# Real Options Valuation Of Cellular Telecommunications Investments in South Africa

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# ABSTRACT

The main purpose of this research was to examine the application of recent investment analytics when making capital investment decisions in next-generation service-oriented technology architectures in the cellular telecommunications industry. Secondary objectives were to conduct risk analysis on this type of investment and to develop a framework that combines both qualitative and quantitative aspects in complex decision analysis.

A quantitative case method was used for this study; based on a next-generation messaging (NGM) system at a cellular telecommunications network operator in South Africa. A combination of static discounted cash flow (DCF) and real options analysis (ROA) was conducted in establishing the active net present value (NPV) of the project. The effects of volatility on cash flows were modeled using risk simulation, and a decision tree model was developed to facilitate optimal investment decision making.

The main finding was that real options and decision analysis techniques can be applied successfully to capital investment decisions in next-generation service-oriented architectures in cellular telecommunications environments. The risky nature of such projects requires the application of a project-specific hurdle rate, which takes into account the project risk and operational risk in discounting the project cash flows. Certain technology infrastructure such as the NGM system provide embedded options, such as the option-to-expand or option-to-defer. The result was a premium being added to the passive NPV that was estimated through DCF analysis.

Results from this study suggest the adoption of a decision analysis process that combines qualitative project screening, discounted cash flow and real option analysis, and quantitative decision tree analysis when making capital budgeting decisions in technology infrastructure in the cellular telecommunications industry.

# DECLARATION

I, Tiisetso Moshate Nathan Moja, declare that this research report is my own, unaided work. It is submitted in partial fulfillment of the requirements for the degree of Master of Business Administration in the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other University.

________________

Tiisetso Moshate Nathan Moja

24 October 2008

# DEDICATION

I dedicate this Research Report to:

My wife, Hilda and my two sons, Moagi and Neo for their love and support

My mother, Margaret, for her love and encouragement

My father, Gabriel, for guiding me spiritually since his passing

# ACKNOWLEDGEMENTS

I would like to express sincere gratitude to:

- my Supervisor, Mr Mkhethwa Mkhize, for his time, patience, guidance and support. I am also thankful for the encouragement and mentoring received, which has culminated in the completion of this Research Report

- the cellular network operator for providing the case site in South Africa

- the data source owners that provided the project data used to develop the financial models

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| SOA | Service Oriented Architecture |
| SDP | Service Delivery Platform |
| OSS | Operations Support System |
| BSS | Business Support System |
| NGM | Next-generation Messaging System |
| DCF | Discounted Cash Flow |
| ROA | Real Options Analysis |
| DTA | Decision Tree Analysis |

# CHAPTER 1

## OBJECTIVES

- To introduce and discuss the purpose of this research
- To discuss the background on technology investments in the information and communications (ICT) industry
- To discuss the background that led to the undertaking of this research
- To present the main problem and sub-problems statements
- To discuss the usefulness of this research
- To present the delimitations and limitations of this research
- To present definitions of terms used in this research
- To present assumptions underlying this research

# 1 INTRODUCTION

## 1.1 Purpose of the Study

This study aims to examine the application of recent investment analytics when making capital investment decisions in next-generation service-oriented technology architectures in the cellular telecommunications industry. Secondary objectives are to conduct risk analysis on this type of investment and to develop a framework that combines both qualitative and quantitative aspects in complex decision analysis.

## 1.2 Background on technology investments in the information and communication technology (ICT) industry

Dai, Kauffman & March (2000) describe the continuing concern among senior executives at having to justify Information Technology (IT) investments, while struggling to establish the correct value propositions for the newest and most innovative technologies. According to Dai et al (2000: 1), a survey conducted by *Information Week* in 1998 indicated that approximately 80% of 150 information system (IS) executives at United States (US) companies had been required to justify IT projects in financial terms.

Mobile telecommunications operators face the complex challenge of having to make the right investment choices amidst rapidly evolving technology, and also of having to deploy the technology at the right time (Iatropoulos, Economides, & Angelou, 2004). According to Iatropoulos et al (2004) and Pollet, Maas, Marien & Wambecq (2006), it is important to address this challenge, given the high capital nature of telecommunications infrastructure investments, volatile cash flows due to variability of customers' demand for a service, coupled with high customer churn, and the technology risk that may result in failed deployments. An example described by Harmantzis & Tanguturi (2007: 107) is the case where an operator needs to make a decision on whether to invest in expanding a network from 2.5G to 3G, defer the investment, or invest in alternate technologies such as WiMax.

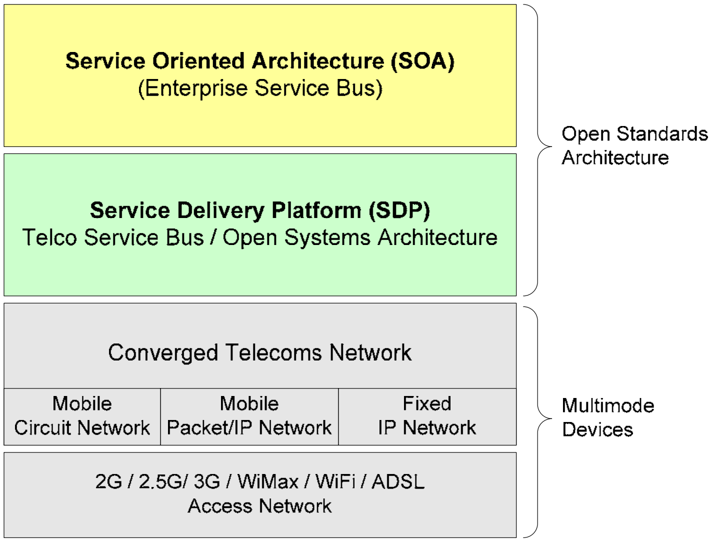
## 1.3 Context of this study

The recent amendments to the South African Electronic Communications Act (36/2005) and the introduction of the Convergence Bill (2005) have made adjustments to the existing PSTS and MCTS license structures, currently held by Telkom, Neotel, MTN, Vodacom and Cell C respectively (Republic of South Africa Department of Communications, 2005). In the interest of providing greater access to affordable and competitive telecommunications services, the new Electronic Communications Network Services (ECNS), Electronic Communications Services (ECS) and Value Added Network Service (VANS) licenses have been introduced by the South African Department of Communications (2005). Consequently, the incumbent cellular operators have been compelled to convert to the new licensing structure. Simply put, the ECNS license relates to the frequency spectrum (2G, 3G, WiMax etc) and infrastructure license (i.e. operating purely as a carrier). The ECS relates to the actual communications services such as voice, messaging services and data. The VANS license relates to the provision of Internet access services.

The amendments made in the S.A. Electronic Communications Act constitute steps towards deregulation of the S.A telecommunications industry and convergence of telecommunications services to promote competition (South African Electronic Communications Act 36/2005). The context of this study is within the provision of electronic communications services (ECS) and the process of considering complex technology investment choices for the provision of such services.

According to Fildes & Kumar (2002), competition in the telecommunications industry has intensified in an increasingly deregulated industry. Pollet et al (2006: 529) identify growing competition as the key driver forcing telecommunications operators worldwide to re-engineer their IT and telecommunications service environments. According to Pollet et al (2006: 529), the business imperative is to deliver telecommunications services faster and more cost-effectively. The result is the growing adoption of a service-oriented paradigm, in the form of next-generation service architectures as illustrated in figure 1 (Pollet et al, 2006: 530).

**Figure 1 Conceptual model of the next-generation telecommunications service architecture***



*Based on Pollet et al (2006: 531) [Adapted]

It is argued that cellular operators must become operationally efficient for their sustained survival, and gain the advantage of being able to rapidly deploy new revenue generating services and un-deploy loss-making services as directed by changing market demand. Pollet et al (2006: 530) further argue that, in striving to attain a sustainable competitive advantage, a telecommunications operator requires flexibility in integrating disparate business functions such as subscriber account management, service provisioning, activation and billing, and the ability to offer its customers a wide range of new products and services, faster and more cost-effectively.

Banerjee & Chintada (2006: 225-6) proposed a design of a middleware based service architecture for enabling telecommunications services, including those requiring explicit network support, in peer-to-peer networks. The middleware architecture consisted of a service delivery layer (SDL) and the service execution engine (SEE), similar to the conceptual model depicted in figure 1 above. Trends show that some telecommunications operators have become early adopters of the service-oriented architecture (SOA) design principles for enterprise services as a strategic leverage point to achieve a sustainable competitive advantage (Sur, Skidmore & Chakravarty, 2006). The belief is that SOA will simplify their enterprise architecture integration, and achieve efficiency, flexibility and agility in service creation. For example, a cellular network operator in South Africa has successfully implemented a highly complex Mobile Number Portability service management and fulfilment application using SOA (Hadlow, 2007).

Senior management at a South African cellular telecommunications operator argue that the decision to invest in the next-generation service architecture is essentially a capital budgeting decision, one that maximizes financial value and incorporates strategic planning and technology fit in the environment. According to Hallman & McClain (1999), telecommunications operators have traditionally applied static models such as the total element long-run incremental cost (TELRIC) model or net present value (NPV) for conducting network infrastructure investment cost/benefit analysis. Hallman & McClain (1999) describe the TELRIC model as one that relies on the discounted cash flow (DCF) method for reflecting the NPV of an investment in the local network.

The main levers in the TELRIC calculation are identified as follows (Jamison, 1999: 58-9):

- *Capital Expenditure (Capex)*
    - Network architecture – assumes fixed architecture and cable routes, but it is known that technology can change
    - Technology – assumes least-cost technology is used
    - Utilization or fill factor – network facilities must be purchased in standard sizes
- *Operating Expenses (Opex)*
    - Obtained by multiplying Capex with a fixed percentage (expense/asset ratio calculated from ILEC's (incumbent local exchange companies) accounting records)
- *Cost of Capital* – model uses whatever the regulator sets (such as the Reserve Bank in South Africa)
- *Depreciation* - model uses whatever the regulator sets (such as the South African Revenue Service)

According to Hallman & McClain (1999: 145), TELRIC methods have the following shortcomings:

- TELRIC assumes that prices, output levels and expenses remain static over time
- Investments are assumed to be one-time with static factor prices, constant capacity, no differentiated risk, and no real options
- Assumption that there are no competitive impacts or market share losses due to changes in price
- Rate base calculations are without dynamics, including input and output price, and discount and interest rate dynamics
- There are no economies of scale or scope, no technological substitution, and no factor price considerations in TELRIC's engineering design and relationships
- Quantities do not rely at all upon demand elasticities or market shares, and are constant throughout time
- Depreciation is based on accounting methods that allocate costs arbitrarily over time, do not calculate economic depreciation, and include depreciation improperly in pricing formulas

Hallman & McClain (1999) further state that the TELRIC methodology tends to oversimplify the investment decision-making process because it does not accurately reflect the investment decisions that telecommunications firms face when evaluating network build opportunities. These shortcomings of traditional TELRIC-based or DCF investment valuation techniques become more apparent when applied beyond network build costs, that is to layers where telecommunications applications and services are created and hosted (Athwal, Harmantzis & Tanguturi, 2005). Cellular telecommunications operators worldwide are assessing the benefits of evolving towards next-generation service-oriented architectures (Pollet et al, 2006). According to Dai et al (2000), these flexible architectures create options and opportunities that did not exist previously, and thus need to be evaluated.

Therefore, cellular telecommunications operators are hoping to find new valuation techniques that overcome all or some of the limitations of traditional investment valuation techniques.

## 1.4 Problem statement

### 1.4.1 *Main problem*

The purpose of this study is to examine whether real options valuation and decision analysis techniques can be used by cellular telecommunications operators when making capital investment decisions in next-generation service-oriented architectures. In other words, this study aims to examine the use of non-probabilistic and probabilistic valuation techniques based on real options in assessing the value of probable future opportunities and benefits provided by the next-generation service architecture investments. In addition, risk analysis of uncertainties in the value of probable future opportunities and benefits will form part of this study. A decision framework based on quantitative options analysis and qualitative criteria in decision making will be developed.

### 1.4.2 *Sub-problems*

The first sub-problem is to test the application of non-probabilistic and probabilistic techniques such as static cash flow and real options in valuing technology investments in the cellular telecommunications industry

The second sub-problem is to analyze the risk or sensitivity associated with investments in new technology architectures in a telecommunications environment

The third sub-problem is to develop a decision framework, capable of analyzing both the quantitative and qualitative aspects of capital investment valuation

## 1.5 Significance of this Study

According to Pollet et al (2006), the cellular telecommunications industry is characterized by fierce competition, amidst ever changing consumer preferences and rapidly evolving technology. Pollet et al (2006) suggest that cellular service providers have the option of avoiding a price-war confrontation on the same service offering, and considering a value-based offering. This comprises value creation through innovative services bundling (such as quadruple play – voice, messaging, data and video) combined with a differentiated tariff scheme. The result is a reduction in customer churn and improvement in average revenue per user (ARPU). They argue that the challenge for the cellular service provider is to maximize its value capturing ability in delivering the added value to the customer. This can be realized through various consolidation efforts in service delivery (such as use of service convergence platforms, sometimes referred to as service delivery platforms (SDP), improvement in operational efficiency, and reduction of time-to-market of new services through flexible deployments, such as the use service-oriented architecture, SOA (Pollet et al, 2006; Sur, Skidmore & Chakravarty, 2006).

One of the objectives of this study is to address the challenge that cellular telecommunications operators currently face, that is applying a suitable framework for valuing their strategic investments in next-generation service architectures, based on SOA and/or SDP design principles. These architectures provide management with unprecedented service creation flexibility and options, which were previously not available in legacy implementations. This valuation framework must be cognisant of the uncertainties (risks) inherent in such deployments, examples being uncertainty in the adoption rate of these technologies (vendor or technology risk), implementation risk (project risk), user adoption of services (consumer risk) and changing market conditions (market risk) as identified by Svavarsson (2004: 1-2). Consequently, this study investigates the application of new analytics investment theory to specific technology implementations within the cellular telecommunications environment.

It is envisaged that findings from this research will provide management in a telecommunications environment with a framework for making more informed decisions concerning which projects to invest in, how much to invest, and when to invest. This is supported by Mun's (2006) view that real options are useful as a strategic business tool in capital investment decisions. According to Mun (2006), the approach should incorporate a learning model which will enable managers to make better and well-informed strategic decisions, amidst business conditions fraught with uncertainty and risk.

Alleman (2002) argues that management does not have to be locked into passive investment strategies, informed by traditional approaches in static cash flow estimation. The proposed real options analysis approach should provide a more dynamic investment planning model, adapting to changing technology and market conditions (Alleman, 2002). He referred to this dynamic investment strategy as the flexibility provided to management, which includes the option to defer, replace, expand or shut down a project capital investment. At the same time, experiential management judgement needs to be catered for through qualitative inputs into the decision framework (Mun, 2006). This view is supported by Ekstrom & Bjornsson (2003) in their suggested use of qualitative decision criteria such an IT balanced scorecard to complement project cash flow analysis.

The benefits of this study are summarized as follows:

- Assessment of the usefulness of new investment analytics in valuing management flexibility, availed through strategic project options and the ability to alter initial operating strategies in delivering end-user services in a cellular telecommunications environment;
- Provide cellular telecommunications service providers with a framework for analysis of investments in next generation service delivery architectures, given the inherent uncertainties and risks associated with such projects and the market, taking into account the strategic goals of the service provider

## 1.6 Delimitations and limitations

### 1.6.1 *Delimitations*

The real options valuation model and decision framework considered in this report is delimited to valuation of management flexibility and strategic options provided by the services architecture investments within the cellular telecommunications operator environment. The scope of the services architecture considered in this research is illustrated in figure 1 (that is, the service delivery platform (SDP) and service-oriented architecture (SOA) layers.

External effects on value estimation are delimited to subscriber interaction with the services created and technological changes in the telecommunications industry. The effect of market development is excluded from this study. The impact of regulatory changes on cash flows is excluded (it is assumed that the current regulation on cellular services tariffs for national access, roaming and interconnect remains static).

### 1.6.2 *Limitations*

In agreement with Bhagat (1999: 8), there are two identified limitations of real options valuations used in this study :

- Unlike financial call options, real options are generally not traded. Their non-tradability may lead to their early (premature) exercise, for example a firm rushing to early expansion as an anticipatory or pre-emptive move against the competition. The value estimation in this study assumes no early exercise of the options.

- Some real options, such as those characterized by the replacement project considered in this study are simple. A project may consist of a series of simple options. The application of simple options cannot be applied to other projects such as R&D investments which are characterized by compound options (option on an option). The second option is the opportunity to invest in the opportunity created by the first option. The focus of this study is delimited to the single stage options (options to expand and the option to defer).

## 1.7 Definition of terms

The following definitions are relevant to this research:

- Service-Oriented Architecture (SOA) – Enables the orchestration of business logic contained in various functional blocks called web-services [Pollet et al (2006: 529)].
- Service Delivery Platform (SDP) – An architecture used for application integration and delivery of converged end-user services in the telecommunications network [Sur, Skidmore & Chakravarty, 2006: 1)].
- Operations Support Systems (OSS) – Operations support systems such as service provisioning.
- Business Support Systems (BSS) – Business support systems such as billing.
- Next Generation Messaging (NGM) - Next generation messaging system such as 3G Voicemail.
- Interactive Voice Response (IVR) - Interactive voice response system used for customer self service.
- Discounted Cash Flow (DCF) – A method for company, project or investment valuation using the concept of time value of money. Estimated future cash flows are discounted at a defined rate (usually the cost of capital) to calculate the present value (Damodaran, 2002: 12-14).
- Real Options Analysis - Use of options theory to evaluate physical (real) assets, as opposed to financial assets or stocks and bonds (Mun, 2006: 89).
- Decision Tree Analysis - A decision graph that models possible decision outcomes. It is often used to identify an investment strategy to achieve the end goal, by choosing between several courses of action (Mun, 2006: 256-7).

- Binomial Lattice - A real options valuation lattice using discrete simulation steps for up and down movements as determined by the volatility of the logarithmic cash flow returns, and risk-neutral probabilities (Mun, 2006: 127-130).

## 1.8 Assumptions

### 1.8.1 *Similarities between IT Architecture Projects and Next-generation Telecommunications Service-Oriented Architecture Projects*

The next-generation telecommunications service architectures discussed in this context are based on the service-oriented architecture (SOA) and the service delivery platform (SDP) design concepts. These implementations result in the integration of IT systems (databases, applications etc) and telecommunications systems (signalling, switching etc). Therefore the assumption made in this research is that the same risk dynamics that impact IT architecture projects also impact next-generation telecommunications service architecture projects as discussed in more detail in section 2.4.

### 1.8.2 *Regulatory Requirements*

It is assumed that any improvements in telecommunications service operations and the delivery of new services created on the next-generation (open standards) architecture is compliant with the prevailing regulatory requirements for the telecommunications operator. This is a reasonable assumption since architecture design decisions have historically been left to the operator by the regulator.

### 1.8.3 *Scope of the Investment*

It is assumed that no changes to the supporting OSS/BSS infrastructure are required when integrating the next-generation architecture in the telecommunications environment, hence no investments costs are allocated for changes to the OSS/BSS infrastructure. The assumption is reasonable provided compatible interfaces can be provided between the next-generation architecture and existing OSS/BSS infrastructure.

### 1.8.4 *Conclusion*

The structure of the investment valuation framework will not be dependent on the assumptions made. The validity of the input data will however be depended on the assumptions being correct.

# CHAPTER 2

**OBJECTIVES**

- To understand the application of capital investment theory
- To review valuation techniques
- To understand the process of risk classification and managing uncertainty
- To review the decision analysis process

# 2 LITERATURE REVIEW

## 2.1 Introduction

The purpose of this section is to understand the application of capital investment theory in the “real-world” environment, where management often have to make decisions in uncertain business environments. Traditional analysis techniques and their limitations are discussed. Recently developed theoretical concepts in real asset investment analysis are discussed, leading to their proposed application to new telecommunications technology platforms.

## 2.2 Background

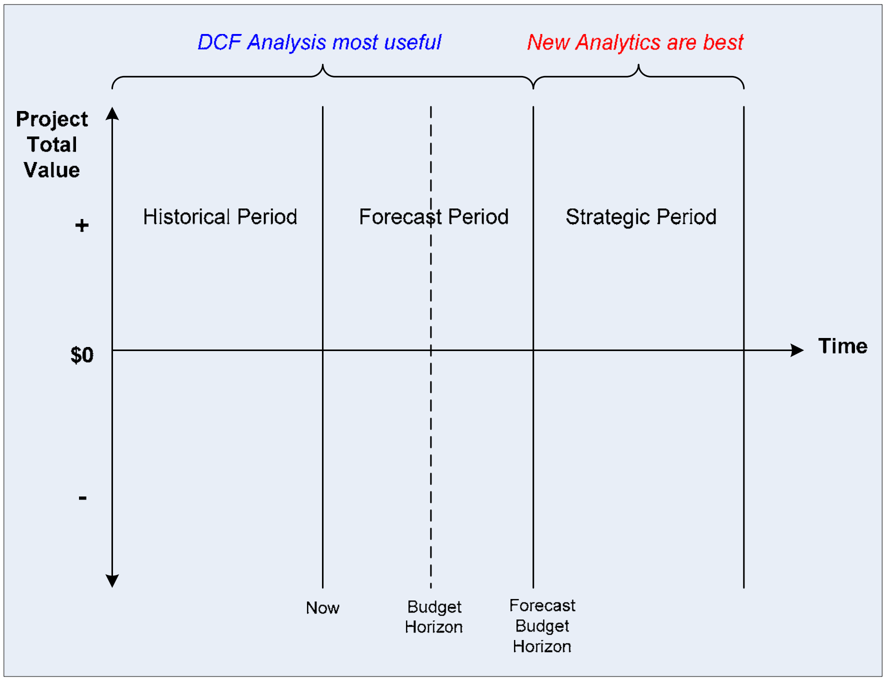
Harmantzis & Tanguturi (2007) describe the challenges that cellular operators face when making capital intensive investment decisions in new technology infrastructure on the core network. They give several examples; How long should an operator defer the expansion from 2.5 to a 3G network? Should an operator rather expand the network from a 2.5G using alternate technologies such as WiMax instead of 3G? These are options that need to be evaluated, and decisions need to be made. According to Harmantzis & Tanguturi (2007), there is also the question of uncertainty in the potential net benefit that new infrastructure investments provide. They identify an element of risk in the user adoption of new products and services, for example high speed wireless data services and integrated solutions for voice and data.

## 2.3 Investment Valuation

The difficulty in valuing IT infrastructure investments is attributable not only to the project’s potential to improve current operations, but also the potential to ‘fuel’ innovation and provide a sustainable competitive advantage over time (Renkema, 2000 cited in Svavarsson, 2004). This finding could be applied to the next-generation telecommunications services architecture investments in that the benefit accrues not only from the improvement in current service operations, but also from future opportunities to innovate.

Mun (2006) describes the process of valuing an investment on a time horizon made up of a shorter time period and longer time period (depicted in figure 2 below). According to Mun (2006), traditional valuation techniques are best suited for shorter time frames that are somewhat deterministic. He states that in the long term, strategic opportunities arise, and proposes a more appropriate investment valuation approach for the long term that incorporates new advanced analytics such as Real Options, Monte Carlo Simulations and Portfolio Optimization. This is because in the long term, it is harder to fully predict all the unknowns, hence management can create value by initiating and executing strategic options.

**Figure 2 Traditional versus new analytics**



Source: Mun (2006: 73)

Figure 2 is interpreted as follows:

Project total value (which can be positive or negative) is based on the DCF value and the Strategic value. DCF analysis usually uses a combination of 12 months trailing (historical period) project financial data for the base year, project budget data for the following year and future cash follow forecasts usually for a period not exceeding 5 years (budget forecast horizon). New investment analytics are best suited to forecast returns in the strategic period, that is usually beyond the 5th year.

Conceptually, the total value of an investment is made up of two components: the traditional (static or passive) NPV of expected cash flows, and the option value of operating and strategic adaptability (Trigeorgis, 1999). This can be represented by an expanded NPV analysis formula as follows (Trigeorgis, 1999: 4) :

$$\text{ENPV} = \text{PNPV} + \text{VOA}$$

Where,

ENPV = Expanded (Strategic) NPV

PNPV = Static (passive) NPV of expected cash flows

VOA = Value of options from active management (Value of operating & strategic adaptability or flexibility)

### 2.3.1 *Classical Valuation Techniques (Discounted Cash Flow)*

Managers are often faced with the challenge of having to assess the value of pursuing certain project opportunities (Shepherd, 1999 and Bharadwaj & Tiwana, 2005 cited in Tiwana, Wang, Keil & Ahluwalia, 2007), but the lack of structured information often leads to significant uncertainty in decision making. According to Ekstrom & Bjornsson (2003), non-probabilistic valuation methods such as discounted cash flow (DCF) and qualitative methods have however proved popular amongst decision makers.

According to Keil & Tiwana (2005) cited in Tiwana et al (2007), rationally acting managers often rely on discounted cash flow (DCF) techniques for project valuation. DCF methods include net present value (NPV) and internal rate of return (IRR) in guiding investment decisions. In their application, for an investment to be deemed profitable, NPV must be greater than or equal to 0 or IRR must be greater than the company's required rate of return.

Dixit & Pindyck (1995) explain how the NPV rule simply provides management with a basic go or do-not-go decision in today's terms. The shortcoming of classical valuation methods such as DCF however is that they do not reflect the value of future strategic options (VOA :- mentioned above). Dixit & Pindyck (1995) further argue that options are opportunities (rights), but not obligations. They add that these rights provide management with flexibility, and hence options have value associated with them.

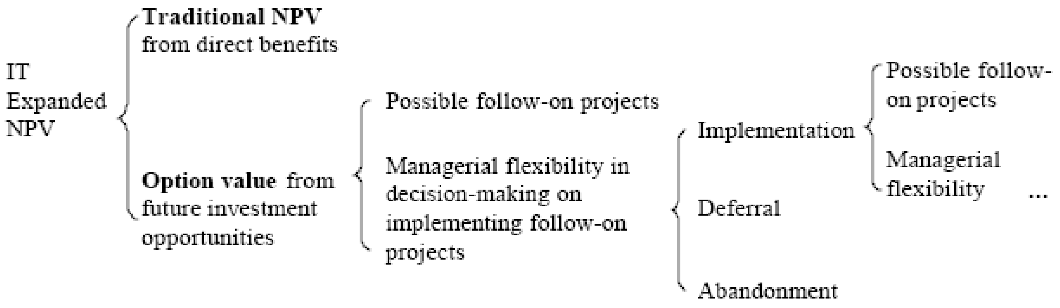
Thinking on real options has cautioned the failure to account for flexibility, which the DCF technique ignores (Tiwana et al, 2007). Flexibility allows managers to create and exploit future strategic opportunities (Perlitz, Peske & Schrank, 1999, Balasubramanian, Kulatilaka & Storck, 2000 and Bowman & Moskowitz, 2001 cited in Tiwana et al, 2007). According to Dos Santos (1991) cited in Ekstrom & Bjornsson (2003), classical valuation methods are not suited for accounting for management flexibility. More specifically, the NPV rule disregards various future options available for a project when considering a capital investment decision, such as the option to expand, option to delay, and option to abandon if market conditions become pessimistic. In support of Ekstrom & Bjornsson (2003), Svavarsson (2004) argues that because DCF valuation assumes a fixed investment strategy and a constant required rate of return, it is unsuitable for valuing future opportunities, such as the option to expand an IT platform investment and exploiting new applications that the expansion would provide.

### 2.3.2 *Application of Expanded (Extended) DCF Technique for Real Options Valuation*

Alleman (2002) suggests developing a real options methodology by taking the best features of DCF and decision tree analysis (excluding their failings) when valuating management flexibility and strategic options in real assets. Decision tree analysis (DTA) addresses multiple possible outcomes. Using an option-based or expanded-DCF is a possibility (Trigeorgis, 1996 cited in Alleman, 2002). DCF models can be extended to incorporate flexibility in investments, and used as an alternative to real options (Jong, Ribbers & Zee, 1999 cited in Ekstrom & Bjornsson, 2003).

Dai, Kauffman & March (2000) suggest using the expanded NPV (extended DCF) method for valuing the option-inclusive value of the project. This is the sum of the traditional NPV and the expected value of future projects made possible by the initial investment, as illustrated in figure 3 below.

**Figure 3 Option-Inclusive Value of an IT Project**



Source: Dai et al (2000: 4)

Figure 3 is interpreted as follows:

The expanded NPV for IT projects comprises the sum of traditional NPV (obtained through DCF) and the value of embedded options provided by the initial infrastructure or technology investment. The embedded options provide management with strategic flexibility for future project expansion, deferral or abandonment. Follow-on projects in the form of compound options (options-on-options are also possible).

### 2.3.3 *Financial Options and Real Options*

Hull (2001) defines the two types of financial options as a call option and a put option. He describes a call option as the right to buy an asset at a certain price by a certain date; and a put option as the right to sell a certain asset at a certain price by a certain date. The dates at which an option can be exercised are different for an American option and for the European option (Hull, 2001).

Real options extend the use of financial options pricing models such as Black-Scholes and the binomial model in the valuation of non-financial assets (Tiwana, Keil & Fichman, 2006). According to Svavarsson (2004), the main difference between the financial option and the real option is that real options apply to ‘real’ assets. Options analysis enables management to capture the business value of future opportunities (Dai, Kauffman & March, 2007). Real options analysis recognizes the importance of flexibility in business activities (Bellalah, Bouri & Levyne, 2007). Accordingly, options are today worth more than ever because of the new realities of today’s economy, driven by information intensity, instantaneous communications, high volatility etc.

The pricing model used for financial options can generally be mapped to real options (Harmantzis & Tanguturi, 2007), but Tiwana et al (2006) argue that the absence of a traded market for IT assets can lead to difficulty in estimating options parameters. Valuation of real options applies to the option to expand, defer, contract, abandon, switch use, or alter a capital investment (Panayi & Trigeorgis, 1998). Ross, Westerfield & Jaffe (2002) cited in Arboleda & Abraham (2006) give an example of an application of real options analysis in the construction industry as follows; The future price of an important construction material required for a project may be uncertain, relative to today’s price of the material. They state that if the future price of the material is likely to be higher than today’s price, then the option available to the contractor is to buy the material at today’s price. They estimate the value of the option in crude terms as being the difference between the future price of the material (market price) and today’s price (exercise price). The cost of the option would be the premium the contractor would have to pay the supplier to secure the right to buy or not to buy the material in future at today’s prices, depending on what the future price is (Ross et al, 2002 cited in Arboleda & Abraham, 2006).

The analysis made by Arboleda & Abraham (2006) in the construction industry makes it seem probable that the same approach could be applied to capital investment analysis of next-generation service architectures in the telecommunications industry. Construction and the telecommunications industry are two different industries, but similar in their requirement for high capital investment in infrastructure, the former is characterized by uncertainty in future material prices, the latter characterized by uncertainty in future technology adoption and demand by the industry, thus influencing prices (Arboleda & Abraham, 2006). In the telecommunications industry, the cost of the option could be equivalent to the deposit or premium the cellular telecommunications operator would have to pay to secure the right to implement new technology or evolve the current service delivery architecture to next-generation architecture in future at today's prices (Yu, Lee & Chang, 2005). Consequently, the deposit or premium would essentially give the cellular telecommunications operator the right, and not the obligation to expand or defer the investment in future.

"Thinking of investments as options substantially changes the theory and practice of decision making about capital investments" (Dixit & Pindyck, 1995: 1). Given the limitations of DCF and qualitative valuation techniques, and the suitability of using options for valuating strategic options in capital investments, real options valuation is explored further in section 2.3.4 below.

### 2.3.4 *Real Options Valuation*

According to Anderson (2000), there is a growing interest in using real options to guide capital budgeting and strategic decisions in dynamic environments. Anderson (2000) argues that the options approach provides a more proactive assessment of future business opportunities and adaptability under uncertainty. Tiwana et al (2006) claim that a real options approach enables more accurate valuation of capital investments.

Real options have been tested empirically to evaluate IT investments such as object-oriented middleware platforms (Dai et al, 2000 cited in Ekstrom & Bjornsson, 2003). Furthermore, real options have been applied in valuations in various industries such as pharmaceutical, energy, mining and information technology (Schwartz & Trigeorgis, 2001, Mun, 2002 and Trigeorgis, 1996 cited in Harmantzis & Tanguturi, 2007).

Alleman (2002) mentions that although real options theory has been increasingly applied in other industries, its application in the telecommunications industry has been very limited. Athwal, Harmantzis & Tanguturi (2005) emphasize this through their observation of the relative newness of using real options to evaluate telecommunications projects in assessing opportunities embedded in the projects. Despite this, Alleman (2002) and Athwal et al (2005) showed that real options could be helpful to the telecommunication industry for strategic evaluation, estimation and cost modelling. A survey conducted by Tiwana et al (2007: 158) in 88 firms revealed an interesting insight in management's application of real options. It was found that managers are less likely to apply real options in projects where the NPV already exhibits an adequate value by the traditional

NPV metric. Tiwana et al (2007) labelled this phenomenon ‘the bounded rationality bias’. This would imply that management’s perception of the benefit of real options analysis is in projects where the NPV is negative or marginal (Tiwana et al, 2007).

According to Dai et al (2007), IT infrastructure investments create growth options which can be evaluated using options analysis. Based on findings from Trigeorgis (1996), Alleman (2002) and Dai, Kauffman & March (2007), it would seem plausible that real options valuation could be extended to valuing investments in next-generation telecommunications service architecture implementations such as SOA and SDP that integrate the IT and telecommunications domains. In that context, the flexibility provided by SOA in developing and integrating business applications, and the strategic options or opportunities that SDPs provide in delivering new and innovative services to subscribers represent embedded options and choices inherent in open standards architecture implementations (Pollet, Maas, Marien & Wambecq, 2006).

The flexibility provided to management includes the option to defer, switch, replace, expand and grow, abandon, shut down, restart and contract (Alleman, 2002). Carlsson & Fuller (2002) suggest following a real option rule that compares the option to invest today with the option to wait (to defer the investment) when making an investment decision. When deferring an investment, the question is for how long should it be postponed (Carlsson & Fuller, 2002).

According to Bowman & Moskowitz (2001), users of real options models should understand the quantitative aspects of these models, and may often need to create a customized model for each situation. They argue that if this is not done, the assumptions used in standard option valuation models could conflict with the conclusions reached through strategic analysis. Consequently, this would suggest that proposing the development of a customized real options valuation and decision model for application in the context of the research problem is recommended. Benninga & Tolkowsky (2002) state that in considering real options for project valuation, the nature of options available to the manager need to be understood. For example when abandoning a project is an option, the costs of abandonment need to be considered.

### 2.3.5 *Real Options Models*

Several models exist for calculating real options, for example the Black-Scholes model and the binomial lattice model. Mun (2006: 188) categorized real options techniques into the following mainstream models:

- Closed-form models (such as Black-Scholes)
- Partial differential equations
- Binomial lattices (such as using risk-neutral probabilities)

According to Mun (2006), closed-form models are exact for European options (exercisable only at maturity), but are only approximations for American options (exercisable at any time prior to and including maturity). He argues that their disadvantage is their limited modelling flexibility; but Binomial lattices on the other hand are highly flexible, and can be used to solve American, European and exotic options. Mun (2006) states that in the limit, results obtained through the use of binomial lattices tend to approach those derived from closed form models. In support, he argues that past research has shown than 100 to 1000 time-steps in the binomial lattice calculation are usually sufficient for a good valuation. He suggests that the binomial lattice can also be used for making more complex, forward-looking compound (options-on-options) investment decisions. Mun (2006) suggests that results from closed-form calculations may be used in conjunction with the binomial lattice approach when presenting a complete real options solution to management.

#### *2.3.5.1 Application of Black-Scholes Technique for Real Options Valuation*

Harmantzis & Tanguturi (2007) used the Black-Scholes model in assessing two cases in a wireless industry; Case A being the option to defer expansion of 2.5G to 3G wireless network, and Case B being the option to expand a 2.5G network to WLAN (as an alternative to 3G). Athwal et al (2005) used the Black-Scholes option pricing model in valuing the replacement of centric voice services with hosted VoIP (Voice over Internet Protocol) services. In a similar approach, the Black-Scholes model could be proposed for valuing the investment a cellular telecommunications operator could make in next-generation service architectures, characterized by uncertainty in future prices, relative to current prices, which affect the investment value.

The Black-Scholes model has been applied in numerous cases for valuing simple or single-stage options, based on single call options, such as the option to expand or replace (Benninga & Tolkowsky, 2002; Sheppard, 2003; Svavarsson, 2004 and Harmantzis & Tanguturi, 2007). A single stage may have multiple periods, for example, years. This is in contrast to compound or multi-stage options where each subsequent stage is dependent on the previous stage. Anderson (2000) however indicated that the Black-Scholes model could be used for valuing compound call options as well. Benninga & Tolkowsky (2002) caution however, that the use of a Black-Scholes model in a real options framework only gives an approximation to the option value intrinsic in the real options.

#### *2.3.5.2 Application of Binomial Lattice Technique for Real Options Valuation*

The binomial lattice decision analysis method can be used for assessing more complex compound options (options to expand, defer, abandon, contract throughout multiple stages of a project) (Anderson, 2000 and Svavarsson, 2004). Benninga & Tolkowsky (2002) discuss the possible application of the binomial lattice model in R&D project valuation such as biotechnology projects in the pharmaceutical industry.

Svavarsson (2004) developed a binomial lattice model using a risk neutral probability approach for valuing real options in strategic IT platform investments, an example being an ERP investment. The model was used for the evaluation of strategic flexibility in the investment and quantifying and managing the associated risks. Svavarsson (2004) describes the ERP project as being characterized by four stages (Financial Management system (FM) pilot, FM full implementation, Project Management system (PM) pilot, PM full implementation), with each stage having its own investment uncertainty, such as user adoption and technological risk.

Implications are that because next-generation telecommunications service-oriented architectures are typically executed in multiple stages, similar to ERP projects mentioned above, the binomial lattice model could be developed for real option valuation of next-generation telecommunications service architectures.

### *2.3.6 Conclusion*

In summary, literature suggests that discounted cash flow (DCF) investment valuation techniques are based on a once-off investment strategy, and assume a static outflow of investment capital and inflow of returns in the future. This technique provides management with a basic guideline for undertaking or not undertaking the investment projects. The limitation of the DCF technique however, is that it does not reflect the strategic value of management flexibility presented by future options or opportunities. Real options can be used to quantify the strategic value of management flexibility. This suggests that the following proposition can be made:

***A combination of discounted cash flow and real options investment valuation provides a more comprehensive and effective means of valuing investment returns in present value terms and strategic flexibility inherent in next-generation telecommunications service architecture investments***

## 2.4 Risk Analysis

According to Svavarsson (2004), quantitative evaluation of strategic IT investments is a challenge for most organizations. Svavarsson (2004) further states that depending on the industry environment (which may be the cellular telecommunications industry in this context), IT investments may yield highly uncertain strategic future benefits, subject to various types of risks.

### *2.4.1 Risk Identification*

Svavarsson (2004: 1-2) classified the major risks associated with IT platform investments as being project risk and market risk and, in turn, project risk comprises the following risks:

- Vendor risk - uncertainty that the system provider will be around in future to support the system
- Technology risk – uncertainty in successful system implementation and operation

- Interaction risk – uncertainty in the extent to which external parties will interact with the system
- User adoption risk - uncertainty in internal user buy-in to the system

### *2.4.2 Investment under Uncertainty*

Winston (1996) describes several scenarios where many companies use simulation or risk analysis to assist with investment decision making under uncertainty. He provides the following example; If future cash flows are not known with certainty, it is not clear how to choose between competing projects. Most companies will tend to default to choosing the investment with the largest NPV. But using simulation techniques to obtain a histogram for the NPV of a project, it becomes apparent that choosing the investment with the largest NPV may not always be the best investment. An investment project with the largest NPV may be the riskiest project.

The question relating to the extent of the project risk and likelihood of a project yielding above or below a certain threshold can be answered through modelling and simulation techniques such as Monte Carlo (Winston, 1996). According to Dixit & Pindyck (1995), the greater the uncertainty over the potential profitability of the investment, the greater the value of the opportunity by keeping it in waiting; keeping it alive rather than exercising it at the wrong time. They further argue that understanding the role of uncertainty in real options analysis plays an important part in guiding investment timing decisions.

Anderson (2000) mentions that parameter sensitivities in the option evaluation models allow for appraisal of value effects from environmental uncertainties, but cautions against excessive model refinements.

### *2.4.3 Conclusion*

In summary, literature suggests that the investment risk in next-generation telecommunications service architectures could be categorized into project and market risk (uncertainty). Modelling and simulation of project investments under uncertainty facilitates more informed decision making as various risk scenarios are analyzed, and the consequential outcome reviewed.

This suggests that the following proposition can be made:

***The uncertainty in value estimation of future opportunities and net benefits derived from investments in next-generation service architectures can be modelled and analyzed***

## 2.5 Decision Analysis Framework

Choosing between options presents a decision making challenge. This form of decision analysis is possible through decision trees (Mun, 2006). In this study, a cellular network operator in South Africa faced a technology decision for developing a service for subscribers; the choice was to develop the service using a new generation service architecture or existing legacy architecture. The decision analysis process requires estimating the likelihood of an outcome, of the proposed investment. This estimation can be provided by experts in that area. For example, IT managers may do so using subjective probabilities (Howard, 1984 cited in Ekstrom & Bjornsson, 2003). These subjective probabilities would have to factor in project risk elements such as vendor risk, technology adoption risk and user adoption risk (Svavarsson, 2004).

### *2.5.1 Decision Tree Analysis*

Anderson (2000) proposes using decision tree analysis to implement a dual options framework when analyzing a two-period investment in various industries such as pharmaceutical and telecommunications, with the options being to invest/defer or to invest/abandon the project. Dai et al (2007) used a two stage model to guide decision making relating to value-based IT infrastructure investments. Stage 1 was characterized by the firm's initial investment cost (K) made up of expenditures such as hardware, software, telecomm and skills required in deploying and operating the infrastructure. Any direct benefit the infrastructure project generates is deducted from the initial investment (K). Stage 2, the growth option, was characterized by products or services developed on the infrastructure provided by stage 1.

Svavarsson (2004) approached the evaluation of strategic IT platform investments in two stages as well. Stage 1 was a pilot investment, stage 2 a full implementation and subsequent stages were options to expand the platform, thus providing further future opportunities. He modelled the process using a combination of real options analysis and decision tree analysis to map the most likely options through the stages. At each stage, the emerging options were valued taking into account further project investments, reduced operational costs and potential new revenue streams.

### *2.5.2 Qualitative Project Valuation*

Ekstrom & Bjornsson (2003) suggest using qualitative criteria to complement DCF or NPV in measuring flexibility in IT investments. Examples of qualitative valuation methods include an IT balanced scorecard to give some qualitative measure of “flexibility” under the “future orientation” criteria (Van Grembergen, 1998 cited in Ekstrom & Bjornsson, 2003). Information economics is another possible method for qualitative evaluation (Benson & Parker, 1989 cited in Ekstrom & Bjornsson, 2003). They argue that this method allows for the recognition of non-tangible benefits such as flexibility in IT investments.

Ekstrom & Bjornsson (2003) argue that Qualitative methods have a limitation of not being able to attach a financial value to the indicated benefits. Sometimes a scoring approach, for example 42% is used as a relative measure to compare and prioritize projects, aligning them with strategic objectives (Ekstrom & Bjornsson, 2003: 6). A cellular network operator in South Africa uses a qualitative scoring matrix (demand matrix) based on the project’s strategic importance and complexity to prioritize projects. When evaluating a capital investment on its own, and not comparing projects however, a qualitative score such as 42% requires an understanding of the model and context before using this technique to evaluate an investment (Ekstrom & Bjornsson, 2003: 6).

### *2.5.3 Conclusion*

In summary, literature suggests that decision analysis frameworks based on qualitative screening criteria and quantitative decision tree analysis (DTA) can be used for capital budgeting in various industries such as pharmaceutical, IT and telecommunications. Various sources of risk such as project risk and uncertainty in the net benefit of new infrastructure investments must be factored into the decision framework. Qualitative factors incorporated into the project investment decision analysis are aimed at complementing quantitative analysis. This suggests that the following proposition can be made:

***A decision framework for guiding capital investments in next-generation telecommunications service-oriented architectures can be developed based on a combination of both quantitative analysis and qualitative criteria in capital investment valuation***

## 2.6 Conclusion of Literature Review

Given the limitations of classical valuation techniques such as traditional DCF methods in valuing strategic investments in next-generation telecommunications service-oriented architectures, and the recent emergence of valuation techniques such as real options, inherited from financial options theory, the following propositions are restated:

### *2.6.1 Proposition 1:*

A combination of discounted cash flow and real options investment valuation provides a more comprehensive and effective means of valuing investment returns in present value terms and strategic flexibility inherent in next-generation telecommunications service architecture investments.

These considerations include:

- The traditional DCF analysis based on NPV provides a static estimate of the project value, with no future options (Harmantzis & Tanguturi, 2004; Alleman, 2002)
- Real options analysis provides a dynamic value estimate of embedded options and flexibility in a project, such as the option to replace, expand, contract, delay or abandon (Alleman, 2002)
- Effective use of real options requires overcoming the challenge of acquiring the data necessary to support the calculations, and making correct assumptions about the

various underlying variables such as risk (Jong et al, 1999). An example of this risk is market risk (economy, labour costs, currency risk, competition) (Svavarsson, 2004)

### *2.6.2 Proposition 2:*

The uncertainty in value estimation of future opportunities and net benefits derived from investments in next-generation service architectures can be modelled and analyzed.

These considerations include:

- Real options account for volatility or uncertainty and integrate with strategic planning (Harmantzis & Tanguturi, 2004; Alleman, 2002)
- Changes in volatility (uncertainty) affect the option value and therefore the decisions (Harmantzis & Tanguturi, 2007)
- Based on the financial call option, the more volatile the price of the stock the more valuable the option, and the greater the incentive to wait and keep the option alive rather than to exercise it (Dixit & Pindyck, 1995). In terms or real options, this translates to the option to defer or delay an investment

### *2.6.3 Proposition 3:*

A decision framework for guiding capital investments in next-generation telecommunications service-oriented architectures can be developed based on a combination of both quantitative analysis and qualitative criteria in capital investment valuation.

These considerations include:

- Using decision tree analysis and real options analysis to assess strategic flexibility can be effective in guiding capital budgeting decisions (Ekstrom & Bjornsson, 2003; Alleman, 2002; Brandão & Dyer, 2005)
- Qualitative criteria can complement NPV in measuring flexibility in IT investments (Ekstrom & Bjornsson, 2003)
- The real options analysis process can be preceded by a qualitative screening of a project (Mun, 2006)

# CHAPTER 3

| OBJECTIVES |
|---|
| • To describe the research methodology<br>• To describe the data collection process and tool<br>• To describe the data analysis process and decision framework |

# 3 RESEARCH METHODOLOGY

This section describes the methodology that is followed to verify the research propositions made in chapter 2 above.

## 3.1 Introduction

According to Creswell (2003), three approaches can be used for defining the research method, namely quantitative, qualitative and mixed methods. A quantitative method of study will be the primary approach taken in investigating the propositions made in this proposal.

Creswell (2003) describes quantitative research as being based on post positivist (that is, cause and effect thinking) knowledge claims, where a process of experimentation or surveys for numeric data collection on predetermined instruments is used to test the theories, explanations and hypotheses and to evaluate certain variables, using statistical procedures. This model is commonly known as a post positivist model. In line with this description, to verify the first proposition, analytical financial models for discounted cash flow analysis and real options analysis will be applied for evaluating capital investment projects based on service-oriented architectures at a cellular network operator in South Africa.

Statistical simulation techniques such as Monte Carlo simulation will be used to assess the sensitivity (risk) of these investments, in verifying the second proposition. To verify the third proposition, a decision tree analysis (DTA) technique will be used, which requires the estimation of project-specific discount rates at different stages of the project. Qualitative project selection criteria will be incorporated into the decision tree. The quantitative approach suits the analytical and experimental nature of the proposed financial modelling exercise. The required numeric data will be sourced from historic project financials and budget forecasts.

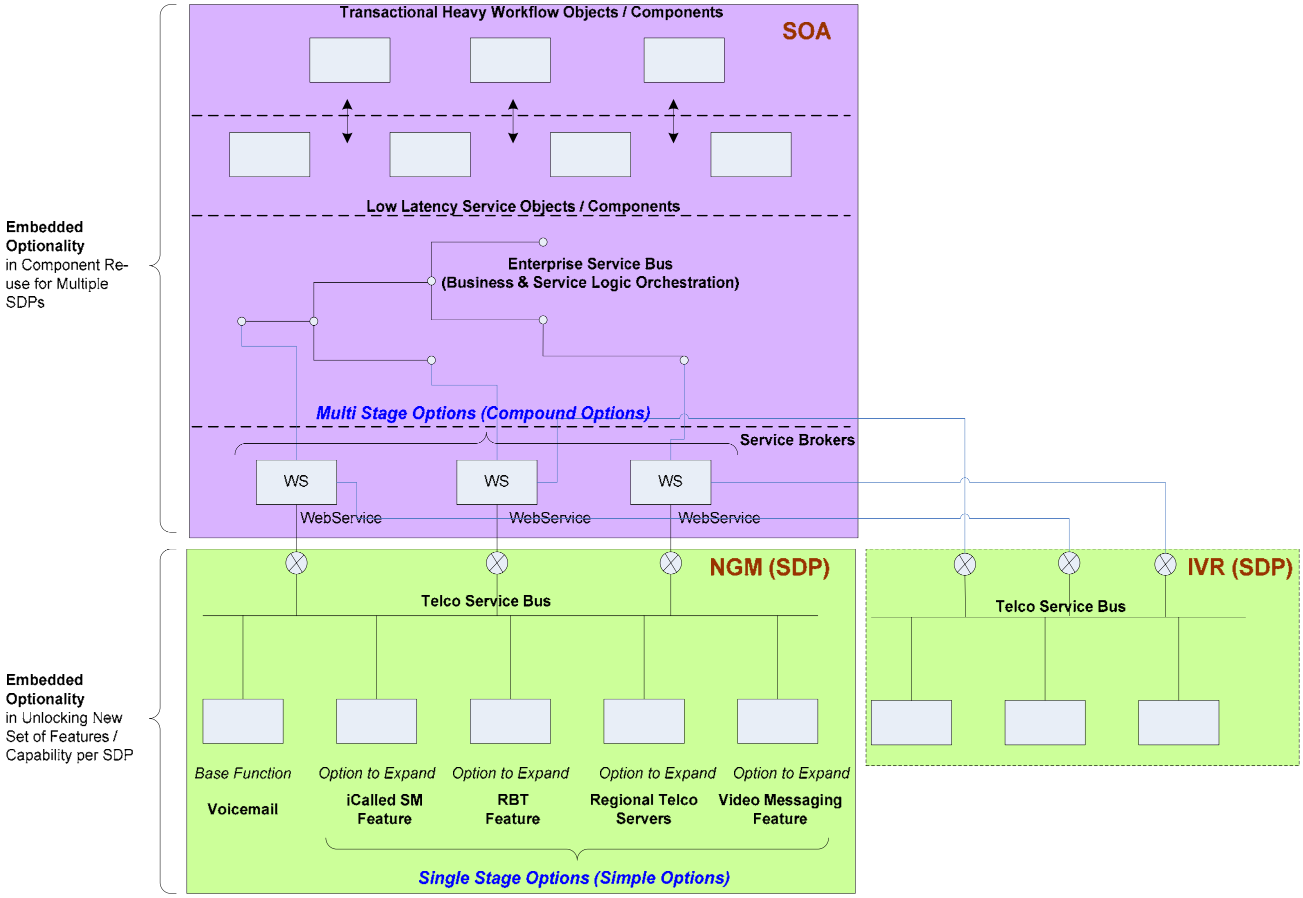
## 3.2 Research design

### *3.2.1 Quantitative Research Design*

The quantitative research design proposed for this study follows a very similar process used by Sheppard (2003) where a base case for a capital investment project is evaluated. Traditional DCF analysis will be used for evaluating the base case. Additionally, sensitivity analysis where there is uncertainty in future cash flows will be conducted. The DCF analysis method will thus be extended to assess the impact of project implementation risk on the investment.

Athwal, Harmantzis & Tanguturi (2005) took the approach of first calculating the NPV of a centrex PBX telephony solution replacement project for a 5 year period, then using derivatives theory to value the option of the investment. In a similar approach, the case study will undertake to quantify the total investment value of the next-generation messaging (NGM) platform investment, taking into account the static NPV and embedded options provided by the new generation architecture (illustrated in figure 4 below).

**Figure 4 Detailed model of the next-generation telecommunications service architecture illustrating strategic flexibility provided by embedded options**[*]



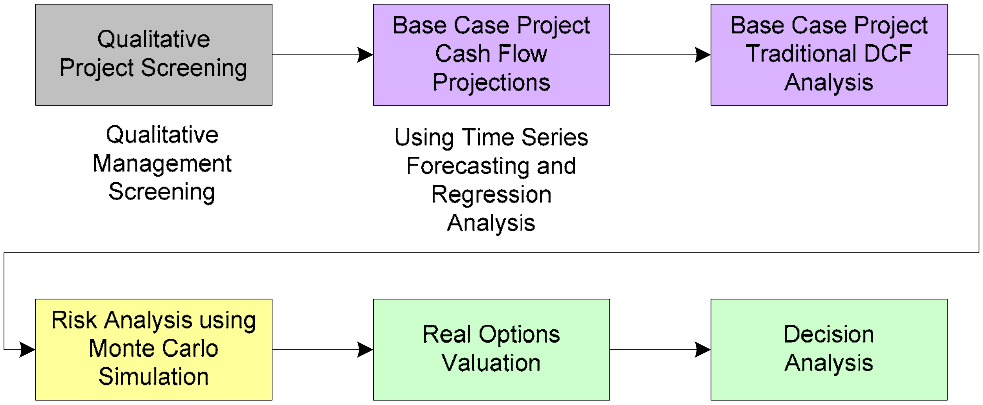
[*] Based on Pollet, Maas, Marien & Wambecq (2006: 531) [Adapted and applied to a cellular operator's services architecture]

Figure 4 is interpreted as follows :

The next-generation messaging system (NGM) is the service delivery platform (SDP) layer that is logically depicted in figure 1 on page 4. The NGM system provides a series of single-stage simple options as illustrated in the diagram. The service-oriented architecture (SOA) layer provides more complex, multi-stage compound options in the form of re-usable components (also known as web-services).

Real options analysis will be used to evaluate the case where future project growth options exist, such as the option to expand or defer, with the associated uncertainty in future cash flows. A decision analysis framework derived from decision tree analysis, incorporating both the classical and new investment analytics, will be developed to guide the decision making process. The investment valuation process as suggested by Mun (2006) is summarized in figure 5 below.

**Figure 5 Investment Valuation Process**



Source: Mun (2006: 107) [Adapted]

Figure 5 is interpreted as follows :

The project valuation process is made up of several phases as suggested by Mun (2006). The first phase is a qualitative project selection process. A business case for each of the shortlisted projects will be formulated, using traditional DCF analysis in the next phase. Risk identification and analysis is recommended (as is the case for new technology considered in this study). Embedded options are assessed in the following phase to determine the project's strategic value. Finally, a decision is made based on a combination of several factors such as project net worth and risk exposure.

According to Tiwana, Keil & Fichman (2006), real options analysis entails the determination of the active NPV of the project, which is equal to the traditional or passive NPV of the project plus the value of managerial flexibility, the latter being the function of the value of the bundle of options embedded in the project. Therefore,

$$NPV_{Active} = NPV_{passive} + f(\text{real options value}) \quad (1)$$

where $f(.)$ is the value of the bundle of real options embedded in the project)

f(.) is modelled in sections 3.5.3.1 and 3.5.3.2 below.

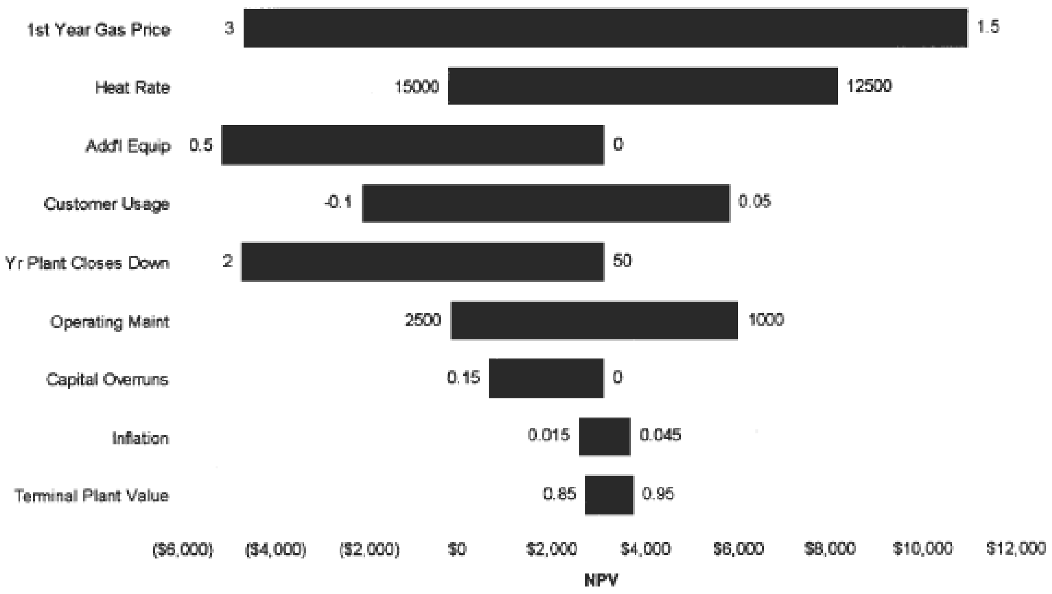
As a means of assessing the usefulness of real options analysis in a company, MacMillan, Van Putten, McGrath & Thompson (2006) suggest taking the approach of selecting three pilot projects, where a Chief Technical Officer's (CTO's) gut feel suggests that they deserve funding but conventional decision making tools lead to an NPV that suggests the opposite. Tiwana et al (2006) support this approach by suggesting that the true value of a project ($NPV_{Active}$) where $NPV_{passive} = 0$ would be equal to the total value of the various real options embedded in the project. Management would traditionally be reluctant to invest in this project, from a passive ($NPV_{passive}$) standpoint, but it could still be worthwhile when the additional value from real options is considered.

Mun (2006) applied real option analysis to several real-life applications such as high tech manufacturing and in the biopharmaceutical industry using super lattice solver and risk simulator software. In a similar approach, valuation of capital investment in a next-generation messaging architecture project at a cellular network operator is conducted in this study, with the aim of verifying the propositions made in the preceding section. The required inputs into the proposed quantitative financial models will be a combination of historical and forecast project budget data in estimating the passive NPV, and expected project financial data based on future options driven by strategic opportunities and management flexibility (refer to figure 2 in section 2.3).

### *3.2.2 Risk Analysis*

Chelst & Bodily (2000) describe the importance of risk management when making decisions under uncertainty. They further suggest using a tornado diagram (illustrated in figure 6 below) as a common method for performing sensitivity analysis in decision trees, where pessimistic and optimistic values for each uncertain input variable are defined. The NPV is calculated for each uncertain variable using both the pessimistic and optimistic values of each uncertain variable. The variable that results in the widest NPV swing is placed in the top bar, then subsequent variables are placed underneath in descending order, thus creating the tornado shape. It is the variables that result in the largest swing in NPV that require the most attention in risk management.

**Figure 6 Tornado diagram used for NPV sensitivity analysis, given the uncertainty in input variables**



Source: Chelst & Bodily (2000: 1427)

Figure 6 is interpreted as follows :

The tornado diagram presents results of NPV sensitivity analysis, with the top-most input variable (1st Year Gas Price) resulting in the largest swing or variance in NPV, and the bottom-most input variable (Terminal plant value) resulting in the smallest swing or variance in NPV.

More complex decision sensitivity analysis is required when analyzing how changes in a continuous random variable resulting in a probability distribution affects the outcome, decisions and optimality (Chelst & Bodily, 2000). According to Winston (1996), many companies are adopting simulation as a method for analyzing risk when doing capital budgeting. In a similar approach to Winston (1996), sensitivity analysis is conducted based on Monte Carlo simulation, developed using @RISK software in analyzing the impact of uncertainty on investment decisions.

Winston (1996) further argues that when future cash flows for an investment project are known with certainty, a company is likely to choose the project with the largest NPV. But if future cash flows are not known with certainty, then it is not clear whether or not to invest in the project. Using simulation, one can obtain a frequency distribution (also known as histogram) for the NPV of a project (Winston, 1996). For example, simulation enables questions like the probability that an investment will yield at least a 20% return, or the probability that an investment will have an NPV ≤ $1 billion to be modelled. Also, investing in a project with the largest NPV may not be the best decision for a risk averse company. A project with a high NPV is usually accompanied by greater risk.

Mun (2006: 136) describes the cone of uncertainty, where uncertainty increases over time, from a static/deterministic cash-flow instance, to a stochastic cash-flow variation instance. The simulated pathway of uncertainty can be generated using a Geometric Brownian Motion represented in equation 7 (refer to section 3.5.3.2) (Mun, 2006).

### *3.2.3 Advantages*

According to Deetz (1996), cited in Falconer & Mackay (1999), there is generally wide acceptance amongst editors and readers of the relevance of quantitative methods. The research design in this study is based on a quantitative model, sometimes referred to as a positivist model (Falconer & Mackay, 1999)

### *3.2.4 Disadvantages*

Silverman (1998) cited in Falconer & Mackay (1999) observed that quantitative studies neglect social interactions and negotiations that could affect systems development outcomes, and also the decision making outcome. This is particularly true in this study since the investment decision making process involves people interaction, and will be impacted by positional authority and the influential power people have in the organization.

## 3.3 Population and sample

### *3.3.1 Quantitative Case Analysis*

The limited number of cellular telecommunications operators in South Africa (MTN, Vodacom and Cell C in 2008), and the context of the research being on valuing next-generation mobile services architecture implementations means that little or no historic data exists for doing comparative analysis in project implementation. The cellular network operator assessed in this instance has recently been considering investing significant capital in a new services oriented architecture (SOA) and a service delivery platform (SDP) to achieve operational efficiencies and maximize its value capturing ability. A quantitative case study research approach is necessary to achieve the required financial modelling, risk and decision analysis in investigating the propositions made in this proposal.

While at the time of this study, in the South African context, there may have been some variability in the incumbent operator's capability and strategic flexibility to implement a next generation messaging (NGM) platform within a SOA framework, this exclusivity would not apply in a global context, as similar implementations have been done before, according to findings by Pollet et al (2006). Other mobile operators in other parts of the world are arguably in a similar position as the incumbent operator in South Africa in that they also have SOA implementations for delivering mobile services, and some have acquired the NGM infrastructure; the closest examples being Mascom in Botswana and Cell One in Namibia, who have invested in the NGM infrastructure. It is expected that the results of this study will be applicable and beneficial to cellular operators in neighbouring countries and other parts of the world, having similar architectures to the incumbent operator in South Africa.

### *3.3.2 Case Site*

The case site is a cellular telecommunications network operator in South Africa. For quantitative analysis, a combination of service-oriented architecture (SOA) and service delivery platform (SDP) projects that require significant capital investment are selected for the study. The suitability of such projects for real options valuation rests in their inherent risk in implementation, uncertainty in future cash flows, and flexibility in their implementation. The new architecture design presents options for future system expansion and delivery of new consumer products and services.

### *3.3.3 Case Study Description*

In 2005, the cellular operator considered in this case analysis, initiated the migration of its legacy middleware services architecture to a more flexible service-oriented architecture (SOA) for providing backend cellular telecommunications services such as billing, self-service and other business support services. The main driver for the architecture migration was the business focus on realizing operational efficiencies in service delivery.

In fourth quarter 2006, the operator procured a next-generation messaging platform (NGM). The NGM platform is a telecommunications service delivery platform (SDP), offering the cellular operator the capability to host both 2G and 3G voice-centric services such as voicemail (VMS), interactive voice response (IVR), video messaging and other consumer services such as ring-back tones (RBT) (see figure 1 in section 1.3 illustrating the SDP). The main drivers behind the NGM platform investment at the time were capacity requirements due to subscriber growth, and for decreasing operating costs. The existing legacy voicemail system (eZoner) was proving expensive to maintain due to its ageing proprietary architecture, and offered no flexibility in consumer service deployment.

## 3.4 Data collection

Data collection proceeded as follows:

The historical capital budgeting data on the NGM project was obtained. Where necessary, financial cash flow forecast was done using established time series forecasting techniques. Assumptions made are clearly stated, for example, revenue derived from future consumer service created. Ekstrom & Bjornsson (2003) do caution, however, that the costs and benefits associated with IT investments are uncertain and difficult to measure. Assumptions regarding future strategic options that the NGM project provides are clearly stated. The following template structure (table 1) was used in collecting the project cash flow data and calculating the project DCF (NPV). The underlying assumptions in the data are stated in the analysis that follows.

## Table 1 Proposed DCF (NPV) analysis tool indicating project cash flow structure

| ***Telecoms NGM Migration Project*** | ***Project Cash Flow Structure*** | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| ***Euro/Rand Exchange Rate*** | | | | | | |
| ***Tax Rate*** | | | | | | |
| ***Forecast Inflation (%)*** | | | | | | |
| ***Subscribers (Forecast)*** | | | | | | |
| NGM License Growth Requirements (Linked to Subscriber Growth) | | | | | | |
| NGM Voicemail box unit license cost (EUR 0.5) | | | | | | |
| | | | | | | |
| **YEAR** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| | | | | | | |
| **Capex** | | | | | | |
| | | | | | | |
| Purchase New (NGM) Telco Service Platform | | | | | | |
| Software | | | | | | |
| Hardware | | | | | | |
| Licenses (3.1 mil subecriber, incl) | | | | | | |
| Specification Workshop | | | | | | |
| Installation & Commissioning | | | | | | |
| Basic Service Fee | | | | | | |
| Services TAC 2 | | | | | | |
| Project Management | | | | | | |
| Training | | | | | | |
| Documentation | | | | | | |
| Acceptance Testing | | | | | | |
| | | | | | | |
| Network Cabling for NGM E-1's | | | | | | |
| | | | | | | |
| NGM Call Flow Changes & Twin Call Development | | | | | | |
| | | | | | | |
| Comptel NGM Provisioning Interface upgrade (InstantLink) | | | | | | |
| | | | | | | |
| Comptel Dual SIM Provisioning BST Logic (HLR+NGM) | | | | | | |
| | | | | | | |
| Accenture Development | | | | | | |
| | | | | | | |
| Advanced ASC & Prompts for MVNO (MUNGO) | | | | | | |
| | | | | | | |
| NGM License Growth Requirements | | | | | | |
| | | | | | | |
| **Opex** | | | | | | |
| eZoner Maintenance & Support | | | | | | |
| NGM Maintenance & Support | | | | | | |
| | | | | | | |
| **Total Investment Cost** | | | | | | |
| | | | | | | |
| **Trade-in of Legacy eZoner Platform** | | | | | | |
| | | | | | | |
| **Capex Savings** | | | | | | |
| **Opex Savings** | | | | | | |
| **Estimated Revenue from services** | | | | | | |
| | | | | | | |
| **EBIT+Depreciation** | | | | | | |
| Depreciation New System | | | | | | |
| Depreciation Old System | | | | | | |
| EBIT-Depreciation | | | | | | |
| Tax | | | | | | |
| | | | | | | |

**TOTAL CASH FLOW**

| | | | | | | |
|---|---|---|---|---|---|---|
| **PV Factor @ 15%** | | | | | | |
| **PV** | | | | | | |

**NPV @15%**

In modelling the next generation messaging (NGM) project cash flow model, capital budgeting data, comprising cost of infrastructure acquisition, project implementation, system integration, operation and maintenance was used. A basic service provided by the NGM system is voicemail. Inbound voicemail deposits to the system generate revenue for the mobile operator. The migration from the legacy eZoner system to NGM would result in the preservation of this basic service, so the historical revenue data generated by the eZoner system during the period Jan - June 2008 was used as a basis for estimating the 2008 revenue forecast for the NGM system. The 2008 inbound voicemail revenue data was used as a basis for revenue extrapolation for the period 2009 to 2011, having adjusted for subscriber growth and projected service uptake. The assumption made was that service uptake would be proportional to subscriber growth. The validity of the assumption is supported by the service provisioning process. The service is by default provided during subscriber account activation.

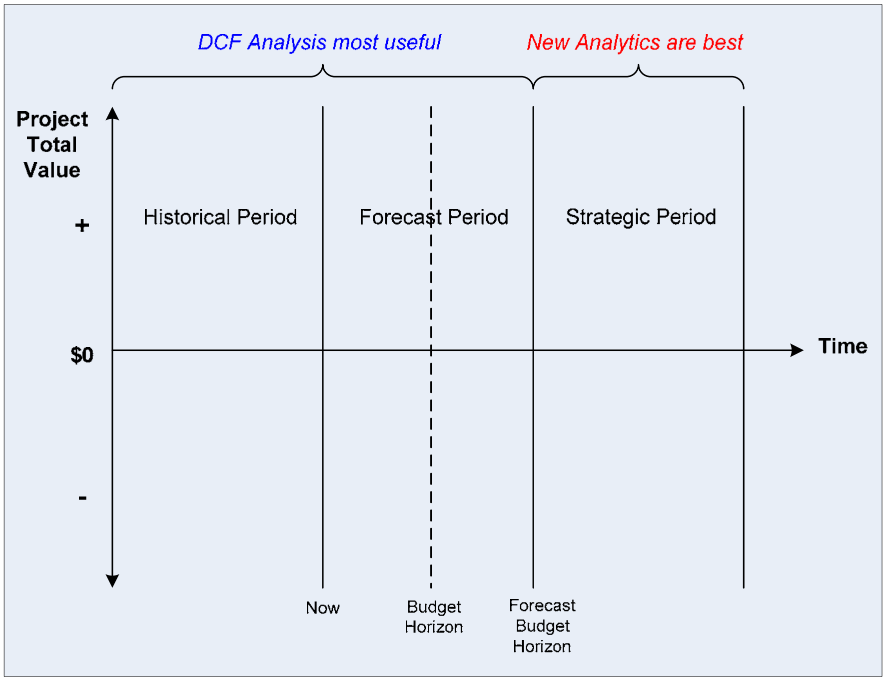
A one and half year history of the NGM project financial data (actual cash outflows and calculated cash inflows) was collected, and a three year budget forecast was estimated to model the five year discounted cash flow.

## 3.5 Data analysis

### *3.5.1 NPV Calculation*

Mun's (2006) suggestion of valuing an investment on a time horizon made up of a shorter time period and a longer time period as re-illustrated in figure 7 below, and discussed in section 2.3 is followed by estimating the base NPV over a five year period from 2007 when the project was initiated, to 2011. Historical capital budgeting data is used for the period 2007 to the second quarter in 2008. Budget forecast data is used for the period starting from the third quarter in 2008 to 2011. The 5 year period is deemed a reasonable window within which the project cash flow forecast can be determined deterministically.

**Figure 7 Traditional versus New Analytics**



Source: Mun (2006: 73)

### *3.5.2 Discounting Future Cash Flows*

#### *3.5.2.1 Objective Risk and Subjective Risk Approach*

According to Firer, Ross, Westerfield & Jordan (2004: 479), using the firm's WACC as the discount rate for future project cash flows is only appropriate for investments that are similar to the firm's existing activities, such as expanding production in an existing facility. For cases where proposed projects have a risk profile that deviates from the firm risk, some form of adjustment to the hurdle rate is required. Firer et al (2004) further claim that a firm using its WACC to accept or reject projects is likely to incorrectly accept risky projects and reject less risky projects.

Firer et al (2004: 481) suggest using a subjective risk approach to adjust the objective risk that is used to determine the firm's WACC. One method of implementing the subjective risk approach is to categorize projects into risk classes, such as high risk (new products), moderate risk (market expansion), low risk (equipment replacement) and mandatory. A positive adjustment factor is suggested for the high risk project; the firm's WACC is suggested for a moderate risk project, and a negative adjustment factor is suggested for the low risk project. A discount rate would not be applicable for mandatory projects as these are governed by regulatory requirements in the telecommunications sector for example. According to  Firer et al (2004: 482), the risk adjustments made through the subjective risk approach result in fewer incorrect decisions than if the firm simply used the WACC to make project investment decisions.

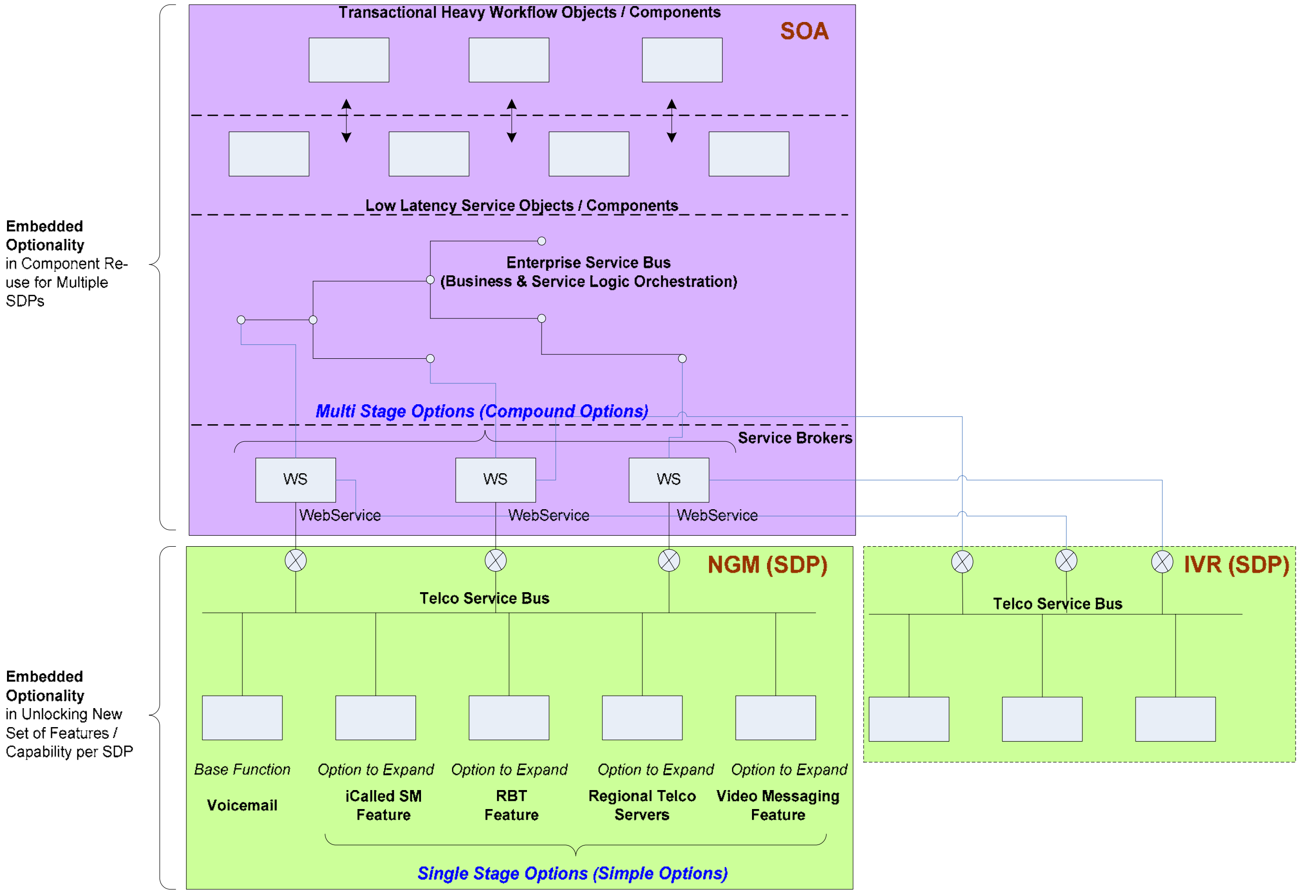
### *3.5.3 Real Options Valuation*

As Mun (2006) points out, the traditional DCF approach in project valuation underestimates the value of the project by ignoring the value of strategic flexibility. This is the learning and adaptive behaviour the project presents to management. Dai, Kauffman & March (2000) describe option analysis as the ability to capture the business value of future opportunities. For real options to have economic value, there needs to be exclusivity to exercise the option; the lower the degree of exclusivity, the lower the option value (Damodaran, 2002: 772).

In 2008, the cellular operator considered in this case was the only operator in South Africa with the telecoms SOA architecture and next-generation messaging (NGM) platform implementation. This unique positioning in the local context provides the company with the exclusive option of integrating the flexible NGM platform to the highly cost-effective SOA architecture to enable next-generation mobile services and to consolidate existing services (as illustrated in figure 8 below). It is estimated that the period of this exclusivity is limited to approximately 5 years, after which the other local operators would have caught up and would be likely to exercise the same or similar option.

As re-illustrated in figure 8, the next generation telecommunications service architecture implementation specific to the incumbent operator presents a series of simple single-stage options and multi-stage compound options provided by design re-use.

**Figure 8 Detailed model of the next-generation telecommunications service architecture illustrating strategic flexibility provided by embedded options***



*Based on Pollet, Maas, Marien & Wambecq (2006: 531) [Adapted and applied to a cellular operator's services architecture]

The total investment value is calculated as follows:

Total Investment Value = NPV + Strategic Opportunities $_{\text{SOA + SDP(NGM)}}$

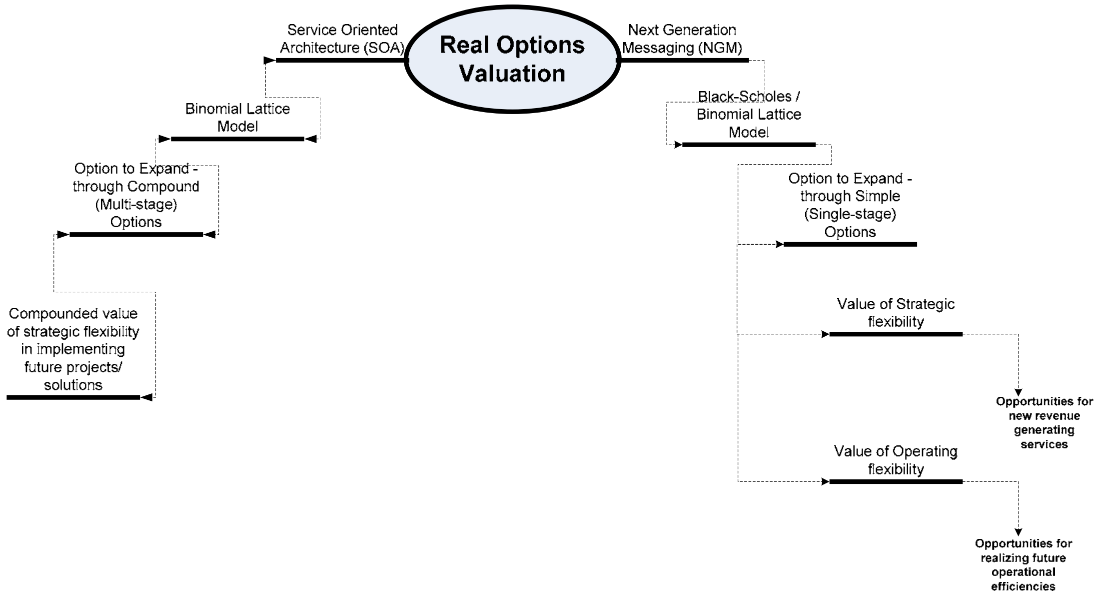
The strategic opportunities (options to expand the NGM implementation) are non-mutually exclusive, and are ranked according to their strategic priority to the company, as illustrated in table 2 below. Section 4.3.1 describes the qualitative screening process followed by the operator’s management in ranking the priority of the various project options.

**Table 2  Priority ranking of options to expand the NGM system**

| Strategic Opportunity (Option to Expand) | Priority Ranking |
|---|---|
| **Capacity Demand Management**<br>(Call Completion Service (iCalled SM)) | 1 |
| **Network Element Consolidation**<br>(SS7 or SIP Interactive Voice Response (IVR) Application) | 2 |
| **IT Architecture Consolidation**<br>(SOA Architecture Migration from Comptel) | 3 |
| **Network Efficiency**<br>(Regional Telco Servers (2G/3G Media Servers)) | 4 |
| **New Revenue Stream**<br>(Ring-back Tone (RBT) and Video Messaging Application) | 5 |

The strategic opportunity (that is, the option to expand the NGM platform) given a priority 1 ranking in table 2 is more precisely referred to as the value of operating flexibility (as illustrated in figure 9). This is the cost saving opportunity to the company by realizing future operational efficiencies through capacity license management.

**Figure 9 Mind-map representation of the proposed real options valuation model for next-generation telecommunications and service-oriented architectures***



*Based on Mun (2006) [Adapted and applied to SOA and NGM architecture valuation]

### *3.5.3.1 Black-Scholes Method*

The Black-Scholes method makes use of an option pricing formula. The European call option is calculated using the generalized Black-Scholes model as follows (Mun, 2006: 124) :

$$Call = Se^{-q(T)}\Phi\left[\frac{\ln(S/X)+(rf-q+\sigma^2/2)T}{\sigma\sqrt{T}}\right] - Xe^{-rf(T)}\Phi\left[\frac{\ln(S/X)+(rf-q-\sigma^2/2)T}{\sigma\sqrt{T}}\right] \quad (2)$$

Where *(q)* is the dividend. In this application of real options analysis, it is assumed that no dividends are payable, therefore equation (2) is re-written as follows (Mun, 2006: 147) :

$$Call = S\Phi\left[\frac{\ln(S/X)+(rf+\sigma^2/2)T}{\sigma\sqrt{T}}\right] - Xe^{-rf(T)}\Phi\left[\frac{\ln(S/X)+(rf-\sigma^2/2)T}{\sigma\sqrt{T}}\right] \quad (3)$$

Where $\Phi$ is the standard normal distribution

The inputs to the above-mentioned call option are defined in table 3 below:

**Table 3 Mapping between project investment growth opportunities and financial (stock) options**

| Investment Opportunity | Variable | Stock Options Equivalent |
|---|---|---|
| Present value of the cash flows obtained from the project expansion (growth) option | S | Stock price |
| Present value of the expenditure required for project expansion | X | Exercise (Strike) price |
| Period that the project expansion option is available for | T | Time to expiration |
| Uncertainty in the cash flow generated by the expansion option | $\sigma$ | Volatility of returns |
| South African prevailing bond rate | $R_f$ | Risk-free rate |

Source: Harmantzis & Tanguturi (2007: 110)

Athwal et al (2005: 13) made the following assumptions regarding the option parameters:

- The value of the underlying asset or the current price (S) is equal to the present value of cost savings realized when a new system is deployed.
- The investment cost (X) is the strike price.
- The maturity of the option (T) is the life of the project.

- For the risk or volatility (σ), the historical stock price of movements of hardware vendor providers could be used.

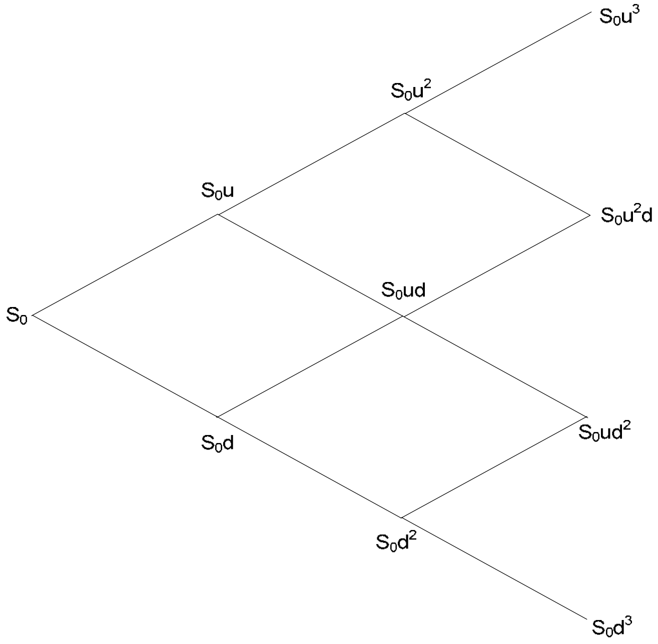
- When valuing hosted Voice-over-Internet Protocol (VoIP) service networks, the standard estimate risk-free rate ($R_f$) applied by several VoIP hosted service providers could be used.

The Black-Scholes method is used in this research for valuing simple (single stage) options such as options to expand the NGM platform (as illustrated in figure 8). This is supported by the prior discussion in section 2.3.5, regarding the application of Black-Scholes model in numerous cases for valuing simple or single-stage options, based on single call options, such as the option to expand or replace [Benninga & Tolkowsky (2002), Svavarsson (2004) and Harmantzis & Tanguturi (2007)].

#### *3.5.3.2 Binomial Lattice Method*

In this method, cash flows of a project are represented as points on a lattice (see figure 10 below) (Mun, 2006: 126).

**Figure 10 Binomial lattice representation for option valuation**



Source: Mun (2006: 126)

Figure 10 is interpreted as follows :

The project revenue or cost saving (present value of underlying investment) at time zero is the first point on the lattice. The method calculates state-dependent present value factors and multiplies them with state-dependent cash flows. The node of a tree is discounted by the relevant state price of the node. The NPV of the project is then the sum of all the discounted cash flows, minus the initial cost (Benninga & Tolkowsky, 2002).

The binomial lattice calculation requires the up (*u*) and down (*d*) factors as in equation 4, as well as the risk-neutral probability measure (*p*) in equation 5 (Mun, 2006: 152).

$$u = e^{\sigma\sqrt{\partial t}} \text{ and } d = e^{-\sigma\sqrt{\partial t}} = \frac{1}{u} \tag{4}$$

According to equation 4, The (*u*) factor is simply the exponential function of the volatility of the cash flow returns multiplied by the square root of time-steps. The volatility is an annualized value, multiplying it by the square root of time-steps breaks it down into the time-step's equivalent volatility. The (*d*) factor is simply the reciprocal of up factor. The higher the volatility, the higher the up and down factors, and the wider the lattice becomes.

The risk-neutral probability is calculated as follows in equation 5 (Mun, 2006: 152).

$$p = \frac{e^{(rf-b)(\partial t)} - d}{u - d} \tag{5}$$

Where (*b)* is the dividend. In this application of real options analysis, it is assumed that no dividends are payable, therefore equation 5 is re-written as follows (Trigeorgis, 1996 cited in Svavarsson, 2004: 4).

$$p = \frac{e^{(rf)(\partial t)} - d}{u - d} \tag{6}$$

The risk-neutral probability is a mathematical factor used in the lattice calculation, but has no particular meaning itself (Mun, 2006). As illustrated in figure 10 above, the binomial lattice calculation process starts with the present value of the underlying investment at time zero ($S_0$). This value is then multiplied with up (*u*) and down (*d*) factors to create the binomial lattice.

The binomial lattice method is used to estimate the value of a single-stage option in this study, and the results compared to the Black-Scholes method. The binomial lattice is also well-suited for valuing compound (multi-stage) options such as a multi-stage options to expand; which could be created through multiple re-use of components in the SOA architecture in this context (as illustrated in figure 8). This is supported by the prior discussion in section 2.3.5, where Svavarsson (2004) developed a binomial lattice model using a risk neutral probability approach for valuing real options in strategic IT platform investments. The model was used for the evaluation of strategic flexibility in the investment, and quantifying and managing the associated risks. The NGM architecture in this research context is a type of next generation IT middleware implementation.

### *3.5.3.3 Risk and Uncertainty Analysis*

According to Mun (2006), a binomial lattice is a type of discrete simulation of uncertainties. Closed-form solutions are a stochastic process, represented by a continuous simulation of uncertainties, where a probability distribution can be constructed at each time period. This continuous simulation can be generated using the Geometric Brownian Motion with a fixed volatility as shown in equation 7.

$$\frac{\partial S}{S} = \mu(\partial t) + \sigma\varepsilon\sqrt{\partial t} \qquad (7)$$

where $\mu(\partial t)$ represents the deterministic part, and $\sigma\varepsilon\sqrt{\partial t}$ represents the stochastic part. Solving a Brownian Motion in a discrete sense yields the binomial equations. Solving it in a continuous sense yields a closed-form equation such as the Black-Scholes.

## 3.6 Decision analysis

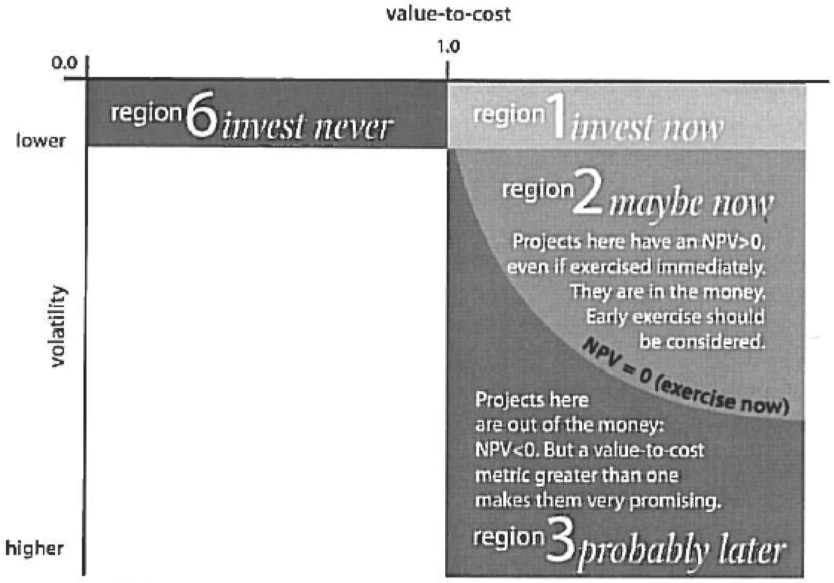
### *3.6.1 Decision Analysis Framework*

The suggestions made by Dai, Kauffman & March (2007) and Svavarsson (2004) in using a two stage model for decision making are adopted in this study, where stage 1 comprises the firm's initial infrastructure investment, that is physical assets, intellectual assets and procedural assets. The total derived benefits (cost savings and/or revenue generated from services) is then deducted from the total investment, thus calculating the project base case cash flow analysis). The stage 1 period is typically characterized by low volatility (σ) in value-to-cost estimation. In terms of a decision tree, stage 1 investment decision analysis consists of two main branches of the tree (that is, to invest or not to invest).

Stage 2 comprises growth options made possible by leveraging the stage 1 infrastructure investment. This stage is typically beyond the initial 5 year window period and is characterized by high uncertainty (i.e. $\sigma\sqrt{t}$) in value-to-cost estimation. Real options analysis is used as described in section 3.5.3 in ascertaining the strategic value of the growth options, which in the specific case of the NGM project are made up of a combination of simple options and compound options (option on an option). Stage 2 creates multiple branches of the decision tree, resulting in multiple paths that can be taken in the decision making process, each path resulting in a different financial outcome.

A Precision Tree® decision analysis tool is used to model the NGM project decision tree. Given that each tree node has an associated probability of outcome (using the subjective probability approach), the optimal path will either be the sum of region-1 (i.e. base case) + region-2 (e.g. option-to-expand) or sum of region-1 (i.e. base case) + region-3 (e.g. option-to-defer), depending on the region combination yielding the highest net payoff, as illustrated in figure 11. The optimum path defined in the Precision Tree® model is the value maximization path.

**Figure 11 Dividing Option Space into Regions**



Projects here have an NPV>0, even if exercised immediately. They are in the money. Early exercise should be considered.

Projects here are out of the money: NPV<0. But a value-to-cost metric greater than one makes them very promising.

Source: Leuhrman (1998: 92)

## 3.7 Validity and Reliability

Validity is the extent to which an instrument measures or describes what we wish to measure or describe. Reliability relates to the consistency of the measuring procedure (Bell, 2006).

### *3.7.1 External Validity*

The external validity of the proposed analysis approach is supported by its prior use in other project valuation scenarios described in the literature review. Since cellular telecommunications operators worldwide tend to invest in similar, standardized systems and architecture, some generality in the research findings can be assumed. The research findings could have wider application in the telecommunications industry.

### *3.7.2 Internal Validity*

The proposed analysis approach is linked to the literature review and the research propositions to ensure internal validity. The investment valuation framework is supported by its application to an active project with actual data to ensure content validity.

### *3.7.3 Reliability*

To ensure reliability in the real options analysis procedure, valuation results obtained using the Black-Scholes procedure are compared against the binomial lattice results to check for consistency. This approach is supported by Mun (2006) by suggesting the comparison of the two methods prior to presenting the complete real options solution to management.

# CHAPTER 4

| OBJECTIVES |
|---|
| • To conduct investment valuation using traditional DCF and Real Options<br>• To conduct risk analysis<br>• To develop a decision tree model |

# 4 RESEARCH RESULTS

## 4.1 Investment Valuation

### *4.1.1 Discounting Future Cash Flows*

The next-generation messaging (NGM) project is considered a high risk project due to its radical, new system architecture design and being the first of its kind to be implemented in a South African mobile operator environment. Due to the perceived high project risk and operational risk, the project-specific hurdle rate was assumed to be greater than the firm-specific WACC to compensate for the additional risk. Following the approach suggested by Firer et al (2004), to use an adjusted discount rate where the project's risk profile deviates from the firm's risk, a risk-adjusted project-specific hurdle rate was used as the discount rate for the project cash flow.

### *4.1.2 NPV Calculation*

The firm's hurdle rate is calculated as follows:

$$\text{WACC } (K_c) = w_e.k_e + w_d.k_d\,(1\text{-}t) \qquad (8)$$

Where,

$t$ = Marginal tax rate (28% in South Africa)(Budget Speech, 2008)

$K_e$ = Cost of equity

$K_d$ = Pre-tax Cost of debt

$w_e$ and $w_d$ = Market value weights

Note : The cellular network operator in this case had no preferred equity capital at the time of this analysis

Given that the cellular operator is a private entity, the market values of debt and equity were unavailable to establish the market value weights ($w_e$ and $w_d$). To overcome this, the South African telecoms industry average debt-to-equity ($D/E$) ratio was calculated (table 4), from which the market value weights ($w_e$ and $w_d$) were estimated as described in equation 10. The assumption made is that the cellular operator in this case, operating in the South African context would tend towards a debt ratio similar to the industry average of comparable firms (in characteristics, not market capitalization size), as the company matures. This is in line with Damodaran's (2002) suggestion that when a private firm is being valued for an initial public offering (IPO), we could assume that the company would structure its debt policy to resemble that of comparable firms.

Using the industry average Debt /Equity ($D/E$) to estimate the debt ratio (δ)

Debt ratio $$\delta = \frac{D}{D+E} = \frac{D/E(\%)}{100 + D/E(\%)} \tag{9}$$

$$w_d = \delta = 1 - w_e \tag{10}$$

**Table 4 South African Telecoms Operator Debt-to-Equity Ratio**

| Telecoms Network Operator | Debt-to-Equity ($D/E$) | Debt ratio (δ) | Source |
|---|---|---|---|
| Telkom S.A | 30.9% | 23.6% | Telkom annual report, 2007 |
| Vodacom | 27.6% | 21.6% | Vodacom annual report, 2007 |
| MTN | 31.2% | 23.8% | MTN annual report, 2007 |
| **Average** | **29.9%** | **23%** | |

Therefore, $w_d = 23\%$ and $w_e = 77\%$ (11)

Estimating the pre-tax cost of debt ($K_d$) for the incumbent operator.

The cost of debt measures the current cost to the firm of borrowing funds to finance projects (Damodaran, 2002). In an emerging market firm, the cost of debt comprises the risk free rate, the company default spread (risk) and the country default spread (risk).

Since the operator is operating in an emerging market (in the Republic of South Africa), the pre-tax cost of debt ($K_d$) is based on the risk free rate ($R_f$), the company's default spread, which is driven by the company's bond rating and the country default spread.

Therefore,

$$K_d = R_f + \text{Company default spread} + \text{Country default spread} \tag{12}$$

Where,

$$\begin{aligned} R_f &= \text{(Rand) Risk free rate} \approx \text{Default-free government bond rate} \\ &= \text{S.A. Government 5 yr retail Bond Rate} - \text{Default spread adjustment} \end{aligned} \tag{13}$$

S.A. Government 5 yr retail Bond Rate = 10.75% (S.A. Retail Bonds, National Treasury, 2008)

For South Africa, the default spread adjustment is estimated to be 0.8%, given the country's long-term "A2" government bond rating (Damodaran, 2008b)

Therefore, $R_f = 10.75\% - 0.8\% = 9.95\%$

Estimating the company default spread (risk) for the operator :-

At the time of this analysis, the operator's corporate bond (valued at EUR 400mil senior secured notes) rating by Standard & Poor was a B-. (Hemscott, 2008)

The default spread associated with B- rated bonds in the market was 6.5% (Damodaran, 2008a)

Therefore,

$$K_d = 9.95\% + 6.5\% + 0.8\% = 17.25\%$$

Estimating the cost of equity ($K_e$) for the operator :-

The cost of equity is the rate of return equity investors in a firm expect to make $E$(Return). $K_e$ measures the corporate equity risk and is calculated as follows:

$$K_e = R_f + \beta(\text{Total Equity Risk Premium})$$

$$= R_f + \beta(R_{\text{Mature market equity risk premium}} + R_{\text{Country risk premium}}) \tag{14}$$

Where

$R_{\text{Mature market equity risk premium}}$ = U.S Equity Risk Premium = 4.79% (at the time of this analysis) (Damodaran, 2008b)

And

$R_{\text{Country risk premium}}$ = 1.2% for South Africa (at the time of this analysis) (Damodaran, 2008b)

Therefore

$$K_e = R_f + \beta(\text{Total Equity Risk Premium})$$

$$= 9.95\% + \beta(5.99\%)$$

Estimating Beta (β) for the operator :-

Given that the operator is a private entity, we cannot use regression beta for the undiversified risk, as the market price returns are unavailable. It is expected that the risk will be higher due to the entire investment being tied in the business, and is undiversified.

In calculating beta, we use the bottom-up approach to estimate the levered beta ($\beta_{\text{private firm}}$) of a private firm (Damodaran, 2002).

$\beta_{\text{private firm}} = \beta_{\text{unlevered}} [1 + (1 - t)(\text{Industry average } D/E)]$

Where :

Assuming that the firm's market leverage resembles the average for the industry,

The Industry average $D/E$ = 29.9% as calculated earlier

$t = 28\ \%$ (South African marginal tax rate, as published in the Minister of Finance, Mr Trevor Manuel in his budget speech 2008)

$\beta_{\text{unlevered}} = \frac{\beta_m}{\sqrt{\sigma^2}}$

Where,

$\beta_m$ = average regression beta across publicly traded comparable firms

$\sigma^2$ = correlation with the market

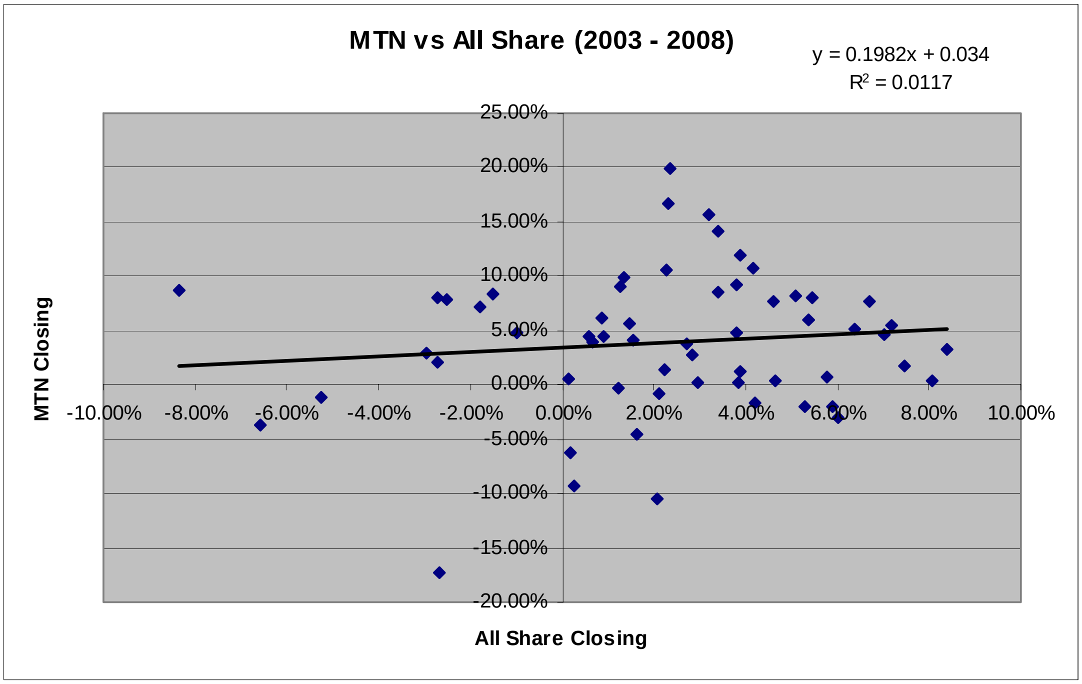
Correlation with the market ($\sigma^2$) = average $\sigma^2$ across comparable firms beta regressions

The company inherent risk = $\sqrt{\text{correlation with the market } (\sigma^2)}$

**Table 5 Derivation of South African Telecoms Operator Regression Beta**

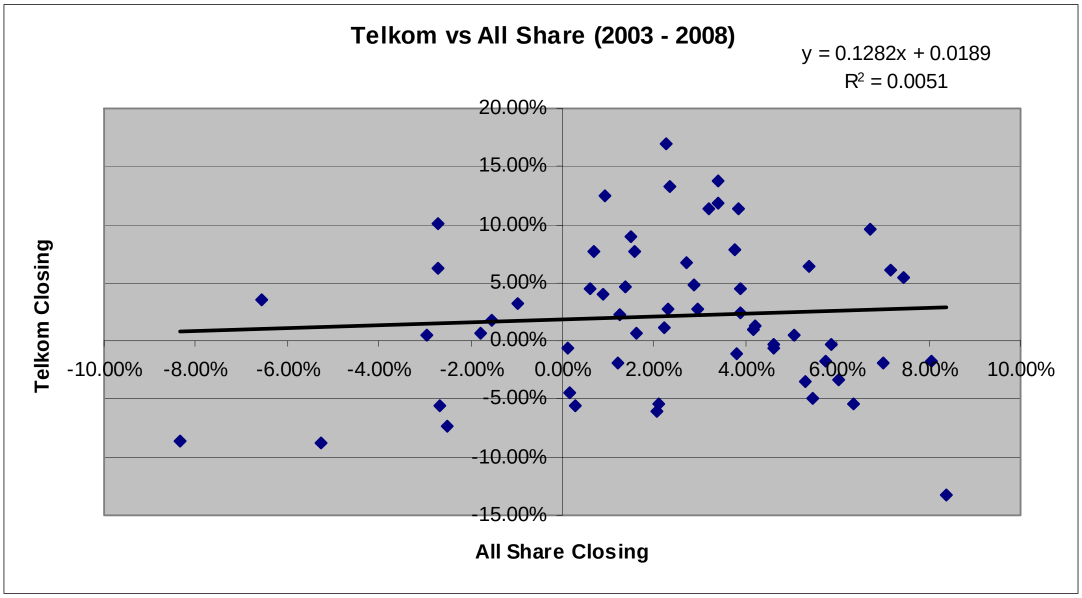
| Telecoms Network Operator | Regression Beta (β) | $R^2$ | Source |
|---|---|---|---|
| Telkom S.A. | 0.1282 | 0.0051 | Telkom closing share price data (2003– 2008); Standard Bank Online Share Trading (Standard Bank, 2008) |
| MTN | 0.1982 | 0.0117 | MTN closing share price data (2003– 2008); Standard Bank Online Share Trading, (Standard Bank, 2008) |
| **Average** | **0.1632** | **0.0084** | |

**Figure 12 Estimation of MTN's Regression Beta***



*Based on data managed by Standard Bank (2008)

**Figure 13 Estimation of Telkom's Regression Beta***



*Based on data managed by Standard Bank (2008)

Therefore

$$\beta_{\text{unlevered}} = 0.1632 \;/\; \sqrt{0.0084} = 1.8 \qquad (15)$$

And

$$\beta_{\text{private firm}} = 1.8 * [1 + (1 - 0.28)(29.9\%)] = 2.19 \qquad (16)$$

Calculating the operator's cost of equity,

$$K_e = 9.95\% + (2.19)(5.99\%) = 23.07\% \qquad (17)$$

Finally, we estimate the cost of capital ($K_c$) for the operator as follows (referring to equation 8),

$$\text{WACC}\ (K_c) = 23\%(23.07\%) + 77\%(17.25\%)(60\%) = 13.28\% \qquad (18)$$

As discussed earlier in section 4.1.1, due to the perceived project risk and operational risk, the project-specific hurdle rate is expected to be greater than the firm-specific WACC to compensate for the additional risk.

The project complexity, represented by the degree of spend on specialized labour is assumed to be a reasonable risk proxy for operational risk. In estimating the project risk, specifically due to implementation delay, a subjective risk approach was taken by calculating the proportion of spend on project management and installation and commissioning relative to the total project spend, and used as a guideline to determine the project risk exposure, which was estimated to be 5%. Similarly, the proportional spend on training relative to the total project spend was used as a guideline to determine the operational risk exposure, which was estimated to be 3%. This risk estimation was assumed to be an upper bound risk. The lower bound project and operational risk were subjectively estimated to be 4% and 2% respectively (i.e. 10 to 20% variability). The impact of this risk assumption on the resulting NPV is analyzed through simulation in section 4.2.1. Therefore we set the project-specific hurdle rate = 13.28% + 4%(project risk e.g. implementation delay) + 2% (operational risk e.g. local skills shortage) = **19.28%** (19)

The resulting risk-adjusted project-specific hurdle rate of 19.28% was used as the discount rate for the project cash flow, as illustrated in table 6 below. Straight line depreciation was used for the 5 year period 2007 to 2011.

## Table 6 DCF (NPV) analysis of the Next Generation Messaging (NGM) project

| *Telecomms Next generation Messaging (NGM) Project* | | | *Project Cash Flow Structure* | | | |
|---|---|---|---|---|---|---|
| ***Euro/Rand Exchange Rate*** | | 9.92 | 12.44 | 12.44 | 12.44 | 12.44 |
| ***S.A Corporate Tax Rate*** | 28% | | | | | |
| ***Forecast Inflation (%)*** | 4.6 | 7.1 | 10.2 | | | |
| ***Subscribers (Forecast)*** | 4,188,880 | 4,835,712 | 6,728,266 | 7,831,581 | 8,608,270 | 9,512,551 |
| NGM License Growth Requirements (Linked to Subscriber Growth) | | | 501,891 | 590,645 | 415,790 | 484,095 |
| NGM Voicemail box unit license cost (EUR 0.5) | | 4.96 | 6.22 | 6.22 | 6.22 | 6.22 |
| **YEAR** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| **CAPEX** | | **-8,582,203** | **-4,212,520** | **-4,173,309** | | |
| Purchase New (NGM) Telco Service Platform | | | | | | |
| Software | | -922,405 | -3,598,465 | | | |
| Hardware | | -4,173,309 | | -4,173,309 | | |
| Licenses (3.1 mil subecriber, incl) | | | | | | |
| Specification Workshop | | -362,334 | | | | |
| Installation & Commissioning | | -283,074 | | | | |
| Basic Service Fee | | | -181,657 | | | |
| Services TAC 2 | | | -68,917 | | | |
| Project Management | | -256,653 | -218,124 | | | |
| Training | | -321,005 | | | | |
| Documentation | | | -88,743 | | | |
| Acceptance Testing | | | -56,614 | | | |
| Network Cabling for NGM E-1's | | -5,897 | | | | |
| NGM Call Flow Changes & Twin Call Development | | -769,200 | | | | |
| Comptel NGM Provisioning Interface upgrade (InstantLink) | | -441,533 | | | | |
| Comptel Dual SIM Provisioning BST Logic (HLR+NGM) | | -63,984 | | | | |
| Accenture Development | | -72,776 | | | | |
| Advanced ASC & Prompts for MVNO (MUNGO) | | -910,033 | | | | |
| NGM License Growth Requirements (excluded from DCF -> Option to Expand) | | | -3,121,759 | -3,673,813 | -2,586,216 | -3,011,071 |
| **OPEX** | **-3,009,689** | **-2,376,000** | **-3,957,215** | **-1,104,000** | **-1,104,000** | **-1,104,000** |
| eZoner Maintenance & Support | -3,009,689 | -2,376,000 | -3,957,215 | | | |
| NGM Maintenance & Support | | | | -1,104,000 | -1,104,000 | -1,104,000 |
| **Total Investment Cost** | **-3,009,689** | **-10,958,203** | **-8,169,735** | **-5,277,309** | **-1,104,000** | **-1,104,000** |
| **Trade-in of Legacy eZoner Platform** | | | **2,290,871** | | | |
| **Capex Savings** | | | | | | |
| **Opex Savings** | | | | **2,010,301** | **2,010,301** | **2,010,301** |
| **Estimated Revenue from services** | **1,442,171** | **1,664,866** | **2,316,445** | **2,696,300** | **2,963,703** | **3,275,034** |
| **EBIT+Depreciation** | **-1,567,518** | **-9,293,337** | **-3,562,419** | **-570,707** | **3,870,005** | **4,181,335** |
| Depreciation New System | | -3,393,606 | -3,393,606 | -3,393,606 | -3,393,606 | -3,393,606 |
| Depreciation Old System | | | | | | |
| EBIT-Depreciation | | -12,686,943 | -6,956,025 | -3,964,314 | 476,398 | 787,729 |
| Tax | | 3,552,344 | 1,947,687 | 1,110,008 | -133,392 | -220,564 |
| **TOTAL CASH FLOW** | | **-5,740,993** | **-1,614,732** | **539,301** | **3,736,613** | **3,960,771** |
| **PV Factor @ 19.28%** | | 0.8384 | 0.7029 | 0.5892 | 0.4940 | 0.4142 |
| **PV** | | -4,813,039 | -1,134,920 | 317,781 | 1,845,898 | 1,640,369 |
| **NPV @19.28%** | **-2,143,911** | | | | | |

The resulting NPV of the Next Generation Messaging (NGM) project investment over a 5 year period is estimated to be **-R2,143,911**. This is a refection of the high capital nature of the project, which is typical of a telecommunications network or services infrastructure investment. The next section 4.1.3 investigates the embedded optionality in the NGM infrastructure investment.

### *4.1.3 Real Options Valuation*

#### *4.1.3.1 Black-Scholes Method*

An option provides the right to buy or sell an asset at a strike/exercise price(K) at or before the option expiration date (t), as illustrated in figure 14 below. Considering a dividend-adjusted Black Scholes model (Damodaran, 2001: 368),

$$\textit{Value of a call option} = S.e^{-yt}.N(d_1) - K.e^{-rt}.N(d_2) \tag{20}$$

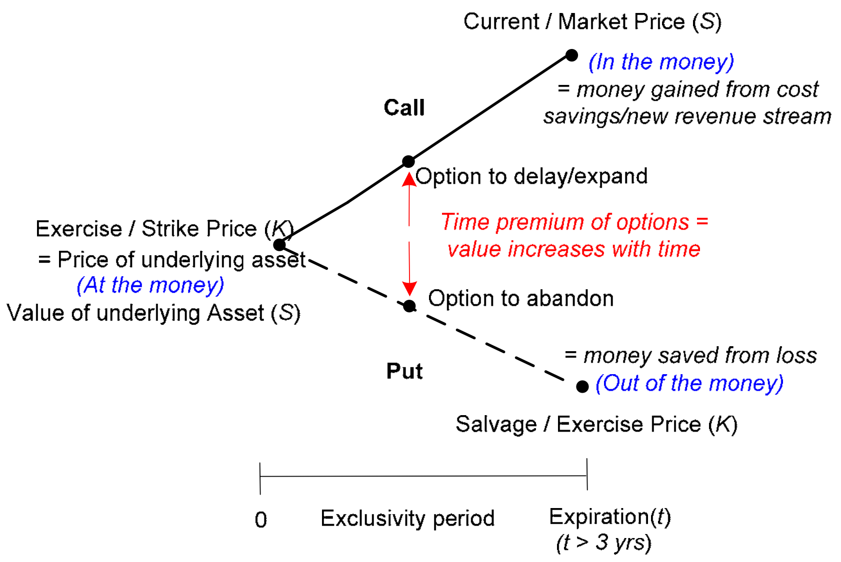
Where, $y$ = dividend yield = dividends / current value of the asset

And, $N(d_1)$ is the risk option probability that the option will end up in the money

Where, $d_1 = \dfrac{\ln\left(\frac{S}{K}\right) + \left(r - y + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$ and $d_2 = d_1 - \sigma\sqrt{t}$

$$\textit{Value of a put option} = K.e^{-rt}.(1-N(d_2)) - S.e^{-yt}.(1-N(d_1)) \tag{21}$$

**Figure 14 Illustration of an Option Pricing Model***



*Based on Damodaran (2001: 391) [Adapted]

When valuing real options, in a scenario where options are not likely to be exercised early (prior to the expiration date) and no dividends are payable, then a dividend-protected options valuation approach can be assumed (Damodaran, 2001: 367).

We calculate the real options value of the iCalled SM option (a priority 1 ranking option as illustrated in table 2 on page 59) using the Black-Scholes method as follows :

The dividend-protected European options Black-Scholes formula (equation 22) is applied in valuing the single call option (option to expand)

$$\textit{Value of a call option} = S.N(d_1) - K.e^{-rt}.N(d_2) \qquad (22)$$

Where, $N(d_2)$ is the risk option probability that the option will end up in the money

And, $d_1 = \dfrac{\ln\left(\frac{S}{K}\right)+\left(r+\frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$ and $d_2 = d_1 - \sigma\sqrt{t}$ (23)

The variables used in equations 22 and 23 are described in table 7 below.

**Table 7 Mapping between project investment growth opportunities and financial (stock) options (Option to expand – Priority 1 option)**

| Investment Opportunity | Variable | Stock Options Equivalent |
|---|---|---|
| Present value of the cash flows (cost savings) obtained from the project expansion option (implementing the iCalled SM option) | S | Stock price |
| Present value of the expenditure required for project expansion | K | Exercise (Strike) price |
| Period that the project expansion option is available for (exclusivity period) | T | Time to expiration |
| Uncertainty in the cash flow (cost savings) generated by the expansion option (implementing the iCalled SM option) | σ | Volatility of returns |
| South African prevailing bond rate<br>i.e. default-free government bond rate<br>(Refer to equation 13) | $R_f$ | Risk-free rate |

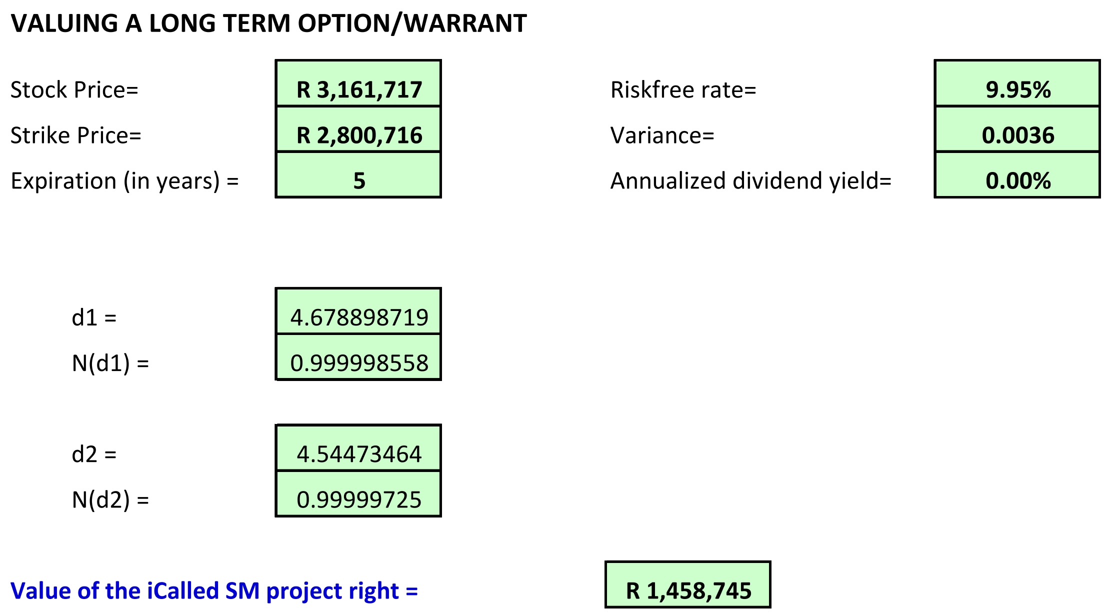
Source: Harmantzis & Tanguturi (2007: 110)

To estimate the volatility (σ) in the cash flow (cost savings) generated by the expansion option (i.e. implementing the iCalled SM priority 1 option), Monte Carlo simulation was used as described in section 4.2.1.2 (table 14). The standard deviation (σ) was estimated to be 6%. According to Athwal et al (2005), an alternative method of estimating volatility (σ) is to use the historical stock price movement of hardware vendor providers. In this instance, the supplier of the NGM hardware is Tecnomen (Finland) which is listed on the OMX Nordic Exchange. Between the first quarter of 2008 and the third quarter of 2008, Tecnomen's closing share price had a standard deviation (σ) of 5.8%. The similarity of the volatility (σ) result obtained using the two methods is assumed to be more on the basis of coincidence rather than causal.

The stock prices (S) is the estimated present value of the cash-flows (Capex savings). The strike price (K) is the total cost towards the iCalled SM option.

**Table 8 Name-Value pairs for the Black-Scholes Option**

| Variable | Value |
|---|---|
| S | 3,161,717 |
| K | 2,800,716 |
| T | 5 years |
| σ<br>(volatility of returns) | 6% |
| $R_f$ | 9.95% |



**VALUING A LONG TERM OPTION/WARRANT**

| | | | |
|---|---|---|---|
| Stock Price= | **R 3,161,717** | Riskfree rate= | **9.95%** |
| Strike Price= | **R 2,800,716** | Variance= | **0.0036** |
| Expiration (in years) = | **5** | Annualized dividend yield= | **0.00%** |

| | |
|---|---|
| d1 = | 4.678898719 |
| N(d1) = | 0.999998558 |
| d2 = | 4.54473464 |
| N(d2) = | 0.99999725 |

**Value of the iCalled SM project right =** **R 1,458,745**

Referring to equation 1, $NPV_{Active} = NPV_{passive} + f(\text{real options value})$

Therefore,

$NPV_{Active}$ (NGM Project) = $NPV_{passive}$ (NGM Project) + Priority 1 Option to Expand

Or

Total Investment Value (NGM Project) = $NPV_{passive}$ + Priority 1 Option to Expand

= -R 2,143,911 + R 1,458,745

= -**R 685,166**

### *4.1.3.2 Binomial Lattice Method*

According to Mun (2006: 139), given the scenario where there is risk or volatility in the project cash flow, and there is an increasing level of uncertainty over time, a binomial lattice can be used to estimate the option value. The greater the uncertainty, the wider the lattice becomes and hence the higher the option value. It can be shown that with volatility in the project cash flow being equal to zero (0), the binomial lattice valuation collapses into a DCF calculation.

Mun (2006: 137) further states that the project risk or volatility (σ) may remain constant over time, but the level of uncertainty increases over time at a factor of $(\sigma\sqrt{\delta t})$, that is, the level of uncertainty increases at the square root of time, and the more time passes, the harder it becomes to predict the future. It is worth noting that it is the uncertainty that drives the value of options in projects. A binomial lattice method is a type of open form discrete simulation, as opposed to a Black-Scholes method in sections 4.1.3.1, which is a closed form valuation method representing a Brownian Motion stochastic process or continuous simulation. But as the discrete simulation steps get smaller and the price process becomes continuous, it can be shown that the binomial model option pricing model converges to a Black Scholes option pricing model (Damodaran, 2002).

We calculate the real options value of the iCalled SM option (a priority 1 ranking option as illustrated in table 2 on page 47) using the binomial lattice method as follows :

The same value of volatility (risk) of 6% which was used in the Black-Scholes method in section 4.1.3.1 is used for the binomial lattice method.

**Table 9 Results of a Binomial Lattice Option Valuation Method**

| ***Assumptions*** | | ***Intermediate Computations*** | |
|---|---|---|---|
| *PV Asset Value ($S_o$)* | R 3,161,717 | *Stepping Time (dt)* | 0.0500 |
| *Implementation Cost* | R 2,800,716 | *Up Step Size (up)* | 1.0135 |
| *Maturity (Years)* | 5.00 | *Down Step Size (down)* | 0.9867 |
| *Risk-free Rate (%)* | 9.95% | *Risk-neutral Probability* | 0.6825 |
| *Dividends (%)* | 0.00% | | |
| *Volatility (%)* | 6.00% | ***Results*** | |
| *Lattice Steps* | 100 | *Auditing Lattice Result (10 steps)* | **R 1,458,744** |
| *Option Type* | European | *Super Lattice Results* | **R 1,458,745** |

The valuation lattice is calculated in two steps (Mun, 2006: 149). The first step is to solve the binomial asset lattice through equations 4 and 6 (pg. 51 and 52), the results of which are illustrated in figure 15. The first node in the lattice (point A) or ($S_0$) is equal to the PV of cost savings from the iCalled SM project expansion option, which totals R3,161,717.

The step size ($\partial t$) = $\frac{Time\ to\ Maturity\ of\ the\ Option\ (yrs)}{No.of\ lattice\ steps}$

$$= 5 / 100$$

$$= 0.05$$

The up ($u$) and down ($d$) step sizes are calculated as follows:

$$u = e^{\sigma\sqrt{\partial t}} = e^{0.06\sqrt{0.05}} = 1.0135$$

$$d = e^{-\sigma\sqrt{\partial t}} = \frac{1}{u} = 0.9867$$

Therefore the up node (point B in figure 15) = $S_0u$ = (R3,161,717)(1.0135) = 3,204,400, and the down node (point C in figure 15) = $S_0d$ = (R3,161,717)(0.9867) = 3,119,581.

The process is repeated as indicated in figure 10 (pg. 51) to show the evolution of the stock price ($S_0$) due to volatility (σ) until the terminal values are reached on the rightmost side of the lattice. This implies that after a period of 5 years, the PV of cost savings from the iCalled SM project expansion option could be anywhere between R2,764,753 and R3,615,678. If the volatility was zero, the lattice would collapse into a straight line, so the terminal value of the lattice would simply be equal to $S_0$.

The second step is to solve the option valuation lattice, the results of which are illustrated in figure 16. The option valuation lattice is calculated through a process called backward induction, moving from right (the terminal nodes) to left, and ending with the option value equal to R1,458,745 (point D on the lattice) in this instance. The terminal nodes in the option valuation lattice are calculated by subtracting the project implementation cost from the terminal values.

The intermediary nodes are calculated using a backward induction analysis formula represented below,

$$[(p)up + (1-p)down]\, e^{-rf(\partial t)}$$

Where, $$p = \frac{e^{rf(\partial t)} - d}{u - d} = \frac{e^{0.0995\,(0.05)} - 0.9367}{1.0135 - 0.9867} = 0.6825$$

And $up$ and $down$ values are the preceding up and down values going from right to left.

As the discrete simulation steps were made smaller (that is, from 10 to 100 steps) the binomial model option pricing model converged to a Black Scholes option pricing model, resulting in a virtually identical value of the iCalled SM project right.

## Figure 15 Binomial Lattice illustration of the Project Expansion Option (NGM iCalled SM Project Option)

***Underlying Asset Lattice***

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | R 3,615,678 |
| | | | | | | | | | R 3,567,492 | |
| | | | | | | | | R 3,519,949 | | R 3,519,949 |
| | | | | | | | R 3,473,039 | | R 3,473,039 | |
| | | | | | | R 3,426,755 | | R 3,426,755 | | R 3,426,755 |
| | | | | | R 3,381,087 | | R 3,381,087 | | R 3,381,087 | |
| | | | | R 3,336,028 | | R 3,336,028 | | R 3,336,028 | | R 3,336,028 |
| | | | R 3,291,569 | | R 3,291,569 | | R 3,291,569 | | R 3,291,569 | |
| | B | R 3,247,703 | | R 3,247,703 | | R 3,247,703 | | R 3,247,703 | | R 3,247,703 |
| A | R 3,204,422 | | R 3,204,422 | | R 3,204,422 | | R 3,204,422 | | R 3,204,422 | |
| **R 3,161,717** | | R 3,161,717 | | R 3,161,717 | | R 3,161,717 | | R 3,161,717 | | R 3,161,717 |
| | R 3,119,581 | | R 3,119,581 | | R 3,119,581 | | R 3,119,581 | | R 3,119,581 | |
| | C | R 3,078,007 | | R 3,078,007 | | R 3,078,007 | | R 3,078,007 | | R 3,078,007 |
| | | | R 3,036,987 | | R 3,036,987 | | R 3,036,987 | | R 3,036,987 | |
| | | | | R 2,996,514 | | R 2,996,514 | | R 2,996,514 | | R 2,996,514 |
| | | | | | R 2,956,580 | | R 2,956,580 | | R 2,956,580 | |
| | | | | | | R 2,917,178 | | R 2,917,178 | | R 2,917,178 |
| | | | | | | | R 2,878,302 | | R 2,878,302 | |
| | | | | | | | | R 2,839,943 | | R 2,839,943 |
| | | | | | | | | | R 2,802,096 | |
| | | | | | | | | | | R 2,764,753 |

**Figure 16 Binomial Lattice illustration of the Project Expansion Option (NGM iCalled SM Project Option)**

***Option Valuation Lattice***

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | R 1,825,840 |
| | | | | | | | | | R 1,786,537 | |
| | | | | | | | | R 1,747,832 | | R 1,730,111 |
| | | | | | | | R 1,709,716 | | R 1,692,084 | |
| | | | | | | R 1,672,183 | | R 1,654,637 | | R 1,636,917 |
| | | | | | R 1,635,222 | | R 1,617,764 | | R 1,600,131 | |
| | | | | R 1,598,827 | | R 1,581,456 | | R 1,563,911 | | R 1,546,190 |
| | | | R 1,562,990 | | R 1,545,704 | | R 1,528,246 | | R 1,510,614 | |
| | | R 1,527,702 | | R 1,510,502 | | R 1,493,131 | | R 1,475,586 | | R 1,457,865 |
| D | R 1,492,956 | | R 1,475,842 | | R 1,458,557 | | R 1,441,099 | | R 1,423,466 | |
| **R 1,458,745** | | R 1,441,716 | | R 1,424,516 | | R 1,407,145 | | R 1,389,600 | | R 1,371,879 |
| | R 1,408,116 | | R 1,391,002 | | R 1,373,717 | | R 1,356,259 | | R 1,338,626 | |
| | | R 1,358,006 | | R 1,340,807 | | R 1,323,435 | | R 1,305,890 | | R 1,288,170 |
| | | | R 1,308,408 | | R 1,291,123 | | R 1,273,665 | | R 1,256,032 | |
| | | | | R 1,259,314 | | R 1,241,942 | | R 1,224,397 | | R 1,206,677 |
| | | | | | R 1,210,716 | | R 1,193,258 | | R 1,175,626 | |
| | | | | | | R 1,162,608 | | R 1,145,063 | | R 1,127,343 |
| | | | | | | | R 1,114,981 | | R 1,097,349 | |
| | | | | | | | | R 1,067,831 | | R 1,050,111 |
| | | | | | | | | | R 1,021,148 | |
| | | | | | | | | | | R 974,928 |

## 4.2 Risk Analysis

### *4.2.1 Monte Carlo Simulations*

#### *4.2.1.1 NPV*

Since no historical risk data on the NGM project implementation exists, a risk simulation approach was selected in modelling the impact of project and operational risk assumptions made in equation 19 (section 4.1.2). The approach is similar to the technique followed by Winston (1996) in conducting sensitivity analysis on a cash flow model using Monte Carlo simulation. As stated earlier, Winston (1996) further argues that when future cash flows for an investment project are known with certainty, a company is likely to choose the project with the largest NPV. But if future cash flows are not known with certainty, then it is not clear whether or not to invest in the project.

Mun (2006: 372) suggests the use of a triangular distribution function where the minimum, maximum and most likely values are known. Given the risk assumptions stated (which resulted in the formulation of equation 19), the triangular distribution function values are stated as follows :

**Table 10 Triangular Distribution Risk Simulation Values**

| | Minimum | Most likely | Maximum |
|---|---|---|---|
| Project risk | 4% | 4.5% | 5% |
| Operational risk | 2% | 2.5% | 3% |

Source: Risk assumptions as described in equation 19 (section 4.1.2)

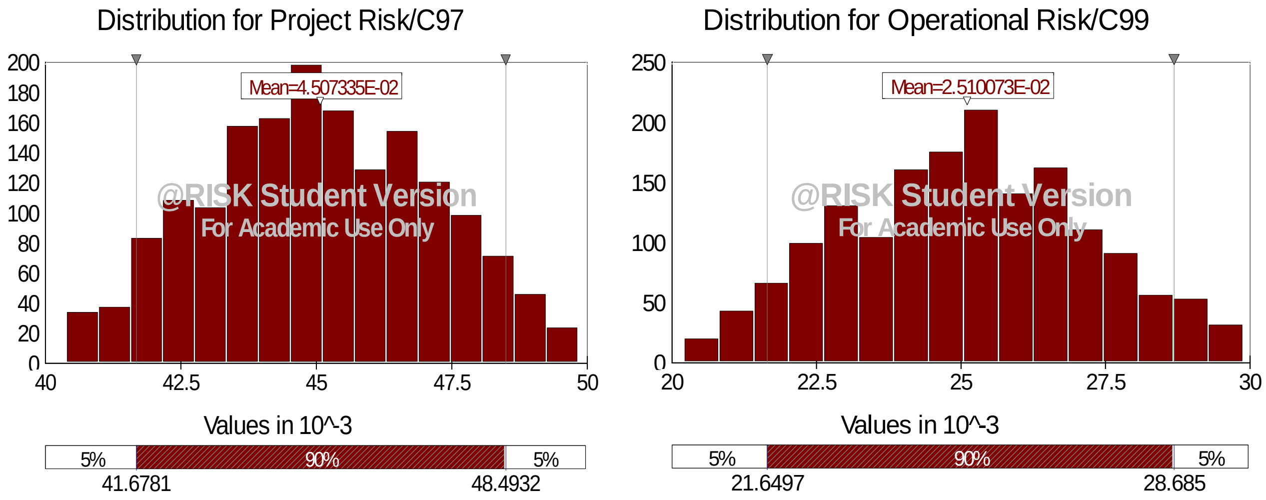
In agreement with Chelst & Bodily (2000), more complex decision sensitivity analysis is required when analyzing how changes in a continuous random variable resulting in a probability distribution affects the outcome, decisions and optimality. Using simulation, one can obtain a frequency distribution (also known as histogram) for the NPV of a project (Winston, 1996). For example, simulation enables questions like the probability that an investment will yield at least a 20% return, or the probability that an investment will have an NPV ≤ $1 billion to be modelled. Also, investing in a project with the largest NPV may not be the best decision for a risk-averse company. A project with a high NPV is usually accompanied by greater risk.

The Monte Carlo simulation results are presented as follows :

**Table 11 Monte Carlo Simulation Input and Output Summary**

| **Output Name** | **Output Cell** | **Minimum** | **Maximum** | **Mean** | **Std Dev** |
|---|---|---|---|---|---|
| **NPV** | **$C$91** | -2,284,166 | -2,162,366 | -2,221,744 | 21,409 |
| | | | | | |
| **Input Name** | **Input Cell** | **Minimum** | **Maximum** | **Mean** | **Std Dev** |
| **Project Risk** | **$C$97** | 0.040405799 | 0.049844362 | 0.045073353 | 0.002076956 |
| **Operational Risk** | **$C$99** | 0.020220075 | 0.029892744 | 0.025100731 | 0.002086887 |

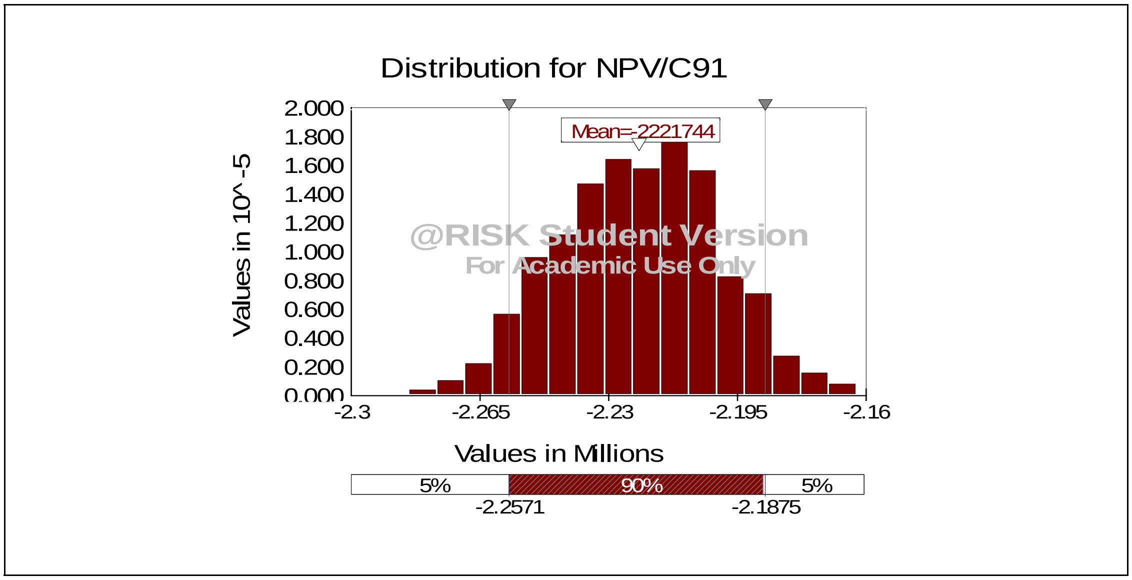
**Figure 17 Monte Carlo Simulation Input Variables (Project and Operational Risk)**



Distribution for Project Risk/C97

Distribution for Operational Risk/C99

**Figure 18 Monte Carlo Simulation Output (NPV)**



As indicated in figure 18, there's a 90% probability that the resulting NPV will be greater than -R2,26m and less than –R2,19m , given a 0.5% variation in the input risk factors (project and operational risk respectively).

### *4.2.1.2 Real Options*

The present value of the cash flows (cost savings) that could be realized from the project expansion option, that is implementing the iCalled SM option is estimated in table 12 below, over a 5 year period. The iCalled SM option essentially results in a Capex license cost saving towards the NGM system voicemailbox capacity growth demand. The growth in capacity demand is linked to the forecast subscriber growth as illustrated in table 12.

## Table 12 PV analysis of the iCalled SM Option

| ***Telecomms Next Generation Messaging (NGM) Project*** | | | ***Project Cash Flow - iCalled SM Option*** | | | | |
|---|---|---|---|---|---|---|---|
| ***Euro/Rand Exchange Rate*** | | 9.92 | 9.85975 | 9.85975 | 9.85975 | 9.85975 | 9.85975 |
| ***S.A Corporate Tax Rate*** | 28% | | | | | | |
| ***Forecast Inflation (%)*** | 4.6 | 7.1 | 10.2 | | | | |
| ***Subscribers (Forecast)*** | 4,188,880 | 4,835,712 | 6,728,266 | 7,831,581 | 8,608,270 | 9,512,551 | 10,107,709 |
| NGM License Growth Requirements (Linked to Subscriber Growth) | | | 501,891 | 590,645 | 415,790 | 484,095 | 318,610 |
| NGM Voicemail box unit license cost (EUR 0.5) | | 4.96 | 4.93 | 4.93 | 4.93 | 4.93 | 4.93 |
| **YEAR** | | | **Year-1** | **Year-2** | **Year-3** | **Year-4** | **Year-5** |
| **CAPEX** | | | **2,474,260** | **2,911,806** | **2,049,793** | **2,386,528** | **1,570,707** |
| NGM License Growth Requirements | | | 2,474,260 | 2,911,806 | 2,049,793 | 2,386,528 | 1,570,707 |
| **Capex Savings** | | | **2,474,260** | **2,911,806** | **2,049,793** | **2,386,528** | **1,570,707** |
| **EBIT+Depreciation** | | | **2,474,260** | **2,911,806** | **2,049,793** | **2,386,528** | **1,570,707** |
| Depreciation New System | | | 2,278,619 | 2,278,619 | 2,278,619 | 2,278,619 | 2,278,619 |
| EBIT-Depreciation | | | 4,752,879 | 5,190,425 | 4,328,412 | 4,665,147 | 3,849,326 |
| Tax | | | -1,330,806 | -1,453,319 | -1,211,955 | -1,306,241 | -1,077,811 |
| **TOTAL CASH FLOW** | | | **1,143,454** | **1,458,487** | **837,838** | **1,080,287** | **492,896** |
| **PV Factor** | | | 0.8314 | 0.6912 | 0.5747 | 0.4778 | 0.3972 |
| **PV** | | | 950,660 | 1,008,128 | 481,481 | 516,137 | 195,789 |
| **PV of cost savings from the project expansion option (S)** | **3,152,196** | | | | | | |
| Project hurdle rate | 20.3% | | | | | | |
| WACC | 0.1328 | | | | | | |
| Project Risk | 0.045 | | | | | | |
| Operational Risk | 0.025 | | | | | | |

According to Svavarsson (2004), depending on the industry environment (the cellular telecommunications industry in this context), IT investments may yield highly uncertain strategic future benefits, subject to various types of risks. The volatility of returns or risk in the cash flow (cost savings) indicated in table 12, generated by the expansion option 1 (that is, implementing the iCalled SM option) is influenced by several factors, namely :

- Price fluctuation in the NGM system voicemail box license unit cost due to Euro/Rand exchange rate fluctuation.
- Volatility in voicemailbox capacity demand growth forecast due to subscriber churn on the network. Svavarsson (2004) described this as interaction risk between external parties and the system, in the context of an IT platform investment. The standard deviation (σ) in the operator's voicemail capacity demand was estimated to be 2% (refer to Appendix D - descriptive statistics of the operator's voicemail capacity planning data).
- Risk in the implementation and operation of the iCalled SM option. Svavarsson (2004) described this as technology risk.

Given the variability in the input variables described above and listed in table 13, a Monte Carlo simulation was performed to establish the resulting volatility of the output variable (volatility of returns) (results shown in table 14), that is the volatility of the present value of cost savings from the project expansion option (S). Following Mun's (2006: 372) suggestion, triangular distribution functions were used for the input variables since the minimum, maximum and most likely values were known.

**Table 13 Triangular Distribution Risk Simulation Input Variables**

| | Minimum | Most likely | Maximum |
|---|---|---|---|
| Rand/Euro exchange rate volatility | R7.19 | R9.56 | R12.84 |

Source: South African Reserve Bank (2006 - 2008)

| | Minimum | Most likely | Maximum |
|---|---|---|---|
| Voicemailbox capacity demand volatility (Yr-1) | 491,853 | 501,891 | 511,929 |
| Voicemailbox capacity demand volatility (Yr-2) | 578,832 | 590,645 | 602,458 |
| Voicemailbox capacity demand volatility (Yr-3) | 407,474 | 415,790 | 424,106 |
| Voicemailbox capacity demand volatility (Yr-4) | 474,413 | 484,095 | 493,777 |
| Voicemailbox capacity demand volatility (Yr-5) | 312,238 | 318,610 | 324,982 |

Source: The operator's voicemail capacity planning data (2006 - 2007)

| | Minimum | Most likely | Maximum |
|---|---|---|---|
| Project risk | 4% | 4.5% | 5% |
| Operational risk | 2% | 2.5% | 3% |

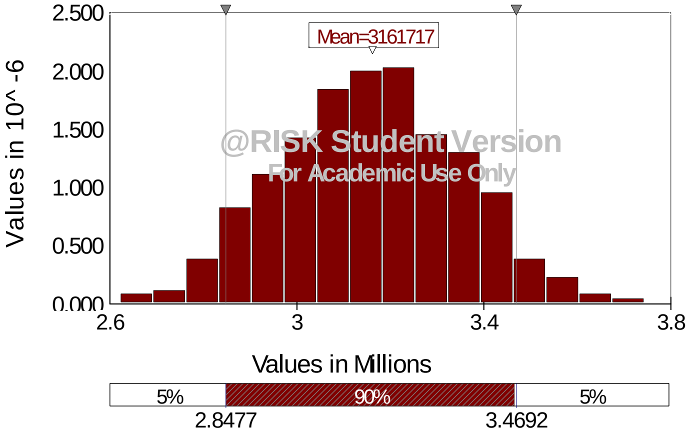
Source: Risk assumptions as described in equation 12 (section 3.5.2.2)

**Table 14 Monte Carlo Simulation Input and Output Summary**

| Output Name (S) | Output Cell | Minimum | Maximum | Mean | Std Dev |
|---|---|---|---|---|---|
| PV of cost savings from the project expansion option (S) | $C$30 | 2,623,551 | 3,745,008 | 3,161,717 | 193,920<br>**(6%)** |
| | | | | | |
| **Input Name** | **Input Cell** | **Minimum** | **Maximum** | **Mean** | **Std Dev** |
| Euro/Rand exchange rate volatility (Year-1) | $G$3 | 7.316734314 | 12.7351675 | 9.957351526 | 1.132819402 |
| Euro/Rand exchange rate volatility (Year-2) | $I$3 | 7.314236164 | 12.65065765 | 9.878611214 | 1.171654893 |
| Euro/Rand exchange rate volatility (Year-3) | $K$3 | 7.303875446 | 12.58619022 | 9.828221738 | 1.1623525 |
| Euro/Rand exchange rate volatility (Year-4) | $M$3 | 7.237301826 | 12.6957407 | 9.845551296 | 1.136296193 |
| Euro/Rand exchange rate volatility (Year-5) | $N$3 | 7.263258934 | 12.6394043 | 9.82661919 | 1.168515185 |
| Capacity demand volatility (Year-1) | $G$7 | 492619.9063 | 511493.0625 | 502100.4733 | 4018.79203 |
| Capacity demand volatility (Year-2) | $I$7 | 579202.125 | 602166.6875 | 590731.0823 | 4844.271567 |
| Capacity demand volatility (Year-3) | $K$7 | 407633.4063 | 423768.6563 | 415919.3473 | 3359.717225 |
| Capacity demand volatility (Year-4) | $M$7 | 474796.2188 | 493630.5 | 484112.8638 | 3946.017086 |
| Capacity demand volatility (Year-5) | $N$7 | 312504.875 | 324544.1563 | 318372.2532 | 2595.729064 |
| Project Risk | $C$36 | 0.040484183 | 0.049757745 | 0.045055563 | 0.002018938 |
| Operational Risk | $C$38 | 0.020236133 | 0.02988001 | 0.025064275 | 0.002102812 |

The resulting simulation distribution graphs representing the input variables in table 13 are listed in Appendix A. The simulation distribution graph representing the output variable (S) is shown in figure 19, having a mean value of R3,161,717, a minimum value of R2,623,551 and a maximum value of R3,745,008. The volatility of the output variable (S), that is the volatility of returns was estimated to be 6%.

**Figure 19 Monte Carlo Simulation Output (*S*)**



## 4.3 Decision Analysis

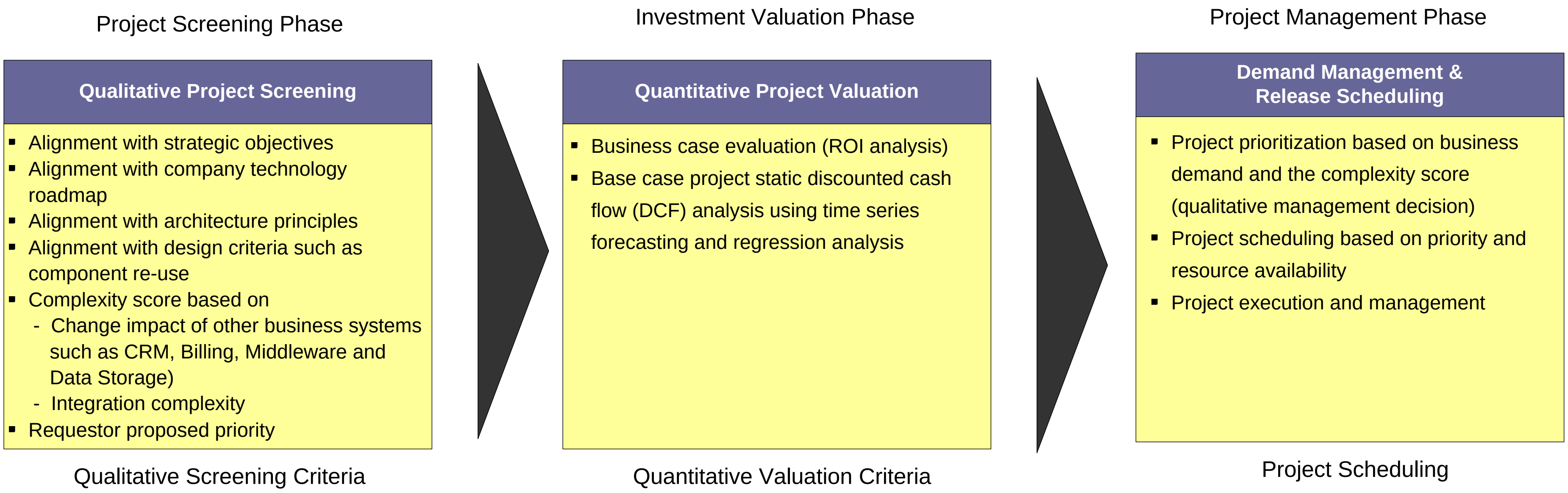
### 4.3.1 *Current Decision Analysis Process*

When valuing and selecting major business projects at the cellular operator considered in this case, the process outlined in figure 20 below is followed in decision making. The process comprises a qualitative screening step guided by company objectives. During this step, executive management review the business requirements originating from the various business units (such as marketing, network operations, service delivery etc). Approval in the qualitative screening process is primarily driven by the degree to which the project supports the company strategy and operating plan.

The second step is quantitative assessment, where the business case for the project is evaluated. The model currently in use is the static DCF analysis, so a blanket criterion of $NPV_{passive} \geq 0$ (refer to equation 1) is used, subject to budget availability. For some projects, only the total investment or total cost of ownership (TCO) in terms of Capex and Opex is compared against the available budget for approval, where business benefits are envisaged, but difficult to estimate (hence the question of not knowing what do with uncertainty).

The final step is project prioritization and scheduling for execution. In this instance projects are ranked by executive management based on a combination of qualitative judgement, pressure in terms of business demand and the project complexity score. The project management office then schedules the project guided by the priority ranking and resource availability.

**Figure 20 Current Project Decision Analysis Process at an incumbent operator**



Project Screening Phase

**Qualitative Project Screening**

- Alignment with strategic objectives
- Alignment with company technology roadmap
- Alignment with architecture principles
- Alignment with design criteria such as component re-use
- Complexity score based on
  - Change impact of other business systems such as CRM, Billing, Middleware and Data Storage)
  - Integration complexity
- Requestor proposed priority

Qualitative Screening Criteria

Investment Valuation Phase

**Quantitative Project Valuation**

- Business case evaluation (ROI analysis)
- Base case project static discounted cash flow (DCF) analysis using time series forecasting and regression analysis

Quantitative Valuation Criteria

Project Management Phase

**Demand Management & Release Scheduling**

- Project prioritization based on business demand and the complexity score (qualitative management decision)
- Project scheduling based on priority and resource availability
- Project execution and management

Project Scheduling

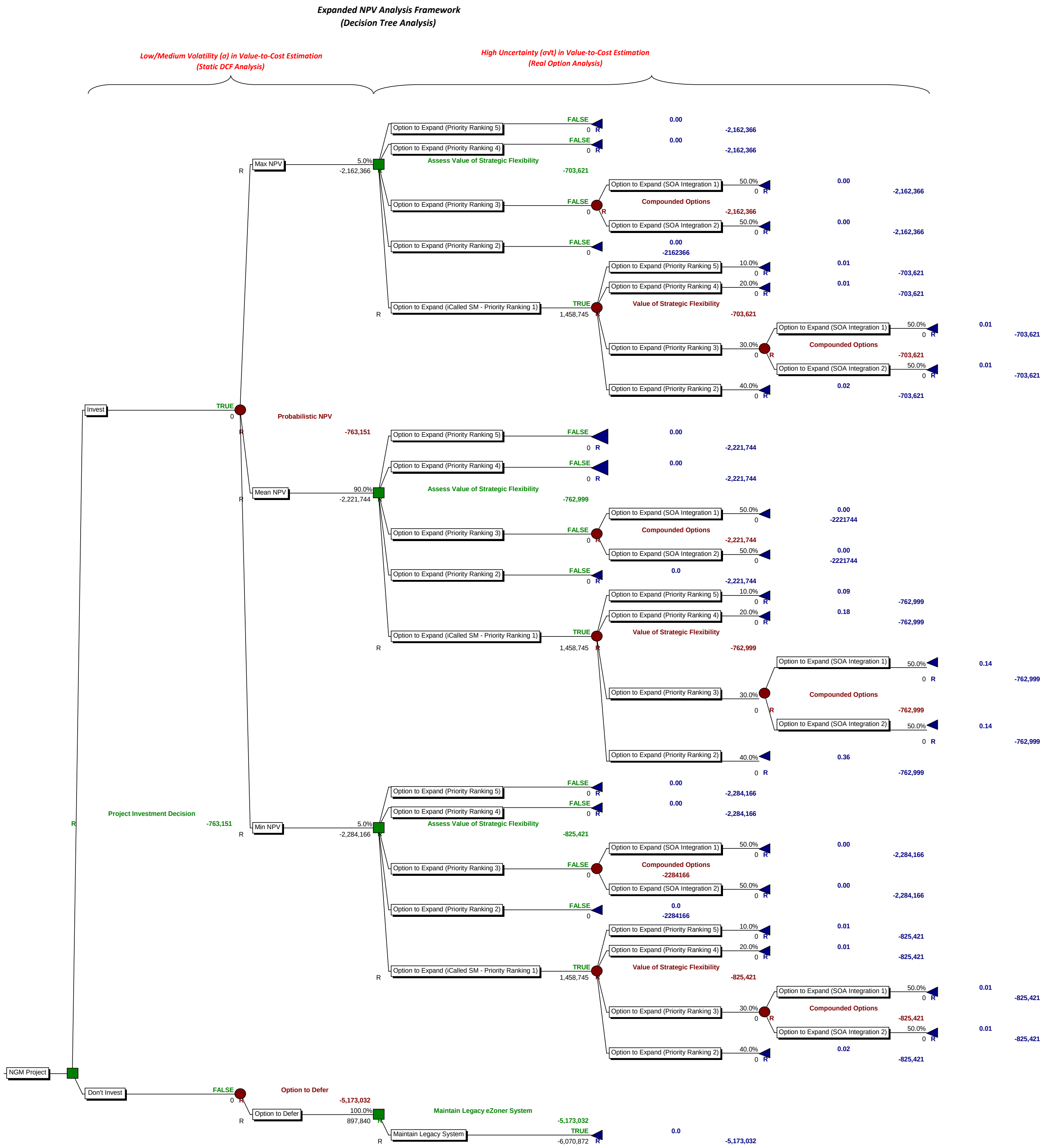
### *4.3.2 Decision Tree Analysis*

A decision tree model is developed in this study to determine its effectiveness is selecting an optimal investment route, given the various options available following the base project implementation. The outcome of the analysis should drive the ultimate decision of whether to invest or not to invest in the next generation messaging (NGM) project, given its total investment potential.

As illustrated in figure 21, the first node in the tree denotes the decision tree name. The green square nodes are the decision nodes, and the brown round nodes are chance nodes indicating that multiple outcomes are possible, along with the subjective probability of that outcome and the associated payoff. The blue triangular nodes are end nodes. The optimal path through the decision tree is made up of nodes labelled 'TRUE'. The payoff of a specific path is indicated by the number to the right of the blue rectangular end node, along with the probability of that specific path.

Appendix B1 illustrates the cash flow model used to estimate the present value of project benefits (S) and present value of the investment cost (K), which were used to calculate the real options value of the option to defer the NGM project (results shown in Appendix B2).

# Figure 21 Decision Tree Analysis Results



# CHAPTER 5

| OBJECTIVES |
|---|
| • To discuss the findings of the study |

# 5 DISCUSSION OF RESULTS

## 5.1 Investment Valuation

Renkema (2000) cited in Svavarsson (2004) found that IT infrastructure investments often fuel innovations, leading to a sequence of investment phases with associated strategic value. An ERP system is a good example, with multiple applications integrated into a single platform. This results in a complex valuation exercise. This study demonstrates similar findings to Svavarsson (2004) with investments in next-generation service delivery architectures in the cellular telecommunications industry. The efficiency of the new service architecture design not only results in operational benefits (cost savings), but often provides a complex set of real options. The next-generation messaging (NGM) system assessed in this study was characterized by five non-mutually exclusive options-to-expand.

The passive NPV of the next-generation messaging (NGM) project is estimated at negative R2,1m, within a 5 year period. This is based on the static discounted cash flow analysis, where the costs and benefits (that is, revenues and cost savings) are estimated deterministically using basic time series forecasting. The risk-adjusted project cash flow discount rate used in the analysis was 19.28%, compared to the firm's WACC of 13.28%; the project discount rate was driven by a combination of objective risk and subjective risk premium, where the latter was accounted for as project risk and operational risk.

The total investment value of the NGM project (also known as the active NPV) was estimated to be negative R685k, having factored in the embedded real option value (option-to-expand) of the iCalled SM option, which was ranked as priority 1 option in this instance. A Black-Scholes model was used to estimate the option value, using a volatility (risk) value of 6% estimated through Monte Carlo simulation. To validate the Black-Scholes model applied in the real option analysis, the results were compared against the binomial lattice approach using 100 lattice steps in estimating the option value and the same result was obtained. This agrees with Damodaran's (2002) finding that when the binomial lattice model steps are made sufficiently small, the binomial option pricing model converges to a Black Scholes option pricing model. Mun's (2006) research where

100 to 1000 time-steps showed sufficiently good valuation approximation also support findings in this study. This indicates that closed form models such as Black-Scholes, traditionally used for valuing financial options can be used in the valuation of embedded options in next-generation service delivery technology architectures in the cellular telecommunications industry. This is despite their limited modelling flexibility as according to Mun (2006).

## 5.2 Risk Analysis

In agreement with Tiwana et al (2006), the absence of a traded market for IT assets can lead to difficulty in estimating real options parameters, the specific example in this study being the volatility (σ) parameter. This constraint was resolved by following Winston's (1996) suggestion of using simulation to conduct risk analysis when investing under uncertainty. Given that the NGM project is based on a new design architecture, with no reference installations in South Africa, hence no historical risk data on the project implementation being available, risk analysis was conducted through simulation. Sensitivity analysis using Monte Carlo simulation showed that a 0.5% variability in the project and operational risk as input factors resulted in 2.8% variability in the project NPV.

In the case of real options, simulation provided insight in estimating the volatility of returns (σ), which was estimated at 6% for the iCalled SM option-to-expand. The volatility in returns is essentially an estimate of the uncertainty of strategic future benefits. In the case of the iCalled SM option, the volatility (risk) is influenced by several factors such as price fluctuation, volatility in voicemailbox capacity demand and the project risk in implementing the option.

Although simulation was used to estimate volatility (σ) in this study, an alternative approach suggested by Harmantzis & Tanguturi (2007) in valuing investments in next-generation wireless networks is that of using the company's historical price movements. Harmantzis & Tanguturi (2007) further suggest using the company's historical price movements for the instance where the company collects its revenue from an existing customer base. This naturally requires the company to be publicly listed, which was not the case in this context. If significant revenue is derived from a new customer base, the country’s telecom index is suggested Harmantzis & Tanguturi (2007). As a way of comparison, the NGM supplier (Tecnomen, Finland) which is listed on the OMX Nordic Exchange, had a historical closing share price standard deviation (σ) of 5.8% between the first quarter in 2008 and the third quarter in 2008, which is similar to the 6% volatility estimated through simulation. The similarity of the volatility (σ) result obtained using the two methods however is likely to be coincidental rather than due to causalilty.

## 5.3 Decision Analysis

Based on data collected from 88 firms, Tiwana et al (2007: 158) found that IT management were likely to associate real options with value only when the easily quantifiable benefits of a project were low. In other words, management tended to apply real options analysis only when the deterministically derived project NPV was negative, and tended to ignore real options value when the project NPV was positive, due to bounded rationality bias (that is, using a subset of the available information to make a decision). This study suggests curbing the bounded rationality bias by integrating real options analysis in the decision analysis process, as illustrated in figure 22 on pg. 99, regardless of the static project NPV. In this way, the decision analysis process extends the NPV concept to incorporate the value of strategic flexibility when dealing with next-generation technology projects in the cellular industry.

The cellular telecommunications next-generation messaging (NGM) project considered in this study seemed to fit the two stage decision tree model suggested by Dai, Kauffman & March (2007) when valuing IT infrastructure investments: stage 1 comprising infrastructure investment and stage 2 being growth options. In analyzing the next-generation messaging (NGM) project investment decision, if the ‘Do Invest’ decision is taken (that is, the branch marked ‘TRUE’ on the decision tree in figure 21), there is a total 90% probability (36% + 13.5% + 13.5% + 18% + 9%) that the net payoff of the NGM project i.e. the active NPV will be negative R762,999. Due to lack of historic data on the NGM project outcome, since it would be the first implementation in South Africa, subjective probabilities were considered the next best option to use in the decision tree, a process supported by Howard (1984) cited in Ekstrom & Bjornsson (2003) when dealing with IT projects. The consequence of subjectively assigned probabilities however, is that they result in a subjective adjustment of the project value. In this study, the subjective adjustment resulted in an 11.4% downward adjustment of the total investment value (NGM project) to negative R762,999, compared to negative R685,166 determined using equation 1 on page 36.

This net payoff estimation takes into account the sensitivity analysis performed on the passive NPV in section 4.2.1.1, where the mean NPV of the initial infrastructure investment was estimated at negative R2,221,744 (at a 90% probability as per figure 18). However, the net payoff calculated has only factored in one of the available options listed in table 2, that is the highest priority ranking option, in stage 2 of the project. This was as per delimitation of this study to demonstrate the concept. The iCalled SM option-to-expand yielded a premium of R1,458,745 as demonstrated in sections 4.1.3.1 and 4.1.3.2. It is expected that if the remaining options-to-expand (with priority ranking 2 to 5) were to be factored into the analysis, the net payoff (active NPV) of the NGM project would be greater than zero.

If the 'Don't Invest' decision is taken (i.e. the branch marked 'FALSE' on the decision tree in figure 21), the option to defer the NGM project results in an option rights value of R897,849 due to management flexibility. But the on-going use of the legacy system however has an implied cost of negative R6,070,872 over a 5 year period as illustrated in appendix C1. As a result, the net payoff of the "Don't Invest" decision carries a net loss of negative R5,173,032.

Based on the decision tree analysis approach, the final recommendation to the cellular operator's management is to extend the investment analysis to encompass all the available options to expand the next generation messaging (NGM) platform to arrive at a net worth value, prior to taking a decision whether or not to invest in the new generation system. The NGM net worth value must then be weighed against the implied net cost of R5.2m for maintaining the legacy system.

## 5.4 Implications on Research Propositions

*Proposition 1 was stated as follow: A combination of discounted cash flow and real options investment valuation provides a more comprehensive and effective means of valuing investment returns in present value terms and strategic flexibility inherent in next-generation telecommunications service architecture investments.*

This proposition is valid. The researcher proposed estimating the net worth of a complex, high risk project characterized by embedded real options, based on the next-generation messaging (NGM) architecture in a telecommunications environment, using a combination of traditional DCF analysis and real options analysis. The result was that the in the money option-to-expand (the iCalled SM expansion option) added a premium on the base value of the project. The option-to-defer the NGM project, albeit an in-the-money benefit, indicated that it would not be of sufficient value to compensate for the expense of maintaining the existing legacy voicemail system.

*Proposition 2 was stated as follows: The uncertainty in value estimation of future opportunities and net benefits derived from investments in next-generation service architectures can be modelled and analyzed.*

This proposition is valid. This study provided insight through the use of sensitivity analysis and risk modelling in estimating the impact of input risk factors on the resulting investment returns. For example, risk modelling demonstrated that a 0.5% change in the input risk factors (that is, project and operational risk) typically resulted in a 2.8% variability in the NPV for the NGM project. This provides management with insight in identifying where to control for risk to mitigate changes in the predicted NPV. In terms of real options, given the newness of the NGM platform architecture, with no historical reference on the project implementation risk, simulation proved useful in estimating the volatility of returns for the embedded options. Changes in volatility (uncertainty) affect the option value and hence the decisions. As with financial call options, the more volatile the real option the more valuable the option.

*Proposition 3 was stated as follows: A decision framework for guiding capital investments in next-generation telecommunications service-oriented architectures can be developed* *based on a combination of both quantitative analysis and qualitative criteria in capital investment valuation.*

This proposition is valid. The researcher proposed developing a framework for guiding capital investments in next generation telecommunications service-oriented architectures which are often associated with high risk and uncertainty. A quantitative decision tree model was developed which demonstrated the process of selecting an optimum path when a series of real options are made available through leveraging the initial infrastructure investment. Additionally, management's qualitative judgement was factored in, through the qualitative screening process of a project, and the real options prioritization process guided by several factors such as business demand. The result is a decision framework that combines a quantitative and qualitative decision process (illustrated in figure 22) for making large scale capital investments in a situation of significant volatility and long-term uncertainty.

# CHAPTER 6

**OBJECTIVES**

- To draw conclusions and make recommendations
- To make suggestions for further research

# 6 CONCLUSIONS & RECOMMENDATIONS

## 6.1 Introduction

This chapter summarizes the main findings of the study, relating to the problem of establishing whether real options valuation and decision analysis techniques can be applied to capital investment decisions in next-generation service-oriented architectures in cellular telecommunications environments. Recommendations are proposed, and suggestions for future research are made.

## 6.2 Conclusion

The first sub-problem was to test the application of non-probabilistic and probabilistic techniques such as static cash flow and real options in valuing technology investments in the cellular telecommunications industry.

This study has established that in the short to medium term time horizon (such as less than or equal to 5 years), static discounted cash flow (DCF) analysis can be applied successfully to a base project in next-generation technology investments in the cellular telecommunications industry. The base project in this context (a next-generation messaging (NGM) project) is primarily an infrastructure project, made up of hardware installation, software configuration and application customization where necessary. It is essential that the costs and benefits (revenue and cost savings) can be estimated deterministically for this approach to be feasible. As illustrated in figure 2, this is made possible by considering cash flows over a historical period and a forecast period which falls within the forecast budget horizon.

The risky nature of the NGM project in a cellular operator environment requires the application of a project-specific hurdle rate, which takes into account the project risk and operational risk in discounting the project cash flows. In this study, the project hurdle rate was estimated at 19.28%, compared to the firm's WACC estimated at 13.28%, which supports the claim made by Firer et al (2004) that WACC should only be applied to projects that share a similar profile to the firm risk, or risky projects are likely to be incorrectly accepted. For the non-probabilistic static cash flow method to yield reliable results however, despite the high discount rate, the volatility (σ) in value-to-cost estimation is required to be relatively low.

In the case where the technology infrastructure has embedded options, such as the option to expand or option to defer, the result is a premium which is added to the passive NPV that was estimated through DCF analysis. Based on the findings of the iCalled SM option to expand project right, the resulting active NPV was substantially greater than the passive NPV, and would most likely positively influence the investment decision. The iCalled SM option to expand in this study resulted in a 68% premium being added to the base value of the NGM project.

The NGM technology platform assessed in this study was recently introduced to the market, with no reference installations in the South African context, and hence no historical reference to volatility (risk). A Monte Carlo simulation method was used to estimate volatility. It is expected that the iCalled SM option to expand considered in this study would only be exercised in the long term time horizon (that is, after year-5, dependant on successful completion of the base project), so there would be significant uncertainty ($\sigma\sqrt{t}$) in the value-to-cost estimation between year-5 and year-10. If the service provider took the decision to exercise the option early, the value of the iCalled SM project right would have to be re-evaluated.

The second sub-problem was to analyze the risk or sensitivity associated with investments in new technology architectures in a telecommunications environment

The Monte Carlo simulation method suggested by Winston (1996) was adopted in this study in modeling the effect of risk on implementing the next generation messaging (NGM) architecture in a cellular telecommunications operator environment. The type of input risk associated with implementing the new service delivery architecture was categorized into project risk and operational risk.

The sensitivity analysis model for the NGM project was developed using triangular distribution functions for input risk factors, where the minimum, maximum and most likely risk values could be estimated based on the stated assumptions. The model resulted in a risk/return ratio that was found to be approximately six times, that is a 0.5% risk factor resulted in a 2.8% variability in the expected NPV. The model output was a frequency distribution for the NPV allowing for a probabilistic estimation of the NPV value; the case example used in this study resulted in a 90% probability that the NPV was greater than -R2,257m and less than –R2,188m, given the 0.5% variation in the input risk. Ultimately, it is management's ability to control for risk that would influence the investment decision.

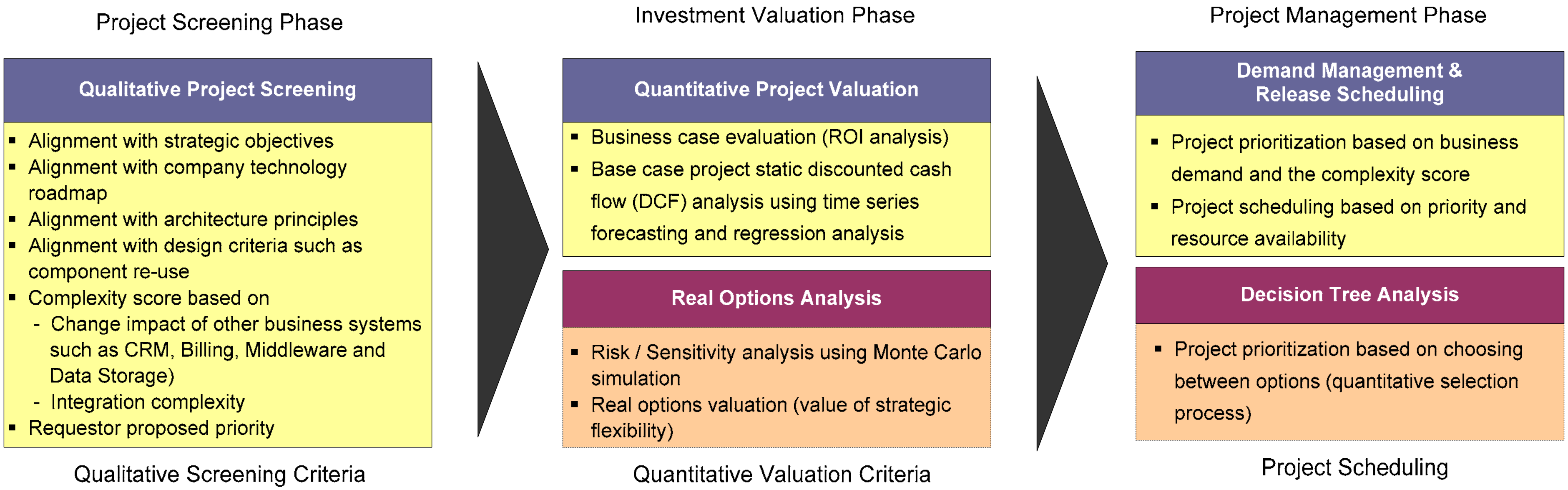
The initial investment in the new messaging architecture base project would make follow-on projects (referred to as real options) possible, together with the associated managerial flexibility in decision making for implementing these projects. In assessing the value contribution of these possible follow-on projects, it was found that the volatility in the expected cash flows, coupled with the period that the option would be available for (time to expiration) contributed positively to the total project value. This was in line with the time premium of options theory. Findings from the study were in agreement with Dixit and Pindyck's (1995) observation that the greater the uncertainty ($\sigma\sqrt{t}$) in the potential profitability of the investment, the greater the value of the option.

The third sub-problem was to develop a decision framework, capable of analyzing both the quantitative and qualitative aspects of capital investment valuation

This study has established that the decision analysis process illustrated in figure 20, consisting of a project screening phase using qualitative criteria (such as alignment with strategic objectives), and an investment valuation phase using traditional static DCF as the quantitative method in guiding the investment decision, as applied to the next generation messaging base project in this study, is useful for instances where project execution is in the short to medium term time horizon and cash flows can be derived deterministically as mentioned earlier; which agrees with Mun's (2006) observation that traditional valuation techniques are best suited for shorter time frames.

The key missing component in the process described in figure 20 on page 84 is the process of accounting for management flexibility and strategic options embedded in some of the projects. This applies especially to projects where there are radical changes in the architecture used to deliver telecommunications services, an example being a new generation architecture investment either on the core network side (such as a 3G/4G network) and/or on a new generation service delivery architecture (such as the NGM SDP/SOA in this study) (refer to figure 1 on page 4). Based on the findings, this study suggests a new decision analysis process is required, as illustrated in figure 22 below. The enhanced process is a combination of the deterministic technique indicated in figure 21 and a real options analysis technique. In this instance, the value of strategic options embedded in base architecture investments (such as the option to expand or option to defer the investment) become quantifiable and the *f*(real options value) can be estimated, as illustrated in equation 1. This is in agreement with Mun's (2006) view that new analytics are best when valuing project investments in the long term (strategic period). Accordingly, in agreement with Trigeorgis (1999), a combination of static DCF analysis and real options analysis yields the total value of the investment, that is as described in equation 1.

**Figure 22 Suggested Project Decision Analysis Process**



Project Screening Phase

**Qualitative Project Screening**

- Alignment with strategic objectives
- Alignment with company technology roadmap
- Alignment with architecture principles
- Alignment with design criteria such as component re-use
- Complexity score based on
  - Change impact of other business systems such as CRM, Billing, Middleware and Data Storage)
  - Integration complexity
- Requestor proposed priority

Qualitative Screening Criteria

Investment Valuation Phase

**Quantitative Project Valuation**

- Business case evaluation (ROI analysis)
- Base case project static discounted cash flow (DCF) analysis using time series forecasting and regression analysis

**Real Options Analysis**

- Risk / Sensitivity analysis using Monte Carlo simulation
- Real options valuation (value of strategic flexibility)

Quantitative Valuation Criteria

Project Management Phase

**Demand Management & Release Scheduling**

- Project prioritization based on business demand and the complexity score
- Project scheduling based on priority and resource availability

**Decision Tree Analysis**

- Project prioritization based on choosing between options (quantitative selection process)

Project Scheduling

Given that some projects can result in a bundle of options, such as the next generation messaging (NGM) project assessed in this study, a quantitative model using decision tree analysis was developed (refer to figure 20) to enable the optimal selection of options (that is, the optimal option path that is most likely to yield optimal returns).

Based on the findings, it can be concluded that the two-stage decision model applied by Dai, Kauffman & March (2007) in value-based IT infrastructure investments comprising the initial infrastructure investment in stage-1 and a growth option in stage-2; and the multi-stage decision analysis framework applied by Svavarsson (2004) in strategic IT platform investments comprising a pilot investment in stage-1 and options to expand the platform in subsequent stages, can be adapted and applied to next generation service delivery architecture projects in cellular telecommunications environments. A case approach was followed in developing the decision analysis framework, but the model parameters as illustrated in figure 21 have been described generically, to ensure generality of the framework.

## 6.3 Recommendations

When a classical valuation technique (discounted cash flow) is applied to new and uncertain technology investments due to various risk factors such as project risk and operational risk, resulting cash flows are likely to be volatile. It is advisable that some form of risk analysis be performed to assess the impact of risk in the input factors on the net return on investment (NPV). Techniques such as sensitivity analysis using Monte Carlo simulation can be used. Additionally, a tornado diagram as depicted in figure 6 can be plotted to establish the main input variable, with its inherent risk factor, that has the greatest impact of the resulting passive NPV. Management can then decide on how to control for the variance in NPV by mitigating the risk in the input variables.

When a base project in stage 1 of implementation is likely to yield a complex array of simple and compound options in subsequent stages, a quantitative decision analysis process, involving real options analysis and decision tree analysis is recommended, to ensure a more comprehensive valuation model, and the optimal selection of options that would yield maximum returns. The decision tree model suggested in the study is similar to that proposed by Anderson (2000) to implement a dual options framework when analyzing a two-period investment in the pharmaceutical and telecommunications industry. The decision framework illustrated in figure 22 is recommended for analyzing such complex new technology investment projects.

## 6.4 Suggestions for further research

This study was limited to the valuation of a base project in implementing a next-generation telecommunications service delivery architecture and some simple options associated with the project, such as the option-to-expand and the option-to-defer the investment. Further research is required to analyse the effect of compound options on the project value, and ultimately, which combination of options would yield the maximum return.

The internal risks considered in this study were described as project and operational risks. The external risk considered was delimited to subscriber interaction with the services provided on the new platform (consumer risk). Further research into the effect of changing market conditions (market risk), driven by the economy, currency fluctuations, labour cost variations, and competition risk as identified by Svavarsson (2004) is suggested.

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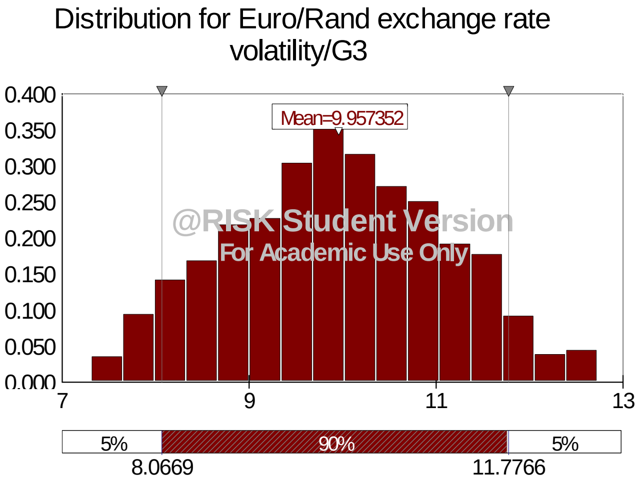
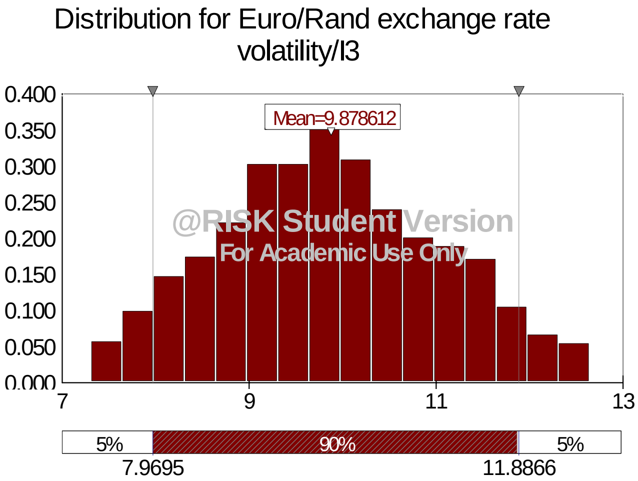
# 8 APPENDIX A - MONTE CARLO SIMULATION DISTRIBUTION GRAPHS

Input variables affecting future cash flows (cost savings) generated by the iCalled SM project expansion option over a 5 year cycle. The resulting distributions are the result of a Monte Carlo simulation with 1000 iterations. Refer to table 14 (section 4.2.1.2) for the simulation input and output summary.

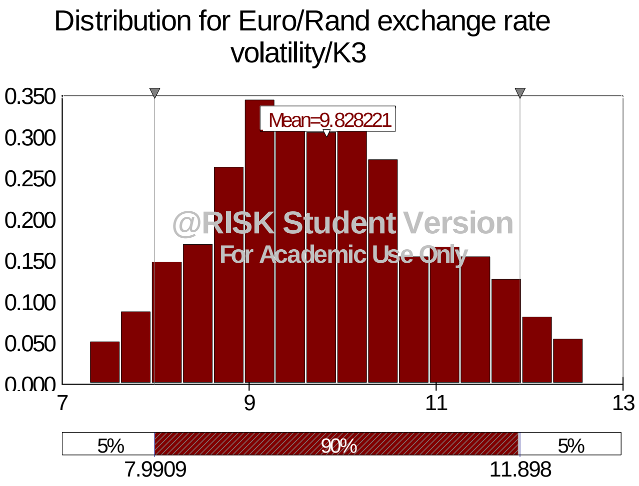
A1 – Euro/Rand exchange rate volatility distribution (Year 1)



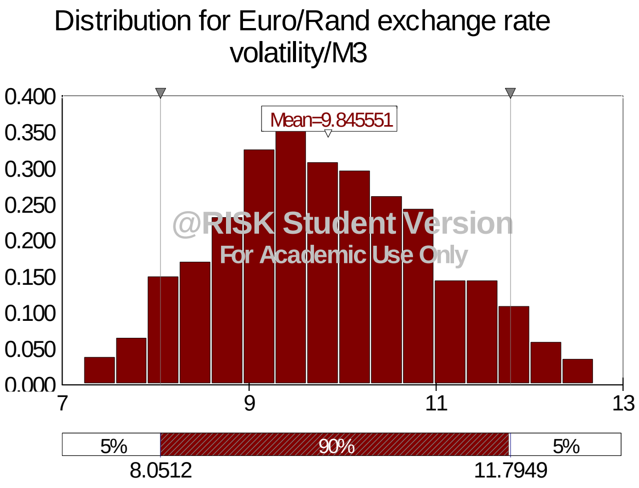
A1 – Euro/Rand exchange rate volatility distribution (Year 2)



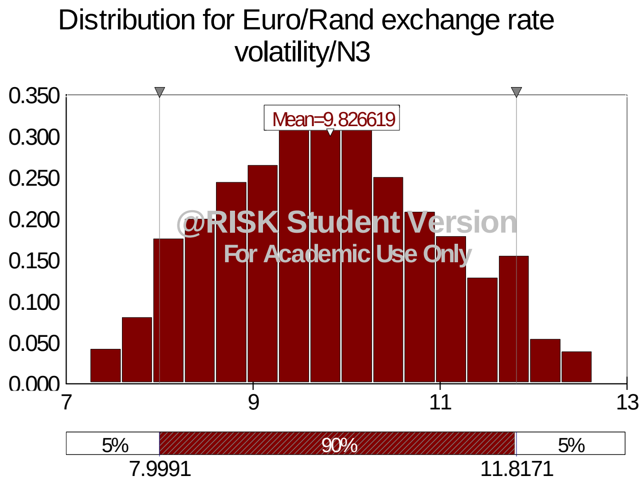
A1 – Euro/Rand exchange rate volatility distribution (Year 3)



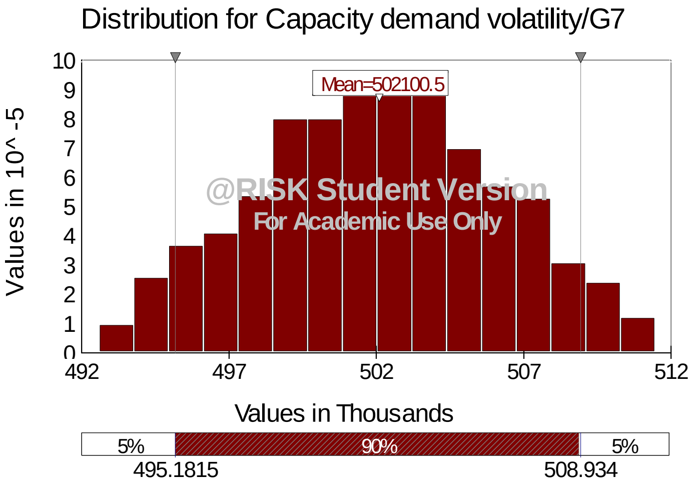
A1 – Euro/Rand exchange rate volatility distribution (Year 4)



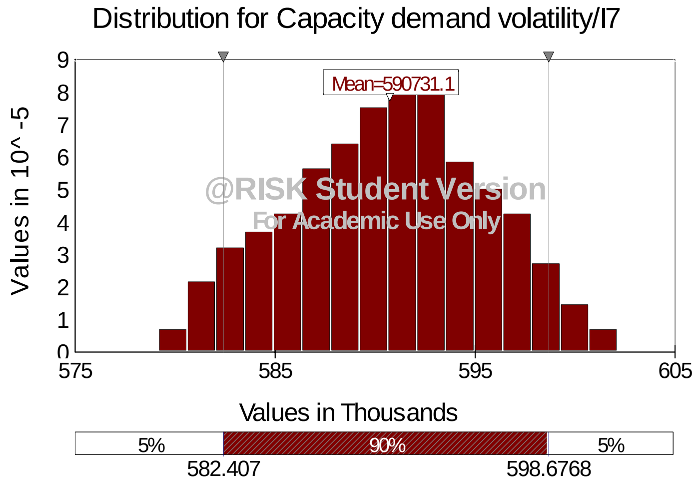
A1 – Euro/Rand exchange rate volatility distribution (Year 5)



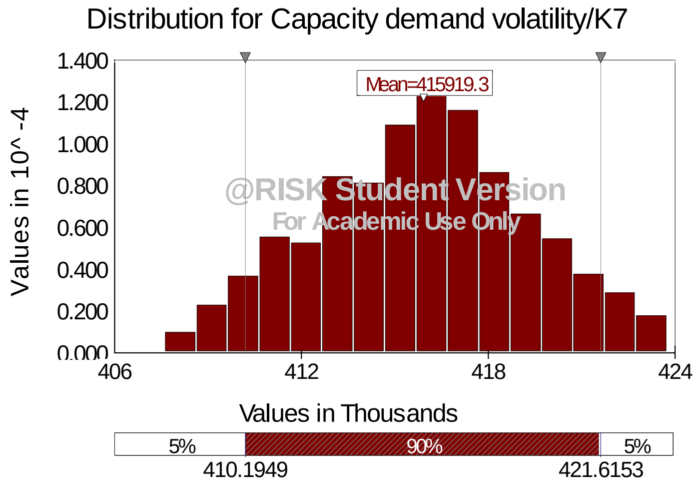
A2 – Voicemailbox capacity demand volatility distribution (Year 1)



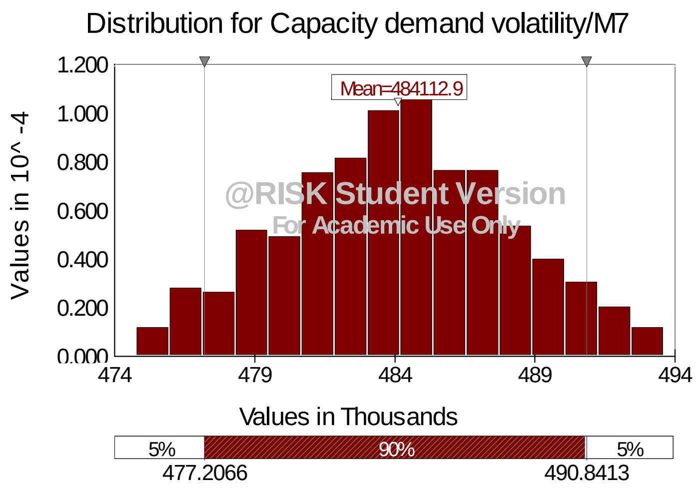
A2 – Voicemailbox capacity demand volatility distribution (Year 2)



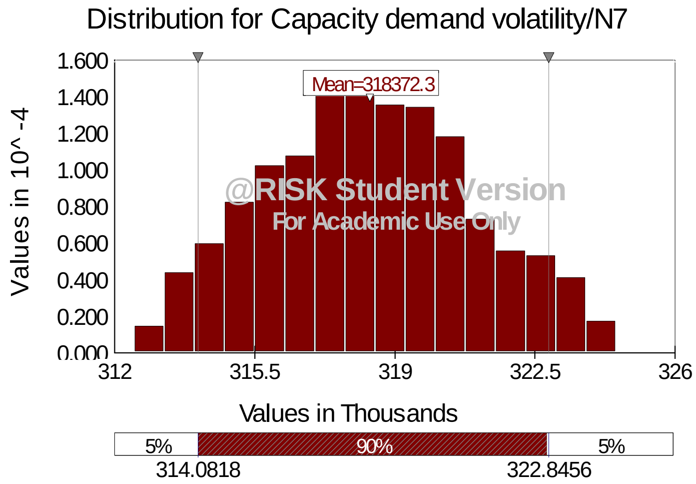
A2 – Voicemailbox capacity demand volatility distribution (Year 3)



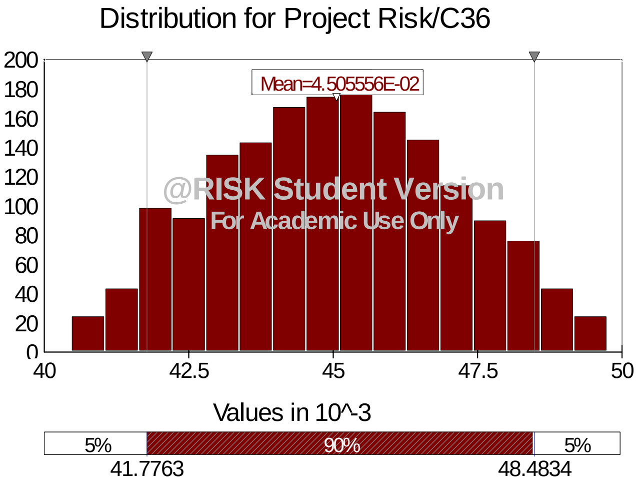
A2 – Voicemailbox capacity demand volatility distribution (Year 4)



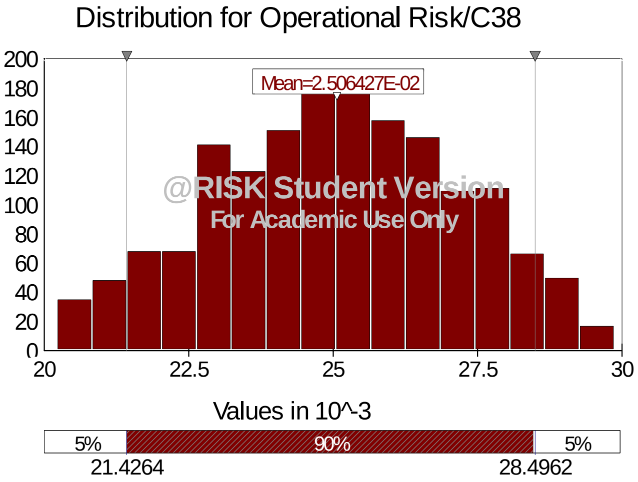
A2 – Voicemailbox capacity demand volatility distribution (Year 5)



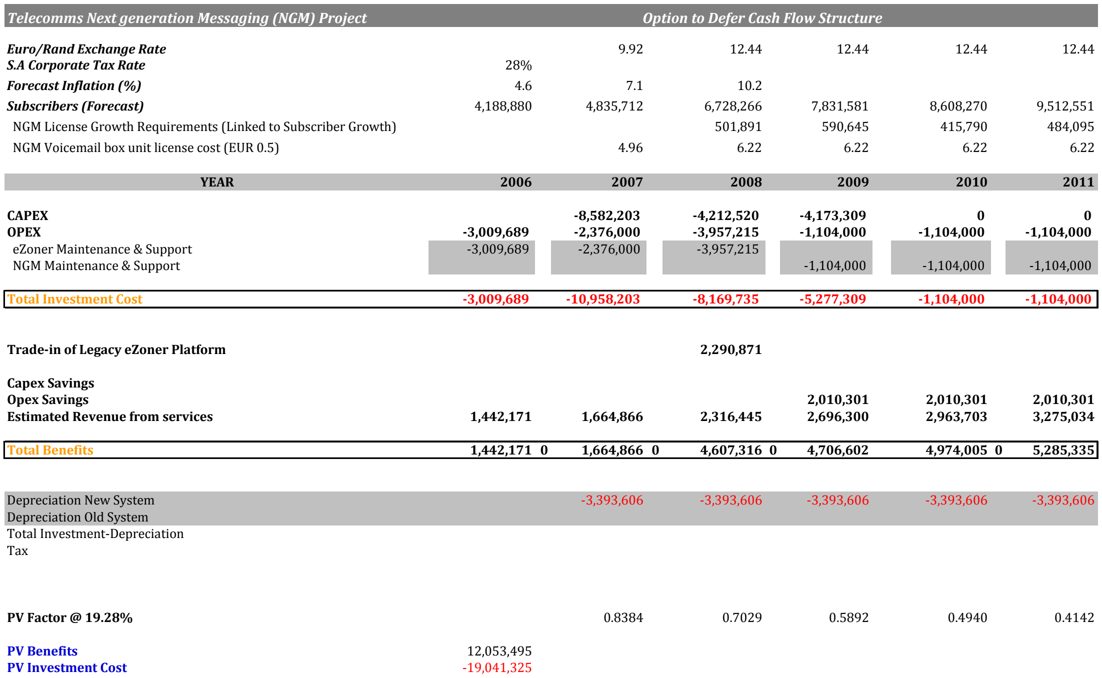
A3 – project risk distribution



A3 – operational risk distribution



# 9 APPENDIX B - OPTION TO DEFER CALCULATION



| *Telecomms Next generation Messaging (NGM) Project* | | | *Option to Defer Cash Flow Structure* | | | |
|---|---|---|---|---|---|---|
| ***Euro/Rand Exchange Rate*** | | 9.92 | 12.44 | 12.44 | 12.44 | 12.44 |
| ***S.A Corporate Tax Rate*** | 28% | | | | | |
| ***Forecast Inflation (%)*** | 4.6 | 7.1 | 10.2 | | | |
| ***Subscribers (Forecast)*** | 4,188,880 | 4,835,712 | 6,728,266 | 7,831,581 | 8,608,270 | 9,512,551 |
| NGM License Growth Requirements (Linked to Subscriber Growth) | | | 501,891 | 590,645 | 415,790 | 484,095 |
| NGM Voicemail box unit license cost (EUR 0.5) | | 4.96 | 6.22 | 6.22 | 6.22 | 6.22 |
| **YEAR** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| **CAPEX** | | **-8,582,203** | **-4,212,520** | **-4,173,309** | **0** | **0** |
| **OPEX** | **-3,009,689** | **-2,376,000** | **-3,957,215** | **-1,104,000** | **-1,104,000** | **-1,104,000** |
| eZoner Maintenance & Support | -3,009,689 | -2,376,000 | -3,957,215 | | | |
| NGM Maintenance & Support | | | | -1,104,000 | -1,104,000 | -1,104,000 |
| **Total Investment Cost** | **-3,009,689** | **-10,958,203** | **-8,169,735** | **-5,277,309** | **-1,104,000** | **-1,104,000** |
| **Trade-in of Legacy eZoner Platform** | | | **2,290,871** | | | |
| **Capex Savings** | | | | | | |
| **Opex Savings** | | | | **2,010,301** | **2,010,301** | **2,010,301** |
| **Estimated Revenue from services** | **1,442,171** | **1,664,866** | **2,316,445** | **2,696,300** | **2,963,703** | **3,275,034** |
| **Total Benefits** | **1,442,171 0** | **1,664,866 0** | **4,607,316 0** | **4,706,602** | **4,974,005 0** | **5,285,335** |
| Depreciation New System | | -3,393,606 | -3,393,606 | -3,393,606 | -3,393,606 | -3,393,606 |
| Depreciation Old System | | | | | | |
| Total Investment-Depreciation | | | | | | |
| Tax | | | | | | |
| **PV Factor @ 19.28%** | | 0.8384 | 0.7029 | 0.5892 | 0.4940 | 0.4142 |
| **PV Benefits** | 12,053,495 | | | | | |
| **PV Investment Cost** | -19,041,325 | | | | | |

B1 – Option to defer NGM project cash flow structure

**VALUING A LONG TERM OPTION/WARRANT**

| | | | |
|---|---|---|---|
| Stock Price= | **R 12,053,495** | Riskfree rate= | **9.95%** |
| Strike Price= | **R 19,041,325** | Variance= | **0.0036** |
| Expiration (in years) = | **5** | Annualized dividend yield= | **0.00%** |

| | |
|---|---|
| d1 = | 0.367035891 |
| N(d1) = | 0.643203877 |
| d2 = | 0.232871812 |
| N(d2) = | 0.592069526 |

**Option to Defer Value of the NGM project =** **R 897,840**

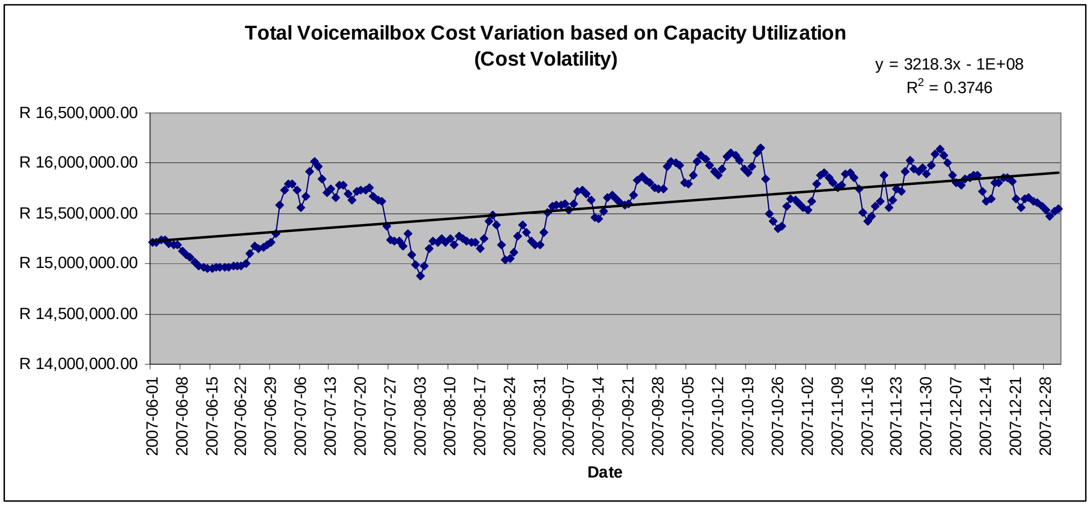
B2 – Option to defer NGM valuation

# 10 APPENDIX C - PV OF MAINTAINING THE LEGACY SYSTEM

| *Telecomms Next generation Messaging (NGM) Project* | | | *eZoner Maintenence Cash Flow Structure* | | | |
|---|---|---|---|---|---|---|
| ***Euro/Rand Exchange Rate*** | | 9.92 | 12.44 | 12.44 | 12.44 | 12.44 |
| ***S.A Corporate Tax Rate*** | 28% | | | | | |
| ***Forecast Inflation (%)*** | 4.6 | 7.1 | 10.2 | 10.20 | 10.20 | 10.20 |
| ***Subscribers (Forecast)*** | 4,188,880 | 4,835,712 | 6,728,266 | 7,831,581 | 8,608,270 | 9,512,551 |
| NGM License Growth Requirements (Linked to Subscriber Growth) | | | 501,891 | 590,645 | 415,790 | 484,095 |
| NGM Voicemail box unit license cost (EUR 0.5) | | 4.96 | 6.22 | 6.22 | 6.22 | 6.22 |
| **YEAR** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| **CAPEX** | | | **-3,121,759** | **-3,673,813** | **-2,586,216** | **-3,011,071** |
| License Growth Requirements | | | -3,121,759 | -3,673,813 | -2,586,216 | -3,011,071 |
| **OPEX** | **-3,009,689** | **-2,376,000** | **-3,957,215** | **-4,360,851** | **-4,805,658** | **-5,295,835** |
| eZoner Maintenance & Support | -3,009,689 | -2,376,000 | -3,957,215 | -4,360,851 | -4,805,658 | -5,295,835 |
| **Total Investment Cost** | **-3,009,689** | **-2,376,000** | **-7,078,974** | **-8,034,664** | **-7,391,874** | **-8,306,906** |
| **Estimated Revenue from services** | **1,442,171** | **1,664,866** | **2,316,445** | **2,696,300** | **2,963,703** | **3,275,034** |
| **EBIT+Depreciation** | **-1,567,518** | **-711,134** | **-4,762,529** | **-5,338,363** | **-4,428,171** | **-5,031,872** |
| Depreciation New System | | -2,478,572 | -2,478,572 | -2,478,572 | -2,478,572 | -2,478,572 |
| Depreciation Old System | | | | | | |
| EBIT-Depreciation | | -3,189,706 | -7,241,101 | -7,816,935 | -6,906,743 | -7,510,444 |
| Tax | | 893,118 | 2,027,508 | 2,188,742 | 1,933,888 | 2,102,924 |
| **TOTAL CASH FLOW** | | **181,984** | **-2,735,021** | **-3,149,621** | **-2,494,283** | **-2,928,948** |
| **PV Factor @ 19.28%** | | 0.8384 | 0.7029 | 0.5892 | 0.4940 | 0.4142 |
| **PV** | | 152,568 | -1,922,319 | -1,855,904 | -1,232,183 | -1,213,035 |
| **NPV @19.28%** | **-6,070,872** | | | | | |

C1 – PV of maintaining the eZoner legacy system

# 11 APPENDIX D - HISTORIC VOICEMAILBOX CAPACITY COST



| *Descriptive Statistics* | |
|---|---|
| Mean | 15,568,235 |
| Standard Error | 22,256 |
| Median | 15,620,361 |
| Mode | 15,744,126 |
| Standard Deviation | 325,581 |
| | 2% |
| Confidence Level(95.0%) | 43,871 |