A Model for the Evaluation of Location Based Services in South Africa based on Soft Systems Methodology and the Process-Outcomes Model

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ABSTRACT

The increasing pervasiveness of technology has led to questions concerning the contribution and value of technology, and to what extent a particular innovation, invention, product, theory or technological development benefits society. The attempt to answer these questions has led to the development of evaluation methodologies to provide a structured approach to this process of inquiry. In most cases, evaluation methodology can be classified as either fundamentally holistic or reductionist in its approach.

This dissertation argues that both holistic and reductionist thinking need to be applied to the evaluation of complex phenomena, and develops theory in order to achieve this. In the context of evaluating Location Based Services (LBS) in South Africa, a conceptual framework was developed to combine the holistic, systems thinking approach of Soft Systems Methodology (SSM) and the reductionist approach of metrics and the Process-Outcomes model. The conceptual framework allows for a model of evaluation to be constructed that draws on the desirable aspects of both methodologies, and provides the intellectual mechanisms to rigorously combine the methodologies based on the identification of common transformation processes.

The conceptual framework was tested by using it to develop a model of evaluation for LBS in South Africa. This model was used as a framework to analyse the case study data, which led to conclusions regarding LBS and recommendations for further action to improve LBS in South Africa.

Finally, the conceptual framework and theory developed is analysed in terms of its effectiveness and validity, highlighting lessons learnt, strengths and weaknesses of this approach to evaluation, and recommendations for improvement and further research.

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DECLARATION OF WORK DONE

I hereby declare that this thesis in my own work, and that I have acknowledged the work of others where appropriate to the best of my knowledge. This work has not been submitted to any other university.

Signed by candidate

Sean Wiid
London
August 2005

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GLOSSARY

2G	Second Generation
3G	Third Generation
AOA	Angle of Arrival
A-GPS	Assisted Global Positioning System
API	Application Programming Interface
ARPU	Average Revenue per User
BEE	Black Economic Empowerment
CDMA	Code Division Multiple Access
CHTML	Compact Hypertext Markup Language
COO	Cell of Origin
CRM	Customer Relationship Management
CSD	Circuit Switched Data
D-GPS	Differential Global Positioning System
DOC	Department of Communication
EDGE	Enhanced Data Rates for Global Evolution
EMS	Enhanced Message Service
E-OTD	Enhanced Observed Time Difference
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
GDP	Gross Domestic Product
GIS	Geographic Information System
GMLC	Gateway Mobile Location Centre
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
HTTP	Hyper Text Transfer Protocol
HSCSD	High Speed Circuit Switched Data
ICASA	Independent Communications Authority of South Africa
IMT-2000	International Mobile Telecommunications 2000
IN	Intelligent Networks
IP	Internet Protocol
ITS	Intelligent Transport System
IVR	Interactive Voice Response
KBPS	Kilobits Per Second
LBS	Location Based Services

LG	Location Gateway
LIF	Location Interoperability Forum
LMU	Location Measurement Unit
MMS	Multimedia Message Service
PDA	Personal Digital Assistant
R&D	Research and Development
RCT	Radio Camera Technology
RF	Radio Frequency
ROI	Return On Investment
RTI	Real Time Information
S&T	Science and Technology
SA	Selective Availability
SDE	Spatial Data Engine
SDK	Software Development Kit
SIM	Subscriber Identity Module
SMS	Short Message Service
SMSC	Short Message Switching Center
SSM	Soft Systems Methodology
STK	SIM Toolkit
TDMA	Time Division Multiple Access
TDOA	Time Difference of Arrival
TOA	Time of Arrival
UMTS	Universal Mobile Telecommunications System
USA	Universal Service and Access
WAP	Wireless Application Protocol
W-CDMA	Wideband Code Division Multiple Access
WML	Wireless Markup Language
XML	Extensible Markup Language
WML	Wireless Markup Language

1 INTRODUCTION

The primary objective of this research is to develop a model for the evaluation of Location Based Services (LBS) in South Africa. In doing so, this thesis investigates several methodologies for the evaluation of Science and Technology (S&T) and proposes that a combination of Soft Systems Methodology (SSM) and the Process-Outcomes model form the basis of the evaluation model. A conceptual framework is developed to combine these methodologies, and is used to guide the construction of the evaluation model. The evaluation model is tested by using it to process and to evaluate LBS case study data collected in South Africa. In this way, the use of SSM and the Process-Outcomes model, as well as the conceptual framework developed to combine them, are tested against a real evaluation situation.

The construction of the evaluation model, and the subsequent analysis based on this model, is carried out from the perspective of a cellular network operator wanting to gain a better understanding of LBS in the South African context with the intention of implementing LBS or improving existing LBS applications. The motivations and reasons for the evaluation are discussed in section 1.2.2. In addition, the evaluation model forms a potential foundation for the continuous evaluation of LBS in South Africa, providing the framework to gain insight into different aspects of the industry and to assess the benefits of LBS to society and the economy.

Furthermore, the conceptual framework and theory developed to combine SSM and the Process-Outcomes model represents new thinking that may prove useful for different evaluation situations and stimulate further research into ways of combining different evaluation methodologies.

This chapter outlines the background, objectives and constraints of the research. It introduces and defines the concepts of evaluation and LBS, and establishes the need for the evaluation of LBS in South Africa. It defines the research objectives and outlines the research methods used. The chapter concludes by establishing the scope and limitations of the research and describing the structure of the dissertation.

1.1 The Evaluation of Science and Technology

S&T has had an increasingly profound impact on humanity over the last few hundred years, particularly over the last century. Public opinion towards S&T has also changed in this time, as society has come to accept the benefits that S&T has provided in healthcare, transportation, communication and general improvements in quality of life. The ever-increasing pervasiveness of S&T has led to questions concerning the contribution and value of S&T, and to what extent a particular innovation, invention, product, theory or development benefits society (Geisler 2000). The attempt to answer these questions has led to the need to develop and apply suitable methods, conceptual tools and measurement instruments that will aid the process of assessing the effects of S&T on society and the economy. In the context of this thesis, these methods and conceptual tools aid the process of assessing the effects of LBS on society and the economy in South Africa. This process is commonly referred to as evaluation, and is defined in the following section.

1.1.1 Operational Definition of Evaluation

The Oxford English Dictionary defines evaluation as a *"process followed to find out, to state the value of, or to assess something"*.

Guba and Lincoln argue that there is no right or wrong way to define evaluation such that all questions of procedure and purpose of evaluation are adequately addressed. They move on to claim that any definition of evaluation is purely a human mental construct that serves a specific purpose (Guba & Lincoln 1989).

The author concurs with the above, having found that the meaning of evaluation changes to suit the intentions of the evaluator and therefore can have many different operational definitions. For the purposes of this dissertation, the operational definition of evaluation is modified from Guba & Lincoln (1989), and is defined as follows;

> *Evaluation is a process consisting of a series of activities, incorporating understanding, measurement, and assessment, and which aims to establish the value or the contribution made and recommend improvements.*

The author chooses this operational definition of evaluation because it accurately encapsulates the approach to evaluation followed in this thesis. More specifically, the fundamental concepts identified by this definition are that evaluation is necessarily a process, that it requires holistic understanding, the measurement of selected aspects, and subjective judgement.

These concepts and their implications for this research are discussed in chapter 2, and are carried throughout the work. In addition, chapter 8 revisits this definition of evaluation in the context of reviewing the processes followed in this thesis.

1.1.2 The Need for the Evaluation of Science & Technology

This section explains the need for the evaluation of S&T from technological, social, economic and organisational perspectives. The arguments presented in this section are carried through to section 1.2.2, which discusses the specific need for the evaluation of LBS in South Africa.

1.1.2.1 Evaluation of S&T from a Technological Perspective

Evaluation from a technological perspective deals with technology itself. In other words, it evaluates a particular product, invention, machine or system [i] in terms of its physical characteristics and capabilities. This could include the assessment of the features and potential of the technology in order to establish how it can best be implemented in a particular situation. It could also involve the measurement of performance in order to ensure quality, to detect faults and to highlight possible areas of improvement.

1.1.2.2 Evaluation of S&T from a Social Perspective

As already stated in this chapter, S&T has had an increasing impact on humanity in recent years. It can be argued that technology exists only to be used by society. In support of this statement, Geisler claims *"technology is only a tool, subjected to human needs, desires, preferences, and emotional as well as material parameters of existence"* (Geisler 1999). In other words, technology needs to be evaluated in terms of its effects on society, both positive and negative. Positive effects could include improvements in health and safety, transport, telecommunications and general quality of life, while negative effects could include compromising human rights, pollution or other damage to the environment. In addition, other social factors such as demographics, market structure and market demand may affect the adoption of the technology by society (Geisler 2000).

1.1.2.3 Evaluation of S&T from an Economic Perspective

Evaluation of S&T from an economic perspective deals primarily with financial consequences of the technology. This could include measuring the cost of developing or purchasing the technology, cost of operating and maintaining the technology, the revenue generated from its use as well as any potential macro-economic benefits to the economy, such as increased Gross Domestic Product (GDP).

1.1.2.4 Evaluation of S&T from an Organisational and Political Perspective

Evaluation of S&T from an organisational and political perspective deals with factors on an organisational or governmental level that affect the implementation and adoption of the technology. On an organisational level, this could include strategy, partnerships, and the support of executive management. On a governmental or regulatory authority level, the evaluation could include legislation, policy and regulations that control the implementation and use of the technology. Political agendas of stakeholders may also be of importance when trying to understand the implications of a particular technology.

Evaluating each of these perspectives provides insight into different aspects of the complex S&T phenomenon, but it is the understanding of the relationships between these perspectives that provides the holistic understanding of S&T.

The following section introduces and defines LBS and builds on the evaluation perspectives discussed above to justify the need for the evaluation of LBS in South Africa.

1.2 Location Based Services

In the early stages of international cellular telecommunications, companies developed and implemented their own proprietary network technology, resulting in limited markets and incompatibility with other networks (Sempere 1997). As cellular telecommunications have evolved, there has been a move towards standardisation and convergence of technology. This has resulted in several important developments which have enabled the international cellular industry to grow beyond early expectations.

The primary purpose and main use of cellular networks is currently and in the foreseeable future will be to facilitate voice communication (Bosch 2002; Crawford & Aftahi 2001). However, network operators have realised the importance of offering a range of value-added services. These would aid in increasing their Average Revenue per User (ARPU), thus helping to recoup their investment in third generation (3G) licenses and network infrastructure (D'Roza & Bilchev 2003), which was estimated at $5 trillion globally between 1998 and 2002 (Budde 2002). These services include, for example, Short Message Service (SMS) and Multimedia Messaging Service (MMS), video calling, mobile games, business data, mobile commerce and Location Based Services (LBS).

1.2.1 Operational Definition of Location Based Services

LBS can generally be defined as any application or service that is dependent on location (D'Roza & Bilchev 2003). These services make use of the user's physical location in combination with other spatial information to provide location sensitivity, contextual awareness and personalisation of mobile information services (Niedzwiadek 2001).

The above general definitions of LBS are not specific enough for this thesis, as the research focuses on LBS provided over cellular networks only. Therefore, for the purposes of this thesis, the author chooses the following operational definition of LBS:

> *Location Based Services (LBS) are those services available on cellular networks that utilise the geographic position of the user to provide value to the user.*

The above definition describes all classes of LBS applications[ii], whether implemented horizontally[iii] as additional stand-alone services, such as vehicle tracking, or vertically as enhancements to existing services, such as locating a caller for emergency purposes.

The following section establishes the need for the evaluation of LBS in South Africa.

1.2.2 The Need for the Evaluation of Location Based Services

The cellular technology industry is highly competitive and is reaching saturation point in terms of the number of cellular users in many global markets. This has been interpreted by industry experts and network operators as a need to find new ways to increase cellular revenues (Adams, Ashwell, & Baxter 2003). To this effect, industry experts have identified LBS as a potentially valuable segment of the cellular market, with an estimated global value of $32 billion by 2005 (Pyramid Research 2001) and 680 million global users by 2006 (Rao & Minakakis 2003). However, over-speculation and over-expectations with regards to LBS has led to unrealistic, or rather over-optimistic, ideas of its value, resulting in hesitation to implement these services and a slower than expected market adoption of LBS on a global basis.

The majority of what is known about LBS in South Africa comes from observing global LBS activities and trends (Hainebach 2002). In addition, there are organisational and social factors specific to South Africa that may affect the implementation of LBS. Following the arguments presented in section 1.1.2, four different perspectives need to be considered for the evaluation of LBS in South Africa.

1.2.2.1 Evaluation of LBS from a Technological Perspective

Although the cellular industry is converging on common standards and technology, network operators are still faced with a complex conundrum of disparate software, hardware, and connectivity components that need to be appropriately integrated to provide LBS (Rao & Minakakis 2003). Furthermore, network operators have a limited understanding of what is technically possible given the location determination technology and cellular network technology currently available in South Africa (Watermeyer 2002). This has led to questions regarding whether the acquisition of additional hardware and software is necessary for the implementation of LBS (Oehely 2002). Therefore, LBS in South Africa needs to be evaluated from a technological perspective.

1.2.2.2 Evaluation of LBS from a Social Perspective

There is an inadequate understanding of the potential market for LBS in South Africa and of the possible benefits of LBS for society (Watermeyer 2002). This understanding is crucial, as market acceptance will directly determine the extent to which a technology is successfully adopted (Geisler 1999). In addition, there are consumer concerns with regards to personal privacy that could possibly hinder the acceptance of LBS. Therefore, LBS in South Africa needs to be evaluated from a social perspective.

1.2.2.3 Evaluation of LBS from an Economic Perspective

At the outset of this research, the primary reason that cellular network operators in South Africa had hesitated to implement LBS is that they had not yet been able to establish a business case for LBS (Hainebach 2002). In other words, they had not been able to justify the cost of LBS technology and implementation in terms of the potential revenue generated by LBS. Network operators have been and still are reluctant to spend large amounts on LBS technology without a thorough understanding of the potential economic benefits and guaranteed return on investment. Therefore, LBS in South Africa needs to be evaluated from an economic perspective.

1.2.2.4 Evaluation of LBS from an Organisational and Political Perspective

The complexity of the LBS Value Network, introduced later in section 4.2, dictates that sound strategy and the formation of partnerships with other industry stakeholders is vital for the implementation of LBS. Other organisational factors such as marketing strategy and obligations in terms of the license agreements may affect LBS. Furthermore, the implications of various legislation, policies and regulations on the provision of LBS need to be understood. Specifically, these could include policy to regulate the cellular industry, protect personal privacy and control access to information. Therefore, LBS in South Africa needs to be evaluated from an organisational and political[iv] perspective.

Based on the above, an evaluation of LBS in South Africa is required in its ***technological, social, economic and organisational contexts***. In addition, the interaction between factors from each of these different views needs to be analysed in order to obtain a holistic understanding of the problem. In order to achieve this, an evaluation model needs to be constructed based on sound methodological theory.

This section has introduced and defined LBS, and established the need for the evaluation of LBS in South Africa. The following section consolidates the discussion thus far by stating the objectives of this research.

1.3 Research Objectives

As stated in the opening paragraphs of this dissertation, the primary objective of this research is to develop a model for the evaluation of LBS in South Africa based on SSM and the Process-Outcomes model, introduced in sections 2.3.5 and 2.3.3 respectively.

It is important to reiterate that the construction of the model and the evaluation of LBS are carried out from the point of view of a network operator wishing to improve their LBS services. This is required as there is a lack of understanding of the LBS market and the possibilities of LBS in the South African context, as discussed in greater detail in section 1.2.2.

The primary research objective, the construction of a model of evaluation, can be broken up into several activities which serve as sub-objectives:

1. Investigate several existing methodologies of evaluation
2. Develop a conceptual framework to combine SSM and the Process-Outcomes model

3. Construct an evaluation model using the conceptual framework
4. Test the evaluation model by using it to evaluate LBS in South Africa
5. Discuss the strengths and weaknesses of the evaluation model and the conceptual framework, and suggest possible improvements and avenues for further research

In addition to the sub-objectives listed above, this research also has three ancillary objectives. These can be defined as direct outcomes of testing the model of evaluation:

1. Evaluate case study data on LBS in South Africa
2. Provide an initial opinion based on the research
3. Recommend key factors for improving LBS in South Africa

This section has established the primary objective and the sub-objectives of the research. In addition, it has stated three ancillary objectives that relate to the actual evaluation of LBS in South Africa. The following section describes how these research objectives were achieved.

1.4 Research Method

This section outlines the research method, explains the data collection techniques and lists the data sources used in this thesis. The research consisted of a number of different stages or activities, which correspond to the sub-objectives of the research as stated in section 1.3. These stages were iterated throughout the research which resulted in progressive improvements in the evaluation model and the results of the evaluation.

1.4.1 Research into Evaluation Methodology

The first stage of the research involved the investigation of several methodologies of evaluation in order to determine a suitable methodology for the evaluation of LBS in South Africa. Methodologies were chosen from different fields, for example traditional science evaluation and social sciences, in order to insure that a broad range of evaluation ideas were investigated. This stage corresponds to sub-objective 1 as listed in section 1.3.

1.4.2 Development of a Conceptual Framework

Based on the research stage discussed in the previous section, Soft Systems Methodology (SSM) and the Process-Outcomes model were selected as suitable methodologies for the evaluation. The second stage of the research involved the development of a conceptual framework based on these two methodologies that would enable them to be meaningfully combined. This involved designing a structural framework that accommodated both methodologies, as well as determining appropriate theoretical links between them. This stage corresponds to sub-objective 2 as listed in section 1.3.

1.4.3 Development of an Evaluation Model

Using the conceptual framework developed in the second stage of this research, the third stage develops a model for the evaluation of LBS in South Africa. This evaluation model consists of SSM conceptual models, a set of metrics and processes, and the evaluation of these metrics and processes in context of the Process-Outcomes model. This stage corresponds to sub-objective 3 as listed in section 1.3.

1.4.4 Testing of the Evaluation Model

The fourth and final stage of the research consisted of testing the evaluation model developed in stage three. This was achieved by using the model to evaluate the case study data on LBS in South Africa. By testing the evaluation model, this research stage provided the mechanism to satisfy the ancillary research objectives as stated in section 1.3. The following section discusses the case study data that was used to test the evaluation model. This stage corresponds to sub-objectives 4 and 5 as listed in section 1.3.

1.4.5 Data Collection

This section outlines the main sources of the LBS case study data collected throughout this research. The quality, availability and nature of the data sources were a fundamental consideration in the selection of suitable evaluation methodologies in stage one and the development of the evaluation model in stage three. Furthermore, this data was used to test the evaluation model in stage four, thereby addressing the ancillary research objectives stated in section 1.3.

1.4.5.1 Commercial Projects

The author was initially exposed to the LBS industry in South Africa through several commercial projects. The majority of these projects were undertaken while employed by a Cape Town-based GIS consultancy and software development company, while one project was undertaken by the candidate in a personal capacity. These commercial projects included:

- ***Project A*** - Industrial research project investigating the use of LBS in Intelligent Transport Systems (ITS) for local government (Project A 2001)
- ***Project B*** - Design and management of an online LBS market survey (Project B 2002)
- ***Project C*** - Initial investigations for implementing a nationwide LBS-enabled emergency call centre, in partnership with local government (Project C 2001)
- ***Project D*** - Tender proposal and technical design of a LBS-enabled intelligent bus system for local government (Project D 2002)
- ***Project E*** - Preliminary stages of LBS-enabling an SMS based weather service in partnership with a large service provider (Project E 2001)
- ***Project F*** - Proof of concept development of a software interface into a network operator's Location Gateway (see section 4.2.3) (Project F 2002)
- ***Project G*** - Discussions and strategy development for an Australian mobile application development company with intentions to implement LBS applications in South Africa (Project G 2003)

In order to adhere to various confidentiality and non-disclosure agreements, the author has not mentioned company names and has provided a limited description of the various projects that will prevent the reader from easily identifying them. The projects provided firsthand experience and insight into the technical, social, organisational and economic aspects of LBS in South Africa. In addition, they provided access to a large range of research resources, including the industry representatives discussed in the following section.

1.4.5.2 *Interviews*

The author approached a number of organisations with the intention of interviewing key people involved with LBS in South Africa. Many of the requests for interviews were ignored, while others were refused on the basis that the author's employment status was a potential conflict of interest. This can be viewed as a possible source of bias or weakness with this data source. However, the author was able to interview influential people from six industry stakeholders. A fortunate and important factor is the diversity of the backgrounds of these industry representatives, as at the time of the interviews they all worked for companies that fulfil different roles in the LBS value network described in section 4.2.

- ***Interview A*** - Divisional managing director of a cellular handset manufacturer
- ***Interview B*** – Sales manager of a messaging solutions and service provider
- ***Interview C*** – LBS manager of a cellular network operator
- ***Interview D*** – Business manager of a mobile applications developer, content and service provider
- ***Interview E*** – Sales manager of a location technology provider
- ***Interview F*** – Managing director of a non-profit health technology organisation

Interviews were conducted in an informal manner, focusing on non-sensitive information regarding the company's approach to LBS, technical aspects of LBS implementation and on the insights and opinions offered by the interviewees regarding LBS in South Africa.

1.4.5.3 *Publications and Other Sources*

In addition to the firsthand knowledge assimilated through commercial involvement and interviews with industry stakeholders, information was gathered from a variety of sources. This information provided additional background information into business and technical aspects of LBS, and allowed the author to keep abreast with developments in the local and international LBS industry. This meant a continuous process of data collection throughout the years of this research from the following sources:

- Academic journals and publications
- Published books
- Industry publications
- Consultant and analyst reports
- Newspapers and magazines
- Legislation and regulations
- Online news sites
- Company websites and product information
- TV news
- TV and radio advertisements

1.4.5.4 *Market Surveys*

The following market surveys were used as data sources for the research:

- Online LBS Market Survey (Project B 2002)
- Vodacom Market Study (Vodacom 2001)
- Global Telecoms Forecasts (Gale Group 2002a)

- Vodacom Online LBS Poll (Vodacom 2004b)

As will be seen from the discussions regarding these market surveys and the analysis of the survey data, the size of the sample and demographic profiles of the respondents are vital considerations when using the data to draw conclusions regarding LBS in South Africa.

This section has reviewed the research method and outlined the sources of data used in the research. The following section discusses the scope and limitations of this dissertation.

1.5 Scope and Limitations

The cellular technology industry is highly competitive and there is a limited amount of publicly available information regarding the specific activities of South African companies involved in LBS. In addition, many companies were not willing to divulge information due to the commercial sensitivity of the information and the author's employment with a potential competitor. Therefore, there is a limitation in the quantity and quality of the data available for this thesis, particularly concerning commercial activities or business arrangements.

Furthermore, the industry is advancing rapidly, and new technology and case study material is continually emerging. While every attempt was made to keep the data in this thesis as current as possible, it was not feasible to consider all new information. Therefore, it is important to understand that the evaluation of LBS in this thesis represents a snapshot of LBS in South Africa at a particular time based on a limited amount of available data.

In addition, at the commencement of this research there were only two cellular operators in South Africa, namely Vodacom and MTN. The third mobile operator, CellC, began operating during the course of the research. The author has had no commercial involvement with CellC, and to the best of the author's knowledge CellC has not as yet become actively involved in LBS (Oehely 2004). Therefore, although CellC is mentioned in this research, it will not be included in the evaluation of LBS in South Africa.

Lastly the author acknowledges the qualitative nature of the evaluation, and recognises that a background in Geomatics and Computer Science may result in a bias towards technical aspects rather than social or organisational aspects of the evaluation. It is hoped that the methodology adopted contributes towards reducing the affects of bias in the evaluation.

1.6 Structure of the Dissertation

This dissertation is presented linearly in order to follow a logical progression according to the research stages as discussed in section 1.4. Therefore, this document moves through the sub-objectives listed in 1.3, with each chapter introducing ideas and concepts that need to understood before moving on to the next.

Chapter 1 introduces and defines the concepts of evaluation and LBS, and establishes the need for the evaluation of LBS in South Africa. It defines the research objectives and outlines the research method. It concludes by establishing the scope and limitations of the research and describing the structure of the dissertation.

After outlining the basic principles of measurement and evaluation, Chapter 2 reviews several evaluation methodologies and investigates the strengths and weaknesses of each. The chapter then provides motivation for the combination of Soft Systems Methodology

(SSM) and the Process-Outcomes model for the evaluation of LBS in South Africa, and concludes by suggesting that a conceptual framework needs to be developed in order to rigorously combine these methodologies.

Chapter 3 discusses the aspects of SSM and the Process-Outcomes model that are relevant to this research, and develops a conceptual framework for combining these methodologies. The conceptual framework consists of a structure that incorporates the Process-Outcomes model as part of the SSM evaluation process, as well as conceptual tools to define meaningful connections between aspects of the methodologies.

A contextual understanding and descriptive background information is required before the framework developed in Chapter 3 can be used to develop an evaluation model. This background knowledge is provided in Chapter 4, which begins with an overview of the origins of LBS. After a brief outline of LBS in different regions of the world, the implications of technology convergence and the merging of standards organisations on LBS are discussed. Moving on to more practical aspects, the chapter discusses each of the technology and service components required to provide LBS, as well as how they interact with each other to fulfil their roles in the LBS Value Network. Finally, after a discussion of the different classes of LBS applications, Chapter 4 concludes by highlighting several key lessons derived from global LBS experience that may be relevant to the situation in South Africa.

After the overview of LBS, the research then progresses to the construction of the evaluation model using the theory developed in Chapter 3. Chapter 5 develops SSM conceptual models to generate an initial understanding of LBS in South Africa in its social, organisational and political context. Chapter 6 uses this initial understanding to build a set of metrics and construct the Process-Outcomes model for the evaluation of LBS in South Africa. The metrics constructed in Chapter 6 are separated from the main body of the thesis, and are discussed in detail in Appendix A.

Once the evaluation model has been constructed, it is tested by using it to process and assess the data collected during the course of this research. To this end, Chapter 7 consists of the analysis of the evaluation model and the metrics, and the formation of conclusions and recommendations with regards to LBS in South Africa, thereby addressing the ancillary research objectives listed in 1.3.

Chapter 8 concludes the dissertation by providing an analysis of the conceptual framework and the theory developed to combine SSM and the Process-Outcomes model, as well as the resulting evaluation model, highlighting strengths, weaknesses and suggesting avenues for further research.

Appendix A contains the case study data used in this thesis, presented in terms of the metrics developed for the evaluation model. This appendix describes each metric in turn, evaluating its suitability for inclusion in the evaluation model and presenting the actual metric data where appropriate.

Appendices B and C contain additional information regarding the cellular technology and location determination technology respectively. These appendices are provided primarily sources of additional information, and are referred to throughout the dissertation when necessary.

[i] In this context, the term 'system' refers to a hard system rather than a soft system, a distinction which is vital in the context of this thesis and is fully explained in section 2.3.5.2.
[ii] The classes of LBS applications for the purposes of this thesis are defined in section 4.3.
[iii] The distinction between horizontal and vertical integration of LBS is important in the context of this thesis, and is introduced in section 4.4.1.5.
[iv] Politics in this context refers to organisational politics, and not politics of the general parliamentary arena.

2 LITERATURE REVIEW: EVALUATION METHODOLOGY RESEARCH

After proposing a definition of evaluation, chapter 1 explained the need for the evaluation of Science and Technology (S&T) and for the evaluation of Location Based Services (LBS) in South Africa. The purpose of this chapter is to review and discuss several evaluation methodologies, and to provide motivation for the use of a combination of Soft Systems Methodology (SSM) and the Process-Outcomes model in this research. This chapter addresses the first sub-objective of this thesis as stated in section 1.3.

The chapter begins with section 2.1, which discusses fundamental problems encountered in the evaluation of S&T. Section 2.2 reviews the two main types of data used in evaluation, namely qualitative and quantitative data, and shows why a combination of these types of data within an interpretive framework is necessary to achieve the most reliable and comprehensive results.

Section 2.3 is dedicated to the discussion of several methodologies of evaluation, and will follow a progressive course from earlier ideas to more recent thinking. Using salient points from the discussion of the strengths and weaknesses of each reviewed methodology, section 2.4 argues for the combined use of Soft Systems Methodology and the Process-Outcomes model to develop an evaluation model for LBS in South Africa. The chapter concludes with section 2.5, which summarises the findings of this literature review in preparation for the development of the conceptual framework in Chapter 3.

2.1 Problems and Difficulties with Evaluation

This section introduces some of the higher-level concepts and complexities involved with evaluation. These need to be taken into consideration when investigating evaluation methodologies available for use in this thesis.

2.1.1 Reductionism vs. Holism

Simple physical phenomena are relatively easy to measure, as they normally only involve one measurable quantity such as heat, weight or length, whose value is defined in a standard unit of measurement such as degrees, kilograms or metres. In contrast, S&T phenomena are complex, multifaceted and unstructured and need to be addressed in economic, social, technological and organisational contexts as discussed in section 1.1.2. They therefore cannot be measured accurately by single values.

Since the data sets are different in nature, they cannot be evaluated in the same way. Thus in order to understand complex phenomena it is still necessary to evaluate certain facets that can represent the whole (Geisler 2000). However, Geisler warns that the reduction of facets of complex phenomena to single measures or quantitative values can often lead to narrow or even completely incorrect conclusions when taken out of context.

Hofstadter identifies the above as the problem of reductionism versus holism, and argues that in the context of evaluating complex phenomena, the concepts of reductionism and holism are dependant on one another (Hofstadter 1979). In other words, a complex system cannot be understood holistically without looking at details, and inversely by reducing a complex phenomenon to its basic parts or facets, one must be mindful of the system as a whole in order understand the parts in the appropriate context.

2.1.2 Determining Measurable Aspects

As discussed in the previous section, the measurement of multi-faceted complex phenomena requires the selection of a few facets to represent the whole. Geisler claims that this selection of facets or determination of which aspects to measure is the first principle of measurement of S&T (Geisler 2000).

In agreement with this statement, Piore says that any uncertainty of the results or quality of an evaluation attempt often results from an initial uncertainty in which particular aspects or variables should be evaluated (Piore 1979). In other words, a poor initial understanding of a problem often results in poor results because the wrong aspects of the problem were measured. This supports the need for contextual understanding, as the only way this problem can be overcome is through a prior holistic understanding of the situation being evaluated.

However, as the initial understanding of the phenomenon is largely subjective, the selection of facets to be measured is also likely to vary depending on the biases of the evaluator. This raises concerns that critical aspects of the phenomenon may be overlooked (Geisler 2000). This is related to the problem of the biases and intentions of the evaluator as discussed in section 2.1.4. In this respect, background, biases and intentions of the author for the purposes of this evaluation have already been stated in section 1.5.

Therefore, paradoxically, the selection of appropriate measurable facets is dependant on the evaluator's contextual understanding of the phenomenon, but the subjective nature of that initial understanding often determines which facets are selected. This suggests the need to iterate the evaluation, so that as the evaluator learns more and the understanding of the situation improves, additional aspects of the phenomenon are taken into consideration.

2.1.3 Combining Qualitative and Quantitative Data

The strengths and weaknesses of quantitative and qualitative data and the justification for combining them in an evaluation are discussed later in section 2.2. For the moment, it is sufficient to state that meaningfully combining these different types of data presents a challenge to the evaluator.

2.1.4 Bias and Intentions of the Evaluator

The paradox identified in section 2.1.2 reinforces the effect of prior knowledge and bias in the evaluation process. Furthermore, the problems associated with combining quantitative and qualitative data, mentioned in the previous section and discussed later in section 2.2, calls for the use of subjective evaluation and interpretation of data. These two points suggest that it is not possible to remove the preconceived ideas or biases of the evaluator from the evaluation process. Therefore, the chosen evaluation methodology needs to recognise the purpose of the evaluation and take the intentions of the evaluator into account.

2.1.5 Determining Quality of Evaluation

A significant problem lies in determining the quality component of an evaluation effort. This filters down from a difficulty in evaluating the quality of qualitative data, and the quality of the evaluator's subjective analysis. Thus obtaining an estimate of the quality of the evaluation is often more complex and time consuming than performing the evaluation itself (Kostoff 1998b).

2.1.6 The Problem of Analysis

The problem of analysis stems from the difficulty of combining quantitative and qualitative data and in evaluating complex qualitative data. With respect to traditional S&T evaluation, there has in the past been a lack of methodology for analysis of complex data (Miles 1979), and more recent thinking suggests that the analysis of this data necessarily involves a significant amount of subjective judgement (Geisler 2000). This subjective analysis is naturally affected by the biases and intentions of the evaluator as stated in section 2.1.4.

This chapter has so far highlighted some of the key issues that need to be considered in the measurement and evaluation of complex S&T phenomena, and therefore need to be considered when selecting a methodology of evaluation. The following section discusses the use of quantitative and qualitative data prior to the review of several evaluation methodologies in section 2.3.

2.2 Quantitative vs. Qualitative Data

The two types of data used in evaluation are quantitative and qualitative data. This section highlights the key aspects of these types of data, and shows why a combination of the two has become more accepted for the evaluation of S&T.

In this discussion it is important to make the distinction between quantitative and qualitative, and objective and subjective. A common misconception is to think of quantitative data as objective and qualitative data as subjective. The terms "objective" and "subjective" refer to the analysis and interpretation of data regardless of whether it is in the quantitative and qualitative form (Moravcsik 1988). Sproles maintains that subjective data is dependant on the judgement of a human being while objective data is independent of human judgement (Sproles 2001). Quantitative data consists of numeric values, while qualitative data can be categorised in some way but cannot be reduced to numerical measurements. The distinction between these concepts is shown below by way of example:

	Quantitative	*Qualitative*
Objective	Average Revenue per User (ARPU); Number of SMS messages sent in a particular period	Government policy; Demonstrated LBS positioning capability
Subjective	Estimated value of LBS market; User estimates on potential LBS expenditure	User opinion on LBS usability; User concerns for personal privacy

Figure 2.1: Subjective, Objective, Quantitative and Qualitative data

Figure 2.1 above provides different examples of measures of LBS that demonstrate the difference between quantitative and qualitative, and objective and subjective, using examples from LBS in South Africa. As shown in the figure, an example of quantitative-objective data is Average Revenue per User (ARPU), which is a measure of the average amount spent in a month on cellular services. This measure is quantitative in that it consists of a single numerical value, and objective in that it is calculated from usage of the cellular network and is unaffected by subjective judgement.

An example of quantitative-subjective data is the estimated value of the LBS market. This metric is quantitative in that it consists of a numerical value in a particular currency, but subjective in that the measure is a subjective assessment of the potential value of LBS based on available data and projections by industry analysts.

An example of qualitative-objective data is the demonstrated positioning capability. This is a qualitative measure in that it cannot be represented by numbers alone as it consists of several factors, but objective in that whether or not a network has these positioning capabilities is not open to subjective interpretation.

An example of qualitative-subjective data includes user concerns for personal privacy, which is qualitative in that it does not involve directly measurable values, and subjective because opinions on a particular subject are by their very nature subjective.

The distinction shown in Figure 2.1 is important as data from all four classifications is used in this research, and the type of data affects the way it must be combined with other data and the way the data is evaluated.

2.2.1 Quantitative Data

The use of quantitative data involves the direct measurement of a particular facet of a phenomenon and results in some numeric value. An understanding of the complex phenomenon is constructed by measuring the values of multiple aspects. Examples of quantitative data in the context of evaluation S&T include:

- Count of publications
- Count of new products and processes
- Count of patents
- Economic and financial measures
- Performance outputs

(Geisler 2000)

2.2.1.1 Strengths of Quantitative Data

Geisler identifies the key strengths of quantitative data as structure, measurement and representation (Geisler 1999):

1. **Structure** - the nature of quantitative measurements makes them inherently easier to select and to fit them into a structured methodological framework
2. **Measurement** - the collection, measurement and analysis of quantitative data is relatively well documented and straight forward to perform (Kostoff 1998b)
3. **Representation** - the simple analysis allows for the identification and representation of trends in S&T (Geisler 1999).

These strengths of quantitative data stem from their relative simplicity. As discussed in the following section, this simplicity is the source of the weaknesses of quantitative data.

2.2.1.2 Weaknesses of Quantitative Data

Kostoff identifies that fundamental problem with quantitative data concerns the methods used for the data collection (Kostoff 1998a). He claims that there are deficiencies in the methods used for collection of raw data and how the analyses thereof are translated into meaningful results.

Geisler takes this statement a step further by stating that the use of quantitative data may increase the difficulty of the overall evaluation effort, as one may be confronted with sets of unrelated results. Any attempt to numerically combine these measures, such as assigning weights and creating aggregate measures, introduces additional bias and uncertainties in the data (Geisler 2000).

2.2.2 Qualitative Data

Guba and Lincoln claim that the integrated role of technology with organisational structures, culture and stakeholders has shifted evaluation to a more subjective analysis of the phenomenon (Guba & Lincoln 1989). This subjective analysis evaluation would facilitate a richer understanding of the phenomenon that in turn would provide better information for future action. This interpretive thinking requires the analysis of qualitative data. Examples of qualitative data in the context of the evaluation of S&T include:

- Compliance with regulations
- Customer satisfaction
- Contributions to capabilities and skills of S&T staff
- Contributions to pool of innovations
- Contributions to prestige and status of organisation

(Geisler 2000)

2.2.2.1 Strengths of Qualitative Data

Sproles identifies that the advantages of qualitative data is evident in situations where:

1. quantitative measurement is difficult or theoretically impossible
2. goals of the evaluation are not clearly stated
3. evaluation is highly sensitive to context or scenario

(Sproles 2001)

Therefore, qualitative data is more suitable to understanding complex phenomena holistically than quantitative data, particularly when there is a deficiency of quantitative data.

2.2.2.2 Weaknesses of Qualitative Data

There are three main problems with qualitative data:

1. The collection and analysis of qualitative data is laborious and intensive, from a volume and complexity point of view. This often results in incomplete data.
2. The combination and comparison of the value of qualitative data from different sources is problematic due to the subjective nature of the measurement of quality of the data. These problems were discussed in section 2.1.
3. There is a lack of appropriate methodologies for the analysis of qualitative data (Miles 1979).

Thus, there are advantages and disadvantages with using either quantitative or qualitative data. The following section motivates for a combination of these types of data in an evaluation.

2.2.3 Combining Quantitative and Qualitative Data

Based on the discussion in the previous sections, it is suggested that both quantitative and qualitative data have their place in evaluation. This would suggest that a combination of the two is required for a more complete evaluation.

In support of this statement, Sproles maintains that there is merit in recognising that both types of data make a valuable contribution to the evaluation effort (Sproles 2001). Van Maanen provides further support for this notion, stating that qualitative and quantitative data are not mutually exclusive (Van Maanen 1979). In addition, Sieber claims that qualitative data can be very useful when compared to quantitative information from the same contextual setting, producing more powerful analysis than either could have produced alone (Sieber 1973).

Kaplan is quoted in Downey and Ireland as stating that *"too often we ask the question of how to measure something without raising the question of what we would do with the measurement if we had it"* (Downey & Ireland 1979). With respect to this statement, quantitative methods tell us how and what to measure, while qualitative methods are more associated with establishing implications of these measures. Thus, qualitative and quantitative data both have there place in evaluation.

However, this adds another level of complexity to the evaluation effort. In addition to the weaknesses of quantitative and qualitative data as discussed in sections 2.2.1 and 2.2.2 respectively, there is the added problem of meaningfully combining qualitative and quantitative data. This problem has already been mentioned in section 2.1.3.

The following section shows that the successful combination of quantitative and qualitative data is dependant on subjective judgement within a methodological framework of evaluation.

2.2.4 The Need for a Methodological Framework of Evaluation

Most researchers investigated suggest that a framework of evaluation is necessary in order to achieve the combination of quantitative and qualitative data. For example, Van Maanen claims that the linking of data must be dependant on an interpretive framework (Van Maanen 1979).

To this effect, Kostoff argues that *"Every S&T metric and associated data should have a decision focus, it should contribute to the answer of a question which in turn would be the basis of a recommendation for future action"* (Kostoff 1998b). In support of this statement, Geisler maintains that as more data has become available and means to assemble data has improved, researchers tend to shift the focus onto the data itself rather than the constructs or decision focuses of the evaluation (Geisler 2000). Based on the above, both authors stress the importance of evaluating collected data within a guiding framework to be able to focus the evaluation into meaningful results.

Guba and Lincoln claim that despite the move towards more subjective evaluation of quantitative and qualitative data, there is still a requirement for a methodological framework for evaluation and constructs through which to perform the measurements (Guba & Lincoln 1989).

The author is of a slightly different opinion, and maintains that it is precisely because of this shift towards subjective and holistic evaluation that a guiding conceptual framework, as opposed to simply an evaluation model, is essential for evaluation. The weaknesses of qualitative data as identified in section 2.2.2.2 suggest that any attempt to analyse the data without a guiding conceptual framework would result in the evaluation losing focus and clarity. The author encountered this problem when initially compiling the data for this research without a suitable conceptual framework for the evaluation.

Thus, several methodologies of evaluation need to be explored in order to develop a conceptual framework and an evaluation model for the evaluation of LBS technology in South Africa. A suitable methodology stipulates methods for data collection, selection of measures, formulation of questions and the analysis of data. The following section discussed several methodologies of evaluation investigated for the purposes of this research.

2.3 Methodologies of Evaluation

This section discusses the fundamental aspects of several methodologies of evaluation, explains how they make use of different types of data, and outlines their strengths and weaknesses. This leads to the selection of SSM and the Process-Outcomes model as suitable methodologies for the evaluation in section 2.4.

Guba and Lincoln provide a useful précis of the evolution of evaluation research, which is summarised in the figure below in context of the methodologies investigated in this research. The author acknowledges that there are many different theories and methodologies of evaluation, and states that it was necessary to select a limited number for investigation in the context of this thesis.

	Example Methodology	**Characteristics**
1st Generation	**Scientific Positivism**	**Measurement** of relevant statistics
2nd Generation	**Science Indicators**	**Description** of patterns of strengths and weaknesses relative to stated objectives, including quantitative and qualitative analysis
3rd Generation	**Metrics and the Process-Outcomes model**	**Judgement** - the acknowledgement that judgements of merit and worth are integral to evaluation and that the evaluator is best placed to make them
4th Generation	**4th Generation Evaluation, Soft Systems Methodology**	**Negotiation** - findings of the evaluation are constructed through an interactive process that includes the evaluator and all stakeholders

adapted from Guba and Lincoln (1989)

Figure 2.2: Evolution of Evaluation Research

Evaluation as it is understood today is a result of numerous attempts at developing appropriate methods of measuring complex phenomena. It has been this process of construction and reconstruction of ideas that has led to the different generations of evaluation methodology as shown in Figure 2.2 above (Guba & Lincoln 1989).

This section discusses methodologies from each of the above classifications or generations of evaluation methodologies, beginning with the first generation methodology of Scientific Positivism.

2.3.1 Scientific Positivism

This methodology will not be discussed at great length as it has been replaced by more sophisticated methodologies. It is briefly discussed here to assist the reader to understand the need for better methods of evaluation. A detailed discussion of the philosophy behind scientific positivism is beyond the scope of this thesis.

This early attempt at evaluation, or rather measurement, of S&T followed a strictly positivist approach. It attempted to apply the methodologies of physical scientific discovery, or scientific positivism, to the problem of evaluation (Guba & Lincoln 1989). In other words, this 1st generation approach tried to assign discrete values to certain aspects of the phenomenon being evaluated, without concern for the context or purposes of the evaluation.

As an example, consider the measure of number of users of a cellular network. A value of 18 million users is meaningless on its own. However, when combined with a history of subscriber statistics and those of a competitor, a network operator is able to measure market share and thus evaluate performance. Alternatively, an industry analyst could use the same information to determine cellular penetration, market saturation and predict market growth. Therefore context and purpose of the evaluation are important aspects that this methodology does not consider.

Although this approach may be suitable for physical sciences, S&T phenomena involve more complex interactions between social, economic, technological and organisational processes, and are thus less precise and cannot be adequately measured by discrete quantities alone (Geisler 2000). Pawson and Tilley concur, claiming that early attempts of evaluation to establish its scientific credibility failed due to the over-simplistic scientific positivist approach adopted. This resulted in early evaluations following perfunctory predefined formats that led to inadequate and disappointing results (Pawson & Tilley 1997). Therefore, it can be interpreted that this approach inherits all of the weaknesses of the use of quantitative data, but not all of the strengths. In other words, this approach made very little attempt to place measurements in any kind of methodological structure, often resulting in an incomplete picture of the complex phenomenon being measured.

The inadequacy of this methodology led to the development of better techniques of defining measurements and their purpose, collecting data, and combining and interpreting these measures for the evaluation of S&T phenomena. A common example of a second generation methodology is the use of science indicators, which is discussed in the following section.

2.3.2 Science Indicators

Geisler defines science indicators as *"a generic term that applies to a broad range of quantitative measures of selected activities, inputs, and outcomes from research, development, and innovation"* (Geisler 2000). Van Raan expands on this definition by stating that science indicators *"represent the research field of utilisation of mathematical, statistical, and data-analytical methods and techniques for gathering, handling, interpreting, and predicting a variety of features of science and technology enterprise, such as performance, development and dynamics"* (Van Raan 1988).

The most widely used methods of evaluating S&T involve the use of science indicators. Science indicators are referred to as metrics in some literature. However, as will be shown in section 3.2.2, in the context of this thesis an indicator is defined differently to a metric, as the adopted concept of a metric is slightly more sophisticated than a basic indicator. Indicators differ from positivist measures, discussed in the previous section, in that they encapsulate an understanding of nature and purpose of the measurement. This is discussed further in 3.2.1.

This section discusses three prominent examples of science indicators, namely bibliometrics, citation analysis, and patent statistics.

2.3.2.1 Bibliometrics

Bibliometrics is a general term that refers to a count of published scientific, technical, academic documents and other means of knowledge transfer. It aims to first measure the quantity of publications, and secondly the quality of these publications (Geisler 1999). Thus bibliometrics consists of both quantitative and qualitative data. Bibliometrics is a complex process that involves stringent rules and criteria for the selection of a publication for inclusion in an evaluation.

2.3.2.2 Citation Analysis

Citation Analysis extends bibliometrics beyond a count of publications by providing a quantitative technique of measuring the quality of a publication. It is a complex process in which scientific and technical articles cited in academic literature are sorted, catalogued and analysed (Geisler 2000). The basic premise of this indicator is to assign a quantitative value to the quality of an article by counting the number of times it is cited in other work. The assumption is that the more often a publication is cited, the more valuable it is deemed to be by the scientific community

2.3.2.3 Patent Statistics

Geisler claims that patent statistics are the preferred indicator of technology progress of economists for four reasons:

- The counts can be directly incorporated into economic models due to their quantitative nature.
- Patents clearly link R&D with technological innovation and thus economic benefits.
- Patents represent a legal document that describes intellectual property rights, and is thus a good indicator of assets.
- Patents measure progress at two stages of the innovation continuum, as direct outcomes of R&D as well as downstream economic outcomes.

2.3.2.4 Strengths of Science Indicators

Science Indicators inherit all of the strengths of quantitative data as discussed in section 2.2.1.1. In summary these are structure, measurement, and representation.

2.3.2.5 Weaknesses of Science Indicators

Science indicators are constructed almost exclusively from quantitative data, and thus inherit the weaknesses of quantitative data outlined in section 2.2.1.2. In addition, Science indicators such as bibliometrics often disregard the influence of the stage of development of a technological discipline (Geisler 1999). The measurement of a developed S&T phenomenon would yield far better science indicators than the measurement of an evolving one. As will be discussed section 2.4.2, this was a problem in attempting to apply science indicators to the case of LBS in South Africa.

2.3.3 Metrics of S&T and the Process-Outcomes Model

Geisler claims that the only viable method for evaluating S&T is by the use of metrics, including economic, social and science indicators (Geisler 2000). This section briefly outlines a methodology for selecting, constructing and combining metrics for evaluation, as well as the Process-Outcomes model for evaluating these metrics at different stages of the innovation continuum. A more detailed description of this methodology is provided in chapter 3 in the context of the development of a conceptual framework for this thesis.

This approach removes itself from evaluation activities such as collecting data or performing statistical analysis, and concentrates on establishing a framework for the evaluation process. Thus the focus is on a framework and not on particular predefined indicators or measures. This approach differentiates itself by considering three key factors:

1. The role and intentions of the evaluator
2. The purpose of the evaluation
3. The available data

By focussing on these key factors, a metrics-based evaluation accommodates both quantitative and qualitative data, recognises the need for subjective evaluation, and acknowledges the bias introduced by the intentions of the evaluator.

2.3.3.1 Criteria of Metric Selection

Geisler argues that no evaluation situation can reuse the same set of metrics, and that in reality the actual metrics used are an opportunistic selection of metrics based on available data and the purpose of the evaluation (Geisler 2000). However, a structured approach is retained by specifying criteria for metric selection, as outlined in section 3.2.4. In this way the methodology takes the focus off the data, and concentrates on the purpose of the evaluation. This has the effect of focussing the data analysis into meaningful and purposeful answers to pertinent questions. This addresses one of the problems that have been identified with evaluation methodologies described in section 2.3.1, namely that evaluators tend to focus on the data rather than the purpose of the evaluation.

2.3.3.2 Process Outcomes Model

This section briefly discusses the Process-Outcomes model, which attempts to overcome three problems identified with other evaluation frameworks, namely;

- The failure to consider the stage of development of a technology when performing S&T evaluation. In other words, attempting to measure the ultimate social benefits of a technology that is still in the development stage is meaningless and/or irrelevant.

- Difficulties in linking Research & Development (R&D) processes with eventual outcomes. In other words, the measurement of patent statistics or initial investment in S&T is difficult to relate to downstream benefits such as increased GDP or increased health of the population.
- Difficulties in linking S&T metrics with economic and social metrics. In other words, measuring technology performance statistics may be difficult to relate to increased profitability or increased public safety.

(Geisler 1999; Kostoff 1998a)

In an attempt to overcome these problems, Geisler proposed the use of the Process-Outcome model in 2000, which is based on identifiable spatial and temporal stages in the innovation process (Geisler 2000). In other words, the Process-Outcomes model recognises that S&T is an on-going process and not a once off event. It takes the stage of development into account and provides a framework to link S&T processes with social and economic systems, allowing the tracking and evaluation of S&T from initial inputs to final outcomes (Kostoff 2001). The Process-Outcomes model is discussed in detail in section 3.3.

2.3.3.3 Strengths of Metrics and the Process-Outcomes Model

The strength this approach to the evaluation of S&T is that it recognises the need for quantitative analysis, but realises the limitations and weaknesses of quantitative data. It thus allows for the use of qualitative and quantitative data, and provides a flexible methodological framework to combine these data types. It also recognises the importance of context, judgement, the role of the evaluator and the evaluator's goals. Furthermore, it does not specify a particular set of metrics one must use, but provides a framework of metric selection based on the needs of the evaluator, the availability of the data and the evaluation objectives.

In addition, the Process-Outcomes model overcomes the limitations of other methodologies by providing the means to link social, technological and economic measures of S&T through all stages of technology development. This overcomes the problem with traditional science indicators identified in section 2.3.2.5.

2.3.3.4 Weaknesses of Metrics and the Process Outcomes Model

In the author's opinion, this approach does not adequately address the problem of analysis of qualitative data. Sieber identifies this as a problem with work of methodologists, finding that typically only between 5% and 10% or their work is dedicated to formal methods of the evaluation of qualitative data (Sieber 1973). The author proposes that the lack of formal analysis techniques of qualitative data is a direct result of the need to use subjective judgement when evaluating qualitative data. It seems counter-intuitive to define formal methods for forming an opinion. This does not detract from the need for a framework of evaluation.

The potential problems of the Process-Outcomes model are associated with its implementation in a specific situation. The specified stages of the process may not accurately represent the actual flow of S&T phenomena. In addition, the activities defined between these stages may not accurately represent the processes that transform S&T from inputs to outputs (Geisler 2000). These problems are linked to the complexity of S&T phenomena, the inherent loss of detail in any abstraction or process modelling, and the fact that the same model cannot approximate all S&T processes.

Despite these potential problems, promising evaluation results have been reported with the Process-Outcomes model. These successes are discussed later in section 2.4.3.2.

2.3.4 Fourth Generation Evaluation

Recognising the problems associated with the measurement of complex phenomena and evaluation methodology discussed in previous sections, a radically different approach to evaluation has been proposed by Guba and Lincoln (1989) in what they have termed *"Fourth Generation Evaluation"*.

Fourth Generation Evaluation begins with the assumption that there are no realities, other than those created by the evaluator in order to try to make sense of a particular situation. Based on this assumption, scientific process is entirely abandoned in this methodology. Guba and Lincoln support this approach by claiming that to treat evaluation as a scientific inquiry is *"to completely miss its fundamentally social, political and value-oriented character"*, and propose a methodology whose key action is negotiation (Guba & Lincoln 1989). The fundamental concepts of this methodology can be summarised as follows:

- The findings of the evaluation are constructed through an interactive process that includes the evaluator and all stakeholders.
- The evaluation results are not considered factual, but rather the best possible explanation of a situation.
- The evaluation is always driven by the intentions of the evaluator.
- It enforces the need for an understanding of context, a need already established in section 2.1.2.
- It recognises that evaluations can be formed to exclude or support stakeholders.
- Defines its activities as action orientated.

(Guba & Lincoln 1989)

The strengths and weaknesses of this methodology are discussed in the following sections.

2.3.4.1 Strengths of Fourth Generation Evaluation

The primary strength of this methodology is that it does not rely on quantitative data, and therefore avoids the associated problems as discussed in section 2.2.1.2. Furthermore, it relies on the holistic appraisal of complex phenomena through a process of discussion, and the involvement of all stakeholders ensures that the most complete understanding of the phenomena is obtained. In addition, this approach incorporates social and political aspects of the phenomenon as integral and meaningful in the evaluation process, enabling a far broader understanding of the phenomenon in question (Guba & Lincoln 1989).

2.3.4.2 Weaknesses of Fourth Generation Evaluation

The primary weakness of Fourth Generation Evaluation is the lack of measures which can be easily analysed and interpreted, i.e. it does not make use of the advantages of quantitative data as discussed in 2.2.1.1. Furthermore, the iterative negotiation between all stakeholders is a time consuming and difficult process. It is more suitable for the evaluation of social systems and organisational problems than the measurement of S&T phenomena, as per the intentions of Guba and Lincoln.

2.3.5 Systems Thinking & Soft Systems Methodology

This section introduces systems thinking and Soft Systems Methodology (SSM). It begins by looking at systems thinking as a tool for conceptualising real-world problems, discusses the fundamental difference between hard and soft systems thinking, and outlines the main aspects of SSM as a potential methodology for evaluation.

2.3.5.1 Systems Thinking

Systems are the complex organisation of a number of different connected elements which form a whole (Barry 1999; Checkland 1981). Hanson defines a system as any two or more parts that are related, such that change in any one part changes all parts (Hanson 1995).

Systems thinking is a way of thinking about, describing and understanding the forces and interrelationships that shape the behaviour of complex systems (Van Zyl 2001). It is a language that views the world as a set of systems in an attempt to conceptualise reality (Johnson 1999). Checkland states that the underlying principle of systems thinking is that complex problems need to be defined in terms of an irreducible whole. Thus, it is the emergent properties of the whole, rather than the properties of the components, that should be the focus of the evaluation of a complex system (Checkland 1981).

In this respect, Barry (1999) states that systems theory challenges the reductionist philosophy (see sections 2.1.1 and 2.1.2) of breaking down complex phenomena into individual components without taking cognisance of the whole system. It therefore recognises the value of holism as opposed to reductionism. Barry further argues that although systems thinking is supposedly the opposite of reductionism, the evaluator still has to reduce a conceptual view of a situation to a manageable aspects (Barry 1999). Rose and Haynes extend this view by stating that systems theory is a complement to conventional reductionist scientific enquiry by providing the means to analyse systems holistically (Rose & Haynes 2001).

Therefore, systems thinking supports the idea that in terms of evaluating complex systems or situations, the concepts of reductionism and holism are not separable, as proposed earlier in section 2.1.1.

2.3.5.2 Hard and Soft Systems Thinking

Systems can be defined as hard or soft. Barry and Fourie state that hard systems apply to structured problems while soft systems apply to unstructured problems (Barry & Fourie 2002). Similarly, Rose classifies hard systems are those that are designed physical systems, and soft systems as those involving social, cultural and organisational considerations (Rose & Haynes 2001). In the context of this thesis, an example of a hard system would be the physical technology required to implement LBS, while an example of a soft system would be the provision of LBS by network operators for use by society.

Checkland concurs with the above descriptions of hard and soft *systems*, but claims that they do not define the difference between hard and soft *systems thinking*. He states that the crucial intellectual distinction is that hard systems thinking tries to define the world itself as a set of systems, while soft systems thinking merely tries to organise the process of inquiry into the world as a set of learning systems (Checkland 1999). Therefore soft systems do not exist in reality, but are conceptual constructs that aid in understanding reality. This is the fundamental principle behind SSM, as discussed in the following section.

2.3.5.3 Soft Systems Methodology (SSM)

This section provides a brief overview of Checkland's Soft System Methodology (SSM) as a methodology of evaluation. This methodology is discussed in more detail in section 3.1.

SSM is an iterative learning process that begins with a real-world problem. Evaluators study the situation, identify systems and develop conceptual models that generate overall understanding and provide insights into the way the problem might be addressed. These SSM conceptual models are then compared to the real-world situation, and any differences discovered form the foundations for any recommendations and planning of changes to improve the situation.

In accordance with the distinction between hard and soft systems thinking established in the previous section, SSM does not claim that reality actually is a set of systems (Johnson 1999). The conceptual models of SSM are not representations of the real world, but help to structure thinking about situations in the real world (Rose & Haynes 2001). Therefore SSM is based on a comparison between the world as it is, and some conceptual models of the world as it is perceived (Williams 2002). A simplistic representation of this concept is shown Figure 2.3 below, namely that the comparison of SSM models with reality yields a better understanding of the situation:

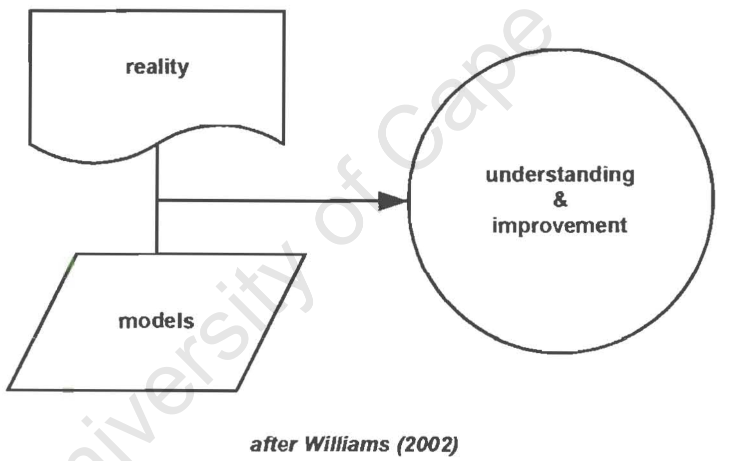


Figure 2.3: Principle of Soft Systems Methodology

This section has introduced the concepts of systems thinking, the difference between hard and soft systems thinking, and briefly outlined the concept of SSM. The following sections discuss the strengths and weaknesses of SSM.

2.3.5.4 Strengths of SSM

The strengths of SSM are as follows:

- It structures the process of generating understanding (Barry & Fourie 2002)
- It is potentially highly creative, but within a rigorous framework (Williams 2002)
- It actively promotes alternative views of exploring the "purpose" of the system and provides insights by cutting across traditional or stereotypical boundaries (Checkland 1981)
- Its iterative nature provides a way to continually assess and improve a situation.

2.3.5.5 Weaknesses of SSM

In a thirty year retrospective study of SSM, Checkland claims that much of the criticism of SSM has come from people who either have only a superficial knowledge of the primary literature or only refer to early work without considering later modifications to SSM (Checkland 1999).

Checkland states that the single biggest mistake of evaluators is confusing the conceptual models with reality, which goes against the essence of SSM (Checkland 1999). In other words, evaluators lose sight of the fundamental difference between hard and soft systems established earlier in section 2.3.5.2. This problem is highlighted by Williams, who also states that SSM is very intellectually demanding as many people find it extremely difficult to move from the real-world problem to the conceptual models and then back to a comparison with the real-world (Williams 2002).

This section has introduced the basic concepts of systems thinking and SSM. In conclusion, Checkland recognises that the point of a methodology is to be moulded by a user to a particular situation, but warns against the misuse of SSM by the inexperienced (Checkland 1999). In attempt to guard against such misuse, constitutive and strategic rules of SSM are provided as guidelines. These rules are discussed in relation to this research in section 3.1.4.

This chapter has thus far introduced the problems associated with evaluating complex situation and has outlined several methodologies for evaluation, moving through the generations of evaluation methodology presented in Figure 2.2. The following section evaluates the suitability of each approach for the evaluation of LBS in South Africa in the context of this research.

2.4 Selection of an Appropriate Methodology

This section assesses the methodologies reviewed in section 2.3 in terms of their suitability for this research, and argues the use of a combination of SSM and the Process-Outcomes model for the evaluation of LBS in South Africa.

Downey and Ireland claim that a methodology for evaluation is not valid until it is applied to a particular research problem (Downey & Ireland 1979). This suggests that a methodology of evaluation is never right or wrong, but may or may not be suitable for a particular situation. Furthermore, the methodologies discussed in the previous section all have their relative strengths and weaknesses. In many cases, the strengths of one methodology are the weaknesses of another and vice versa.

Therefore, the evaluator needs to assess not only which methodology is more appropriate, but also how best to implement a particular methodology or a mixture of suitable aspects of different methodologies for his or her purposes. This is summarised by Checkland's statement that the point of a methodology is to be moulded by a particular user for a particular situation as outlined in the previous section (Checkland 1999).

The assessment of the evaluation methodologies discussed in section 2.3 begins with Scientific Positivism in the following section.

2.4.1 Assessment of Scientific Positivism

Scientific positivism is not suitable for the evaluation of LBS in South Africa for reasons already discussed in section 2.3.1. In summary, these include the failure to take the context of the evaluation into account and the sole reliance on basic quantitative measures to evaluate complex phenomena.

As discussed in section 1.4.5, a relatively large portion of the data collected during this research is qualitative in nature. Since this methodology does not accommodate this type of data, it cannot be applied to the evaluation of LBS in South Africa. More importantly, this methodology does not consider the need for a holistic understanding of the problem.

2.4.2 Assessment of Science Indicators

This section explains why science indicators are not suitable for the evaluation of LBS in South Africa. This is done by constructing an argument against the use of bibliometrics, and subsequently extending that argument in order to exclude traditional science indicators as an appropriate method of evaluation in the context of this research.

Geisler regards bibliometric measurements of S&T as a key measure of intensive activity in our society of knowledge creation and management (Geisler 2000). After a review of the process of bibliometric evaluation the author concurs that it is indeed a valuable metric to gauge the value of pure S&T research activity. However, the author chooses to exclude the use of bibliometrics for the purposes of this research for four reasons.

Firstly, as discussed in section 2.3.2.5, science indicators fail to take the stage of the stage of development into account. The technology and ideas involving LBS are still emerging and thus the number of academic publications is relatively small, especially in the context of LBS in South Africa. However there are a number of industry-related magazine articles, internet news reports, and consultant reports on the subject, and these sources therefore form a significant portion of the case study data for this thesis. Bibliometric analysis on this type of data would be difficult, as it comes from disparate sources and the primary assumption of bibliometrics is that strong correlation exists between published works in a particular field.

Secondly, if the available data was to be used to construct bibliometric indicators, it would raise the question of which data sources would qualify as valid academic outputs. This would require an evaluation of the quality of various publications, which is beyond the scope of this thesis.

Thirdly the use of bibliometrics, in the author's opinion, inherently requires a definition of the technological boundaries of the subject. In this case it would be extremely difficult to put a distinctive boundary around the LBS as it draws on so many different areas of scientific, technological, organisational and social issues. There are a number of related industry sectors in the LBS Value Network, discussed in section 4.2, and an exhaustive count of the number of bibliometric outputs in all sectors relating to LBS is well beyond the scope of this thesis.

Finally, bibliometrics are not appropriate for the purposes of this research as they do not serve the purposes and intentions of the evaluator and are based on data that is unavailable. In other words, bibliometrics fails two out of three of the selection criteria discussed later in section 3.2.4.

Similar arguments can be constructed for other traditional science indicators such as patent counts and citation analysis. Therefore, although science indicators are a powerful tool for the evaluation of pure S&T activity, they are not appropriate for use as the sole methodology in this research.

2.4.3 Assessment of Metrics of S&T and Process-Outcomes Model

This methodology is suitable for the evaluation of LBS in South Africa because it provides a framework for the combination of qualitative and quantitative data. It contains mechanisms for focusing the evaluation by defining criteria for the selection of metrics, and overcomes the limitations of other methodologies by providing the means to link social, technological, organisational and economic measures of S&T through all stages of technology development. As discussed in section 1.1.2, linking these different perspectives is fundamental to the evaluation process. Finally, this approach is flexible enough to allow the evaluator to draw on other techniques or methodologies depending on the needs of the evaluation and the available data.

2.4.3.1 Support for the Process-Outcomes Model

In an earlier paper, Kostoff claims that the most S&T metrics literature focus on the metrics as an end to themselves (Kostoff 1998a), adding that at that time very few studies had concentrated on the principles and problems underlying the evaluation of S&T and how these evaluations could be practically carried out in real-world situations. In a subsequent review of the Process-Outcomes model, Kostoff states that the methodology analyses the principles of evaluating S&T using metrics from multiple perspectives, addresses the practical ways in which these metrics can be employed and overcomes the problems in linking S&T activities to economic benefits at different stages of development (Kostoff 2001).

Geisler offers examples of successful uses of the Process-Outcomes model in the case of two federal laboratories in the United States (Geisler 2000). In addition, the model was applied to the evaluation of healthcare technology in Canada for a doctoral dissertation by Dr George Eisler, the dean of the British Columbia Institute of Technology (Geisler 2002). In summary, Geisler claims that the model appears to be a superior approach to more simplistic methodologies such as science indicators, and encourages it to be tested in a variety of situations.

2.4.3.2 Criticism of the Process-Outcomes Model

In addition to the weaknesses of the Process-Outcomes model identified in section 2.3.3.4, Kostoff offers the criticism that the methodology does not adequately address the biases associated with self-evaluation of an organisation for purposes other than operational monitoring (Kostoff 2001). This criticism does not apply in this case as the evaluation of LBS in South Africa does not apply to one organisation only, and is in no way a self-evaluation of any organisation. This does not detract from the need to consider the biases and intentions of the evaluator, as discussed in section 2.1.4.

In a personal communication with the author, Kostoff implied that he was unaware of other reviews, evaluations or applications of the Process-Outcomes model (Kostoff 2002). In addition, the author was unable to find further reviews of the Process-Outcomes model. This does not mean that this methodology does not warrant criticism, only that the methodology is relatively new and is yet to be tested in different situations.

The author has already expressed concern for the lack of methods to analyse qualitative data in section 2.3.3.4. These concerns apply directly to the Process-Outcomes model, which provides a general framework for combining qualitative and quantitative data, but does not include methods for the subjective evaluation thereof. In addition, significant emphasis is placed on the social and technological context of the evaluation as a prerequisite to using metrics and the Process-Outcomes model, but no tools or methods are provided to generate this conceptual understanding.

In summary, the Process-Outcomes model has characteristics that are suitable for the evaluation of LBS in South Africa. However, it needs to be complemented by a methodology that generates a holistic understanding of a complex situation, and promotes a rigorous approach to the subjective evaluation of both quantitative and qualitative data.

2.4.4 Assessment of Fourth Generation Evaluation

In the author's opinion, Fourth Generation methodology has some favourable characteristics. These include the recognition of the inherent preconceptions of the evaluator and the realisation that the results of any evaluation are only one interpretation of a complex situation. These aspects of the methodology are suitable for evaluating LBS in South Africa because they take into account the biases and intentions of the evaluator as discussed in section 2.1.4. Furthermore, the nature of the available data as outlined in section 1.4.5 and the shortcomings of science indicators as discussed in section 2.4.2 suggest that a subjective and flexible approach to evaluation is more appropriate for the evaluation of LBS in South Africa.

However, Fourth Generation methodology is based on the iterative negotiation between the evaluator and all stakeholders. In the case of LBS in South Africa, the stakeholders include all organisations in the LBS Value Network (discussed in section 4.2), government regulatory bodies and all potential users of LBS. In the context of this dissertation, the negotiation of all aspects of this evaluation with all stakeholders was both impractical and impossible for three reasons.

The first and most obvious reason is that LBS involves a large number of stakeholders, as discussed above, and establishing contact with all stakeholders was infeasible. Secondly, obtaining commercially sensitive information from major stakeholders proved to be problematic, as previously stated in section 1.5. Finally, even if it were possible to involve all stakeholders and they were fully willing to cooperate, the timescales and costs involved in the iterative negotiation between all stakeholders exclude this methodology as a viable option for evaluating LBS in South Africa in the context of this dissertation.

2.4.5 Assessment of Soft Systems Methodology

This section assesses SSM and discusses which aspects of SSM may be applicable to this research to complement the use of the Process-Outcomes model.

There are distinct parallels between SSM and 4th Generation Evaluation, particularly with regards to the qualitative nature of the processes, the action-oriented approach to evaluation, the focus on negotiation and iteration as a learning process to improve a situation, and the realisation that any evaluation is only one possible description of the real-world situation. In this respect, the author suggests that SSM could possibly be classified as a type of 4th Generation evaluation according to the taxonomy defined by Guba and Lincoln depicted in Figure 2.2.

More specifically, SSM is suitable for the evaluation of LBS in South Africa because it allows for the holistic evaluation of a complex situation, a need established in section 2.1.1, and its action-orientated approach aims to suggest ways to improve a situation. In this manner, the use of SSM would directly contribute to the ancillary objectives of this thesis as discussed in section 1.3.

However, SSM cannot be used as the sole means of evaluation in this research, largely for the same reasons discussed in the previous section. In summary, it was not possible to interact with all stakeholders and the author is unlikely to bring about improvement in LBS in South Africa through a process of iteration and learning.

Nevertheless, SSM is more structured than 4th Generation evaluation, and there are specific aspects of SSM that are suitable for the purposes of this thesis. Section 2.4.2 identified that the two main problems with the Process Outcomes model where the lack of framework for holistic and subjective evaluation, and the lack of theory for formulating the required contextual understanding of the system. As stated in section 2.3.5.3, SSM provides a method of structuring the process of generating understanding and subjectively analysing a complex situation (Barry & Fourie 2002). The author therefore proposes the use of SSM to construct conceptual models of LBS in South Africa. These conceptual models are used to generate the contextual understanding required for use of metrics and the Process-Outcomes model, and as a framework for the subjective analysis of the system as a whole.

This chapter concludes with a summary of the literature review in preparation for the development of a conceptual framework to combine SSM and the Process-Outcomes model in chapter 3.

2.5 Summary & Conclusions

Chapter 1 introduced the concept of evaluation and determined the need for a prior understanding of the social, organisational and technological context of the evaluation situation. This chapter has reviewed some of the main difficulties and problems with evaluation, and explained the need to use both quantitative and qualitative data. Section 2.3 reviewed several methodologies of evaluation and discussed the strengths and weaknesses of each.

A recurring theme in the literature was the need to evaluate S&T in its social and technological context, which requires a holistic understanding of the problem prior to the actual evaluation. The most promising methodology initially uncovered by the literature review was the approach to metrics and the Process-Outcomes model proposed by Geisler.

The Process-Outcomes model recognises the necessity of using both quantitative and qualitative data in the process of evaluation, and provides a framework in which both types of data can be combined. However, in the author's opinion, the methodology does not sufficiently address the problem of subjective and holistic analysis of quantitative data in conjunction with qualitative data. It also does not provide a structured approach to initially conceptualising the complex phenomena and obtaining the prior contextual understanding required for the use of the model. An examination of systems thinking and in particular

Soft Systems Methodology (SSM) revealed that aspects of SSM may provide a possible solution to the shortcomings of the Process-Outcomes model.

The following chapter describes the aspects of SSM and the Process Outcomes model relevant to this thesis in detail, and develops a conceptual framework to combine these methodologies. This conceptual framework is used in chapter 5 and chapter 6 to develop a model for the evaluation of LBS in South Africa.

3 A FRAMEWORK TO COMBINE SOFT SYSTEMS METHODOLOGY AND THE PROCESS OUTCOMES MODEL

This chapter develops a conceptual framework to combine Soft Systems Methodology (SSM) and the Process-Outcomes model. This conceptual framework is used in chapters 5 and 6 to develop a model for evaluating LBS in South Africa.

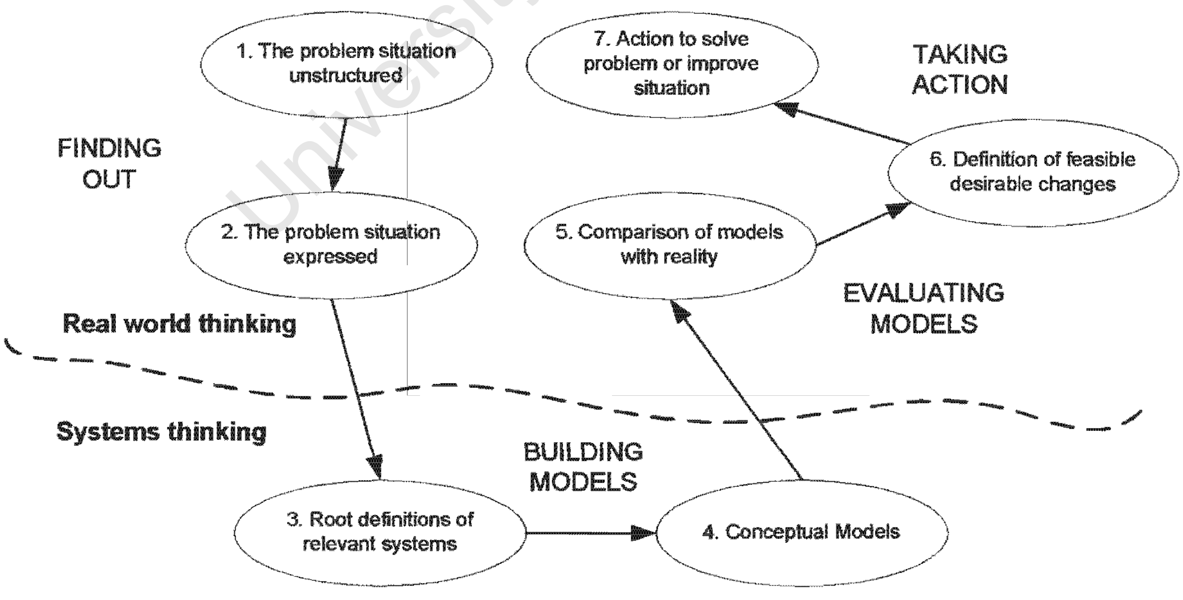
The chapter begins by describing SSM in section 3.1, concentrating on the main aspects of the methodology that were used in this research. Section 3.2 discusses the process of constructing a set of metrics and section 3.3 explains the Process-Outcomes model in detail. Section 3.4 examines the key characteristics of these two methodologies and develops a conceptual framework to combine them.

3.1 Soft Systems Methodology

The fundamental principles behind systems thinking and SSM were introduced in section 2.3.5, and the aspects of the methodology that may prove useful for this research where outlined in section 2.4.5. This section expands on these preliminary discussions by explaining SSM in more detail, focussing in particular those aspects of SSM that are relevant to the construction of the conceptual framework.

3.1.1 Overview of SSM

Checkland's early versions of SSM consisted of seven stages as shown in Figure 3.1 below:



after Checkland (1981)

Figure 3.1: Seven Stages of Soft Systems Methodology

In later refinement of SSM, Checkland abbreviates the above seven stages into four main activities in order to make SSM less structured and more generic, which are in summary:

1. Finding out about a problem situation, including cultural and political aspects (stages 1 & 2 of Figure 3.1)
2. Formulating some relevant purposeful activity models (stages 3 & 4 of Figure 3.1)
3. Debating the situation, using the models, seeking from that debate both
    a. Changes which would improve the situation and are regarded as both desirable and feasible changes, and
    b. The accommodations between conflicting interests which will enable the action to improve to be taken (stages 5 & 6 of Figure 3.1)
4. Taking action in the situation to bring about improvement. (stage 7 of Figure 3.1)

(Checkland 1999)

The stages of Figure 3.1 shown in parentheses above relate (approximately) the four main activities to their origins in the seven stage version of SSM.

As stated in section 2.4.5, the primary use of SSM in this thesis is to provide the means for generating initial understanding and a framework for subjective analysis. Thus the purpose of using SSM in this thesis is to provide structure to the evaluation. Therefore, Checkland's earlier seven stage version of SSM will be used in this thesis because it provides a more rigid structure than later, more general versions of SSM. The remainder of this section describes the stages of SSM that are most relevant to this research.

3.1.2 Finding Out About a Problem Situation

This section explains the two stages of activity one (i.e. the finding out phase) of SSM. In brief, these are the building rich pictures to initially explore the situation, and analysis of different aspects of the situation.

3.1.2.1 The Problem Unstructured: Rich Pictures

Checkland suggests the use of rich pictures as a starting point for finding out about a problem situation. This corresponds to stage 1 of SSM as depicted in Figure 3.1. The rationale behind the use of rich pictures is that graphics are a better medium than prose for expressing relationships, as pictures can be understood as a whole. They can therefore promote holistic as opposed to reductionist thinking from the outset (Checkland 1999). The pictures are developed iteratively and depict the current situation, problems and the relationships between the stakeholders as a starting point to generate a general understanding of the situation (Barry & Fourie 2002). The rich pictures relating to LBS in South Africa are developed in sections 5.1.1.1 and 5.1.2.1.

3.1.2.2 The Problem Expressed: Analyses One, Two and Three

In addition to the rich picture building, the finding out phase requires the analysis of the situation from different perspectives. The examination of different aspects of the situation is known as Analysis One, Two and Three, and is shown as stage 2 of SSM as depicted in Figure 3.1.

- **Analysis One** is an examination of the intervention itself. In other words it is an analysis of what effect the evaluator has on the problem situation.
- **Analysis Two** is an examination of the social aspects of the situation
- **Analysis Three** is an analysis of the organisational and political situation, and the distribution of power.

(Barry & Fourie 2002; Checkland 1981)

The combination of these analyses and the rich pictures described in the previous section generate an initial understanding of the problem situation. An important note is that this process of finding out is never complete, and Checkland claims that it must carry on through out an evaluation (Checkland 1999).

3.1.3 Developing Conceptual Models

This section explains activity 2 of SSM, namely the development of conceptual models of the problem situation. This activity consists of two stages, structuring the systems using root definitions and the conversion of these definitions to conceptual models. These represent stages 3 and 4 of Figure 3.1 respectively.

3.1.3.1 Root Definitions, CATWOE & Multi-level Thinking

The first step in building a conceptual model is the clear definition of the purposeful activity to be modelled (Checkland 1999). This begins by using multi-level thinking to identify the relevant systems and the construction of root definitions to describe these systems.

Checkland maintains that the definition of what constitutes a system, the environment and sub-systems entirely dependent on the observer (Checkland 1981). In other words, when selecting relevant systems to model, there are always a number of levels available. Thus, when attempting to define the root definitions of the various systems it is vital to understand different levels of the problem. The root definitions are the levels at which the different sub-systems lie, i.e. the level at which the transformation T of CATWOE (as shown below in Figure 3.2) is defined. Therefore each root definition always covers three levels, the wider-system, the system and the sub-systems. This multi-level approach prevents thinking from being too limited and stimulates thoughts about the exploration of different levels of the problem. The use of multi-level thinking to identify relevant systems for LBS in South Africa is depicted in Figure 5.3.

Once the relevant systems have been identified, root definitions of these systems are constructed. In order to ensure that the root definitions are well-formed and precise, they need to consist of several elements as summarised by the mnemonic CATWOE. These elements are described in Figure 3.2 below (Checkland 1981):

	Element	***Description***
C	Customer	the victim or beneficiaries effected by the systems activities, especially T
A	Actors	those who carry out main activities of the system, especially T
T	Transformation Process	the conversion of input to output, the main purpose of the system
W	*Weltanschauung*, or world view	the outlook, framework or image which makes this T meaningful in context
O	Owners	those who have prime concern for the system and could stop T
E	Environmental constraints	elements outside the system which it has to take as a given

Figure 3.2: The CATWOE Elements of Root Definitions

Checkland identifies the primary element of a root definition is the expression of a transformation process or purposeful activity, shown as T in Figure 3.2 (Checkland 1999). Therefore, the construction of conceptual models themselves is built around the identified processes of the system.

In addition to including the above elements in the root definitions, Checkland suggests that there is value in expressing the definitions in the form:

*Do **P** by **Q** in order to contribute to achieving **R***

This ensures that the root definitions answer 3 pertinent questions:

1. What to do? (P)
2. How to do it? (Q)
3. Why do it? (R)

By clearly building the root definitions based on the guidelines discussed in this section, the evaluator expresses the problem situation in a structured manner that forms the basis for the actual constructing of the conceptual models. By basing the conceptual models on the root definitions, the conceptual models are focused and aligned with the intentions and purpose of the evaluation. The construction of the models is outlined in the following section.

3.1.3.2 Building Conceptual Models

The construction of the conceptual models is based on the preliminary structured thinking developed by means of the root definitions. Checkland warns that although knowledge of the real-world situation is important in creating conceptual models, a common mistake is to lose focus of the root definitions and start modeling the real-world situation itself (Checkland 1999). Drawing on Checkland (1999), the distinction between models of reality and models of thinking about reality has already been established as one fundamental difference between hard and soft systems thinking in section 2.3.5.2, and thus to make this mistake would be paramount to the misuse of SSM.

In order to help avoid this mistake and guide the inexperienced, Checkland provides example methods for the building of conceptual models, which are meant to be discarded as experience in model building is gained. Since the author falls into the category of the inexperienced in terms of the use of SSM, Checkland's guideline procedures were followed in this thesis, and are summarized below. The guidelines assume the root definitions as a starting point.

1. Write down the activities necessary to carry out the transformation T.
2. Select activities which do not have any dependencies.
3. Write these activities out on a line, those dependent on the first activities on the second line etc. until all activities are accounted for. Indicate the dependencies
4. Redraw to avoid overlaps (Checkland 1999)

Although these steps may seem trivial, the author maintains that they are an important part of the process for the purposes of this thesis. More specifically, the listing of activities required to carry out transformation T is fundamental to creating the conceptual links between SSM and the Process-Outcomes model, as discussed in section 3.4.2.

This section has thus far discussed stages 1 to 4 of SSM methodology, and described the theory that enables the construction of the SSM root definitions and conceptual models. The remaining stages of SSM methodology include the comparison of the conceptual models to reality, the development of an action plan to facilitate change, and the actual implementation of the change. Section 3.4 shows how these remaining stages apply to this research in the context of developing a theoretical framework to combine SSM and the Process-Outcomes model.

As stated previously section 2.4, Checkland advocates the adaptation of a methodology to a particular situation. However, the author was concerned that in selecting aspects of SSM to apply to this research, the actual approach followed may prove to be too different from SSM to claim to have effectively used SSM methodology. To this end, the constitutive rules of SSM are covered in the following section. These constitutive rules are used as guidelines to assess the use of SSM in Chapter 8.

3.1.4 Constitutive Rules

This section examines the rules or guidelines that define the use of SSM. Howell in Checkland (1999) argues that to use SSM means to comply at three levels; the ***assumptions***, the ***process of inquiry*** and the ***elements of the process of inquiry***.

The ***assumptions*** for use of SSM are in summary:

1. that reality is only an observer's perception of reality
2. intellectual devices must be used to explore the situation
3. the intellectual devices must include conceptual systems models

The requirements of the ***process of inquiry*** is that it follows a process formed by the understanding of history, culture, politics and social aspects of the situation, and brings about improvement through an iterative cycle of debate, understanding and learning. Finally, the requirements for the ***elements of the process of inquiry*** are that it includes a selection of tools such as rich pictures, root definitions, and CATWOE (Checkland 1999).

The author's initial thought on this matter is that the intended use of SSM in this research does comply with these three levels of constitutive rules and their requirements, and therefore constitutes a valid application of SSM methodology. An exception is the requirement that the process of inquiry should bring about improvement in the situation. However, the author maintains that this is not an issue because improving the situation of LBS in South Africa is well beyond the scope of this work. Nevertheless, the use of SSM in this research needs to continue using these constitutive rules as guidelines. These constitutive rules are revisited in the conclusions of this dissertation as the benchmark to assess whether SSM was applied appropriately in Chapter 8.

This section described the aspects of SSM theory used in this research. The following two sections are concerned with metrics and the Process-Outcomes model. Thereafter, section 3.4 develops the conceptual framework that combines SSM and the Process-Outcomes model.

3.2 Creating a Set of Metrics for Evaluation

This section describes the general tools and criteria proposed by Geisler for the construction of a set of metrics that can be used for the evaluation of S&T.

As stated in section 2.3.3.1, Geisler argues that there are no fundamental metrics that can be used as building blocks for the evaluation of S&T. He claims that the reality for evaluating S&T is the selection of metrics from a pool of available metrics for each situation. In support of this claim, Geisler highlights the work of Luukkonen-Gronow (1987) that reviewed several metrics of science and technology. Geisler concurs with Luukkonen-Gronow's conclusion that a standardised set of metrics that can be applied to every situation does not exist (Geisler 2000; Luukkonnen-Gronow 1987).

It is therefore important to establish tools for the construction of metrics and criteria for their selection in order to assemble a relevant set of metrics. This section begins by explaining the difference between basic measures and metrics in section 3.2.1, and provides an operational definition of a metric in section 3.2.2. The process of reducing complex phenomena to measurable aspects is outlined in section 3.2.3, and the section concludes by presenting the criteria for selecting a set of metrics for the evaluation in section 3.2.4.

3.2.1 Measures, Indicators and Metrics

This section introduces the concepts of measures, indicators and metrics as used in this thesis. It is important to establish the differences between these concepts and how they relate to each other within the context of evaluation, as this is vital in understanding the process of constructing and selecting appropriate metrics as discussed in the following sections.

Geisler defines a **measure** as a given quantity or an item on a subjective scale or an instrument (Geisler 2000). Thus a measure is simply a generic value and does not indicate the purpose or the context of the value. Measures defined this way are characteristic of Scientific Positivism discussed in section 2.3.1.

An **indicator** differs from a measure in that it includes a notion of what the measurement is attempting to achieve (Geisler 2000). Therefore, even though the value of an indicator may be the same as its corresponding measure, the concept of an indicator is more meaningful is it incorporates an explanation of the measure and its purpose. However, by this definition indicators still lack the context of the evaluation as a whole. Indicators, by this definition, are the primary tool for science indicators as discussed in section 2.3.2.

Since complex phenomena are too complex to evaluate on their own, measures are simply meaningless values and indicators lack context, there is a need for a conceptual construct that reaches a compromise between measurable values and complex phenomena. It is proposed that the theoretical construct of a metric as defined in the following section provides this compromise.

3.2.2 Definition of a Metric

A **metric** may consist of one or more indicators and differs in principle from an indicator in that in addition to the actual indicator(s), it encapsulates a sense or a slice of the phenomenon being evaluated. A metric encapsulates the measurement, the reason for measurement and the context of the measurement (Geisler 1999).

In addition, Geisler claims the term 'metric' can be generically used to describe a system of measurement that includes the following;

1. The item, object or variable being measured;
2. The units or tool of measurement;
3. The value of the measurement as compared to other measurements

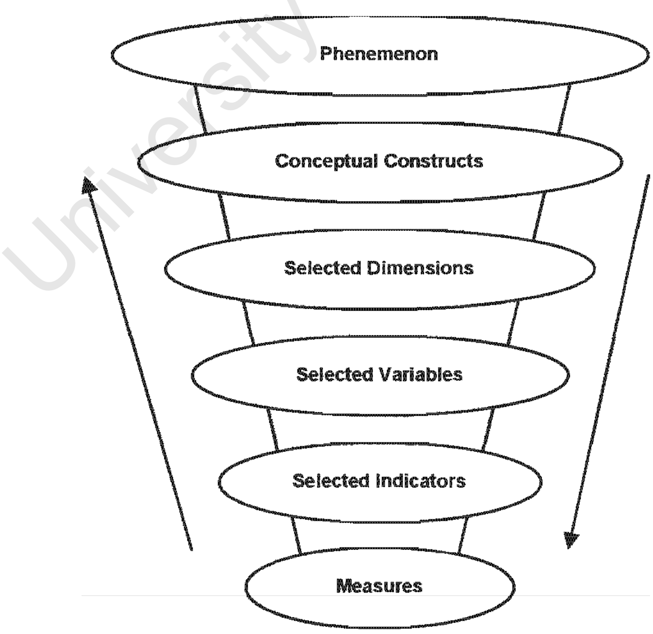
(Geisler 2000)

Therefore, every metric must include its associated data, the meaning of the data in the context of other metrics and should answer a particular question that would then become the basis of recommendation for future action (Kostoff 2001).

3.2.3 Reducing Complex Phenomena to Measurable Aspects

This section discusses the reductionist approach used to determine measurable aspects of a phenomenon. In the discussion of the fundamental problems of evaluation, section 2.1.2 described the difficulties involved with measuring and understanding complex phenomena. It proposed that to understand complex phenomena, one must reduce the phenomena to measurable aspects based on a prior understanding.

Figure 3.3 below depicts Geisler's abstraction of the process of reducing a complex phenomenon to a hierarchy of measurable aspects, and shows that it is necessary to move from the general to the particular to be able to target certain aspects of a phenomenon accurately.



Adapted from Geisler, 2000

Figure 3.3: Capturing Critical Aspects of Complex Phenomena

The process shown in the above figure was applied to the situation of LBS in South Africa, as discussed in section 6.1. Once a set of measurable aspects has been created, metrics need to be selected based on the criteria outlined in the following section.

3.2.4 Criteria for Metric Selection

This section describes the criteria for metric selection. Geisler defines three key criteria and two key considerations for the selection of metrics. As discussed in section 2.3.3.1, these criteria have the effect of structuring the evaluation, and focusing the data analysis on the purposes of the evaluation.

The criteria for metric selection are as follows:

1. ***The selected metric must be relevant.*** In other words the metrics selected must measure the desired phenomena, and be closely linked to the objectives and intentions of the evaluator. Any metrics that do not meet this criterion are not relevant to the evaluation.

2. ***The selected metrics must be available, accessible and affordable.*** The use of partially available data could affect the quality of the evaluation and produce misleading results. Data that is unavailable or too expensive to obtain also creates the desire to use surrogate measurements, which in many cases magnifies problems and provides misleading analysis.

3. ***The set of selected metrics must allow for manipulation, analysis, interpretation and comparison with one another.*** For example, statistics are useless unless they lend themselves to useful analysis and interpretation.

Two additional factors should be considered while selecting metrics.

- ***Metrics must be selected to tie in with the appropriate view of the world.*** An example would be the metrics used by engineers to evaluate a particular technology would be different from those used by a manager. This is because the two parties are trying to evaluate different facets of the complex technological phenomenon and thus require a different overall understanding.

- ***The selection of any metric needs to take into account the stage of innovation process at which the metric needs to be applied.*** This issue has been discussed in section 2.3.3.2, and is one of the reasons why the Process-Outcomes model was selected as an evaluation methodology for this thesis.

(Geisler 2000)

These criteria are applied to the set of potential metrics in Appendix A, resulting in a set of relevant metrics for the evaluation of LBS in South Africa. These selected metrics need to be evaluated within a guiding framework in order to be assessed in their appropriate context. The Process-Outcomes model was selected to provide the framework for the metrics in this research, and is discussed in detail in the following section.

3.3 The Process-Outcomes Model

The Process-Outcomes model was introduced in chapter 2 as a possible framework for evaluation of S&T. The strengths and weaknesses of the Process-Outcomes model were discussed in section 2.3.3, and section 2.4 argued the use of Process-Outcomes model for the evaluation of LBS in South Africa. This section describes the model in detail prior to the development of a conceptual framework to combine it with SSM methodology in section 3.4.

3.3.1 Key Aspects of the Process-Outcomes Model

The Process-Outcomes model forms the basis for an evaluative framework of the selected metrics by describing the flow of S&T from basic inputs to final outputs. Its main points are as follows:

1. There are distinct identifiable stages in the innovation process
2. These stages may serve as the building blocks to describe S&T processes
3. S&T flows through the stages, from research, development, new products, to the final stage of technology that is commercialised and used
4. Each stage has distinct outputs that are measurable and can be compared across stages
5. Between each S&T stage, there are processes that transform the outputs of one stage into the inputs of the next. These processes are called transformation and diffusion activities.
6. Social and economic organisations take part in the transformation and diffusion activities.

(Geisler 2000)

By taking the stage of development of S&T into account, and focusing on the transformation processes of input into output at these different stages, the Process-Outcomes model provides a framework for the evaluation of the selected set of metrics in their appropriate context.

3.3.2 Stages of S&T Outcomes

The Process-Outcomes Model describes the innovation process in terms of the outputs and impacts on society at all stages of development. The model specifies five stages of S&T metrics:

1. Inputs to the S&T Process
2. Immediate Outputs
3. Intermediate Outputs
4. Pre-Ultimate Outputs
5. Ultimate Outputs

The above stages are depicted as stages 1 through 5 in Figure 3.4. The first stage is an initial input stage, while all stages are output stages. The following sections discuss these stages in more detail.

3.3.2.1 Inputs to the S&T Process

The inputs include the initial parameters and constraints, as well as initial resources invested in S&T. The constraints may include skills and experience, nature of the subject, current state of the art, and institutional constraints. Initial resources could include human resources, capital expenditure, existing equipment, infrastructure, technology or facilities, and intangible aspects such as company reputation and past performances. This input stage is shown as stage 1 in Figure 3.4.

3.3.2.2 Immediate or Direct Outputs

In this stage, the Process-Outcomes model identifies the outputs from the initial S&T activity. These are typically traditional S&T activity outputs such as ideas, discoveries, inventions and methods which are measured by indicators of performance as discussed in section 2.3.2, including bibliometrics, patent counts and citation analysis. This outcome stage is shown as stage 2 in Figure 3.4.

An important point to re-iterate at this stage is that previously these indicators have been used in attempt to evaluate downstream effects of S&T, although they are only measures of immediate outputs. The Process-Outcomes model only associates inputs with the appropriate outputs by taking the stage of development into consideration. In other words, it does not attempt to associate immediate science outputs with ultimate benefits of technology to society.

3.3.2.3 Intermediate Outputs

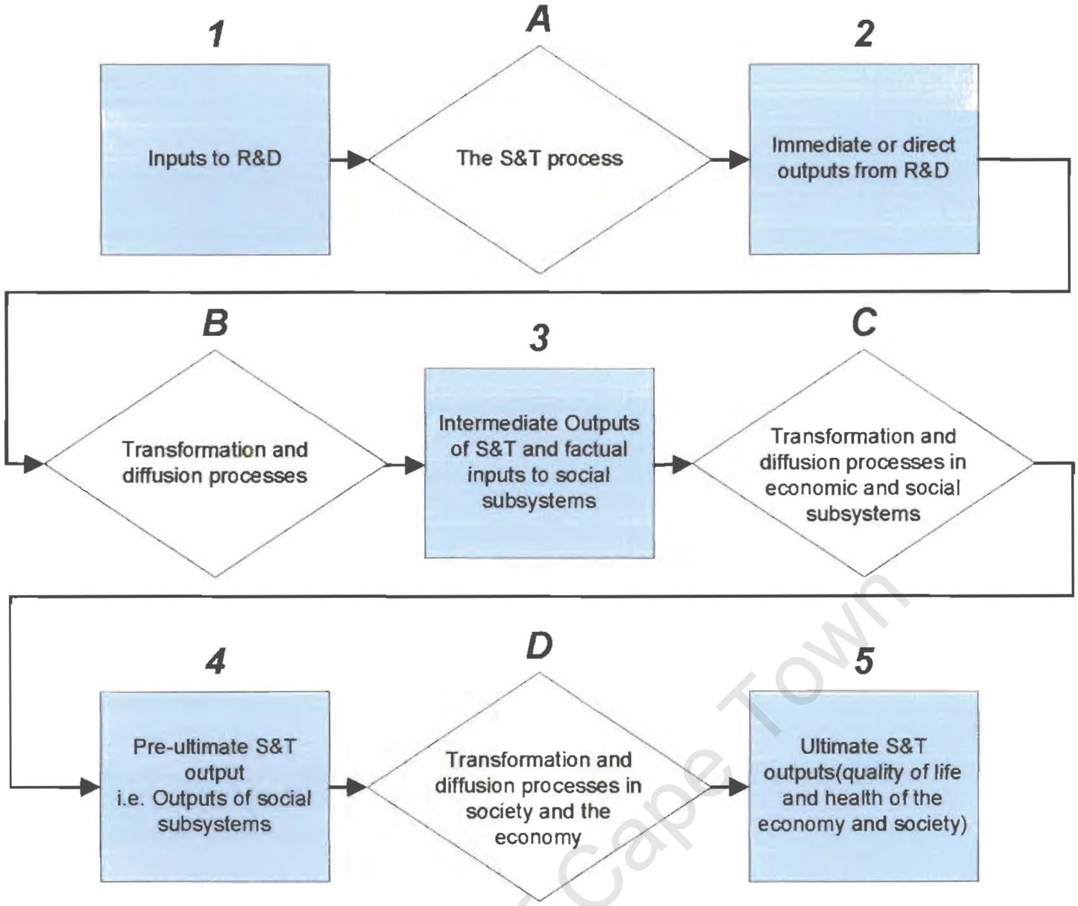
Intermediate outputs emerge from the transformation and diffusion activities that operate on the immediate outputs as discussed in the previous section. For example, an organisation may choose to implement a methodology described in an academic journal and thus discovers an innovative way of designing a product. This new way of designing the product is the intermediate output. This outcome stage is shown as stage 3 in Figure 3.4.

3.3.2.4 Pre-Ultimate Outputs

Pre-ultimate outputs result from the transformation of intermediate outputs by social and economic organisations, i.e. are the consequences of the inputs into the organisations. These can be new products, revenues, economic benefits from patent licensing etc. This outcome stage is shown as stage 4 in Figure 3.4.

3.3.2.5 Ultimate Outputs

The ultimate outputs define the things of value to society and the economy, such as general well-being, quality of life, and growth and economic progress. These are the ultimate goals and value of S&T to the economy. The various outputs from S&T that have been identified in the model move downstream toward their final contribution to the ultimate outputs. These outputs measure the final downstream effects and overall benefits from initial investment in S&T. This outcome stage is shown as stage 5 in Figure 3.4.



after Geisler (2000)

Figure 3.4: The Process Outcomes Model

Figure 3.4 above shows a simplistic, linear representation of the Process-Outcomes model. It is important to emphasise that that the Process-Outcomes model is cyclical and, when applied to any real evaluation situation, the model would contain any number of iterations and feedback loops to assist in representing the complexity of the situation.

3.3.3 Transformation and Diffusion Activities

The previous section described the stages of outcomes of the Process-Outcomes model, and referred to the transformation and diffusion activities that translate outcomes from one stage to the outcomes of another. This section will discuss these transformation and diffusion activities, labelled A-D in Figure 3.4, showing how they relate to their inputs and how they translate those inputs into outcomes.

3.3.3.1 The S&T Process

This activity refers to R&D, or the pure science portion of the S&T process. These are the operations of research organisations who transform their inputs of human, physical and financial resources into the immediate outputs described in section 3.3.2.2 above.

3.3.3.2 Transformation and Diffusion Processes

Transformation and diffusion processes include the transfer, marketing and adoption of immediate outputs such as patents, ideas, theories, methods and inventions by organisations.

3.3.3.3 Transformation and Diffusion Processes in Social and Economic Subsystems

These are transformation and diffusion activities that act on intermediate outputs. For example, they would include the processes that would incorporate new products into economic or social entities such as health care organisations. These results are transformed into pre-ultimate outputs such as improved health and safety as described in section 3.3.2.4.

3.3.3.4 Transformation and Diffusion Processes in Society and the Economy

These are the processes that convert the pre-ultimate outputs to ultimate outcomes of S&T activity, the final outcomes that affect the general quality of life of the population and ultimate effects on the economy. For example, safer working environments and products may lead to a better quality of life. This is because the improved working conditions will be transformed into a more satisfied and healthier workforce, hence a higher quality of life of the entire population.

This chapter has thus far discussed the theory of SSM, metrics and the Process-Outcomes model that apply to this research. The following section describes how this theory was applied in this research and develops a conceptual framework for the evaluation.

3.4 Developing the Conceptual Framework

This section develops a conceptual framework for the evaluation of LBS in South Africa based on SSM and the Process-Outcomes model. Previously, Chapter 2.4 showed that aspects of each of these methodologies are useful to the evaluation, and this chapter has thus far explained the pertinent aspects of each methodology for the purposes of this thesis. Section 3.4.1 explains an initial attempt to combine these two methodologies, and outlines the problems encountered with this preliminary approach. Section 3.4.2 re-examines the fundamental characteristics of the methodologies to find a logical connection between them, and develops a conceptual framework to combine the methodologies based on this connection.

3.4.1 A Preliminary Framework

There were four main stages in the initial application of SSM, metrics and the Process-Outcomes model in this research.

1. Construct SSM conceptual models (section 3.1)
2. Construct and select a set of possible metrics (section 3.2)
3. Construct the Process-Outcomes model (section 3.3)
4. Subjective analysis of metrics

It must be noted that these stages were not followed linearly, but had many iterations and repetitions as the research progressed. Therefore there was a constant interplay between each of the stages, which led to a clearer overall understanding of the problem, increasingly refined SSM conceptual models and a more complete Process-Outcomes model. A representation of the preliminary evaluation framework is shown in Figure 3.5:

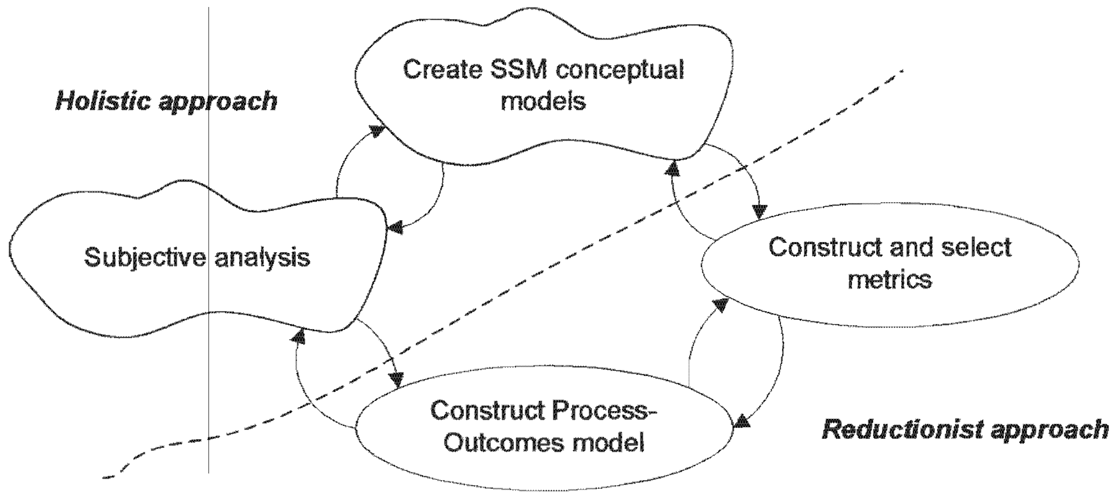


Figure 3.5: Preliminary Framework for Evaluation

While applying the relevant aspects of each methodology within the above framework seemed to produce adequate results, the author found it difficult to relate the work done using SSM with work done using metrics and the Process-Outcomes model in logical and meaningful manner. Without the proper means to establish these linkages, the arguments presented in section 2.4 for using these different methodologies in tandem seemed to lose credibility, as the combination of the methodologies seemed superficial and lacked rigour.

It was therefore necessary to develop a more rigorous and structured conceptual framework to combine SSM and the Process-Outcomes model. The development of this conceptual model is described in the following section.

3.4.2 Development of Theory to Combine Methodologies

This section develops conceptual framework and theoretical tools that enable SSM and the Process-Outcomes model to be combined in a logical, consistent and meaningful manner. This ensures that the holistic and reductionist approaches are meshed together using a rigorous framework rather than combining them in the superficial manner described in the previous section.

3.4.2.1 The Co-dependence of SSM and the Process-Outcomes Model

In an attempt to determine the most appropriate structure for the conceptual framework, the author revisited the manner in which SSM and the Process-Outcomes model complement each other. The relationship between the methodologies is shown in Figure 3.6:

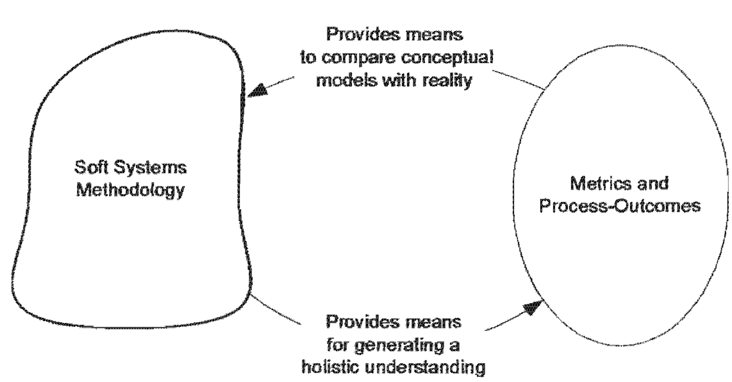


Figure 3.6: The Co-dependence of SSM and the Process Outcomes Model

As shown in Figure 3.6 above, SSM generates the holistic understanding required for the use of the Process-Outcomes model, while metrics and the Process-Outcomes model provide the means to compare the SSM conceptual models with reality.

Based on the relationship between the methodologies, the author determined that a possible structure for the conceptual framework would be to encapsulate the use of metrics and the Process-Outcomes model within the seven stage version of SSM as depicted in Figure 3.1. Thus, metrics and the Process-Outcomes model are incorporated into SSM as stage 5, the comparison of the conceptual models with reality. Therefore, the basic structure of the conceptual framework is as follows:

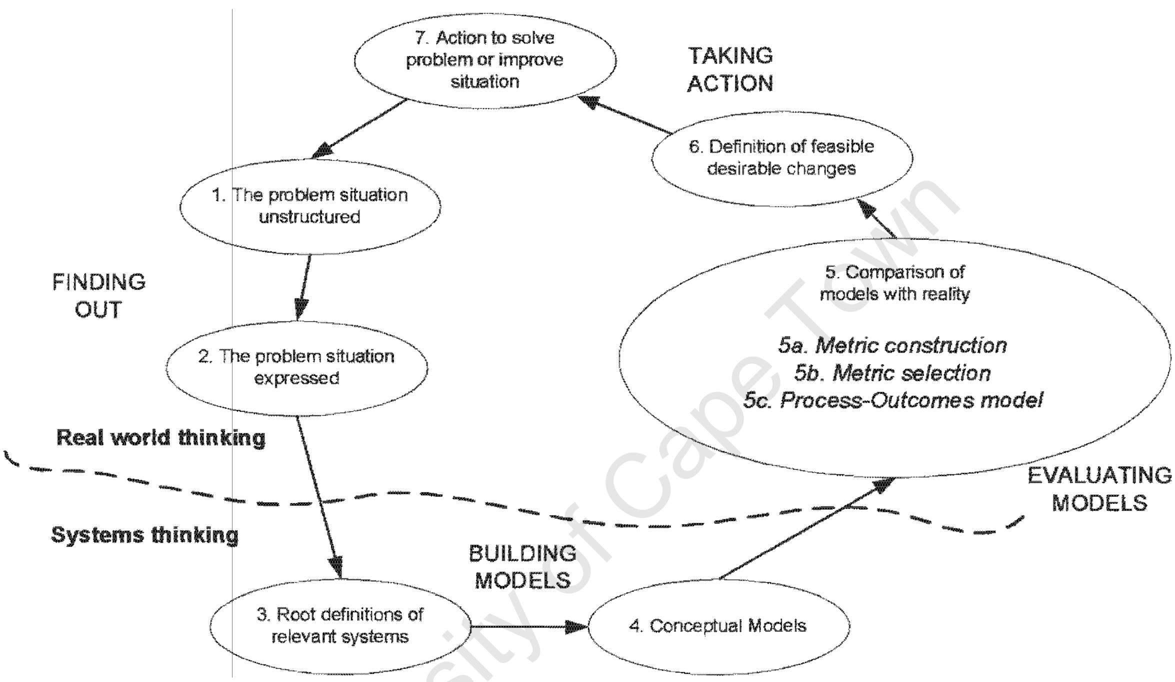


Figure 3.7: SSM Framework Incorporating the Process-Outcomes Model

Figure 3.7 above shows how metrics and the use of the Process-Outcomes model are incorporated into SSM as tools for the comparison of the conceptual models with reality. Although the figure defines a basic structure for the framework, it still lacks theoretical links between the methodologies. This prompted a re-evaluation of the fundamental characteristics of the methodologies in order to determine a connection between them.

3.4.2.2 Finding a Fundamental Connection

Section 3.1.3.1 identified that the root definitions, and therefore the conceptual models of SSM, are based on identified transformation processes or purposeful activities. In fact, Checkland's guidelines for creating the conceptual models include identifying the processes required to model the system, as discussed in section 3.1.3.2. Furthermore, the key aspects of the Process-Outcomes model outlined in section 3.3.1 showed that a fundamental aspect of this methodology is the identification of stages of transformation and diffusion, and of the transformation processes that exist at each stage.

The author speculated that the focus on processes by both methodologies may provide the theoretical connection between the methodologies. By comparing the transformation processes identified using SSM and the processes identified in initially constructing the Process-Outcomes model, it was discovered that the same or similar processes were being identified in both methodologies. Based on this discovery, the author developed three theoretical links between methodologies, as discussed in the following sections.

3.4.2.3 Linking SSM Processes and Process-Outcomes Transformation & Diffusion Activities

The first link developed is a direct outcome of the discovery outlined in the previous section. The author proposes that the processes identified while constructing the SSM conceptual models provide a comprehensive set of processes that should be incorporated into the Process-Outcomes model. A consequence of this is that if the process is not identified during the initial phase of generating a holistic understanding of the problem through SSM, then the process falls outside the scope of the evaluation and should not be considered for inclusion in the Process-Outcomes model. Therefore, the identification of processes for the entire evaluation is dealt with when constructing the SSM conceptual models. In this way, the identification of processes for the Process-Outcomes model is reduced to associating a previously identified process with a stage of S&T innovation.

3.4.2.4 Linking SSM to Metric Construction

The link developed between SSM and metric construction expands on the concept of common processes discussed in the previous sections. In constructing the set of metrics, it was noticed that many of the metrics that passed the selection criteria, discussed in section 3.2.4, could be classified as inputs or outputs of transformation processes identified while building the conceptual models. The author thus proposes that in order for any metric to be valid for use in the evaluation, one should be able to derive it from or associate it with one of the SSM conceptual models. Therefore, the framework includes an additional criterion for the selection of metrics:

"Can the metric be associated with any of the identified processes of the SSM conceptual models?"

This formally creates a link between the SSM conceptual models and the construction of a set of metrics.

3.4.2.5 Linking Metric Construction to Process Outcomes

Geisler provides suggestions as to which metrics can be associated with the different stages of development of a technology (Geisler 2000). These proved to be useful in initial iterations, but the author felt that with the two theoretical links established in previous sections, there should similarly be a more formal way of associating selected metrics with stages of outcomes in the Process-Outcomes model. On closer examination, the answer was a simple result of the two previous conjectures. Section 3.4.2.3 described how each process identified in the conceptual models should be associated with a stage of innovation in the Process-Outcomes model. Furthermore, the previous section discussed the added criteria for metric selection that ensures all of the metrics are associated with a conceptual model and therefore with a process in that conceptual model. Therefore, by defining whether a metric is an input or an output of its associated process in the conceptual model, the stage of S&T output for that metric can be immediately determined.

3.4.3 The Complete Conceptual Framework of Evaluation

This section revisits the basic structure of the conceptual framework for evaluation as outlined in section 3.4.2.1, and augments this framework with the theoretical links developed in the previous sections. A detailed representation of the conceptual framework for the evaluation is shown below in Figure 3.8.

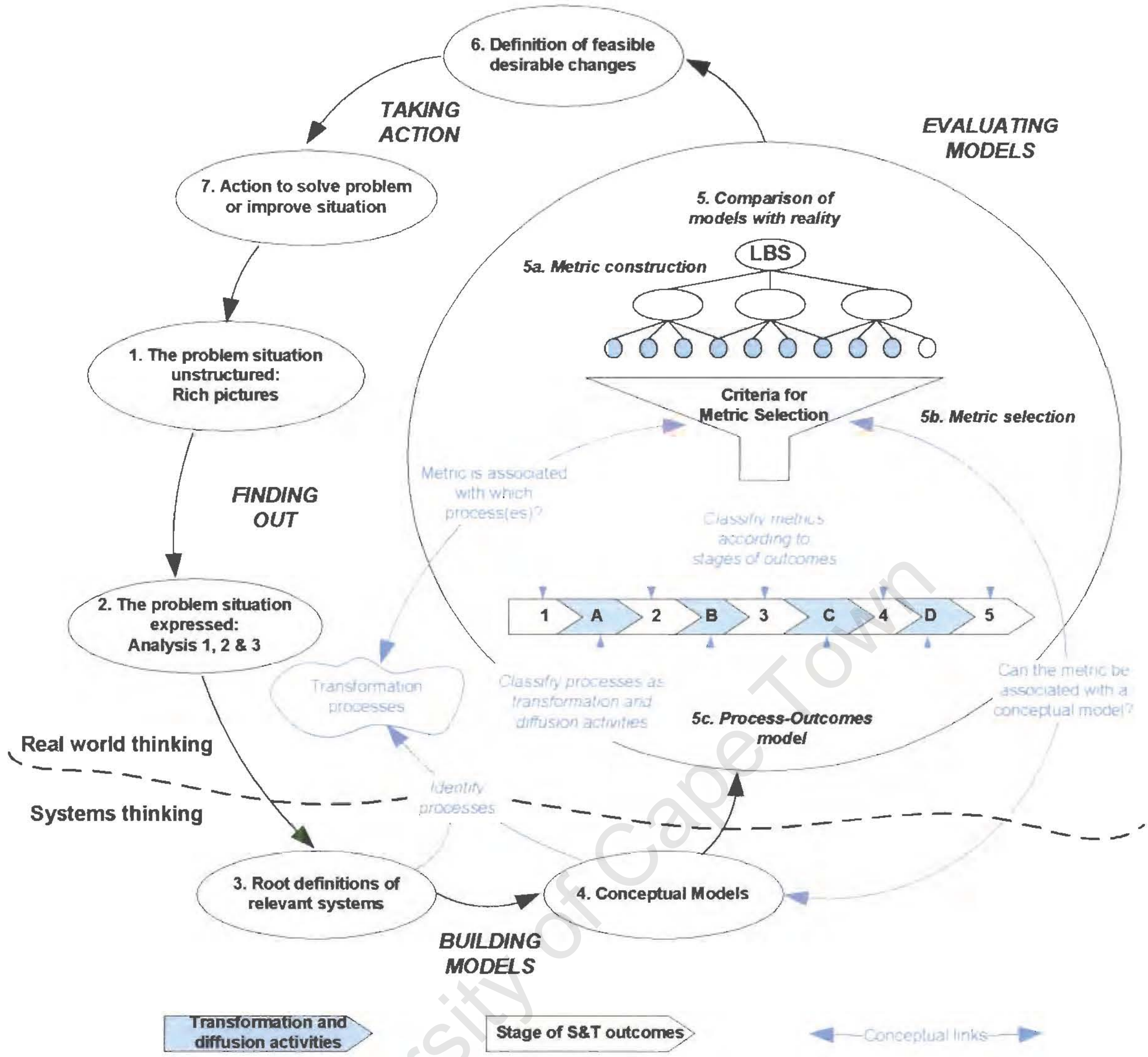


Figure 3.8: Framework Combining SSM and the Process-Outcomes Model

The author proposes that the conceptual framework shown in the figure above provides a rigorous means to combine the use of SSM and the Process-Outcomes model. Thus, the conceptual framework guides the evaluation through the following activities:

1. Development of SSM rich pictures;
2. Analyses One, Two and Three of SSM;
3. Identification of systems and root definitions;
4. Development of SSM conceptual models;
5. Identification of transformation processes from SSM conceptual models;
6. Reduction of the problem to a set of measurable aspects or metrics;
7. Selection of metrics according to metric criteria, and presentation of the metric data;
8. Association of identified processes with transformation and diffusion stages of the Process-Outcomes model;
9. Association of metrics with stages of outcomes of the Process-Outcomes model;
10. Subjective analysis of the metrics within the framework of the Process-Outcomes model and in the context of the associated conceptual models.

In order to test the conceptual framework, the activities listed above were applied to the problem of LBS in South Africa. The following 4 chapters present the evaluation according to the conceptual model and the component activities, and chapter 8 evaluates the effectiveness of this approach for evaluating a complex situation.

The following section concludes this chapter by summarising the key aspects of the theory developed in this chapter, before the ideas presented here are used to construct a model for the evaluation of LBS in South Africa in the chapters that follow.

3.5 Summary

This chapter has developed a conceptual framework for the evaluation of LBS in South Africa. The chapter was presented in two main parts, firstly the discussion of the relevant existing SSM and Process-Outcomes model theory, and secondly the development of a conceptual framework to rigorously combine these methodologies.

In the first part of the chapter, section 3.1 described the stages of SSM and defined the constitutive rules that guide the use of SSM in this thesis. Section 3.2 explained the construction of metrics and outlined the criteria for metric selection. Section 3.3 presented the Process-Outcomes model and described the stages of outcomes as well as the different stages of transformation and diffusion processes.

In the second part of the chapter, an analysis of how SSM and the Process-Outcomes model complement each other led to the development of a conceptual framework based on the identification of common transformation processes. This conceptual framework incorporates the Process-Outcomes model within the seven stage version of SSM as the means to compare SSM conceptual models with reality. As the final step in the development of the conceptual framework, theoretical links between the methodologies were developed based on the discovery that both methodologies were based on the identification of transformation processes.

The framework developed in this chapter is used to construct a model for the evaluation of LBS in South Africa. Chapter 5 uses SSM to construct the conceptual models, while chapter 6 builds the metrics and the Process-Outcomes model. As a precursor to the development of the model, it is necessary to provide background information on LBS technology and the global LBS situation. This background information influences the use of SSM, the construction of a set of metrics and the Process-Outcomes model. It can be regarded as the initial constraints and parameters of the evaluation, as it presents prior LBS knowledge that directly affects but cannot be affected by LBS in South Africa. This overview of LBS is provided in the following chapter.

The theory developed in this chapter is tested over the following 3 chapters by applying it to the evaluation of LBS in South Africa. Thereafter, chapter 8 analyses the practical application of this theory, identifying the strengths, weaknesses and potential flaws in the thinking.

4 OVERVIEW OF LOCATION BASED SERVICES

This chapter provides background information regarding LBS technology, and a brief overview of the international LBS industry. As established in section 1.2.2, the majority of what is known about LBS in South Africa comes from global LBS activities and experiences, and therefore an overview of LBS in a global context is an appropriate precursor to the evaluation. Most importantly, the technical background adds to the contextual understanding of LBS, and aids in determining which technological aspects of LBS should be included in the evaluation. This chapter is a vital supplement to the social and organisational understanding generated by the SSM conceptual models in the following chapter.

The chapter begins with an explanation of the origins of the global LBS industry in section 4.1. Section 4.2 describes the LBS Value Network and each of the LBS technology components, including brief discussions on current trends and expected future developments where relevant. After an overview of the classes of LBS applications in section 4.3, section 4.4 identifies key issues and lessons from global experience that could be applicable to LBS in South Africa. Section 4.5 concludes with a brief summary of the pertinent points before the development of the SSM conceptual models in chapter 5.

4.1 The Global LBS Industry

This section describes the origins of LBS and provides a basic snapshot of the current state of the global LBS industry. LBS have been deployed in several regions around the world (Dao, Rizos, & Wang 2002), and this section briefly reviews LBS efforts in regions that have influenced the key lessons discussed in section 4.4. Section 4.1.4 discusses some of the global standards organisations that are influencing the development of LBS, and the importance of the convergence of these standards organisations.

4.1.1 US LBS Industry

In the mid-to-late 1990's an increasing number of North American cellular operators started to adopt the Global System for Mobile Communication (GSM) standard for cellular networks (Adams, Ashwell, & Baxter 2003) as part of the move towards 2G networks (see section 4.2.1). This led to the definition of stringent industry regulations by the US Federal Communications Commission (FCC). The most significant of these regulations with respect to LBS was a mandate published in July 1996 that defined positioning requirements for GSM networks (Oehely 2002). This mandate required the introduction of technology to locate cellular handsets for emergency purposes (E911) to the following positioning accuracies:

1. Handset based positioning needed to locate a mobile user to within 50m 67% of the time, and to within 150m 95% of the time.
2. Network based positioning needed to be accurate to 100m 67% of the time and 150m 95% of the time

(Adams, Ashwell, & Baxter 2003; Christensen 2001)

The deadline for the above requirements was originally the 1st of October 2001. However, the industry was unable to comply with the requirements on time, and the deadline was delayed until the end of 2005 (Krenik 2002). McCabe predicted this slow progress towards compliance, stating incomplete legislation, lack of business models for cost recovery and overly complex contracts between operators and public safety representatives as the primary reasons for the delay (McCabe 1999). In addition, the requirements were technically challenging, and it was only in 2002 that key technology suppliers had developed suitable technology to comply with the FCC mandate (Adams, Ashwell, & Baxter 2003). In the author's view, the global downturn in the mobile telecommunications industry in 2001 was also a contributing factor in the delay to meet deadlines. The global downturn was caused partly by overspending on licenses to operate third generation (3G) cellular networks (Budde 2002), and resulted in operator reluctance to spend more money on technology without guaranteed return on investment.

Despite the failure to deploy LBS on time, the FCC mandate acted as a catalyst for the LBS industry. It led to the development of LBS technology (see section 4.2), standards organisations (see section 4.1.4) and the establishment of national committees to drive the LBS industry for emergency services (Oehely 2002). Furthermore, network operators began to look for ways to recoup money spent on government mandated positioning technology, and began developing applications and business models to generate revenue through LBS (Dao, Rizos, & Wang 2002).

The drive by network operators and technology vendors to recoup on investment resulted in substantial industry over-speculation concerning the market demands and revenue potential for LBS. Analyst predictions claimed that the US LBS industry would be worth up to $4 billion by 2004 (Budde 2001) and up to $32 billion globally by 2005 (Pyramid Research 2001). However, these levels of revenues have yet to be generated.

4.1.2 European LBS Industry

Following the example of the FCC mandate in the US, the European Commission defined a pan-European location provisioning system called LOCUS (location of cellular users for emergency services). This system is to be accessed and used by all European emergency services operators and was planned to be completed by the end of 2003 (Christensen 2001). The LOCUS project was initiated to advise the European Union (EU) on implementing emergency calling services in Europe (El12), and recommended that providing access to the location of emergency callers is delayed until 2005. As with the FCC mandate in the US, a number of technical, regulatory, and business concerns were cited as causes for the delays (Wright 2004).

Despite the delays in the E112 LBS rollouts, Europe has had several successful LBS deployments. Vizzavi, a joint venture between Vodafone and Vivendi, offers one of the largest LBS implementations, providing LBS services that cover more than eight countries. Other examples of LBS implementations include T-Mobile in Germany, the UK and Austria (Gale Group 2002b).

Analysts estimate that the LBS industry will generate over $32 billion in Europe by 2005 (Krenik 2002). It may be prudent to note that this prediction conflicts with the global estimate of $32 billion by 2005 as quoted in the previous section. This suggests that these estimates of worth by analysts are for the most part speculative, are related to early industry over-estimation, and do not reflect the true value of the LBS industry.

4.1.3 Asia & Middle East LBS Industry

Orange, a cellular network operator in Israel, offers a wide range of LBS applications to both the consumer and the corporate markets. Although LBS is not a major source of revenue as yet, there has been a significant uptake in these services (Gale Group 2002b). The success has been accredited to several main factors:

1) Technology incubation strategies, i.e. actively investing in third party start-up development companies, and providing these companies with access to the cellular infrastructure
2) The use of third party developers for all LBS offerings as opposed to developing applications in-house
3) Flexible business models and revenue sharing with the third party developers
4) Initial cautious and low profile approach to marketing
5) Premium transaction charges per use, instead of a subscription pricing model

(Gale Group 2002b)

NTT DoCoMo's iMode in Japan is often referred to as the classic success case of cellular technology, having implemented the world's first commercial 3G networks in 2001 (Botha 2004). The success of iMode, like that in Israel, has been largely credited to the encouragement of 3rd party developers and flexible business models which has resulted in a wide variety of consumer offerings (Hainebach 2002). This success has extended to the provision and adoption of LBS applications. Since its launch in December 2001, KDDI's EZ Navigation service has expanded to include over 70 LBS applications, resulting in related sales of over one million handsets by the second quarter of 2002 (Wright 2004). LBS are expected to grow in Japan, especially with the recent announcement that all phones released after April 2007 are likely to have built-in GPS support (Cellular.co.za 2004a).

4.1.4 Convergence of LBS Standards Organisations

This section discusses the importance of the convergence of various mobile technology standards organisations and outlines the role of the Open Mobile Alliance (OMA) in consolidating standards for LBS.

The large-scale adoption of LBS is largely dependant on consistent communication across different areas, technology platforms, networks, location determination technology, and classes of LBS applications (Dao, Rizos, & Wang 2002). This has led to the establishment of several different and overlapping standards organizations, all attempting to define standards for LBS. These include the Location Interoperability Forum (LIF), OpenGIS's Open Location Services (OpenLS), and WAP Forum's Location Drafting Committee (WAPF) to name but a few. The issue of conflicting or overlapping standards bodies poses a significant problem to the broader cellular telecommunications industry as well, which has led to efforts to establish global cellular standards, such as UMTS for 3G networks (see appendix B.3.2) and the Open Mobile Alliance (OMA).

The OMA was formed in June 2002 in order to counter the increasing diversity of mobile standards. The OMA represents all stakeholders in the cellular and LBS value network (see section 4.2) and aims to consolidate the different standards organisations across the various sectors of the industry (OMA 2004). The specific goals of the OMA are to establish open standards based on industry requirements, perform interoperability testing, facilitate a common industry architectural framework and serve as a catalyst for the consolidation of other standards bodies (Adams, Ashwell, & Baxter 2003).

The OMA Location Working Group (LWG) has been created to develop specifications to ensure interoperability of LBS. The group has already facilitated the convergence of LIF and WAPF standards organisations, and has subsequently adopted and merged the specifications developed by those bodies (OMA 2004). In addition to the broad goals of the OMA as stated in the previous paragraph, the LWG has specific goals relating to LBS, including standardising location information transfer, location technology interoperability and location privacy protocols (OMA 2003).

The OMA is a significant step in the convergence of mobile and LBS technology for the following reasons:

1. It forms an international umbrella organisation for all standards bodies within each industry sector, and therefore facilitates communication and cooperation between these sectors.
2. It is representative of all industry sectors, i.e. covers the whole value network as discussed in section 4.2.
3. It has the support and collaboration of nearly 200 of the world's leading companies, including mobile operators, mobile device manufacturers, network suppliers, information technology companies and content and service providers.

This section has provided an overview of global LBS and briefly introduced the efforts of the industry to ensure consistent standards across the LBS value network. The following section discusses the LBS value network and the various technology components that are required to provide LBS.

4.2 The LBS Value Network and LBS Technology

This section provides an overview of the LBS Value Network and the various technology components required to provide LBS. The delivery of LBS applications over cellular networks is the result of the integration of different technology components and services, often provided or managed by different organisations. The interdependency of these different components and/or organisations forms the LBS Value Network. Terminology for these components has not yet been completely standardised, and the terminology defined in this section is used throughout this thesis to maintain consistency. Figure 4.1 shows a high-level representation of the author's interpretation of the LBS Value Network.

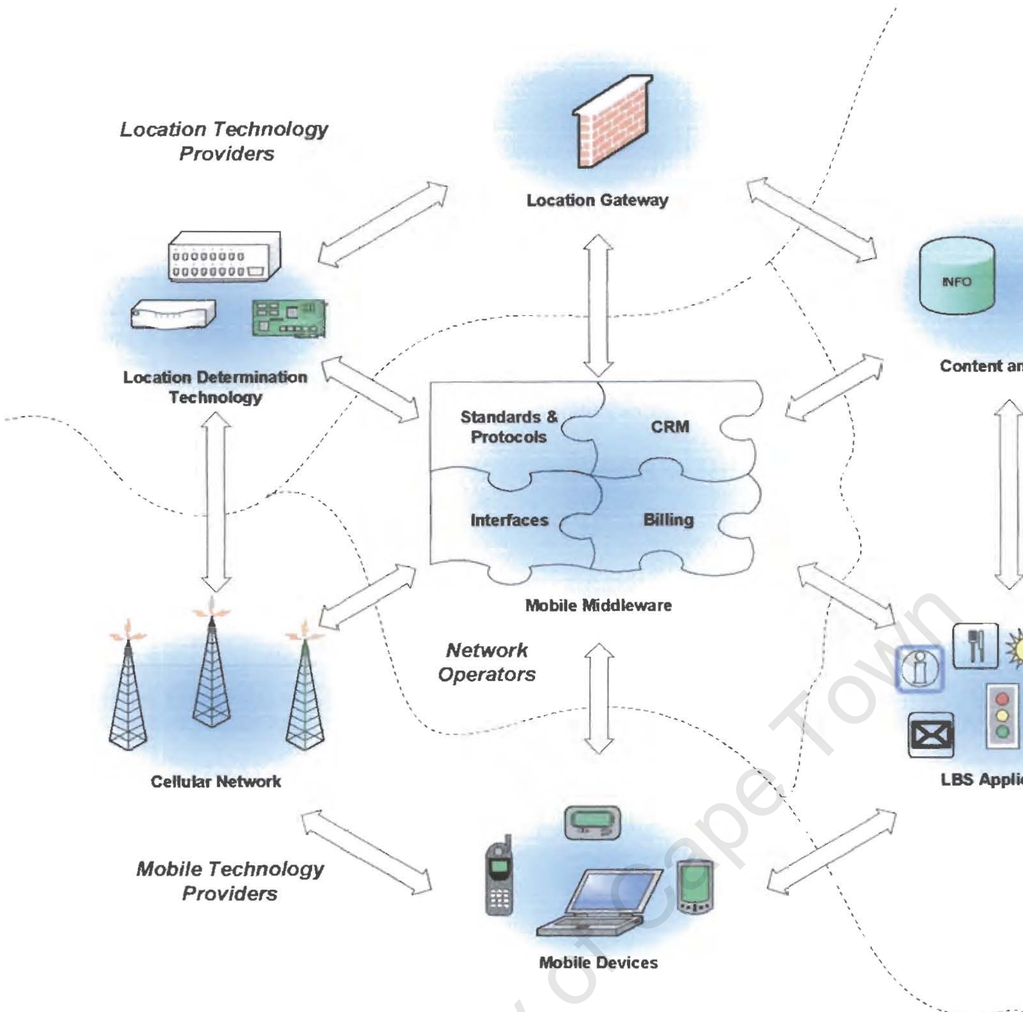


Figure 4.1: LBS Value Network and Technology Components

Figure 4.1 shows the technology components required to provide LBS. The **cellular network** (section 4.2.1) provides the infrastructure for communication, and is thus the backbone of any wireless service, location-based or otherwise. Information is transmitted over the cellular network by means of **communication protocols** or **data formats** (section 4.2.6.2). The **location determination technology** (section 4.2.2) provides the means for the determination of the physical location of the mobile device. The **location gateway** (section 4.2.3) provides access to the position information and is independent of the actual positioning technology. The **content and data** (section 4.2.8) consist of relational and spatial databases containing the information to be used by various **LBS applications**. These **applications** (section 4.2.7) combine the position information made available through the location gateway with the content and data to provide a particular service to the user. The **mobile middleware** (section 4.2.4) is the software platform that integrates all of these components by managing the flow of information through various interfaces, standards and protocols, allowing information to be sent in the correct format for a specific **mobile device** (section 4.2.5). The mobile middleware is also provides interfaces to the customer data and billing systems as may be required by applications.

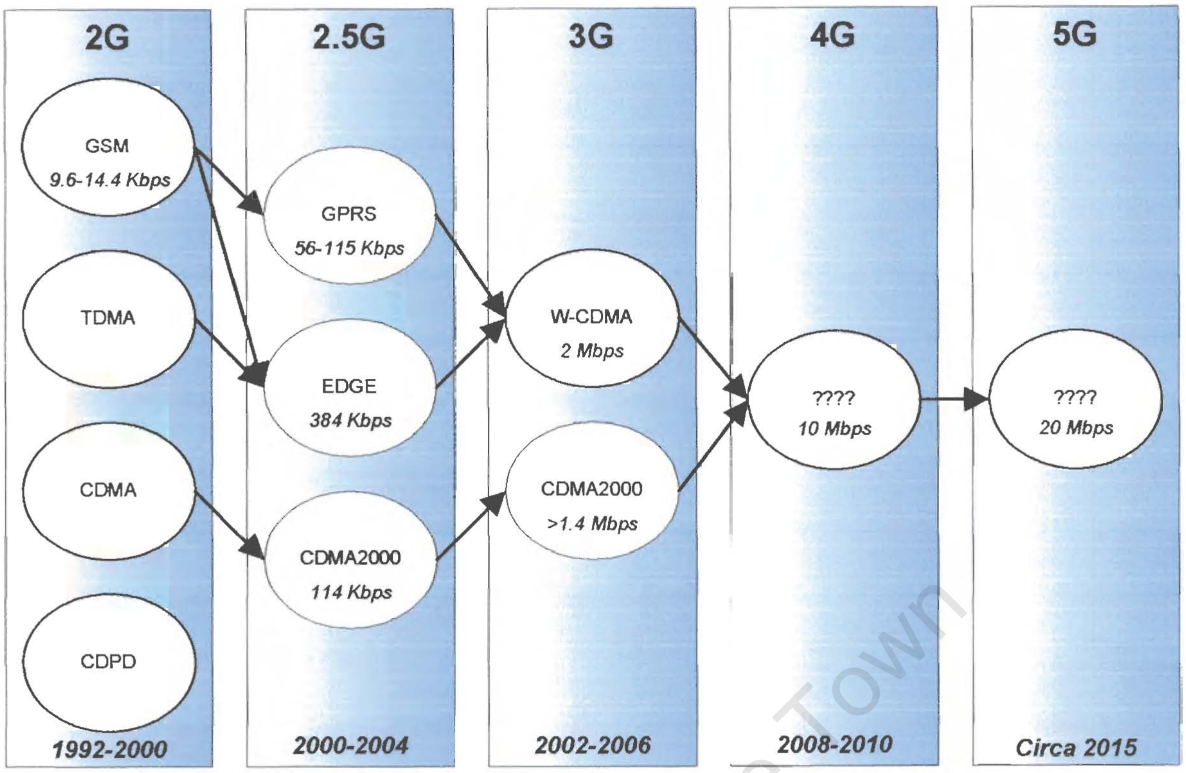
In addition to the technology components, Figure 4.1 also depicts which types of organisations are involved in the LBS Value Network and the technology components for which they are typically responsible. Network operators are the owners of the cellular networks and integrate various components on middleware systems to provide cellular services to consumers. Examples of network operators include Vodafone, T-Mobile and Orange internationally and MTN, Vodacom and Cell C in South Africa. Mobile technology providers such as Motorola, Nokia and Sony Ericsson provide the operators with the network equipment. These companies are typically also producers of the mobile devices, which are distributed to consumers to enable use of the cellular networks. Service providers develop and manage cellular applications on behalf of the network operators. These service providers also create and manage content for their applications. Examples of service providers in South Africa include iTouch and ExactMobile. Location technology providers, such as Airflash, Cambridge Positioning Systems (CPS), Covigo and SignalSoft, supply equipment and software to determine the position of the mobile device, and location gateways to manage access to the location information.

This section has provided a basic overview of the organisations in the LBS Value Network, and briefly outlined the interaction between the technology components. The following sections deal with each of these technology components in turn, highlighting the aspects that are most important for the provision of LBS.

4.2.1 Cellular Networks

This section provides a brief overview of the development of current cellular networks, and outlines the expected future developments. It briefly outlines the capabilities of different cellular network technologies and what effect this would have on the provision of information to mobile devices.

The cellular network is the backbone of all cellular services, i.e. both voice and data, and thus any LBS application is inherently reliant on the capabilities of the cellular network. Therefore, an understanding of the characteristics of cellular networks is integral to the evaluation of LBS. The technical overview provided in this section is used to derive the metrics for the evaluation of the capabilities of South African cellular networks in section 6.1.2.1. The case study data for these metrics is presented in Appendix A.1.1.



Adapted from Budde (2001) and Crawford (2001)

Figure 4.2: Evolution of Cellular Network Protocols

Figure 4.2 depicts the evolution and convergence of the most dominant cellular technologies after the move from the analogue systems of First Generation (1G) networks, and the expected upgrade path for future cellular networks. As networks are being upgraded at different times around the world, the timescales shown in the figure refer to general adoption of the technology rather those of any specific network. In addition, it shows the realised or expected data rates to indicate the realised or expected increase in bandwidth due to improved cellular technology.

Most 1G cellular technologies were proprietary, meaning there was limited interoperability with other networks. In addition, the quality and reliability of the networks was often poor (Sempere 1997). These problems led to the development of Second Generation (2G) digital cellular networks and the first step towards standardised cellular communication. It was the convergence of cellular technology on GSM, and the features and capabilities of digital networks that led to the exponential growth of the cellular industry and the increased interest in LBS (Adams, Ashwell, & Baxter 2003).

The digital nature of the new 2G networks rapidly led to digital compression and modulation enhancements that improved the network capacity or bandwidth of the networks, as shown in Figure 4.2. These network technologies, including General Packet Radio Service (GPRS) and Evolved Data-rates for GSM Evolution (EGDE), are known as 2.5G, and are an essential interim step towards 3G cellular networks. The principle difference between 2G and 2.5G networks is that the former are circuit-switched while the latter are packet-switched. This means that 2.5G networks can offer both permanent connectivity and higher data rates by making better use of the available spectrum. The author's representation of this concept is illustrated in Figure 4.3:

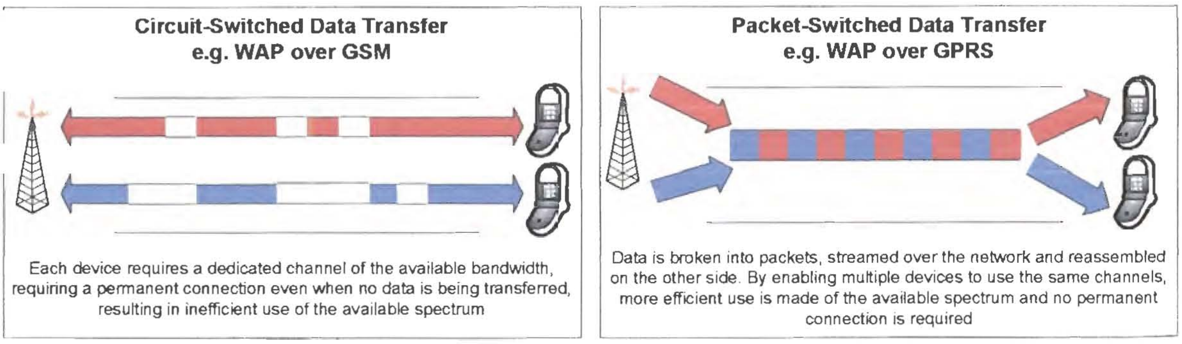


Figure 4.3: Packet-based vs. Circuit-switched Data Transfer

The move to packet-switched cellular technology enables the provision of advanced types of mobile data applications where users do not have to stay connected to send or receive information, and are only charged for data transferred rather than time connected. In the author's opinion, the move to packet-based data transfer is the single most important development in cellular networks for the provision of mobile data applications such as LBS.

3G technology combines high speed cellular technology with Internet Protocol (IP) based services (Botha 2004). This enables full multimedia capabilities and data rates of to up to 2 Mbps (Budde 2001). The types of applications provided over 3G networks include full video communication, interactive games and a high speed alternative to fixed line internet connections, resulting in convergence of communication, business and entertainment services (Botha 2004). This has an influence on what kind of LBS applications can be delivered, and how the data is presented to the user. Up to 70 network operators are estimated to have implemented 3G network capabilities by the end of 2004 (Botha 2004).

This section has provided a technical overview of cellular network technology. This overview provides the initial understanding required to derive the cellular network metrics in section 6.1.2.1 and the discussion of these metrics in the South African context in Appendix A.1.1. Additional information regarding the technical aspects and implications of the various network technologies is provided in Appendix B.

4.2.2 Location Determination Technology

This section provides an overview of the researched Location Determination Technology (LDT) and summarises of the characteristics of several positioning methods. The discussions in this section form the basis for the formation of LDT metrics in section 6.1.2.2 and the presentation of the South African LDT metric data in Appendix A.1.2.

LDT can be broken down into two categories, namely handset-based or network-based positioning.

1. **Handset-based positioning** uses hardware and/or software on the mobile device itself to determine the position
2. **Network-based positioning** uses hardware and/or software integrated with the cellular network to determine the position
   (Adams, Ashwell, & Baxter 2003; Choi & Tekinay 2003; D'Roza & Bilchev 2003)

Handset-based positioning includes the Global Positioning System (GPS). Network-based positioning includes Cell of Origin (COO), Time of Arrival (TOA), Time Difference of

Arrival (TDOA) and Enhanced Observed Time Difference (E-OTD). In addition, some positioning methods are a mixture of network and handset based positioning, such as Assisted-GPS. Each method has advantages and disadvantages, and no single method is suitable for all LBS applications or operating environments.

It is difficult to provide a detailed and accurate side-by-side comparison of all of the different methods as there are conflicting claims from technology vendors, and some technologies are still in the testing stage without any definite or concrete results. Figure 4.4 provides a summary of the location determination technologies researched, outlining the main characteristics and suitable LBS applications of each. Figure 4.4 represents the author's synthesis of data from a variety of sources (e.g. Crawford & Aftahi 2001, Cooper & Julian 2001, Cellocate 2001, Adams, Ashwell, & Baxter 2003, Rao & Minakakis 2003), and therefore represents a more holistic view of the capabilities of each technology than the information from individual sources.

The location determination technologies shown in Figure 4.4 are discussed in detail in Appendix C. The classes of LBS applications referred to in the diagram are discussed in section 4.3. The performance and modification measures were derived as part of the construction of the set of metrics for the evaluation of LBS in South Africa in section 6.1.2.2.

		Cell of Origin	Angle of Arrival	Time of Arrival	Time Difference of Arrival	Enhanced Observed Time Difference	Assisted GPS	Global Positioning System	Radio Camera Technology
	Positioning technology	COO	AOA	TOA	TDOA	E-OTD	A-GPS	GPS	RCT
Implementation Requirements	Network software	✓	✓	✓	✓	✓	✓	✓	✓
	Network hardware	✗	✓	✓	✓	✓	✗	✗	✓
	Handset software	✗	✗	✗	✗	✓	✓	✓	✗
	Handset hardware	✗	✗	✗	✗	✗	✓	✓	✗
	Network upgrade cost	minimal	high	high	medium	low	medium	nil	medium
	Handset cost increase	nil	nil	nil	nil	nil	medium	high	nil
Performance Indicators	Number of base stations	1	2	3	3	3	1	0	1
	Claimed accuracy	250m - 30km	>150m	150m	<100m	<50m	3m-30m	<20m	<100m
	Indoor performance	avg	avg	avg	avg	good	good	avg	good
	Urban performance	poor	avg	avg	poor	good	good	good	good
	Rural performance	poor	avg	avg	poor	good	good	good	good
	User controlled privacy	no	no	no	no	yes	yes	yes	yes
	Speed of response	<10sec	<10sec	<10sec	<10sec	<10sec	2sec	up to 5 min	<10sec
Classes of LBS Applications	Emergency Services	✓	✓	✓	✓	✓	✗	✗	✓
	Asset and Person Tracking	✓	✓	✓	✓	✓	✓	✓	✓
	Navigation and Information Services	✗	✗	✗	✓	✓	✓	✓	✓
	Entertainment and Personal Messaging	✓	✓	✓	✓	✓	✓	✓	✓
	Mobile Commerce and Advertising	✓	✓	✓	✓	✓	✓	✓	✓
	Location Sensitive Billing	✓	✓	✓	✓	✓	✓	✗	✓
	Intelligent Transport Systems	✗	✗	✗	✓	✓	✓	✓	✗

data compiled from multiple sources

Figure 4.4: A Comparison of Location Technologies

As different methods are suitable for different operating environments and different applications, many operators are deploying hybrid location technologies. This approach makes use of two or more different methods to provide the best possible location information for a particular scenario and required accuracy. This requires a software platform to manage access to these hybrid technologies. This software platform is known as the Location Gateway and is discussed in the following section.

4.2.3 Location Gateway

The Location Gateway (LG) is a software platform that provides the interface between the Location Determination Technology (LDT), mobile middleware and LBS applications. It should be interoperable with any LDT, and make use of the best available method. In addition, the LG should have open standards allowing 3rd parties to have controlled access to location information (SignalSoft 2001).

The LG allows 3rd parties to access position information via a set of standard software interfaces. The author was involved in developing such an interface into the LG of one of the South African cellular networks as part of a proof of concept exercise (Project F 2002). The interface, created using a Java Application Programming Interface (API), passes the cell phone number as well as authentication credentials over the internet to the LG. The LG authenticates the request by checking the credentials against other databases, and retrieves the position information using the most accurate positioning method available. The position information is passed back through the Java API to the specific application that requires information. The interface makes use of Extensible Mark-up Language (XML) as a means of structuring the data for the request and the response, and Hyper Text Transport Protocol (HTTP) as a means to transmit the XML data over the Internet. This is shown in Figure 4.5 below:

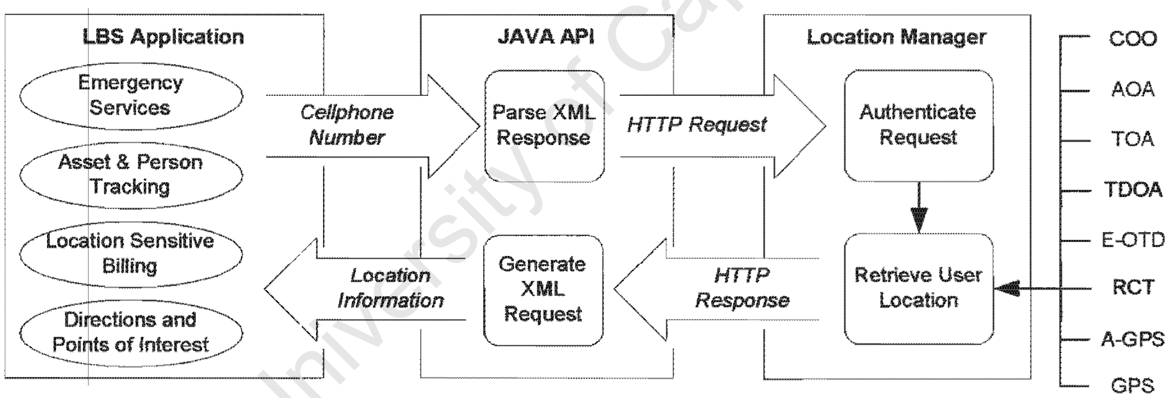


Figure 4.5: Interacting with the Location Gateway

The implementation of a LG on a cellular network is of utmost importance to the successful deployment of LBS (Oehely 2004). It manages access to position information both internally and by 3rd parties, provides security and manages personal privacy, allows for passive tracking (see section 4.3), and is independent of the Location Determination Technology.

In addition to managing access to location information, the LG often integrates with components of the mobile middleware in order access content and spatial data pertaining to the location. Extending the example in Figure 4.5, a request type would be sent in addition to the cell phone number, and the requested data would be returned with the location of the device. This was successfully used in a proof of concept exercise to return a list of restaurants within a certain range of the mobile device (Project F 2002).

The following section discusses mobile middleware, which is the software that enables LBS information to be retrieved and formatted for different devices.

4.2.4 Mobile Middleware

Varshney and Vetter define mobile middleware as an "*enabling layer of software that is used by applications developers to connect their applications with different mobile networks and operating systems without introducing mobility awareness in the applications*" (Varshney & Vetter 2002). In other words, mobile middleware integrates different technologies and data formats to enable the provision of mobile applications to all cellular devices, without the developers needing to explicitly cater for the capabilities of different devices. There are a number of vendors offering mobile middleware platforms for LBS, including Oracle, SignalSoft, Covigo, xMarc and Gravitate.

According to the Oracle Corporation, a mobile middleware platform must adhere to the following principles (Oracle 2001):

1. **Any content or data source** – the middleware must be able to interface with and extract data from a range of different data sources, including relational databases, spatial data sources and file systems.
2. **Any device** – the middleware must have the capability of translating data into a variety of data transfer formats, e.g. MobileXML, c-HTML, WML, VoiceXML or any other standard mark-up language for mobile devices. In addition, the middleware must have the capability of formatting content to suit the capabilities of the target mobile device
3. **Any application** – the middleware must be an open platform based on industry standards, allowing any 3rd party to use the capabilities of the middleware to develop LBS applications

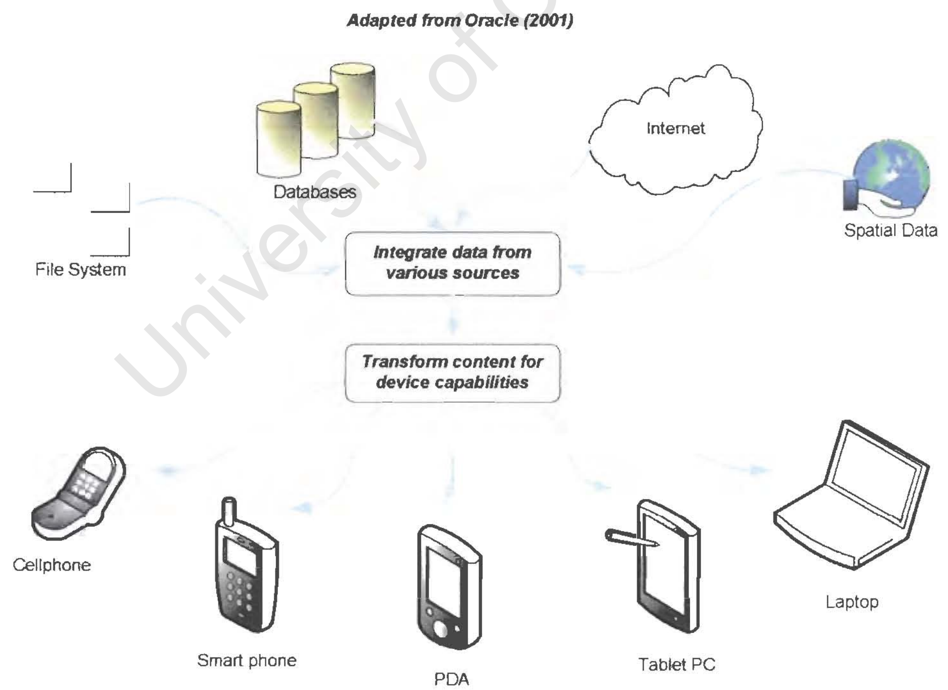


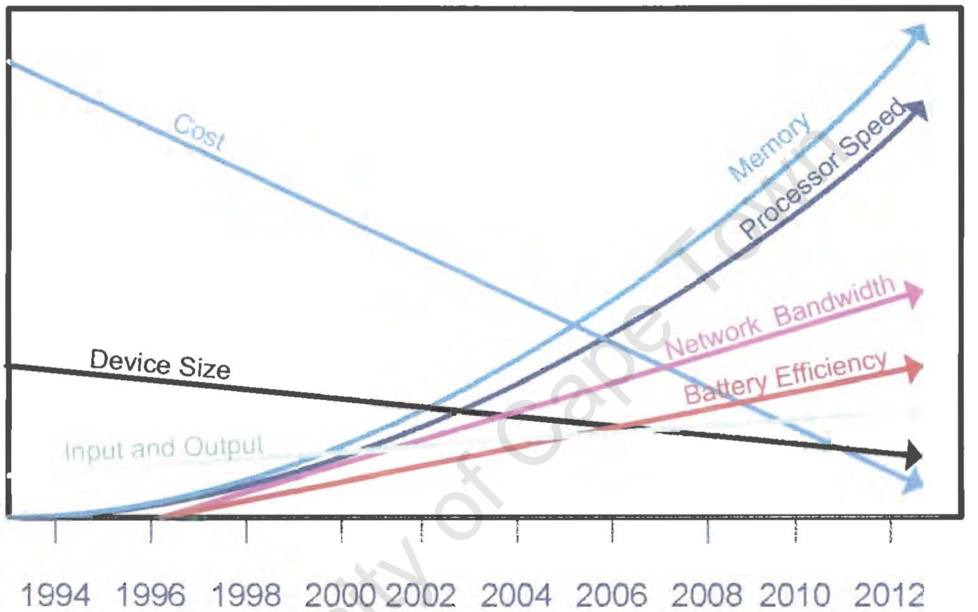
Figure 4.6: Mobile Middleware

Figure 4.6 above shows how mobile middleware controls the flow of data from its source to the individual mobile devices. As stated previously, one of the primary functions of mobile middleware is to be able to provide information to any device. This thesis is concerned with cellular LBS only, and as such the capabilities and characteristics of cellular handsets are discussed in the following section.

4.2.5 Cellular Handsets

This section discusses the general capabilities of mobile devices or cellular handsets, and defines three classes of cellular handsets for the purposes of discussion in this thesis. Metrics to evaluate the capabilities of these classes of devices are derived in section 6.1.2.3, and discussed in the context of their implications for LBS in South Africa in section A.1.3.

Cellular handset design over the past several years has witnessed a rapid progression toward smaller, lighter, and lower cost designs with exponential increases in functionality (Krenik 2002). Figure 4.7 shows the relative improvements of characteristics of mobile devices from the mid 1990's through to the predictions made for the next decade.



Adapted from Crawford et al. (2001)

Figure 4.7: Predicted Improvements in Mobile Device Capabilities

The above diagram shows an increase in processor speed, memory, battery efficiency and support for greater network bandwidth. These will enable devices to support content rich applications and access more information than previously possible, while the devices are becoming less costly and therefore more accessible to a greater number of people. There are however two characteristics of mobile devices that are unlikely to change greatly in the immediate future. The first is the screen size, and the second is the input method.

The range of available cellular handsets and range of handset capabilities is too broad to discuss fully in the context of this thesis. Therefore, in order to provide a platform for the evaluation of handset capabilities as they pertain to LBS in South Africa, three classes of cellular handsets are defined:

1. Entry-level handsets
2. Mid-tier handsets
3. Advanced handsets

Until recently, most cell phones were entry-level handsets that have a small, monochrome display, restricting the amount and type of information that can be presented to the user.

However, an increasing number of mid-tier handsets with full colour displays and built-in cameras are being distributed. The Gartner Group estimates that 66% of phones sold in Western Europe by 2006 will have full colour screens and built-in cameras, up from 6% in 2003 (Reuters 2003). The more advanced capabilities coupled with lower costs due to cheaper components and the introduction of MMS (see the following section) has been responsible for the increased market penetration of these of these mid-tier handsets.

Capabilities of advanced handsets include Bluetooth and Infrared wireless connectivity, built-in GPS receivers, video capture, built-in FM radios, MP3 players and slots for extra storage such as Compaq Flash or SD cards. It must be noted that these capabilities are becoming characteristic of mid-tier devices. These advanced capabilities mean that traditionally dedicated devices are becoming multipurpose information tools and incorporating PDA functionality. However, there will always be a need for dedicated devices at the high end of technology, as all-in-one devices that combine many different functions make compromises that may not meet the requirements of power users (Crawford & Aftahi 2001).

Another aspect of mobile phones that has made significant advancements is the mobile operating system. There is a major difference between the capabilities of personal computers and mobile devices, and a general-purpose operating system is therefore not suitable. Most mobile devices require specialised operating systems with a small footprint and reduced memory requirements to suit the specifications of the device. Until recently, developing applications for these devices has been difficult because of the limitations of the operating systems. However, advances in the mobile operating systems and the release of software development kits for different operating systems have allowed 3rd party developers to create applications for advanced handsets (Varshney & Vetter 2002). An example of such an operating system is the Symbian OS.

The advanced capabilities of the phones and the ability for 3rd party applications to be developed have increased the range and the capabilities of possible LBS applications. For example, phones with colour screens and built-in GPS can support navigation applications providing full colour maps, such as the SmartRoute application discussed in section A.4.3.7.

Despite the capabilities of advanced handsets, the majority of new handsets sold are entry-level or mid-tier handsets (Bosch 2002). Therefore, in order to leverage new services and applications such as LBS, these services need to be aimed at devices with basic capabilities while taking advantage of the capabilities of the newer phones where possible (Kong 2001b). This reiterates the need for mobile middleware, as discussed in the previous section. In summary, the mobile middleware should format the content and transmit the information in the most suitable way for a specific device. The following section discusses various data formats and data transfer protocols available for use with mobile devices.

4.2.6 Messaging and Data

This section briefly outlines different messaging and data services available over cellular networks. These are discussed in more detail in the context of LBS in South Africa in sections A.1.1 and A.1.3, which cover the technical capabilities of cellular networks and cellular handsets in South Africa respectively.

4.2.6.1 Personal Messaging

This section briefly outlines the existing types of messaging available over cellular networks. This overview provides the platform for metrics evaluating the effect of messaging on LBS in South Africa in sections A.1.1.4 and A.1.3.6.

Over the past few years, mobile messaging has evolved from the simple text based Short Message Service (SMS), through Enhanced Message Service (EMS) and finally to Multimedia Message Service (MMS). The basic characteristics of these personal messaging services are shown in Figure 4.8 below:

	Characteristics	Content Formatting Required	Applications	Support	Availability
SMS	100-200 characters	Yes	Person to person text	Entry-level handsets	1990's
EMS	Text messages, basic sound, monochrome images, text formatting enhancements	Yes	Person to person with visual feel	Mid-tier handsets	2000-2001
MMS	Messages in multiple rich media formats, including video, audio and text	No	Person to person full visual messaging	Initially advanced handsets, already migrating to mid-tier	2002

Adapted from MobileLifeStreams 2001

Figure 4.8: Comparison of Cellular Messaging Formats

SMS has seen an unprecedented global rate of adoption, being responsible for the majority of the increase in data revenues for cellular operators around the world (Gale Group 2002a). The relatively low cost of SMS messages and ubiquitous handset support means that SMS is the lowest common denominator for any messaging based application. EMS was essentially a step between SMS and MMS, and its limited functionality and the introduction of MMS resulted in a low rate of adoption and usage.

MMS incorporates different types of media, and was initially available on advanced handsets and thus received a slow market adoption. However, the introduction of 3G networks and the increased market penetration of MMS capable handsets have caused an increase in MMS messaging (Reuters 2003). Thus, MMS messaging has become a feature of mid-tier handsets due to the constantly changing capabilities and market penetration of handsets, as shown by Figure A.41.

Cellular messaging, in particular SMS messaging, has been widely regarded as the most logical choice for the delivery of value-added cellular services such as LBS. This is primarily because the mass adoption of SMS means that the value-added service would be immediately available to a wider market. The implications and effects of this on LBS in South Africa are discussed in section A.4.3.7 in the context of existing LBS applications and their delivery formats.

In addition to messaging, value-added cellular services such as LBS can be delivered via data services, as discussed in the following section.

4.2.6.2 Data Transfer

This section briefly introduces the data connectivity types available over cellular networks. Data over cellular networks has been available for some time, but is only receiving attention and greater adoption in recent years.

Initially, data communication of cellular networks was achieved through Wireless Application Protocol (WAP) over circuit-switched GSM networks. WAP failed to achieve mass adoption due to high costs, slow connection speeds and poor user experience. This is discussed in more detail in appendix B.1.4.

The introduction of packet-based 2.5g GPRS-enabled networks meant that data connectivity became faster and cheaper, primarily because of the differences between circuit-switched and packet-switched networks as discussed previously in section 4.2.1. This allowed for a greater adoption of data for services such as email and internet connectivity.

As already discussed in section 4.2.1, the recent introduction of 3G technology on many cellular networks allow for high data transfer rates over standard Internet Protocol (IP). 3G data is cost effective, and provides access to a range of multi-media and data applications on cellular devices.

Typical data rates for the technologies discussed in this section are presented in section A.1.1.1, and the costs of these data services in South Africa are presented in section A.2.3.3.

The messaging formats and data protocols discussed in this section are mechanisms for the provision of value-added cellular services. These mobile applications are discussed in the following section.

4.2.7 LBS Mobile Applications

Mobile applications provide the specific functionality of a particular service. They can reside on a central server or on the mobile device itself, depending on the nature of the application or on the capabilities of the device. A comprehensive discussion of the different types of mobile applications is beyond the scope of this thesis, with the exception of the classes of LBS applications discussed in chapter 4.3.

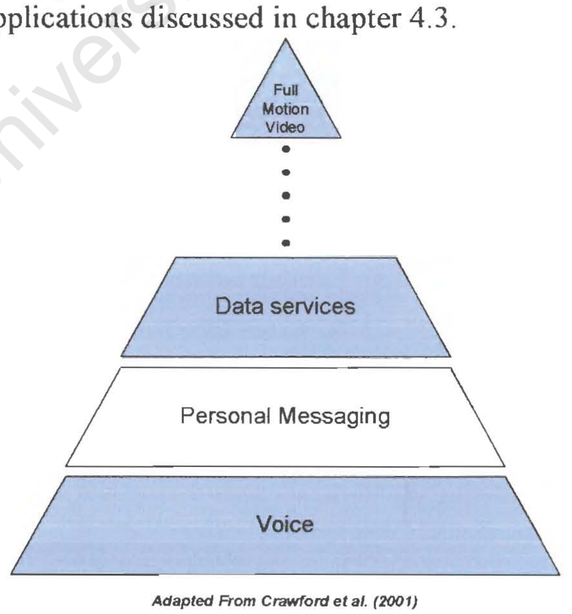


Figure 4.9: Hierarchy of Mobile Applications

One aspect that is relevant to this discussion is that mobile applications can be classified into a hierarchy depending on the level of demand for that particular type of application.

This is shown in Figure 4.9 above. It remains to be seen exactly where LBS applications in South Africa fit into this hierarchy, and for now the assumption is made that they fall within the region between data services and video services as depicted in the figure.

4.2.8 Content and Data

Arguably, the most important aspect of the LBS service hierarchy is the data itself. Even with the most advanced technology in place, the lack of accurate and valid content will hinder the adoption of any LBS applications (Dao, Rizos, & Wang 2002).

The content to be incorporated into LBS applications could include:

1. Spatial information (e.g. maps or location)
2. Business data (e.g. sales per region)
3. Travel information (e.g. tourist attractions, weather forecast data)
4. Navigation information (e.g. directions)
5. Personal data and preferences
6. Advertising content
7. Directory information

The technology components discussed thus far all integrate to provide LBS applications. The following section defines classes of LBS applications for the purposes of this thesis.

4.3 Classes of LBS Services

This section describes the different classes of LBS applications defined for the purposes of this thesis. These classes of LBS applications are used as a framework for discussion of LBS applications in South Africa for the remainder of this thesis.

LBS applications fall into two main categories, namely active or passive.

1. An **Active LBS** originates from the mobile device, requiring the mobile handset user to request or location service.
2. A **Passive LBS** originates from the network, and requires the mobile handset user to give permission to trusted third parties to locate their whereabouts.

There is no standard classification for different types of LBS. The classification provided in this section is of the author's creation for the purposes of discussion in this thesis. In reality LBS applications could fall into more than one of these classes, and could be operated as either active or passive LBS. The classes of LBS applications are:

1. Emergency Services, Safety and Security
2. Asset and Person Tracking
3. Navigation and Directory Information
4. Entertainment and Personal Messaging
5. Mobile Commerce and Advertising
6. Location Sensitive Billing
7. Intelligent Transport Systems

The following sections briefly discuss each of these LBS application classes in turn.

4.3.1 Emergency Services, Safety & Security

One of the driving factors in LBS technology is the Federal Communications Commission (FCC) mandate for wireless 911 Emergency Services. Emergency services are the application that naturally suits LBS, as they provide a way to improve the safety and security of the public.

There are three main uses of LBS for emergency services.

1. Route the call to the appropriate regional authority, avoiding the need for national operator based dispatch.
2. Locate the caller and pass this information on to the appropriate response team. This would help the improve response time and additionally help to filter out hoax calls.
3. The third and most complex use of LBS would be to provide real time traffic sensitive directions to the response vehicles.

4.3.2 Asset and Person Tracking

This class of LBS application includes child tracking and sales force tracking, vehicle tracking and fleet management. These applications often overlap with emergency services and safety application of LBS applications.

4.3.3 Navigation and Directory Information Services

Tourist information services include "FindMe" services that locate the nearest hotel or restaurant, and provide the traveller with reviews, directions and booking capabilities. These services are extendable to include any business or place of interest.

4.3.4 Entertainment and Personal Messaging

The importance of personal messaging has already been discussed in the context of SMS and Email. Extensions of personal messaging applications using LBS include "Buddy Finder" and dating applications.

These applications allow people to communicate with friends or others of similar interests, and be notified when these people are nearby. This type of application will have a greater appeal in the youth segment of the market, who is already the biggest users of SMS text messaging.

4.3.5 Mobile Commerce and Advertising

In the same way that the Internet brought about the success of eCommerce, the developments in the wireless industry will create the opportunity for mobile commerce to flourish. mCommerce will allow the user to make transactions using a mobile device to procure goods or services. mCommerce can be integrated with LBS in order to pay for hotel reservations, meals and restaurants or movie tickets in conjunction with other LBS applications.

Mobile advertising is a potentially massive market that is plagued with controversy. It involves companies sending messages to users advertising products and services. This can be combined with the location of the user to enable the sending of wireless vouchers and advertisements that are valid for stores in the proximity of the user.

The problem with this idea is that consumers do not necessarily want to be bombarded with advertisements, and would consider it a nuisance and an invasion of privacy.

The only way that this application of LBS would be successful is if it is managed correctly. This means that only users who have requested this type of service would receive adverts or special offers. Incentive for agreeing to mobile advertisements could include reduced call rates, free minutes or cheaper subscriptions.

4.3.6 Location Sensitive Billing

Location sensitive billing could provide people with more flexibility in terms of managing their cellular expenditure. It allows for variable rate calling plans based upon the location of the caller. Discounts could be provided for calls from home or a place of business. This would help service providers to position cellular devices as an alternate to fixed line telephone services (Budde 2001).

4.3.7 Intelligent Transport Systems

Intelligent Transport Systems (ITS) have been implemented world wide to aid in traffic management and to increase the efficiency of public transport facilities. LBS can be used to track the position and status of public transport vehicles, as well as enable live communication of updated routes and schedules to commuters. ITS can also be used to monitor traffic flow, taxi services, and vehicle security.

This section has described the difference between active and passive LBS, discussed each of the classes of LBS applications defined for the purposes of this thesis. The following section outlines the key issues and lessons that can be drawn from global LBS experience.

4.4 Key Issues and Lessons

This section analyses the key problems and lessons that have arisen from global experience in bringing LBS technology to market. Since the majority of what is known about LBS comes from global experience (Oehely 2002), these lessons should ideally have formed the basis for implementation of LBS technology in South Africa. The relevance of these lessons to the South African situation will be discussed later in this study in the analysis of the findings and recommendations for future improvement. In summary, the lessons relate to location technology, business models, pricing structures, personal privacy and how LBS applications are integrated into existing service offerings.

4.4.1.1 Location Technology

Network operators are generally satisfied with COO (or Cell-ID) positioning for most of their current LBS applications. However, most recognise the need for more accurate positioning for some types of LBS applications, in particular business applications (Gale Group 2002b).

It is estimated that up to 70% of the demand for navigation and information LBS applications, as discussed in section 4.3.3, will be for planning purposes (Gale Group 2002b). Therefore, in addition to positioning the user's current location, operators are stressing the importance of the user being able to define a location manually in order to use an LBS service based on some future location.

In addition, global experience has shown that a location gateway, the LBS technology component as described in section 4.2.3, is of utmost importance because it provides a central access point to location information, allows passive tracking, and is independent of the actual positioning technology implemented on the network (Oehely 2004). Whichever positioning technology or location gateway is chosen, it needs to provide an easy upgrade path for future technology (Gale Group 2002b).

4.4.1.2 Business Models

Network operators recognise the importance of third party application developers and content providers as part of the LBS value network as discussed in section 4.2. Experience has shown the need to be flexible in business agreements these third parties, as some generate profits through revenue sharing while others prefer licensing their technology to network operators. This was highlighted in section 4.1.3.

Arguably, the most important global lesson to be learnt is from experience in Israel, discussed in section 4.1.3, where operators acted as 3rd party incubators (Gale Group 2002b). This has resulted in a strong LBS value chain and a number of implemented LBS applications in that country. Thus, technology incubation and flexible business models with partners are important for the implementation of LBS.

4.4.1.3 Pricing Structures

The dominant global trend has been to offer LBS free of charge with the exception of standard airtime charges in an effort to stimulate market adoption, and increase the charges once the market has been sufficiently developed (Gale Group 2002b). In cases where high charges have been introduced from the outset, the uptake does not seem to have been negatively effected, possibly because they provided niche LBS applications that targeted a specific hi-end market. The consensus is that pay-per-use pricing structure for LBS is more suitable for consumer applications while subscription pricing models are more suitable for business applications.

4.4.1.4 Market Adoption and Demand

Network operators claim to be satisfied with the market adoption of LBS, but are for the most part unwilling to release actual statistical information. In the author's opinion, this indicates that market adoption of LBS has not reached the predicted levels. With respect to marketing initiatives, the consensus is that LBS should be introduced cautiously, using low profile marketing if any, to test user reaction in unknown market space (Gale Group 2002b). There is still a lack of knowledge of the LBS market and actual consumer demands, and therefore a need for more market research.

4.4.1.5 Integration of LBS

With respect to the range and type of LBS applications offered and how these services are integrated with the broader suite of cellular services, there are two schools of thought, namely vertical and horizontal integration.

Advocates of vertical integration claim that LBS should be offered and marketed as stand-alone services, and seem to be in constant search of "killer" LBS applications, meaning LBS applications with large market demands and revenue generation (Dao, Rizos, & Wang

2002). It is the author's opinion that this search for the "killer" LBS application by network operators and developers has largely been responsible for the industry hype associated with LBS.

Many network operators are shifting towards horizontal integration of LBS technology, and are looking beyond a portfolio of vertical LBS applications and are investigating ways that LBS can be used to enhance a wider range of services. Therefore, they are looking at ways to integrate LBS with the existing product offering as well as adding new LBS services. In this outlook, LBS are regarded predominantly as a value-add to a broad range of services rather than as a stand-alone industry.

Thus, the two main approaches to LBS integration are LBS as a technology on its own, i.e. vertical integration, or LBS as an integrated part of the cellular service offering, i.e. horizontal integration. These are two fundamentally different approaches and both will be taken into account when evaluating LBS in South Africa.

This concept is of vital importance for this research, and is discussed further in relation to the approach taken by the South African network operators in section A.4.1.8.

4.4.1.6 Privacy Concerns

There is a unanimous agreement amongst researchers, industry analysts and consultants that the personal privacy of users is of utmost importance for the provision of LBS services.

Casal (2004) states that although personal privacy needs to be protected, personal information must also be made available for law enforcement and the protection of individuals. He claims that there can never be a clear-cut policy on this issue, and states that the optimal situation is a balance between privacy and security.

Casal claims that the changing balance between security and privacy and the lack of an internationally accepted legal and policy framework is causing society to lose trust in new technologies (Casal 2004). Therefore, although opt-in/opt-out strategies have been adopted for LBS and so far seem successful, there is also a need for regulation to be defined to maintain the balance of privacy vs. security.

The three main pillars of maintaining personal privacy are therefore

1. Technology – user opt-in, secure databases, firewalls and virus protection
2. Policy – laws and regulations to control the use of personal information
3. User education – ensure individuals know how information is handled and what the risks are

(Gale Group 2002b); (Casal 2004)

An appropriate mix of these three aspects will ensure that personal privacy is protected while allowing services such as LBS are allowed to develop.

4.4.1.7 Start Simple

A critical success factor has been identified as beginning with simple LBS applications with simple business models and pricing structures. An example of this approach is iMode in Japan, as discussed in section 4.1.3. Simplicity in the early phases of systems deployment seems to be a key factor for successful LBS implementations (Casal 2004).

4.5 *Summary & Conclusions*

This chapter has discussed the origins of the global LBS industry and provided a brief overview of LBS in the US, Europe, Asia and the Middle East. This discussion provided reasons for the slower than expected international rollout of LBS and highlighted efforts of the OMA to promote interoperability and standardise LBS technology. Section 4.2 provided an overview of the LBS Value Network and a description of the critical aspects of LBS technology components. Section 4.3 classified LBS applications in order to provide a framework for the discussion of LBS applications in South Africa. Section 4.4 extracted key issues and lessons learnt from global experience and suggested that these lessons form the ideal basis for the implementation of LBS in South Africa.

The information in this chapter forms part of the contextual understanding required for the evaluation of LBS in South Africa using the conceptual framework defined in chapter 3. In terms of systems thinking, this chapter has covered some of the hard technological systems required for LBS implementation. In terms of the Process-Outcomes model, this chapter has established some of the initial inputs to the stages of innovation of LBS in South Africa, which includes existing standards and technology as discussed in section 3.3.2.1. Thus, the material in this chapter provided vital understanding of the general concepts of LBS that will be used in both the construction of the SSM conceptual models and the construction of a set of metrics for the evaluation of LBS in South Africa.

The following chapter develops the SSM conceptual models of LBS in South Africa, according to the conceptual framework developed in section 3.4.2.

5 CONCEPTUAL MODELS OF LBS IN SOUTH AFRICA

This chapter develops SSM conceptual models for Location Based Services (LBS) in South Africa according to the methods described in section 3.1. By constructing the conceptual models, this chapter partially fulfils one of the research sub-objectives stated in chapter 1.3, namely the construction of an evaluation model based on the conceptual framework developed in section 3.4.

The conceptual models form learning systems which, when combined with the technological background provided in chapter 4, form the basis of the evaluator's contextual understanding of LBS in South Africa. As suggested in section 2.1.2, this initial understanding influences the evaluator's decision as to which aspects to measure, and therefore influences the construction of the set of metrics in the following chapter. In addition, the framework uses the conceptual models to identify the processes that form the theoretical connections between the SSM and the Process-Outcomes model.

This chapter follows the stages of SSM as incorporated in the conceptual framework shown in Figure 3.8, beginning with the development of rich pictures and analysis from different perspectives in section 5.1. Root definitions are structured in section 5.2, and conceptual models of the situation are constructed from these definitions in section 5.3. Following the theory developed in chapter 3.4.2, section 5.4 analyses the root definitions and conceptual models to identify the transformation processes that will form the fundamental connection between SSM and the Process-Outcomes model. The final section of the chapter concludes by reviewing the use of SSM in preparation for the construction of a set of metrics and the Process-Outcomes model in chapter 6.

5.1 The Problem Unstructured and Expressed

This section is concerned with the "finding out" phase of SSM as shown in Figure 3.1. It presents two different unstructured views of the problem space in the form of rich pictures and analyses the situation from different perspectives. Presenting the situation using two separate views is necessary to facilitate a better understanding the complex phenomenon, as LBS can be viewed as one sub-system within the system of the cellular industry as a whole. This initial multi-level view is extended later in section 5.2.1, where the identification of different levels of systems is used to structure the SSM root definitions of the conceptual models for LBS in South Africa.

The cellular industry in South Africa is addressed in section 5.1.1, and the more specific case of LBS in South Africa is presented in section 5.1.2. As per SSM theory discussed in 3.1.2, rich pictures and analyses do not attempt to represent the actual situation, but the evaluator's particular view of the situation based on a prior understanding. In this case, the author's prior understanding is generated by the available research data and commercial involvement in LBS as discussed in section 1.4.5.

5.1.1 The Cellular Industry in South Africa

This section presents the author's understanding of the cellular industry in South Africa through a rich picture in Figure 5.1. The analyses in the sections that follow are high-level discussions about the cellular industry in South Africa, and use only a limited amount of case study data where necessary to support arguments. A more detailed presentation of the research data is presented in the context of the Process-Outcomes model in the following chapter and in Appendix A.

5.1.1.1 Rich Picture of the South African Cellular Industry

The rich picture in Figure 5.1 below shows the author's unstructured view of the South African cellular industry, depicting the external influences, the relationships between the stakeholders, and some of the issues that influence the industry.

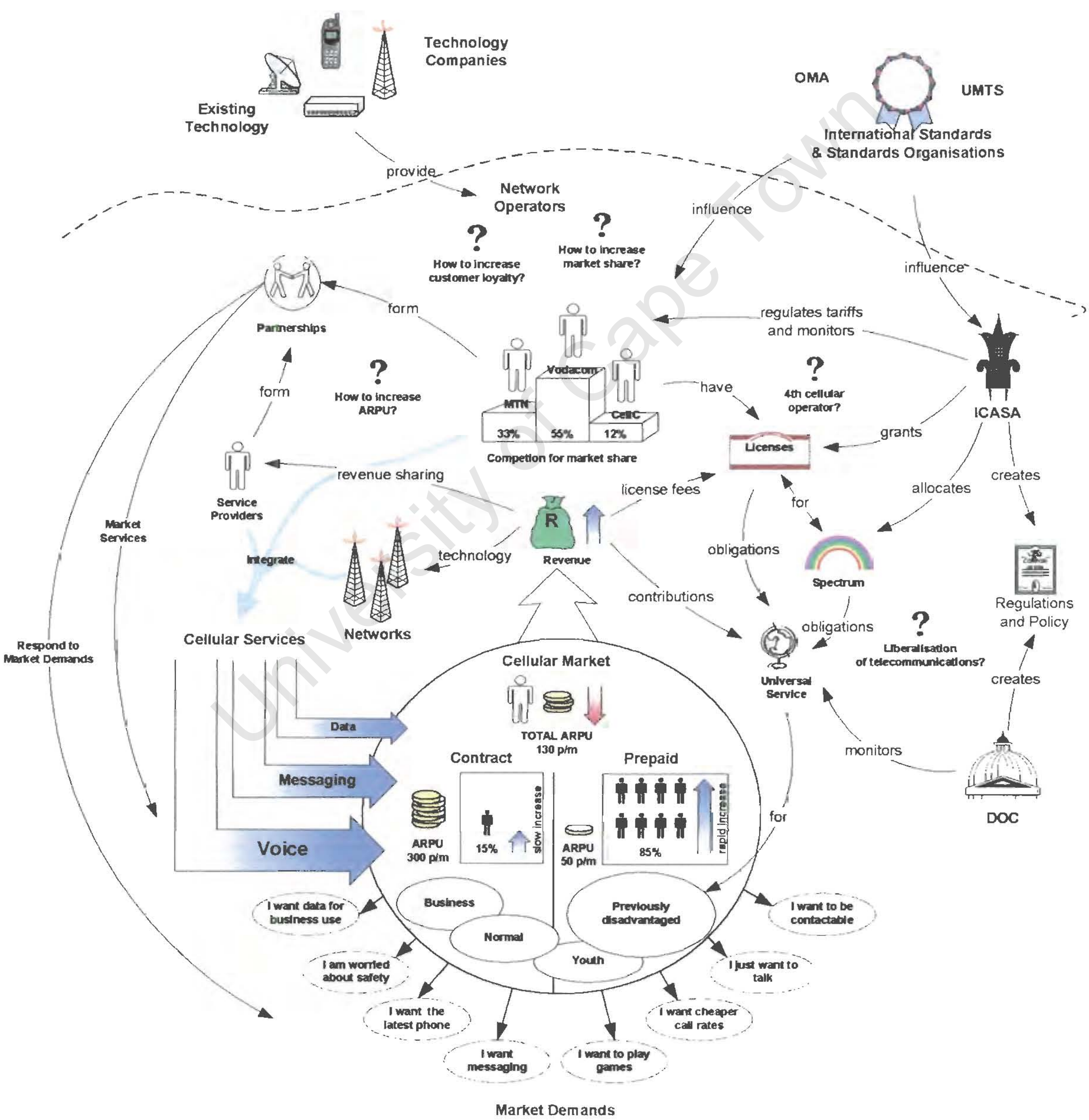


Figure 5.1: Rich Picture of the South African Cellular Industry

The initial inputs and influences to the cellular industry in South Africa are the existing technology and influence of technology providers, and the telecommunications standards as defined by international standards bodies. As discussed in chapter 4, these external influences are inputs to the cellular industry and therefore should also form part of the evaluation.

As can be seen from the rich picture in Figure 5.1, the network operators play a central role in the cellular industry. They are provided with licenses to operate the cellular networks from the relevant regulatory bodies. The network operators are constantly in competition for market share, customer loyalty and increased Average Revenue per User (ARPU). In order to do this, they are looking for new ways to leverage existing technology. This involves creating partnerships with other companies and obtaining an understanding of the cellular market. Revenue generated from providing cellular services is invested in, amongst other things, cellular license fees, social obligations and technology upgrades. These technology upgrades allow for new services to be offered which may contribute to diversifying the services provided by the network and thereby increasing revenue. The South African market is split between contract and prepaid users, who have different levels of expectations and demands from the cellular networks, and also have significantly different spending patterns.

The following sections express the problem shown in Figure 5.1 in more detail by analysing the situation from 3 different perspectives, according to the SSM theory outlined in section 3.1.2.2.

5.1.1.2 Analysis of Intervention

The author's role as the evaluator of LBS in South Africa has no influence on the cellular industry in South Africa.

5.1.1.3 Analysis of Social Situation

This section analyses the social situation in South Africa as it pertains to the provision of cellular services. The initial understanding developed in this section will provide input to the development of the root definitions in section 5.2 and conceptual models in section 5.3.

The growth of the cellular industry in Africa between 1998 and 2003 averaged 63% per year, almost twice the global average (Mattheus 2004). The success of cellular has been due to two main reasons. Firstly, network infrastructure costs are low in comparison to fixed lines, are easier to maintain and can service large areas. Secondly, cellular technology has provided people in rural areas with affordable access to communication where no services existed previously. South Africa has experienced the highest growth rate and has achieved the highest market penetration in Africa (see sections A.3.1.9 and A.3.1.10), and has a well established cellular industry.

South Africa's history of racial segregation through the apartheid system has had profound implications for the social structure of its population (Barry 1999). At the highest level, the social system in South Africa in terms of cellular communication can be broken in to two groups, previously advantaged and previously disadvantaged. This is to some extent related to the distinction between contract and prepaid users, although a large percentage of the youth and young adult market also make use of the prepaid subscription model. The majority of South Africa's population are poor (see A.3.1.5), previously disadvantaged under the apartheid regime, and live in informal communities close to cities or in rural areas. In addition, South Africa has between 12 and 13 million "un-banked" people, meaning that they do not make use of any banking facilities. The "un-banked" population consists primarily of the previously disadvantaged portion of the population (Morning Live 2004). For more information on South Africa's demographics, see section A.3.1.

The large percentage of previously disadvantaged and "un-banked" people in South Africa has a significant effect on the structure of the cellular industry. The ratio between income and cost of owning a private fixed line is very high in South Africa in comparison to other countries, and fixed telephone lines are becoming increasingly more difficult to afford for most South Africans (Pieterse 2001). This problem is thus a driver for the cellular industry. However, obtaining a standard cell phone contract requires a bank account, credit card and credit references, and usually binds the consumer for a period of up to two years. In response to this problem, the cellular networks have developed alternate pricing strategies, and subsequently the majority of the population access cellular services by means of a prepaid subscription model (see section A.3.1.11).

Prepaid starter packs are inexpensive and are not contractually binding. For this reason, they are the perfect choice for most South Africans and are obtainable without divulging personal information or banking details. However, prepaid does have its disadvantages. For the consumer, the prepaid charges are significantly more expensive than contract charges. A disadvantage for operators is that the anonymity of prepaid means that cellular operators do not have customer information about the majority of their clients. Furthermore, prepaid is conducive to a high customer turnover (also referred to as customer churn) and lower customer loyalty, as to replace a prepaid card or to switch networks operators has no cost implications for consumers. For this reason, there is a marked difference in the active vs. inactive subscribers in South Africa, with approximately two million inactive subscribers artificially inflating the cellular usage statistics (Gale Group 2003). Keeping in line with international trend of reporting on Average Revenue per User (ARPU) as a performance indicator, network operators have started keeping track of the number of inactive subscribers in order to avoid the inflated figure of total subscribers negatively affecting the ARPU. Active subscribers are generally regarded as those who have made use of a service sometime during the preceding 3 months, although network operators have been known to change this definition as and when it suits their purposes (ITWEB 2004).

While the majority of cellular users are previously disadvantaged making use of cellular services for voice and basic messaging only, there are three overlapping market segments that are taking the market forward in terms of adopting new cellular services. These are the business, youth, and early adopters market, and are responsible for adoption of cellular data services, mobile games, the increase of SMS and MMS traffic on networks, and the increase in the market penetration of high-end cellular devices. These market segments are dealt with more specifically in the metrics of the Process-Outcomes model in the following chapter, but are mentioned here to mark them as drivers of the cellular industry.

Despite the rapid uptake of cellular in South Africa, much of the population still do not have access to basic communications, emergency services and financial services. The South African Government and Department of Communication regard this as a major social problem. Overviews of the policies that attempt to alleviate this problem are discussed in the following section, which analyses the political situation in the cellular industry in South Africa.

This section has identified some of the social issues that confront the cellular industry in South Africa. In summary, these are the rapid uptake of cellular services due to the lack of access to communication services, the social structure of the population and its relation to the dominance of prepaid subscribers, and the relatively small market sector that drives the adoption of new cellular services and handsets.

The social issues identified in this section contribute to the construction of the SSM conceptual models for LBS in South Africa, and to the contextual understanding needed for deriving social metrics in section 6.1.4. The following section analyses the stakeholders, distribution of power and political issues influencing the cellular industry in South Africa.

5.1.1.4 Analysis of Political Situation

This section analyses the cellular industry in South Africa depicted by the rich picture in Figure 5.1 from a political perspective. This analysis is referred to as Analysis Three according to Checkland's SSM theory as described in section 3.1.2.2, and aims to identify the stakeholders in the industry, the issues confronting the stakeholders and the subsequent balance of power in the industry as they pertain to LBS in South Africa.

The political situation of the telecommunications industry is complex, involving many stakeholders with different agendas. Analysing all of these aspects is beyond the scope of this thesis, and this analysis focuses on political aspects and stakeholders that the author deems to have relevance to LBS in South Africa. Issues that are deliberately excluded are the monopoly of Telkom, the national fixed-line operator, and the delays in appointing a second national fixed-line operator (SNO), the proposed liberalisation of the telecommunications industry, and plans for a potential 4th mobile operator.

The Independent Communications Authority of South Africa (ICASA) governs the South African telecommunications and broadcasting industry. ICASA works in conjunction with the Department of Communication (DOC) to create, to monitor and to enforce telecommunications policy in South Africa. ICASA is also responsible for awarding licenses, allocating spectrum and regulating telecommunication tariffs (ICASA 2003b). Therefore, ICASA and the DOC are the organisations that have regulatory power over the cellular industry and thus over LBS in South Africa.

The primary stakeholders in the South African cellular industry are the three cellular network operators, namely Vodacom, MTN and CellC[i], listed in descending order of market share. The three operators serve a market of approximately 18.6 million total subscribers as of June 2004, excluding, for the moment, the issue of inactive subscribers as discussed in the previous section (Cellular.co.za 2004b). South Africa has a predicted growth of 73% between 2002 and 2010, and is rated the 10th fastest growing cellular industry in the world (Gale Group 2002a). Despite a healthy subscriber base, increasing profits and optimistic projections, all three operators are facing the problem of a steadily declining ARPU (Gale Group 2003; Scott 2004a; Scott 2004b). Network operators therefore need to find ways to diversify their services in order to increase ARPU. LBS have been identified as one potential way of achieving this.

Vodacom, the dominant network operator, is owned partly by Telkom, the national fixed-line operator, which is in turn partly owned by the South African government. Therefore, the government has a direct stake in the business. In addition, 35% of Vodacom is owned by the international company Vodafone, one of the largest operators in the world. This potentially gives Vodacom an advantage over their competitors in terms of their influence over the market and their access to technology and value networks through Vodafone.

As discussed in the previous section, South Africa has a large previously disadvantaged population that do not have access to telecommunications services. In response to this problem, the DOC and ICASA have defined a policy of Universal Service and Access (USA) endorsed by the International Telecommunications Union (Pieterse 2001). Universal Service refers to providing a phone for every household or office, while Universal Access refers to the provision of telecommunications through pay phones or community communications centres. In South Africa, Universal Service is seen as a long term goal, and the immediate focus is on providing Universal Access. As part of the cellular license obligations, ICASA has defined goals and target for the cellular operators to financially contribute to the Universal Service Fund (USF), and also to directly improve the situation by providing community phones and distributing free SIM cards.

This section has identified the major stakeholders in the cellular industry in South Africa and highlighted some of the issues that affect the balance of power. In summary, the regulatory power is held by the DOC and ICASA. The primary stakeholders are the 3 cellular operators, who are facing a slow-down in the market and competing against each other for market share. In addition, the operators are obliged to work towards the government's political (and social) goal of USA. The political and organisational issues identified in this section contribute to the formation of the conceptual models, and influence the construction of the organisational metrics for the evaluation in section 6.1.5.

Through the rich picture shown in Figure 5.1, section 5.1.1 has used SSM to present an unstructured view of the cellular industry in South Africa and expressed the problem through the analysis of the broad social, political and organisational issues. The following section repeats this process for the more specific case of LBS in South Africa.

5.1.2 LBS in South Africa

This section begins by presenting an unstructured view of LBS in South Africa in the form of a SSM rich picture in Figure 5.2. It then expresses the problem in terms of Analysis One, Two, and Three in sections 5.1.2.2, 5.1.2.3 and 5.1.2.4 respectively. As with the analyses of the broader cellular industry in section 5.1.1, limited data is presented in this section to support arguments, while reference is made to the comprehensive presentation of the research data provided in Appendix A.

5.1.2.1 Rich Picture of LBS in South Africa

This section depicts the unstructured view of the South African cellular industry through the use of a rich picture. The rich picture is briefly explained and then analysed from different perspectives in sections that follow.

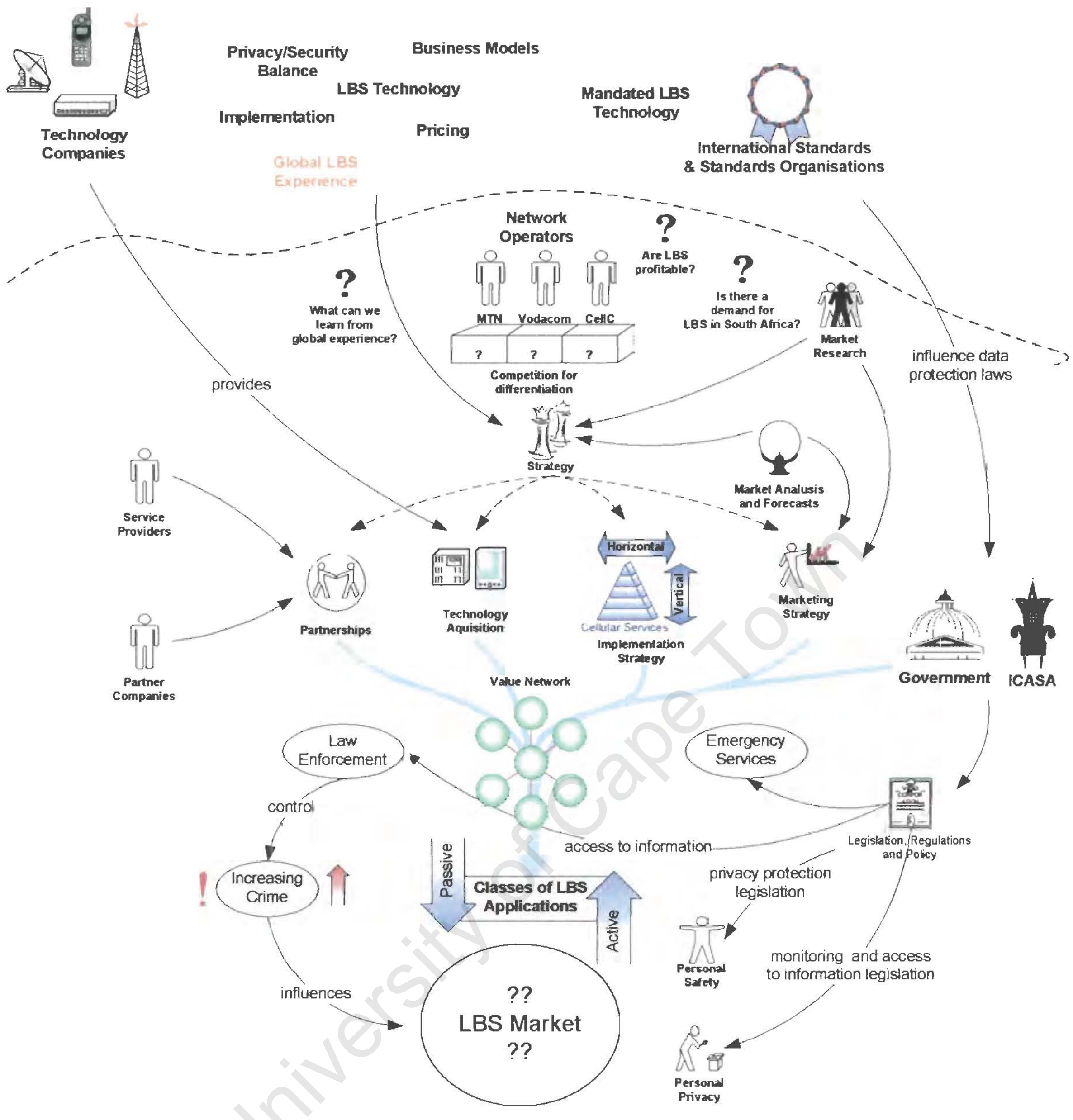


Figure 5.2: Rich Picture of LBS in South Africa

The rich picture in Figure 5.2 above depicts the author's unstructured view of the South African LBS industry. As stated most recently in the opening paragraph of Chapter 4, the LBS industry in South Africa is strongly influenced by global activities. These are shown at the top of the rich picture in the form of technology and technology providers (see 4.2), global lessons from LBS activities (see 4.4), and the convergence of international standards (see 4.1.4).

As with the rich picture in Figure 5.1, the network operators play a central role in LBS in South Africa. They are faced with the question of whether or not to implement LBS technology, if there is a market for such technology, and if so, which LBS technology to implement and which LBS applications are likely to generate revenue. The market demand for LBS services in South Africa is largely unknown. The regulatory bodies have the responsibility to ensure both access to information and protection of personal privacy with respect to the access to LBS information.

This section has presented the rich picture for LBS in South Africa and provided a preliminary high-level overview of the different components. Following the methodology defined in section 3.1.2.2, the following sections present a more detailed expression of the problem through analysis from different perspectives.

5.1.2.2 Analysis of Intervention

Over the course this research, the author was involved in several commercial LBS projects (see section 1.4.5), some of which had potential to affect the LBS industry in South Africa. However, none of these projects progressed beyond research or proof of concept stage, and some were terminated for political or financial reasons. The result is that although the author's commercial involvement in LBS provided access to information and insights into the South African LBS industry, it has not influenced the industry in any real or tangible way. Similarly, the evaluation of LBS for the purposes of this dissertation has had no immediate effect on LBS, although it is hoped that the results and conclusions of this research may be of some benefit to stakeholders in the LBS Value Network in South Africa.

5.1.2.3 Analysis of Social Situation

This section provides initial analysis of the social situation in South Africa as it pertains to LBS. The analysis in this section will provide input to the development of the root definitions in section 5.2 and conceptual models in section 5.3.

South Africa has one of the highest levels of crime, theft and violence per capita in the world (UNODC 2004). Subsequently, personal safety and the security of assets is a concern for all South Africans. As identified in section 4.3, specific use classes for LBS include emergency service, person tracking and asset tracking. This may suggest that the most likely social motivation for LBS in South Africa is for emergency services, law enforcement, personal safety and security.

In section 4.4.1.6 the issue of personal privacy was discussed in relation to the need for a balance between privacy and security. As shown by the metric data in section A.3.2.7, research has shown that a sample of technologically literate South Africans, who know about LBS and are interested in LBS technology, do have concerns with regards to the effects of LBS on personal privacy (Project B 2002; Vodacom 2004b). Based on this observation, the author poses the question that if the minority that do understand the technology have reservations regarding its implications, then how receptive will the majority of the population (previously disadvantaged, low income and 'un-banked' as discussed in section 5.1.1.3) be to the technology? Equally, one could argue that un-educated users may not understand the personal privacy implications and therefore may not have concerns in this regard. Thus, in addition to the demographic profile of the country, it is possible that personal privacy is a major social issue for LBS in South Africa.

A further social concern for the implementation of LBS relates to the high proportion of low income, prepaid users of cellular technology in South. Given the high cost of cellular services in South Africa, it seems unlikely that these users would be able to afford or be particularly interested in additional cellular services such as LBS if they are expensive. Therefore, an additional social problem is that LBS services need to be financially viable for low income users in order to achieve mass adoption. This poses a problem for operators who intend to use LBS to increase revenues.

In summary, there is motivation for LBS in South Africa purely from a safety and security perspective. However, research has indicated that those few people who know about LBS are sceptical because of its implications for personal privacy. In addition, because the majority of the population consists of people from the lower income groups, there are also questions as to whether LBS are affordable and thus economically feasible in South Africa.

This section has analysed the rich picture in Figure 5.2 from a social perspective. The following section looks at the situation from an organisational and political perspective, linking it to the social analysis presented in this section where appropriate.

5.1.2.4 Analysis of Political Situation

This section provides initial analysis of the organisational and political situation in South Africa as it pertains to LBS. The analysis in this section will provide input to the development of the root definitions in section 5.2 and conceptual models in section 5.3.

The organisational situation and the balance of power for LBS is essentially the same as cellular services in general. DOC and ICASA are responsible for the industry, and create legislation and policy to regulate the industry. Importantly, with respect to LBS this should include legislation to protect personal privacy, a potential issue identified in the previous section and in section 4.4.1.6, and the provision of access to information under controlled situations for the purposes of emergency services or law enforcement.

The network operators are primarily concerned that investment in LBS technology will not translate into increased revenue, due to the lack of demand for LBS services. However, the operators still need to diversify their services, and need to investigate the potential for LBS to provide this competitive advantage. Although network operators have to some extent been influenced by global LBS experiences, there has been little focus on specifically what will work in South Africa's context (Watermeyer 2002). Thus, LBS services could potentially be seen as a potential benefit to operators in terms of differentiating themselves from their competitors, but operators has hesitated due to a lack of business case.

Section 5.1 has covered the finding out stage of SSM by presenting the rich pictures and the analyses for the cellular industry and the LBS industry in South Africa. The following section moves from real-world thinking to soft-systems thinking by formulating the root definitions for the sub-systems to be modelled.

5.2 The Problem Structured: Root Definitions

The purpose of this section is to identify the systems and define the root definitions for the sub-systems of LBS in South Africa according to the theory discussed in section 3.1.3.1. The rich pictures and analyses in section 5.1 form the basis for these root definitions, which are in turn used to generate the SSM conceptual models in section 5.3.

Extending on the view of LBS in South Africa as comprising of more than one system introduced in the previous section, multi-level thinking is used to identify the different sub-systems relevant to this evaluation. This multi-level thinking assists in creating overlapping and interrelated root definitions, resulting in conceptual models that are representative of the complexity of the problem. The root definitions are presented in the form PQR and CATWOE as described in section 3.1.3.1.

5.2.1 Using Multi-level Thinking to Identify Systems

Following Checkland's theory of multi-level thinking presented in section 3.1.3.1, and examining the rich pictures and the analyses presented in section 5.1, the different levels that need to be considered for the evaluation of LBS in South Africa are identified in Figure 5.3:

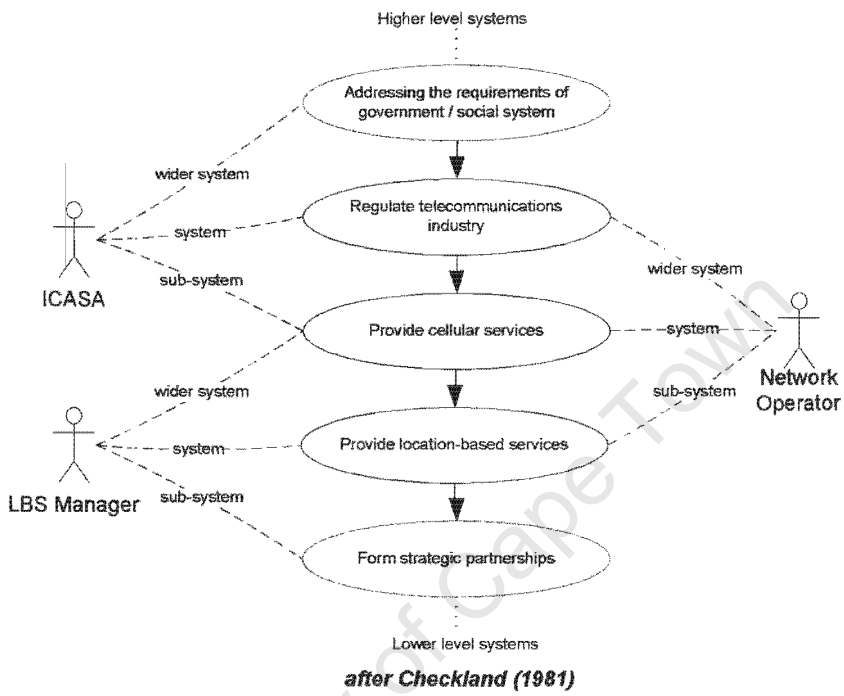


Figure 5.3: Sub-System Identification using Multi-level Thinking

The above figure shows how the complex problem of LBS in South Africa can be viewed as several levels of systems that are relevant from different angles or perspectives. For example, from the perspective of a network operator, the provision of cellular services is the primary system. LBS is regarded as a sub-system, while the regulation of the telecommunications industry is seen as the wider-system or the environment.

Thus, the SSM conceptual learning models for the evaluation of LBS in South Africa will consist of the three systems that are common to at least two of the perspectives shown in Figure 5.3 above:

- A System to Regulate the Cellular Industry
- A System to Provide Cellular Services
- A System to Provide Location-Based Services

By dealing with these individual sub-systems, the conceptual models will also incorporate the specific elements of the higher or lower systems that are deemed relevant to LBS in South Africa.

The following sections construct the root definitions for each of the three sub-systems identified in this section.

5.2.2 A System to Regulate Cellular Industry

This section develops a root definition for a system to regulate the cellular industry. Following the SSM theory discussed in section 3.1.3.1, the system is expressed in terms of the CATWOE mnemonic in the figure below:

	Element	***Description***
C	Customer	Network operators
A	Actors	Department of Communication, ICASA
T	Transformation Process	Create legislation and policy. Monitor cellular industry
W	*Weltanschauung* or world view	Control the cellular industry within the structure of social requirements
O	Owners	South African Government
E	Environmental constraints	Efficient use of available spectrum, control tariffs to protect consumers, yet generate income for USF and GDP.

Figure 5.4: CATWOE for a System to Regulate the Cellular Industry

Based on the CATWOE elements identified above, the root definition for the system to regulate the cellular industry can be defined in the form PQR as follows:

> ***"A system administered by the Department of Communication and ICASA to control the telecommunications industry, provide Universal Service and to regulate the network operators in order to ensure growth of the industry and sustainable income while acting in the interests of the consumer and the wider social system."***

This root definition forms the basis for the conceptual learning model developed in section 5.3.1. The following section constructs a root definition for a system to provide cellular services.

5.2.3 A System to Provide Cellular Services

This section develops a root definition for a system to provide cellular services. Following the SSM theory discussed in section 3.1.3.1, the system is expressed in terms of the CATWOE mnemonic in the figure below:

	Element	*Description*
C	Customer	Users of the cellular network
A	Actors	Network operators
T	Transformation Process	Assess market demands, integrate technology and service.
W	*Weltanschauung* or world view	Need to operate a competitive business within the regulatory framework
O	Owners	ICASA, DOC
E	Environmental constraints	Social structure, USF, technology, partnerships?

Figure 5.5: CATWOE for Provision of Cellular Services

Based on the CATWOE elements identified above, the root definition for the system to provide cellular services can be defined in the form PQR as follows:

> ***"A system run by the network operators to provide cellular services to the public in order to generate a profit, taking into account available technology and standards, cost of providing service, and adhering to regulations and policy defined by the Department of Communication and ICASA."***

This root definition forms the basis for the conceptual learning model developed in section 5.3.2. The following section constructs a root definition for a system to provide location-based services.

5.2.4 A System to Provide Location Based Services

This section develops a root definition for a system to provide location-based services. Following the SSM theory discussed in section 3.1.3.1, the system is expressed in terms of the CATWOE mnemonic in the figure below:

	Element	***Description***
C	Customer	Users of the cellular network
A	Actors	Network operators, Service providers
T	Transformation Process	Provision of LBS
W	*Weltanschauung* or world view	Diversification and improvement of service offering in order to differentiate
O	Owners	Government, Department of Communications, ICASA
E	Environmental constraints	Available technology, cost of service, market demand, concerns for privacy and regulations defined by owners

Figure 5.6: CATWOE for LBS Provision

Based on the above elements, the root definition for the system to provide location based services can be defined in the form PQR as follows:

> ***"A system run by the network operators and service providers to diversify and improve their cellular services by providing LBS to users of the cellular network, taking into account available technology, cost of providing service, market demand for LBS, user concerns for privacy and adhering to regulations and policy defined by the Department of Communication and ICASA."***

The root definition above forms the basis for the conceptual learning model developed in section 5.3.3.

This chapter has thus far provided an unstructured expression of the problem of LBS in South Africa in the form of rich pictures, analysed the rich pictures from different perspectives to identify key issues, identified the different sub-systems of the problem, and created root definitions for each of those sub-systems. The following section uses these root definitions to construct SSM conceptual learning models. These conceptual models are a fundamental component of the formation of an evaluation model according to the conceptual model developed in section 3.4.

5.3 The Problem Structured: Conceptual Models

This section develops the SSM conceptual models for LBS in South Africa using the unstructured definition of the problem presented in section 5.1 and the root definitions developed in section 5.2.

5.3.1 System to Regulate Cellular Industry

This section presents the conceptual model constructed for a system to regulate the cellular industry in South Africa. As per the SSM theory outlined in section 3.1.3.2, the conceptual model is based entirely on the root definition of the system as developed in section 5.2.2.

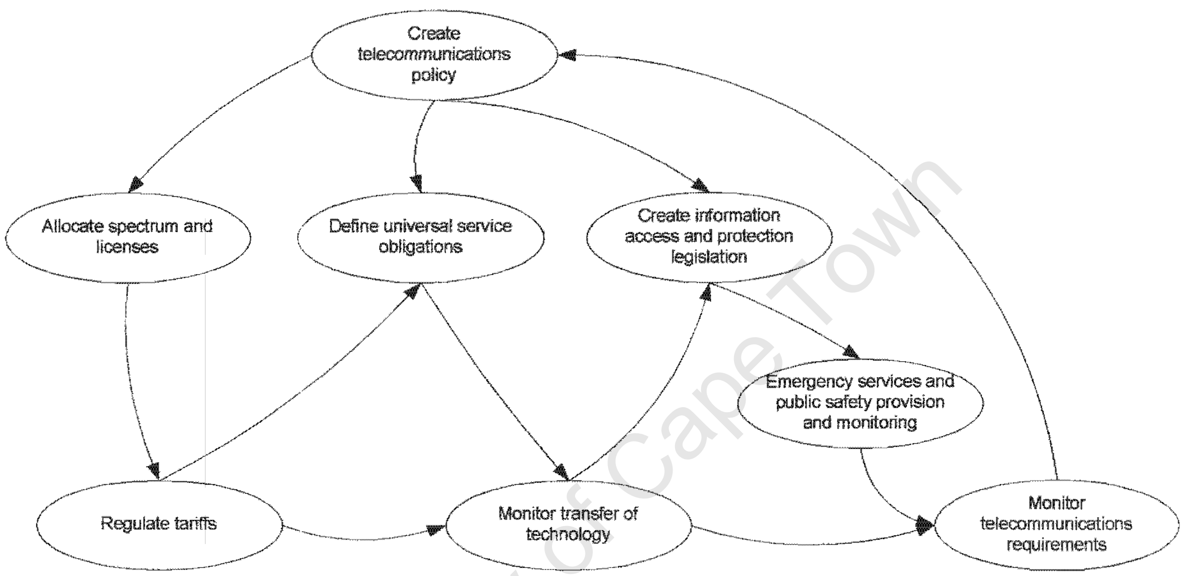


Figure 5.7: A System to Regulate the Cellular Industry

Figure 5.7 above depicts the SSM conceptual model for a system to regulate the cellular industry in South Africa. As defined in the root definition for this system, the primary actors are the regulatory bodies, namely the DOC and ICASA. The remainder of this section discusses the processes that drive the system.

According to this learning model, the first stage is to create the high-level policy that will govern the cellular industry. This would essentially consist of a sub-set of general policy to regulate telecommunications in South Africa as a whole. However, this conceptual model is only concerned with policy effecting cellular communications.

Once the relevant policy and regulations have been established, the regulators need to allocate the available frequency spectrum to cellular operators and administer licenses. Given the Universal Service goals as discussed in 5.1.1.4, the obligations and contribution targets of the cellular operators need to be established. The purpose of tariff regulation should be to protect consumer interests while still maintaining a competitive market. There also need to be mechanisms in place to monitor the transfer of cellular technology to parts of the population with no previous access to service.

A vital part of managing the cellular industry is the creation of legislation to protect personal privacy by controlling access to operator phone records. As highlighted in section 4.4.1.6, this protection of information needs to be balanced with the need to provide access to the same information for the purposes of public safety.

The final component of the conceptual model is the monitoring of telecommunication requirements and the assessment of all policy and regulations. In response to the changing needs of society with regards to telecommunications, this feedback loop prompts the amendment of policy and regulations in order to further improve the situation.

The following section constructs a conceptual model for a system to provide cellular services in South Africa.

5.3.2 System to Provide Cellular Services

This section presents the conceptual model constructed for a system to provide cellular services in South Africa. As per the SSM theory outlined in section 3.1.3.2, the conceptual model is based entirely on the root definition of the system as developed in section 5.2.3.

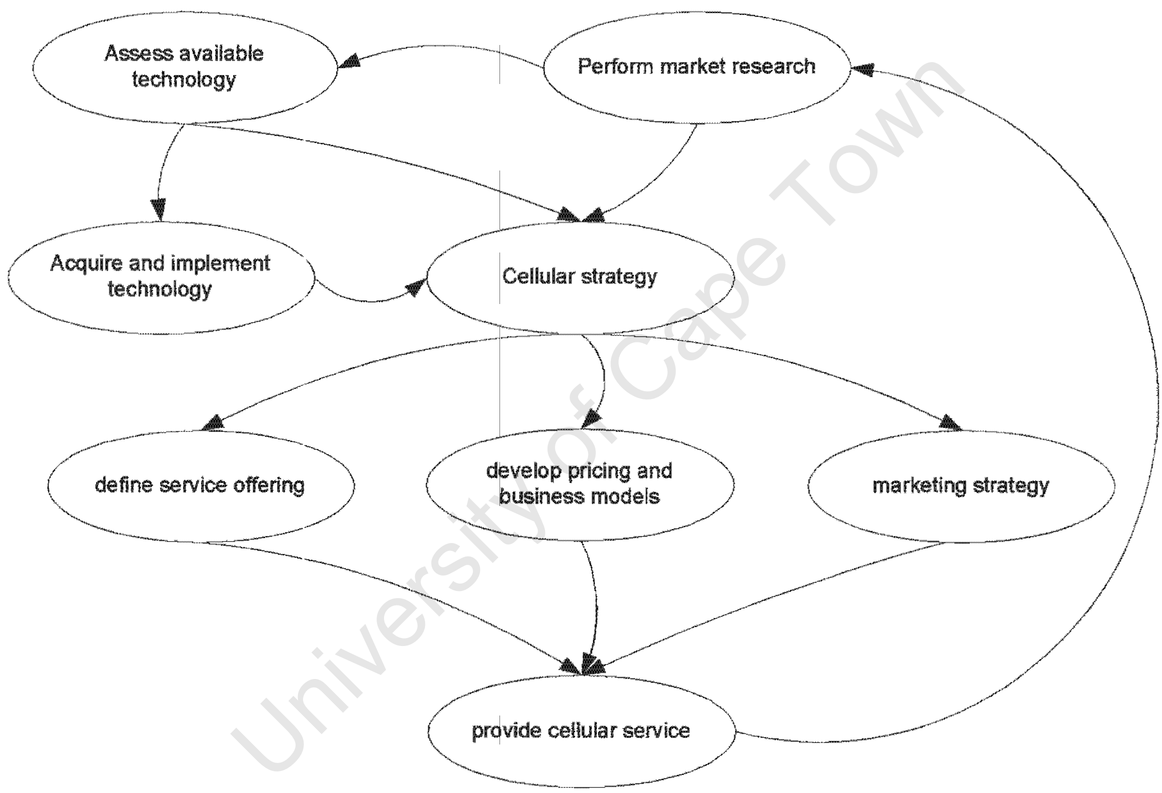


Figure 5.8: A System to Provide Cellular Services

Figure 5.8 above depicts the SSM conceptual model for a system to provide cellular services in South Africa. As defined in the root definition for this system in section 5.2.3, the actors in the system are the cellular network operators. The remainder of this section discusses the processes that drive the system.

As shown in Figure 5.1, the existing technology and standards discussed in chapter 4 are the preconditions and inputs to the system. Network operators therefore need to assess the available cellular technology and decide which technology to acquire and implement. At the same time, the South African market needs to be studied in order to understand which technology should be implemented and best to implement it in South Africa. The acquired network technology and market knowledge should lead to the development of a strategy to deliver cellular services, incorporating a definition of the service offering, the development of business models and pricing plans, and a marketing strategy to suit the different target market segments.

Once all of these elements are in place, the running of the cellular network as a business activity needs to be coupled with continuous market research and assessment of currently implemented and newly available technology. This will allow the cellular operators to continuously improve their service offerings and potentially leverage technology to differentiate through value-added services such as LBS.

The following section constructs a SSM conceptual model for a system to provide location-based services in South Africa.

5.3.3 System to Provide Location Based Services

This section presents the conceptual model constructed for a system to provide location based services in South Africa. As per the SSM theory outlined in section 3.1.3.2, the conceptual model is based entirely on the root definition of the system as developed in section 5.2.4.

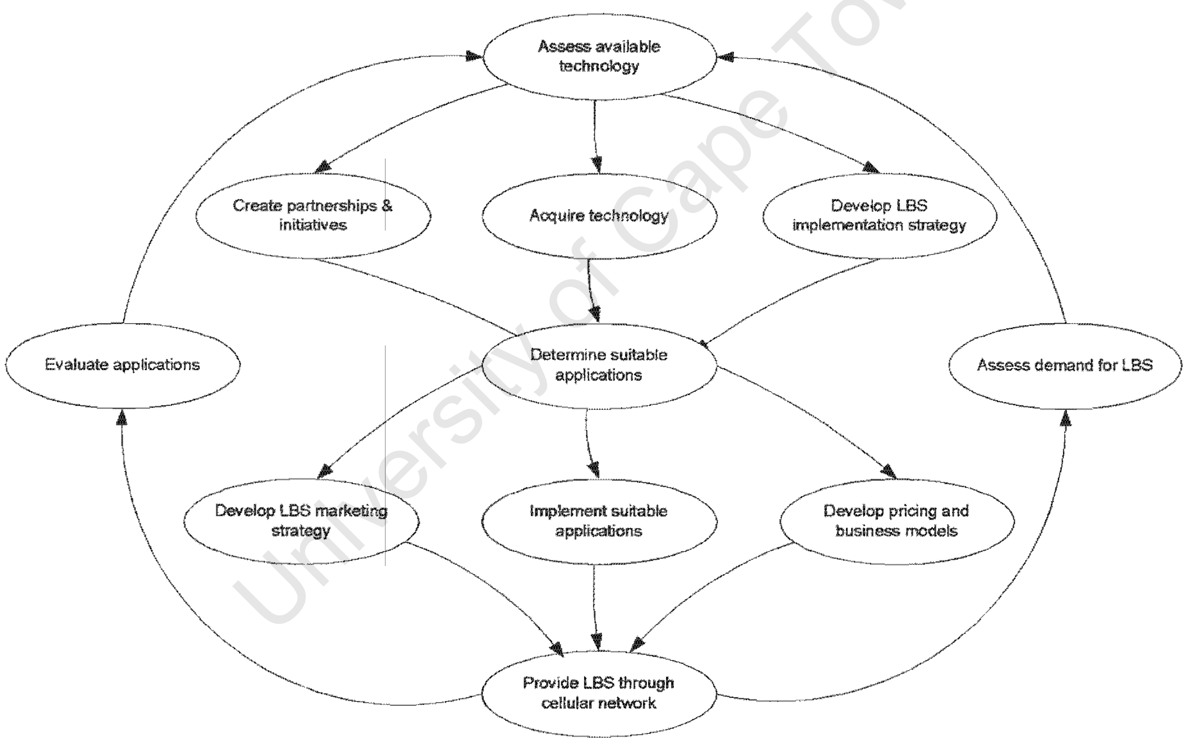


Figure 5.9: System to Provide LBS Services

Figure 5.9 above depicts the SSM conceptual model for a system to provide location-based services in South Africa. As defined in the root definition for this system in section 5.2.4, the actors in the system are the cellular network operators. The remainder of this section discusses the processes that drive the system.

A starting point for the system is market research to understand the relevance of LBS and to assess the demand for LBS in South Africa. This should be followed by an assessment of the capabilities of the existing cellular infrastructure and available LBS technology (see section 4.2.2) to determine if additional network or LBS technology is required.

The lessons drawn from global LBS experience discussed in section 4.4 have shown that the creation of partnerships, incubation of 3rd party initiatives and creation of flexible business models and revenue sharing is vital to provision of LBS. In addition, an LBS implementation strategy needs to be developed to determine whether LBS will be horizontally or vertically integrated, as discussed in section 4.4.1.5.

The process of determining suitable LBS application is a result of the available technology, partnerships, LBS integration strategy and an analysis of the market research. This leads to the development of a marketing strategy, and implementation phase and the development of suitable business models and pricing structures. The final stage is the actual provision of LBS over the cellular network.

The feedback loop for the system would consist of the continual market research and assessment of the LBS industry in order to prompt further improvement in the situation. This is necessary, as there is an inadequate understanding of the demand for LBS, as discussed in section 4.4.1.4.

This chapter has thus far used the SSM methodology discussed in section 3.1 to construct conceptual models of LBS in South Africa. It is vital to re-iterate that these conceptual models are not intended to represent reality. The soft systems thinking used to create the conceptual models aims to break the problem down into several SSM learning systems. These learning systems are incorporated into the conceptual framework developed in 3.4 as the means to generate the initial understanding required create a set of metrics and the Process-Outcomes model for LBS in South Africa.

The following section extracts relevant processes from the conceptual models that will be used to link the Process-Outcomes model to SSM in within a single framework of evaluation.

5.4 Identifying Processes for the Process-Outcomes Model

This section is fundamental to the construction of a model for the evaluation of LBS in South Africa, as it uses theory developed in chapter 3.4 to identify the conceptual connections between reductionist and holistic thinking.

In developing the conceptual framework to combine SSM and the Process-Outcomes model in section 3.4, it was proposed that the fundamental connection between the methodologies was their dependence on transformation processes. In line with the theory developed in section 3.4.2.3, this section analyses the three SSM conceptual models constructed in the previous section, and identifies a set of transformation processes for each system or conceptual model.

The processes identified in this section are incorporated into the Process-Outcomes model in 6.2.1 in the following chapter, where the processes are associated with stages of transformation and diffusion in order to structure the Process-Outcomes model.

It is important to reiterate that the identified processes are valid only from the perspective of the *Weltanschauung*, or world view, of evaluating LBS in South Africa for the purposes of this thesis, and only in the context of the conceptual learning models. For example, ensuring access to communication could arguably be regarded as a complex situation or soft system that requires an entire SSM evaluation in itself.

5.4.1 Government and Regulatory System Processes

This section identifies the transformation processes required in a system to regulate the cellular industry as it applies to LBS in South Africa. These processes are derived from the conceptual model depicted in Figure 5.7.

The processes are as follows:

1. Creation of telecommunications policy and legislation
2. Monitoring transfer of technology and access to communication
3. Allocation of spectrum and cellular licenses
4. Regulation of cellular tariffs
5. Creation of legislation to protect personal data and privacy
6. Provision of emergency services and public safety
7. Creation of access to information legislation to facilitate law enforcement

The above processes are broadly defined and could easily be further broken down into further processes and sub-systems. The author maintains that this is due to the fact that the source of these processes is the highest level system identified in the construction of the SSM conceptual models, and stresses that these processes are the aspects of the system that apply to LBS in South Africa.

5.4.2 Cellular Industry System Processes

This section identifies transformation processes required in a system to provide cellular services as they apply to LBS in South Africa. These processes are derived from the conceptual model shown in Figure 5.8.

The processes are as follows:

1. Evaluate Available Technology
2. Implement Cellular Network Infrastructure
3. Perform Market Research
4. Develop Marketing Strategy
5. Develop Business and Pricing Models
6. Provision of Cellular Services
7. Diversification of Cellular Services

The identification of these processes helps to structure the Process-Outcomes model and the selected metrics as they pertain to the cellular industry in the following chapter.

5.4.3 LBS Processes

This section identifies transformation processes required in a system to provide location-based cellular services in South Africa. These processes are derived from the conceptual model shown in Figure 5.9.

The processes are as follows:

1. Assess Global LBS Lessons
2. Research LBS Market Demand
3. Assess LBS Technology Requirements
4. Develop LBS Strategy

5. Implement LBS Enabling Technology
6. Create Strategic Partnerships
7. Implement LBS Applications
8. Facilitate the Adoption of LBS

The identification of these processes helps to structure the Process-Outcomes model and the selected metrics as they pertain to LBS in South Africa in the following chapter.

This section has extracted transformation processes from the SSM conceptual models as a means to link SSM and the Process-Outcomes model. All of these processes could in themselves be broken down into further systems and processes. The author maintains that the processes as defined in this section are specific enough to facilitate the organisation of the Process-Outcomes model, while remaining broad enough to encompass a wide range of metrics.

The following section concludes this chapter by reviewing the use of SSM to generate conceptual models prior to the construction of a set of metrics and the Process-Outcomes model in the following chapter.

5.5 Summary & Conclusions

This chapter has partially fulfilled the research objective 3 as defined in section 1.3, namely the construction of a model for the evaluation of LBS in South Africa. This has been achieved by using SSM theory to develop conceptual models of LBS in South Africa as per the conceptual framework proposed in section 3.4.

Section 5.1 presented an unstructured view of the problem of LBS in South Africa through the use of rich pictures, and analysed the situation from different perspectives using the SSM structure of Analyses One, Two and Three. Section 5.2 facilitated a shift from real-world thinking to systems thinking by identifying different levels of the problem and constructing root definitions for each sub-system. Section 5.3 converted the root definitions of the soft-systems into conceptual models.

Finally, section 5.4 analysed the conceptual models and identified transformation processes as per the conceptual framework developed in 3.4 and depicted in Figure 3.8. These processes are fundamental to this evaluation as they link the SSM conceptual models to the Process outcomes model, and thus rigorously combine holistic and reductionist thinking.

Furthermore, one of the primary justifications for selecting SSM was to generate a holistic understanding of LBS in South Africa. The conceptual learning models, along with the hard systems-thinking background provided in chapter 4, provide the contextual basis and the framework for the remainder of the evaluation.

The following chapter addresses the remainder of research objective 3 by completing the model for the evaluation of LBS in South Africa. This is achieved by hierarchically deriving a pool of metrics and constructing the Process-Outcomes model.

[i] Although mentioned in passing, CellC is not included in the evaluation of LBS in South Africa in this thesis for reasons previously stated in section 1.5, i.e. primarily because CellC did not exist when this research began.

6 CONSTRUCTION OF THE PROCESS-OUTCOMES MODEL

This chapter develops a set of metrics and constructs the Process-Outcomes model for evaluating LBS in South Africa, and in doing so, completes research object 3 as stated in section 1.3, the first part of which was addressed in the previous chapter.

Theory for combining SSM and the Process-Outcomes model was developed in section 3.4. Using this conceptual framework, chapter 5 built SSM conceptual models to holistically describe the complex situation of LBS in South Africa. In addition, key processes for each system, i.e. processes for each conceptual model, were identified according to the theory proposed in section 3.4.2. In this chapter, the soft-systems thinking expressed in chapter 5 is combined with the overview of LBS in chapter 4 to form a set of metrics and construct the Process-Outcomes model for the evaluation of LBS in South Africa.

This chapter consists of two primary parts. Firstly, a comprehensive set of metrics is constructed in section 6.1. This uses the abstraction process defined in section 3.2.3 to break down the complex phenomenon of LBS into a hierarchy of measurable aspects.

In order to conform to Geisler and Kostoff's definitions of a metric as encapsulating its purpose and data, as defined in section 3.2.2, each metric derived in section 6.1 is presented in Appendix A. Here, each metric is described and passed through the selection criteria defined in sections 3.2.4 and 3.4.2.4. If the metric passes the selection criteria, the data for the metric is presented and discussed in relation to other metrics where appropriate. As suggested in section 2.3.3, separating the metric selection and the metric data from the construction of the Process-Outcomes model itself allows the structure of the model to be separated from the data contents of the model, thus shifting the focus of the evaluation onto a guiding framework rather than the data itself.

Based on the set of selected metrics derived in 6.1, the second part of this chapter constructs the Process-Outcomes model for LBS services in South Africa, drawing on the SSM conceptual models and the transformation processes identified in the previous chapter to structure to the evaluation model.

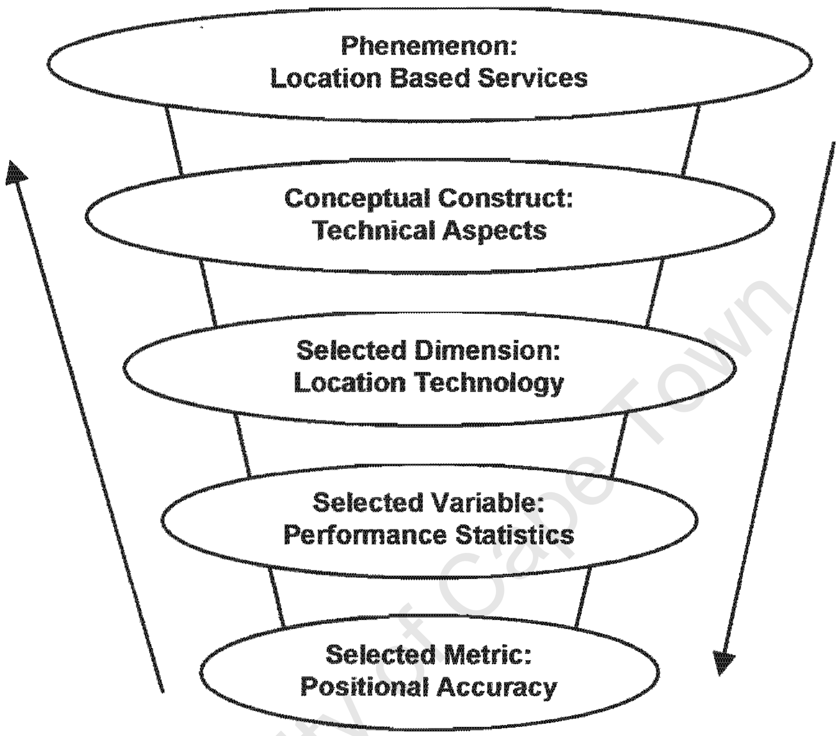
Finally, section 6.3 summarises and concludes the chapter, leading to the analysis of the metric data within the framework of the newly constructed evaluation model in chapter 7.

6.1 Construction of a Set of Metrics

This section constructs a hierarchical set of metrics according to the process depicted in Figure 3.3. At this stage it is appropriate to revisit the four aspects required for the evaluation of LBS in South Africa introduced in sections 1.1.2 and 1.2.2. In summary, these are:

1. Technological Aspects
2. Financial and Economic Aspects
3. Social Aspects
4. Political and Organisational Aspects

In terms of the abstraction process depicted in Figure 3.3, the general aspects listed above correspond to the conceptual constructs of the LBS phenomenon that need to be evaluated in order to achieve a holistic understanding of the problem. These constructs in turn get broken down into more specific aspects until a set of measurable metrics has been derived. An example relevant to LBS in South Africa is shown in the figure below, which drills down into the technological aspect of the phenomena until a measure of the positional accuracy of the location technology is reached:



Adapted from Geisler, 2000

Figure 6.1: Determining Measurable Aspects of LBS

This section follows the process shown above until a hierarchy of possible metrics is created. It is important to reiterate the issue identified in section 2.1.2, i.e. that the selection of measures depends on the evaluator's contextual understanding and therefore critical aspects may be overlooked. In this respect, the purpose of chapters 4 and 5 is in part to provide sufficient contextual understanding to reduce the effects of this problem.

A final note on the structure of this section in relation to Appendix A: each derived metric is allocated a unique number in the metric hierarchy diagrams. These numbers are used to identify the metrics in Appendix A and in the Process-Outcomes model presented later in this chapter. In addition, a list of metrics is provided at the beginning of this document to provide easy reference to the relevant pages for each metric.

6.1.1 Selected Dimensions

This section creates a high-level set of selected dimensions that are broken down into individual metrics in the sections that follow. The results of this high-level abstraction of LBS are shown in the figure below:

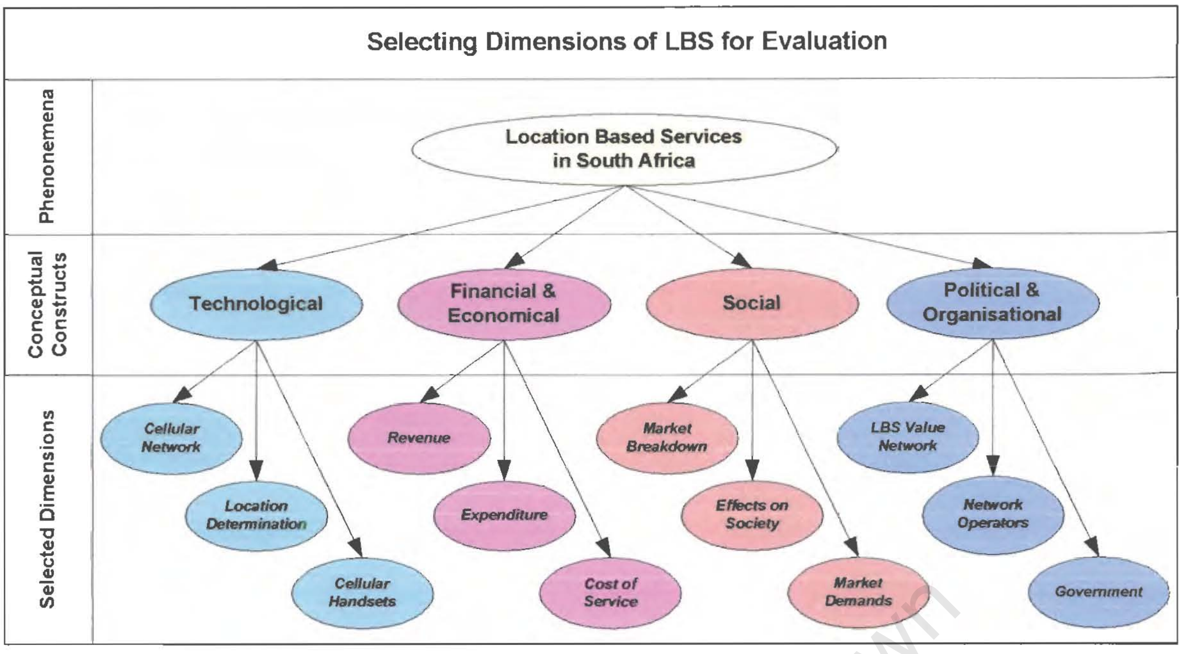


Figure 6.2: Abstracting LBS to Selected Dimensions

Figure 6.2 above shows how the conceptual constructs, i.e. the four perspectives required for the evaluation, were broken down into twelve selected dimensions. These dimensions are further broken down into individual metrics in the remainder of section 6.1.

Note that metrics across different conceptual constructs and dimensions are in many cases related to one another. The relationships between the metrics will be determined as a product of constructing the Process-Outcomes model later in the chapter, and are discussed in more detail in the analysis in chapter 7. Furthermore, the selected dimensions are only broken down into metrics to a level of detail that serves the purposes of this evaluation. For example, for the purposes of this thesis, the telecommunications policy in South Africa is evaluated at a higher level than the technical capabilities of the available location technology. This is in principle the same as the multi-level thinking in section 5.2.1, and it is therefore important to keep in mind that the metrics are addressed at a resolution that suits the purpose of the evaluation.

The following sections create metrics for each of the selected dimensions shown in Figure 6.2.

6.1.2 Technology Metrics

This section creates a set of technology metrics for the evaluation of LBS in South Africa. These metrics relate to the cellular network infrastructure, the location determination technology available in South Africa, and the capabilities of cellular handsets in use in South Africa.

The technology metrics are described, passed through the metric selection criteria, and presented in appendix A.1.

6.1.2.1 Cellular Networks

Figure 6.3 below shows the possible metrics for evaluating the cellular network infrastructure as it pertains to LBS in South Africa.

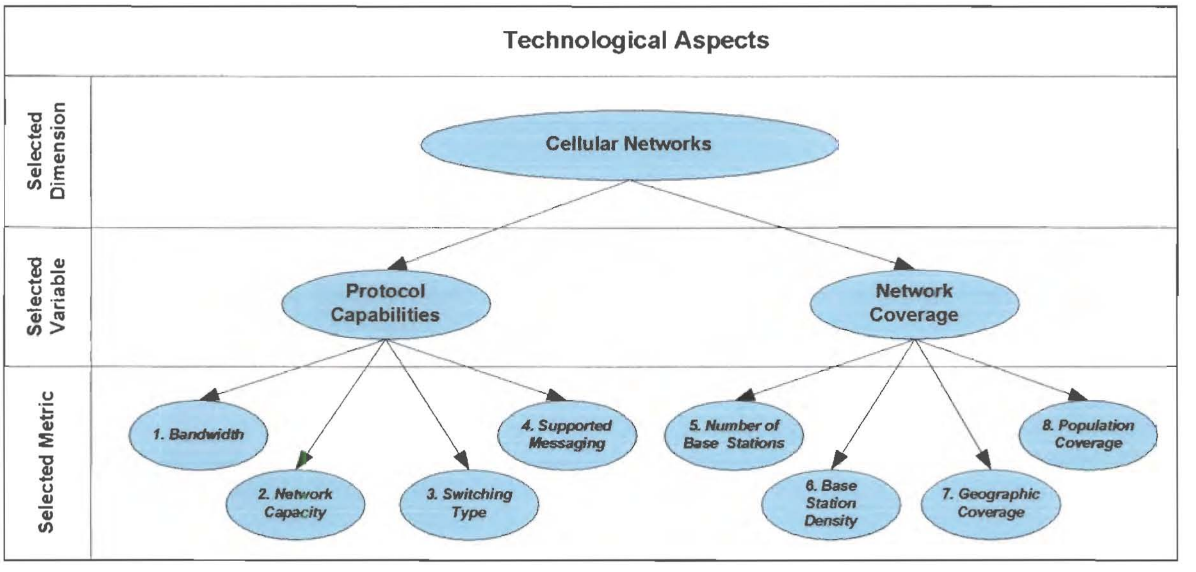


Figure 6.3: Cellular Network Metrics

Based on the technical discussions in chapter 4 and the discussions regarding the social issue of access to communication in section 5.1, the cellular network infrastructure in South Africa can be evaluated in terms of the capabilities of the implemented cellular networks and the network coverage.

Metrics for the evaluation of the network capabilities include the bandwidth (or data transfer rate), network capacity in terms of number of concurrent users, the network switching type and the supported data and messaging formats. Network coverage is measured by the number of base stations, the density of the base stations, the geographic coverage of the network, and the percentage of the population the network is capable of serving.

Section A.1.1 describes each of these metrics in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics that satisfy the criteria. Of the metrics shown in Figure 6.3, network capacity (A.1.1.2) and number of base stations (A.1.1.5) were rejected on the basis that they had no bearing on LBS, and are therefore irrelevant for the evaluation of LBS in South Africa.

6.1.2.2 Location Determination Technology

Figure 6.4 depicts the hierarchy of possible metrics for evaluating the location determination technology implemented on South African cellular networks.

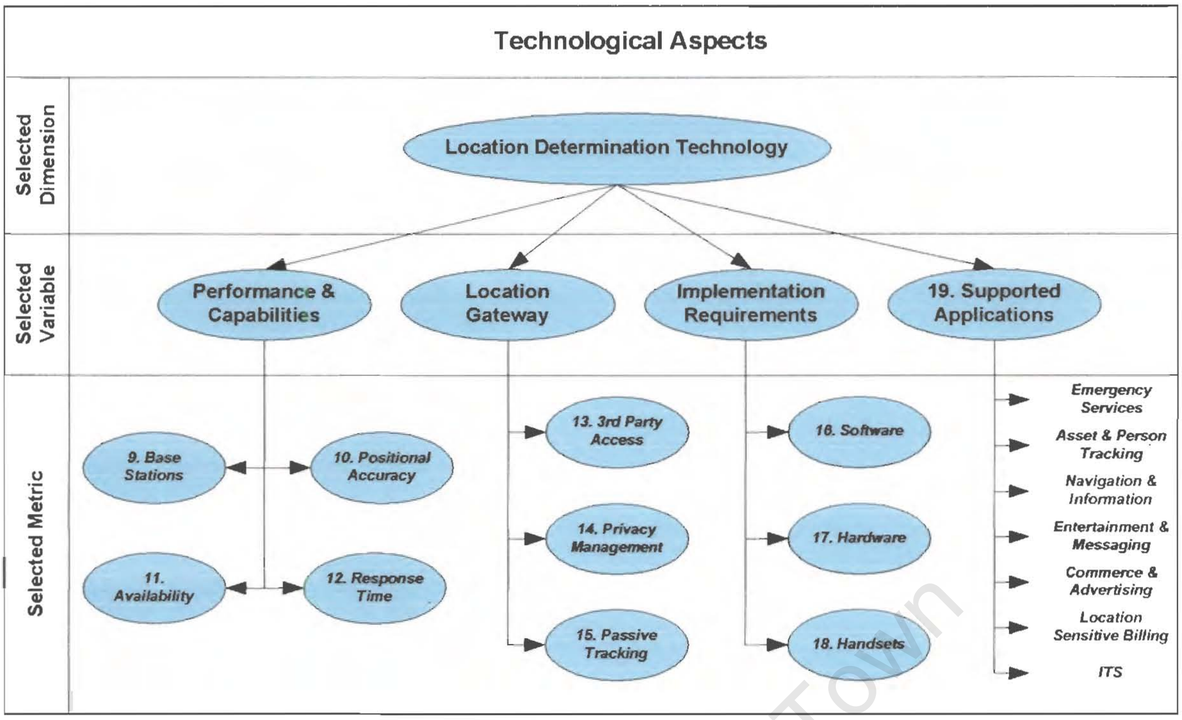


Figure 6.4: Location Determination Technology

Based primarily on the technical discussions in section 4.2.2 and the key success factors outlined in 4.4, location determination technology can be evaluated according to its performance and capabilities, the existence and characteristics of the location gateway, the implementation requirements, and the supported LBS applications.

Performance metrics of the location determination technology include positional accuracy, number of base stations, availability and response time. In terms of implementation requirements, section 4.2.2 identifies that the choice of location determination technology has associated costs for additional network software, network hardware, as well as potential implications for cellular handsets. Therefore, a measure of these requirements forms part of the hierarchy of possible metrics to evaluate the location determination technology.

Section 4.2.3 identified that capabilities of the location gateway should include the provision of 3rd party access, privacy management and the ability to passively track cell phones. Therefore, in addition to checking for the existence of a location gateway, a measure of the location gateway's capabilities should be included in the hierarchy of potential metrics.

Finally, the location determination technology needs to be assessed in terms of its ability to support the different classes of LBS applications defined in section 4.3.

Section A.1.2 describes each of these metrics in detail, evaluates them in terms of the metric selection criteria, and presents the case study data for the metrics that satisfy the criteria. All of the metrics shown in Figure 6.4 passed the selection criteria and were thus selected for use in the Process-Outcomes model for the evaluation of LBS in South Africa.

6.1.2.3 Cellular Handsets

Figure 6.5 below shows the hierarchy of possible metrics for evaluating the cellular handsets in use on South African cellular networks.

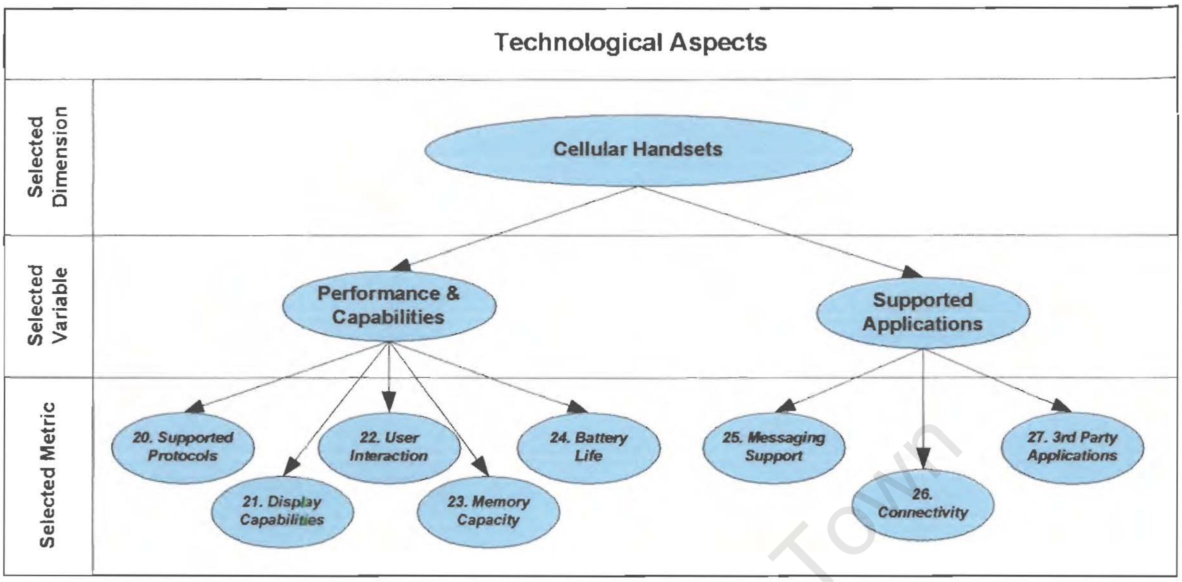


Figure 6.5: Cellular Handsets Metrics

Based primarily on the technical discussions in section 4.2.5, cellular handsets can be evaluated in terms of their technical performance and specifications, and the supported applications because of those specifications.

The possible basic measures of the performance and capabilities of a cellular handset include the display, user interaction, memory capacity, supported data protocols, and battery life. Vital to an evaluation of value-added LBS services would be the evaluation of the applications supported, including the messaging, connectivity capabilities and support for 3rd party applications.

Section A.1.3 describes each of these metrics in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics according to the classes of cellular handsets defined for the purposes of this thesis in section 4.2.5. Of the metrics shown in Figure 6.5 above, only battery life (A.1.3.5) was excluded from the Process-Outcomes model on the basis that it is not a relevant metric for the evaluation of LBS in South Africa.

6.1.3 Financial and Economic Metrics

This section creates a set of financial and economic metrics for the evaluation of LBS in South Africa. These metrics relate to the revenue generated from cellular networks, cost of operating the network, and the cost of cellular services in South Africa.

The financial and economic metrics are described and presented in appendix A.2.

6.1.3.1 Revenue

Figure 6.6 below shows the hierarchy of possible metrics for evaluating the revenue generated by the provision of cellular services in South Africa.

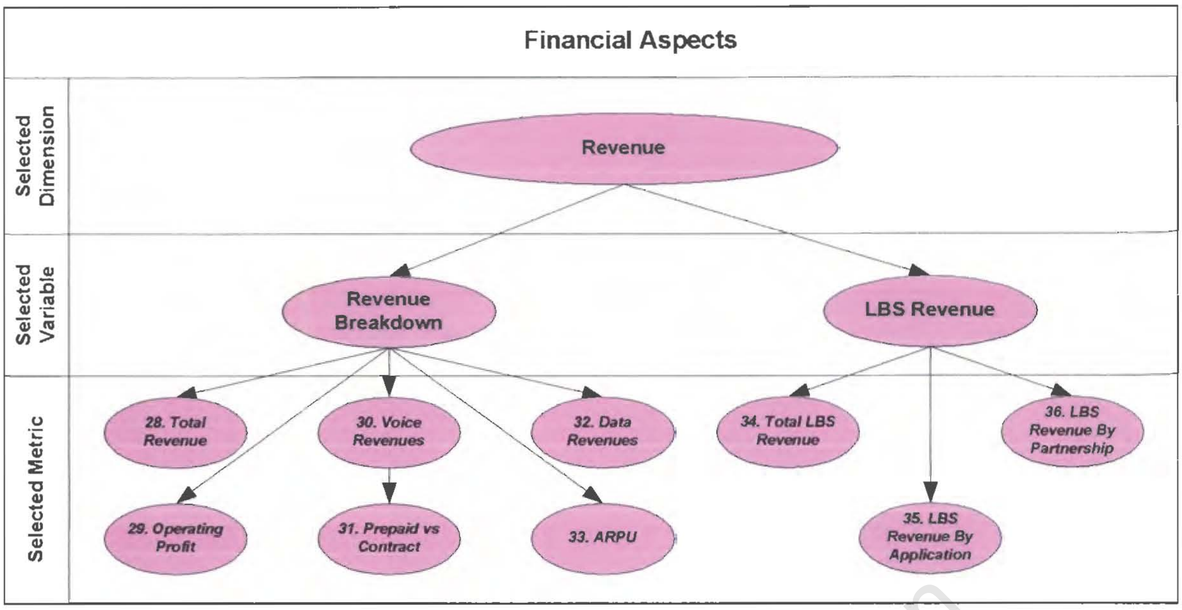


Figure 6.6: Revenue Metrics

For the purposes of this thesis, revenue metrics can be broken down into metrics relating to the revenue generated by cellular services and metrics specific to revenue generated by LBS.

The total revenue provides the benchmark for comparison to all other revenue metrics, while operating profit provides insight into the profitability of the cellular industry in South Africa.

To understand the sources of the revenue, the percentages of revenue generated from voice and data services need to be evaluated. This also provides insight into the usage patterns of voice and data services. To relate the revenue to its source market sector, the metrics for Average Revenue per User (ARPU) and prepaid vs. contract revenues are included.

In order to evaluate LBS revenue, the total revenue generated by LBS should be evaluated against LBS revenue from each LBS application as well as against the LBS revenue generated through each LBS partnership. This helps to assess the value derived through strategic partnerships with members of the LBS Value Network.

Section A.2.1 describes each of these revenue metrics in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics. Of the metrics shown in Figure 6.6 above, operating profit (A.2.1.2) is excluded as there is not enough data available to meaningfully relate the metric to its revenue and expenditure components. Furthermore, all of the revenue metrics for LBS (A.2.1.7, A.2.1.8 and A.2.1.9) are excluded on the basis that none of the data is available to the author. This represents a significant gap in the case study data, and will be discussed in more detail in the assessment of the evaluation model in chapter 7.

6.1.3.2 Expenditure

Figure 6.7 below shows the hierarchy of possible metrics for measuring the expenditure in the context of evaluating LBS in South Africa.

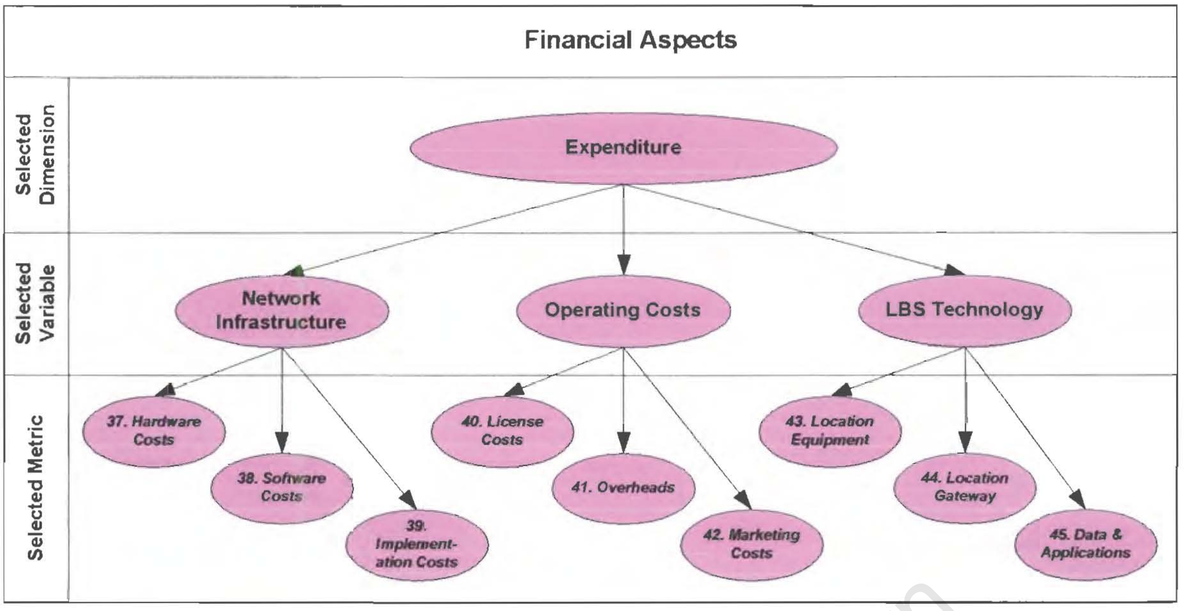


Figure 6.7: Expenditure Metrics

Expenditure metrics are broken down into network infrastructure costs, operating costs, and costs associated with implementing LBS technology.

Network infrastructure costs can be further broken down into the cost the cellular network technology, costs of the required software, and costs of implementing and maintaining the purchased technology in order to operate the cellular network.

Operating costs include the costs of the licenses to operate the cellular networks, overhead costs associated with running the networks as a business, and the marketing costs associated with facilitating the adoption of cellular services by society.

The metrics to evaluate the costs of LBS technology include the additional network equipment costs, location gateway costs and the costs of acquiring or creating the LBS applications and associated data.

Section A.2.2 describes each of the expenditure metrics in detail, evaluates them in terms of the metric selection criteria. The analysis of these metrics shows that none of them are fit for inclusion into the model of evaluation for LBS in South Africa, as only some of these metric data is available. The lack of data for the majority of the expenditure metrics means that there is no basis for comparison. Thus, all of the expenditure metrics are excluded from the evaluation model for the purposes of this thesis. As with the revenue metrics for LBS discussed in section 6.1.3.1, this represents a gap in the research data, and will be revisited in the assessment of the evaluation model in chapter 8.

6.1.3.3 Cost of Service

Figure 6.8 below shows the hierarchy of possible metrics for measuring the cost of cellular services to consumers as they pertain to LBS in South Africa.

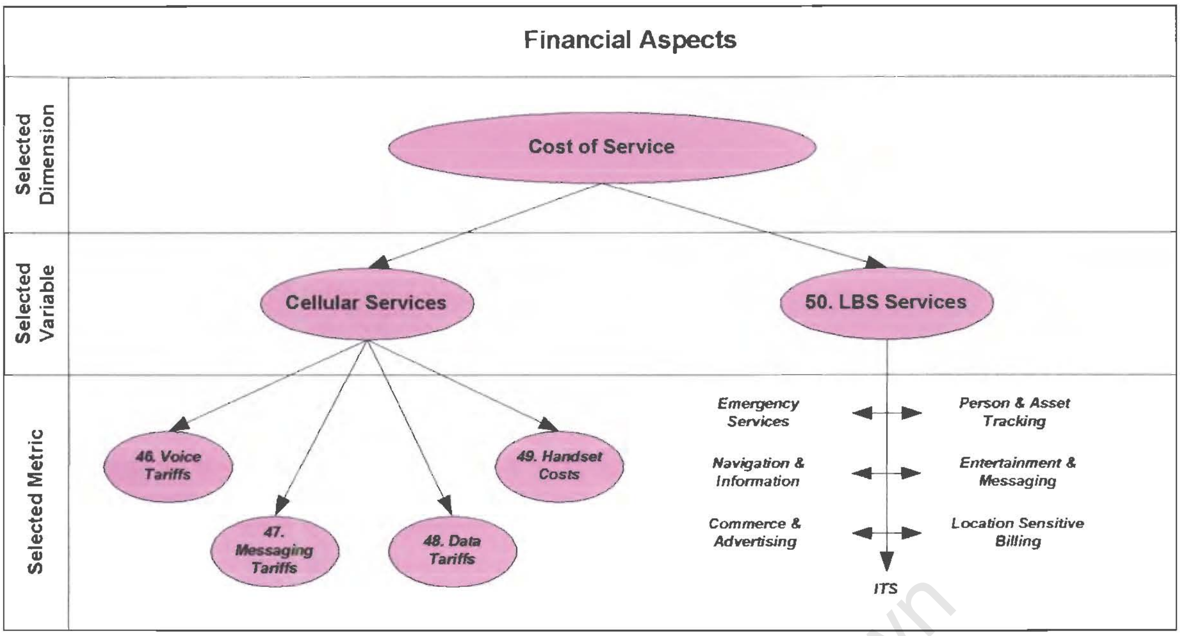


Figure 6.8: Cost of Service Metrics

The cost of services metrics for the evaluation of LBS in South Africa are divided into the costs of general cellular services and the costs of LBS services.

Cost of service for cellular services can be broken down into voice tariffs, messaging tariffs, data tariffs, and the costs of cellular handsets. Understanding these metrics will provide the basis for the discussion and comparison of the costs of LBS services, which are broken down into the costs of each class of LBS application as defined in section 4.3.

Section A.2.3 describes each of the cost of service metrics in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics. The analysis of these metrics shows that all of them are relevant to the evaluation, and hence they are all included in the model for the evaluation of LBS in South Africa for the purposes of this thesis.

6.1.4 Social Metrics

This section creates a hierarchy of potential social metrics for the evaluation of LBS in South Africa. These metrics include the analysis of the market structure, the analysis of market demands in terms of cellular and LBS services, and metrics to evaluate the effects of LBS on society in South Africa.

6.1.4.1 Market Analysis

Figure 6.9 below shows the metrics for analysing the existing cellular market in South Africa.

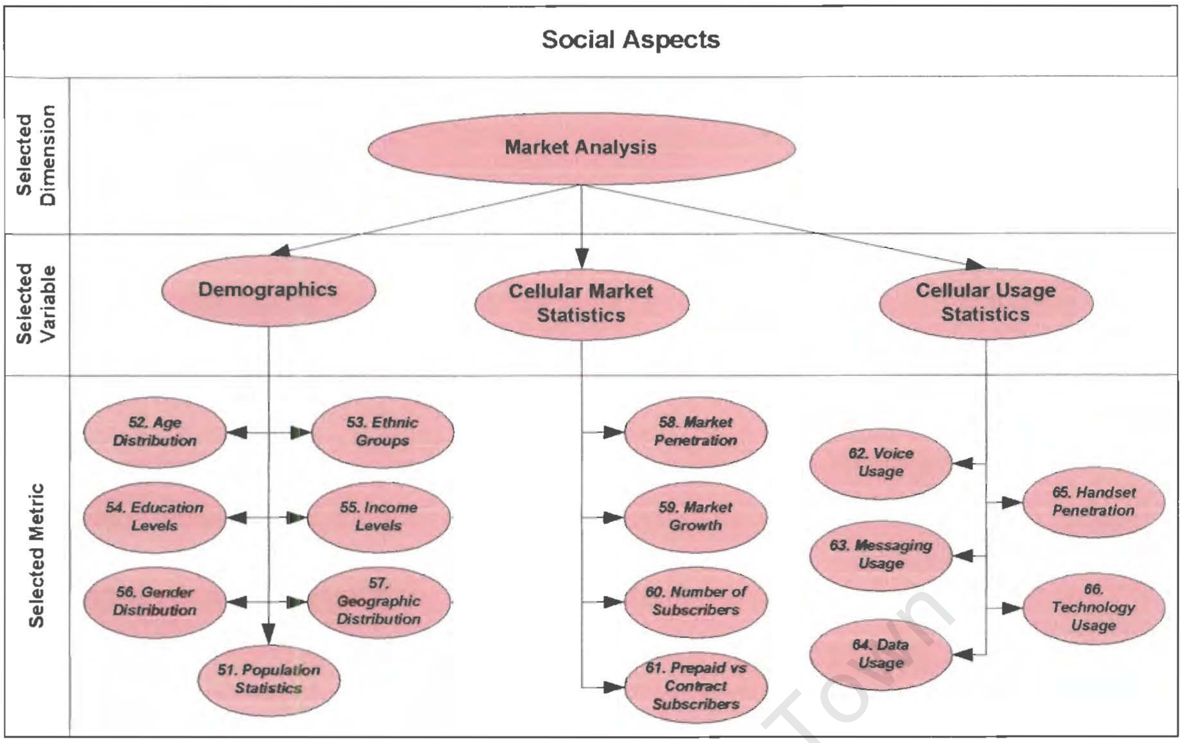


Figure 6.9: Metrics for Market Analysis

The analysis of the social situation in South Africa in sections 5.1.1.3 and 5.1.2.3 indicates that the implications of the demographics of South Africa, the analysis of the cellular market, and understanding the cellular usage patterns of cellular users could aid the evaluation of LBS in South Africa.

Demographic metrics include an analysis of the age, race, education, income, gender and geographic distribution of the population of South Africa versus the same metrics for cellular users in South Africa. These statistics could also be used to determine how well the sample groups of the various market surveys used in this thesis are representative of the population of the country, thus assisting in determining the quality and limitations of the survey data.

The metrics for the cellular market include the total number of users, market penetration, market growth, and the number prepaid vs. contract users. These metrics should include current statistics, predictions for the future, and comparisons to other regions.

In order to understand how receptive the market would be to new applications such as LBS, the usage patterns of existing cellular services need to be evaluated. These could include the market penetration of the different classes of cellular handsets (as defined in section 4.2.5), usage of different cellular technologies, and the relative usage patterns of voice, messaging and data services. As with the market statistics, this should include current statistics as well as predictions for the future and comparisons to other regions.

Section A.3.1 describes each of the market analysis metrics in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics. Of these potential metrics, only gender (A.3.1.6) was excluded from the evaluation model as it was deemed irrelevant to the evaluation of LBS in South Africa.

6.1.4.2 Market Demands & Trends

Figure 6.10 below shows the hierarchy of possible metrics for evaluating the market demands for various cellular services as they pertain to the evaluation of LBS in South Africa.

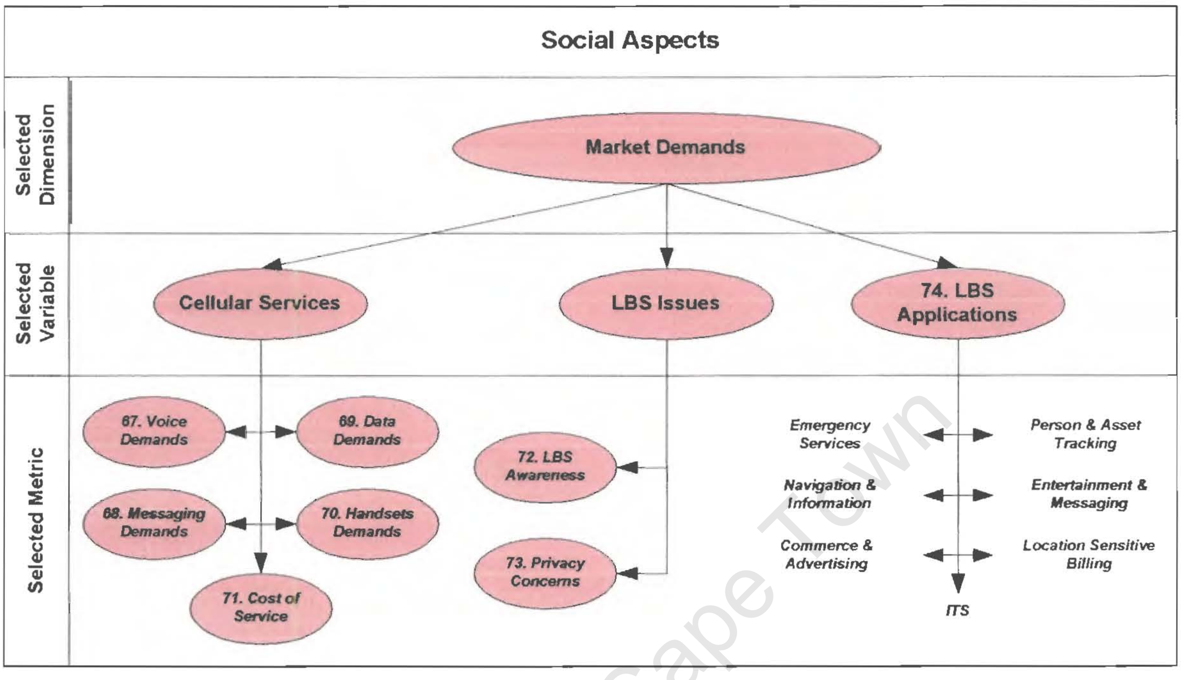


Figure 6.10: Metrics for Market Demands

Metrics to evaluate market demand can be broken down into the demand for cellular services, consumer opinions regarding LBS, and the demand for specific LBS applications.

The demand for cellular services can be measured by demand for voice, messaging and data services. They could also include measures of the cost of service demands and the demand for different classes of cellular handsets.

Section 5.1.2.3 indicated that a potential issue for LBS was consumer concerns regarding personal privacy and ability of the South African market to afford additional LBS services such as LBS. Therefore, potential metrics include the evaluation of public opinion regarding personal privacy, consumer concerns over costs of cellular services, and the level to which users are aware of LBS and the potential advantages or disadvantages thereof.

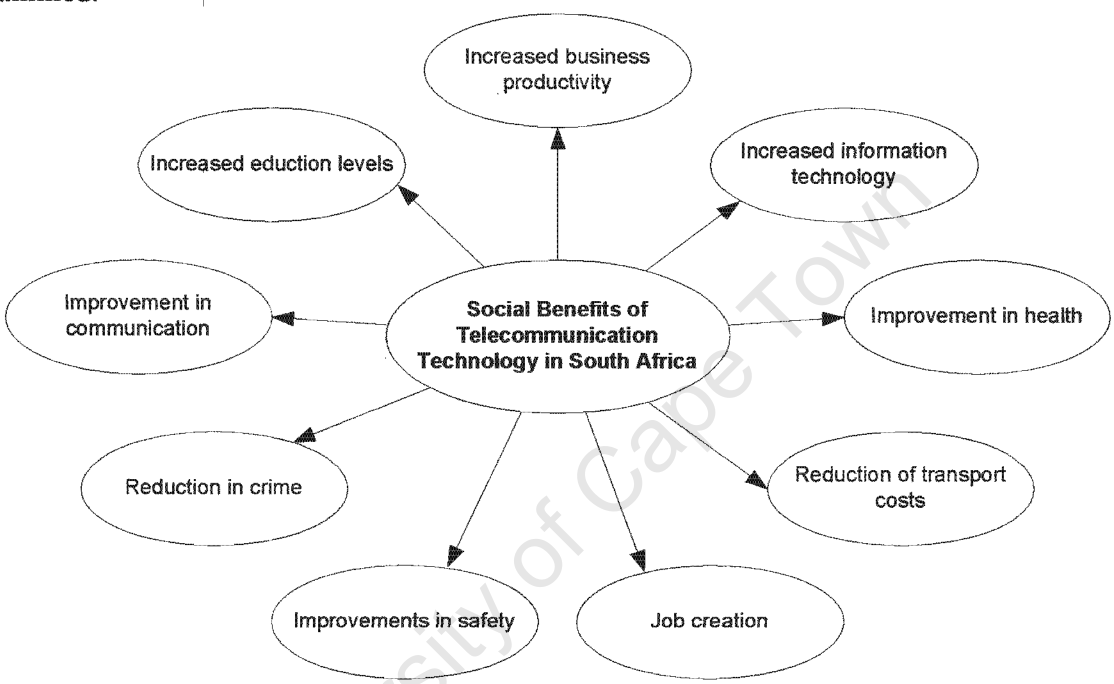
Finally, market demand metrics for LBS need to include an evaluation of the demand for each class of LBS application as defined in section 4.3.

Section A.3.2 describes each of the potential market demand metrics in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics. Of the potential metrics, the market demand for voice, messaging and data services (A.3.2.1, A.3.2.2, and A.3.2.3) were excluded on the grounds that the data was not directly available. However, it could be argued the relative revenue and relative usage metrics for the different cellular services provide a suitable approximation for these metrics. Nevertheless, these metrics were not used for the evaluation of LBS in South Africa in the context of this thesis.

6.1.4.3 Effects on Society

This section creates the hierarchy of metrics for the evaluation of the effects of LBS on society.

Geisler maintains that the long term effects of technology to society and the economy are the ultimate outputs of science and technology, and the lack of tangible effects often relates to the stage of innovation of the scientific or technological item in question (Geisler 2000). This relates directly to the case of LBS in South Africa, as the technology is relatively new and thus has not progressed far along enough the innovation continuum for the effects on society to be immediately evident. Therefore, the potential effects of LBS need to be examined.



Adapted from Pieterse (2001)

Figure 6.11: Social Benefits of Telecommunications Technology in South Africa

By cross referencing the above benefits of telecommunications technology in South Africa proposed by Pieterse (Pieterse 2001) with Geisler's list of typical ultimate outputs of technology (Geisler 2000) and the social analysis in sections 5.1.1.3 and 5.1.2.3, a hierarchy of metrics of the potential effects of LBS on society was constructed. These metrics are shown below in Figure 6.12.

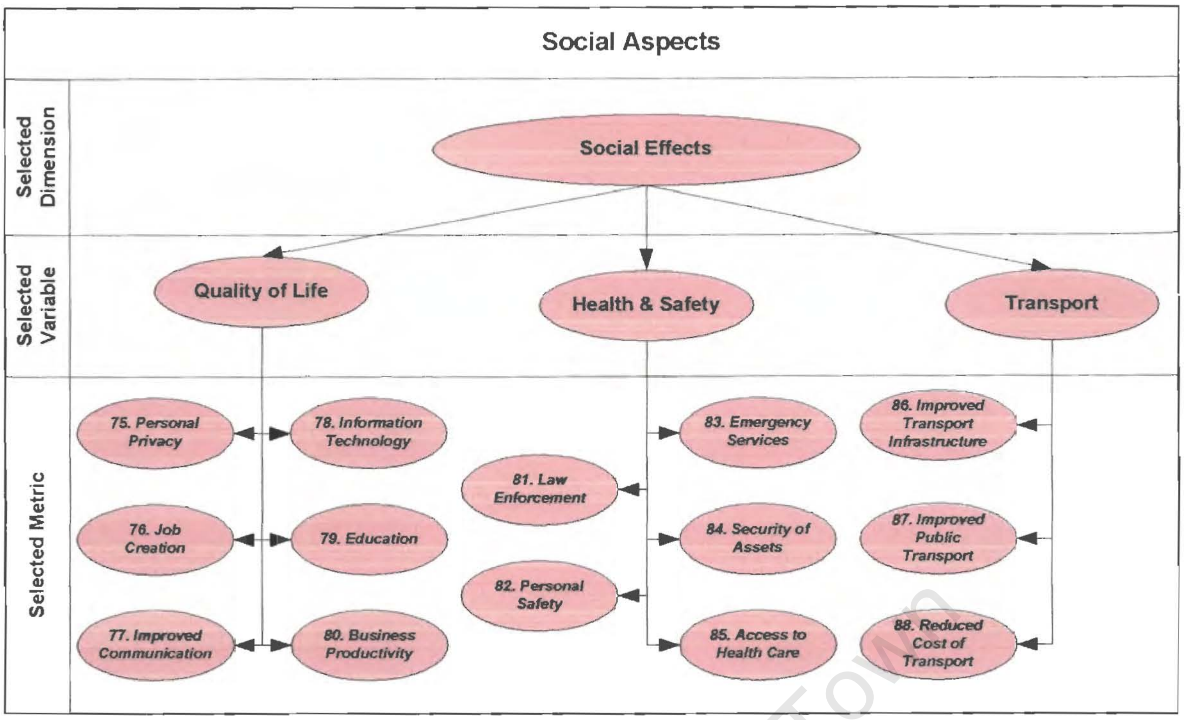


Figure 6.12: Metrics for Social Benefits

Metrics to evaluate the effects of LBS to society can be broken down into those pertaining to general quality of life, health and safety, and improvements in transport.

Quality of life indicators include the effects on personal privacy, the number of jobs created, improvements in communication, information technology and education, and improved business productivity.

Health and safety metrics include the effect on law enforcement and crime levels, improvement of emergency services, security of assets, improvements of personal safety and improvements in access to health care. Transport metrics could include the improvement of the transport infrastructure, improved public transport and the reduction in the cost of transport.

Section A.3.3 describes each of the potential social benefit metrics in detail, evaluates them in terms of the metric selection criteria. Due to the lack of measurable data, the conclusion reached was that LBS has not progressed not far enough down the innovation continuum to have had any significant or tangible effect on society. Therefore, all of the metrics for the social benefits of LBS are included in the model of evaluation for the purposes of this thesis.

6.1.5 Political & Organisational Metrics

This section creates a set of potential metrics to evaluate the political and organisational aspects of LBS in South Africa. These metrics consist of organisational issues concerning the network operators, government organisational and political factors, and metrics concerning the LBS Value Network in South Africa.

6.1.5.1 Network Operators

Figure 6.13 below shows the hierarchy of possible metrics to evaluate organisational issues concerning the cellular network operators that may influence LBS in South Africa.

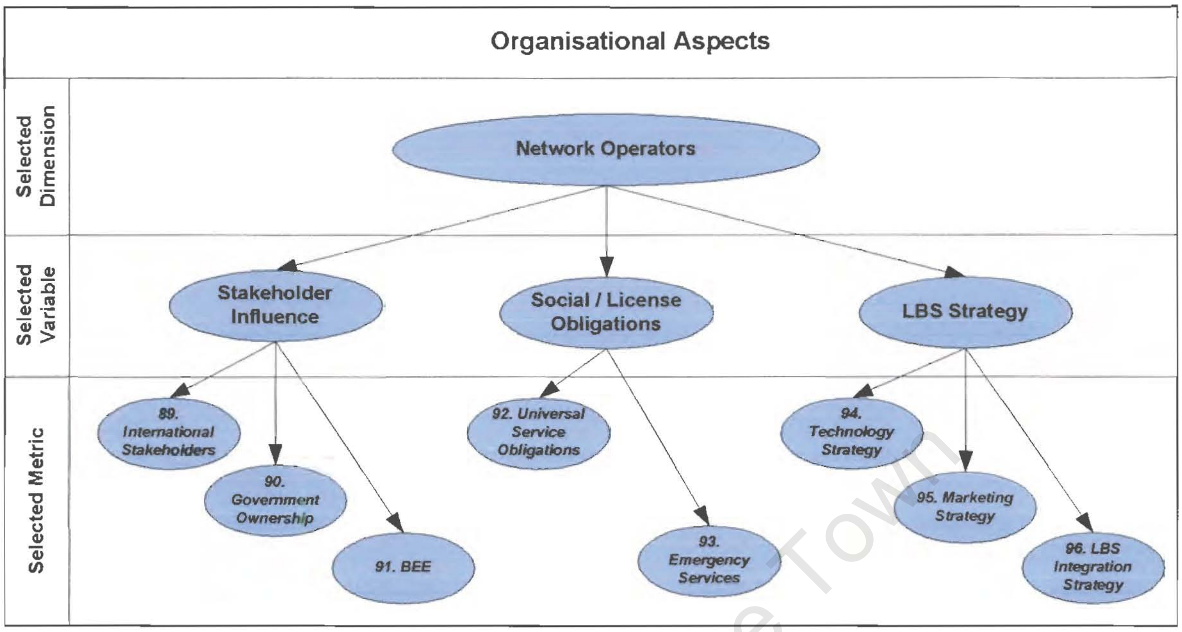


Figure 6.13: Metrics for Network Operators

The organisational metrics for network operators can be broken down into issues relating to the stakeholders, obligations in terms of license agreements, and the strategy adopted for LBS.

Stakeholder metrics could include the role of international stakeholders, the role of government, the role of Black Economic Empowerment (BEE) organisations and the assessment of the positive or negative effects these stakeholders may have for LBS within the organisation.

The obligations of the networks in terms of USA, license agreements and emergency services need to be evaluated to determine their effect on the provision of cellular services, and more specifically their effect on LBS.

Finally, the strategy of the network operators with respect to LBS needs to be evaluated. This includes their approach to LBS technology, LBS marketing strategy, and the strategy adopted for the horizontal or vertical integration of LBS within the existing cellular service, as discussed in section 4.4.1.5.

Section A.4.1 describes each of the potential organisational metrics for network operators in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics. Of the potential metrics shown in Figure 6.13, the influence of BEE stakeholders (A.4.1.3) was excluded on the basis of being an overly complicated and political issue that had no direct bearing or relevance to LBS in South Africa.

6.1.5.2 Government & Regulatory Boards

Figure 6.14 below shows the hierarchy of possible metrics to evaluate the organisational and political issues of the South African government and regulatory authorities that may influence LBS in South Africa.

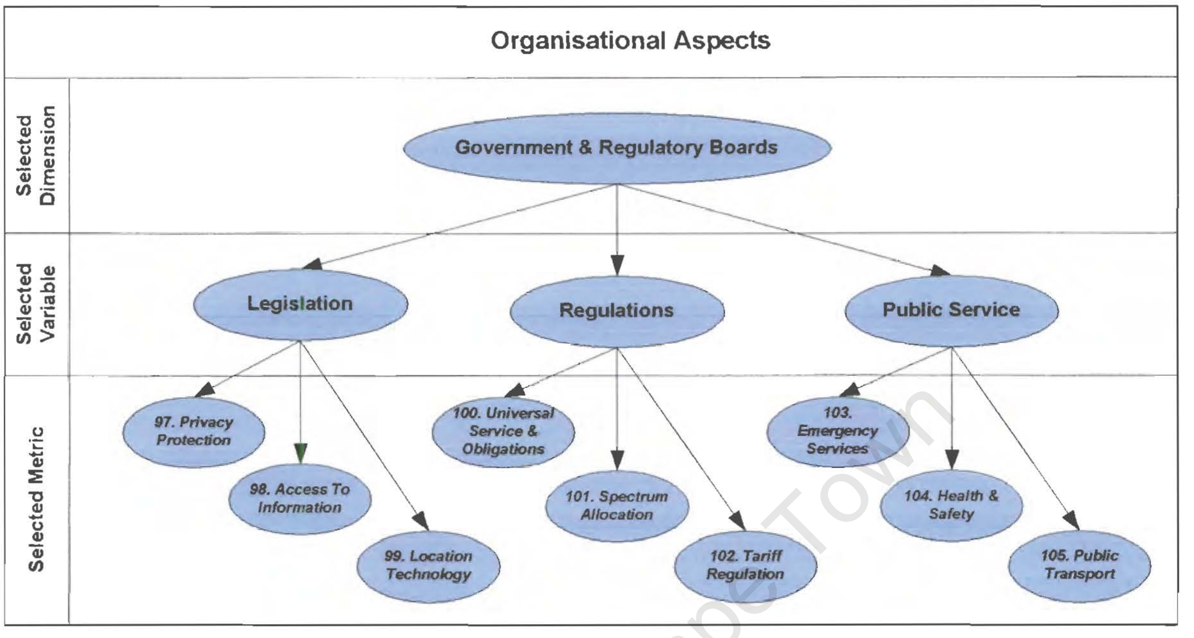


Figure 6.14: Metrics for Government

Government and regulatory authority organisational metrics can be broken down into metrics regarding legislation, telecommunications policy and regulations, and public service issues that may affect or be affected by LBS.

Legislation includes legislation to protect personal privacy, as well as legislation to allow access to information. This follows from the discussion on the need to maintain a balance of personal privacy and public safety as discussed in section 4.4.1.6. In addition, legislation that may promote or prohibit LBS technology needs to be evaluated and understood, as mandated location technology has been identified as a catalyst for the LBS industry (see section 4.1.1).

Regulatory issues include the evaluation of the USA policy, spectrum allocation and licensing, and tariff regulation in the cellular industry. In terms of public service, government policy on emergency services, health and safety and transport need to be evaluated in order to understand their impact or potential impact on LBS.

Section A.4.2 describes each of the potential government organisational metrics in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics. All of these metrics are included in the model for the evaluation of LBS in South Africa. However, it must be reiterated that these metrics can only be covered in the level of detail sufficient to understand the impact on LBS. A full analysis of these metrics is both irrelevant to the evaluation and beyond the scope of this thesis.

6.1.5.3 LBS Value Network

Figure 6.15 below depicts the hierarchy of possible metrics to evaluate the LBS Value Network in South Africa.

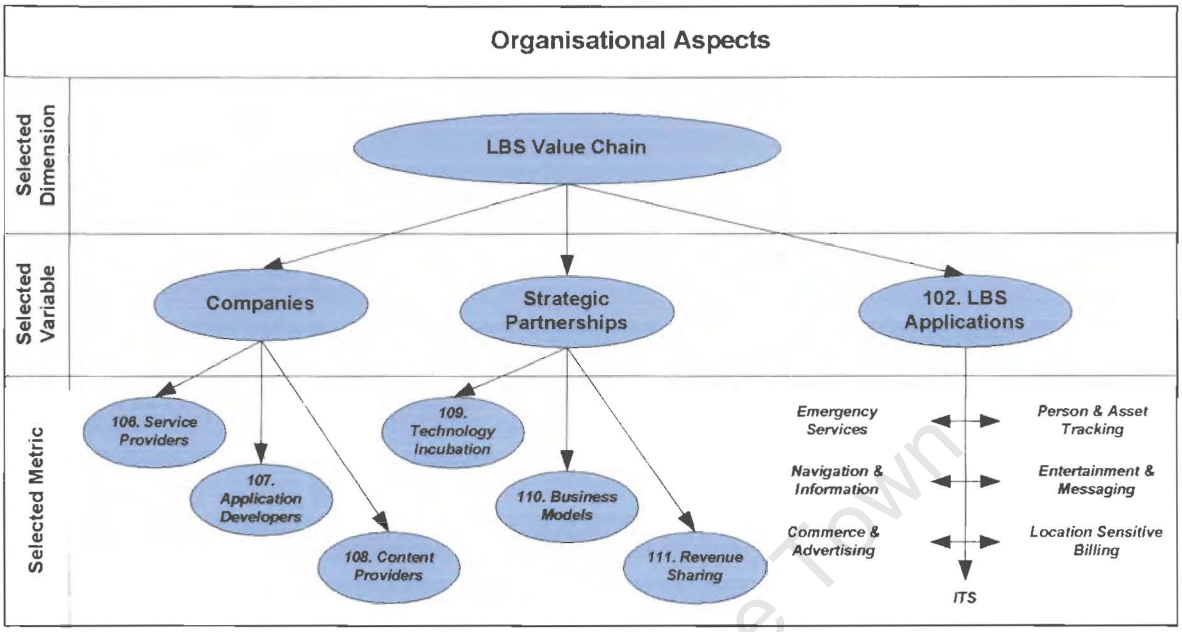


Figure 6.15: Metrics for LBS Value Network

Metrics to evaluate the LBS value network in South Africa include an examination of the companies involved in the value network, the strategic partnerships with network operators, and the LBS products and applications that have been brought to market as a result.

Section 4.2 introduced the LBS value network and outlined the different roles required to provide LBS services. Thus, the existence and activities of service providers, application developers and content providers need to be evaluated.

The LBS value network is defined in part by the partnerships between the companies that take part in it. Therefore, metrics should include an analysis of how network operators have facilitated the development of the value network through technology incubation, the business models that exist between the partners and the level of revenue sharing with stakeholders in the LBS value network.

Finally, the outputs of the LBS value network need to be evaluated. In other words, the number, nature and relative success of the LBS applications that have already been implemented in South Africa need to be assessed. As with all other metrics directly concerning LBS applications, this should be done in terms of the classes of LBS applications as defined in section 4.3.

Section A.4.3 describes each of the potential organisational metrics for the LBS value network in detail, evaluates them in terms of the metric selection criteria, and presents the data for the metrics. All of these metrics are included in the model for the evaluation of LBS in South Africa.

6.1.6 Summary of Hierarchy of Metrics

This section summarises this chapter thus far in preparation for the final stage of the construction of the model of evaluation in section 6.2. Section 6.1 constructed a comprehensive hierarchy of potential metrics for the evaluation of LBS in South Africa. This was done by using the reductionist technique of progressively breaking down the problem into smaller, more manageable components until measurable aspects where reached.

As stated in section 2.1.2, determining which aspects of the problem to measure is often a problematic task which is affected by the biases and intentions of the evaluator. In an attempt to overcome these problems, the hierarchy of metrics was derived from a contextual understanding of the problem generated by the descriptive overview of LBS technology in chapter 4 and the SSM conceptual models for LBS in South Africa developed in chapter 5.

The hierarchy of metrics presented in this section are tightly integrated with the detailed presentation of these metrics in Appendix A. Together, these provide a set of measures and the corresponding data which allow us to construct the Process-Outcomes model as a framework for the subjective, holistic analysis of LBS in South Africa in chapter 7.

The following section completes the construction of the model of evaluation by building the Process-Outcomes model, thereby completing research objective 3 as stated in section 1.3.

6.2 Construction of Process-Outcomes Model

This section constructs the Process-Outcomes model for LBS in South Africa, thereby completing the construction of the combined model of evaluation based on the theory developed in section 3.4.

The construction of the Process-Outcomes model occurs in 3 phases. Section 6.2.1 examines the SSM conceptual models developed in chapter 5, and determines how the sub-systems represented by the conceptual models relate to each other in terms of the temporal stages of innovation of the Process-Outcomes model introduced in section 3.3.2. This analysis is extended in section 6.2.2, which maps the transformation processes identified for each SSM conceptual model to stages of transformation and diffusion of the Process-Outcomes model, as per the theory presented in section 3.4.2.3.

Finally, section 6.2.3 associates the selected metrics presented in the previous section with the appropriate transformation processes from the conceptual models. According to the theory proposed in section 3.4.2.5, this inherently associates the metrics with the appropriate outcome stage of the Process-Outcomes model, thereby rigorously fusing SSM thinking with the Process-Outcomes model.

6.2.1 SSM Conceptual Models and Stages of Innovation

An initial examination of the conceptual models and the processes identified in chapter 5 in conjunction with the selected metrics showed that a single Process-Outcomes model was not sufficient to accurately describe the situation. In other words, the relationships between the systems, processes and metrics within a framework of the Process-Outcomes model could only be represented by creating a separate Process-Outcomes model for each sub-system, where the individual Process-Outcomes models are offset from each other with respect to stages of innovation.

To explain this concept by means of an example, consider metric 102, the allocation of spectrum and awarding of cellular licenses by ICASA. Only once the spectrum has been allocated and the licences have been awarded can the network operators implement the appropriate technology and provide cellular services. Similarly, only once the cellular network is delivering basic voice services can network operators consider introducing value-added services such as LBS. Thus, each conceptual model represents a system that is at a different stage of innovation as defined by the Process-Outcomes model.

This introduced an additional and unexpected layer of complexity into the evaluation model, as the situation needs to be represented by 3 inter-related Process-Outcomes models, all offset from each other in terms of temporal stage of progress. This is shown conceptually in the figure below:

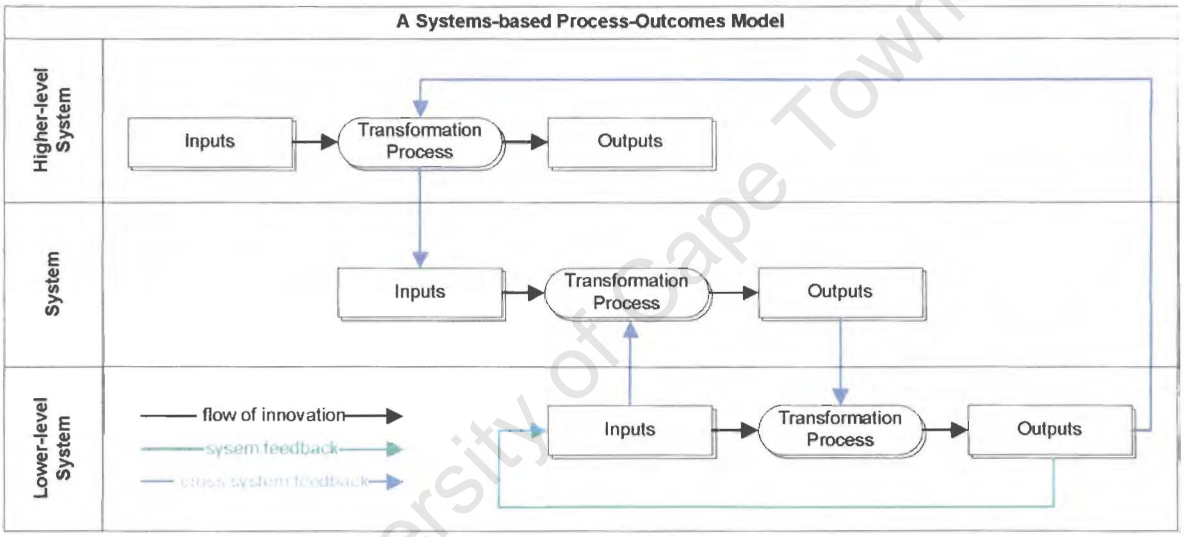


Figure 6.16: Conceptual View of a Systems-based Process-Outcomes Model

An important aspect of the systems-based Process-Outcomes model shown in the figure above is the existence of a number of feedback loops or connections. These connections can either be within a single level of Process-Outcomes model, i.e. a system feedback loop, or can provide linkages between different levels of Process-Outcomes models, i.e. a cross system feedback loop.

The feedback loops define the relationships between processes and metrics not accounted for by the flow of innovation. In addition, the cross-system feedback loops define the relationships between processes and metrics from different levels or systems.

6.2.2 Associating Processes with Stages of Transformation

As per the ideas presented in section 3.4.2.3, the processes identified in section 5.4 were associated with the stages of transformation and diffusion of the Process-Outcomes model, which were described previously in section 3.3.3.

A weakness of the Process-Outcomes model identified in section 2.3.3.4 was that the specified stages of transformation processes may not accurately represent the flow of S&T for a particular evaluation situation. This weakness was encountered while trying to associate the processes identified from the conceptual models with stages of transformation of the Process-Outcomes model. For example, the initial stage of the Process-Outcomes model described in section 3.3.3.1 is the stage of S&T processes, which describes a stage of pure academic research process. This stage of transformation was not relevant to the evaluation of LBS in South Africa, as there were no pure research inputs or outputs associated with the evaluation. Thus, it was necessary to redefine the stages of transformation and diffusion processes of the Process-Outcomes model for the purposes of this thesis in order to make them more generic.

Therefore, the stages of transformation and diffusion processes of the Process-Outcomes model used for the evaluation of LBS in South Africa are as follows:

A. Initial Processes
B. Transformation Processes in the Organisation
C. Transformation Processes in Social and Economic Sub-Systems
D. Transformation Processed in Society and the Economy

The only change from the original stages of transformation processes defined in section 3.3.3 is the first stage, which has been broadly defined to include the processes facilitating market research, technology research and assessment of global LBS lessons.

As per the concepts outlined in the previous section, the processes are displayed in the same levels as their source conceptual models.

6.2.3 Associating Metrics with Stages of Inputs/Outcomes

The Process-Outcomes model is completed by associating the selected metrics with stages of outcomes and with the appropriate transformation and diffusion processes, as per the ideas proposed in section 3.4.2.5. These were identified as part of the metric selection in Appendix A.

The resulting complete model of evaluation for LBS in South Africa is presented over the following four pages in Figure 6.17, Figure 6.18, Figure 6.19 and Figure 6.20. Metrics that have failed the selection criteria, and thus have been excluded from the model for the purposes of this thesis, are shown as crossed-out in red. This is to indicate that in subsequent evaluations, these metrics should be reconsidered for inclusion in the model.

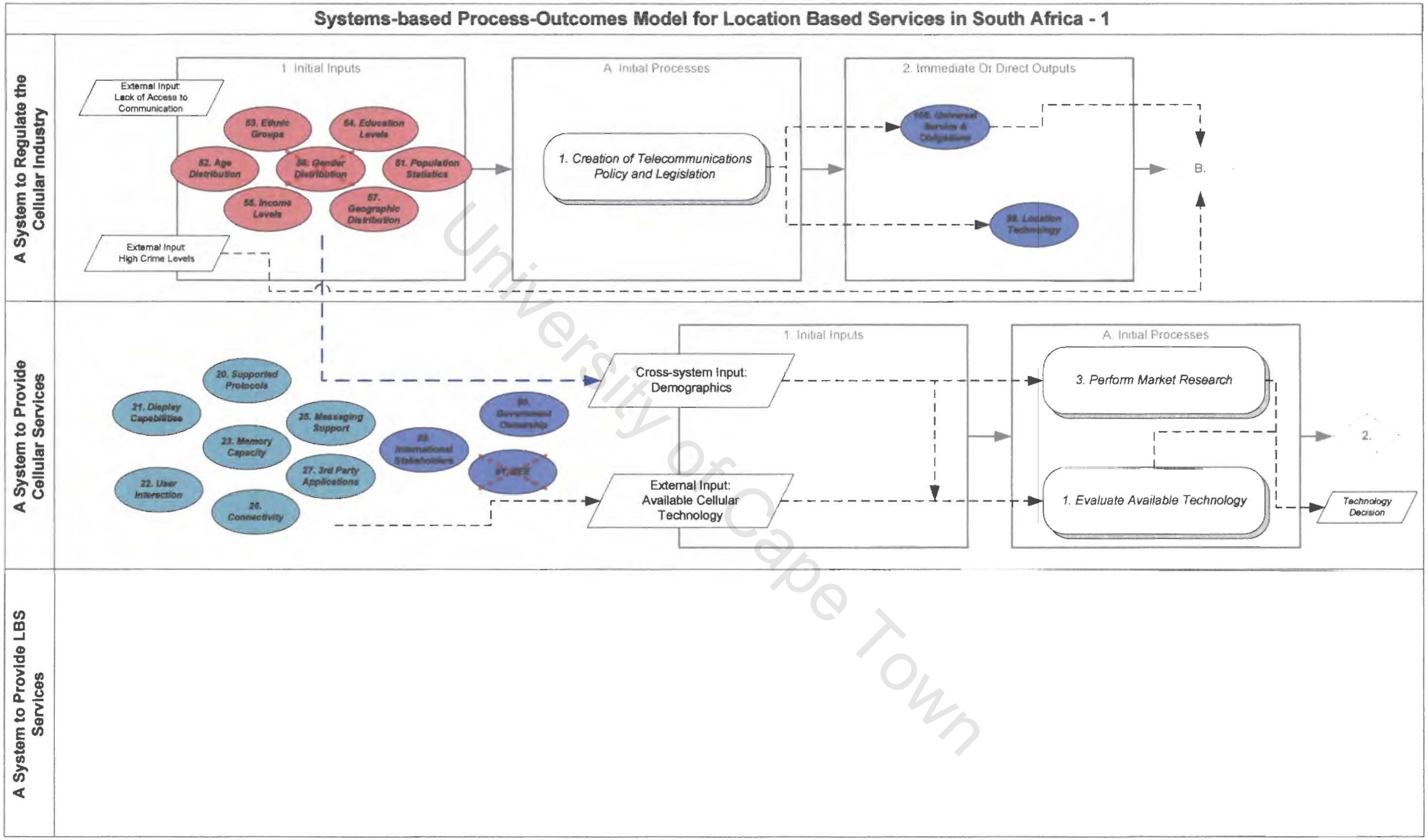


Figure 6.17: Evaluation Model for Location Based Services in South Africa 1

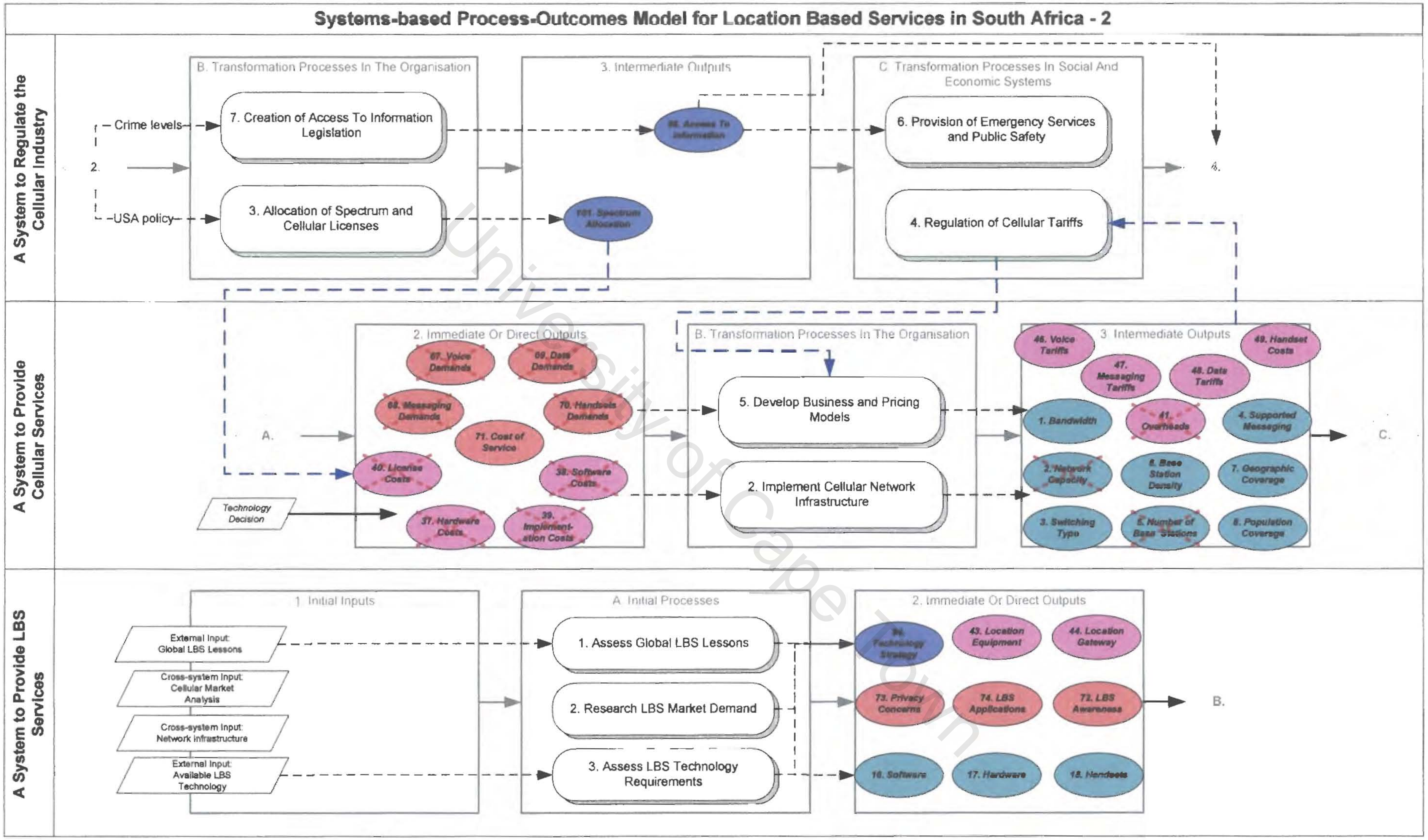


Figure 6.18: Evaluation Model for Location Based Services in South Africa 2

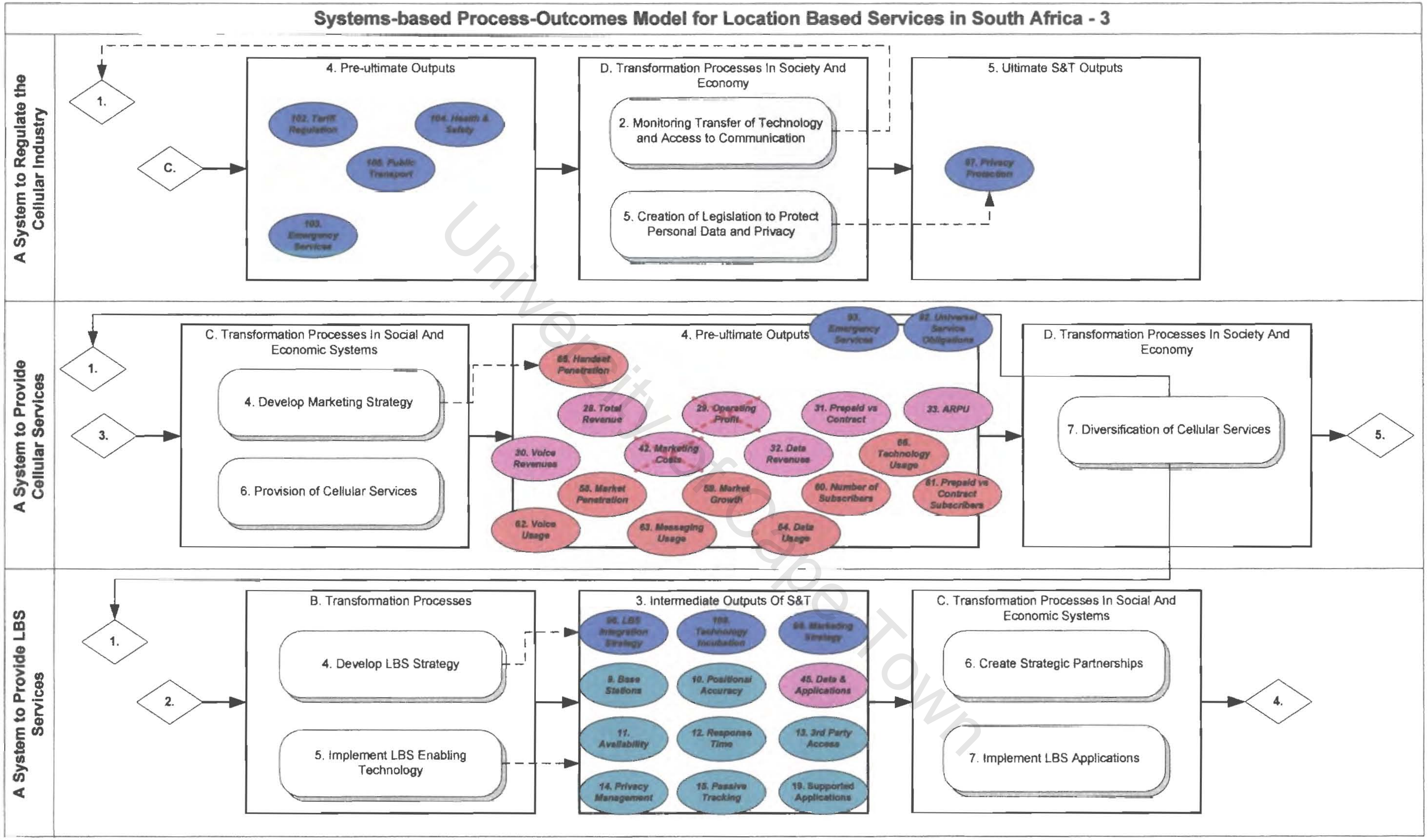


Figure 6.19: Evaluation Model for Location Based Services in South Africa 3

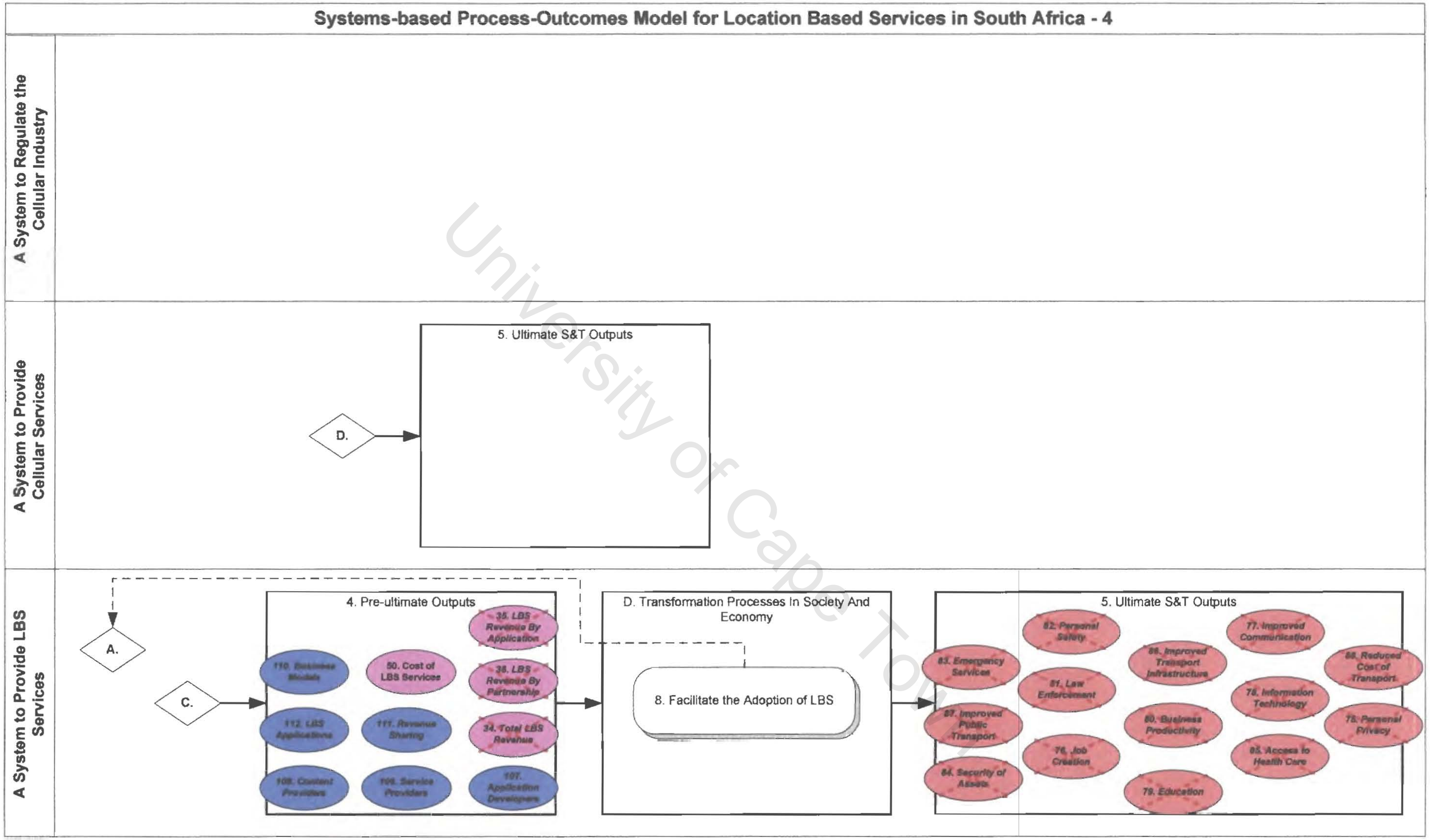


Figure 6.20: Evaluation Model for Location Based Services in South Africa 4

6.3 Summary and Conclusions

This chapter has completed the construction of the model of evaluation for LBS in South Africa based on the conceptual framework developed in chapter 3. In so doing, the chapter has satisfied research objective 3 as stated in section 1.3.

As stated in sections 2.1.2, a contextual understanding of a complex phenomenon is critical in determining which aspects to measure. Based on this observation, Section 6.1 derived a hierarchical set of metrics based on the contextual understanding generated by the descriptive overview of LBS technology in chapter 4 and the SSM conceptual models for LBS in South Africa developed in chapter 5.

Throughout the construction of the metrics, Section 6.1 referred constantly to the appropriate sections of Appendix A, where the metrics are described, passed through the selection criteria defined in sections 3.2.4 and 3.4.2.4. In addition, the case study data for these metrics is presented and discussed where relevant. Thus, although being physically separated from this chapter, Appendix A is a fundamental part of the construction of the set of metrics, as it presents the discussions and data that give the metrics meaning for the evaluation of LBS in South Africa. Thus, as per the definition of a metric in section 3.2.2, every metric includes its associated data, the meaning of the data in the context of other metrics, and answers a particular question that becomes the basis of recommendation for future action.

Using the set of metrics as a point of departure, section 6.2 constructed the Process-Outcomes model to serve as a framework for the holistic evaluation of the metrics. In section 6.2.1, a preliminary structuring of the Process-Outcomes model using the processes identified from the SSM conceptual models revealed that three inter-related Process-Outcomes models were required to accurately represent the relationships between the different levels of systems and the processes. Following this, the Process-Outcomes model was constructed by linking the SSM conceptual models, the transformation processes identified from the SSM models, and the metrics according to the theory proposed in section 3.4.2.

The final outcome of this chapter is the systems-based Process-Outcomes model for the evaluation of LBS in South Africa, depicted by Figure 6.17, Figure 6.18, Figure 6.19 and Figure 6.20.

The following chapter holistically examines LBS in South Africa from the multiple perspectives facilitated by the structure of the evaluation model developed in this chapter, thereby effectively comparing the conceptual models of LBS with reality in order to determine how the situation could be improved. This is in accordance with the structure of the conceptual framework developed in section 3.4, which incorporates the Process-Outcomes model within SSM as the means to compare the conceptual models with reality.

7 ANALYSIS OF THE MODEL OF EVALUATION FOR LBS IN SOUTH AFRICA

This chapter uses the systems-based Process-Outcomes model for the evaluation of LBS in South Africa developed in chapter 6 as a structural framework to holistically analyse the metrics presented in Appendix A. Based on this analysis, conclusions are drawn and recommendations formed regarding LBS in South Africa. In terms of the original research objectives, this chapter primarily addresses research objective 4, namely testing the constructed model of evaluation.

At this point it is important to reiterate the point of view of the evaluator and the purposes of the evaluation. As originally established in the opening paragraphs of this dissertation, the construction and analysis of the model of evaluation are carried out from the perspective of a network operator in South Africa wishing to improve LBS, for reasons outlined in section 1.2.2. Thus, the analysis in this chapter takes this view into account, and is possibly biased by this standpoint.

Chapters 5 and 6 followed a top-down approach, starting with a high-level overview and contextual understanding, and progressively working towards a more detailed model of the complex situation. This chapter applies the inverse, and uses a bottom-up approach to work from the individual metrics and the model of evaluation to a set of conclusions and recommendations regarding LBS in South Africa. In this way, the analysis is working towards understanding the emergent properties of the whole situation, which is a critical aspect of a holistic, systems-thinking approach to evaluation, as outlined in section 2.3.5.1. In order to achieve this, this chapter progresses through each of the ancillary research objectives stated in section 1.3, namely:

1. Evaluate case study data on LBS in South Africa
2. Provide an initial opinion based on the research
3. Recommend key factors for improving LBS in South Africa

This chapter begins with a holistic evaluation of LBS in South Africa from the multiple perspectives enabled by the structural framework of the evaluation model.

Firstly, section 7.1 analyses the evaluation model according to each level of Process-Outcomes model, i.e. according to each sub-system or conceptual model, as well as each stage of transformation and diffusion within the sub-system. In this way, the model is providing the means to compare the SSM conceptual models with reality, as per the conceptual framework developed in section 3.4.

Secondly, section 7.2 analyses the evaluation model in terms of the four perspectives of the evaluation outlined in sections 1.1.2 and 1.2.2. In summary, these are the technological, financial and economic, and social and organisational perspectives.

The second ancillary research objective is fulfilled in section 7.3, which provides conclusions and an initial opinion with respect to LBS in South Africa based on the holistic evaluation of the model. Section 7.3.3 addresses the final ancillary research objective by recommending key factors for the future success of LBS in South Africa.

Thus, this chapter is broken into two main sections, the comparison of the model with reality, and the definition of feasible and desirable changes, which correspond to stages 6 and 7 of SSM and the conceptual framework developed for this thesis, depicted in Figure 3.1 and Figure 3.8 respectively.

This chapter is followed by the conclusions of this thesis in chapter 8, which addresses the final research objective stated in section 1.3 by evaluating the effectiveness of the models and methodologies used to create the evaluation model for LBS in South Africa.

7.1 Comparing SSM Conceptual Models with Reality

This section analyses the conceptual models in terms of the transformation processes and associated input and output metrics depicted in Figure 6.17, Figure 6.18, Figure 6.19 and Figure 6.20. In doing so, it compares the conceptual models of LBS in South Africa with the reality as revealed by the metrics. This is an important distinction from reality itself, as one of the principle assumptions of SSM is that reality is only an observer's perception of reality (section 3.1.4). Therefore, in the context of this thesis, the author's perception of reality can only be defined by the metrics and their associated case study data.

Furthermore, given the large number of metrics and the complexity of the evaluation model, it is infeasible and counter-productive for the analysis to cover each one of these metrics in detail, as to do so would essentially be repeating the content presented in Appendix A. Thus, this section focuses primarily on the transformation processes themselves, and refers to key metrics where necessary to describe the relationships between the processes and the metrics. In doing so, key differences are identified between the ideal processes of the conceptual models, and the real processes revealed by the metrics. By highlighting these differences, this section provides the basis for recommendations by identifying the processes of each sub-system that could be targeted for improvement in order to improve the LBS in South Africa from the perspective of a network operator.

7.1.1 A System to Regulate the Cellular Industry

This section compares the SSM conceptual model describing a system to regulate the cellular industry, as depicted in Figure 5.7, to the reality of the situation as revealed by the metrics of the Process-Outcomes model for the system. Each stage of transformation of the Process-Outcomes model is discussed in relation to the transformation processes identified for this system, which were outlined in section 5.4.1.

7.1.1.1 Initial Processes

The initial process for the regulatory system is the creation of telecommunications legislation, policy and regulations, depicted as part of the evaluation model in Figure 6.17.

The inputs to this process are requirements of the social system in South Africa, represented in the evaluation model by the market demographic metrics (section A.3.1). The outputs of this transformation process are the relevant acts and legislation which may directly affect LBS in South Africa through mandated location technology (section A.4.2.3) and through the definition of Universal Service and Access obligations (section A.4.2.4).

An analysis of the metrics reveals that although the government legislation makes provision for location technology, and in fact requires network operators to provide positioning capability, there are no stipulated deadlines or mandated accuracy requirements. The result is that the network operators are under no real obligation to implement advanced location determination technology on their networks, and the industry therefore lacks the LBS catalyst that has stimulated the LBS industry in the USA (see section 4.1.1).

However, the government policy on Universal Service and Access, in response to the social issue of lack of access to communication, suggests to the author that the government is prioritising more serious telecommunications issues in South Africa. Thus, it seems unlikely to the author that ICASA or the DOC will take steps to mandate location technology until such stage as these more pressing issues have been addressed to a more satisfactory level.

Thus, the situation revealed by the metrics indicates that this stage of transformation process is not aligned with the conceptual model. From a LBS perspective, the process of creating telecommunications legislation and policy needs to be improved to result in mandated LBS technology. However, this may not be aligned with the broader goals and priorities of the regulatory boards, and therefore may not be a suitable course of action in the foreseeable future.

From the perspective of a South African network operator, the lack of mandated location technology can arguably be seen as a benefit, as it means that the operators are not obliged to invest heavily in LBS technology when there is no real means to achieve a return on the investment, due to the current low market demand for LBS in South Africa (section A.3.2.8).

7.1.1.2 Transformation Processes in the Organisation

In terms of the conceptual model for a system to regulate the cellular industry, the transformation processes in the regulatory or government organisation include spectrum allocation and the awarding of cellular licenses, as well as the creation of legislation to provide access to information. These are shown as part of the evaluation model in Figure 6.18.

In terms of LBS, the spectrum allocation and awarding of cellular licenses is significant as it specifies which technologies network operators are permitted to use. An analysis of the resulting output metric in section A.4.2.5 indicates that this process compares favourably with the conceptual model for two reasons. Firstly, ICASA has provided the cellular operators with licenses to operate 3G networks, which has an effect on the types of LBS applications that can be offered over the networks (section A.1.1.1). Secondly, by incorporating the USA policy, an output of the process discussed in the previous section, as an integral part of the cellular licensing process, the government has abandoned the typically high fees for 3G licenses in favour of community obligations and social commitments on the part of network operators. This has the dual effect of stimulating the telecommunications industry in South Africa and allowing network operators to potentially free up more capital for investment in LBS infrastructure and technology. The negative effect of high 3G license fees on LBS technology investment was a problem encountered in global LBS experiences, as discussed in section 4.1.1.

As discussed in the social analysis in section 5.1.2.3, South Africa has a high level of crime and violence. Using this social problem as an input, the process of creating legislation for access to information has resulted in the legislation discussed in A.4.2.2. In summary, this legislation enables information to be accessible for the purposes of law enforcement or in the interest of public safety. Thus, the reality revealed by the metrics compares favourably with the conceptual models, and the implications for LBS is that the legislative framework exists for the use of the technology for law enforcement and the provision of emergency services. However, as identified in section 4.4.1.6, providing access to information needs to be balanced against legislation to protect personal privacy. In this regard, the process of creating legislation for the protection of personal privacy in South Africa is discussed later in section 7.1.1.4.

In summary, the metrics indicate that the processes at this stage of transformation compare favourably with the conceptual model describing a system to regulate the cellular industry. This indicates that the regulatory processes at this stage of transformation are adequate for the implementation of LBS in South Africa, and do not require improvement at this time in the context of this thesis..

7.1.1.3 Transformation Processes in Social and Economic Subsystems

In terms of the conceptual model for a system to regulate the cellular industry, the transformation processes in social and economic sub-systems include the regulation of tariffs and the provision of emergency services. These are shown as part of the evaluation model in Figure 6.18.

The initial social analysis in section 5.1.1.3 suggested that the cost of telecommunications in South Africa is high in comparison to global standards. This, coupled with the social structure of the population (section A.3.1), emphasises the need for effective tariff regulation processes. The tariff regulation metric in section A.4.2.6 and the cost of service metrics in section A.2.3 suggest that tariffs are in fact being regulated effectively in South Africa, and suggest that tariffs are in fact more affordable than in many other countries. Furthermore, the metrics in sections A.2.1.1, A.3.1.9 and A.3.1.10 indicate significant growth of the cellular industry in South Africa, which supports Knott-Craig's claim that tariffs match affordability as consumers are clearly making use of cellular services in South Africa (Knott-Craig 2005a).

However, tariff regulation does not as yet affect LBS tariffs, which are much higher than standard cellular services (section A.2.3.5). Therefore, although the tariff regulation processes are seemingly effective for standard services, they do not as yet extend to value-added services in South Africa. This suggests that if LBS tariffs are also to be regulated, the scope of the tariff regulation process needs to be broadened. This would require LBS to be recognised as a core communications requirement by the DOC and ICASA, which is unlikely unless LBS technology is mandated for the provision of emergency services.

In the context of this thesis, the process of providing emergency services results in a measure of the use of LBS by emergency services in South Africa. As indicated by the metrics in section A.4.2.7 and A.4.2.8, there is currently no use of LBS by national emergency services providers. Section A.4.2.7 shows that although legislation has made provision for a national emergency call centre, and efforts have been made to incorporate LBS capabilities into these call centres (Project C 2001), there has been no practical implementation as yet. This indicates that the government approach to using technology such as LBS in emergency services could be improved. However, the metrics also indicate that there are private organisations making use of LBS for emergency services. The author suggests that this is a direct result of government priorities to improve basic emergency services, while private organisations are looking to improve their services in order to differentiate themselves from their competitors and attract high income consumers.

Thus, the metrics indicate that the processes at this stage of transformation do not compare favourably with the conceptual model for a system to regulate the cellular industry as it pertains to LBS, as tariff regulation does not affect LBS tariffs, and LBS technology is not being used for national emergency services. Thus, process improvements in both tariff regulation and in the provision of emergency services on a national level could arguably have a positive effect on LBS in South Africa.

7.1.1.4 Transformation Processes in Society and the Economy

In terms of the conceptual model for a system to regulate the cellular industry, the transformation processes in society and the economy include the monitoring of transfer of technology and access to communication, and the creation of legislation to protect personal privacy. These are shown as part of the evaluation model in Figure 6.19.

A full evaluation of monitoring the transfer of technology and access to communication is beyond the scope of this thesis, and has no direct relevance to LBS in South Africa. However, this process forms a vital feedback loop for the system, linking the system back to the initial process of creating telecommunications policy as discussed in section 7.1.1.1. This feedback loop was identified during the creation of the conceptual model for this system in section 5.3.1. For the purposes of this thesis, no assumptions are made regarding the effectiveness of this process.

The process of creating legislation for protection of personal data and privacy has direct implications for LBS in South Africa, as the metric in section A.3.2.7 identified that potential users have concerns regarding the impact on personal privacy. Thus, as highlighted in section 4.4.1.6, there needs to be a balance of privacy and security through providing access to information (section 7.1.1.2). The data presented in section A.4.2.1 reveals that South Africa has taken steps towards creating legislation for the protection of personal privacy that is in line with international standards. The author therefore concludes that this process compares well with the conceptual model, and further that appropriate processes are in place to maintain a suitable balance of privacy vs. security with respect to accessing personal information in South Africa.

Thus, the metrics indicate that the processes at this stage of transformation compare favourably with the conceptual model for a system to regulate the cellular industry.

To conclude and summarise section 7.1.1; the conceptual model for the system to regulate the cellular industry does to a large extent describe the situation revealed by the metrics. Possible improvements include the extension of tariff regulation processes to include value-added LBS services, and the improvement of national emergency services processes through the mandated use of LBS technology. Processes identified as adequate at this time include the spectrum and license allocation based on USA requirements, and the legislative processes in place to maintain the privacy vs. security balance.

The following section compares the conceptual model for a system to provide cellular services to the reality revealed by the metrics of the Process-Outcomes model.

7.1.2 A System to Provide Cellular Services

This section compares the SSM conceptual model describing a system to provide cellular services, as depicted in Figure 5.8, to the reality of the situation as revealed by the metrics of the Process-Outcomes model. Each stage of transformation of the Process-Outcomes model is discussed in relation to the transformation processes identified for this system, which were outlined in section 5.4.2.

7.1.2.1 Initial Processes

In terms of the conceptual model for a system to provide cellular services, initial processes of the Process-Outcomes model include market research and the evaluation of available technology. These are shown as part of the evaluation model in Figure 6.17.

The market research process consumes the cross-system input of market demographics (see section A.3.1), and results in measures of market demand for cellular services (see section A.3.2). Understanding the demand for different cellular services plays a role in the evaluation of available technology. To this end, the available cellular technology, as discussed in 4.2.1, forms the primary input for the technology evaluation process. The direct output of this process is the selection of an appropriate network technology to match the market demands for cellular services.

At this point, it is not possible to evaluate the effectiveness of these processes in the context of the conceptual models of LBS in South Africa. This is because the effects of these processes only become evident further downstream, i.e. at later stages of innovation, when the outputs of the processes have been consumed by later stages of transformation processes. These processes are revisited in the following section.

7.1.2.2 Transformation Processes in the Organisation

In terms of the conceptual model for a system to provide cellular services, transformation processes in the network operator organisation include the implementation of the cellular network infrastructure and development of business models and pricing structures. These are shown as part of the evaluation model in Figure 6.18.

The process of infrastructure implementation takes as its inputs the selected technology, an output from the previous stage of processes, and financial resources. For reasons already stated section 6.1.3.2, namely that not enough data was available for meaningful comparison, these financial input metrics are excluded from the evaluation. The results of the network infrastructure implementation are the capabilities of the existing networks (section A.1.1), which in turn provides a cross-system input for the initial processes of a system to provide LBS services, as discussed in section 7.1.3.1.

The process to develop business models and pricing structures takes the market demands into account, is affected by the cross-system input of tariff regulation discussed in section 7.1.1.3, and results in the tariff structures and contract types.

At this point it is possible to revisit the processes in the previous section. Firstly, by examining the market demand metrics (section A.3.2) and comparing them with the capabilities of the cellular networks (section A.1.1), it is evident that the implemented network technology is capable of addressing all the current cellular market needs, and moreover is capable of delivering cellular services that are not yet in great demand in South Africa, such as LBS applications, 3G data and video calling. This suggests to the author that the processes of evaluating available cellular technology and implementing selected technology compare favourably with the ideal processes of the conceptual model. Not only does the network technology in South Africa cater for the current market demands, but is also capable of catering for market demands into the foreseeable future.

In addition, the metrics in sections A.3.2 and A.2.3 suggest that the market research and business model and pricing structure processes are well established with respect to standard cellular services such as voice, messaging and data, as both Vodacom and MTN are constantly developing new pricing structures to suit market demands and differentiate from their competitors. The best example of this available to the author is Vodacom's dramatic decrease of GPRS and 3G data tariffs, as discussed in section A.2.3.3.

Thus, the core business processes in the network operator organisation are aligned with the conceptual model for a system to provide cellular services, as the network operators seem to be responding to market demands. Discussions in section 7.1.3 will reveal how well these processes extend to the provision of LBS services in South Africa.

7.1.2.3 Transformation Processes in Social and Economic Subsystems

In terms of the conceptual model for a system to provide cellular services, transformation processes in social and economic subsystems include the actual provision of cellular services and the implementation marketing strategies to facilitate the adoption of cellular services by society. These are shown as part of the evaluation model in Figure 6.19.

The outputs of these processes are the levels to which society is using cellular services, measured by the market growth and cellular usage metrics presented in section A.3.1, and the revenue metrics presented in section A.2.1. These processes have the largest number of measurable outputs or metrics for this system, and these provide a basis for assessing the health of the cellular industry and determining how best to implement value-added cellular services such as LBS.

The cellular usage metrics (section A.3.1) and revenue metrics (section A.2.1) indicate that the cellular industry in South Africa has grown significantly and will continue to grow in the near future. More specifically, the increased market growth and mobile market penetration, increased revenues, and the increased usage of messaging and data services indicate that there is a strong industry platform to leverage value-added services such as LBS. In addition, the predicted decline in the market growth rates, subscriber growth rates, and the fact that mobile penetration is tending towards a saturation point indicates that cellular network operators need to look for ways to diversify their service offerings in order to facilitate continuing growth.

Thus, the significant growth in the South African cellular industry indicates that the processes of providing cellular services and marketing these services are aligned with the conceptual model for a system to provide cellular services at this stage of transformation of the Process-Outcomes model.

7.1.2.4 Transformation Processes in Society and the Economy

In terms of the conceptual model for a system to provide cellular services, transformation processes in society and the economy include the diversification of the cellular services. This is shown as part of the evaluation model in Figure 6.19.

This process consumes the market analysis and market demand metrics as discussed in the previous section. The direct outputs are the final benefits to society, for example improved communication. However, it is important to remember that this evaluation is not concerned with the effects of cellular communication on society, but specifically the effects of LBS on society. Therefore, the outputs of this process are not measurable in the context of this thesis. This is shown graphically in the evaluation model in Figure 6.17, Figure 6.18, Figure 6.19 and Figure 6.20 by the association of all of the metrics for social benefits with the final outcome stage of the LBS Process-Outcomes model, rather than the higher level systems.

In the context of this evaluation, the purpose of this diversification process is to provide a feedback loop to link back to the initial processes of the system to provide cellular services, as identified in the construction of this conceptual model in section 5.3.2. In addition, since the conceptual model for the system to provide location based services has been constructed with the specific *Weltanschauung* or perspective of diversifying cellular services (see section 5.2.4), this process provides a direct cross-system connection to the initial stage of transformation processes of the system to provide location based services.

In summary and conclusion of section 7.1.2; the conceptual model for a system to provide cellular services compares favourably to the reality revealed by the metrics. More specifically, all the processes identified while building the conceptual model are well represented by the processes in reality. As a result, the author can not suggest any processes that need to be improved for the system to provide cellular services in South Africa. However, as will be seen in the following section, some of the processes in place for the provision of general cellular services do not translate well into the provision of value-added services such as LBS.

7.1.3 A System to Provide LBS

This section compares the SSM conceptual model describing a system to provide location based services, as depicted in Figure 5.9, to the reality of the situation as revealed by the metrics of the Process-Outcomes model. Each stage of transformation of the Process-Outcomes model is discussed in relation to the transformation processes identified for this system, which were outlined in section 5.4.3.

As stated in the opening paragraphs of this thesis and in the beginning of this chapter, the evaluation is undertaken from the point of view of a network operator attempting to improve LBS in South Africa. Thus, this section deals with the sub-system and conceptual model that is of most interest to the evaluator in the context of this thesis, i.e. a system to provide LBS. Therefore the analyses presented in this section are more detailed than in previous sections, which relate to higher-level systems. More specifically, the processes of this system will be evaluated with respect to both MTN and Vodacom where appropriate. This will highlight the different approaches and strategies taken by the operators with regards to LBS in South Africa, and provide the basis of the recommendations for improvements.

7.1.3.1 Initial Processes

In terms of the conceptual model for a system to provide LBS, initial transformation processes include the assessment of global lessons, research of market demands, and the assessment of LBS technology requirements. These are shown as part of the evaluation model in Figure 6.18.

As discussed in section 7.1.2.4, the initial processes for this system are spawned by the diversification process identified in the higher-level system to provide cellular services. Thus, the inputs to the initial processes include the cross-system inputs of the implemented network infrastructure and market analysis. In addition, the initial processes consume the external inputs of the available LBS technology, and the global experiences with regards to LBS.

The assessment of global LBS lessons has outputs that span different stages of the Process-Outcomes model. These outputs correspond to the different key lessons discussed in section 4.4, and are therefore discussed as and when relevant to each stage of transformation. It is important to note that, in the context of this research, it is not possible to distinguish between cases where network operators have acted because of the global lessons and cases where they have acted in response to independent or unrelated factors. However, industry sources representative of both MTN and Vodacom have indicated that global lessons were a key factor in decisions made regarding LBS (Hainebach 2002; Oehely 2002; Oehely 2004; Watermeyer 2002). Therefore, for the purposes of this analysis, the assumption is made that network operators have taken each of the global lessons into consideration, and have either absorbed or rejected them.

The initial processes share both inputs and outputs. The outputs include an understanding of the LBS market, a LBS technology strategy, an understanding of the implementation requirements for the chosen technology, and the allocation of resources for the implementation thereof.

In terms of the LBS technology strategy (A.4.1.6), both Vodacom and MTN have to date not invested in advanced LBS positioning technology for several reasons. These include the high costs associated with LBS positioning technology, the lack of government mandated LBS technology (a cross-system connection discussed in section 7.1.1.1), and the low demand for LBS services and thus lack of revenue streams to offset the cost of the technology. In addition, a global experience suggests that COO positioning is satisfactory for most LBS applications, as identified in section 4.4.1.1. In this regard, it seems that both Vodacom and MTN have absorbed this global lesson and adopted a cautious approach to LBS positioning technology.

Global experience outlined in section 4.4.1.1 shows that another vital technology component for LBS provision is the location gateway, as described in section 4.2.3. As discussed in section A.4.1.6, a key difference between the technology strategies of Vodacom and MTN is that Vodacom's technology strategy included the decision to implement a location gateway. In this instance, Vodacom's process of absorbing global experience is seemingly better than MTN. As will be seen in the sections that follow, this key technology strategy difference has far reaching outcomes.

As indicated by the market demand metrics in section A.3.2, there is no direct evidence of LBS market research available to the author from either cellular operator. Therefore, the only presumption that can be made with regards to this process is that the results of Vodacom's market research contributed to the decision to implement a location gateway and take a proactive approach to LBS, while MTN's market research resulted in a far more cautious approach to LBS. The market research process will be revisited in the context of the LBS applications implemented in South Africa in section 7.1.3.3.

Thus, a comparison of the initial stage of processes with the situation revealed by the metrics has already highlighted an important difference between the two network operators, namely Vodacom's decision to implement a location gateway. This difference has far reaching effects on the LBS industry in South Africa, as shown in the sections that follow.

7.1.3.2 Transformation Processes in the Organisation

In terms of the conceptual model for a system to provide location based services, transformation processes in the network operator organisation include the implementation of LBS enabling technology and the development of an LBS integration, technology incubation and marketing strategy. These are shown as part of the evaluation model in Figure 6.19.

The outputs of implementing of LBS enabling technology are the metrics concerning the capabilities of the LBS technology presented in section A.1.2. As discussed in the previous section, both of the network operators rely on COO for network-based positioning. However, the metrics show that Vodacom have access to additional capabilities by virtue of their implementation of a location gateway. These capabilities include privacy management (A.1.2.6), passive tracking (A.1.2.7), and 3rd party access (A.1.2.5), and allow for a wider range of potential LBS applications (A.1.2.11).

In terms of the development of an LBS integration strategy, the data in section A.4.1.8 shows that Vodacom has opted for a horizontal strategy while MTN has opted for a vertical strategy. Similarly, the data in section A.4.3.4 shows that Vodacom has shown more initiative in terms of technology incubation than MTN. Thus, since both the adoption of a horizontal integration strategy (section 4.4.1.5) and technology incubation (section 4.1.3) have been identified as key factors, this strengthens the observation in the previous section that Vodacom's process of absorbing global experience is seemingly more efficient than MTN's.

Therefore, in terms of the transformation processes in the organisation discussed in this section, Vodacom's processes appear to be "stronger" or at least more proactive with respect to LBS than MTN.

In comparing the conceptual model for a system to provide location based services with the situation described by the metrics, significant differences between the network operators are already emerging at this relatively early stage of innovation. The following sections show how these differences translate into downstream impacts on the LBS industry in South Africa.

7.1.3.3 Transformation Processes in Social and Economic Subsystems

In terms of the conceptual model for a system to provide location based services, transformation processes in social and economic subsystems organisation include the creation of strategic partnerships and the implementation of LBS applications. These are shown as part of the evaluation model in Figure 6.19.

The development of strategic partnerships and flexible business models was identified as an important lesson to be learnt from global experience in sections 4.1.3 and 4.4.1.2 respectively. The data presented in section A.4.3 shows that both MTN and Vodacom have created strategic partnerships for the delivery of value-added services such as LBS.

With regards to the business models, there is evidence to suggest that the network operators are making an effort to create flexible business models with partners through WASP programs and the migration towards aggregator WASP business models (section A.4.3.5). There are however, indications that the revenue sharing and billing models in place for value-added services are not optimal, and there are concerns by stakeholders in the LBS Value Network that the small profit margins currently provided by the revenue sharing structures are not sustainable (section A.4.3.6).

Thus, in terms of the strategic partnerships, technology incubation, business models, and revenue sharing, MTN and Vodacom are comparable. However, it seems that Vodacom's investment in a location gateway and horizontal integration strategy has resulted in a healthier set of relationships with players in the LBS Value Network, and a range of LBS applications as presented in section A.4.3.7.

The metrics in section A.4.3 indicate that MTN's relationships with stakeholders in the LBS Value Network have resulted in specific vertical LBS applications, as presented in section A.4.3.7.

In terms of the LBS marketing strategy, a result of the processes outlined in section 7.1.3.2, the metrics in section A.4.1.7 reveal a different situation for each of the operators. MTN has no direct LBS marketing as they have no core LBS applications in their service offering. Vodacom, on the other hand, has taken a relatively aggressive approach to the marketing of their horizontal LBS applications, which contrasts to the low-key approach suggested by global experience in section 4.1.3.

This stage of processes includes the revenue and usage metrics for LBS applications as outputs. As stated in section 6.1.3.1, this information was not available for the purposes of this thesis. As with the other missing financial data, this represents a major gap in the data available for this evaluation.

Thus, the differences between the Vodacom and MTN's approach to LBS as outlined in the previous section have had significant effects on this stage of transformation processes. Vodacom's processes have resulted in an array of horizontally integrated LBS applications, while MTN has a relatively small number of vertical applications.

7.1.3.4 Transformation Processes in Society and the Economy

In terms of the conceptual model for a system to provide location based services, transformation processes in social and economic subsystems organisation include the facilitation of the adoption of LBS by society. These are shown as part of the evaluation model in Figure 6.20.

This process uses the LBS marketing strategy as its input, and results in an increase in the use of LBS and the ultimate effects of LBS on society. There is no data to indicate to what extent society has adopted LBS. Similarly, there is no data to indicate that LBS has had any effect on society. This is because LBS has not yet reached the stage whereby the effects of the technology on society can be measured. Therefore, this thesis does not make any assumptions regarding the ultimate effects of LBS on society in South Africa. A potential set of metrics for the effects of LBS on society has been derived in section A.3.3, and these would need to be re-evaluated once LBS has progressed further down the innovation continuum.

In conclusion and summary of section 7.1.3; the comparison of the conceptual models for a system to provide location based services to the reality described by the metrics shows a different set of results for Vodacom and MTN. From the initial process stage, Vodacom's processes seemed to align more to the SSM conceptual models than MTN's. The author is of the opinion that the differentiating factor is Vodacom's decision to implement a location gateway in the early stages of innovation. This has allowed them to make a number of key strategic decisions, some absorbed from global experience, that have placed them significantly ahead of MTN in terms of LBS in South Africa.

Section 7.1 has analysed the metrics data within the framework provided by the evaluation model developed in the previous chapter. In doing so, it has highlighted dependencies between the systems based on the inputs and outputs of the transformation processes, and identified which processes of the conceptual learning models do not compare well with the situation described by the metrics. These identified processes will form the basis for the recommendation of improvements in section 7.2.

The following section briefly analyses the data in terms of the original four perspectives required for the evaluation as originally presented in section 1.2.2.

7.2 Analysis in Terms of Perspectives

This section briefly analyses the data in terms of the original four perspectives required for the evaluation as originally presented in section 1.2.2, namely the technological, financial and economic, social and organisational perspectives.

7.2.1 Technological Aspects

This section analyses the metric data for LBS in South Africa from a technological perspective.

7.2.1.1 Cellular Networks

The metrics in section A.1.1 indicate that the cellular infrastructure in South Africa is more than capable of supporting LBS applications. More specifically, a combination of the supported messaging capabilities and the implementation of 3G technology means that LBS applications could be delivered via a number of different formats to suit both the nature of the LBS application and the capabilities of the target handset.

7.2.1.2 Location Determination Technology

The metrics in section A.1.2 show a very different situation for each of the network operators in question. Both MTN and Vodacom have access to COO positioning only, but Vodacom has additional capabilities by virtue of their location gateway. This enables them to potentially support a wider range of LBS applications.

7.2.1.3 Cellular Handsets

According to the metrics shown in section A.1.3, all handsets available in South Africa are able to support LBS, as COO is by definition available to all cell phones. Furthermore, the metrics show that the available handsets are able to support different types of LBS applications, depending on the class of handset as defined in section 4.2.5. Essentially, all handsets are capable of supporting LBS for emergency services and any LBS applications delivered through SMS messaging. Thus, with respect to the capabilities of the handsets in use by consumers, there is the potential for a large penetration of basic LBS applications. In addition, the capabilities of advanced handsets allow for the delivery of more advanced LBS applications through MMS or 3G technology.

7.2.2 Financial and Economic Aspects

This section summarises key aspects of the metric data presented in section A.2.1 from a financial and economic perspective.

7.2.2.1 Revenue

An issue raised in section 5.1.1.4 was the claim by network operators that declining ARPUs are affecting revenues, and as a result network operators need to diversify their services in order to increase ARPUs. The data presented in this thesis has shown that this claim is not entirely accurate. The market has experienced a steady growth rate and the number of subscribers is still increasing (sections A.3.1.8 and A.3.1.10). In addition, the network operators have experienced a steadily increasing rise in total revenue (section A.2.1.1). Therefore, the only reason the ARPU statistics have been interpreted as declining is because of the mathematical dilution of the figures, as the number of prepaid subscribers (lower ARPU) is increasing faster than the number of contract subscribers (higher ARPU). Therefore, decreasing ARPUs are not a serious threat to network operators at this time.

However, as market growth slows down and the market penetration of mobile services reaches a saturation point, these decreasing ARPUs will begin to be a problem, particularly when combined with the significant reduction of cellular tariffs predicted by industry experts (Knott-Craig 2005a). Therefore, network operators need to start stimulating the use of value-added services in the industry, in order to counter the effects of declining ARPU, lower tariffs and a saturated market in the future.

The distribution of revenue currently shows that voice services are currently and will for some time be the primary source of income for cellular network operators. However, the data shows a distinct increase in the contribution of data services to revenues in recent years, and predictions for significant increases in the near future. The most likely contributors to this in South Africa are messaging and data over cellular networks. There is no data to indicate the percentage that LBS may be able to contribute to data revenues. However, the increase of the contribution of value added data services indicates that services such as LBS could potentially be more profitable to operators in the future.

7.2.2.2 Expenditure

As stated in section 6.1.3.2, the metrics for the expenditure on LBS technology were not available for this thesis. Therefore, there are no conclusions or analyses that can be presented to this effect. This represents a significant gap in the research, and in the event of further iterations of the evaluation or further research into LBS, expenditure metrics should receive more attention.

7.2.2.3 Cost of Service

As indicated by the metrics in section A.2.3, current LBS applications are relatively expensive when compared to ARPU statistics, and the cost of voice, messaging and data services. This is not surprising, particularly for vertical applications which have a number of players in the LBS value network that need to recoup a portion of their costs. This unfortunately translates to an increase in the cost of LBS for consumers, as shown by the cost of LBS services in metric A.2.3.5.

Given the social structure of South Africa (i.e. mainly people in the lower income brackets), the high cost of LBS inherently provides a barrier to entry for the adoption of LBS services. A good example of this is the Smart Route and Smart assist, which are prohibitively expensive for most consumers in terms of the required hardware and in terms cost of service. However, even Vodacom's horizontally integrated LBS applications are currently, in the author's opinion, prohibitively expensive. In addition to the issue identified above regarding revenue sharing amongst members of the value network, the author proposes that Vodacom have set relatively high prices in an attempt to recoup their investment on LBS technology and marketing. However, as discussed in section 6.1.3.2, the expenditure metrics are not available for the purposes of this thesis, and therefore this claim remains unsubstantiated at this time.

In terms of the cost of handsets, South African contract subscribers have benefited from subsidised phones through cellular contracts and bi-annual contract renewal (section A.3.2.4). This has assisted the penetration of different classes of handsets into the prepaid market through second-hand sales or donations, as shown by the model in Figure A.41.

7.2.3 Social Aspects

This section summarises the key aspects of the social metrics presented in section A.3.

7.2.3.1 Market Analysis

In terms of cellular uptake, the data indicates that the South African market will experience continuing growth over the next few years.

The analysis of the population demographics in conjunction with the demographics of the cellular market corroborates the initial social analysis in section 5.1.1.3, which indicated that the majority of the population in South Africa were poor, uneducated and previously disadvantaged.

Thus, the social situation in South Africa is such that LBS technology will most likely only reach a small minority of the population for the foreseeable future. More specifically, the data shows that the potential market for revenue generating LBS consists predominantly of white, high income, highly educated, technologically literate young to middle-aged adults living in or around metropolitan areas. When considered in conjunction with the high costs of currently implemented LBS applications, it seems that the network operators have specifically targeted this group.

Therefore, in order to facilitate mass adoption, LBS services need to be horizontally integrated into the cellular services offering to provide basic access to emergency service. In addition, the costs need to be dramatically reduced in order for the technology to be more accessible to the majority of South Africans.

7.2.3.2 Market Demands

The metrics show that there is currently a low market demand for LBS in South Africa. In addition, this demand has been manifested primarily amongst the technological early adopters and the more affluent sectors of market, i.e. the target market identified in the previous section.

In terms of LBS applications, the highest demand is for security and safety related LBS applications, which corresponds to the social issue regarding crime as per the social analysis in section 5.1.2.3.

7.2.3.3 Effects on Society

As can be seen from the discussion and selection of the metrics in section A.3.3, there is very little evidence to suggest that LBS has as yet had any benefits to society. Therefore, these metrics can not be included in this evaluation.

It may transpire that LBS ultimately provide no significant or tangible benefits to society in South Africa. However, this is impossible to determine this at this time, as the use of LBS technology has not matured enough for the initial inputs in the technology to have been transformed into ultimate outputs. The conceptual framework incorporating SSM and the Process-Outcomes model provides the structure and the rules to avoid making the mistake of trying to associate initial and intermediate outputs of LBS with ultimate outputs, by taking the stage of innovation into account. This was one of the primary reasons for selecting the Process-Outcomes model, as it counters the fundamental problem identified in section 2.3.3.2.

Thus, LBS in South Africa is still progressing through the stages of innovation of the Process-Outcomes model, and needs to mature to the stage where the ultimate benefits to society can be measured.

7.2.4 Organisational and Political Aspects

This section summarises the key aspects of the organisational and political metrics presented in section A.4.

7.2.4.1 Network Operators

The primary lessons with regards to the organisational aspects for the network operators are the LBS technology strategy and the integration strategy.

Based on the metrics and the analysis of the metrics in section 7.1.3, Vodacom has a distinct upper hand over MTN in terms of the strategic aspects of LBS. The data shows that Vodacom has adopted a horizontal integration strategy of LBS within their service offerings, while MTN's focus on specific applications and lack of commitment indicates a vertical integration strategy.

The author proposes that MTN's approach may seem to be a vertical integration strategy at this time, but that this is seemingly in line with MTN's "wait and see" approach to LBS (Oehely 2002). In other words, MTN have not as yet found any reason or business case to invest heavily in LBS.

Thus, it seems that Vodacom has progressed further along the innovation continuum than MTN, in terms of LBS technology. However, given the poor market adoption of LBS services thus far, it would seem that MTN's hesitant approach to LBS is possibly a sensible one. Nevertheless, since the technology is still at an early stage of integration in South

Africa, it is possible to draw conclusions at this stage as to which approach is more suitable.

7.2.4.2 Government Issues

The metrics indicate that there is adequate legislation in place to deal with the issues of access to information and the protection of personal privacy. This is positive for the LBS industry in South Africa, as it provides a legislative framework in which such services can be rolled out in a structured manner that can benefit society.
In addition, the government has taken a positive approach to spectrum allocation and license fees, by forfeiting high license fees for 3G spectrum in exchange for the operators taking additional responsibility for improving access to communication. This is beneficial to the cellular industry, and therefore is indirectly beneficial to LBS in South Africa.

There is a lack of mandated LBS technology in South Africa, but given the financial implications of such technology and the higher social priorities of providing universal service, this cannot be regarded as a criticism. Essentially, there are far higher priorities at this stage of the development of the telecommunications industry as a whole for the government to be overly concerned about LBS.

A final note on the organisational aspects of the government, is that although tariff regulation is having a positive effect on the cost of cellular services, this does not as yet apply to LBS applications, and since LBS is not regarded as a core communications requirement by the government this is not likely to change in the foreseeable future.

7.2.4.3 LBS Value Network

As shown by the metrics in sections A.4.3.1-A.4.3.3, the different players of the LBS value network are well represented in South Africa. Moreover, the network operators are working towards increasingly more flexible business models with these partner companies.

At this stage, the major concern is the level and models of revenue sharing. Participants in the LBS value network are seemingly dissatisfied with the level of the sharing, and in order to provide a sustainable environment for further development of value-added services and LBS, this issue needs to be addressed such that all parties are satisfied.

Section 7.2 has analysed the evaluation model from the perspectives of the evaluation defined in sections 1.1.2 and 1.2.2. When considered in conjunction with the comparison of the conceptual models with reality in section 7.1, these perspectives provide a summary and the identification of major issues and trends of each of the selected dimensions of LBS in South Africa as originally derived in section 6.1.1.

This chapter has thus far analysed the metric data according to the different perspectives facilitated by the framework of the evaluation model. The following section uses this analysis to draw conclusions regarding LBS in South Africa, and to derive key success factors and recommendations aimed at network operators wanting to improve LBS in South Africa.

7.3 Opinions and Conclusions Regarding LBS in South Africa

This chapter has thus far subjectively and holistically analysed the evaluation model in terms of the conceptual models, the identified transformation processes, the selected metrics and their associated data, and the technological, economic, social and organisational aspects of LBS in South Africa. Based on this analysis, this section develops a set of opinions, predictions and conclusions regarding LBS in South Africa. This section represents the author's interpretation of the results of the evaluation, and addresses the final ancillary research objective as stated in section 1.3.

It is important to reiterate that in providing these opinions and conclusions, the author is taking the standpoint of a network operator wanting to improve LBS in South Africa. This standpoint was established in chapter 1, and again at the beginning of this chapter, in order to define the frame of reference for the evaluation. In addition, the construction of the SSM conceptual models and the evaluation model for LBS in South Africa was carried out with this perspective in mind. Thus, the potential biases introduced by this standpoint need to be kept in mind when considering the opinions and conclusions in this section. This issue will be revisited in the summary and conclusions of this chapter in section 7.3.3.

Gulati et al (2002) define a number of frameworks for the analysis of LBS applications and the representation of LBS evaluation results. Keeping with the view that subjective evaluation requires a guiding framework to focus the analysis, as defined in section 2.2.4, two of these frameworks are adopted as a guiding structure for the discussion in this section. These include the following:

- a framework to visualise how the value generated by network operators from LBS changes over time
- a framework to visualise the market opportunity for each class of LBS application

By merging the results of the evaluation of LBS in South Africa with these frameworks as a basis for the discussion, the conclusions presented in this section form a basis for the recommendation of further action to improve LBS in South Africa.

7.3.1 Value Migration of LBS in South Africa

The analysis of the evaluation model revealed distinct differences between the proactive approach to LBS adopted by Vodacom, and the cautious approach to LBS adopted by MTN. Thus, at this stage of innovation, Vodacom is in a position where they have differentiated themselves from their competitors by providing LBS services.

Therefore, at this time Vodacom is deriving value from providing LBS services, despite the fact that they are yet to become widely adopted in South Africa, and as yet do not represent a significant revenue stream for the network operator. However, the value derived from LBS by network operators will change over time as other network operators become involved in LBS, new applications are introduced, and the market adoption of LBS increases. This is represented conceptually in Figure 7.1 below:

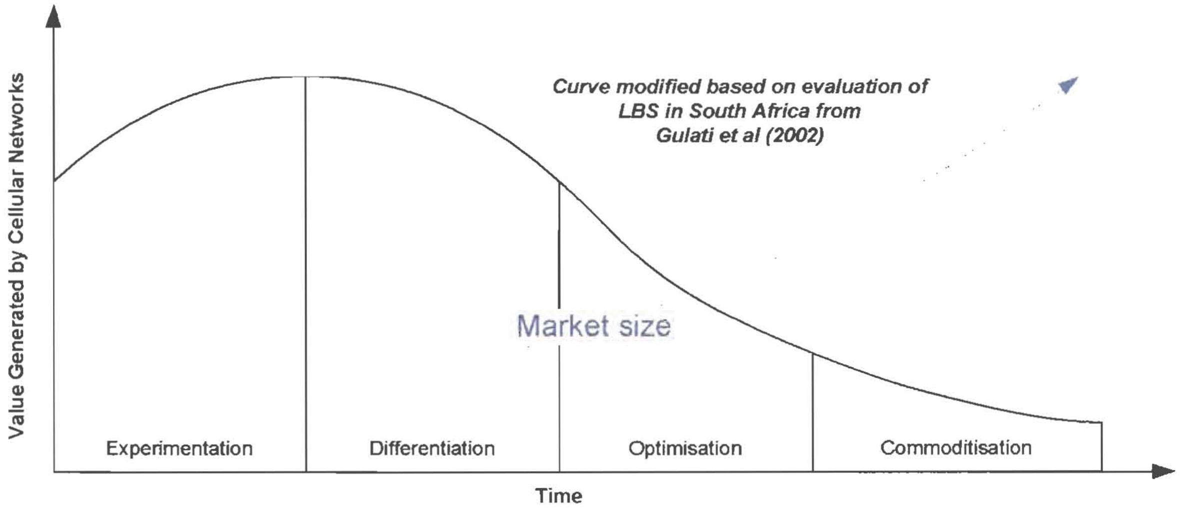


Figure 7.1: Value Migration of LBS in South Africa

The figure above shows the authors interpretation of how the value derived from LBS will change over time in South Africa. In this context, value does not relate to financial value alone, but rather a broader concept of value that encapsulates the ability to differentiate from competitors, and uniqueness of new services, and attractiveness of these services to customers. Gulati et al (2002) propose three stages of LBS value migration, namely differentiation, optimisation, and commoditisation. Based on the analysis of the evaluation model developed in this thesis, the author proposes that four stages of LBS value migration would be more appropriate in South Africa.

7.3.1.1 Experimentation Phase

In the experimentation phase, there is a limited understanding of the potential market and which applications are technically and economically feasible in the South African context. Therefore, this phase involves a great deal of experimentation with different technologies and applications in order to prove concepts and test the LBS market. The value of LBS increases in this phase as LBS understanding, technologies, and applications are improved to the point where they can be brought to market.

7.3.1.2 Differentiation

In the differentiation phase, network operators implement LBS applications to distinguish themselves from their competitors and to derive value through the provision of new services, including financial value through increased revenue as the market adopts these services. However, in this phase an increasing number of available LBS applications and LBS providers means that the relative value of LBS through differentiation begins to decrease.

7.3.1.3 Optimisation

In the optimisation phase, network operators will begin to compete for market share by continually improving LBS applications, introducing new applications, and decreasing the cost of LBS. Thus, the value will be generated through providing the "best-of-breed" applications that suit the market demands at the time. An important factor will be the ability to respond quickly to market demands and bring applications to market.

7.3.1.4 Commoditisation

In this phase, LBS applications have become and pervasive enough and achieved a high enough market penetration to be considered as a standard part of the cellular service offering, and would typically be horizontally integrated throughout all of the network operators' services.

In terms of the value migration of LBS in South Africa, the author maintains that LBS in South Africa is still primarily in the experimental phase of value migration, with only Vodacom having migrated to the differentiation stage. This strengthens the observation made several times in this thesis, e.g. in section 7.2.3.3, that LBS in South Africa is still in the initial stages of innovation as defined by the stages of transformation of the Process-Outcomes model

However, LBS applications are easily imitated by other network operators (Gulati, Sawhney, & Paoni 2002a). Therefore, the author maintains that as soon as the LBS market in South Africa starts showing signs of providing a return on investment for Vodacom, other operators will begin to invest in LBS technology, causing a shift into the differentiation phase.

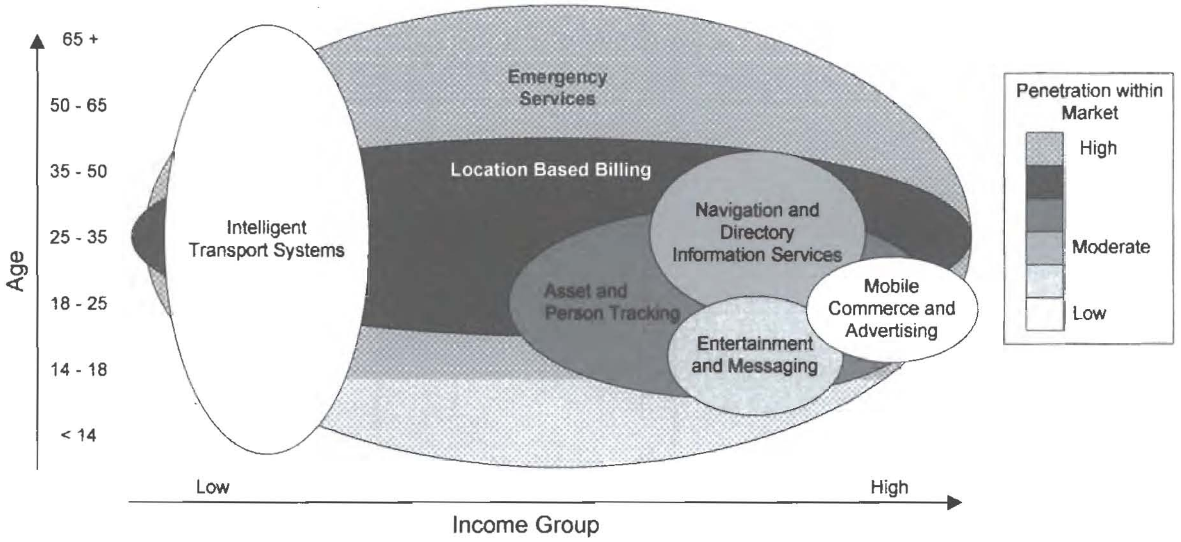
As established in the analyses in the first sections of this chapter, the primary difference between Vodacom and MTN is Vodacom's investment in a location gateway. The author maintains that the barrier between the differentiation and the optimisation phases of the LBS value migration process will be broken when other network operators in South Africa invest in a Location Gateway.

The stages of LBS value migration discussed in this section described the author's interpretation of how the relative value of providing LBS will change over time in South Africa. When considering this value migration from the point of view of a network operator wanting to improve LBS, the classes of LBS applications that would be suited to the South African market need to be evaluated. These are discussed in the following section.

7.3.2 Market Size of LBS Applications

This section presents the author's interpretation of the market size for each of the classes of LBS applications. In order for a network operator to implement LBS, they need to have an understanding of the potential market for each of the classes of LBS applications defined in section 4.3. The views in this section are based on the author's analysis of the market-related aspects of the evaluation model of LBS in South Africa.

Gulati et al (2002) propose a framework for the representation of this information based on the classes of LBS applications, age distribution of potential market, penetration within the market, and the income groups of the target market of each class of LBS application. Drawing on this framework, the author analysed the metrics in order to estimate the relative market size for each class of LBS application in South Africa. This is shown in Figure 7.2 below:



Framework from Gulati et. al. (2002), adapted from analysis of the evaluation model of LBS in South Africa

Figure 7.2: Potential Market Size of Classes of LBS Applications

Drawing on the framework proposed by Gulati et al (2002), Figure 7.2 depicts the author's long term predictions of the estimated market for each class of LBS application in South Africa, based on the subjective analysis of evaluation model and the metrics. Using this figure, an explanation of the potential market for each class of LBS application follows.

An important factor in this interpretation of the market size of the classes of LBS applications is that the metrics have established a distinct difference between the population of South Africa and the cellular market. Thus, this analysis is carried out relative to the cellular market rather than the population of South Africa.

7.3.2.1 Emergency Services

The use of LBS for emergency services should be a core public service in South Africa. As such, the potential market spans all age groups and income brackets. In addition, the market penetration within the group would be relatively high, especially if steps are taken by the government to mandate the use of LBS technology for the provision of emergency services.

In the author's opinion, emergency services should not be seen by the network operators as a potential source of revenue. Providing access to emergency services is a key goal of the USA policy of ICASA and DOC, as discussed in section 5.1.1.4. Thus, they are a basic public service, and in the author's opinion it is not ethical to turn emergency services into a revenue stream.

However, the above relies on the assumption that the government mandates LBS technology for the provision of national emergency services. It has been established that mandated LBS technology is unlikely in South Africa in the foreseeable future. Thus, the reality of the current situation is that use of LBS for emergency services will remain a value-added service provided to high-income consumers through private organisations, as opposed to national emergency services.

7.3.2.2 Asset and Person Tracking

As discussed in section A.3.2.8, the demand for asset tracking using standard LBS technology over cellular networks is low due to the inaccuracy of COO technology and the mature market for tracking technology in South Africa. Thus, the asset tracking market is likely to be small, and restricted to high income groups, i.e. those who have assets to protect.

In addition, section A.3.2.8 showed that there has been a slow uptake of Vodacom's Look4me person tracking LBS application, due to limited demand, low accuracy, and high costs of the service. In the author's opinion, this use of LBS in South Africa still has the potential for some growth, but the high costs of the service and user concerns regarding personal privacy will restrict this to a moderate market penetration in a high income market group.

Thus, in the author's opinion, asset and person tracking applications are unlikely to see large scale market adoption in South Africa. Two factors that change this situation would be an increase in the accuracy of the available positioning technology, and a reduction of the cost of the service.

7.3.2.3 Navigation and Directory Information

The data shown in section A.3.2.8 reveals that the demand for navigation and directory services is relatively low. In the author's opinion, these will be restricted to middle to high income groups, in the middle age groups, with a relatively low market penetration within the markets. One of the primary factors in this is the cost factor, in particular for navigation application, such as SmartSurv's SmartRoute discussed in section A.4.3.7.

However, the author is of the opinion that the horizontal integration of LBS will stimulate an increase in the use of LBS information services. This would need to correspond with a decrease in the costs of these services to bring them in line with standard service charges.

7.3.2.4 Entertainment and Personal Messaging

In the author's opinion, this class of LBS application will have a very small market in South Africa, and would be limited to the lower age groups with a small market penetration. Once again, this would be different in the commoditisation phase, as outlined in 7.3.1.4, as the horizontal integration of LBS throughout the operator service offering coupled with lower costs could potentially stimulate an increase in the demand for this class of LBS application.

7.3.2.5 Mobile Commerce and Advertising

The author is of the opinion that mobile commerce and advertising LBS applications are not feasible in the short term in South Africa. This opinion is based primarily on the fact that messaging based advertising applications have been unsuccessful thus far in South Africa (Hainebach 2002; Watermeyer 2002).

This observation, coupled with user concerns over personal privacy, means that mobile commerce and advertising applications will be restricted to niche applications, primarily for young, technologically literate adults in the higher income groups.

7.3.2.6 Location Sensitive Billing

Based on the evaluation and case study data, the author is of the opinion that Location Sensitive Billing has the greatest potential for large scale adoption in South Africa in the short term. This observation is based on the following reasoning:

- The data has shown that, although cellular tariffs are decreasing, South Africa has relatively high telecommunications costs, and consumers are constantly looking for cheaper call rates or subscription packages in order to increase the value they are obtaining from cellular services.
- Network operators need to attract new customers through attractive pricing models and structures in order gain a competitive advantage and gain market share.
- In an attempt to increase cellular usage, network operators are trying to stimulate cellular services as a replacement for fixed line phones.
- Vodacom is currently trying to advocate their 3G data packages as a viable alternative to fixed-line internet in South Africa.
- Location Sensitive Billing has low technical requirements; it does not require a location gateway or high accuracy positioning equipment.
- Location Sensitive Billing potentially circumvents the privacy issue, as by taking up a location sensitive pricing plan, consumers are inherently as by signing up for the contract users are by default giving consent. However, the privacy issue still should be approached with caution.
- As identified in section 7.1.2.2, the network operators have well established processes to update pricing structures and business models, and therefore the implementation costs of LBS-enabled billing could potentially be kept to a minimum by leveraging off existing processes.

Based on the factors listed above, the author concludes that, besides emergency services, Location Sensitive Billing is the most compelling class of LBS applications for the South Africa market in the short term. Although this application of LBS technology will not directly influence revenue, it will help the network operators to diversify their offerings, attract new subscribers, and may stimulate the use of cellular data and voice services as an alternative to fixed-line voice and internet services.

7.3.2.7 Intelligent Transport Systems

The use of LBS for Intelligent Transport Systems (ITS) relates to transport management and public transport. Based on the data presented in section A.4.2.9 and the author's project experience, there is no real immediate use for LBS in ITS in South Africa.

This section has analysed the market potential for each class of LBS application. The following section concludes this chapter, by providing the final conclusions and recommendations regarding LBS in South Africa.

7.3.3 Conclusions and Recommendations for LBS in South Africa

This chapter has thus far holistically analysed the evaluation model developed in chapters 5 and 6. In so doing, the chapter has addressed the ancillary research objectives of this research, as stated in section 1.3.

This section provides the final recommendations for LBS in South Africa, thereby fulfilling the final ancillary research objective stated in section 1.3. In addition, it is important to reiterate that these conclusions and recommendations are delivered from the perspective of a network operator with a view to improve the situation of LBS in South Africa.

The conclusions regarding LBS in South Africa are as summarised follows:

1. A Location Gateway is essential for any network operator wanting to implement LBS on their networks. This concurs with the key lesson from global experience discussed in section 4.4.1.1.
2. Horizontal integration of LBS technology is a more appropriate strategy for the provision of LBS in South Africa. This concurs with the key lesson from global experience discussed in section 4.4.1.5.
3. Network operators will only implement more accurate location determination technology when required to do so by government mandate.
4. The costs of existing LBS services in South Africa are currently too high for most consumers, and this issue needs to be addressed in order to facilitate the adoption of LBS services.
5. There is no such thing as a "killer" LBS application, and LBS will not be a significant revenue stream on its own in South Africa. It is a differentiator, not a core product.
6. The most suitable application of LBS technology in South Africa, besides emergency services, is Location Sensitive Billing.

Based on the analysis of the evaluation model and the above conclusions, the author's recommendations for a South African network operator wishing to improve LBS are as follows:

1. If necessary, implement a location gateway.
2. Investigate ways of improving revenue sharing with players in the LBS value network. This will create a sustainable platform moving forward.
3. Implement LBS-enabled emergency services first, as this is a high profile class of application addressing a real social issue. There should be no cost for this service over and above standard call charges.
4. Consider implementing Location Sensitive Billing. This should first target 3G and GPRS data packages in order to test the market and test the business model. This could have the additional effect of stimulating the use of cellular data. Based on the results of this initial implementation, Location Sensitive Billing could be considered for voice and messaging as well.
5. Ensure that the cost of LBS applications is as close to standard data tariffs as possible, taking into account item 2 above. Low cost of LBS could help to facilitate the adoption of LBS applications.

Finally, the author maintains that once LBS have been employed in a manner that has direct benefits to consumers, such as emergency services and location sensitive billing, it may stimulate market demand for other types of LBS applications.

The following section summarises this chapter and concludes the evaluation of LBS in South Africa based on the evaluation model.

7.4 Summary and Conclusions

This chapter used the systems-based Process-Outcomes model for the evaluation of LBS in South Africa developed in chapter 6 as a structural framework to holistically analyse the metrics presented in Appendix A. In doing so, the chapter has fulfilled research objective 4, namely the testing of the evaluation model, as well as all of the ancillary research objectives stated in section 1.3.

Section 7.1 compared the SSM conceptual models with the reality described by the metrics presented in Appendix A. This was done by systematically analysing each level of the Process-Outcomes model, as well as each stage of transformation and diffusion within the sub-system. In so doing, this section identified processes in each of the sub-systems that could be improved in order to improve LBS in South Africa. Section 7.2 analysed the evaluation model in terms the technological, financial and economic, and social and organisational perspectives.

In the course of the analyses, sections 7.1 and 7.2 sections identified several key differences between MTN and Vodacom's approach to LBS, as well as a number of emergent properties of LBS in South Africa that formed the basis for the conclusions and opinions in section 7.3, and the for recommendations in section 7.3.3.

A potential weakness of this evaluation is that there is a significant amount of data missing, particularly concerning the expenditure and revenue metrics. This data is typically not public knowledge, particularly with regards to LBS. In addition, the author experienced problems in obtaining data from stakeholders in LBS in South Africa, as discussed in section 1.5.

The following chapter concludes this thesis by analysing the research methodology and research progress in terms of the research objectives, and summarising the strengths and weaknesses of the conceptual framework developed to combine SSM and the Process-Outcomes model. The final chapter also outlines the key lessons learnt from the practical application of the conceptual framework to an evaluation situation, and provides recommendations for improvement and further research.

8 CONCLUSIONS & RECOMMENDATIONS

This chapter concludes this thesis by reviewing the research in conjunction with the primary research objectives stated in section 1.3. The chapter evaluates the effectiveness of methodologies used, and examining the strengths and weaknesses of the conceptual framework developed for the purposes of this research in conjunction with the problems associated with evaluation, as discussed in section 2.1.

The ancillary research objectives stated in section 1.3, i.e. objectives regarding the evaluation of LBS in South Africa, have already been concluded in chapter 7. This chapter removes itself entirely from the actual case study used in the research, and focuses completely on the theory, methodologies, and conceptual frameworks used in the research to develop a model for the evaluation of LBS in South Africa.

This chapter begins with a review of the research objectives in relation to the actual progress of the work and a brief summary of how each research objective was achieved in section 8.1. Building on this initial discussion, section 8.2 analyses the research methods used in this thesis in detail, discussing and shows how they contributed to the primary research objective of constructing an evaluation model for LBS in South Africa. Drawing on this discussion, section 8.3 analyses the theory and the conceptual framework developed in section 3.4, which discusses the strengths and weaknesses of the conceptual framework, and recommends avenues for further research.

In the final conclusions of this thesis, section 8.4 revisits the operational definition of evaluation as defined in section 1.1.1, as well as some of the initial concepts introduced in section 2.1, in order to determine whether or not the methods applied in this research address these issues.

8.1 Summary of Research Objectives and Research Progress

This section summarises the research objectives in conjunction with the progress of the research. The purpose of this section is to summarise what was achieved in this research as a precursor to the analysis of how it was achieved in the sections that follow. The discussions in this section are kept brief, and the reader is urged to review the relevant sections of the thesis should further information be required.

The opening paragraphs of the dissertation established that the primary research objective of this research was to develop a model for the evaluation of LBS in South Africa. Section 1.3 expanded the primary research objectives into a number of sub-objectives, as listed below;

1. Investigate several existing methodologies of evaluation
2. Develop a conceptual framework to combine SSM and the Process-Outcomes model
3. Construct an evaluation model using the conceptual framework
4. Test the evaluation model by using it to evaluate LBS in South Africa
5. Discuss the strengths and weaknesses of the evaluation model and the conceptual framework, and suggest possible improvements and avenues for further research.

The final research objective listed above will not be discussed in this section, as it is currently being addressed by this chapter. This research objective will be revisited in section 8.4.

The remainder of this section reviews each of the research objectives in turn and explains how they were achieved.

8.1.1 Investigate Several Methodologies of Evaluation

Chapter 1 explained why the evaluation of LBS in South Africa was necessary, and suggested that an evaluation model needed to be developed that allowed LBS in South Africa to be evaluated from multiple perspectives.

To this end, the first research objective was addressed in the literature review of Chapter 2. The chapter began with a discussion of common problems and difficulties associated with evaluation in section 2.1, and suggested that a holistic and reductionist techniques should be applied to the evaluation situation in order to achieve the most complete results. Subsequently, several evaluation methodologies were reviewed in order to determine which methodology or combination of methodologies would be most suitable for this research.

The literature review concluded that a combination of the holistic approach of SSM and the reductionist approach of Process-Outcomes model was the most suitable blend of methodologies for the evaluation of LBS in South Africa, and suggested that conceptual framework was required to combine these fundamentally different methodologies.

8.1.2 Develop a Conceptual Framework

The second research objective was addressed in Chapter 3, which explained the aspects of SSM and the Process-Outcomes model that were relevant to the research.

The most important aspect of this chapter was the development of a conceptual framework to combine the methodologies in Section 3.4. This conceptual framework was based on an examination of how the methodologies complemented each other when applied to a practical evaluation situation, and the discovery that both methodologies were based on the identification of transformation processes. The conceptual framework also defined theoretical connections between the methodologies based on the common focus on transformation processes.

Section 3.4.3 presents this conceptual framework, and lists the 10 activities that need to be followed in order to practically apply the conceptual framework to an evaluation situation. These 10 activities are used to guide the evaluation of the conceptual framework in section 8.2.

8.1.3 Construct an Evaluation Model

Using the conceptual framework developed in Chapter 3, the third research objective was addressed in chapters 4, 5 and 6.

Chapter 4 provided an overview of LBS technology and the global LBS industry. Although this was not specifically part of the conceptual process, it was an essential step as it provided invaluable technical background information and contextual understanding that was used throughout the construction of the evaluation model.

Chapter 5 applied the SSM component of the conceptual framework to the evaluation model by developing SSM conceptual models. These conceptual models, when considered in parallel with Chapter 4, provided the contextual understanding required to construct a set of metrics and the Process-Outcomes model in Chapter 6.

8.1.4 Test the Evaluation Model

The fourth research objective was addressed in Chapter 7, which tested the evaluation model by subjectively and holistically analysing the metric data presented in Appendix A, and by using the analysis to develop conclusions, opinions and recommendations regarding LBS in South Africa. In doing so, Chapter 7 also addressed all of the ancillary research objectives regarding the case study itself.

As stated in the beginning of this section, the final research objective, i.e. the analysis of the strengths and weaknesses of the evaluation model and the methods used to construct it, is revisited in section section 8.4.

8.2 Analysis of Research Method

This section discusses the theory applied to the evaluation of LBS in South Africa in detail, highlighting the pertinent points of the approaches used and the difficulties encountered with the practical application of the conceptual framework. Section 3.4.3 presents the conceptual framework developed in this thesis, and lists the 10 activities that allow SSM and the Process-Outcomes model to be combined to create an evaluation model.

In order to simplify this discussion, this section follows the activities of the conceptual framework linearly. Section 8.2.1 discusses SSM activities, section 8.2.2 discusses metric creation and selection activities, section 8.2.3 discusses the Process-Outcomes model activities, and finally section 8.2.4 discusses the activities relating to the subjective analysis of the evaluation model.

8.2.1 Soft Systems Methodology

This section deals with each of the activities related to SSM that were incorporated into the conceptual framework.

As discussed in section 2.4.5, SSM was selected for this evaluation as it provides a structured way to generate the contextual understanding required for the use of the Process-Outcomes model, and provides a framework for the holistic and subjective analysis of the final evaluation model. The activities are as follows:

1. ***Development of SSM rich pictures***
2. ***Analyses One, Two and Three of SSM***

The activities listed above were addressed in section 5.1. The theory for these activities was presented in section 3.1.2, were it was discussed that these activities represent the unstructured expression of the situation. The author found the rich pictures difficult at first, not being accustomed to such casual, creative and descriptive representations of a situation. Thus, several attempts and iterations were required before acceptable results were achieved. The second activity was relatively straightforward, and was vital in extracting pertinent issues such as the social issues and the stakeholders in the problem space. However, the author found it impossible to achieve these analyses without referring to some of the case study data, which resulted in some repetition of the metric data presented in Appendix A.

*3. **Identification of systems and root definitions***

This activity is addressed in section 5.2. The author initially found it difficult to progress from rich pictures to the root definitions, and initially created a great number of possible root definitions. Multi-level thinking, discussed in section 3.1.3.1, was a crucial intellectual tool used to identify the different levels of the problem and the CATWOE elements for the 3 different systems. The creation of the root definitions themselves was a straightforward expression of the CATWOE elements in the form PQR, as identified in section 3.1.3.1.

*4. **Development of SSM conceptual models***

This activity is addressed in section 5.3. The author initially found it very difficult to differentiate between systems thinking and reality when creating the conceptual models, which is a difficulty with SSM identified in section 2.3.5.5.

After some time, the author realised that conceptual models cannot be right or wrong, as they are simply learning tools that establish a platform for the discussion of the problem, and are based on the best possible available prior knowledge and contextual understanding. Subsequently, this activity became straightforward by following the simplistic guidelines to transform the root definitions into conceptual models. These guidelines were discussed in section 3.1.3.2, and led directly to the next activity, as discussed below.

*5. **Identification of transformation processes from SSM conceptual models***

This activity is addressed in section 5.4, and is based on the theory developed in section 3.4.2.3. This was a simple process, as the construction of the conceptual models inherently required the identification of transformation processes.

In revisiting the constitutive rules for the use of SSM, as defined in section 3.1.4, the author maintains that the use of SSM in the context of this thesis is a valid application of the methodology, as per the original assessment presented by the author in section 3.1.4.

The strengths and weaknesses of SSM in the context of the conceptual framework used in this research are discussed in section 8.3.

8.2.2 Metric Construction and Selection

This section deals with the activities relating to metric construction and selection that were incorporated into the conceptual framework, which are as follows:

*6. **Reduction of the problem to a set of measurable aspects or metrics***
*7. **Selection of metrics according to metric criteria, and presentation of the metric data***

These activities are covered in section 6.1 and Appendix A respectively. The theory for these activities was presented in section 3.2. The contextual understanding generated by the SSM conceptual models proved invaluable in the reduction of the problem to a set of measurable aspects. Thus, the use of SSM addressed the problem of determining which aspects to measure, as discussed in section 2.1.2.

In order to conform to the definition of a metric presented in section 3.2.2, the metric description, selection and the presentation of the metric data were kept together in Appendix A. The selection criteria, defined in section 3.2.4, filtered out metrics that were not available or were not relevant to the evaluation, and the process of applying the selection criteria clarified the purpose of the metric and thus focussed the presentation of the metric data. This is in accordance with the purpose of the selection criteria as discussed in section 3.2.4.

Applying the selection criteria to the metrics also involved applying the additional metric criterion, defined as part of the conceptual framework in section 3.4.2.4. More specifically, the conceptual framework included an additional selection criterion which asked the question *"Can the metric be associated with any of the identified processes of the SSM conceptual models?"* When applying this selection criterion to the metrics in Appendix A, it became increasingly clear that this was not an effective metric selection criterion, as it was always possible to associate a metric with a conceptual model or identified process, even when metrics failed on all other criteria.

Therefore, the author declares that the conceptual link developed in section 3.4.2.4 is not useful for selecting metrics, and as such represents a problem with the conceptual framework. However, the question asked by the selection criterion proved to be an invaluable intellectual tool for the construction of the Process-Outcomes model, as discussed in the following section.

8.2.3 Constructing the Process-Outcomes Model

This section deals reviews activities relating to the construction of the Process-Outcomes model incorporated into the conceptual framework. These activities are covered in section 6.2, and result in the Process-Outcomes model shown in Figure 6.17, Figure 6.18, Figure 6.19 and Figure 6.20. The theory for the Process-Outcomes model was presented in section 3.3.

8. ***Association of identified processes with transformation and diffusion stages of the Process-Outcomes model***

A weakness of the Process-Outcomes model identified in section 2.3.3.4 was that the specified stages of transformation processes may not describe the situation in reality. This was a problem encountered by the author, as the evaluation of LBS in South Africa did not include any initial pure S&T research processes as defined in section 3.3.3.1. Thus, it was necessary to slightly modify the definition of the transformation and diffusion stages of the Process-Outcomes model for the purposes of this thesis. This is presented in section 6.2.2.

In addition, it was not possible to associate the processes identified from the SSM conceptual models within a single Process-Outcomes model as the systems represented by the conceptual models were at different stages of innovation. It was therefore necessary to create 3 levels of Process-Outcomes models, as discussed in section 6.2.1. Thus, the evaluation model had gained an extra level of complexity by using SSM to create multi-dimensional Process-Outcomes models. At this point, associating the SSM processes with stages of transformation of the Process-Outcomes model was straightforward.

9. Association of metrics with stages of outcomes of the Process-Outcomes model

This activity was the final stage of the construction of the evaluation model. As discussed in the previous section, the additional metric selection criterion defined in section 3.4.2.4 proved to be an ineffective tool for selecting metrics. However, the thought processes involved in the attempt to use this conceptual link between the methodologies as a selection criterion proved to be invaluable in placing the metrics within the Process-Outcomes model.

Essentially, the conceptual link developed in section 3.4.2.4 resulted in a clear definition of which level of the Process-Outcomes model and to which stage of input or output the metric belonged. Thus, the author maintains that this conceptual link is a critical part of the conceptual framework, but should be redefined as an intellectual tool as opposed to a criterion for metric selection.

8.2.4 The Model of Evaluation

This section deals with activity associated with the constructed evaluation model

10. Subjective analysis of the metrics within the framework of the Process-Outcomes model and in the context of the associated conceptual models.

This activity is carried out in section 7.1. In developing the conceptual framework, section 3.4.2.1 identified that the Process-Outcomes model provided a way to compare the SSM conceptual models with reality, while the SSM conceptual models provided the guiding framework for the subjective analysis of the Process-Outcomes model. Based on this relationship, section 7.1 analysed the model by systematically working through the Process-Outcomes model and the stages of transformation for each conceptual model, comparing the ideal processes of the conceptual models with the processes revealed by the metrics. In this way, a structured approach was retained for the subjective analysis of the model which allows the emergent properties of the whole system to be identified as the basis for conclusions and opinions regarding LBS in South Africa, which was presented in section 7.3. These emergent properties of the whole are a fundamental characteristic of holistic, systems thinking evaluation, as discussed in section 2.3.5.1

This section has discussed the use of the SSM and Process-Outcomes model in this thesis in the context of the activities defined by the conceptual framework, and identified problems, difficulties and experiences gained in the process. The following section presents the strengths and weaknesses of each methodology used as well as the conceptual framework developed to combine them, and recommends avenues for further research.

8.3 Analysis of the Conceptual Framework

This section analyses the conceptual framework developed to combine SSM and the Process-Outcomes model, focussing on the strengths and weaknesses of each methodology in the context of the conceptual framework, the strengths and weaknesses of the conceptual framework as a whole, and the recommendations for possible improvements and further research.

8.3.1 Strengths of the Conceptual Framework

This section lists the strengths of the conceptual framework used for the construction of the evaluation model for LBS in South Africa in this thesis.

1. The SSM conceptual models generated a thorough contextual understanding of the problem situation, and therefore played a critical role in determining which aspects of the complex phenomenon should be evaluated. This helped to counter the problem identified in section 2.1.2, namely that the determination of measurable aspects is dependant on the prior contextual understanding of the situation.

2. The criteria of metric selection filtered out metrics that were not available or not relevant, and focussed the data on the purposes of the evaluation. Thus, the limitations of the available data and the purposes of the evaluator where taken into account from the outset, assisting in removing any potential biases or inconsistencies in the data.

3. The conceptual framework included theoretical links between SSM and the Process-Outcomes model that acted at every stage of the model construction, thereby facilitating meaningful and valid connections between holistic and reductionist thinking.

4. The rigorous merging of the SSM conceptual models and the Process-Outcomes model facilitated by the conceptual framework allowed for a more detailed, multi-dimensional evaluation model to be constructed. This assisted in countering the problem of analysis, identified in section 2.1.6, by providing a structure for the subjective evaluation of the model from a number of perspectives.

5. The structure provided by the SSM conceptual models overcomes the lack of means for the subjective, holistic analysis of metrics using the Process-Outcomes model, as identified by the author in section 2.4.3.2.

6. The use of the conceptual framework retains the strengths of the Process-Outcomes model as discussed in section 2.3.3.3, i.e. it provides the means to link measures from all four required perspectives of the evaluation, namely social, technological, economic and organisational, through all stages of innovation.

7. The structure provided by the Process-Outcomes overcomes the problems associated with linking metrics at different stages of development, as discussed in section 2.4.3.1.

8. The metrics of the Process-Outcomes model provided the means to compare the SSM conceptual models with reality.

9. The subjective analysis of the evaluation model created using the conceptual framework was fundamentally tied into the core concept of the framework, namely the identification of transformation processes. The analysis used this central theme of the conceptual framework to identify processes that could be improved, and thus process improvement provided the basis for the recommendations.

8.3.2 Weaknesses of the Conceptual Framework

This section lists the weaknesses of the conceptual framework used for the construction of the evaluation model for LBS in South Africa in this thesis.

1. The practical application of all stages of the conceptual framework is highly labour intensive, and therefore potentially expensive if applied in a commercial environment.

2. One of the difficulties identified with combining qualitative and quantitative data is the bias introduced by assigning values to qualitative data and attempting to numerically aggregate the two types of data. In an effort to avoid this problem, aggregation of data was specifically avoided in this thesis in favour of holistic subjective evaluation, as advocated in section 2.2.3. However, in hindsight, the lack of numerical scores for metrics and categories of metrics makes it difficult for someone to understand the results of the evaluation without understanding the whole evaluation model. This makes the evaluation model impractical for management purposes.

3. The hierarchical approach used to construct the set of metrics drilled down through different layers of complexity until measurable aspects were reached. This resulted in a comprehensive set of metrics that were derived from the different perspectives of the evaluation, namely the technological, economic, social and organisational perspectives. Due to the complexity of the phenomena, many of the resulting metrics were tightly related and in some cases were overlapping. An example of this is the Universal Service metric, discussed in section A.4.2.4. This meant that in some cases metrics were essentially repeated, even though they were derived independently from each other.

4. The conceptual framework does not incorporate measures to assess the quality of the evaluation. This has been identified as a problem associated with qualitative evaluation in section 2.1.5.

This section has discussed some of the weaknesses of the conceptual framework developed for the evaluation of LBS in South Africa. The following section uses this discussion to suggest improvements and further research.

8.3.3 Suggested Improvements and Further Research

This section discusses potential improvements to the conceptual model, and recommends avenues for further research.

A correction of the conceptual model has already been identified in section 8.2.3. More specifically, it was identified that the additional metric selection criterion defined in section 3.4.2.4 did not have any bearing on metric selection, but was a valuable tool for linking the metrics to the SSM processes while constructing the Process-Outcomes model. An improvement to the conceptual framework would therefore be to re-define the role of this conceptual link.

The first weakness identified in the previous section was the lack of methods to aggregate and combine metrics into composite indicators, which would improve the understandability of the model, albeit at the expense of possibly introducing biases in the data. Thus, the author recommends that further research into ways of scoring and combining quantitative and qualitative data, and the investigation of how these methods may be incorporated into this model. This should be in addition to, rather than in replacement of, the subjective and holistic analysis used in this thesis.

Another weakness identified in the previous section was the issue of overlapping and repeating metrics. This suggests to the author that a further improvement to the framework could be a process that identifies and combines overlapping metrics. The author believes that this weakness could be turned to an advantage, as these overlapping metrics could provide insight into how different systems interact with each other. In other words, the overlapping metrics could potentially be used as theoretical pivot points, or points of reference, that exist between the different levels of the Process-Outcomes model. These pivot points could potentially be used to align the stages of transformation between the different levels of the Process-Outcomes model. Thus, the author recommends further research into ways that overlapping metrics can be turned into an advantage in terms of structuring the evaluation model.

The final recommendation for further research relates to the approach used for the subjective analysis. In creating a conceptual framework based on the identification of processes between SSM and the Process-Outcomes model, the author inadvertently created a framework for analysis that focused on process improvement as its key action for improving a situation. Thus, the author recommends further research in to process improvement concepts, with a view to improve the way that the evaluation model is subjectively analysed for the purposes of recommending improvements to the evaluation situation.

This section has suggested improvements to the conceptual model and recommended potential avenues for further research. The following section presents the final conclusions of this thesis.

8.4 Final Conclusions

This chapter has addressed the final research objective of this thesis, namely the analysis of the strengths and weaknesses of the evaluation model and the conceptual framework. In addition, these conclusions have suggested possible improvements to the conceptual framework and recommended avenues for further research.

This thesis has migrated through many different stages, both in the theory of evaluation developed and the practical application of the theory to the evaluation of LBS in South Africa. At this stage, it is pertinent to revisit the operational definition of evaluation, presented in section 1.1.1, in order to determine to what extent the definition describes the evaluation processes carried out in this research:

> *Evaluation is a **process** consisting of a series of **activities**, incorporating **understanding**, **measurement**, and **assessment**, and which aims to establish the **value** or the contribution made and **recommend** improvements.*

The author maintains that this research has ratified this operational definition of evaluation, as the evaluation in this thesis has:

- followed a well defined **process** according to the conceptual framework
- consisted of a number of **activities** defined by the conceptual framework
- incorporated **understanding** through the SSM conceptual models
- incorporated **measurement** through metrics and Process-Outcomes model
- incorporated **assessment** through the subjective and holistic analysis of the evaluation model
- established the **value** of LBS in the South African context
- **recommended** improvements to LBS in South Africa

Thus, the operational definition of evaluation is fitting for the process followed in this research.

Based on the experiences of this research, it is the author's view that evaluation also incorporates the selection of one or many suitable methodologies and frameworks for the evaluation, as well as the customisation of the methodologies to suit the evaluation situation. This notion is strengthened by the views expressed in section 2.4, i.e. that the purpose of a methodology is to be moulded by a particular user for a particular evaluation situation.

Section 2.1.1 argued that in the context of evaluating complex phenomena, the concepts of reductionism and holism are entirely dependant on each other. The experiences gained from this research supports this view, and in the author's opinion an evaluation cannot be properly carried out unless the evaluator has a holistic understanding of the situation as well as a detailed knowledge of the finer facets of the phenomenon.

In conclusion, the theory developed in this thesis proved an effective way of combining the holistic approach of SSM and the reductionist approach of the Process-Outcomes model, in the context of primary research objective of constructing a model for the evaluation of LBS in South Africa. The conceptual framework has its strengths and weaknesses, and a number of avenues have been identified for further research. The author believes that the ideas presented in this thesis are of merit, and encourages the theory to be tested in different evaluation situations.

Finally, the evaluation model developed using this conceptual framework satisfied the primary objective of this research. This evaluation model provides a comprehensive platform for the continuous evaluation of LBS in South Africa, and the author hopes that the evaluation model and the results of the evaluation may be of some assistance to network operators in improving LBS in South Africa.

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A METRICS FOR THE EVALUATION OF LBS IN SOUTH AFRICA

This appendix presents the metrics generated in Chapter 6 for the Process-Outcomes model. This appendix is of vital importance in this thesis as it serves two purposes; firstly as an integral part of constructing the evaluation model in Chapter 6, and secondly as the presentation of the case study data in support of the analysis of the model in Chapter 7. For these reasons, and due to the volume of the data, it has been included as an appendix rather than in the main body of the thesis.

The section is arranged using the same structure as the hierarchical derivation of the metrics in Chapter 6, with the four main sections dealing with technological, social, economic and organisational metrics respectively. Within each section, every metric is dealt with individually in two stages; namely the description and selection of the metric, and the metric data itself. The first stage includes an explanation of the metric and the determination of the metric's suitability for the evaluation model according to the selection criteria defined in sections 3.2.4 and 3.4.2.4. These selection criteria filter out metrics that do not have any bearing on the research objectives, or are immeasurable in terms of the available data. The metrics are presented in the format shown in the table below:

Metric Name	**Unique Metric Number and Metric Name**	
Description	Brief description of the nature and purpose of the metric.	
Data type	The type of data used in the metric as per the classification in Figure 2.1.	
Relevant to evaluation?	Evaluates metric according to the first criteria for metric selection, defined in section 3.2.4.	✗ ✓
Available and accessible?	Evaluates metric according to the second criteria for metric selection, defined in section 3.2.4.	✗ ✓
Interpretable and comparable?	Evaluates metric according to the third criteria for metric selection, defined in section 3.2.4.	✗ ✓
Associated with identified process or SSM conceptual model?	Evaluates the metric according to the fourth criteria for metric selection as developed in section 3.4.2.4, namely that the metric can be associated with a process identified in the SSM conceptual models.	✗ ✓
Does metric pass selection criteria?	Does the metric pass all criteria? If so, then the metric is selected for use in the model and the data will be presented. If not then the metric will not be evaluated for the purposes of this thesis, but may be included in the model of evaluation if it was rejected based on missing data.	✗ ✓

Figure A.1 Table used for Description and Selection of Metrics

If a metric passes the selection criteria listed above and is selection for use in the evaluation model for the purposes of this thesis, the second stage of the metric is presented. This incorporates the discussion of the actual research case study data for the metric. To this end, the sources of the case study data collected for the purposes of this research were discussed in section 1.4.5.

As discussed in section 3.2.2, a metric contains not only its own value, but also the meaning of the data in the context of other metrics (Geisler 2000). In order to facilitate this, the discussion of metric data in this appendix is done in conjunction with other metric data to facilitate such comparisons. Examples of the comparative data used include:

- Data from other regions, for example those discussed in section 4.1
- Data examined over a period of time
- Comparison of data between technologies
- Comparison of data between products
- Comparison of data between organisations
- Discussion in conjunction with related metrics

Therefore, as per the definition of a metric as presented in section 3.2.2, each metric will contain it's value, it's value comparable to other values, and the meaning and implications of the value in the context of the purpose of the evaluation. Presenting metrics in this way, whether they are qualitative, quantitative, objective or subjective according to the classification in Figure 2.1, will facilitate the comparison of metrics and the analysis of how different metrics relate to each other and affect LBS in South Africa, especially when considered within the framework of SSM and the Process-Outcomes model.

A final note on the presentation of this appendix is that it is not always possible to present the metrics in a logical order, so that each metric follows on from the next. This is due to the complexity of S&T phenomena, as discussed in section 2.1.1, and the complex interaction between all the metrics. Therefore, although this section contains some discussion and comparison of metrics where necessary, the metrics are analysed holistically in terms of the Process-Outcomes model and their effect on LBS in South Africa in Chapter 7.

A.1 Technology Metrics

This section presents all the technology metrics affecting LBS in South Africa as derived in section 6.1.2. Section A.1.1 covers the cellular network metrics, section A.1.2 covers location technology metrics, and section A.1.3 deals with cellular handset metrics.

A.1.1 Cellular Networks

The capabilities of the available cellular network infrastructure are an important aspect of the evaluating LBS in South Africa, as the capabilities of the network determine which kinds of LBS applications can be supported. The metrics dealt with in this section are derived from the hierarchy of cellular network metrics shown in Figure 6.3. Cellular network technologies were introduced in 4.2.1, and supplementary technical information can be found in Appendix B.

A.1.1.1 Bandwidth

Metric Name	**1. Bandwidth**	
Description	Measures the data transfer capability of the network.	
Data type	Quantitative - objective	
Relevant to evaluation?	Influences the type of applications, including LBS applications that can be provided over the cellular network.	✓
Available and accessible?	Available from technical specifications of networks	✓
Interpretable and comparable?	Can be compared across different technologies and across different networks.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 1: Bandwidth

Figure A.2 below shows a comparison of the theoretical maximums versus the actual bandwidths offered by Vodacom and MTN for each of the network technologies used in South Africa. 3G has been recently introduced, and the operators are currently rolling out 3G infrastructure focussing initially on metropolitan areas (Botha 2004).

	2 G		2.5 G		3 G
	GSM	HSCD	GPRS	EDGE	W-CDMA
Theoretical Maximum	14.4kpbs	57.6kbps	115 kpbs	384 kpbs	Vehicular 144 kbps Pedestrian 384kbps Indoor/Nomadic 2Mbps
Vodacom	2.4 or 9.6 kpbs	N/A	56.6kbps	N/A	December 2004, no data rates quoted
MTN	9.6kpbs MTNdataLINK	57.6kbps MTNdataFAST	44 kbps MTNdataLIVE	150 kpbs planned for 2005	388 kbps planned for 2006

data compiled from Sempere (1997), Budde (2001), MobileLifestreams (2001), Whitford (2004)
www.mtn.co.za and www.vodacom.co.za

Figure A.2: Bandwidth of RSA Networks

There is some debate as to the pertinence of bandwidth for mobile applications and the provision of LBS. Some analysts claim that GPRS is more than sufficient for provision of mobile data services, stating that the amount of data that can be displayed on a low resolution monochrome screens is limited and high bandwidth is therefore not a prerequisite for these services (Crawford & Aftahi 2001). However, with the increase of the display capabilities of handsets (see section A.1.3) and the increasing penetration of advanced devices (see section A.3.1.15), available bandwidth has become a significant contributing factor for the provision of advanced mobile applications.

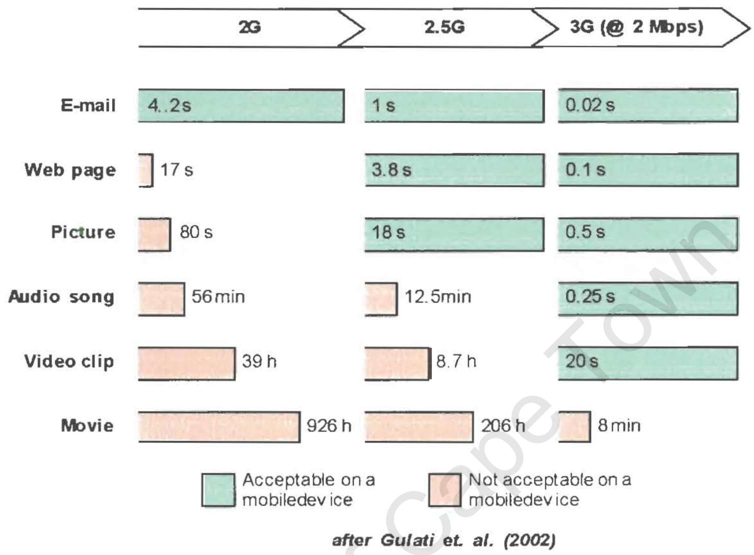


Figure A.3: Download Times for Various Applications

Figure A.3 above shows the download times of different types of data over the available network technologies, thereby demonstrating how the bandwidth available on South African networks shown in Figure A.2 translates into the ability to provide more advanced mobile applications. Higher bandwidth has already enabled provision of MMS messaging (section A.1.1.4) and cheaper data tariffs (section A.2.3.3), which has in turn enabled the provision of colour maps to cellular devices by LBS applications such as Vodacom's Look4me and SmartRoute, as discussed in section A.4.3.7.

An important factor when considering the implications of bandwidth is the network switching type, discussed in section A.1.1.3.

A.1.1.2 Network Capacity

Metric Name	**2. Network Capacity**	
Description	Measures the number of users supported at one time, i.e. network traffic	
Data type	Quantitative – objective	
Relevant to evaluation?	LBS demand is relatively low in comparison to voice demand. Therefore, if the network can handle the large number of concurrent voice users, then it can easily accommodate the demand for LBS.	✗
Available and accessible?	Available from technical specifications of networks.	✓
Interpretable and comparable?	Can be compared across different technologies and across different networks.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?	Network capacity will not effect the provision of LBS services and is not included in the model for evaluation	✗

Metric 2: Network Capacity

A.1.1.3 Network Switching Type

Metric Name	**3. Network Switching Type**	
Description	Determines whether the network supports packet-based or circuit-switched connections.	
Data type	Qualitative – objective	
Relevant to evaluation?	Influences the types of applications and the data connectivity that can be provided over the cellular network.	✓
Available and accessible?	Available from technical specifications of networks.	✓
Interpretable and comparable?	Can be compared across different technologies and interpreted as to how the different switching type applies to LBS.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 3: Network Switching Type

The difference between circuit and packet-based switching types and the significance thereof has already been discussed in section 4.2.1. Further technical information on implications of packet-based switching can be found in the discussion of 2.5G technology in Appendix B.2. Figure A.4 below shows how the two switching types are implemented on South African cellular networks according to the underlying cellular technology.

	2 G		2.5 G		3 G
	GSM	HSCD	GPRS	EDGE	W-CDMA
Switching Type	Circuit-switched	Circuit-switched	Packet-switched	Packet-switched	Circuit-switched Packet-switched

data compiled from Budde (2001) and Crawford et al. (2001)

Figure A.4: Network Switching by Technology

As depicted in the figure above, both circuit-switched and packet-switched connections are supported on South African networks. This means that applications such as voice and video can take advantage of the dedicated connectivity of dedicated circuit-switched connections, while data applications such as MMS and advanced LBS can take advantage of permanent connectivity of packet-switched technologies. The switching type also has implications for the pricing structure of cellular data services, discussed in section A.2.3.3.

A.1.1.4 Supported Data and Messaging

Metric Name	**4. Supported Data and Messaging**	
Description	Determines what data and messaging formats are supported over the cellular networks.	
Data type	Qualitative - objective	
Relevant to evaluation?	Influences the types of applications that can be provided over the cellular network, and the data transfer methods for LBS applications.	✓
Available and accessible?	Available from technical specifications of networks.	✓
Interpretable and comparable?	Can be compared across different technologies and networks, and used to determine possible options for LBS applications.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 4: Supported Data and Messaging

Different data and messaging formats were introduced in section 4.2.6 in the discussion of LBS technology components. The cellular networks in South Africa have the ability to support SMS and MMS messaging, as well as the WAP data transfer protocol which allows for IP connectivity over the cellular networks. All of these can currently be provided over GSM or GPRS, i.e. over a circuit-switched or a packet-switched connection as discussed in section A.1.1.3. In addition, as identified in A.1.1.1, 3G technology is being implemented in South Africa by both MTN and Vodacom, and therefore high-bandwidth Internet Protocol (IP) is also available for data transfer and delivery of messaging.

Therefore, cellular networks in South Africa are capable of supporting any data or messaging format required for the delivery of LBS applications, based on currently available technology.

When considering which data or messaging formats to use for the implementation of LBS applications, the penetration of different classes of cellular handsets must also be considered (see section A.3.1.15).

A.1.1.5 Number of Base Stations

Metric Name	**5. Number of Base Stations**	
Description	The number of base stations in the network infrastructure.	
Data type	Quantitative - objective	
Relevant to evaluation?	Has no bearing on the evaluation objectives.	✗
Available and accessible?	Available from technical specifications of networks.	✓
Interpretable and comparable?	Has no meaning as a standalone metric and therefore cannot be interpreted in terms of its implications for LBS.	✗
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?	Number of base stations is not included in evaluation model	✗

Metric 5: Number of Base Stations

A.1.1.6 Base Station Density

Metric Name	**6. Base Station Density**	
Description	The density of the base stations in the cellular network, for both rural and urban areas.	
Data type	Quantitative – objective	
Relevant to evaluation?	Density of the cellular infrastructure affects the accuracy of network based positioning methods.	✓
Available and accessible?	Available from network operator technical specifications and industry publications.	✓
Interpretable and comparable?	Infrastructure density has implications of for the accuracy of the location determination technology, and therefore the accuracy of LBS applications.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 6: Base Station Density

A possible measure of base station density is the radius of the radio footprint, or the area coverage, of one network base station. In urban areas or areas of high use in South Africa, the area covered is typically between 150m and 1km, while in rural areas this can be as much as 35km (Project E 2001). For the COO positioning used in South Africa, the radius of the base station footprint is directly related to the accuracy of the position (see section A.1.2.2).

For location technologies that rely on triangulation techniques, such as TOA, TDOA and E-OTD, the relationship is slightly different. This is because a balance needs to be found between being in range of enough base stations to calculate a position and having large enough footprints to obtain an accurate geometrical fix on the position. Technical information on COO and other network positioning methods can be found in Appendix B.

An often overlooked factor that influences the base station density is the spectrum allocation of the implemented network technology. The operating frequency of the 3G networks in South Africa is between the 1920-1980 MHz and the 2110-2170 MHz frequency ranges. In contrast, the GSM networks in South Africa operate in the 900 MHz and 1800 MHz frequency ranges (Botha 2004). Therefore, the potential range of a 3G base station is much shorter than a GSM base station because it operates at a higher frequency. To counter this, 3G networks will require 4 to 16 times as many base stations to obtain the same coverage as GSM base stations (Gulati, Sawhney, & Paoni 2002a). Both Vodacom and MTN are currently deploying 3G technology, and therefore the density of the cellular network infrastructure can be expected to increase in the near future, especially in metropolitan areas (Whitford 2004b). This will possibly have an influence on the accuracy of the COO location method used by the operators, as discussed in section A.1.2.2.

A.1.1.7 Geographic Coverage

Metric Name	**7. Geographic Coverage**	
Description	Measures the geographic coverage of the cellular network.	
Data type	Quantitative - objective	
Relevant to evaluation?	An important consideration for implementation of LBS, particularly for emergency, child and vehicle tracking applications.	✔
Available and accessible?	Available from operator technical specifications.	✔
Interpretable and comparable?	Areas with no coverage can be compared to the population in those areas in order to interpret the coverage implications for LBS.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✔
Does metric pass selection criteria?		✔

Metric 7: Geographic Coverage

The combined infrastructure of the three cellular operators in South Africa provides 60% of the geographical area of the country, including most of the urban areas and national roads, with GSM 900 MHz coverage (Cellular.co.za 2004b). Provinces that have large rural areas with no cellular coverage include the Northern Cape, Eastern Cape and the Northern Province.

In order to properly contextualise the implications of this metric, it must be compared with the geographic distribution of the population (see section A.3.1.7) and the population coverage of the cellular networks (see section A.1.1.8). The lack of service in rural areas with relatively a high population is cause for concern, and is one of the reasons for government's policy of Universal Service (see section A.4.2.4). GPRS coverage is mainly in urban areas, and rollout of 3G networks is initially concentrating on metropolitan areas. This may have implications for the availability of LBS applications that require GPRS or 3G network technology.

Nevertheless, the geographic coverage of the networks in South Africa is sufficient to implement LBS, as most of the urban areas and national roads are covered. Measures to improve on accuracy along major routes in rural areas are discussed in section A.1.2.2. There are however quality and consistency of service implications for LBS, especially with regards to emergency services or navigation LBS applications in remote areas (Project C 2001).

In addition, this metric is likely to change rapidly as network operators are continually expanding their networks into under-serviced areas.

A.1.1.8 Population Coverage

Metric Name	**8. Population Coverage**	
Description	The coverage of the cellular network with respect to the percentage of the population it is able to serve.	
Data type	Quantitative - objective	
Relevant to evaluation?	An important consideration for universal service policy in general, particularly specifically for emergency services in the case of LBS.	✓
Available and accessible?	Available from operator specifications and industry publications.	✓
Interpretable and comparable?	Comparable to universal service goals, and has implications for emergency services to under-serviced areas.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 8: Population Coverage

The combined infrastructure of Vodacom, MTN and Cell C currently has the potential to provide approximately 71% of the population of South Africa with cellular services (Cellular.co.za 2004b). The remaining 29% of the population live in geographic areas that do not currently have cellular coverage (see section A.1.1.7).

Providing the entire population with access to telecommunications is a major goal of the government's Universal Service policy (see section A.4.2.4) and would ultimately enable the provision of LBS emergency services to the entire population. However, the current population coverage has no immediate bearing on the implementation of revenue generating LBS, as this portion of the population typically falls within the lower income groups and is least likely to spend money on value-added cellular services such as LBS (see sections A.3.1.5 and A.3.1.7).

In addition, as with the geographic coverage discussed in the previous section, this metric is likely to change rapidly as the network operators are continually expanding their network infrastructure.

A.1.2 Location Determination

The capability to locate a user's cell phone is integral to the provision of LBS. This section covers all the technical metrics describing the location technology used by South African network operators. The metrics in this section were derived in Figure 6.4 and cover four main aspects of the location determination technology affecting LBS, namely performance, location gateway capabilities, implementation requirements and supported LBS applications.

A.1.2.1 Base Stations

Metric Name	**9. Base Stations**	
Description	The number of base stations required to calculate the position of a cellular handset.	
Data type	Quantitative - objective	
Relevant to evaluation?	Number of base stations required to calculate position effects positional accuracy when considered in conjunction with the density and distribution of the network infrastructure.	✔
Available and accessible?	Available from technical specifications of location technology.	✔
Interpretable and comparable?	Number of base stations required can be compared across technologies, and to the density of the cellular infrastructure in different areas.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 9: Base Stations

Network positioning technology was introduced in section 4.2.2, and additional information regarding different network positioning techniques is provided in Appendix B. Network triangulation techniques, such as TOA, TDOA and E-OTD, require more than one base station to calculate a position, and therefore may fail in rural areas with sparse cellular infrastructure. However, Vodacom and MTN have not implemented any of these network positioning technologies and rely on COO positioning alone for network positioning LBS. Therefore, in the general case, only one base station is needed for the calculation of a position, and the infrastructure density affects only the position accuracy and not the ability to calculate a position.

Two examples of exceptions to the general case are the SmartRoute wireless navigation application operated by Vodacom and MTN, and the Matrix vehicle tracking application operated by MTN. SmartRoute makes use of an external GPS receiver and therefore requires no base stations to obtain a position. Matrix vehicle tracking uses devices which return signal strength for the six surrounding base stations. This information is used in conjunction with the coordinates of the base stations to obtain a position via an inverse square law calculation of the signal strength attenuation (Oehely 2004). Thus, multiple base stations are required to calculate the position for this application. For more information on these applications see section A.4.3.7.

A.1.2.2 Positional Accuracy

Metric Name	**10. Positional Accuracy**	
Description	The positional accuracy of the location determined by the implemented positioning technology.	
Data type	Quantitative - objective	
Relevant to evaluation?	Accuracy of the available location determination technology is fundamental to the provision of LBS.	✔
Available and accessible?	Available from technical specifications and industry reports.	✔
Interpretable and comparable?	By comparing across different technologies and requirements of different LBS Applications, the implications of positional accuracy for implementation of LBS can be established.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 10: Positional Accuracy

As stated in section A.1.2.1, the only network positioning technique currently available to the RSA network operators is COO. This means that the positional accuracy is directly related to the density of the cellular infrastructure as discussed in section A.1.1.6. Therefore the basic positional accuracy available on South African networks ranges from 150m in dense urban areas to approximately 35km in rural areas. Vodacom has improved on this accuracy by using the signal direction to determine which quadrant of the cell the handset is in, as well as using the signal strength to determine approximately how far away from the base station the handset is situated. Using these optimisations, the accuracy is improved to approximately 50m in urban areas and 5km in rural areas (Whitford 2004b).

Poor accuracy along major routes in rural areas can be improved by applying intelligent navigation techniques similar in principle to those suggested by Scott-Young and Kealy (Scott-Young & Kealy 2002). In summary, these techniques improve accuracy by making certain assumptions. As the majority of the cellular infrastructure in rural areas extends along major routes (see section A.1.1.7), and assuming that in many cases the LBS user is making use of the route, the position can be narrowed down to a stretch of highway. In this case, COO can still be utilised for the provision of emergency and rescue services along national highways, despite the poor positional accuracy due to sparse cellular infrastructure (Project A 2001).

As discussed in section 4.4.1.1, although COO has proved to be sufficient for most LBS applications, there is still a need for more accurate positioning for niche applications. In South Africa network operators have experimented with more accurate network-based location techniques, but COO will be the only method of network-based location for the foreseeable future in South Africa (Oehely 2004).

A.1.2.3 Availability

Metric Name	11. Availability	
Description	The ability of the location determination technology to operate indoors or outdoors, and in rural or urban areas.	
Data type	Qualitative - objective	
Relevant to evaluation?	Availability of the positioning technology is fundamental to provision of LBS, in particular emergency services applications.	✔
Available and accessible?	Available from technical specifications.	✔
Interpretable and comparable?	By comparing against different technologies and requirements of different LBS Applications, the implications of availability for implementation of LBS can be established.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 11: Availability

The availability of the positioning method varies between different location technologies, as shown in Figure 4.4 and discussed in Appendix B. The availability of some technologies, such as GPS and RCT, is affected by the topography of the terrain, multi-path effects of urban areas, whether the user is indoors or outdoors, the density of the network, and other environmental factors.

However, the COO method used by South African network operators is constant and is available under all conditions providing there is network coverage. This is a benefit to deploying LBS applications as a consistent and predictable result can be achieved in terms of the availability of the technology.

A.1.2.4 Response Time and Latency

Metric Name	**12. Response Time and Latency**	
Description	The amount of time required to calculate a position and return a response to a request for a LBS application.	
Data type	Quantitative - objective	
Relevant to evaluation?	Affects the types of LBS applications that can be supported.	✔
Available and accessible?	Available from technical specifications.	✔
Interpretable and comparable?	By comparing across different technologies and requirements of different LBS Applications, the implications of response time for implementation of LBS can be established.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 12: Response Time

The time it takes to calculate a position is vital for LBS applications such as navigation and emergency services. Typical response times for various positioning technologies are shown in Figure 4.4. Obtaining a GPS position from scratch requires the acquisition of locks on a number of satellites, and in the author's experience as a geomatician and surveyor can take as long as 10 or 15 minutes depending on the weather conditions, multi-path environment and satellite configuration at the time. Hybrid technologies such as A-GPS, discussed in appendix C.2, attempt to overcome this problem while retaining the accuracy of GPS positioning. In the case of COO positioning used on South African networks, the response time is typically less than 10 seconds which is acceptable for the provision of LBS applications (Oehely 2002).

In addition to the response time of the positioning technology, the time of the actual response to the user needs to be considered. This is referred to as the latency delay, and is particularly relevant with packet-switched technologies such as GPRS (BluekK 2001; MobileLifeStreams 2001b). The delivery of SMS over GSM is also affected as it is sent over the signalling channel of the GSM network, which is packet-switched and has a limited capacity (MobileLifeStreams 2001a). Therefore, although delivery priorities can be assigned, the delivery of SMS and MMS messages is not guaranteed within a particular time frame. For most LBS purposes, any latency delay will result in a minor inconvenience to the user, if anything at all. However, in the author's opinion SMS or MMS should not be relied upon for time critical LBS applications such emergency services. These should in the first instance be handled via direct contact with a call centre or via passive tracking, with any SMS or MMS messages serving as supporting communication.

A.1.2.5 3rd Party Access

Metric Name	**13. 3rd Party Access**	
Description	Measures the network operators' ability to provide 3rd parties with controlled access to location information for the purposes of delivering LBS applications	
Data type	Qualitative - objective	
Relevant to evaluation?	Providing 3rd party access potentially opens network to larger variety of LBS applications by distributing the responsibility for developing, operating and maintaining the applications to 3rd parties.	✔
Available and accessible?	Available from personal experience, product information and interviews.	✔
Interpretable and comparable?	Comparable across networks	✔
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 13: 3rd Party Access

Vodacom has purchased and implemented SignalSoft Location Gateway (Cellular.co.za 2002; Hainebach 2002). In addition to providing Vodacom with access to location information, SignalSoft allows 3rd party access to the location of a cell phone via a JAVA API, as shown in Figure 4.5 (Project F 2002). This means that technically, 3rd parties can access the position of any user of the cellular network, through either active or passive tracking.

MTN has not implemented any commercial location gateway software on their network. However, it is still possible for 3rd parties to access location information using active tracking. In order to achieve this MTN has set up basic servers to provide the COO location of a caller to 3rd parties (Oehely 2004). This was used for the implementation of Discovery Health's emergency call centre as discussed in section A.4.3.7. Alternatively, the 3rd party is provided with information such as the signal strength and the coordinates of the base stations, and left to calculate the position themselves, such as the Matrix vehicle tracking application discussed in section A.4.3.7.

Providing 3rd party access to the location of cellular users has personal privacy implications, and requires policy and technology to manage access to information as discussed in section A.1.2.6. Another important factor related to 3rd party access is the ability to provide active or passive tracking, as introduced in section 4.3 and discussed in section A.1.2.7.

A.1.2.6 Privacy Management

Metric Name	14. Privacy Management	
Description	Measures the privacy management functionality of the implemented location technology.	
Data type	Qualitative - objective	
Relevant to evaluation?	Managing user privacy is fundamental to provision of LBS.	✔
Available and accessible?	Available from product information, personal experience, industry publications and interviews.	✔
Interpretable and comparable?	Comparable across networks and to global LBS lessons.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 14: Privacy Management

Vodacom's SignalSoft location gateway, mentioned in the previous section, provides functionality for the management of personal privacy (Project F 2002). Access to location information is controlled via a security layer, as discussed in section A.1.2.5, allowing for the implementation of user opt-in strategies and privacy management (SignalSoft 2001). An example of the privacy management capabilities in practise is Vodacom's Look4me application discussed in section A.4.3.7, which allows a user to access another person's location information only if prior consent has been granted by the person being located. This consent is managed through the location gateway.

MTN has no network-wide system to protect location information. However, as they do not have a location gateway that provides passive tracking capabilities, user opt-in is inherent in the use of any LBS application provided over MTN's network. This is because the application would rely on the user establishing direct contact, thereby consenting to the service (Oehely 2002). However, this does not detract from the need to manage data discretely in order to protect personal privacy.

In both cases discussed above, access to location information is only provided to trusted partners. As established in section 4.4.1.6, managing privacy appropriately consists of technology, policy and user education. Therefore in addition to the technology capabilities, an important factor in managing personal privacy are the policies of the company and any governing legislation controlling privacy or access to information (see section A.4.2.1 and A.4.2.2). Consumer awareness with regards to privacy rights and the use of personal information by 3rd parties is important, which relates to the LBS marketing strategy as discussed in section A.4.1.7.

The privacy concerns of potential users of LBS in South Africa are outlined in section A.3.2.7.

A.1.2.7 Passive Tracking

Metric Name	**15. Passive Tracking**	
Description	Measures the passive tracking ability of the implemented location technology.	
Data type	Qualitative - objective	
Relevant to evaluation?	This has implications for the types of LBS applications that can be provided, and for user controlled privacy.	✓
Available and accessible?	Available from product information, personal experience, industry publications and interviews	✓
Interpretable and comparable?	Can be compared across different technologies and to the requirements of different LBS applications.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 15: Passive Tracking

The difference between active and passive tracking was discussed in section 4.3. Vodacom's SignalSoft Location Gateway platform allows the passive tracking of cellular users. This capability enables the provision of applications such as Look4me as discussed in section A.4.3.7. Passive tracking requires the capability to control access to location information as discussed in section A.1.2.5, and to manage user opt-in strategies as discussed in section A.1.2.6.

MTN has not implemented a location gateway, and therefore cannot provide network-wide passive tracking. They have however experimented with alternate methods, for example a SIM-based active tracking solution that simulates passive tracking by initiating and terminating a call without user intervention (Oehely 2002). This is not feasible for large scale user adoption of LBS as it requires specific handset capabilities and installation of software on the SIM card. MTN has also experimented with a custom developed system that allows passive tracking on a small scale, but is not feasible for network-wide passive tracking (Oehely 2004).

A.1.2.8 Hardware Requirements

Metric Name	**16. Hardware Requirements**	
Description	Network infrastructure hardware requirements to implement the chosen location technology	
Data type	Qualitative - objective	
Relevant to evaluation?	Have initial cost and implementation implications.	✔
Available and accessible?	Available from technical specifications and interviews.	✔
Interpretable and comparable?	A greater initial expenditure relates to a greater operator intention to implement LBS and a greater need to obtain an ROI.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 3, Assess LBS Technology Requirements, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 16: Network Hardware Requirements

Both Vodacom and MTN make use of COO network positioning. As shown in Figure 4.4 and discussed in appendix C.4, this location technology has no additional network hardware requirements.

A.1.2.9 Software Requirements

Metric Name	**17. Software Requirements**	
Description	Network software and middleware requirements to implement the chosen location technology.	
Data type	Qualitative - objective	
Relevant to evaluation?	Have initial cost and implementation implications.	✔
Available and accessible?	Available from technical specifications and interviews.	✔
Interpretable and comparable?	A greater initial expenditure relates to a greater operator intention to implement LBS and a greater need to obtain an ROI.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 3, Assess LBS Technology Requirements, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 17: Network Software Requirements

For basic active tracking, the COO location method used by MTN and Vodacom does not require additional software. However, as discussed in section 4.2.3, a lesson drawn from global experience is that a Location Gateway is a vital technology component of LBS. This effects the privacy management (section A.1.2.6), passive tracking capabilities (section A.1.2.7), and enables 3rd party access (section A.1.2.5) by providing a common interface to location information. Furthermore, as it is typically independent of the actual positioning method, it enables operators to upgrade the underlying location technology at a later stage without affecting any of the implemented LBS applications.

Vodacom has purchased and implemented the SignalSoft Location Gateway on their networks (Project F 2002). MTN has not implemented a location gateway as yet, but have investigated several options (Oehely 2004). MTN has experimented with various solutions to overcome the lack of location gateway, as discussed in sections A.1.2.5, A.1.2.6 and A.1.2.7.

A.1.2.10 Handset Requirements

Metric Name	**18. Handsets Requirements**	
Description	The hardware or software requirements for cellular handsets to be compatible with the chosen location technology.	
Data type	Qualitative - objective	
Relevant to evaluation?	Has cost implications for the consumer and potentially affects the market penetration of different classes of cellular handsets.	✔
Available and accessible?	Available from technical specifications.	✔
Interpretable and comparable?	Comparable across technologies, with the market penetration of compatible devices and has implications for penetration of LBS applications.	✔
Associated with identified process or SSM conceptual model?	Outcome of process 3, Assess LBS Technology Requirements, identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 18: Handset Requirements

The COO network-based positioning method used on South African networks does not have any specific handset requirements. This is beneficial as it means that every cell phone in use in South Africa is inherently a potential target for LBS. The exception to this is MTN's attempt at implementing SIM-based passive tracking as discussed in section A.1.2.7.

Although COO is compatible with all handsets, the capabilities and market penetration of different classes of cellular handsets must still be taken into consideration for determining the most suitable delivery mechanism for LBS content. This is discussed in section A.3.1.15.

A.1.2.11 Supported LBS Applications

Metric Name	**19. Supported LBS Applications**	
Description	Determines which of the classes of LBS applications are technically possible with positioning technology currently available on South African networks.	
Data type	Qualitative - subjective	
Relevant to evaluation?	May determine which applications should be implemented, or contribute to motivation for additional location technology.	✓
Available and accessible?	Technical capabilities of the positioning technology compared to the requirements of the class of LBS application.	✓
Interpretable and comparable?	Comparable across networks and to the LBS applications that have been implemented already.	✓
Associated with identified process or SSM conceptual model?	Outcome of process 5, Implement LBS Enabling Technology, identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 19: Supported LBS Applications

Based on commercial involvement and data collected in this research, Figure A.5 below shows the author's interpretation of which classes of LBS applications, defined for the purposes of this thesis in section 4.3, are technically possible with the network-based positioning technology currently implemented on South African networks.

Classes of LBS Applications	Vodacom COO	MTN COO	MTN Matrix
Emergency Services	✓	✓	X
Person & Asset Tracking	✓	X	✓
Navigation & Information	✓	✓	X
Entertainment & Personal Messaging	✓	X	X
Mobile Commerce & Advertising	✓	X	X
Location Sensitive Billing	✓	✓	X
Intelligent Transport Systems	✓	X	X

Figure A.5: Supported Classes of LBS Applications on South African Networks

The figure above shows that Vodacom can technically support all classes of LBS applications on a network-wide implementation. Primarily, this is due to the passive tracking and privacy management capabilities enabled by their SignalSoft Location Gateway as discussed in sections A.1.2.5, A.1.2.6 and A.1.2.7.

As already stated in the previous section, MTN has not implemented a Location Gateway they do not have network-wide passive tracking and privacy management abilities. They are therefore not able to achieve a network-wide implementation of all classes of LBS applications.

More specifically, MTN is not able to offer Person & Asset Tracking, Entertainment & Personal Messaging, Mobile Commerce & Advertising and Intelligent Transport Systems, as these applications typically require passive tracking. An exception is the Matrix vehicle tracking application, which uses software on the cellular handset to calculate a position. However, as discussed in section A.1.2.5, this is not feasible for large-scale implementation of LBS applications as has additional device requirements which provides a barrier to the mass adoption of the application, and therefore can only be used for niche applications such as vehicle tracking.

Navigation and Information LBS services are possible on both networks using current technology. However, as discussed in section A.1.2.2, LBS navigation is an example of a niche application of LBS that would require greater positional accuracy. Vodacom has already addressed this issue with the introduction of the SmartRoute application (see section A.4.3.7), which relies on an external GPS for its positioning. As this application is provided by a 3rd party and makes use of external device-based positioning, device software and GPRS for the transfer of data, it is also available on MTN's network without the need for a Location Gateway.

A.1.3 Cellular Handsets

Metrics concerning the technical capabilities of cellular handsets available in South Africa are fundamental to the evaluation of LBS, as they determine which technologies can be used to implement LBS applications. Cellular handset technology metrics can be divided into two groups, those pertaining to the physical characteristics and capabilities of existing handsets, and those pertaining to supported applications. These metrics are shown in the hierarchy depicted in Figure 6.5 in section 6.1.2.3.

Due to the large number of different handsets available, the different capabilities of these handsets and the rapid progress of handset technology, it is not feasible to perform a thorough evaluation of all available cellular handsets. Therefore, the metrics in this section are evaluated in terms of the 3 general classes of cellular handsets as defined for the purposes of this thesis in 4.2.5. In summary, these classes are entry-level handsets, mid-tier handsets, and advanced handsets. Reiterating the points discussed in section 4.2.5, the distinctions between these handset classes represents the author's classification of available handsets according to their characteristics at a particular time. These classifications will change as newer handsets with more advanced capabilities are introduced into the market, as shown in Figure A.41.

A.1.3.1 Supported Network Technology

Metric Name	20. Supported Network Technology	
Description	The network technology supported by each class of cellular handset.	
Data type	Quantitative – objective	
Relevant to evaluation?	Has associated implications for the choice of technology for the delivery of LBS applications.	✔
Available and accessible?	Available from product specifications.	✔
Interpretable and comparable?	Comparable across network technologies and handset classes, and has bearing on how LBS applications are implemented.	✔
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers, and are therefore external inputs to the system.	✔
Does metric pass selection criteria?		✔

Metric 20: Supported Protocols

Figure A.6 below shows the network technologies supported by each class of cellular handset.

	Entry Level Handset	Mid-tier Handset	Advanced Handset
Supported Network Technology	GSM 900	Dual-Band GSM 900/1800 GPRS	Tri-Band GSM 900/1800/1900 GPRS EDGE W-CDMA

data compiled from handset product brochures, manufacturer websites and operator websites

Figure A.6: Supported Network Technology of Handset Classes

As shown in the figure above, entry-level handsets typically only support GSM technology, mid-tier handsets can support GSM and GPRS, while advanced handsets can typically support GSM, GPRS and 3G technology (W-CDMA).

When considering the implications of supported cellular technology for the different handset classes, the bandwidth and capabilities of the technology (section A.1.1.1), the technology usage (see section A.3.1.16) and handset penetration (section A.3.1.15) need to be taken into account. These underlying technologies enable features such as various messaging capabilities (section A.1.3.6) and internet connectivity (section A.1.3.7).

A.1.3.2 Display Capabilities

Metric Name	**21. Display Capabilities**	
Description	Screen size and display capabilities of handset classes.	
Data type	Qualitative - objective	
Relevant to evaluation?	Influences the way information is presented to the user, in particular for LBS applications such as directions which could potentially display colour maps.	✓
Available and accessible?	Available from handset manufacturers' product catalogues.	✓
Interpretable and comparable?	Screen size and display capabilities are comparable across handsets classes and LBS application requirements.	✓
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers, and are therefore external inputs to the system.	✓
Does metric pass selection criteria?		✓

Metric 21: Screen

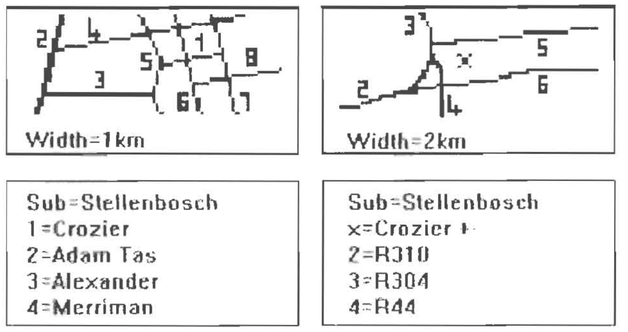
	Entry Level Handset	**Mid-tier Handset**	**Advanced Handset**
Display and Imaging	Monochrome display 96 x 65 pixels Up to 5 lines of text and basic graphics	4096 colour display 128 x 128 pixels Higher resolution enables more lines text at once	65,536 colour display 176 x 208 pixels Integrated digital camera 640 x480 pictures 128 x 96 video

data compiled from handset product brochures, manufacturer websites and operator websites

Figure A.7: Display Capabilities of Handset Classes

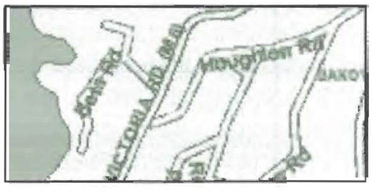
Figure A.7 above shows how the display characteristics and capabilities vary between handset classes, ranging from the small monochrome display of the typical entry-level handset to the relatively large, full colour display of advanced handsets.

The display capabilities effect the way information is presented to the user and either enable or restrict the provision of LBS applications that require maps. An example of how LBS maps can be formatted to suit the display characteristics of different handset classes is shown in the following three figures:



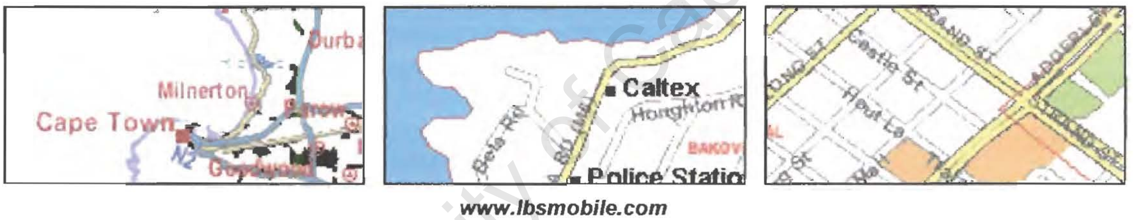
www.lbsmobile.com

Figure A.8: SMS-based Diagrammatic LBS Maps for Entry-level Handsets



www.lbsmobile.com

Figure A.9: EMS-based LBS Map for Mid-tier Handsets



www.lbsmobile.com

Figure A.10: MMS-based LBS Maps for Advanced Handsets

Figure A.8, Figure A.9 and Figure A.10 above show how MobiMap, a South African mobile application development company, is making use of the display capabilities of different handset classes to format map content for the provision of LBS applications (LBS Mobile 2004). As can be seen from the images, the colour screens of advanced handsets enable the provision of richer, more detailed and easier to understand maps.

When considering the implications of the display characteristics between handset classes, the usage of the supported technology must be considered (see section A.3.1.16), as well as the market penetration of each of the handset classes (section A.3.1.15) and the messaging and data capabilities of the handsets (section A.1.3.6).

A.1.3.3 User Interaction

Metric Name	**22. User Interaction**	
Description	User input and interaction capabilities of the handset classes.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Influences the user interaction with the LBS application, and highlights particular issues that may affect the design of the LBS user interface.	✓
Available and accessible?	Available from handset manufacturer's product catalogues and analyst reports.	✓
Interpretable and comparable?	Different methods of input and their impact on the usability of potential and existing LBS applications can be compared.	✓
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers.	✓
Does metric pass selection criteria?		✓

Metric 22: User Interaction

	Entry Level Handset	Mid-tier Handset	Advanced Handset
User Interface	Numeric keypad Menu driven operation Predictive text input	Numeric keypad Menu driven operation Predictive text input 5-way joystick Voice dialling	Numeric keypad Icon menu driven operation Voice operation Predictive text input 5-way joystick Alphanumeric keypad Touch screen

data compiled from handset product brochures, manufacturer websites and operator websites

Figure A.11: User Input Methods of Handset Classes

In comparison to all other characteristics of cellular handsets, the user interaction methods are likely to change the least in the foreseeable future (Crawford & Aftahi 2001). Possible exceptions to this are the touch screen capabilities of some advanced handsets, the introduction of basic voice recognition. However, the primary method of input will remain the limited keypad provided on all devices. Innovations such as predictive text and easy to navigate menu systems make this method of interaction acceptable, but ease of use has been identified as a major user concern in the LBS Market survey (Project B 2002).Therefore, improvements in user interaction need to be driven by the improvement of the software user interface and menu systems.

An example of such improvements in user interaction is the SMS "panic button" launched by Vodacom in May of 2004 (Vodacom 2004b). This links a single button on a user's cell phone to Vodacom's Look4Help emergency services application, as discussed in section A.4.3.7.

A.1.3.4 Memory Capacity

Metric Name	**23. Memory Capacity**	
Description	Amount of memory available for data storage on different classes of cellular handsets.	
Data type	Quantitative - objective	
Relevant to evaluation?	Influences the type and amount of data that can be stored on a handset, for example MMS messages containing a map for an LBS directions application.	✔
Available and accessible?	Available from handset manufacturer product catalogues and analyst reports.	✔
Interpretable and comparable?	The metric is comparable across handset classes, and the effect on the implementation of LBS applications can be interpreted.	✔
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers.	✔
Does metric pass selection criteria?		✔

Metric 23: Memory Capacity

	Entry Level Handset	**Mid-tier Handset**	**Advanced Handset**
Memory	Limited to built-in applications 100 contacts 50 SMS messages	500kb - 2mb	up to 64 MB internal memory support for external memory cards

data compiled from handset product brochures, manufacturer websites and operator websites

Figure A.12: Memory of Handset Classes

The amount of memory affects the operating system that can be used in the device and the type and amount of data and applications that can be stored on the handset (Varshney & Vetter 2002). This in turn affects the type of LBS applications that can be implemented, as typically only advanced handsets are able to support LBS applications that have significant requirements for storage of data and applications on the device itself. However, since the majority of the LBS applications currently implemented in South Africa (see section A.4.3.7) provide content to the users phone by means of SMS or MMS, the issue of handset memory for actual data storage is currently of little consequence to the actual provision of LBS applications in comparison to the supported messaging of the handset.

A.1.3.5 Battery Life

Metric Name	**24. Battery Life**	
Description	Capacity of handset battery under various conditions	
Data type	Quantitative - subjective	
Relevant to evaluation?	Has no influence on the type of LBS applications that can be offered or the way they are implemented. Would have relevance to handsets containing GPS devices as these use additional power. However, these handsets are currently not readily available on South African networks.	✗
Available and accessible?	Available from handset manufacturer product catalogues and analyst reports.	✓
Interpretable and comparable?	Comparable across handset classes and under different usage conditions.	✓
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers.	✓
Does metric pass selection criteria?	May become relevant in subsequent evaluations when built in GPS receivers place additional power requirements on handsets. This metric is excluded from the evaluation model for the purposes of this thesis.	✗

Metric 24: Battery Life

A.1.3.6 Messaging Support

Metric Name	**25. Messaging Support**	
Description	Messaging formats supported by the different handset classes.	
Data type	Qualitative - objective	
Relevant to evaluation?	Influences type and implementation of LBS applications.	✓
Available and accessible?	Available from handset manufacturer product catalogues and analyst reports.	✓
Interpretable and comparable?	This metric can be compared across handsets classes, and the effects on the implementation of LBS applications can be interpreted.	✓
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers.	✓
Does metric pass selection criteria?		✓

Metric 25: Messaging Support

	Entry Level Handset	Mid-tier Handset	Advanced Handset
Messaging	Text messaging (SMS) Operator logos	Text messaging (SMS) Concatenated SMS Picture messaging (EMS) Email over SMS	Text messaging (SMS) Concatenated SMS Picture messaging (EMS) Email (SMTP, POP3, IMAP4) Multimedia Messaging (MMS)

data compiled from handset product brochures, manufacturer websites and operator websites

Figure A.13: Supported Messaging of Handset Classes

The pervasiveness of personal messaging services, in particular SMS as discussed in section 4.2.6.1, has shown that messaging is the ideal method of delivering content to handheld devices. This is supported by Figure A.13 above, shows the types of messaging are supported by the different classes of handsets.

The supported messaging needs to be considered in parallel with the handset penetration (see section A.3.1.15) and the usage of personal messaging (see section A.3.1.13) when determining which messaging formats would prove most suitable for the delivery of LBS applications.

In summary, the data shows that the most pervasive delivery method for LBS applications is SMS messaging. However, as MMS enabled cellular handsets become more pervasive in the market, LBS applications that provide more detailed information such as colour maps through MMS messaging will become a more viable option for large scale use in South Africa.

A.1.3.7 Connectivity

Metric Name	**26. Connectivity**	
Description	Internet connectivity, data support, and ability of the different handset classes to connect to other devices.	
Data type	Qualitative - objective	
Relevant to evaluation?	Influences type and implementation of LBS applications	✓
Available and accessible?	Available from handset manufacturer product catalogues and technical specifications.	✓
Interpretable and comparable?	This metric can be compared across handsets classes, and the effects on the implementation of LBS applications can be interpreted.	✓
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers.	✓
Does metric pass selection criteria?		✓

Metric 26: Connectivity

	Entry Level Handset	Mid-tier Handset	Advanced Handset
Connectivity	none	Infrared WAP (CSD) WAP (GPRS)	Infrared Bluetooth 802.11b WAP (HSCSD) WAP (GPRS) xHTML browser

data compiled from handset product brochures, manufacturer websites and operator websites

Figure A.14: Connectivity of Handset Classes

Figure A.14 above shows the connectivity capabilities of the handset classes. This has implications for how the handset connects to other devices, as well as the data transfer capabilities of the handset.

Infrared is the capability used most to connect handsets with personal computers, allowing the synchronisation of contacts, calendar and 3rd party applications as discussed in section A.1.3.7. This has no real implications for LBS. However, Bluetooth is an emerging wireless connectivity protocol that has implications for advanced LBS applications such as Vodacom's SmartRoute, which requires the use of a Bluetooth enabled GPS receiver (see section A.4.3.7). The support of WAP over GPRS connectivity is also required for this application.

It remains to be seen what implications what role full internet connectivity and browsing using xHTML, a language for formatting internet content, will have for future LBS applications. In the meantime, it suffices to say that the capabilities of advanced devices allow for the delivery of advanced LBS applications, and the market penetration of the advanced handsets currently matched the demand for these specialist LBS applications such as SmartRoute, as discussed in section A.4.3.7.

A.1.3.8 3rd Party Applications

Metric Name	**27. 3rd Party Applications**	
Description	Ability of the operating systems of the different handset classes to support 3rd party applications.	
Data type	Qualitative - objective	
Relevant to evaluation?	Influences the way LBS applications are implemented and deployed.	✔
Available and accessible?	Available from handset manufacturer product catalogues, technical specifications, author's experience and analyst reports.	✔
Interpretable and comparable?	Determines how the support of 3rd party applications allows for a wider range of LBS applications, and determines how these applications can be distributed to consumers.	✔
Associated with identified process or SSM conceptual model?	Input of process 1, Evaluate Available Technology, identified in section 5.4.2. Associated with input stage of S&T as they are developed and supplied by international cellular technology providers.	✔
Does metric pass selection criteria?		✔

Metric 27: 3rd Party Applications

	Entry Level Handset	Mid-tier Handset	Advanced Handset
Applications	Built-in applications only	Java applications OTA downloads Contact and calendar synchronisation	Java applications OTA downloads Advanced gaming MMS composer and video editing MP3 player Microsoft Outlook synchronisation

data compiled from handset product brochures, manufacturer websites and operator websites

Figure A.15: 3rd Application Support of Handset Classes

Figure A.15 shows the support for various software applications for each of the handset classes. Entry-level handsets typically only support built-in software, including basic applications such as calculators, currency converters or timers. The limited software capabilities of this handset class limit the device-based LBS applications that can be supported.

A significant development for 3rd party software support is Java. The fundamental principle of Java technology is that there is a layer of software, known as a virtual machine, between the hardware and the application that enables the same application to be run on any device without the overhead of compiling the software specifically for a particular hardware platform or operating system. Sun Microsystems has developed a version of Java, Java 2 Micro Edition (J2ME), which allows this concept to be extended to mobile devices (Niedzwiadek 2000). This means that 3rd party applications are available to a wider range of devices then previously possible. Java technology, in combination with Over the Air (OTA) application downloading and installation capability, means that software is easily available to anyone with a compatible handset. An example of OTA distribution of handset software for LBS applications is Vodacom's SmartRoute application as discussed in section A.4.3.7.

3rd party support is largely dictated by the operating system. For example, the Nokia Series 60 operating system available on some advanced handsets enables the development and deployment of 3rd party applications. This capability has been targeted by mobile application developers for the deployment of LBS applications (Project G 2003).

The majority of LBS applications currently implemented in South Africa make use of either SMS or MMS for delivery of LBS content, and therefore require no specific device-based software. However, the author is of the opinion that in time 3rd party application support will enable a far greater range of LBS-enabled applications.

A.2 Financial and Economic Metrics

This section presents all the financial and economic metrics affecting LBS in South Africa, as derived in section 6.1.3. Section A.2.1 covers the revenue metrics, section A.2.2 covers the expenditure and cost of technology metrics, and section A.2.3 deals with the cost of service metrics.

A.2.1 Revenue

Revenue metrics provide insight to the profitability of providing cellular services, including LBS, as well as provide insight to the relative proportions of the revenue generated from different cellular services. This contributes to the understanding of the demand for and the usage patterns of cellular services. The metrics dealt with in this section are derived from the hierarchy of metrics shown in Figure 6.6.

A.2.1.1 Total Revenue

Metric Name	**28. Total Revenue**	
Description	Revenue generated from operating cellular networks	
Data type	Quantitative - objective	
Relevant to evaluation?	Total revenue will be used in conjunction with other measures of revenue to determine relative profitability of LBS	✓
Available and accessible?	Available from industry reports and network operator financial figures	✓
Interpretable and comparable?	Comparable to other regions and to revenue components will aid to interpret the effects of LBS on revenue	✓
Associated with identified process or SSM conceptual model?	Output of process 6, Provision of Cellular Services, identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 28: Total Revenue

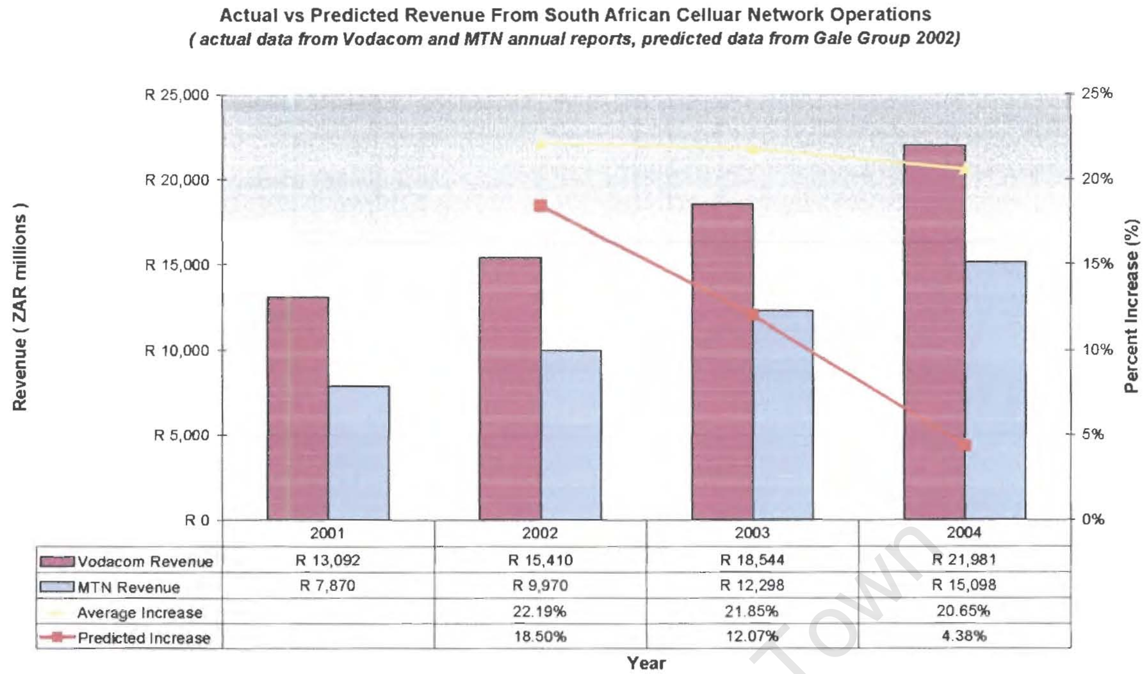


Figure A.16: Total Cellular Revenue in South Africa

Figure A.16 above shows the revenue generated by Vodacom and MTN between 2001 and 2004, and shows the actual versus predicted percentage increase in total revenue for the same period. The data shows that the total revenue of both cellular operators has been increasing steadily, and has in fact been increasing at a higher than predicted rate. This indicates that the cellular industry has been growing steadily in South Africa, and that the growth has yet to show real signs of slowing down.

A.2.1.2 Operating Profit

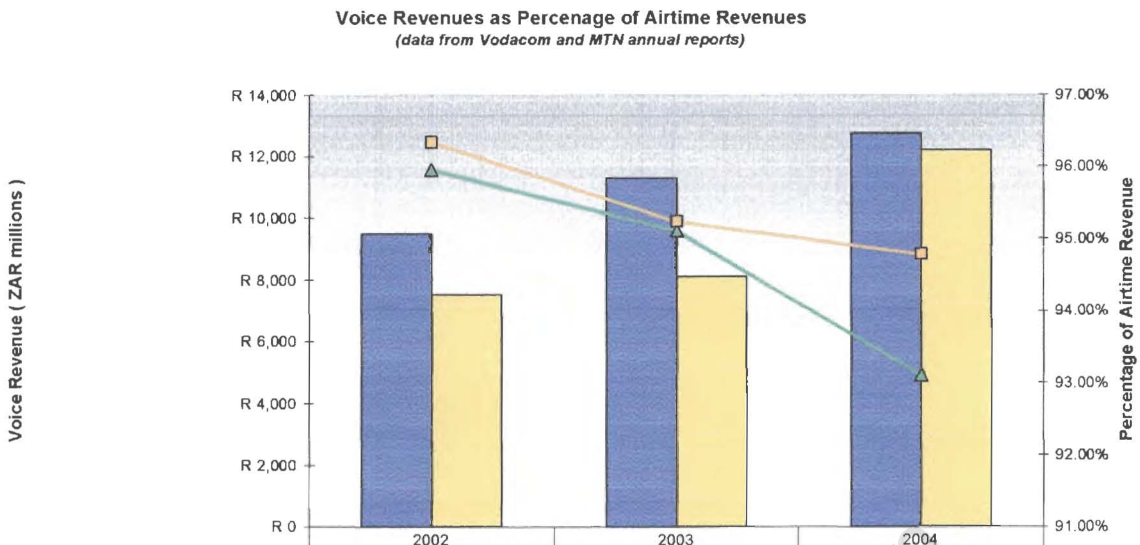
Metric Name	29. Operating Profit	
Description	Operating profit generated from cellular networks.	
Data type	Quantitative - objective	
Relevant to evaluation?	Operating profit takes into account a number of factors such as tax, expenditure and depreciation of assets. The metric takes many high level factors into consideration for the influence of LBS to be detectable, especially when expenditure metrics are not available and revenue metrics for LBS are unknown.	✗
Available and accessible?	Available from industry reports and network operator financial figures. No data is available for LBS activities.	✓
Interpretable and comparable?	It is not possible to correlate this metric with LBS profitability, as there is no data on LBS expenditure or revenue.	✗
Associated with identified process or SSM conceptual model?	Output of process 6, Provision of Cellular Services, identified in section 5.4.2.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation model for the purposes of this thesis. However, this metric should be considered for subsequent evaluations.	✗

Metric 29: Operating Profit

A.2.1.3 Voice Revenues

Metric Name	30. Voice Revenues	
Description	Revenues generated by voice services.	
Data type	Quantitative - objective	
Relevant to evaluation?	Relative revenues of different cellular services will provide an idea of the relative worth and usage of each type of service, potentially including LBS.	✓
Available and accessible?	Available from industry reports and network operator financial figures	✓
Interpretable and comparable?	Comparable to other geographical areas, comparable over time and can be interpreted as a measure of demand for voice services.	✓
Associated with identified process or SSM conceptual model?	Output of process 6, Provision of Cellular Services, identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 30: Voice Revenues



	2002	2003	2004
Vodacom Voice Revenue	R 9,487	R 11,301	R 12,738
MTN Voice Revenue	R 7,526	R 8,120	R 12,182
Vodacom % of Airtime Revenue	95.95%	95.11%	93.11%
MTN % of Airtime Revenue	96.34%	95.24%	94.79%

Year

Figure A.17: Voice Revenues in South Africa

Figure A.17 above shows the revenue generated by voice revenue by Vodacom and MTN between 2002 and 2004. The data shows an increase in voice revenues for both network operators, but shows a decrease in the relative percentage of voice revenue to other sources of revenue. This suggests that although the vast majority of revenue currently comes from the provision of voice services, there is an increasing contribution from other types of cellular services, i.e. the data services (including LBS) discussed in section A.2.1.5. In order to provide more meaning to this data, the predicted percentages of voice revenues need to be considered:

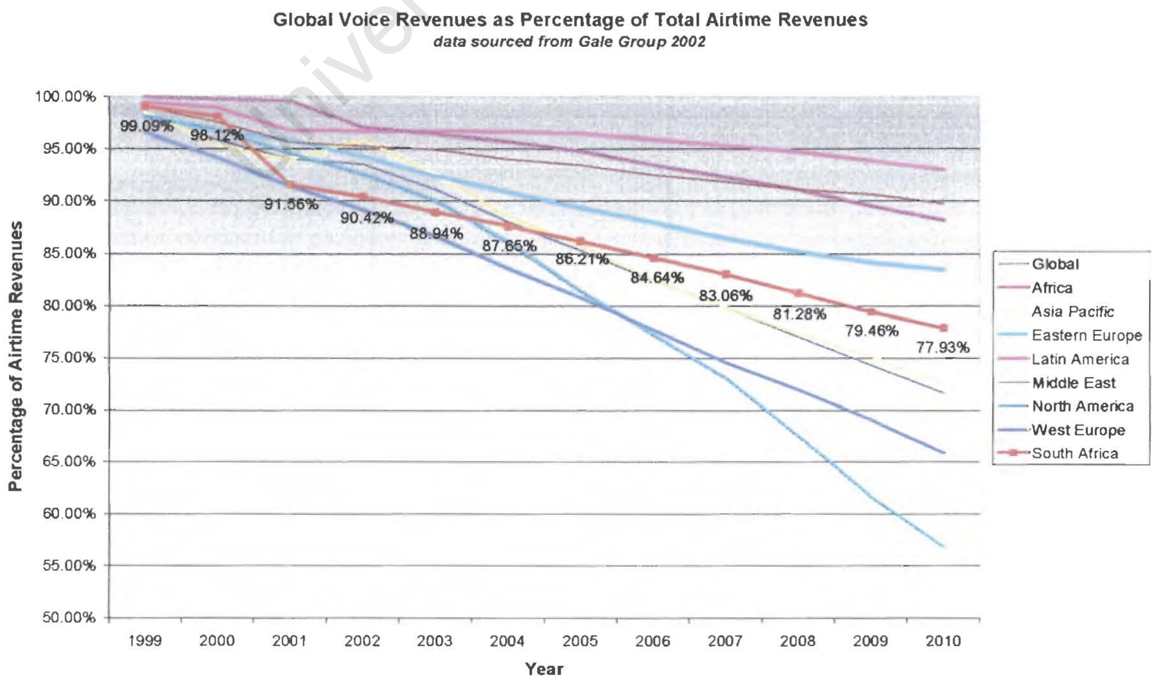


Figure A.18: Predicted Voice Revenues as Percentage of Total Revenue

Figure A.18 shows the predicted voice revenues as a percentage of the total revenue for South Africa versus other regions. The data shows that South Africa is predicted to have a steady decrease in the percentage contribution of voice services, which matches the trend revealed by the data shown in Figure A.17. However, it must be noted that the predicted data does not correspond exactly to the actual data shown in Figure A.17.

More specifically, the actual data shows that voice services are a greater percentage component of the total revenue than predicted. For example, in 2003 both Vodacom and MTN generated 95% of their airtime revenues through voice services, while the prediction for South Africa was around 89%. This indicates that the cellular industry in South Africa is slower than expected in adopting new value-added services such as messaging, data and LBS applications.

This point will be revisited in the context of data revenues in section A.2.1.5.

A.2.1.4 Prepaid vs. Contract Revenues

Metric Name	**31. Prepaid vs. Contract Revenues**	
Description	Revenues generated by contract subscriptions and prepaid subscriptions	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding which business model is more profitable influences the business model and pricing structure for LBS.	✓
Available and accessible?	Available from industry reports and network operator financial figures.	✓
Interpretable and comparable?	Comparable to other geographical areas, comparable over time, comparable between operators.	✓
Associated with identified process or SSM conceptual model?	Output of process 6, Provision of Cellular Services, identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 31: Prepaid vs. Contract Revenues

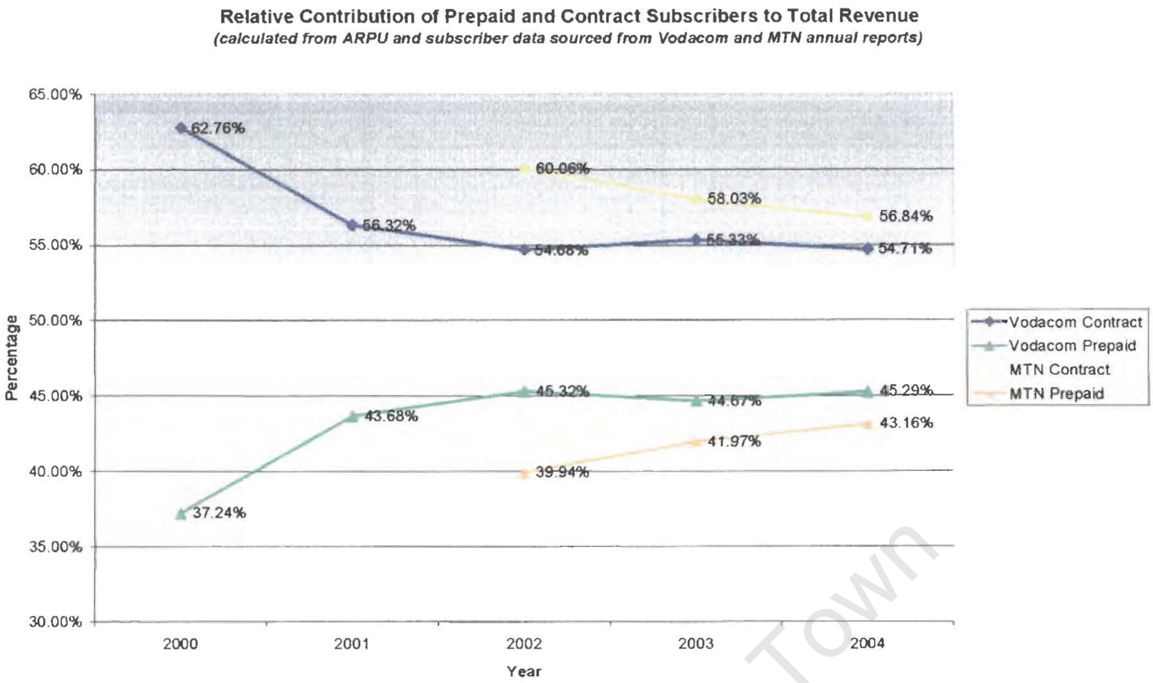


Figure A.19: Contribution of Prepaid and Contract to Revenue

Figure A.19 above shows the relative contribution of prepaid and contract subscribers for Vodacom and MTN between 2000 and 2004. The data shows that even though the great majority of subscribers in South Africa are prepaid users (see section A.3.1.11), most of the revenue still comes from contract subscribers. The data also shows that the difference between the revenue contribution of prepaid and contract users is decreasing. By examining the subscriber statistics (section A.3.1.11) and the ARPU statistics (section A.2.1.6), it can be argued that this is due to the increase of prepaid users rather than the change in the spending behaviour of either contract or prepaid users. The author proposes that the stabilising of the curve above is related to the stabilising of the relative proportions of contract vs. prepaid users, as discussed in A.3.1.11.

Thus, despite significantly fewer contract subscribers than prepaid subscribers, the contract market is still more profitable than the prepaid market for the cellular networks in South Africa. This indicates that the contract market is a more likely target for revenue generating LBS applications, a notion supported by the ARPU statistics presented in section A.2.1.6.

A.2.1.5 Data Revenues

Metric Name	**32. Data Revenues**	
Description	Revenues generated by cellular data services in South Africa.	
Data type	Quantitative – objective	
Relevant to evaluation?	Most LBS applications are a subset of data applications, and a measure of data revenue can help to provide an idea of worth of LBS applications, and also the usage patterns of data services.	✔
Available and accessible?	Available from industry reports and network operator financial figures.	✔
Interpretable and comparable?	Comparable to other regions, comparable over time, comparable between network operators, and comparable to other revenue components.	✔
Associated with identified process or SSM conceptual model?	Output of process 6, Provision of Cellular Services, identified in section 5.4.2.	✔
Does metric pass selection criteria?		✔

Metric 32: Data Revenue

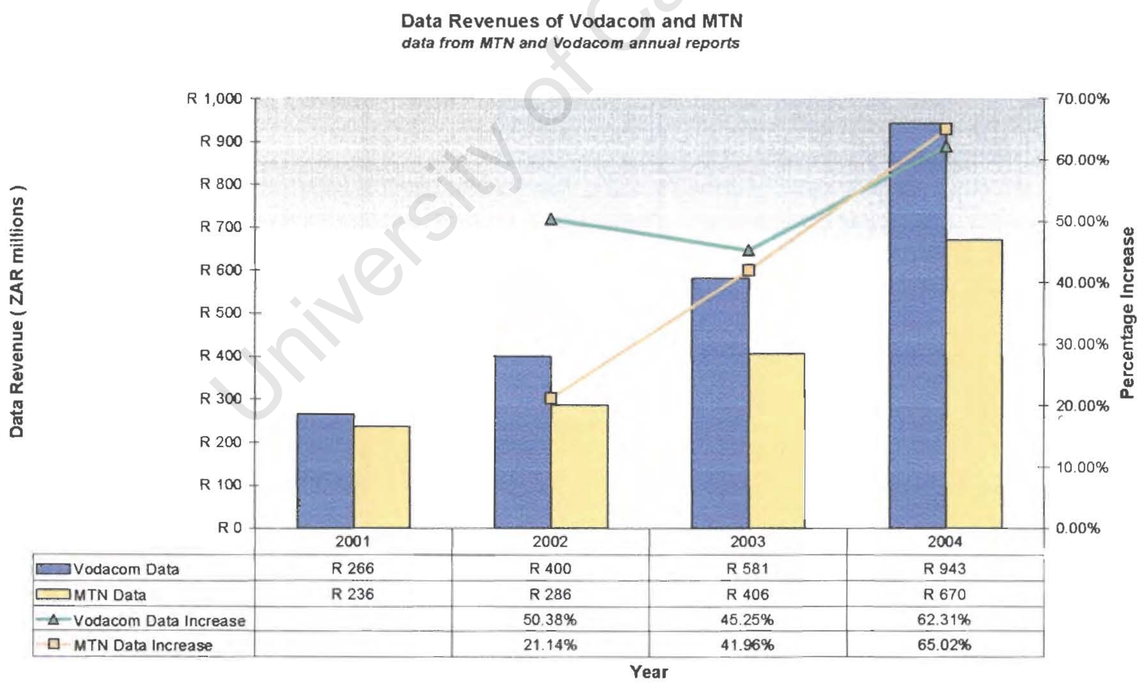
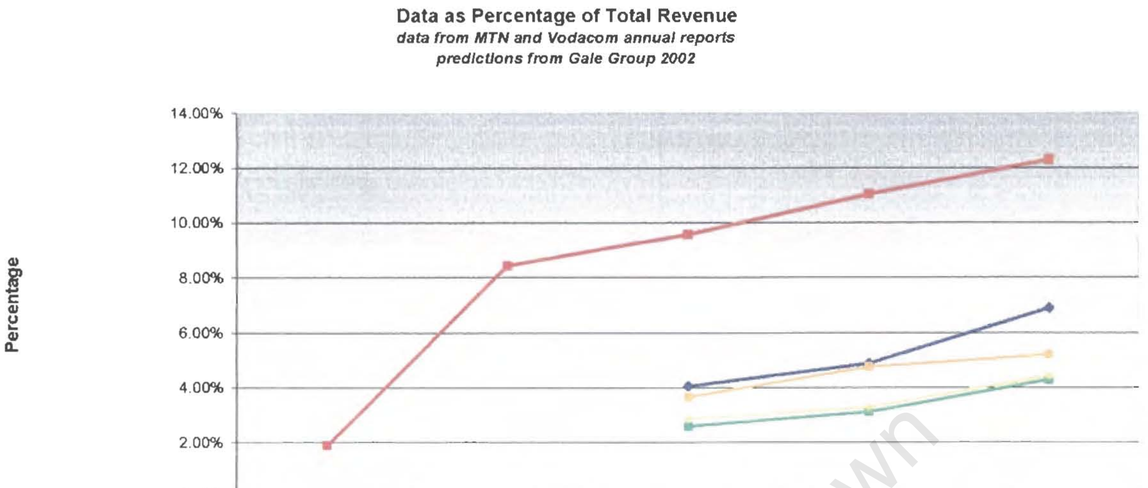


Figure A.20: Increase in Data Revenues in South Africa

Figure A.20 shows a significant increase in data revenues earned by MTN and Vodacom between 2001 and 2004. As can be seen by the data, both operators are experiencing a steady increase in data revenues. In addition, the rate at which these revenues are increasing is also increasing. The rate of increase seems to be somewhat comparable between the network operators, and the fact that Vodacom has greater absolute data revenues is attributable to Vodacom's greater market share as opposed to higher usage of data services than MTN. In order to support this argument, it is necessary to investigate data revenue as a percentage of total revenue for both MTN and Vodacom. This is shown in the figure below.



	2000	2001	2002	2003	2004
Vodacom % of Airtime			4.05%	4.89%	6.89%
MTN % of Airtime			3.66%	4.76%	5.21%
Vodacom % of Total			2.60%	3.13%	4.29%
MTN % of Total			2.87%	3.30%	4.44%
Predicted % of Airtime	1.88%	8.44%	9.58%	11.06%	12.32%

Figure A.21: Actual vs. Predicted Percentage of Data Revenues in South Africa

Figure A.21 above shows the actual vs. predicted contribution of data revenues to the total airtime revenues for MTN and Vodacom in South Africa between 2000 and 2004. The actual data for MTN and Vodacom is only available from 2002, and predicted data from before then has deliberately included in order to highlight a potential anomaly in the data, as discussed below.

The data shows that both MTN and Vodacom are experiencing an increasing contribution of their revenue generated through data services, which corresponds to the decrease in the relative revenue contribution of voice services discussed in section A.2.1.3. As with the voice revenues, the data shows that contribution of data revenues are less than predicted, although the rate of increase in later years seems to be consistent with the actual data.

The problem with the predicted data seems to be between 2000 and 2001, where a large increase the usage of data services was predicted. The author proposes that this discrepancy with reality was due to the expected increase in data services associated with the implementation of 2.5G GPRS enabled networks in South Africa. Although GPRS network technology was deployed over this time, a lack of GRPS enabled handsets and a lack of applications and content meant that little increase in the usage of data services was actually observed.

Although there is a discrepancy with the actual percentage contribution of data revenues, the rate of increase seems to be consistent, and therefore the long term predictions need to be examined in an attempt to determine how the contribution of data revenues could change in future. This is shown in the following figure.

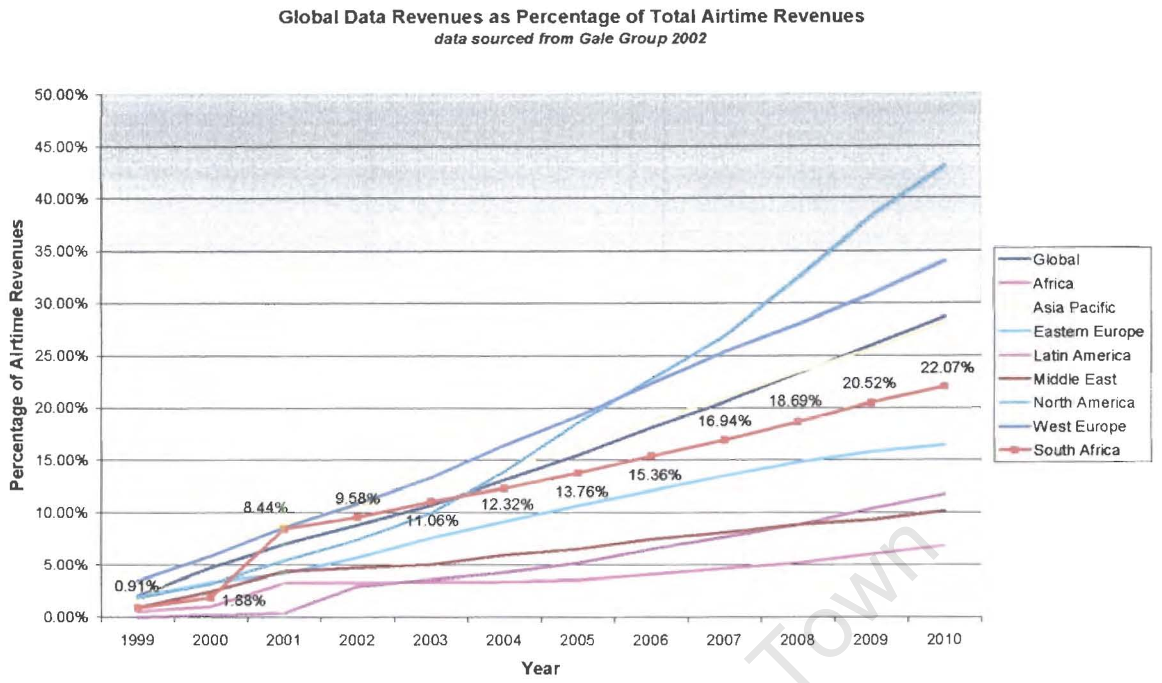


Figure A.22: Predicted Global Data Revenues

Figure A.22 above shows the predicted increase in data revenues in South Africa between 1999 and 2010, in comparison to other regions. The data shows a steady increase in the portion of revenues earned from data for all regions, with South Africa just below the global average.

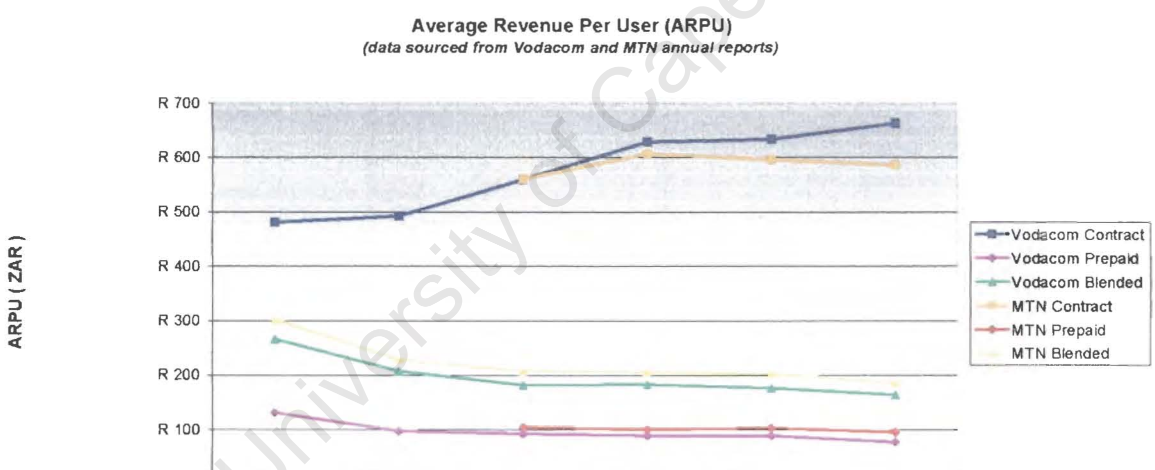
Thus, the data presented in this section has shown that data revenues and the relative contribution of data to total revenues are steadily increasing in South Africa. However, data revenues are below the predicted levels. Nevertheless, data revenues are expected to continue to increase in the foreseeable future.

The implications of increase data revenues for LBS in South Africa is that the market demand for value-added data services, which include LBS, is steadily increasing. Therefore, even though the demand is currently below expected levels, the actual and expected growth in data revenues is positive indicator for the future of LBS in South Africa.

A.2.1.6 Average Revenue per User

Metric Name	**33. Average Revenue Per User (ARPU)**	
Description	Average amount of revenue generated per user per month.	
Data type	Quantitative - objective	
Relevant to evaluation?	Decreasing ARPUs have been identified as a problem facing network operators in South Africa.	✔
Available and accessible?	Available from industry reports and network operator financial figures	✔
Interpretable and comparable?	Comparable to other geographical areas, comparable over time, and between subscription models.	✔
Associated with identified process or SSM conceptual model?	Output of process 6, Provision of Cellular Services, identified in section 5.4.2.	✔
Does metric pass selection criteria?		✔

Metric 33: Average Revenue per User



	2000	2001	2002	2003	2004	2004HI
Vodacom Contract	R 481	R 493	R 560	R 629	R 634	R 663
Vodacom Prepaid	R 132	R 98	R 93	R 90	R 90	R 79
Vodacom Blended	R 266	R 208	R 182	R 183	R 177	R 165
MTN Contract			R 561	R 607	R 597	R 587
MTN Prepaid			R 105	R 101	R 104	R 97
MTN Blended	R 302	R 229	R 208	R 206	R 203	R 187

Figure A.23: ARPU Trends in South Africa

Figure A.23 above shows the actual ARPU data for MTN and Vodacom between 2000 and the first quarter of 2004. The data shows contract, prepaid as well as the blended (or combined) ARPUs in order to show the differences between ARPUs for the different subscription models.

The data shows that both network operators are experiencing a decreasing blended ARPU. The decrease in prepaid ARPUs is marginal, but the rapidly increasing number of prepaid subscribers (section A.3.1.11) means that this ARPU component has the effect of steadily decreasing the total ARPU. Contract ARPUs are shown as increasing or relatively stable. In order to interpret the implications of ARPU for LBS in South Africa, the long term predictions or ARPU trends need to be investigated. These are shown in the figure below.

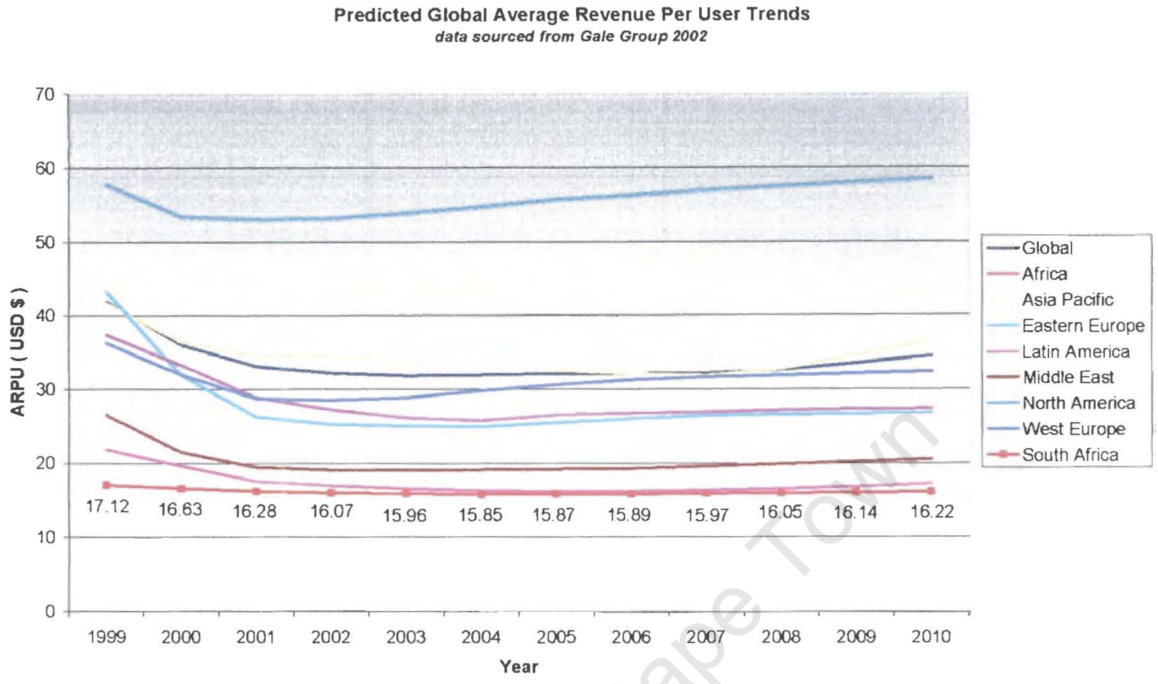


Figure A.24: Predicted Global ARPU Trends

Figure A.24 shows the predicted ARPU trends for South Africa in comparison to other regions. As the above predictions were based on data calculated in 2001, it is likely that the effects of the weak dollar-rand exchange rate at that time had an effect on the absolute values attached to the ARPUs in South Africa. This can be seen by comparing the predicted ARPU data to the actual ARPU data shown in Figure A.23. Therefore the absolute values in the predicted data cannot be used, as any attempt assumptions made regarding exchange rates would distort the data. However, the trends shown by both figures indicate that the ARPUs are decreasing and will continue to decrease in the near future before a predicted increase in ARPUs in around 2007.

Thus, the metric data presented in this section has shown that the ARPU in South Africa is currently decreasing, and will continue to fall for the next few years. However, the decrease in the ARPU is due mainly to the dilution of ARPU by a larger percentage of prepaid subscribers, and, in the author's opinion, does not represent a serious threat to the network operators. Nevertheless, the declining market growth rate (section A.3.1.9) and the probability of lower service charges (section A.2.3) show that alternative sources of income need to be investigated to increase ARPUs. This means that revenue generating value-added services such as LBS need to be investigated.

According to trends shown in the data above, the effects of these value-added services on the ARPU in South Africa will begin to become evident around 2007. This corresponds favourably with the increase of the percentage of revenue from data revenues as shown in A.2.1.5.

A.2.1.7 Total LBS Revenue

Metric Name	**34. Total LBS Revenue**	
Description	Total amount of LBS revenue generated	
Data type	Quantitative – subjective	
Relevant to evaluation?	Help determine feasibility and profitability of implementing LBS.	✔
Available and accessible?	Data not available due to sensitive nature.	✘
Interpretable and comparable?	Comparable to other regions, comparable to between network operators, and comparable over time.	✔
Associated with identified process or SSM conceptual model?	Output of process 7, Implement LBS Applications, identified in section 5.4.3.	✔
Does metric pass selection criteria?	This data is not available to the author. It therefore cannot be included in this evaluation, but should be included in subsequent evaluations as it is an important metric for the evaluation of LBS in South Africa.	✘

Metric 34: Total LBS Revenue

A.2.1.8 LBS Revenue by Application

Metric Name	**35. LBS Revenue By Application**	
Description	Total amount of LBS revenue generated for each LBS application class	
Data type	Quantitative - subjective	
Relevant to evaluation?	Help determine feasibility and profitability of implementing different classes of LBS applications.	✔
Available and accessible?	Data not available due to sensitive nature.	✘
Interpretable and comparable?	Comparison between LBS applications will help to determine which LBS applications are more financially viable to implement and could provide insight for implementation strategy.	✔
Associated with identified process or SSM conceptual model?	Output of process 7, Implement LBS Applications, identified in section 5.4.3.	✔
Does metric pass selection criteria?	This data is not available to the author. It therefore cannot be included in this evaluation, but should be included in subsequent evaluations as it is an important metric for the evaluation of LBS in South Africa.	✘

Metric 35: LBS Revenue by Application

A.2.1.9 LBS Revenue by Partnership

Metric Name	**36. LBS Revenue By Partnership**	
Description	Revenue generated by LBS applications grouped by the service provider or 3rd party developer.	
Data type	Quantitative - objective	
Relevant to evaluation?	Shows which partnerships are proving most successful in terms of providing profitable LBS applications.	✓
Available and accessible?	Data not available due to sensitive nature.	✗
Interpretable and comparable?	Comparison across partnerships would provide a notion of the health of the partnership/technology incubation initiative.	✓
Associated with identified process or SSM conceptual model?	Output of process 7, Implement LBS Applications, identified in section 5.4.3.	✓
Does metric pass selection criteria?	This data is not available to the author. It therefore cannot be included in this evaluation, but should be included in subsequent evaluations as it is an important metric for the evaluation of LBS in South Africa.	✗

Metric 36: LBS Revenue by Partnership

A.2.2 Expenditure

Expenditure metrics show the cost of implementing LBS enabling technology and LBS applications, as well as costs of cellular licenses, marketing costs and operating costs. The comparison of these metrics to the revenue metrics could aid in determining the profitability and thus the economic feasibility of LBS in South Africa. The metrics presented in this section are derived from the hierarchy of metrics depicted in Figure 6.7.

A.2.2.1 Hardware Costs

Metric Name	**37. Hardware Costs**	
Description	Amount spent on network infrastructure hardware.	
Data type	Quantitative - objective	
Relevant to evaluation?	Provide benchmark for comparison of LBS technology costs and measure of need to realise an ROI.	✓
Available and accessible?	Data is only partially available, but not enough so to determine its implications for LBS.	✗
Interpretable and comparable?	Could be comparable to other expenses, across networks, across technologies and to cellular revenues.	✓
Associated with identified process or SSM conceptual model?	This metric is an input of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✗

Metric 37: Hardware Costs

A.2.2.2 Software Costs

Metric Name	**38. Software Costs**	
Description	Amount spent on network infrastructure software and middleware.	
Data type	Quantitative - objective	
Relevant to evaluation?	Provide benchmark for comparison of LBS technology costs and measure of need to realise an ROI.	✓
Available and accessible?	Data is not available to the author due to sensitive nature.	✗
Interpretable and comparable?	Comparable to other expenses, across networks, across technologies and to cellular revenues.	✓
Associated with identified process or SSM conceptual model?	This metric is an input of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✗

Metric 38: Software Costs

A.2.2.3 Implementation Costs

Metric Name	**39. Implementation Costs**	
Description	Amount spent on implementing network infrastructure.	
Data type	Quantitative - objective	
Relevant to evaluation?	Provide benchmark for comparison of LBS technology costs and measure of need to realise an ROI.	✓
Available and accessible?	This data is not available to the author in sufficient detail to be able to relate it to LBS expenditure, and the LBS expenditure is in itself not available.	✗
Interpretable and comparable?	Comparable to other expenses, across networks, across technologies and to cellular revenues.	✓
Associated with identified process or SSM conceptual model?	This metric is an input of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✗

Metric 39: Implementation Costs

A.2.2.4 License Costs

Metric Name	**40. License Costs**	
Description	Amount spent on obtaining and maintaining operating licenses.	
Data type	Quantitative – objective	
Relevant to evaluation?	Provide benchmark for comparison of LBS technology costs and measure of need to realise an ROI.	✓
Available and accessible?	The data is available as it is available from ICASA and the network operator annual reports.	✓
Interpretable and comparable?	Could potentially be compared to other expenses, across networks, across technologies and to cellular revenues. However, the implications of the license costs cannot be interpreted as there is a lack of data regarding other expenditure metrics.	✗
Associated with identified process or SSM conceptual model?	This metric is an input of process 2, Implement Cellular Network Infrastructure, as identified in section 5.4.2.	✓
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✗

Metric 40: License Costs

A.2.2.5 Overheads

Metric Name	**41. Overheads**	
Description	Additional operating costs associated with running the cellular networks as a business.	
Data type	Quantitative - objective	
Relevant to evaluation?	Provide benchmark for comparison of LBS running costs and measure of need to realise an ROI.	✔
Available and accessible?	This data is not available to the author due to sensitive nature.	✖
Interpretable and comparable?	Potentially comparable to other expenses, across networks, across technologies and to cellular revenues.	✔
Associated with identified process or SSM conceptual model?	This metric is an input associated with process 6, Provision of Cellular Services, as identified in section 5.4.2.	✔
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✖

Metric 41: Overheads

A.2.2.6 Marketing Costs

Metric Name	**42. Marketing Costs**	
Description	Marketing expenses for cellular services, including the marketing of LBS applications.	
Data type	Quantitative - objective	
Relevant to evaluation?	Establish the cost of marketing LBS in comparison to the LBS revenues.	✔
Available and accessible?	This data is not available to the author due to sensitive nature.	✖
Interpretable and comparable?	Potentially comparable to other LBS expenses and to LBS revenue.	✔
Associated with identified process or SSM conceptual model?	Associated with process 4, Develop Marketing Strategy, identified in section 5.4.2, and process 8, Facilitate the Adoption of LBS, identified with 5.4.3.	✔
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✖

Metric 42: Marketing Costs

A.2.2.7 Location Equipment

Metric Name	43. Location Equipment	
Description	Amount spent on purchasing and implementing location determination hardware and equipment.	
Data type	Quantitative - objective	
Relevant to evaluation?	Establish cost of LBS enabling technology.	✔
Available and accessible?	This data is not available to the author due to its sensitive nature. Also, the operators have not spent significant amounts on LBS hardware, over and above the testing of different technologies.	✘
Interpretable and comparable?	Comparable to other expenses and to LBS revenue.	✔
Associated with identified process or SSM conceptual model?	This metric is an input of process 5, Implement LBS Enabling Technology, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✘

Metric 43: Location Equipment

A.2.2.8 Location Gateway

Metric Name	44. Location Gateway	
Description	Amount spent on Location Gateway software.	
Data type	Quantitative - objective	
Relevant to evaluation?	Establish cost of LBS enabling technology.	✔
Available and accessible?	This data is not available to the author due to its sensitive nature.	✘
Interpretable and comparable?	Comparable to other expenses and to LBS revenue. As only Vodacom has implemented a location gateway, it is difficult to compare this metric between operators.	✔
Associated with identified process or SSM conceptual model?	This metric is an input of process 5, Implement LBS Enabling Technology, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✘

Metric 44: Location Gateway

A.2.2.9 Data & Applications

Metric Name	**45. Data & Applications**	
Description	Amount spent in purchasing, developing and maintaining LBS data and applications.	
Data type	Quantitative - objective	
Relevant to evaluation?	Establish cost of implementing LBS applications in comparison to the revenue generated.	✔
Available and accessible?	This data is not available to the author due to its sensitive nature.	✘
Interpretable and comparable?	Comparable to other expenses and to LBS revenue.	✔
Associated with identified process or SSM conceptual model?	This metric is an input of process 7, Implement LBS Applications, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric can not be included in the evaluation model as there is a lack of available data for the metric itself and a lack of available data for comparative purposes. This metric should, however, be considered for subsequent evaluations.	✘

Metric 45: Data & Applications

This section has presented all the expenditure metrics for the financial and economical aspect of LBS in South Africa. Although it is recognised that the expenditure of the operators on various technologies and operating expenses is a vital measure for the evaluation of LBS, there is not enough data available to make any meaningful comparisons or to draw any conclusions regarding the implications of expenditure for LBS in the context of this thesis.

While the basic expenditure data is available from the operator's annual financial reports, these reports do not break down the expenditure information to a sufficient level of detail to be relevant and interpretable for this evaluation. In addition, there is no data concerning the expenditure on LBS technology, implementation or marketing. Coupled with the lack of data regarding LBS revenues, this represents a significant gap in the data available for the purposes of this thesis.

Therefore, it is necessary to exclude all of the expenditure metrics from the evaluation model for the purposes at this time. In the event of subsequent evaluations, these metrics should be revisited and considered for inclusion in the evaluation model if more data is available.

A.2.3 Cost of Service

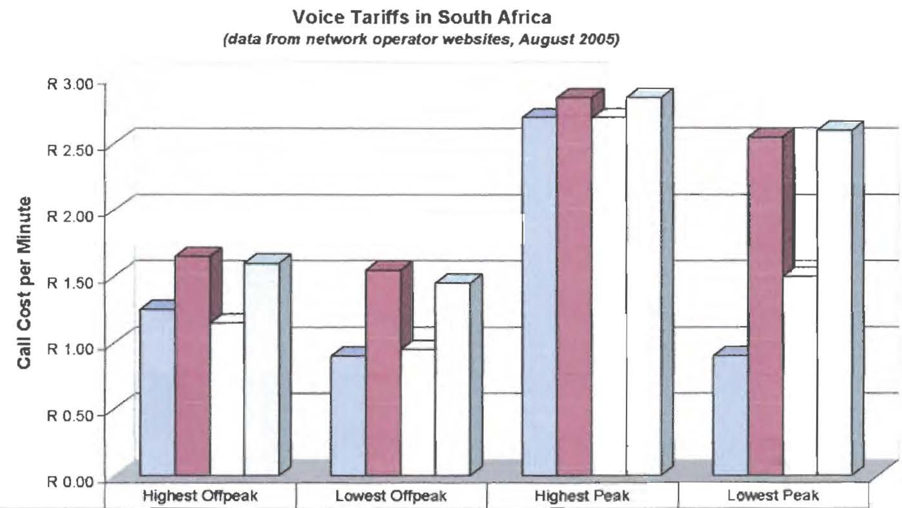
The cost of service metrics provide an insight into the affordability of cellular services in South Africa, and the affordability of LBS applications relative to other cellular services. The cost of service metrics presented in this section are derived from the hierarchy of metrics shown in Figure 6.8.

A.2.3.1 Voice Tariffs

Metric Name	**46. Voice Tariffs**	
Description	The cost to consumer of cellular voice services in South Africa	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding the costs of voice services contribute towards understanding affordability and determining a benchmark for evaluation of LBS tariffs and pricing models.	✓
Available and accessible?	Cellular voice tariffs are available from the operator websites.	✓
Interpretable and comparable?	The voice tariffs can be compared between operators, compared to usage, compared to different cellular services, and compared to cost fixed line services. For the purposes of this thesis they will be compared to other services and across operators only.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Regulation of cellular tariffs, as identified in section 5.4.1, and process 5, Develop Business and Pricing Models, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 46: Voice Tariffs

It is beyond the scope of this thesis to perform a full analysis of the voice tariffs in South Africa. This is because of the number of different pricing structures offered and the variability of this data between operators and over time. The data in this section is shows a subset of the voice tariffs at a particular time, for the purposes of comparing the cost of other cellular services and the cost of LBS services. The data is presented by operator, and by contract and prepaid subscription model.



	Highest Offpeak	Lowest Offpeak	Highest Peak	Lowest Peak
Vodacom Contract	R 1.25	R 0.90	R 2.70	R 0.90
Vodacom Prepaid	R 1.65	R 1.55	R 2.85	R 2.55
MTN Contract	R 1.15	R 0.95	R 2.70	R 1.50
MTN Prepaid	R 1.60	R 1.45	R 2.85	R 2.60

Figure A.25: Voice Tariffs in South Africa

Figure A.25 above shows typical examples of voice tariffs in South Africa as of August 2005. Due to the variability of contracts, this data does not include monthly subscription costs or free minutes, but lists the typical voice tariffs per minute in order to provide a basis for the comparison of the cost of LBS services in section A.2.3.5.

The data shows consistency between operators, showing the effects of tariff regulation. In addition it shows that contract tariffs are cheaper than prepaid tariffs.

A.2.3.2 Messaging Tariffs

Metric Name	**47. Messaging Tariffs**	
Description	The cost to consumer for cellular messaging services in South Africa	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding the costs of messaging services contribute towards a benchmark for LBS tariffs and pricing models.	✓
Available and accessible?	Cellular messaging tariffs are available from the operator websites.	✓
Interpretable and comparable?	Comparable between operators and to the cost of other cellular services including LBS applications.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Regulation of cellular tariffs, as identified in section 5.4.1, and process 5, Develop Business and Pricing Models, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 47: Messaging Tariffs

As with the presentation of the voice tariffs in the previous section, a full examination of the available voice tariffs is both not relevant to this evaluation, and is beyond the scope of this thesis. Therefore, examples of messaging tariffs are provided at a particular time to provide a basis for the evaluation of the cost of LBS services.

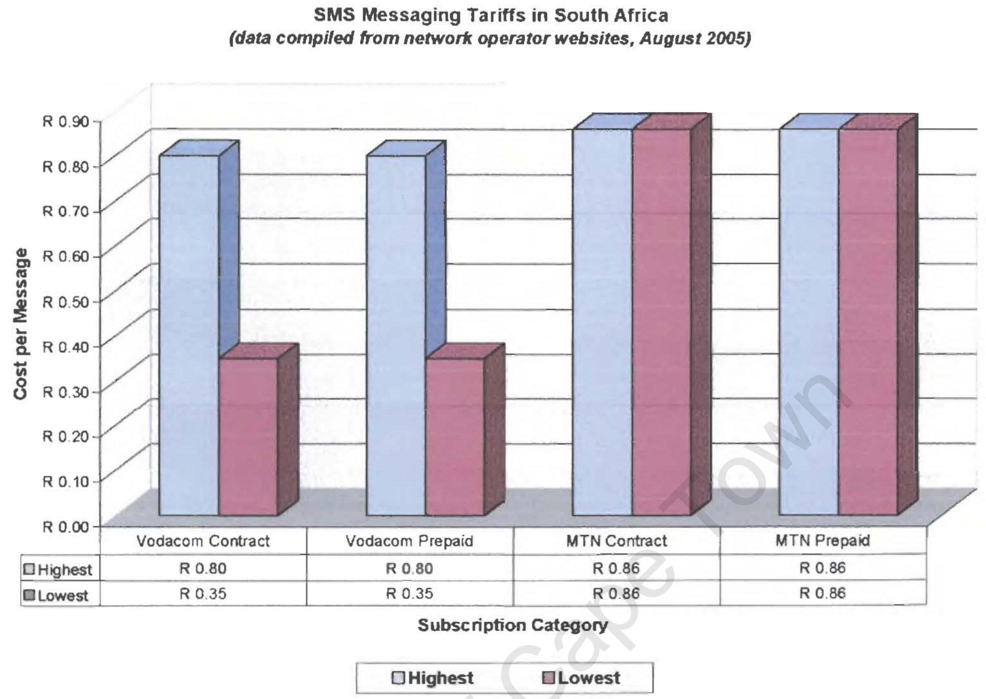


Figure A.26: SMS Messaging Tariffs in South Africa

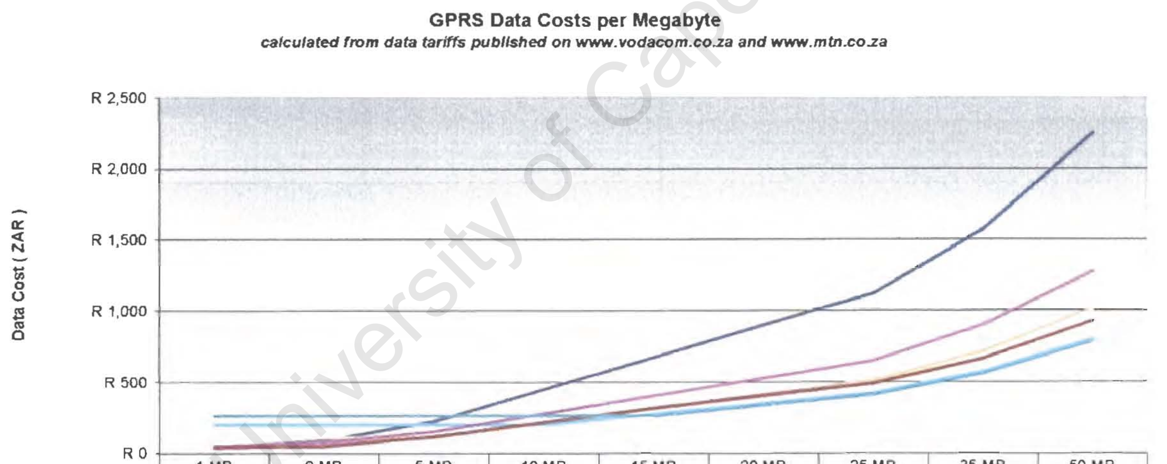
Figure A.26 above shows the standard SMS messaging costs in South Africa as of August 2005. This data does not take into consideration the SMS bundles offered by both MTN and Vodacom, which provide a fixed number of SMSs per month at a reduced cost. Only standard tariffs are included in this thesis to provide a platform for the evaluation of the cost of LBS services in section A.2.3.5.

In addition to SMS messaging, the cost of MMS messaging must also be considered. Vodacom charges for MMS messages based on the message size, ranging from R1.00 for a message that is less than 5kb to R1.70 for messages between 10kb and 20kb. Thereafter, an additional 50c is charged for each additional 10kb. MTN has a different approach, and charges a flat fee of R2.00 for every MMS message, regardless of the size of the message. The cost of MMS messages has an implication for the cost of some LBS services, as discussed in section A.2.3.5.

A.2.3.3 Data Tariffs

Metric Name	**48. Data Tariffs**	
Description	The cost to consumer for GPRS and 3G cellular data services.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding the costs of data services and applications contribute towards a benchmark for LBS tariffs and pricing models.	✓
Available and accessible?	Cellular data tariffs are available from the operator websites.	✓
Interpretable and comparable?	Comparable between operators and to the cost of other cellular services including LBS applications.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Regulation of cellular tariffs, as identified in section 5.4.1, and process 5, Develop Business and Pricing Models, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 48: Data Tariffs



	1 MB	2 MB	5 MB	10 MB	15 MB	20 MB	25 MB	35 MB	50 MB
Vodacom 1	R 45	R 90	R 225	R 450	R 675	R 900	R 1,125	R 1,575	R 2,250
Vodacom 2	R 35	R 55	R 115	R 215	R 315	R 415	R 515	R 715	R 1,015
Vodacom 3	R 110	R 110	R 110	R 210	R 310	R 410	R 510	R 710	R 1,010
Vodacom 4	R 200	R 200	R 200	R 200	R 275	R 350	R 425	R 575	R 800
MTN 1	R 50	R 80	R 155	R 280	R 405	R 530	R 655	R 905	R 1,280
MTN 2	R 50	R 50	R 118	R 218	R 318	R 405	R 493	R 668	R 930
MTN 3	R 263	R 263	R 263	R 263	R 263	R 338	R 413	R 563	R 788

Megabytes (MB)

Figure A.27: GPRS Data Tariffs in South Africa 2004

Figure A.27 above shows the GPRS data tariffs offered for different pricing plans on MTN and Vodacom's networks as of August 2004. As discussed in section A.1.1.3, GPRS data is packet-based. This allows users to be charged on for the bandwidth they have used, rather than the time connected. The data in the figure shows that from approximately 2mb, the cost of GPRS data increases linearly depending on the amount of data used. In order to provide a basis of comparison, this data needs to be compared to the cost of recently implemented 3G data services, and the corresponding decrease in GPRS pricing by Vodacom. This is shown in the following figure.

GPRS Data Package	3G Data Package	Subscription	Bundled Data*	Out of Bundle	Effective in Bundle
MyMeg 0	3G 0	R 0.00	0	R 2.00/MB	N / A
MyMeg 20	3G 20	R 35.00	20MB	R 2.00/MB	R 1.75/MB
MyMeg 75	3G 75	R 110.00	75MB	R 2.00/MB	R 1.47/MB
MyMeg 150	3G 150	R 149.00	150MB	R 2.00/MB	R 0.99/MB
MyMeg 250	3G 250	R 200.00	250MB	R 2.00/MB	R 0.80/MB
MyMeg 500	3G 500	R350.00	500MB	R 2.00/MB	R 0.70/MB
MyMeg 1Gig	3G 1Gig	R 599.00	1GB	R 2.00/MB	R 0.60/MB
MyMeg 2Gig	3G 2Gig	R 1,198.00	2GB	R 2.00/MB	R 0.60/MB
MyMeg 3Gig	3G 3 Gig	R 1,797.00	3GB	R 2.00/MB	R 0.60/MB
MyMeg 5Gig	3G 5Gig	R 2,995.00	5GB	R 2.00/MB	R 0.60/MB
MyMeg 10Gig	3G 10Gig	R 5,990.00	10GB	R 2.00/MB	R 0.60/MB

Figure A.28: Vodacom's 3G Data Tariffs

Figure A.28 above shows Vodacom's tariffs for 3G data and the new pricing structure for GPRS. There was no data available for MTN's 3G pricing at the time of writing this thesis. The data shows that following the introduction of 3G, the cost of data, including GPRS data, has been dramatically reduced. As operators are still busy implementing 3G networks and are focussing on metropolitan areas first, GPRS connections can be made available to 3G users at the same tariffs when they are in areas not yet covered by 3G technology. The introduction of 3G and the subsequent change in data pricing has been largely responsible for the increase in data usage reported by Vodacom, as discussed in section A.3.1.14.

The data tariffs discussed in this section will be discussed in terms of the cost of LBS applications in section A.2.3.5, and in terms of the potential of LBS sensitive billing in the analysis of section 7.3.2.6.

A.2.3.4 Handset Costs

Metric Name	**49. Handset Costs**	
Description	The cost to consumer for different classes of cellular handsets required for different types of LBS applications.	
Data type	Quantitative - objective	
Relevant to evaluation?	Section 4.2.5 identified that the capabilities of mobile devices were a key consideration for LBS applications. Understanding the costs of these handsets to consumers is therefore relevant to the evaluation.	✔
Available and accessible?	Costs of different cellular handsets are available online.	✔
Interpretable and comparable?	Comparable between handset classes, LBS applications supported and to the market penetration of each class of cellular device.	✔
Associated with identified process or SSM conceptual model?	Associated with process 1, Evaluate Available Technology, and process 5, Develop Business and Pricing Models, as identified in section 5.4.2.	✔
Does metric pass selection criteria?		✔

Metric 49: Handset Costs

A full evaluation of the costs of handsets in South Africa is not relevant to this research and beyond the scope of this thesis. For the purposes of the evaluation of LBS in South Africa, it is sufficient to note the following:

The cost of cellular devices has been decreasing rapidly in the recent years, as discussed in section 4.2.5. Nevertheless, the cost of cell phones is highly variable, and is subject to change rapidly. The prices range from about R400 for a basic entry-level cell phone, to over R5000 for a more expensive advanced cellular device. In comparing these costs to the ARPU statistics in section A.2.1.6 and the income levels in section A.3.1.5, it is clear that anything other than a basic handset is beyond the means of most South Africans to purchase outright.

Network operators have overcome this problem by including a subsidised handset as part of a cellular contract. In this way, the more advanced cellular devices are pushed into the market through contract renewals, thereby freeing up older phones for redistribution or resale. The effects of handset subsidisation on the market penetration of the different classes of handsets are discussed in more detail in section A.3.1.15.

Thus, handset costs are expensive in South Africa, but the network operators have circumvented this problem by offering free phones with contracts. This indirectly effects the handset penetration by stimulating the second-hand cell phone market.

A.2.3.5 Cost of LBS Service

Metric Name	**50. Cost of LBS Service**	
Description	The cost to consumers of currently implemented LBS applications.	
Data type	Quantitative - objective	
Relevant to evaluation?	Section 4.4.1.3 identified that the pricing of LBS applications was a key factor in implementing LBS successfully. Therefore, measuring the cost of LBS service is relevant to the evaluation.	✓
Available and accessible?	The cost of using LBS applications is available online from operator websites and partner websites.	✓
Interpretable and comparable?	Comparable to other countries, across available LBS applications and costs of other cellular services	✓
Associated with identified process or SSM conceptual model?	Associated with process 5, Develop Business and Pricing Models, as identified in section 5.4.2, and process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 50: Cost of LBS Service

The cost of LBS services is possibly one of the biggest inhibiting factors. In this section, Vodacom's LBS applications and SmartSurv's SmartRoute applications are discussed in terms of their pricing structures and cost implications for consumers.

All cost information in this section was retrieved from www.vodacom.co.za and www.smartsurv.co.za on the 25th of August 2005.

Vodacom's Look4help charges a monthly subscription of R11.40, as well a charge of R3.42 for every emergency services call made. This call notifies four pre-designated numbers of a user's location and their request for help. This service is only available to contract subscribers.

Vodacom's Look4it services are accessed through a menu driven interface called USSD. The charges are 67c per 20 seconds of USSD browsing through the various menu options, with an automatic timeout set at 2 minutes after which the user needs to start over. This means that a single request could cost as much as R4, assuming the user finds the correct option within 2 minutes. At this time, the result is delivered free of charge via SMS or MMS, until further notice. These services are available to prepaid and contract subscribers.

Vodacom's Look4me LBS application is available to both contract and prepaid subscribers. Contract subscribers are obliged to pay a monthly subscription fee of R10.50, while prepaid subscribers can opt not to pay the subscription fee but rather increased rates on a per use basis. Users are also charged for both requests and content responses, and can expect to pay between approximately R2 and R6 every time they locate someone.

SmartSurv's SmartRoute is available via a prepaid or a contract subscription to their service, and is only available to users who have a contract with their network provider. SmartSurv requires the purchase of a GPS receiver, an advanced handset, and a starter pack which costs approximately R170. Contract subscribers pay R59 per month for unlimited usage of the service, while prepaid subscribers pay between R20 for 6 routes and R100 for 60 routes. This excludes the GPRS fees charged by the network operators over and above the fees charged by SmartSurv. GPRS fees are discussed in section A.2.3.3.

Examining the pricing structure and fees charged for the commercial LBS applications discussed in this section in conjunction with the ARPU statistics in section A.2.1.6 and the voice, messaging and data tariffs discussed in sections A.2.3.1, A.2.3.2 and A.2.3.3 respectively, it is clear that LBS applications are too expensive for most consumers. Given these high costs, the author is not surprised with the poor adoption of LBS services in South Africa thus far.

A.3 Social Metrics

This section presents all the social metrics concerning LBS in South Africa as derived in section 6.1.4. Section A.3.1 covers the metrics for the analysis of the market, section A.3.2 deals with market demands and trends, and section A.3.3 discusses the affects of LBS on society.

A.3.1 Market Analysis

An understanding the cellular market in South Africa is important for the evaluation of LBS. The metrics covered in this section were derived from the hierarchy of metrics shown in Figure 6.9. These metrics deal with the demographics of South Africa and the existing cellular market.

A.3.1.1 Population

Metric Name	**51. Population**	
Description	Population size and breakdown for South Africa.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding population size and breakdown in comparison to cellular usage provides insight to potential LBS market.	✔
Available and accessible?	Available from census survey data.	✔
Interpretable and comparable?	Comparable to other demographic statistics and cellular penetration, and is also a vital comparator statistic to measure how well the samples from other surveys are representative of the actual population.	✔
Associated with identified process or SSM conceptual model?	Population statistics are inputs to process 3, Perform Market Research, in section 5.4.2 and process 2, Research LBS Market Demand, in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 51: Population

Figure A.29 below shows the 2004 mid-year population estimates for South Africa (STATSSA 2004). These figures are not meaningful in isolation, and will be referred to from the remainder of the demographics metrics in the sections that follow.

	Male		**Female**		**Total**	
Population Group	**Number**	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**
African	18,254,444	39.20%	18,679,737	40.10%	36,934,181	79.30%
Coloured	2,004,048	4.30%	2,082,742	4.50%	4,086,790	8.80%
Indian/Asian	554,119	1.20%	577,223	1.20%	1,131,342	2.40%
White	2,174,799	4.60%	2,259,495	4.90%	4,434,294	9.50%
Total	22,987,410	49.30%	23,599,197	50.70%	46,586,607	100.00%

(STATSSA 2004)

Figure A.29: South African Population Estimate

A.3.1.2 Age Distribution

Metric Name	**52. Age Distribution**	
Description	Comparison of the age distribution of the population of South Africa and of the sample groups from two primary market studies used as data sources in this thesis.	
Data type	Quantitative - objective	
Relevant to evaluation?	Provides insight into the age structure of cellular market and thus potential target market groups for LBS.	✓
Available and accessible?	Available from census survey data and Vodacom cellular market survey (Vodacom 2001) as well as independent market research (Project B 2002).	✓
Interpretable and comparable?	Comparable to age mix from survey data to determine the suitability of the sample. Comparable to cellular usage of age groups to determine market segments	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 3, Perform Market Research, in section 5.4.2 and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 52: Age Distribution

Figure A.30 below shows the age distribution of cellular users from the Vodacom subscriber base and from the LBS market survey in relation to the whole South African population.

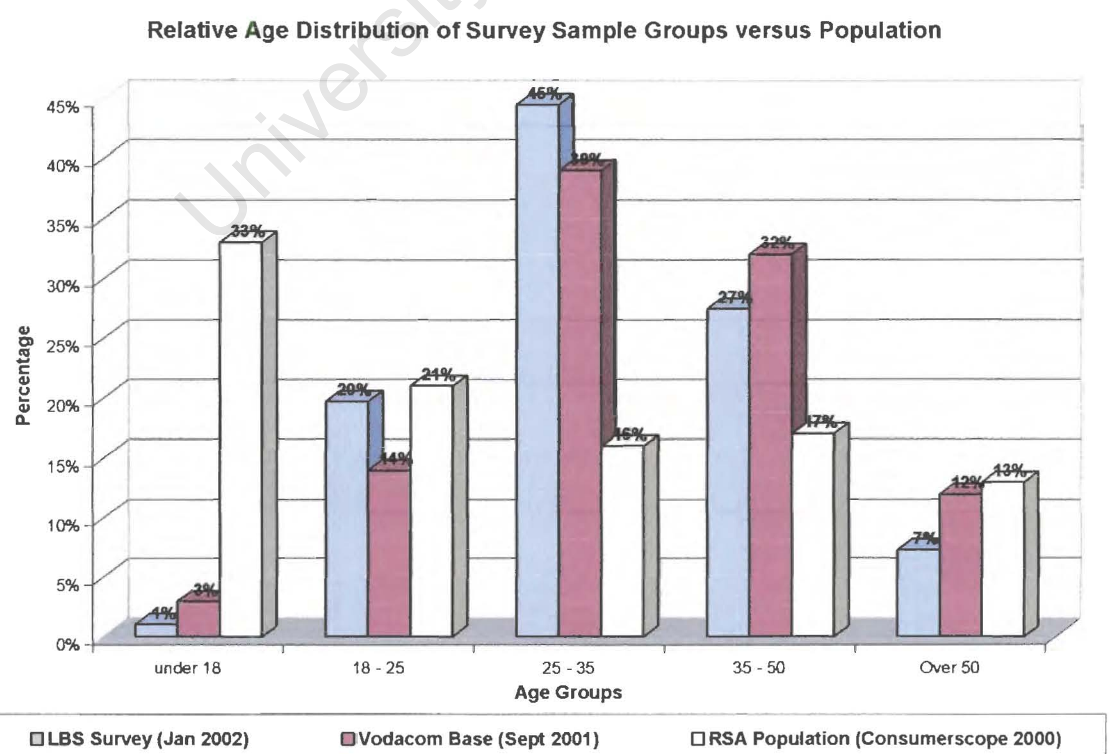


Figure A.30: Age Distribution of SA Population and Survey Sample Groups

As can be seen from Figure A.30, there is some correlation between the age distribution of the LBS market survey sample group and the age distribution of the Vodacom subscriber base. This means that the LBS survey is to some extent representative of the age distribution of cellular users in South Africa.

The data shows that the by far the highest uptake of cellular service is in the 25-35 age group. The vast majority of cellular users are between the ages of 25 and 50, although there is an increasing use of cellular services by younger groups, in particular between the ages of 18 and 25.

Therefore, it would seem that the most likely target market for LBS applications in South Africa would be young to middle aged adults.

A.3.1.3 Ethnic Groups

Metric Name	**53. Ethnic Groups**	
Description	Distribution of race within population of South Africa and cellular market	
Data type	Quantitative – objective.	
Relevant to evaluation?	Provides insight into structure of cellular market and thus potential LBS market.	✔
Available and accessible?	Available from census survey data and Vodacom cellular market survey.	✔
Interpretable and comparable?	Comparable to cellular usage of different ethnic groups to determine potential target markets for LBS.	✔
Associated with identified process or SSM conceptual model?	This metric is an input to process 3, Perform Market Research, in section 5.4.2 and process 2, Research LBS Market Demand, in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 53: Ethnic Groups

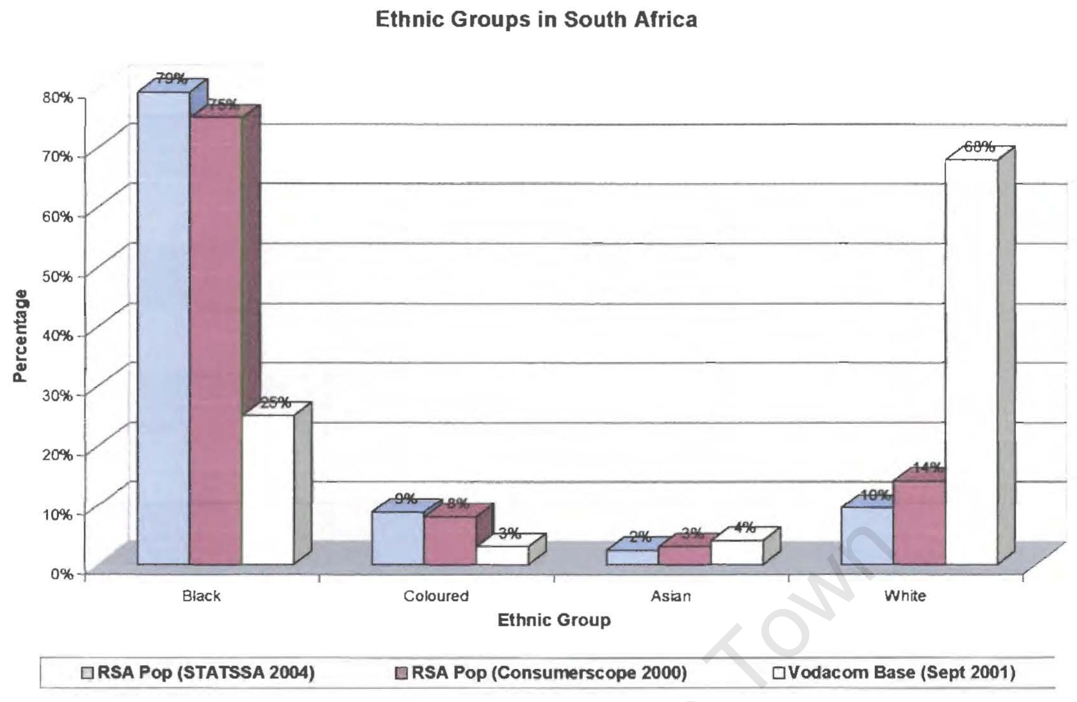


Figure A.31: Ethnic Groups in South Africa

Figure A.31 above shows the distribution of ethnic groups in South Africa versus the Vodacom subscriber base at a similar point in time. This data indicates that although the vast majority of people in South Africa are black, the vast majority of the cellular users in South Africa are white.

This suggests that the largest potential market segment for LBS in South Africa is the white population.

It also indicates that the observation that the prepaid market is largely dominated by previously disadvantaged members of the society under the apartheid regime, as indicated in section 5.1.1.3, is not correct given the percentages of prepaid versus contract subscribers in section A.3.1.11.

Therefore, the data shows that the prepaid subscription model is popular amongst other types of cellular users, other than previously disadvantaged users. This other market segment consists predominantly of the youth market.

A.3.1.4 Education Levels

Metric Name	**54. Education Levels**	
Description	Distribution of education levels of population of South Africa and survey respondents.	
Data type	Quantitative - objective	
Relevant to evaluation?	Education level may be an indicator of technological literacy and awareness, and may indicate which sectors of the market would first adopt value-added services such as LBS.	✓
Available and accessible?	Available from census survey and market survey data.	✓
Interpretable and comparable?	Has input in determining the potential target markets for value-added services such as LBS.	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 3, Perform Market Research, in section 5.4.2 and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 54: Education Levels

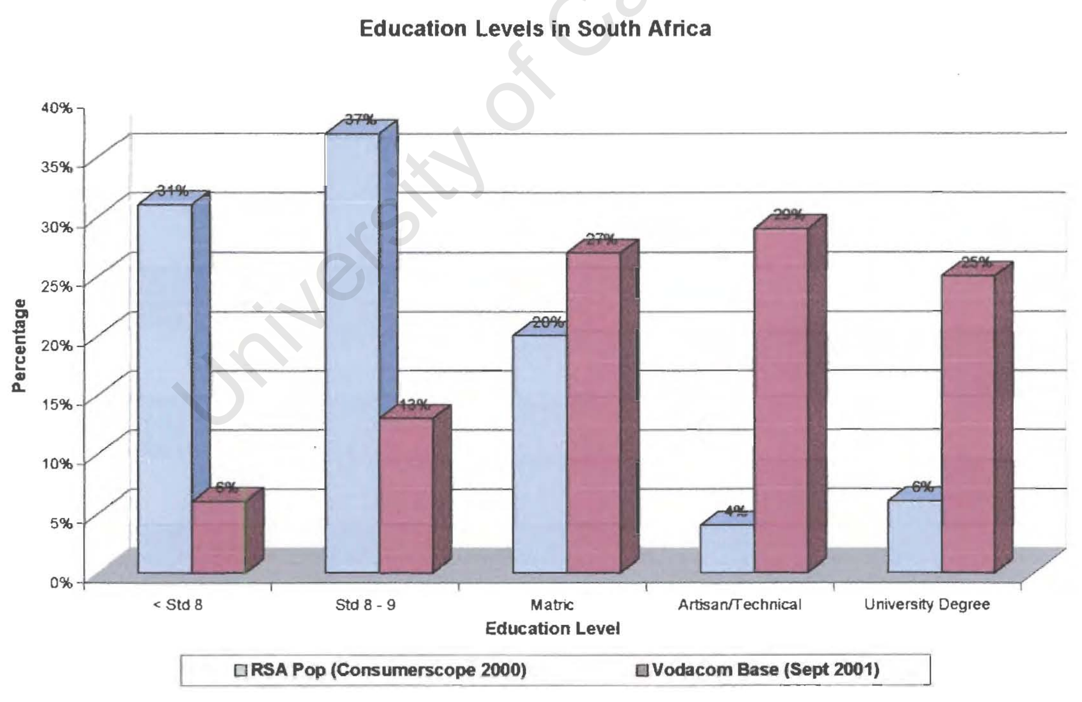


Figure A.32: Education Levels in South Africa

Figure A.32 above shows the education levels of the population of South Africa versus that of the Vodacom subscriber base at a similar point in time. The data indicates that the majority of the cellular market consists of highly educated or skilled individuals, which are a minority of the adult population. As LBS technology is still new and is regarded as a value-added service, one could argue that LBS would most likely appeal to educated users before they appeal to uneducated users.

A.3.1.5 Income Levels

Metric Name	**55. Income Levels**	
Description	Distribution of income levels of population of South Africa versus survey respondents.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding the income levels of the cellular market is important in determining the potential market for LBS.	✓
Available and accessible?	Available from census survey, Vodacom market survey and LBS market survey.	✓
Interpretable and comparable?	ARPU or cellular expenditure comparable across income brackets. Could lead to establishment of market segments for different types of LBS services. Also, important for understanding the sample groups of surveys used in this evaluation.	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 3, Perform Market Research, in section 5.4.2 and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 55: Income Levels

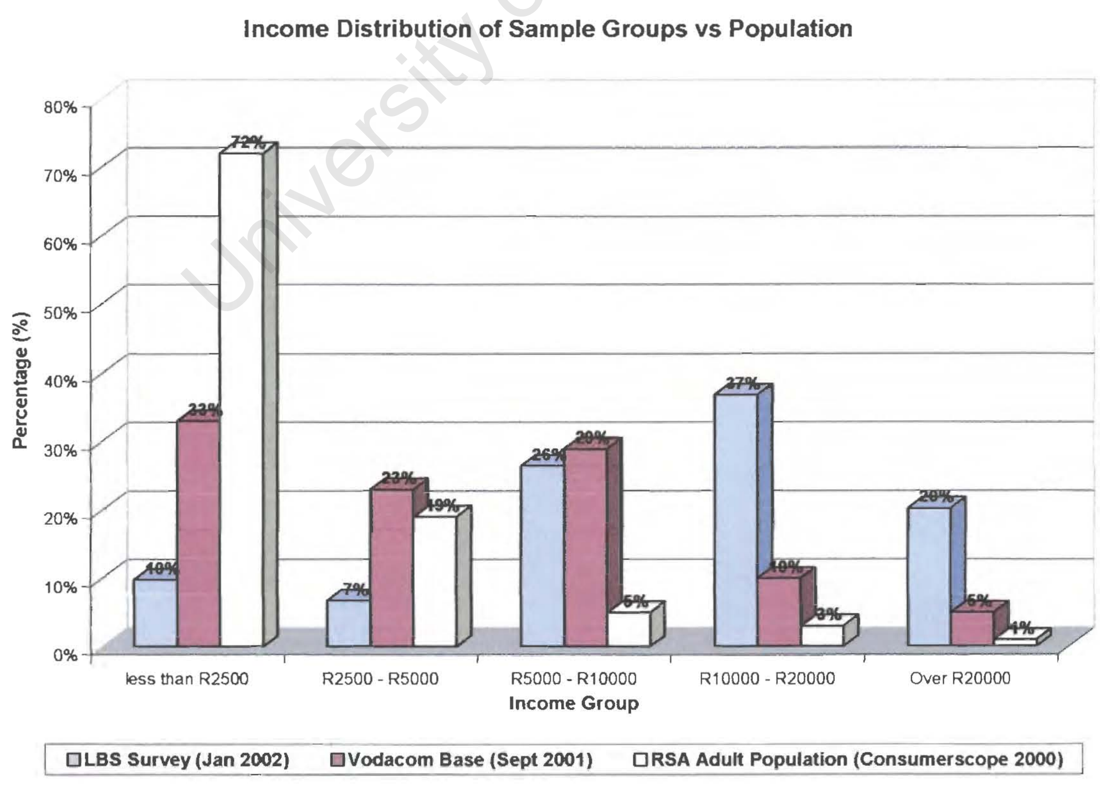


Figure A.33: Income Distribution of SA Population and Survey Sample Groups

Figure A.33 shows the income groups for the RSA population, the Vodacom subscriber base, and the LBS market survey used in this thesis (Project B 2002). It shows three contrasting pictures in terms of income groups for the different surveys.

The data shows that 72% of the entire population fall in the lowest income group, while only 1% falls within the top income group. This is very different to the cellular market, where the majority of the sample falls in the low to middle income groups.

The greatest contrast is with the sample group from the LBS market survey undertaken by the author in a commercial capacity. This shows that 57% of the survey respondents were from the top two income brackets. This indicates that the sample is representative of a certain market sector, i.e. high income earners, and this bias in the data needs to be taken into account when evaluating the survey data results.

A.3.1.6 Gender Distribution

Metric Name	**56. Gender Distribution**	
Description	Ratio of males to females in the population, the cellular market, and the survey sample groups.	
Data type	Quantitative - objective	
Relevant to evaluation?	There is no data available to suggest that gender has any influence on LBS in South Africa.	✗
Available and accessible?	Although this data is available from general demographic statistics (see A.3.1.1), there is no gender data available to the author regarding gender in cellular operator's subscriber base or LBS market survey.	✗
Interpretable and comparable?	There are no meaningful comparisons to be made to other metrics, nor can it be interpreted as having any effect on LBS.	✗
Associated with identified process or SSM conceptual model?	This metric is an input to process 3, Perform Market Research, in section 5.4.2 and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?	This metric failed all three of Geisler's selection criteria, and will not be included in the evaluation model.	✗

Metric 56: Gender Distribution

A.3.1.7 Geographic Distribution

Metric Name	**57. Geographic Distribution**	
Description	Geographic distribution of people into different provinces, and the ratio of people in urban and rural areas.	
Data type	Quantitative - objective	
Relevant to evaluation?	The location of people is central to LBS, has infrastructure coverage and universal service implications.	✓
Available and accessible?	Available from census survey, Vodacom market survey and LBS market survey.	✓
Interpretable and comparable?	Comparable to cellular infrastructure density and could lead to an indication of first target areas of implementation of LBS.	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 3, Perform Market Research, in section 5.4.2 and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 57: Geographic Distribution

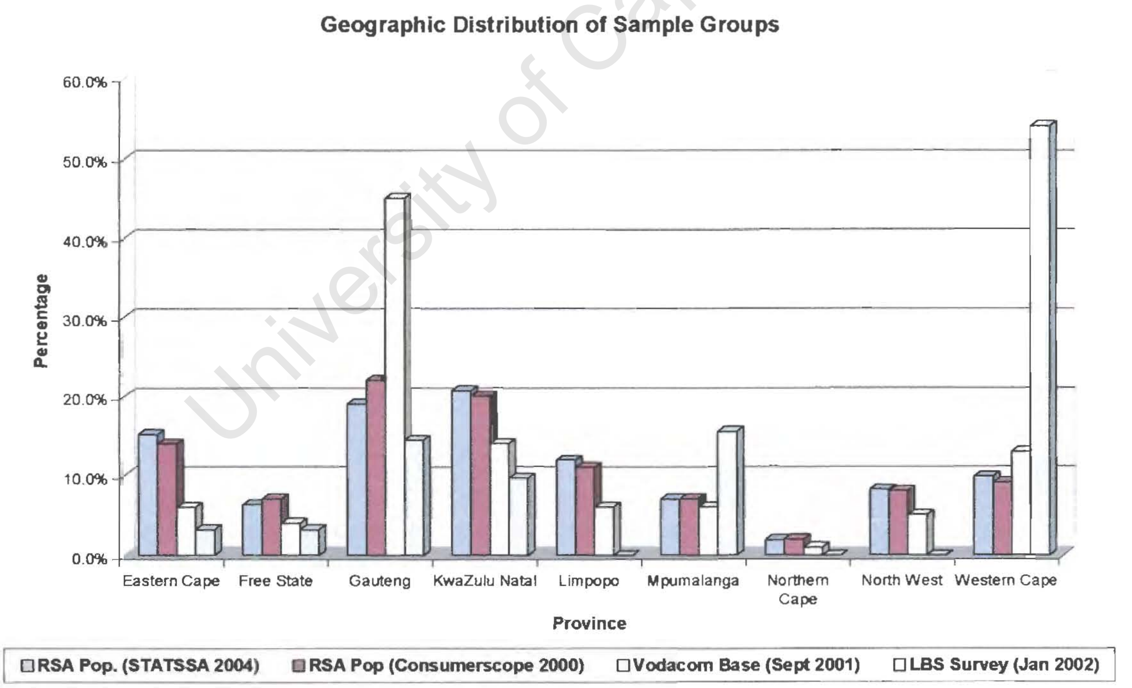


Figure A.34: Geographic Distribution by Province

Figure A.34 above shows the distribution of the population, the cellular market, and the LBS sample survey by province. The data highlights two primary points.

Firstly, the data shows that the distribution of the population does not match that of the cellular market, as the vast majority of the cellular users in South Africa are situated in the metropolitan area of Gauteng. In addition, the data shows that the LBS survey data is significantly skewed towards respondents from the Western Cape. This data needs to be considered in conjunction with a breakdown of the cellular market in terms of the type of area people live in, as shown in the figure below.

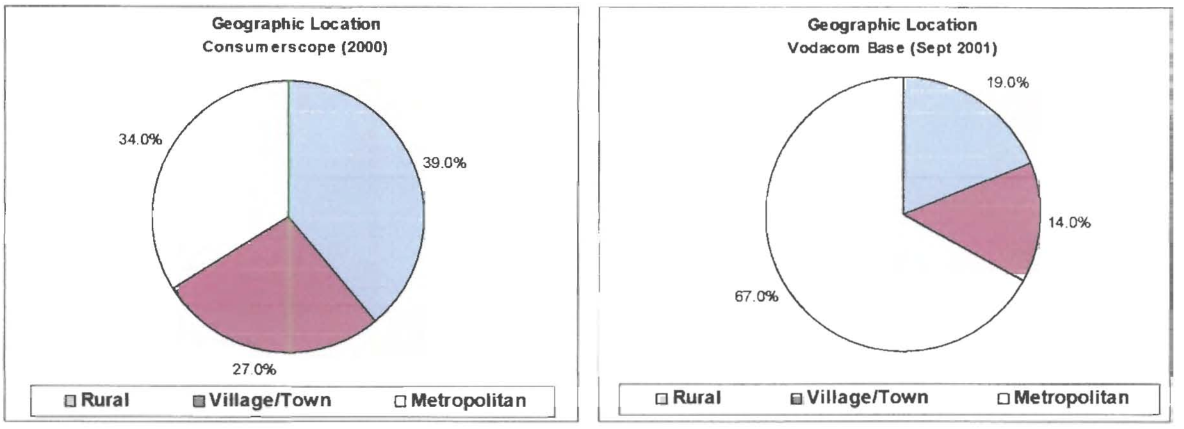


Figure A.35: Geographic Distribution by Area Type

Figure A.35 above shows the geographic distribution of the population and of the cellular market in terms of area type. The data indicates that the majority of cellular users live in or near metropolitan areas such as Johannesburg, Durban or Cape Town. This contrasts with the population of South Africa, which are mainly in rural areas or small villages and towns.

Therefore, the potential market for LBS application is primarily in metropolitan areas, as the majority of the cellular market is situated in metropolitan areas, particularly in Gauteng as shown in Figure A.34. This could be a factor in determining where to implement advanced technology first, should the need ever arise. This prioritisation strategy has been used by both MTN and Vodacom in their implementation of 3G technology (see section A.1.1.1).

A.3.1.8 Market Penetration

Metric Name	**58. Market Penetration**	
Description	The percentage of the population who make use of cellular services. This has become a global standard measure of a cellular market.	
Data type	Quantitative - objective	
Relevant to evaluation?	Is related to market growth and is an indicator of potential LBS market	✓
Available and accessible?	Available from global data and predictions.	✓
Interpretable and comparable?	Comparable across regions and over time, interpretable with regards to market growth and need to provide value-added services such as LBS.	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 6, Provision of Cellular Services, identified in section 5.4.2, and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 58: Market Penetration

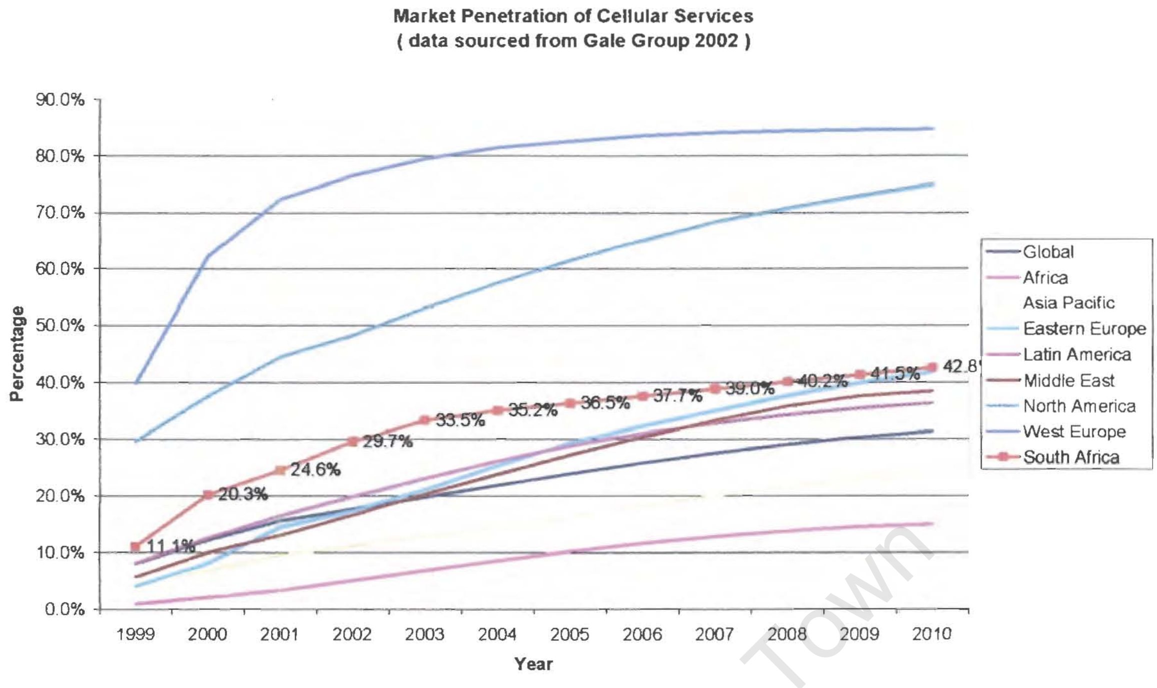


Figure A.36: Market Penetration of Cellular Services

Figure A.36 above shows the predicted penetration of cellular services in South Africa versus other areas of the world. The predicted data for South Africa compares favourably to the actual measured data as of the end of 2002 from a number of sources (Cellular.co.za 2004b; Vodafone 2005). However, more recent data estimates that mobile penetration has already reached as much as 44% (MTN 2005a). This is inline with other metrics indicating better than expected growth in South Africa, e.g. the total revenue statistics in section A.2.1.1.

Nevertheless, the data shows that the penetration of cellular services is tending towards a saturation point. At this stage, it is not possible to determine what the saturation point for the penetration of mobile in South Africa will be, as it has already surpassed most expectations. When combined with the market growth metrics (see section A.3.1.9) and revenue statistics (section A.2.1) this indicates that mobile penetration will start to level off and market growth will begin to slow down. This, when combined with the falling ARPUs currently experienced by operators, is motivation to develop new channels of revenue through the delivery of value-added services, for example LBS.

A.3.1.9 Market Growth Rate

Metric Name	59. Market Growth Rate	
Description	The historical and predicted market growth rates for the cellular industry in South Africa.	
Data type	Quantitative - objective	
Relevant to evaluation?	As LBS is a subset of cellular services, cellular market growth is directly related to growth in the potential LBS market.	✔
Available and accessible?	Available from global survey and industry reports.	✔
Interpretable and comparable?	Comparable across regions and over time, interpretable along with penetration to determine if market is reaching saturation and therefore the need to provide value-added services such as LBS.	✔
Associated with identified process or SSM conceptual model?	This metric is an input to process 6, Provision of Cellular Services, identified in section 5.4.2, and process 2, Research LBS Market Demand, in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 59: Market Growth Rate

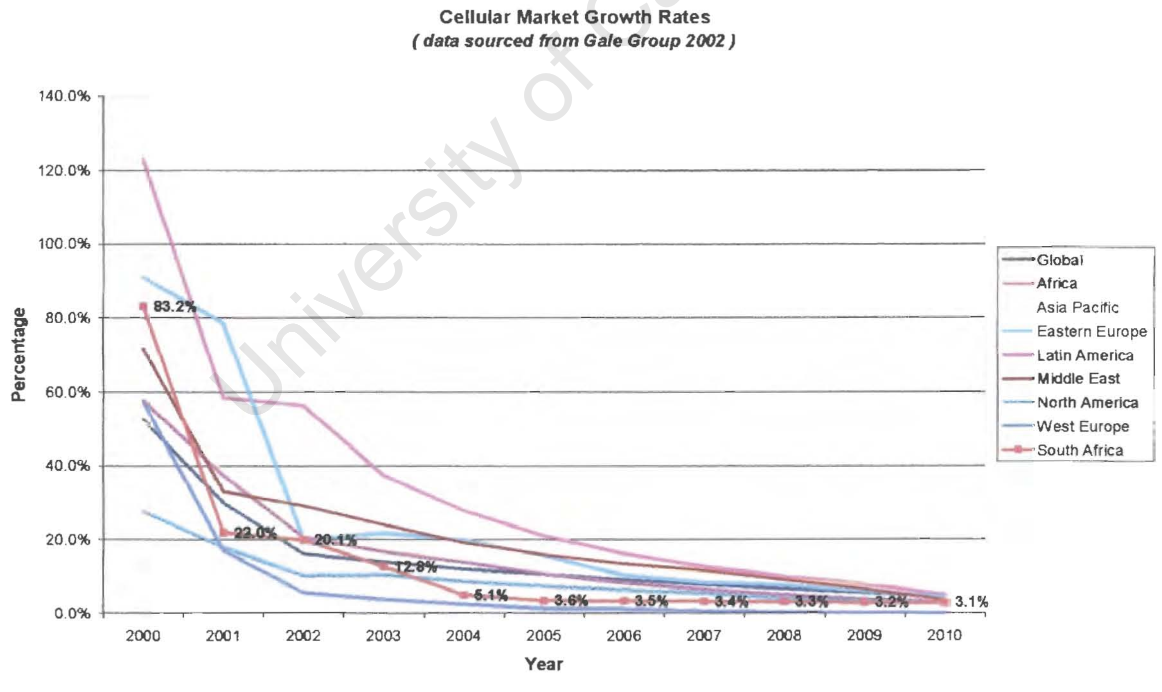


Figure A.37: Market Growth Rates

Figure A.37 shows actual and predicted growth rates of the cellular market in South Africa in comparison to other regions. The data indicates a steady decline in market growth rates over the next few years. This corresponds favourably with the market penetration statistics discussed in section A.3.1.8, and the subscriber statistics discussed in section A.3.1.10. Thus, network operators are at some point going to need to stimulate growth in the industry through value-added services, such as LBS.

A.3.1.10 Number of Subscribers

Metric Name	**60. Number of Subscribers**	
Description	Total number of active subscribers to cellular services.	
Data type	Quantitative - objective	
Relevant to evaluation?	Indicates potential number of users for LBS	✓
Available and accessible?	Available from global survey and industry reports	✓
Interpretable and comparable?	Comparable over time, to ARPU, growth rates, and comparison to contract versus prepaid subscribers.	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 6, Provision of Cellular Services, identified in section 5.4.2, and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 60: Number of Subscribers

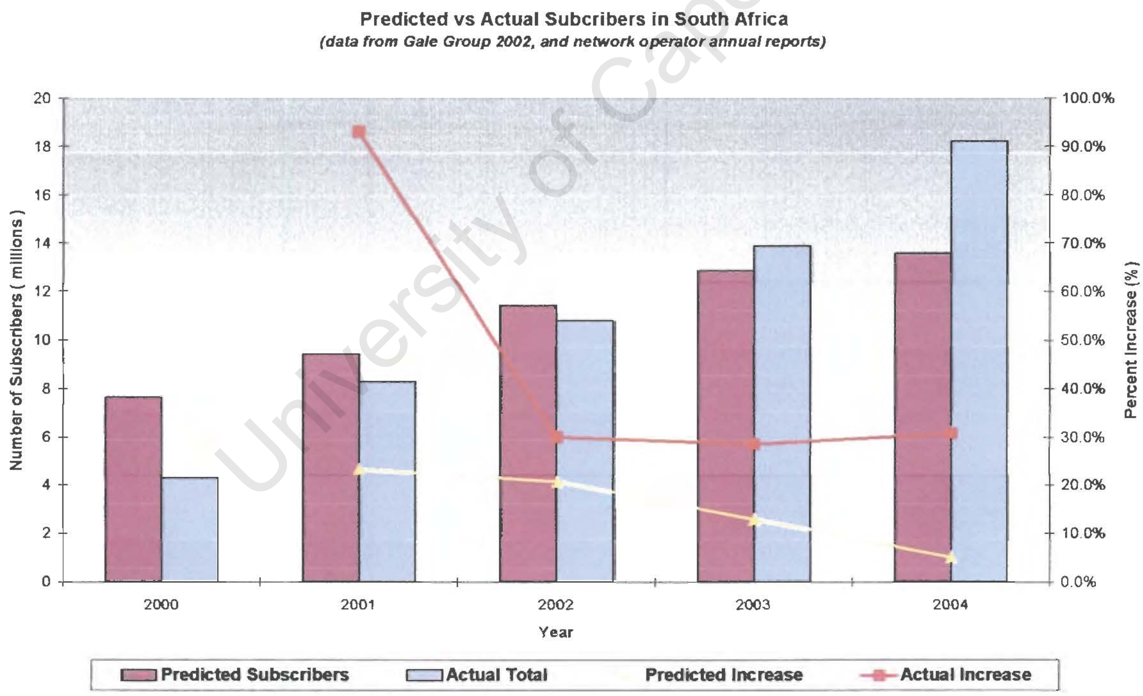


Figure A.38: Total Subscribers in South Africa

Figure A.38 above shows the total number of active subscribers, predicted number of active subscribers, and the actual versus predicted percentage increase in subscriber numbers in South Africa between 2000 and 2004. The data indicates that the number of subscribers, currently around 18 million in total, has been increasing faster than predicted. This, when combined with the revenue and growth rate statistics, shows a healthy growth in the cellular industry in South Africa. However, as the metrics in the previous two sections show, there is a saturation point that will be reached in the near future.

A.3.1.11 Prepaid vs. Contract Subscribers

Metric Name	**61. Prepaid vs. Contract Subscribers**	
Description	The ratio of contract subscribers as apposed to prepaid subscribers.	
Data type	Quantitative - objective	
Relevant to evaluation?	Has a role in determining LBS target market segments, LBS strategy and the pricing models for LBS by understanding which subscription model is more successful in the market.	✓
Available and accessible?	Available from global survey data.	✓
Interpretable and comparable?	Comparable across regions and time and interpretable as target market segments for LBS.	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 6, Provision of Cellular Services, identified in section 5.4.2, and process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 61: Prepaid vs. Contract Subscribers

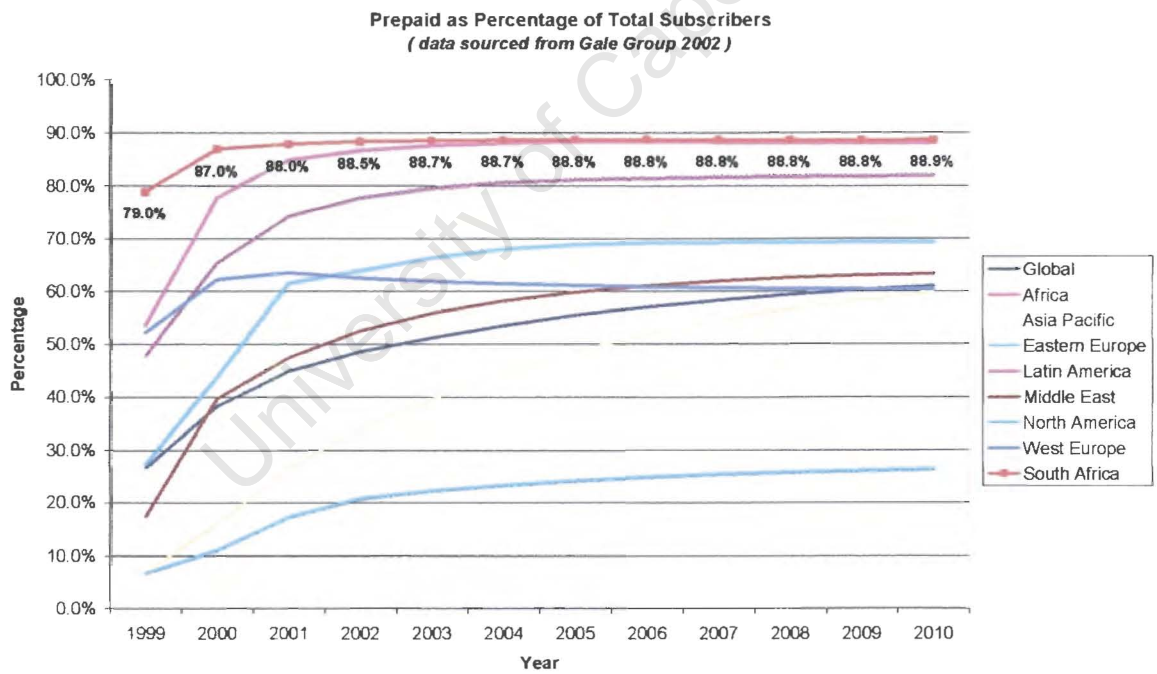
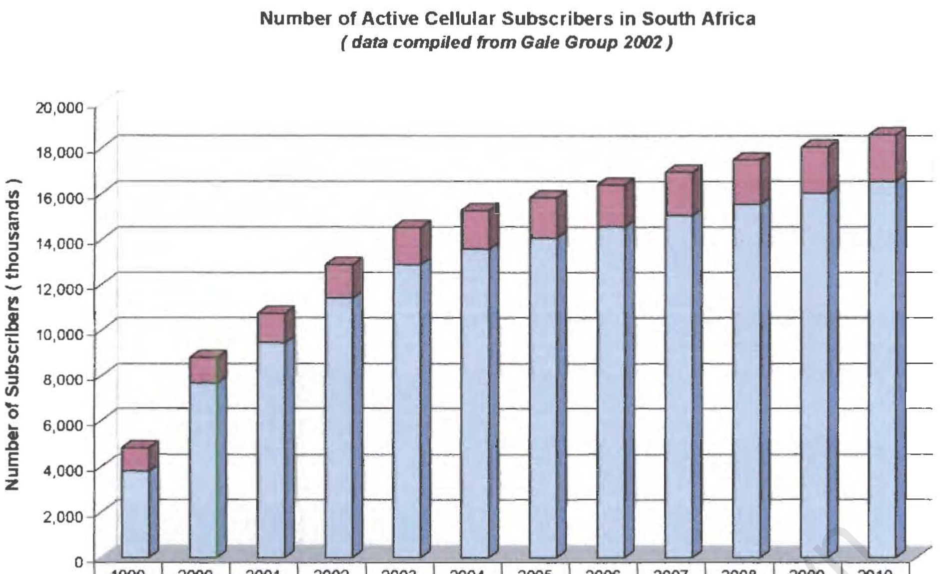


Figure A.39: Prepaid as Percentage of Total Subscribers



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Contract	1,008	1,143	1,288	1,482	1,650	1,721	1,774	1,834	1,894	1,954	2,014	2,074
Prepaid	3,792	7,652	9,444	11,402	12,889	13,564	14,063	14,556	15,048	15,541	16,034	16,527

Year

Figure A.40: Number of Active Subscribers

Figure A.39 and Figure A.40 show the increase in the percentage of prepaid subscribers and the predictions for the number of active prepaid and contract subscribers in South Africa. The data shows that South Africa has highest percentage of prepaid subscribers in the world. This percentage has been increasing steadily over a number of years, but is now stabilising at around 90% of the market. This data agrees with the market statistics reported by the network operators in their annual reports (MTN 2005a; Vodacom 2005a), as well as several other industry sources (Cellular.co.za 2004b).

With respect to LBS, the large percentage of prepaid subscribers indicates that prepaid users should be taken into account for the development of any pricing models for LBS. However, this conflicts with the data shown in A.2.1.4, which indicated that contract subscribers are the most profitable market sector. This suggests that any value-added product or service that is introduced must take both prepaid and contract subscription models into account from the outset, as both are valuable in the cellular market in South Africa.

A.3.1.12 Voice Usage

Metric Name	**62. Voice Usage**	
Description	The actual usage statistics for the usage of voice services in South Africa.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding how the cellular market uses different cellular services contributes to the understanding of market demand for various cellular services.	✔
Available and accessible?	This data is available from the operator annual reports. In addition, the assumption is made that the scale of voice service usage can be directly related to the revenue statistics for voice services in section A.2.1.3.	✔
Interpretable and comparable?	Voice usage statistics can be compared to usage statistics of other cellular services and the relative revenues earned from all cellular services.	✔
Associated with identified process or SSM conceptual model?	Associated with process 6, Provision of Cellular Services, as identified in section 5.4.2.	✔
Does metric pass selection criteria?		✔

Metric 62: Voice Usage

As stated above, the voice usage statistics are, for the purposes of this thesis, assumed to be directly related to the voice revenue statistics discussed in section A.2.1.3, which show that the network operators are experiencing an increase in the total voice traffic on their networks.

For purposes of comparison of voice usage per user, MTN reports a decrease in average minutes per month from 172 in 2001 to 140 in 2005 (MTN 2005a). Similarly, Vodacom reports a 14.1% decrease to 226 minutes per month for contract users in 2005 (2004: 263 minutes per month), and 7.1% decrease to 52 per month for prepaid users in 2005 (2004: 56 minutes per month) (Vodacom 2005a).

Thus, although the total voice traffic and voice revenues are increasing in South Africa due to the increase in number of users, the average minutes of use of voice services per user is decreasing. This indicates a need to stimulate growth in other cellular services, such as messaging, data and LBS.

A.3.1.13 Messaging Usage

Metric Name	**63. Messaging Usage**	
Description	A measure of usage of SMS and MMS personal messaging services.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding how the cellular market uses different cellular services contributes to the understanding of market demand for various cellular services.	✓
Available and accessible?	Available primarily from network operator annual reports.	✓
Interpretable and comparable?	This data is available from operator annual reports. In addition, for the purposes of this thesis, the assumption is made that the scale of messaging service usage can be directly related to the revenue statistics for data services in section A.2.1.5.	✓
Associated with identified process or SSM conceptual model?	Associated with process 6, Provision of Cellular Services, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 63: Messaging Usage

As stated above, the messaging usage statistics are, for the purposes of this thesis, assumed to be directly related to the data revenue statistics discussed in section A.2.1.5, which show a rapid increase in the data traffic (which includes messaging) on the cellular networks.

There is no complete data source that allows a thorough, meaningful comparison of messaging traffic available to the author. However, Vodacom notes a dramatic increase in the number of SMS and MMS messages set over their network in recent years (Vodacom 2003b; Vodacom 2004a; Vodacom 2005a). More specifically, the number of active MMS users has risen from 61,374 in March 2004 to 328,974 in March 2005. Similarly, the number of MMS messages sent monthly has risen from 350,260 to 1,780,657 over the same period. Vodacom attribute the increase in MMS usage to the decrease in the cost of MMS messaging and a higher penetration of MMS capable handsets, discussed further in section A.3.1.15.

Another important aspect is the increased use of premium SMS services provided by 3rd parties, i.e. service providers, which has increased to nearly 10 million messages a month on Vodacom's network alone (Vodacom 2005a). This shows that consumers in South Africa are starting to make use of 3rd party messaging applications, which were identified as a possible delivery mechanism for LBS in section A.1.3.6.

A.3.1.14 Data Usage

Metric Name	64. Data Usage	
Description	The actual usage statistics of cellular data services in South Africa.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding how the cellular market uses different cellular services contributes to the understanding of market demand for various cellular services.	✓
Available and accessible?	Available primarily from network operator annual reports.	✓
Interpretable and comparable?	Data service usage statistics can be compared to usage statistics of other cellular services and the relative revenues earned from all cellular services.	✓
Associated with identified process or SSM conceptual model?	Associated with process 6, Provision of Cellular Services, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 64: Data Usage

There is little data regarding the usage of MTN's data services, and the data in this section uses the data usage statistics on Vodacom's website in order to identify trends in data usage in South Africa.

Vodacom introduced 3G data services in December 2004, and the number of active 3G users on the network as of March 2005 has already reached 10,853. In addition, there has been an increase in the number of GPRS users over the same period from 100,128 to 579,581 (Vodacom 2005a). The reduction of the cost of data, discussed in section A.2.3.3, has been largely responsible for the increase in data usage.

Thus, the data shows that the use of cellular data services is increasing rapidly in South Africa. However, it is difficult to relate the increased use of data services directly to the data revenues discussed in section A.2.1.5, as these revenues also include messaging revenues.

A.3.1.15 Handset Penetration

Metric Name	**65. Handset Penetration**	
Description	A measure of to what extent different classes of handsets have penetrated the cellular market.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Handset capabilities affect the types of LBS applications that can be deployed, thus it is important to understand the level of handset penetration.	✓
Available and accessible?	Available from analysis of industry reports and interviews.	✓
Interpretable and comparable?	Interpretable as potential market for these types of LBS applications and contributes to the LBS implementation strategy.	✓
Associated with identified process or SSM conceptual model?	Associated with process 6, Provision of Cellular Services, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 65: Handset Penetration

Due to the high-turnover of cellular devices through contract renewal and second-hand sales, it is impossible to determine the exact penetration of different classes of cellular devices in South Africa in the context of this thesis. In addition, handset distributors in South Africa are reluctant to release the actual figures of the sales of different classes of mobile devices (Vecchiatto 2003b). The majority of new phones sold are entry-level devices, but there are an increasing number of mid-tier and advanced cellular devices entering the market (Bosch 2002).

The cell phone market can be divided into two, namely where contract renewal drives handset penetration, and those where new or second hand sales drives handset penetration. The contribution of package renewal is relatively small due to the relative minority of contract users. The South African market has been identified as being driven by new sales, predominantly to prepaid subscribers (Vecchiatto 2003b).

The biggest drivers of the adoption of advanced cellular devices are the contract packages, which offer phones for free in exchange for the guarantee of business for a fixed time period (Knott-Craig 2005b). This means that the average contract user receives a new cellular handset every 2 years, as they receive a new handset in return for renewing the contract. The old phones are given away or sold second-hand, stimulating the filtering down of advanced classes of phones into the prepaid mass market.

Figure A.41 represents the authors view on how these factors will combine to effect the penetration of the classes of handsets in the long term. What must be kept in mind is that this process of penetration of devices is cyclical and continuous. As new devices are introduced, advanced devices migrate towards mid-tier devices, mid-tier devices become classified as entry-level devices, and entry-level device are phased out the market.

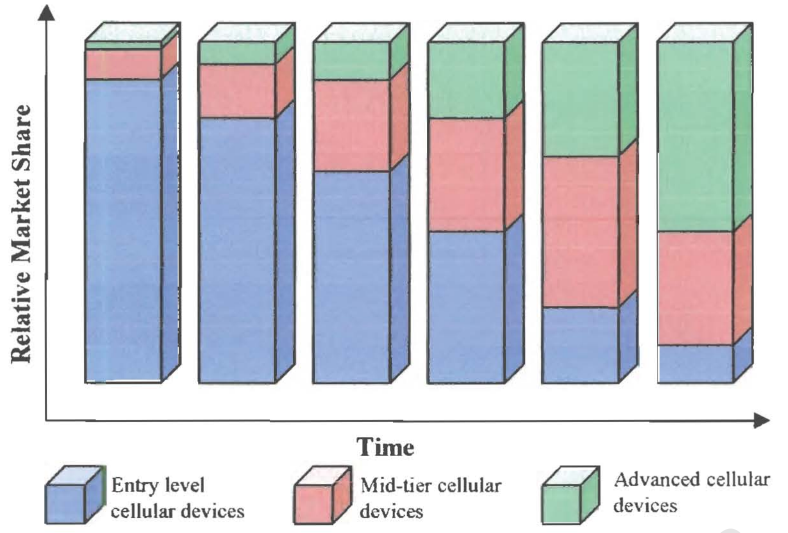


Figure A.41: Market Penetration of Cellular Handsets

The biggest inhibitor of advanced services such as 3G data is the lack of 3G-enabled phones, and until such time as the high cost of these devices decreases to the average price of an entry level device, there will not be a mass market adoption of advanced services (Whitford 2004b). This will occur through the process shown in Figure A.41 above.

There has been speculation in recent months regarding ICASA's decision to investigate the practise of handset subsidisation in the interest of consumer protection, and the possible effects this may have on handset penetration and on the cellular industry in general (Weiderman 2005a). It remains to be seen what the results of this investigation will be. However, it is claimed that handset subsidisation is largely responsible for the success of the cellular industry in South Africa, and that the practise does not in any way effect consumer rights or compromise fair competition in the industry (Knott-Craig 2005a; Knott-Craig 2005b).

A.3.1.16 Technology Usage

Metric Name	**66. Technology Usage**	
Description	Relative usage of different cellular technologies (e.g. 2G, 2.5G, 3G)	
Data type	Quantitative - objective	
Relevant to evaluation?	Contributes to implementation strategy and affects the choice of technology for deployment of LBS.	✓
Available and accessible?	Available from global cellular survey.	✓
Interpretable and comparable?	Adoption of various technologies relates to handset penetration and indicates cellular technology usage, influencing the choice of technology platforms for LBS applications.	✓
Associated with identified process or SSM conceptual model?	Associated with process 6, Provision of Cellular Services, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 66: Technology Usage

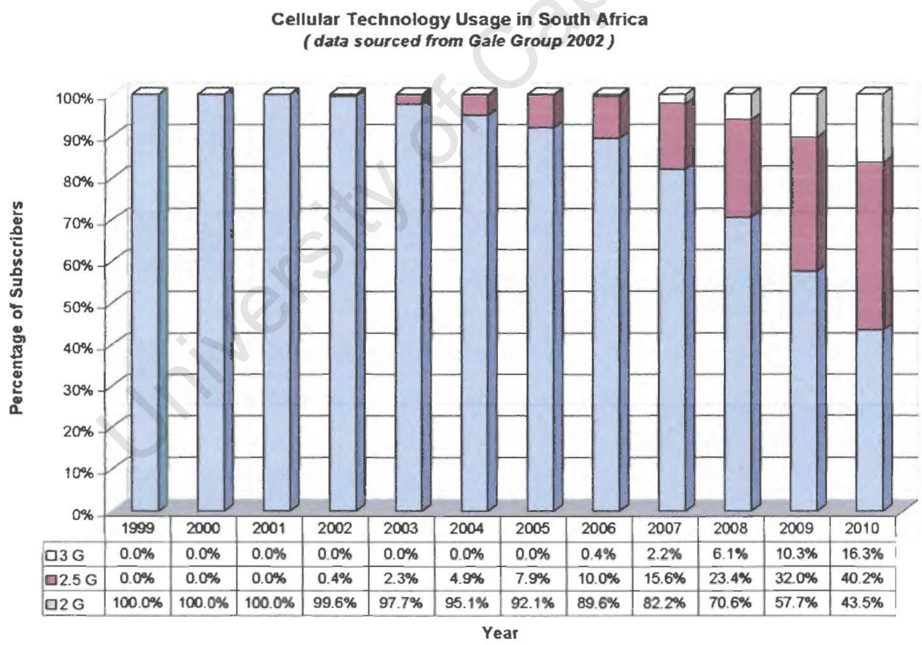


Figure A.42: Cellular Technology Usage in South Africa

Figure A.42 above shows the actual and predicted relative technology usage in South Africa. The figure shows an increasing use of 2.5G (GPRS) and 3G technology over the next few years. More recent data, for example the data usage statistics in section A.3.1.14, has indicated that these estimates are conservative, and the use of 2.5G and 3G data is likely to increase more rapidly than shown above. In fact, there are claims that in 5 years time most people in South Africa will be using 3G phones and communicating with one another using video calls (Whitford 2004b), which is over-optimistic in the author's opinion.

A.3.2 Market Demands & Trends

An understanding of market demands for cellular services and, more specifically for LBS, is important for the evaluation of LBS in South Africa. The metrics presented in this section were derived from the hierarchy of metrics depicted in Figure 6.10, and include the demand for different cellular services, handset demand, cost of service concerns, and metrics relating directly to LBS.

A.3.2.1 Voice Demands

Metric Name	**67. Voice Demands**	
Description	Market demand for cellular voice services.	
Data type	Quantitative – objective	
Relevant to evaluation?	Understanding market demands for various cellular services is critical to implementing value-added services such as LBS.	✓
Available and accessible?	This data is not directly available for use in this thesis. This is either because no such surveys have been done, or the data is not publicly available. However, it could be argued that this data is implied by the actual usage statistics of cellular voice services, as described in A.3.1.12.	✗
Interpretable and comparable?	Comparable over time, and to the demand for other cellular services such as messaging, data and value-added applications.	✓
Associated with identified process or SSM conceptual model?	This metric is an output of process 3, Perform Market Research, in section 5.4.2.	✓
Does metric pass selection criteria?	This metric cannot be directly incorporated into the evaluation model, as the data is not directly available, can only be inferred from other data which would potentially introduce bias in the data.	✗

Metric 67: Voice Demands

A.3.2.2 Messaging Demands

Metric Name	**68. Messaging Demands**	
Description	Market demand for cellular messaging services.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding market demands for various cellular services is critical to implementing value-added services such as LBS.	✔
Available and accessible?	This data is not directly available for use in this thesis. This is either because no such surveys have been done, or the data is not publicly available. However, it could be argues that data is implied by the actual usage statistics of cellular messaging services, as described in A.3.1.13.	✘
Interpretable and comparable?	Comparable over time, and to the demand for other cellular services such as voice, data and value-added applications.	✔
Associated with identified process or SSM conceptual model?	This metric is an output of process 3, Perform Market Research, in section 5.4.2.	✔
Does metric pass selection criteria?	This metric cannot be directly incorporated into the evaluation model, as the data is not directly available, can only be inferred from other data which would potentially introduce bias in the data.	✘

Metric 68: Messaging Demands

A.3.2.3 Data Demands

Metric Name	**69. Data Demands**	
Description	Market demands for cellular data services.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding market demands for various cellular services is critical to implementing value-added services such as LBS.	✔
Available and accessible?	This data is not directly available for use in this thesis. This is either because no such surveys have been done, or the data is not publicly available. However, it could be argues that data is implied by the actual usage statistics of cellular data services, as described in A.3.1.14.	✘
Interpretable and comparable?	Comparable over time, and to the demand for other cellular services such as voice, messaging and value-added applications.	✔
Associated with identified process or SSM conceptual model?	This metric is an output of process 3, Perform Market Research, in section 5.4.2.	✔
Does metric pass selection criteria?	This metric cannot be directly incorporated into the evaluation model, as the data is not directly available, can only be inferred from other data which would potentially introduce bias in the data.	✘

Metric 69: Data Demands

A.3.2.4 Handsets

Metric Name	**70. Handsets**	
Description	Evaluates the market demand for different classes of handsets.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.2.5 identified that implementation of LBS applications depended on the capabilities of handsets in the market. Therefore, market demand for different classes of handsets is relevant to the evaluation of LBS in South Africa.	✓
Available and accessible?	This data is not directly available for use in this thesis. This is either because no such surveys have been done, or the data is not publicly available. However, it could be argues that data is implied by the market penetration of cellular handsets, as discussed in section A.3.1.15.	✗
Interpretable and comparable?	Comparable over time, and to the demand for other cellular services such as voice, messaging and value-added applications.	✓
Associated with identified process or SSM conceptual model?	This metric is an output of process 3, Perform Market Research, in section 5.4.2.	✓
Does metric pass selection criteria?	This metric cannot be directly incorporated into the evaluation model, as the data is not directly available, can only be inferred from other data which would potentially introduce bias in the data.	✗

Metric 70: Handsets

A.3.2.5 Cost of Service

Metric Name	**71. Cost of Service**	
Description	Market opinion and demands regarding cost of cellular services.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Understanding how much consumers are willing to spend on cellular services and value-added services such as LBS is relevant to the evaluation.	✓
Available and accessible?	Available from LBS market surveys, industry reports, and consumer internet sites.	✓
Interpretable and comparable?	Used as an indicator for determining pricing models. This should be compared to existing service costs and the costs of existing LBS applications.	✓
Associated with identified process or SSM conceptual model?	This metric is an output of process 3, Perform Market Research, and input to process 5, Develop Business and Pricing Models, both identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 71: Cost of Service

South Africa has been identified as a country with one of the highest telecommunications costs in the world, and therefore there has been increasing pressure on network operators to reduce the costs of cellular communication, or at least keep the increases to a minimum (Weiderman 2005b). This has been a major focus of the regulatory body, ICASA, and has been part of the strategy of MTN and Vodacom over the past two years (MTN 2005a; Vodacom 2005a). As a result, the cost of cellular communications in South Africa has been brought down, and it is claimed that cellular services in South Africa is now cheaper than many other countries in the world (Knott-Craig 2005a). In addition, the cost of data metrics in section A.2.3.3 shows how network operators are responding to consumer demands by significantly reducing the cost of some cellular services.

Nevertheless, there will continue to be consumer demand for cheaper and therefore more accessible cellular services in South Africa.

A.3.2.6 Use LBS Awareness

Metric Name	**72. User LBS Awareness**	
Description	User awareness of LBS and opinion regarding the potential advantages or disadvantages thereof.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Consumers do not use services they do not understand or are not aware of.	✓
Available and accessible?	Available from LBS market surveys and personal observations only.	✓
Interpretable and comparable?	Has implications for marketing strategy of LBS applications	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 72: User LBS Awareness

There is little direct data with regards to user awareness of LBS applications and the implications thereof. In addition, this data is difficult to consolidate and summarise as there is variability in the data, which consists primarily of subjective opinion.

A market survey performed by the author showed that some consumers were aware of LBS and relatively enthusiastic regarding the possibilities. However, the bias of the sample group, i.e. high income and mainly working in technology related industries, must be taken into account and therefore this sample can not be regarded as representative of the entire cellular industry (see demographic metrics in section A.3.1). As the sample consisted mainly of people working in the high-tech and GIS industries, they were more likely to be aware of and responsive to LBS technology (Project B 2002).

The only other available survey data for this metric comes from Vodacom's online LBS opinion poll, the results of which are shown on the following page in Figure A.43.

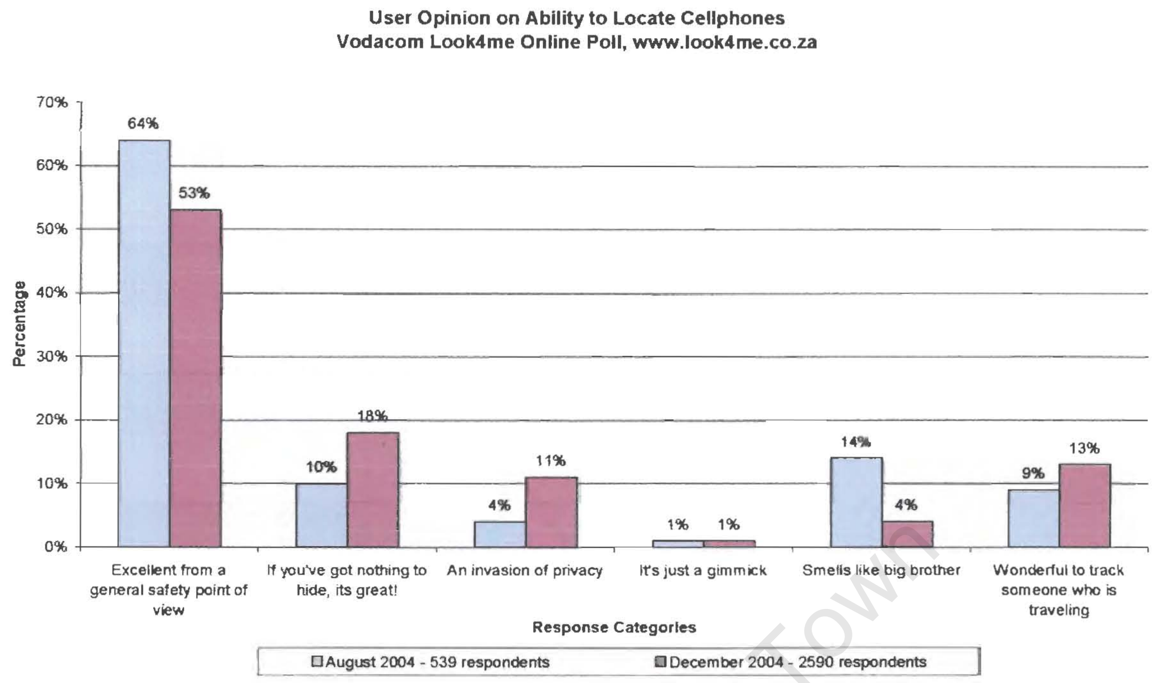


Figure A.43: Vodacom LBS Opinion Survey

Figure A.43 above shows the results of the Vodacom's online LBS opinion survey. The data shows respondent opinions regarding LBS at two different times and with a larger sample group at the later time. The data shows that there is generally a positive response to the idea of LBS from a safety point of view, but approximately 20% of the respondents at both points in time responded negatively, including *"an invasion of privacy"*, *"it's just a gimmick"* and *"smells like big brother"*.

Once again, the author must call into question the level to which this survey data is representative of the cellular market in general. Although no data is available to support this claim, the author suggests that in order for a person to have made the effort to go onto an LBS-related website and take part in an LBS survey, they must have a pre-existing interest in LBS technology. If this holds true, the survey results must be considered to be biased.

A final note with regards to consumer awareness of LBS; in the author's personal experience, there has been an increase in LBS awareness in South Africa. The author observed that the number of times LBS needed to be explained to people querying the subject matter of this thesis decreased significantly over the last few years. This is possibly due to the aggressive marketing efforts of Vodacom to promote its LBS applications, as discussed in section A.4.1.7.

A.3.2.7 Privacy Concerns

Metric Name	**73. Privacy Concerns**	
Description	A measure of user concerns for privacy.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Personal privacy is an important issue for the implementation of LBS as identified in section 4.4.1.6.	✓
Available and accessible?	Available from LBS market survey, Vodacom LBS survey and industry analyst reports.	✓
Interpretable and comparable?	Concern for privacy translates into need for privacy policy and regulation, effects marketing and user education of the issues and effects implementation of LBS.	✓
Associated with identified process or SSM conceptual model?	This metric is an input to process 2, Research LBS Market Demand, in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 73: Privacy Concerns

Despite the lack of data representative of the whole cellular industry, there is evidence that privacy is a concern for potential users of LBS applications in South Africa.

Firstly, the LBS market survey undertaken by the author indicated that at least 20% of the respondents had concerns over the implications of LBS for personal privacy, even if user opt-in strategies were in place (Project B 2002). In addition, Figure A.43 in the previous section shows that approximately 20% of the respondents of the Vodacom online LBS opinion poll indicated that they thought LBS was an invasion of privacy or indicated that they were fearful of the "Big Brother" implications of the technology (Vodacom 2004b).

In addition, interviews with several industry representatives has indicated that the protection of privacy is a major concern for LBS in South Africa, and should be taken very seriously in terms of managing user expectations and maintaining the appropriate balance of privacy and security (Hainebach 2002; Oehely 2002; Oehely 2004; Watermeyer 2002). To this effect, the legislation that governs the privacy/security balance in South Africa is discussed in sections A.4.2.1 and A.4.2.2.

Therefore, the available data has shown that at least 20% consumers have indicated that they are concerned about personal privacy in the context of LBS. The author speculates that in reality this figure is much higher, as the survey data comes from sample groups who were already interested in LBS technology, which potentially skews the survey results.

A.3.2.8 LBS Application Demand

Metric Name	**74. LBS Application Demand**	
Description	User demand for different classes of LBS applications.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Knowing which application users will use is fundamental to LBS implementation.	✔
Available and accessible?	A limited amount of data is available from LBS market survey and industry reports, and from the actual uptake of LBS services.	✔
Interpretable and comparable?	Comparable across LBS application classes and contributes towards LBS implementation strategy.	✔
Associated with identified process or SSM conceptual model?	This metric is an input to process 2, Research LBS Market Demand, in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 74: LBS Applications Demand

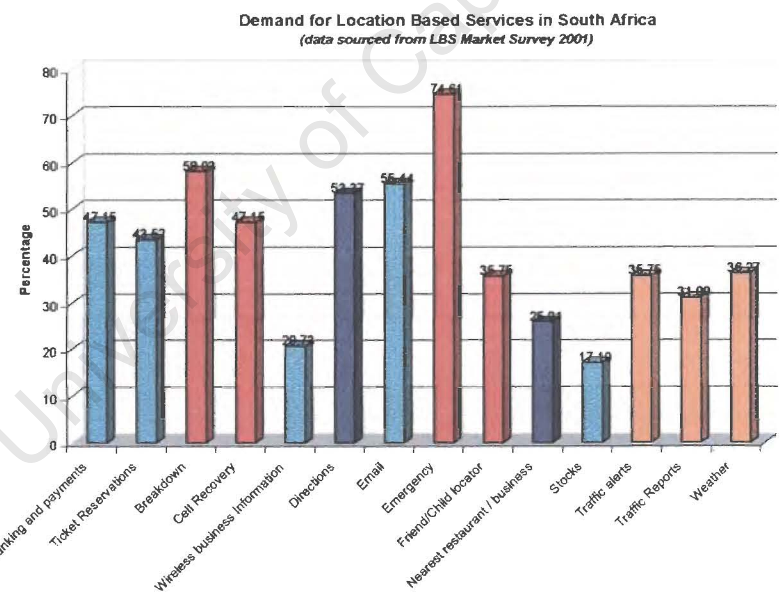


Figure A.44: Demand for LBS Related Cellular Services

Figure A.44 above shows the demand for various LBS-related cellular services in South Africa (Project B 2002). Unfortunately, this survey was undertaken before the classification of LBS applications outlined in section 4.3. In order to avoid biases in the data through re-allocating and aggregating the data, it is reported in its original form. The only other data available for the demand for LBS services is the poor uptake of Vodacom's LBS applications, Look4me and Look4it. Despite extensive investment in marketing by Vodacom, as discussed in section A.4.1.7, only 40,000 people or 0.4% of Vodacom's subscribers had tried the service two months after its launch date (Whitford 2004a).

The author's interpretation of the data presented in this section, as it pertains to the demand for the different classes of LBS Applications in South Africa, is illustrated by Figure 7.2 in section 7.3.2.

A.3.3 Benefits to Society

As stated in section 1.1.2.2, the benefits and effect of technology on society is the ultimate output of S&T. The metrics presented in this section are derived from the hierarchy of metrics shown in Figure 6.12. This section presents the metrics for measuring the effects of LBS on society.

A.3.3.1 Compromise of Personal Privacy

Metric Name	**75. Compromise of Personal Privacy**	
Description	An evaluation of whether or not LBS currently has an effect on personal privacy in South Africa.	
Data type	Qualitative - Subjective	
Relevant to evaluation?	Understanding the effects of LBS on personal privacy is integral in an evaluation of LBS in South Africa. This is because global lessons have shown that personal privacy is a key factor for LBS, and the data in section A.3.2.7 has shown that South Africans are concerned about effects of LBS on personal privacy.	✔
Available and accessible?	The author is not aware of any reported complaints or real incidents where there has been a compromise of personal privacy due to LBS. This may be due to lack of data, or because LBS currently does not negatively effect personal privacy in South Africa.	✘
Interpretable and comparable?	Actual effect on personal privacy compared to consumer concerns over privacy implications, as well as to assess the technological and regulatory mechanisms in place to deal with the issue.	✔
Associated with identified process or SSM conceptual model?	This can be associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric cannot be included in the evaluation as there is no data available to the author. However, this metric should be included in the model of evaluation for subsequent evaluations.	✘

Metric 75: Compromise of Personal Privacy

A.3.3.2 Job Creation

Metric Name	**76. Job creation**	
Description	Measure of how LBS has positively or negatively affected society in terms of creating or destroying employment opportunities on a large scale.	
Data type	Qualitative – Objective	
Relevant to evaluation?	Job creation is a key measure of technology's effects on society, as identified by Geisler (2000) and Pieterse (2001).	✔
Available and accessible?	There is no data available for this metric.	✘
Interpretable and comparable?	Can be interpreted as a measure of positive effect on society, and compared with job creation in other sectors.	✔
Associated with identified process or SSM conceptual model?	This can arguably be associated with any of the processes or conceptual models, as all require someone to be doing the work. However, as the metric is concerned with large scale benefits to society in general (i.e. ultimate outputs of S&T), it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric cannot be included in this evaluation as the data does not exist. However, this metric should be included in the evaluation model for subsequent evaluations.	✘

Metric 76: Job Creation

A.3.3.3 Improved Communication

Metric Name	**77. Improved Communication**	
Description	A measure of how LBS has improved communication in South Africa.	
Data type	Qualitative	
Relevant to evaluation?	LBS is a subset of communication technology, and therefore LBS's effect on communication technology as a whole is a relevant measure. In addition, one the proposed uses of LBS is location sensitive billing as discussed in 4.3.6, which would constitute an improvement in access to communication.	✔
Available and accessible?	This data is not available. This is either because LBS has no effect on improving communications in South Africa, or because LBS is still at an early stage and has not yet had a measurable effect.	✘
Interpretable and comparable?	Can be compared relatively to other technologies or to other benefits of the technology to society.	✔
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric cannot be included in the evaluation as there is not data. However, the metric should be considered for subsequent evaluations.	✘

Metric 77: Improved Communication

A.3.3.4 Information Technology

Metric Name	**78. Information Technology**	
Description	Measure of how LBS has effected Information Technology in South Africa	
Data type	Qualitative	
Relevant to evaluation?	LBS is part of telecommunications technology, and increased information technology is a potential social benefit of LBS as identified by Pieterse (2001) in Figure 6.11. In addition, an identified class of LBS applications are Navigation and Directory Information Services as discussed in section 4.3.3. An evaluation of the effect of LBS on Information Technology is therefore relevant to this evaluation	✓
Available and accessible?	The author has no data to suggest that LBS has had any tangible effect on information technology in South Africa. This is perhaps because LBS is still in early stages of innovation.	✗
Interpretable and comparable?	This metric could be compared to other outputs of LBS and contribute to determining if the technology is beneficial.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	The metric cannot be included in the evaluation as there is no data. However, this metric should be considered for subsequent evaluations.	✗

Metric 78: Information Technology

A.3.3.5 Education

Metric Name	**79. Education**	
Description	A measure of the effect LBS has on education in South Africa	
Data type	Qualitative – Subjective	
Relevant to evaluation?	The author does not believe that education is or ever will be greatly effected by LBS, and can not find any justifiable reason for the metric to be included in the evaluation.	✗
Available and accessible?	This data is not available, most likely because LBS has not had any effect on education.	✗
Interpretable and comparable?	Could be comparable against other benefits.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric is not relevant and not available. It can not be included in the model of evaluation for the purposes of this thesis.	✗

Metric 79: Education

A.3.3.6 Productivity

Metric Name	**80. Productivity**	
Description	A measure of any increase in business productivity attributable to LBS in South Africa.	
Data type	Qualitative – Subjective	
Relevant to evaluation?	Increased business productivity is one of the identified benefits of LBS. It aims to streamline access to information as discussed in section 4.3.3 and improve on mobile commerce and advertising as discussed in section 4.3.5.	✓
Available and accessible?	The author has no data to suggest that LBS has had any tangible effect on business productivity in South Africa. This is perhaps due to the fact that the LBS is still in early stages and has not been adopted as yet.	✗
Interpretable and comparable?	This metric could be compared to other outputs of LBS and contribute to determining if the technology is beneficial.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation as there is no data. However, it must be considered for subsequent evaluations.	✗

Metric 80: Productivity

A.3.3.7 Law Enforcement

Metric Name	**81. Law Enforcement**	
Description	A measure of the effect LBS has had on Law Enforcement.	
Data type	Qualitative – Subjective	
Relevant to evaluation?	One of the uses identified for LBS is law enforcement and person tracking as identified in section 4.3.2. LBS could also aid law enforcement by providing navigation and information services as discussed in section 4.3.3.	✓
Available and accessible?	The author has no data to suggest that LBS has had any tangible effect on Law Enforcement in South Africa at this time.	✗
Interpretable and comparable?	This metric is comparable to other benefits of LBS in society. In addition, it should be measured against privacy issues and regulations.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation as there is no data. However, it must be considered for subsequent evaluations.	✗

Metric 81: Law Enforcement

A.3.3.8 Personal Safety

Metric Name	**82. Personal Safety**	
Description	A measure of improvements in Personal Safety attributable to LBS.	
Data type	Qualitative – Subjective	
Relevant to evaluation?	Identified classes of LBS applications in section 4.3 include safety & security and person tracking. A measure of how these applications of LBS are affecting personal safety is thus relevant to the evaluation.	✔
Available and accessible?	There is no available data to indicate that LBS is having a tangible effect on personal safety in South Africa. This could be due to slow uptake of the new technology, an ineffectiveness of the existing applications, or simply that the data was not available to the author.	✘
Interpretable and comparable?	Comparable to other benefits and interpretable as a real benefit to society.	✔
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric cannot be included in this evaluation due to the lack of data. However, since personal safety is one of the primary motivators for LBS, the metric should be included in subsequent evaluations.	✘

Metric 82: Personal Safety

A.3.3.9 Emergency Services

Metric Name	**83. Emergency Services**	
Description	Measurements in improvements of emergency services attributable to LBS.	
Data type	Qualitative – Subjective	
Relevant to evaluation?	Emergency services was identified as a key use of LBS in section 4.3.1, and thus any effects of LBS on emergency services needed to be evaluated.	✔
Available and accessible?	The author is not aware of any evidence that LBS has had any effect on emergency services in South Africa as yet.	✘
Interpretable and comparable?	Comparable to other benefits and can help to determine if LBS has been translated into tangible benefits.	✔
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✔
Does metric pass selection criteria?	This metric cannot be included in this evaluation due to the lack of data. However, the metric should be considered for subsequent evaluations.	✘

Metric 83: Emergency Services

A.3.3.10 Security of Assets

Metric Name	**84. Security of Assets**	
Description	A measure of how LBS has affected security of assets and property through applications of the technology such as vehicle tracking.	
Data type	Quantitative – Objective	
Relevant to evaluation?	Asset and vehicle tracking was identified as a primary use class of LBS in section 4.3.2, and measuring LBS's benefits for securing of assets is thus relevant in an evaluation of LBS in South Africa.	✓
Available and accessible?	There is no data available to the author to indicate that network-based LBS tracking technology has effected security of assets in South Africa. The author reiterates here that standard vehicle tracking systems are not included in the evaluation; only network positioning-based LBS tracking systems.	✗
Interpretable and comparable?	Comparison success rates of vehicle or asset recovery with and without LBS technology.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation due to the lack of data.	✗

Metric 84: Security of Assets

A.3.3.11 Access to Health Care

Metric Name	**85. Access to Health Care**	
Description	A measure of the influence LBS has had to the improvement of and the improvement of access to Health Care in South Africa	
Data type	Qualitative – Subjective	
Relevant to evaluation?	Improvement of health care is an important benefit to society of telecommunications technology as identified by Pieterse (2001). In terms of LBS, Health Care overlaps with Emergency Services applications of LBS.	✓
Available and accessible?	There is no data available to the author to indicate that LBS is improving access to health care in South Africa at this point in time.	✗
Interpretable and comparable?	Comparable across other benefits and comparable to pre-LBS situations or situations where LBS is not used.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation due to a lack of data. However, this metric should be considered for subsequent evaluations.	✗

Metric 85: Access to Health Care

A.3.3.12 Improved Transport Infrastructure

Metric Name	**86. Improved Transport Infrastructure**	
Description	Measure the level to which LBS has helped to improve transport infrastructure in South Africa.	
Data type	Qualitative – Subjective	
Relevant to evaluation?	Intelligent Transport Systems were identified as a class of use for LBS in section 4.3.7.	✓
Available and accessible?	Data regarding attempts to use LBS to improve transport infrastructure is available to the author through experience in the industry (Project A 2001; Project D 2002). However, to the author's knowledge, these attempts have not resulted in any tangible improvements to the transport infrastructure in South Africa.	✗
Interpretable and comparable?	Showing improvements in transport infrastructure directly attributable to LBS will aid in the assessment of its usefulness	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation as there is a lack of data. However, the metric should be considered for subsequent evaluations.	✗

Metric 86: Improved Transport Infrastructure

A.3.3.13 Improved Public Transport

Metric Name	**87. Improved Public Transport**	
Description	A measure of the benefits LBS has had for public transport.	
Data type	Qualitative – Subjective	
Relevant to evaluation?	Intelligent Transport Systems were identified as a class of use for LBS in section 4.3.7.	✓
Available and accessible?	Data regarding attempts to use LBS to improve transport infrastructure is available to the author through experience in the industry (Project A 2001; Project D 2002). However, to the author's knowledge, these attempts have not resulted in any tangible improvements to the transport infrastructure in South Africa.	✗
Interpretable and comparable?	Showing improvements in public transport directly attributable to LBS will aid in the assessment of its success.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation as there is a lack of data. However, the metric should be considered for subsequent evaluations.	✗

Metric 87: Improved Public Transport

A.3.3.14 Reduced Cost of Transport

Metric Name	**88. Reduced Cost of Transport**	
Description	Measure of the effect LBS has had on reducing the cost of transport.	
Data type	Qualitative – Subjective	
Relevant to evaluation?	Intelligent Transport Systems and Navigation systems are an identified use of LBS, both of which are aimed (in part) at making transport easier and cheaper.	✓
Available and accessible?	This data is not available to the author.	✗
Interpretable and comparable?	Comparable to other benefits, to situations not using LBS and interpretable as a tangible benefit of LBS.	✓
Associated with identified process or SSM conceptual model?	As the metric is concerned with large scale benefits to society in general, it is associated with the process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric cannot be included in the evaluation as there is a lack of data. However, the metric should be considered for subsequent evaluations.	✗

Metric 88: Reduced Cost of Transport

This section has presented all of the metrics for the social benefits of LBS in South Africa. Due to the lack of available data, all of these metrics were excluded from the evaluation model. The author maintains that this is because LBS has not yet progressed far enough down the innovation continuum to result in ultimate outputs, i.e. the effects on society.

These metrics should all be reconsidered for subsequent evaluations of LBS in South Africa.

A.4 Political & Organisational Metrics

This section presents all the political and organisational metrics effecting LBS in South Africa as derived in section 6.1.5. Section A.4.1 covers the organisational metrics concerning the network operators, section A.4.2 deals with the metrics concerning the South Africa government and regulatory authority, and section A.4.3 covers the metrics concerning the LBS Value Network.

A.4.1 Network Operators

As identified in sections 5.2.3 and 5.2.4, the network operators are the primary actors in the SSM systems to provide cellular services and to provide location based services in South Africa. The metrics presented in this section are derived from the hierarchy of metrics depicted in Figure 6.13, and deal with the influence of the stakeholders, the social obligations of the network operators in terms of their license agreements, and the strategy of the network operators towards the implementation of LBS.

A.4.1.1 International Stakeholders

Metric Name	**89. International Stakeholders**	
Description	Measure of how much influence and stake holding international companies hold in the South African cellular industry.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding the role of international stakeholders may provide insight into partnerships and sources of technology that may be beneficial to LBS in South Africa.	✓
Available and accessible?	This data is available publicly as the ownerships and stakeholders details are available for the cellular operators.	✓
Interpretable and comparable?	Strategic benefits gained from these stake holdings can be compared between the cellular operators.	✓
Associated with identified process or SSM conceptual model?	Although this metric is an input to any of the identified systems, the strategic implications of this metric are associated with process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 89: International Stakeholders

A direct stake holding in a network operator by an international company could translate into a strategic advantage for that network operator.

The Vodafone Group Plc., one of the world's largest mobile companies, has a 35% shareholding of Vodacom (Vodacom 2005a). Vodacom has benefited from this international partnership by having access to market research, technology research, and implementation of Vodafone products.

In November 2004, the relationship was extended to include a strategic operational partnership as well as board level agreements. The result is the Vodacom is able to make use of Vodafone's R&D into 3G networks and applications, access to new 3G phones and mobile data cards specifically developed specifically for Vodafone. In addition, Vodacom has access to the Vodafone live! portal, which is a collection of horizontally integrated value-added services, including a number of LBS applications (Vodacom 2005a). Vodafone live! will introduce the South African market to global and local content, including picture messaging, games, polyphonic ring tones, 3D Java games and video messaging (Vodacom 2005b). In addition to this, it includes a number of "Find and Seek" LBS services, classed as directory information LBS applications for the purposes of this thesis.

Based on the above, the author believes it is highly likely that Vodacom has benefited from Vodafone's LBS experiences in other countries. Certainly, as discussed in the analysis in chapter 7, the case study data indicates the Vodacom has taken notice of the lessons learnt from global LBS experience. At the time of writing this thesis, MTN had no partnerships with international companies that could potentially benefit them in terms of the delivery of LBS applications.

A.4.1.2 Government Ownership

Metric Name	**90. Government Ownership**	
Description	A measure of the government shareholding in the cellular operators in terms of its potential implications for LBS.	
Data type	Quantitative - objective	
Relevant to evaluation?	Understanding if the government of South Africa has a business interest in any of the cellular operators may provide insight into any strategic advantages gained by such a relationship.	✓
Available and accessible?	This data is available publicly as the ownerships and stakeholders details are available for the cellular operators.	✓
Interpretable and comparable?	Strategic benefits gained from these stake holdings can be compared between the cellular operators.	✓
Associated with identified process or SSM conceptual model?	Although this metric is an input to any of the identified systems, the strategic implications of this metric are associated with process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 90: Government

Telkom, the national fixed-line operator in South Africa, owns a 30% shareholding in Vodacom. Telkom is in turn partly owned by the South African Government. There is some speculation that this close relationship with the government gives Vodacom a strategic advantage in the market. However, the role of ICASA as the industry watchdog is to ensure that this does not occur.

There is no directly data available to suggest that the relationship between Vodacom and the South African government is directly beneficial to Vodacom in terms of the implementation of LBS applications.

The author's experience in commercial LBS-related projects involving government organisations showed more involvement from Vodacom than MTN (Project A 2001; Project C 2001; Project D 2002; Project E 2001). However, this was most likely because of Vodacom proactive approach to LBS rather than the influence of the government stake holding.

Based on information gathered from several interviews, it was concluded that MTN has had little involvement in LBS related projects with government organisations (Oehely 2002; Oehely 2004).

Therefore, government stake holding in a network operator has no effect on the implementation of LBS applications in South Africa.

A.4.1.3 BEE Stakeholders

Metric Name	91. BEE Stakeholders	
Description	A measure of the government shareholding in the cellular operators.	
Data type	Quantitative - objective	
Relevant to evaluation?	Although Black Economic Empowerment (BEE) is an important issue in South Africa in the current post apartheid economic climate, there is no grounds to suggest that BEE shareholdings would affect the LBS industry in South Africa. In addition, the issue is highly political and is beyond the scope of this thesis to cover in sufficient detail.	✗
Available and accessible?	This data is available publicly as the ownerships and stakeholders details are available for the cellular operators.	✓
Interpretable and comparable?	Strategic benefits gained from these shareholdings can be compared between the cellular operators.	✓
Associated with identified process or SSM conceptual model?	Although this metric is an input to any of the identified systems, the strategic implications of this metric are associated with process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?	This metric is cannot be included in the evaluation as it is not relevant to the evaluation.	✗

Metric 91: BEE Stakeholders

A.4.1.4 Universal Service

Metric Name	92. Universal Service	
Description	A measure of Universal Service obligations and revenue contributions for the cellular operators.	
Data type	Quantitative – subjective	
Relevant to evaluation?	Universal service obligations effect not only operator licenses but also have social implications for implementation of LBS, particularly for emergency services related applications.	✓
Available and accessible?	Available from industry reports and ICASA annual telecommunications report.	✓
Interpretable and comparable?	Measure of the governments US policy and can be related to final outcomes of cellular and LBS technology, i.e. benefits to society.	✓
Associated with identified process or SSM conceptual model?	Associated with process 1, Creation of telecommunications policy and legislation, as identified in section 5.4.1	✓
Does metric pass selection criteria?		✓

Metric 92: Universal Service

As part of their license obligations, networks operators are required to contribute towards the Universal Service Fund (UDF) to the amount of 0.2% of their annual revenue (DOC

2003). The Universal Service Agency (USA) is mandated to utilise these funds to subsidise projects whose objectives are to promote the universal and affordable provision of telecommunications services (ICASA 2003a).

In addition to USF contributions, operators have individual license obligations to extend service into previously disadvantaged and rural areas. For example, CellC is obligated to provide 56,000 community cell phones over a period of 6 years as part of their license obligations (ICASA 2003b). Vodacom and MTN have had similar license obligations, and have agreements in place with the DOC and ICASA to receive access to the 1800 MHz spectrum (i.e. 3G technology) in exchange for four million SIM cards and 250,000 community phones over a 5 year period (MTN 2004; Vecchiatto 2003a; Vodacom 2004a). The implications of 3G technology has already been discussed in section A.1.1.1.

The provision of SIM cards further extends the reach of cellular technology in to rural and disadvantaged communities by providing access to communications services, emergency services and a link to the country's economic lifeline (Weiderman 2003).

In the author's opinion this approach to spectrum allocation, awarding of cellular license, and Universal Service and Access is positive for the cellular industry in South Africa, as the government has forfeited the high license fees typically associated with 3G licenses (Budde 2001) in favour of a mutually beneficial strategy that will ensure social upliftment and long term growth of the cellular industry. In terms of the effect of the policy on LBS, the access to 3G licenses has allowed for network operators to implement enabling technology. In addition, the growth of the cellular industry through USA directly influences the LBS market, in particular for emergency services.

A.4.1.5 Emergency Services and Law Enforcement Obligations

Metric Name	**93. Emergency Services and Law Enforcement**	
Description	A measure of the obligations of the cellular operators in terms of assisting with the provision of emergency service and law enforcement in South Africa.	
Data type	Qualitative – subjective	
Relevant to evaluation?	As discussed in section 4.1.1, the FCC mandate aimed at improving emergency services was a primary catalyst for cellular operators implementing LBS technology. Investigating if similar factors influenced LBS in South Africa is therefore integral to the evaluation.	✓
Available and accessible?	This data is available from legislation, telecommunications policy documents, and commercial project experience and industry reports.	✓
Interpretable and comparable?	Comparable to the situation in other regions, and can be interpreted as a contributing or restricting factor for the LBS industry.	✓
Associated with identified process or SSM conceptual model?	Associated with process 1, Creation of telecommunications policy and legislation, and process 6, Provision of emergency services and public safety, as identified in section 5.4.1	✓
Does metric pass selection criteria?		✓

Metric 93: Emergency Services and Law Enforcement Obligations

At the time of writing this thesis, there were no direct obligations regarding the use of LBS technology for emergency services and law enforcement in South Africa. The exception to this is arguably the legislation in place to provide access to information for the purposes of public safety and the efforts for a national emergency call centre discussed in section A.4.2.7.

Thus, although the operators do need to provide free access to emergency service numbers, they are not obliged at this time to make use of LBS technology.

A.4.1.6 LBS Technology Strategy

Metric Name	**94. LBS Technology Strategy**	
Description	LBS technology implementation strategy of the cellular operators	
Data type	Qualitative - subjective	
Relevant to evaluation?	Global LBS lessons discussed in section 4.4.1.1 identified LBS technology decisions as vital to LBS implementation.	✓
Available and accessible?	The official technology decisions of the cellular operators are not public knowledge nor available to the author. However, a perspective on this issue can be derived from various interviews and observations from experience.	✓
Interpretable and comparable?	The LBS technology choices of the operators can be compared to each other and compared to the perspectives discussed in section 4.4.1.1.	✓
Associated with identified process or SSM conceptual model?	Associated with process 3, Assess LBS Technology Requirements, and process 5, Implement LBS Enabling Technology, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 94: LBS Technology Strategy

As stated in the selection criteria above, there is no direct information available with regards to the LBS technology strategy of Vodacom and MTN. The data presented in this section is based on the empirical evidence of the case study data, and is discussed more fully throughout the analysis in chapter 7.

Vodacom's investment in a location gateway indicates that they have a more pro-active strategy towards LBS technology. In addition, Vodacom has been experimenting with advanced LBS positioning technology, although no information is available as to whether or not they will implement the technology in the near future (Hainebach 2002).

MTN has taken a more cautious strategy towards LBS technology, and seem to be trying to learn as much as possible through experimenting with various LBS technologies until such stage as they can justify the business case for large scale consumer LBS.

It remains to be seen which strategy is more effective in the South African context.

A.4.1.7 LBS Marketing Strategy

Metric Name	**95. LBS Marketing Strategy**	
Description	LBS marketing strategy of the cellular operators.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Marketing strategy was identified as a contributing factor to the success of LBS in Israel in section 4.1.3. Understanding the approach of South African cellular operators to LBS marketing is thus important in this evaluation.	✔
Available and accessible?	Available from interviews and empirical evidence of marketing campaigns in South Africa.	✔
Interpretable and comparable?	The LBS marketing strategy of the cellular operators can be compared to each other and to global LBS lessons. The marketing strategy can be interpreted as being a contributing to the success or failure of LBS in South Africa.	✔
Associated with identified process or SSM conceptual model?	Associated with process 4, Develop LBS Strategy, as identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 95: LBS Marketing Strategy

Vodacom has adopted an active marketing strategy for its Look4me, Look4help and Look4it LBS applications. These include TV, radio, newspaper and magazine advertisements as well as printed product brochures and pamphlets distributed at cellular outlets. The only form of advertising Vodacom has not made use of is online advertising, besides its own website (Whitford 2004a). A recurring theme in the advertisements is the issue of personal privacy, and Vodacom's advertisements emphasise the fact that a user's cell phone can only be tracked with the consent of the cell phone owner.

Given the scale of the marketing, there has been a relatively poor uptake in these services to date (Whitford 2004a). It is interesting to note that relatively aggressive marketing strategy adopted by Vodacom is different to the cautious, low-profile marketing suggested by global experience, as discussed in section 4.4.1.4. This is the only instance where Vodacom has not acted according to the lessons drawn from global experience. However, it is beyond the scope of this thesis to determine whether the marketing strategy adopted by Vodacom is the correct approach.

MTN has no commercially active LBS applications of its own, and therefore there is no evidence of any LBS marketing strategy. The author is of the opinion that this is in line with their cautious approach to LBS in general, as discussed in the previous section.

A.4.1.8 LBS Integration Strategy

Metric Name	**96. LBS Integration Strategy**	
Description	LBS integration strategy of the cellular operators, in terms of horizontal or vertical integration.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.4.1.5 identified horizontal vs. vertical integration of LBS as an important factor in the provision of LBS services.	✓
Available and accessible?	This data is not directly available from the cellular operators. However, the LBS integration approach of the cellular operators can be determined from various interviews, industry experience and empirical evidence of deployed applications and other metrics.	✓
Interpretable and comparable?	Comparable across operators and comparable to global lessons outlined in section 4.4 for LBS implementation.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Develop LBS Strategy, process 5, Implement LBS Enabling Technology, process 6, Create Strategic Partnerships, and process 7, Implement LBS Applications, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 96: LBS Integration Strategy

Section 4.4.1.5 briefly discussed LBS integration strategy, and stated that a lesson learnt from global experience was that horizontal integration of LBS technology was preferable to vertical integration of LBS technology. This metric discusses this concept and it's implications for LBS in more detail, and more specifically determines the integration strategy adopted by the network operators for the deployment of LBS in South Africa.

To summarise section 4.4.1.5, vertical integration of LBS technology aims at deploying a particular technology to deliver a particular LBS service, normally for a specific market. This was the early approach taken in the LBS industry, where network operators tried to focus on finding particular LBS applications, referred to as "killer" applications, which addressed a specific consumer need and were capable of generating a significant revenue stream.

On the other hand, horizontal integration of LBS technology takes a broader approach, and tries to integrate a standardised LBS technology across a broad range of existing and new services. In this way, horizontal integration of LBS technology lowers the cost of the infrastructure by leveraging off a wider range of revenue generating applications (Gulati, Sawhney, & Paoni 2002b). As LBS become an enhancement to existing services, as well as providing additional niche services, the addressable market is much larger and the cost to the consumer is reduced. This is shown conceptually in Figure A.45 below:

Adapted from Gulati et al (2002)

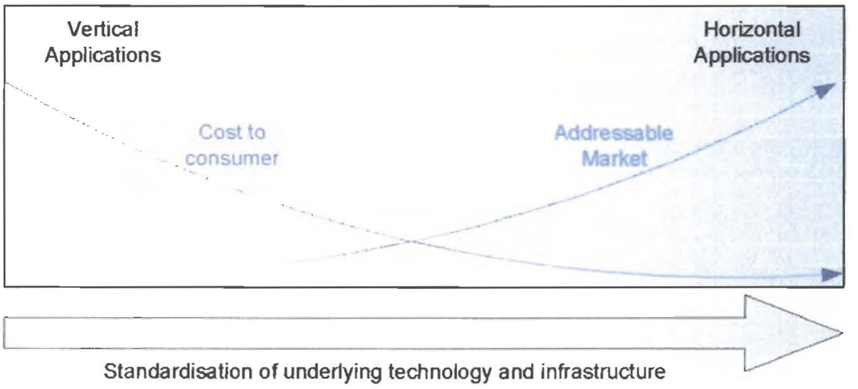


Figure A.45: Horizontal versus Vertical Integration of LBS Technology

The concept shown in Figure A.45 above can be further illustrated by means of a practical example. The Matrix vehicle tracking system (section A.4.3.7) implemented on MTN's networks is an example of a vertical application, as it uses specific non-standard location technology (section A.1.2.1) to address a particular need.

On the other hand, Vodacom's suite of LBS applications (section A.4.3.7) are horizontally integrated, as they tie in with existing services such as directory enquiry, emergency services and information services such as weather reports. This horizontal integration is enabled by Vodacom's decision to invest in SignalSoft's location gateway, and they therefore have access to a standard platform for leveraging location capability across all their cellular services (sections A.1.2.5-A.1.2.9, and A.4.1.6).

Thus, the data indicates that Vodacom has opted for a horizontal integration strategy, while MTN has opted for a vertical integration strategy. This is a crucial difference between the operators in terms of their approach to LBS.

A.4.2 Government

This section covers the metrics to evaluate the effects of legislation and government policy on LBS in South Africa. The metrics presented in this section are derived from the hierarchy of metrics shown in Figure 6.14.

A.4.2.1 Privacy Protection Legislation

Metric Name	**97. Privacy Protection Legislation**	
Description	Evaluates existing legislation and policy for the protection of individual privacy in South Africa.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Personal privacy issues have been stressed as a possible inhibiting factor for LBS (see section 4.4.1.6), and understanding what measures are in place to protect personal privacy in South Africa is thus relevant to the evaluation.	✓
Available and accessible?	This data is available from South African Law, various industry reports and online articles.	✓
Interpretable and comparable?	Comparable to other regions, and determines whether law does protect privacy rights of individuals thus controlling how LBS position information is accessed and used.	✓
Associated with identified process or SSM conceptual model?	Associated with process 5, Creation of legislation to protect personal data and privacy, as identified in section 5.4.1	✓
Does metric pass selection criteria?		✓

Metric 97: Privacy Protection Legislation

Section 4.4.1.6 identified that personal privacy is an issue for the provision of LBS, and that a balance between access to information and personal privacy needs to be maintained. Furthermore, the metric data in section A.3.2.7 provided evidence that South Africans are concerned about personal privacy in the context of LBS.

The right to personal privacy is recognised fundamental human right by section 14 of the South African Constitution. Recognising the growing risk to consumers following greater use of technology for information collection and dissemination, the South African Law Commission (SALC) has recently recommended that legislation be introduced to protect citizen's personal information. According to section 1.2.1 of the SALC issue paper 24, a *"person's right to privacy entails that such a person should have control over his or her personal information and should be able to conduct his or her personal affairs relatively free from unwanted intrusions" (SALC 2003).*

The motivation behind the development of privacy legislation is to align with international trends. The United Kingdom (Data Protection Act 1998), Canada (Privacy Act 1983 and Personal Information Protection and Electronic Documents Act, 2000), Australia (Privacy Act, 1988 and The Privacy Amendment Act 2000), New Zealand (Privacy Act 1993) and most European countries already have enacted privacy legislation (SALC 2002).

The SALC draws significantly on the principles of privacy protection from the international legislation mentioned above. These principles include that the data is:

- obtained fairly and lawfully;
- used only for the specified purpose for which it was originally obtained;
- adequate, relevant and not excessive to the purpose;
- accurate and up to date;
- accessible to the subject;
- kept secure; and
- destroyed after its purpose is completed.

(SALC 2003)

The SALC's efforts to introduce privacy protection legislation means that South Africa may become one of the few countries recognised by the EU as having adequate legislation in place for the protection of personal information, and therefore safe to trade information with (Goodburn 2003). It is not clear at this stage when the legislation will be passed.

With respect to LBS in South Africa, this legislation prevents the location of individuals other than for legitimate LBS applications as requested by the consumer, except in cases where accessing the location information is required by access to information law. Recognising the need to balance privacy with public safety and national interests, the privacy protection act will mean changes to other legislation, including the Promotion of Access to Information Act 2 of 2000 and the Electronic Communications and Transactions Act, 2002 (SALC 2002). The legislation to provide access to information is discussed in the following section.

A.4.2.2 Access to Information Legislation

Metric Name	**98. Access to Information Legislation**	
Description	Evaluates existing legislation and policy to provide controlled access to information.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Although personal privacy needs to be protected, section 4.4.1.6 identified that it is important to balance privacy with access to information for public safety and law enforcement. Understanding what measures are in place to provide access to LBS information is this important to the evaluation.	✓
Available and accessible?	This information is available from South African Law, industry reports and various online articles.	✓
Interpretable and comparable?	Determine whether law allows for access to information for purposes of public safety and the provision of emergency services.	✓
Associated with identified process or SSM conceptual model?	Associated with process 6, Provision of emergency services and public safety, and process 7, Creation of access to information legislation to facilitate law enforcement, as identified in section 5.4.1.	✓
Does metric pass selection criteria?		✓

Metric 98: Access to Information Legislation

There are a number of acts that allow for access to information in the context of telecommunications and LBS in South Africa. These include the Interception and Monitoring Bill (RSA Government 1992), and the Promotion of Access to Information Act (RSA Government 2000).

The purpose of the Interception and Monitoring Bill is, in part, to regulate the interception and monitoring of certain communications, to regulate authorised telecommunications monitoring, and to prohibit the provision of certain telecommunications services which do not have the capacity to be monitored.

Section 2 of the Bill states that no person may monitor any communication without knowledge or consent or to gather confidential information about an organisation or individual unless you are part of the communication or one of the communicators has consented to the monitoring. This specifically includes the origin and destination of the communication. It also provides for the recording of communications for business purposes without the consent of the other party. Sections 3 to 6 of the Bill provide the rules and conditions under which communications can be intercepted when required by the authorities.

Section 7(1) states that by law all service providers must have the facilities to monitor all communications. Furthermore, section 7(2) states that the service provider is responsible for the installation and maintenance of all monitoring devices. These requirements are not optional. The cellular network operators are therefore required by law to have the capability to monitor and intercept communication, including location information. Section 9 and 10 of the Bill deal with call related information and allows the authorities to request the interception of call related information for criminal investigations.

Thus, the Interception and Monitoring Bill explicitly requires the positioning of a cellular device, but contains specific clauses for the protection of personal privacy. To this end, the network operators have always inherently had the ability to determine the COO of a cellular communication, albeit a manual process that takes too much time to be viable for large scale LBS and requires a warrant from a supreme court judge (Oehely 2002). There are, however, no positional accuracy requirements in this legislation.

Furthermore, the purpose of the Promotion of Access to Information Act has been created to *"give effect to the constitutional right of access to any information held by the State and any information that is held by another person and that is required for the exercise or protection of any rights"* (RSA Government 2000). Therefore the act provides for access to location information in cases were it is required for the protection of rights.

Thus, there is adequate legislation in place to provide access to the location information of a cellular device in cases where it is required in the interests of public safety or law enforcement. In addition, some of the legislation discussed in this section also makes provision for location technology, as discussed in more detail in the following section.

A.4.2.3 Mandated Location Technology

Metric Name	**99. Mandated Location Technology**	
Description	Evaluates existing legislation and policy to determine whether LBS technology is required by law.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Sections 4.1.1 and 4.1.2 identified that government mandates to implement location technology on cellular networks were a major catalyst for LBS in the USA and Europe. Therefore, determining whether or not similar legislation exists in South Africa is relevant to the evaluation.	✓
Available and accessible?	This information is available from South African legislation (RSA Government 1992; RSA Government 2001).	✓
Interpretable and comparable?	Understanding whether operators are required to implement LBS technology contributes to the understanding of the decisions cellular operators have made in terms of LBS technology in South Africa.	✓
Associated with identified process or SSM conceptual model?	Associated with process 1, Creation of telecommunications policy and legislation, as identified in section 5.4.1, and process 4, Develop LBS Strategy, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 99: Mandated Location Technology

As discussed in sections 4.1.1 and 4.1.2, mandated location technology proved to be a major catalyst for LBS in the USA and Europe. The legislation that has implications for LBS in South Africa in terms of mandated positioning technology includes the Telecommunications Amendment Bill (RSA Government 2001), and the Monitoring and Interception Act. The latter has already been discussed in the previous section in the context of providing access to information, and it is sufficient to state here that the Act requires network operators to store information regarding cellular communications, including the origin and destination of calls. Thus, the Act mandates cellular positioning technology.

Section 82 of the Telecommunications Amendment Bill provides for the establishment of national emergency call centres, and requires that centres must make use of advanced technology, specifically including GPS positioning, to aid emergency situations using the national 112 emergency number as far as is practically possible.

Although both of these acts essentially mandate cellular positioning technology, primarily for emergency services, public safety and law enforcement, there are no positional accuracy requirements and no deadlines to implement any specific technology. Thus, network operators have been able to avoid the issue of providing advanced location capabilities, and will most likely continue to do so until such stage as more specific requirements and deadlines and positional accuracy requirements are mandated by legislation (Oehely 2002; Watermeyer 2002).

A.4.2.4 Universal Service

Metric Name	**100. Universal Service**	
Description	Evaluates the government's universal service policy to determine its effects on LBS in South Africa	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 5.1.1.3 identified that a large percentage of South Africans do not have easy access to telecommunications of any kind, and explained why cellular services were a viable solution. The Universal Service policy could potentially have an influence on the growth of the cellular industry in South Africa and the potential market for LBS. It is therefore relevant to this evaluation.	✓
Available and accessible?	Data regarding Universal Service policy is available from South African telecommunications regulations, industry reports, cellular operator's annual reports and online articles.	✓
Interpretable and comparable?	The actual progress made can be compared to original Universal Service goals.	✓
Associated with identified process or SSM conceptual model?	Associated with process 1, Creation of telecommunications policy and legislation, and process 2, Monitoring transfer of technology and access to communication, as identified in section 5.4.1.	✓
Does metric pass selection criteria?		✓

Metric 100: Universal Service

The data for this metric and its implications for LBS in South Africa have already been discussed in section A.4.1.4, in the context of the obligations of the network operators with respect to the government's policy of Universal Service and Access. In summary, the policy is encouraging the growth of the cellular industry and increasing access to communication for under-serviced areas. This metric and its implications are tightly integrated with the spectrum allocation and licensing, as discussed in the following section. It is not necessary to go into any greater detail in the context of this thesis.

This metric is an example of where the process of deriving a hierarchy of metrics has potentially gone into too much detail, or that different overlapping metrics may need to be combined to avoid repetition of data. This may suggest that a process of identifying common metrics or metrics that could potentially be combined needs to be incorporated into the conceptual framework. This is discussed in more detail in the criticism of the evaluation methodology in section 8.3.2.

A.4.2.5 Spectrum Allocation and Licenses

Metric Name	**101. Spectrum Allocation and Licenses**	
Description	Evaluates how the government's spectrum allocation and licensing policy may have affected the LBS industry in South Africa.	
Data type	Qualitative – subjective	
Relevant to evaluation?	Section 4.2.1 introduced the capabilities of different cellular network technologies and explained that any LBS application is reliant on the capabilities of the cellular network. Since these different technologies operate over different frequencies, the allocation of licenses and frequency spectrum has a direct influence on LBS.	✓
Available and accessible?	This data is available through ICASA annual telecommunications report, and through online articles.	✓
Interpretable and comparable?	The implications of this metric need to be understood in the context of the technology metrics as outlined in section A.1.	✓
Associated with identified process or SSM conceptual model?	Associated with process 3, Allocation of spectrum and cellular licenses, as identified in section 5.4.1, and process 1, Evaluate Available Technology, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 101: Spectrum Allocation and Licenses

As with the Universal Service policy discussed in the previous section, the data for this metric has already been discussed in sufficient detail for the purposes of this thesis. The spectrum allocation and awarding of cellular licenses was discussed in section A.4.1.4, were it was shown that this is linked to the Universal Service and Access policy of the government. As discussed in sections A.4.1.4 and A.4.2.4, the implications for LBS is that the cellular operators have been able to implement 3G technology without the typically high costs associated with those licenses, and that the approach taken is helping to stimulate the cellular industry in South Africa.

The fact that this data overlaps significantly with other metrics indicates that the conceptual framework should include mechanisms to identify and combine metrics that are in essence the same. This issue was identified in the previous section in the context of the Universal Service and Access policy.

A.4.2.6 Tariff Regulation

Metric Name	**102. Tariff Regulation**	
Description	Evaluates the government policy on tariff regulation to determine if there is any impact on LBS in South Africa.	
Data type	Qualitative – subjective	
Relevant to evaluation?	Section 5.1.1.3 identified that a major concern was the high cost of telecommunications in South Africa. Cost of service will directly affect LBS adoption, and therefore government efforts to regulate tariffs are relevant to the evaluation.	✓
Available and accessible?	Information regarding tariff regulation is available from ICASA annual reports, various industry reports and online publications.	✓
Interpretable and comparable?	Tariff regulation efforts can be compared to the actual cost of cellular services and LBS. This can also be matched against consumer cost of service demands as covered by metric A.3.2.5.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Regulation of cellular tariffs, as identified in section 5.4.1, and process 5, Develop Business and Pricing Models, as identified in section 5.4.2.	✓
Does metric pass selection criteria?		✓

Metric 102: Tariff Regulation

As originally stated in section 5.1.1.4, ICASA is responsible for the regulation of tariffs for the cellular industry in South Africa. It does so within the framework determined by the Telecommunications Act 106 of 1996 (RSA Government 2001). Essentially, any tariff increases need to be approved by ICASA before coming in to effect. ICASA analyses the proposed tariff increases, and makes a decision based on factors such as inflation, cost of providing the service, and the affordability of the tariffs by the population (Weiderman 2005b).

Although there is constant criticism of the high cellular tariffs in South Africa in the media, there is evidence to suggest that the regulation of tariffs is having a positive effect. Firstly, the subsidised community call centres are among the cheapest in the world, and an analysis of the standard cellular tariffs in conjunction with other regions shows that tariffs match the affordability levels in South Africa (Knott-Craig 2005a).

It is difficult to relate the effects of tariff regulation to LBS in South Africa, primarily because LBS applications are seen as a value-added service, have premium pricing structures (section A.2.3.5), and therefore fall outside the scope of ICASA's regulatory policy. However, with the move to more horizontally integrated LBS technology, as discussed in the previous section, tariff regulation may have an increasing role in regulating the cost of LBS services in South Africa.

A.4.2.7 Emergency Services

Metric Name	**103. Emergency Services**	
Description	Evaluates existing government legislation, policy or programs for national emergency services to determine their impact on the implementation on LBS.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.3.1 identified emergency services as the primary use of LBS, and section 5.1.2.3 identified that safety and security is a major concern for South Africans. Evaluating any government legislation, policy or programs that may facilitate or promote LBS is thus relevant to the evaluation.	✓
Available and accessible?	This data is available from direct experience, interviews, from existing legislation and from online industry sources.	✓
Interpretable and comparable?	Can be compared to actual LBS implementations in South Africa to determine if government policy had had any influence. Can also be compared to the emergency services policy affecting LBS of other countries to determine key differences.	✓
Associated with identified process or SSM conceptual model?	Associated with process 6, Provision of emergency services and public safety, as identified in section 5.4.1.	✓
Does metric pass selection criteria?		✓

Metric 103: Emergency Services

As mentioned in the metric selection criteria above, a major motivation for LBS in South Africa is emergency services, safely and security. In addition, as discussed in section 4.1.1, government mandated emergency services LBS technology proved to be a major catalyst for LBS in the United States.

Section A.4.2.3 identified that existing legislation made provision for a national 112 emergency call centres, but did not specifically mandate LBS technology for locating cell phones making use of the emergency services.

There has been some effort made to integrate LBS technology with emergency call centres. To this end, the author was involved in a project for a metropolitan council in South Africa that aimed to location-enable emergency call centres for three primary purposes:

- To automatically route the caller to the correct emergency response centre
- To assist in distinguishing between hoax calls and genuine emergency calls
- To dispatch emergency services nearest to the caller

(Project C 2001)

However, there were a number of issues which prevented this from being implemented at the time, which the author is not at liberty to discuss. At the time of writing this thesis, there is no indication that this project has moved forward.

There have been a number of private organisations which have made use of LBS technology in emergency services. These include Discovery Health's LBS through MTN, and Vodacom's Look4help applications as discussed in section A.4.3.7.

Thus, the lack of mandated location technology for emergency services has meant that LBS technology has not yet been implemented on a national scale to assist emergency services, and LBS in South Africa has not yet been influenced by the government's policy regarding emergency services.

A.4.2.8 Health and Public Safety

Metric Name	**104. Health and Public Safety**	
Description	Evaluates aspects of government legislation, policy or programs on health and public safety that may influence LBS.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Health and safety have both been identified as major social issues in South Africa (see section 5.1.2.3). Therefore, any government legislation, policy or supported programs that may encourage the use of LBS to improve these issues is relevant to the evaluation.	✓
Available and accessible?	This data is available from South African legislation, author's experience, internet sites, industry reports and publications.	✓
Interpretable and comparable?	Determine how policy on health and safety either promotes or hinders the implementation of LBS	✓
Associated with identified process or SSM conceptual model?	Associated with process 2, Monitoring transfer of technology and access to communication, and process 6, Provision of emergency services and public safety, as identified in section 5.4.1.	✓
Does metric pass selection criteria?		✓

Metric 104: Health and Public Safety

There is no indication that government policy on Health and Safety currently has or will have an effect on LBS in South Africa.

An example of a private not-for-profit company using cellular technology for assisting in healthcare is Cell-life. The company is using cell phones to assist with the distribution and monitoring of anti-retroviral drugs to rural areas of South Africa in an attempt to help combat and control AIDS (Vodacom 2003a). The company is beginning to experiment with LBS technology to assist them in their efforts (Rivette 2003).

The network operators also run HIV and AIDS programs as part of their social responsibility programs (MTN 2005b; Vodacom 2005a), but there is no indication that LBS has any role to play in these programs at this time.

A.4.2.9 Public Transport

Metric Name	**105. Public Transport**	
Description	Evaluates existing government legislation, policy or programs relating to public transport to determine the impact in LBS in South Africa.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.3.7 identified ITS as a potential application of LBS technology. Any government efforts to improve transport networks or public transport that may affect LBS are thus relevant to the evaluation.	✓
Available and accessible?	This data is available from government websites, industry reports, and from the author's experience in various LBS related projects.	✓
Interpretable and comparable?	Can be compared to existing LBS applications to determine how policy or programs have influenced LBS in South Africa. Also, can be analysed to determine potential future applications of LBS.	✓
Associated with identified process or SSM conceptual model?	Associated with process 2, Monitoring transfer of technology and access to communication, as identified in section 5.4.1.	✓
Does metric pass selection criteria?		✓

Metric 105: Pubic Transport

In the author's experience, there have been attempts made at using technology like LBS in order to improve public transport in South Africa.

The author was involved in two commercial projects relating to LBS in public transport, a research project investigating the feasibility of using LBS for Intelligent Transport Systems (ITS) in Cape Town (Project A 2001), and a commercial project building on this initial research to design and implement LBS a "Smart Bus" system for Cape Town's inner city (Project D 2002). The "Smart Bus" system was to be installed on several new busses operating on major tourist routes in the inner city, and serve as a demonstration project for the possibilities of combining LBS with ITS.

More specifically, the research project investigated ways to leverage of existing cellular network infrastructure to offer LBS services to passengers via electronic displays on busses, at bus stops and on cellular devices. Subsequently, the second project involved designing the system for the purposes of a tender proposal. Although the tender reached the final stages of the adjudication process, the entire project was shelved due to a change in local government, a shift in priorities and the reallocation of financial resources.

Thus, although the intention to implement LBS technology may exist in some government departments, the technology has not been identified as a priority and in the author's experience local government has as yet not been able to justify the cost of LBS for improvement of public transport.

A.4.3 LBS Value Network

Section 4.2 identified that the provision of LBS was reliant on a value network, discussed the different stakeholders in the LBS Value Network, and explained the technology components for which they were typically responsible. This section presents the metrics evaluating the LBS Value Network in South Africa and the issue concerning their relationships with the network operators in the context of LBS. The metrics in this section were derived from the hierarchy of metrics depicted in Figure 6.15 of section 6.1.5.3.

A.4.3.1 Service Providers

Metric Name	**106. Service Providers**	
Description	Evaluates the presence and activities of service providers in the LBS Value Network in South Africa.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.2 established that the provision of LBS services is dependant on a value network, of which service providers are one component. Therefore, an evaluation of service providers in South Africa as they pertain to LBS is relevant to the evaluation.	✔
Available and accessible?	This data is available from the author's experience, interviews, service provider websites and online industry publications.	✔
Interpretable and comparable?	Service providers that are active in LBS can be interpreted as positive for the LBS industry. They can be evaluated in conjunction with other members of the LBS value network.	✔
Associated with identified process or SSM conceptual model?	Associated with process 4, Develop LBS Strategy, and process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✔
Does metric pass selection criteria?		✔

Metric 106: Service Providers

There are an increasing number of active service providers in South Africa. Vodacom reports that as of the end of March 2005, there were 136 service providers who had applied to operate value-added services on the Vodacom network (Vodacom 2005a).

In terms of LBS, the most prominent service providers are Leaf Wireless, who are associated with MTN, Cellfind, who run Vodacom's Look4me, Look4it and Look4help LBS applications, and SmartSurv, who operate a navigation service on both networks. These service providers and their relationships with the network operators are discussed in more detail in section A.4.3.4 in the context of technology incubation.

A complete evaluation of all of the service providers and their activities is beyond the scope of this thesis, and it is sufficient to note that in South Africa, the service provider role of the LBS Value Network is well represented.

A.4.3.2 Application Developers

Metric Name	**107. Application Developers**	
Description	Evaluates the presence and activities of application developers in the LBS Value network	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.2 established that the provision of LBS services is dependant on a value network, of which application developers are one component. Therefore, an evaluation of application developers in South Africa as they pertain to LBS is relevant to the evaluation.	✓
Available and accessible?	This data is available from the author's experience, interviews, application developer websites and online industry publications.	✓
Interpretable and comparable?	The existence of application developers that are active in LBS can be interpreted as positive for the LBS industry. They can be evaluated in conjunction with other members of the LBS value network.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Develop LBS Strategy, and process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 107: Application Developers

In South Africa, the service providers discussed in the previous section are typically active in developing applications as well. There are a number of other application development companies who have been actively involved in developing LBS applications in South Africa. These include AfriGIS, MapIt, MobiMap, and ExactMobile.

As with the service providers in the previous section, it is beyond the scope of this thesis to discuss the application developers and their activities in detail. It is sufficient to state that the application developer role of the LBS Value Network is well represented in South Africa.

A.4.3.3 Content Providers

Metric Name	**108. Content Providers**	
Description	Evaluates the presence and activities of content providers in the LBS Value network.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.2 established that the provision of LBS services is dependant on a value network, of which data and content providers are one component. In addition, section 4.2.8 identified that content and data are important aspects of LBS. Therefore, an evaluation of content providers in South Africa as they pertain to LBS is relevant to the evaluation.	✓
Available and accessible?	This data is available from the author's experience, interviews, websites and online industry publications.	✓
Interpretable and comparable?	The existence of suitable content providers and the associated data and content can be interpreted as positive for the LBS industry. They can be evaluated in conjunction with other members of the LBS value network.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Develop LBS Strategy, and process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 108: Content Providers

Service providers and application developers, as discussed in the previous two sections, are typically involved in managing and providing content for LBS in South Africa. In addition, there are a number of companies who have been involved directly in the provision of LBS related content. These include AfriGIS, Knowledge Factory, Map Studio, iTouch as well as global mapping data companies such as NavTech.

It is beyond the scope of this thesis to fully discuss the activities of all of the content providers for LBS in South Africa. It is sufficient to state that the content provider role of the LBS Value Network is well represented in South Africa.

The author is aware of one case where, in the author's opinion, this role was not properly fulfilled in the delivery of an LBS application. This was the case of the proof of concept directory services application on the MTN network, which is discussed in more detail in section A.4.3.7.

A.4.3.4 Technology Incubation

Metric Name	**109. Technology Incubation**	
Description	Evaluate technology incubation initiatives by operators to stimulate the LBS Value Network.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.1.2 identified that technology incubation strategies undertaken by network operators in Israel were key in the success of LBS. Subsequently, section 4.4.1.2 recognised technology incubation as a key lesson for the South African LBS industry and is therefore relevant to the evaluation.	✓
Available and accessible?	This data is available from the author's experience, interviews, websites and online industry publications.	✓
Interpretable and comparable?	Network operator attempts to nurture application developers or service providers can be compared between operators, compared to the number of applications implemented, and evaluated in conjunction with the associated business and revenue sharing models.	✓
Associated with identified process or SSM conceptual model?	Associated with process 4, Develop LBS Strategy, and process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 109: Technology Incubation

Both MTN and Vodacom have strategic initiatives and acquisitions with regards to increasing the use of their cellular networks for value-added services.

Vodacom has initiated a Wireless Application Service Provider (WASP) program (Vodacom 2003b; Vodacom 2005a), which is a partnership program to allow service providers and application developers to access the network infrastructure for the delivery of value-added services. To this end, Vodacom is taking advantage of the global lessons learnt in Israel and Japan identified in section 4.1.3, and has acquired shares in several start-up technology companies (Hainebach 2002).

MTN has also started a partnership program, and has several strategic acquisitions and investments, including Leaf Wireless and the research division Airborne (MTN 2004; MTN 2005a).

Thus the data indicates that the network operators are actively pursuing technology incubation and acquisitions for strategic purposes, including the delivery of LBS applications.

A.4.3.5 Business Models

Metric Name	**110. Business Models**	
Description	Evaluate the business models in place for the provision of LBS services through partners in the LBS value chain.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Section 4.4.1.2 identified that flexible business models with partners in the value chain are a key factor in the success of LBS.	✓
Available and accessible?	This data is available from the author's experience, interviews, websites and online industry publications.	✓
Interpretable and comparable?	Business models used in South Africa can be compared to those used elsewhere in the world, and compared between operators.	✓
Associated with identified process or SSM conceptual model?	Associated with process 5, Develop Business and Pricing Models, as identified in section 5.4.2, and process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 110: Business Models

The primary business model in place for the provision of value-added cellular services in South Africa is the Wireless Application Service Provider (WASP) model, as identified in the previous section (Benn 2004; Hainebach 2002). This has in one sense proved successful, as there have been an increasing number of WASP participants over the last few years (Vodacom 2005a), and it is estimated that 170 WASP's are now active on South Africa's networks (Phitidis 2005).

However, the rapid increase in the number of WASPs has also been a cause of problems for the network operators, as their organisation is not geared towards managing relationships with numerous partners. Thus, the business models in place are moving towards WASPs operating through aggregator companies, which provide an interface between the network operators and the WASPs (Phitidis 2005).

This move is yet to have an effect on the business models for the delivery of LBS applications, as the service providers and application developers are currently dealing directly through the network operator's WASP programs.

A.4.3.6 Revenue Sharing

Metric Name	**111. Revenue Sharing**	
Description	Evaluate the levels of operator revenue sharing with the LBS value chain, and determine if the level of revenue sharing is sufficient for a sustainable value chain.	
Data type	Qualitative - subjective	
Relevant to evaluation?	Revenue sharing as part of the business models and pricing of LBS services has been identified as a key global lesson in sections 4.4.1.2 and 4.4.1.3 respectively.	✓
Available and accessible?	This data is available from the author's experience, interviews, websites and online industry publications.	✓
Interpretable and comparable?	Levels of revenue sharing can be compared between operators and compared to different business models. The reaction of the value network to the current levels of revenue sharing can contribute to our understanding of the sustainability of the situation.	✓
Associated with identified process or SSM conceptual model?	Associated with process 5, Develop Business and Pricing Models, as identified in section 5.4.2, and process 6, Create Strategic Partnerships, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 111: Revenue Sharing

The primary method for revenue sharing in South Africa is the provision of value-added services at a premium rate through the WASP business model discussed in the previous section. In this model, the operators claim standard airtime charges for cellular traffic, and the WASP partners charge an inflated rate for the service in the form of premium call or premium SMS charges. This has to some extent proved successful, and there is increased use of value-added services using this revenue-sharing model (Vodacom 2005a).

The first criticism is that the network operator billing models are inflexible (Alberts 2005). More specifically, operators have been using the Mobile Originating (MO) billing model, which means that once a request has been made the user is charge for the service, regardless of whether the content was delivered or not. This has caused problems for WASP's in cases where the content or application was not received by the user. In order to counter this problem, network operators are investigating a Mobile Terminating (MT) billing model, where users are only charged for content or applications delivered.

The second criticism is that WASPs do not feel that revenue is being shared appropriately, as there are many companies in the value network that need to take a portion of the revenues. Since the profit margins are thin, WASPs rely on large volumes and as a result many are not likely to be able to stay in business (Business Day 2001).

Thus, although revenue sharing models are in place, it is likely that these will need to evolve to meet the requirements of the consumers and the Value Network stakeholders providing value-added services such as LBS.

A.4.3.7 LBS Applications

Metric Name	**112. LBS Applications**	
Description	Evaluate LBS applications already implemented in South Africa	
Data type	Qualitative - subjective	
Relevant to evaluation?	Evaluating the existing LBS applications in South Africa provides an insight to the current situation, and helps to validate other data regarding the LBS industry in South Africa.	✓
Available and accessible?	Available from industry experience, product information, web sites, industry reports and press releases.	✓
Interpretable and comparable?	Implemented LBS applications should be placed in their LBS application class as defined in section 4.3, and can be compared against any number of the metrics defined above.	✓
Associated with identified process or SSM conceptual model?	Associated with process 6, Create Strategic Partnerships, process 7, Implement LBS Applications, and process 8, Facilitate the Adoption of LBS, as identified in section 5.4.3.	✓
Does metric pass selection criteria?		✓

Metric 112: LBS Applications

Operator	Application Name	Primary Partner	LBS Class	Tracking	Type	Status
Vodacom	Look4me	MapIt	Asset and Person Tracking	Passive COO	Commercial	Live
Vodacom	Look4help		Emergency Services	Passive COO	Commercial	Live
Vodacom	Look4it	AfriGIS	Directions and Information	Active COO	Commercial	Live
Vodacom	SmartRoute	SmartSurv Wireless	Directions and Information	GPS	Commercial	Live
MTN	MTN LBS	Knowledge Factory	Directions and Information	Active COO	Proof of Concept	Dis-continued
MTN	Discovery Emergency	Discovery Health	Emergency Services	Active COO	Commercial	Live

Figure A.46: Existing LBS Applications in South Africa

As new LBS applications are being implemented on a constant basis, it is impractical to review all LBS application in the context of this thesis. Figure A.46 above shows several of the more prominent examples of LBS applications that have been implemented in South Africa. The figure shows which network the application was originally implemented on, the primary partner in the LBS Value Network, the class of LBS application, the LBS positioning technology and the type and status of the application. These applications are discussed individually in the remainder of this section.

Vodacom Look4me

Look4me allows contract or prepaid customers the ability to track up to ten different subscribers with their permission. This leverages the user opt-in management and passive tracking abilities of Vodacom's SignalSoft Location Gateway as discussed in section A.1.2.6 and A.1.2.7 respectively. Look4me provides the ability to receive the location information via SMS, an MMS map, or on the Internet.

Vodacom Look4help

Look4help sends a distress message to four predefined numbers. A number is saved on the handsets speed dial which generates an emergency SMS and sends to those four numbers.

Vodacom Look4it

Look4it provides the ability to search for the nearest ATM, petrol station, retailer, the local weather, movies, emergency service or hotel. The service is driven by a customisable menu which allows the user to choose the way the content is presented. As with the Look4me service, the LBS information is deliverable via SMS or an MMS map.

As discussed in sections A.3.2.8 and A.4.1.7, despite Vodacom's aggressive marketing campaign, these services have so far had a low market adoption. More information on these LBS applications can be found at www.vodacom.co.za.

SmartRoute

SmartRoute is a GPRS-based personal navigation system. The system consists of an appropriate cell phone (i.e. advanced class with capabilities described in A.1.3), the SmartRoute software and an external GPS receiver. By entering a destination, the system delivers street level directions to the handset. The information is provided via a colour map as well as voice directions.

There is a high barrier to entry for this LBS service, and subsequently the market is likely to be small. The primary factors contributing to this barrier to entry are a high initial cost and high operating costs as discussed in section A.2.3.4. However, this barrier to entry has been well anticipated, and an alternative LBS navigation application has been developed by Vodacom and SmartSurv as discussed below.

SmartAssist

SmartAssist is a navigation and information assistance call centre. It uses the user's location to determine the most appropriate route to the destination. The service is available to any caller, and calls, SMS, and MMS are charged at inflated rates. These rates are made possible by the revenue sharing agreements discussed in section A.4.3.6.

Although an initial limitation to SmartSurv's LBS application was the fact they were only open to Vodacom contract subscribers, SmartSurv has subsequently made the service available to MTN and Vodacom contract and prepaid subscribers.

MTN LBS

MTN's proof of concept LBS application was similar in principle to Vodacom's Look4it as discussed above. The principle difference was that the system was based on an IVR call centre rather than text-based menus. This meant the user had to listen to a list of menu choices and make selections based on what they were looking for. The final results would be sent to the user's handset via SMS. This application was developed by the Knowledge Factory, who also supplied the content for the application.

The author used this application on several occasions and found it cumbersome to use and, at the time of use, it was not populated with enough data to be of any real assistance. In addition, the author found the Interactive Voice Response (IVR) system frustrating to navigate, to say the least. However, this was a proof of concept application and was never intended to be offered commercially. In terms of proving the technical possibility of operating an automated LBS IVR call centre, this application was deemed a success by MTN (Oehely 2002). IVR was used as the delivery mechanism out of necessity, as MTN's lack of location gateway resulted in limitations in what was achievable.

MTN Discovery

Discovery Health is a major medical insurance company in South Africa, who runs their own emergency call centres. In early 2004, Discovery began using active positioning on LBS networks (see 3rd Party Access in section A.1.2.5) and Caller Line Identity (CLI) to identify and locate users in emergency situations. This has helped to shorten the response time of emergency services to the caller (Whitford 2004a).

This section has briefly outlined some of the LBS applications that have been deployed on South African networks. The cost implications of these LBS applications are discussed in section A.2.3.5.

B CELLULAR TECHNOLOGY

This appendix briefly describes each generation of cellular technology and the capabilities and characteristics of each protocol. Note that the purpose of this appendix is not to provide a detailed specification of all past, present and future existing cellular technologies. Its purpose is to support the discussion of the implications of the relevant technologies, especially those that will effect the development of South Africa's cellular networks and the implementation of location based services.

B.1 2G Cellular Networks

In the early stages of cellular systems, companies developed and implemented their own proprietary systems, resulting in limited markets and incompatibility with other systems (Sempere 1997). As cellular technology progressed, there has been a move towards the standardisation of cellular network technology.

The second generation of cellular networks represent the shift from analogue to digital networks. Due to the digital nature of these networks, they also represent the first technology that allowed the transfer of data over a cellular connection at the maximum data rate of 14.4kbps. The two largest 2G technologies are GSM and CDMA.

B.1.1 FDMA

Frequency Division Multiple Access (FDMA) assigns a frequency to a user. This means that the larger the number of users, the larger the number of available frequencies needs to be. The limited spectrum and the fact that a frequency is not free until a user releases it means that the capability of FDMA is limited (Sempere 1997).

B.1.2 TDMA

Time Division Multiple Access (TDMA) allows several users to share the same channel by assigning each user their own bursts within a group of bursts (Sempere 1997). This time division multiplexing divides a radio frequency onto time slots and allocated slots to multiple calls. This allows a single frequency can support multiple data channels at the same time (Budde 2001).

B.1.3 GSM

Global System for Mobile Communications was created in the mid 1980's to fulfil the need for a unified cellular system governed by specific rules and standards (Unknown 2001). It is an open, non-proprietary system that is constantly evolving and improving. Its strengths include international roaming capabilities, speech encryption, facsimile, data services and SMS (Budde 2001).

GSM uses TDMA within a FDMA framework to deliver data speeds of between 9.6 and 14.4 Kbps. 25 MHz frequency bands are divided using FDMA into 124 carrier frequencies spaced one from each other by a 200khz band. Each carrier frequency is divided in time using a TDMA scheme to assign time frames to individual users (Sempere 1997). In this way the available frequency bands are shared in time amongst users thereby saving a considerable amount of bandwidth.

Another bandwidth saving feature of GSM is the different voice channel coding options, which allows the operator to double the capacity of the network by using a half-rate speech codec (Unknown 2001). Frequency hopping is used to dynamically assign the carrier and transmission frequencies, avoiding frequency collisions by only assigning those that are unused.

Due to the nature of GSM and its widespread use, subscribers to one GSM operator are able to use their phones in many different countries using GSM international roaming capabilities (Kong 2001a).

B.1.4 WAP

The Wireless Application Protocol is simply a standardised way that a mobile phone communicates with a server installed in a cellular network. It is a circuit switched data protocol that operates over GSM networks, allowing users to dial-up to WAP portals. It is designed to provide users of mobile terminals with rapid and efficient access to the Internet. It is optimised for the narrow bandwidth on 2G networks and for the limited display capabilities and functionality of current mobile devices (Budde 2001).

WAP is perceived failed because it needs a permanent connection to a portal in order to operate. This means that users need to dial in to use a WAP service. The marketing hype surrounding WAP also led users to believe that the mobile connectivity would be comparable to desktop Internet. Difficult to operate, lacking applications and providing a poor user experience, WAP does not live up to expectations. Although some believe there is still room for WAP to generate revenue, the introduction of packet based technologies is likely to ensure that WAP remains a failed technology.

The importance of WAP lies in the lessons that can be learnt from what the consumer will and will not tolerate. The failures of WAP point to the successes of future wireless data services.

B.1.5 CDMA

Code Division Multiple Access (CDMA) is a digital wireless technology that allows numerous users to simultaneously use the same radio frequencies without interference (MobileOffice.co.za 2001).

It is characterised by high capacity and small cell radius, and employs spread spectrum technology to spread transmission over multiple frequencies (MobileOffice.co.za 2001). This is done by assigning unique codes to each transmission segment (Budde 2001). This allows a higher network capacity of up to 5 times that of GSM. The random coding of the transmission also helps to prevent interception of a signal (Kong 2001a).

The original CDMA technology is now referred to as cdmaOne as there are now many variants and improvements in existence.

B.1.6 HSCSD

High Speed Circuit Switched Data (HSCSD) enables transmission of data over existing GSM networks at speeds of up to 57.6Kbps. This increase in the data capacity of GSM is achieved by concatenating up to four consecutive GSM timeslots at 14.4 kbps each. A permanent connection is established between the parties for the exchange of the information (Budde 2001).

As HSCSD is still circuit switched, it is more useful for dedicated applications such as video conferencing and multimedia than it is for always-on applications such as e-mail.

B.2 2.5G Cellular Networks

The advances in digital signal processing, especially modulation and compression techniques, and the need for higher data rates and compatibility has led to improvements in cellular standards. These new standards are called 3G. 2.5G represents an interim technology in the evolution towards 3G networks (MobileOffice.co.za 2001). They involve the implementation of several key network components and protocols that will provide the backbone of 3G technology at a later stage.

Although they are seen as a temporary measure, they will probably be the predominant technology worldwide for the next few years for a number of reasons. The biggest reason is the huge cost of 3G licenses and the 3G infrastructure. Another reason is that the data rates offered by 2.5G are sufficient to satisfy existing and foreseeable wireless applications.

B.2.1 GPRS

General Packet Radio Services (GPRS) is an overlay to existing GSM networks that lays the foundation for UMTS and 3G networks that are based on packet switched architecture as opposed to a circuit-switched architecture (Anywhere You Go 2001). GPRS makes more efficient use of the available spectrum by only using the network when data is being sent rather than a continuous stream (Budde 2001).

This enhancement will enable higher data speeds, permanent Internet connection, and a billing system that is based on the amount of data transferred rather than connection time (MobileOffice.co.za 2001). In addition, more advanced devices will allow simultaneous voice and data communication.

The implementation of GPRS will be achieved by enhancing existing GSM networks with additional elements including packet control units, serving GPRS support nodes and gateway GPRS support nodes (Anywhere You Go 2001). Using GPRS, information is split into separate but related packets. These packets are sent over the network and reassembled at the receiving end.

As packet switching means that radio resources are only being used when users are sending or receiving data, the available resources can be shared simultaneously by several users (MobileLifeStreams 2001b). This spectrum efficiency allows operators to maximise the use of their network resources in a dynamic and flexible manner, avoiding the need for built-in idle capacity to cater for peak periods. It also reduces the load on the signalling channel by transferring SMS traffic to GPRS as well.

GPRS will provide theoretical maximum speeds of up to 171.2kbps using all eight timeslots simultaneously. This is about three times as fast as current fixed line data transmission speeds, and ten times as fast as circuit switched data over current GSM networks (MobileLifeStreams 2001b). This efficiency will cause data transmission over GPRS to be more cost effective than data over GSM.

In addition to increased data speeds, GPRS offers instant connections when data is required. This permanent connection or high immediacy is an important feature for time critical applications such as credit card authorisation or emergency response.

While GPRS is an important enabling technology, both for future network capabilities and in terms of satisfying immediate network requirements, it must be noted that it does have several limitations.

Firstly, GPRS limits a network's cell capacity. The available radio spectrum can be deployed for different uses, but the use for one purpose precludes simultaneous use for another. The extent of the impact depends on the number of timeslots allocated for dedicated GPRS usage. However, GPRS does dynamically manage channel allocation, and this allows for load reduction on the signalling channel during peak times (MobileLifeStreams 2001b).

The theoretical data rates are practically unrealistic, as it would involve a single user occupying all 8 timeslots. It is unlikely that a network operator would allow a single user to use all of its bandwidth on a specific channel. In addition GPRS enabled handsets are expected to support up to three timeslots, reducing the actual data rate significantly. This still means that data rates of up to 56.6Kbps can be achieved, which is comparable to standard fixed line bandwidth and significantly higher than current data rates.

Another problem with GPRS is the potential transit delays inherent in any packet based data protocol. This potential problem is avoided as far as possible with data integrity and retransmission strategies, but there is still the potential for delays (MobileLifeStreams 2001b). This means that for applications such as video, dedicated data protocols such as HSCSD are more suited.

The modulation technique used for GPRS is known as Gaussian minimum shift keying. This is not an optimal technique, and network operators will have to upgrade to EDGE in order to later make the move to 3G.

B.2.2 EDGE

Evolved Data-rates for GSM Evolution (EDGE) represents the final stage of evolution of data communication within the framework of the GSM standard. EDGE is an enhancement of GPRS that is based on a new digital modulation scheme that allows much higher data rates across the air interface called 8 PSK (MobileLifeStreams 2001b). Since this technique will also be used for UMTS, operators will have to incorporate it in order to upgrade to 3G at a later stage. However, as the 384kbps data rates of EDGE equal those of the first phase of 3G deployments, it may offer an alternative to operators who are unable to obtain a 3G license or who are unwilling to pay the exorbitant license fees (Budde 2001).

B.3 3G Cellular Networks

If the transition from 1G to 2G was important because of the change to digital, then the change to 3G is even more so because of advances in digital modulation and digital compression techniques. The 2.5G technologies described in the previous section made some use of these advances, but they are really manifested with 3G.

3G is a generic name for a set of mobile technologies set to be launched in the near future which use a combination of new network infrastructure, digital modulation and compression, handsets, base stations and other equipment that will allow high speed wireless internet and multimedia services at speeds of up to 2Mbps (MobileOffice.co.za 2001).

The main goal of 3G networks is to provide seamless, global communications services through small, lightweight terminals. Most of the new 3G technologies are varieties of CDMA (MobileOffice.co.za 2001), first described here in Section B.1.5.

B.3.1 IMT-2000

International Mobile Telecommunications 2000 is a standards initiative that is commonly known as third generation mobile systems (3G).

The key features are a high degree of worldwide commonality and compatibility, worldwide roaming, small terminals and the capability for a wide range of services and applications.

B.3.2 UMTS

The Universal Mobile Telephony Standard is the European version of the IMT-2000 group of 3G systems and has the same goals.

B.3.3 W-CDMA

Many regard Wideband Code Division Multiple Access (W-CDMA) as the most suitable platform for 3G as it provides a way to migrate from both GSM and narrow band CDMA networks, thus creating a larger worldwide coverage with backward compatibility to older networks.

W-CDMA is optimised for packet-switched data for applications such as email and high-speed Internet access, but it also has the capability to support high capacity circuit-switched data for dedicated applications such as video and high quality voice transmission.

B.4 4G & 5g Networks

There are already plans for 4th and 5th generation cellular networks, and Japan's I-Mode has already made a considerable investment in the development of 4G technology (Budde 2001). Although very little information is available at present, these technologies are predicted to provide up to 10 Mbps and 20 Mbps respectively.

C LOCATION TECHNOLOGY

C.1 GPS

The Global Positioning System started as a US military satellite navigation system that is freely available for commercial or private use. In May 2000 the US Government switched off Selective Availability (SA) on its positioning signals, instantly improving the positional accuracy available with a single receiver to around 10 meters.

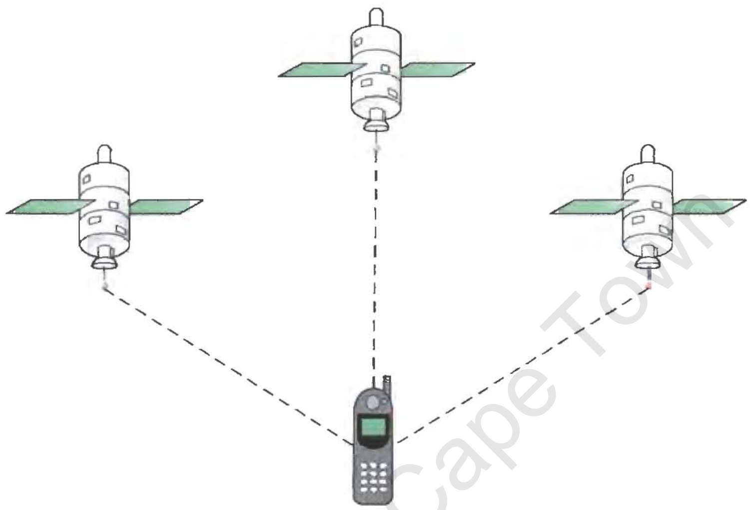


Figure C.1: GPS Positioning

The advantage of GPS is that it is accurate and that it is a well established and reliable method of position determination. A stand-alone GPS receiver can deliver accuracies of better than 10 meters in suitable conditions, and should be accurate to within 30m at all times.

There are disadvantages with GPS that make it unsuitable for LBS applications other than dedicated applications.

Firstly, GPS is dependant on a variable satellite network. This means that the accuracy of the GPS receiver will vary depending on the current configuration of available satellites. Furthermore it does not work well in dense urban environments, where the effects of multi-path combined with a lack of line of sight of satellites prevent the receiver from obtaining a satellite lock. In this type of environment a receiver may need an external antenna. A GPS receiver may take a few minutes to calculate a position if it still has to lock on to satellites. This makes it unsuitable for time critical LBS applications.

In addition, expensive modifications will be required to GPS enable mobile devices. Devices are either going to have to be designed and constructed with built in GPS chips, or will have to communicate with a handheld GPS receiver through a serial connection. While extremely accurate, traditional GPS is not the most viable solution for the implementation LBS because it will not reach a wide spread consumer base. It may however be an acceptable method for dedicated applications where high accuracy is required.

C.2 A-GPS

Assisted GPS makes use of combination of GPS and data sent from the network to accurately determine the position of the cell phone. The network sends almanac or satellite availability data to the handset to assist in obtaining a lock on the satellites, and could also send D-GPS information to improve accuracy of the positional fix.

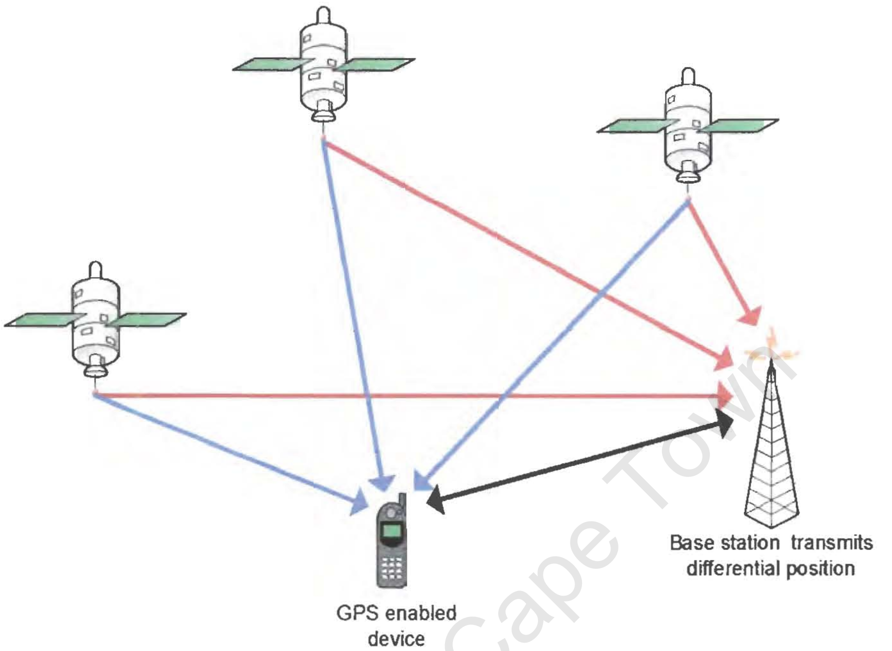


Figure C.2: Assisted GPS Positioning

The principle of AGPS is shown above in Figure C.2. The BSC is equipped with a GPS receiver. This receiver maintains a lock on satellites, sending initialisation information to the handset when required. This enables the handset GPS to calculate a position faster. The base station could also calculate the difference between the GPS position at that particular time and its actual position, sending this data to the mobile device. This would enable the device to correct for errors in the satellite position, significantly improving the accuracy.

The most outstanding example of the AGPS is by SnapTrack. It must be noted that while solutions such as SnapTrack might not be viable for the general public, they may be the most reliable and accurate method of implementing LBS for ITS public transport services and emergency services vehicles.

C.3 Radio Camera Technology (RCT)

Radio Camera Technology (RCT) uses the RF signals sent out from a cellular device. These are reflected by the surrounding environment and buildings before reaching the cellular base station. This interference produces a distinct RF fingerprint or signature that is unique to that location (US Wireless Corp 2001a). Radio Camera Technology uses pattern matching algorithms to measure the RF signatures received at a base station and matches them to RF patterns stored in a central database in order to determine location (Crawford & Aftahi 2001). The principle of RCT is depicted in Figure C.3.

RCT is compatible with existing network infrastructure, and requires no modifications to the base station or user handsets and is accurate to less than 100m. Unlike other methods of positioning, it does not rely on line of sight or multiple antennae, and it thrives in dense urban environments where the multi-path effects are greatest (US Wireless Corp 2001b). Where other methods are degraded by multi-path effects, RCT is strengthened. In addition, RCT can determine a user's location accurately using only one base station, as opposed to multiple base stations required by triangulation methods.

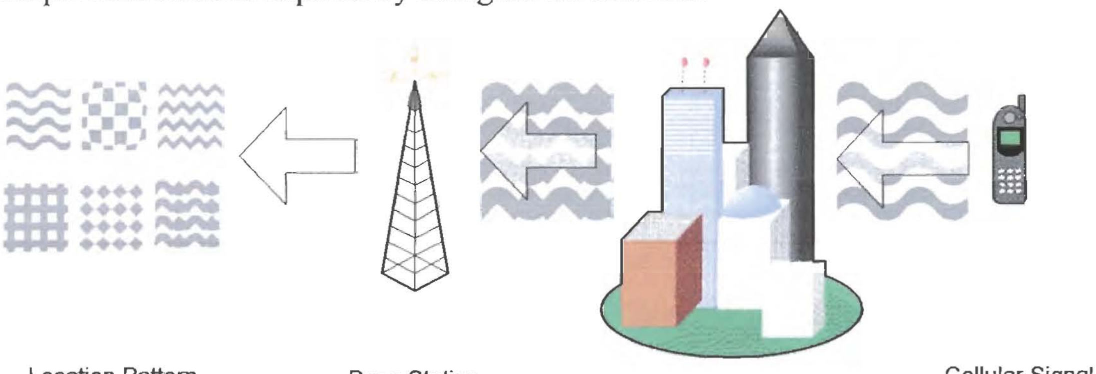


Figure C.3: Positioning using Radio Camera Technology

The system makes the assumption that the frequency patterns at a specific location remain static over time. This is not the case, and methods will have to be developed to frequently update the RF pattern database to ensure that RCT remains accurate and reliable (Crawford & Aftahi 2001).

RCT requires additional equipment that operates in conjunction with existing network infrastructure. It has the advantage of working with all existing handsets. There is also the additional overhead of establishing and maintaining the location pattern database. The cost implications of the establishment or maintenance of this signal signature database are not available at present. This will be the factor in determining whether or not this positioning method is financially viable.

C.4 COO

Cell of Origin (COO) is simply the network cell from which the call was made. This information is necessary for the operation of the network and thus can be used by existing subscribers without modification to either the network or the handsets. The accuracy depends entirely on the size of the cell. In dense urban areas with smaller cells, the accuracy could be 500m, while the accuracy in sparse rural areas could be as bad as 25km.

Figure C.4: COO Positioning Method

COO had the major advantage that it does not require any network or handset upgrades. The only requirement is the network software that makes the COO available to external applications or 3rd party services.

COO is not accurate enough for most LBS applications. It is however a viable solution for broad services such as weather reports, call routing, traffic SMS reports or any LBS relying on cell broadcast for message delivery.

C.5 AOA

Angle of Arrival (AOA) estimates the angles that the signals emitted from the device arrive at two or more BSC, and use these angles to compute an approximate position. This method is not very accurate (around 300m), depending on the geometry of the cell phone in relation to the network towers.

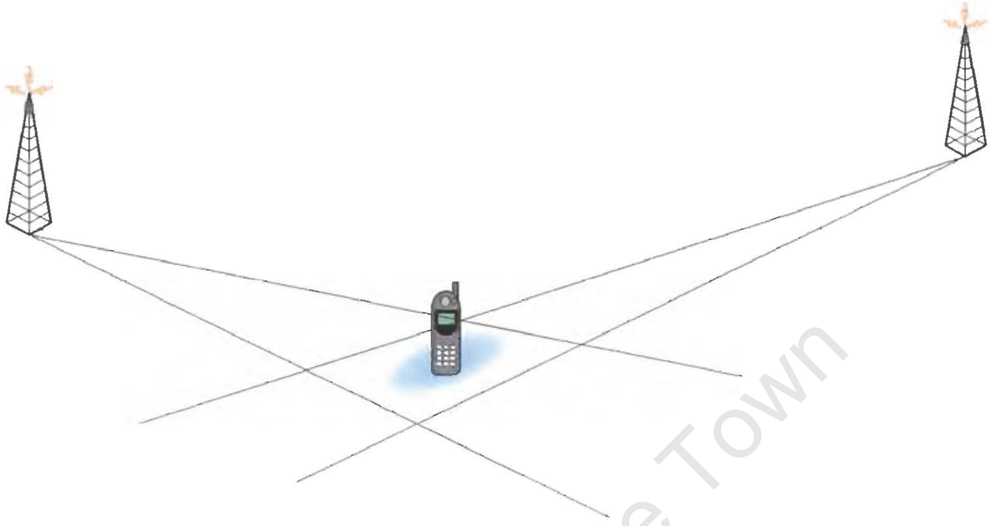


Figure C.5: Angle of Arrival Positioning Method

Poor intersection geometry leads to a lower accuracy because of a looser fix. The more oblique the angle of intersection, the more uncertain the position calculation will be. The most accurate angle of intersection is 90 degrees, and the more base stations used in the position determination the more accurate the fix will be.

The main disadvantage of this method is that it requires significant network infrastructure upgrade. The expense of these upgrades does not justify the poor location determination performance.

C.6 TOA

Time of Arrival (TOA) uses the time it takes a signal from a cellular phone to reach three different base stations. These times are then converted into distances by a simple calculation using the speed of light, and the position of the cell phone is determined by coordinate geometry as depicted Figure C.6 below.

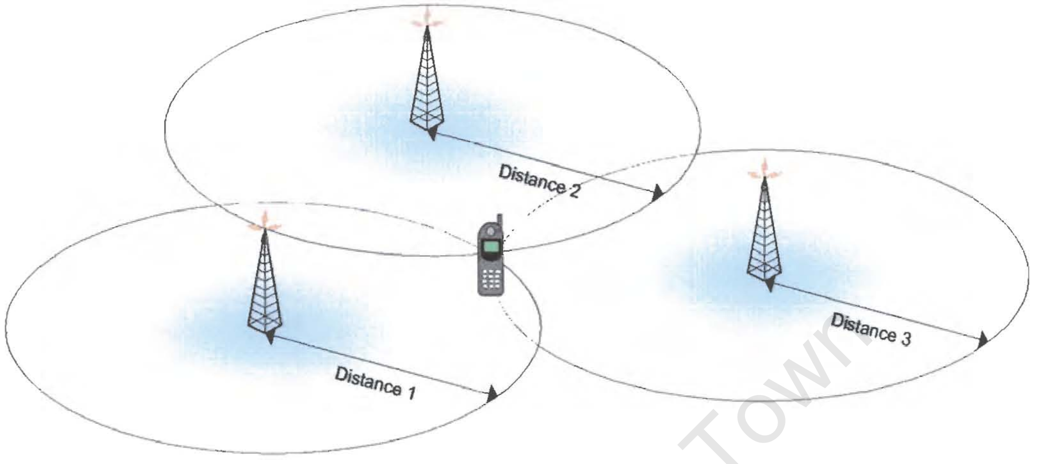


Figure C.6: Time of Arrival Positioning Method

The principle is that all three circles can theoretically only intersect at one point. This point becomes an area of possible intersection when there is any uncertainty involved. The uncertainty in the position is related to the uncertainty in the distance calculation, which is directly proportional to the accuracy of the time measurement. This method works with existing GSM networks but has the disadvantage that it only works when the call is active, and that it requires expensive network extensions. TOA solutions are estimated to be as much as ten times the cost of E-OTD positioning.

TOA is fairly accurate at about 150m, and is therefore viable as a positioning method for most LBS applications. It requires additional network equipment, but no handset modifications are needed.

TOA and AOA can be used concurrently to provide a more accurate solution. However this would be an expensive undertaking for a comparatively small gain in accuracy.

C.7 TDOA

Time Difference of Arrival positioning is achieved by estimating the TOA of wireless handset signals at a number of fixed network sites that have well determined geographical positions. The difference in TOA measurements is used to define hyperbolas along which the device must lie. The intersection of these hyperbolas is used to determine the position. This method of positioning is known as hyperbolic multi-lateration (Cellocate 2001). TDOA has the advantage of working with existing handsets, but requires modification to the network infrastructure (Cooper & Julian 2001).

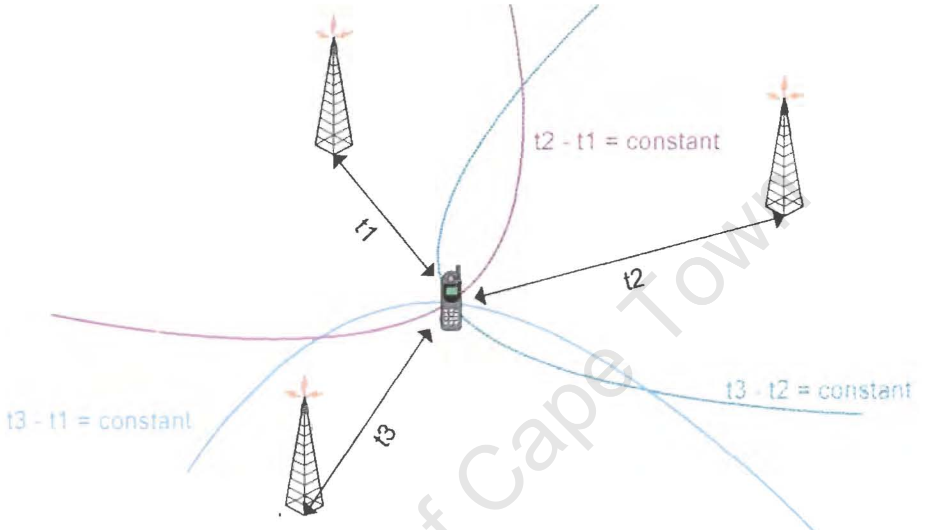


Figure C.7: Time Difference of Arrival Positioning

TDOA is accurate to less than 100m most of the time. It is less expensive that TOA or AOA, but still requires network modifications. No modifications are necessary for the handsets, and TDOA is therefore a potential positioning method for all LBS applications and will enable the services to reach the majority of the population.

C.8 E-OTD

Enhanced Observed Time Difference uses the existing infrastructure of a GSM network to determine position. The system works by observing the signals sent from the base stations to both the cellular phone and the underlying network base stations and uses the relative time of arrivals to calculate the position. It is essentially the reverse of other network based solution, as it measures the time from the base station to the mobile device. For the actual position calculation E-OTD can use either the intersection of circles as used in TOA, or hyperbolic multi-lateration as used in TDOA.

This positioning method requires less modification to the existing mobile network than TDOA, but has the disadvantage of requiring handset software upgrades (Cooper & Julian 2001). This method provides accuracies better than 50 meters on an appropriately planned GSM network.

E-OTD is significantly cheaper than other accurate network based methods. Once the technology has been implemented, the software will be integrated with new phones for no additional cost. It remains to be seen how easy it will be to upgrade existing handsets for E-OTD location.