	1.000	31.6%	52.6%	0.0%	15.8%	0.0%
5.4	19	4.579	5	5	11	4	5	0.507	57.9%	42.1%	0.0%	0.0%	0.0%
5.5	19	4.000	4	4	10	2	5	1.000	31.6%	52.6%	0.0%	15.8%	0.0%
5.6	19	4.316	5	5	10	2	5	0.946	52.6%	36.8%	0.0%	10.5%	0.0%
5.7	19	4.526	5	5	10	4	5	0.513	52.6%	47.4%	0.0%	0.0%	0.0%
5.8	19	3.737	4	4	12	2	5	0.991	15.8%	63.2%	0.0%	21.1%	0.0%
5.9	19	3.947	4	4	8	2	5	1.129	36.8%	42.1%	0.0%	21.1%	0.0%
5.10	19	4.789	5	5	15	4	5	0.419	78.9%	21.1%	0.0%	0.0%	0.0%
5.11	19	4.737	5	5	16	2	5	0.733	84.2%	10.5%	0.0%	5.3%	0.0%
5.12	19	4.474	5	5	13	2	5	0.964	68.4%	21.1%	0.0%	10.5%	0.0%
5.13	19	4.158	4	4	10	2	5	0.898	36.8%	52.6%	0.0%	10.5%	0.0%
5.14	19	4.526	5	5	12	2	5	0.772	63.2%	31.6%	0.0%	5.3%	0.0%
5.15	19	4.158	4	4	10	2	5	0.898	36.8%	52.6%	0.0%	10.5%	0.0%
5.16	19	4.579	5	5	11	4	5	0.507	57.9%	42.1%	0.0%	0.0%	0.0%
6.1	19	4.211	4	4	9	2	5	0.918	42.1%	47.4%	0.0%	10.5%	0.0%
6.2	19	4.211	5	5	10	2	5	1.084	52.6%	31.6%	0.0%	15.8%	0.0%
6.3	19	4.263	4	5	9	2	5	0.933	47.4%	42.1%	0.0%	10.5%	0.0%
6.4	19	3.895	4	5	8	2	5	1.243	42.1%	31.6%	0.0%	26.3%	0.0%
6.5	18	4.722	5	5	13	4	5	0.461	72.2%	27.8%	0.0%	0.0%	0.0%
6.6	19	4.368	4	Mult.	9	2	5	0.761	47.4%	47.4%	0.0%	5.3%	0.0%
6.7	19	4.526	5	5	10	4	5	0.513	52.6%	47.4%	0.0%	0.0%	0.0%

Table 5.2: First round Delphi descriptive statistics and response percentages

A response percentage of 66.7% has been selected as the level of consensus for this research (refer to §5.2.2). The results show that consensus has been gained on 12 of the 80 factors (highlighted in light-gray in table 5.2):

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- **1.1** A capable project manager that manages the AM service on behalf of the service provider (68.4%)
- **2.2** Continued and sustained commitment from the client's senior management in support of the AM service (84.2%)
- **2.7** The alignment of the client organisation's AM service requirements with their overall organisational and business strategies (68.4%)
- **2.10** Compilation and availability of formal contractual documents (68.4%)
- **3.7** Ensuring that pre-project arrangements are made for logistics, feasibility studies and changes in organisational structures that might arise from the AM service (68.4%)
- **3.16** The integration of operational excellence methodologies, such as TPM, TQM, 5S into the AM service offering or to align the service to existing standards (68.4%)
- **4.5** An adequate training programme in place for all AM service role players, both in the service provider and client teams (78.9%)
- **4.6** An effective organisational change management programme in support of the AM service (73.7%)
- **5.10** Open and effective communication (78.9%)
- **5.11** Mutual trust and respect between the service provider and client organisation (84.2%)
- **5.12** Active client participation in reporting, problem solving and improvement relating to the AM service (68.4%)
- **6.5** Proof of operational and financial performance achievements as a result of the AM service (72.2%)

According to the Delphi method the factors which gain consensus can either be removed from the next round questionnaire or included, with the advantage of an opportunity to gain a higher level of consensus. The advantage of removing

the factors is that the next questionnaire is shorter, reducing the risk of attrition (Keeney *et al.*, 2011, 1900).

For this research the consensus factors are removed. The specific level of consensus is less important at this stage, since the next phase of the research will address the degree of importance of the factors.

5.3.2 Sensitivity Analysis

Sensitivity analysis is performed on the results to determine the degree of uncertainty of the responses and to consider exceptions from consensus. The response reliability is calculated to measure response consistency. Response analysis is performed for determining if panellist sub-group responses differ significantly from another. In such cases the evidence is considered for deciding whether such factors should be included with the consensus factors.

5.3.2.1 Response Reliability

Cronbach's α coefficient is the most widely used method for estimating the internal consistency reliability of Likert scale responses, surveys and questionnaires (Multon and Coleman 2010, 160; Barnett 2010, 717-718). According to Multon and Coleman (2010, 163) a reliability test minimises random measurement error so that the error is not highly correlated with the true scores. The relationship between true and observed responses should be strong. The Cronbach α coefficient is the proportion of the observed response variance that is true variance. For example, a Cronbach α coefficient of 0.7 means that 30% of the variance in responses are random and not meaningful. Theoretically, the larger the number of items in a scale – in this case 80 – the more reliable the internal consistency will be. A meta-analysis by Peterson (1994, 390) has however found that only 10% of variance in Cronbach α coefficient can be attributed to the number of scale items. Eighty items in the scale therefore does not guarantee high response reliability. The Cronbach α coefficient is calculated as (StatSoft Electronic Statistics

Textbook [Online], 2013):

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum s_i^2}{s_{\text{sum}}^2}\right) \quad (5.1)$$

where k equals the number of items in scale; s_i^2 is the variance of item i ; and s_{sum}^2 is the variance for the sum of all items.

A high reliability Cronbach α coefficient is considered to be 0.9 or above, very good is 0.8 to 0.89 and good or adequate is 0.7 to 0.79. The Cronbach α coefficient for the first round responses is 0.928, which is associated with a high internal consistency reliability.

5.3.2.2 Response Analysis

Table 5.1 shows that a panellist's role is either that of a service provider or asset owner, and that each panellist operates in one or more industries. Role and industry are two possible sub-groups within the panel responses which could affect the questionnaire results. The *Kruskal-Wallis* test is used for testing whether the sub-group responses of the roles and industries are the same for the sample results.

It is evident from the histograms and results of the *Kolmogorov-Smirnov test for normality* (Sager, 2010, 663-668) that the responses are not all *normally* distributed (see appendix A.3). This violates the conditions for using *ANOVA* to test for differences between sub-group means. The *Kruskal-Wallis* test is a non-parametric alternative to *ANOVA*. The interpretation of the *Kruskal-Wallis* test is similar to *ANOVA*, except that it is based on ranks rather than means (Schmidt, 2010, 674).

The *Kruskal-Wallis H* statistic is calculated as (Kruskal and Wallis, 1952, 586):

$$H = \frac{12}{N(N+1)} \sum_{i=1}^C \frac{R_i^2}{n_i} - 3(N+1) \quad (5.2)$$

where C is the number of sub-groups, n_i is the number of responses in the i^{th} sub-group, N is the number of responses in all sub-groups combined, and R_i is the

sum of the ranks in the i^{th} subgroup.

For large samples, H is approximated by the chi-squared (χ^2) distribution with $k - 1$ degrees of freedom. For smaller samples an exact test has to be performed and the test statistic H are compared to the critical values in the tables published by Kruskal and Wallis (1952, 614-617) (Schmidt, 2010, 675). The *Statistica* calculations are based on the χ^2 -distribution.

For the H -test the panellist's role and industry are the two factors of interest. For the role, the sub-groups are: service provider and asset owner. For the industry, the sub-groups are: Mining and Quarrying, Manufacturing, Electricity Supply, Water Supply and Facilities. The hypotheses are defined as:

H_0 : there is no difference between sub-group responses

H_a : there is a difference between sub-group responses

The results of the role H -test are included in appendix A.4. A level of significance, $\alpha = 5\%$ applies.

The H -test results show for 71 (of the 80) factors there is no significant proof to reject the null hypothesis. For nine factors the p -values are less than the desired level of significance. The nine factors are: 1.9, 2.12, 3.15, 4.1, 6.2, 6.4, 6.5, 6.6 and 6.7. For these factors the hypothesis that the responses by service providers and asset owners are the same, is rejected. This indicates that the two roles have significantly different views about the importance that these factors have toward the success of AMS.

Factor 6.5 is the only factor in the list that has also gained consensus (72.2%) and is removed from the second round questionnaire. The other eight factors are included in the second round questionnaire and analysed as part of the second round sensitivity analysis. The H -test results (table 5.3) and box-and-whisker plot (figure 5.1) of factor 6.5 show that all seven asset owner panellists rated it as

very important (5). The mean ranks are 7.909 and 12 for the service providers and asset owners, respectively. The consistent high response of the asset owners and the variability in the service provider responses explain the significant difference between the two sub-groups' results. Although the H -test indicates a significant difference, there is no reason not to accept that the factor gained consensus and to remove it with the other consensus factors from the second round questionnaire.

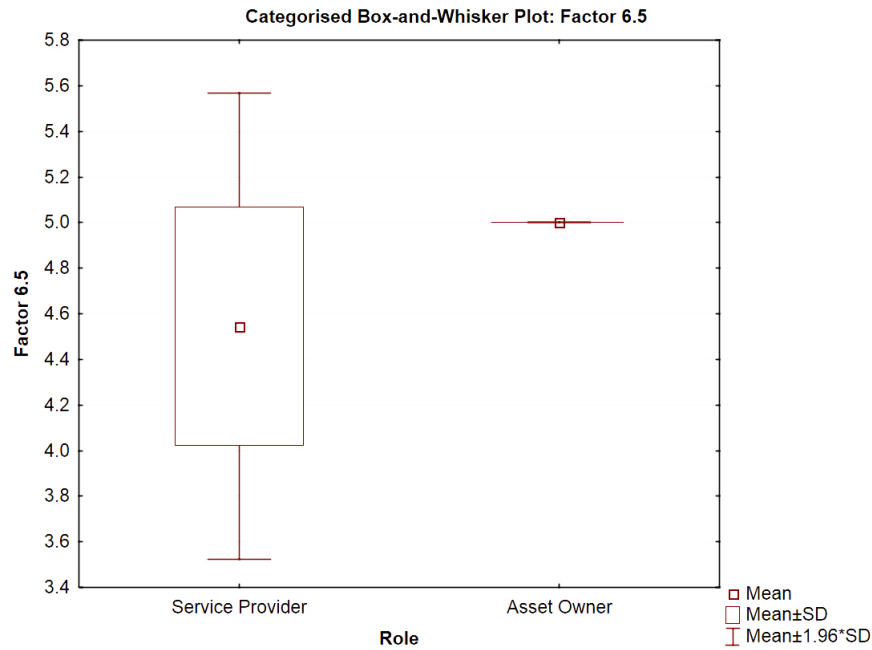


Figure 5.1: Box-and-whisker plot of factor 6.5 role responses

Role	Kruskal-Wallis ANOVA by Ranks		
	N	Sum of Ranks	Mean Rank
Service Provider	11	87	7.909
Asset Owner	7	84	12

Table 5.3: Kruskal-Wallis results for factor 6.5

The industry H -test results reveal p -values greater than the level of significance for all 80 factors. It is therefore concluded that there is no proof of significant

differences between the five industry responses by the panellists. One panellist did not provide an industry. The individual's responses were excluded from the industry *H*-test.

5.3.3 Additional Factors

Twenty-eight comments were received from the panellists. These comments range from additional factors that need to be considered to general feedback. Refer to appendix A.5 for the full list of comments. Based on the feedback the following additional success factors are formulated for inclusion in the second round questionnaire (sub-category headings are given in brackets):

1. Organisational Environment and Capabilities

- 1.15. The ability to integrate and be accepted in the client's organisation structure (Organisational Environment)
- 1.16. The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service (Managerial Capabilities)
- 1.17. The ability of the service provider to proactively gain an understanding of the client's business outcomes and to go beyond key performance measures to deliver and support these business outcomes (Organisational Environment)

2. Initiation Phase and Pre-contract Activities

- 2.16. The cultural readiness of the client organisation to change in business model for delivering AM (in other words having the right skills in the client organisation to manage the commercial partnership and business strategy and outcomes, instead of daily management of AM) (Client Involvement)
- 2.17. The service provider must have the ability to broaden the client's view of all aspects of AM (Proposed Solution)

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- 2.18.** The belief by the service provider that they will deliver some benefit by overcoming obstacles that are unknown at this stage of the process, and that the collaboration will result in positive benefits for the individuals and the organisation (Contracting)

3. Preparation and Design Processes

- 3.23.** The ability to design a practical solution for the client's existing AM maturity, but also to consider in the design long term goals AM maturity targets (Service Design Processes)
- 3.24.** The involvement of knowledgeable and demanding individuals from the client during the design and preparation, rather than individuals that want to abdicate their AM responsibilities (Service Design Processes)

4. Implementation and Commissioning

- 4.7.** The verification that what was implemented will meet the requirements in the service level agreement (Quality Control)

5. Control Processes

- 5.17.** The ability of the client leadership and AM personnel to act with integrity in the collaboration with the service provider to ensure sustainable AM (Relationships)

6. Benefits and Value-add

- 6.8.** The understanding that AM is a journey and not a destination (in other words it is about the the ongoing process and behavioural improvement and cannot be looked at from a high level where money is the primary measurement) (Quantitative Benefits)

5.4 Second Round Questionnaire

The format of the second round questionnaire is similar to that of the first round. In this questionnaire the factors that gained consensus in the first round are removed (§5.3.1). Statistical feedback of group and individual responses are given to encourage convergence towards consensus (Keeney *et al.*, 2011, 1889). For each of the factors which did not gain consensus, group feedback in the form of the median and standard deviation are included. The median is an indication of location of the most selected responses, while the standard deviation gives an indication of the response variances. Individual feedback is given in the form of a panellist's own first round responses. Panellists are asked to rate the factors on the same 5-level scale as in the first round. By taking the group feedback into consideration, the panellists can change their first round responses or keep them the same.

5.4.1 Questionnaire Feedback

Table 5.4 summarises the descriptive statistics from the second round responses. Similar to the first round, the response percentage is shown for each of the factors. All 19 panellists completed the questionnaire. Similar descriptive statistic ranges are seen between the first and second round results. Contrary to the first round results, 29 factors achieved the level of consensus of 66.7%. This is more than double the factors which gained consensus in the first round. The H -test results for comparing the first and second round feedback, indicate no significant differences between the two rounds' results. It can therefore be concluded that the group and individual feedback in the second round lead to the convergence in responses which came close to consensus in the first round. This convergence is one of the underlying principles for which the Delphi method is known (Keeney *et al.*, 2011, 516). To the contrary, there are 39 factors which have not gained consensus, despite the group feedback which was given. This shows that panellists did not change their responses if they disagreed with the group opinion, or if they noticed a degree of variance in the responses.

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Factor	Descriptive Statistics								Response Percentage (Level of Consensus)				
	Valid N	Mean	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)
1.2	19	3.789	4	4	11	1	5	1.084	21.1%	57.9%	5.3%	10.5%	5.3%
1.3	19	4.421	5	5	11	2	5	0.838	57.9%	31.6%	5.3%	5.3%	0.0%
1.4	19	3.947	4	4	12	2	5	0.848	21.1%	63.2%	5.3%	10.5%	0.0%
1.5	18	3.944	4	4	11	2	5	0.873	22.2%	61.1%	5.6%	11.1%	0.0%
1.6	19	3.684	4	4	8	2	5	1.003	21.1%	42.1%	21.1%	15.8%	0.0%
1.7	18	4.444	5	5	10	2	5	0.784	55.6%	38.9%	0.0%	5.6%	0.0%
1.8	19	4.632	5	5	12	4	5	0.496	63.2%	36.8%	0.0%	0.0%	0.0%
1.9	19	3.895	4	4	12	2	5	0.737	15.8%	63.2%	15.8%	5.3%	0.0%
1.10	19	3.632	4	4	10	2	5	0.831	10.5%	52.6%	26.3%	10.5%	0.0%
1.11	19	4.105	4	4	17	4	5	0.315	10.5%	89.5%	0.0%	0.0%	0.0%
1.12	19	4.632	5	5	13	3	5	0.597	68.4%	26.3%	5.3%	0.0%	0.0%
1.13	19	4.263	4	4	14	4	5	0.452	26.3%	73.7%	0.0%	0.0%	0.0%
1.14	19	4.000	4	4	13	3	5	0.577	15.8%	68.4%	15.8%	0.0%	0.0%
1.15	19	4.421	5	5	10	2	5	0.769	52.6%	42.1%	0.0%	5.3%	0.0%
1.16	19	4.105	5	5	10	2	5	1.150	52.6%	21.1%	10.5%	15.8%	0.0%
1.17	19	4.316	4	5	9	2	5	0.820	47.4%	42.1%	5.3%	5.3%	0.0%
2.1	19	4.526	5	5	10	4	5	0.513	52.6%	47.4%	0.0%	0.0%	0.0%
2.3	19	4.368	4	4	12	4	5	0.496	36.8%	63.2%	0.0%	0.0%	0.0%
2.4	19	4.211	4	4	15	4	5	0.419	21.1%	78.9%	0.0%	0.0%	0.0%
2.5	19	3.263	4	4	10	2	4	0.872	0.0%	52.6%	21.1%	26.3%	0.0%
2.6	19	4.421	5	5	10	2	5	0.769	52.6%	42.1%	0.0%	5.3%	0.0%
2.8	19	3.474	4	4	10	2	5	0.841	5.3%	52.6%	26.3%	15.8%	0.0%
2.9	19	3.316	3	3	11	2	5	0.820	10.5%	21.1%	57.9%	10.5%	0.0%
2.11	19	4.474	5	5	11	3	5	0.697	57.9%	31.6%	10.5%	0.0%	0.0%
2.12	19	4.158	4	4	13	2	5	0.688	26.3%	68.4%	0.0%	5.3%	0.0%
2.13	19	4.579	5	5	11	4	5	0.507	57.9%	42.1%	0.0%	0.0%	0.0%
2.14	19	4.474	5	5	10	3	5	0.612	52.6%	42.1%	5.3%	0.0%	0.0%
2.15	19	4.158	4	4	10	3	5	0.688	31.6%	52.6%	15.8%	0.0%	0.0%
2.16	19	4.474	5	5	11	3	5	0.697	57.9%	31.6%	10.5%	0.0%	0.0%
2.17	19	4.316	4	4	11	3	5	0.582	36.8%	57.9%	5.3%	0.0%	0.0%
2.18	19	4.316	4	4	13	4	5	0.478	31.6%	68.4%	0.0%	0.0%	0.0%

5.4. SECOND ROUND QUESTIONNAIRE

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Factor	Descriptive Statistics								Response Percentage (Level of Consensus)				
	Valid N	Mean	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)
3.1	19	4.526	5	5	10	4	5	0.513	52.6%	47.4%	0.0%	0.0%	0.0%
3.2	19	4.105	4	4	15	3	5	0.459	15.8%	78.9%	5.3%	0.0%	0.0%
3.3	19	4.105	4	4	17	4	5	0.315	10.5%	89.5%	0.0%	0.0%	0.0%
3.4	19	3.158	3	4	8	1	4	0.898	0.0%	42.1%	36.8%	15.8%	5.3%
3.5	19	4.421	5	5	11	3	5	0.769	57.9%	26.3%	15.8%	0.0%	0.0%
3.6	19	3.842	4	4	14	2	5	0.765	10.5%	73.7%	5.3%	10.5%	0.0%
3.8	19	4.000	4	4	13	3	5	0.577	15.8%	68.4%	15.8%	0.0%	0.0%
3.9	19	4.316	4	4	11	3	5	0.582	36.8%	57.9%	5.3%	0.0%	0.0%
3.10	19	3.737	4	4	12	2	5	0.806	10.5%	63.2%	15.8%	10.5%	0.0%
3.11	19	3.737	4	4	12	2	5	0.806	10.5%	63.2%	15.8%	10.5%	0.0%
3.12	19	4.053	4	4	13	2	5	0.705	21.1%	68.4%	5.3%	5.3%	0.0%
3.13	19	4.579	5	5	12	3	5	0.607	63.2%	31.6%	5.3%	0.0%	0.0%
3.14	19	3.947	4	4	16	3	5	0.405	5.3%	84.2%	10.5%	0.0%	0.0%
3.15	19	4.526	5	5	12	3	5	0.697	63.2%	26.3%	10.5%	0.0%	0.0%
3.17	19	4.211	4	4	15	4	5	0.419	21.1%	78.9%	0.0%	0.0%	0.0%
3.18	19	4.632	5	5	12	4	5	0.496	63.2%	36.8%	0.0%	0.0%	0.0%
3.19	19	3.789	4	4	16	2	4	0.535	0.0%	84.2%	10.5%	5.3%	0.0%
3.20	19	4.053	4	4	9	2	5	0.848	31.6%	47.4%	15.8%	5.3%	0.0%
3.21	19	3.789	4	4	12	2	5	0.713	10.5%	63.2%	21.1%	5.3%	0.0%
3.22	19	3.789	4	4	14	2	5	0.631	5.3%	73.7%	15.8%	5.3%	0.0%
3.23	19	4.526	5	5	11	3	5	0.612	57.9%	36.8%	5.3%	0.0%	0.0%
3.24	19	4.474	5	5	10	3	5	0.612	52.6%	42.1%	5.3%	0.0%	0.0%
4.1	19	4.474	5	5	11	2	5	0.772	57.9%	36.8%	0.0%	5.3%	0.0%
4.2	19	4.474	5	5	11	3	5	0.697	57.9%	31.6%	10.5%	0.0%	0.0%
4.3	19	4.526	5	5	11	3	5	0.612	57.9%	36.8%	5.3%	0.0%	0.0%
4.4	19	4.474	4	4	10	4	5	0.513	47.4%	52.6%	0.0%	0.0%	0.0%
4.7	19	4.368	4	4	10	3	5	0.597	42.1%	52.6%	5.3%	0.0%	0.0%
5.1	19	4.421	4	4	11	4	5	0.507	42.1%	57.9%	0.0%	0.0%	0.0%
5.2	19	4.000	4	4	15	3	5	0.471	10.5%	78.9%	10.5%	0.0%	0.0%
5.3	19	4.000	4	4	15	3	5	0.471	10.5%	78.9%	10.5%	0.0%	0.0%
5.4	19	4.684	5	5	13	4	5	0.478	68.4%	31.6%	0.0%	0.0%	0.0%

Factor	Descriptive Statistics								Response Percentage (Level of Consensus)				
	Valid N	Mean	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)
5.5	19	4.316	4	4	9	3	5	0.671	42.1%	47.4%	10.5%	0.0%	0.0%
5.6	19	4.526	5	5	11	3	5	0.612	57.9%	36.8%	5.3%	0.0%	0.0%
5.7	19	4.737	5	5	14	4	5	0.452	73.7%	26.3%	0.0%	0.0%	0.0%
5.8	19	3.947	4	4	14	3	5	0.524	10.5%	73.7%	15.8%	0.0%	0.0%
5.9	19	4.263	4	4	12	3	5	0.562	31.6%	63.2%	5.3%	0.0%	0.0%
5.13	19	4.211	4	4	15	4	5	0.419	21.1%	78.9%	0.0%	0.0%	0.0%
5.14	19	4.684	5	5	13	4	5	0.478	68.4%	31.6%	0.0%	0.0%	0.0%
5.15	19	4.263	4	4	12	3	5	0.562	31.6%	63.2%	5.3%	0.0%	0.0%
5.16	19	4.737	5	5	14	4	5	0.452	73.7%	26.3%	0.0%	0.0%	0.0%
5.17	19	4.316	4	4	9	3	5	0.671	42.1%	47.4%	10.5%	0.0%	0.0%
6.1	19	4.211	4	4	13	3	5	0.535	26.3%	68.4%	5.3%	0.0%	0.0%
6.2	19	4.632	5	5	13	3	5	0.597	68.4%	26.3%	5.3%	0.0%	0.0%
6.3	19	4.211	4	4	13	3	5	0.535	26.3%	68.4%	5.3%	0.0%	0.0%
6.4	19	4.263	4	4	12	3	5	0.562	31.6%	63.2%	5.3%	0.0%	0.0%
6.6	19	4.211	4	4	15	4	5	0.419	21.1%	78.9%	0.0%	0.0%	0.0%
6.7	19	4.737	5	5	14	4	5	0.452	73.7%	26.3%	0.0%	0.0%	0.0%
6.8	19	4.579	5	5	11	4	5	0.507	57.9%	42.1%	0.0%	0.0%	0.0%

Table 5.4: Second round Delphi descriptive statistics and response percentages

The results show that consensus is gained on 29 of the 91 factors (highlighted in grey in table 5.4). One of the new 11 factors – factor 2.18 – is included.

- **1.11** Degree to which the service provider’s client facing team (sales representatives, project managers, service personnel) are knowledgeable in the full range of the service provider’s value proposition and combination of service options available (89.5%)

- **1.12** The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants (68.4%)
- **1.13** The availability of the most appropriate skilled resources for providing industry specific AM service requirements (73.7%)
- **1.14** The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations) (68.4%)
- **2.4** The active participation of the client personnel and their commitment towards completing the pre-contract activities (78.9%)
- **2.12** A detailed project plan with milestones in place (68.4%)
- **2.18** The belief by the service provider that they will deliver some benefits by overcoming obstacles that are unknown at this stage of the process, and that the collaboration will result in positive benefits for the individuals and the organisation. (68.4%)
- **3.2** Design and integration of service and performance metrics for all stakeholders (service provider and client) involved in the AM service (78.9%)
- **3.3** The inter-company flow of information (between the service provider and client organisation) during the AM service design (89.5%)
- **3.6** Compilation and active use of design documents (73.7%)
- **3.8** The potential of the AM service to be scalable (expandable to other business units within the client organisation) (68.4%)
- **3.12** The strategic fit of the AM service with the service provider and client's current service propositions, systems and capabilities (68.4%)
- **3.14** Evaluation and consideration of different AM service designs (84.2%)
- **3.17** The availability of adequate infrastructure and interfaces in support of the AM service (78.9%)

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- **3.19** Adequate legacy system knowledge, if such systems are required to interface with the AM service information systems (84.2%)
- **3.22** The security and protection of information, relating to information systems that forms part of the AM service (73.7%)
- **5.2** The monitoring of budgets and costs relating to the AM service (78.9%)
- **5.3** Configuration control of current AM service processes and systems (78.9%)
- **5.4** Management of mutual expectations between the service provider and client relating to the AM service (68.4%)
- **5.7** The active management of the relationship between the service provider and client organisation personnel involved in the AM service (73.7%)
- **5.8** The appreciation of diversity among inter-company teams involved in the AM service (73.7%)
- **5.13** Agility (responsiveness) in responding to changes in AM service demands (78.9%)
- **5.14** Measurement and improvement of the AM service to increase the value-add and benefits (68.4%)
- **5.16** Proper priority setting of improvement actions, irrespective whether it is service or value-add related (73.7%)
- **6.1** The consideration of intangible (not measurable) benefits and value creation (i.e. increased effectiveness, risk mitigation, improved decision-making capability) as a result of the AM service (68.4%)
- **6.2** Feedback and sharing of lessons learned from successful improvements made to the AM service (68.4%)
- **6.3** Formal post launch evaluations of the AM service to determine what can be improved (68.4%)
- **6.6** The ability to measure the AM service quality and value creation (78.9%)

- **6.7** Focused and continuous improvement to the AM service through monitoring, analysis and feedback (73.7%)

Items which gained consensus are removed from next round questionnaire similarly to the first round (§5.3.1).

5.4.2 Sensitivity Analysis

The Cronbach α coefficient for the second round responses is calculated as 0.953. This indicates a high level of internal response consistency reliability (see §5.3.2.1).

The role H -test results show that for 76 (of the 79) factors there is no significant proof to reject the null hypothesis. For three factors the p -values are less than the desired significance level, α . The three factors are: 2.1, 3.15 and 5.14. For these factors the hypothesis is rejected that sub-group responses by service providers and asset owners are the same. This indicates that the two roles have significantly different views about the importance that these factors have in the success of an AMS.

In the first round factors 1.9, 2.12, 3.15, 4.1, 6.2, 6.4, 6.5, 6.6 and 6.7 showed significant differences between role responses (factor 6.5 gained consensus and was removed). This is not the case in the second round analysis. Factors 2.12, 6.2, 6.6 and 6.7 gained consensus in this round, while factors 1.9, 3.15, 4.1 and 6.4 have not.

Factor 2.1 did not show any significant difference between roles in the first round results and also does not achieve consensus. In the second round it shows a significant difference between the roles' responses. The H -test results (table 5.5) and histogram (figure 5.2) show variation in responses amongst both service providers and asset owners. Although the H -test indicates a significant difference, there is no unanimity response by either role. There is thus no reason for factor 2.1 to be considered as an exception from the rest of the factors which have not gained consensus.

Role	Kruskal-Wallis ANOVA by Ranks		
	$H(1, N = 19) = 6.193; p = 0.013$		
	N	Sum of Ranks	Mean Rank
Service Provider	12	145	12.125
Asset Owner	7	44.5	6.357

Table 5.5: Kruskal-Wallis results for factor 2.1

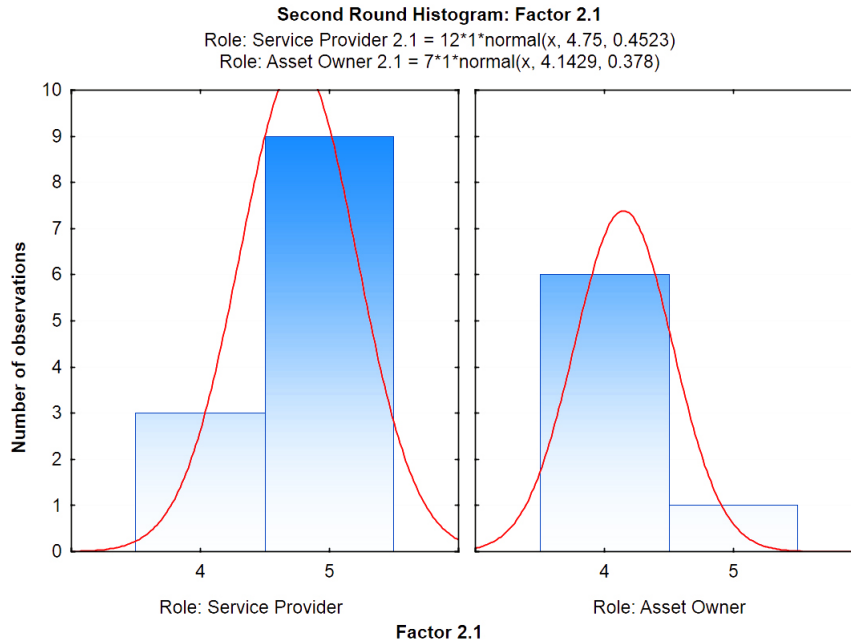


Figure 5.2: Histogram of factor 2.1 role responses

Factor 3.15 show significant differences in both rounds and failed to gain consensus in this round. Factor 3.15's H -test results and histograms for both rounds are shown in figure 5.3 and table 5.6. It can be seen that in both rounds the responses of the asset owners were unanimously *very important* (5), while there is variation in the service providers' responses. It is also evident that in both rounds 12 out of the 19 responses are in favour of a *very important* rating. Thirteen responses would have given consensus. In light of the significant difference between the role responses and the unanimous agreement among asset owners for a *very important* rating in both rounds, factor 3.15 is also included in the final list of consensus factors.

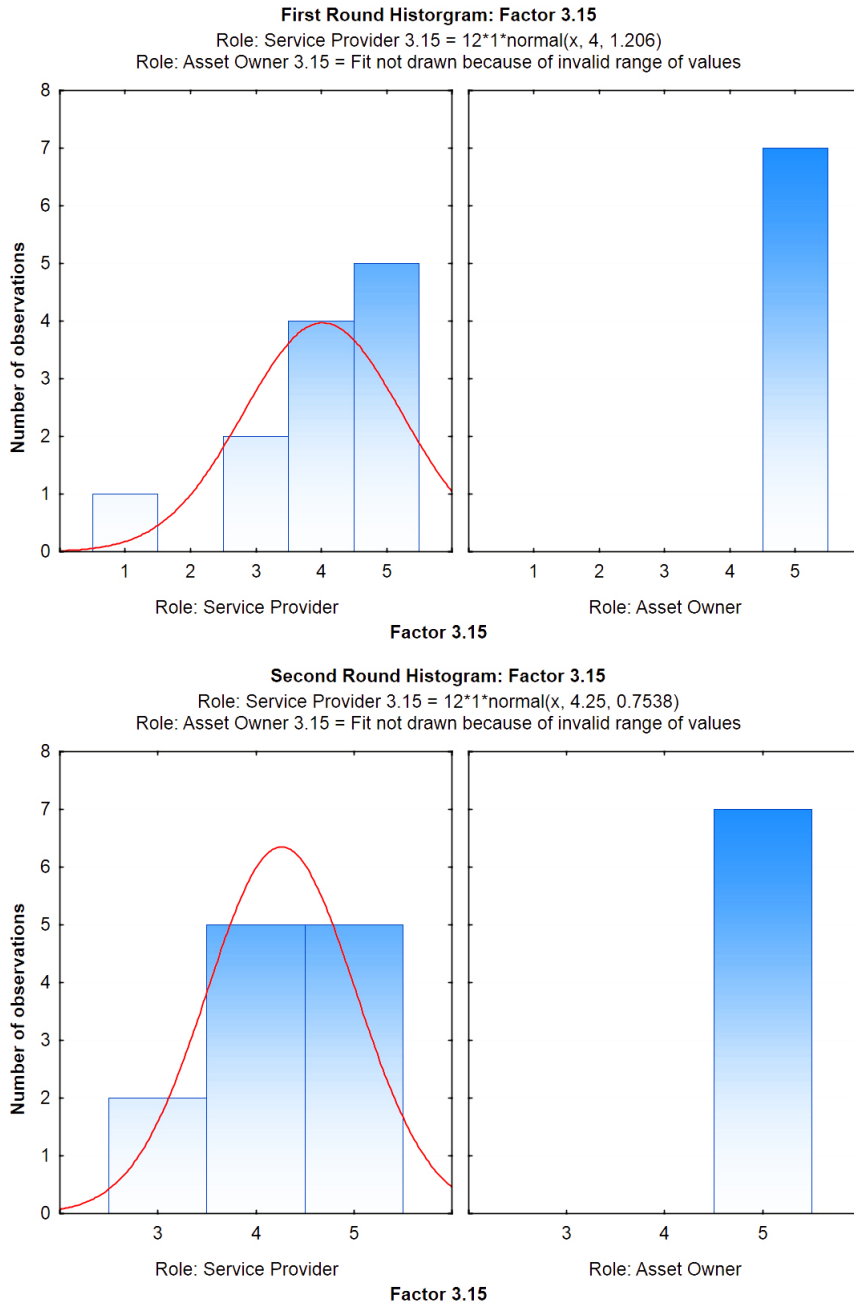


Figure 5.3: First and second round histograms of factor 3.15

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Role	Round 1			Round 2		
	N	Sum of Ranks	Mean Rank	N	Sum of Ranks	Mean Rank
Service Provider	12	95.5	7.958	12	95.5	7.958
Asset Owner	7	94.5	13.5	7	94.5	13.5

Table 5.6: Kruskal-Wallis results for factor 3.15

Factor 5.14 is the only second round factor also gaining consensus (68.4%) and will be removed from the questionnaire. The H -test (table 5.7) and box-and-whisker plot (figure 5.4) of factor 5.14 show that all seven asset owner panellists rated it as *very important* (5). The response mean of the service providers is 4.5. The consistent high response of the asset owners and the variability in the service provider responses explain the significant difference. Although the H -test indicates a significant difference, there is no reason not to accept that the factor gained consensus and to remove it with the other consensus factors from the third round questionnaire.

Role	Kruskal-Wallis ANOVA by Ranks		
	N	Sum of Ranks	Mean Rank
Service Provider	12	99	8.25
Asset Owner	7	91	13

Table 5.7: Kruskal-Wallis results for factor 5.14

The industry H -test results show that for 77 (of the 79) factors there is no significant proof to reject the null hypothesis. For two factors the p -values fall within the critical region, with $\alpha = 5\%$. The two factors are: 1.13 and 6.6. Both factors also gained consensus in the second round. For these factors the hypothesis is rejected that the panellist responses from the different industry sub-groups are the same. One panellist did not provide an industry. The individual's responses are excluded from the industry analysis.

Figure 5.5 and table 5.8 show the differences in means and mean ranks between the Facilities and Electricity Supply sub-groups compared to the Manufacturing,

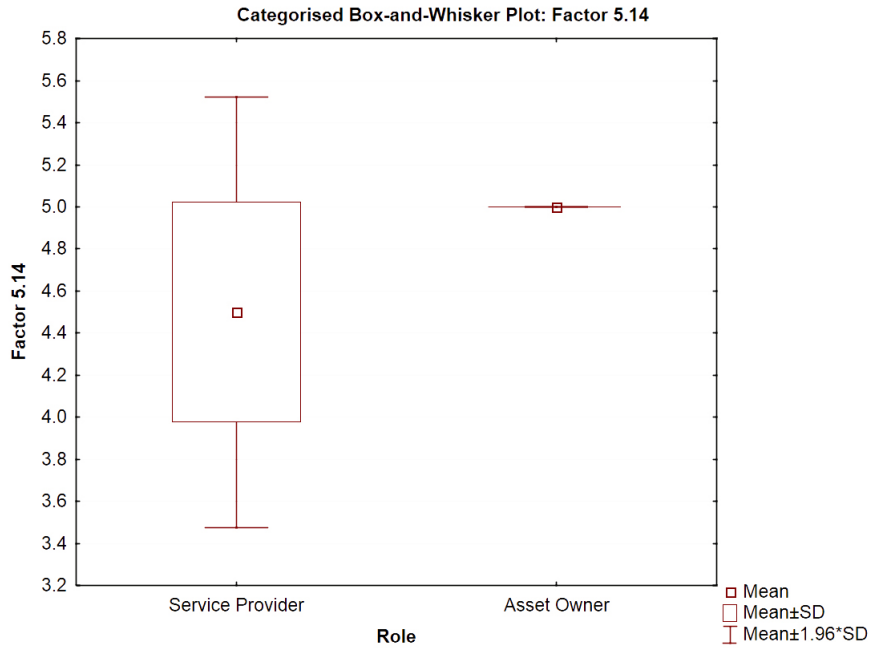


Figure 5.4: Box-and-whisker plot of factor 5.14 role responses

Role	Kruskal-Wallis ANOVA by Ranks		
	$H(4, N = 39) = 10.602; p = 0.0314$		
	N	Mean Rank	Sum of Ranks
Manufacturing	11	192.5	17.5
Mining	9	157.5	17.5
Electricity Supply	7	161.5	23.071
Water Supply	5	87.5	17.5
Facilities	7	181	25.857

Table 5.8: Industry Kruskal-Wallis results for factor 1.13

Mining and Water Supply sub-groups. Although the H -test results indicates significant differences, there is no reason not to accept that the factor gained consensus and to remove it with the other consensus factors from the third round questionnaire.

The results of factor 6.6 shows exactly the same analysis as 1.13. The reason is that factors 1.13 and 6.6 were rated exactly the same by the panellists. Similarly to factor 1.13 there is no reason not to accept that the factor gained consensus and

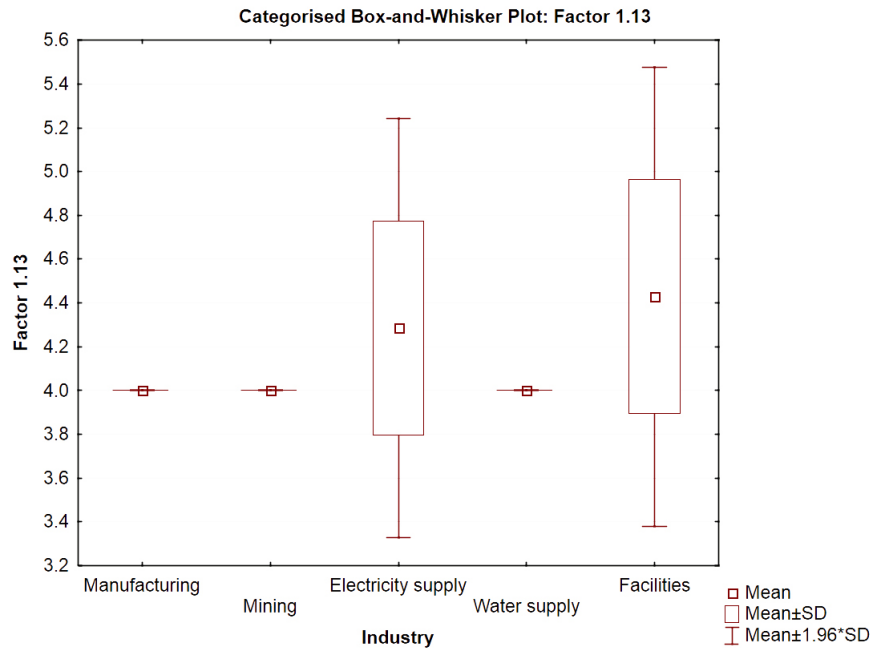


Figure 5.5: Box-and-whisker plot of factor 1.13 industry responses

to remove it with the other consensus factors from the third round questionnaire.

5.5 Third Round Questionnaire

A third and final round questionnaire is required to give the panellists the opportunity to review group and individual feedback for the 11 additional factors which were identified in the first round.

The format of the third round questionnaire is the same as that of the first two rounds. In this round only the additional factors which have not gained consensus are included. The original factors (from the content analysis) which have not gained consensus after the first two rounds are removed to keep the questionnaire short and not to lose the interest and/or motivation of the panellists. No significant differences between the first two round responses were evident; supporting the unlikelihood of gaining new information by including these factors in this round (refer to §5.3.1).

5.5.1 Questionnaire Feedback

Table 5.9 summarises the descriptive statistics for the third round questionnaire. Four of the ten factors in the third round questionnaire gained consensus. Similar to the *H*-tests between the first and second round responses, the *H*-test results between the second and third rounds show that none of the factors (at a level of significance, $\alpha = 5\%$) significantly differ between the two rounds' responses. This concludes that the group and individual feedback in the third round lead to the convergence in responses similarly to the second round results.

Factor	Descriptive Statistics								Response Percentage (Level of Consensus)				
	Valid N	Mean	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)
1.15	16	4.563	5	5	10	3	5	0.629	62.5%	31.3%	6.3%	0.0%	0.0%
1.16	16	4.625	5	5	12	2	5	0.806	75.0%	18.8%	0.0%	6.3%	0.0%
1.17	16	4.188	4	4	9	3	5	0.655	31.3%	56.3%	12.5%	0.0%	0.0%
2.16	16	4.688	5	5	11	4	5	0.479	68.8%	31.3%	0.0%	0.0%	0.0%
2.17	16	4.250	4	4	9	2	5	0.775	37.5%	56.3%	0.0%	6.3%	0.0%
3.23	16	4.625	5	5	12	3	5	0.719	75.0%	12.5%	12.5%	0.0%	0.0%
3.24	16	4.688	5	5	12	3	5	0.602	75.0%	18.8%	6.3%	0.0%	0.0%
4.7	16	4.063	4	4	10	2	5	0.772	25.0%	62.5%	6.3%	6.3%	0.0%
5.17	16	4.438	4	4	9	4	5	0.512	43.8%	56.3%	0.0%	0.0%	0.0%
6.8	16	4.563	5	5	10	3	5	0.629	62.5%	31.3%	6.3%	0.0%	0.0%

Table 5.9: Third round Delphi descriptive statistics and response percentages

Only 16 panellists completed the third round questionnaire. Three panellists withdrew, by not completing the questionnaire after repeated follow-up requests from the researcher. The insignificant difference between the second and third

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round responses indicates that the smaller sample of panellists does not adversely affect the results of the survey. The effect is further minimised by the low number of factors rated (10 out of 91) compared to the factors rated in the first two rounds. The unwillingness to further participate is also an indication that the Delphi study should be concluded and that it is unlikely that new information will be uncovered with further rounds.

The factors gaining the 66.7% level of consensus, with response percentages in brackets are:

- **1.16** The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service (75.0%)
- **2.16** The cultural readiness of the client organisation to change in business model for delivering AM (in other words having the right skills in the client organisation to manage the commercial partnership and business strategy and outcomes, instead of daily management of AM) (68.8%)
- **3.23** The ability to design a practical solution for the client's existing AM maturity, but also to consider in the design long term goals aligned with AM maturity targets. (75.0%)
- **3.24** The involvement of knowledgeable and demanding individuals from the client during the design and preparation, rather than individuals that want to abdicate their AM responsibilities. (75.0%)

5.5.2 Sensitivity Analysis

The Cronbach α coefficient for the third round responses is calculated as 0.845. Although not as high as in the first two rounds, it is still within the 0.8 to 0.89 range, which is associated with a very good internal response consistency reliability (see §5.3.2.1).

For all ten factors the role and industry H -tests results show no significant proof to reject the null hypothesis. No further sensitivity analysis is therefore performed.

The Delphi study is concluded after the three rounds of questionnaires with 46 factors out of 91 gaining consensus.

5.6 Asset Management Services Success Factors

Forty-six factors gained a 66.7% level of consensus in the three Delphi rounds. Table 5.10 shows the thematic categories and sub-categories, with the number of corresponding consensus factors. The *preparation and design process* category includes the most consensus factors (14). This category also has the most generic factors (24) resulting in a 58.3% consensus attainment. In the *control processes* category, 64.7% of the original generic factors gained consensus, while the *benefits and value-add* category has the highest proportional number of consensus factors (75%). The *implementation and commissioning* category has the lowest number and proportional consensus factors and consensus attainment – 2 and 28.6%, respectively.

Table 5.11 shows the original response percentages and a relative ranking of the factors based on the means. Of interest is that all consensus factors are of scales *very important* (5) and *important* (4) – none gained consensus on the three lower scales. All factors are therefore included for further study. These results confirm the relevance of the literature reviewed in preparation for the Delphi study (§4.2) as well as its relationship with AMS.

Factor	Response Percentage (Level of Consensus)					Rank	Mean	Standard Deviation
	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)			
1.1	68%	16%	0%	5%	11%	22	4.263	1.368
1.11	11%	89%	0%	0%	0%	31	4.105	0.315

Factor	Response Percentage (Level of Consensus)					Rank	Mean	Standard Deviation
	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)			
1.12	68%	26%	5%	0%	0%	14	4.632	0.597
1.13	26%	74%	0%	0%	0%	22	4.263	0.452
1.14	16%	68%	16%	0%	0%	35	4.000	0.577
1.16	75%	19%	0%	6%	0%	16	4.625	0.806
2.2	84%	11%	0%	5%	0%	3	4.737	0.733
2.4	21%	79%	0%	0%	0%	24	4.211	0.419
2.7	68%	26%	0%	5%	0%	18	4.579	0.769
2.10	11%	68%	0%	16%	5%	46	3.632	1.065
2.12	26%	68%	0%	5%	0%	30	4.158	0.688
2.16	69%	31%	0%	0%	0%	10	4.688	0.479
2.18	32%	68%	0%	0%	0%	21	4.316	0.478
3.2	16%	79%	5%	0%	0%	31	4.105	0.459
3.3	11%	89%	0%	0%	0%	31	4.105	0.315
3.6	11%	74%	5%	11%	0%	43	3.842	0.765
3.7	11%	68%	21%	0%	0%	41	3.895	0.567
3.8	16%	68%	16%	0%	0%	35	4.000	0.577
3.12	21%	68%	5%	5%	0%	34	4.053	0.705
3.14	5%	84%	11%	0%	0%	39	3.947	0.405
3.15	63%	26%	11%	0%	0%	19	4.526	0.697
3.16	16%	68%	11%	0%	5%	41	3.895	0.875
3.17	21%	79%	0%	0%	0%	24	4.211	0.419
3.19	0%	84%	11%	5%	0%	44	3.789	0.535
3.22	5%	74%	16%	5%	0%	44	3.789	0.631
3.23	75%	13%	13%	0%	0%	16	4.625	0.719
3.24	75%	19%	6%	0%	0%	10	4.688	0.602
4.5	79%	21%	0%	0%	0%	1	4.789	0.419
4.6	74%	26%	0%	0%	0%	3	4.737	0.452
5.2	11%	79%	11%	0%	0%	35	4.000	0.471
5.3	11%	79%	11%	0%	0%	35	4.000	0.471
5.4	68%	32%	0%	0%	0%	12	4.684	0.478
5.7	74%	26%	0%	0%	0%	3	4.737	0.452

Factor	Response Percentage (Level of Consensus)					Rank	Mean	Standard Deviation
	Very Important (5)	Important (4)	Neither (3)	Less Important (2)	Unimportant (1)			
5.8	11%	74%	16%	0%	0%	39	3.947	0.524
5.10	79%	21%	0%	0%	0%	1	4.789	0.419
5.11	84%	11%	0%	5%	0%	3	4.737	0.733
5.12	68%	21%	0%	11%	0%	20	4.474	0.964
5.13	21%	79%	0%	0%	0%	24	4.211	0.419
5.14	68%	32%	0%	0%	0%	12	4.684	0.478
5.16	74%	26%	0%	0%	0%	3	4.737	0.452
6.1	26%	68%	5%	0%	0%	24	4.211	0.535
6.2	68%	26%	5%	0%	0%	14	4.632	0.597
6.3	26%	68%	5%	0%	0%	24	4.211	0.535
6.5	72%	28%	0%	0%	0%	9	4.722	0.461
6.6	21%	79%	0%	0%	0%	24	4.211	0.419
6.7	74%	26%	0%	0%	0%	3	4.737	0.452

Table 5.11: Consensus AM services success factors

In conclusion, the objective of this phase of the study is to identify factors that are deemed important in facilitating and achieving a successful AMS between a service provider and an asset owner. Such factors have not been previously identified in the context of AM or AMS. The outcome of this chapter therefore contributes to the AMS scholarship by identifying a list of factors that are verified by a panel of AMS experts. The results further suggest that the success factors in AMS are not significantly different for different role players or industries involved in AMS. The list of AMS success factors are (with the consensus percentage and corresponding scale level in brackets):

- **1.1** A capable project manager that manages the AM service on behalf of

Categories	Total Factors	Consensus Factors	Consensus Attainment
1. Organisational Environment and Capabilities	17	6	35.3%
Managerial capabilities	4	2	50%
Organisational environment	9	0	0%
People	4	4	100%
2. Initiation Phase and Pre-contract Activities	18	7	38.9%
Client involvement	5	3	60%
User requirements	4	1	25%
Contracting	4	2	50%
Proposed solution	5	1	20%
3. Preparation and Design Process	24	14	58.3%
Data availability during design	3	2	66.7%
Service design processes	9	5	55.6%
Service integration	6	4	66.7%
System integration	6	3	50%
4. Implementation and Commissioning	7	2	28.6%
Project management	2	0	0%
Quality control	3	0	0%
Training and change management	2	2	100%
5. Control Processes	17	11	64.7%
Management of service levels	4	3	75%
Quality control	2	0	0%
Relationship	6	4	75%
Service improvement	5	4	80%
6. Benefits and Value-add	8	6	75%
Intangible benefits	4	3	75%
Quantitative benefits	4	3	75%

Table 5.10: Consensus results per thematic categories and sub-categories

the service provider (68%, 5).

- **1.11** Degree to which the service provider's client facing team (sales representatives, project managers, service personnel) are knowledgeable in the full range of the service provider's value proposition and combination of service options available (89%, 4).
- **1.12** The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants (68%, 5).
- **1.13** The availability of the most appropriate skilled resources for providing industry specific AM service requirements (74%, 4).

- **1.14** The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations) (68%, 4).
- **1.16** The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service (75%, 5).
- **2.2** Continued and sustained commitment from the client's senior management in support of the AM service (84%, 5).
- **2.4** The active participation of the client personnel and their commitment towards completing the pre-contract activities (79%, 4).
- **2.7** The alignment of the client organisation's AM service requirements with their overall organisational and business strategies (68%, 5).
- **2.10** Compilation and availability of formal contractual documents (68%, 4).
- **2.12** A detailed project plan with milestones in place (68%, 4).
- **2.16** The cultural readiness of the client organisation to change in business model for delivering AM (in other words having the right skills in the client organisation to manage commercial partnership and business strategy and outcomes, instead of daily management of AM) (69%, 5).
- **2.18** The belief by the service provider that they will deliver some benefits by overcoming obstacles that are unknown at this stage of the process, and that the collaboration will result in positive benefits for the individuals and the organisation (68%, 4).
- **3.2** Design and integration of service and performance metrics for all stakeholders (service provider and client) involved in the AM service (79%, 4).
- **3.3** The inter-company flow of information (between the service provider and client organisation) during the AM service design (89%, 4).
- **3.6** Compilation and active use of design documents (74%, 4).

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- **3.7** Ensuring that pre-project arrangements are made for logistics, feasibility studies and changes in organisational structures that might arise from the AM service (68%, 4).
- **3.8** The potential of the AM service to be scalable (expandable to other business units within the client organisation) (68%, 4).
- **3.12** The strategic fit of the AM service with the service provider and client's current service propositions, systems and capabilities (68%, 4).
- **3.14** Evaluation and consideration of different AM service designs (84%, 4).
- **3.15** The integration of health, safety, environmental and quality considerations as part of the AM service or to align the service to existing standards (see §5.4.2).
- **3.16** The integration of operational excellence methodologies, such as TPM, TQM, 5S into the AM service offering or to align the service to existing standards (68%, 4).
- **3.17** The availability of adequate infrastructure and interfaces in support of the AM service (79%, 4).
- **3.19** Adequate legacy system knowledge, if such systems are required to interface with the AM service information systems (84%, 4).
- **3.22** The security and protection of information, relating to information systems that forms part of the AM service (74%, 4).
- **3.23** The ability to design a practical solution for the client's existing AM maturity, but also to consider in the design long term goals AM maturity targets (75%, 5).
- **3.24** The involvement of knowledgeable and demanding individuals from the client during the design and preparation, rather than individuals that want to abdicate their AM responsibilities (75%, 5).
- **4.5** An adequate training programme in place for all AM service role players, both in the service provider and client teams (79%, 5).

- **4.6** An effective organisational change management programme in support of the AM service (74%, 5).
- **5.2** The monitoring of budgets and costs relating to the AM service (79%, 4).
- **5.3** Configuration control of current AM service processes and systems (79%, 4).
- **5.4** Management of mutual expectations between the service provider and client relating to the AM service (68%, 5).
- **5.7** The active management of the relationship between the service provider and client organisation personnel involved in the AM service (74%, 5).
- **5.8** The appreciation of diversity among inter-company teams involved in the AM service (74%, 4).
- **5.10** Open and effective communication (79%, 5).
- **5.11** Mutual trust and respect between the service provider and client organisation (84%, 5).
- **5.12** Active client participation in reporting, problem solving and improvement relating to the AM service (68%, 5).
- **5.13** Agility (responsiveness) in responding to changes in AM service demands (79%, 4).
- **5.14** Measurement and improvement of the AM service to increase the value-add and benefits (68%, 5).
- **5.16** Proper priority setting of improvement actions, irrespective whether it is service or value-add related (74%, 5).
- **6.1** The consideration of intangible (not measurable) benefits and value creation (i.e. increased effectiveness, risk mitigation, improved decision-making capability) as a result of the AM service (68%, 4).

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- **6.2** Feedback and sharing of lessons learned from successful improvements made to the AM service (68%, 5).
- **6.3** Formal post launch evaluations of the AM service to determine what can be improved (68%, 4).
- **6.5** Proof of operational and financial performance achievements as a result of the AM service (72%, 5).
- **6.6** The ability to measure the AM service quality and value creation (79%, 4).
- **6.7** Focused and continuous improvement to the AM service through monitoring, analysis and feedback (74%, 5).

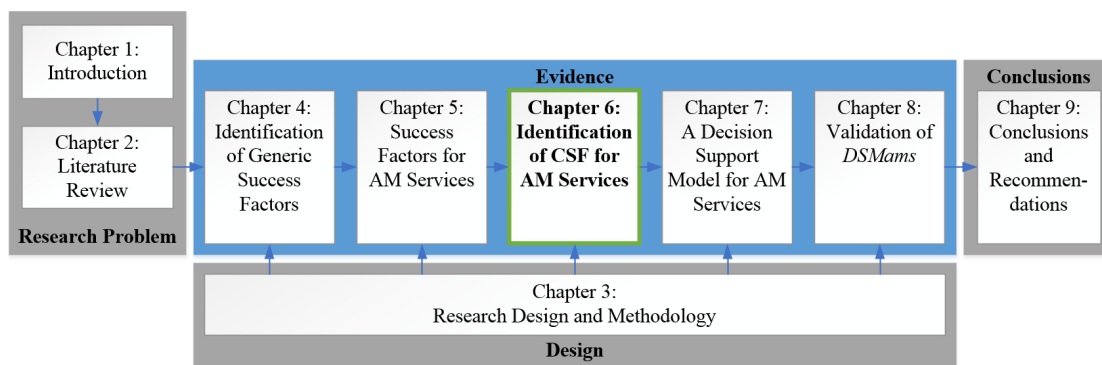
In the next chapter the AMS success factors are further developed to identify the critical factors which are essential in facilitating the success of AMS.

Chapter 6

Identifying Critical Success Factors for Asset Management Services

Critical power ... tends to make an intellectual situation of which the creative power can profitably avail itself. It tends to establish an order of ideas, ... to make the best ideas prevail

– Matthew Arnold (1822-1888)



The objective of this chapter is to identify the CSF for AMS by conducting a survey study to assess the criticality of the success factors confirmed in chapter 5. The chapter begins with the background and design of the survey study. This is followed by the collecting of data by means of a questionnaire. The questionnaire feedback is statistically analysed and the chapter is concluded with the final results identified in the form of a list of CSF for AMS.

6.1 Introduction

Generalisation based on a sample of a population only gained acceptance at the beginning of the twentieth century, when W.S Gossett was faced with the problem of testing the quality of products produced at their liquor distillery in England (Rea and Parker, 2005, 7). This method became known as sample survey research. It is defined more formally by Mouton (2009, 152) as:

a data collection method aiming to provide an overview of a representative sample of a large population of respondents.

Generally, surveys collect information about respondents' behaviours, attitudes, beliefs and emotions. It is commonly used in correlational research and is in the form of open-ended and/or closed-ended questions assessing the constructs of interest (Mrug, 2010, 1472). Survey research is characterised by its versatility, efficiency and generalisability. The latter two characteristics of a survey supports the objective of this phase of the research – which is to obtain the perspectives of a large, global sample of AM role players in a time and cost efficient way (Check and Schutt, 2012, 160). A meta-analysis by Esteves (2004, 52) further supports the choice of a survey as the most commonly used method for identifying CSF.

The method of administration is a consideration in survey design. A web-based survey based on a combination of probability and non-probability sampling is employed for this research. Traditionally, only probability based surveys were acceptable for scientific research (Manfreda and Vehovar, 2008, 265), but Battaglia (2008, 526) states that “a considerable amount of research has recently moved to non-probability approaches due to cost considerations.” A combined sampling approach is used to mitigate the risk of non-probability bias, and also to cost effectively reach a large sample of AM role players via electronic media (i.e. email, company and association electronic newsletters and online discussion groups). Cloud-based survey SaaS simplifies the data collection and analysis process and allows for the self-administration by the researcher (Check and Schutt 2012, 176; Mrug 2010, 1475; Manfreda and Vehovar 2008, 264).

Surveys have both strengths and weakness in comparison to other methods of collecting respondent opinions. The first advantage of a survey is its ability to generalise about a population by drawing inferences from data collected from a small portion of that population (Rea and Parker, 2005, 7-8). A second advantage is that the time and cost of surveys are significantly less in comparison to canvassing the entire population. The third advantage is that the method allows for the generation of standardised data that can be quantified, computerised and statistically analysed. A fourth advantage is its replicability, which allows for comparison among grouped data (Rea and Parker, 2005, 7-8).

Weisberg (2008, 223) states that each stage of a survey is characterised by its own challenge; such as the choice of sample, to minimise non-responses and the measurement of attitudes. Surveys are limited in measuring individual opinion, while opinion is often formed as part of group discussion. Surveys are also weak in determining the real cause of the respondents associated opinion on a matter. The quality of a survey rests upon how each of these challenges are dealt with.

Compared to traditional modes of surveys, a web survey has added advantages in that it will have a shorter transmitting time, lower delivery cost, more design options and less data entry time. Its disadvantages are however the exclusion of respondents who do not have access to the internet and bias due to low response rates (Yan and Fan, 2010, 132). Groves (1989) provides a systematic treatment of several types of survey errors in his *total survey error approach* (Groves 1989, 35; Weisberg 2005, 19) (figure 6.1). This approach is used during the survey implementation to mitigate risks associated with web survey weaknesses.

Types of survey errors are grouped into three tiers; respondent selection issues, response accuracy issues and survey administration issues (Weisberg, 2008, 225-228). The errors are summarised below with the section describing mitigation measures indicated in brackets.

The three *respondent selection issues* are summarised:

- Sampling error is the error made by selecting a sample, which inevitably

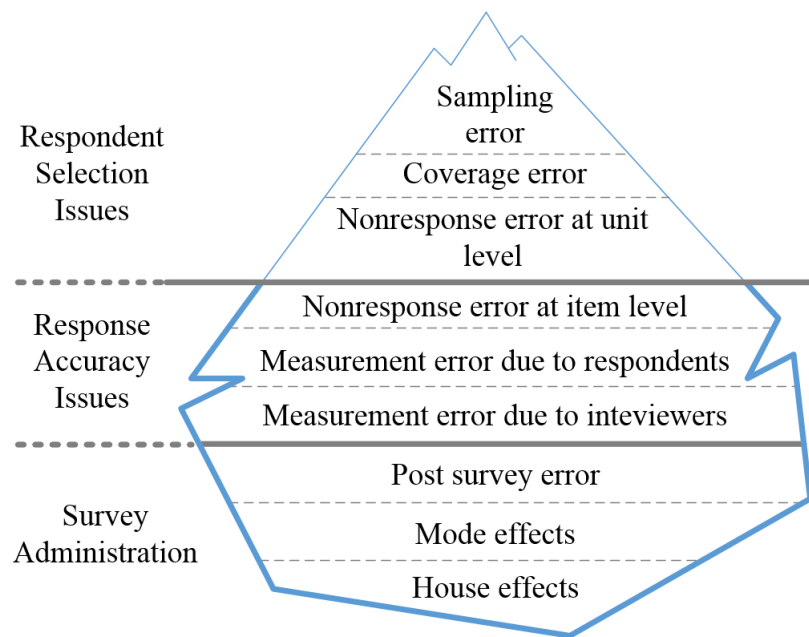


Figure 6.1: Types of survey error (Adopted from Weisberg (2005, 19))

differs from the full population (§6.2.1).

- Coverage error occurs when some subset(s) of the target population is omitted from the sampling frame. Coverage error will result in bias if a large proportion of the population is omitted and when the mean of the sampling frame differs from the subset(s) omitted (§6.2.3.4).
- Non-response error at unit level happens if designated respondents do not respond or participate in the survey (§6.2.1).

The three *response accuracy issues* forms the next tier of the survey error “iceberg”:

- Non-response at item level refers to the problem of when respondents do not answer particular questions (§6.2.3.2).
- Measurement error due to respondents occurs when respondents provide incorrect answers due to question construction (§6.2.3.2).

- Measurement error due to interviewers relates to how interviewers affect responses. This type of error does not apply to this study, since no interviews are done.

The last tier relates to *survey administration issues*:

- Post-survey errors occur after the actual completion of the survey as part of the coding, data management, statistical analysis and reporting process (§6.3).
- Mode effect is an issue since different modes (i.e. web, telephone, interviews) are characterised by different sampling approaches and coverage problems. A mode effect of a web survey is the exclusion of respondents without internet access (§1.5).
- House effects are relevant when survey results are compared based on results obtained from different survey organisations. This issue is not applicable to this research.

6.2 Survey Design

The implementation of a survey is a multi-step process. The survey implementation framework published by (Belfo and Sousa, 2011) is used as a guideline for the implementation of the survey (figure 6.2). The framework addresses the research foundations of a survey and highlights delivery concerns to consider. The implementation phase starts with the selection of an appropriate tool, followed by the questionnaire design and administration of the survey. The following sections describe these phases.

6.2.1 Research Foundations

Leeuw *et al.* (2008, 4) states that the first step of a survey is to determine its objective. The objective of this research survey is to answer two of the research questions. The first, to ask a representative sample of AM role players what the CSF for AMS are and the second, to determine if there are different perspectives

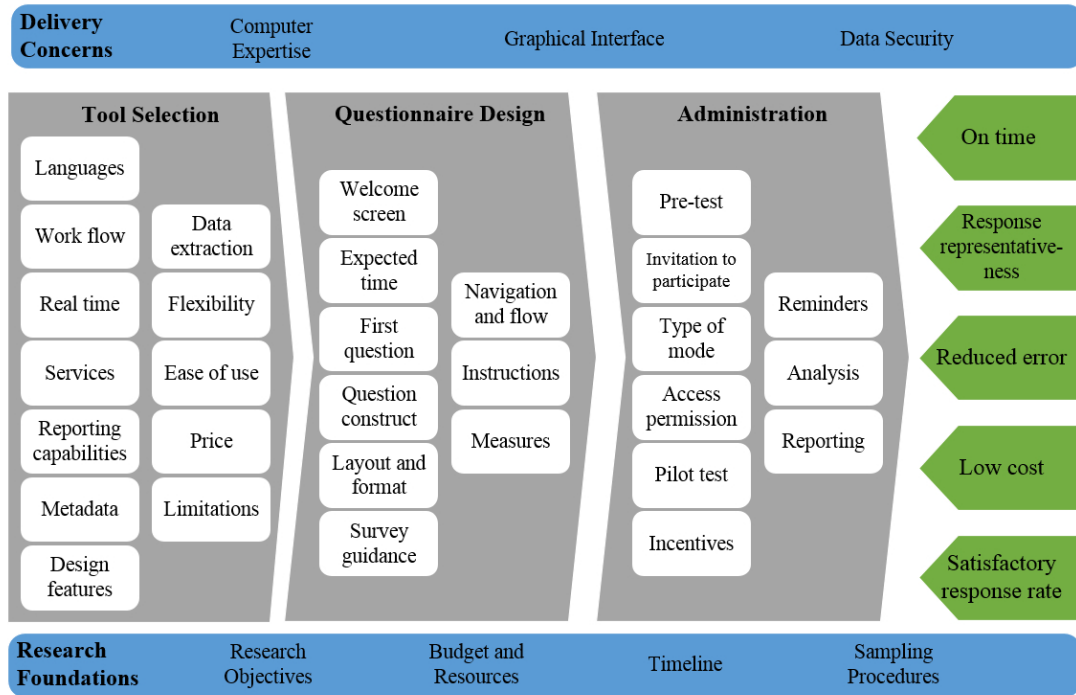


Figure 6.2: Web survey implementation framework (Adopted from Belfo and Sousa (2011, 4))

about CSF across different AMS strata. Human resources available for designing, testing, data collection and analysis of the research are limited to the researcher’s time after business hours, with ad hoc time available from a few AM and AMS consultants for meetings. Limited university funding is available for tool subscriptions and questionnaire localisation. The research timeline foreseen for this phase of the research is seven months, of which three months is planned for data collection.

The selection of a number of units of analysis (i.e. people, companies) from a population is referred to as sampling. There are two types of sampling methods: *probability sampling* and *non-probability sampling*. In probability sampling every unit of analysis of the population has a known non-zero probability of being included in the sample (Trobia, 2008, 784). In contrast, non-probability sampling is used when populations are not well defined – where a sample is produced by

applying knowledge about the population to select a non-random sample of units that represents the population (Battaglia, 2008, 524).

The fields of AM and AMS are diverse with unclear population boundaries (refer to commentary on the definition of AM by Woodhouse (2006, 1) and British Standards Institution (2008*a*, vi)). To attempt to define an accurate sampling frame, which is representative of the full population of AM role players is unrealistic. For the purpose of this study a combination of *intercept probability* and *purposive, non-probability* sampling is used (Battaglia 2008, 524; Manfreda and Vehovar 2008, 268). The combined sampling mitigates the risk of bias and produces a sample from which benchmarking information can be elicited, rather than claiming representativeness of the entire AM population.

Intercept probability sampling is a systematic process of intercepting visitors of a website to participate in the survey. Respondents represent the visitors or members of the website (Manfreda and Vehovar, 2008, 266). *LinkedIn* is a social networking website for professionals founded in 2002 (LinkedIn [Online], 2002). The AM community is active on *LinkedIn* through a variety of AM groups, companies and member groups. For the intercept probability sampling a selection of the most prominent AM *LinkedIn* groups are selected, and their members invited to participate in the survey. The groups, a short description, the survey post date and number of members on the post date are included in appendix B.1.1.

Purposive non-probability sampling is used to produce a purposive sample which can logically assume to be representative of the population. For this sampling the researcher's network of contacts built up over a ten year period in the field of AMS is utilised. Individual contacts and distribution lists are used for this purpose. Respondents are requested to distribute the survey questionnaire within their networks or organisations (if allowed and/or willing to do so). Organisations in which respondents are invited to participate are listed in appendix B.1.2. Individuals are not personally identified due to confidentiality requirements (refer to §B.2). At least one respondent from each of the organisations is personally invited to participate.

The following distribution lists are identified as channels to distribute the survey through: two promotions in the *Reliabilityweb Uptime Magazine* newsletter (Reliabilityweb.com [Online], 2014); the client database of the AM service provider, *Pragma's* South African and Brazilian companies (Pragma [Online], 2013) (consisting of predominantly African and South American clients, as well as international clients); the member database of the Brazilian Maintenance Associations (ABRAMAN) and the student list of the Masters in Business Administration in Management of Engineering Maintenance presented by the Brazilian Pragma Academy in association with the universities of São Paulo and Campinas.

Shapiro (2008, 782) states that it is a common misconception that sample size is a function of the size of the population of interest, with some studies suggesting that sample size does not affect a survey results' accuracy (Lau 1994, 18; Crespi 1988, 167). A survey will however not be credible if the sample is too small, which confirms the need to identify a sample size which will produce sufficiently reliable estimates (Weisberg 2008, 226; Shapiro 2008, 782).

According to the *central limit theorem* when the sample size is sufficiently large the distribution of a point estimator of the population mean is approximately normal (Devore and Farnum, 1999, 277). The sample size for this study is estimated by deriving the sample size, n , from the large-sample confidence interval for a population mean, μ , which is given by Devore and Farnum (1999, 281):

$$\bar{x} \pm z \frac{s}{\sqrt{n}} \quad (6.1)$$

where \bar{x} is the point estimate, z is the critical value associated with the chosen confidence interval, s is the sample standard deviation and n is the sample size. It follows that:

$$n = \left(\frac{1.96s}{B} \right)^2 \quad (6.2)$$

where 1.96 is the z critical value for a 95% confidence interval for the point estimator and B the specified bound of error of estimation.

In §5.6 the standard deviation of the last round Delphi study is reported. The estimate for S is chosen as 0.8, since more variation than the Delphi study average is expected. The bound of error, B , is selected as 0.1 for the 7-point Likert-type scale to be used in the questionnaire (refer to §6.2.3.3). The estimated sample size is given as:

$$n = \left(\frac{1.96 \times 0.8}{0.1} \right)^2 = 245.9 \quad (6.3)$$

The aim is to close the study, as soon as 250 valid responses are collected.

6.2.2 Tool Selection

The cloud-based survey and questionnaire SaaS, *SurveyMonkey*, is used as the tool for designing and distributing the survey questionnaire and collecting the data. Although many other similar survey platforms exist, the researchers' familiarity with *SurveyMonkey* and its benefits in support of this study are the deciding factors for selecting this SaaS. The benefits in support of this study are:

- The self-administration of the design, distribution and data collection phases.
- The integrity of the confidentiality of respondents through no third party involvement.
- The ease of designing a questionnaire with work flow features and custom templates.
- Real-time availability of data collected.
- Multi-language capability for translation into other languages.
- The ability to distribute the questionnaire link via any electronic platform through a link to the questionnaire web page.
- The exporting of the data into a spreadsheet format for further analysis.

The choice of *SurveyMonkey* addresses the delivery concerns in figure 6.2. The graphical interface of the *SurveyMonkey* questionnaire is intuitive and no special computer expertise is required for completing the questionnaire. The survey data

is stored on the researcher's secure *SurveyMonkey* account, which is not accessible to third parties.

6.2.3 Questionnaire Design

The survey questionnaire consists of five sections; a combined introduction and qualification page, consent information, instructions, CSF questions and strata questions. The sections comply with the ethics requirements of the University of Stellenbosch (see appendix B.2). With reference to the sampling strategy (§6.1) the survey questionnaire is translated into Brazilian Portuguese to mitigate the risk of response inaccuracy associated with Brazilian respondents responding to an English questionnaire. Refer to appendix B.3 for the English and Brazilian Portuguese questionnaires.

6.2.3.1 Front Matter

The survey link navigates to the information page. In this page the researchers are introduced and the estimated time (of 15-20 minutes) to complete the questionnaire is indicated. The purpose of the research and the study is explained, followed by qualification criteria. Qualification criteria are specified to ensure participants belong to the population aimed at for this research. A respondent should comply with at least one of the criteria for qualifying to complete the questionnaire. The criteria are:

- The respondent works in the field of AM.
- The respondent is part of a service provider's team that consults, advises, trains and/or delivers AMS to improve or manage the physical assets of asset owning organisations.
- The respondent is part of an asset owning organisation's team that contracts or collaborates with as service provider for advice, training, or services relating to the organisation's physical assets.

The questionnaire exits when respondents respond that they do not qualify. Two choices are available for respondents who do qualify; to go directly to the instruc-

tions section, or to first go to the consent information section.

The consent information section informs the respondent of the required ethical considerations for participating in the research. The page explains potential risks and benefits of the research and that participation is voluntary and without payment. The participant is informed about the confidentiality of their views, participant rights and that withdrawal is possible at any time. The researchers' contact details are specified, followed by a choice to consent to further participation or not. In the case of those not consenting, the questionnaire exists, otherwise it navigates to the instructions section.

The instruction section informs the respondent of the number of questions and how they should be rated. It states that respondents should base their responses on collective experience, or a single successful AMS intervention. The respondent is informed that only primary, and not secondary, role players in AMS should be considered. The section is concluded by indicating the strata questions which should be answered to provide context to the CSF question responses.

6.2.3.2 Critical Success Factor Questions

The CSF question section of the questionnaire covers the rating of the success factors identified in chapter 5. The section is divided into six service life cycle phases (refer to §4.3). Each section is characterised by a description, a single question and a range of success factors which should be rated, based on the question. The first sub-section is:

1. Organisational Environment and Capabilities

The following factors relate to the organisational environment and capabilities of the AM service provider.

How critical are the following towards the success of AM services?

- **1a** A capable project manager that manages the AM service on behalf of the service provider.

- **1b** Degree to which the service provider's client facing team (sales representatives, project managers, service personnel) are knowledgeable in the full range of the service provider's value proposition and combination of service options available.
- **1c** The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants.
- **1d** The availability of the most appropriate skilled resources for providing industry specific AM service requirements.
- **1e** The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations).
- **1f** The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service.

For each of the six sub-sections the description is unique, collectively describing the success factors included in the sub-section. The question for the six sub-sections are the same. The remaining sub-sections and the associated success factors are:

2. Initiation Phase and Pre-contract Activities

- **2a** Continued and sustained commitment from the client's senior management in support of the AM service.
- **2b** The active participation of the client personnel and their commitment towards completing the pre-contract activities.
- **2c** The alignment of the client organisation's AM service requirements with their overall organisational and business strategies.
- **2d** Compilation and availability of formal contractual documents.
- **2e** A detailed project plan with milestones in place.

- **2f** The cultural readiness of the client organisation to change in business model for delivering AM (in other words having the right skills in the client organisation to manage commercial partnership and business strategy and outcomes, instead of daily management of AM).
- **2g** The belief by the service provider that they will deliver some benefits by overcoming obstacles that are unknown at this stage of the process, and that the collaboration will result in positive benefits for the individuals and the organisation.

3. Preparation and Design Processes

- **3a** Design and integration of service and performance metrics for all stakeholders (service provider and client) involved in the AM service.
- **3b** The inter-company flow of information (between the service provider and client organisation) during the AM service design.
- **3c** Compilation and active use of design documents.
- **3d** Ensuring that pre-project arrangements are made for logistics, feasibility studies and changes in organisational structures that might arise from the AM service.
- **3e** The potential of the AM service to be scalable (expandable to other business units within the client organisation)
- **3f** The strategic fit of the AM service with the service provider and client's current service propositions, systems and capabilities
- **3g** Evaluation and consideration of different AM service designs
- **3h** The integration of health, safety, environmental and quality considerations as part of the AM service or to align the service to existing standards
- **3i** The integration of operational excellence methodologies, such as TPM, TQM, 5S into the AM service offering or to align the service to existing standards

- **3j** The availability of adequate infrastructure and interfaces in support of the AM service
- **3k** Adequate legacy system knowledge, if such systems are required to interface with the AM service information systems
- **3l** The security and protection of information, relating to information systems that forms part of the AM service
- **3m** The ability to design a practical solution for the client's existing AM maturity, but also to consider in the design long term goals AM maturity targets.
- **3n** The involvement of knowledgeable and demanding individuals from the client during the design and preparation, rather than individuals that want to abdicate their AM responsibilities.

4. Implementation and Commissioning

- **4a** An adequate training programme in place for all AM service role players, both in the service provider and client teams.
- **4b** An effective organisational change management programme in support of the AM service.

5. Control Processes

- **5a** The monitoring of budgets and costs relating to the AM service.
- **5b** The configuration control of current AM service processes and systems.
- **5c** The management of mutual expectations between the service provider and client relating to the AM service.
- **5d** The active management of the relationship between the service provider and client organisation personnel involved in the AM service.
- **5e** The appreciation of diversity among inter-company teams involved in the AM service.

- **5f** Open and effective communication.
- **5g** Mutual trust and respect between the service provider and client organisation.
- **5h** Active client participation in reporting, problem solving and improvement relating to the AM service.
- **5i** Agility (responsiveness) in responding to changes in AM service demands.
- **5j** The use of performance measurement to monitor, control and improve the AM service.
- **5k** Proper priority setting of improvement actions, irrespective whether it is service or value-add related.

6. Benefits and Value-add

- **6a** The consideration of intangible (not measurable) benefits and value creation (i.e. increased effectiveness, risk mitigation, improved decision-making capability) as a result of the AM service.
- **6b** Feedback and sharing of lessons learned from successful improvements made to the AM service.
- **6c** Formal post launch evaluations of the AM service to determine what can be improved.
- **6d** Proof of operational and financial performance achievements as a result of the AM service.
- **6e** The ability to measure the AM service quality and value creation.
- **6f** A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback.

Weisberg (2008, 227) states a researcher should be cognisant of response accuracy (refer to §6.1). Potential *measurement error by respondents* are mitigated in the questionnaire by including the success factor statements unaltered from the

third round Delphi results in chapter 5. The feedback from the Delphi study's three rounds of questionnaires indicates no adverse quality or comprehension issues with success factor statement constructions. *Non-response at item level* is addressed by making all questions compulsory, without options of "not applicable" or "don't know".

6.2.3.3 Rating Scale

According to Frey (2010, 1120) ratings are summaries of attitudes organised such that a number is assigned to a defined scale. The Likert scale is the most widely used scale in ordinal measurement, especially to measure attitudes in survey research (Brill, 2008, 428). The distinction between Likert and Likert-type scales is of importance. For this study a *Visual Analogue Scale (VAS)* scale is used, which is a *Likert-type* scale. A Likert-type scale is not the same as a Likert scale "because the respondent does not indicate the degree of agreement with a stimulus attitude statement; rather, the respondent is asked to indicate a level of satisfaction or dissatisfaction with a characteristic of some object or entity", according to Brill (2008, 428).

The criticality of the 46 success factors are rated on a 7-point VAS, with 1 corresponding to *not being critical* and 7 corresponding to *extremely critical*. The respondent can respond by selecting any integer level of criticality from 1 to 7. The choice of a 7-point, instead of a 5-point scale is ratified by Finstad (2010, 109), whose research indicates that 5-point scales elicit interpolations, are not granular enough and "are consistently outperformed by 7-point scales, which are more accurate, easier to use and a better reflection of a respondent's true evaluation."

Over the last decade consensus was reached among researchers (Frey 2010, 1220; Carifio and Perla 2007, 110; Norman 2010, 631) that parametric statistics, such as average scores, normality and ANOVA, are acceptable for analysing ordinal Likert-type data. Parametric statistics produce fairly accurate results and concerns about treating ordinal data as interval data in the process is unfounded and "primarily academic".

6.2.3.4 Stratification

Lohr (2008, 106) refers to *stratified random sampling* as probability sampling that is used to ensure that a sample contains representation from population subgroups of interest. In this sampling method a population is divided into groups or so-called *strata* (singular: stratum) and sampling is done to include respondents covering all strata. Although this method is not primarily used for sampling in this study, strata are important to determine whether there are different perspectives on CSF within the strata (refer to the second research question in §1.2). The inclusion of strata in the questionnaire draws attention to the potential coverage issues as highlighted in §6.1.

For each stratum, sub-groups are specified. These sub-groups form the basis for determining whether there are different perspectives on CSF within the strata. The strata sub-groups are identified from the literature review. A set of strata are designed and integrated in the survey questionnaire. Each respondent is asked to specify a predominant option for each stratum which characterise their responses.

Strata were identified in §2.1.2, §2.1.4.1, §2.2.6, §2.2.7 and §2.2.8 of the literature review (chapter 2) and those relevant to this research are used to develop the strata section of the questionnaire:

Participant Role

1. Which role do you play in relation to AM services?

- Asset-, equipment or facilities owner/representative
- AM consultant, service provider/supplier

2. Which of the following levels within your organisational hierarchy best describe your position in relation to AM services?

- Strategic (i.e. CEO, managing director, divisional manager, technical director, plant engineer)

- Tactical (i.e. reliability engineer, maintenance manager, project or service manager, key account manager)
- Operational (i.e. supervisor, team leader, planner, scheduler, craftsman, artisan, operator)

Economies and Industries

1. In which of the following economies do you predominantly collaborate in AM services?

- Developed economies (i.e. USA, UK, Japan, Europe)
- Developing economies (i.e. BRICS)

2. In which of the following regions do you collaborate in AM services?

- Africa
- Asia
- Australasia
- Europe
- North America
- South America
- More than one of the above regions

3. In which industry does the asset owning organisation (to whom an AM service is delivered) predominantly operate in?

- Agriculture, forestry and fishing
- Mining and quarrying
- Manufacturing
- Electricity, gas, steam and air conditioning supply
- Water supply; sewerage, waste management and remediation activities

- Construction
- Wholesale and retail trade
- Transportation and storage
- Information and communication
- Financial and insurance
- Real estate
- Professional, scientific and technical activities
- Public administration and defence
- Education
- Health care
- Arts, entertainment and recreation
- More than one of the above
- Other (please specify)

4. In which of the following business sectors do you predominantly collaborate in AM services?

- Private sector (organisations which are run by private individuals or groups for profit)
- Public sector (part of the economy concerned with providing basic government services)
- Non-profit sector (organisations which have undertaken activities which are not for profit)

Service Details

1. In which phase of the AM life cycle do you predominantly collaborate in AM services?

- Needs identification, feasibility studies and/or planning
 - Specification and design
 - Acquisition, installation and commissioning
 - Operation and maintenance
 - Decommissioning and disposal
 - More than one of the above
2. What type of physical assets are predominantly being managed through the AM services?
- Mechanical or electro-mechanical equipment or machinery (i.e. manufacturing or production equipment, vehicles, computers, trains, airplanes, transformers, medical equipment, defence systems)
 - Facilities (i.e. properties, buildings, furniture, fixtures, air conditioning)
 - Infrastructure and linear assets (i.e. dams, reservoirs, roads, pipelines, power lines)
 - Other (please specify)
3. By referring to the diagram below which of the types of services best describe the AM service which you predominantly collaborate in..
- Basic asset-orientated services
 - Professional support services
 - Outsourcing services
 - Integrated life cycle services
4. Which of the following timespans predominantly characterize the AM services that you are involved in?
- Short term (<3 months continuously or intermittently)

- Short to medium term (3 months to 1 year continuously or intermittently)
- Medium term service contract (1 to 3 years continuously)
- Long term service contract (>3 years continuously, or timespan independent)

5. Which of the following levels of maturity (advancement) predominantly describe the environment in which you collaborate in AM services?

- Initial; the AM environment is undefined, unpredictable, poorly controlled and/or reactive
- Managed; some processes and aspects in the AM environment are defined and formally managed
- Defined; most processes in the AM environment are defined and proactively managed
- Quantitatively managed; all processes in the AM environment are measured and controlled
- Optimising; the focus in the AM environment is on improvement

6. How many stakeholders (of the asset owner and service provider combined), are involved in the AM service?

- 1 to 5
- 6 to 15
- 16 to 30
- 31 to 100
- >100

6.2.4 Survey Administration

To ensure the questionnaire construction is unambiguous and the questions clearly constructed, a pre-testing is done. Both the English and Brazilian Portuguese questionnaires were distributed and completed by an invited group of respondents, two of which took part in the Delphi study. Following the respondents' feedback, preparation for distributing the questionnaire is done.

The questionnaire is distributed with an invitation to participate in the form of an email or a discussion group comment (see appendix B.3.3). Distribution is done via individual or group emails, *LinkedIn* discussion comments and newsletter promotions. To ensure compliance with confidentiality requirements, blind copying of names in emails is used and no personal identifiable information is stored as part of the data collection process.

Access to the questionnaire is gained by following the link included in the invitation to participate. The respondent's IP address is recorded as soon as the questionnaire is accessed for the first time. The questionnaire allows respondents repeated access to alter and complete responses until all of the questions are answered. Thereafter the questionnaire is closed and cannot again be accessed from the IP address.

It is common practice to use incentives to increase response rates and response quality (Jie *et al.*, 2008, 344). A meta-analysis study by Göritz (2006, 67) reveals that material incentives in web surveys increase response and decrease dropout. However, the study results show that the effect of incentives versus no incentives is low and that consideration needs to be given to the benefit gained compared to that of the cost of the incentive. Based on the cost of incentives and the small effect of incentives versus no incentives, participation in this study is not incentivised.

6.3 Survey Results and Analysis

The primary purpose of this section is to present the survey results and analysis. A secondary purpose is to present it systematically to ensure that no post survey errors are committed (refer to §6.1). The sample characteristics and response descriptive statistics are discussed. This is followed by a section on sensitivity analysis and analysis of variance of the strata. The section is concluded with a summary of the CSF for AMS.

6.3.1 Sample Characteristics

The survey closed with 254 valid responses received for both the English and Brazilian Portuguese questionnaires, respectively. The responses exclude a 35% non-response rate at item level (refer to §6.1). A non-response at item level is any response with incomplete answers. Figure 6.3 and table 6.1 show the total responses, and valid responses received for the questionnaires. The number of valid responses is in line with other similar research studies on CSF (Shah *et al.* 2007, 516; Chow and Ha 2009, 260; Han and Noh 2000, 33; Stankovic *et al.* 2013, 1665; Esteves 2004, 102).

Of the total 392 responses 2.8% of respondents did not qualify to participate and

Questionnaire	Total Responses	Valid Responses	Retention Rate
English	308	197	64%
Portuguese	84	57	68%
Combined	392	254	65%

Table 6.1: Questionnaire responses

exited the questionnaire (table 6.2). A further 56 potential participants indicated they would first like to read the consent information. Eight of these participants exited without further response. Of the remaining 48 respondents 93.8% agreed to participate after reading the consent information. The majority (82.9%) of respondents agreed to participate without reading the consent information. For

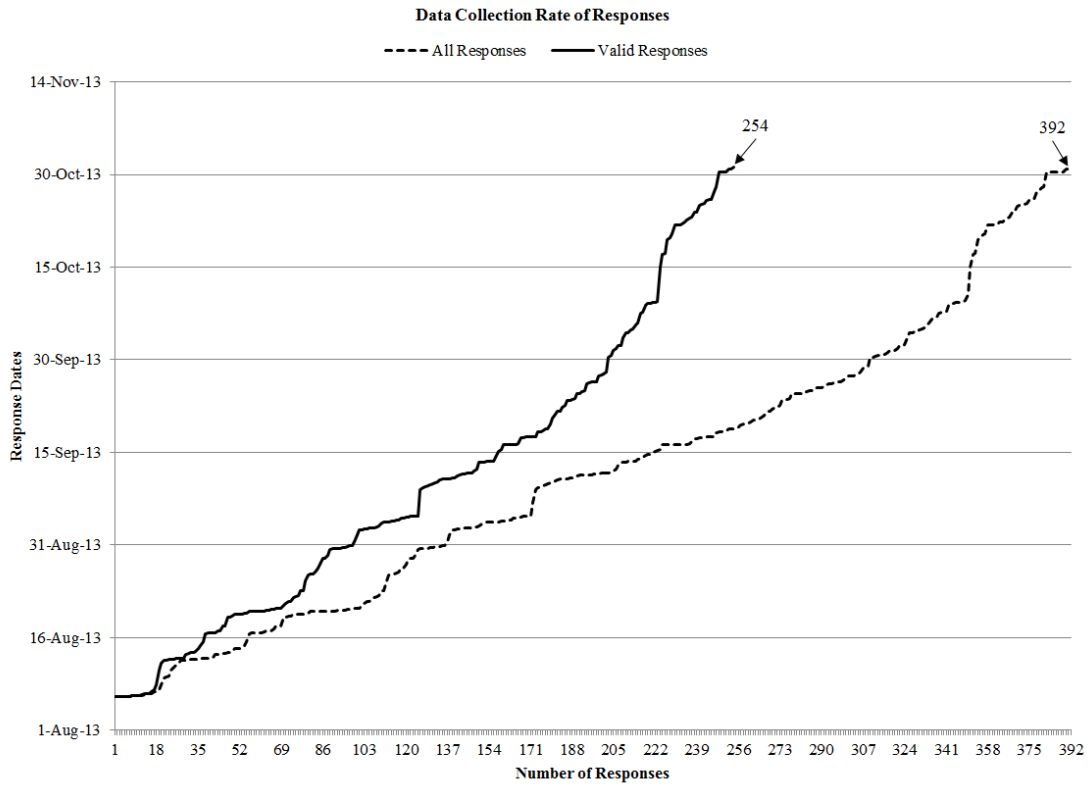


Figure 6.3: Response rate for the data collection phase

the purpose of further analysis only the 254 valid responses are analysed.

	Count	%
Do you qualify to participate?		
I qualify and want to get started	325	82.9%
I qualify, but want to read the consent information	56	14.3%
I do not qualify	11	2.8%
	392	
Do you consent to participate?		
Yes	45	93.8%
No	3	6.2%
	48	

Table 6.2: Qualification and consent responses

Tables 6.3, 6.4 and 6.5 show the participant distribution for the strata (refer

to §6.2.3.4). In table 6.3 it is seen that almost twice as many service providers (64.6%) completed the questionnaire compared to the 35.4% asset owners which participated. More than 80% of the sample is represented by strategic and tactical participates (47.6% and 34.6%, respectively).

	Valid N	%
Participant Role		
Service Provider	164	64.6%
Asset Owner	90	35.4%
Participant Organisational Level		
Tactical	121	47.6%
Strategic	88	34.6%
Operational	45	17.7%

Table 6.3: Role representation in the sample

Table 6.4 shows the representation of economies and industries. More than two thirds of the sample consists of responses from developing economies, which is also reflected in the regional distribution with 38.6% representation from Africa and 25.2% from South America. The sample consists of 10.6% respondents involved in AMS in multiple regions. Australasia, Europe and North America only accounts for 21.6% of the sample.

The predominant industries represented are manufacturing and mining and quarrying, accounting for 29.1% and 21.3% of the sample, respectively. Involvement in multiple industries and electricity supply also account for double digits of 13.4% and 11% respectively. All other industries contribute towards the rest of the 25.1%, but none contributes more than 3.9% individually.

Private sector companies account for 76.8% of the sample and the public sector for 22.4%.

Table 6.5 shows the service related characteristics of the sample. More than half of the AMS represented in the sample are related to the operation and maintenance of assets (52.4%). A further 34.3% are involved in multiple phases of the

	Valid N	%
Economies		
Developing economies	173	68.1%
Developed economies	81	31.9%
Region		
Africa	98	38.6%
South America	64	25.2%
Multiple regions	27	10.6%
Australasia	26	10.2%
Europe	17	6.7%
North America	12	4.7%
Asia	10	3.9%
Industries		
Manufacturing	74	29.1%
Mining and quarrying	54	21.3%
Multiple industries	34	13.4%
Electricity supply	28	11.0%
Other	10	3.9%
Water supply	9	3.5%
Public administration and defence	9	3.5%
Transportation and storage	7	2.8%
Agriculture, forestry and fishing	6	2.4%
Construction	5	2.0%
Wholesale and retail trade	3	1.2%
Arts, entertainment and recreation	3	1.2%
Education	3	1.2%
Information and communication	3	1.2%
Real estate	2	0.8%
Professional, scientific and technical activities	2	0.8%
Health care	1	0.4%
Wholesale and retail trade	1	0.4%
Sectors		
Private sector	195	76.8%
Public sector	57	22.4%
Non-profit sector	2	0.8%

Table 6.4: Economies and industries representation in sample

asset life cycle. Responses relating to AMS for managing equipment and machinery accounts for 72% of the sample, while 13% relates to facilities management and 10.2% to infrastructure and linear assets.

Responses relating to professional support services represent 39.4% of the sample, followed by outsourcing services with 29.5%. Basic asset-orientated services accounts for 15.7% and a further 15.4% of responses relates to integrated life cycle

services.

Most responses in the sample relate to long term service contracts (41.7%), followed by medium term contracts, representing 28.3%. Short to medium term contracts account for 23.6% and the remaining 6.3% accounts for short term contracts.

Services included in the sample are predominantly associated with low-medium AM practices (46.9%). A further 23.6% relates to medium AM maturity. High, medium-high and low AM maturity characterise 12.2%, 7.9% and 9.4% of the sample, respectively.

The size of the AMS is represented by the number of people involved in the service. The most common size service included in the sample are 6 to 15 people, accounting for 27.2%. This is followed by large service involvement with more than 100 people affected, with 22%. Service sizes involving 1 to 5, 16 to 30 and 31 to 100 represent 13%, 19.3% and 18.5% of the sample respectively.

6.3.2 Response Descriptive Statistics

This section reports on the descriptive statistics of the responses collected in the questionnaires. The combined responses are summarised in figure 6.4. The histogram shows the distribution of values with a mean of 5.807 and a standard deviation of 1.121. The histogram is skewed to the right, but the normal probability plot and Kolmogorov-Smirnov test (Sager, 2010, 663) show insufficient evidence to reject that the data is normally distributed.

The Cronbach α coefficient for the responses of the 46 success factors is calculated as 0.954, which is associated with a high level of internal response consistency reliability (refer to §5.3.2.1).

Table 6.6 summarises the descriptive statistics of the survey results for the 46 success factors. The rank of the mean is shown in the last column of the table. The factors are referenced with the identifier assigned in §6.2.3.2 (refer to appendix

	Valid N	%
Asset Life Cycle		
Operation and maintenance	133	52.4%
Multiple phases	87	34.3%
Needs identification, feasibility studies and/or planning	22	8.7%
Acquisition, installation and commissioning	8	3.1%
Specification and design	4	1.6%
Asset Types		
Mechanical or electro-mechanical equipment	183	72.0%
Facilities	33	13.0%
Infrastructure and linear assets	26	10.2%
Other	12	4.7%
Type of Service		
Professional support services	100	39.4%
Outsourcing services	75	29.5%
Basic asset-orientated services	40	15.7%
Integrated life cycle services	39	15.4%
Service Timespan		
Long term service contract (>3 years continuously)	106	41.7%
Medium term service contract (1 to 3 years continuously)	72	28.3%
Short to medium term (3 months to 1 year)	60	23.6%
Short term (<3 months)	16	6.3%
AM Maturity		
Managed (low-medium)	119	46.9%
Defined (medium)	60	23.6%
Optimising (high)	31	12.2%
Initial (low)	24	9.4%
Quantitatively managed (medium-high)	20	7.9%
Service Size (people involved)		
6 to 15	69	27.2%
>100	56	22.0%
16 to 30	49	19.3%
31 to 100	47	18.5%
1 to 5	33	13.0%

Table 6.5: Service characteristics representation in the sample

B.4 for the histogram, normal probability and box-and-whisker plot for each of the success factors).

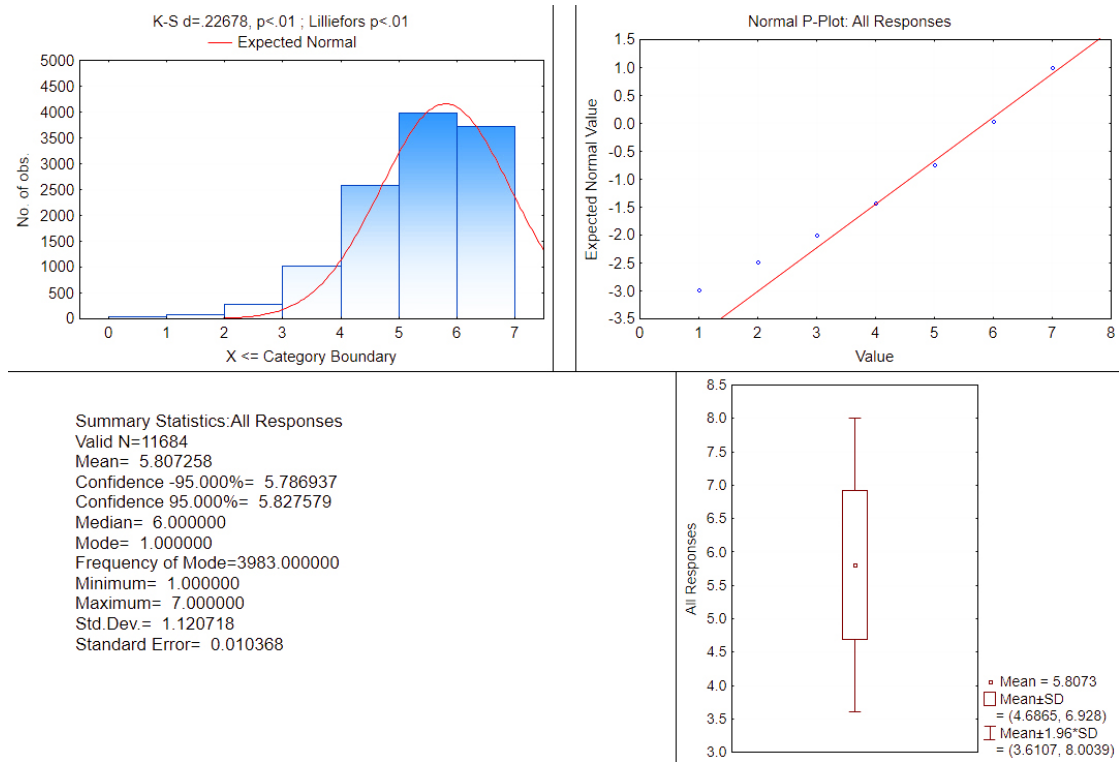


Figure 6.4: Histogram of all responses across 46 success factors

Factor	Descriptive Statistics											
	Valid N	Mean	Lower Conf. Limit	Upper Conf. Limit	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Standard Error	Rank (Mean)
1a	254	5.953	5.817	6.089	6	7	97	1	7	1.099	0.069	19
1b	254	5.720	5.583	5.858	6	6	87	1	7	1.109	0.070	32
1c	254	5.969	5.852	6.085	6	6	104	2	7	0.945	0.059	16
1d	254	5.870	5.754	5.987	6	6	106	3	7	0.942	0.059	23
1e	254	5.831	5.701	5.960	6	Multiple	81	2	7	1.048	0.066	27
1f	254	6.110	5.989	6.231	6	7	110	3	7	0.980	0.061	10
2a	254	6.413	6.303	6.524	7	7	158	2	7	0.897	0.056	1
2b	254	5.965	5.831	6.098	6	7	93	1	7	1.083	0.068	17
2c	254	6.150	6.033	6.266	6	7	108	2	7	0.946	0.059	5

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Factor	Descriptive Statistics											
	Valid N	Mean	Lower Conf. Limit	Upper Conf. Limit	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Standard Error	Rank (Mean)
2d	254	5.276	5.114	5.437	5	5	74	1	7	1.308	0.082	40
2e	254	5.827	5.686	5.967	6	7	86	1	7	1.136	0.071	28
2f	254	5.980	5.854	6.106	6	Multiple	92	2	7	1.019	0.064	15
2g	254	5.752	5.622	5.882	6	6	91	2	7	1.055	0.066	31
3a	254	5.713	5.584	5.842	6	6	98	3	7	1.045	0.066	33
3b	254	5.776	5.650	5.901	6	6	86	3	7	1.018	0.064	30
3c	254	5.260	5.112	5.407	5	5	85	2	7	1.194	0.075	42
3d	254	5.268	5.118	5.417	5	6	76	1	7	1.209	0.076	41
3e	254	5.193	5.027	5.358	5	5	76	1	7	1.339	0.084	44
3f	254	5.524	5.379	5.668	6	5	80	2	7	1.172	0.074	36
3g	254	5.142	4.989	5.294	5	5	80	1	7	1.233	0.077	45
3h	254	5.791	5.636	5.947	6	7	91	1	7	1.257	0.079	29
3i	254	5.500	5.332	5.668	6	7	71	1	7	1.362	0.085	38
3j	254	5.858	5.731	5.985	6	6	98	2	7	1.027	0.064	25
3k	254	5.402	5.251	5.552	5	5	81	1	7	1.218	0.076	39
3l	254	5.228	5.049	5.408	5	6	66	1	7	1.451	0.091	43
3m	254	5.862	5.739	5.985	6	6	109	2	7	0.994	0.062	24
3n	254	6.087	5.968	6.205	6	7	102	2	7	0.958	0.060	11
4a	254	6.134	6.022	6.246	6	7	106	3	7	0.906	0.057	6
4b	254	6.134	6.009	6.259	6	7	107	1	7	1.013	0.064	6
5a	254	5.839	5.718	5.960	6	6	97	3	7	0.979	0.061	26
5b	254	5.504	5.376	5.631	5	5	87	2	7	1.032	0.065	37
5c	254	5.957	5.834	6.079	6	6	91	1	7	0.991	0.062	18
5d	254	5.984	5.863	6.105	6	7	96	3	7	0.978	0.061	14
5e	254	5.118	4.953	5.283	5	5	81	1	7	1.337	0.084	46
5f	254	6.323	6.216	6.429	7	7	130	1	7	0.861	0.054	2
5g	254	6.157	6.034	6.281	6	7	118	2	7	0.997	0.063	4
5h	254	6.067	5.949	6.185	6	6	99	2	7	0.953	0.060	12
5i	254	5.878	5.757	5.999	6	6	108	2	7	0.980	0.062	22
5j	254	6.118	6.005	6.231	6	7	104	3	7	0.912	0.057	9
5k	254	5.921	5.806	6.037	6	6	113	2	7	0.933	0.059	20
6a	254	5.673	5.538	5.808	6	6	99	1	7	1.092	0.069	34

Factor	Descriptive Statistics											
	Valid N	Mean	Lower Conf. Limit	Upper Conf. Limit	Median	Mode	Frequency (Mode)	Minimum	Maximum	Standard Deviation	Standard Error	Rank (Mean)
6b	254	5.902	5.779	6.025	6	6	101	2	7	0.995	0.062	21
6c	254	5.646	5.503	5.788	6	6	92	1	7	1.153	0.072	35
6d	254	6.122	5.998	6.246	6	7	112	2	7	1.000	0.063	8
6e	254	6.059	5.943	6.175	6	6	103	3	7	0.937	0.059	13
6f	254	6.181	6.072	6.290	6	7	112	3	7	0.884	0.055	3

Table 6.6: Survey descriptive statistics

Overall the central tendency of the success factors ratings is high on the VAS, where 7 represents *extremely critical* and 1 represents *not critical*. The means for the 46 factors range between 5.118 and 6.413, while the medians and modes range between 5 and 7. The measures of variability indicate the variation in the responses. The minimum and maximum for the factors show minimums of 1, 2 and 3 and a maximum of 7. The standard deviation, which is a measure of variation from the mean varies between, 0.861 and 1.451. The mean and standard deviation for the factors are graphically depicted in the box-and-whisker plot in figure 6.5. By assuming a normal distribution the box includes 68%, and whiskers 95% of the responses.

With the close spread of responses the standard error of the mean and the mean's upper and lower confidence limits are of interest. The sample mean – as calculated – is an estimator of the population mean. The standard error is the standard deviation of the sample mean. Table 6.6 shows the values of the standard error and the upper and lower 95% confidence limits of the mean. These values are graphically depicted in figure 6.6. Standard errors for the factors vary between 0.054 and 0.091.

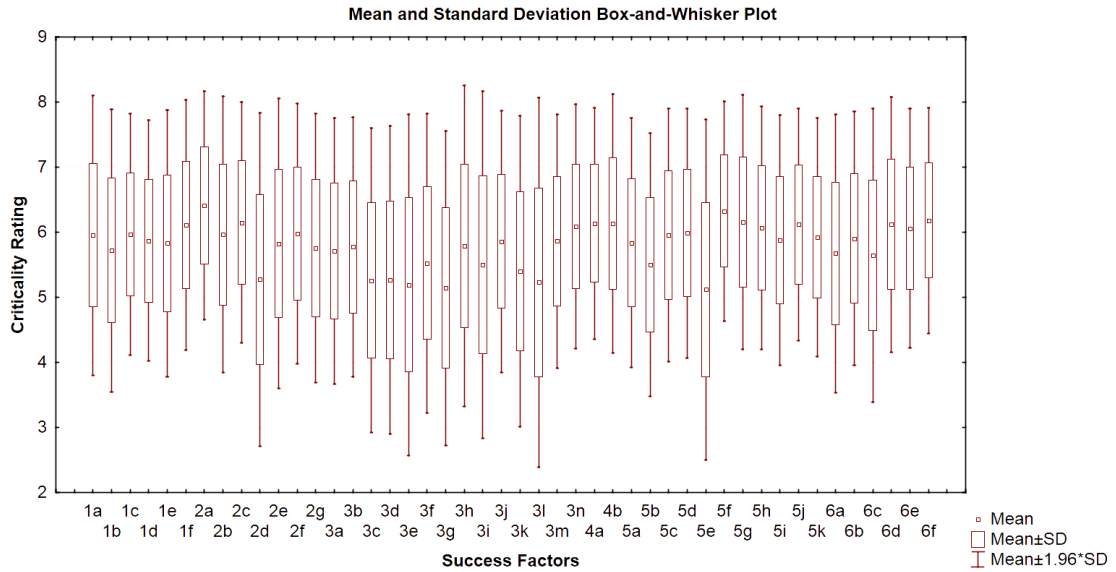


Figure 6.5: Box-and-whisker plot of means and standard deviations

From table 6.6 and figures 6.5 and 6.6 it is seen that factors *2a* and *5f* have the

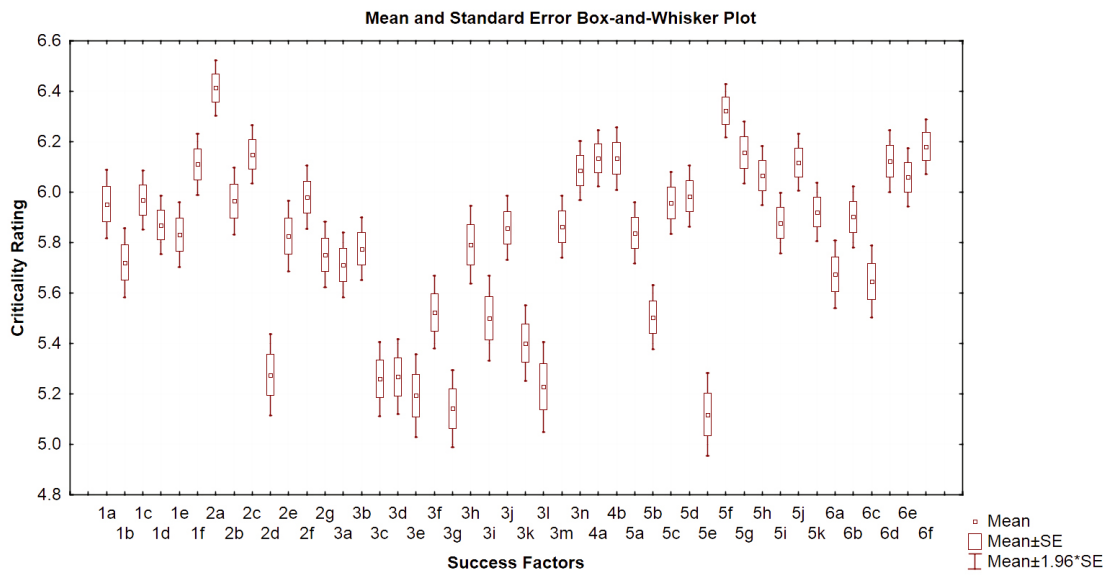


Figure 6.6: Box-and-whisker plot of means and standard errors

highest means of 6.413 and 6.323, respectively. In addition, factors *1f*, *2c*, *3n*, *4a*, *4b*, *5g*, *5h*, *5j*, *6d*, *6e* and *6f*, all have means above 6. The remaining 33 factors'

means fall in the band 5 to 6.

The latest research indicates the use of parametric statistics for analysing ordinal data is scientifically acceptable (see §6.2.3.3). Traditionally non-parametric statistics are used to analyse this type of data. For the sensitivity analysis the mean ranks are compared with the ranks of the median (non-parametric) and four other measures commonly used to analyse data relating to respondent attitude and satisfaction. The four measures are: *top box*, *top two box* and *net top box* percentages, as well as the *z*-score to percentile rank (Sauro, 2011). The definitions of the measures are:

Top box The percentage of respondents who rated a success factor as seven on the VAS.

Top two box The percentage of respondents who rated a success factor six or seven on the VAS.

Net top box The difference between the total number of top responses (sevens) and the number of bottom responses (ones) expressed as a percentage of the total responses.

Percentile rank A six sigma technique converting the raw score to a normal score and expressing it as a percentile rank. The *z*-value is calculated by comparing the success factor mean to a reasonable benchmark. A benchmark of 5.807 – the mean of all the collected data – is used¹

The correlation matrix in table 6.7 and figure 6.7 summarise the correlations of the ranks. In appendix B.5 the comparisons are tabulated. It is evident that the alternative ranks are closely correlated with the mean ranks. This confirms that the choice of using the mean as a standard for the analysis accurately describes the data, with no evidence of adversities for applying parametric statistics to ordinal data.

¹A meta-analysis of 70 research papers by Nielsen and Levy (1994, 71) reports that 5.6 (the combined mean for the papers) is a reasonable value for goal setting for a 7-point scale.

Measure	Rank Correlations of Measures					
	Mean	Median	T/Box	T/2 Box	Net Top	%-tile
Mean	1.000	0.739	0.957	0.982	0.963	0.998
Median	0.739	1.000	0.743	0.744	0.743	0.743
Top Box	0.957	0.743	1.000	0.935	0.998	0.958
Top Two Box	0.982	0.744	0.935	1.000	0.939	0.980
Net Top Box	0.963	0.743	0.998	0.939	1.000	0.963
Percentile	0.998	0.743	0.958	0.980	0.963	1.000

Table 6.7: Correlations of ranks between parametric and non-parametric measures

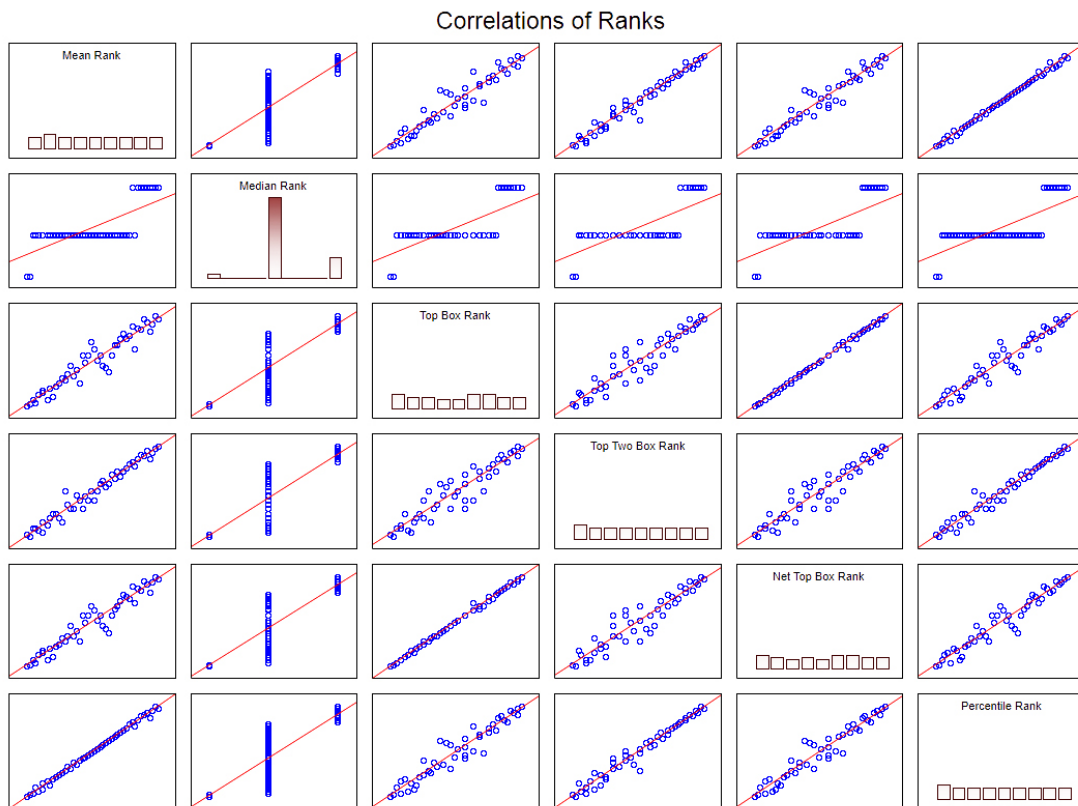


Figure 6.7: Correlation graphs of parametric and non-parametric measures

6.3.3 Analysis of Variance (ANOVA)

ANOVA is used to statistically analyse the strata results. In statistical terms the collected data consists of 46 dependant variables the so-called success factors and

12 categorical predictors the strata. It is of interest what the relationships among the dependant variables and predictors are. In addition to the 12 strata, success factors were categorised by their phase in the service life cycle (§4.3). Analysis of this *phase* stratum is of interest to determine whether the collective success factors differ significantly across the six phases.

The analysis of the 46 dependant variables require multivariate ANOVA. Multivariate analysis does not only take the relationships within the strata into account but also relationships among the 46 success factors (Statsoft [Online], 2013). The *Wilks' lambda* multivariate measure of association is used to test the variance in the success factors that is accounted for by the strata (Foster *et al.*, 2006, 19-21).

The strata sub-groups are analysed for fixed effects, rather than random effects. Strata sub-groups were researched (in chapter 2) and selected to be representative of the wider field of AMS and are therefore seen as fixed. Although there could potentially be different perspectives on sub-groups, such differences are unlikely to be adverse, requiring random effect models (Devore and Farnum, 1999, 400).

The *Tukey-Kramer* post hoc test is used for post hoc testing of sub-group differences (Ramsey and Ramsey, 2007, 1017-1020). This test is not as conservative as the *Scheffè* test (with the risk of detecting no differences), but not as liberal as *Fisher's LSD* and the *Duncan* tests (Cramer and Howitt, 2004, 130).

In order to analyse the strata and success factor relationships a one-way ANOVA is performed to investigate the effect of each stratum independently in the context of the success factors². A multivariate test of significance is done to account for all success factor relationships within each stratum. For the strata showing significance as a result of the multivariate test, univariate ANOVA is performed to determine which of the individual success factors contribute to the significant differences. Effect plots and post hoc tests are presented for the success factors which show significant differences.

²Higher order (additive or factorial) effects are not studied, due to the small sample size which does not cover all combinations of the 12 strata's 63 sub-groups (Cohen, 1990, 1305).

6.3.3.1 Service Life Cycle Phase ANOVA

The ANOVA results in table 6.8 indicated that there are significant differences between the means of the combined success factors for the different phases in the service life cycle. Figure 6.8 and post hoc testing (table 6.9) show the phases with significant mean differences. It is seen that there are no significant differences between the success factors belonging to the organisational environment and capabilities, initiation phase and pre-contract activities, control processes and benefits and value-add phases. However both the preparation and design process and implementation and commissioning phases show significantly different responses compared to the other four phases, as well as a significant difference to each other. The results show that the mean of the preparation and design processes phase is significantly lower (5.543), compared to the other five phases. In contrast, the implementation and commissioning phase mean is significantly higher (6.134) than the other phases and the overall mean.

Source	df	SS	MS	F	p
Phase	5	382.1	76.4	62.4	0.000
Error	11678	14291.8	1.2		
Total	11683	14673.9			

Table 6.8: Service life cycle phase ANOVA

		Unequal Tukey HSD Test					
		Error: MS = 1.224, df = 11678					
		Differences significant at $p < .05$					
Phase	Mean	1	2	3	4	5	6
1.	5.909		1.000	0.000	0.015	0.999	0.995
2.	5.909	1.000		0.000	0.015	0.999	0.995
3.	5.543	0.000	0.000		0.000	0.000	0.000
4.	6.134	0.015	0.015	0.000		0.008	0.04
5.	5.897	0.999	0.999	0.000	0.008		0.961
6.	5.930	0.995	0.995	0.000	0.04	0.961	

Table 6.9: Phase stratum post hoc test

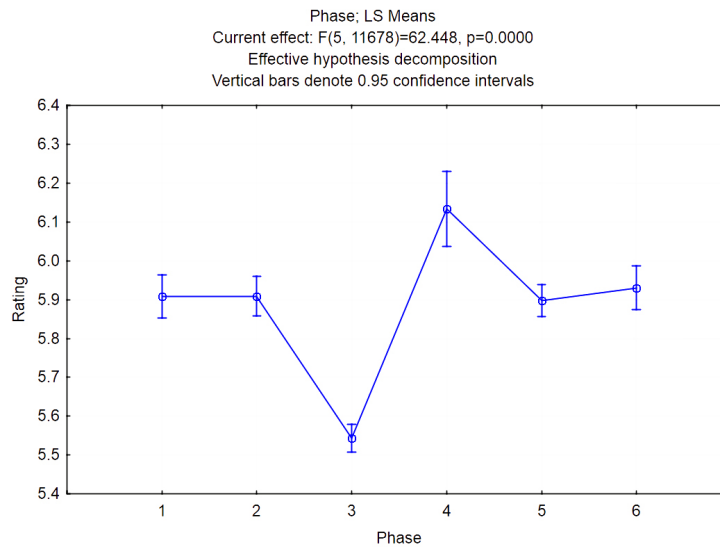


Figure 6.8: Least square means of success factors with significant differences between means according to one-way ANOVA for the service life cycle stratum

6.3.3.2 Strata ANOVA

The multivariate tests of significance for the strata is summarised in table 6.10. It is seen that the participant role, organisational level and the region strata show significant differences between the means of the sub-groups.

The univariate ANOVA results for the 46 success factors for the participant role, organisational level and the region strata are shown in appendix B.6. The results show that five of the 46 success factors show significant mean differences for the participant role. Twenty-nine and 22 show significant differences for the organisational level and region, respectively. Figures 6.9, 6.10 and 6.11 graphically depict the factors with significant differences for the three strata. Post hoc tests (included in appendix B.6) elucidate further on which of the strata sub-groups account for the significant differences.

The post hoc tests for the role strata confirms significant mean differences for success factors *1a*, *5a* and *5d*, but not for *2e* and *3h*. From figure 6.9 and the post hoc results it can be said that service providers value a capable project manager

Strata Effect	Multivariate Tests of Significance (Wilks' Lambda Marked differences are significant at $p < .05$)				
	Value	F	Effect df	Error df	p
Participant Role					
Intercept	0.006	774.122	46	207	0.000
Role	0.721	1.744	46	207	0.005
Organisational Level					
Intercept	0.006	740.082	46	206	0.000
Level	0.564	1.487	92	412	0.005
Economy					
Intercept	0.006	734.326	46	207	0.000
Economy	0.828	0.934	46	207	0.596
Region					
Intercept	0.009	481.329	46	202	0.000
Region	0.213	1.303	276	1212.118	0.002
Industry					
Intercept	0.019	211.705	46	191	0.000
Industry	0.034	0.943	782	3137.703	0.848
Sector					
Intercept	0.073	57.239	46	206	0.000
Sector	0.617	1.225	92	412	0.096
Asset Life Cycle					
Intercept	0.023	186.260	46	204	0.000
Life Cycle	0.413	1.100	184	816.590	0.196
Asset Type					
Intercept	0.013	346.221	46	205	0.000
Asset Type	0.560	0.952	138	615.283	0.633
Service Type					
Intercept	0.006	716.583	46	205	0.000
Service Type	0.561	0.948	138	615.283	0.644
Service Timespan					
Intercept	0.008	535.911	46	205	0.000
Timespan	0.572	0.914	138	615.283	0.739
AM Maturity					
Intercept	0.008	554.283	46	204	0.000
Maturity	0.407	1.122	184	816.590	0.150
Service Size					
Intercept	0.006	798.014	46	204	0.000
Size	0.501	0.840	184	816.59	0.928

Table 6.10: Multivariate tests of significance of strata for one-way ANOVA

(1a) and the active management of the service relationship (5d) significantly higher than asset owners. In contrast, the asset owner is significantly more concerned about the close monitoring of budgets and costs of the AMS.

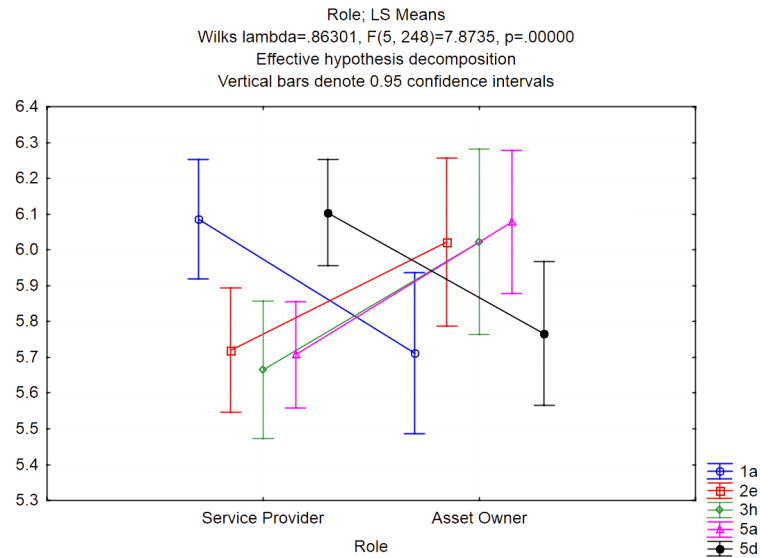


Figure 6.9: Least square means of success factors with significant differences between means according to one-way univariate ANOVA for role stratum

The post hoc tests for the organisational level reveal that 19 of the 29 success factors show significant mean differences for the different sub-groups. The 19 factors show the following difference between strategic, tactical and operational levels' responses:

- The operational sub-group differs significantly from both strategic and tactical sub-groups (*2d, 2e, 3c, 3d, 3g, 3h, 3l, 5b, 5e, 6c, 6f*)
- The operational sub-group differs significantly from the tactical sub-group (*2g, 3e, 3j, 3k, 5i, 5k, 6e*)
- The operational sub-group differs significantly from the strategic sub-group (*3i*)

It can be seen that none of the significant differences are attributed to differences between the tactical and strategic sub-group perspectives. The operational sub-group views differ significantly from both strategic and tactical sub-group perspectives for 11 of the factors. Seven factors show significant mean differences between the operational and tactical sub-group perspectives and one between the

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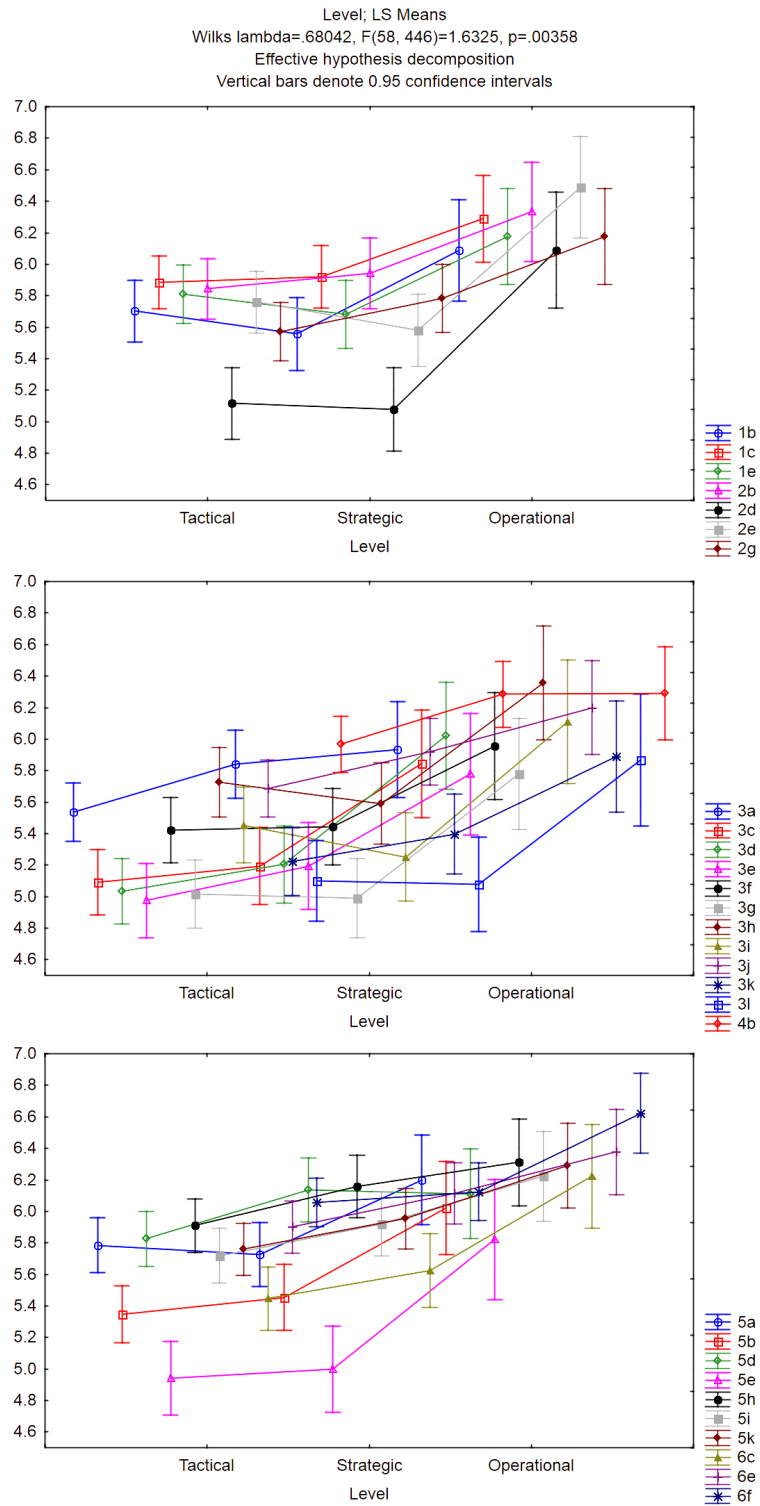


Figure 6.10: Least square means of success factors with significant differences between means according to one-way univariate ANOVA for organisational level stratum

operational and strategic sub-group perspectives.

The different perspectives of the operational sub-group's CSF compared to the other two sub-groups have potential implications on employee engagement and team dynamics. Operational stakeholders might become disengaged, because the priorities set by their superiors might be seen as less important for ensuring the operational success of the AMS. Similarly tactical and strategic stakeholders might become frustrated by the lack of ownership of the tactical and strategic priorities by the operational stakeholders.

The post hoc tests for the regions reveal that 12 of the 22 success factors show significant differences for the different sub-groups. The 12 factors show the following difference between the region sub-group responses:

- The South American sub-group differs significantly from Australasia sub-group (*2e, 3d, 3e, 3i*)
- The South American sub-group differs significantly from Europe sub-group (*3g, 5i*)
- The South American sub-group differs significantly from Africa sub-group (*5e*)
- The South American sub-group differs significantly from multiple regions sub-group (*5b*)
- The South American sub-group differs significantly from Africa and multiple regions sub-groups (*3h*)
- The South American sub-group differs significantly from Australasia and Europe sub-groups (*1b*)
- The South American sub-group differs significantly from Australasia, Europe and multiple regions sub-groups (*3k*)
- The South American sub-group differs significantly from Africa, Australasia, Europe and multiple regions sub-groups (*3l*)

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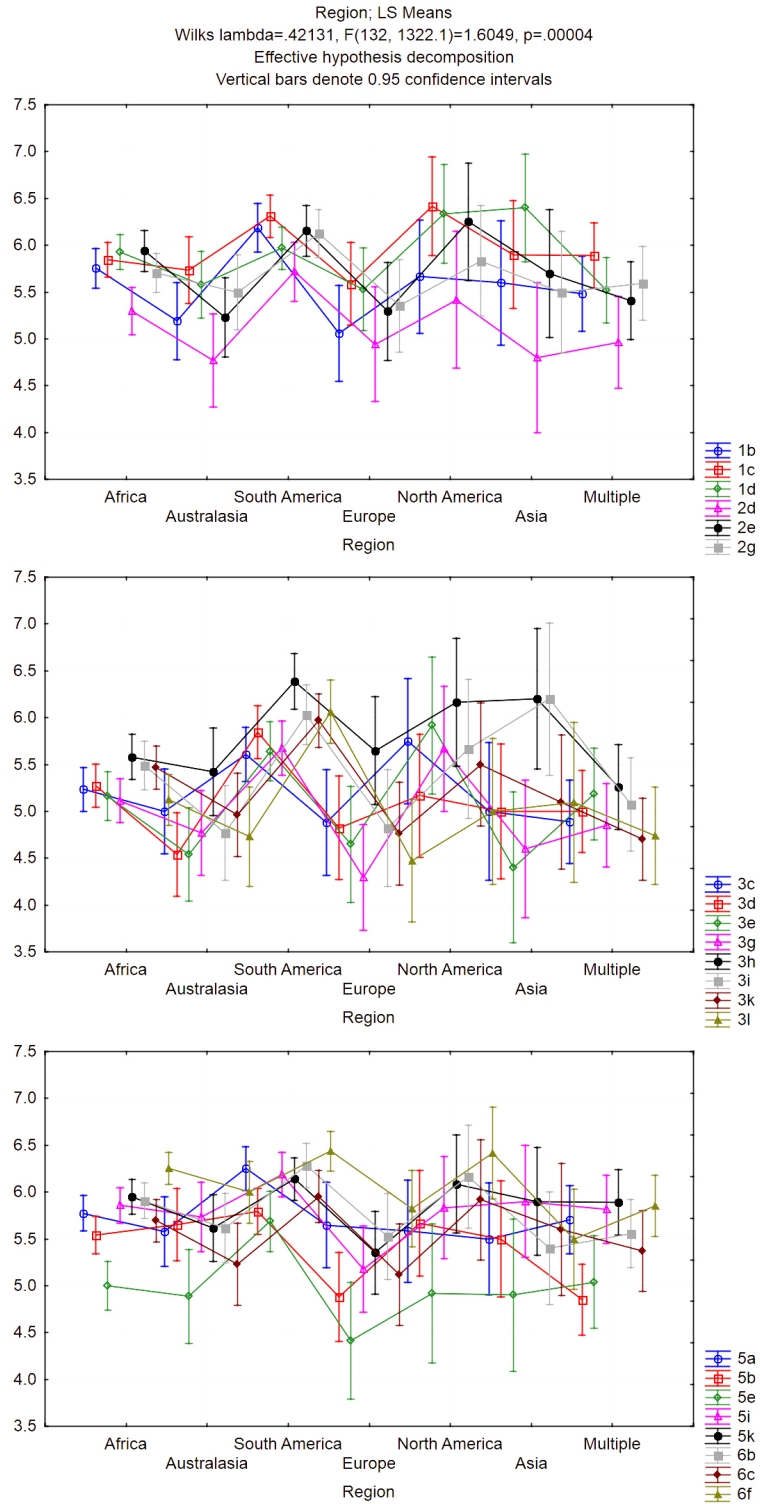


Figure 6.11: Least square means of success factors with significant differences between means according to one-way univariate ANOVA for region stratum

It can be seen that the South America sub-group is the common denominator for all significant differences among success factors in the regional stratum. None of the factors show significant differences between any combination of the other six regions.

The unanimity with which the operational and South American sub-groups differ from the other strata sub-groups could be related. Figure 6.12 shows that 58% of the operational sub-group responses originate from the South American region. The contribution to the operational responses for the next region is 29% from Africa. South American responses therefore contribute to more than half of the operational responses and is also double of the closest sub-group. This is an indication that the operational perspective on CSF for AMS are influenced by the South American regional sub-group.

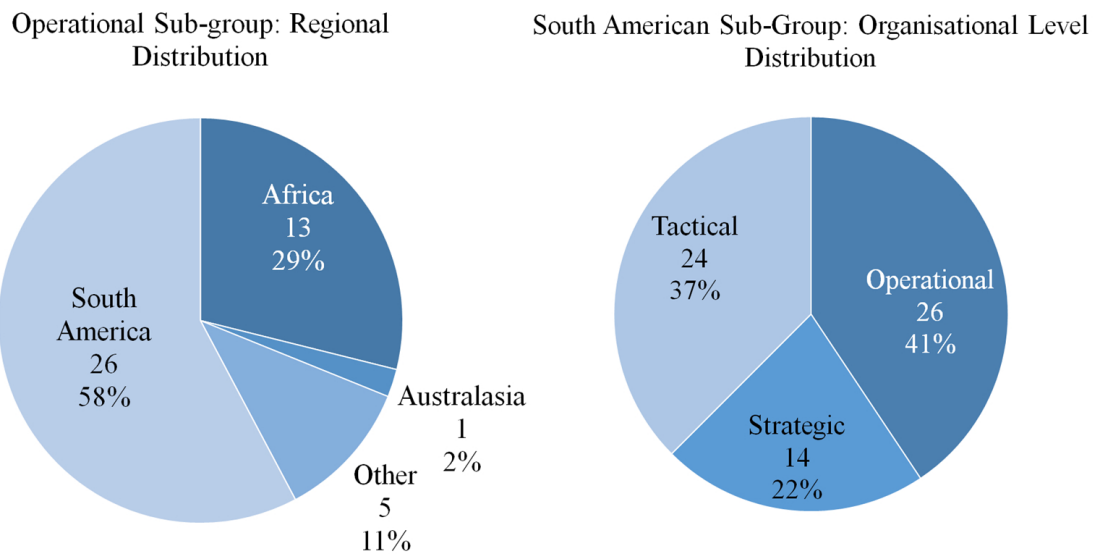


Figure 6.12: The operational sub-group with regional distribution of responses and the South American sub-group with the organisational level distribution of responses

In comparison, the operational sub-group responses contributes to 41% of the South American region, while 37% and 22% are represented by the tactical and

strategic sub-groups respectively. Proportionally, in comparison to the tactical and strategic sub-groups, the operational sub-group impact is less on the South American perspective on CSF for AMS.

This interrelationship and influence between the operational level and region strata is an area for future research.

6.3.4 Participant Feedback

For 53 of the questionnaires the respondents included written feedback (refer to appendix B.3.4). The feedback includes positive, neutral and negative comments about the questionnaire and also highlighted additional factors which respondents considered to be missing from the survey. Thirty-six (68%) of the comments are neutral, including respondents describing the AMS they are involve in or requesting access to the final results. In 15% of the comments positive feedback is received – such as acknowledging the usefulness and potential of the research.

Criticism is expressed in 23% of the comments. This feedback centers around three themes: the difficulty with interpreting the differences between factors; issues with the rating scale (i.e. no *Not Applicable* option and replacing *Not Critical* with *Essential*); and factors being asset-centric and not covering aspects such as business development and intangible assets.

Three of the received comments request additional factors to be included in the research. These factors are: payment, legal and customs issues for international AMS; diversity of the service portfolio; retention of employees and contractors; service provider networks; skills transfer to the asset owner; and factors relating to financial-technical reporting, transparency, internal controls and alignment to Sarbanes-Oxley Act of 2002 (SOX).

The feedback serves as a source for future research and are further discussed in §9.5.

6.4 Critical Success Factors for Asset Management Services

In summary the survey results show that the top 30% CSF for AMS are:

1. The continued and sustained commitment from the asset owner senior management in support of the AM service (2a)
2. Open and effective communication between the asset owner and service provider (5f)
3. A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback (6f).
4. Mutual trust and respect between the service provider and asset owner (5g)
5. The alignment of the asset owner's AM service requirements with their overall organisational and business strategies (2c)
6. An adequate training programme in place for all AM service role players, both in the service provider and asset owner teams (4a)
7. An effective organisational change management programme in support of the AM service (4b)
8. Proof of operational and financial performance achievements as a result of the AM service (6d)
9. The use of performance measurement to monitor, control and improve the AM service (5j)
10. The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service (1f)
11. The involvement of knowledgeable and demanding individuals from the client during the design and preparation, rather than individuals that want to abdicate their AM responsibilities (3n)

12. Active client participation in reporting, problem solving and improvement relating to the AM service. (5h)
13. The ability to measure the AM service quality and value creation (6e)

Collectively, the preparation and design activities for establishing an AMS are significantly less important towards the success of the overall AMS, compared to the other phases. In contrast the implementation and commissioning activities are significantly more important than the other phases.

Of the 12 strata only three show significant differences in CSF perspectives. It is concluded that overall, there are not significantly different perspectives of what the CSF for AMS are. The three strata showing significant differences are the role which is played in the AMS (service provider or asset owner), the organisational level which is involved in the AMS and the global region in which the AMS is collaborated in.

Closer investigation into the different perspectives which service providers and asset owners have on CSF, figure 6.9 shows that there are significant differences in only five of 46 success factors – none of which feature in the top ranked CSF.

For the organisational level the significant differences are due to the perspectives of the operational sub-group, compared to their strategic and tactical counterparts. Of interest is that operational people differ on 19 of the 46 success factors of which 11 relate to the preparation and design activities. Although these activities are shown to be significantly less important overall, the significant difference in the operational sub-group's perspective means that the contribution of these factors towards the AMS success cannot be ignored. The operational perspectives show significant differences on two of the top ten CSF (*4b* and *6f*), of which only *6f* is shown as significant in the post hoc analysis.

The regional ANOVA reveals that only the South American sub-group has a significantly different perspective on CSF compared to the other global regions. The South American sub-group differs on 22 of 46 success factors. Only *6f* of the

6.4. *CRITICAL SUCCESS FACTORS FOR ASSET MANAGEMENT SERVICES* **169**

top ranked CSF is included in the 22 factors and are not shown as significant in the post hoc analysis.

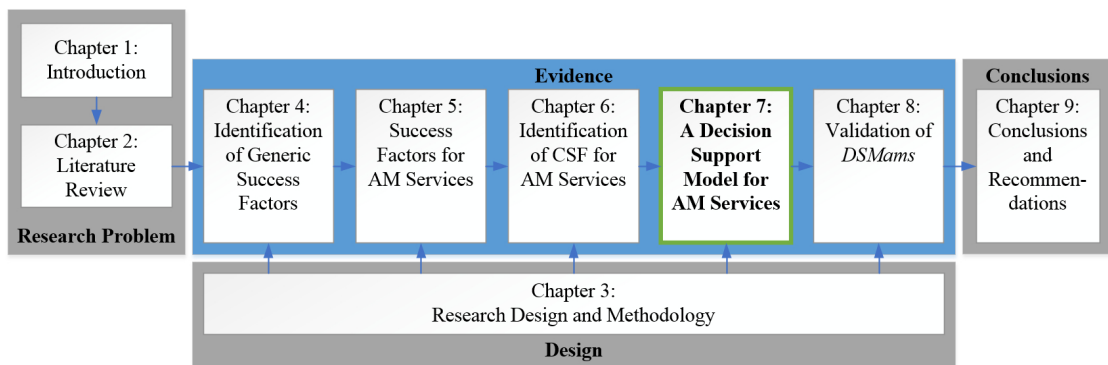
In conclusion, the results show that in the presence of significant differences within some of the strata, the overall effect on the CSF are negligible and should not adversely affect the use of all the CSF across strata.

In the next chapter the research results are developed into a model which industry can use in support of decision-making to improve AMS relations and partnerships.

Chapter 7

Decision Support Model for Asset Management Services

The whole of science is nothing more than a refinement of everyday thinking
 – Albert Einstein (1879-1955)



The objective with this chapter is to develop a decision support system which the AMS industry can use for decision-making purposes. The chapter begins with the background and design of decision support systems, which is followed by a high level overview and the requirements of a Decision Support Model for Asset Management Services (DSMams). The design of DSMams is discussed, and the detailed development of its components are covered. The chapter is concluded by explaining how users should use DSMams for AMS decision-making.

7.1 Introduction

Up to this stage the focal point of the research was to answer the first two research questions – what are the CSF of AMS and how do they differ for AMS strata? The last research question addresses how the CSF are used in industry for decision-making.

Based on the work of Brady *et al.* (2005b, 363) (refer to figure 2.7 in §2.2.8) the AMS life cycle starts with a strategic engagement phase, followed by a value proposition phase. In the value proposition phase a tailored AM product-service offering is identified to fulfill the goals that the client set out for the AMS. This is in the form of a proposal and Service Level Agreement (SLA). A SLA is an agreement between a service provider and client which quantifies the minimum quality of the service to meet the business need¹. It implies that it is developed during the value proposition phase, but that it is also used and reviewed throughout the life cycle of the service to monitor and ensure the quality of the service. The characteristics of a SLA are (Hiles, 1994, 14):

- That it is an agreement, based on the mutual understanding of the needs and constraints between parties.
- That it quantifies the level of service, whereby both parties agree to the quality levels of the service which will be delivered.
- That *delivered quality* is the minimum acceptable level, where anything above the minimum could be excess resulting in unnecessary cost.

The literature review on CSF in §2.3.2 indicates that an organisation's strategic goals should align with its mission. This alignment should be interpreted into operational goals and activities. To achieve these goals, CSF support the strategic goals which should be monitored by making the factors explicit.

¹Business need implies the overall need, which could include any combination of performance, cost, risk and relationship needs

The same principle applies to the CSF for AMS, which should support the strategic goals of the AMS. The SLA aligns the service goals with operational activities in the services life cycle and it is appropriate to incorporate, measure and monitor the CSF for ensuring the quality of the AMS (Brady *et al.* 2005b; Hiles 1994; Caralli 2004).

Rockart (1981) (§2.3.3) found that CSF could differ by: industry, the competitive situation, by manager and according to temporary and environmental circumstances. This implies that one rigid set of CSF could be unsuitable for all aspects of an AMS. Flexibility is necessary for an asset owner and service provider to select and agree on a set of CSF, and a *modus operandi* for prioritising and managing the CSF in support of the current dynamics of the AMS.

The CSF identified in chapter 6 provide overall benchmarking data for AMS. There is a need for a mechanism to facilitate the process of agreeing on the specific CSF which need to be incorporated in the SLA of the AMS. A decision support system is an appropriate way of supporting this decision-making process.

7.2 Background to Decision Support Systems

Computer-based modelling is routinely used in support of decision support processes in many areas of business and engineering. Decision Support Systems (DSS), and in particular model-driven DSS aim to support users in addressing and solving problems (Savic *et al.* 2011, 551; Power and Sharda 2007, 1044). Concepts of DSS were first articulated in the 1970's under the term "management decision systems" (Sprague, 1980, 1). The concept of DSS is broad and definitions vary depending on the research perspective (Druzdzal and Flynn, 2002). DSS can be typically described as a computer-based system that aids the process of decision-making (Finlay, 1994, 29). Formally DSS is defined as: "an interactive, flexible and adaptable computer-based information system, especially developed for supporting the solution of a non-structured management problem for improved decision-making" (Savic *et al.* 2011, 551; Turban 1989, 109). It utilises data, provides an easy-to-use

interface, and allows for the decision maker's own insights to play a role.

The classification of DSS varies. Research suggests that DSS could form part of user, conceptual or technical taxonomies. From a user perspective, DSS can be passive, active or cooperative. Passive DSS assist the decision-making process, but do not give explicit suggestions or solutions. Active DSS do give decisions, while cooperative DSS allow the decision maker to modify or refine suggestions by the system and then to send it back to the DSS for validation (Hättenschwilder, 2002, 2).

Conceptually DSS can be communication-, data-, document-, knowledge- or model-driven. Communication-driven DSS facilitate the collaboration among a group of people. Data-driven DSS facilitate access to time-series of mostly internal company related data, while document-driven DSS manage and retrieve unstructured, electronic information. Knowledge-driven DSS provide specialised problem-solving capabilities based on facts, rules and procedures. And lastly, model-driven DSS are based on access to statistical, financial, optimisation or simulation models, whereby data and parameters of the model is used to assist with decision-making and analysis of a situation (Power and Sharda 2007, 1045; Power 2002, 12). Spreadsheets are one of the major enabling technologies for deploying model-based DSS. Spreadsheet software qualifies as being a DSS generator due to its sophisticated data-handling and graphical capabilities, its ability for "what if" analysis and its facilitation in building a DSS (Power and Sharda 2007, 1050; Savic *et al.* 2011, 555).

On a technical level a DSS can be enterprise-wide or desktop based. Enterprise-wide DSS are linked to large data warehouses serving many role players which are in contrast to desktop DSS which are stand-alone and serve a small group of people (Power, 1997).

The main purpose of this research – to identify the CSF for AMS – is best supported by a *passive, model-driven* Decision Support Model (DSM). Such a DSM will provide asset owners and service providers with a model which gives them

access to the information collected and analysed during this research. Such information can be used for decision-making to improve the AMS which they are involved with.

The performance requirements for DSS are determined by the specific circumstances which they are used in. The seminal work by (Sprague, 1980, 1) – cited by more than a 1000 scholars – on designing DSS identifies six performance requirements that DSS can be characterised by. These requirements should serve as criteria for any DSS design:

1. Support should be provided for semi- or unstructured decision-making (i.e. little or no support from electronic data processing, management information systems or past management science or operations research).
2. Support decision-making for role players at all levels to assist with the integration between the levels, when applicable.
3. Support interdependent (collaborative) and independent (individual, authoritative) decision-making.
4. Support all phases of the decision-making process.
5. Support a variety of decision-making processes, but not dependent on any one.
6. Easy to use (i.e. flexible, user friendly, non-threatening).

The next section gives an overview of a DSMams which is in answer to the final research questions (see §1.2).

7.3 DSMams – A Decision Support Model for AM Services

A prototype DSMams (pronounced as *DS-Mams*) is developed to consolidate the research findings for supporting the AM industry in AMS decision-making. The model aims to allow asset owners and service providers access to the research data.

This is done through a structure approach whereby they can self-assess their AMS, compare it to the industry benchmarking data and use the results for improving the service.

Figure 7.1 illustrates the basic components of the DSMams. Macro-enabled Microsoft Excel with Visual Basic Applications is used to integrate the components. The database consists of the research data which serves as industry benchmarking data. The user interface is in the form of standard Excel worksheets and data entry controls. The model component collects inputs, compares it to the benchmarking data and applies logic to produce output graphs and tables. DSMams

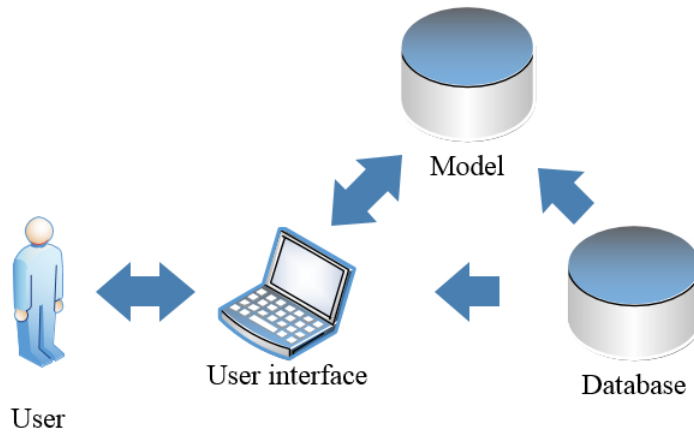


Figure 7.1: Components of the DSMams

is flexible by allowing users to customise the benchmarking data for their specific AMS. The customisation enables the user to select separate or combined service life cycle phases and any combination of economic, industry, and regional data filters. Custom organisational level selection allows for decision-making by all role players who are involved in the AMS.

DSMams supports interdependency and independency. It incorporates independent self assessments by the asset owner and service provider and collaborative

reviews of the self assessment results by means of an *agreement matrix* graph.

It supports various decision-making phases. The self assessment results highlight potential risks and problem areas. A short list of CSF and the customisation of ranking logic allows for designing a plan of action to mitigate risks. A prioritised list of CSF gives guidance as to which factors should be focused on. Follow-up self assessments and benchmark compliance can be compared to previous AMS assessments to determine if there are improvements as a result of the plan of action.

DSMams further supports various decision-making processes. It can be used at the beginning of the AMS for determining criteria for the SLA. For an existing AMS, the model is used for governance through SLA reviews, for problem-solving when problems are encountered, as well as for continuous improvement.

7.4 Designing DSMams – The Architect’s Perspective

The premise of DSMams is a pivot table with dynamic filters which manipulate benchmarking data with macros, for setting user inputs and executing ranking logic. The outputs are in the form of two graphs, a prioritised list of CSF and an infographic. The model with logical relationships between its components are presented in figure 7.2:

Sequence 1 A pivot table links to a database of industry benchmarking data collected during the research.

Sequence 2 Setup parameters are entered by the user to filter the data in the pivot table for a selection of records (2a) and service characteristics (2b).

Sequence 3 Self assessment user forms (3a) are created from the data from the pivot table and success factor descriptions are determined from a database table (3b). An agreement matrix graph (3c), a *t*-test function (3d) and a ranking logic function (3e) are updated with the subset of factors from the pivot table.

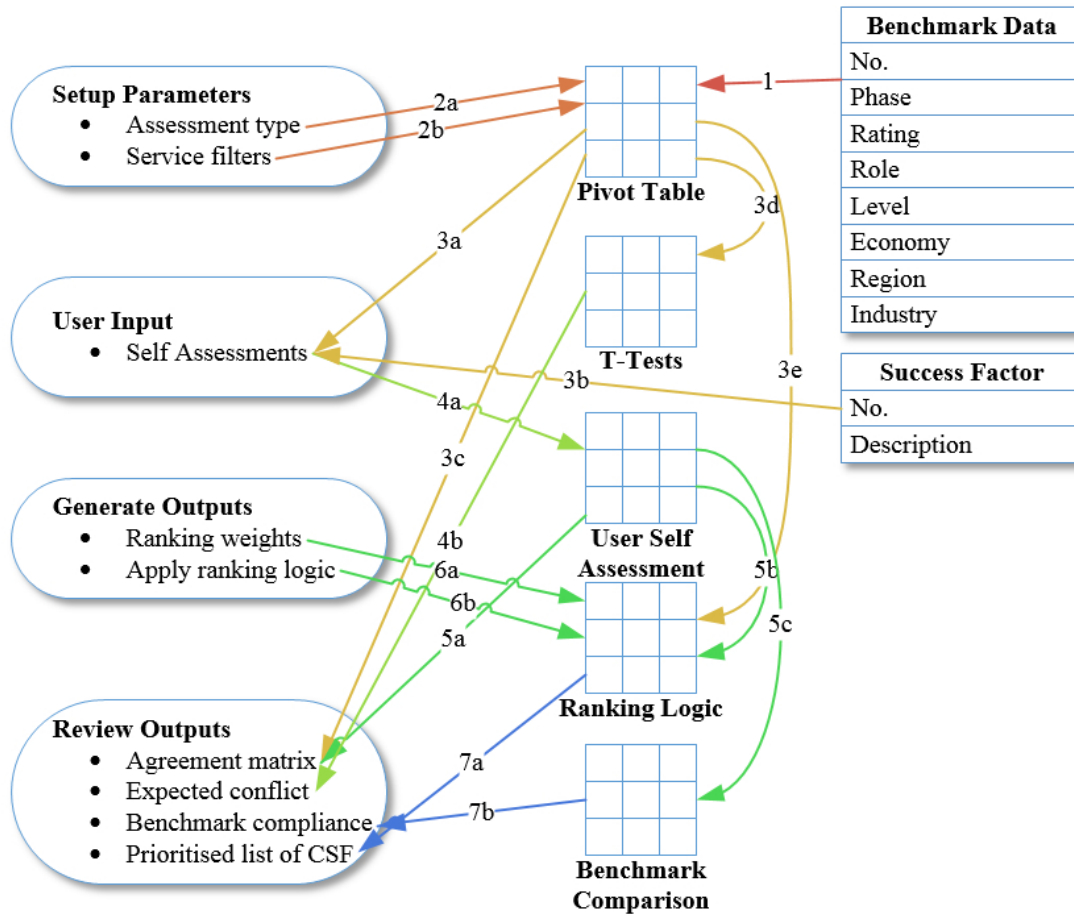


Figure 7.2: The DSMams relationship diagram

Sequence 4 The self assessment function is updated (4a) with the user inputs from the self assessment user forms. The expected conflict bar chart is updated (4b) based on the *t*-tests of industry benchmarking data between service providers and asset owners.

Sequence 5 The agreement matrix (5a), the ranking logic function (5b) and the benchmarking comparison function (5c) are updated with the self assessment results.

Sequence 6 Ranking weights are customised (6a) and the ranking logic function, for generating the ranked CSF, is initiated by the user (6b).

Sequence 7 The prioritised list of CSF is updated (7a) according to the outputs

of the ranking logic function and a benchmark compliance infographic are updated by the outputs of the benchmark comparison function (7b).

The next section expands on the high level design of DSMams by detailing the development of its architectural components.

7.5 Developing DSMams – The Developer’s Perspective

The design of DSS is dependent on the performance and technical requirements of the decision to be supported. Three fundamental building blocks are used for designing the DSMams (Hättenschwilder 2002, 2; Power 2002, 12; Marakas 1998, 9; Sprague 1980, 14-20):

- a database, consisting of the industry benchmark data from the research results (§7.5.1)
- the user interface, for the user to configure user inputs and view results (§7.5.2), and
- the model, consisting of the decision context and user criteria (§7.5.3)

Figure 7.3 shows the architecture of DSMams with the subcomponents for each of the building blocks, which are covered in detail in the following sections.

7.5.1 Database

The requirements for a database subsystem of a comprehensive DSS is the ability to (Sprague, 1980, 17):

1. Combine multiple data sources
2. Add and delete data sources
3. Portray sources logically to the user

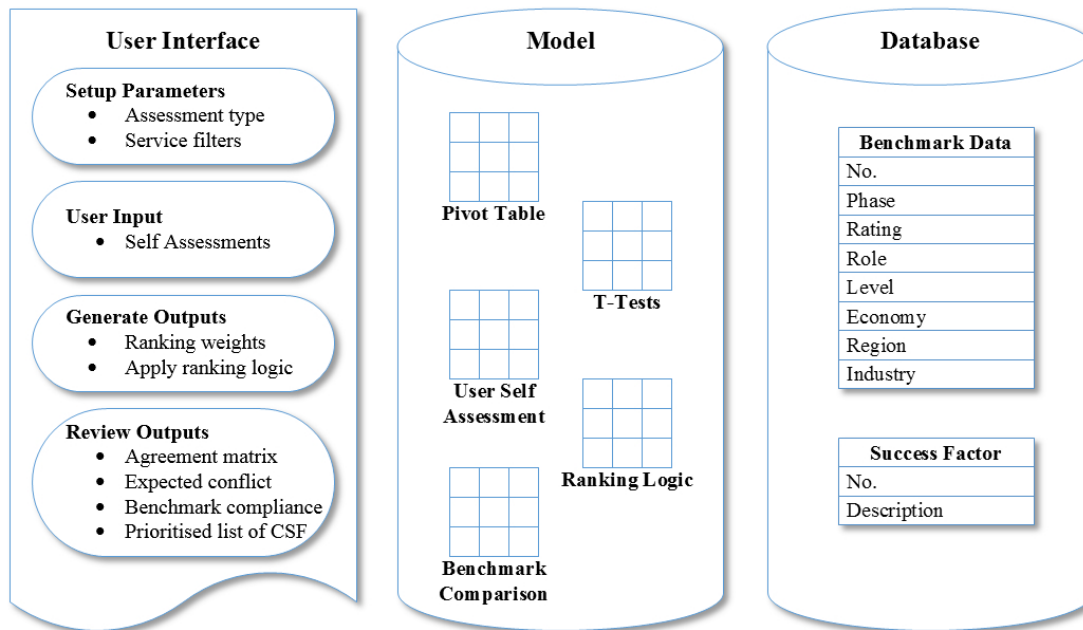


Figure 7.3: The DSMams architecture

4. Handle personal and unofficial data to enable the users to experiment with alternatives based on their personal judgement
5. Manage the variety of data structurally with a range of data management functions

The requirements for the DSMams database subsystem are less complex. The database consists of two independent tables; the first containing the benchmarking data collected during the research (refer to chapter 6), and the second containing the descriptions of the 46 success factors from the research.

Table 7.1 illustrates a table extract containing the benchmarking data. The table contains 11684 records which correspond to the 46 success factors rated by the 254 survey respondents (refer to §6.3.1 and §6.3.2). Five strata are retained in the model. The participant role, organisational level and region showed significant statistical differences between subgroups for some factors (refer to §6.3.3.2). Although the economy and industry strata did not show significant differences,

these strata, as well as the service life cycle phase are included for additional customisation options by the user.

No.	Service Life Cycle Phase	Rating	Participant Role	Organisational Level	Economy	Region	Industry
1a	1	7	Service Provider	Tactical	Developing	Africa	Manufacturing
..
6f

Table 7.1: Database table for benchmarking data

For simplicity and increased statistical power some of the strata subgroups are combined (based on suggestions by Cohen (1990, 1304-5)). Also see §7.5.2.3 on the filtering criteria and minimum sample sizes. Table 7.2 shows the subgroups which are reflected in the benchmarking data table (with explanations in brackets, where applicable).

Stratum	Stratum subgroups
Participant Role	Asset owner Service provider
Organisational Level	Strategic Tactical Operational
Economy	Developed Developing
Region	Africa Australasia (combined Australasia and Asia) South America Multiple regions Other (combined Europe and North America in Other)
Industry	Mining and quarrying Manufacturing Electricity supply Multiple industries Other (all other industries combined in Other)

Table 7.2: Strata subgroups in the database benchmark data table

Table 7.3 illustrates the table containing the success factor description data. The table contains 46 records corresponding to the 46 success factors identified in chapter 6. The table consists of the success factor's number and description, which are used in the self assessments and prioritised list of CSF which are referred to in §7.5.2. The DSMams database is static and is not updated with user inputs

No.	Success Factor Description
1a	A capable project (or key account) manager ...
...	...
6f	A focused and continuous improvement process ...

Table 7.3: Database table for success factor descriptions

or model calculations. The model pivot table (§7.5.3) uses selective records from the database, based on the user input (§7.5.2). The model does the DSMams calculations and data processing.

7.5.2 User Interface

The user interface determines the power, flexibility and usability characteristics of a DSS. The user, terminal and software system are components of the user interface. The requirements for the interface experience created by the components are (derived from Savic *et al.* 2011, 553; Sprague 1980, 17):

- Software and input devices – how the user interacts and communicates with the system (i.e. voice commands, keyboard, mouse) (§7.5.2.1)
- Knowledge base – the knowledge the user requires to operate the system (i.e. user experience, user manual, help commands) (§7.5.2.2)
- Control sequences – how the user executes system functions (i.e. menus, action buttons, input boxes) (§7.5.2.3)
- Output displays – what is displayed to the user (i.e. display screens, graphics, charts) (§7.5.2.4)

The aim of the DSMams user interface is to allow users to specify user specific criteria, self assess themselves against benchmarking information and to make decisions based on the outputs produced.

7.5.2.1 Software and Input Devices

DSMams requires a standard personal computer which is enabled to run macro-enabled 2007 (or later) Microsoft Excel files. The user interface is opened by opening the DSMams Excel file. It is presented in the standard Excel workbook format. A standard keyboard and mouse (or similar pointing device) are required as input devices. A printer, able to print A4 page size, is required for printing self assessment forms and the output graphs and table, if required.

7.5.2.2 Knowledge Base

DSMams is based on basic engineering and managerial principles, which requires users to be familiar with concepts associated within these disciplines. DSMams is intended for use by strategic and tactical role players with the knowledge, skills and authority to use management information systems, to make decisions and to solve problems in their organisations. The users should have a understanding of the implications of outsourcing business and AM activities or of contracting service providers to perform such activities. A understanding of AM principles is also required.

Help commands are embedded in the model for components that require additional explanation during its use. Figure 7.4 shows an example of a help command.

7.5.2.3 Control Sequences

The user executes the DSMams functions in three main control sequences: the setting of setup parameters, the user inputs through self assessments and the generation of outputs (figure 7.5). The order in which the control sequences are executed is important. The setup parameters is the first step and determines the conditions under which the DSMams are used. Based on these parameters, the

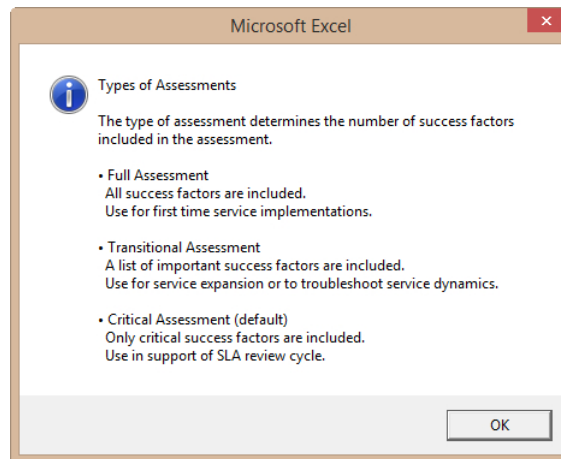


Figure 7.4: The assessment type help command

model creates self assessment forms for user input. Following the user input the outputs are generated by the setting of ranking weights and applying the ranking logic. Once the user input has started, setup parameters cannot be changed without re-entering the user inputs in the assessment forms. Changes to user inputs and ranking weights can be reapplied by generating the outputs again.

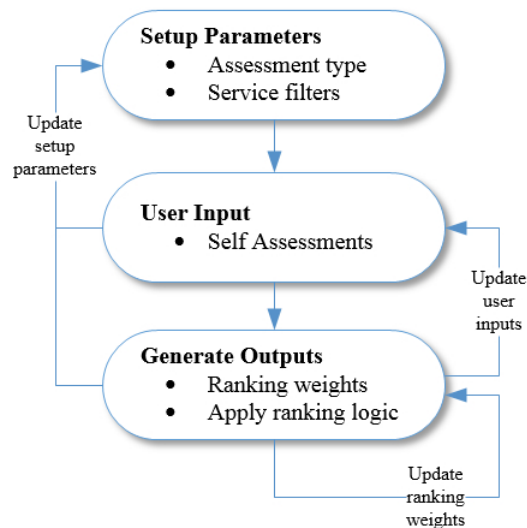


Figure 7.5: Logical flow of the user interface control sequences

1. Setup Parameters

The setup parameters is the first control sequence used by the user. The user selects the assessment type and service specific filters to start using the model. The two sets of parameters are passed to the model to include only matching database records for processing the next control sequences. Figure 7.6 shows the setup parameters in DSMams.

The screenshot shows the following setup parameters:

- 1. Select assessment type** (Section 1)
- 2. Customise filters for service** (Section 2)
 - Phase**: 1. Organisational Environment and Capabili..., 2. Initiation Phase & Pre-contract Activities, 3. Preparation and Design Processes, 4. Implementation & Commissioning, 5. Control Processes, 6. Benefits and Value-add
 - Region**: Africa, Australasia, Multiple regions, Other, South America
 - Industry**: Electricity supply, Manufacturing, Mining and quarrying, Multiple industries, Other
 - Economy**: Developed, Developing
 - Level**: Operational, Strategic, Tactical
- Sample size OK**: Sample size: 254

Figure 7.6: Setup parameters in the DSMams user interface

The *assessment type* uses a control button to initialise a user form with radio buttons for making the selection (figure 7.7). There are three types of assessments; full, transitional and critical. Based on the selection, one of three values is used to filter the model pivot table for all further data processing. The three values associated with the full, transitional and critical assessment types are zero, 5.807 and 6, respectively. These are mean thresholds which include success factors (see table 6.6) with mean values greater or equal to the threshold. A full assessment with a value zero will include all 46 success factors in the assessment. The value of 5.807 are the sample mean for the data collected (see figure 6.4). A transitional

assessment uses 5.807, which will include the success factors with mean values greater or equal to the benchmarking data mean. A value of 6 is associated with the *top two box* measure (see §6.3.2) which is the most widely used measure in customer satisfaction scoring (Morgan and Rego, 2006, 426). The users are allowed

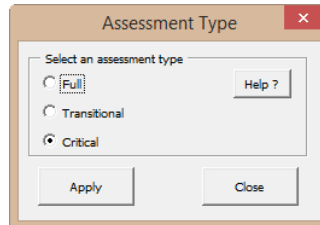


Figure 7.7: The assessment type user form

to select any assessment type based on the unique circumstances of their AMS. A help command suggests under which conditions they could use the different assessment types (figure 7.4). See Appendix C.1 for the assessment type user form macro.

The second selection is the filters for the specific service to be assessed (see figure 7.6). The selection of the filters are discussed in §7.5.1 and shown in table 7.2. For the filtering *slicers* are used, which are standard filtering controls for pivot tables in Excel. Slicers allow for dynamic and interactive filtering (Microsoft [Online], 2014). Users can make a single or multiple subgroup selections in a single filter or across filters.

Visual validation of the sample size is implemented for the service filters. Due to the relatively small sample size there are not enough records to provide a sufficiently large sample for all combinations of filtering criteria. The background of the DSMams filter section displays red if the selection criteria results in a smaller sample size than 25. A message is displayed to the user that the sample is too small and that some of the filter criteria need to be reduced. For sample sizes greater than 25, the filter section displays green and states the sample size is in order. Figure 7.8 shows a filter combination resulting in a too small sample size. After selecting the setup parameters the two self assessment work sheets are updated and used for the user inputs.

2. Customise filters for service

Phase	Region	Industry
1. Organisational Environment and Capabili...	Africa	Electricity supply
2. Initiation Phase & Pre-contract Activities	Australasia	Manufacturing
3. Preparation and Design Processes	Multiple regions	Mining and quarrying
4. Implementation & Commissioning	Other	Multiple industries
5. Control Processes	South America	Other
6. Benefits and Value-add		

Sample size too small - reduce filter criteria
Sample size: 23

Economy	Level
Developing	Operational
Developed	Strategic
	Tactical

Figure 7.8: An assessment type user form with selection criteria for an insufficient sample size

2. User Inputs

User input requires both the service provider and asset owner to independently self assess the AMS. The two self assessments include the success factors which correspond to the parameter setup settings. In the quality management domain the terminology “in place” and “in use” are used for the requirements for International Standards Organisation [Online] (2005) certification. It means that a list of requirements are formally implemented (“in place”) and actively used or followed (“in use”). For the self assessment the two parties assess each factor on a continuum where it is “not in place, it is dysfunctional and needs improvement” on the left extreme, while being “in place, effective or optimal with no improvement required” on the right extreme. This is referred to as the level of adherence to the success factor.

The two self assessments are in the form of separate work sheets. The factors are listed, each with a scroll bar slider with 20 increments. The value range is 0.5 to 10², where 0.5 corresponds to a factor not being in place and a 10 for it being in

²Due to the possibility for dividing by zero in the model output generation, zero is excluded

place and at its optimum. The users move the scroll bar to the position where they perceive the success factor to be for the current service. Figure 7.9 illustrates an example of the asset owner self assessment. The following practical considerations

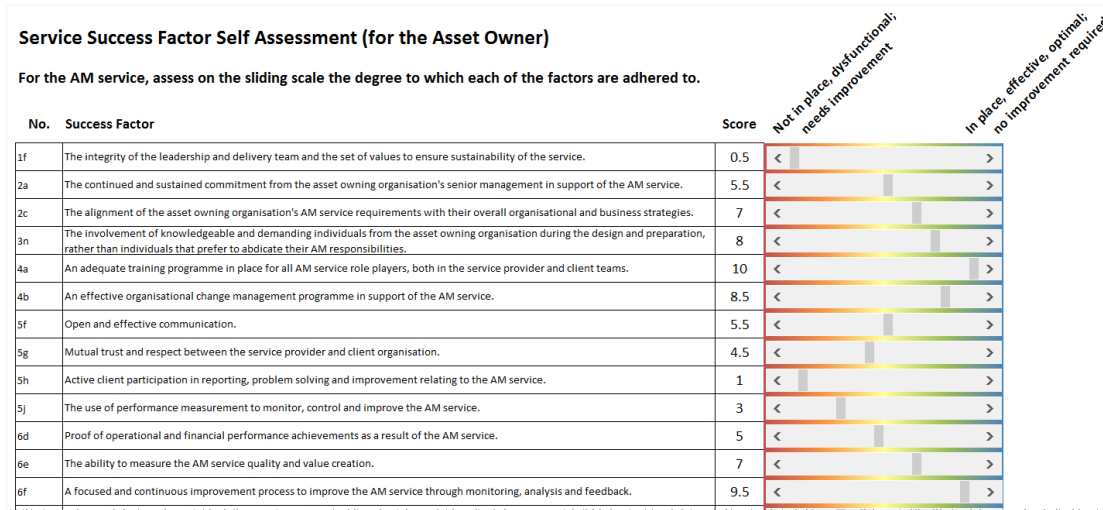


Figure 7.9: The self assessment user input worksheet

need to be taken into account in preparation for the self assessment:

How should the user input be recorded? Both the self assessments should be printed and supplied to the parties for completion. The self assessment is completed in hard copy and entered into the worksheets afterwards.

Who should do the self assessment? The type and nature of the AMS will determine who should be involved in the self assessment. For larger AMS with more role players, it is suggested that a group of people complete the self assessment. A group should consist of role players who are knowledgeable and represent the various facets of the AMS. Each factor is assessed by the group and the consensus decision is recorded.

After recording the self assessment user inputs the model outputs can be generated.

from the range.

3. Output Generation

The generation of the model outputs is the final control sequence executed by the user. The user has the option of changing the weights of the equally weighted ranking factors before applying the ranking logic for generating the model outputs. Figure 7.10 shows the output generation control button in DSMams. The

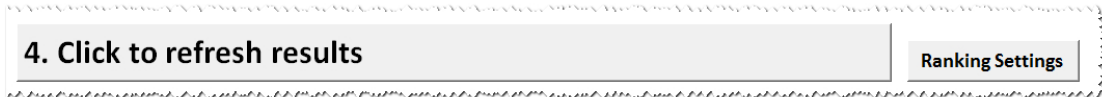


Figure 7.10: Output generation in the DSMams user interface

ranking settings uses a control button to initialise a user form with input boxes for the weights, W_{BR} , W_{CR} and W_{AR} , of the three ranking factors (figure 7.11). Refer to §7.5.3.4 for the ranking logic and associated calculations. The weights are expressed in percentages and should add up to 100%. The user form recalls previously configured weights and validates that the sum is equal to 100% when the values are applied. Figure 7.12 shows invalid rank weight inputs. A help com-

 A screenshot of a dialog box titled 'Ranking Weights'. The dialog has a title bar with a close button (X). Inside the dialog, there is a section titled 'Enter the ranking weights'. Below this title, there are three rows of input fields: 'W1 = 33.3 %', 'W2 = 33.3 %', and 'W3 = 33.4 %'. To the right of the input fields is a 'Help ?' button. At the bottom of the dialog, there are two buttons: 'Apply' and 'Close'.

Figure 7.11: The ranking settings user form

mand explains the use of weights and ranking logic to the user (figure 7.13). See appendix C.2 for the the ranking settings macro. The final ranking logic and formatting of the outputs are executed by the *Click to refresh results* control button. See Appendix C.3 for the associated macro.

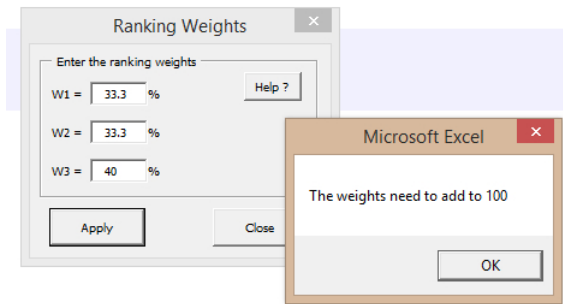


Figure 7.12: Message for the sum of weights not equalling 100%

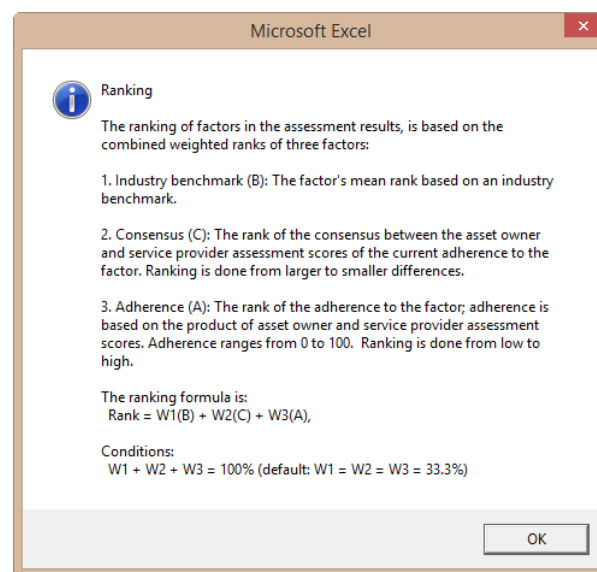


Figure 7.13: The ranking settings help command

7.5.2.4 Output Displays

Output displays are concerned with the format of the results which are produced by DSMams. Four outputs are produced: two graphs, a ranked list and an infographic. Users use the outputs to make decisions regarding AMS improvements and progress. The outputs are sized for A4 printing or for digital image extraction. The primary outputs are an *agreement matrix* graph and a *prioritised list of CSF*. A bar chart on *expected conflict* supports the primary outputs to resolve potential conflicting perspectives of CSF between the asset owner and service provider. A *benchmark compliance* infographic is used as a management control to show

compliance with the current AMS success status against the expected industry benchmark.

1. Agreement Matrix

The agreement matrix graph depicts the ranking variables (see §7.5.3.4). The graph shows the corresponding service provider and asset owner perceptions of adherence for the success factors resulting from the setup parameters (§7.5.2.3). The x -axis represents the service provider adherence rating and the y -axis that of the asset owner. Figure 7.14 shows the separate ranking variable overlays:

Benchmark mean ranks The bubble sizes correspond to the ranks of the success factor means from the benchmarking data. The larger the bubble size the higher the rank of the factor's mean. In other words, larger bubbles indicate higher importance based on empirical evidence.

Consensus The three diagonal zones corresponds with the consensus between the service provider and asset owner about the adherence to the success factor for the AMS. The central *agreement zone* shows factors with a 25% or less difference between the parties. This is seen as a safe zone, since parties agree on adherence. The outside *danger zones* show factors with a larger difference. Factors with larger differences (less consensus) are ranked higher due to misalignment between the parties' perceptions and the potential problems and conflict which could arise from these differences.

Level of adherence The four contour bands represents the level of adherence. Adherence is calculated as the product of the adherence ratings of the asset owner and service provider. The blue (top-right) zone represents adherence of 75-100, with 100 being the highest level of adherence (both service provider and asset owners rated a factor a maximum rating of 10 during the self assessment). The green band represents, 50-75, the orange band, 25-50 and the red band, 0-25. The lower the adherence of a factor, the higher its risk to the AMS and therefore the higher its ranking.

Figure 7.15 shows an illustrative example of the agreement matrix with the three ranking variable overlays. While the agreement matrix is effective in visually de-

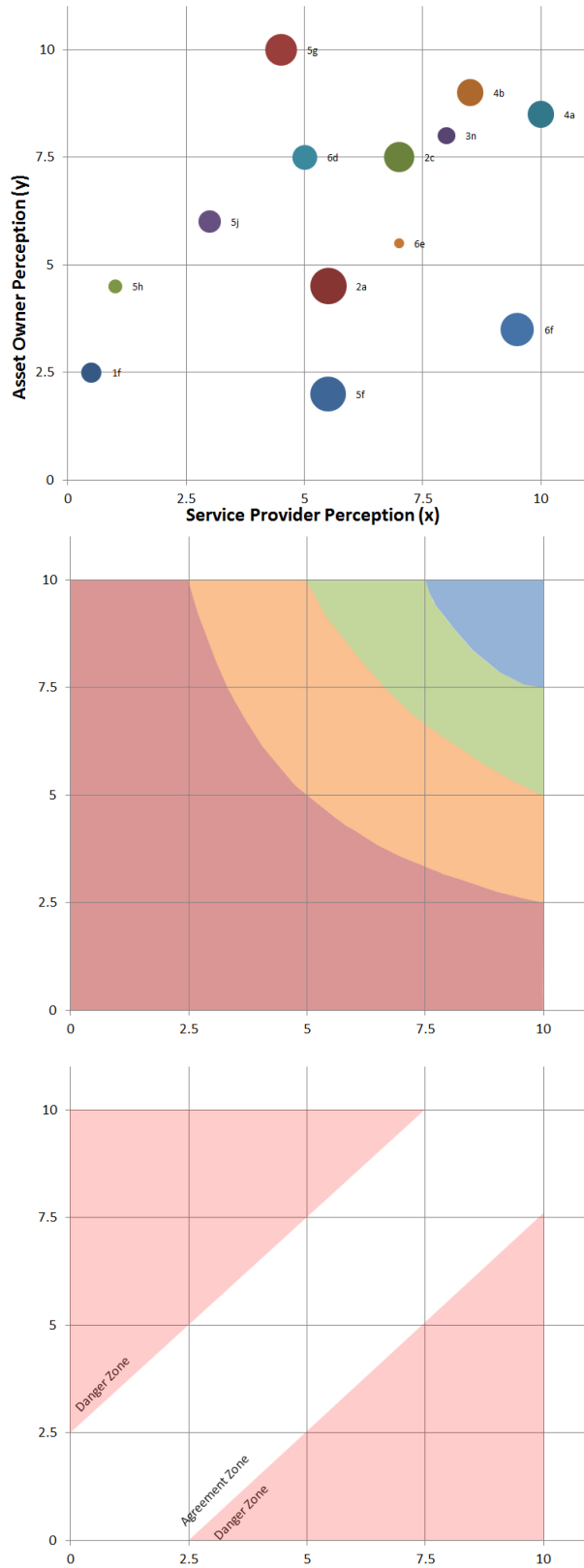


Figure 7.14: The ranking variable overlays of the agreement matrix

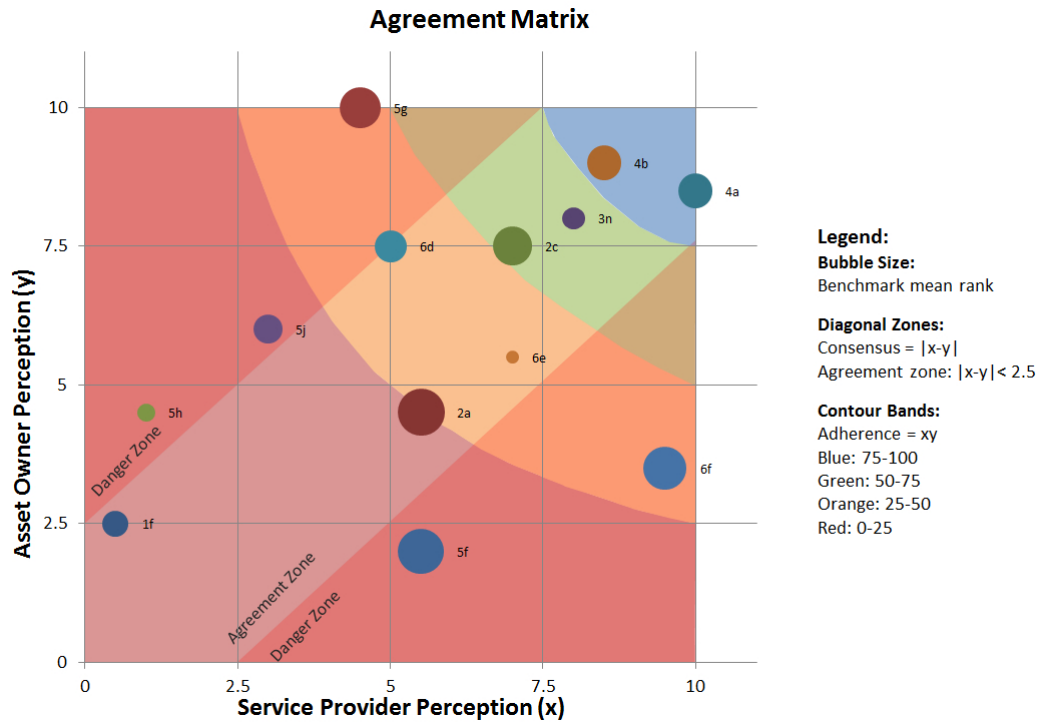


Figure 7.15: The agreement matrix is a primary output

By picturing the benchmark and self assessment results, it is less obvious what the actual rank of each success factor is based on the weighted ranking logic of the three ranking variables. The prioritised list of CSF clarifies the ranking.

2. Prioritised List of CSF

The prioritised list of CSF forms part of the primary outputs of DSMams. It is the main output as a result of the output generation control sequence (§7.5.2.3). Figure 7.16 illustrates the corresponding list of CSF for figure 7.15. The prioritised list of CSF consists of six columns. The first and the last columns show the success factor number and description. Columns two to four show the actual values of the industry benchmark mean, consensus (absolute value of the difference adherence ratings between the asset owner and service provider) and the adherence level. Column five is the rank from applying the ranking logic, which is used to sort the CSF descending. Conditional formatting highlights the importance of the variables and rank. The consensus difference and the adherence formatting

Prioritised List of CSF

* Rank = W1(Benchmark mean rank) + W2(Consensus rank) + W3(Adherence rank), where W1 = 33.3%, W1 = 33.3%, W1 = 33.4%

CSF	Benchmark	Consensus Diff	Adherence	Rank*	Description
5f	6.323	3.5	11	2.667	Open and effective communication.
6f	6.181	6	33.25	3.336	A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback.
5g	6.157	5.5	45	5.004	Mutual trust and respect between the service provider and client organisation.
2a	6.413	1	24.75	5.333	The continued and sustained commitment from the asset owning organisation’s senior management in support of the AM service.
5h	6.067	3.5	4.5	5.663	Active client participation in reporting, problem solving and improvement relating to the AM service.
1f	6.110	2	1.25	5.995	The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service.
5j	6.118	3	18	5.998	The use of performance measurement to monitor, control and improve the AM service.
6d	6.122	2.5	37.5	7	Proof of operational and financial performance achievements as a result of the AM service.
2c	6.150	0.5	52.5	8.668	The alignment of the asset owning organisation’s AM service requirements with their overall organisational and business strategies.
4a	6.134	1.5	85	9.004	An adequate training programme in place for all AM service role players, both in the service provider and client teams.
6e	6.059	1.5	38.5	9.665	The ability to measure the AM service quality and value creation.
4b	6.134	0.5	76.5	9.669	An effective organisational change management programme in support of the AM service.
3n	6.087	0	64	11.666	The involvement of knowledgeable and demanding individuals from the asset owning organisation during the design and preparation, rather than individuals that prefer to abdicate their AM responsibilities.

Figure 7.16: The prioritised list of CSF forms part of the primary outputs

correspond to the agreement matrix formatting. The industry benchmark mean and rank values are formatted according to a colour scale, with red as the most important and green the least important.

The prioritised list of CSF (together with the agreement matrix) should be used as the most important output for making decisions regarding focus areas for improving the AMS. The list supports the outsourcing and contracting requirements for AM as specified in §8.3 of ISO 55001 (International Standards Organisation, 2014b, 8) and the *procurement and supply chain management* subject of GFMAM’s *Asset Management Landscape* (GFMAM, 2014, 42). The list should serve as input towards the initial AMS contracting process and for continual service level agreement reviews. It should further be included in management reviews, reports and to also serve as a baseline for AMS maturity improvement.

3. Expected Conflict Bar Chart

The expected conflict chart is a secondary output (figure 7.17). It presents the mean difference between the industry benchmarking data of the service providers and the asset owners. Included in the chart is a hypothesis test for determining

whether the difference is significant. The corresponding t -test's p -values at a level of significance, $\alpha = 5\%$ is shown. The mean difference represents the value range on the primary y -axis, while the secondary y -axis is configured to only show p -values less or equal to $\alpha = 5\%$. These values originate from the t -test analysis function (see §7.5.3.2). The research study findings revealed that the participant

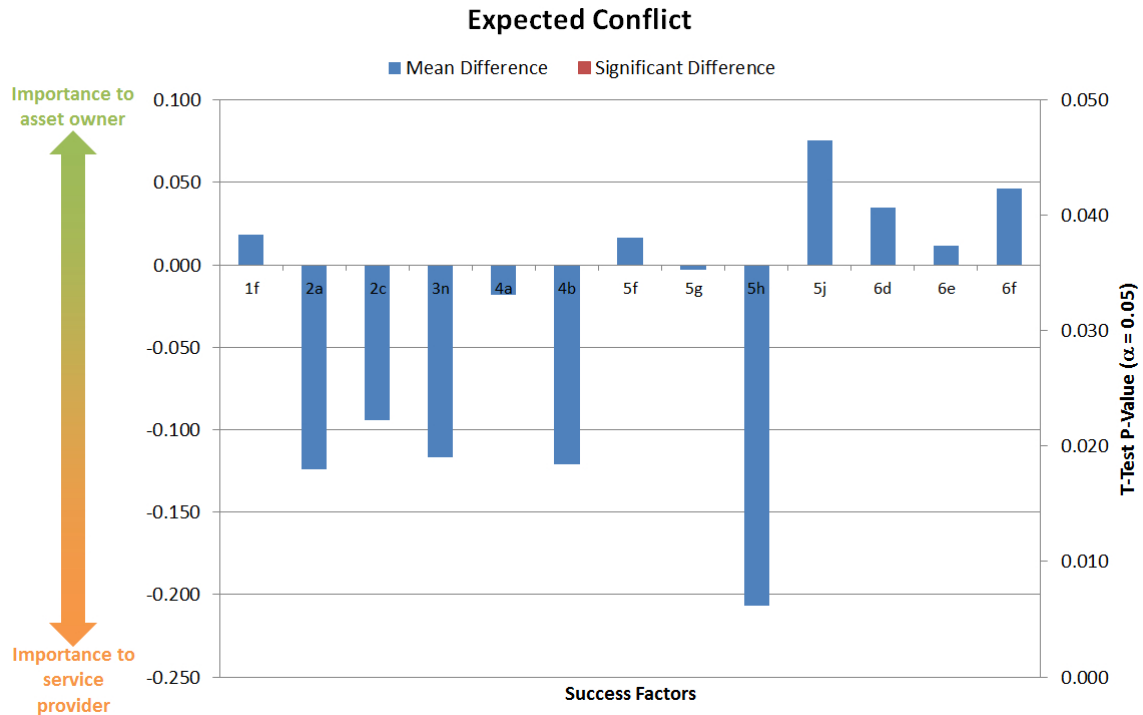


Figure 7.17: The expected conflict bar chart supplements the primary outputs

role stratum showed statistical significant differences between the subgroup means for some factors (refer to §6.3.3.2 and §7.5.1). It is expected that similar differences of opinion may arise as a result of the DSMams primary outputs and during the decision-making process. The expected conflict chart highlights the factors for which the industry benchmarks showed large differences and for which role player the factor is more and less important. The p -value indicates the factors with significant different means (if any exists). The expected conflict chart ensures that potential conflicting perspectives on factors are made explicit and consequently aid in the resolution process.

4. Benchmark Compliance Infographic

The benchmark compliance infographic shows how the service compares to the industry benchmarking data (figure 7.18). It overlays compliance percentages for each of the service life cycle phases and also shows a combined compliance for overall service. The compliance percentage is based on the sum-product of the minimum adherence percentages and benchmark means expressed as a percentage of the sum of the benchmark means (for more details see §7.5.3.5). A phase's compliance percentage is omitted and ignored from the overall compliance if the user excludes the phase in the service filters (§7.5.2.3). The percentages are conditionally formatted with a colour scale, with red as low compliance and green as full compliance. Together with the prioritised list of CSF the benchmark compliance

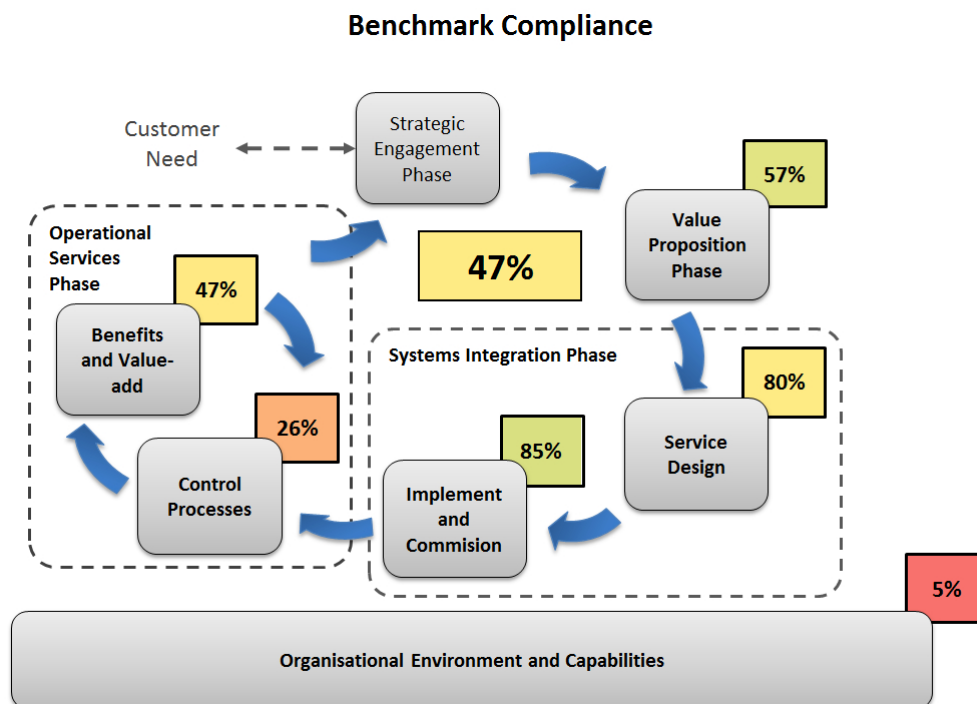


Figure 7.18: The benchmark compliance infographic shows compliance to industry benchmarks

should be included in management reports to serve as a measure of how well the service is improving against industry benchmarking data.

7.5.3 Model

The ability of a DSS to integrate data access, user input and decision logic is based on embedding models in the information system for communicating between the DSS building blocks. The model subsystem should be based on an appropriate modelling language and could consist of functions which defines the model. The capabilities of the model should be to (Sprague, 1980, 17):

1. Create new models quickly and easily
2. Maintain a range of models and supporting all levels of management
3. Interrelate the models with appropriate links to the database
4. Access and integrate functions
5. Manage the model with management functions

The model subsystem contains the processing logic of DSMams. The model logically draws data from the database based on the user inputs. It consists of functions which process the data subset into outputs for decision-making. The functions embedded in the model subsystem are; a pivot table, *t*-test analysis, self assessment lookup, ranking logic and benchmark comparison.

7.5.3.1 Pivot Table

The main integration function between the database and all the other components of the DSMams is a pivot table. A pivot table is used because of its ability to automatically summarise, sort, count, sum and average records for data groups and totals. A fundamental principle of DSMams is to allow users to filter industry benchmarking data according to their specific AMS. A pivot table allows for this dynamic filtering. It provides the corresponding success factor means, standard deviations and record counts for both the service provider and asset owner, as well as the combined totals (figure 7.19). These dynamically updateable data sets form the basis for all of the other model functions. The setup parameters entered by the user (in §7.5.2.3) determines the filtering which allows the pivot table to extract the data from the database. The *Total Mean* column is filtered according to the

Pivot Table										
Industry benchmark data subset with descriptive statistics based on setup parameters (assessment type and service filters)										
	Column Labels									
	Asset owner	Asset owner	Asset owner	Service provider	Service provider	Service provider	Total Mean	Total Std Dev	Total Count	
Factor	Mean	Std Dev	Count	Mean	Std Dev	Count				
1f	6.122	0.992	90	6.104	0.976	164	6.110	0.980	254	
2a	6.333	0.912	90	6.457	0.889	164	6.413	0.897	254	
2c	6.089	0.967	90	6.183	0.935	164	6.150	0.946	254	
3n	6.011	1.033	90	6.128	0.914	164	6.087	0.958	254	
4a	6.122	0.981	90	6.140	0.864	164	6.134	0.906	254	
4b	6.056	1.105	90	6.177	0.959	164	6.134	1.013	254	
5f	6.333	0.912	90	6.317	0.835	164	6.323	0.861	254	
5g	6.156	0.923	90	6.159	1.039	164	6.157	0.997	254	
5h	5.933	0.981	90	6.140	0.933	164	6.067	0.953	254	
5j	6.167	0.939	90	6.091	0.899	164	6.118	0.912	254	
6d	6.144	0.931	90	6.110	1.039	164	6.122	1.000	254	
6e	6.067	0.981	90	6.055	0.915	164	6.059	0.937	254	
6f	6.211	0.828	90	6.165	0.915	164	6.181	0.884	254	

Figure 7.19: The pivot table function

value associated with the assessment type choice (i.e. 0, 5.807 or 6). Only success factors with means greater or equal to this value are included in the pivot table data subset. In addition, the service filter criteria for the strata determine which database records are included and/or excluded from the pivot table data subset. The pivot table data subset determines the success factors which are passed to the self assessment user forms, the agreement matrix, the t -test analysis and the ranking logic.

7.5.3.2 t -Test Analysis

The t -test analysis function calculates the t - and p -values for testing the hypothesis that the success factor means of the service provider and the asset owner from the benchmarking data are the same. Figure 7.20 shows the function. The Welch’s t -test, which is an adaptation of the Student t -test is used for the analysis due to unequal variances between the asset owner and service provider samples (Welch, 1947). In the t -test analysis table the following formulas apply. For the mean difference:

$$d_i = \bar{a}_i - \bar{b}_i \quad (7.1)$$

where \bar{a}_i and \bar{b}_i are the respective benchmarking means of the asset owner and the service provider samples for the i^{th} success factor. The mean difference, d_i , implies that a positive value is associated with being more important to the asset owner, while negative values indicate greater importance to the service provider

t-test Analysis			
t-test for significant difference between AO and SP benchmarks			
Mean Difference	t-value	p-value	Signif. Diff. 0.05
0.019	0.143	0.886	No
-0.124	1.046	0.297	No
-0.094	0.750	0.454	No
-0.117	0.898	0.370	No
-0.018	0.146	0.884	No
-0.121	0.876	0.382	No
0.016	0.140	0.889	No
-0.003	0.024	0.981	No
-0.207	1.636	0.103	No
0.075	0.620	0.536	No
0.035	0.272	0.786	No
0.012	0.094	0.925	No
0.046	0.412	0.681	No

Figure 7.20: The t -test analysis function

(also refer to figure 7.17). For the t -value:

$$t_i = \frac{\bar{a}_i - \bar{b}_i}{\sqrt{\frac{S_a^2}{N_a} + \frac{S_b^2}{N_b}}} \quad (7.2)$$

where $S_{a,b}^2$ and $N_{a,b}$ are the sample variance and sample size, respectively. The degrees of freedom, ν , associated with the variance estimate is approximated as:

$$\nu \approx \frac{\left(\frac{S_a^2}{N_a} + \frac{S_b^2}{N_b}\right)^2}{\frac{S_a^4}{N_a \nu_i} + \frac{S_b^4}{N_b \nu_i}} \quad (7.3)$$

where $\nu_i = N_i - 1$ is the degrees of freedom of the i^{th} variance estimate, with N_i the.

The p -value is the probability of obtaining a test statistic value based on the Student t -distribution. The significant difference column (in figure 7.20) tests the p -value against $\alpha = 5\%$. For $p \leq \alpha$ there is evidence of significant differences between the means of the asset owner and the service provider responses. A *Yes* is displayed where there is evidence of a significant difference, while a *No* indicates there is no such evidence.

The mean difference and p -values are passed to the expected conflict bar chart (see §7.5.2.4).

7.5.3.3 Self Assessment Lookup

The self assessment lookup function is the simplest in the model, but plays a vital role to ensure that ranking and outputs are processed consistently. Its purpose is to lookup the values entered by the asset owner and service provider in the self assessment worksheets. The lookup function integrates these values into the model as inputs for the ranking logic and benchmark comparison functions, as can be seen in figure 7.21. It is also used by the agreement matrix to plot the self assessment ratings.

7.5.3.4 Ranking Logic

The ranking logic is fundamental to the logic in how DSMams presents output and support decision-making. The ranking logic is based on the combination of three variables: the importance of the industry benchmark, consensus about the adherence between service provider and asset owner and the adherence to the industry benchmark. These variables are integrated into the ranking logic based on its improvement, collaboration and good governance properties:

Industry benchmark importance Bogan (1994, 5) states that “best practice benchmarking, which includes but isn’t limited to the study of statistical benchmarks, can – and should – be applied at many levels of the organisation and in many different contexts. The benefits of benchmarking have been well recognized in industries and operating areas.” The foremost reason for conducting this research was to find empirical evidence of the CSF for AMS. It is important to include this evidence of industry benchmarks in the ranking logic to ensure the most important factors are focused on first.

Consensus The research results presented in §6.4 highlight that five of the top ten CSF for AMS involves relationship-type characteristics such as communication, trust, respect and integrity. Reviewing the differences between the service provider and the asset owner perceptions of adherence to CSF is a

necessary inclusion in the ranking logic. It facilitates dialogue between the parties, clarification of differences and improvement of value co-creation.

Level of adherence Adherence is about being committed to implementing and working according to the CSF for AMS. Quality management refers to requirements being formally implemented (“in place”) and actively used or followed (“in use”). The level of adherence as part of the ranking logic ensures the CSF which are neglected are higher prioritised.

The ranking logic function is used for generating the prioritised list of CSF. It uses the self assessment lookup value to calculate the agreement and adherence functions. It ranks the three ranking variables, and it calculates the final ranks by using the weights from the ranking settings (see §7.5.2.3):

$$R_i = W_{BR}(BR_i) + W_{CR}(CR_i) + W_{AR}(AR_i) \quad (7.4)$$

where for the i^{th} success factor, $BR_i = \text{rank}(\bar{z}_i)$, $CR_i = \text{rank}(|x_i - y_i|)$, $AR_i = \text{rank}(x_i y_i)$, with x_i and y_i the respective service provider and asset owner adherence ratings, \bar{z}_i , the benchmarking mean and W_{BR} , W_{CR} , W_{AR} the respective percentage weighting factors adding up to 100%. The ranking logic columns are shown in figure 7.21.

Standard competition ranking is used in the ranking logic, where items which compare equal, receive the same ranking number with an opening left in the ranking numbers. Ascending ranks are used, which means one (1) is the highest rank.

For the agreement matrix descending benchmark mean ranks are used for bubble sizes. This allows for depicting the largest bubble with the highest mean rank factor. The graphs of $|x_i - y_i|$ and $x_i y_i$ are available in appendix C.4. The graphs represent the overlays for the agreement matrix as seen in figure 7.14.

With the execution of the output generation control sequence the ranking logic function values are passed on to the prioritised list of CSF for sorting.

S/A Lookup		Ranking Logic						
Service Provider Ratings (x)	Asset Owner Ratings (y)	Benchmark Mean Rank	Consensus	Consensus Rank	Adherence	Adherence Rank	Overall Rank	Inverse Mean Rank
		Weight 33%	F(C)= x-y	Weight 33%	F(A)=xy	Weight 33%	Weight 100%	for Bubble Size
0.5	2.5	10	2	7	1.25	1	5.995	4
5.5	4.5	1	1	10	24.75	5	5.333	13
7	7.5	5	0.5	11	52.5	10	8.668	9
8	8	11	0	13	64	11	11.666	3
10	8.5	6	1.5	8	85	13	9.004	7
8.5	9	6	0.5	11	76.5	12	9.669	7
5.5	2	2	3.5	3	11	3	2.667	12
4.5	10	4	5.5	2	45	9	5.004	10
1	4.5	12	3.5	3	4.5	2	5.663	2
3	6	9	3	5	18	4	5.998	5
5	7.5	8	2.5	6	37.5	7	7	6
7	5.5	13	1.5	8	38.5	8	9.665	1
9.5	3.5	3	6	1	33.25	6	3.336	11

Figure 7.21: The ranking logic function

7.5.3.5 Benchmark Comparison

The benchmark comparison function performs the calculations for the benchmark compliance infographic (see §7.5.2.4). The function calculates compliance for each of the service life cycle phases against the industry benchmarks (figure 7.22). The basis for the compliance is the minimum adherence rating from the two self-assessments, which is compared to the industry benchmark mean. The calculation allows for higher overall compliance as a result of higher adherence to more important CSF.

In the benchmark comparison table the following equations for benchmark compliance per service life cycle phase, BC_j , and for the overall service, BC_T , apply:

$$F(BC_j) = \frac{\sum_i \bar{z}_i \left(\frac{\{x_i; y_i\} \min}{r_{\max}} \right)}{\sum_i \bar{z}_i}, \quad (7.5)$$

where \bar{z}_i , x_i and y_i are the respective benchmark mean, service provider and asset owner adherence ratings for the i^{th} success factor in the j^{th} service life cycle

Benchmark Comparison												
Benchmark compliance calculations for the six service life cycle phases and combined service												
Accumulated Service Total	Phase: 1		Phase: 2		Phase: 3		Phase: 4		Phase: 5		Phase: 6	
	B/Compl'nce	B/Mean	B/Compl'nce	B/Mean	B/Compl'nce	B/Mean	B/Compl'nce	B/Mean	B/Compl'nce	B/Mean	B/Compl'nce	B/Mean
0.306	0.306	6.110										
2.886			2.886	6.413								
4.305			4.305	6.150								
4.869					4.869	6.087						
5.214							5.214	6.134				
5.214							5.214	6.134				
1.265									1.265	6.323		
2.771									2.771	6.157		
0.607									0.607	6.067		
1.835									1.835	6.118		
3.061											3.061	6.122
3.332											3.332	6.059
2.163											2.163	6.181
37.828	0.306	6.110	7.191	12.563	4.869	6.087	10.428	12.268	6.478	24.665	8.557	18.362
47%	5%		57%		80%		85%		26%		47%	

Figure 7.22: The benchmark comparison function

phase, with $r_{\max} = 10$, the maximum allowed adherence rating.

$$F(BC_T) = \frac{\sum_{i=1}^n \bar{z}_i \left(\frac{\{x_i; y_i\}_{\min}}{r_{\max}} \right)}{\sum_{i=1}^n BM_i}, \tag{7.6}$$

for the i^{th} to the n^{th} success factor.

The benchmark compliance percentages are passed on to the benchmark compliance infographic (see §7.5.2.4).

7.6 Using DSMams – The User’s Perspective

This section explains how the user operates DSMams. Figure 7.23 illustrates the partial user interface of DSMams. This interface guides the user stepwise through the use of the model and also integrates some of the user inputs. The operating procedure for DSMams is described in the following steps.

- 1. Select assessment type** The first step in using DSMams is to select the assessment type. There are three types of assessments, which determine the

Decision Support Model for AM Service - DSMams

- Select assessment type**
- Customise filters for service**

Phase <ul style="list-style-type: none"> 1. Organisational Environment and Capabilities 2. Initiation Phase & Pre-contract Activities 3. Preparation and Design Processes 4. Implementation & Commissioning 5. Control Processes 6. Benefits and Value-add 	Region <ul style="list-style-type: none"> Africa Australasia Multiple regions Other South America 	Industry <ul style="list-style-type: none"> Electricity supply Manufacturing Mining and quarrying Multiple industries Other
Sample size OK Sample size: 254	Economy <ul style="list-style-type: none"> Developed Developing 	Level <ul style="list-style-type: none"> Operational Strategic Tactical
- Complete service assessment (asset owner and service provider complete independantly)**
- Click to refresh results** Ranking Settings
- Review results**

Figure 7.23: The DSMams working procedure

number of success factors which are included in the model. A full assessment includes all, a transitional assessment the important majority and a critical assessment the critical few success factors from the industry benchmarking data set. Users can use their discretion when selecting the assessment type. It is however suggested that for a first time AMS implementation a full assessment is used including all of the factors in the various phases. For service expansion the transitional assessment can be selected and for ongoing support of the SLA the critical assessment can be selected.

- 2. Customise filters for the service** The second step is setting data filters for the specific AMS. These filters will include only corresponding records from the benchmarking data set. It is suggested that the full data set is used and as few filters as possible are applied. Filtering on more than two of the region, industry, economy and organisational level filters is not advised. A warning system is shown for filtering which results in sample sizes smaller

than 25. The following guidelines should be used for filtering.

Phase The service life cycle phases should be selected to correspond with the AMS which is being assessed. For new AMS include all of the phases. For an existing AMS, in its operational phase, exclude phases two to four, but include phase one. For service expansion include phases two to four until the AMS is implemented.

Region, economy and industry Filter on either the region or the economy filters, but not on both. In addition to the region or economy filter, it is optional to filter on the industry, providing that the sample size is still of sufficient size.

Level Use the organisational level if there is a requirement to identify CSF for specific role players involved in the AMS. For example, by filtering on the preparation, design and implementation service life cycle phases (phases three and four) and the operational level will result in CSF relevant to operational role players during the implementation phases. By following this logic CSF for specific role players are identified for specific service life cycle phases.

- 3. Complete service self assessment** The third step is for both the asset owner and the service provider to complete the service self assessments according to the instructions. The data should be entered on the two assessment worksheets. Practically, it is advisable to print the worksheets, complete them in hard copy and then to enter the values into the two worksheets.
- 4a. Refresh results** The fourth step is to refresh the result, which will apply the ranking logic and prepare the outputs for review by applying the correct formatting.
- 4b. Ranking settings** The ranking settings are optional. The default setting applies equal weights for the ranks of the benchmark mean, the consensus and the adherence. Users can adjust the weights if required. A zero weight will omit the corresponding variable from the ranking calculation. The weights are validated for adding to 100%.

5. Review results The final step is to review the results. In §7.5.2.4 the four outputs are described in detail. The following guidelines should be used for interpreting the results.

Agreement matrix and prioritised list of CSF These are the primary outputs. The agreement matrix will likely evoke debate about the different self assessment ratings between the asset owner and service provider. The second CSF of a successful AMS is open and effective communication so do not avoid this debate – this is the first step in improving the AMS. Discuss the different perspectives constructively and update self assessment ratings, if required. The intention is not to agree on all of the factors, but to come to a reasonable agreement as to why there is a difference, and how both parties perceive the service. Once the self assessment updates are made, refresh the results and review the prioritised list of CSF which shows the ranked CSF to focus on. Use this list to derive a plan of action to improve the adherence to the factors, starting from the top ranked CSF.

Expected conflict bar chart The expected conflict bar chart should be used to manage conflict that might arise during the results review. This chart is disconnected from the self assessments and user inputs and shows the differences between the asset owner and service provider industry benchmarking data. Use the chart to make differences of opinion explicit – discuss why there are differences and agree on how to proceed constructively.

Benchmark compliance The benchmark compliance infographic shows a measure of the current compliance to industry benchmark. It is used periodically with re-assessments to monitor improvements.

In conclusion, this chapter covers the design and development of the DSMams, which allows AM role players access to the industry benchmarking data collected as part of previous chapters of this research. DSMams is based on decision-making theory, complies to DSS requirements and supports AMS improvement and decision-making.

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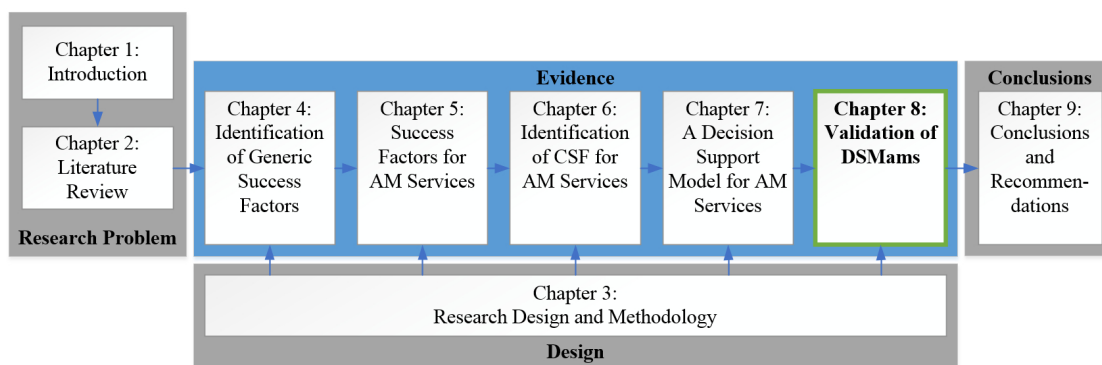
In the next chapter the DSMams is validated and verified according to a structured DSS validation process to confirm that it fulfills its intended purpose and meets the necessary requirements and specifications.

Chapter 8

Validation of DSMams

The first principle is that you must not fool yourself and you are the easiest person to fool

– Richard Feynman (1918-1988)



The objective with this chapter is to conduct quality assurance to validate that the Decision Support Model for Asset Management Services (DSMams) meets industry’s needs and that it is functioning correctly. The chapter begins with the background of the validation process. This is followed by the laboratory testing of DSMams through face-, sub-system-, predictive- and user validation. The chapter is concluded with the field testing of DSMams in the form of a case study.

8.1 Introduction

There is consensus about the need to validate complex model-based systems to assure decision-making success. The lack of validation can lead to poor decisions, which could result in the loss of confidence in a model and lead to discontinued use and financial loss (O’Leary, 1987, 468). Decision Support Systems (DSS) validation is therefore fundamental in pursuit of effective computer based models. The process of validation is further supported as being one of the key components of a quality assurance process. Quality assurance forms part of a quality management system which is defined as the activities implemented to demonstrate confidence that a product or service will fulfill the requirements for quality (International Standards Organisation [Online] 2005, 1; American Society for Quality [Online] 2014).

In the context of quality assurance, validation and verification are procedures which are used to confirm that a product, service or system fulfills its intended purpose and that it meets the necessary requirements and specifications (International Standards Organisation [Online], 2005, 9). In practice, the use of the terms validation and verification varies and are sometimes used interchangeably. Validation can be expressed by asking: “Are you building the correct product?”, while verification can be expressed by asking: “Are you building the product correct?”. Validation often involves acceptance and suitability with external role players, while verification involves an internal process or product consistency (Institute, 2011, 452). This means that validation is concerned with confirming that DSMams meets the industry need, as it is defined in the initial problem statement. That is: does DSMams provide industry access to the research findings on CSF for AMS and does it enable asset owners and service providers to improve decision-making in support of the success of these services? Verification of DSMams needs to evaluate and confirm that the model complies to the specification and performs with consistency.

Finlay (1994) defines DSS validation as:

the process of testing the agreements between behaviour of the DSS and that of

the real world system being modelled.

The objective of DSS validation is however, not to prove a truthful representation of the real world system, since this is impossible. DSS validation should serve to demonstrate “that the DSS has appropriate underlying relationships to permit an acceptable representation” of the real world system (Finlay, 1994).

The DSS validation method by Borenstein (1998, 228) is used for validating DSMams. It draws from the work of Finlay (1994) and validation methods in the fields of operations research, management science (Landry and Oral 1993; Gass 1983) and expert systems (King and Phythian 1992; Sturman and Milkovich 1995; O’Leary 1987; Preece 1990). Scholars have successfully used the method to validate DSS in mass customisation environments (Frutos and Borenstein, 2004, 132), solid waste management (Simonetto and Borenstein, 2007, 1288), the dairy industry (Bryant *et al.*, 2010, 26) and in the selection of consultants for engineering projects (Omar *et al.*, 2011, 772).

8.2 Decision Support System Validation

The validation method for DSS is based on three principles, namely (Borenstein, 1998, 228):

1. Formal validation, which occurs as part of the DSS development process.
2. Prescriptive validation, which is designed to be performed under research constraints, such as time and cost.
3. Qualitative validation, which is a subjective comparison to performance.

Despite their importance, quantitative methods are used less frequently during prototype development. These methods usually require a number of observations, which have time and cost implications, making qualitative methods more appropriate during prototyping (O’Leary 1987, 477; Preece 1990).

The validation process is incorporated into the development cycle of the DSS and consists of two phases of evaluation: laboratory and field testing (figure 8.1). The first phase, laboratory testing includes face-, sub-system-, predictive- and user validation. The validation process is iterative, which allows for changes during any step of the validation process.

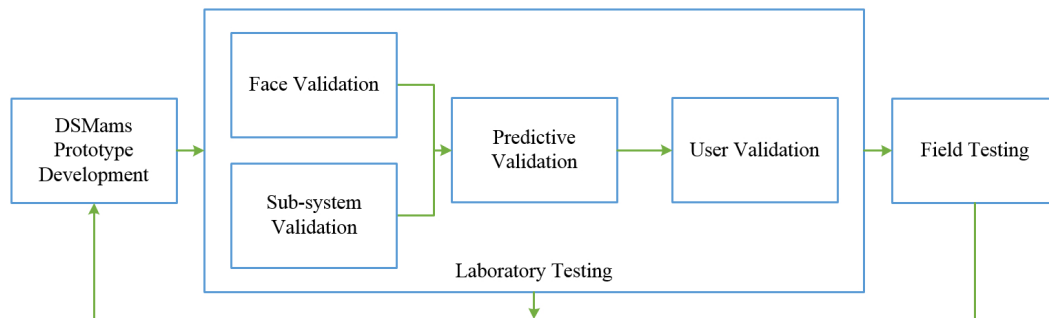


Figure 8.1: DSS validation process (Adopted from Borenstein (1998, 229))

The laboratory testing involves tests done by the developer or development team. These tests may include potential users and involve the use of interviews and questionnaires. Laboratory testing consists of the following:

Face validation The objective is to ensure that the developer's understanding of the problem is consistent with the potential user's understanding of the problem. This validation step further ensures that the problem is sufficiently comprehensive and structured.

Sub-system validation The objective is to test the individual sub-systems or modules of the DSS and to guarantee the quality of the output for each of the sub-systems. This step focuses on the internal validity of the DSS.

Predictive validation The objective is to test the DSS against existing test cases for which the results are known. Past results are used as inputs and the results are compared to the known results.

User validation The objective is for potential users, who were not involved in the development process, to determine whether the DSS's results can be

used with confidence in decision-making. This step obtains usability confirmation from the users and assesses simplification considerations from these independent sources.

The second phase of the validation process is field testing, which is a process whereby the DSS is used in the field to confirm its usability in decision-making and to identify performance issues that might occur. It is the most effective of all validation tests and necessary before full implementation (O'Keefe *et al.*, 1987, 86).

In the laboratory testing predictive validation follows face validation and subsystem testing, with user validation following as the last of the laboratory tests. Field tests only follow after the DSS has been internally validated by the laboratory tests.

Borenstein (1998, 237) highlights two potential problems with this DSS validation approach. The lack of generality and integration of quantitative validation. Due to the wide use and variability of a DSS there is a risk that one validation method (as described above) is insufficient for covering all of the possible applications and situations under which the DSS is used. This may impact on the generality of the DSS. Furthermore, the integration of quantitative tests require repeated observational data and controlled data procedures, which could be time, resource and cost intensive. The inclusion of these tests require careful consideration in validating a DSS and should be considered depending on the complexity and type of DSS which are being validated. In the case of DSMams the marginal benefits of these additional validation tests do not justify the additional cost and effort involved.

8.3 Face Validation

The face validation of DSMams is done through a workshop with the management team of a South African AMS service provider (Pragma [Online], 2013). The main objective with the workshop is to ensure that the problem – not knowing the CSF for AMS – was correctly identified and that the essential concepts were properly

defined.

The eight participants from the management team are experienced in AMS, with expertise in selling, designing, implementing and managing the delivery of AMS. The participants include: the managing director, three operational managers, a national projects manager, a key account manager, a people and organisational development manager and a customer relationship manager. The workshop agenda is as follows: (i) Presentation of the research methodology and results; (ii) Introduction to DSMams; (iii) Demonstration of DSMams, illustrating a simple example; (iv) Discussion and feedback.

The demonstration covered all the aspects of DSMams. This ensures that the participants have a sound understanding of the objectives of the research, its relationship to DSMams and the DSMams functionality. At the end of the workshop questionnaires are issued to the participants with the purpose of collecting data for supporting the validation. The questionnaire acts as the formal instrument to measure the validity of DSMams.

8.3.1 Face Validation Results

The questionnaire starts with a problem statement and the objectives of the face validation, followed by the questions. Refer to appendix C.5 for the questionnaire and participant feedback.

Overall the participants expressed affirmation for the potential of DSMams as a decision-making tool; in the words of one participant: “DSMams will greatly assist to facilitate a structured discussion related to service successes and issues, over and above the specific service deliverables.” Two of the participants mention that it will assist with change management during new service implementations, while another notes that “it can be used as part of or in support of the SLA to ensure open communication regarding focus areas, possible risks and conflicts.” Two of the participants’ feedback allude that DSMams requires improvement to make it more user friendly.

One participant remarks: “The strong point of the research methodology was the great use of the problem statement and to derive a useful model that enables the research to address the problem in a very practical manner that can produce tangible results. Other strong points mentioned are: the research methodology, the model logic, the presentation of the results, and how it complements the SLA.”

“More explanation that can assist in understanding/interpreting the results will be good.” This statement was echoed by six of the eight participants. Two participants felt the narrow range of the 46 success factors means is a weak point. Another two participants commented that the ranking logic is not intuitive, and could be confusing and requires clear guidance on its use.

The participants’ opinions about the architectural aspects of DSMams are indicated in figure 8.2.

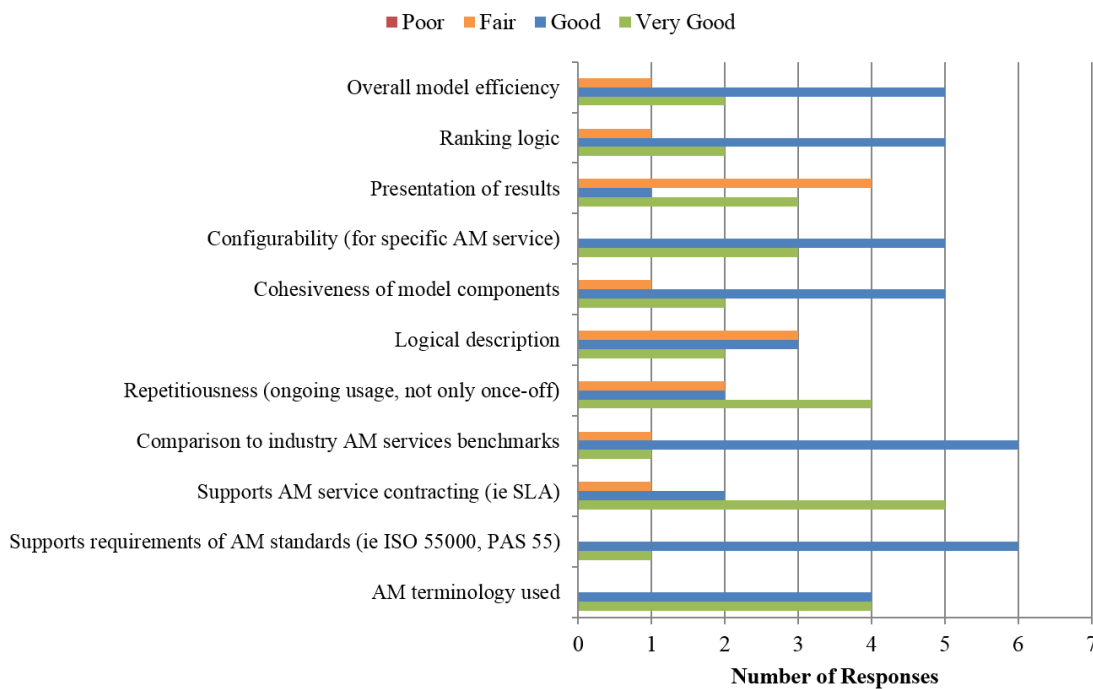


Figure 8.2: Participant feedback on the architectural aspects of DSMams during face validation

Six of the eight participants stated that a user manual is required to explain the different aspects of DSMams. Participants also stated that the sample size should be increased and the explanations of the output graphs clarified.

Following the feedback, it can be observed that participants are generally satisfied that DSMams is based on a scientific foundation and that it will add value to the AMS domain. The model however requires improvement in explaining its operation, the ranking logic and the interpretation of its outputs. The narrow range of responses and the need to increase the asset owner sample size will need to be addressed with future research. A potential insufficient sample size has been highlighted in §1.5 as a potential risk of the study.

8.3.2 DSMams Improvements

To address the shortcomings of user-friendliness, complexity and the need to understand the DSMams background, a user manual in web help format is developed to supplement DSMams. The user manual gives an overview of the model, illustrates the process of its intended use and explains the details on how each of the DSMams steps works. It also explains the ranking logic as well as all of the model statistics and calculation clarifications. Figure 8.3 shows the contents of the user manual.

8.4 Sub-System Validation

Sub-system validation focuses on the internal validity of DSMams, where each of its functions are tested and verified to ensure its quality. Each function is assessed as an input–output transformation process, where its performance is observed for a set of input data (Borenstein, 1998, 229). The user interface control sequence macros (§7.5.2.3) and the functions associated with the underlying model of DSMams (§7.5.3) are validated during this phase. The sub-system validation is performed in parallel to the DSMams development, as soon as the relevant function or control

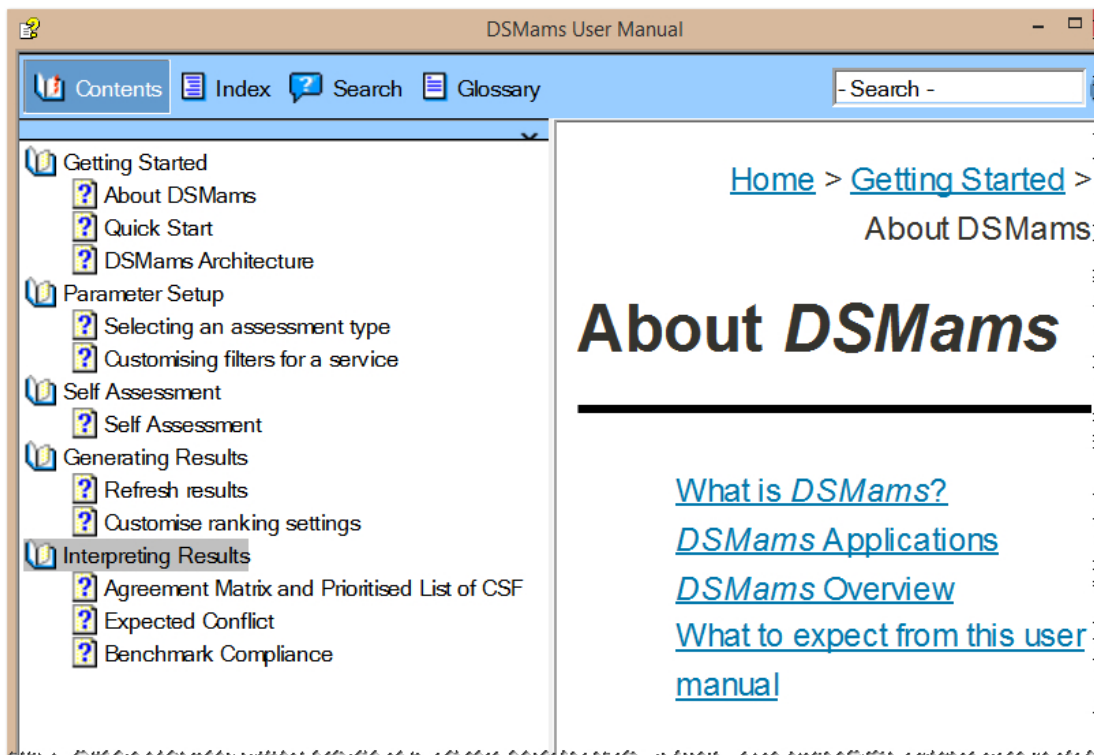


Figure 8.3: DSMams user manual contents menu

sequence is sufficiently developed to be considered as an input–output process. The following validation steps are performed as part of this validation process:

Assessment Types The assessment type macro is validated by comparing the number of records (for a full assessment) or record mean values (for transitional and critical assessments) in the pivot table to each of the chosen assessment types (figure 7.7).

Service Filters The service filters utilise a built-in pivot table filtering function which is validated by comparing the total record count in the pivot table to the count of the corresponding records in the raw data (figure 7.8).

Self Assessment Worksheets The self assessment worksheets are validated by comparing the list of factors from the worksheets to those in the pivot table (figure 7.9).

Ranking Settings and Output Generation The values from the ranking settings macro are confirmed in the corresponding cells in the ranking logic function (figure 7.11). For the output generation macro the results are validated against the values in the ranking logic function (figure 7.10).

Pivot Table (refer to §7.5.3.1) The pivot table function utilises Microsoft Excel's standard built-in pivot table functionality. The table is validated by manually comparing a filtered set of results with the records and summaries of the corresponding records from the raw data.

t-Test (refer to §7.5.3.2) The t -test is validated by comparing the calculations between DSMams and *Statistica*. Equations 7.2 and 7.3 are used to manually calculate the t -value and degrees of freedom, ν . These values are used in *Statistica's* probability distribution calculator to verify the corresponding p -value in DSMams.

Self Assessment (refer to §7.5.3.3) The self assessment function is validated by manually comparing the *vlookup*-formula results with those in the two assessment worksheets.

Ranking Logic (refer to §7.5.3.4) The ranking logic function is validated manually, by firstly verifying the formulas based on the self assessment function and secondly verifying that the correct overall rank is calculated from the variables and weights.

Benchmark Comparison (refer to §7.5.3.5) The benchmark comparison function is validated by verifying a 100% benchmark compliance score for each of the service life cycle phases, when all of the self assessment factor scores are set to the maximum value. The same verification is done for all factor scores set to the minimum, which returns a 5% benchmark compliance.

The process of sub-system validation identified minor miscalculations in the DSMams prototype. The functions and formulas were revised and corrected as appropriate.

8.5 Predictive Validation

Predictive validation focuses on testing the DSS against test cases for which the results are known. The nature of DSMams and this research is such that no existing comparable cases or data are available for conducting this type of validation. In the absence of existing data to benchmark the model against, arbitrary self assessment factor scores are entered into DSMams. Various random scenarios are tested with different assessment types, service filters and ranking settings. Output results are generated for each scenario.

8.6 User Validation

The user validation of DSMams is done through a workshop with selected users from a South African AMS service provider (Pragma [Online], 2013). The objective with the workshop is to perform a laboratory experiment in which the DSMams outputs and decision-making process are compared with a user's prediction and decision-making process. For simplification one of the test scenarios from the predictive validation (§8.5) is used for the user testing.

Seven participants from different backgrounds and perspectives participated in the user validation. All of the participants are experienced in AMS, with expertise in product development, international relations, service management and solutions selling. The participants include: the managing director of the research and development division, two managers of international services operations, a key account manager, a new product development manager and an AM consultant, as well as two local services operations managers. Two of the participants participated in the face validation, while the other five participants had no prior exposure to DSMams. The workshop was conducted through the following activities:

1. DSMams was introduced to the participants by presenting the *About DSMams* section of the user manual (see §8.3.2 and figure 8.3).
2. DSMams was demonstrated to the participants through a simple example.

3. User testing was conducted, with each participant using DSMams on their own computer. The self assessment scores from the test scenario was given to each participant who used it as input for simulating the decision-making process and results in DSMams. The participants also had the opportunity to use DSMams with their own test scenarios.
4. A discussion of the results, the participants' experience with DSMams and their feedback concluded the workshop.

At the end of the workshop questionnaires are issued to the participants to collect data for supporting the user validation. The questionnaire acts as the formal instrument to measure the validity of DSMams.

8.6.1 User Validation Results

The questionnaire starts with a problem statement and the objectives of the user validation, followed by the questions. Refer to appendix C.5 for the questionnaire and participant feedback.

The participants indicate their opinion about the architectural aspects of DSMams in figure 8.4.

All of the participants agreed that DSMams facilitated the decision process during the user testing. One participant states that DSMams “provides pertinent insight into some of the risk factors that would be associated with service delivery on all levels of an organisation, and thus could be a very useful tool in determining the ... *pressure points* that need to be effectively managed for ensuring successful implementation of AMS.”

The majority of participants confirmed that they will use DSMams to solve AMS related problems. One participant alludes that the level of maturity of the asset owner and the existing relationship could affect how applicable DSMams is – hinting that it could be less useful at a lower maturity AMS.

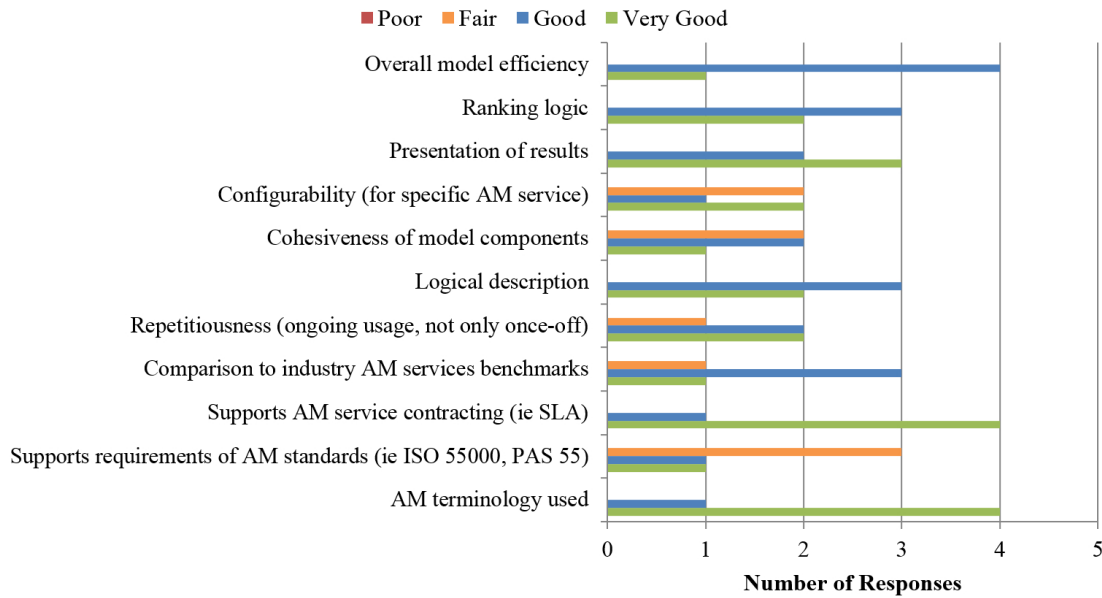


Figure 8.4: Participant feedback on the architectural aspects of DSMams during user validation

Four out of the seven participants endorsed the potential of DSMams as an objective decision-making model for assisting in the improvement of AMS. Criticism is expressed about some factors being closely worded and actually meaning the same thing. The participants suggest that combining these similar factors will also shorten the list of CSF. Another participant raised concerns about the sample size and the nonsignificant differences between the success factors.

Participants state that the strong points of DSMams are: “It can be used as advance warning (leading indicator) by both parties that the relationship has a high risk of failure”; “the fact that it is open-ended for interpretation”; “It will be a very useful tool to open up healthy debate between [service] provider and [asset] owner. From the debate and hopeful alignment, improvements in the relationship can happen”; “it brings objectivity into decision-making and highlights areas of potential conflict/difference of opinion so that these areas can be closely managed. ... the research quantifies the gap between service providers and service consumers and establishes a defensible baseline against which service providers can evaluate themselves and which service consumers can use to select or evaluate

service providers.”

On the weak points of DSMams the participants reported the following: “The model should have allowed factors to apply across more than one phase.”; “there are too many factors – it would have been easier if we only had around 10 CSF instead of so many”; “I do not believe that the industry is significant enough to warrant inclusion in the model – it merely injects additional complexity”; “[It cannot] be used as a tool to measure progress against a plan as there is not [provision] for previous scores. The questions lack some *verification points* to quickly align understanding of the different factors... .”

Additional remarks focused on the potential risks associated with perception-based models and the difficulty in determining correct weighting for the ranking logic function.

8.6.2 DSMams Improvement Suggestions

The participants recommend various improvements to enhance DSMams. It is recommended that the filtering on industries and service life cycle phases be removed and replaced by a filter for service types. It is reiterated that the addition of qualifying descriptions of the specific characteristics of a factor (the so-called *verification points*) will add value to DSMams. One participant suggests provision to allow for the customisation of a specific output scenario. The self assessment worksheets are found to be cumbersome and it is recommended they be replaced with a web-based survey. Web-based surveys will allow separate data collection for respondents from different organisational levels, which will provide customised CSF for these different levels in the AMS. Finally a mechanism is suggested to record DSMams results for correlating these to the actual success of the AMS over time – this will prove the accuracy of DSMams and give insight into the weighting for the ranking logic function.

The improvement suggestions and aforementioned feedback (§8.6.1) focuses on future improvements to DSMams, with none identifying adversities warranting the

redesign or structural or computational changes to DSMams at this point in the validation process. The recommendations are consolidated and further discussed for future research in §9.5.

The laboratory testing phase is concluded with the user validation. Field testing is the final phase of the validation and is performed in the next section.

8.7 Field Testing

The objective of the field testing is to simulate the operational use of DSMams *in situ* and to identify opportunities for improvement. The DSMams field testing is performed by conducting a case study.

For the case study data is collected from an AMS and DSMams is used for the decision-making process. The results are prepared and the researcher facilitates the feedback of the results with the service provider and asset owner involved in the AMS.

An overview of the case study is given, followed by the results from DSMams and a discussion. A questionnaire is issued to the participants to collect data for supporting the field testing. The questionnaire acts as the formal instrument to measure the validity of DSMams.

8.7.1 Case Study Overview

The Electrical Support Services (ESS) department is responsible for civil projects and maintenance, corrosion protection, electrical projects and transformer refurbishment for the City of Cape Town's Electricity Directorate.

ESS and Pragma partnered in 2007 in response to the problematic control of work requirements, the associated frustration from internal clients, long work lead times and the under utilisation of their SAP Plant Maintenance (SAP PM) ERP system for accessing information. A team of seven Pragma employees work

together with the ESS team on various AM related activities in the context of the AMS. These activities include: work planning, monitoring and control, system analysis and optimisation for improving alignment between SAP PM and ESS business requirements, AM reporting, root cause and failure analysis (Pragma [Online], 2010).

In 2010, ESS was awarded the best client award (from 155 participants across all sectors) by Pragma. For their role as an ISO accredited organisation, the South African Bureau of Standards (SABS) also awarded them for excellence in business growth, productivity and continuous improvement (City of Cape Town [Online], 2014).

8.7.2 DSMams Field Testing

The head of ESS (hereafter “Asset Owner”) and key account manager of Pragma responsible for the AMS at ESS (hereafter “Service Provider”) participated in the case study. Based on the long standing relationship and associated accolades, it is expected that the AMS between ESS and Pragma should show high levels of adherence to the CSF results from DSMams.

For the setup parameters, a transitional assessment is selected (see §7.6). For the filters, the implementation phases of the service life cycle are excluded and only the electricity supply industry is selected. The initial setup of DSMams resulted in 14 CSF. For ease of data collection the CSF were transformed into a web-based questionnaire for collecting the self assessment data from the Asset Owner and Service Provider. The ratings are transferred to the DSMams self assessment worksheets. Equal weights for the ranking variables are used and the results are subsequently generated.

Figure 8.5 shows the agreement matrix results. The results illustrate the CSF are highly concentrated in the *blue zone*, which means most of the CSF for this AMS are strongly adhered to and agreed upon by both the Asset Owner and

Service Provider. CSF *1a*, *1f*, *1e* and *1d* are the exceptions and show opportunities for improvement. Figure 8.6 shows the ranks of the CSF depicted in figure 8.5.

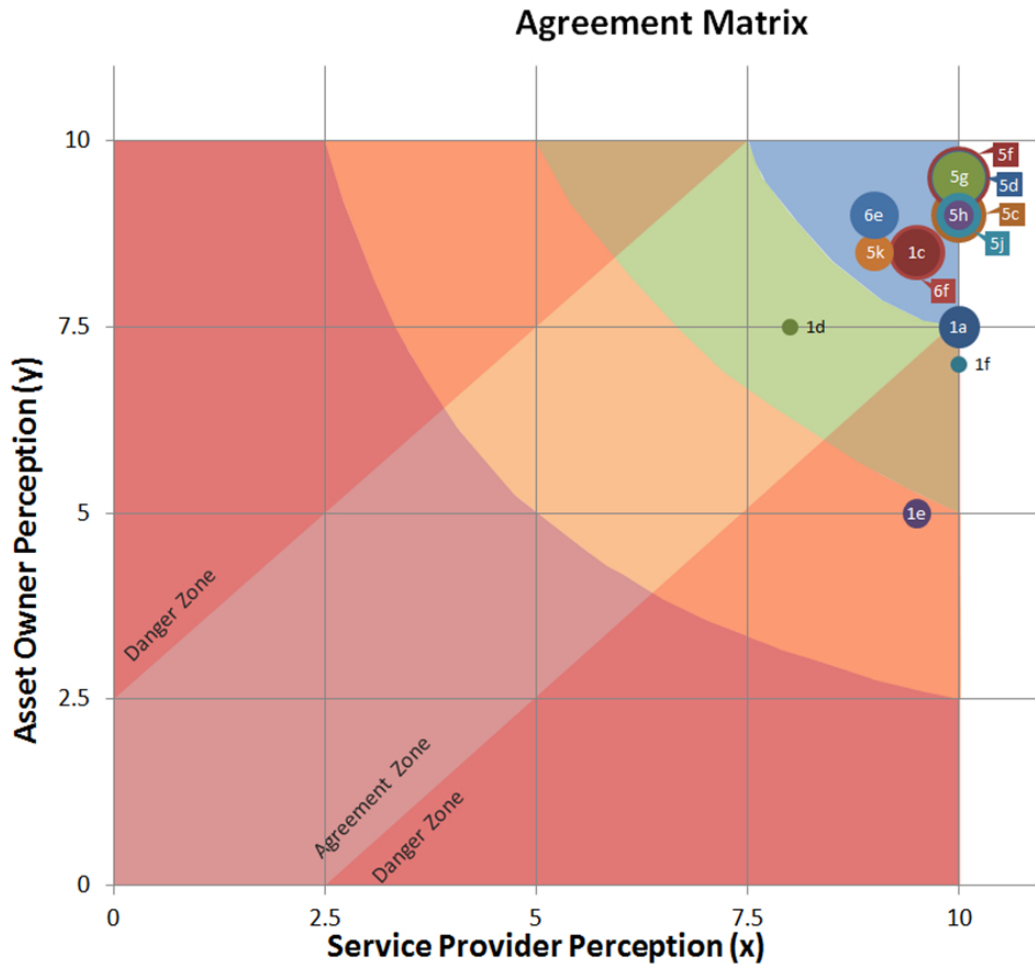


Figure 8.5: The agreement matrix results for the case study AMS

A brief overview of the research process and DSMams are presented to the participants, followed by the presentation of the results and a feedback discussion. They are satisfied overall that the results represent the current status of success for their AMS. Further discussion followed on two points.

CSF	Bench- mark	Consen- sus Diff	Adherence	Rank*	Description
6f	6.214	1	80.75	4.002	A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback.
1e	5.964	4.5	47.5	4.33	The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations).
5c	6.214	1	90	5.004	The management of mutual expectations between the service provider and client relating to the AM service.
1a	6.036	2.5	75	5.332	A capable project (or key account) manager that manages the AM service on behalf of the service provider.
1c	6.107	1	80.75	5.334	The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants.
1f	5.929	3	70	5.997	The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service.
5j	6.071	1	90	7.002	The use of performance measurement to monitor, control and improve the AM service.
5f	6.464	0.5	95	7.338	Open and effective communication.
5d	6.214	0.5	95	7.671	The active management of the relationship between the service provider and client organisation personnel involved in the AM service.
1d	5.929	0.5	60	7.994	The availability of the most appropriate skilled resources for providing industry specific AM service requirements.
5k	6.000	0.5	76.5	7.997	Proper priority setting of improvement actions, irrespective whether it is service or value-add related.
5h	5.964	1	90	8.001	Active client participation in reporting, problem solving and improvement relating to the AM service.
5g	6.143	0.5	95	8.67	Mutual trust and respect between the service provider and client organisation.
6e	6.107	0	81	9.332	The ability to measure the AM service quality and value creation.

Figure 8.6: The prioritised list of CSF for the case study AMS

Firstly, the participants expected CSF *1a*, *1f*, *1e* and *1d* to be the high priority items in the prioritised list of CSF (figure 8.6) – CSF *1e* is ranked second, CSF *1a* is ranked fourth, CSF *1f* is ranked sixth and CSF *1d* is ranked tenth. The observation is made that the industry benchmark importance could have an excessive influence due the narrow range of means (5.929 to 6.464) on which the ranks are based. A suggestion is to change the weighting for the industry benchmark importance to 20%, and 40% for both the consensus and level of adherence (refer to §7.5.3.4). This change produced a new prioritised list of CSF, seen in figure 8.7. The participants agreed that the lower weight for the benchmark compensated for its narrow range of means and is a better representation of the CSF which they felt they should focus their improvement efforts on.

Secondly, the participants discussed CSF *1a*, *1f* and *1e*, which showed the

CSF	Benchmark	Consensus Diff	Adherence	Rank*	Description
1e	5.964	4.5	47.5	3	The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations).
6f	6.214	1	80.75	4.4	A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback.
1a	6.036	2.5	75	4.6	A capable project (or key account) manager that manages the AM service on behalf of the service provider.
1f	5.929	3	70	4.6	The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service.
1c	6.107	1	80.75	5.2	The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants.
5c	6.214	1	90	5.6	The management of mutual expectations between the service provider and client relating to the AM service.
5j	6.071	1	90	6.8	The use of performance measurement to monitor, control and improve the AM service.
1d	5.929	0.5	60	7	The availability of the most appropriate skilled resources for providing industry specific AM service requirements.
5h	5.964	1	90	7.4	Active client participation in reporting, problem solving and improvement relating to the AM service.
5k	6.000	0.5	76.5	7.6	Proper priority setting of improvement actions, irrespective whether it is service or value-add related.
5f	6.464	0.5	95	8.6	Open and effective communication.
5d	6.214	0.5	95	8.8	The active management of the relationship between the service provider and client organisation personnel involved in the AM service.
5g	6.143	0.5	95	9.4	Mutual trust and respect between the service provider and client organisation.
6e	6.107	0	81	10	The ability to measure the AM service quality and value creation.

Figure 8.7: The prioritised list of CSF with updated ranking weights for the case study AMS

lowest levels of consensus. For all three the CSF the Asset Owner ratings are significantly lower than the Service Provider ratings. All three of these CSF relate to the service provider's organisational environment and capabilities, which could have lead to conflict. Upon closer investigation the Asset Owner indicated he misinterpreted the questions on these factors, which lead to the updating of the self assessment ratings and the DSMams results.

Figure 8.8 shows the final prioritised list of CSF reflecting changes to the ranking variable weights and updated Asset Owner self assessment scores. Figure 8.9 depicts the associated compliance percentages against the benchmarking data for each of the three service life cycle phases included in the case study.

CSF	Benchmark	Consensus Diff.	Adherence	Rank*	Description
6f	6.214	1	80.75	2.4	A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback.
1c	6.107	1	80.75	3.2	The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants.
1d	5.929	1.5	76	3.4	The availability of the most appropriate skilled resources for providing industry specific AM service requirements.
5c	6.214	1	90	4	The management of mutual expectations between the service provider and client relating to the AM service.
5j	6.071	1	90	5.2	The use of performance measurement to monitor, control and improve the AM service.
1a	6.036	1	90	5.4	A capable project (or key account) manager that manages the AM service on behalf of the service provider.
5h	5.964	1	90	5.8	Active client participation in reporting, problem solving and improvement relating to the AM service.
5k	6.000	0.5	76.5	6	Proper priority setting of improvement actions, irrespective whether it is service or value-add related.
1e	5.964	0.5	85.5	7.8	The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations).
5f	6.464	0.5	95	7.8	Open and effective communication.
5d	6.214	0.5	95	8	The active management of the relationship between the service provider and client organisation personnel involved in the AM service.
6e	6.107	0	81	8.4	The ability to measure the AM service quality and value creation.
5g	6.143	0.5	95	8.6	Mutual trust and respect between the service provider and client organisation.
1f	5.929	0	100	13.4	The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service.

Figure 8.8: The final prioritised list of CSF with updated ranking weights and Asset Owner self assessment scores for the case study AMS

8.7.3 Field Testing Feedback

The questionnaire starts with a problem statement and the objectives of the field testing, followed by the questions. Refer to appendix C.7 for the questionnaire and participant feedback.

Both participants expressed their agreement with the overall potential of DS-Mams. The Asset Owner stated: "This will help many engineers when they set up an AMS or similar operations", while the Service Provider indicated: "It should be incorporated in [AMS] to ensure that the [service provider] team is set up in the most suitable way."

On the question of whether the results are a true reflection of the current state

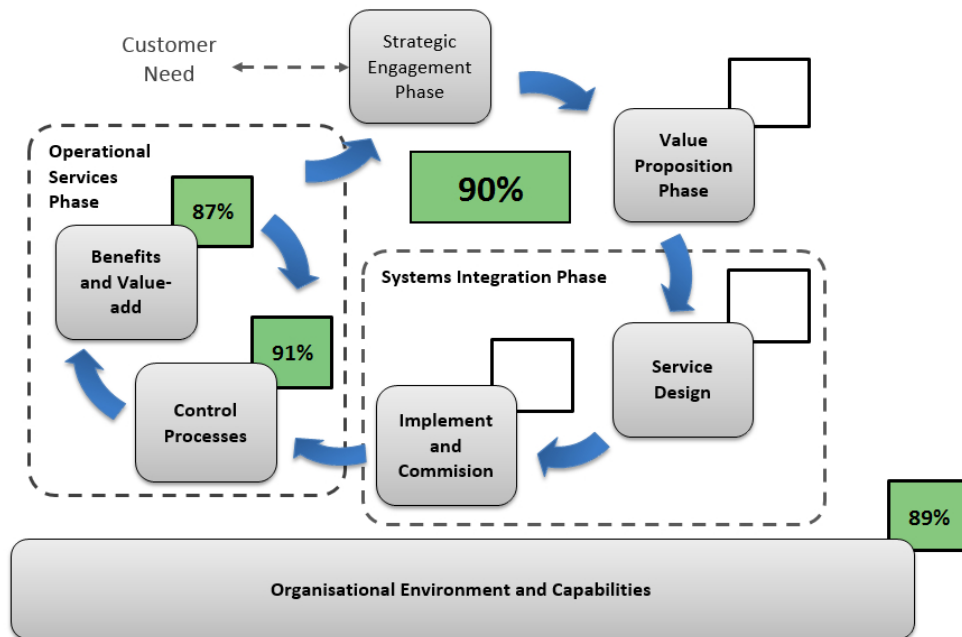


Figure 8.9: The benchmark compliance infographic for the case study AMS

of the AMS, the Asset Owner stated: “I was amazed to see the results and how close both parties’ results came out. Yes, I believe they are true reflective results.” And the Service Provider seconded: “As we have an excellent client/service provider relationship which correlates with the high scores in the matrix, I would deem the criteria to be a true reflection.”

To validate DSMams retrospectively the participants were asked whether they think the AMS and the partnership would have benefited from having access to DSMams at the beginning of the service. They confirmed: “Yes, they would. It took about 2-4 years to establish all of these CSF, but having this information I believe it would have shortened this period by at least half.”; “Thinking back definitely. If you reflect on rather serious times of conflict and disagreement it would have helped to have known which CSF were lacking and which not, to be able to prioritise”

In conclusion, a multi-phase process, consisting of laboratory and field testing,

was followed to validate DSMams. Generally the feedback from the 14 participants involved in the validation was in support of DSMams, its potential for adding value to the AMS industry and its ability to facilitate the decision-making process towards more successful AMS (§8.3.1, §8.6.1 and §8.7.3). According to the participants, DSMams' strongest characteristic is its support for the AMS contracting and SLA processes, with a combined 70% of participants rating this aspect as *very good* (see figures 8.2 and 8.4).

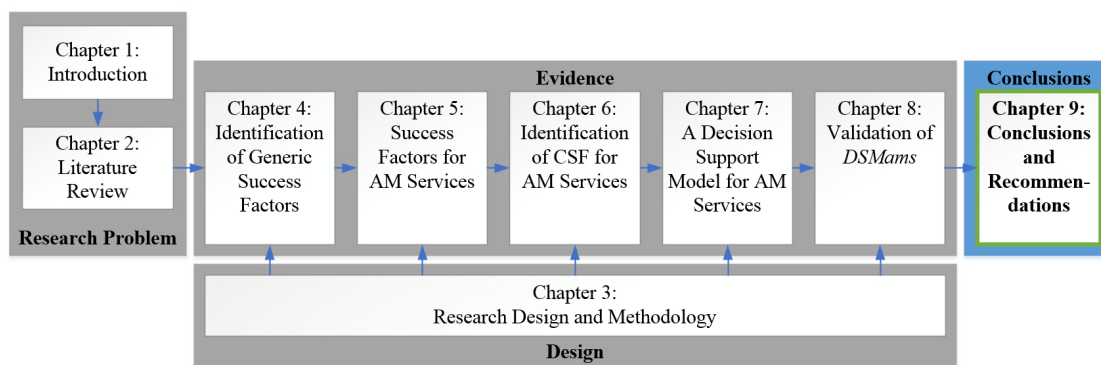
Initial concerns about usability and complexity associated with the model were addressed with the development of a user manual (§8.3.2). The impact of the user manual can be seen in the improvements of the comparative ratings between the *overall model efficiency, ranking logic, presentation of results* and *logical description* in figures 8.2 and 8.4. A sample of future DSMams users made various design improvement suggestions to improve the practical use of DSMams (§8.6.2). This should be considered for future research.

Considering that the third and last research question – the type of model and associated characteristics required for making the CSF available to the AMS industry – and the overall outcomes and feedback from the validation process, the quality and validity of DSMams and its contribution to the AMS scholarship are proven.

Chapter 9

Conclusions and Recommendations

Science when well digested is nothing but good sense and reason
– Stanislas Leszczynski (1677-1766)



The objective of this chapter is to summarise the findings of this research and to draw conclusions. The theoretical and practical contributions are discussed and recommendations for future research is made.

9.1 Summary of Research Results

The results of the research are summarised in support of the three research questions (§1.2).

9.1.1 Critical Success Factors for Successful Asset Management Services

The answer to the problem which is set out for investigation in this research is to identify and gain an understanding of the Critical Success Factors (CSF) for Asset Management Services (AMS). Through a structured process of studying literature, analysing content, conducting a Delphi study and collecting information through a web-survey this answer is obtained.

In response to the first research question – what are the CSF for ensuring successful AMS? – a list of 46 success factors for AMS are identified (listed in §6.3.2). The research results indicate that all of the 46 success factors contribute to the success of AMS during specific phases of the life cycle of an AMS. The top 30% of success factors, the so-called CSF, grouped according to the relevant life cycle phases (refer to figure 2.7), are:

1. Organisational Environment and Capabilities

- 1.1. The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service (1f)

2. Initiation Phase and Pre-contract Activities

- 2.1. The continued and sustained commitment from the asset owner senior management in support of the AM service (2a)
- 2.2. The alignment of the asset owner's AM service requirements with their overall organisational and business strategies (2c)

3. Preparation and Design Processes

- 3.1. The involvement of knowledgeable and demanding individuals from the asset owner during the design and preparation, rather than individuals that want to abdicate their AM responsibilities (3n)

4. Implementation and Commissioning

- 4.1. An adequate training programme in place for all AM service role players, both in the service provider and asset owner teams (4a)
- 4.2. An effective organisational change management programme in support of the AM service (4b)

5. Control Processes

- 5.1. Open and effective communication between the asset owner and service provider (5f)
- 5.2. Mutual trust and respect between the service provider and asset owner (5g)
- 5.3. Active asset owner participation in reporting, problem solving and improvement relating to the AM service (5h)
- 5.4. The use of performance measurement and monitor, control and improve the AM service (5j)

6. Benefits and Value-add

- 6.1. A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback (6f)
- 6.2. Proof of operational and financial performance achievements as a result of the AM service (6d)
- 6.3. The ability to measure the AM service quality and value creation (6e)

Of these factors the *continued and sustained commitment from the asset owner senior management (2a)* and *open and effective communication between the asset owner and service provider (5f)* are significantly more important than the other CSF.

9.1.2 Differences in Critical Success Factors for Asset Management Service Strata

In response to the second research question – are the CSF different for different role, industry and service strata associated with AMS? – three out of 12 AMS strata show significant differences in CSF perspectives between strata sub-groups (table 9.1).

Stratum	Sub-group	S/D
Participant role	Asset owner; service provider	*
Organisational level	Strategic; tactical; operational	*
Economy	Developed economies, developing economies	
Region	Africa; Asia; Australasia; Europe; North America; South America; more than one of the above regions	*
Industry	Agriculture; mining; manufacturing; electricity supply; water supply; construction; wholesale and retail trade; transportation and storage; information and communication; finance and insurance; real estate; professional, scientific and technical activities; public administration and defence; education; health care; arts, entertainment and recreation; more than one of the above; other	
Sector	Private; public; non-profit	
Asset life cycle	Needs identification; feasibility studies and/or planning; specification and design; acquisition, installation and commissioning; operation and maintenance; decommissioning and disposal; more than one of the above	
Asset type	Mechanical or electro-mechanical equipment or machinery; facilities; infrastructure and linear assets; other	
Service type	Basic asset-orientated services; professional support services; outsourcing services; integrated life cycle services	
Service timespan	Short term; short to medium term; medium term service contract; long term service contract	
AM maturity	Low; low-medium; medium; medium-high; high	
Service size (people)	1 to 5; 6 to 15; 16 to 30; 31 to 100; >100	

Table 9.1: Three out of 12 strata reveal significant different (S/D) perspectives on CSF between sub-groups

The univariate results show that for five of the 46 success factors there are significant different perspectives between asset owners and service providers, but that none of the factors are represented in the top 30% CSF. For the organisational level the significant differences are due to the perspectives of the operational sub-group, compared to their strategic and tactical counterparts. The regional stratum reveals that only the South American sub-group has a significantly different perspective on CSF compared to the other global regions.

9.1.3 A Decision Support Model for Asset Management Services

In response to the third research question – what type of model and associated characteristics are required for making the CSF available to the AMS industry? – a prototype Decision Support Model for Asset Management Services (DSMams) is developed and validated. DSMams is based on decision-making theory and complies with the requirements for Decision Support Systems (DSS).

DSMams allows for a specific AMS to be assessed against a list of customised CSF – serving as industry benchmarking data – which should be complied to for such a service. DSMams facilitates a structured approach whereby asset owners and service providers self-assess the AMS they are involved with, compare the service to the CSF of other similar services and use the results for improving the AMS and their relationship.

The results from the validation process attest to the potential of DSMams for adding value to the AMS industry and its ability to facilitate the decision-making process towards a more successful AMS. The results indicate the strongest characteristic of DSMams is in its potential to support the AMS contracting and Service Level Agreement (SLA) processes.

9.2 Contribution of the Research

This research contributes to the existing AMS scholarship in theory and in practice:

9.2.1 Theoretical Contributions

The following theoretical contributions are made:

1. A list of CSF for AMS is established.
2. A DSMams is developed, which incorporates the research results, allowing asset owners and service providers access to the CSF for decision-making and for improving AMS.
3. The contextual understanding of the different and similar perspectives of service providers and asset owners about CSF for AMS is expanded.
4. The ISO 55000 series of standards and the GFMAM 39 AM subjects are supported with sound theory for improving the outsourcing of AM activities and the related AMS.
5. The DSMams provides a theoretical basis for greater focus on relationship transparency and collaborative communication in managing the outsourcing of AM activities and the related AMS.
6. The existing AM scholarship is enriched and a contribution is made to the scholarship in the emerging field of AMS with the CSF affecting the success of such services.

9.2.2 Practical Contributions

The following practical contributions are made (supported by selective feedback, in *italics*, collated during the course of the research):

1. Support objective decision-making through guidelines for the effective implementation and delivery of AMS, as well as specifying focus areas which are important for adding value to the asset owner's business.
"It brings objectivity into decision-making and highlights areas of potential conflict/difference of opinion so that these areas can be closely managed. ... the research quantifies the gap between service providers and service consumers and establishes a defensible baseline against which service providers

can evaluate themselves and which service consumers can use to select/evaluate service providers.”

2. Enhance communication and collaboration between the asset owner and the service provider for aligning role players from both parties towards a more successful AMS.

“DSMams will greatly assist to facilitate a structured discussion related to service successes and issues, over and above the specific service deliverables.”

“[DSMams] can be used as part of or in support of the SLA to ensure open communication regarding focus areas, possible risks and conflicts.”

3. Support the change management process associated with the implementation and optimisation of AMS.

“This can be a great tool as part of change management initiatives during implementation or specific project phases.”

4. Support the identification and mitigation of risks associated with the outsourcing of AM activities and AMS.

“[DSMams] provides pertinent insight into some of the risk factors that would be associated with service delivery on all levels of an organisation, and thus could be a very useful tool in determining the ... pressure points that need to be effectively managed for ensuring successful implementation of AMS.”

“It can be used as advance warning (leading indicator) by both parties that the relationship has a high risk of failure.”

5. Support the establishing of an effective AMS partnership in less time, with the potential of realising value and benefits sooner.

“It took about 2-4 years to establish all these CSF, but having this information I believe it would have shortened this period by at least half.”

Final conclusions are drawn against the background of the research results and contributions.

9.3 Conclusions

For an AMS to be successful and beneficial to all of its stakeholders, the asset owner and service provider need to work in partnership on various success factors during each of the phases of the AMS life cycle. It is not as important to design the perfect AMS, as it is to select an appropriate partner, as well as having effective control and monitoring processes in place to improve the AMS continuously. The most fundamental is to gain the support for the AMS from all of the stakeholders during the implementation and commissioning phases of the AMS.

These findings can be attributed to the *heterogeneity* and *inseparability* characteristics of services which state that services are difficult to control, highly variable and requires the active participation of the client to realise value from the service. In the context of AMS the service provider approaches heterogeneity and inseparability by valuing a capable project manager and the active management of the service relationship significantly higher than asset owners. This is supported by Matthyssens and Vandembemt (1998, 349) who state that project managers in industrial services “coordinate and stimulate the value creation process from the first stages of the transaction cycle to the final steps of joint evaluation of outcome and process quality”. In contrast, the asset owner more closely monitors budgets and costs in response to the heterogeneity of the AMS. This is likely because of the traditional project management environment, where the operational efficiency of projects is determined by whether it is completed within budget and cost (Tishler *et al.*, 1996, 154).

The continued and sustained commitment from the asset owner’s senior management is non-negotiable for ensuring AMS success (regardless of who the service provider is), especially during the initial contracting phase of the AMS. This emphasises the importance of personal relationships between the asset owner’s senior management and the service provider. It is also indicative of why AM service providers are often replaced when managers (who often have established relationships with service providers) change positions. During the ongoing operational services phase, open and effective communication between the asset owner and

service provider is also critical towards the success of the AMS.

With the exception of the two aforementioned CSF the differences in importance between the rest of the identified success factors for AMS are omissible. Instead of a select few CSF, all of the identified success factors for AMS play an important role during specific phases of the AMS life cycle. Ranking the success factors according to the industry benchmarks and the stakeholder assessments of the adherence to the success factors for an AMS allows for prioritising the factors and identifying the CSF which asset owners and service providers should focus on for improving the AMS during a specific situation or phase.

The use of performance measurement and a focused and continuous improvement process for controlling and improving the AMS, as well as proving the operational and financial benefits form part of the top rated CSF. Asset owners regard performance measurement and the proof of benefits more highly than service providers. In support of these findings it is recommended that these CSF are regarded as a high priority for any AMS and form a standard part of the contractual agreements of such services. This will ensure full alignment and focus by both the asset owner and service provider in support of these CSF.

Success factors for AMS are universal and unaffected by the type of AMS, the AM environment or industry type. Some different perspectives exist between asset owners and service providers and how operational and South American role players experience CSF. The overall effect of these differences, especially for the CSF – the topmost 30% success factors – are however negligible and should not adversely affect the universal use of the CSF across all AMS. The different perspectives between the operational stakeholders and their tactical and strategic counterparts are however indicative of potential implications on employee engagement and team dynamics. It is therefore important that all of the AMS stakeholders are aligned regarding the CSF for an AMS.

The relationship between the CSF and organisational AM maturity is worthy of comment. Statistical analysis suggests that CSF for AMS for organisations with

different AM maturities are not significantly different, which implies the universal use of the CSF irrespective of AM maturity. However, the results from the DSMams validation process suggest the usefulness of CSF for improving AMS is less when a low AM maturity environment is prevalent. This corresponds to findings in the servitisation literature indicating client maturity affects the willingness to adopt more advanced services (Kindström, 2010, 489). The phenomenon explains the need for the asset owner to be prepared for the changes that the CSF will bring and the willingness to embrace these changes.

The improvement of a specific AMS based on the CSF and the growth of the partnership as a result of the process is important. A structured approach for providing asset owners and service provider access to the CSF for AMS is needed. The DSMams provides such an approach. For gaining the most benefit, DSMams and the CSF for AMS need to be incorporated as part of the contractual, SLA and operational processes of an AM management system.

9.4 Limitations

A limitation of the research is its generalisability across all AMS. In §1.5 the research sets out to investigate AMS in its broadest sense, while it is anticipated that response rate and sample composition could negatively influence the outcomes. Although the analysis shows no overall adversity between the sub-group responses for the Delphi study and survey, a limitation is the unlikelihood that all possible AMS variations are represented in the samples. For example, only two of the nineteen Delphi panellists and a relatively small percentage of survey respondents represent the capital goods manufacturing industry which offers AMS as part of their servitisation endeavors. Similarly, the CSF strata analysis indicates a limited representation of asset owners, operational AMS stakeholders and AMS in developed economies. Although the differences are potentially marginal, the research results cannot be fully generalised across all AMS, especially those forming part of the mentioned sub-groups.

To address the limitation, recommendations for future research are made in the next section.

9.5 Recommendations and Future Research

To further expand on the new contributions made during this research the following recommendations for future research are suggested:

1. The research approached the identification of the CSF from the basis of the service life cycle phase which the factors belong to. Feedback from participants during the research process suggests that CSF could affect the success in more than one life cycle phase. Further research is suggested to identify the influence of the identified CSF across the various AMS life cycle phases.
2. Feedback from a small percentage of respondents ($\approx 1.8\%$) indicates difficulty in distinguishing between success factor meanings, in spite of the precaution taken to mitigate the risks relating to data collection errors (§6.2.3.2). Although there is no evidence that these errors invalidate the results, a degree of error in the list of success factors is to be expected. More research is necessary to clarify any ambiguities between success factors meanings. The original CSF methodology by Rockart (1981) defines Key Performance Indicators (KPI) for each CSF for monitoring its progress. Defining a set of supporting KPI for the success factors is suggested which will further clarify the meaning of each success factor.
3. An opportunity for further research is to collect more data on the success factors by enlarging the sample size and improving on the diversity of respondents. This would enrich the current research findings in the following ways:
 - Allow for higher order, factorial analysis of variance of the CSF differences between different sub-groups of different strata.
 - Further the understanding of CSF differences between the operational and South American role players compared to their respective counterparts.

- Larger asset owner representation in the sample will bring further understanding between the CSF perspective of asset owners and service providers.
 - Larger representation of European and North American respondents in the sample will further the CSF understanding between developing and developed economies.
4. It is recommended that DSMams is formalised into a web-based information system. Such a system will allow easy access to the CSF for the wider AMS community, while also creating the opportunity for collecting more data from users in support of 3 above.

These recommendations could provide interesting research opportunities to further expand on the understanding and scholarship of the underlying factors ensuring successful AMS and improvement opportunities in AM.

“It is not the critic who counts; not the man who points out how the strong man stumbles, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena, whose face is marred by dust and sweat and blood; who strives valiantly; who errs, who comes short again and again, because there is no effort without error and shortcoming; but who does actually strive to do the deeds; who knows great enthusiasms, the great devotions; who spends himself in a worthy cause; who at the best knows in the end the triumph of high achievement, and who at the worst, if he fails, at least fails while daring greatly, so that his place shall never be with those cold and timid souls who neither know victory nor defeat.”

– Theodore Roosevelt (1858-1919)

Appendices

Appendix A

Delphi Study Analysis

A.1 Research Ethics Committee Approval



UNIVERSITEIT-STELLENBOSCH-UNIVERSITY
jou kennisvermoë - your knowledge partner

Approval Notice New Application

15-Nov-2012
JOOSTE, Johannes Lodevyk

Protocol #: DESC_Jooste2012

Title: Physical asset management as a service a critical success factor model for asset management services

Dear Mr Johannes JOOSTE,

The **New Application** received on **24-Oct-2012**, was reviewed by staff members of the REC office on **13-Nov-2012** and was approved. Please note the following information about your approved research protocol:

Protocol Approval Period: **13-Nov-2012 -12-Nov-2013**

Standard provisions

1. The researcher will remain within the procedures and protocols indicated in the proposal, particularly in terms of any undertakings made in terms of the confidentiality of the information gathered.
2. The research will again be submitted for ethical clearance if there is any substantial departure from the existing proposal.
3. The researcher will remain within the parameters of any applicable national legislation, institutional guidelines and scientific standards relevant to the specific field of research.
4. The researcher will consider and implement the foregoing suggestions to lower the ethical risk associated with the research.

You may commence with your research with strict adherence to the abovementioned provisions and stipulations.

Please remember to use your **protocol number** (DESC_Jooste2012) on any documents or correspondence with the REC concerning your research protocol.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

After Ethical Review:

Please note that a progress report should be submitted to the Committee before the approval period has expired if a continuation is required. The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit.

National Health Research Ethics Committee (NHREC) number REC-050411-032.

This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

Provincial and City of Cape Town Approval

Please note that for research at a primary or secondary healthcare facility permission must be obtained from the relevant authorities (Western Cape Department of Health and/or City Health) to conduct the research as stated in the protocol. Contact persons are Ms Claudette Abrahams at Western Cape Department of Health (healthres@pgwc.gov.za Tel: +27 21 483 9907) and Dr Helene Visser at City Health (Helene.Visser@capetown.gov.za Tel: +27 21 400 3981). Research that will be conducted at any tertiary academic institution requires approval from the relevant parties. For approvals from the Western Cape Education Department, contact Dr AT Wyngaard (awynjaar@pgwc.gov.za, Tel: 0214769272, Fax: 0865902282, <http://wced.wcape.gov.za>).

Institutional permission from academic institutions for students, staff & alumni. This institutional permission should be obtained before submitting an application for ethics clearance to the REC.

Please note that informed consent from participants can only be obtained after ethics approval has been granted. It is your responsibility as researcher to keep signed informed consent forms for inspection for the duration of the research.

We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at 0218089183.

Sincerely,

Investigator Responsibilities

Protection of Human Research Participants

Some of the responsibilities investigators have when conducting research involving human participants are listed below:

1. Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2. Participant Enrollment. You may not recruit or enroll participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use. If you need to recruit more participants than was noted in your REC approval letter, you must submit an amendment requesting an increase in the number of participants.

3. Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the REC-approved consent documents, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4. Continuing Review. The REC must review and approve all REC-approved research protocols at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period**. Prior to the date on which the REC approval of the research expires, **it is your responsibility to submit the continuing review report in a timely fashion to ensure a lapse in REC approval does not occur**. If REC approval of your research lapses, you must stop new participant enrollment, and contact the REC office immediately.

5. Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, number of participants, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written REC review and approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6. Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouch within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the REC's requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch University Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7. Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research protocol and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC

8. Reports to Sponsor. When you submit the required reports to your sponsor, you **must** provide a copy of that report to the REC. You may submit the report at the time of continuing REC review.

9. Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

10. Final reports. When you have completed (no further participant enrollment, interactions, interventions or data analysis) or stopped work on your research, you must submit a Final Report to the REC.

11. On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.

A.2 First Round Questionnaire

Delphi Study: Variables affecting the success of physical asset

Participant Information Sheet

You are invited to participate in a research study conducted by Wyhan Jooste (MSc.Eng) and Prof PJ Vlok (PhD), from the Department of Industrial Engineering at Stellenbosch University. The results of the research study will contribute towards Wyhan's PhD research. You were selected as a potential participant in this study through your acquaintance with the researchers, your public profile as an asset management expert or your association with some of the leading global asset management consultancies.

1. PURPOSE OF THE STUDY
 Industry trends show that the demand for physical asset management services (AM services hereafter) is on the increase due to industrial, economic and technological pressures on asset owning companies. There is little research to date that has examined the factors affecting the success of AM services, let alone the critical few that are essential to these services.

From initial research a list of generic factors were identified that could influence the success of AM services. These factors need to be verified by experts familiar with AM services to ensure that the factors are applicable to the AM services field.

Once the verification study is complete, a sample of respondents from the AM services community will be asked to identify, from this verified list, the factors that are critical to the success of AM services.

2. PROCEDURE
 This verification study will be carried out using the Delphi technique which consists of three questionnaires (known as rounds), at the end of which a consensus will be reached. For each of the rounds a link to an online questionnaire will be emailed to you.

After you indicate your willingness to participate, you will receive the first questionnaire. Specific instructions will be included in each questionnaire.

The amount of time necessary for completing of each questionnaire (or round) will vary with each panelist, but should range in approximately 15-20 minutes for Round 1; and 10-15 minutes for Rounds 2 and 3. There are no right or wrong answers to the questions. This study is seeking your expert opinion.

3. POTENTIAL RISKS
 We are not aware of any complications or risks that could arise from you taking part in this study. However, should you have any complaints or difficulties with any aspect of the study you can contact the researchers at the contact details specified in Section 8.

4. POTENTIAL BENEFITS TO PARTICIPANTS AND/OR SOCIETY
 We cannot promise the study will benefit you as an individual, but the information we obtain may contribute in improving the understanding and future research of asset management and AM services.

5. PAYMENT FOR PARTICIPATION
 You will receive no payment for your participation, but will receive our gratitude.

6. CONFIDENTIALITY
 Any information that is obtained in connection with this study and that you can be identified with will remain confidential and will only be disclosed with your permission or as is required by law. Confidentiality will be maintained by means of allocating an unique code to you that will only be identifiable to the researchers. You will remain anonymous to the other participants (or experts) throughout the Delphi study and only the researchers will be able to identify your specific answers.

7. PARTICIPATION AND WITHDRAWAL
 You can choose whether to be in this study or not. If you volunteer for this study, you may withdraw at any time without consequences of any kind. The researchers may withdraw you from this research if circumstances arise which warrant their doing so.

8. IDENTIFICATION OF RESEARCHERS
 If you have any questions or concerns about the research, please contact the primary researcher, Wyhan Jooste (12882046@sun.ac.za; +27 83 456 0648), or the research promoter, Prof PJ Vlok (pjvlok@sun.ac.za; +27 82 821 2108).

9. RIGHTS OF RESEARCH SUBJECTS
 You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Maléne Fouché [mfouche@sun.ac.za; +27 21 808 4622] at the Division for Research Development.

Delphi Study: Variables affecting the success of physical asset

*** Consent to participate in research:**

I am willing to participate in this study.

I am NOT willing to participate in this study.

Delphi Study: Variables affecting the success of physical asset

Round 1 Delphi: Instructions

Thank you for your consent and willingness to participate.

The first round of this Delphi study lists all of the factors identified from a comprehensive literature study on factors that affect the success of AM services.

For the purpose of the questionnaire an AM service can be defined as a medium to long term intervention where value is co-created between a service provider and asset owning customer. For simplicity, only consider the primary role players – the AM service provider and the customer. Ignore second and third tier sub-providers and contractors. The nature of the intervention can be across any combination or all of the AM life cycle phases.

It is important that you answer the questionnaire in the context of your experience as a customer with your AM service providers; or as an AM service provider to your customer.

You will see a scale beside each factor. It is a 5-point scale with options for: Very Important, Important, Less Important, Unimportant and Neither important or unimportant. Please tick the box which you feel best describes how important each factor is towards the success of AM services, as defined above.

Your choices will be anonymously saved on a database for analysis and preparation for Round 2.

Please complete the demographics page at the end of the questionnaire. It is important that the researcher can put the responses in context with the demographics of the respondent.

Please complete the questionnaire by Wednesday, 5 December 2012.

Delphi Study: Variables affecting the success of physical asset

Round 1 Delphi: Generic Success Factors

***How important are the following variables relating to the ORGANISATIONAL ENVIRONMENT AND CAPABILITIES of the organisation that provide AM services, towards the success of AM services?**

	Very Important	Important	Less Important	Unimportant	Neither
A capable project manager that manages the AM service on behalf of the service provider	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A clear management structure and role understanding within the service provider organisation in order not to overlap in the AM service provision process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The leadership, technical and managerial styles of the AM service provider's management (i.e. their involvement in the AM service provision process, their decision-making style as well as how they motivate and supervise subordinates)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The innovation culture of the service provider (i.e. how innovative is the organisation with their design and delivery processes)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A good reputation in the field or industry the service provider operates in	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A dedicated service team that only focuses on delivering a specific type of service (in contrast to a team that delivers a variety of different types of service and product-service combinations)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The level of employee engagement and morale (i.e. good team spirit, in contrast to a disengaged workforce)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The degree to which the service provider leverage their existing knowledge and capabilities to provide a more efficient service to their clients	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The service provider's culture towards the learning and growth of its employees	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The geographic location and distance between the operational office of the service provider and the client's operations at which the AM services are delivered	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Degree to which the service provider's client facing team (sales representatives, project managers, service personnel) are knowledgeable in the full range of the service provider's value proposition and combination of service options available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The availability of the most appropriate skilled resources for providing industry specific AM service requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify additional variables for consideration or any comments on the current list of variables.

Delphi Study: Variables affecting the success of physical asset

***How important are the following variables relating to INITIATION PHASE AND PRE-CONTRACT ACTIVITIES, towards the success of AM services?**

	Very Important	Important	Less Important	Unimportant	Neither
The involvement of all client stakeholders in the initiation and specification of an AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Continued and sustained commitment from the client's senior management in support of the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The awareness and knowledge that the client's management have towards the type of AM service that is required by their organisation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The active participation of the client personnel and their commitment towards completing the pre-contract activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The urgency with which the client organisation requires a solution to their AM problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clear and well defined technical and operational user requirements for the AM service required	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The alignment of the client organisation's AM service requirements with their overall organisational and business strategies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The client organisation's acquisition process for AM and other services (i.e. evaluation of service providers, tender processes)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Agreement on a predefined invoicing and payment plan between the service provider and client organisation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compilation and availability of formal contractual documents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Willingness by both the client organisation and service provider to consider new approaches (compared to preconceived ideas) to ensure an effective AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A detailed project plan with milestones in place	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The service provider's process for compiling a solution for the client (ie the understanding of the problem, evaluation of alternative solutions and consideration of various aspects such as logistics and safety considerations)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The conciseness and effectiveness of the presentation and communication of the proposed solution to the client	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The AM service solution offering consisting of the appropriate bundling of products and services at a market related price (in other words obtaining value from a spot-on solution)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify additional variables for consideration or any comments on the current list of variables.

Delphi Study: Variables affecting the success of physical asset

***How important are the following variables relating to the PREPARATION AND DESIGN PROCESSES, towards the success of AM services?**

	Very Important	Important	Not Important	Unimportant	Neither
The availability and transparency of information (for design and implementation purposes) between the service provider and client team for preparing and designing the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Design and integration of service and performance metrics for all stakeholders (service provider and client) involved in the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The inter-company flow of information (between the service provider and client organisation) during the AM service design	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The use of the latest methods in managing risks that could arise during the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A formal service level agreement or policy (i.e. outlining budgets, communication, configuration control, personnel management, service provider performance requirements, client responsibilities) forming part of the design process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compilation and active use of design documents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ensuring that pre-project arrangements are made for logistics, feasibility studies and changes in organisational structures that might arise from the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The potential of the AM service to be scalable (expandable to other business units within the client organisation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Setting realistic project deadlines and budget targets	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The use of a practice run or pilot projects for the designed AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The degree to which the client is knowledgeable and experienced in AM and AM services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The strategic fit of the AM service with the service provider and client's current service propositions, systems and capabilities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The ability to integrate the AM service into the client's core business processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Evaluation and consideration of different AM service designs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The integration of health, safety, environmental and quality considerations as part of the AM service or to align the service to existing standards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The integration of operational excellence methodologies, such as TPM, TQM, 5S into the AM service offering or to align the service to existing standards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The availability of adequate infrastructure and interfaces in support of the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
An adequate information system implementation (i.e. CMMS, EAMS, ERP) strategy, including data migration (if applicable), and data quality assurance to support the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Adequate legacy system knowledge, if such systems are required to interface with the AM service information systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Avoidance of unnecessary customisation to existing information systems, especially ERP systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Incorporation of the latest technology (i.e. mobility solutions) into the AM service design	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The security and protection of information, relating to information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Delphi Study: Variables affecting the success of physical asset
 systems that forms part of the AM service

Please specify additional variables for consideration or any comments on the current list of variables

***How important are the following variables relating to the IMPLEMENTATION AND COMMISSIONING PHASES, towards the success of AM services?**

	Very Important	Important	Less Important	Unimportant	Neither
The use of a formalised project plan or schedule for implementing the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Good project scope management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formal design or implementation reviews at logical stages during the implementation and commissioning phases	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalised handover, testing and a quality control plan to ensure that the implementation was done successfully	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
An adequate training programme in place for all AM service role players, both in the service provider and client teams	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
An effective organisational change management programme in support of the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify additional variables for consideration or any comments on the current list of variables

Delphi Study: Variables affecting the success of physical asset

***How important are the following variables relating to the AM service CONTROL PROCESSES, towards the success of AM services?**

	Very Important	Important	Less Important	Unimportant	Neither
The active management of the roles and responsibilities of the service provider and client organisation, relating to the AM service contract	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The monitoring of budgets and costs relating to the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Configuration control of current AM service processes and systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Management of mutual expectations between the service provider and client relating to the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The management of quality assurance of third party suppliers (contractors), if they are used as part of the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Periodic audits to ensure all aspects of the AM service is up to standard as per the agreement between the service provider and client	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The active management of the relationship between the service provider and client organisation personnel involved in the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The appreciation of diversity among inter-company teams involved in the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The degree to which there is inter-company learning and collaboration between the service provider and the client organisation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Open and effective communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mutual trust and respect between the service provider and client organisation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Active client participation in reporting, problem solving and improvement relating to the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Agility (responsiveness) in responding to changes in AM service demands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Measurement and improvement of the AM service to increase the value-add and benefits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Multi-level feedback, reviews and reporting (i.e. all hierarchical levels in the service provider and client organisations are periodically involved in improvement initiatives)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Proper priority setting of improvement actions, irrespective whether it is service or value-add related	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify additional variables for consideration or any comments on the current list of variables.

Delphi Study: Variables affecting the success of physical asset

***How important are the following variables relating to BENEFITS AND VALUE-ADD, towards the success of AM services?**

	Very Important	Important	Less Important	Unimportant	Neither
The consideration of intangible (not measurable) benefits and value creation (i.e. increased effectiveness, risk mitigation, improved decision-making capability) as a result of the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feedback and sharing of lessons learned from successful improvements made to the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formal post launch evaluations of the AM service to determine what can be improved	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Proof of technological and systemic benefits and value creation as a result of the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Proof of operational and financial performance achievements as a result of the AM service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The ability to measure the AM service quality and value creation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Focused and continuous improvement to the AM service through monitoring, analysis and feedback	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify additional variables for consideration or any comments on the current list of variables.

Delphi Study: Variables affecting the success of physical asset

Round 1 Delphi: Generic Success Factors

Any final comments or feedback to be considered for the next round



Delphi Study: Variables affecting the success of physical asset

Round 1 Delphi: Demographic Information

Please supply the following information

Name

Company

Position

What is your gender?

Female

Male

What is your age category?

25-34

35-44

45-54

55-65

>65

In which of the following industry sectors do you work in?

Agriculture, forestry and fishing

Mining and quarrying

Manufacturing

Electricity, gas, steam and air conditioning supply

Water supply, sewerage, waste management

Construction

Wholesale and retail trade

Transportation and storage

Other (please specify)

Delphi Study: Variables affecting the success of physical asset

What is the primary country which you operate from?

- Australia
- Brazil
- Canada
- Netherlands
- South Africa/Africa
- Sweden

Other (please specify)

How many years experience do you have in asset management services?

- <5
- 5-10
- 10-20
- 20-30
- >30

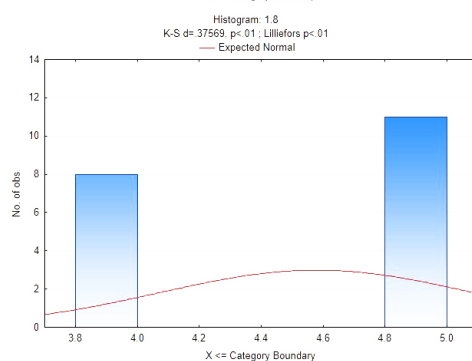
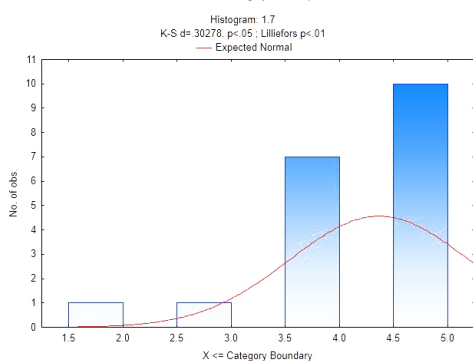
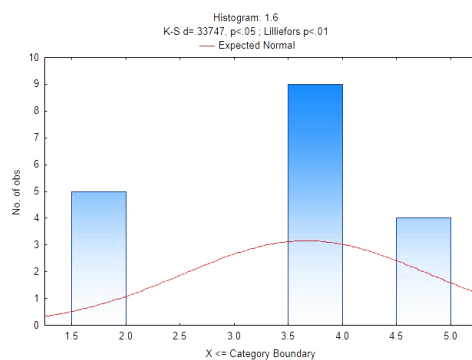
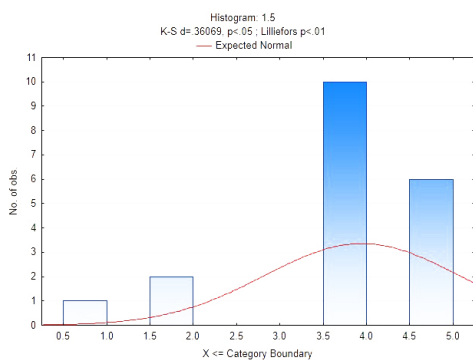
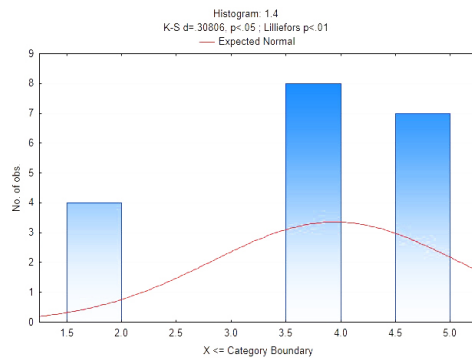
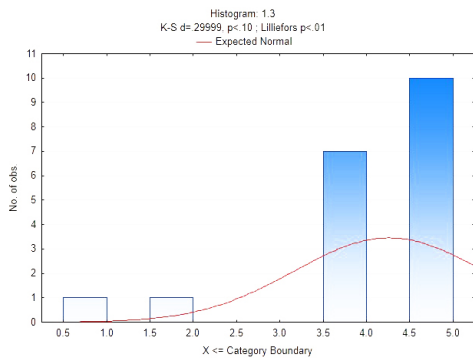
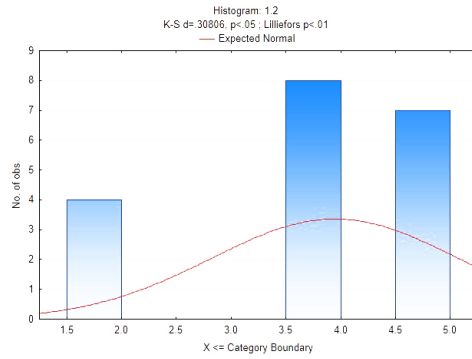
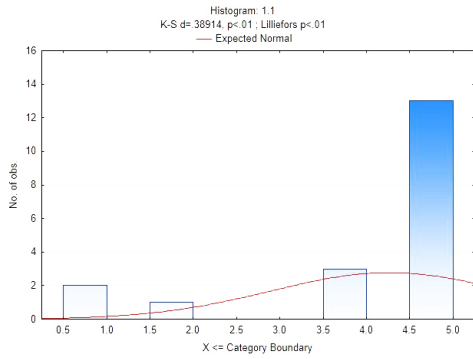
What is your role in relation to asset management services?

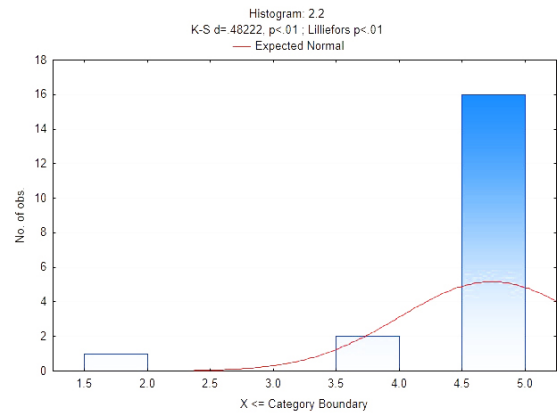
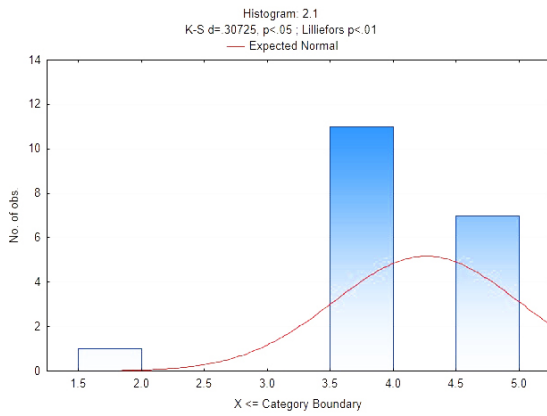
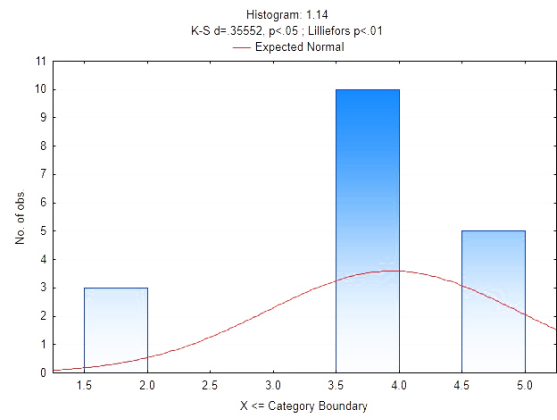
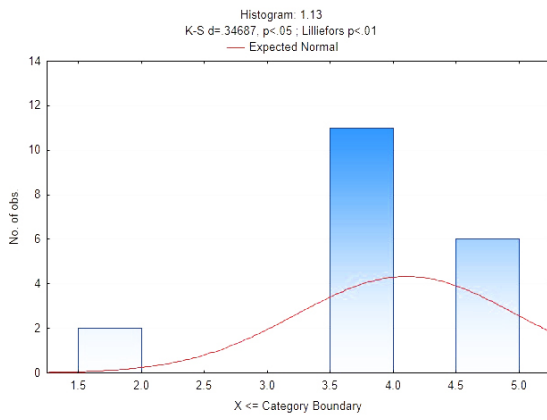
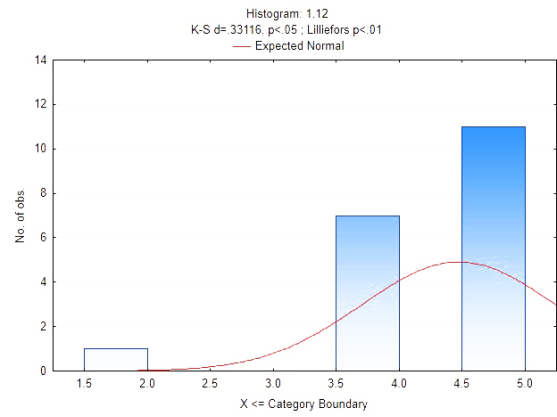
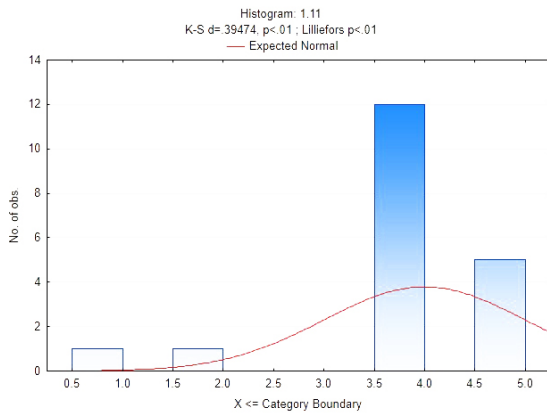
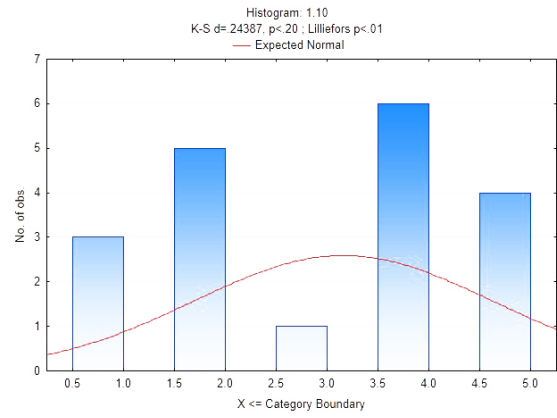
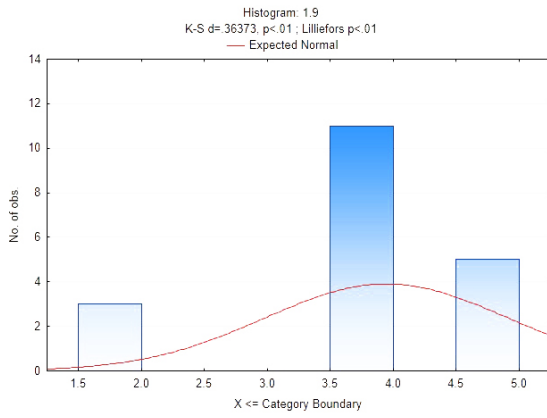
- Asset, equipment or facilities owner/representative
- Consultant/service provider/supplier

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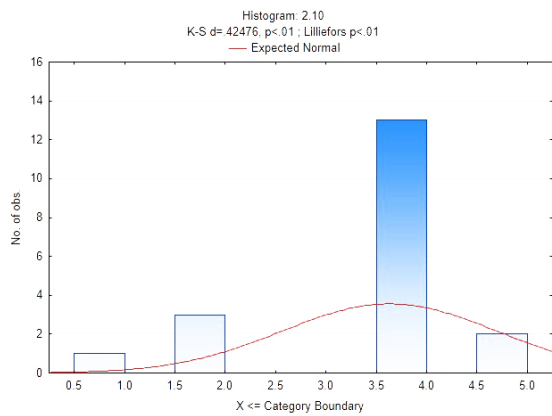
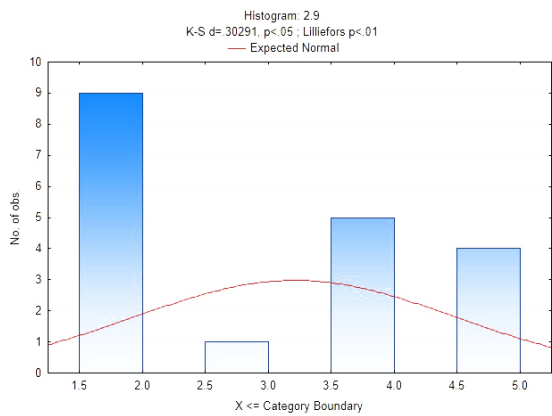
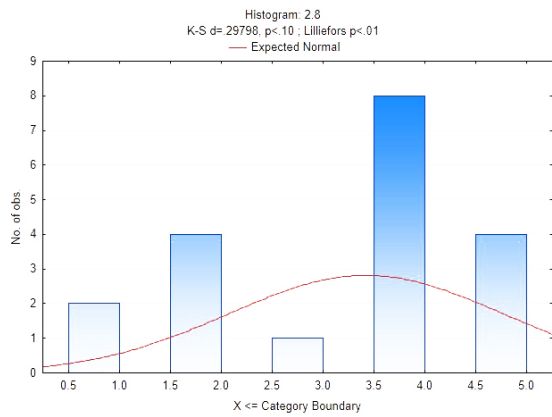
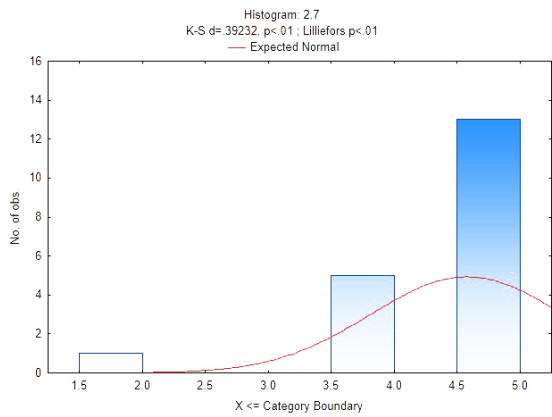
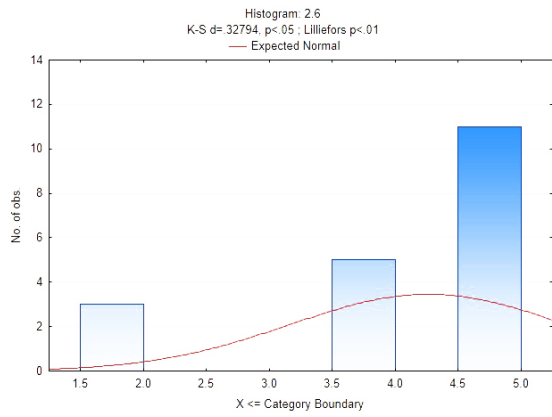
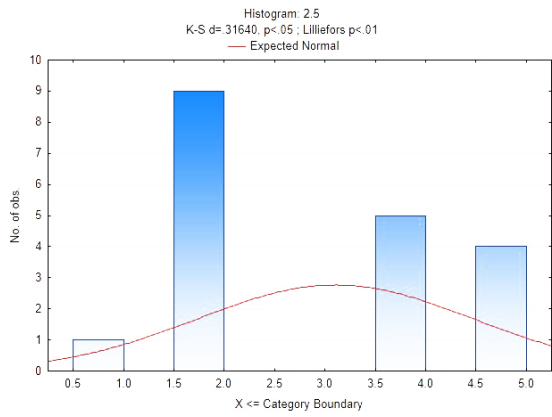
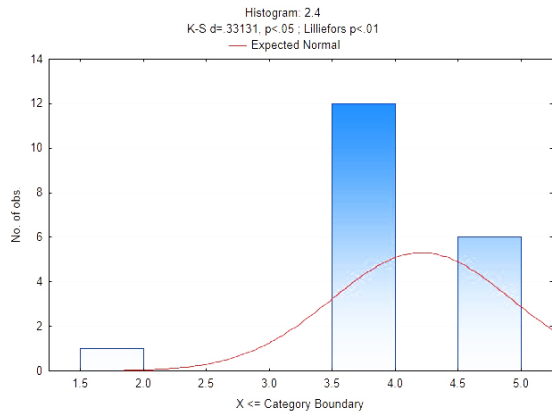
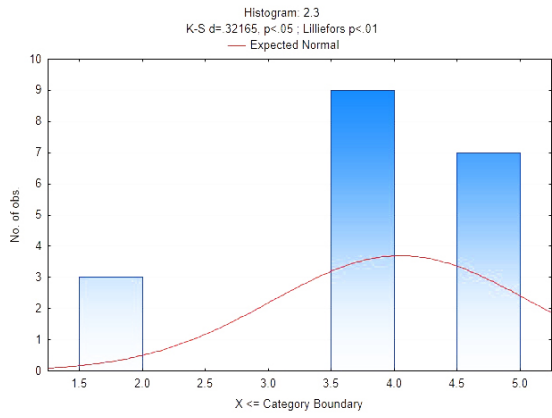
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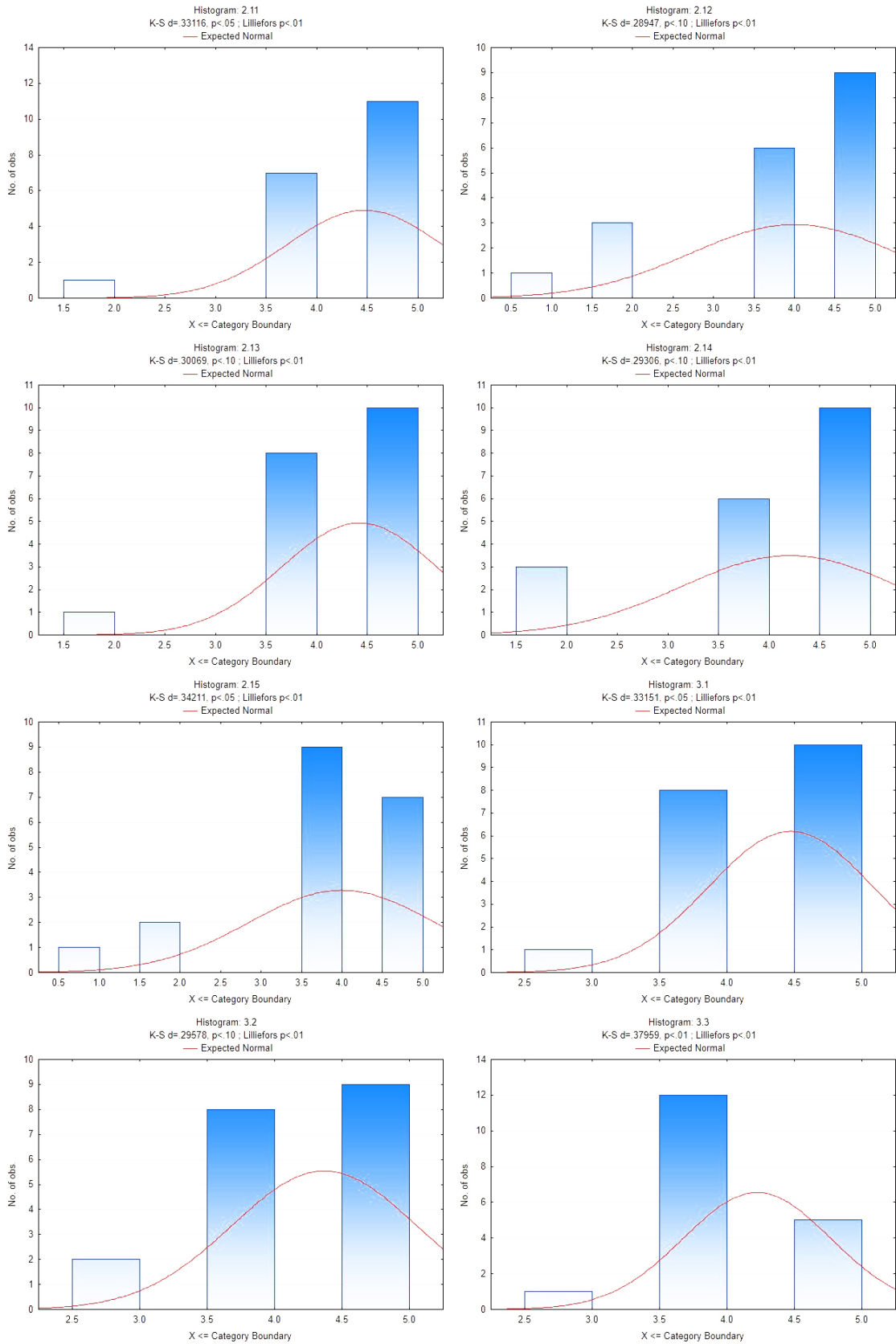
A.3 Histograms of First Round Responses



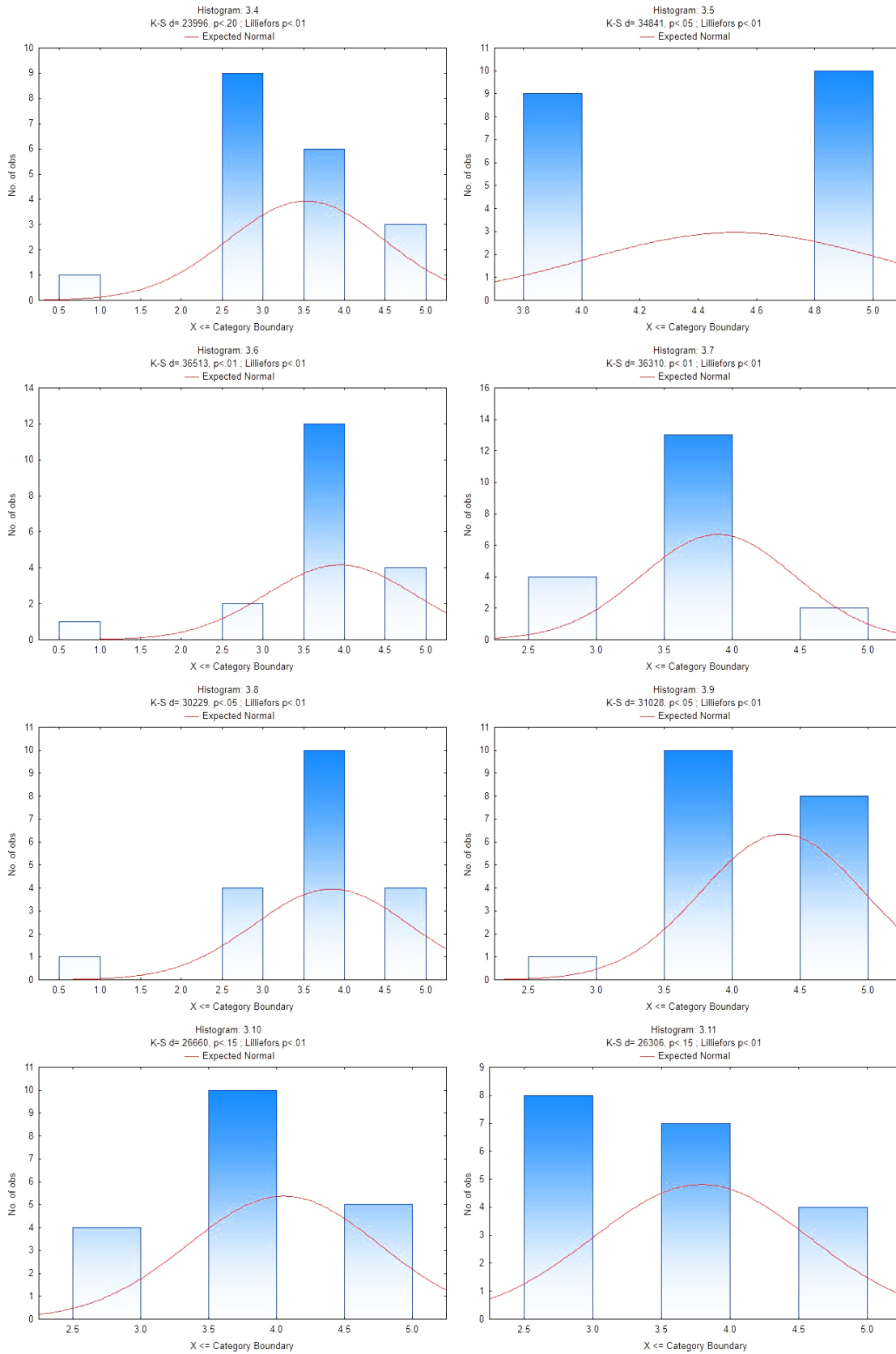


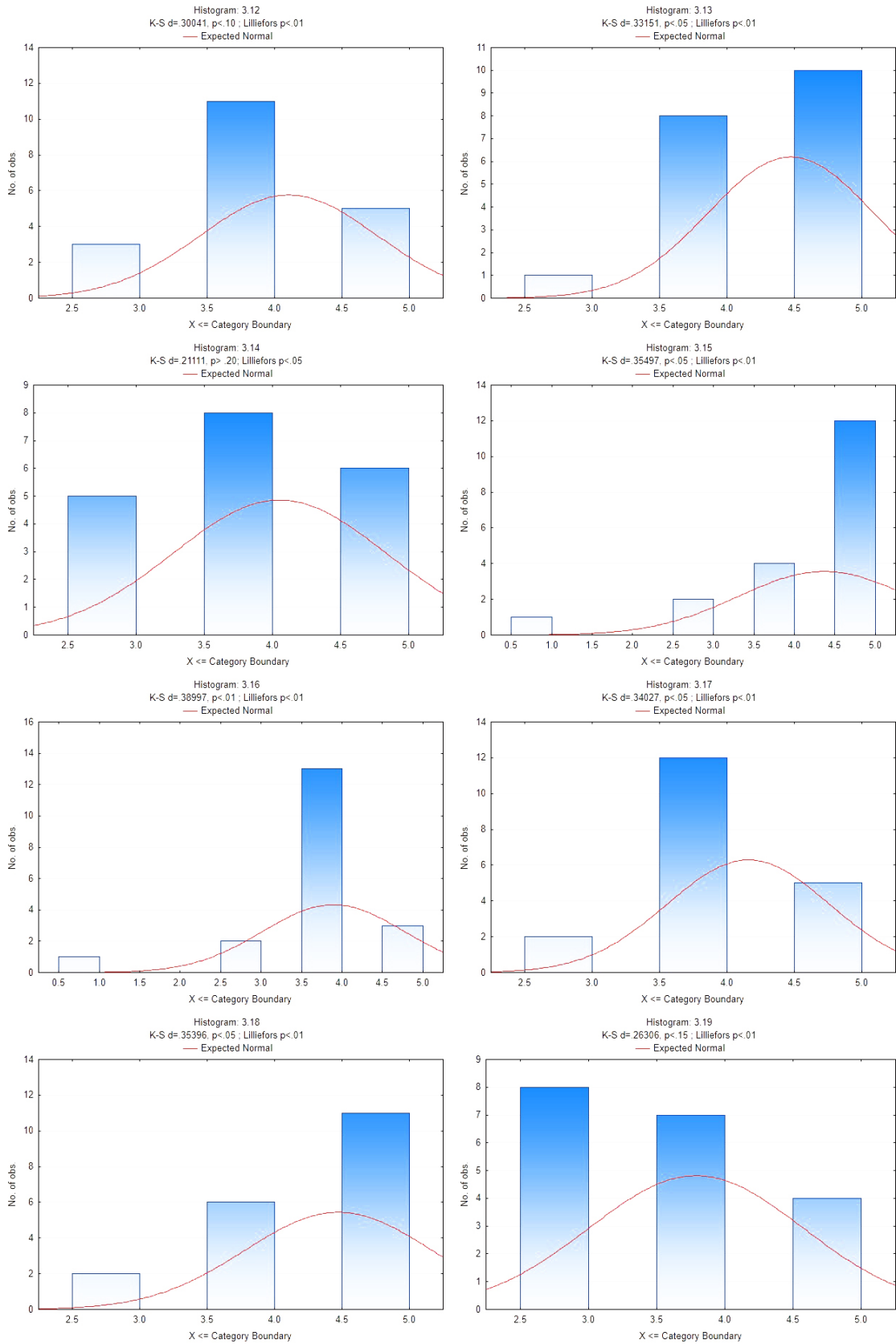
A.3. HISTOGRAMS OF FIRST ROUND RESPONSES



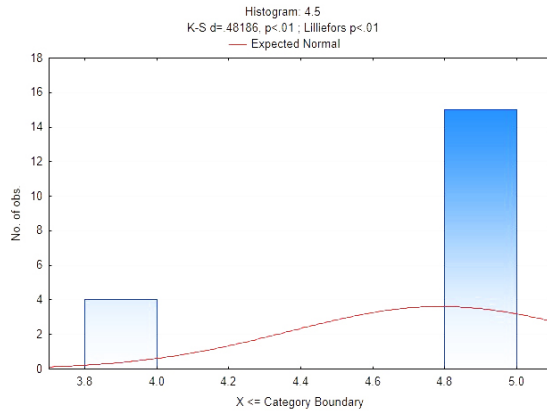
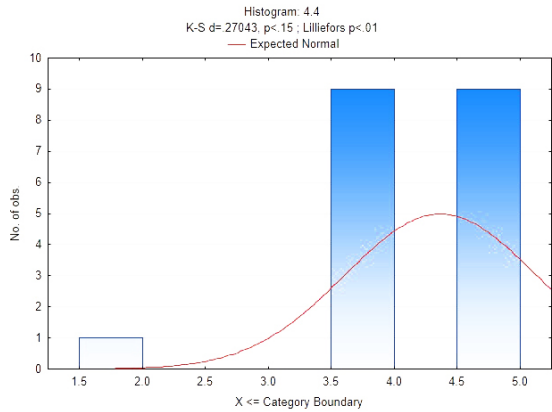
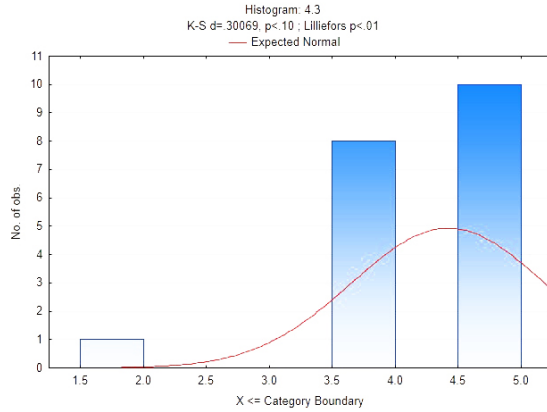
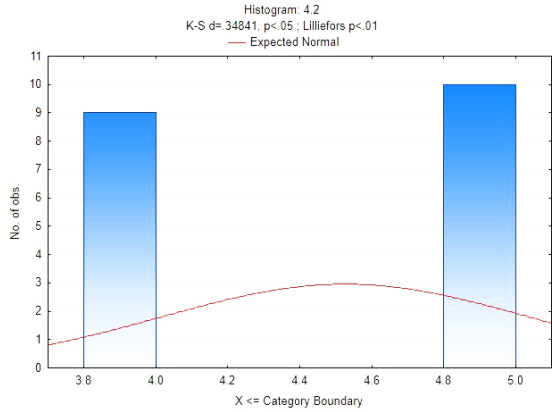
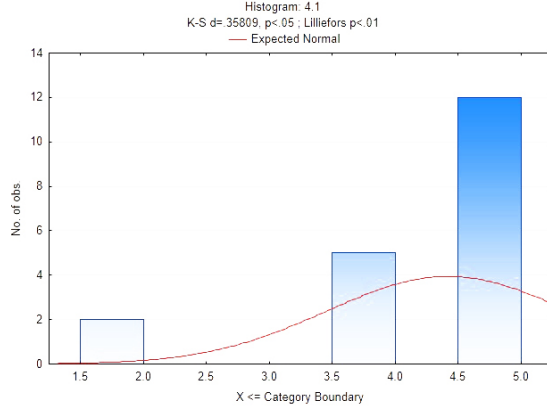
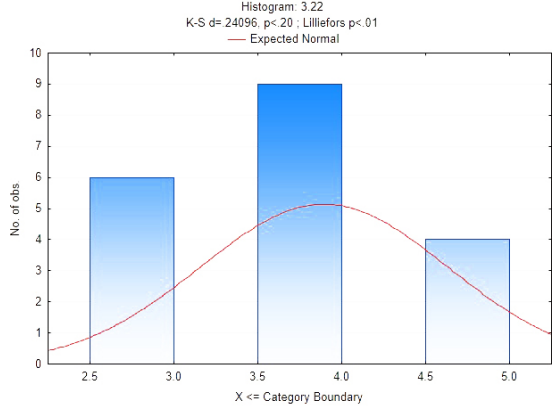
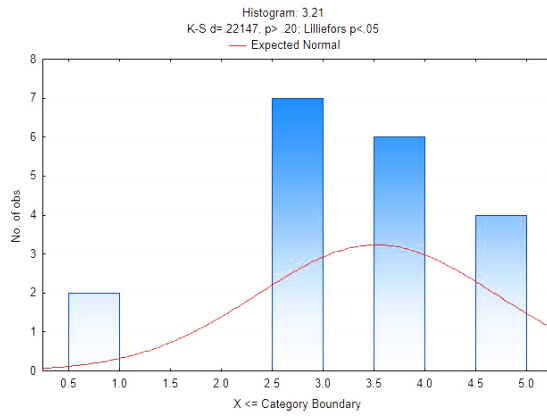
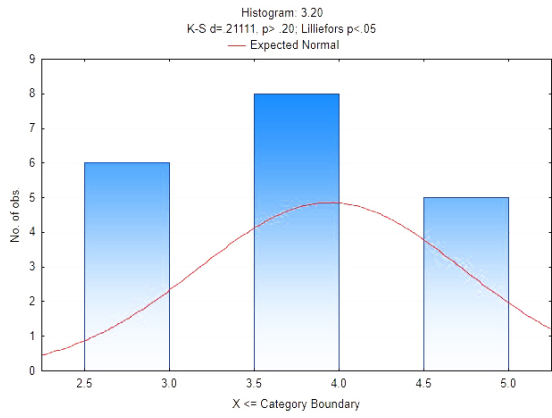


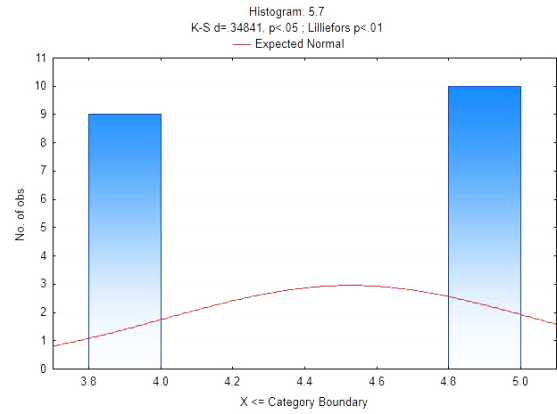
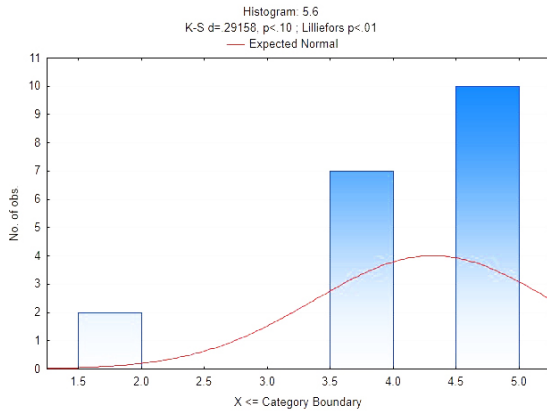
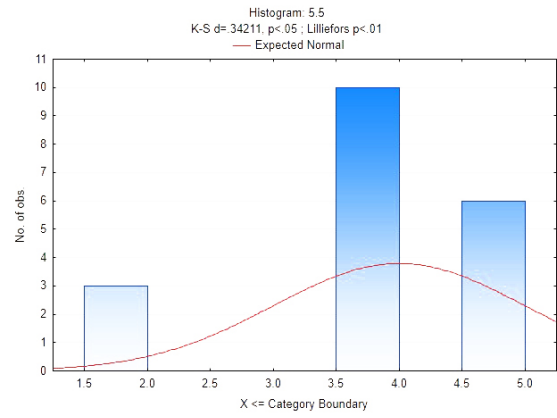
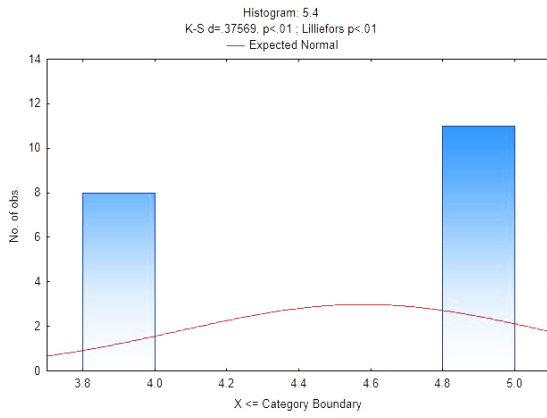
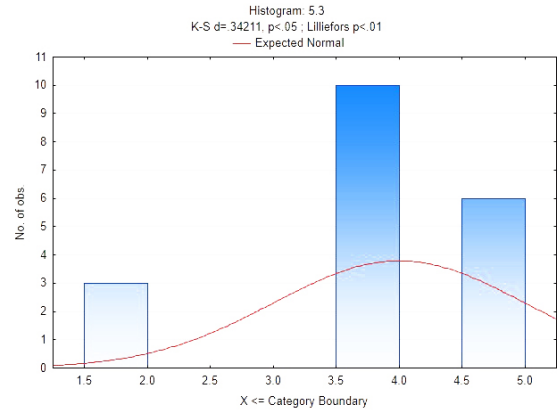
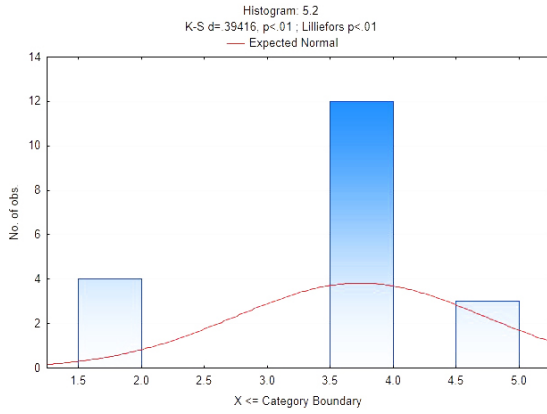
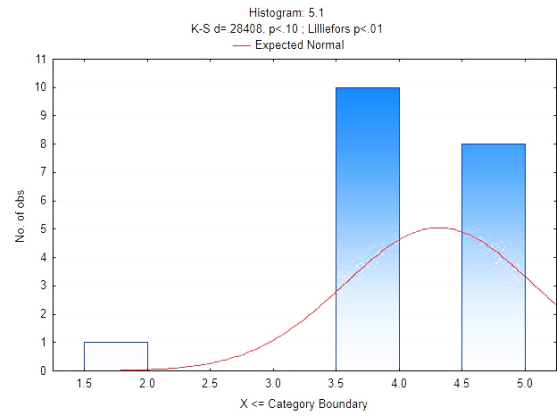
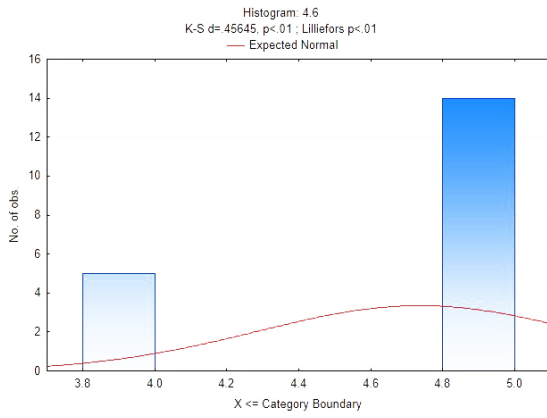
A.3. HISTOGRAMS OF FIRST ROUND RESPONSES



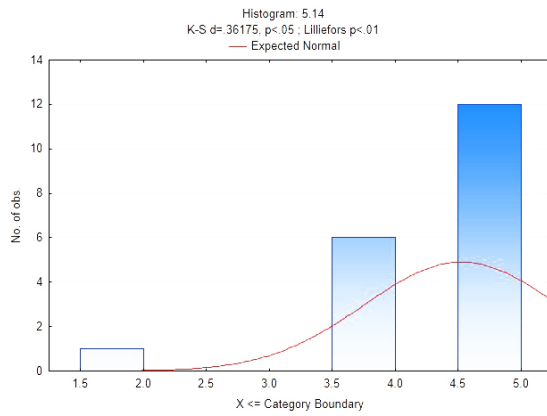
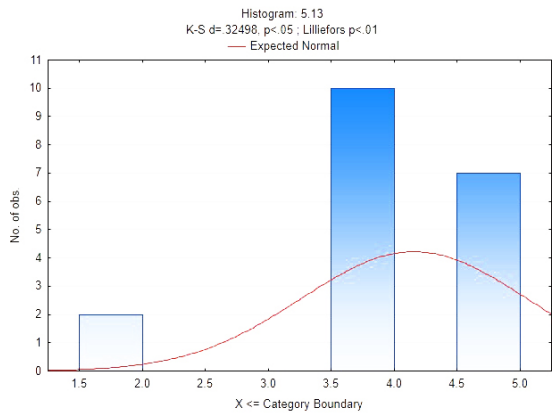
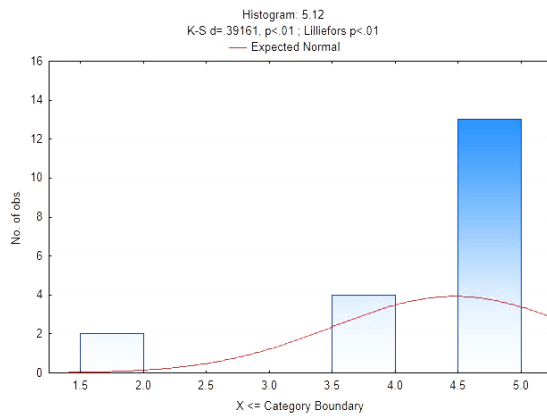
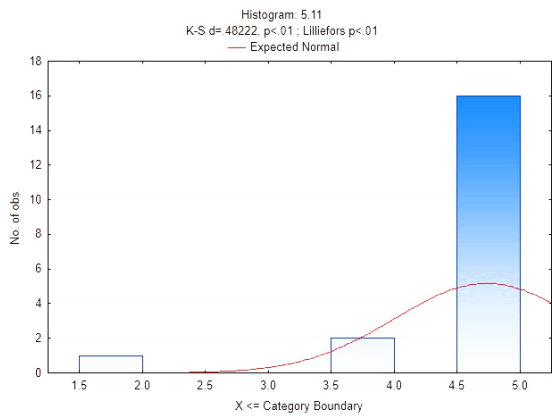
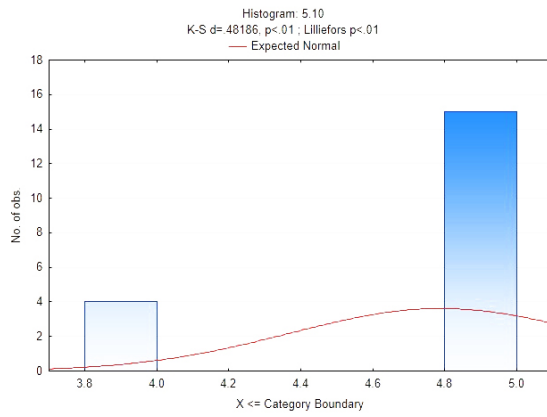
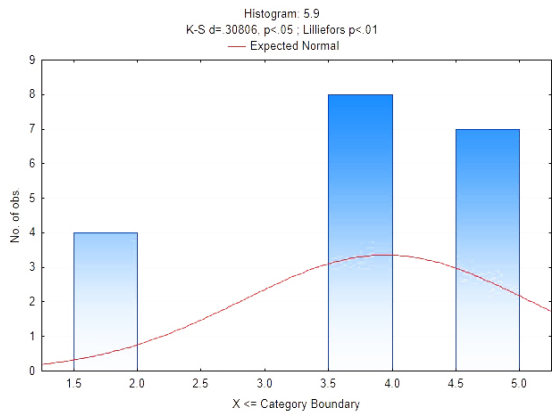
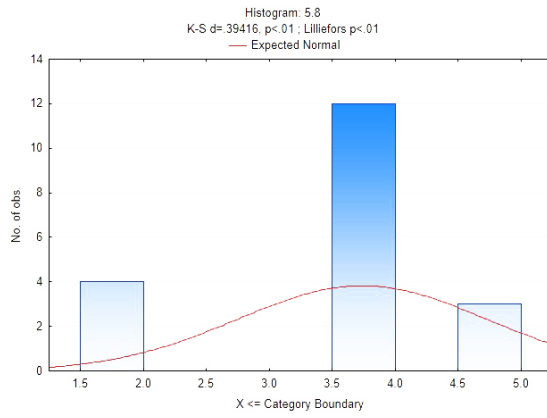
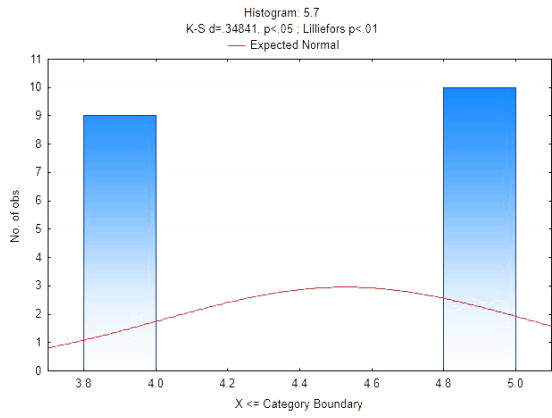


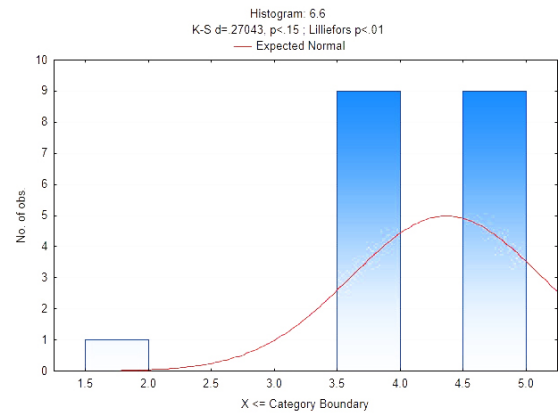
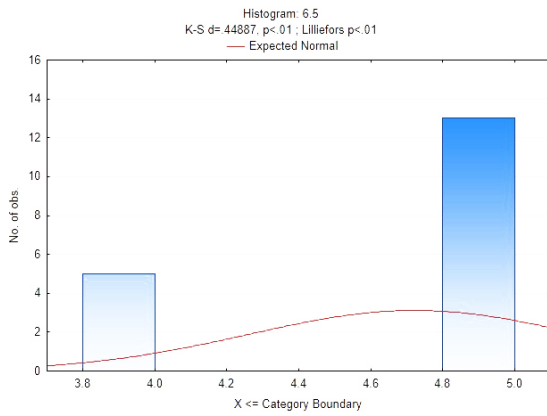
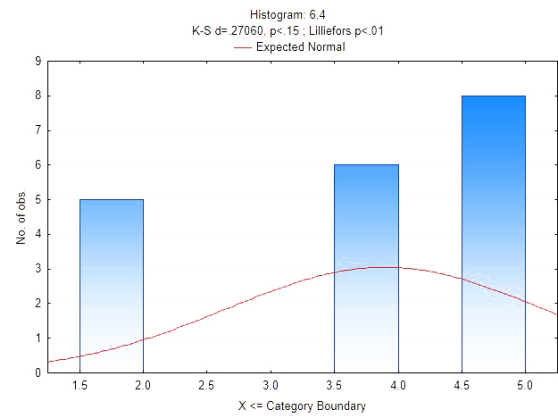
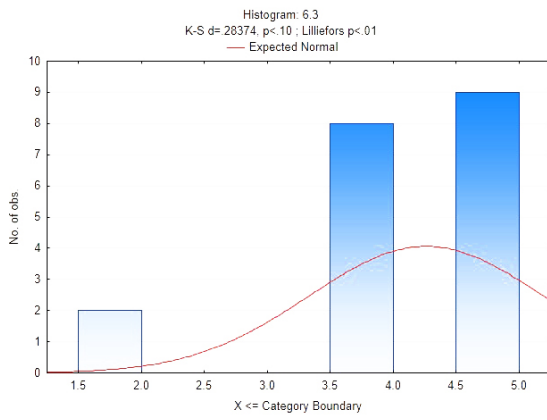
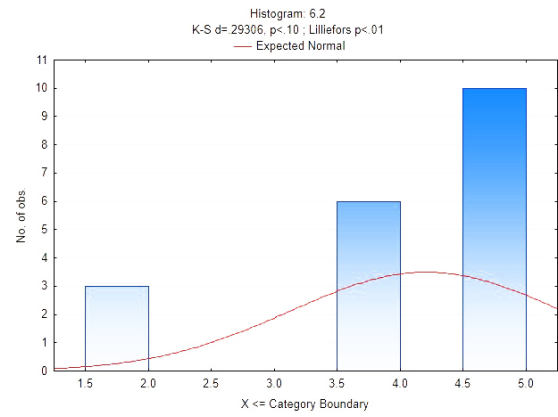
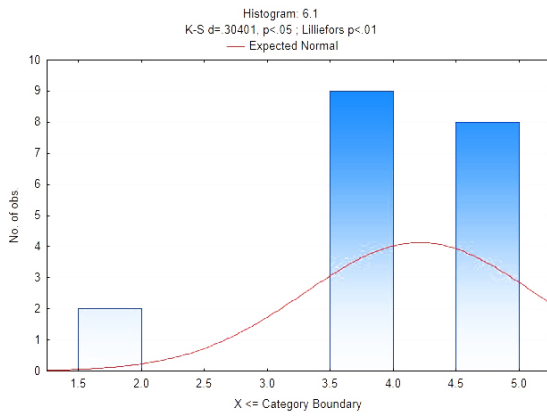
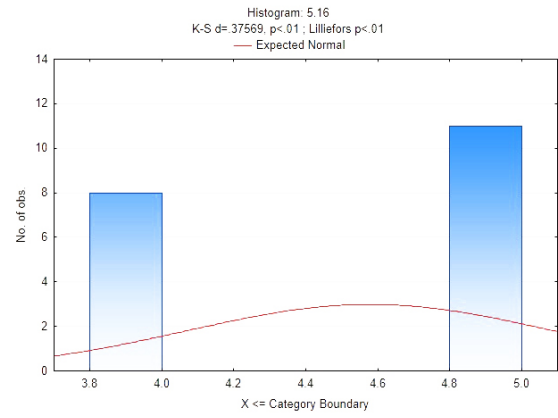
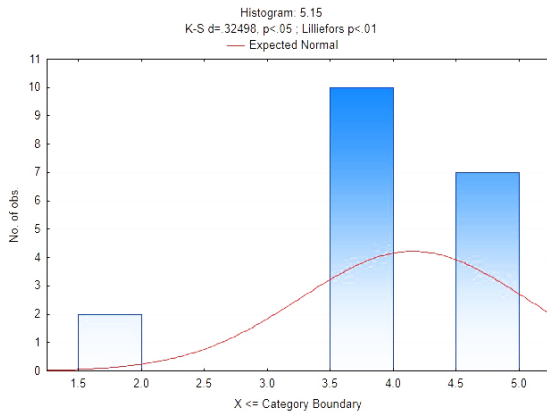
A.3. HISTOGRAMS OF FIRST ROUND RESPONSES





A.3. HISTOGRAMS OF FIRST ROUND RESPONSES





A.4 First Round Panellist Role Kruskal-Wallis Tests

Kruskal-Wallis by Rank (First Round Panellist Role)								
Marked effects are significant at $p < .05$								
Factor	Service Provider			Asset Owner			<i>H</i>	<i>p</i> _{5%}
	N	Sum of Ranks	Mean Rank	N	Sum of Ranks	Mean Rank		
	1.1	12	107	8.917	7	83		
1.2	12	106.5	8.875	7	83.5	11.929	1.499	0.221
1.3	12	114	9.500	7	76	10.857	0.319	0.572
1.4	12	108	9.000	7	82	11.714	1.184	0.277
1.5	12	128.5	10.708	7	61.5	8.786	0.627	0.429
1.6	11	101.5	9.227	7	69.5	9.929	0.087	0.768
1.7	12	105.5	8.792	7	84.5	12.071	1.863	0.172
1.8	12	120.5	10.042	7	69.5	9.929	0.002	0.961
1.9	12	141	11.750	7	49	7.000	4.008	0.045
1.10	12	122.5	10.208	7	67.5	9.643	0.048	0.827
1.11	12	120	10.000	7	70	10.000	0.000	1.000
1.12	12	132	11.000	7	58	8.286	1.357	0.244
1.13	12	108.5	9.042	7	81.5	11.643	1.218	0.270
1.14	12	97.5	8.125	6	73.5	12.250	2.967	0.085
2.1	12	138	11.500	7	52	7.429	3.054	0.081
2.2	12	129	10.750	7	61	8.714	1.437	0.231
2.3	12	110	9.167	7	80	11.429	0.848	0.357
2.4	12	110.5	9.208	7	79.5	11.357	0.897	0.344
2.5	12	115.5	9.625	7	74.5	10.643	0.167	0.683
2.6	12	120	10.000	7	70	10.000	0.000	1.000
2.7	12	129	10.750	7	61	8.714	0.872	0.350
2.8	12	111.5	9.292	7	78.5	11.214	0.568	0.451
2.9	12	123	10.250	7	67	9.571	0.074	0.786
2.10	12	121	10.083	7	69	9.857	0.011	0.918
2.11	12	101	8.417	7	89	12.714	3.402	0.065
2.12	12	92.5	7.708	7	97.5	13.929	6.277	0.012
2.13	12	111	9.250	7	79	11.286	0.740	0.390
2.14	12	125	10.417	7	65	9.286	0.217	0.641
2.15	12	107.5	8.958	7	82.5	11.786	1.321	0.250
3.1	12	115.5	9.625	7	74.5	10.643	0.185	0.667

Kruskal-Wallis by Rank (First Round Panellist Role)								
Marked effects are significant at $p < .05$								
Factor	Service Provider			Asset Owner			<i>H</i>	<i>p</i> _{5%}
	N	Sum of Ranks	Mean Rank	N	Sum of Ranks	Mean Rank		
3.2	12	124	10.333	7	66	9.429	0.139	0.709
3.3	12	115.5	9.625	6	55.5	9.250	0.029	0.865
3.4	12	101.5	8.458	7	88.5	12.643	2.841	0.092
3.5	12	136	11.333	7	54	7.714	2.438	0.118
3.6	12	122.5	10.208	7	67.5	9.643	0.060	0.806
3.7	12	130	10.833	7	60	8.571	1.064	0.302
3.8	12	123.5	10.292	7	66.5	9.500	0.104	0.747
3.9	12	126.5	10.542	7	63.5	9.071	0.386	0.534
3.10	12	122	10.167	7	68	9.714	0.034	0.853
3.11	12	115.5	9.625	7	74.5	10.643	0.167	0.683
3.12	12	118	9.833	7	72	10.286	0.036	0.849
3.13	12	111	9.250	7	79	11.286	0.740	0.390
3.14	12	109	9.083	7	81	11.571	0.984	0.321
3.15	12	95.5	7.958	7	94.5	13.500	5.798	0.016
3.16	12	119.5	9.958	7	70.5	10.071	0.003	0.959
3.17	12	129	10.750	7	61	8.714	0.792	0.374
3.18	12	121.5	10.125	7	68.5	9.786	0.021	0.886
3.19	12	123	10.250	7	67	9.571	0.074	0.786
3.20	12	110.5	9.208	7	79.5	11.357	0.734	0.392
3.21	12	107	8.917	7	83	11.857	1.326	0.250
3.22	12	115	9.583	7	75	10.714	0.209	0.648
4.1	12	95.5	7.958	7	94.5	13.500	5.868	0.015
4.2	12	126.5	10.542	7	63.5	9.071	0.402	0.526
4.3	12	115.5	9.625	7	74.5	10.643	0.185	0.667
4.4	12	117	9.750	7	73	10.429	0.081	0.775
4.5	12	125	10.417	7	65	9.286	0.357	0.550
4.6	12	121.5	10.125	7	68.5	9.786	0.028	0.868
5.1	12	114	9.500	7	76	10.857	0.329	0.566
5.2	12	117	9.750	7	73	10.429	0.087	0.768
5.3	12	135.5	11.292	7	54.5	7.786	2.090	0.148
5.4	12	139.5	11.625	7	50.5	7.214	3.704	0.054
5.5	12	121	10.083	7	69	9.857	0.009	0.926
5.6	12	114	9.500	7	76	10.857	0.319	0.572
5.7	12	126.5	10.542	7	63.5	9.071	0.402	0.526

Kruskal-Wallis by Rank (First Round Panellist Role)								
Marked effects are significant at $p < .05$								
Factor	Service Provider			Asset Owner			<i>H</i>	<i>p</i> _{5%}
	N	Sum of Ranks	Mean Rank	N	Sum of Ranks	Mean Rank		
5.8	12	109.5	9.125	7	80.5	11.500	1.069	0.301
5.9	12	114	9.500	7	76	10.857	0.296	0.586
5.10	12	115.5	9.625	7	74.5	10.643	0.289	0.591
5.11	12	129	10.750	7	61	8.714	1.437	0.231
5.12	12	130.5	10.875	7	59.5	8.500	1.174	0.279
5.13	12	118	9.833	7	72	10.286	0.035	0.851
5.14	12	104.5	8.708	7	85.5	12.214	2.389	0.122
5.15	12	118	9.833	7	72	10.286	0.035	0.851
5.16	12	111	9.250	7	79	11.286	0.789	0.374
6.1	12	129.5	10.792	7	60.5	8.643	0.786	0.375
6.2	12	96.5	8.042	7	93.5	13.357	4.804	0.028
6.3	12	107	8.917	7	83	11.857	1.472	0.225
6.4	12	94	7.833	7	96	13.714	5.499	0.019
6.5	11	87	7.909	7	84	12.000	4.161	0.041
6.6	12	94	7.833	7	96	13.714	6.116	0.013
6.7	12	98	8.167	7	92	13.143	4.610	0.032

A.5 Panellist Feedback

Organisational Environment and Capabilities

1. *“The proactive nature and ownership of the business outcomes by the service provider. Understanding the context of our business (our client needs) and going beyond KPI’s to deliver the best business outcomes.”*

Action: A new factor is added to the Delphi Round 2 questionnaire: “The ability of the service provider to proactively gain an understanding of the client’s business outcomes and to go beyond key performance measures to deliver and support these business outcomes.”

2. *“The Service Provider’s client staff must be able to manage change and resistance. The Service Provider’s Client staff must understand communication*

channels and be able to recognise breakdown in communication and provide a strategy to restore two way communication. The Service Provider must be able to provide 'best practice' options throughout the Life Cycle. Every Client must feel as important as other clients and receive the best staff."

Action: The wording for the change management factor in the implementation and commissioning phase category is updated.

3. *"Service provider also needs a certain values set to ensure sustainability of the service. Critical for management to live these values."*

Action: A new factor is added to the Delphi Round 2 questionnaire: "The integrity of the service provider's leadership and delivery team and the set of values they live by to ensure sustainability of the service."

4. *"The ability to integrate and be accepted in the client's organisation structure."*

Action: A new factor is added to the Delphi Round 2 questionnaire: "The ability to integrate and be accepted in the client's organisation structure."

5. *"Organisational one needs good Operations managers not project managers - the ability to provide a consistent service over and over is more important than odd ad hoc improvement projects (hence role of project management is less)."*

Action: The wording is updated to provide for project manager and/or operations manager.

6. *"The integrity of the leadership and the delivery team."*

Action: A new factor is added to the Delphi Round 2 questionnaire: "The integrity of the service provider's leadership and delivery team and the set of values they live by to ensure sustainability of the service."

Initiation Phase and Pre-contract Activities

1. *"The selling of services is a multi contact activity. Often the client needs to be brought up to speed on the possibilities of the service. Services are rarely sold based on a single interaction. Therefore the service or solution sold to the clients will be directly proportional to their AM organisational maturity."*

For example selling risk based management to a reactive organisation will not work.”

Action: A comment from the panelist; no action taken.

2. *“The cultural readiness of the client organization to a change in business model for delivering AM. Having the right skills in the client organization team to manage a commercial relationship and business strategy/outcomes rather than day to day management of AM.”*

Action: A new factor is added to the Delphi Round 2 questionnaire: “The cultural readiness of the client organisation to change to a business model for delivering AM as a service (in other words having the right skills in the client organisation to manage commercial partnership and business strategy and outcomes, instead of daily management of AM).”

3. *“Service provider must have the ability to broaden their client’s view of all aspects of AM.’*

Action: A new factor is added to the Delphi Round 2 questionnaire: “The service provider’s ability to advise and broaden the client’s view on all aspects of AM.”

4. *“The sales process does not have a huge impact on overall long term success.”*

Action: A comment from the panelist; no action taken.

5. *“All very important checked items in my opinion are deal breakers. These are the go no go questions. They must be clearly understood, supported and cast in stone moving forward. Here is where the success or failure factors of the project are put in place.”*

Action: A comment from the panelist; no action taken.

6. *“The change management with the organisation’s staff and the service provider is absolutely critical.”*

Action: No changes are made; change management is already included in the implementation and commissioning phase category.

7. *“The client does not know what he/she does not know at this point so a ‘leap of faith’ is required to move forward. IN other words, there is a belief in the*

service provider that they will deliver some benefit by overcoming obstacles that are unknown and unknowable. Again integrity plays a vital role because of this required 'leap of faith' that engaging will result in positive benefits for the individuals and the organization"

Action: A new factor is added to the Delphi Round 2 questionnaire: "The belief of the client in the service provider that they will deliver benefits by overcoming obstacles that are unknown at this stage of the process, and that the collaboration will result in positive benefits for the individuals and the organisations."

Preparation and Design Process

1. *"I assumed that the column header 'Not Important' refers to 'Less Important' like other question blocks? Critical to come up with design that takes the client's existing maturity into account. Take the long term maturity target in mind but design practical solution for their existing maturity (cannot jump maturity stages)."*

Action: The wording is corrected for Delphi Round 2 questionnaire. A new factor is added to the Delphi Round 2 questionnaire: "The ability to design a practical solution for the client's existing AM maturity, but also to consider long term goals and AM maturity targets in the design."

2. *"Here the middle column is described as not important(Should be less important) and one lower as unimportant. Some of the criteria can vary from case to case. Knowledgeable demanding clients are the best (hard work but the best). Poor managers from clients that want to abdicate their AM responsibilities condemn the relationship to failure within a year or 2."*

Action: The wording is corrected for Delphi Round 2 questionnaire. A new factor is added to the Delphi Round 2 questionnaire: "The involvement of knowledgeable and demanding individuals from the client during the design and preparation, rather than individuals that are likely to abdicate their AM responsibilities."

3. *"All these questions have a client context component. Understanding your client fully will dictate import vs. very import answers. Generically this is*

how I would see it all questions fall into the 3-5 band. Anything that comes back as a 1 or 2 should raise alarm bells i.r.o. understanding client / service success factors.”

Action: A comment from the panelist; no action taken.

4. *“Accurate drawings, PID, Asset Data, even asset location is often not accurate or available from client. Very few companies have a process of managing asset life cycle information and asset performance in one system. Even ERP systems fall short of this capability. If the service provider is dependent upon accurate drawings and ERP data in order to deliver results the project will fall short of any reasonable expectation. Of course an effort must be made to have accurate data about assets however few companies have it all or are even willing to invest in re-generating it.”*

Action: A comment from the panelist; no action taken.

Implementation and Commissioning

1. *“Verify that what has been implemented will meet the required SLA (steering comm to agree). Change management is a 4 letter word for most clients. Experience has shown that while happily identifying their needs, they hate to change to achieve their goals. Items 1-6 however will create a more receptive environment. Never forget the people factor.”*

Action: A new factor is added to the Delphi Round 2 questionnaire: “The verification that the implementation deliverables will meet the requirements, as stipulated in the service level agreement.”

2. *“Cannot stress enough the variables associated with the effective change management programme. This makes or breaks the entire implementation phase.”*

Action: A comment from the panelist; no action taken.

3. *“There is a HUGE disconnect in the Capital Expense (Capex) side of the business with the Operational Expense (Opex) side of the business. Each had opposing priorities and opposing performance measurement. All elements and aspects identified above are VERY IMPORTANT however the list of what is important to ensure success and high performance needs to be much*

deeper and it is NOT common practice.”

Action: A comment from the panelist; no action taken.

Control processes

1. *“See previous comment about people. These are all people, perception and accountability issues. Echoing the requirement for integrity.”*

Action: A new factor is added to the Delphi Round 2 questionnaire: “The ability of the client leadership and AM personnel to act with integrity in the collaboration with the service provider to ensure sustainable AM.”

Benefits and value-add

1. *“The AM process is a journey not a destination. This concept is key. Ensure it is engrained into the minds of all players. Most organizations take a high level view and money is the primary measurement.”*

Action: A new factor is added to the Delphi Round 2 questionnaire: “The understanding that AM is a journey and not a destination (in other words it is about the the ongoing process and behavioural improvement, instead of a high level view where money is the primary measurement).”

General Comments

1. *“It would be good to separate out the operational, strategic and behavioral aspects and evaluate them as three distinct areas I believe that the key to unlocking value is getting each of those elements right and to clearly establishing objectives on how to operate in each of those buckets to ensure alignment of expectations and establish the foundations required to succeed long term in the AM space.”*

Action: The analysis of strategic, tactical and operational groupings will be done at a later stage in the analysis.

2. *“Items like industry and geographical distribution can influence some of the ratings. Not sure if this should be take into account when people complete this study.’*

Action: Industry and geographical distribution analysis will be done in later

phases of the research. The aim with Delphi is to short list the most important factors irrespective of industry.

3. *“These may vary from situation to situation. Sometimes scopes, specs and project plans are all important and sometimes the relationship and change management is more important, sometimes the system is more important. I think it is difficult to generalise. People will answer this related to their most recent or strongest experience where the situation was very positive or very negative, That might build a bias into the research.”*

Action: The aim is to gain insight from the panelists' experience. Panelists would have applied the cumulative knowledge and experience from their previous experiences to the most recent one. It is expected that the most recent experience encapsulates the combined insight from all previous experiences.

4. *“Questions are predominantly important to very important and covers the majority of factors determining the success or failure of an AM service. What is not addressed is the importance of the correct climate (and other factors) within an organisation to set the table for running a successful AM support service. All too often a situation is created where the service provider is kept responsible for the program success but the environment within which he should perform makes it very difficult or sometimes impossible.”*

Action: Add a new factor to the Delphi Round 2 questionnaire: “The cultural readiness of the client organisation to change to a business model for delivering AM as a service (in other words having the right skills in the client organisation to manage commercial partnership and business strategy and outcomes, instead of daily management of AM)”

5. *“Well considered questionnaire, thanks. You have asked all the right questions. Failure is because so many of the items on your list are seen as 1 or 2 in the minds of the client and sadly even in the minds of some service suppliers. I feel AM is an all or nothing project requiring the same level of commitment from all role players.”*

Action: A comment from the panelist; no action taken.

6. *“If you want to write about the way companies seek out meager gains from good AM process management - then attention to these elements are all good. Think about it for a moment - if it were simply a matter of creating the right checklist for the right process - then any engineering company should be able to create high performance AM results. Look deeper, look beyond technical approaches and look outside of asset intensive industries for examples of what created high performance in individuals and teams. Yes, almost all of the elements your survey includes are important from a tactical and technical point of view - but mastering technical tactics is not what generates high performance results from people. I urge you to do something different and seek a new perspective - one that extends beyond those of the university and beyond of those you may already be working with in industry. Again these elements are important and required but they do not hold the key to extraordinary performance. You are the future and my desire is to support a new kind of thinking to ensure that AM practices are effective so organizations can focus on and deliver the triple bottom of social responsibility, environmental stewardship AND economic prosperity. Good luck on your journey to knowledge and even better luck on your journey to wisdom.”*

Action: This viewpoint needs to be considered for future research. It however does not form part of the scope for this research.

Appendix B

Survey Study Implementation and Analysis

B.1 Sampling

Intercept probability sampling and purposive non-probability sampling are used in the study.

B.1.1 Probability Sample

The following *LinkedIn* groups are included in the sample for the survey study:

AM Council (AMC) (Asset Management Council (AMC) [Online], 2011)

Description: A technical society of engineers in Australia and founding member of the Global Forum on Maintenance and AM.

Member count: 825

Date posted: 26 September 2013

Global Forum on Maintenance and AM (GFMAM) (Global Forum on Maintenance and AM (GFMAM) [Online], 2011)

Description: An association of professional maintenance and AM societies formed with the purpose of creating knowledge and sharing information.

Member count: 207

Date posted: 18 September 2013

Institute of AM (IAM) (Institute of Asset Management (IAM) [Online], 2008)

Description: A professional body for people involved in acquisition, operation and care of physical assets and for professionals worldwide dedicated to furthering the knowledge of AM.

Member count: 5454

Date posted: 18 September 2013

International Team of Enterprise AM (i-TEAM) Professionals (International Team of Enterprise AM (i-TEAM) Professionals [Online], 2008)

Description: A group focused on enterprise AM, with members including product specialists, vertical solution specialists, service providers and value-added solution resellers.

Member count: 2814

Date posted: 26 September 2013

ISO55000 / PAS55 AM (ISO 55000 / PAS 55 Asset Management [Online], 2009)

Description: A group of both in-house practitioners and consultants globally dealing with ISO 55000 and PAS 55. Its purpose is to connect people to share knowledge and provide a platform for discussing ISO 55000, PAS 55 and AM.

Member count: 4274

Date posted: 18 September 2013

Operational Excellence (Operational Excellence [Online], 2008)

Description: A group with the mission where change agents can exchange ideas, best practices and seek guidance on topical include, but not limited to; Lean Six Sigma, Theory of Constraints, Total Productive Maintenance, Total Quality Management, etc.

Member count: 34999

Date posted: 23 October 2013

Reliability and Maintainability Center (RMC) (Reliability and Maintainability Center (RMC) [Online], 2009)

Description: The group bridges the gap between industry and academia to provide education, research and development and information exchange in the application of reliability and maintenance engineering tools and concepts. It consists of over 30 member companies and organisations.

Member count: 580

Date posted: 18 September 2013

Reliability Success (Reliability Success [Online], 2008)

Description: The largest maintenance and reliability networking group on *LinkedIn*. It is dedicated to the areas of AM, reliability, asset integrity and safety engineering.

Member count: 22907

Date posted: 26 September 2013

Southern African AM Association (SAAMA) (Southern African Asset Management Association (SAAMA) [Online], 2010)

Description: A portal to a body of knowledge and services on physical AM. The group aims to source access to and build knowledge on physical AM and making it available to general AM practitioners. SAAMA is also South Africa's PAS 55 and GFMAM representative.

Member count: 134

Date posted: 18 September 2013

Total Productive Maintenance (Total Productive Maintenance [Online], 2010)

Description: A group to promote Total Productive Maintenance.

Member count: 3125

Date posted: 14 October 2013

TPM (TPM [Online], 2008)

Description: A group for TPM practitioners to share thoughts, ideas and pose questions to the community.

Member count: 8182

Date posted: 26 September 2013

EAMC EFNMS AM Committee (EAMC EFNMS AM Committee [Online], 2009)

Description: The group of the European Federation of National Maintenance Societies and member of GFMAM.

Member count: 440

Date posted: 21 October 2013

B.1.2 Non-Probability Sample

At least one potential respondent in each of the following organisations are personally invited to participate in the survey study:

South Africa and Africa

- AngloGold Ashanti
- Argon Supply Chain Solutions
- Aurecon
- Aveng EPC
- Collaborit
- Council for Scientific and Industrial Research (CSIR)
- DAL Food company (Sudan)
- e-Logics
- Exxaro

- Fresenius Kabi
- Growthpoint Properties
- Itemba Technical Services
- LTS Consulting
- Mediclinic
- PPC Cement
- Rand Refinery
- Sasol Synfuels
- Servest
- SFI Facilities Management
- Total Coal

United States and North America

- GP Allied
- Meridium
- PR&O Solutions
- Reliabilityweb
- Shoplogix (Canada)
- Suncor Energy (Canada)
- Vesta

Europe

- Institute for AM (UK)
- Meyn Poultry Processing Solutions (Netherlands)

- SIG Combibloc (Switzerland)
- Shell (UK)
- Tetra Pak (Sweden)

Australia and Asia

- BHP Billiton (Australia)
- Mengnui Dairy (China)
- Santos Energy (Australia)

B.2 Research Ethics Committee Approval



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Approval Notice New Application

19-Jul-2013
JOOSTE, Johannes Lodewyk

Proposal #: DESC_ Jooste2013

Title: Physical asset management as a service a critical success factor model for asset management services

Dear Mr Johannes JOOSTE,

Your DESC approved **New Application** received on **19-Jul-2013**, was reviewed by members of the **Research Ethics Committee: Human Research (Humanities)** via Expedited review procedures on **17-Jul-2013** and was approved.

Please note the following information about your approved research proposal:

Proposal Approval Period: **17-Jul-2013 - 16-Jul-2014**

Please take note of the general Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

Please remember to use your **proposal number (DESC_ Jooste2013)** on any documents or correspondence with the REC concerning your research proposal.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Also note that a progress report should be submitted to the Committee before the approval period has expired if a continuation is required. The Committee will then consider the continuation of the project for a further year (if necessary).

This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki and the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health). Annually a number of projects may be selected randomly for an external audit.

National Health Research Ethics Committee (NHREC) registration number REC-050411-032.

We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at 0218839027.

Included Documents:

Survey
Informed consent form
Research proposal
DESC form
DESC form (2)

Sincerely,

Susara Oberholzer
REC Coordinator
Research Ethics Committee: Human Research (Humanities)

Investigator Responsibilities

Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1. Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2. Participant Enrollment. You may not recruit or enroll participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use. If you need to recruit more participants than was noted in your REC approval letter, you must submit an amendment requesting an increase in the number of participants.

3. Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the REC-approved consent documents, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4. Continuing Review. The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period**. Prior to the date on which the REC approval of the research expires, **it is your responsibility to submit the continuing review report in a timely fashion to ensure a lapse in REC approval does not occur**. If REC approval of your research lapses, you must stop new participant enrollment, and contact the REC office immediately.

5. Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, number of participants, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written REC review and approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6. Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouch within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch University Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7. Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC

8. Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

9. Final reports. When you have completed (no further participant enrollment, interactions, interventions or data analysis) or stopped work on your research, you must submit a Final Report to the REC.

10. On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.

B.3 English and Portuguese Questionnaires

B.3.1 English Questionnaire

Critical Success Factors for Asset Management Services

Introduction

As part of doctoral research at the University of Stellenbosch, you are invited to participate in a research survey conducted by Wyhan Jooste and Prof PJ Vlok.

It should take no more than 15-20 minutes to complete the questionnaire.

1. PURPOSE OF THE STUDY

A physical asset management service (AM service hereafter) is defined as: the providing of value adding activities by a service provider (or supplier) to support the managing of a customer organisation's physical assets. AM services are characterised by the participation of the customer in the service delivery process.

Industry trends show that the demand for AM services is increasing due to industrial, economic and technological pressures on asset owning organisations. To date there is little research which has examined the factors which lead to a successful AM services partnership - both from the service provider and customers perspective. Initial research identifies a short list of important factors attributed to AM service success. To gain a better understanding of why AM services are successful the short listed factors which are critical in pursuit of success must be identified.

To achieve this, role players involved in AM services are required to rate these factors based on their experience of how critical each factor is towards a successful AM service.

2. DO YOU QUALIFY TO PARTICIPATE IN THE RESEARCH?

To qualify to participate in the research you need to comply with at least one of the following characteristics:

- you work in the field of asset management (including, but not limited to: capital projects, asset planning and acquisition, asset life cycle planning, asset design, asset operation, maintenance management, reliability engineering, TPM, predictive maintenance, RCM, MRO and spares management, asset renewal and asset disposal)
- you are part of a service provider's team that consults, advises, trains and/or delivers AM services to improve or manage the physical assets of asset owning organisations
- you are part of an asset owning organisation's team that is contracting or collaborating with a service provider for advice, training or services related to your organisation's physical assets (machinery, infrastructure, etc.)

*** Do you qualify to participate?**

- I qualify and want to get started
- I qualify, but first want to read the consent information
- I do not qualify

Critical Success Factors for Asset Management Services

Questionnaire Instructions

You will be presented with 46 factors which have been identified as playing an important role in the success of AM services. You will be asked to rate how critical each factor is towards the success of an AM service on a scale ranging from "not critical" to "extremely critical".

Base your responses on YOUR collective experience in AM services, or on a single successful AM service that YOU are involved with (or were involved in). The nature of the AM service can be across any combination or all of the AM life cycle phases.

For simplicity, only consider primary role players (i.e. service provider and asset owning organisation/customer). Ignore second and third tier sub-providers and contractors.

Please complete the role, service and economy questions at the end of the questionnaire. These responses are important in providing context, which take into account different perspectives from the respondents.

Critical Success Factors for Asset Management Services

Consent Information

1. **POTENTIAL RISKS**
We are not aware of any complications or risks that could arise from you taking part in this study. However, should you have any complaints or difficulties with any aspect of the study you can contact the researchers at the contact details specified in paragraph.

2. **POTENTIAL BENEFITS TO PARTICIPANTS AND/OR SOCIETY**
We cannot promise the study will benefit you as an individual, but the information we obtain may contribute to improving the understanding and future research of asset management and AM services.

Results of the research will be published in relevant industry journals and made available on the researchers' LinkedIn group.

3. **PAYMENT FOR PARTICIPATION**
You will receive no payment for your participation, but will receive our gratitude.

4. **CONFIDENTIALITY**
Any information that is obtained in connection with this survey and which you can be identified with will remain confidential and will only be disclosed with your permission or as is required by law. Confidentiality will be maintained by means of a secured database which is only accessible by the researchers. The results of the study will be published following the completion of the research. The consolidated results will be reported on and no individual responses will be disclosed during the reporting or publication process.

5. **PARTICIPATION AND WITHDRAWAL**
You can choose whether to be in this study or not. If you volunteer for this study, you may withdraw at any time without consequences of any kind. The researchers may withdraw you from this research if circumstances arise which warrant their doing so.

6. **IDENTIFICATION OF RESEARCHERS**
If you have any questions or concerns about the research, please contact the primary researcher, Wyhan Jooste (12882046@sun.ac.za; +27 83 456 0648), or the research promoter, Prof P.J. Vlok (pvl@sun.ac.za; +27 82 821 2 108).

7. **RIGHTS OF RESEARCH SUBJECTS**
You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Malene Fouche (mfouche@sun.ac.za; +27 21 808 4622) at the Division for Research Development, Stellenbosch University.

***Do you consent to participate?**

Yes

No

Critical Success Factors for Asset Management Services	
AM Service Initiation Phase and Pre-Contract Activities	
The following factors relate to the AM service initiation phase and pre-contract activities.	
* How critical are the following factors towards the success of AM services?	
	Extremely Critical
1. The continued and sustained commitment from the asset owning organisation's senior management in support of the AM service.	C C C C C C
2. The active participation of the asset owning organisation personnel and their commitment towards completing the pre-contract activities.	C C C C C C
3. The alignment of the asset owning organisation's AM service requirements with their overall organisational and business strategies.	C C C C C C
4. Completion and availability of formal contractual documents.	C C C C C C
5. A detailed project plan with milestones in place.	C C C C C C
6. The cultural readiness of the asset owning organisation to change in business model for delivering AM (in other words having the right skills in the organisation to manage a commercial AM service partnership, business strategy and outcomes, instead of only the daily management of AM).	C C C C C C
7. The belief by the service provider that they will deliver benefits by overcoming obstacles that are unknown at this stage of the process, and that the collaboration will result in positive benefits for the individuals and the organisation.	C C C C C C

Critical Success Factors for Asset Management Services	
Organisational Environment and Capabilities of the AM Service Provider	
The following factors relate to the organisational environment and capabilities of the AM service provider.	
* How critical are the following factors towards the success of AM services?	
	Extremely Critical
1. A capable project (or key account) manager that manages the AM service on behalf of the service provider.	C C C C C C
2. The degree to which the service provider's client facing team (sales representatives, project managers, service personnel) are knowledgeable in the full range of the service provider's value proposition and combination of service options available.	C C C C C C
3. The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants.	C C C C C C
4. The availability of the most appropriate skilled resources for providing industry specific AM service requirements.	C C C C C C
5. The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases such as implementation to operations).	C C C C C C
6. The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service.	C C C C C C

Critical Success Factors for Asset Management Services

AM Service Preparation and Design Processes

The following factors relate to the AM service preparation and design processes.

***How critical are the following factors towards the success of AM services?**

	Not Critical		Critical	
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
			Extremely Critical	
1. The design and integration of service and performance metrics for all stakeholders (service provider and asset owner) involved in the AM service.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. The inter-company flow of information (between the service provider and asset owning organisation) during the AM service design.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. The compilation and active use of design documents.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Ensuring that pre-project arrangements are made for logistics, feasibility studies and changes in organisational structures that might arise from the AM service.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. The potential of the AM service to be scalable (expandable to other business units within the asset owning organisation).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. The strategic fit of the AM service with the service provider and asset owning organisation's current service propositions, systems and capabilities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. The evaluation and consideration of different AM service designs.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. The integration of health, safety, environmental and quality considerations as part of the AM service or to align the service to existing standards.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. The integration of operational excellence methodologies, such as TPM, TQM, 5S into the AM service offering or to align the service to existing standards.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. The availability of adequate information system infrastructure and interfaces in support of the AM service.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. Adequate legacy system knowledge (i.e. ERP), if such systems are required to interface with the AM service information systems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. The security and protection of information, relating to information systems that forms part of the AM service.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. The ability to design a practical solution for the asset owning organisation's existing AM maturity, but also to consider in the design long term goals AM maturity targets.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. The involvement of knowledgeable and demanding individuals from the asset owning organisation during the design and preparation, rather than individuals that prefer to abdicate their AM responsibilities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Critical Success Factors for Asset Management Services

AM Service Implementation and Commissioning Phase

The following factors relate to the AM service implementation and commissioning phases.

***How critical are the following factors towards the success of AM services?**

	Not Critical		Critical	
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
			Extremely Critical	
1. An adequate training programme in place for all AM service role players, both in the service provider and client teams.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. An effective organisational change management programme in support of the AM service.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Critical Success Factors for Asset Management Services	
AM Service Benefits and Value-Add	
The following factors relate to the AM service benefits and its value-add.	
* How critical are the following factors towards the success of AM services?	
1. The consideration of intangible (not measurable) benefits and value creation (i.e. increased effectiveness, risk mitigation, improved decision-making capability) as a result of the AM service.	Extremely Critical
2. Feedback and sharing of lessons learned from successful improvements made to the AM service.	Not Critical
3. Formal post launch evaluations of the AM service to determine what can be improved.	Extremely Critical
4. Proof of operational and financial performance achievements as a result of the AM service.	Not Critical
5. The ability to measure the AM service quality and value creation.	Extremely Critical
6. A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback.	Not Critical

Critical Success Factors for Asset Management Services	
AM Service Control Processes	
The following factors relate to the AM service control processes.	
* How critical are the following factors towards the success of AM services?	
1. The monitoring of budgets and costs relating to the AM service.	Extremely Critical
2. The configuration control of current AM service processes and systems.	Not Critical
3. The management of mutual expectations between the service provider and client relating to the AM service.	Extremely Critical
4. The active management of the relationship between the service provider and client organisation personnel involved in the AM service.	Not Critical
5. The appreciation of diversity among inter-company teams involved in the AM service.	Extremely Critical
6. Open and effective communication.	Not Critical
7. Mutual trust and respect between the service provider and client organisation.	Extremely Critical
8. Active client participation in reporting, problem solving and improvement relating to the AM service.	Not Critical
9. Agility (responsiveness) in responding to changes in AM service demands.	Extremely Critical
10. The use of performance measurement to monitor, control and improve the AM service.	Not Critical
11. Proper priority setting of improvement actions, irrespective whether it is service or value-add related.	Extremely Critical

Critical Success Factors for Asset Management Services
Economies and Industries
<p>* In which of the following economies do you predominantly collaborate in AM services?</p> <ul style="list-style-type: none"> <input type="radio"/> Developed economies (i.e. USA, UK, Japan, Europe) <input type="radio"/> Developing economies (i.e. BRICS) <p>* In which of the following regions do you collaborate in AM services?</p> <ul style="list-style-type: none"> <input type="radio"/> Africa <input type="radio"/> Asia <input type="radio"/> Australasia <input type="radio"/> Europe <input type="radio"/> North America <input type="radio"/> South America <input type="radio"/> More than one of the above regions

Critical Success Factors for Asset Management Services
Participant Role
<p>Answer the following questions with the same frame of reference which you rated the criticality of the preceding factors.</p> <p>* Which role do you play in relation to AM services?</p> <ul style="list-style-type: none"> <input type="radio"/> Asset; equipment or facilities owner/representative <input type="radio"/> AM consultant, service provider/supplier <p>* Which of the following levels within your organisational hierarchy best describe your position in relation to AM services?</p> <ul style="list-style-type: none"> <input type="radio"/> Strategic (i.e. CEO, managing director, divisional manager, technical director, plant engineer) <input type="radio"/> Tactical (i.e. reliability engineer, maintenance manager, project or service manager, key account manager) <input type="radio"/> Operational (i.e. supervisor, team leader, planner, scheduler, craftsman, artisan, operator)

Critical Success Factors for Asset Management Services

Service Details

*** In which phase of the AM life cycle do you predominantly collaborate in AM services?**

- Needs identification, feasibility studies and/or planning
- Specification and design
- Acquisition, installation and commissioning
- Operation and maintenance
- Decommissioning and disposal
- More than one of the above

*** What type of physical assets are predominantly being managed through the AM services?**

- Mechanical or electro-mechanical equipment or machinery (i.e. manufacturing or production equipment, vehicles, computers, trains, airplanes, transformers, medical equipment, defence systems)
- Facilities (i.e. properties, buildings, furniture, fixtures, air conditioning)
- Infrastructure and linear assets (i.e. dams, reservoirs, roads, pipelines, power lines)
- Other (please specify)

*** By referring to the diagram below which of the types of services best describe the AM service which you predominantly collaborate in.**

- Basic asset-orientated services
- Professional support services
- Outsourcing services
- Integrated life cycle services

Critical Success Factors for Asset Management Services

*** In which industry does the asset owning organisation (to whom an AM service is delivered) predominantly operate in?**

- Agriculture, forestry and fishing
- Mining and quarrying
- Manufacturing
- Electricity, gas, steam and air conditioning supply
- Water supply, sewerage, waste management and remediation activities
- Construction
- Wholesale and retail trade
- Transportation and storage
- Information and communication
- Financial and insurance
- Real estate
- Professional, scientific and technical activities
- Public administration and defence
- Education
- Health care
- Arts, entertainment and recreation
- More than one of the above
- Other (please specify)

*** In which of the following business sectors do you predominantly collaborate in AM services?**

- Private sector (organisations which are run by private individuals or groups for profit)
- Public sector (part of the economy concerned with providing basic government services)
- Non-profit sector (organisations which have undertaken activities which are not for profit)

Critical Success Factors for Asset Management Services

*** How many stakeholders (of the asset owner and service provider combined), are involved in the AM service?**

C 1-5
 C 6-15
 C 16-30
 C 31-100
 C >100

Critical Success Factors for Asset Management Services

Value proposition for the asset owner

Revenue generation logic for the service provider

Source: Kujala, 2010

*** Which of the following timespans predominantly characterize the AM services that you are involved in?**

C Short term (<3 months continuously or intermittently)
 C Short to medium term (3 months – 1 year continuously or intermittently)
 C Medium term service contract (1-3 years continuously)
 C Long term service contract (>3 years continuously, or timespan independent)

*** Which of the following levels of maturity (advancement) predominantly describe the environment in which you collaborate in AM services?**

C Initial – the AM environment is undefined, unpredictable, poorly controlled and/or reactive
 C Managed – some processes and aspects in the AM environment are defined and formally managed
 C Defined – most processes in the AM environment are defined and proactively managed
 C Quantitatively managed – all processes in the AM environment are measured and controlled
 C Optimising – the focus in the AM environment is on improvement

Critical Success Factors for Asset Management Services

Please forward the survey link to anyone who you think could add value to this research.
Join our LinkedIn group and follow the research progress and results at: Critical Success Factors for Asset Management Services.
Thank you for your time and participation.

Critical Success Factors for Asset Management Services

Commentary

Do you have any commentary which should be considered in the analysis of the feedback?

B.3.2 Portuguese Questionnaire

Fatores essenciais de sucesso para serviços de
Introdução
<p>Como parte da pesquisa de doutorado na Universidade de Stellenbosch, você está convidado a participar de uma pesquisa realizada por Wyhan Jooste e Prof. PJ Vlok.</p> <p>Essa pesquisa não deve levar mais de 15-20 minutos para ser concluída.</p> <p>1. OBJETIVO DO ESTUDO Um serviço de gerenciamento de ativos físicos (serviços de AM) é definido como: a prestação de atividades de agregação de valor por um prestador de serviços (ou fornecedor), para apoiar o gerenciamento de ativos físicos de uma organização do cliente. Os serviços de AM são caracterizados pela participação do cliente no processo de prestação de serviços.</p> <p>Tendências do setor mostram que a demanda por serviços de AM está aumentando devido a pressões industriais, econômicas e tecnológicas sobre as organizações que possuem ativos. Até o momento, poucas pesquisas analisaram os fatores que levam a uma parceria bem-sucedida de serviços de AM, tanto da perspectiva do prestador de serviços e do cliente. A pesquisa inicial identifica uma pequena lista de fatores importantes para o sucesso do serviço de AM. Para obter uma melhor compreensão por que os serviços de AM são bem-sucedidos, os fatores indicados essenciais para a busca do sucesso devem ser identificados.</p> <p>Para conseguir isso, os envolvidos nos serviços AM devem avaliar esses fatores com base em sua experiência de quanto cada fator é essencial para que um serviço seja bem-sucedido.</p> <p>2. SE VOCÊ SE QUALIFICA PARA PARTICIPAR DA PESQUISA? Para se qualificar para participar da pesquisa, é necessário cumprir com pelo menos uma das seguintes características:</p> <ul style="list-style-type: none">- você trabalha na área de gerenciamento de ativos (incluindo, mas não limitado a: projetos de investimento, planejamento e aquisição de ativos, planejamento do ciclo de vida do ativo, design de ativos, operação de ativos, gestão de manutenção, engenharia de confiabilidade, TPM (Manutenção produtiva total), manutenção preditiva, RCM, MRO e gestão de peças, renovação de ativos e eliminação de ativos)- você faz parte da equipe de um fornecedor de serviços que fornece consultoria, treinamento e/ou serviços AM para melhorar ou administrar os ativos físicos de organizações que possuem ativos- você faz parte de uma equipe da organização proprietária de ativos e está contratando ou colaborando com um prestador de serviços para consultoria, treinamento ou serviços relacionados aos ativos físicos da sua organização (máquinas, infraestrutura, etc.) <p>*Você se qualifica para participar?</p> <ul style="list-style-type: none"><input type="radio"/> Eu me qualifico e quero iniciar a pesquisa<input type="radio"/> Eu me qualifico, mas primeiro quero ler as informações de autorização<input type="radio"/> Eu não me qualifico

Fatores essenciais de sucesso para serviços de**Informações de autorização**

1. RISCOS POTENCIAIS
Não temos conhecimento de quaisquer complicações ou riscos que possam surgir de sua participação nesse estudo. No entanto, se você tiver quaisquer preocupações ou dificuldades com qualquer aspecto da pesquisa, você pode entrar em contato com os pesquisadores - utilize as informações de contato especificadas no parágrafo.

2. BENEFÍCIOS POTENCIAIS PARA OS PARTICIPANTES E/OU A SOCIEDADE
Não podemos prometer que o estudo irá beneficiar você como um indivíduo, mas as informações que obtermos poderão contribuir para a melhoria da compreensão e investigação futura de gerenciamento de ativos e serviços de AM.
Os resultados da pesquisa serão publicados em revistas relevantes do setor e disponibilizados no grupo de pesquisadores do LinkedIn.

3. INCENTIVO PELA PARTICIPAÇÃO
Você não receberá incentivos por sua participação, mas vai receber a nossa gratidão.

4. CONFIDENCIALIDADE
Qualquer informação obtida em conexão com esse estudo e que possa identificar você permanecerá confidencial e somente será divulgada com a sua permissão, ou conforme exigido por lei. A confidencialidade será mantida por meio de um banco de dados seguro que apenas é acessível pelos pesquisadores. Os resultados do estudo serão publicados após a conclusão do estudo. Os resultados consolidados serão publicados e nenhuma resposta individual será divulgada durante o processo de comunicação ou publicação.

5. PARTICIPAÇÃO E DESISTÊNCIA
Você pode optar por participar desse estudo ou não. Se você se candidatar a participar desse estudo, você pode desistir a qualquer momento, sem consequências de qualquer tipo. Os pesquisadores poderão retirar você da pesquisa se surgirem circunstâncias que justifiquem fazê-lo.
Se você tiver dúvidas ou preocupações sobre a pesquisa, entre em contato com o pesquisador principal, Wyhan Jacobs (12882046@sun.ac.za; +27 83 456 0648), ou o promotor de pesquisa, Prof. P.J. Vlok (pvlok@sun.ac.za; +27 82 821 2108).

7. DIREITOS DOS PARTICIPANTES DA PESQUISA
Você pode retirar sua autorização a qualquer momento e interromper a participação sem penalidades. Você não está renunciando qualquer reivindicação legal, direitos ou recursos por causa de sua participação neste estudo. Se você tiver dúvidas sobre seus direitos como participante da pesquisa, entre em contato com Malene Fouché (mfouch@sun.ac.za; +27 21 808 4622) da Divisão de desenvolvimento da pesquisa, da Universidade de Stellenbosch.

***Você autoriza sua participação?**

- Sim
 Não

Fatores essenciais de sucesso para serviços de**Instruções do questionário**

Serão apresentados 46 fatores identificados como tendo um papel importante no sucesso de serviços de AM. Você será solicitado a avaliar como cada fator é essencial para o sucesso de um serviço de AM em uma escala que varia de "não essencial" para "extremamente essencial".

Baseie suas respostas em SUA experiência coletiva em serviços de AM ou em um único serviço de AM bem-sucedido no qual você está envolvido (ou estava envolvido). A natureza do serviço de AM pode ser qualquer combinação ou todas as fases do ciclo de vida de AM. Para simplificar, consideramos apenas os principais envolvidos (ou seja, o prestador de serviços e a organização proprietária dos ativos/cliente). Ignore fornecedores de segundo e terceiro nível e outros terceirizados.

Por favor, responda às questões sobre função, serviços e economia no final do questionário. Essas respostas são importantes no fornecimento de contexto, levando em conta as diferentes perspectivas dos participantes.

Fatores essenciais de sucesso para serviços de implementação do serviço de AM e fase de ativação

Os fatores a seguir referem-se às fases de implementação e ativação do serviço de AM.

*** O quê críticos são os seguintes fatores para o sucesso dos serviços de AM?**

	Não essencial		Essencial	
	C	C	C	C
1. Um programa de treinamento adequado para todos os participantes do serviço de AM, para o prestador de serviços e equipes de clientes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Um programa de gestão de mudança organizacional eficaz para suporte ao serviço de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Fatores essenciais de sucesso para serviços de preparação do serviço de AM e processos de design

Os fatores a seguir referem-se à fase de preparação do serviço de AM e os processos de design.

*** O quê críticos são os seguintes fatores para o sucesso dos serviços de AM?**

	Não essencial		Essencial	
	C	C	C	C
1. O desenvolvimento e integração de serviços e métricas de desempenho para todas as partes interessadas (prestador de serviços e proprietário dos ativos) envolvidos no serviço de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. O fluxo de informações entre empresas (entre o prestador de serviços e organização proprietária dos ativos) durante o design de serviço de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. A compilação e uso ativo de documentos do projeto.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Garantir que acordos pré-projeto sejam feitos para logística, estudos de viabilidade e mudanças nas estruturas organizacionais que possam surgir a partir do serviço de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. O potencial de escalabilidade do serviço de AM (expansível para outras unidades de negócios dentro da organização proprietária dos ativos).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. A adequação da estratégia do serviço de AM com o prestador de serviços e atuais propostas de serviços, sistemas e capacidades da organização proprietária dos ativos.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. A avaliação e consideração dos diferentes projetos de serviço de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. A integração das considerações de saúde, segurança, ambientais e de qualidade como parte do serviço de AM ou para alinhar o serviço com os padrões existentes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. A integração de metodologias de excelência operacional, como TPM, TQM, 6S na oferta de serviços de AM ou para alinhar o serviço com os padrões existentes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. A disponibilidade de infraestrutura adequada de sistemas de informação e as interfaces de apoio do serviço de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. O conhecimento do sistema legado adequado (isto é, ERP), caso esses sistemas sejam obrigados a fazer interface com os sistemas de informação de serviços de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. A segurança e proteção das informações, relativas aos sistemas de informação que fazem parte do serviço de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. A capacidade de projetar uma solução prática para maturidade de AM existente da organização proprietária dos ativos, mas também a ser considerada no desenvolvimento de metas de longo prazo de maturidade de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. O envolvimento de indivíduos exigentes e com conhecimento dos ativos da organização proprietária dos ativos durante o desenvolvimento e a preparação, em vez de indivíduos que preferem abdicar de suas responsabilidades de AM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Fatores essenciais de sucesso para serviços de

Processos de controle de serviços de AM

Os fatores a seguir referem-se à fase de processos de controle do serviço de AM.

*** O quê críticos são os seguintes fatores para o sucesso dos serviços de AM?**

	Não essencial		Essencial	
	C	<input type="radio"/>	C	<input type="radio"/>
1. O monitoramento de orçamentos e custos relativos ao serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. O controle de configuração dos processos atuais de serviços e sistemas de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. A gestão das expectativas mútuas entre o prestador de serviços e o cliente sobre o serviço AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. A gestão ativa da relação entre o prestador de serviços e pessoal da organização do cliente envolvidos no serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. A valorização da diversidade entre as equipes das empresas envolvidas no serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Comunicação aberta e eficaz.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Confiança e respeito mútuo entre o prestador de serviços e a organização do cliente.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. Participação ativa do cliente nos relatórios, resolução de problemas e melhoria relativa ao serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. Agilidade (capacidade de resposta) na resposta às mudanças nas demandas de serviços de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. O uso de medições de desempenho para monitorar, controlar e melhorar o serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. Definição de prioridades adequadas de ações de melhoria, independentemente de ser relacionado ao serviço ou valor agregado.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Fatores essenciais de sucesso para serviços de

Benefícios de serviços de AM e valor agregado

Os fatores a seguir referem-se aos benefícios de serviços de AM e seu valor agregado.

*** O quê críticos são os seguintes fatores para o sucesso dos serviços de AM?**

	Não essencial		Essencial	
	C	<input type="radio"/>	C	<input type="radio"/>
1. A consideração de benefícios intangíveis (não mensuráveis) e criação de valor (ou seja, maior eficácia, mitigação de riscos, a melhoria da capacidade de tomada de decisões), como resultado do serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Feedback e compartilhamento de lições aprendidas a partir de melhorias bem-sucedidas aplicadas ao serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Avaliações formais pós-implantamento do serviço de AM para determinar o que pode ser melhorado.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Comprovação de realizações de desempenho operacional e financeiro, como resultado do serviço de AM.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. A capacidade de medir a qualidade do serviço de AM e criação de valor.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Um processo de melhoria focado e contínuo para melhorar o serviço de AM por meio do monitoramento, análise e feedback.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Fatores essenciais de sucesso para serviços de Economias e indústrias

*** Em qual das seguintes economias você colabora em serviços de AM?**

- Economias desenvolvidas (ou seja, EUA, Reino Unido, Japão, Europa)
- As economias em desenvolvimento (ou seja, BRICS)

*** Em qual das seguintes regiões você colabora em serviços de AM?**

- África
- Ásia
- Australásia
- Europa
- América do Norte
- América do Sul
- Mais do que uma das regiões acima

*** Em qual setor predominante a organização proprietária de ativos opera (a quem o serviço de AM é fornecido)?**

- Agricultura, silvicultura e pesca
- Indústria extrativa
- Manufatura
- Eletricidade, gás, vapor e ar condicionado
- Abastecimento de água, atividades saneamento, gestão de resíduos e despoluição
- Construção
- Alacado e varejo
- Transporte e armazenamento
- Informação e comunicação
- Finanças e seguros
- Bens imóveis
- Profissionais, científicas e técnicas
- Administração pública e defesa
- Educação
- Assistência médica
- Artes, entretenimento e lazer
- Mais de uma das opções acima
- Outros (especifique)

Fatores essenciais de sucesso para serviços de Função do participante

Responda às seguintes perguntas com o mesmo quadro de referência que você classificou a criticidade dos fatores anteriores.

*** Qual é a sua função em relação aos serviços AM?**

- Representante/proprietário de ativos, equipamentos ou instalações
- Consultor, prestador/fornecedor de serviços de AM

*** Qual dos seguintes níveis da hierarquia organizacional melhor descrevem a sua posição em relação aos serviços de AM?**

- Estratégico (ex.: CEO, diretor, gerente divisional, diretor técnico, engenheiro da fábrica)
- Tático (ex.: engenheiro de confiabilidade, gerente de manutenção, projeto ou gerente de atendimento, gerente de principais contas)
- Operacional (ex.: supervisor, chefe da equipe, planejador, planejador, artesão, operador)

Fatores essenciais de sucesso para serviços de

*** Em qual dos seguintes setores de negócios você colabora em serviços de AM?**

- Setor privado (organizações que são operadas por indivíduos ou grupos privados com fins lucrativos)
- Setor público (parte da economia preocupada com a prestação de serviços públicos básicos)
- Setor sem fins lucrativos (organizações que realizam atividades sem fins lucrativos)

Fatores essenciais de sucesso para serviços de

Detalhes do serviço

*** Em que fase do ciclo de vida de serviços de AM você colabora?**

- Identificação de necessidades, estudos de viabilidade e/ou planejamento
- Especificações e design
- Aquisição, instalação e comissionamento
- Operação e manutenção
- Desativação e descarte
- Mais de uma das opções acima

*** Que tipo de ativos físicos são gerenciados por meio dos serviços de AM?**

- Equipamentos mecânicos ou eletromecânicos e máquinas (ex.: fabricação ou produção de equipamentos, veículos, computadores, trens, aviões, transformadores, equipamentos médicos, sistemas de defesa)
- Instalações (ou seja, propriedades, prédios, móveis, luminárias, ar condicionado)
- Infraestrutura e ativos lineares (ex.: barragens, represas, estradas, oleodutos, oleodutos, linhas de energia)
- Outros (especifique)

*** Ao consultar o diagrama abaixo, quais os tipos de serviços que melhor descrevem o serviço de AM com o qual você colabora.**

- Serviços básicos orientados a ativos
- Serviços de suporte profissional
- Terciarização de serviços
- Serviços de ciclo de vida integrado

Fatores essenciais de sucesso para serviços de

*** Quantas partes interessadas (do proprietário do ativo e prestador de serviços combinados) estão envolvidas no serviço de AM?**

C 1-5
 C 6-15
 C 16-30
 C 31-100
 C >100

Fatores essenciais de sucesso para serviços de

Proposta de valor para o proprietário do ativo

Orientado ao ativo	Orientado ao processo do proprietário do ativo
Com base em transações	Com base em relacionamentos

Serviços básicos orientados a ativos

- Documentação de ativos
- Transporte para o cliente
- Instalação/comissionamento
- Treinamento orientado ao produto
- Help Desk
- Reparos/peças de reposição
- Recondicionamento/reciclagem

Serviços de suporte profissional

- Suporte ao cliente
- Engenharia de processos (testes, otimização, simulação, P&D)
- Treinamento (orientado a negócios e processos)
- Consultoria (orientado a negócios e processos)

Terceirização de serviços

Planejamento ativo, design e aquisição de terceirização

Modelo de terceirização e/ou terceirização de peças de reposição

Gerenciamento de manutenção, terceirização de planejamento de trabalho

Contratos de manutenção completos

Serviços operacionais

Serviços de ciclo de vida integrado

- Prestador de serviços de gerência e opera os processos do proprietário do ativo
- Contratos de desempenho
- Contratos específicos
- Contratos de desenvolvimento

Logica de geração de receita para o prestador de serviços

*** Quais dos seguintes períodos de tempo caracterizam os serviços de AM nos quais você está envolvido?**

C Curto prazo (< 3 meses de forma contínua ou intermitente)
 C Curto e médio prazo (3 meses - 1 ano de forma contínua ou intermitente)
 C Contrato de serviço de médio prazo (1-3 anos de forma contínua)
 C Contrato de serviço de longo prazo (> 3 anos de forma contínua, ou período de tempo independente)

*** Qual dos seguintes níveis de maturidade (avanço) descreve o ambiente em que você colabora em serviços de AM?**

C Inicial - o ambiente de AM é indefinido, imprevisível, mal controlado e/ou reativo
 C Gerenciado - alguns processos e aspectos no ambiente de AM são definidos e formalmente gerenciados
 C Definido - a maioria dos processos no ambiente de AM são definidos e administrados de forma proativa
 C Quantitativamente gerenciado - todos os processos no ambiente de AM são medidos e controlados
 C Otimização - o foco no ambiente de AM é na melhoria

Fatores essenciais de sucesso para serviços de

Por favor, envie o link de pesquisa para outras pessoas que poderiam agregar valor à pesquisa.
Participe do nosso grupo no LinkedIn e acompanhe o andamento da pesquisa e os resultados em: Critical Success Factors for Asset Management Services.
Obrigado pelo seu tempo e por sua participação.

Fatores essenciais de sucesso para serviços de

Comentários

Você tem algum comentário que deva ser considerado na análise do feedback?

B.3.3 Questionnaire Cover Letter

B.3.3.1 *LinkedIn* Group Post

What are the Critical Success Factors (CSF) for AM (AM) Services?

I am conducting doctoral research to identify those CSF which facilitate the success of AM services between service providers and asset owning organisations.

I am interested in the opinion of role players (both service providers and asset owners) involved in AM services on what these CSF are. If you are willing to share your experience - please participate by following the link and completing the research questionnaire at: <https://www.surveymonkey.com/s/KMXWF3D>

B.3.3.2 Invitation to Individuals and Groups

Dear "Respondent",

I am currently busy with doctoral research to identify the critical success factors (CSF) responsible for making AM services between service providers and asset owning organisations successful and value-adding. I recognise you as one of the thought leaders in the field of AM services and knowledgeable to contribute to this identification process.

First and foremost I am interested in your opinion on the matter and want to invite you to participate in an online questionnaire to help identify the CSF. Follow this link to the questionnaire: <https://www.surveymonkey.com/s/KMXWF3D>

Secondly, the success of my research will be determined by the sample size of knowledgeable respondents that complete the questionnaire. As you are well connected in the field of study, I would greatly appreciate if you could assist in distributing the questionnaire link to your colleagues, peers and clients who will be willing to contribute to the research and who stands to gain from the results.

As researchers we are bound to the confidentiality and ethics requirements of the University of Stellenbosch. The research results will be published in relevant

industry publications. You can also follow the research progress by joining our LinkedIn group; Critical Success Factors for AM Services.

Kind Regards,

B.3.4 Comments From Survey Respondents

“We are active in more than 90 countries around the world at more than 600 customers. With this the follow are important to note: 1. Payment, legal and custom issues are our major issues not fully addressed in the AM CSF. 2. Maturity of customer base are widely different. Half of our revenue comes from USA that have most customers locked in in AM contracts. In Europe we see the opposite trend at less mature customer. Training and teaching customers are more important to grow maturity. Also not addressed in AM CSF.”

“Difficult to rate the various questions in such a way that the individual importance can be compared.”

“The selections are limited for example, many individuals associated with AM Services will have worked across many industry types, in many countries and across most of the asset life cycle processes. The focus on Business Development is very light on. For Asset Service Providers to be successful, not only do they need to be able to do the work, but they first have to secure the work. Other items for consideration: - The diversity of the portfolio of services offered to enable flexibility and sustainability. - The sourcing, attraction and retention of employees/contractors - typical high turnover exists especially in Australia where AM Service consultants are not remunerated well with very little commission based incentives. - Networking and associateships to work with, and benefit from a network of AM Service Providers.”

“Have worked with ABB and Siemens with over 23 years experience in the delivery of outsourced AM services, energy , mining , manufacturing , power generation”

“Build the plan and stick to it, too many managers move away from the core basics of CSF. What when how and who”

“excellent test”

“I would hope you publish the results on LinkedIn for us who have participated can review.”

“The questions are good. My only comment is that they remain a little asset centric. In Australia, AM is recognised as a tool to deliver outcomes. This includes identification of stakeholder needs, business capability (esp knowledge, skills, it, finance etc) and processes of which only a small part is the asset (and that’s from the perspective of the heavily engineering water industry). its the outcomes that we target. the assets are always and only a tool to deliver those outcomes.”

“Asset Management, in my opinion and relative to my experience, is a multi level, multi discipline, organization wide program that directly affects the decisions and the culture of the company and its people. However, there has yet to be a defining ‘standard’ or guide that defines AM at all levels. ISO 55000 and PAS55 target the management system level but do nothing for the tactics and activities that constitute the actual AM strategy. API 691 attempts to address the machinery level AM but only reiterates many of the failed and non-contributory activities already in use. New asset management programs require new asset management strategies that force asset owners to identify activities that provide continuous improvement of asset performance, value, and sustainability. The key differences in present AM strategies and the new, more effective, AM strategies are not asset related but rather behavior related.”

“Good Survey. But 7 point rating scale sometime provide problem for user to select from. Also I feel number of questions with very minor differences.”

“I found that the vast majority of considerations within the survey were of relatively high criticality; I believe the ultimate survey results will reflect this”

“Strategically, many CEO’s are moving to a customer focused business model, even in asset centric organisations. This is challenging for AM practitioners as it is very easy to become disenchanted when support and funding is constantly diverted to other areas.”

“The asset management process is an important opportunity for organisations to develop replacement and maintenance programs which are a direct result of clearly defined relationships between the infrastructure’s ability to meet business and stakeholder requirements and funding requirements and constraints. We tend to set out the following as the key points to be addressed (in order): 1. Business, customer and stakeholder requirements must be defined and are the fundamental drivers of the asset management process. 2. Customer service level requirements are defined to provide a basis for the operating and maintenance strategies. 3. The operating strategy is defined to facilitate the development of the asset strategy, which in turn determines the required condition and configuration of the network. 4. The current configuration and condition of the assets is understood and when compared with those required by the business strategy, identifies gaps which must be addressed by capital and maintenance activities.”

“Inventory and financial analysis feedback is critical for profitability . Downtime for maintenance is also critical for overall performance of asset management.”

“In my experience understanding that the entire asset life requires focus is poor, as is implementation of AM protocols and practice across the whole of asset life. We find many "false prophets" marketing services such as Maintenance Management, Reliability Engineering etc representing themselves as AM experts delivering AM services, and this may be true to some degree however they should be representing themselves as specialists within an aspect, or sub-set of AM, not AM holistically. For example, a South African based organisation with whom I have interacted markets themselves as "Thought Leaders" in AM yet they deliver Maintenance Management services and whilst they may be excellent in that AM sub-set, they miss heaps of equally important and critical AM activities.”

“In New Zealand local government set the foundation and initial exceptions for asset management and asset management outcomes. To a large extent this has been in response to statutory requirements. Significantly however over the last 3 years the commercial sector, and specifically the corporate real estate sector, is beginning to drive asset management and asset management improvements. There is currently a low level of awareness of the new ISO standard but I anticipate this will reinforce the move of AM from a ‘bolt-on’ to core business process.”

“The integrity of the asset owning company is crucial to the delivery of AM services. This will impact their choices between alternatives, readiness for change, flexibility and adaptability, true partnership with the service providers including suppliers, etc.”

“An integrated logistic approach, in my view, is the best way to incorporate AM services and operations as an asset is employed within the company for a reason/role. This means that it impacts on one or more areas within the business and that different inputs and outputs are required then they must be considered.”

“I miss aspects regarding financial-technical reporting, transparency, intern controls, link to SOX, ...”

“Very often Asset Management practices focus so much on the assets, that maintaining the documentation is neglected. Cannot stress enough how important it is to have asset data with a high degree of quality and completeness. And to implement processes that keep it that way. Photo based data collection and asset documentation is underrated. In our work, it has proven to be extremely efficient.”

“AM very important for all companies that really want stay and do better.”

“Compliance with available international standard of AM services”

“Very good research, in Brazil AM play a big roll in manufacturing industry. Well done.”

“I would be interested in the results if possible.”

“Provision of Asset management services to multiple clients with differing needs and objectives ...”

“The company I work owns the AM process with SME function of the Maintenance work processes outsourced”

“Today we deliver more of a basic asset care offer to our customers, however we are piloting a full asset management approach where we take responsibility for a plant wide approach covering our own and competitor equipment, with a scope to design a company wide AM system for our customer, that is ISO55000 compliant.”

“we currently busy building up our AM service and would like to be a leader in the next 2-3 years”

“Make sure the Requirements document from the client is understood by the service provider team Make sure the Deliverables conform to the Requirements and are well spelled out and understood by the client and service/product provider Make sure the Expectations of the service/product supplied are understood by the client and service/product provider.”

“My experience is that technical expertise is in abundance. The tie breaker is the personal relationships. People are threatened when change is implemented. Consequently, there is significant resistance to change, for it upsets the delicate balance in an ecosystem”

“1. For South African Municipalities the best solution would be to develop a national standard to simplify the implementation at the different municipalities and to assist the auditors with the test of the data. 2. Skill transfer to the client is of utmost importance. The client should be able to understand the new system implemented and be capable to better the system. 3. Be careful of not getting you

level of detail to low. You will get entangled in the complexity and not be able to meet the required deadlines. It is very important to state these assumptions in a policy at the client for future reference.”

“I found the survey interesting. Thank you for inviting me to participate. I wish you all the best!”

“We provide Road Asset Management support services, Road Asset Management is increasingly being required of Road Authorities by National Dept of Transport and National Treasury from a regulatory perspective. Funding for road infrastructure asset management is already of direct mode for provinces through grant systems (ie not through provincial allocations), soon to follow would be metros and then local municipalities. In such an environment it is important for Treasury to have controls in place regarding all aspects of asset management. The aim is to force the road authorities in the ISO55000 direction.”

“I work in the government sector, which has a very different focus from the private sector, particularly industry. In the government sector we tend to be initiating IAM, rather than improving or optimising. We can only dream about advanced IAM at this stage.”

“Really good survey - well done”

“All questions relate to pretty important success factors and the variance of my answers are pretty narrow - some normalization might be needed.”

“Most everything listed is essential. Not critical to very critical is a poor meter stick. Suggest essential to critical to obtain a better spread.”

“I found the questions fairly difficult to understand and as a result of the variety of industries I have been involved in decided to focus on manufacturing. I hope my answers are consistent!”

312 APPENDIX B. SURVEY STUDY IMPLEMENTATION AND ANALYSIS

“NB! The consideration to measure collaborative integration between stakeholders (Asset Owners, versus the Service Providers. The clear Role Descriptions and definitions as well as level of Accountability is NB! The factor of "how much "bang for buck" " the client is getting from this process as a measurable and the secondary and tertiary knock on effect for the business because of a resultant better performance and quality of product supplied. All of the best!”

“I am finally elated that there is someone looking at Integrated Asset Management”

“Suggest to add Middle East as a separate region of activity. Some aspects warrant the possibility to answer with Not Applicable. In some of these cases my answer was neutral. Our company provide multiple "type of services", from Basic to Outsourced, from transactional to 3 year fixed price performance contracts”

“some of the questions i had more than one answer, but I used my current client as a reference”

“It is essential as a AM service provider to proactively manage the client relationships and ensure a trust relationship is built between yourselves and the asset owner. This helps minimise the level of management that the asset owner has to exercise over your services and in that case you will be viewed as adding value to the asset owner.”

“Questions are unnecessarily too long (structure) but quite thought provoking!”

“Some asset owners like ourselves prefer to self-perform rather than outsource. Therefore, we rather enter into short-term professional support agreements to implement Business Intelligence around AM and manage the systems and related processes in-house.”

“I work for a large global based OEM and thus Asset Management Services can be quite different looking at it from our perspective vs our customer’s perspective.

This is a big challenge in our environment where we need to provide effective and efficient support and AM services for our thousands of machines but also understand that we do not maintain, manage and control all of the customer's assets as it is not our core business. Many times to have an effective AM service at our customers the root cause of performance problems for example is not related to our machines at all and we need to expand our scope. We are continuously expanding and rethinking our AM service offerings to our customer base but the reality is that more and more flexible custom solutions and services are being demanded by our customer's which is very difficult to manage and control on a global scale. Simply not feasible from a financial or resource perspective to have a custom AM service solution for every customer. Finding the balance between flexibility (customization) and standardized AM service offerings is a big focus for us to ensure we can sell and support more AM Service contracts to our customers."

"Being involved in the Continuous Business Improvement environment as a consultant in various business sectors one item stood out in this questionnaire - the questions regarding not only measure, feedback and maintain, but those closing the loop with ACTIONS to improve and FOLLOW UP afterwards. In the best Asset Management or rather the most effective asset management solutions that I have encountered locally and internationally, this is probably one of the core Critical Success Factors - not just measuring but actual improvement. It impacts on the business, return on investment, business growth, etc (for both the supplier and client company)."

"Please note that the bulk of the activities was marked as critical as AM is my passion. Thanks"

"In the time that I have been involved with physical asset management, I have found that a good relationship with all the stakeholders at a client organization as well as a clear understanding of AM and the requirements, is the leading point of criticality in successfully implementing and maintaining the application of AM."

"Communication of AM best practices should be in a understandable way for

those who should understand it within the organisation.”

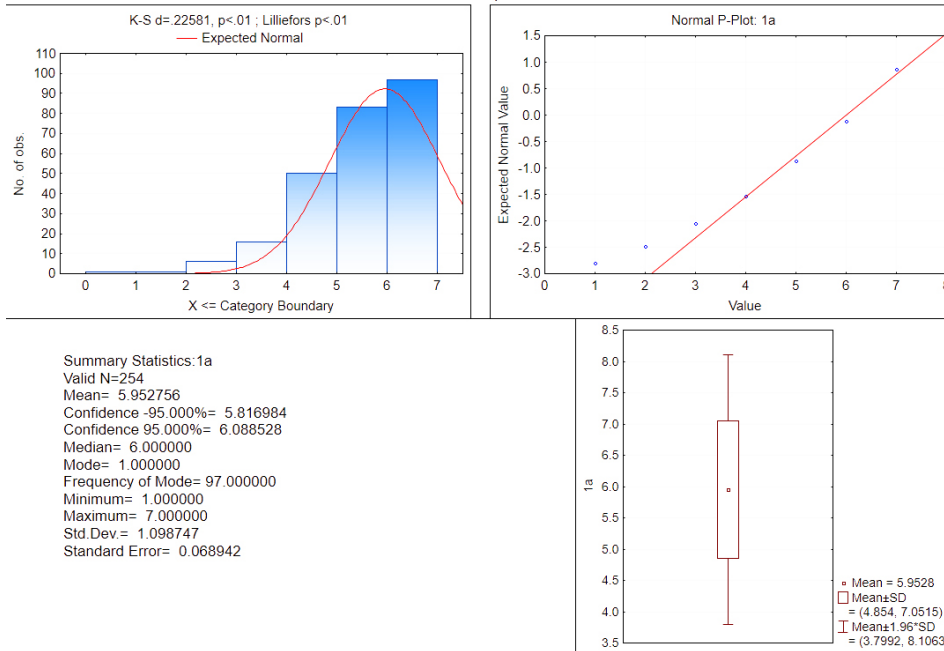
“Feedback is an essential part of the process that guides people to submit performance and behavior appropriate to a given situation, letting them know how they are being seen in the market or in the workplace, this way we can know how they are being seen and assessed around. The lack of feedback may leave without knowing which direction to go. One can consider it as a compass that gives direction that should be taken to achieve the goal and customer satisfaction.”

“Always make clear what are the goals to be achieved”

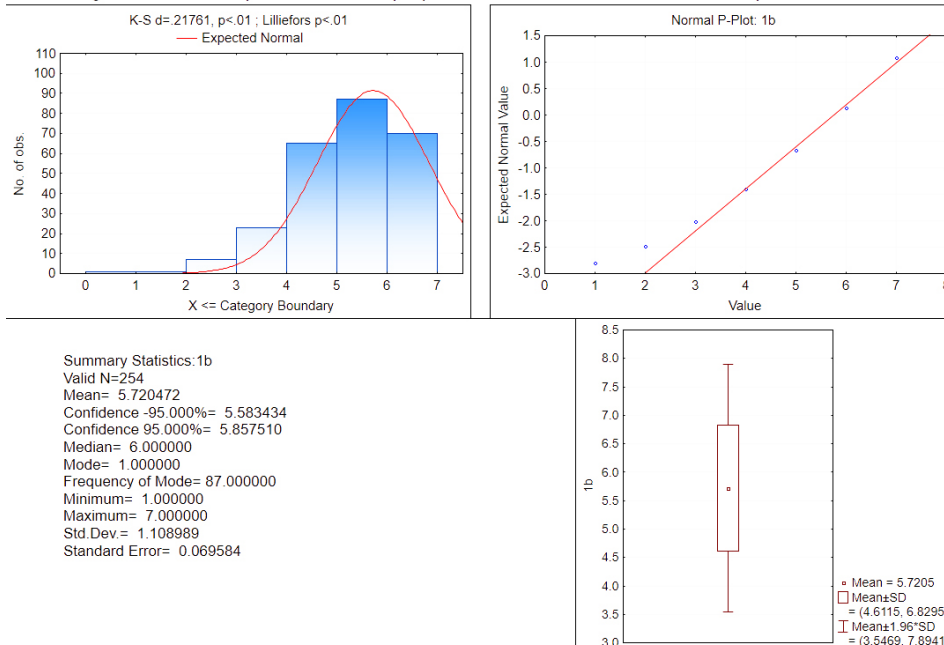
“The questions seem very equal and not seen in a few questions for anyone working with intangible assets.”

B.4 Descriptive Statistics per Success Factor

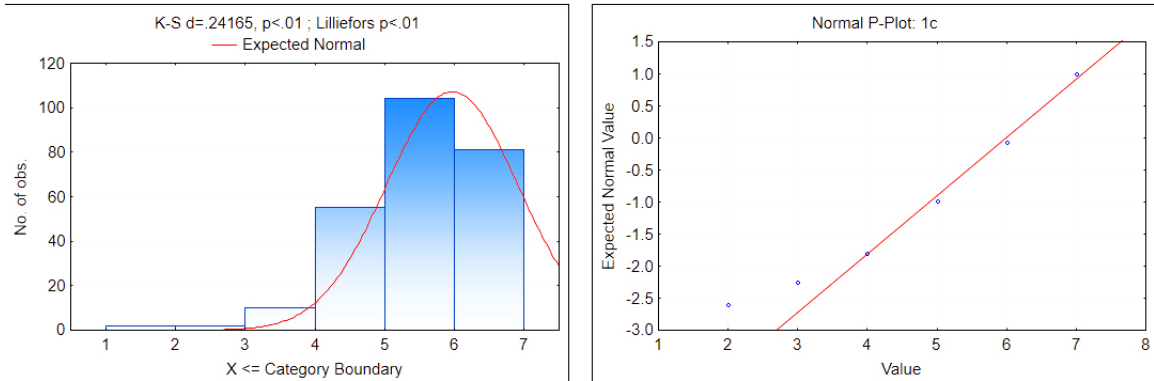
Summary: 1a: A capable project (or key account) manager that manages the AM service on behalf of the service provider.



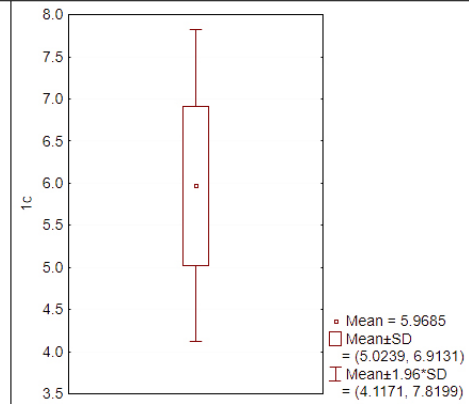
Summary: 1b: The degree to which the service provider's client facing team are knowledgeable in the full range of the service provider's value proposition and combination of service options available.



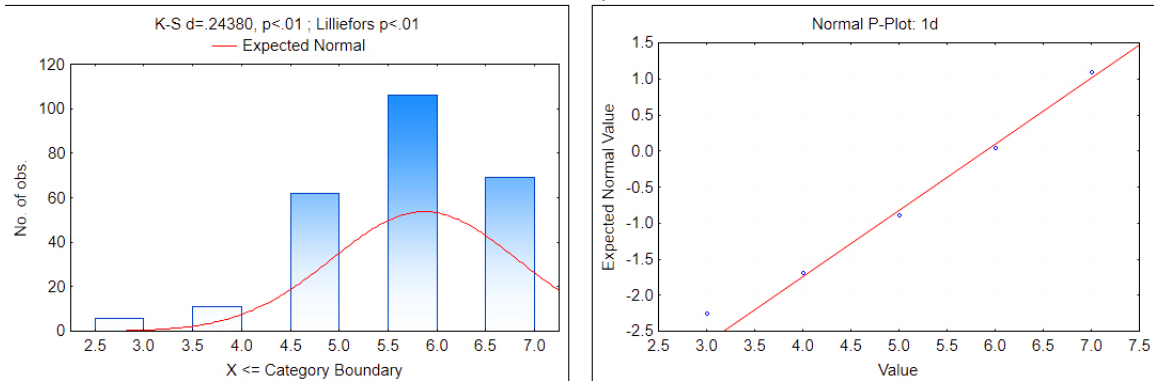
Summary: 1c: The technical knowledge, expertise and capabilities of the service provider's client facing team and consultants.



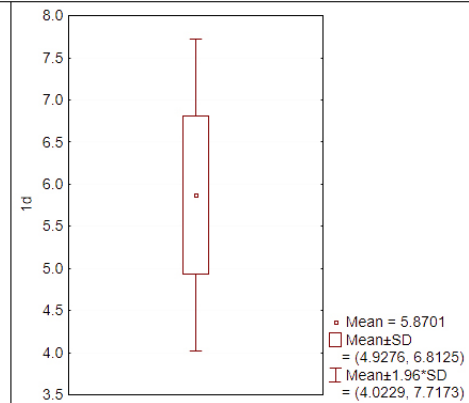
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Confidence 95.000%= 6.085229
Median= 6.000000
Mode= 1.000000
Frequency of Mode=104.000000
Minimum= 2.000000
Maximum= 7.000000
Std.Dev.= 0.944608
Standard Error= 0.059270



Summary: 1d: The availability of the most appropriate skilled resources for providing industry specific AM service requirements.

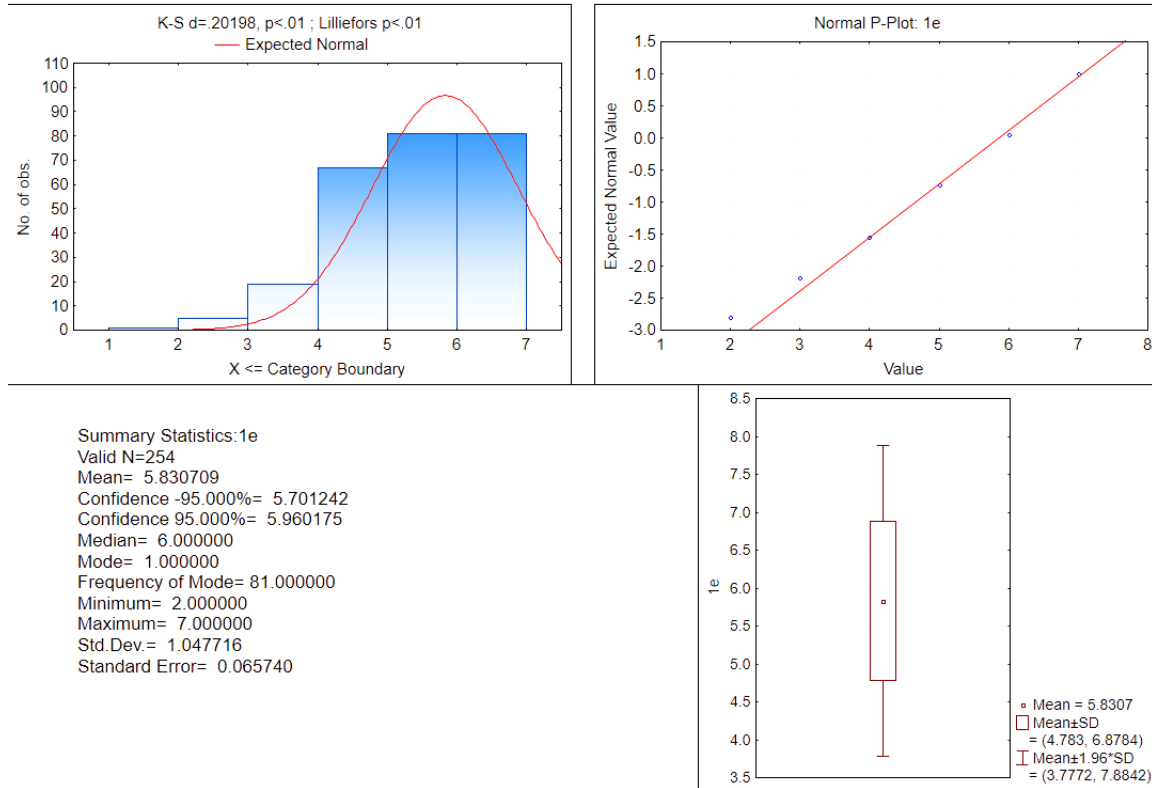


Summary Statistics:1d
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Confidence 95.000%= 5.986536
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Standard Error= 0.059134

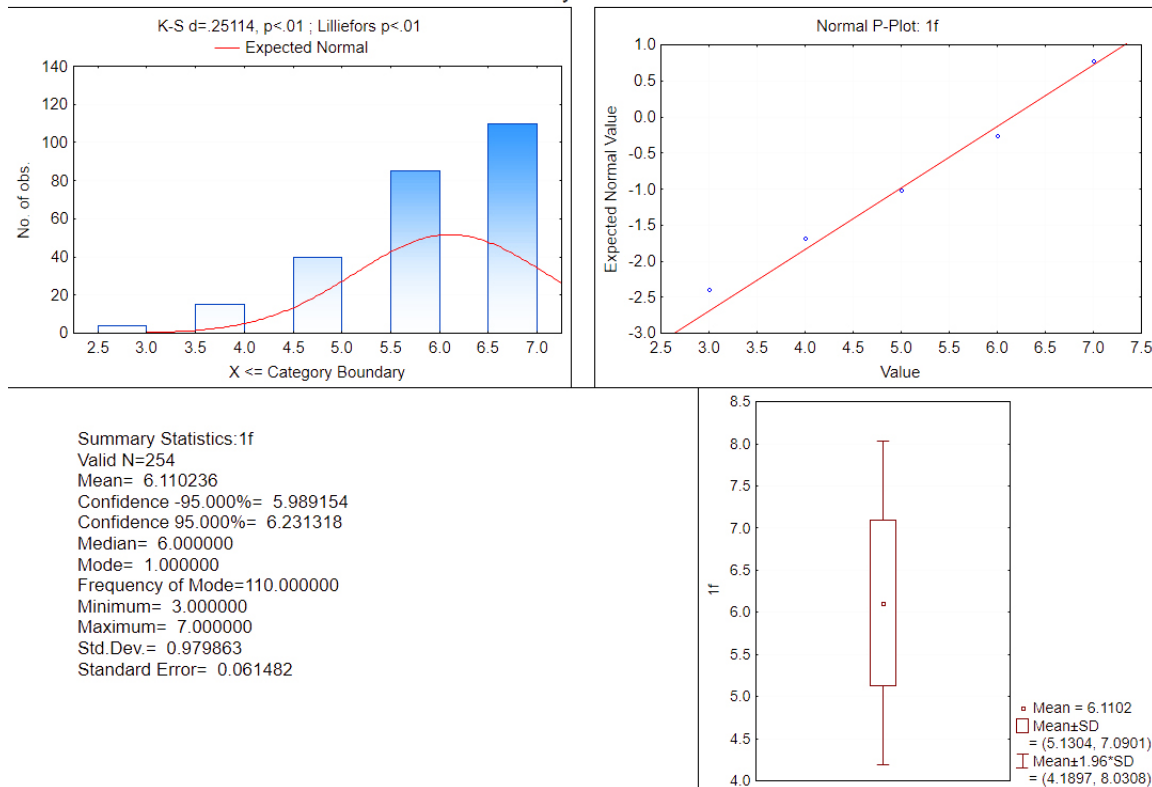


B.4. DESCRIPTIVE STATISTICS PER SUCCESS FACTOR

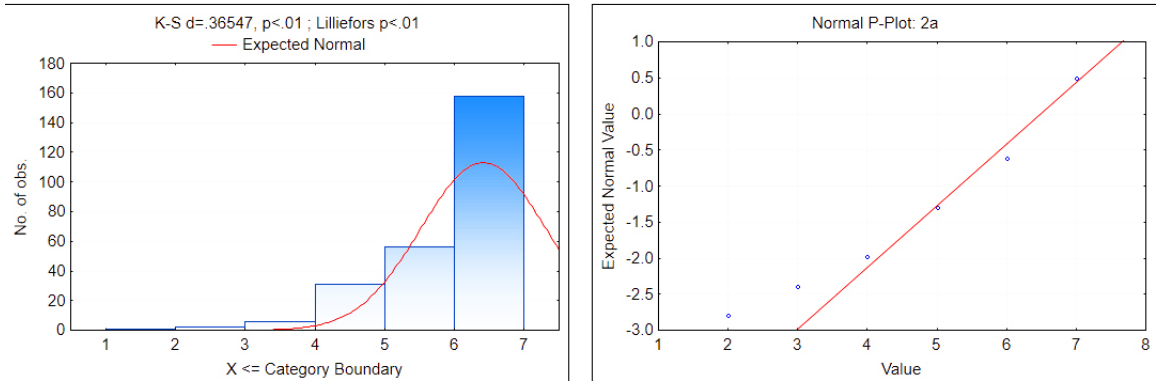
Summary: 1e: The service provider team's internal characteristics (i.e. service continuity when team members are redeployed to other services, handover between service phases).



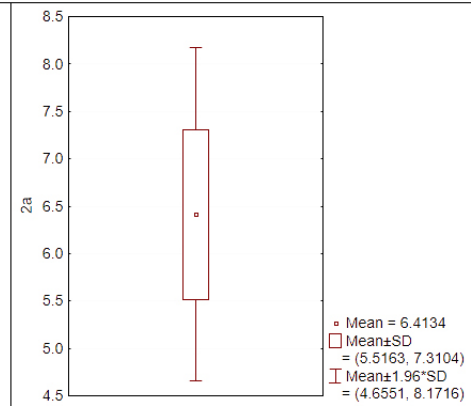
Summary: 1f: The integrity of the leadership and delivery team and the set of values to ensure sustainability of the service.



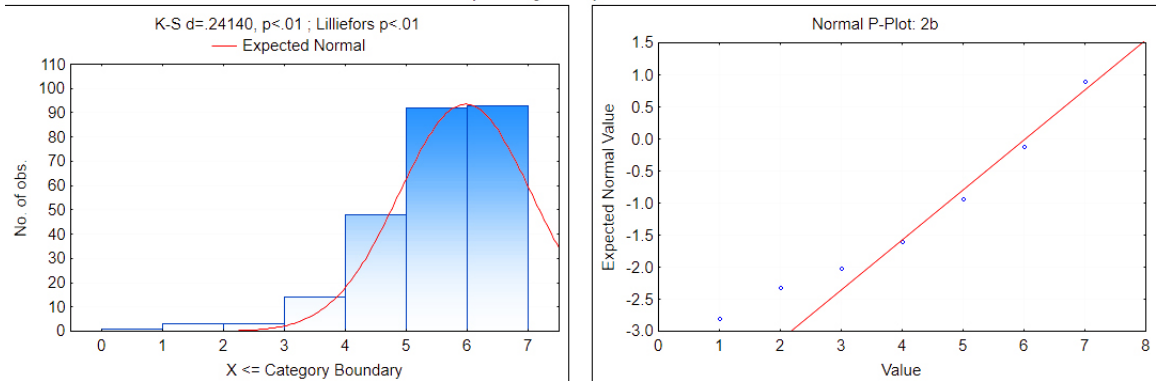
Summary: 2a: The continued and sustained commitment from the asset owning organisation's senior management in support of the AM service.



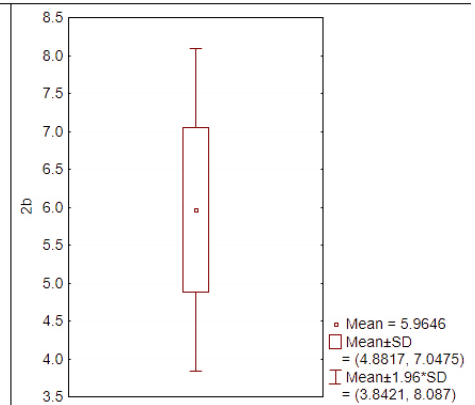
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Mode= 1.000000
Frequency of Mode=158.000000
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Std.Dev.= 0.897063
Standard Error= 0.056287



Summary: 2b: The active participation of the asset owning organisation personnel and their commitment towards completing the pre-contract activities.

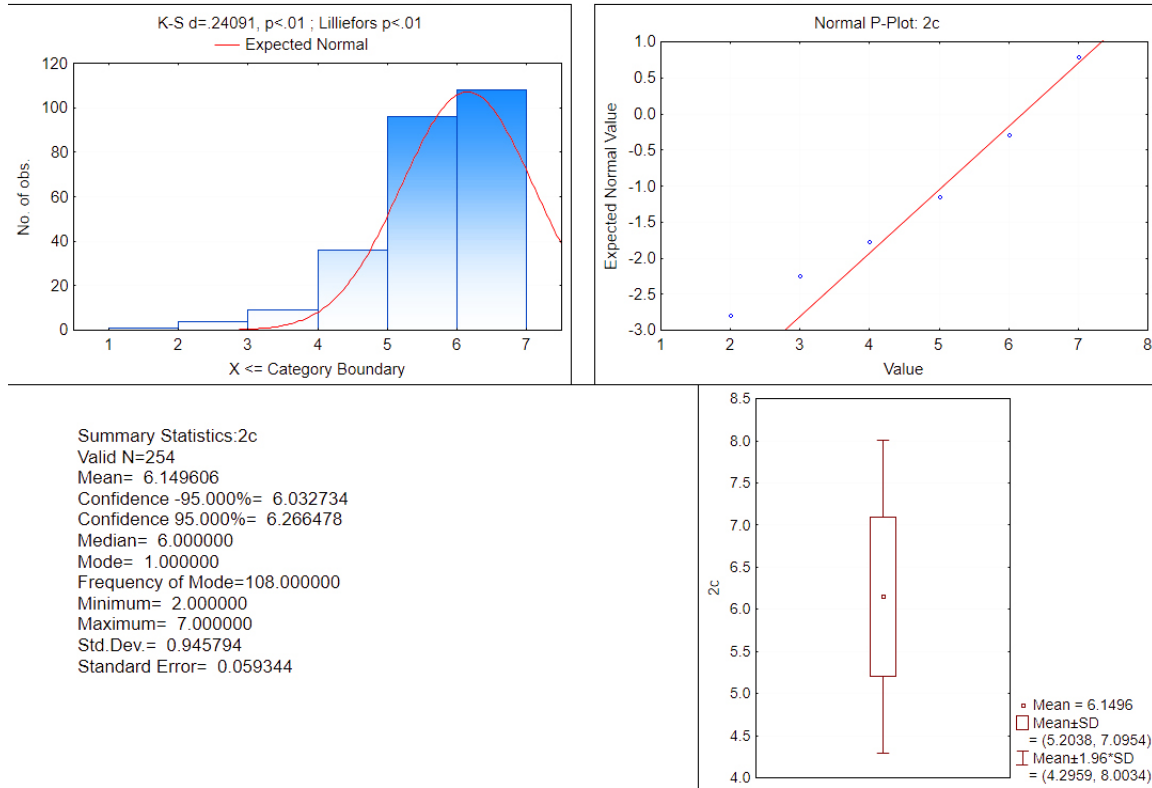


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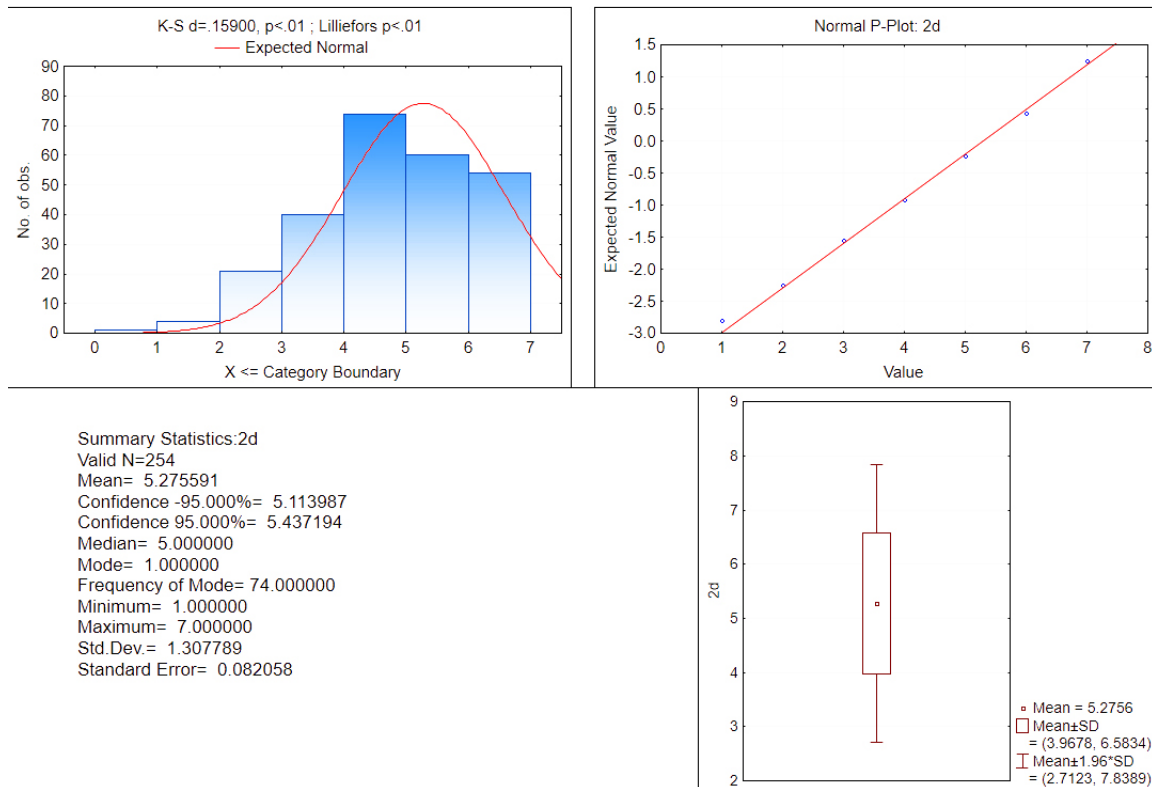


B.4. DESCRIPTIVE STATISTICS PER SUCCESS FACTOR

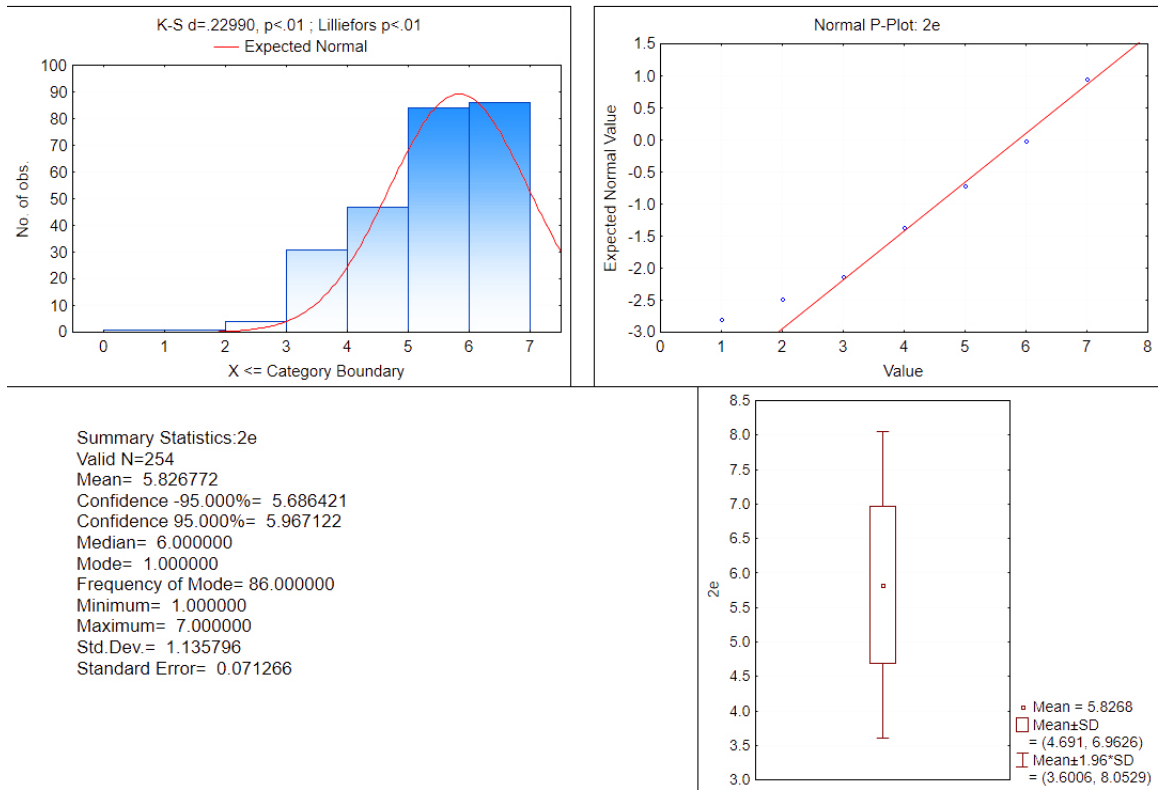
Summary: 2c: The alignment of the asset owning organisation's AM service requirements with their overall organisational and business strategies.



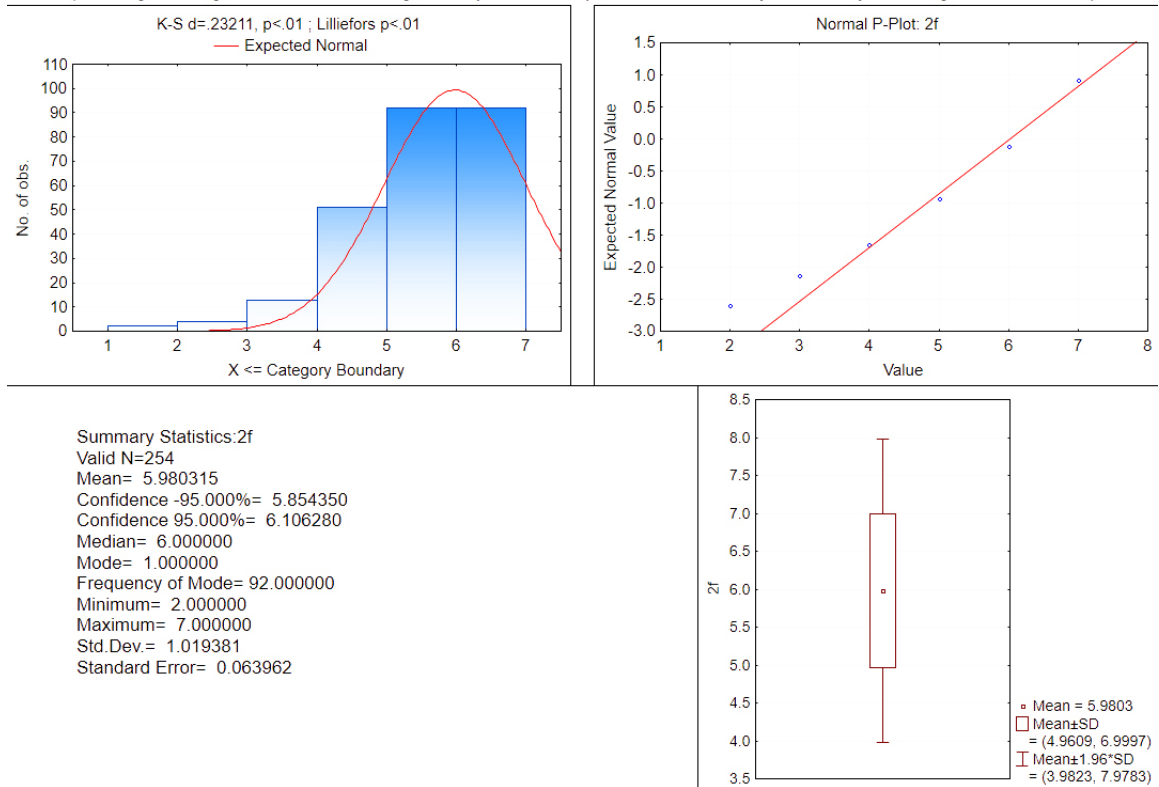
Summary: 2d: Compilation and availability of formal contractual documents.



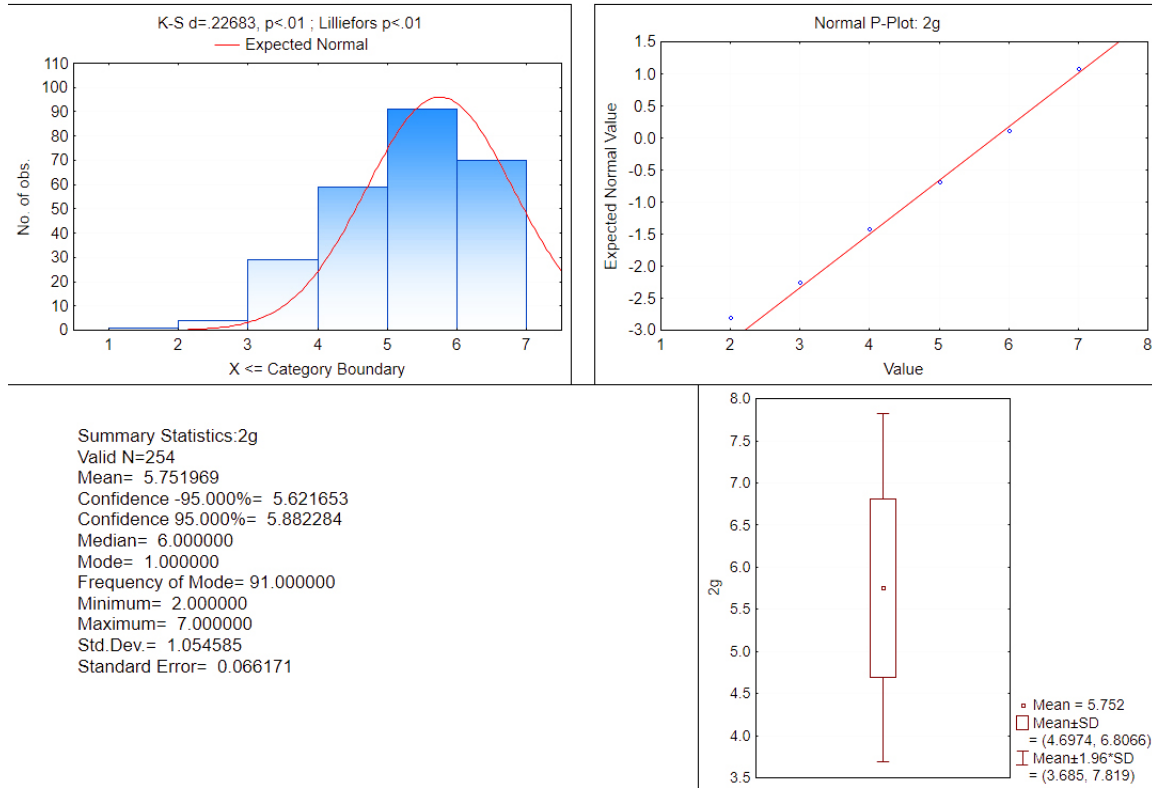
Summary: 2e: A detailed project plan with milestones in place.



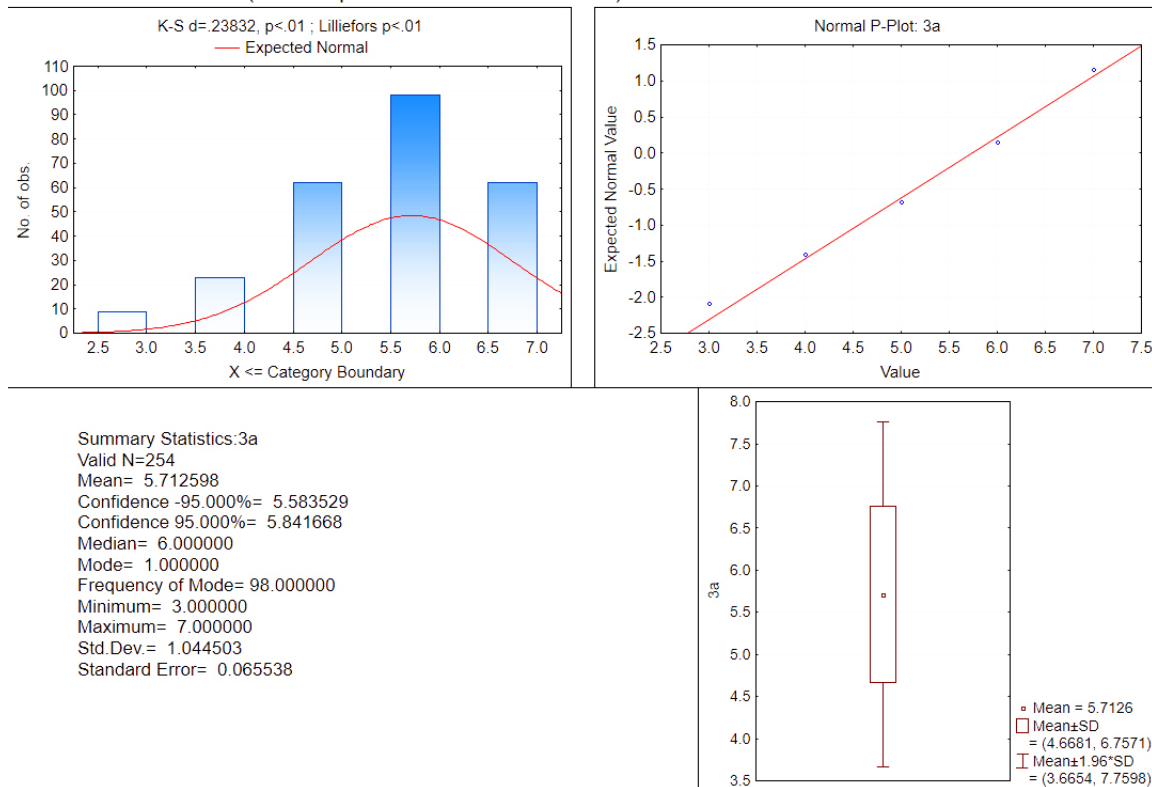
Summary: 2f: The cultural readiness of the asset owner to change in business model for delivering AM (having the right skills to manage the partnership, instead of only the daily management of AM)



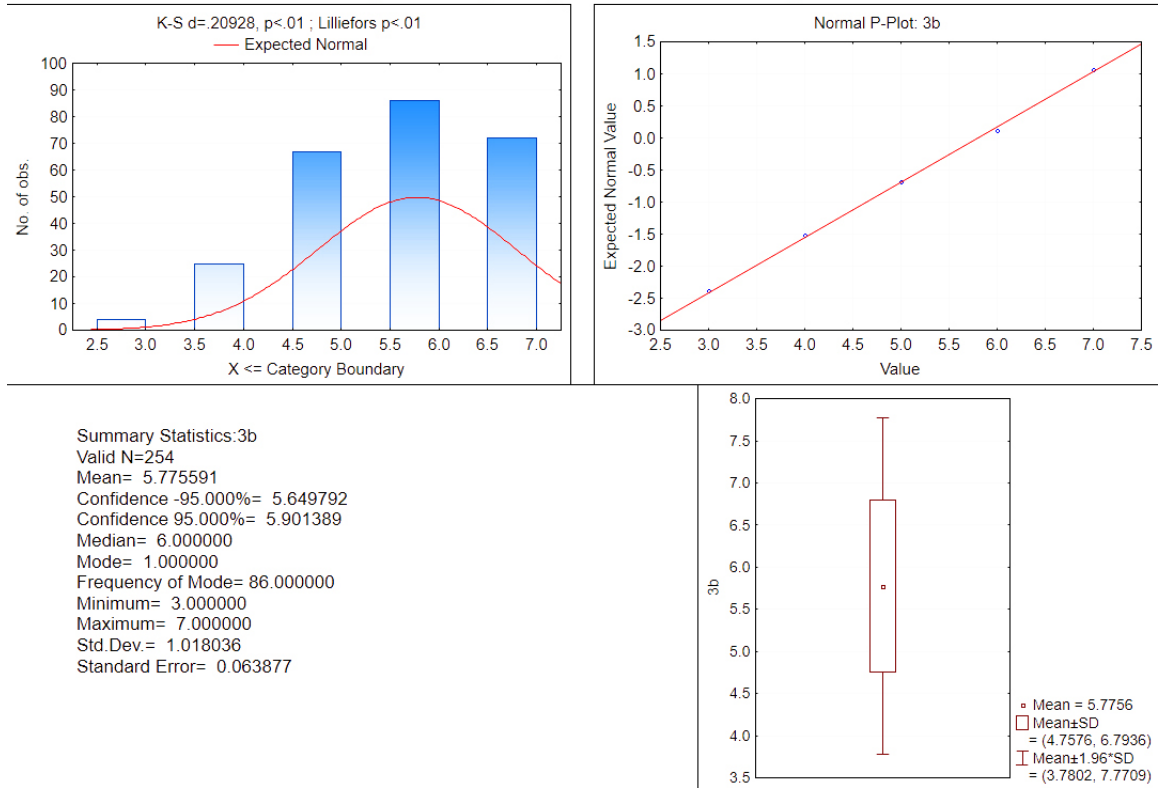
Summary: 2g: The belief by the service provider that they will deliver benefits, and that the collaboration will result in positive benefits for the individuals and the organisation.



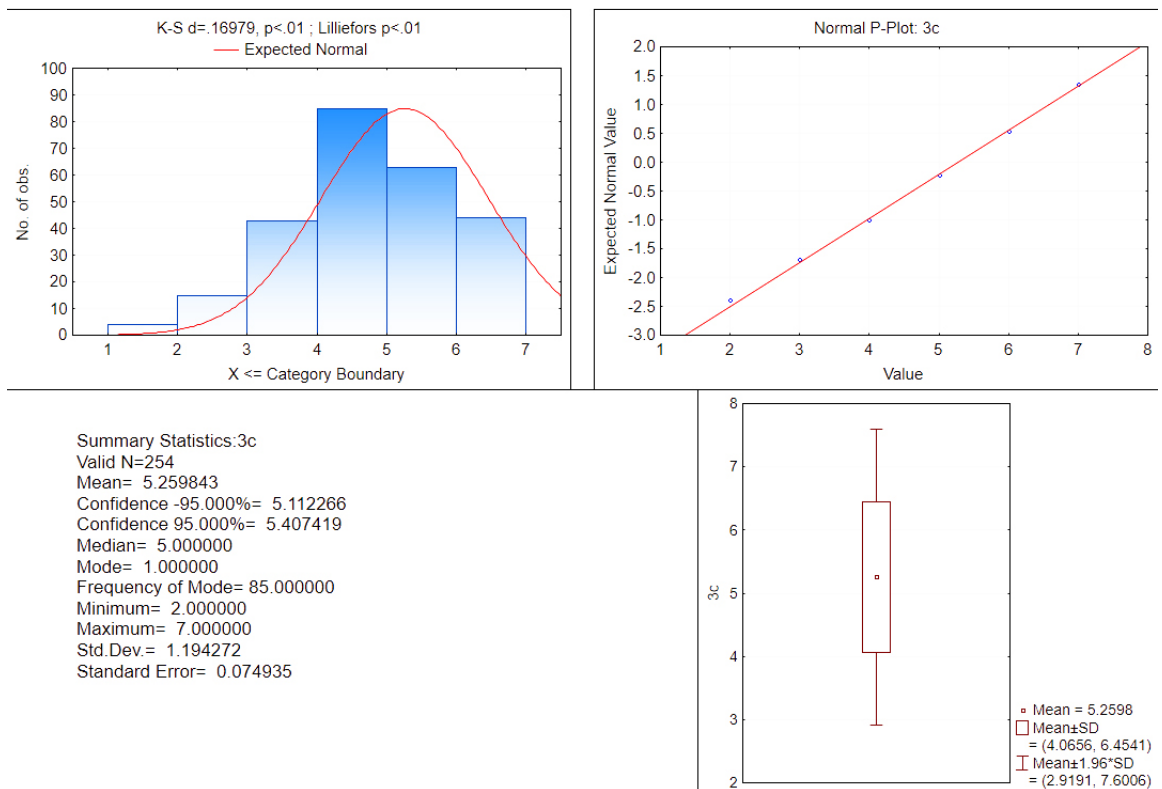
Summary: 3a: The design and integration of service and performance metrics for all stakeholders (service provider and asset owner) involved in the AM service.



Summary: 3b: The inter-company flow of information (between the service provider and asset owning organisation) during the AM service design.

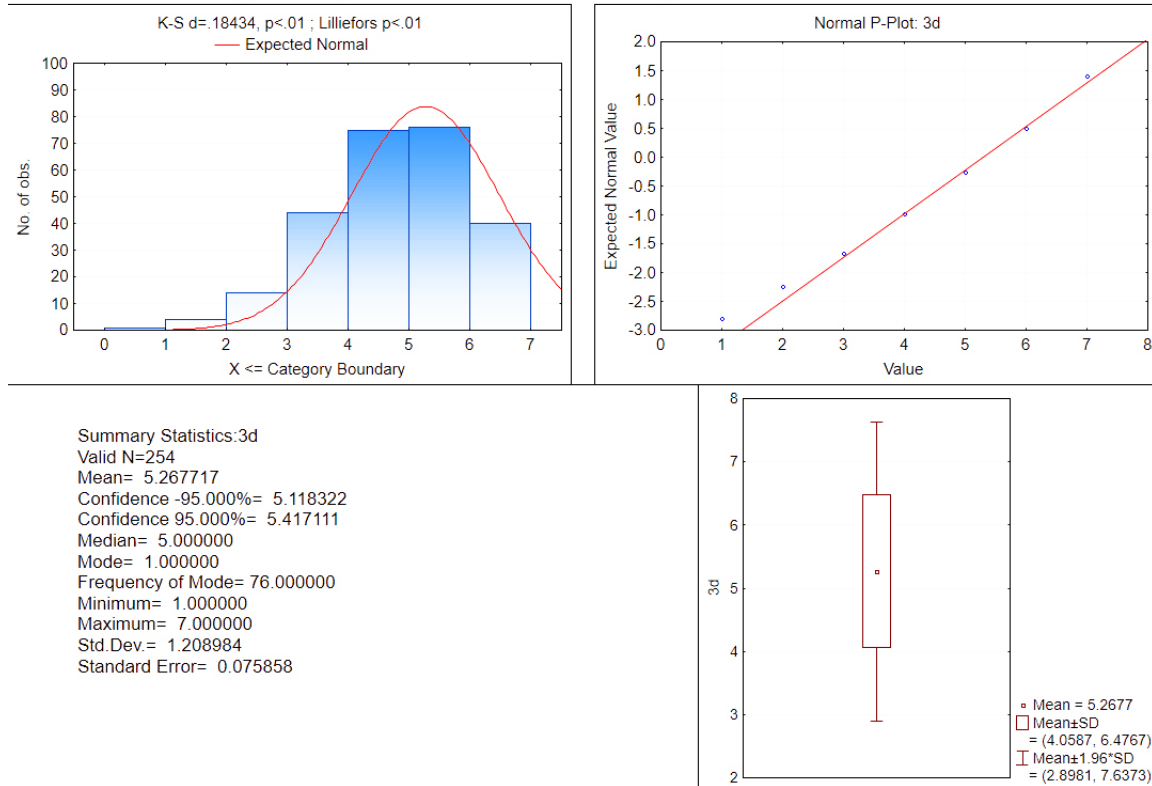


Summary: 3c: The compilation and active use of design documents.

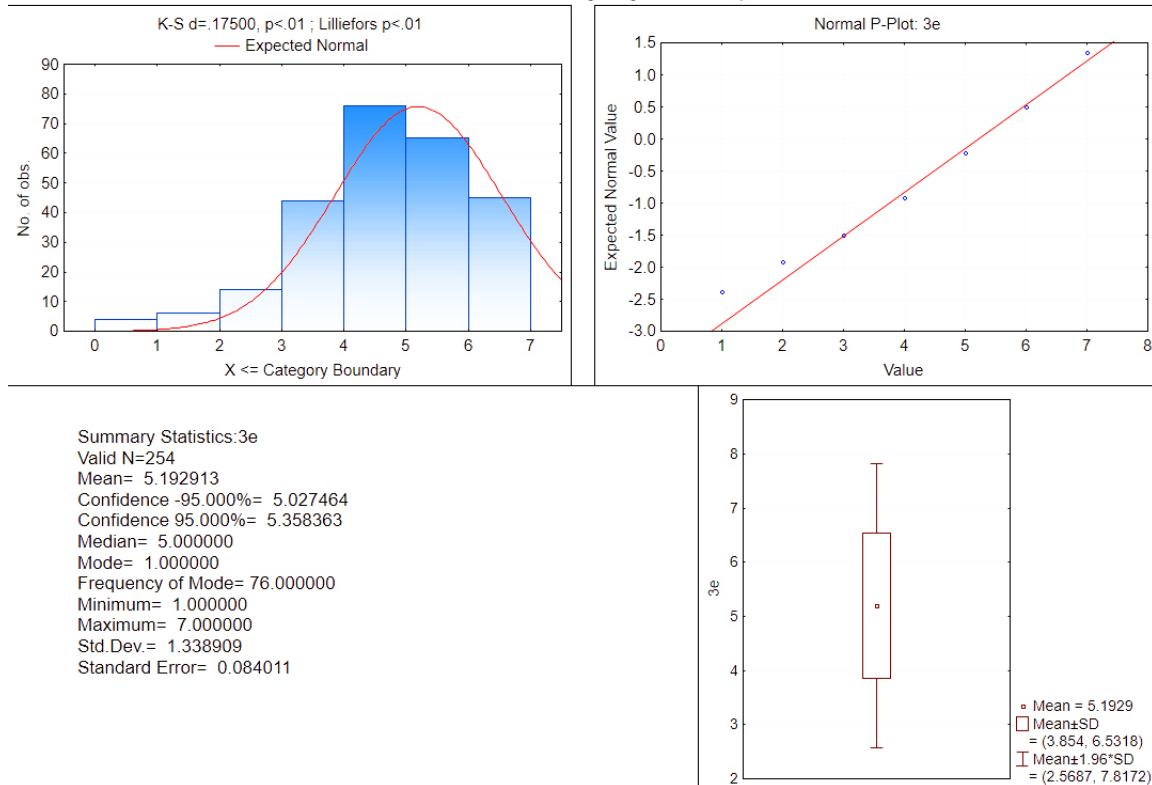


B.4. DESCRIPTIVE STATISTICS PER SUCCESS FACTOR

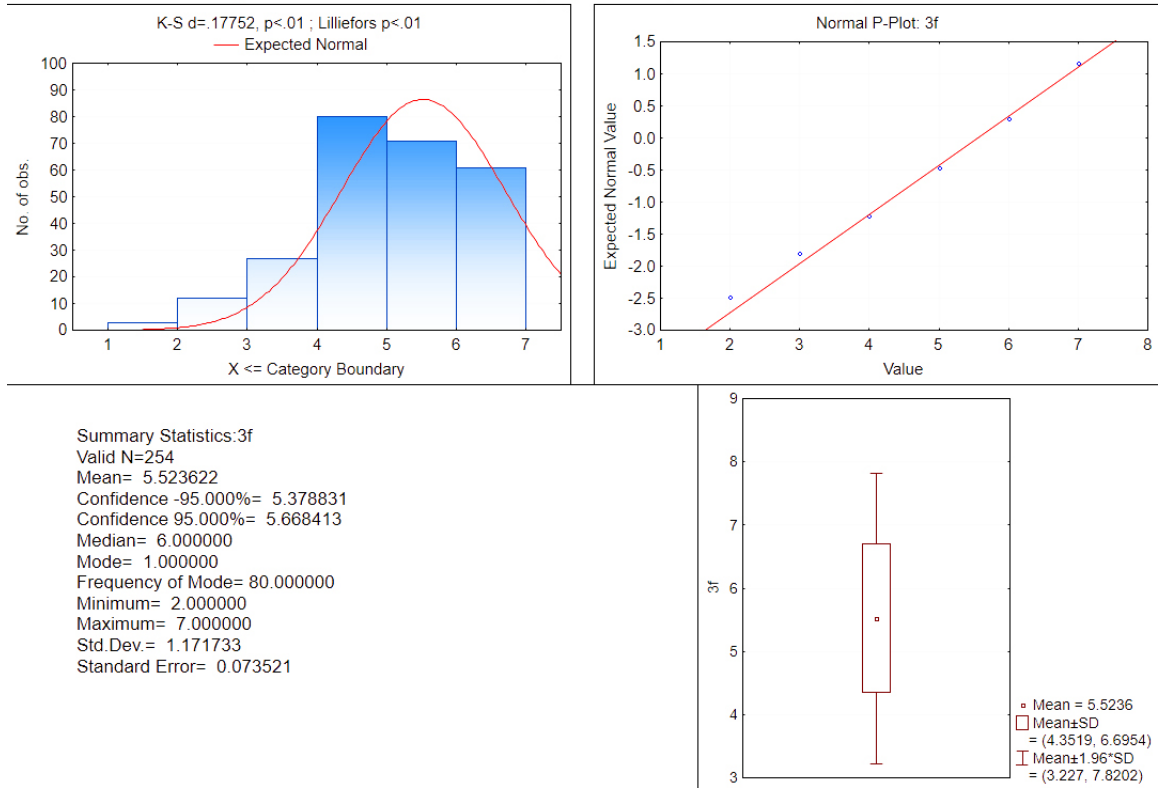
Summary: 3d: Ensuring that pre-project arrangements are made for logistics, feasibility studies and changes in organisational structures that might arise from the AM service.



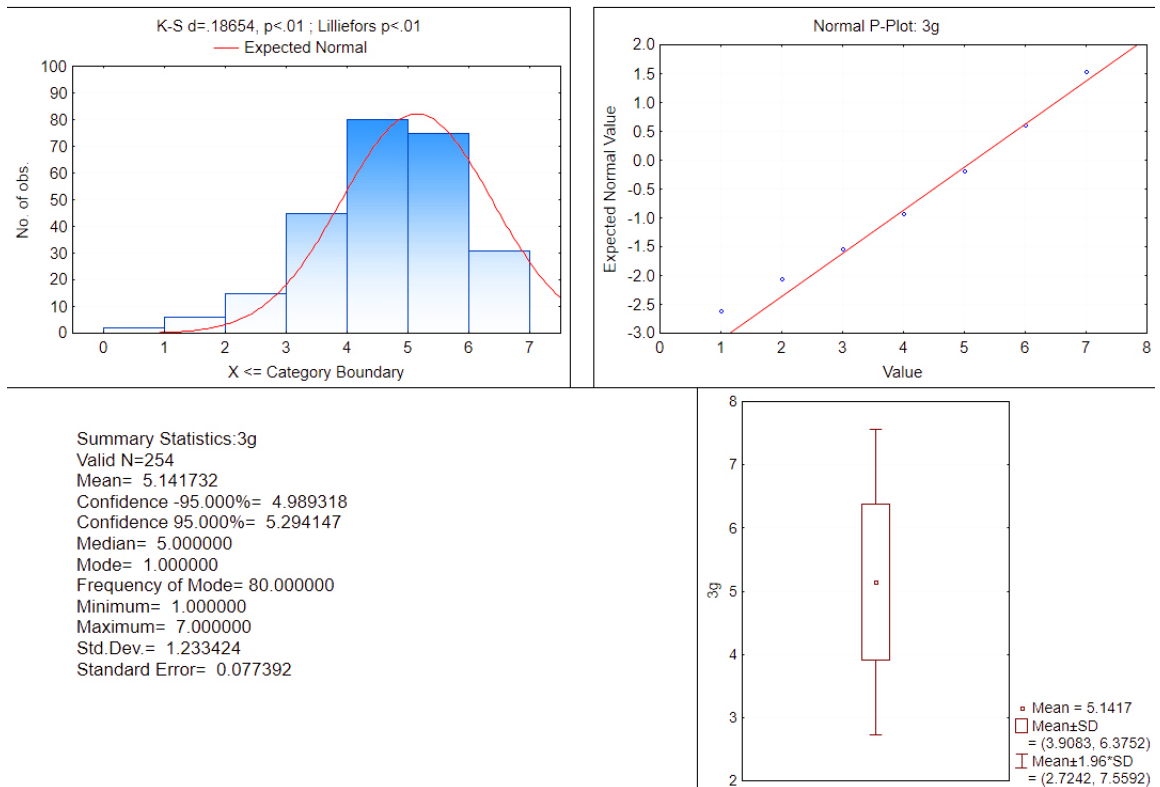
Summary: 3e: The potential of the AM service to be scalable (expandable to other business units within the asset owning organisation).



Summary: 3f: The strategic fit of the AM service with the service provider and asset owning organisation's current service propositions, systems and capabilities.

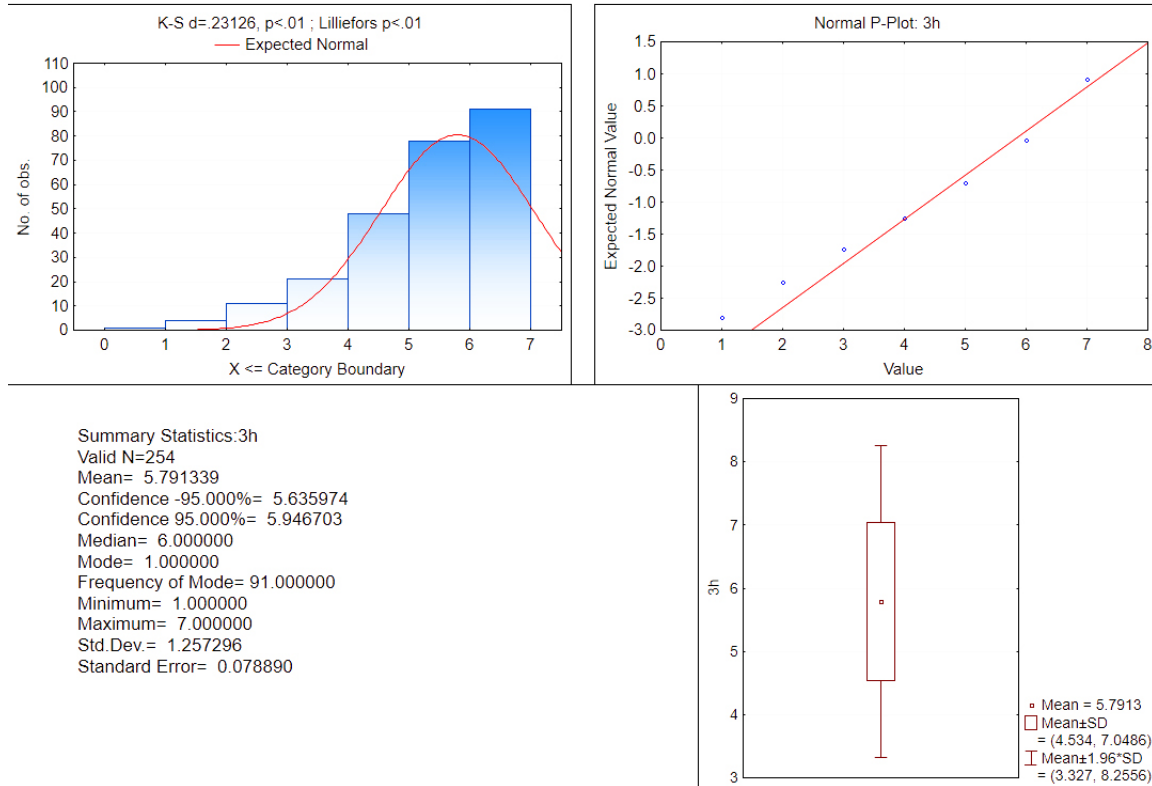


Summary: 3g: The evaluation and consideration of different AM service designs.

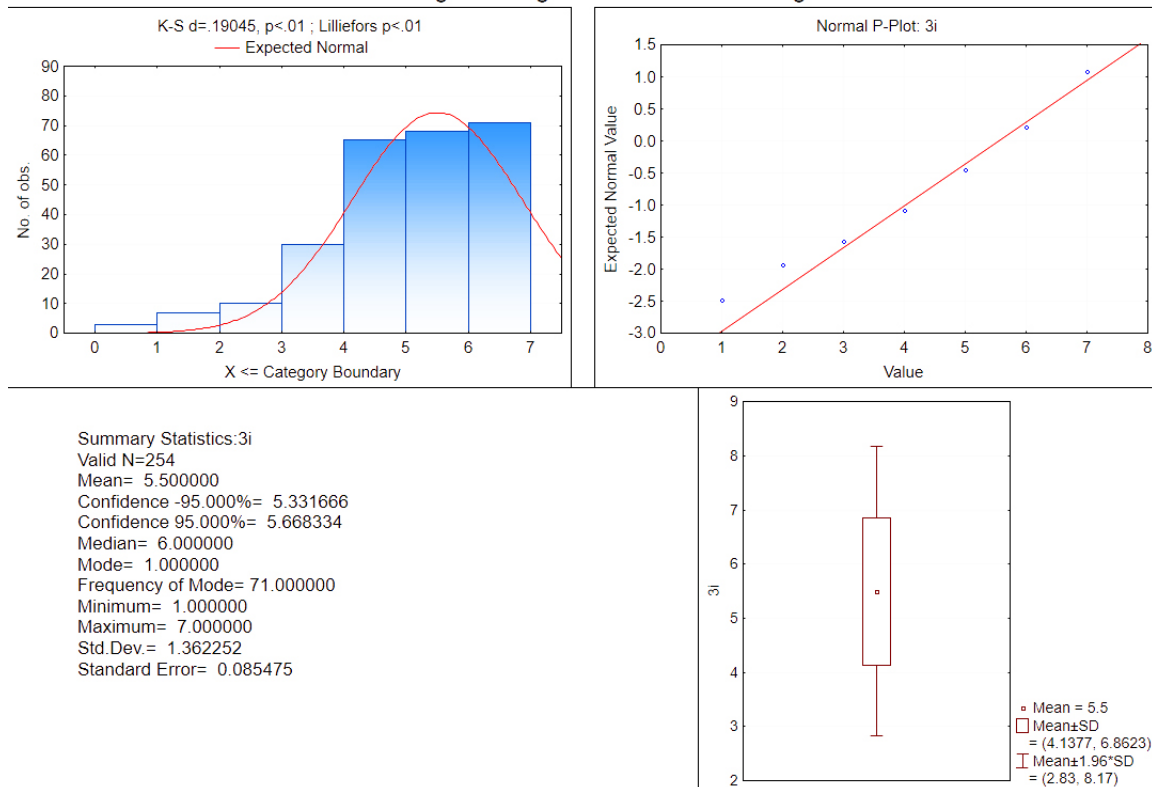


B.4. DESCRIPTIVE STATISTICS PER SUCCESS FACTOR

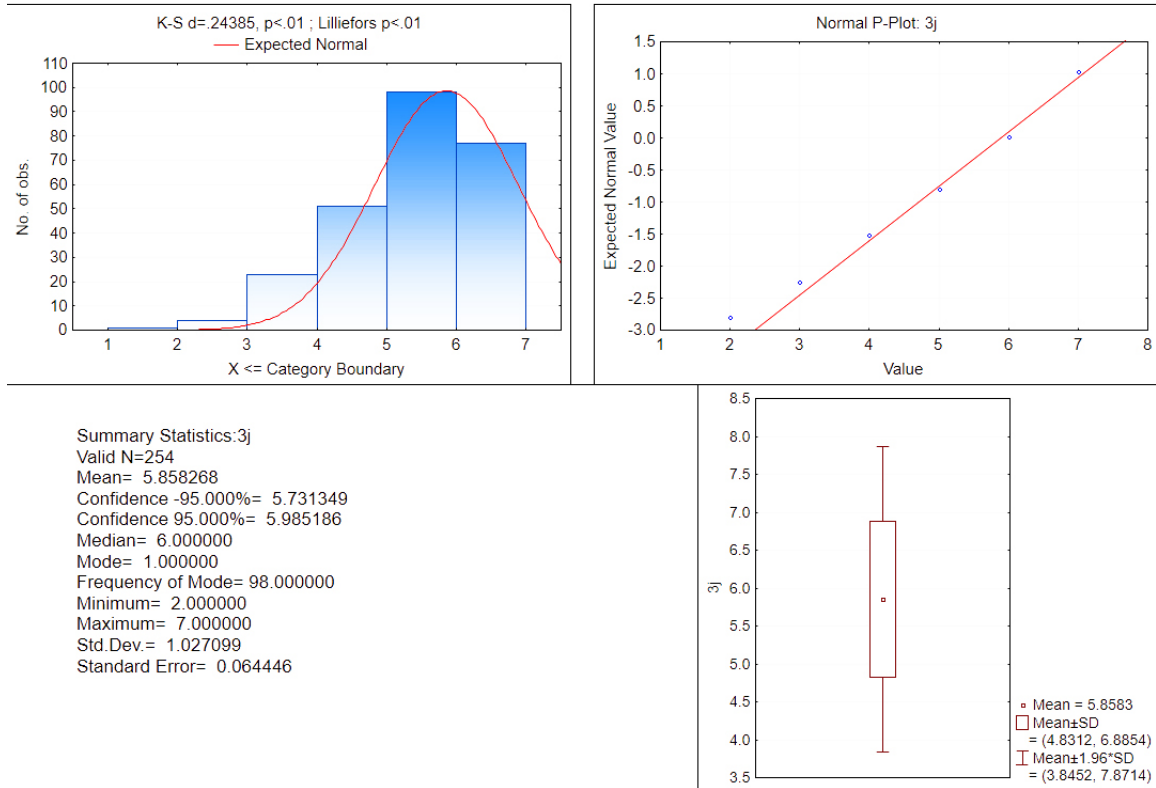
Summary: 3h: The integration of health, safety, environmental and quality considerations as part of the AM service or to align the service to existing standards.



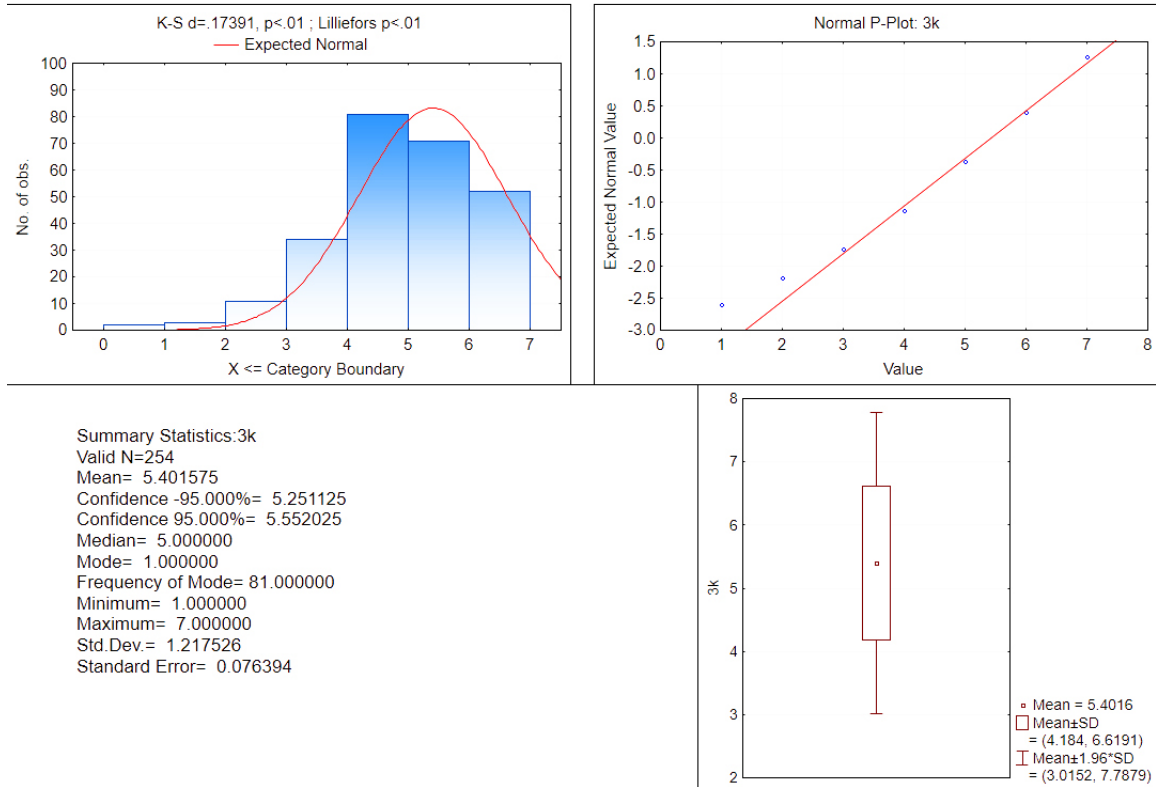
Summary: 3i: The integration of operational excellence methodologies, such as TPM, TQM, 5S into the AM service offering or to align the service to existing standards.



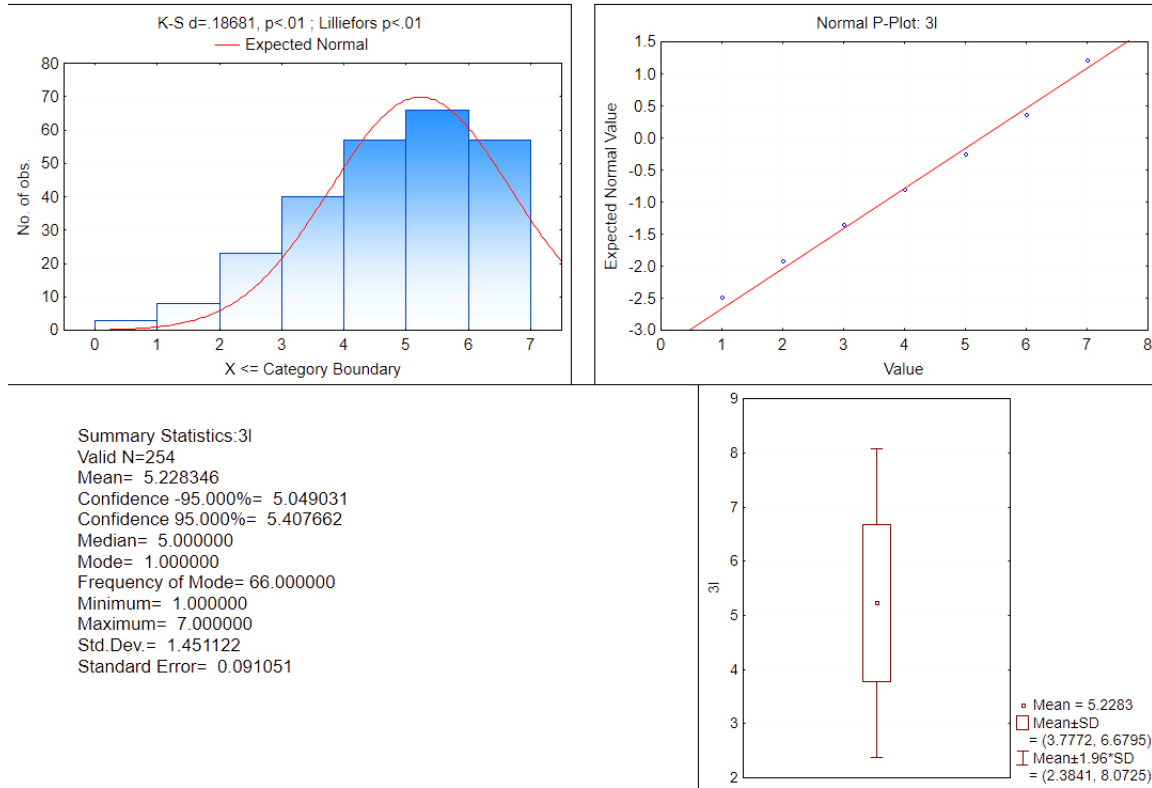
Summary: 3j: The availability of adequate information system infrastructure and interfaces in support of the AM service.



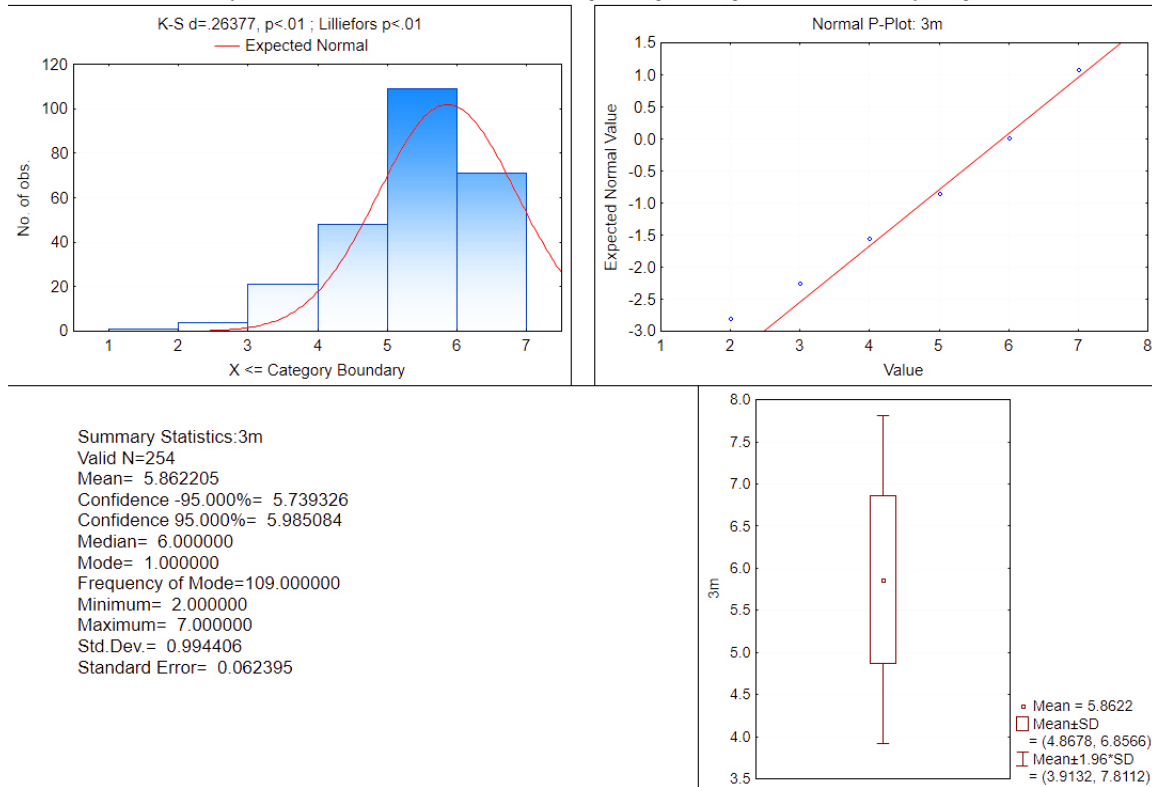
Summary: 3k: Adequate legacy system knowledge (i.e. ERP), if such systems are required to interface with the AM service information systems.



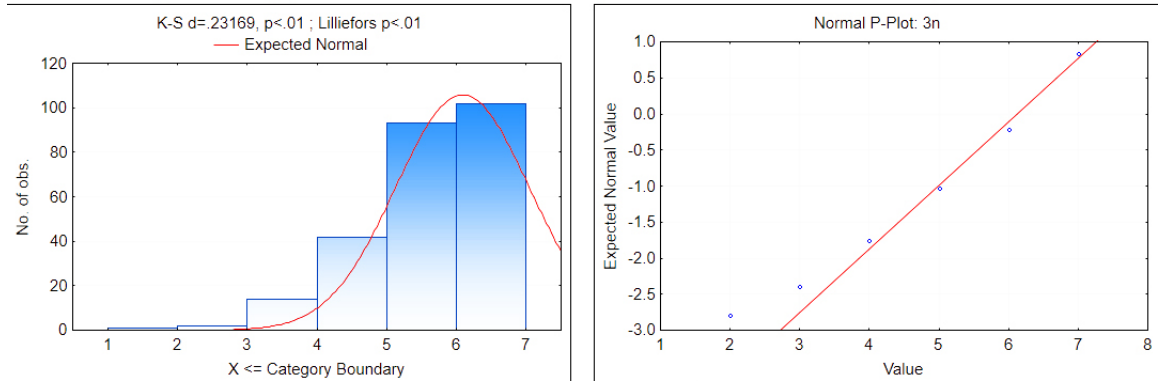
Summary: 3l: The security and protection of information, relating to information systems that forms part of the AM service.



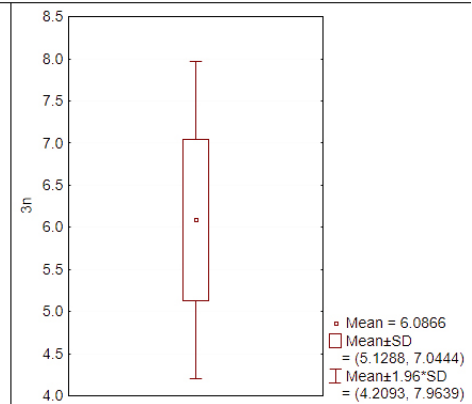
Summary: 3m: The ability to design a practical solution for the asset owning organisation's existing AM maturity, but also to consider in the design long term goals AM maturity targets.



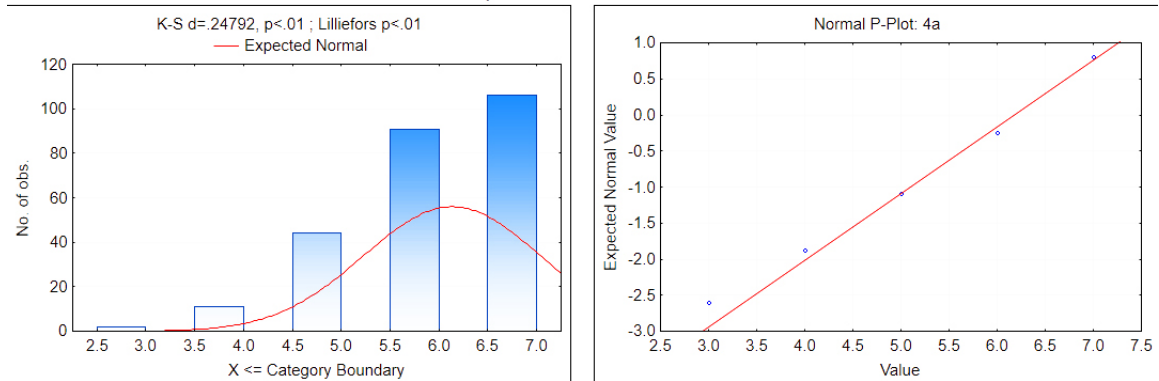
Summary: 3n: The involvement of knowledgeable and demanding individuals from the asset owner during the design, rather than individuals that prefer to abdicate their AM responsibilities.



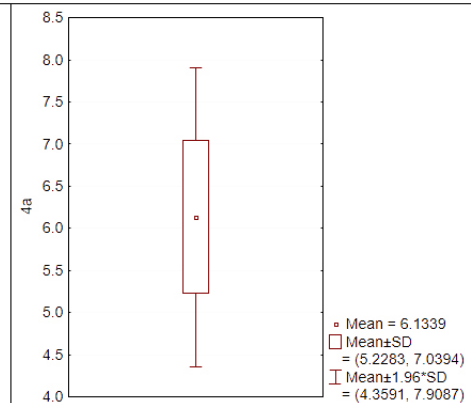
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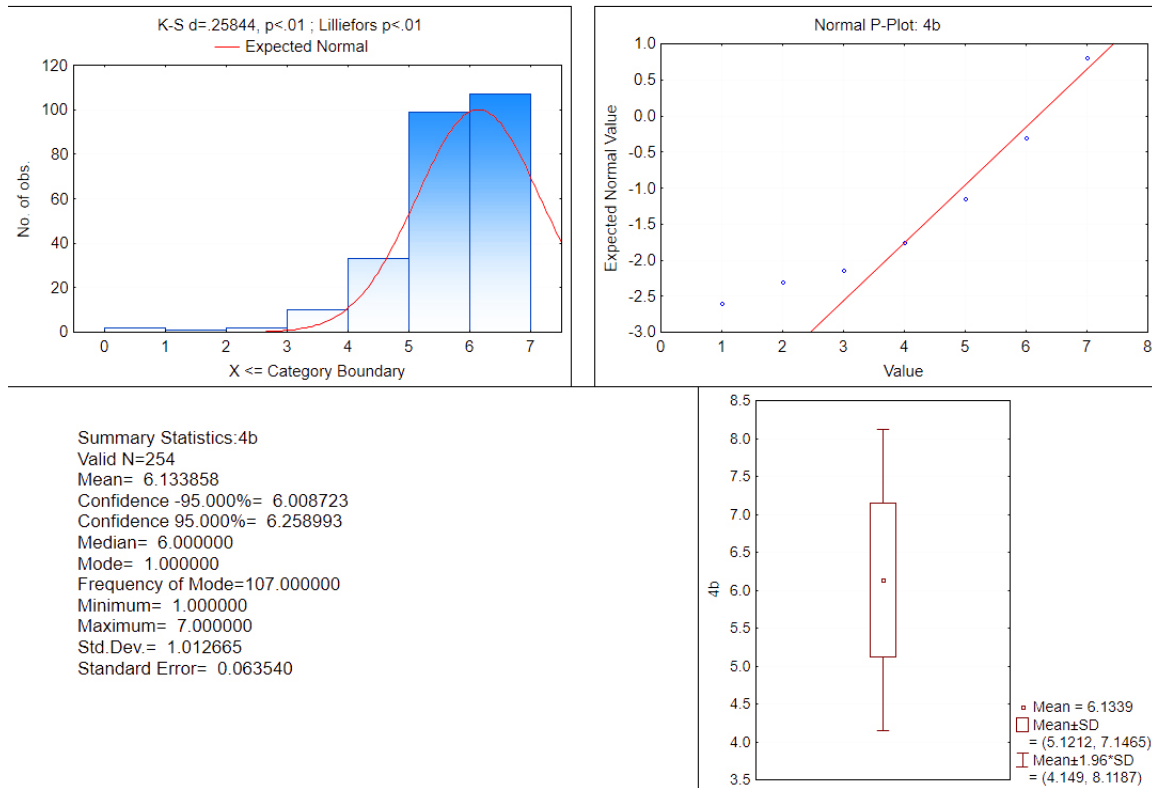
Summary: 4a: An adequate training programme in place for all AM service role players, both in the service provider and client teams.



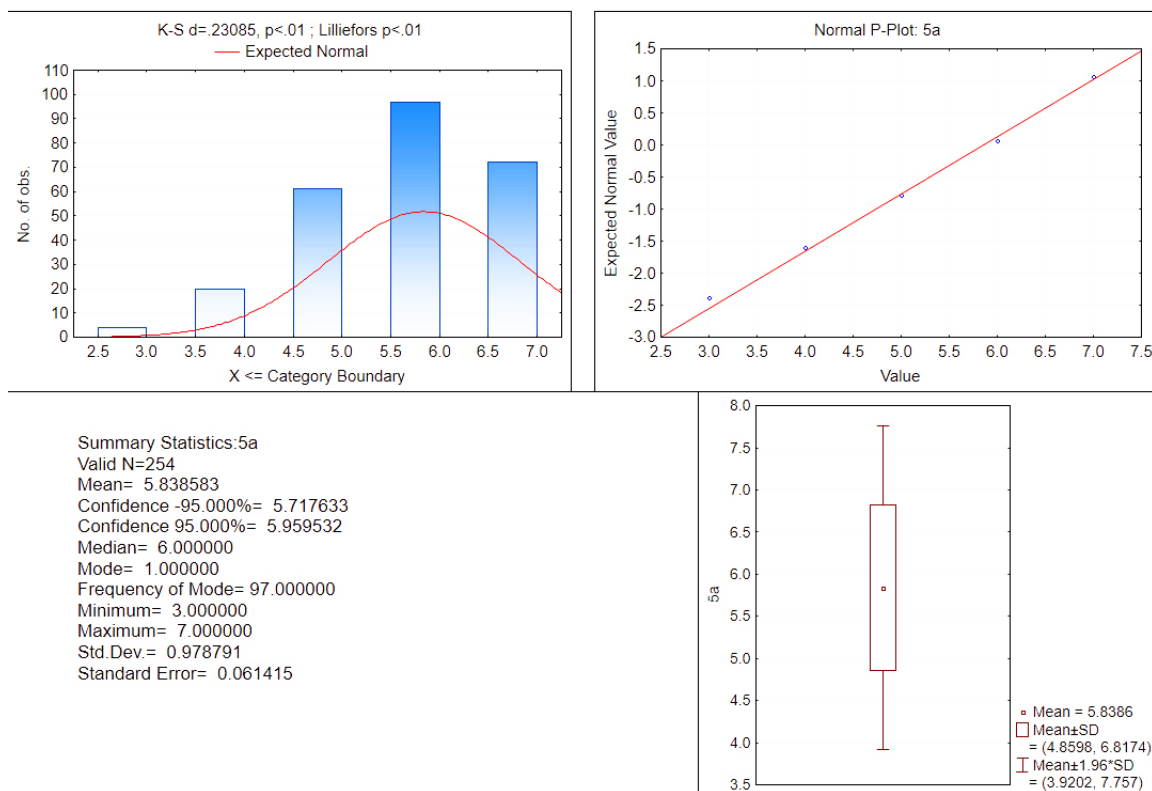
Summary Statistics:4a
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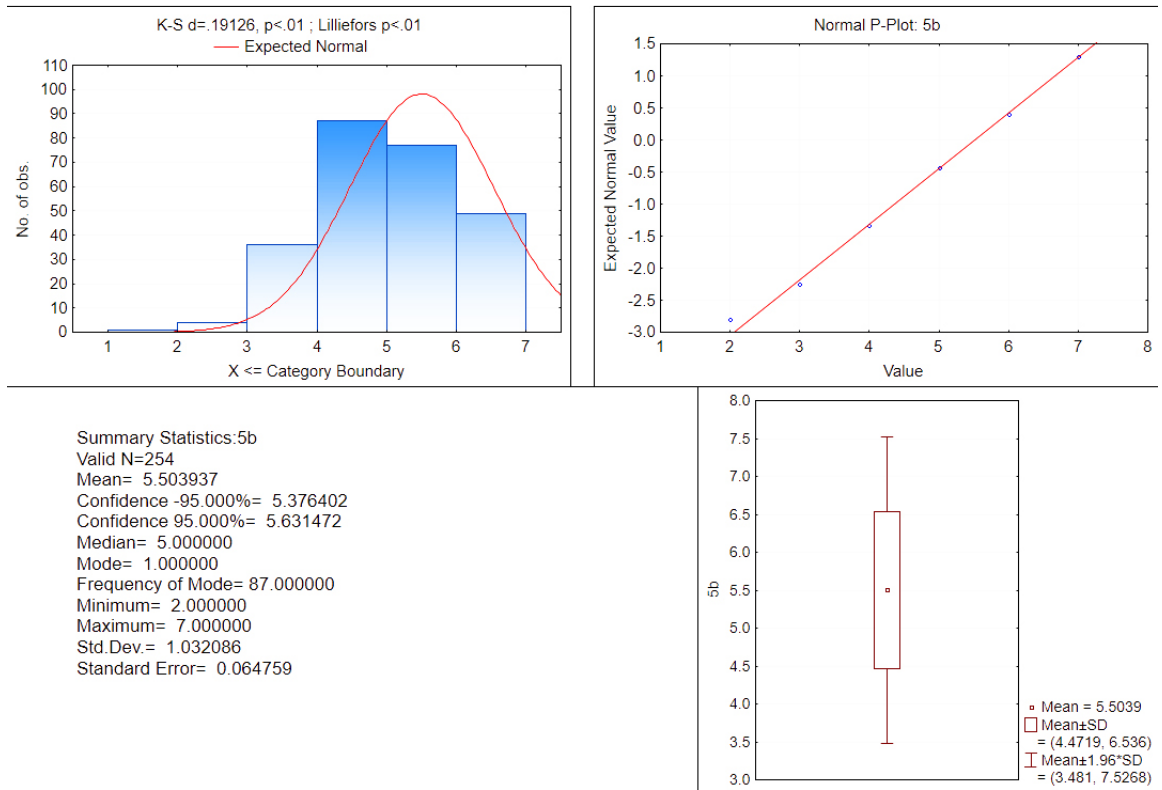
Summary: 4b: An effective organisational change management programme in support of the AM service.



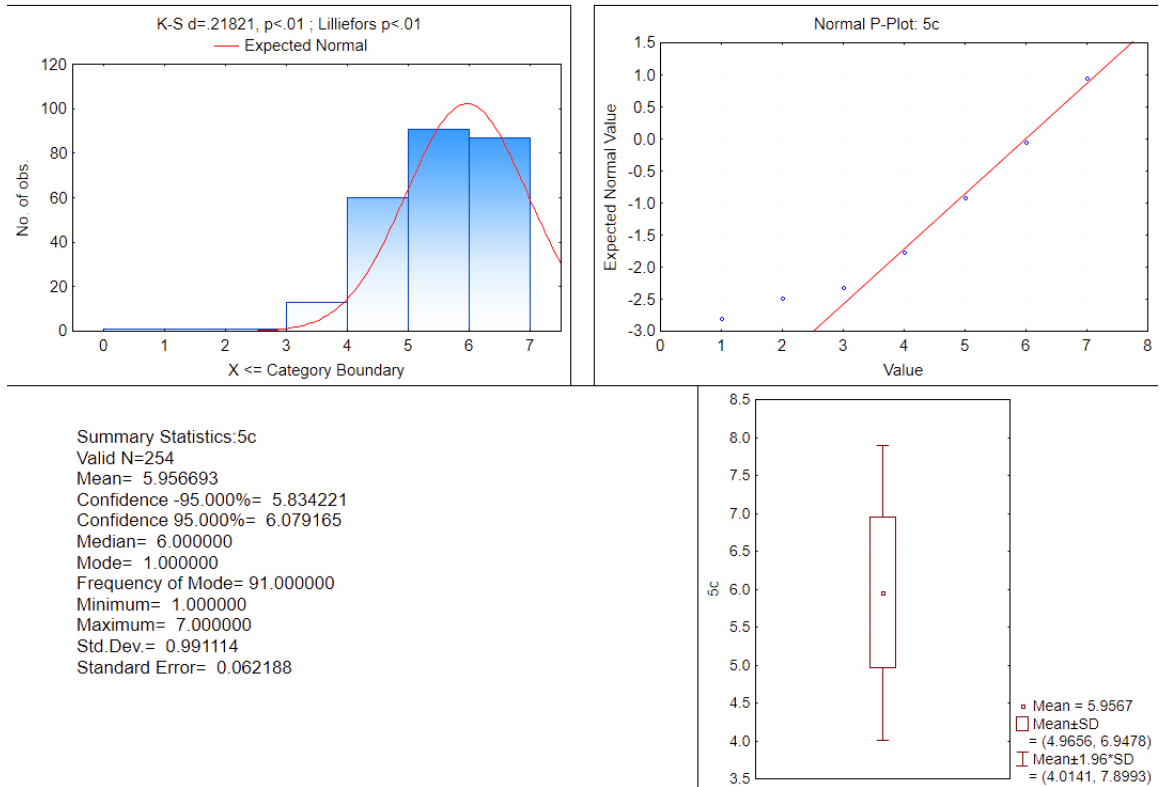
Summary: 5a: The monitoring of budgets and costs relating to the AM service.



Summary: 5b: The configuration control of current AM service processes and systems.

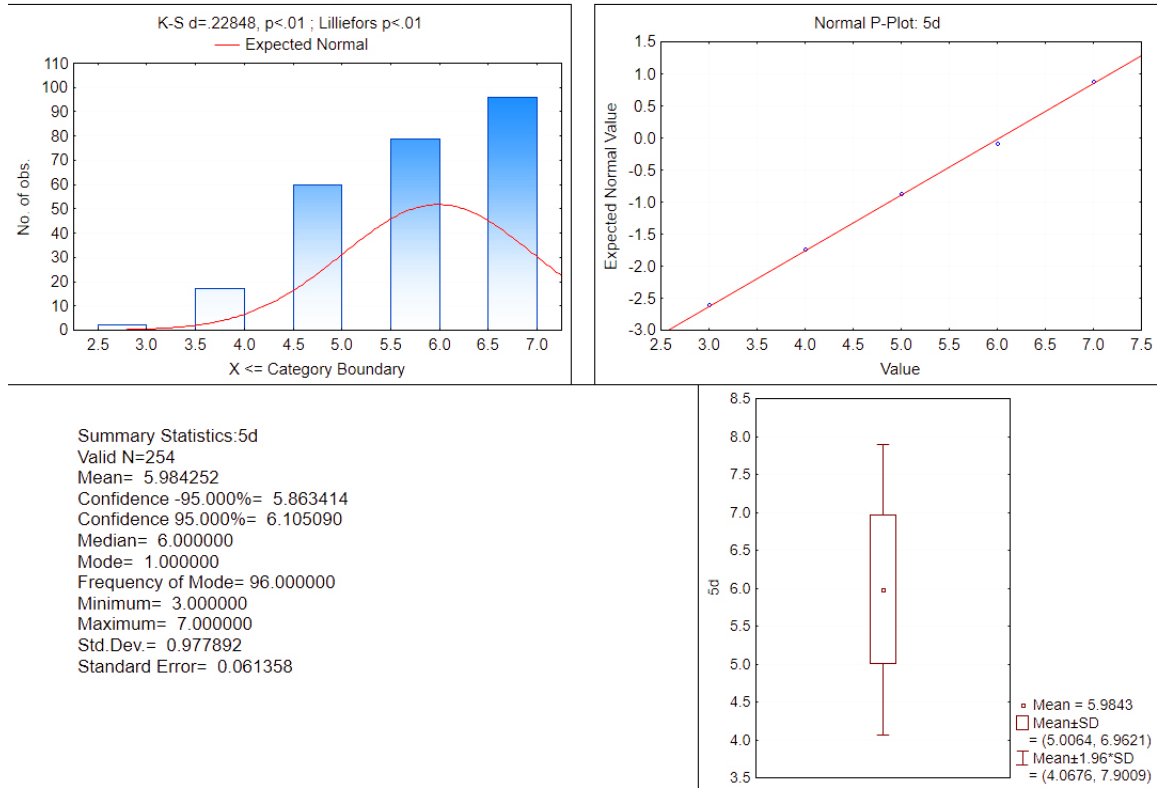


Summary: 5c: The management of mutual expectations between the service provider and client relating to the AM service.

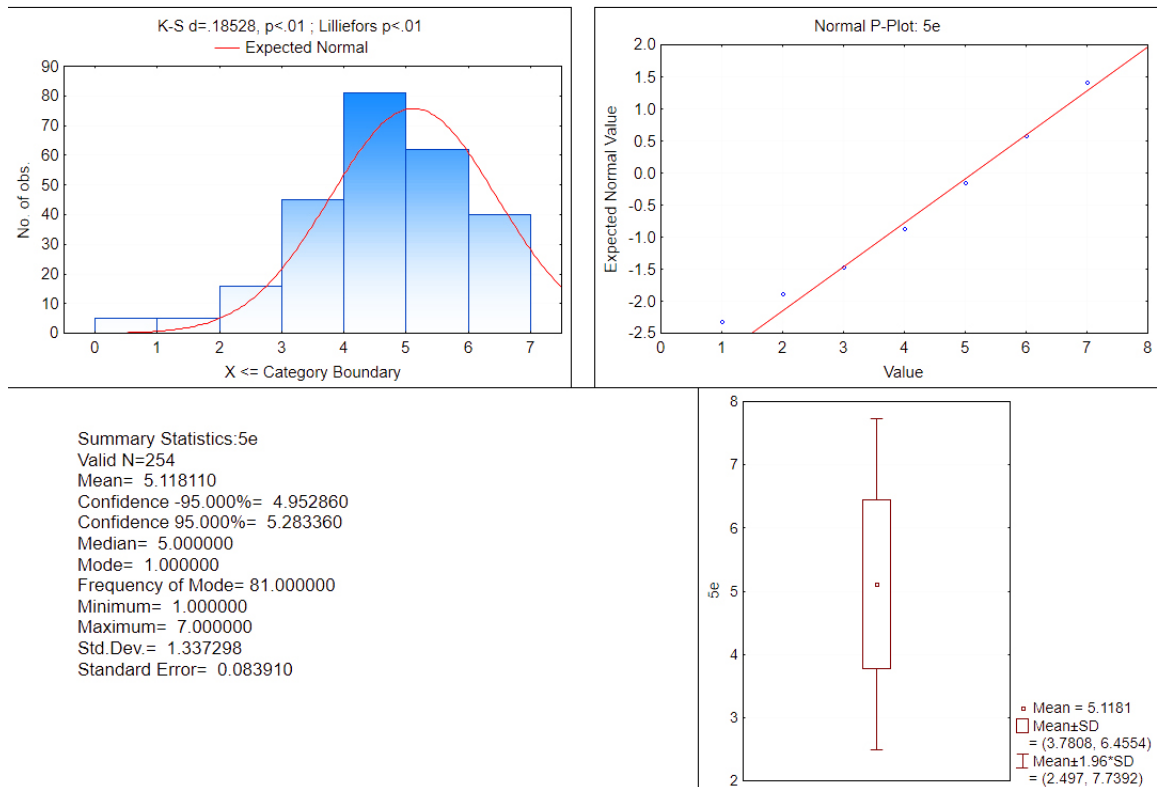


B.4. DESCRIPTIVE STATISTICS PER SUCCESS FACTOR

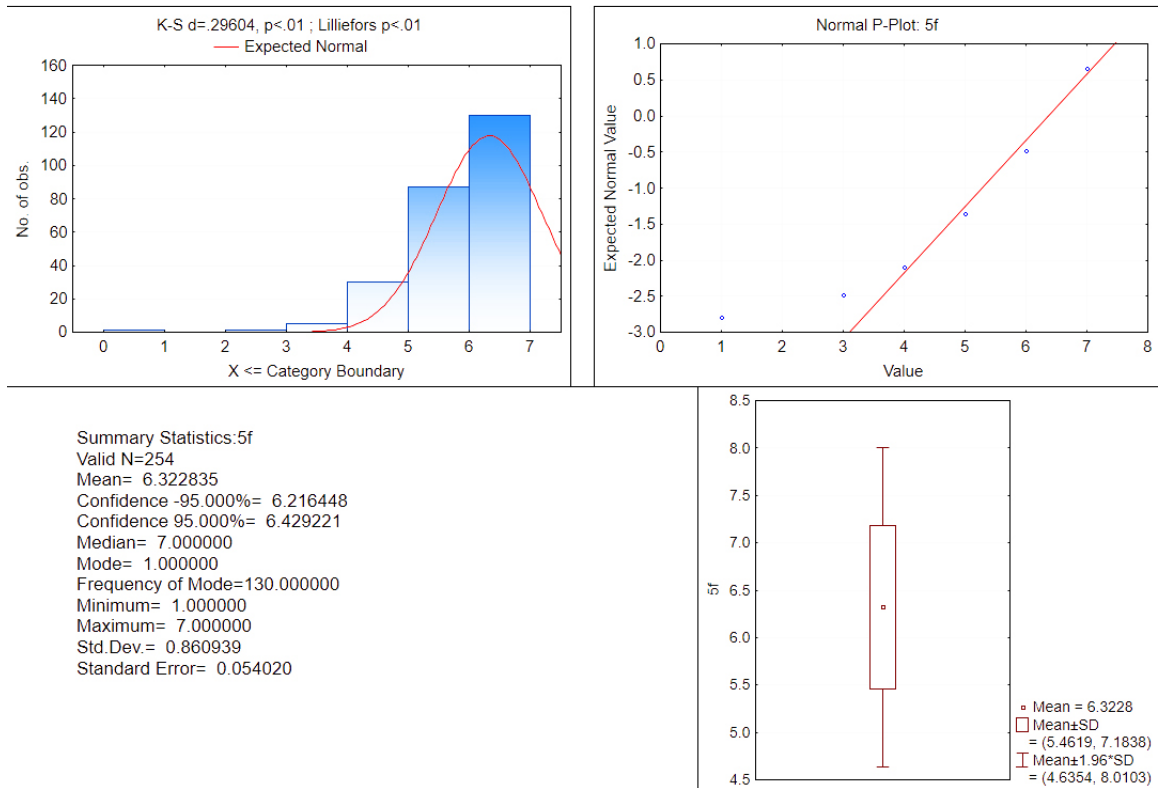
Summary: 5d: The active management of the relationship between the service provider and client organisation personnel involved in the AM service.



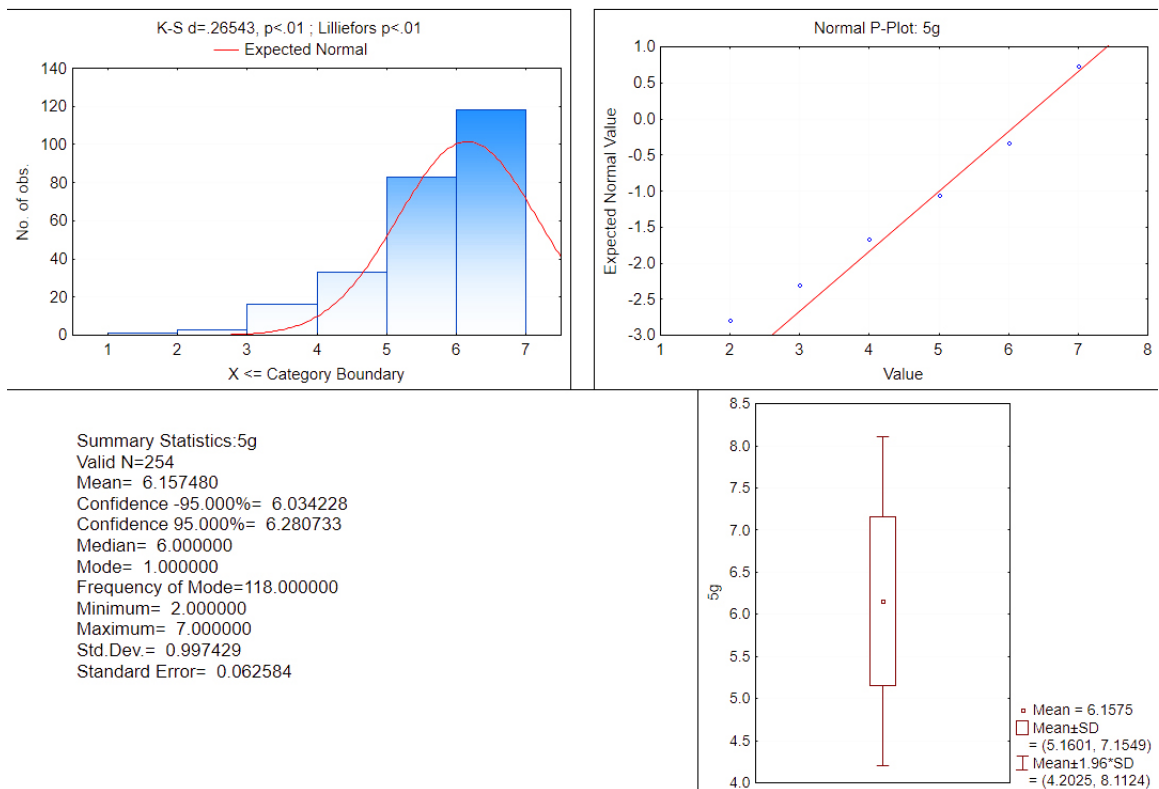
Summary: 5e: The appreciation of diversity among inter-company teams involved in the AM service.



Summary: 5f: Open and effective communication.

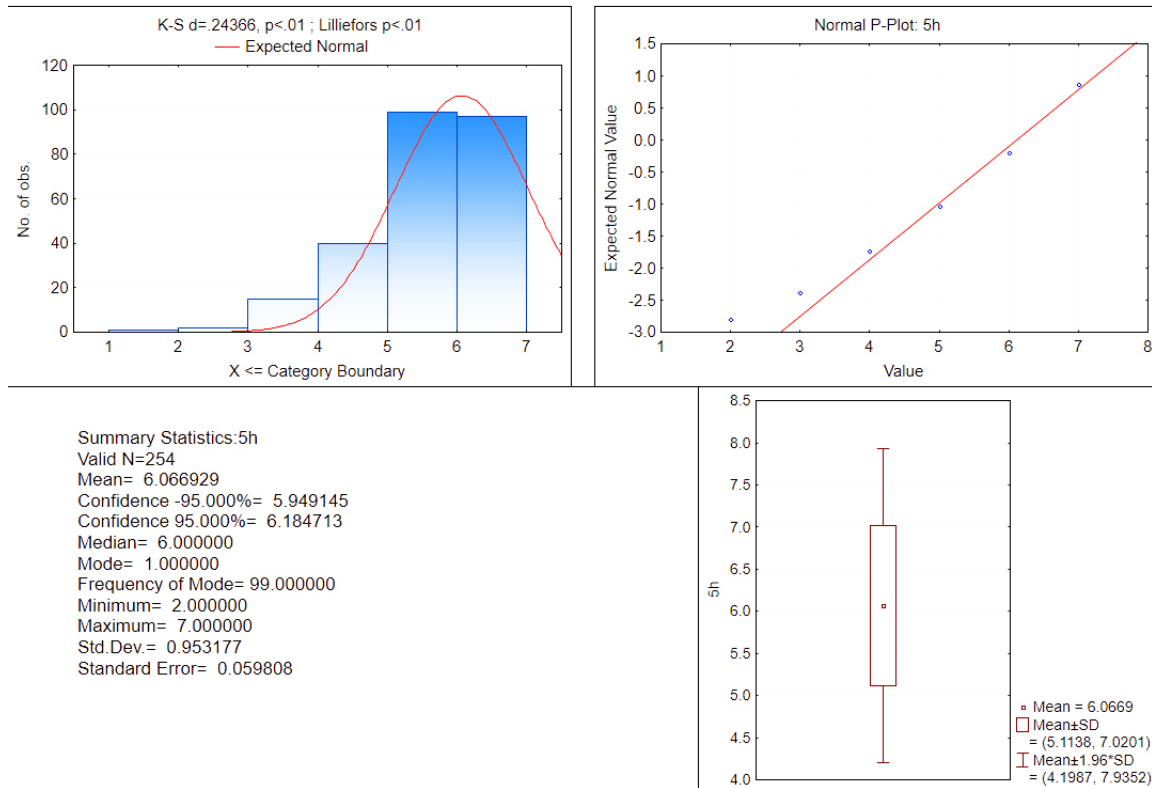


Summary: 5g: Mutual trust and respect between the service provider and client organisation.

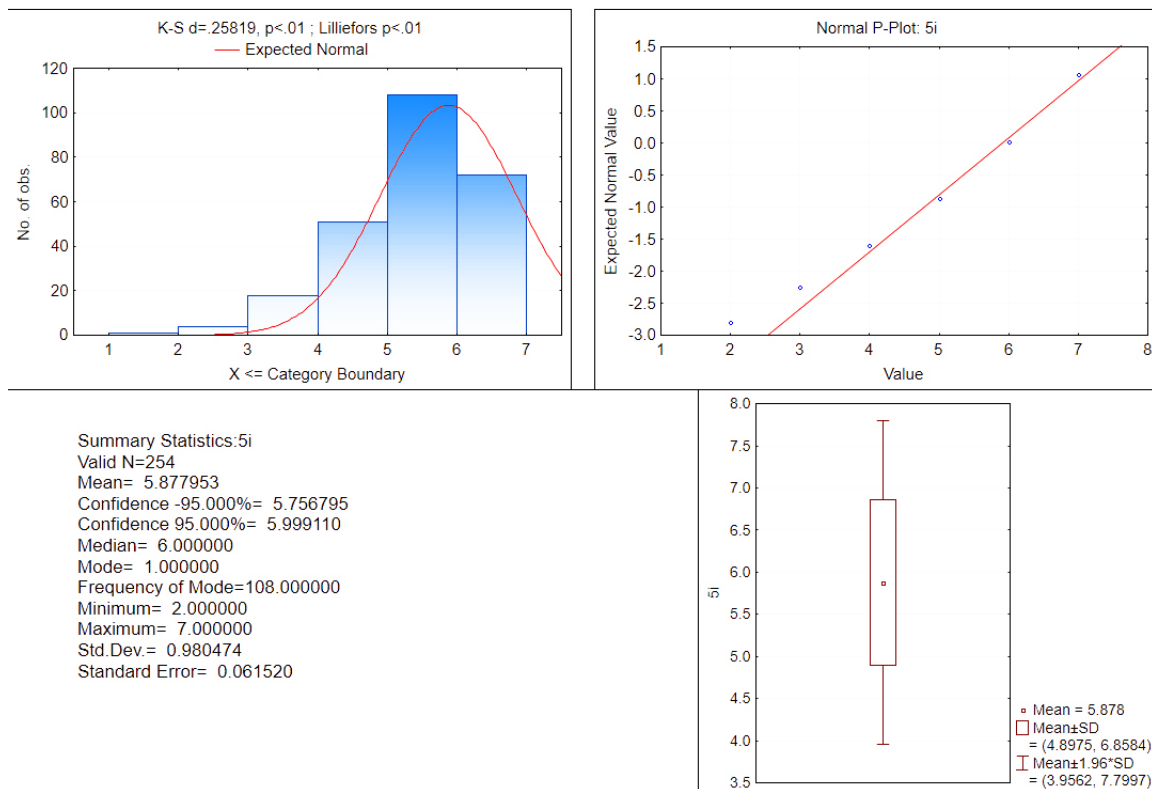


B.4. DESCRIPTIVE STATISTICS PER SUCCESS FACTOR

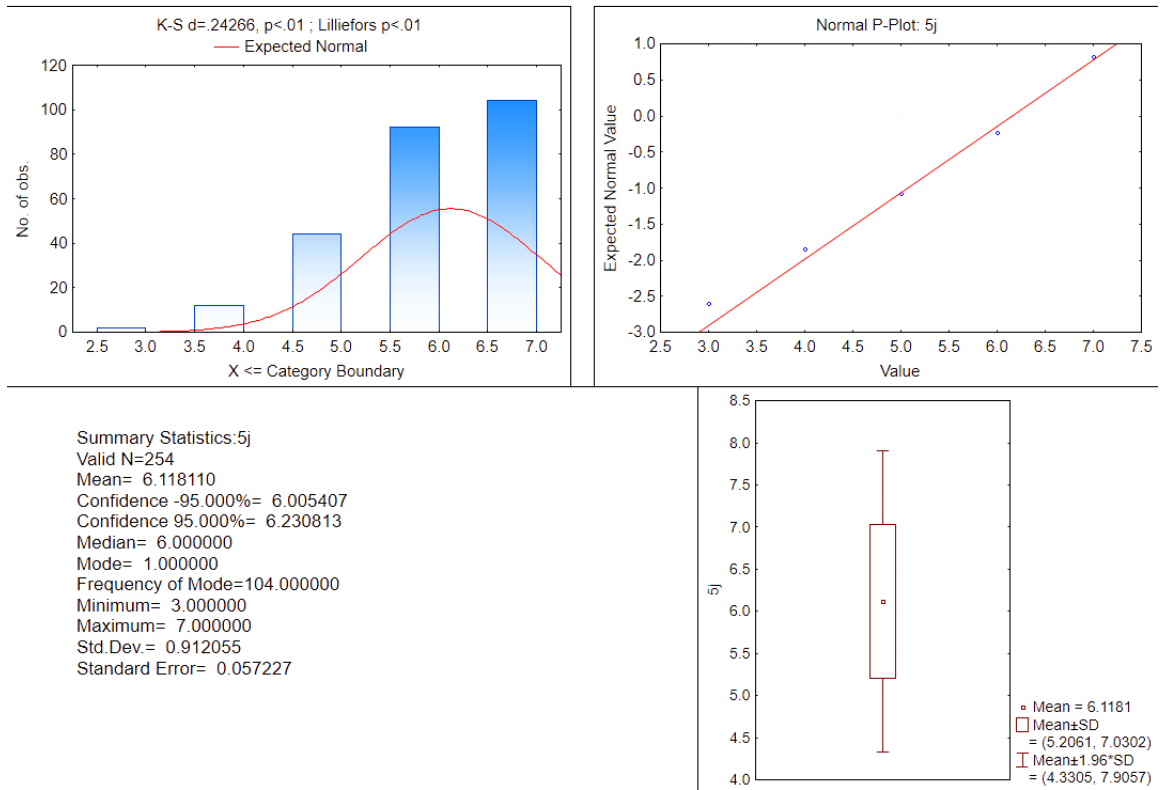
Summary: 5h: Active client participation in reporting, problem solving and improvement relating to the AM service.



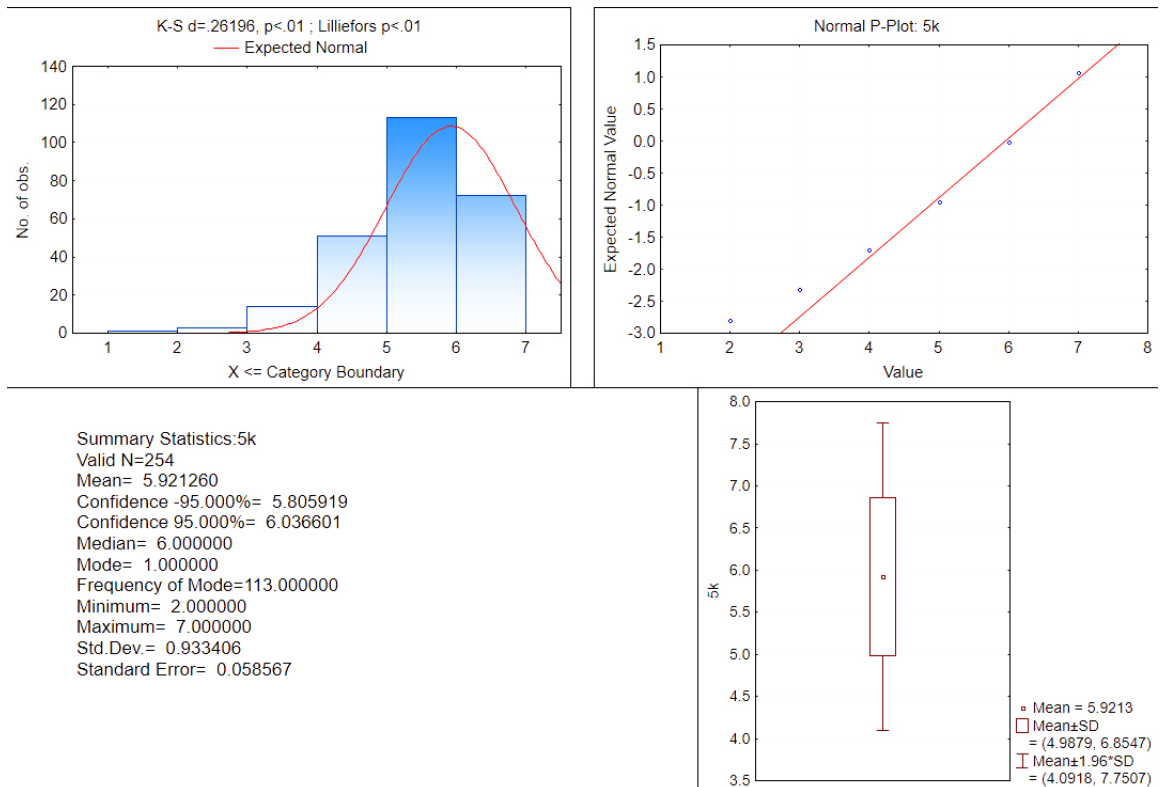
Summary: 5i: Agility (responsiveness) in responding to changes in AM service demands.



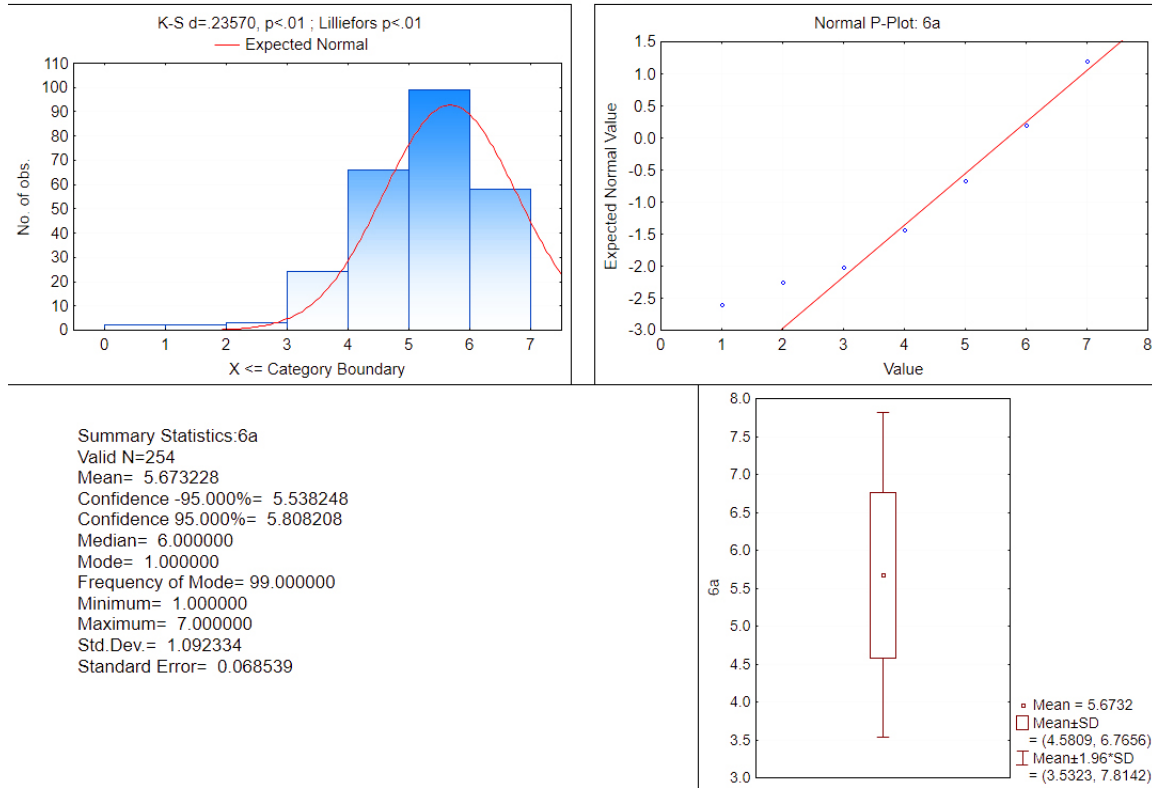
Summary: 5j: The use of performance measurement to monitor, control and improve the AM service.



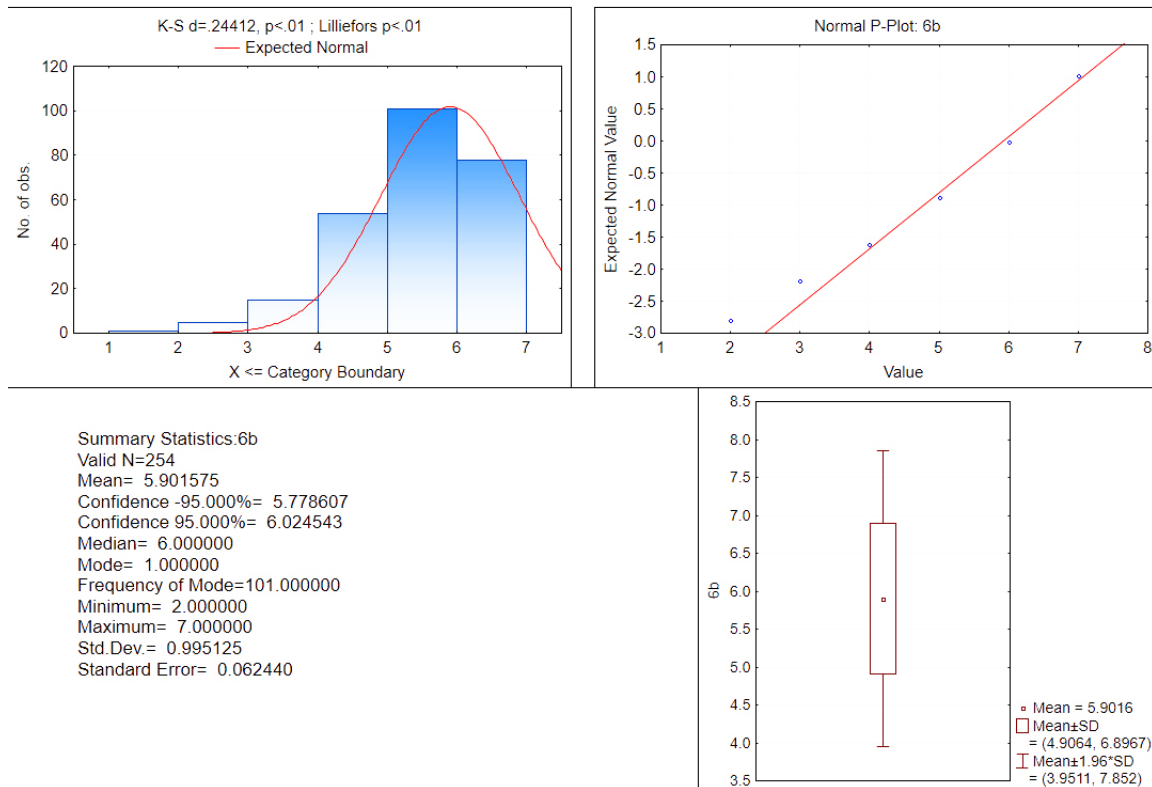
Summary: 5k: Proper priority setting of improvement actions, irrespective whether it is service or value-added related.



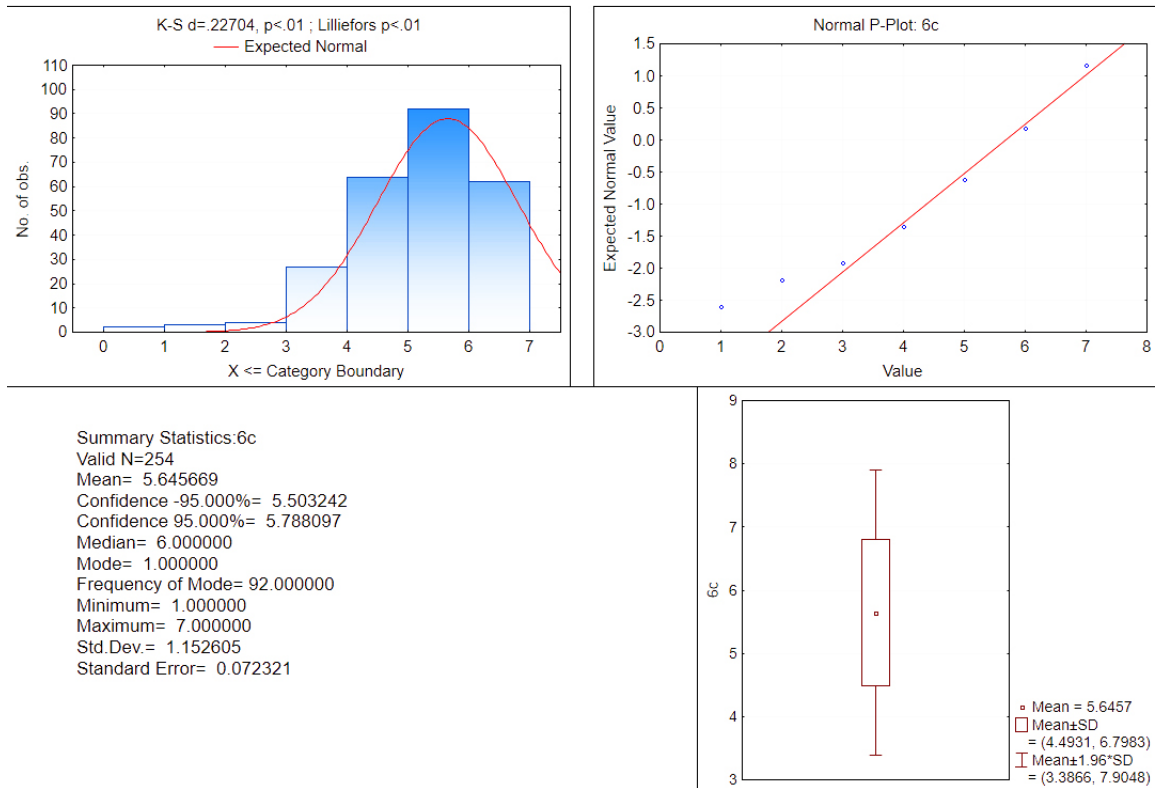
Summary: 6a: The consideration of intangible (not measurable) benefits and value creation (i.e. increased effectiveness, risk mitigation) as a result of the AM service.



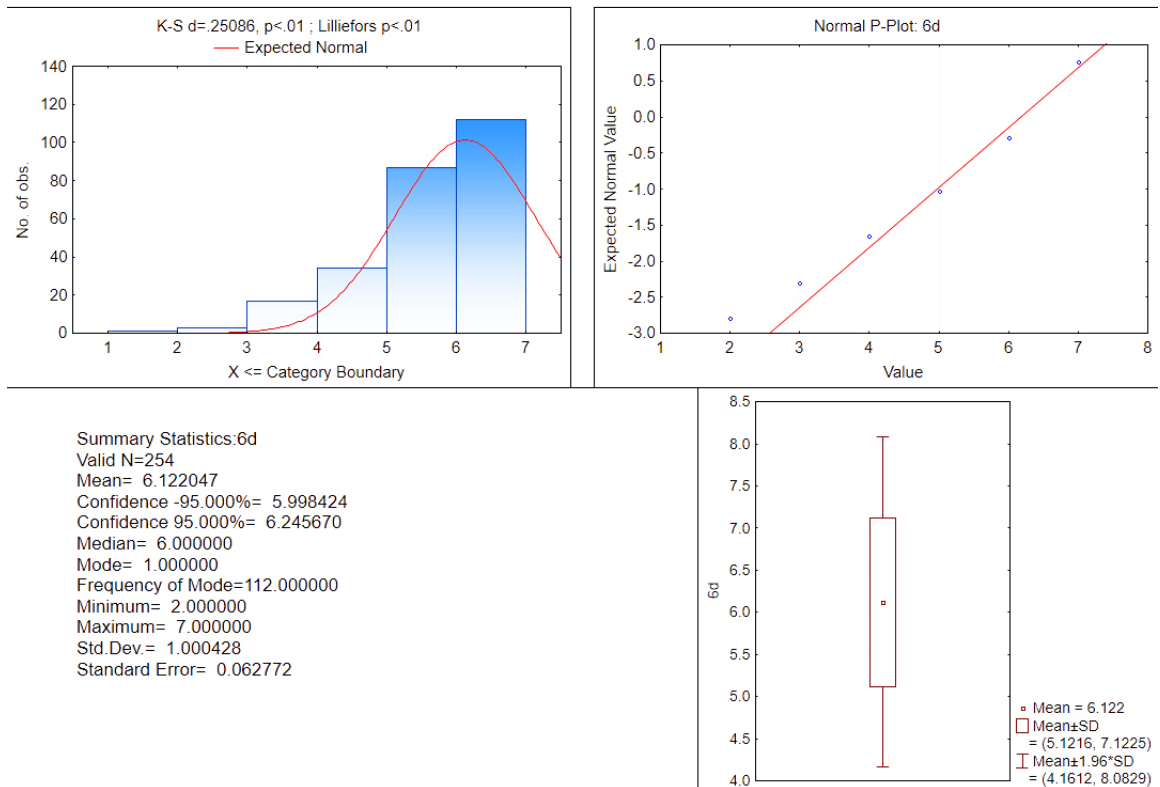
Summary: 6b: Feedback and sharing of lessons learned from successful improvements made to the AM service.



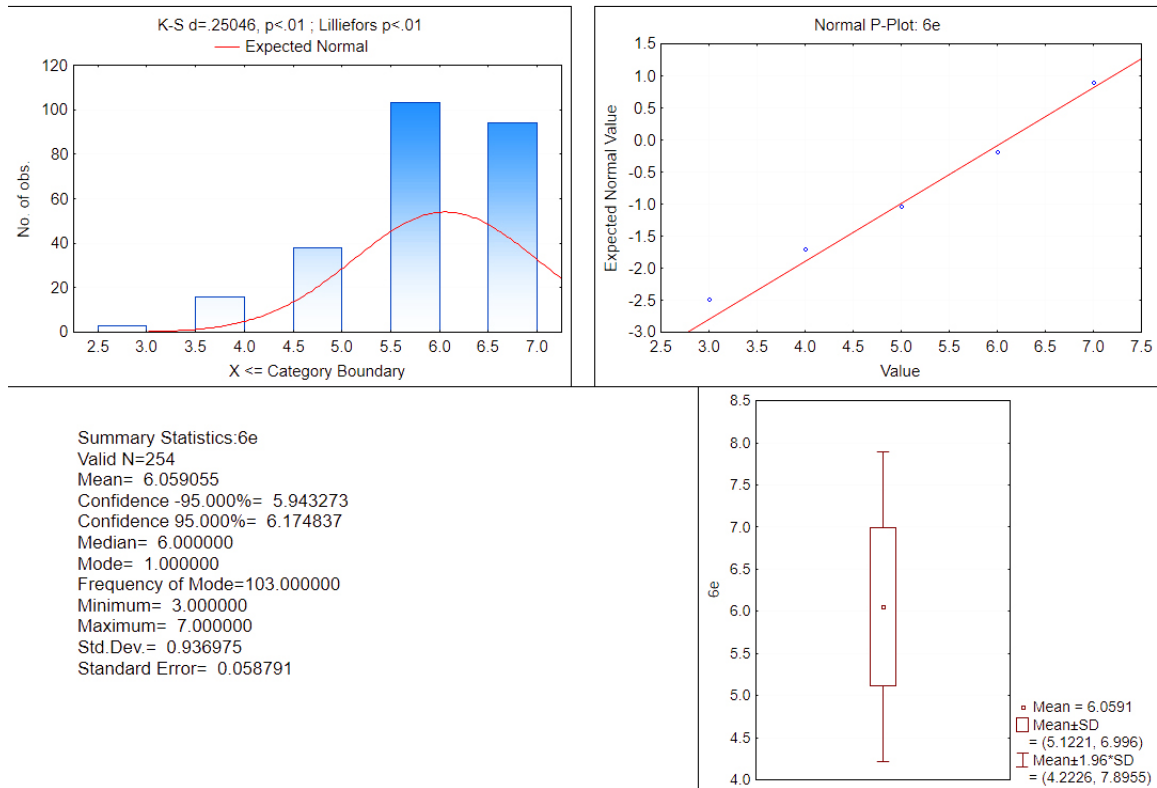
Summary: 6c: Formal post launch evaluations of the AM service to determine what can be improved.



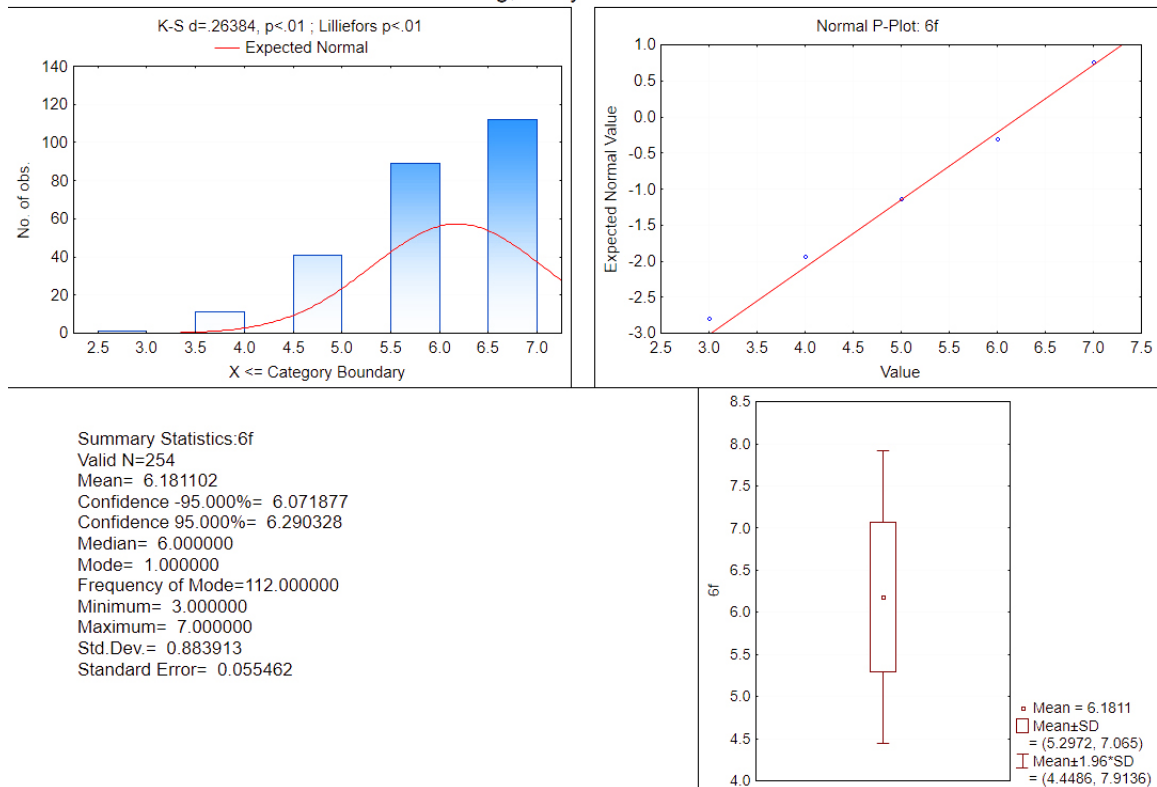
Summary: 6d: Proof of operational and financial performance achievements as a result of the AM service.



Summary: 6e: The ability to measure the AM service quality and value creation.



Summary: 6f: A focused and continuous improvement process to improve the AM service through monitoring, analysis and feedback.



B.5 Rank Sensitivity Analysis

Factor	Values						Ranks					
	Mean	Median	Top Box	Top Two Box	Net Top Box	Percentile	Mean	Median	Top Box	Top Two Box	Net Top Box	Percentile
1a	5.953	6	38.2%	70.9%	37.8%	55.3%	19	20	12.5	19	13.5	19
1b	5.720	6	27.6%	61.8%	27.2%	46.9%	32	20	31.5	33.5	31.5	32
1c	5.969	6	31.9%	72.8%	31.9%	56.8%	16	20	21.5	15	21.5	15
1d	5.870	6	27.2%	68.9%	27.2%	52.7%	23	20	33	24	31.5	23
1e	5.831	6	31.9%	63.8%	31.9%	50.9%	27	20	21.5	29	21.5	27
1f	6.110	6	43.3%	76.8%	43.3%	62.2%	10	20	6	12.5	6	10
2a	6.413	7	62.2%	84.3%	62.2%	75.0%	1	1.5	1	2	1	1
2b	5.965	6	36.6%	72.8%	36.2%	55.8%	17	20	16	15	16.5	18
2c	6.150	6	42.5%	80.3%	42.5%	64.1%	5	20	7	4	7	4
2d	5.276	5	21.3%	44.9%	20.9%	34.2%	40	42	39	42	39	41
2e	5.827	6	33.9%	66.9%	33.5%	50.7%	28	20	20	26	20	28
2f	5.980	6	36.2%	72.4%	36.2%	56.8%	15	20	17	17	16.5	16
2g	5.752	6	27.6%	63.4%	27.6%	47.9%	31	20	31.5	30	30	31
3a	5.713	6	24.4%	63.0%	24.4%	46.4%	33	20	34.5	31	34	33
3b	5.776	6	28.3%	62.2%	28.3%	48.8%	30	20	26.5	32	26.5	30
3c	5.260	5	17.3%	42.1%	17.3%	32.3%	42	42	43	44	42	43
3d	5.268	5	15.7%	45.7%	15.4%	32.8%	41	42	44.5	41	44	42
3e	5.193	5	17.7%	43.3%	16.1%	32.3%	44	42	42	43	43	44
3f	5.524	6	24.0%	52.0%	24.0%	40.4%	36	20	36	37	35	37
3g	5.142	5	12.2%	41.7%	11.4%	29.5%	45	42	46	45	46	46
3h	5.791	6	35.8%	66.5%	35.4%	49.5%	29	20	18	27.5	18	29
3i	5.500	6	28.0%	54.7%	26.8%	41.1%	38	20	29.5	36	33	36
3j	5.858	6	30.3%	68.9%	30.3%	52.0%	25	20	24	24	24	25
3k	5.402	5	20.5%	48.4%	19.7%	37.0%	39	42	40	39.5	40	39
3l	5.228	5	22.4%	48.4%	21.3%	34.5%	43	42	38	39.5	38	40
3m	5.862	6	28.0%	70.9%	28.0%	52.2%	24	20	29.5	19	29	24
3n	6.087	6	40.2%	76.8%	40.2%	61.5%	11	20	11	12.5	11	11
4a	6.134	6	41.7%	77.6%	41.7%	64.1%	6.5	20	9	8.5	8	5
4b	6.134	6	42.1%	81.1%	41.3%	62.7%	6.5	20	8	3	9	8
5a	5.839	6	28.3%	66.5%	28.3%	51.3%	26	20	26.5	27.5	26.5	26
5b	5.504	5	19.3%	49.6%	19.3%	38.5%	37	42	41	38	41	38

5c	5.957	6	34.3%	70.1%	33.9%	56.0%	18	20	19	22	19	17
5d	5.984	6	37.8%	68.9%	37.8%	57.2%	14	20	14	24	13.5	14
5e	5.118	5	15.7%	40.2%	13.8%	30.3%	46	42	44.5	46	45	45
5f	6.323	7	51.2%	85.4%	50.8%	72.5%	2	1.5	2	1	2	2
5g	6.157	6	46.5%	79.1%	46.5%	63.7%	4	20	3	5.5	3	6
5h	6.067	6	38.2%	77.2%	38.2%	60.7%	12	20	12.5	10.5	12	12
5i	5.878	6	28.3%	70.9%	28.3%	52.9%	22	20	26.5	19	26.5	22
5j	6.118	6	40.9%	77.2%	40.9%	63.3%	9	20	10	10.5	10	7
5k	5.921	6	28.3%	72.8%	28.3%	54.9%	20	20	26.5	15	26.5	20
6a	5.673	6	22.8%	61.8%	22.0%	45.1%	34	20	37	33.5	37	34
6b	5.902	6	30.7%	70.5%	30.7%	53.8%	21	20	23	21	23	21
6c	5.646	6	24.4%	60.6%	23.6%	44.4%	35	20	34.5	35	36	35
6d	6.122	6	44.1%	78.3%	44.1%	62.4%	8	20	4.5	7	4.5	9
6e	6.059	6	37.0%	77.6%	37.0%	60.6%	13	20	15	8.5	15	13
6f	6.181	6	44.1%	79.1%	44.1%	66.4%	3	20	4.5	5.5	4.5	3

B.6 Strata ANOVA Results

B.6.1 Participant Role Univariate ANOVA and Post hoc Tests

		Analysis of Variance (Participant Role)							
		Marked effects are significant at $p < .05$							
		Effect			Error				
Factor		SS	df	MS	SS	df	MS	F	p
1a		8.139	1	8.139	297.294	252	1.180	6.899	0.009
1b		0.058	1	0.058	311.095	252	1.235	0.047	0.828
1c		0.000	1	0.000	225.748	252	0.896	0.001	0.982
1d		0.235	1	0.235	224.478	252	0.891	0.263	0.608
1e		0.131	1	0.131	277.589	252	1.102	0.119	0.730
1f		0.020	1	0.020	242.893	252	0.964	0.021	0.886
2a		0.893	1	0.893	202.701	252	0.804	1.111	0.293
2b		0.001	1	0.001	296.680	252	1.177	0.001	0.982
2c		0.514	1	0.514	225.801	252	0.896	0.573	0.450
2d		3.468	1	3.468	429.240	252	1.703	2.036	0.155
2e		5.325	1	5.325	321.053	252	1.274	4.180	0.042

Factor	Analysis of Variance (Participant Role)							
	Marked effects are significant at $p < .05$							
	Effect			Error			F	p
SS	df	MS	SS	df	MS			
2f	3.264	1	3.264	259.638	252	1.030	3.168	0.076
2g	2.766	1	2.766	278.608	252	1.106	2.501	0.115
3a	1.065	1	1.065	274.955	252	1.091	0.976	0.324
3b	0.011	1	0.011	262.198	252	1.040	0.011	0.918
3c	1.939	1	1.939	358.912	252	1.424	1.361	0.244
3d	3.328	1	3.328	366.468	252	1.454	2.288	0.132
3e	1.598	1	1.598	451.949	252	1.793	0.891	0.346
3f	0.452	1	0.452	346.906	252	1.377	0.328	0.567
3g	0.473	1	0.473	384.424	252	1.525	0.310	0.578
3h	7.431	1	7.431	392.510	252	1.558	4.771	0.030
3i	4.973	1	4.973	464.527	252	1.843	2.698	0.102
3j	0.570	1	0.570	266.328	252	1.057	0.539	0.463
3k	1.672	1	1.672	373.367	252	1.482	1.129	0.289
3l	3.113	1	3.113	529.643	252	2.102	1.481	0.225
3m	0.994	1	0.994	249.184	252	0.989	1.005	0.317
3n	0.795	1	0.795	231.300	252	0.918	0.866	0.353
4a	0.019	1	0.019	207.430	252	0.823	0.023	0.880
4b	0.855	1	0.855	258.594	252	1.026	0.833	0.362
5a	7.975	1	7.975	234.407	252	0.930	8.574	0.004
5b	1.286	1	1.286	268.210	252	1.064	1.209	0.273
5c	0.868	1	0.868	247.656	252	0.983	0.883	0.348
5d	6.599	1	6.599	235.338	252	0.934	7.066	0.008
5e	5.807	1	5.807	446.649	252	1.772	3.276	0.071
5f	0.015	1	0.015	187.512	252	0.744	0.021	0.886
5g	0.001	1	0.001	251.700	252	0.999	0.001	0.982
5h	2.488	1	2.488	227.374	252	0.902	2.757	0.098
5i	0.278	1	0.278	242.939	252	0.964	0.288	0.592
5j	0.329	1	0.329	210.128	252	0.834	0.394	0.531
5k	0.864	1	0.864	219.561	252	0.871	0.992	0.320
6a	0.044	1	0.044	301.834	252	1.198	0.036	0.849
6b	2.029	1	2.029	248.510	252	0.986	2.057	0.153
6c	0.411	1	0.411	335.699	252	1.332	0.309	0.579
6d	0.070	1	0.070	253.147	252	1.005	0.070	0.792
6e	0.008	1	0.008	222.106	252	0.881	0.009	0.924
6f	0.126	1	0.126	197.544	252	0.784	0.160	0.689

		Tukey-Kramer HSD Test for Participant Role	
		Diff. signif. at $p < .05$	
		Success Factor 1a	
		Error: MSE=1.1797, df=252	
Role	Mean	Service Provider	Asset Owner
Service Provider	6.085		0.021
Asset Owner	5.711	0.021	
		Success Factor 2e	
		Error: MSE=1.2740, df=252	
		Service Provider	Asset Owner
Service Provider	5.720		0.072
Asset Owner	6.022	0.072	
		Success Factor 3h	
		Error: MSE=1.5576, df=252	
		Service Provider	Asset Owner
Service Provider	5.665		0.055
Asset Owner	6.022	0.055	
		Success Factor 5a	
		Error: MSE=0.93019, df=252	
		Service Provider	Asset Owner
Service Provider	5.701		0.009
Asset Owner	6.078	0.009	
		Success Factor 5d	
		Error: MSE=0.93388, df=252	
		Service Provider	Asset Owner
Service Provider	6.104		0.019
Asset Owner	5.767	0.019	

B.6.2 Organisational Level Univariate ANOVA and Post hoc Tests

Factor	Analysis of Variance (Organisational Level)							
	Marked effects are significant at $p < .05$							
	Effect			Error			F	p
SS	df	MS	SS	df	MS			
1a	1.376	2	0.688	304.057	251	1.211	0.568	0.567
1b	8.504	2	4.252	302.650	251	1.206	3.526	0.031
1c	5.680	2	2.840	220.068	251	0.877	3.239	0.041
1d	3.030	2	1.515	221.683	251	0.883	1.715	0.182
1e	7.424	2	3.712	270.297	251	1.077	3.447	0.033
1f	2.371	2	1.186	240.542	251	0.958	1.237	0.292
2a	2.358	2	1.179	201.237	251	0.802	1.470	0.232
2b	7.949	2	3.974	288.732	251	1.150	3.455	0.033
2c	0.836	2	0.418	225.479	251	0.898	0.465	0.629
2d	36.241	2	18.120	396.468	251	1.580	11.472	0.000
2e	25.641	2	12.820	300.737	251	1.198	10.700	0.000
2f	4.904	2	2.452	257.998	251	1.028	2.385	0.094
2g	12.246	2	6.123	269.128	251	1.072	5.710	0.004
3a	7.364	2	3.682	268.655	251	1.070	3.440	0.034
3b	3.457	2	1.729	258.752	251	1.031	1.677	0.189
3c	19.223	2	9.612	341.627	251	1.361	7.062	0.001
3d	32.632	2	16.316	337.164	251	1.343	12.146	0.000
3e	21.128	2	10.564	432.419	251	1.723	6.132	0.003
3f	10.227	2	5.114	337.131	251	1.343	3.807	0.024
3g	22.164	2	11.082	362.733	251	1.445	7.668	0.001
3h	18.357	2	9.179	381.584	251	1.520	6.038	0.003
3i	22.556	2	11.278	446.944	251	1.781	6.333	0.002
3j	9.188	2	4.594	257.709	251	1.027	4.475	0.012
3k	14.540	2	7.270	360.499	251	1.436	5.062	0.007
3l	22.303	2	11.151	510.453	251	2.034	5.483	0.005
3m	3.750	2	1.875	246.428	251	0.982	1.910	0.150
3n	3.794	2	1.897	228.301	251	0.910	2.085	0.126
4a	2.883	2	1.441	204.566	251	0.815	1.769	0.173
4b	6.439	2	3.219	253.010	251	1.008	3.194	0.043
5a	7.314	2	3.657	235.068	251	0.937	3.905	0.021
5b	15.279	2	7.639	254.217	251	1.013	7.543	0.001
5c	3.013	2	1.506	245.511	251	0.978	1.540	0.216

		Analysis of Variance (Organisational Level)						
		Marked effects are significant at $p < .05$						
		Effect			Error			
Factor	SS	df	MS	SS	df	MS	F	p
5d	5.774	2	2.887	236.163	251	0.941	3.068	0.048
5e	27.284	2	13.642	425.173	251	1.694	8.053	0.000
5f	2.472	2	1.236	185.055	251	0.737	1.677	0.189
5g	1.928	2	0.964	249.773	251	0.995	0.969	0.381
5h	6.445	2	3.223	223.417	251	0.890	3.620	0.028
5i	8.549	2	4.275	234.667	251	0.935	4.572	0.011
5j	3.815	2	1.908	206.642	251	0.823	2.317	0.101
5k	9.313	2	4.656	211.112	251	0.841	5.536	0.004
6a	6.534	2	3.267	295.344	251	1.177	2.776	0.064
6b	5.624	2	2.812	244.915	251	0.976	2.882	0.058
6c	19.807	2	9.903	316.304	251	1.260	7.859	0.000
6d	3.859	2	1.929	249.358	251	0.993	1.942	0.146
6e	7.863	2	3.931	214.251	251	0.854	4.606	0.011
6f	10.871	2	5.436	186.798	251	0.744	7.304	0.001

		Tukey-Kramer HSD Test for Organisational Level		
		Approx. Probabilities for Post hoc Test		
		Success Factor 1b		
		Error: MSE=1.2058, df=251		
Level	Mean	Tactical	Strategic	Operational
Tactical	5.703		0.653	0.217
Strategic	5.557	0.653		0.056
Operational	6.089	0.217	0.056	
		Success Factor 1c		
		Error: MSE=0.87676, df=251		
		Tactical	Strategic	Operational
Tactical	5.884		0.964	0.101
Strategic	5.921	0.964		0.149
Operational	6.289	0.101	0.149	
		Success Factor 1e		
		Error: MSE=1.0769, df=251		
		Tactical	Strategic	Operational

		Tukey-Kramer HSD Test for Organisational Level		
		Approx. Probabilities for Post hoc Test		
Tactical	5.810	0.691	0.212	
Strategic	5.682	0.691	0.061	
Operational	6.178	0.212	0.061	
		Success Factor 2b		
		Error: MSE=1.1503, df=251		
		Tactical	Strategic	Operational
Tactical	5.843	0.809	0.077	
Strategic	5.943	0.809	0.196	
Operational	6.333	0.077	0.196	
		Success Factor 2d		
		Error: MSE=1.5796, df=251		
		Tactical	Strategic	Operational
Tactical	5.116	0.980	0.001	
Strategic	5.080	0.980	0.000	
Operational	6.089	0.001	0.000	
		Success Factor 2e		
		Error: MSE=1.1982, df=251		
		Tactical	Strategic	Operational
Tactical	5.760	0.517	0.005	
Strategic	5.580	0.517	0.000	
Operational	6.489	0.005	0.000	
		Success Factor 2g		
		Error: MSE=1.0722, df=251		
		Tactical	Strategic	Operational
Tactical	5.570	0.357	0.015	
Strategic	5.784	0.357	0.168	
Operational	6.178	0.015	0.168	
		Success Factor 3a		
		Error: MSE=1.0703, df=251		
		Tactical	Strategic	Operational
Tactical	5.537	0.126	0.164	
Strategic	5.841	0.126	0.906	
Operational	5.933	0.164	0.906	
		Success Factor 3c		
		Error: MSE=1.3611, df=251		

		Tukey-Kramer HSD Test for Organisational Level		
		Approx. Probabilities for Post hoc Test		
		Tactical	Strategic	Operational
Tactical	5.091		0.830	0.006
Strategic	5.193	0.830		0.022
Operational	5.844	0.006	0.022	
		Success Factor 3d		
		Error: MSE=1.3433, df=251		
		Tactical	Strategic	Operational
Tactical	5.033		0.589	0.000
Strategic	5.205	0.589		0.002
Operational	6.022	0.000	0.002	
		Success Factor 3e		
		Error: MSE=1.7228, df=251		
		Tactical	Strategic	Operational
Tactical	4.975		0.513	0.010
Strategic	5.193	0.513		0.087
Operational	5.778	0.010	0.087	
		Success Factor 3f		
		Error: MSE=1.3432, df=251		
		Tactical	Strategic	Operational
Tactical	5.422		0.992	0.074
Strategic	5.443	0.992		0.090
Operational	5.956	0.074	0.090	
		Success Factor 3g		
		Error: MSE=1.4452, df=251		
		Tactical	Strategic	Operational
Tactical	5.017		0.987	0.008
Strategic	4.989	0.987		0.005
Operational	5.778	0.008	0.005	
		Success Factor 3h		
		Error: MSE=1.5203, df=251		
		Tactical	Strategic	Operational
Tactical	5.727		0.744	0.041
Strategic	5.591	0.744		0.009
Operational	6.356	0.041	0.009	
		Success Factor 3i		

		Tukey-Kramer HSD Test for Organisational Level		
		Approx. Probabilities for Post hoc Test		
		Error: MSE=1.7807, df=251		
		Tactical	Strategic	Operational
Tactical	5.455		0.566	0.051
Strategic	5.25	0.566		0.006
Operational	6.111	0.051	0.006	
		Success Factor 3j		
		Error: MSE=1.0267, df=251		
		Tactical	Strategic	Operational
Tactical	5.686		0.274	0.043
Strategic	5.921	0.274		0.390
Operational	6.200	0.043	0.390	
		Success Factor 3k		
		Error: MSE=1.4363, df=251		
		Tactical	Strategic	Operational
Tactical	5.223		0.598	0.023
Strategic	5.398	0.598		0.126
Operational	5.889	0.023	0.126	
		Success Factor 3l		
		Error: MSE=2.0337, df=251		
		Tactical	Strategic	Operational
Tactical	5.099		0.995	0.029
Strategic	5.080	0.995		0.024
Operational	5.867	0.029	0.024	
		Success Factor 4b		
		Error: MSE=1.0080, df=251		
		Tactical	Strategic	Operational
Tactical	5.967		0.091	0.281
Strategic	6.284	0.091		1.000
Operational	6.284	0.281	1.000	
		Success Factor 5a		
		Error: MSE=0.93652, df=251		
		Tactical	Strategic	Operational
Tactical	5.786		0.917	0.104
Strategic	5.727	0.917		0.053

		Tukey-Kramer HSD Test for Organisational Level		
		Approx. Probabilities for Post hoc Test		
Operational	6.200	0.104	0.053	
		Success Factor 5b		
		Error: MSE=1.0128, df=251		
		Tactical	Strategic	Operational
Tactical	5.347		0.759	0.004
Strategic	5.455	0.759		0.020
Operational	6.022	0.004	0.020	
		Success Factor 5d		
		Error: MSE=0.94089, df=251		
		Tactical	Strategic	Operational
Tactical	5.826		0.086	0.345
Strategic	6.136	0.086		0.992
Operational	6.111	0.345	0.992	
		Success Factor 5e		
		Error: MSE=1.6939, df=251		
		Tactical	Strategic	Operational
Tactical	4.942		0.953	0.004
Strategic	5.000	0.953		0.008
Operational	5.822	0.004	0.008	
		Success Factor 5h		
		Error: MSE=0.89011, df=251		
		Tactical	Strategic	Operational
Tactical	5.909		0.184	0.107
Strategic	6.159	0.184		0.725
Operational	6.311	0.107	0.725	
		Success Factor 5i		
		Error: MSE=0.93493, df=251		
		Tactical	Strategic	Operational
Tactical	5.719		0.350	0.036
Strategic	5.921	0.350		0.300
Operational	6.222	0.036	0.300	
		Success Factor 5k		
		Error: MSE=0.84108, df=251		
		Tactical	Strategic	Operational

		Tukey-Kramer HSD Test for Organisational Level		
		Approx. Probabilities for Post hoc Test		
Tactical	5.760	0.338	0.017	
Strategic	5.955	0.338	0.194	
Operational	6.289	0.017	0.194	
		Success Factor 6c		
		Error: MSE=0.87676, df=251		
		Tactical	Strategic	Operational
Tactical	5.446	0.541	0.003	
Strategic	5.625	0.541	0.031	
Operational	6.222	0.003	0.031	
		Success Factor 6e		
		Error: MSE=0.85359, df=251		
		Tactical	Strategic	Operational
Tactical	5.901	0.278	0.038	
Strategic	6.114	0.278	0.364	
Operational	6.378	0.038	0.364	
		Success Factor 6f		
		Error: MSE=0.74421, df=251		
		Tactical	Strategic	Operational
Tactical	6.058	0.863	0.005	
Strategic	6.125	0.863	0.017	
Operational	6.622	0.005	0.017	

B.6.3 Region Univariate ANOVA and Post hoc Tests

Analysis of Variance (Region)								
Marked effects are significant at $p < .05$								
Factor	Effect			Error			F	p
	SS	df	MS	SS	df	MS		
1a	6.830	6	1.138	298.603	247	1.209	0.942	0.466
1b	30.494	6	5.082	280.659	247	1.136	4.473	0.000
1c	15.578	6	2.596	210.170	247	0.851	3.051	0.007
1d	13.886	6	2.314	210.826	247	0.854	2.711	0.014
1e	10.599	6	1.766	267.122	247	1.081	1.633	0.138
1f	10.037	6	1.673	232.877	247	0.943	1.774	0.105
2a	6.700	6	1.117	196.894	247	0.797	1.401	0.215
2b	11.367	6	1.894	285.314	247	1.155	1.640	0.137
2c	3.485	6	0.581	222.830	247	0.902	0.644	0.695
2d	26.317	6	4.386	406.392	247	1.645	2.666	0.016
2e	29.294	6	4.882	297.083	247	1.203	4.059	0.001
2f	10.167	6	1.695	252.734	247	1.023	1.656	0.132
2g	14.888	6	2.481	266.486	247	1.079	2.300	0.035
3a	12.978	6	2.163	263.041	247	1.065	2.031	0.062
3b	12.036	6	2.006	250.173	247	1.013	1.981	0.069
3c	19.333	6	3.222	341.518	247	1.383	2.330	0.033
3d	41.198	6	6.866	328.598	247	1.330	5.161	0.000
3e	41.690	6	6.948	411.857	247	1.667	4.167	0.001
3f	16.625	6	2.771	330.734	247	1.339	2.069	0.057
3g	42.404	6	7.067	342.494	247	1.387	5.097	0.000
3h	42.179	6	7.030	357.762	247	1.448	4.853	0.000
3i	49.868	6	8.311	419.632	247	1.699	4.892	0.000
3j	11.023	6	1.837	255.875	247	1.036	1.773	0.105
3k	47.144	6	7.857	327.896	247	1.328	5.919	0.000
3l	69.039	6	11.507	463.716	247	1.877	6.129	0.000
3m	7.989	6	1.331	242.188	247	0.981	1.358	0.232
3n	7.566	6	1.261	224.528	247	0.909	1.387	0.220
4a	6.263	6	1.044	201.186	247	0.815	1.281	0.266
4b	5.487	6	0.914	253.962	247	1.028	0.889	0.503
5a	16.046	6	2.674	226.336	247	0.916	2.918	0.009
5b	24.577	6	4.096	244.920	247	0.992	4.131	0.001
5c	4.711	6	0.785	243.812	247	0.987	0.795	0.574
5d	11.433	6	1.905	230.504	247	0.933	2.042	0.061

Factor	Analysis of Variance (Region)							
	Marked effects are significant at $p < .05$							
	Effect			Error			F	p
SS	df	MS	SS	df	MS			
5e	33.156	6	5.526	419.301	247	1.698	3.255	0.004
5f	5.018	6	0.836	182.509	247	0.739	1.132	0.344
5g	11.324	6	1.887	240.377	247	0.973	1.939	0.075
5h	6.148	6	1.025	223.714	247	0.906	1.131	0.345
5i	15.240	6	2.540	227.977	247	0.923	2.752	0.013
5j	6.808	6	1.135	203.648	247	0.824	1.376	0.225
5k	11.426	6	1.904	208.999	247	0.846	2.251	0.039
6a	12.479	6	2.080	289.398	247	1.172	1.775	0.105
6b	20.306	6	3.384	230.233	247	0.932	3.631	0.002
6c	18.441	6	3.074	317.669	247	1.286	2.390	0.029
6d	7.618	6	1.270	245.598	247	0.994	1.277	0.268
6e	10.491	6	1.748	211.624	247	0.857	2.041	0.061
6f	16.002	6	2.667	181.667	247	0.735	3.626	0.002

		Tukey-Kramer HSD Test for Region						
		Approx. Probabilities for Post hoc Test						
		Success Factor 1b						
		Error: MSE=1.1363, df=247						
Region	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.755		0.478	0.246	0.477	1.000	1.000	0.966
Australasia	5.192	0.478		0.013	1.000	0.931	0.979	0.959
S America	6.188	0.246	0.013		0.033	0.896	0.882	0.185
Europe	5.059	0.477	1.000	0.033		0.804	0.917	0.910
N America	5.667	1.000	0.931	0.896	0.804		1.000	1.000
Asia	5.600	1.000	0.979	0.882	0.917	1.000		1.000
Multiple	5.482	0.966	0.959	0.185	0.910	1.000	1.000	
		Success Factor 1c						
		Error: MSE=0.85089, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.847		0.999	0.065	0.983	0.737	0.999	0.999
Australasia	5.731	0.999		0.256	0.999	0.533	0.999	0.996

		Tukey-Kramer HSD Test for Region						
		Approx. Probabilities for Post hoc Test						
S America	6.313	0.065	0.256		0.249	0.999	0.954	0.624
Europe	5.589	0.983	0.999	0.249		0.295	0.988	0.964
N America	6.417	0.737	0.533	0.999	0.295		0.873	0.801
Asia	5.900	0.999	0.999	0.954	0.988	0.873		0.999
Multiple	5.889	0.999	0.996	0.624	0.964	0.801	0.999	
		Success Factor 1d						
		Error: MSE=0.85355, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.927		0.816	0.999	0.870	0.936	0.915	0.662
Australasia	5.577	0.816		0.727	0.999	0.411	0.419	0.999
S America	5.969	0.999	0.727		0.809	0.961	0.943	0.554
Europe	5.529	0.870	0.999	0.809		0.333	0.348	0.999
N America	6.333	0.936	0.411	0.961	0.333		0.999	0.317
Asia	6.400	0.915	0.419	0.943	0.348	0.999		0.332
Multiple	5.519	0.662	0.999	0.554	0.999	0.317	0.332	
		Success Factor 2d						
		Error: MSE=1.6453, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.296		0.756	0.503	0.984	0.999	0.977	0.963
Australasia	4.769	0.756		0.106	0.999	0.880	0.999	0.998
S America	5.719	0.503	0.106		0.570	0.997	0.681	0.314
Europe	4.941	0.984	0.999	0.570		0.971	0.999	0.999
N America	5.417	0.999	0.880	0.997	0.971		0.935	0.977
Asia	4.800	0.977	0.999	0.681	0.999	0.935		0.999
Multiple	4.963	0.963	0.998	0.314	0.999	0.977	0.999	
		Success Factor 2e						
		Error: MSE=1.2028, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.939		0.230	0.921	0.606	0.992	0.999	0.561
Australasia	5.231	0.230		0.037	0.999	0.255	0.963	0.997
S America	6.156	0.921	0.037		0.247	0.999	0.967	0.155
Europe	5.294	0.606	0.999	0.247		0.331	0.982	0.999
N America	6.250	0.992	0.255	0.999	0.331		0.921	0.492
Asia	5.700	0.999	0.963	0.967	0.982	0.921		0.996
Multiple	5.407	0.561	0.997	0.155	0.999	0.492	0.996	

		Tukey-Kramer HSD Test for Region Approx. Probabilities for Post hoc Test						
		Success Factor 2g Error: MSE=1.0789, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.704		0.992	0.247	0.957	0.999	0.999	0.999
Australasia	5.500	0.992		0.312	0.999	0.986	1	0.999
S America	6.125	0.247	0.312		0.313	0.993	0.830	0.491
Europe	5.353	0.957	0.999	0.313		0.918	0.999	0.994
N America	5.833	0.999	0.986	0.993	0.918		0.991	0.997
Asia	5.500	0.999	1	0.830	0.999	0.991		0.999
Multiple	5.593	0.999	0.999	0.491	0.994	0.997	0.999	
		Success Factor 3c Error: MSE=1.3827, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.235		0.991	0.546	0.976	0.935	0.999	0.933
Australasia	5.000	0.991		0.501	0.999	0.706	1	0.999
S America	5.609	0.546	0.501		0.546	0.999	0.909	0.268
Europe	4.882	0.976	0.999	0.546		0.542	0.999	0.999
N America	5.750	0.935	0.706	0.999	0.542		0.787	0.552
Asia	5.000	0.999	1	0.909	0.999	0.787		0.999
Multiple	4.889	0.933	0.999	0.268	0.999	0.552	0.999	
		Success Factor 3d Error: MSE=1.3304, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.276		0.241	0.078	0.914	0.999	0.998	0.975
Australasia	4.539	0.241		0.000	0.991	0.835	0.973	0.778
S America	5.8437	0.078	0.000		0.132	0.781	0.659	0.101
Europe	5.844	0.914	0.991	0.132		0.990	0.999	0.999
N America	5.167	0.999	0.835	0.781	0.990		0.999	0.999
Asia	5.000	0.998	0.973	0.659	0.999	0.999		1
Multiple	5.000	0.975	0.778	0.101	0.999	0.999	1	
		Success Factor 3e Error: MSE=1.6674, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.163		0.585	0.357	0.907	0.786	0.842	0.999
Australasia	4.539	0.585		0.034	0.999	0.121	0.999	0.544

		Tukey-Kramer HSD Test for Region						
		Approx. Probabilities for Post hoc Test						
S America	5.641	0.357	0.034		0.272	0.998	0.324	0.854
Europe	4.647	0.907	0.999	0.272		0.194	0.999	0.888
N America	5.917	0.786	0.121	0.998	0.194		0.118	0.808
Asia	4.400	0.842	0.999	0.324	0.999	0.118		0.823
Multiple	5.185	0.999	0.544	0.854	0.888	0.808	0.823	
		Success Factor 3g						
		Error: MSE=1.3866, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.112		0.942	0.101	0.398	0.911	0.959	0.983
Australasia	4.769	0.942		0.083	0.903	0.502	0.999	0.999
S America	5.672	0.101	0.083		0.011	0.999	0.392	0.138
Europe	4.294	0.398	0.903	0.011		0.065	0.997	0.812
N America	5.667	0.911	0.502	0.999	0.065		0.398	0.619
Asia	4.600	0.959	0.999	0.392	0.997	0.398		0.999
Multiple	4.852	0.983	0.999	0.138	0.812	0.619	0.999	
		Success Factor 3h						
		Error: MSE=1.4484, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.582		0.999	0.002	0.999	0.897	0.912	0.957
Australasia	5.423	0.999		0.057	0.998	0.736	0.778	0.998
S America	6.391	0.002	0.057		0.547	0.999	0.999	0.009
Europe	5.647	0.999	0.998	0.547		0.940	0.947	0.966
N America	6.167	0.897	0.736	0.999	0.940		0.999	0.516
Asia	6.200	0.912	0.778	0.999	0.947	0.999		0.583
Multiple	5.259	0.957	0.998	0.009	0.966	0.516	0.583	
		Success Factor 3i						
		Error: MSE=1.6989, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.490		0.418	0.220	0.750	0.999	0.887	0.904
Australasia	4.769	0.418		0.008	0.999	0.625	0.176	0.980
S America	6.031	0.220	0.008		0.097	0.993	0.999	0.098
Europe	4.824	0.750	0.999	0.097		0.692	0.215	0.997
N America	5.667	0.999	0.625	0.993	0.692		0.970	0.924
Asia	6.200	0.887	0.176	0.999	0.215	0.970		0.459
Multiple	5.074	0.904	0.980	0.098	0.997	0.924	0.459	

		Tukey-Kramer HSD Test for Region						
		Approx. Probabilities for Post hoc Test						
		Success Factor 3k						
		Error: MSE=1.3275, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.469		0.689	0.177	0.559	0.999	0.991	0.181
Australasia	4.962	0.689		0.027	0.998	0.914	0.999	0.984
S America	5.969	0.177	0.027		0.037	0.954	0.625	0.001
Europe	4.7647	0.559	0.998	0.037		0.705	0.995	0.999
N America	5.500	0.999	0.914	0.954	0.705		0.987	0.620
Asia	5.100	0.991	0.999	0.625	0.995	0.987		0.987
Multiple	4.704	0.181	0.984	0.001	0.999	0.620	0.987	
		Success Factor 3l						
		Error: MSE=1.8774, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.122		0.947	0.002	0.809	0.999	0.999	0.948
Australasia	4.731	0.947		0.008	0.997	0.999	0.996	0.999
S America	6.063	0.002	0.008		0.012	0.480	0.701	0.007
Europe	4.471	0.809	0.997	0.012		0.964	0.947	0.997
N America	5.000	0.999	0.999	0.480	0.964		0.999	0.999
Asia	5.100	0.999	0.996	0.701	0.947	0.999		0.997
Multiple	4.741	0.948	0.999	0.007	0.997	0.999	0.997	
		Success Factor 5a						
		Error: MSE=0.91634, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.776		0.989	0.074	0.999	0.998	0.995	0.999
Australasia	5.577	0.989		0.146	0.999	0.999	0.999	0.999
S America	6.250	0.074	0.146		0.523	0.612	0.580	0.354
Europe	5.647	0.999	0.999	0.523		0.999	0.999	0.999
N America	5.583	0.998	0.999	0.612	0.999		0.999	0.999
Asia	5.500	0.995	0.999	0.580	0.999	0.999		0.999
Multiple	5.704	0.999	0.999	0.354	0.999	0.999	0.999	
		Success Factor 5b						
		Error: MSE=0.99158, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.541		0.999	0.771	0.461	0.999	0.999	0.144
Australasia	5.654	0.999		0.998	0.264	0.999	0.999	0.056

		Tukey-Kramer HSD Test for Region						
		Approx. Probabilities for Post hoc Test						
S America	5.797	0.771	0.998	0.103	0.999	0.994	0.008	
Europe	4.882	0.461	0.264	0.103	0.460	0.809	0.999	
N America	5.667	0.999	0.999	0.999	0.460	0.999	0.411	
Asia	5.500	0.999	0.999	0.994	0.809	0.999	0.771	
Multiple	4.852	0.144	0.056	0.008	0.999	0.411	0.771	
		Success Factor 5e						
		Error: MSE=1.6975, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.000		0.999	0.044	0.844	0.999	0.999	0.999
Australasia	4.885	0.999		0.283	0.940	0.999	0.999	0.999
S America	5.688	0.044	0.283		0.065	0.774	0.827	0.524
Europe	4.412	0.844	0.940	0.065		0.964	0.980	0.802
N America	4.917	0.999	0.999	0.774	0.964		0.999	0.999
Asia	4.900	0.999	0.999	0.827	0.980	0.999		0.999
Multiple	5.037	0.999	0.999	0.524	0.802	0.999	0.999	
		Success Factor 5i						
		Error: MSE=0.92298, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.857		0.999	0.450	0.373	0.999	0.999	0.999
Australasia	5.731	0.999		0.606	0.628	0.999	0.999	0.999
S America	6.188	0.450	0.606		0.035	0.972	0.994	0.788
Europe	5.177	0.373	0.628	0.035		0.633	0.626	0.455
N America	5.833	0.999	0.999	0.972	0.633		0.999	0.999
Asia	5.900	0.999	0.999	0.994	0.626	0.999		0.999
Multiple	5.8148	0.999	0.999	0.788	0.455	0.999	0.999	
		Success Factor 5k						
		Error: MSE=0.84615, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.949		0.848	0.902	0.487	0.999	0.999	0.999
Australasia	5.615	0.848		0.377	0.981	0.876	0.993	0.936
S America	6.141	0.902	0.377		0.160	0.999	0.997	0.952
Europe	5.353	0.487	0.981	0.160		0.450	0.838	0.616
N America	6.083	0.999	0.876	0.999	0.450		0.999	0.998
Asia	5.900	0.999	0.993	0.997	0.838	0.999		0.999
Multiple	5.889	0.999	0.936	0.952	0.616	0.998	0.999	

		Tukey-Kramer HSD Test for Region Approx. Probabilities for Post hoc Test						
		Success Factor 6b Error: MSE=0.93212, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.908		0.930	0.303	0.914	0.994	0.902	0.832
Australasia	5.615	0.930		0.163	0.999	0.802	0.998	0.999
S America	6.281	0.303	0.163		0.258	0.999	0.388	0.083
Europe	5.529	0.914	0.999	0.258		0.671	0.999	0.999
N America	6.167	0.994	0.802	0.999	0.671		0.564	0.714
Asia	5.400	0.902	0.998	0.388	0.999	0.564		0.999
Multiple	5.556	0.832	0.999	0.083	0.999	0.714	0.999	
		Success Factor 6c Error: MSE=1.2861, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	5.694		0.761	0.855	0.756	0.999	0.999	0.942
Australasia	5.231	0.761		0.245	0.999	0.756	0.990	0.999
S America	5.953	0.855	0.245		0.324	0.999	0.992	0.488
Europe	5.118	0.756	0.999	0.324		0.598	0.964	0.995
N America	5.917	0.999	0.756	0.999	0.598		0.996	0.901
Asia	5.600	0.999	0.990	0.992	0.964	0.996		0.999
Multiple	5.370	0.942	0.999	0.488	0.995	0.901	0.999	
		Success Factor 6f Error: MSE=0.73549, df=247						
Level	Mean	Afr	Aust	SA	Eur	NA	Asia	Mult
Africa	6.255		0.936	0.893	0.764	0.999	0.434	0.597
Australasia	6.000	0.936		0.521	0.996	0.898	0.850	0.996
S America	6.438	0.893	0.521		0.360	0.999	0.180	0.155
Europe	5.824	0.764	0.996	0.360		0.620	0.980	0.999
N America	6.417	0.999	0.898	0.999	0.620		0.202	0.673
Asia	5.500	0.434	0.850	0.180	0.980	0.202		0.969
Multiple	5.852	0.597	0.996	0.155	0.999	0.673	0.969	

Appendix C

DSMams Functions and Validation

C.1 Assessment Type Macro Code

```
'Code for the Apply button
Private Sub butATApplyButton_Click()

'Declare variables
Dim BM As Double
Dim PvtTbl As PivotTable

'Statistical values associated with the selection of each of the assessments
types
If obFull.Value = True Then BM = 0
If obTrans.Value = True Then BM = 5.807
If obCrit.Value = True Then BM = 6

'Assessment type value is passed to pivot table for filtering data
Set PvtTbl = ActiveSheet.PivotTables("PivotTable1")
PvtTbl.PivotFields("Number").ClearAllFilters
PvtTbl.PivotFields("Number").PivotFilters.Add
Type:=xlValueIsGreaterThanOrEqualTo, DataField:=PvtTbl.PivotFields("Mean"),
Value1:=BM

End Sub
```

```
'Code for the Close button
Private Sub butATCloseButton_Click()

Unload Me

End Sub
```

```
'Code for the Help button
Private Sub butATHelp_Click()

'A help command explaining the different types of assessments.
Dim strMsg As String

    strMsg = "Types of Assessments" & vbNewLine & vbNewLine
    strMsg = strMsg & "The type of assessment determines the number of success
factors included in the assessment." & vbNewLine
    strMsg = strMsg & "" & vbNewLine
    strMsg = strMsg & "• Full Assessment" & vbNewLine
    strMsg = strMsg & " All success factors are included." & vbNewLine
    strMsg = strMsg & " Use for first time service implementations." &
vbNewLine
    strMsg = strMsg & "" & vbNewLine
    strMsg = strMsg & "• Transitional Assessment" & vbNewLine
    strMsg = strMsg & " The most important 28 success factors are included." &
vbNewLine
    strMsg = strMsg & " Use for service expansion or to troubleshoot service
dynamics." & vbNewLine
    strMsg = strMsg & "" & vbNewLine
    strMsg = strMsg & "• Critical Assessment (default)" & vbNewLine
    strMsg = strMsg & " Only critical success factors are included." &
vbNewLine
    strMsg = strMsg & " Use in support of SLA review cycle." & vbNewLine

    MsgBox strMsg, vbInformation

End Sub
```

C.2 Ranking Setting Macro Code

```

'Code to "remember" previously entered weights
Private Sub UserForm_Initialize()

'Add default weights
tbW1.Value = Range("Z7").Value * 100
tbW2.Value = Range("AB7").Value * 100
tbW3.Value = Range("AD7").Value * 100

End Sub

```

```

'Code for the Apply button
Private Sub butApplyButton_Click()

Dim TW As Double

TW = CDb1(tbW1.Value) + CDb1(tbW2.Value) + CDb1(tbW3.Value)

'Ranking weights are passed to model
If TW = 100 Then
    Range("Z7").Value = tbW1.Value / 100
    Range("AB7").Value = tbW2.Value / 100
    Range("AD7").Value = tbW3.Value / 100
Else
    MsgBox "The weights need to add to 100"
End If

End Sub

```

```

'Code for the Close button
Private Sub butCloseButton_Click()

Unload Me

End Sub

```

```

'Code for the Help button
Private Sub butWHelp_Click()

'A help command explaining the ranking and weights.
Dim strMsg As String

strMsg = "Ranking" & vbNewLine & vbNewLine
strMsg = strMsg & "The ranking of factors in the assessment results, is
based on the combined weighted ranks of three factors:" & vbNewLine
strMsg = strMsg & "" & vbNewLine
strMsg = strMsg & "1. Industry benchmark (B): The factor's mean rank based
on an industry benchmark." & vbNewLine
strMsg = strMsg & "" & vbNewLine
strMsg = strMsg & "2. Consensus (C): The rank of the consensus between the
asset owner and service provider assessment scores of the current adherence
to the factor. Ranking is done from larger to smaller differences." &
vbNewLine
strMsg = strMsg & "" & vbNewLine
strMsg = strMsg & "3. Adherence (A): The rank of the adherence to the
factor; adherence is based on the product of asset owner and service
provider assessment scores. Adherence ranges from 0 to 100. Ranking is done
from low to high." & vbNewLine
strMsg = strMsg & "" & vbNewLine
strMsg = strMsg & "The ranking formula is:" & vbNewLine
strMsg = strMsg & " Rank = W1(B) + W2(C) + W3(A), " & vbNewLine
strMsg = strMsg & "" & vbNewLine
strMsg = strMsg & "Conditions:" & vbNewLine
strMsg = strMsg & " W1 + W2 + W3 = 100% (default: W1 = W2 = W3 = 33.3%) " &
vbNewLine

MsgBox strMsg, vbInformation

End Sub

```

C.3 Output Generation Macro Code

```
'Code to prioritise the CSF based on user inputs and ranking settings
Sub Prioritise()

'Unhide previously hidden rows
ActiveSheet.Range("$A2:$42:$BD$88").AutoFilter Field:=5

'Copy factors from model to Prioritised List of CSF
Range("A243").Select
  ActiveCell.FormulaR1C1 = "=R[-35]C[-38]"
  Range("A243").Select|
  Selection.AutoFill Destination:=Range("A243:A288")
Range("BA43").Select
  ActiveCell.FormulaR1C1 = "=IF(R[-35]C[-32]=0,"""",R[-35]C[-32])"
  Range("BA43").Select
  Selection.AutoFill Destination:=Range("BA43:BA88")
Range("BB43").Select
  ActiveCell.FormulaR1C1 = "=R[-35]C[-27]"
  Range("BB43").Select
  Selection.AutoFill Destination:=Range("BB43:BB88")
Range("BC43").Select
  ActiveCell.FormulaR1C1 = "=R[-35]C[-26]"
  Range("BC43").Select
  Selection.AutoFill Destination:=Range("BC43:BC88")
Range("BD43").Select
  ActiveCell.FormulaR1C1 = "=R[-35]C[-25]"
  Range("BD43").Select
  Selection.AutoFill Destination:=Range("BD43:BD88")

'Copy all formula-based ranking values and paste as values only to Prioritised
List of CSF
Range("A243:BD43").Select
  Range(Selection, Selection.End(xlDown)).Select
  Selection.Copy
  ActiveWindow.SmallScroll Down:=-33
  Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
    :=False, Transpose:=False

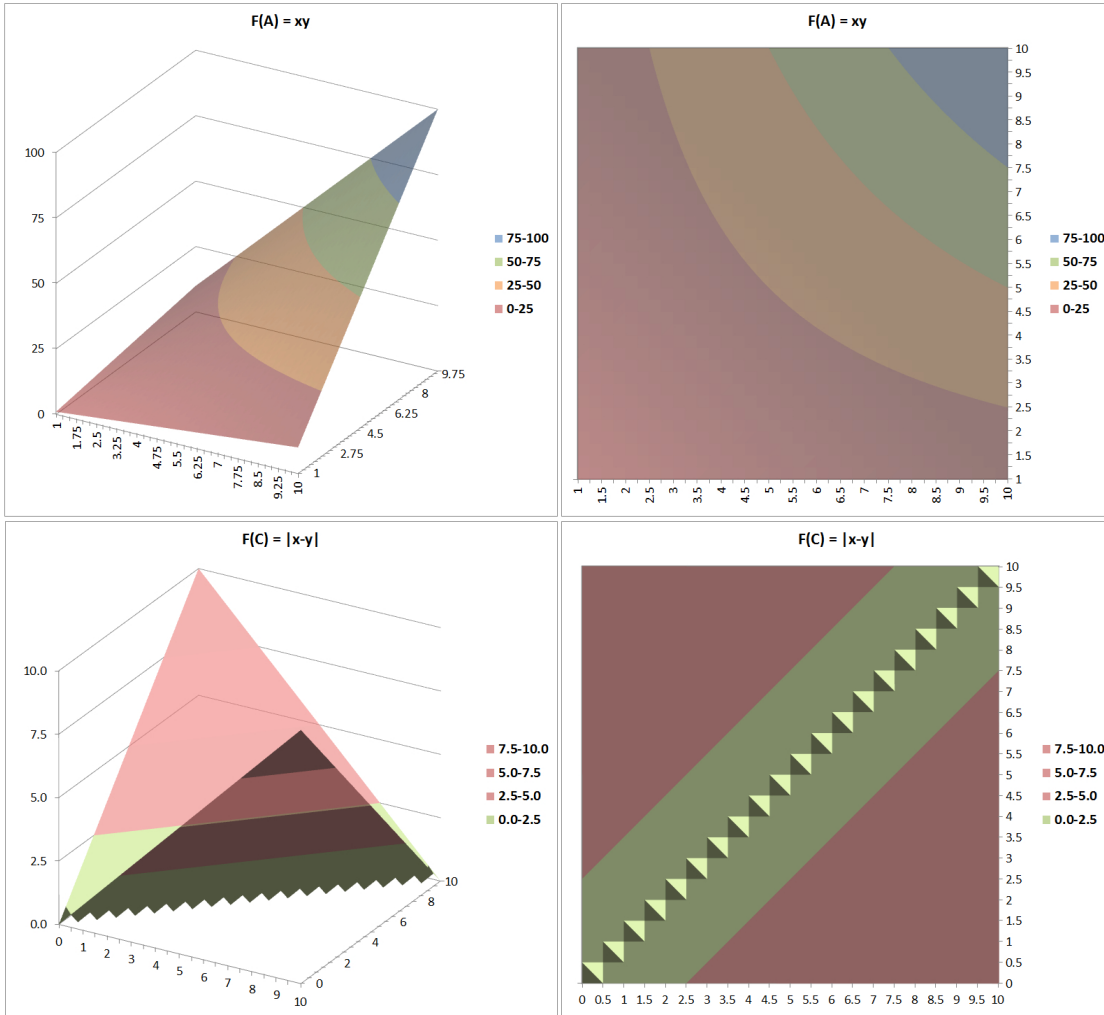
'Sort factors in Prioritised List of CSF descending
Range("A243:BD43").Select
  Range(Selection, Selection.End(xlDown)).Select
  ActiveWorkbook.Worksheets("CSF Model").Sort.SortFields.Clear
  ActiveWorkbook.Worksheets("CSF Model").Sort.SortFields.Add Key:=Range( _
    "BD43:BD88"), SortOn:=xlSortOnValues, Order:=xlAscending, DataOption:= _
    xlSortNormal
  With ActiveWorkbook.Worksheets("CSF Model").Sort
    .SetRange Range("A242:BD88")
    .Header = xlYes
    .MatchCase = False
    .Orientation = xlTopToBottom
    .SortMethod = xlPinYin
    .Apply
  End With

'Exclude filtered out records
ActiveSheet.Range("A243:BD88").AutoFilter Field:=5, Criterial:="<>#N/A", _
  Operator:=xlAnd

'Format outputs by setting consistent row heights
Rows("1:88").Select
  Selection.RowHeight = 13.8
  Rows("42:88").Select
  Selection.RowHeight = 26
  Range("A238:BC39").Select

End Sub
```

C.4 Consensus and Adherence Functions



C.5 Face Validation Questionnaire and Feedback

The problem

In the midst of technological and industry pressures there are no empirical research that sheds light on the critical success factors (CSF) for AM services.

Objectives of face validation:

- Achieve consistency between the researcher and potential user's view of the problem.
- Ensure the formulated problem contains the entire problem and is sufficiently well structured that a credible solution can be derived.
- Serve as feedback mechanism for prototype refinement, reformulation and revision.

Questions

1. Considering the research methodology which was followed to identify the CSF for AM services, what is your opinion of the potential of the DSMams as an objective decision-making tool for assisting asset owners and service providers to improve AM services?

P1 *"I think it will add value. I like the compliance graph at the end, which shows compliance of CSF to industry benchmark. I am comfortable with the calculation and answers".*

P2 *"Well thought through process. My opinion is that the tool indeed has potential in industry."*

P3 *"Great potential for tool, especially in identifying the possible areas where conflict might arise from. It will contribute as a structural framework to add to existing project management tools in order to improve the success rate of new projects."*

P4 *"I think it is a good tool, however more work can be done in refining the model to be more "user friendly" and easier to understand for the end users who*

have not been involved with the problem and may not fully comprehend the process followed in developing the model, so maybe include some form of a detailed 'user manual' to assist the user and getting more value out of utilizing the model."

- P5** *"It seems that you have thought about the selection and methodology well. I might still not understand all the statistics of the output, but I would like to use it as a tool to identify areas of concern. It will help with change management and service relationships."*
- P6** *"Traditional service evaluation methods focus a lot on specific service deliverables. But service relationship is more than just meeting service deliverables. The CSF identified clearly list many 'soft issues' that need to be considered. DSMams will greatly assist to facilitate a structured discussion related to service successes and issues, over and above the specific service deliverables."*
- P7** *"I believe the tool will help align the strategic, tactical and operational levels of the business. This in turn will ensure that everyone in the organization is well informed and understands the Service that will be rendered. It also supports the change management process. Great potential."*
- P8** *"This can be a great tool as part of change management initiatives during implementation or specific project phases. During operational phases it can be used as part of or in support of SLA to ensure open communication regarding focus areas, possible risks and conflicts. Can be used well in support of marketing focus when entering new clients."*

2. In your opinion, what are the strong points of the research methodology and/or DSMams?

- P1** *"Research methodology: Good. Nice to have the ranking of the top 13, etc. DSMams: splitting the 46 criteria into the phases is very nice. Having all the further evaluations then speak to these phases are very nice."*
- P2** *"Methodology: 250+ responses in the AM field = good; Tool: good presentation of results."*

- P3** *“The mathematical model behind the output provides much more intelligence to the answer than the previously used ranked list of potential risks for sustained partnership.”*
- P4** *“The strong points of the research methodology was the great use of the problem statement and to derive a useful model that enables the research to address the problem in a very practical manner that can produce tangible results. I like the fact that as much as it is an academic research it can also be used effectively in industry to improve business.”*
- P5** *“Very good for identifying POD’s in service. Gives a guideline on what is in place and what not (Compliment our SLA audits). You included experts in the study, so its not just your or Pragma’s opinion.”*
- P6** *“Highlight CSF outside the tradition service deliverables that also require evaluation and discussion.”*
- P7** *“Asset owner and Service Provider agree and understand the Critical success factors. The in depth research that has been done by Wyhan.”*
- P8** *“Good statistical process followed to get to final CSF and inputs to the model.”*

3. In your opinion, what are the weak points of the research methodology and/or DSMams?

- P1** *“The fact that all the 46 came out so close.”*
- P2** *“Tool: A bit more explanation that can assist in understanding/interpreting the results will be good.”*
- P3** *“The final output after the assessment of the 2 graphs and the prioritization table needs a lot of insight. At this stage you need to have worked through the research paper and understood the mathematical concept behind it to interpret it. Ideally you want a tool that can be used by someone only picking up the tool without necessarily understanding the research behind it. The graphs and prioritization must be displayed in such a way that the person looking at it can interpret it by merely looking at these 3, thus if I look at the bubble graph*

and see something in the bottom corner instinct would tell me that the client and service provider agree that they are really not doing well on that point and thus needs to be focused on. Once you add the benchmark prioritization to the score, this statement however is likely to change when you look at the prioritized table. The weighting for the prioritized list of CSF should not be left totally open for own interpretation. At least recommend based on research the weighting balance for looking at the 13 critical CSF, the next level and the full assessment.”

- P4** *“I would say an area of improvement would be to make the model a bit more simplistic to address the intuitive nature of the end user and this could be addressed by providing more detail on the importance and the objective of using adherence as a measure that identifies prioritization and providing more insight into the steps taken in the research that support the development of the model, to assist the user in better interpreting the result and better understanding of the objectives of the model to increase the value add of utilizing the model. "Simplifying the ranking logic" so an end user who was not involved in the research and development of the model, can find value add in the process.”*
- P5** *“Not too user friendly (not intuitive) You need to understand the study and detail in order to understand the output. Would be great if it was easier to layman.”*
- P6** *“Apart from top 2 CSF, no real differentiation between the rest - scores very close to one another.”*
- P7** *“The user of this Model would need to understand how the Model was built so that they can explain the results. Would like to see a higher selection of Asset Owners and Service Providers used in the study (Source Data).”*
- P8** *“I would have liked to have a better spread of input between service providers and asset owners. On the final model it would be good to have more clarity on the outputs graphs in terms of inputs, interpretation, calculations and the use of the results. Where do I really need to focus and what is the expected*

benefit? I am just weary that it might be over the top for the average Joe. I would also like to see expected conflicts where points are important for the owner and not for the service provider. Does this make sense? This being said it is also true that if you would just give a client AMIP graphs without having a proper introduction and background to the process then the graphs will also be confusing. I presume for DSMams the process will be similar with some introduction and basic background to the client before the process is started and the graphs shown and discussed.”

4. Please comments on the following architectural aspects of the DS-Mams? See figure 8.2.

5. Based on your previous comments, how do you think it is possible to improve the DSMams?

P1 *“I might have to get to know it better to comment further. The box-and-whiskers graph of the results is confusing.”*

P2 *“See 3 above.”*

P3 *“Increase the response sample from clients to increase the ratio between clients and service providers. Make it more ‘user friendly’ - ease of understanding output.”*

P4 *“As stated on point 3”*

P5 *“Would be great to get a report that explains everything. Almost like a report you usually get with personality tests. That is, a nice description of the results with explanations of the graphs that makes it easy to understand. Also, tips or actions could be useful to add to our master plan.”*

P6 *“Make it clear the last graph of DSMams is just related to Benchmark data and not influenced by the assessment.”*

P7 *“I am sure that Wyhan will put the Model together with a user manual so that the layman can use and understand the tool.”*

P8 *“As stated on point 3.”*

C.6 User Validation Questionnaire and Feedback

The problem

In the midst of technological and industry pressures there are no empirical research that sheds light on the CSF for AMS.

Objectives of face validation:

- To obtain a statement of the applicability of DSMams by possible users.
- To assess the impact of the DSMams's assumptions, simplifications, methods, and generic structure from independent users.

Questions

1. Please comments on the following architectural aspects of the DS-Mams? See figure 8.4.
2. Do you believe that DSMams facilitated the decision process in the utilisation example proposed as part of the validation session? Yes or no, and please give reasons for your answer:

P1 *"Yes, it illustrated the use of the system clearly."*

P2 *"Yes – the guidance from the tool results seemed credible. Not sure about the validity of the sample size."*

P3 *"Yes, because it provides pertinent insight into some of the risks factors that would be associated with service delivery on all levels of an organization, and thus could be a very useful tool in determining the SLA 'pressure points' that need to be effectively managed for ensuring successful implementation of AMS"*

P4 *"Yes"*

P5 *"Yes, the use of the tool was easy enough to get visual output that can be taken into further discussion."*

P6 *"Yes – having formal set of questions to evaluate ensures that all aspects are considered for decision-making."*

P7 “Yes”

3. Would you apply the DSMams methodology to solve AM services problems, based on the experience gained through the example? Yes or no, and please motivate your answer

P1 *“Yes, it will help to increase the success rate of service delivery. I believe that it should be used during the initial contracting phase to ensure that all CSF have been addressed in the project content, KPI, SLA and governance structures – this should focus on ‘in place’. We can then use it on an ongoing basis (e.g. quarterly steering committee meetings) to monitor adherence to these CSF – ‘in use’”*

P2 *“Yes – the model provides guidance to the significant success factors that should be addressed first or should not be addressed even.”*

P3 *“Yes, however I think the real benefit would mostly be derived in utilising the DSMams methodology in the initial stages (proposal/value proposition) in order to limit the challenges and reduce problems during implementation phases. The tool could be very effective as a monitoring and performance enhancement tool during the contract implementation especially in longer term contracts 5 years or more.”*

P4 *“Yes and No. Depending on time permitted and the level of maturity of the client and our relationship. This is the more ‘corporate’ methodology.”*

P5 *“Yes, as a minimum I would like my team to do a self-assessment and become aware of the CSF in our environment. I would then open it up for possible collaboration with the asset owner.”*

P6 *“Yes – it gives additional information above the SLA scorecard that is currently in place.”*

P7 *“Yes, I would just be interested in keeping the benchmarking data recent as industry changes.”*

4. Considering the research methodology which was followed to identify the CSF for AMS, what is your opinion of the potential of the DSMams as an objective decision-making tool for assisting asset owners and service providers to improve AM services?

P1 *“I think the process was sound but it still depended on someone defining the success factors, with interpretation of words. Many of the factors are quite close to each other and actually mean the same thing (worded differently), which ended up as separate success factors. It may have been useful to consolidate the list into a shorter list by combining similar factors to eliminate duplication and ensure mutual exclusivity. To deal with so many factors is difficult – most people battle to get their heads around more than 10 factors.”*

P2 *“Yes – it is general enough to assist with all industries.”*

P3 *“I think it would be a good ‘determinant’ tool as it provides the information required but not necessarily the solutions.”*

P4 *“It has potential to add value in mature environments/clients.”*

P5 *“The obvious concern is the sample pool for determining the CSF and the little variance in the importance of many of the results. A big part of the output is that your relationship is guided by the industry consensus. So considering that it is possible to increase the pool size in order to get better variance between CSF, the research will become more valuable. For the rest, the thinking and approach is very logical and I believe can be very useful.”*

P6 *“Database can be increased by adding a column of importance to each CSF in the questionnaire and adding the feedback.”*

P7 *“I think DSMams can be a valuable tool for decision makers to set strategy and track progress towards better matching services to industry needs.”*

5. In your opinion, what are the strong points of the research methodology and/or DSMams?

- P1** *“It can be used as an advance warning (leading indicator) by both parties that the relationship has a high risk of failure. If used properly it should have a major impact on the success rate of service projects. It is definitely a value-adding and practical PhD, as opposed to so many academic and intellectual PhDs – congratulations!”*
- P2** *“Assists with the discussion on potential service breakdown points and clarifies between both provider and owner what are the significant factors to monitor.”*
- P3** *“I think that the fact that it is open ended in interpretation is a strong point as it allows the user organization, to use the information in a manner that will best suit a current situation and the information can be used to develop very specific solutions to suit various client environments. I believe its non-prescriptive element is a strong point.”*
- P4** *“It will be a very useful tool to open up healthy debate between provider and owner. From the debate and hopeful alignment, improvements in the relationship can happen.”*
- P5** *“It highlights perception differences between client and supplier and facilitates the discussion in a formal way.”*
- P6** *“I think it brings objectivity into decision-making and highlights areas of potential conflict/difference of opinion so that these areas can be closely managed. I think the research quantifies the gap between service providers and service consumers and establishes a defensible baseline against which service providers can evaluate themselves and which service consumers can use to select/evaluate service providers.”*

6. The weak points?

- P1** *“Many of the factors are very similar – see my comments above. Also, I do not believe that these factors only apply to one of the phases in such a project. The model should have allowed factors to apply across more than one phase. Also, there are too many factors - it would have been easier if we only had*

around 10 CSF instead of so many. Also, I do not believe that the industry is significant enough to warrant inclusion in the model – it merely injects additional complexity.”

P2 *“I am not sure that the tool can be used as a tool to measure progress against a plan as there is not space for previous scores. The questions lack some verification point to quickly align understanding of the different factors so that there is not a wide gap that needs to be discussed.”*

P3 *“I found the fact that even though the tool be utilized at all the various phases of asset management delivery, the actual information and data analysis cannot be split into and look at separately i.e. it would be good to only analyze the expected conflict data as a separate element in order to utilize the data to develop a specific part of the SLA for example ‘dispute resolution measures’, I think there is more value that the user could derive if this was possible.”*

P4 *“The tool is perception based and with that comes risk. I have already discussed the limitation regarding the sample size”*

P5 *“It combines the different levels in the organization on both sides of the relationship and this might have the effect that a problem area is averaged out and critical actions to ensure success might be missed.”*

P6 *“I think there are no absolutes in identifying CSF and although the tool will help to guide decision-making it cannot (and is not expected to) give an absolute answer. Weighting between different factors, benchmarking data, etc. will influence the outcomes but it will be difficult to determine the correct weightings.”*

7. Based on your previous comments, how do you think it is possible to improve the DSMams?

P1 *“Instead of focusing on industries or service phase, it may have been more useful to differentiate between service types, eg consulting, outsourced AM, transactional activities such as training, construction/acquisition, etc.”*

- P2** *“Add verification points to the success factors. A consensus score could potentially also add some value.”*
- P3** *“As discussed in No 6.”*
- P4** *“Regarding configurability, I would rather want to be able to configure my output type than all the input filter criteria. For example, if I just want to top CSF per industry, the tool should be able to give it; or if I want to top 6 factors as input to SLA, the tool can give specific output to that. I can then decide in what way I use the tool.”*
- P5** *“Change the assessment sheets to surveys and compare organization levels separately to ensure actions on all levels are applied where needed.”*
- P6** *“Correlating assessment outcomes with actual performance results over time will certainly help to validate the accuracy of the tool and will also give some insight into which weighting factors to us.”*

C.7 Field Testing Questionnaire and Feedback

The problem

In the midst of technological and industry pressures there are no empirical research that sheds light on the CSF for AMS.

Objectives of field testing:

- To test the DSMams in a real world setting and to seek any performance errors which may occur.
- To obtain a statement of applicability for DSMams and its decision-making logic.
- To retrospectively assess the applicability of the DSMams results for an actual AM service.

Questions

1. Considering your involvement and experience with DSMams, what

is your opinion of the overall potential of DSMams and its associated CSF for assisting asset owners and service providers to improve AMS?

P1 *“It can be of enormous value. This will help many engineers when they set up an AMS or similar operation and during the contract. In the past there has been nothing like these guidelines before.”*

P2 *“I think it has huge potential. It should be incorporated in projects to ensure that teams are set up in the most suitable way. Team members should be chosen/recruited/trained to be able to fulfil the requirements. In the setup phase this should be part of the agreement between client and service provider.”*

2. Is the list of CSF, which you assessed, a true reflection of the factors that are most important to ensure a successful AMS relationship in your industry? Please motivate

P1 *“True leadership and commitment from both parties. Utmost honesty about where you are and how to move forward and how to solve the issues at hand. Integrity and honesty are very important from both parties. If this is not present you will not achieve your goals of a top class AM partnership.”*

P2 *“I have confidence in the study because participants in the study were not only from SA but also from Europe, South America and elsewhere.”*

3. Are the DSMams assessment results a true reflection of the current state of your AMS? Please motivate

P1 *“I was amazed to see the results and how close both parties results came out. Yes, I believe they are true reflective results.”*

P2 *“As we have an excellent client/service provider relationship which correlates with the high scores in the matrix, I would deem the criteria to be a true reflection.”*

4. Considering the results which DSMams produced, do you agree with the final ranks and priorities of the CSF which should be focus on? Please motivate

P1 *“Yes, the results speak for themselves and yes these are the items that addressing.”*

P2 *“In general the scores were in the right range and grouping. We had to tweak some of the scores as there was some misinterpretation of the statements. ”*

5. If you had access to DSMams and its associated CSF, when your AMS was first implemented, would the service and relationship have benefited from knowing these CSF upfront? Please motivate.

P1 *“Yes they would. It took about 2-4 years to establish all these critical success factors, but having this information I believe it would have shortened this period by at least half.”*

P2 *“Thinking back definitely. If you reflect on rather serious times of conflict and disagreement it would have helped to have known which CSF were lacking and which not to be able to prioritise. Maybe in some cases it can cause a total breakdown in the relationship.”*

6. Please specify possible improvements to DSMams and the decision-making process?

P1 *“I don’t believe I can. You have thought about every possible scenario and I would like to rather use this and see how one can improve over time. Congratulations on a job well done.”*

P2 *“It needs a user manual with clear instructions to prevent misinterpretation. It should clearly state whether the statement is the ideal desired state or the state reflecting the current partnership.”*

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