A REAL OPTION STRATEGIC SCORECARD DECISION FRAMEWORK FOR IT PROJECT SELECTION

by

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ABSTRACT

The problem of project selection is of significant importance in management of information systems. Almost $2 trillion is spent worldwide every year on IT projects, with over $600 billion spent in the US alone. Traditionally, managers have being using the classical net present value (NPV) method in conjunction with multicriteria scoring models for ROI analysis and selection of IT project investments The multicriteria models use ad-hoc evaluation criteria to assign priority weights and then rate the alternatives against each criterion. These models have two limitations. First, the criteria and weights are based on subjective judgments, allowing the introduction of politics in the information management decision process and the generation of arbitrary results. Second, the classical approach uses deterministic estimations of the cost, benefits and the returns of the projects, without considering the impact of uncertainty and risk in the business decisions.

This research proposed a better alternative for ROI analysis and selection of IT projects using a real option strategic scorecard (ROSS) approach. In contrast with traditional methodologies and previous research work, the ROSS decision framework uses a more comprehensive, axiomatic approach for systematically measuring both the business value and the strategic implications of IT project investments. The ROSS approach integrates in a unified IT project management decision framework the best elements of real option theory, strategic balanced scorecards, Monte Carlo simulations and analytical network processes to fully

analyzes the effect of uncertainty and risk in the IT investment decisions. In addition, the ROSS approach complies with the critical success factors that have being identified in the literature for validation of IT decision frameworks. The main benefit of the ROSS approach is to enable managers to better compare and rank projects in the IT portfolio, optimizing the ROI analysis and selection of information system projects.

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I dedicated this research to my recently born daughter, Anabella Munoz, who is three months old at the time of my dissertation defense.

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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchical Process
ANP	Analytical Network Process
BBS	Balanced Business Scorecard
IRR	Internal Rate of Return
NPV	Net Present Value
ROI	Return on Investment
ROSS	Real Option Strategic Scorecard
SIT	Strategic Information System
VMM	Value Measuring Methodology

CHAPTER 1

INTRODUCTION

1.1 Background of Research Problem

One of the most important responsibilities of IT managers is to make good decisions regarding the return on investment (ROI) and selection of the projects. This decision making process is complex because is affected by quantitative factors such as the cost and benefits of each alternative, and by intangibles elements that are more difficult to evaluate and measure such as the alignment of IT projects with the overall strategy of the business.

In the current knowledge based economy, these long-term intangible benefits of IT technologies are very important. “Our primary assets, which are our software and software development skills, do not show on the balance sheet at all”, says Bill Gates (London Business School Interview 1999).

To maximize the business value of IT investments, it is very important that managers use good decision frameworks to measures both the tangible (monetary) and intangible (non-monetary) benefits of projects.

Traditionally, IT managers have been using classical capital budgets methods such as the pay-back period or the net present value (NPV), combined with multicriteria scoring methods for ROI analysis and selection of projects.

The classical IT project decision frameworks use static and deterministic values for the estimation of costs and benefits of the projects, and as a result, the impact of uncertainty is in general overlooked. Furthermore, the criteria and weights used by the traditional multicriteria scoring models are based on subjective judgments, allowing the introduction of politics in the information management decision process and, in many cases, generating arbitrary results

The aim of this research is to propose a decision framework using a Real Option Strategic Scorecard (ROSS) approach as a better alternative for the ROI analysis and selection of IT projects. In contrast with traditional methodologies and previous research work, the ROSS decision framework uses a more comprehensive, axiomatic approach for systematically measuring both the business value and the strategic implications of IT project investments.

The major research contribution of the ROSS approach is to integrate into a unified and multidimensional IT project management decision framework the best elements of real option theory, strategic balanced scorecards, Monte Carlo simulations and analytical network processes to fully analyzes the effect of uncertainty and risk in the IT investment decisions.

The main practical benefit of the ROSS approach is to provide a strategic balanced scorecard view of the business impact of IT projects, optimizing the ROI analysis and selection of projects in the presence of risk, and allowing managers to better compare and rank projects in the IT portfolio.

1.2 The IT Spending Paradox

Almost $2 trillion is spent worldwide every year on IT projects, with over $600 billion spent in the US alone. For over a decade, researchers have been debating about the business value of these IT technology investments. Data has been collected at the economy level, industry level, firm level, and information system application level to quantify the impact of IT on productivity, profitability and consumer value. The results of these studies have been mixed and the term "IT spending and productivity paradox" was coined to describe such findings (Laudon 2004).

Some studies show that sectors such as banking did not experience any gains on productivity during the 1990s, even though the banking industry is one of the biggest expenders on IT (Olozabal, 2002). Other studies, shows that the success of retailers like as Walt-Mart in terms of profitability and productivity over the last decade, is due to the use of IT technology to manage efficiently the supply chain (Johnson 2002).

Some authors like Strassman (1990) has questioned repeatedly the belief that more spending on IT leads to better economic performance. He used financial results and computer spending figures for 468 corporations and found that profit, expressed as return on assets, return on net investment or economic value added, divided by equity, was never related to IT spending.

Hitt and Brynjolfsson (1996) in an analysis of IT spending in 370 firms from 1988 to1992, found that while IT has increased productivity and created substantial value for consumers, there is not evidence that these benefits have been translated into higher profitability. The authors used least squares and regression analysis to account for correlation across time between the IT spending and the corresponding stock market valuation. For productivity, the authors found that the gross marginal product of IT stock, computed as elasticity of value added divided by the percentage of IT in value added, was 94.9% (R^2 was 97.2% and 1109 data points were used). However, the correlation between IT spending and profitability was null or slightly negative.

These results indicates the paradox between the overall increase in IT spending, and the conflicting results generated by the traditional metrics to evaluate the impact of IT project investments. Willcocks (2001) has summarizes the paradoxes caused by the current IT evaluation techniques. First, there are high investments in IT but it is difficult to measure and justified the strategic benefits of these investments. Second, the strategic information systems are high risk, however risk analysis is rare. Over the recent years, the greater the spend on IT, the worse the IT evaluation became. There is a need to research for new models to capture the intangible benefits of information systems and to avoid the current pitfalls of the IT paradox.

1.3 IT Project Implementation Paradigms

IT managers have the difficult and complex task to analyze different project alternatives and to choose the most optimal implementation option. Currently there are three major alternatives to implement information system projects: build the system in-house, outsource the development to a third party company that implements the system using proprietary processes and software, and the option of implementing the system using the new web services utility computing architecture.

Under the in-house implementation option, the firm is responsible for implementing, deploying, and supporting information systems using internal resources. Major upgrades of technology require considerable investments and hiring and training of technical personnel.

For the outsourcing option, the information system are implemented and maintained by a third party consulting company which provides the software and hardware using a fixed priced and fixed capacity schemas. This approach has the major limitation of locking-up the business with a particular contractor who charges the same annual fees regardless the use of computer resources or consulting services.

The web services utility computing model is being offered by big companies such as Google, Microsoft, IBM, HP, Sun and Oracle. Under the web services utility computing model the information systems are accessed over the Internet, with pay-as-you-use contracts that can be extended or cancelled any time. A business pays only for the actual use of computer grid infrastructure, network bandwidth, or software application access.

The web services utility model is a major paradigm shift. Instead of buying hardware and software, firms are starting to access over the Internet computational resources from remote data centers and paying only for the usage on monthly basis, in the same fashion as the business pays for water or electricity. Utility computing allows firms to focus on their core competitive competences and markets, delegating the managing of information systems to utility computing providers.

The benefits of web services utility computing are attractive. A company can access powerful end-to-end application solutions for significantly less than an "in-house" or traditional outsourced implementation. In addition to lower cost, other benefits are specialized expertise, a faster time to market, and a reduced risk due to a lower capital investment.

Web services utility computing allows IT managers to have more flexibility to deal with uncertainty and competition, adapting IT projects dynamically to the changes of market conditions or technology. If the market share for a business increase or there is a technologic update, it is possible to expand the contracted utility computing services. Consistently, if the market shrinks, the company will be charge less because it will use less computer resources.

However, utility computing generates risks too. Firms that are unsure of the value of utility computing services and their demands, in terms of the number of users and a usage level, may be reluctant to commit. Many customers are also concerned with security and loss of control and performance, especially when the software becomes more critical as the company grows. Therefore, the decision to implement a web services utility computing system should consider all these uncertainties and risks.

Utility computing extends the range of options that an IT manager has to implement and deploy strategic IT projects. However, regardless the implementation option, it is critical to make a careful and thorough analysis of the risks and uncertainty associated with the IT investments. The traditional models for project selection do not work because they do not consider all the possible implications of risk. There is a need for developing new decision frameworks for allowing managers to better compare and rank projects implementation alternatives in the presence of risk.

1.4 Limitations of Current Models for IT Project Selection.

The current set of tools for ROI analysis, project selection and decision-making just does not work for the new business realities of the knowledge economy, where knowledge and the intangible benefits of information and technology are the most important assets. In the past, especially during the dot.com frenzy years of 1995 to 2000, hundreds of billions of IT dollars have been wasted either because no valuation metrics were used, or, worse, because the wrong metrics were used (Brynjolfsson 2004).

The traditional methods to identify the business value of IT projects are inadequate because are based only in the quantification of tangible monetary factors. Nowadays, most of the value of IT investment is embedded in intangibles such as the knowledge and strategic capabilities of the firm. The market value is not reflected in the tangible assets (book value), but in the talent and strategic position of the firm. For example, in 1978, the typical book-value to the market value ratio of a company was 95%. Today, companies like Microsoft or Amazon.com have a ratio of just 10%.

The classical methodologies used until now to determine the business value of IT projects, are based on the net present value (NPV) model. The traditional managerial practice for project selection has been to calculate the benefits that the investment will generate, and the costs required to undertake the project. A project should be undertaken when the NPV is greater than zero (when the expected present value of the benefits exceeds the expected present value of the costs). The present value adjusts the benefits and costs of the project using an interest rate for the money that is based on the financial and economic conditions of the market.

The NPV method was developed originally to analyze the business value of long term investment on manufacturing infrastructure assets, and because this historical reason, the NPV approach has many shortcomings for analyzing the business value of IT projects. NPV does not consider many of the intangible benefits generated by information technology, leading to sub-optimal decisions and valuations. NPV does not have flexibility, ignoring the value opportunities of delaying the decision until the business decisions are more favorable. Uncertainty and competition interaction are not considered in the NPV model.

In the traditional approach, IT managers combined the NPV approach with multicriteria scoring methods for the ROI analysis and selection of projects. Under these traditional models, ad-hoc evaluation criteria are used to assign priority weights and then rate the alternatives against each criterion. A major limitation of these models is that the criteria and weights are based on subjective judgments, allowing the introduction of politics in the information management decision process and generating arbitrary results. There is a need for developing new, more objective decision frameworks to solve the shortcomings of the traditional methods for ROI analysis and project selection.

1.5 Purpose of the Research

The aim of this research is to develop a more comprehensive approach for ROI analysis and project selection of strategic information technology (SIT) projects. This research proposes a Real Option Strategic Scorecard (ROSS) approach as a better alternative to evaluate project decisions.

In contrast with traditional methodologies and previous research work, the ROSS decision framework uses a multidimensional and axiomatic approach for systematically measuring both the business value and the strategic implications of IT projects.

The major research contribution of the ROSS approach is to integrate into a unified and comprehensive IT project management decision framework the best elements of real option theory, strategic balanced scorecards, Monte Carlo simulations and analytical network processes to fully analyzes the effect of uncertainty and risk in the IT investment decisions.

The main practical benefit of the ROSS approach is to provide a strategic balanced scorecard view of the business impact of IT projects. The ROSS decision framework optimizes the ROI analysis and selection of projects in the presence of risk, allowing managers to better compare and rank projects in the IT portfolio.

1.6 Synopsis of Research Document

The rest of this research document is organized as follows. Chapter 2 contains a review of the most relevant journal papers, doctoral dissertations, and conferences and articles regarding the traditional and state-of-the-art methods for ROI analysis and project selection, the results are summarized and the research gaps in literature are identified. In Chapter 3, the research methodology to develop and validate the real option scorecard framework is presented. Chapter 4 describes the components and phases of the real option strategic scorecard (ROSS) decision framework. Chapter 5 and 6 present case studies results of applying the ROSS approach to the ROI analysis of the Seminole County Florida SCINET e-government project , and the project selection between open source and proprietary implementations for the NASA Geospatial Interoperability Applications. Finally, in Chapter 7, the conclusions and further research are established.

CHAPTER 2

RESEARCH LITERATURE REVIEW

2.1 Limitations of Traditional Capital Budget Methods

Capital Budget is the process of analyzing and selecting a project from several capital expenditures alternatives. The traditional capital budget methods were developed to analyze and select investments with long life expectancy such as manufacturing equipment and new plant investments. Traditionally, IT projects have being considered long-term capital investment, although the life expectancy of IT technology is shorter due to the innovation that made them obsolescent very quickly.

The traditional capital budget methods are based on the calculation of the cash flows input and outputs. Six traditional budgeting models are used to evaluate capital projects (Laudon, 2004): the payback method, the rate of return on the investment, the cost-benefit ratio, the net present value (NPV), the profitability index and the rate of return (IRR). The calculations formulas are presented in Table 1.

The payback method measure number of years required to pay back the initial investment of a project, by dividing the original investment by the annual net cash inflow.

Table 1 Traditional Capital Budget Methods

$$\text{Payback} = \frac{\text{Initial Investment}}{\text{Annual Net Cash Inflow}}$$

$$\text{ROI} = \frac{\text{Net benefit}}{\text{Investment}}, \text{ where}$$

$$\text{Net Benefit} = \frac{(\text{Total benefits} - \text{Total Cost} - \text{Depreciation})}{\text{Useful Life}}$$

NPV = (Present Value of expected cash flows – Investment)

where,
the Present Value of the expected cash flows are calculated using the following formula:

$$\text{Present Value} = \text{Cash flow} * [1-(1+\text{interest})^{-n}]/\text{interest}$$

$$\text{Cost-benefit ratio} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

$$\text{Profitability Index} = \frac{\text{Present value of cash inflows}}{\text{Investment}}$$

IRR = discount rate such as NPV – Investment = 0

The rate of return on investment (ROI) method calculated the net benefits considering the total benefits minus the total cost and the depreciation, and divide by the useful life. Then the rate of return is found dividing the net benefits by the total initial investment.

The net present value (NPV) method is the amount of money an investment is worth, taking in account the costs, the earnings and the time value of money.

The cost-benefit ratio method, calculates the returns from a capital investment using the ratio between the total benefits and the total costs.

The profitability index is calculated by dividing the present value of cash inflows by the initial cost of the investment.

The internal rate of return (IRR) is the discount rate of return that an investment is expected to earn such as equate the present value of the project expected cash flows to the initial investment.

The traditional capital budget methods have many shortcomings for analyzing the business value of IT projects. NPV does not consider many of the intangible benefits generated by information technology. Uncertainty and risk are not considered in the NPV model.

Problems with the traditional approaches to valuating IT projects had been identified by the research community.

Dos Santos (1991) point out how difficult is to justify an IT project just based on tangible financial benefits where most of the costs are upfront and tangible, whereas benefits tend to be back loaded and intangible These traditional valuation methods assume that all the costs and benefits are known, and can be expressed in monetary terms. In the case of IT projects these assumptions are rarely met, although they can be approximated. Tangible benefits (cost savings) can be quantify and assigned a monetary value. Intangible benefits such as improving knowledge, customer service or decision making are more difficult to quantify.

Irani et al. (2000) draw attention to many of the new organizational issues associated with IT evaluation and management. Willcocks (1994) mentions that the past IT evaluation practice has been geared to asking questions about the price of IT and that the traditional approach is producing less than useful answers. The future challenge is to move to the problem of value of IT to the organization, and builds techniques and processes that can go some way towards answering the resulting questions.

McGrath (1997) concluded that traditional tools for project evaluation, like IRR or the NPV, are inadequate for dealing with the uncertainty and risk that characterizes most IT projects. Costs and benefits are highly uncertain due to the rapid changes of technology. The IT technology could change in the middle of the project, requiring unexpected updates.

Ryand, Harrison and Schkade (2002) considered that the classic valuation methods overlook the cost to train users, the learning curve to adapt to new technologies, and the socials subsystems costs and benefits of the IT projects.

Myers (1984) argued that traditional financial models had a bias for projects that provide tangible benefits, relegating IT investments that deal with more strategic although intangible benefits such as testing a new business model or developing decision support systems.

Myers indicated that the traditional discounted cash flow (DFC) approach ignores the impact of uncertainty and risk in investment projects, and tend to understate the option value attached to growing profitability line of businesses. In other words, investments that do not pay off immediately but provide future growth opportunities are not recognized in the traditional NPV framework.

Usually IT managers combined the classic capital approach with multicriteria scoring methods for the analysis and selection of projects. The traditional multicriteria scoring models are based on ad-hoc evaluation criteria to assign priority weights and then rate the alternatives against each criterion.

The algorithm to select project with multicriteria scoring models can be summarized in five steps. The first step is to establish and agree with some selection criteria. Second, priority weights are associated to each criterion. Third, the project alternatives receive a rating based on the extend to which they satisfy the selected criteria. Four, the project score is calculated by multiplying the category weights per the project ratings. Finally, the project alternative with the greatest score is selected.

A major limitation of these models is that the criteria and weights are based on subjective judgments, allowing the introduction of politics in the information management decision process and the generation of arbitrary results.

2.3 The Concept of Real Options

Real options have being proposed in the research literature as an alternative to the deterministic capital budget methodologies. Real options are being use analysis IT projects such as acquisition of hardware and software, development of new systems, consolidation or integration projects.

The concept of options was developed originally in the financial industry. The seminal paper was published by Black , Scholes and Merton (1973). In the paper the authors derived a formula that allows pricing of financial call options. In

1997, the authors of the formula Myron Scholes and Robert Merton won the Nobel Prize of Economy due to these accomplishments.

In financial terms, a European call option gives the holder the right, but not the obligation, to buy a piece of the underlying asset (e.g. stock, bond) for a specified price at a specified future date. The real option will be exercised only if the price of the stock on that date exceeds the specified price. An American financial option is like a European option, except that it can be exercised any time before it expires. Options are a bet to the future value of the underlying asset and are only worth when there is uncertainty.

The following example illustrates the concepts of financial options. Let said that today you get the right for $100 (European call option) but not the obligation to buy 100 shares of Microsoft at $60/share on June 2007. If on June 2007, the Microsoft stock is greater than $60 dollars, let said $70, you exercise the right to buy the stock at $60 dollars, and obtaining a profit equal to 100 shares * ($70-$60) = $1000. If the on June 2007, the Microsoft stock is less than $60, then you don't exercise the right of buying the 100 shares, but you lost the value of the European call option, in this case $100.

In the mid 1970s, Wall Street began trading the financial call options. At the same time, academic researchers started to look for application of the concepts of call options outside the world of finance.

Stewart Myers (1984), pioneered the concept of applying options to managing capital budget investments of a firm and coined the term “real options”. The real option approach is the extension of the financial option theory to the options on real (non-financial) assets. While financial options are details in the contract, real options are embedded in strategic project investments and must be identifies and specified. Real options try to link strategic planning with finance.

The real option became the conceptual framework for applying option pricing analysis to technology projects. Myer’s work stimulated intense discussion in the early 1980s. Myers argued that the traditional discounted cash flow (DFC) approach ignores the impact of uncertainty and risk in investment projects, and tend to understate the option value attached to growing profitability line of businesses. In other words, investments that do not pay off immediately but provide future growth opportunities are not recognized in the traditional NPV framework. The interest in real options was consolidated by Dixit and Pindyck (1994) who published the seminal book on the subject and identify the different categories of real options.

Trigeorgis (1998) published a comprehensive review of the real option literature and its applications. Trigerogis used real options for evaluating an IT telecommunications infrastructure project. The project was implemented in two phases. In the first phase, the information system was developed. In the second phase, the network was expanded. The valuation of the project included the value of the growth option for the second phase which was computed as a European call option maturing at the year in which network expansion was schedule.

Benaroch and Kauffman (1999) used a Black-Scholes approximation for valuating an IT project for the implementation of a point-of-sale banking service. In their model, the option opportunity was modeled as an American option that pays dividends, and the value of the asset on a particular period was calculated by subtracting the present value of the cash flows foregone during waiting from the present value of the project cash flows at time zero.

Amram and Kulatilaka (1999) used real options to translate vision into investment strategy, by linking real options with the firm core capabilities and competences. The key is to identify the gap between the current and desired competencies to achieve a vision. Then, proceed to outline the strategy choices to close the gap. The next step is to identify the business value of the technology alternatives using the real option approach. This integrated model, better articulate the effect of uncertainty and how the information technology fit into the larger picture of the company.

Schwartz and Zozaya-Gorostiza (2000) developed two models for the valuation of IT investment projects using the real options approach. The first model is suited for the valuation of IT projects in which a firm invests an uncertain amount of money over an uncertain period of time to develop an IT asset that can be sold to third parties or used for its own purposes. The second model is suited for the valuation of investments in which a firm acquires an IT asset for its own use. In this model, investment is assumed to be instantaneous and the benefit associated with the investment are represented as a stream of differential cash flows over the life cycle of the technology.

Techopitayakul (2001) applied real options to analyze a form of utility computing known as the application service provider model (ASP). Three approaches for the usage-based pricing structure: a real option to switch to a fixed subscription fee, an option to bring the software in-house, and an option to end an ASP contract prior to expiration:

Jeffery and et al. (2003) use real options to identify the best strategy of deployment to consolidate 15 data mart into a centralized enterprise data warehouse for Teradata EDW. In this study, the managers have the options to implement the consolidation in one- phase (all 15 datamart at once); two-phases (5 data marts consolidated the first years, and 10 the second year); or three phases (5 data marts each year, during three years). The manager has the option to wait until the end of the first year to confirm the successful consolidation of the first 5 data marts, and decide to continue or cancel the consolidation project.

Jeffery found that the calculated volatility of the project is relatively low (11%). In this case the management decisions should be to consolidate the entire 15 datamart in a single phase, since the option premium resulting from the multi-phase deployment does not compensate for the time delay of the costs savings. If the volatility of the project is large, the option premium added to the NPV or the delayed phase may be larger that the NPV of the single phase project. For the EDW project, a volatility greater than 26% would have made the expanded NPV of the two phase strategy greater than the traditional NPV. The main conclusion is that the selection of a particular phase strategy depends upon the returns and volatility of the project phases.

Paleologo (2004) developed a methodology for pricing utility computing services. It takes in account uncertainty in the pricing of decision and considers several factors such as: rate or service adoption or demand elasticity. This methodology optimized the expected "net present value" subject to financial performance constraints, and thus improves on both the cost –based and value-based found in the research literature.

Ross and Waterman (2004) examine the impact of utility computing on IT outsourcing. The authors found after studying eleven firms with outsource contracts that the firms' ability to generate value from outsourcing depends on the capability of managing their vendor relationship and the maturity of their IT architectures. Also, the authors pointed out that using IT architectures based on standards can enable a firm to capitalize on the strategy agility that utility computing offers.

2.4 Real Option Methodologies

2.4.1 The Black-Scholes Formula

Since the mid 1960s, the research community was trying to solve one of the major problems of the traditional discount cash flow: the limitation to value the uncertain payoffs of contingent investment decisions, where managerial decision making can shape outcomes. For example, an investment can have the option to abandon. If the option is used, the asset is abandoned and there is not further risk. If the option is not used, there is risk of holding the option and the asset. No single discount rate can bring those risky cash flows to the present (Samuelson, 1965).

To solve the discount rate dilemma, Black and Scholes (1973) wrote a set of partial differential equations to capture the dynamics of the relationship between the option value and the stock price. The solution to these partial differential equations is known as the Black Scholes formula, and it is the basis for the options valuation. Black and Scholes demonstrated that in order to price a stock option, it is necessary and sufficient to have reasonable estimation of the following variables: the current price of the stock (P); the time to exercise the option (t); the variance rate of the price of the stock (σ); the exercise price (X); and the risk free-rate of return (r). Table 2 presents the formula to determine the value of a call option.

Table 2 The Black Scholes Equation

Black Scholes Equation
Option Value = P *N(d1) – X* e $^{-rt}$ * N(d2) d1 = $\dfrac{[\ln(P/X) + r + \sigma^2 * t/2]}{\sigma * SQRT(t)}$ d2 = d1 - σ* SQRT (t)
Where, X = the cost to exercise the option P = the current price of the stock N(D) = The cumulative normal probability function t = time to exercise the option σ^2 = variance of the rate of return of the stock during the "t" period Assumptions: The risk-free rate is constant and known. variance is know and constant The underlying asset does not pay any dividends The options are European (can expire only at maturity). The exercise price is known and constant Markets are complete, the firm is risk neutral, or risk is fully diversifiable.

The Black-Scholes formula is the basis for valuation of the managerial flexibility of IT projects. The key parameter in the Black-Scholes model is the volatility σ. For IT project applications, the volatility quantifies the risk of the project. The challenge in any real options valuation models is to accurately calculate the volatility of the project.

Some of the assumptions of the Black-Scholes limit the scope of its application to IT projects. The Black-Scholes formula dealt only with one source of uncertainty. Most IT projects are subject to several source of uncertainty. The Black-Scholes formula can not be applied when there are more than one option, because of that, the formula cannot be used in the case of multi-phase project, where the options are compound and the option value of a particular phase affects the options and values of future phases. The Black-Scholes formula assumes a fixed exercise price of the option. Instead, for IT projects the cost can change.

To deal with these limitations of the original stock option formula, researchers had developed variants to the pioneering work of Black and Scholes. Margrabe (1978) developed a model that determines the value of an option to exchange one risky asset for another. For SIT projects involving risky cost and benefits, Margrabe's model will provide a more accurate estimate of exercising options for strategic information system projects (Dos Santos, 1991). The Dos Santos version of the Margrabe model determines the option value to exchange the risky development cost of a strategic IT project for its risky benefits (Table 3).

Table 3 Dos Santos Real Option Equation

Dos Santos Real Option Equation
Option Value = $B * N(D_1) - C*N(D_2)$ $D1 = \dfrac{[\ln(B/C) + \sigma^2 * (t/2)]}{[\sigma * SQRT(t)]}$ $D_2 = D_1 - \sigma * SQRT(t)$
Where: B = present value of the expected benefits of the project C = present value of the expected cost of the project. N(Di) = The cumulative normal probability function for Di , $i={}_{1,2}$ σ^2 = variance of the ratio B/C = $\sigma^2_B + \sigma^2_C - 2 * \rho_{BC} * SQRT(\sigma^2_B \sigma^2_C)$ σ^2_B= variance of the rate of change of benefits of the project σ^2_C= variance of the rate of change of costs of the project ρ_{BC} = Correlation between development costs and benefits (Dos Santos, 1994)

2.4.2 The Binomial Method

To deal with these multiple source of volatility or compound options, methods based on binomial trees and Monte Carlo simulations have been developed for option valuation.

Cox, Ross, and Rubinstein's (1979) developed an alternative method for pricing options using a binomial approach to value the options in discrete time. The discrete time binomial model assumes that the value of the risky underlying asset V follows a multiplicative binomial distribution (Figure 1). Starting a time period zero t_o, in one time period Δt, V may increase in value to uV (u>1) with a probability p, or decrease to dV (d<1) with a probability q = 1-p., where $d < 1+ rf < u$, and rf is the risk free rate (Figure 1).

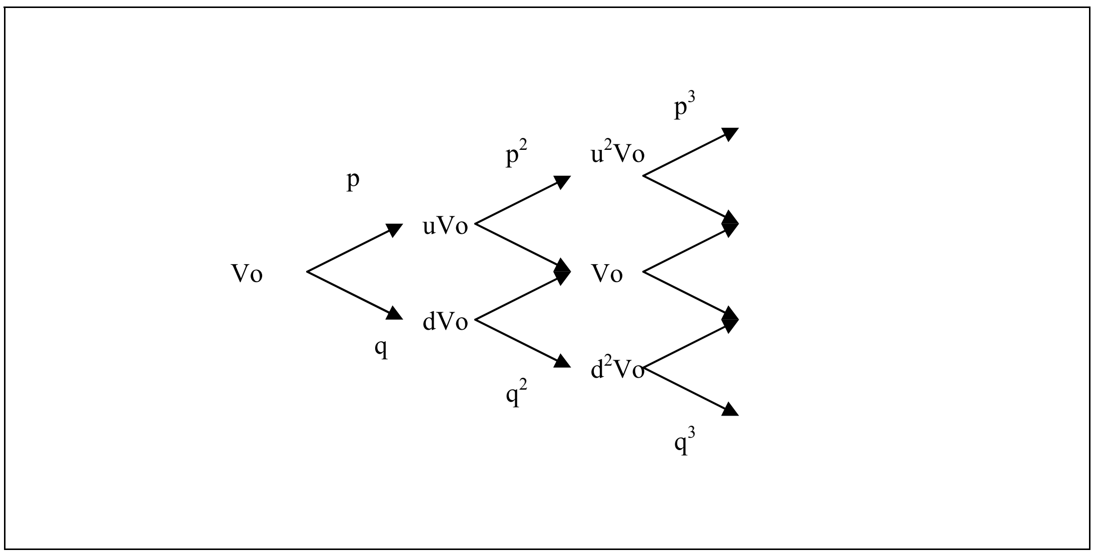
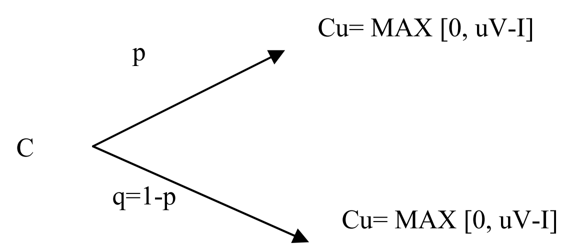


Figure 1 Multiplicative Binomial Tree

The assumption of a binomial distribution implies that the up and down follow the equations: $u = \exp [\sigma\ SQRT(t/n)]$, $d = \exp [-\sigma\ SQRT(t/n)]$ where n is the number of steps in the binomial lattice and σ is the volatility, defined as the standard deviation of the log normal distribution of the continuously compound returns of the value of the project.

The terminal value of the call option C in the up or down state is determined by Cu = max [0,uV-I] or Cd = max [0, dV-I], where I is the investment required to exercise the option. By defining p = (r-d)/(u-d), the value of the call option C at t=0 can be calculated as shown in Figure 2:



$$C = \frac{\text{MAX }[0, uV-I]}{r} = \frac{p*\text{MAX }[0, uV-I] + (1-p)*\text{MAX}[0,dV-I]}{r}$$

Figure 2 Binomial Call Option Equation

The equation for binomial call option enables the calculation of the option value when there is a step up or down management decision. These formulas are extended with multiple ups and downs steps with spacing Δt, using the multiplicative binomial trees. Algorithmically, one begins at the end states of the tree (time = n * Δt) and works backwards on the lattice to t=0 calculating the option value at each previous node

When the binomial model is used to value a call option on a stock, the time to maturity is divided intro small intervals Δt. As the number of periods in the lattice approaches to infinity, the multiplicative binomial model approaches the log-normal distribution of underlying asset returns. In other words, the binomial formula converges to the continuous Black-Scholes formula in the limit that Δt. goes to zero.

2.4.3 Monte Carlo Simulations

Boyle (1977) applied the Monte Carlo simulation method for estimation of the value of options at the time of the exercise expiration. Thousands of simulations will create a distribution of future stock values, and from this probability distribution the expected value of the stock at the time of option expiration can be calculated. The more simulations are performed, the higher accuracy of the result.

The Monte Carlo method solves the real option valuation problem by simulating the dynamics of a process, without requiring using Black Scholes differential equations to describe the behavior of the system. In the real options applications of Monte Carlo simulations, variables such as interest rates applications, stock prices and discount rates have a know or estimated range of values but an uncertain value for any particular time or event. The possible values are defined with a normal or lognormal probability distribution. During a particular simulation scenario, the value to use for each variable is selected randomly from the defined possibilities. The Monte Carlo simulation calculates numerous scenarios. Each scenario has a result forecast (e.g. total net profit or gross expenses).

In the case of the options approach to projects, the Monte Carlo simulation is being used to simulate multiple sources of uncertainties that affect the value of the managerial decision options, given a rule to exercise or trigger a decision.

Monte Carlo simulations allow to analyzed American options (options that can be exercised at any time) in order to get the threshold curves for options can be exercise earlier.

Although Monte Carlo simulations are very useful for many risk assessment problems, the method have some limitations (Ferson, 1996): Monte Carlo methods are data intensive, the simulations requires the existing of empirical information or a set of reasonable assumptions, otherwise, the method yield incorrect or unjustifiable results. Monte Carlo simulations are appropriate for analysis of variability and stochasticity, but should not be used for frequentist interpretation of probability.

In order to use Monte Carlo simulations in the valuation of IT projects, it is very important that the selected distribution for analysis have an empirical justification, and that the dependencies among variables should be appropriate modeled. It is indispensable to avoid making unjustified assumptions for computational convenience.

2.5 The Concept of Strategy Balanced Scorecard

Traditionally, most companies use metrics such as ROI or capitalization to diagnostic the state of the company. However, these measures do not take in account the intangible assets of a company: its processes, people and information technology. In the new knowledge based economy, these intangible assets are what actual define the value of a business. 75% of the average firm's market value is derived from intangible assets that traditional financial metrics don't capture. Because of these limitations, Kaplan and Norton (1996) developed strategy balanced scorecards to translate the business strategy into an actionable, measurable plan that can be embraced by all the members and units of the organization. The goal of is to convert intangible assets (people, processes, and information) into tangible outcomes (sustained value creation), and to align all the business mission and goals.

Kaplan and Norton (2004) described the strategy maps scorecard model as blueprints that describe business strategy in a way that can be easily communicated and measured. Strategy maps are the result of ongoing research with hundreds of companies around the globe. Kaplan and Norton found on their researched data that only 5% of the workforce understands their company's strategy, that only 25% of managers have incentives linked to strategy, that 60% of organizations do not link budgets to strategy, and 85% of executive teams spend less than one hour per month discussing strategy.

The strategic map scorecard tries to balance the measures between tangibles and intangibles assets across four different perspectives: financial, customer, operational (internal process), and knowledge management (learning and growth) perspective (Figure 3).

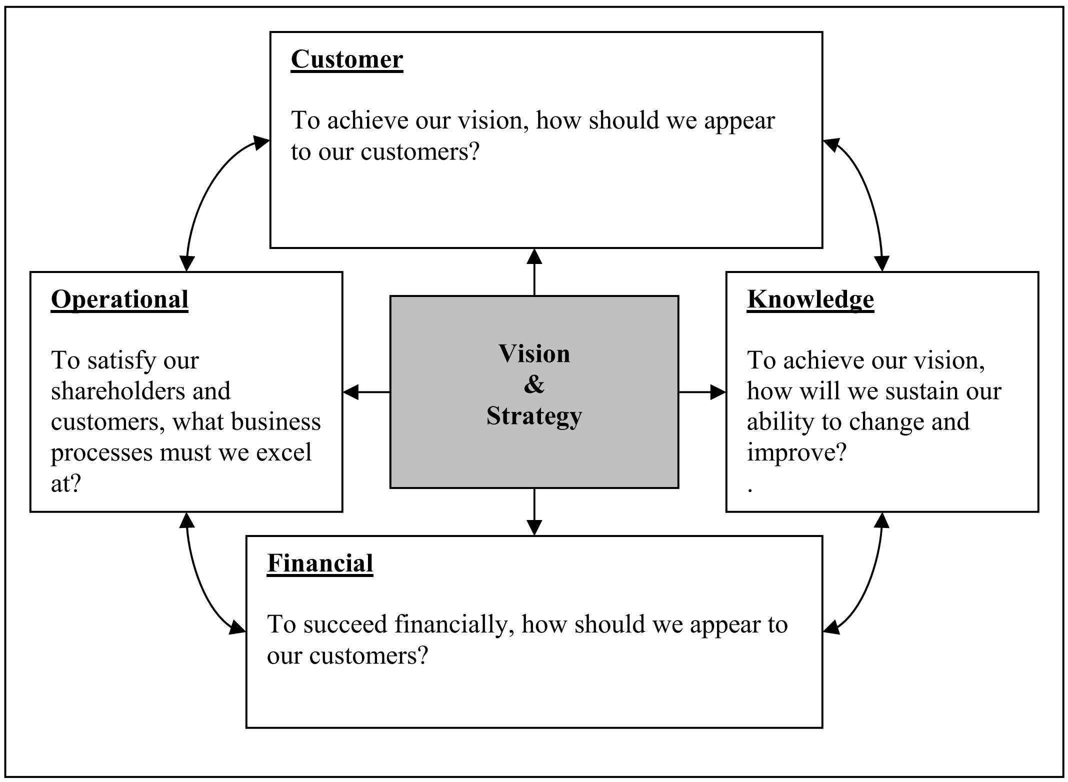


Figure 3 The Balanced Business Scorecard

The financial perspective looks at creating long-term shareholder value, and builds from a productivity strategy of improving cost structure and asset utilization and a growth strategy of expanding opportunities and enhancing customer value.

The customer perspective focuses on the price, quality, availability, selection, functionality, service, partnerships and branding.

The operational perspective is oriented to improve operations, customer management processes, innovation, and more responsible regulatory and social processes.

The learning and growth (knowledge management) perspective deals with the allocation of human resources, and information and organizational capital. Finally, the strategy map describes the cause and effect relationships are described by connecting arrows.

2.6 Summary of Research Literature

Table 4 presents a summary of the reviewed research literature. The table indicates the multicriteria method and the ROI analysis methods employed by the researchers. The table allows seeing that there is a gap in the research literature for integrating in a unified IT project decision management framework real options, balanced scorecard and analytical network process concepts to fully analyze the impact of uncertainty, risk and business goal interdependencies. The purpose of this research is to fulfill this gap by decision framework using a Real Option Strategic Scorecard (ROSS) approach as a better alternative for the ROI analysis and selection of IT projects. In contrast with traditional methodologies and previous research work, the ROSS decision framework uses a more comprehensive, axiomatic approach for systematically measuring both the business value and the strategic implications of IT projects.

Table 4 Research Summary and Gaps

Researcher	**Multicriteria Method**				**ROI Analysis Method**				**Application**
	Traditional Scoring	**AHP Method**	**ANP Method**	**Balanced Scorecard**	**Real Options**	**Monte Carlo**	**Traditional Risk**	**Traditional NPV**	
Jeffery and al. (2003)					**Y**				Data warehouse
Benaroch (2001)					**Y**				Web-based
Schwartz and al. (2000)					**Y**				Acquisition/Dev
Paleologo (2004)								**Y**	Pricing
Techopiitayakul(2001)					**Y**	**Y**			ASP Software
Kontio (2002)							**Y**		Software Dev.
Foley (2006)		**Y**					**Y**	**Y**	VMM
Cottrell and al. (2000)					**Y**		**Y**		Software Release
Kulatilaka and al (1999)					**Y**	**Y**			E-mail
Tallon and al (2003)									Alignment Survey
Luehrman (1998)					**Y**				Chemical
Weeds and al(2000)							**Y**		Mergers
Holtan (2002)						**Y**			NPV
Meade (2002)			**Y**						R&D
Dos Santos (2004)					**Y**				Strategic IT
Willcocks (2001)				**Y**					E-Commerce
Munoz and Rabelo (2006)			**Y**	**Y**	**Y**	**Y**			**E-government ROI NASA Project Selection**

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Framework Development

The review of the research literature shows that there is an evident need for the development of new and better IT multicriteria decision analysis frameworks to avoid the limitations of the traditional models.

The focus of this research is developing a more comprehensive managerial decision framework for the ROI analysis and selection of IT projects. In contrast with traditional methodologies and previous research work, the ROSS decision framework uses a multidimensional, axiomatic approach for systematically measuring both the business value and the strategic implications of IT projects.

The major research contribution of the ROSS approach is to integrate into a unified IT project management decision framework the best elements of real option theory, strategic balanced scorecards, Monte Carlo simulations and analytical network processes to fully analyzes the effect of uncertainty and risk in the IT investment decisions.

The ROSS approach uses a four phase process for the decision analysis (Table 5).

Table 5 The Four Decision Analysis Phases of the ROSS Approach

Phase I: **Project Modeling**	**Phase II:** **Real Option Analysis**	**Phase III:** **Strategic Analysis**	**Phase IV** **Project Decision**
Phase I: *Model the project by, identifying the alternatives, estimating the costs and benefit of each alternative, and establishing the business goals for the project. The goals are classified using the four balanced scorecard business value categories (customer, financial, operational, knowledge)*	***Phase II*** *Measure the Real Option Score of each implementation alternative using Monte Carlo simulations and the Black-Scholes equation:* B* N(D) – C*N(D’)	***Phase III:*** *Measure the Strategic Score of each implementation alternative using the analytical network process to find the weight (impact) of each project alternative in the business goals.*	***Phase IV:*** *Select for the IT portfolio the project alternative that provides the best combination of real option and strategic scores.*

In phase I, the balanced scorecard is established as the control criteria for comparison. The managers classify the business goals into the four perspectives of the balanced scorecard, identifying the target and measures relevant for the mission and vision of the business. The resulting balanced scorecard will be used to compare the project alternatives. The cost and benefits of the implementation alternatives are estimated for the timeline of the project. Time series and forecasting are used when historical data is available. Expert opinion and fuzzy numbers are used when previous data is not available.

In phase II, real option analysis is used to consider the variability of expected costs and benefits for the projects. Monte Carlo simulations are employed to evaluate all the possible scenarios of variation and to estimate the corresponding project returns. The output of the Monte Carlo simulations is the probability distribution of the project returns. The mean and volatility (standard deviation) can be used to calculate the real option values for the different implementation alternatives using the modified Black Scholes equation $B*N(D1) – C*N(D2)$. This equation basically adjust the benefits (B) and costs (C) for the values of the probability distribution N(D), where D is a factor depending in the volatility of the rate of returns for the projects. The advantage of using the Black Scholes equation is to include the risk adjustment directly in the equation, without requiring the additional risk analysis that is characteristic of the traditional cost and benefit analysis methods.

In Phase III, the strategic alignment of each project alternatives is measured using the balanced scorecard as the control criteria for the analysis. Pair-wise comparisons are applied to the four categories of the balanced scorecard and corresponding business goals. All the interrelations between categories and business goals are evaluated using analytical network processes (ANP). For each project goal, the implementation alternatives are assigned a rating reflecting the probability of the project to satisfy the business goal. The category and business goal weights are multiplied by the corresponding project alternatives ratings to obtain the project alternatives scores for each business goal. Finally, the project score are aggregated to obtain the Strategic Scorecard Value that shows the percentage of alignment of the alternative with the overall mission and vision of the business.

Finally, in Phase IV, the results of the ROSS analysis are summarized. The Real Option Value and the Strategic Scorecard Value are used to guide the selection decision. Using the ROSS approach managers can select the project with the best combination of Real Option and Strategic Scorecard values. The ROSS approach is a descriptive method to generate quantitative results and to guide the decision, but it is not a prescriptive method. The final decision should be made by the managers based on the specific trade-offs that are required for the current business conditions.

3.2 Framework Validation

The ROSS approach satisfied the critical success factors that have been identified in the literature for the validation of decision analysis frameworks.

Santhanam et al. (1989) indicate that a decision framework method should be able to provide a realistic description of the selection problem, support a comprehensive analysis of alternatives and should be easy to apply. Muralidhar et al. (1990) said that an evaluation method should also include both qualitative and quantitative factors, and a procedure to measure the relative importance of factors. Huizingh and Vrolijk (1994) add the criteria of supporting group decision making and structuring the decision (Table 6).

Table 6 Critical Success Factors for evaluation of IT decision frameworks

Critical Success Factor Research Literature	ROSS Approach
Providing a realistic description of the selection problem. Santhanam et al. (1989)	The ROSS approach provides a realistic description of the selection problem by using the existing balanced scorecard of the business criteria for comparison of implementation alternatives and by using more realistic estimation of the cost and benefits for the project, considering the whole range of variability and the impact of risk and uncertainty.
Supporting group decision-making. Huizingh and Vrolijk (1994)	The ROSS approach support group decision. Managers discuss and agree to use the balanced scorecard as the control criteria. Managers should reach an agreement for the values of the different pair-wise comparison between the business goals.
Structuring the decision making problem Hazelrigg (2003)	In the ROSS approach the decision making process is structured in four phases. The first phase model the project selection. The second phase uses a real option analysis to find out the returns of the project alternatives in the presence of risk and uncertainty. The third phase consists in a strategic analysis to quantify alignment of the project with the overall mission and vision of the business. The four phase, summarized the results and recommend the selection of projects that have the best combination of Real Option Value (return in $) and Strategic Scorecard Values (% of alignment).
Incorporating both quantitative and qualitative factors Muralidhar et al. (1990)	The ROSS approach use real option for the quantitative analysis of cost and benefits. Qualitative factors are evaluated and measure using the balanced scorecard and analytical network processes (ANP)
Expressing the relative importance of the factors Saaty (2004) Meade and Presley (2002)	The ROSS approach determines the relative importance of the factors using analytical network process (ANP) pair-wise comparisons to consider dependences and feedback between the business goals.
Analyzing alternatives Hazelrigg (2003)	In the ROSS approach the alternatives are analyzed using the Real Option Value and the Strategic Scorecard Value.
Comprehensibility of the methods Santhanam et al. (1989)	The ROSS approach provided an integrated view of the ROI analysis and project selection problem in the presence of risk. All the factors and interrelations impacting the decision are considered.
Applicability of the method Santhanam et al. (1989)	The ROSS approach was applied to two case studies. The first case study considers the ROI of the SCINET e-government for Seminole County. The second case, analyze thea project selection problem for NASA Geospatial Interoperability Office.

3.2.1 Description of the selection problem

The ROSS approach provides a realistic description of the selection problem by using the existing balanced scorecard of the business criteria for comparison of implementation alternatives and by using more realistic estimation of the cost and benefits for the project, considering the whole range of variability and the impact of risk and uncertainty

3.2.2 Group Decision Making

Most IT project selections require the consensus of a group of executives, IT managers and other department personnel. The ROSS approach proposed in this research provides the ability to generate a selection criteria by evaluating and combining the different judgments and opinions. Managers discuss and agree to use the balanced scorecard as the control criteria. Managers should reach an agreement for the values of the different pair-wise comparison between the business goals

3.2.3 Decision-Making Process

In the ROSS approach the decision making process is structured in four phases. The first phase model the project selection. The second phase uses a real option analysis to find out the returns of the project alternatives in the presence of risk and uncertainty. The third phase consists in a strategic analysis to quantify alignment of the project with the overall mission and vision of the business. The four phase, summarized the results and recommend the selection of projects that have the best combination of Real Option Value (return in $) and Strategic Scorecard Values (% of alignment).

3.2.4 Quantitative and Qualitative Factors

The real option scorecard framework consider both qualitative (strategic) and quantitative (financial) factors for the selection of projects. The framework calculates two measures (Strategic Scorecard Value and Real Option Value) for each project alternative.

The Strategic Scorecard Value is calculated using pair-wise comparison over an ANP structure representing the strategic balanced scorecard of the company. The balance scorecard includes factors such as customer satisfaction, learning and growth, process improvement, and the financial value.

The Real Option Value is calculated using real option approach. When historical or market research data is available, the option premium of a project is calculated using time series forecast of cost and revenues, identifying the net present value (NPV) of the cash flows, and using Monte Carlo simulations for the uncertainty variables impacting the NPV, and identifying the value of managerial flexibility. When there is a lack of historical data, the framework incorporated the use of fuzzy logic to estimate the cash flows using expert opinions.

3.2.5 Relative Importance of Factors

The ROSS framework allows to rate the relative importance of the balanced scorecard criteria and the corresponding business goals. The ROSS approach determines the relative importance of the factors using analytical network process (ANP) pair-wise comparisons to consider dependences and feedback between the business goals.

3.2.6 Analyzing Alternatives

The ROSS approach helps managers to systematically analyze the different IT implementation alternatives. The Strategic Scorecard Value and Real Option Value allow to consistently comparing the different alternatives and made a selection that is align with the strategic vision of the business.

3.2.7 Comprehensibility of the Method

The ROSS approach provides a unified view of the project selection problem allowing managers to deal with the strategic and the engineering economics implication of projects. The ROSS approach is a multidimensional decision framework considering risks, the tangible return on investment of a project and the intangible strategic alignment of project initiatives. The Real Option Value measure identifies the returns (increase in profitability) expected from the project. The Strategic Scorecard Value provides a quantitative evaluation of the impact of a project in strategy and competitive advantage.

The ROSS approach is a more comprehensive alternative for the ROI analysis and selection of information system projects. In the ROSS approach all the factors and interrelations impacting the decision are considered.

3.2.8 Applicability of the Method

In this research the real option strategic scorecard (ROSS) decision framework is applied to two different case studies.

In the first case study, the ROSS approach is applied to the ROI analysis of e-government projects. In particular, ROSS approach is used to measure the cost and benefits and the strategic alignment of implementing a strategic e-government system for Seminole County. The project initiative is known as the Seminole County Integrated Network (SCINET) and it is being developed in conjunction with the Engineering Technology Department at the University of Central Florida. The SCINET project has a great potential to generate benefits and to provide a strategic advantage for the Seminole County. However, there are also risks and uncertainties involved because the system is brand new and it is being built from the scratch. Uncertainty is a typical characteristic of strategic information technology projects where uncertain benefits are exchange for risky investments. The results of the case study shows that the ROSS approach is best alternative to analyze the return on investment of the SCINET project in the present of risk and uncertainties.

The second case study used the ROSS approach to the analysis of a project selection decision for the NASA Geospatial Interoperability Office. In this case, the NASA managers were trying to select the best platform to implement new geospatial applications. Two options were considered. One option was to implement the system using the open software and standards. The second option was to use proprietary software.

The different case studies show that ROSS satisfied the success factors identified in the research literature for the validation of decision frameworks for project selection. The ROSS framework provides a realistic description of the selection problem, support group decision making, structure the decision problem incorporating both quantitative and qualitative factors, expresses the relative importance of the factors to analyze alternatives, and provides a comprehensive methodology to select the best project alternative.

Halzerigg (2003) provides a summary of the proprieties used to validate alternative selection frameworks (Table 7). This summarize is use to compare the characteristic of the ROSS approach against the traditional multicriteria scoring model.

Table 7 Validation Design Proprieties for alternative Selection Framework

	Alternative Selection Framework	
Design Propriety	**Traditional Multicriteria Method**	**ROSS Approach**
Rank Ordering Should provide rank ordering of candidate designs	Highly restricted	Axiomatic Approach to rank ordering using ANP
Non Preferences Should not impose preferences	Could result in arbitrary preferences	Less prone to generate arbitrary preferences
Uncertainty and Risk Should consider uncertainty conditions and risky outcomes	It is not considered	Fully Considered
Bias Should not depend on the result (bias)	More Bias	Less Bias
Scalability Consistency Should make the same recommendation when considering a reduced set of alternatives	Inconsistence	More consistent
Order Consistency Should make the same recommendation regardless of the order in which the design alternatives are considered.	Satisfied	Satisfied
Constraint Consistency Should not impose constraints in the design of the alternatives	Constraint and assumption are ad-hoc and sometimes arbitrary.	Less restrictions in the assumption and the comparison criteria.
Scalability Consistency Should allow the addition of new alternatives without affecting the existing alternatives	Satisfied	Satisfied
Information Consistency Should assign a positive value to improved information.	Does not consider managerial flexibility	Provides managerial flexibility for the decision under new business conditions.
Self-consistent and logic Should be self-consistent and logic.	Comparison can be illogical and not self-consistent.	Logic is supported by axiomatic pair-wise comparisons.

3.3 Data Gathering

The ROSS approach increases the ability of a group of managers to work together in the decision analysis process and arrive at a generally accepted answer. The ROSS approach combines the managers judgments using balanced scorecard, real options and pair-wise analytical network processed (ANP) to get the ROI and strategic priorities for a project initiative.

The ROSS approach gathers data during panel members' discussions with the participation of executives, managers, technical personnel and business analysts. Table 8 shows the panel members and participation responsibility for the four phases of the ROSS decision process.

In Phase I (Project Modeling), the executive and manager establish the financial, customer, operational and knowledge goals. Technical personnel and business analyst provides their input for the some of the operational and knowledge management goals. In Phase II (Real Option Analysis), the executives and managers provide the baseline for the project options and to estimate the cost, benefits and risk of the projects. Business analyst and technical personnel provides the actual estimations of these input parameters. In Phase III (Strategic Analysis) the managers and executives establish the input for the pair-wise comparison by categories and business goals. Business Analysts and technical personnel provided information for the project ratings. Finally, in Phase IV (Project Decision), managers and executives reach the final decision based on the ROSS final results.

Table 8 Panel Members for the Four Phases of the ROSS Approach

Phase I Project Modeling	**Panel Members for Balanced Scorecard Project Goals**			
	Executive	**Managers**	**Technical**	**Business Analysts**
Financial Goals	X	X		
Customer Goals	X	X		X
Operational Goals	X	X	X	
Knowledge Goals	X	X	X	X
Phase II Real Option Analysis	**Panel Members for Estimation of Cost, Benefits and Risk**			
	Executive	**Managers**	**Technical**	**Business Analysts**
Project Options	X	X		
Project Cost	X	X	X	X
Project Benefits	X	X	X	X
Risks Estimation	X	X	X	X
Phase III Strategic Analysis	**Panel Members for Estimation of Strategic Scorecard Weights**			
	Executive	**Managers**	**Technical**	**Business Analysts**
Pair-wise Comparison by Category	X	X		
Pair-wise Comparison by Business Goal	X	X		
Pair-wise Project Ratings	X	X	X	X
Phase IV Project Selection	**Panel Members for Project Selection**			
	Executive	**Managers**	**Technical**	**Business Analysts**
Project Selection Trade-offs	X	X		

The ROSS approach data gathering process is summarized in Figure 4. The first step is to select the panel members based on the expertise required for each of the four phases of the ROSS approach. Meetings are prepare for establishing the balanced scorecard comparison criteria, to estimate cost and benefits and to assign pair wise comparison values to business categories and goals. Several sessions are scheduled until an agreement is achieved. Finally, the input data is used to generate the Monte Carlo simulations, the real option calculation and the analytical network process comparisons to obtain the Real Option Value and the Strategic Scorecard Value of each project alternative.

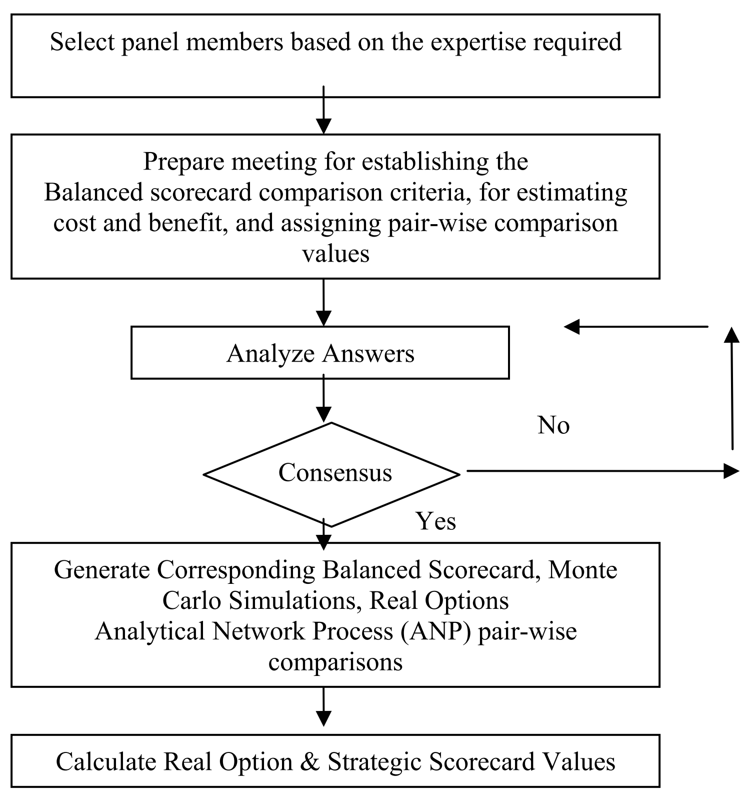


Figure 4 Data Gathering Process

CHAPTER 4

REAL OPTION STRATEGIC SCORECARD FRAMEWORK

4.1 Introduction

The problem of project selection is of significant importance in management of information systems. Almost $2 trillion is spent worldwide every year on IT projects, with over $600 billion spent in the US alone. Seventy nine percent of companies now require return on investment (ROI) analysis to be performed on IT investments. The Federal government only supports projects that provide a strong business case. To maximize the business value of IT investments, it is very important that managers use comprehensive decision frameworks to analyze the return on investment and justify the selection of new information systems.

The project selection process is complex because is affected by costs/benefit factors such as the return on investment of each alternative, and by business factors that are more difficult to evaluate and measure such as the alignment of IT projects with the overall strategy of the firm.

Multicriteria decision frameworks use quantitative methods to associate with each project alternative scores representing the return on investment (ROI) and the business value of the selection decision.

Traditionally, IT managers have being using the classical multicriteria scoring models for the selection of projects. These methods first assign weights to the criteria and then rate the alternatives against each criterion. These classical decision frameworks have two limitations. First, the identification and weight assigned to the business criteria are based on subjective, ad-hoc judgments. This empirical approach is prone to generating arbitrary results and allowing the introduction of politics in the information management decision process. Second, the classical approach use static and deterministic values for the estimation of costs and benefits of the projects, and as a result, the impact of uncertainty and the dynamic of the business decisions are in general overlooked.

New decision frameworks are being developed for the research and practitioner community to solve the shortcomings of the traditional project selection methods. In 2004, the Harvard University's Kennedy School of Government in conjunction with the consulting firm Booz Allen Hamilton developed the Value Measuring Methodology (VMM) for the evaluation of e-government projects. VMM use a more structured approach, based on the analytical hierarchical process (AHP) to obtain the weights for the business criteria. VMM is a progress over the classical priority scoring decision frameworks. However, VMM has its own limitations. First, VMM is still based on the traditional and static NPV methodology. Second, interdependencies among the business factors are not considered. Third, the calculation of risk is based on a proprietary algorithm based on the risk categories used by Booz Allen.

This research proposed a better alternative for the ROI analysis and selection of IT projects using a real option strategic scorecard (ROSS) approach. In contrast with traditional model and previous research work, the ROSS approach uses a more comprehensive, axiomatic approach for the decision making process. The ROSS framework considers an integrated perspective that systematically measures both the business value and the strategic implications of selecting and implementing a project.

The major research contribution of the ROSS approach is to integrate into a unified and multidimensional IT project management decision framework the best elements of real option theory, strategic balanced scorecards, Monte Carlo simulations and analytical network processes to fully analyzes the effect of uncertainty and risk in the IT investment decisions.

The ROSS decision framework uses real option methods for the cost/benefit analysis and balanced scorecard as the control criteria to compare projects. The business goals and project alternatives are compared using pair-wise comparison analytical network processes (ANP) to consider interdependencies and to provide a more objective approach that minimizes the introduction of politics in project decision process. ROSS allows IT managers to better compare and rank projects in the IT portfolio, as well as, to select the most optimal IT project investment.

Table 9 compares the (ROSS) approach with the traditional scoring model and the Value Measuring Methodology (VMM).

Table 9 Comparison of Decision Frameworks for IT Project Selection

	Traditional Methodology:	**Emergent Methodology:**	**State-of-Art Research:**
	1983	2005	2006 →
	Multicriteria Scoring Models	**Value Measuring Medhodology (VMM)**	**Real Option Strategic Scorecard (ROSS)**
Cost/Benefit Method	<u>Static Method</u> : Based on Net Present Value Scoring Models uses static and deterministic values for the estimation of costs and benefits of the projects, and as a result, the impact of uncertainty is in general overlooked.	<u>Static Method</u> : Based on Net Present Value VMM is still based on the traditional net present value methodology.	<u>Dynamic Method</u> : Based on Real Option Value ROSS allows a more comprehensive cost/benefit analysis of risk using real option valuation, instead of the net present value.
Business Value Method	<u>Empirical Approach:</u> Based on Subjective Business Factors Scoring models uses a priority weighted comparison based on ad-hoc, subjective factors established by IT managers. The weight assigned to the business value factors allows the introduction of politics in the information management decision process.	<u>Structured Approach:</u> Based on Five Specific Business Factors (Customer, Social, Operational, Financial, and Strategic) VMM compares business factors using an Analytical Hierarchical Process (AHP). The way VMM identifies the business value factors is too generic and there is not guarantee that the factors are aligned with the business strategy.	<u>Comprehensive Approach:</u> Based on The four perspectives of the Strategy Balanced Scored (Customer, Financial, Operational and Knowledge) ROSS compared the business goals using an Analytical Network Process (ANP) ROSS identifies and compares business value factors using the existing balanced scorecard of the company, minimizing subjective or political considerations.
Seminal Paper	Buss, Martin D.J. "How to Rank Computer Projects". Harvard Business Review (January, 1983). (For an example see Appendix A)	Nasa Geospatial Interoperability Return on Investment. (NASA GIO Report, 2005) (For an example see Appendix B)	Munoz, C. and Rabelo L. "A Framework for IT project selection : A Real Option Strategic Scorecard (ROSS) Approach" (August, 2006) (For an example see Chapters 5 and 6)

4.2 Real Option Strategic Scorecard Methodology

The research framework proposes a four phase methodology for the ROI analysis and selection of project alternatives (Table 10).

In Phase I, the four perspectives of the balanced scorecard (customer value, financial value, operational value, knowledge value) are used to classify the business goals that are relevant to achieve the mission and vision of the business. The implementation alternatives are identified, and the benefits and costs of each alternative are estimated.

In Phase II, the risk (volatility or standard deviation) of the rate of return of the project will be derived using Monte Carlo simulations, where the inputs are estimated variation distributions for the costs and benefits of each project alternative. Once the volatility σ is determined, the modified Black-Scholes equation B* N(D1) – C*N(D2) is used to calculate the Real Option Value of each alternative. B is the present value of the estimated benefits for the project. C is the present value of the project costs. N(D) is the cumulative probability distribution where the factors D depend on the volatility of the expected returns of the project σ.

Table 10 Phase for the Real Option Strategic Scorecard Decision Framework

Phase I: Project Modeling

Identify the business goals for the project using the four balanced scorecard perspectives (customer, financial, operational, knowledge). Estimation of the costs and benefit of each alternative.

Balanced Scorecard	Goals
1. User Value	
2. Financial Value	
3. Operation Value	
4. Knowledge Perspective	

Project	*Year 0*	*Year 1 …*
Benefits		
Cost		

Phase II: Real Option Analysis

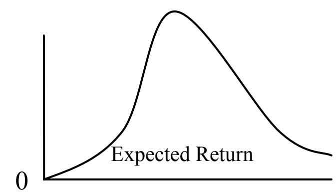
Measure the Real Option Value of each implementation alternative using Monte Carlo simulations and the modified Black-Scholes equation:

$B^* N(D) - C^*N(D')$

Where,
B = Estimated Benefit
C = Estimated Cost (C)/
N(D) = The cumulative normal probability of factor D which depends on the risk or volatility (σ) of expected project returns.

	Project Alternative 1	Project Alternative 2
Real Option Value	$B1^* N(D_1) - C1^*N(D_2)$	$B2^* N(D_1) - C2^*N(D_2)$

Estimated Costs (C) → Monte Carlo Simulations → Return Volatility (σ)
Estimated Benefits (B)



Phase III: Strategic Analysis

Measure the Strategic Scorecard Value of each implementation alternative using analytical network process(ANP) pair-wise comparisons to consider all the interrelation between business goals and categories.

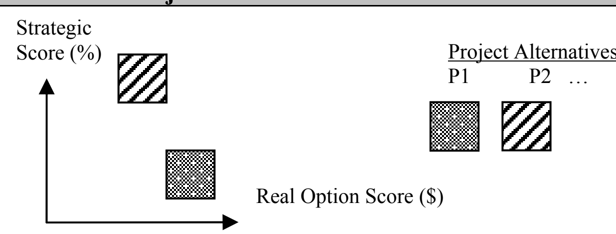
For each business goal, the project is assigned a rateP(Sij) that indicates the extend on which the goal will be satisfied for the project alternative.

*The project score is equal to the product of the project rating P(Sij) * the business goal weight (Wij). The sum of these products is the Strategic Scorecard Value*

Business Goal	Weight	Project Alternative 1: P1 Rating	P1 Score	Project Alternative 2: P2 Rating	P2 Score
1. User Value	W1				
1.1 Goal	W_{11}	$P_1(S_{11})$	$P_1(S_{11})^*W_{11}$	$P_2(S_{11})$	$P_2(S_{11})^*W_{11}$
1.2 Goal	W_{12}	$P_1(S_{12})$	$P_1(S_{12})^* W_{12}$	$P_2(S_{12})$	$P_2(S_{12})^* W_{12}$
……					
2. Financial Value	W2				
2.1 Goal	W_{21}	$P_1(S_{21})$	$P_1(S_{21})^*W_{21}$	$P_2(S_{21})$	$P_2(S_{21})^*W_{21}$
2.2 Goal	W_{22}	$P_1(S_{21})$	$P_1(S_{21})^*W_{22}$	$P_2(S_{22})$	$P_2(S_{22})^*W_{22}$
…….					
3. Operation Value	W3				
3.1 Goal	W_{31}	$P_1(S_{31})$	$P_1(S_{31})^*W_{31}$	$P_2(S_{31})$	$P_2(S_{31})^*W_{31}$
3.2 Goal	W_{32}	$P_1(S_{32})$	$P_1(S_{32})^*W_{32}$	$P_2(S_{32})$	$P_2(S_{32})^*W_{32}$
……….					
4. Knowledge Value	W4				
4.1 Goal	W_{41}	$P_1(S_{41})$	$P_1(S_{41})^*W_{41}$	$P_2(S_{41})$	$P_2(S_{41})^*W_{41}$
4.2 Goal	W_{42}	$P_1(S_{42})$	$P_1(S_{42})^*W_{42}$	$P_2(S_{42})$	$P_2(S_{42})^*W_{42}$
…………					
Strategic Scorecard Value		$\sum_{j=1}^{4}\sum_{i=1}^{k} P_1(Sij)^*W_{ij}$		$\sum_{j=1}^{4}\sum_{i=1}^{k} P_1(Sij)^*W_{ij}$	

Phase IV : Project ROI and Selection

Select for the IT portfolio the project alternative that provides the best combination of real option and strategic scorecard values.



In Phase III, the priority vector "w" (weights) for the balanced scorecard categories and business goals are estimated using analytical network process (ANP) pair-wise comparisons to consider all the possible interrelations. For each business goal, the project is assigned a rate P(Sij) that indicates the extend on which the goal will be satisfied for the project alternative. The project score for a business goal is equal to the product of the project rating P(Sij) multiplied by the business goal weight (Wij). The sum of these products is the Strategic Scorecard Value.

Finally, in *Phase IV*, the research framework suggests to select the project alternative that provides the best combination of real option and strategic scorecard values.

4.2.1 Phase IV: Project Selection

In Phase I, the business goals for the each of the four balanced scorecard perspectives (customer value, financial value, operational value, knowledge value) are identified. The impact of each IT project initiative is evaluated using the four perspectives of a balanced scorecard strategy map as shown in Figure 5. The factors for each perspective need to be measured based on the alignment with the overall business mission and vision.

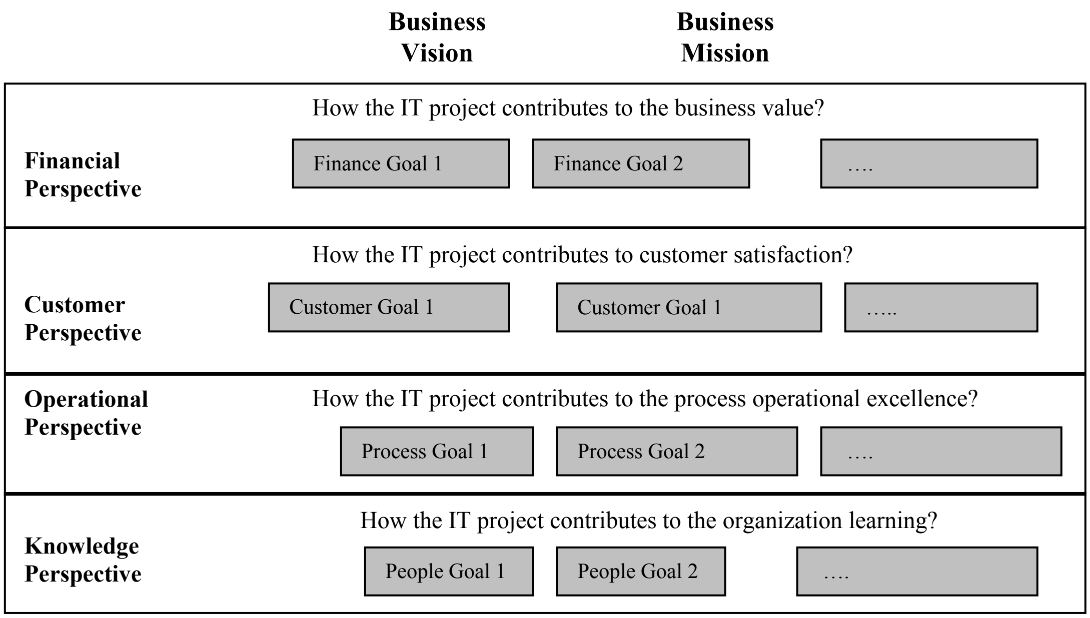


Figure 5 Identifying Business Goal for the IT project

In the financial perspective, managers identify the quantitative or monetary factors of the IT project such as the expected cost, the annual revenue growth rate that the project can generate and the expected return rate. The key question of the financial perspective is how the IT project contributes to the business value.

In the customer perspective, the factors of the IT project contributing to the customer satisfaction are identified such as reliability, quality, responsiveness, flexibility, and security.

In the operational perspective, the contribution of the IT project to the operational excellence is considered. Factors such as the expected increase in efficiency and effectiveness due to the streamline of operations and automatization of task by the IT project are evaluated.

In the knowledge perspective, the training, the allocation of staff members and the level of expertise requirements for the IT project are considered.

After identifying the business goal, the next step in this phase, is to establish the metrics and targets for the IT project business goals. This information is estimated by the IT managers and the data is tabulated as shown in Table 11.

Table 11 Measurements and Targets for the Factors Impacted by the IT projects

Financial	**Measurement**	**Target**
Finance Goal 1		
Finance Goal 2		
…….		
Customer	**Measurement**	**Target**
Customer Goal 1		
Customer Goal 2		
…		
Operational	**Measurement**	**Target**
Process Goal 1		
Process Goal 2		
……		
Knowledge	**Measurement**	**Target**
People Goal 1		
People Goal 2		
…….		

The final step in this phase is to estimate the revenues and costs for the project alternatives (Table 12).

Table 12 Project Cost and Revenue Estimation

Project Cost and Revenue Estimation					
	Year 0	***Year 1***	***Year 2***	***Year 3***	***…….***
Project Alternative Revenue (+)					
Project Alternative Cost (-)					

There are two alternatives to find out these expected cash flows. In the cases where historical data exist or where it is possible to do a market research, time series forecasting or simulations can be used to estimate the expected cash flows for the life cycle of the IT project. However, there are situations where the IT project is an innovative application, and it is not clear how to generate or gather data. In these cases, it is possible to use fuzzy logic and expert opinion estimations to generate an interval with the potential values of the expected cash flows.

Fuzzy logic allows decision making with estimated values under incomplete and uncertain information where there are not a lot of data available. For these kinds of systems, fuzzy logic uses approximate reasoning to deal with the no statistical uncertainties. When not data is available, the research framework suggests to use a modified version of Carlsson and Fuller (2001) trapezoidal fuzzy numbers to estimate the present values of expected cash flows .

A trapezoidal fuzzy number M (a,b,α,β) is defined for four numbers where the base of the trapezoid is the interval [a-α, b+β] and its tops is [a,b]. The present value of expected cash flows can be estimated using the trapezoidal distribution B = (B_1, B_2, α, β) (Figure 6). Similarly, the expected costs can be estimated by C= (C_1, C_2, α', β') (Figure 7).

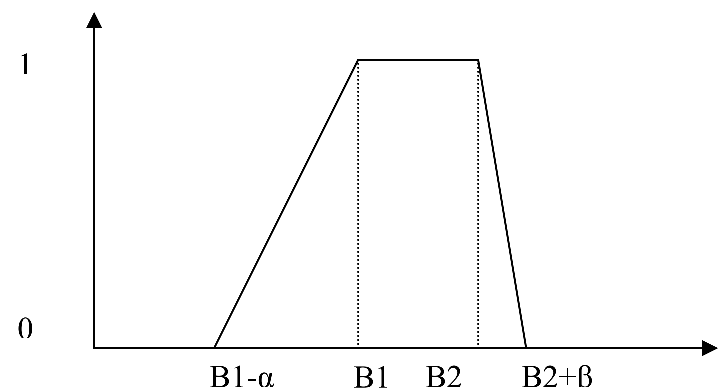


Figure 6 Benefit (B) Estimation Trapezoidal Fuzzy Number

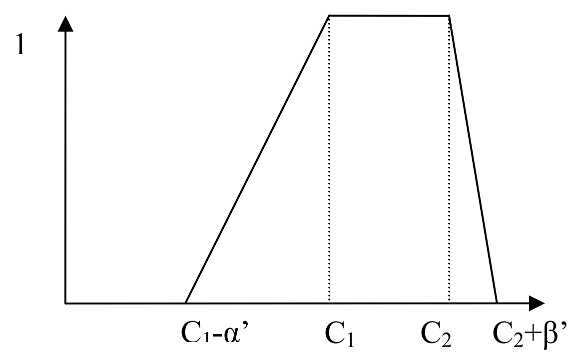
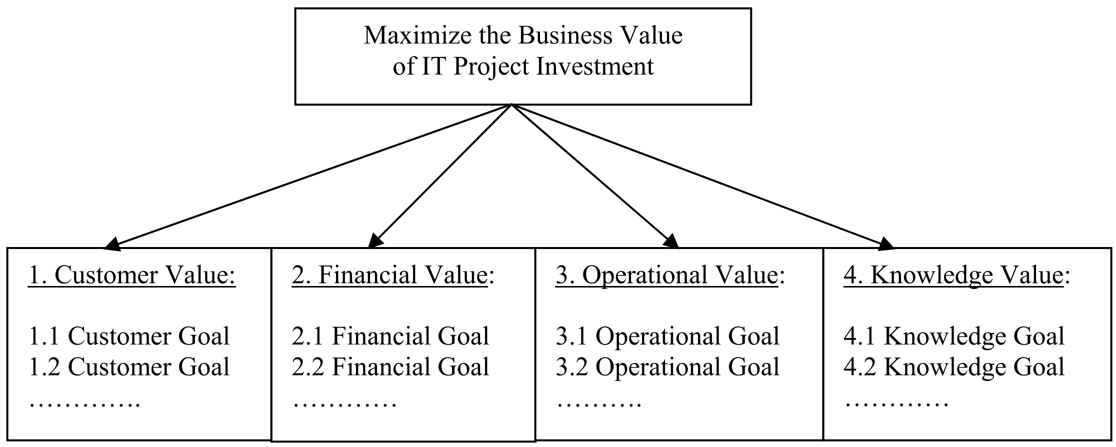


Figure 7 Costs(C) Estimation Trapezoidal Fuzzy Number

The final outcome of the project modeling phase is summarized in Figure 8. The balanced scorecard is the control criteria for comparison and it will be used during the strategic analysis. The initial estimation and cost and benefits will be used during the real option analysis.



Alternative 1: Benefits and Cost Estimation

	Year 0	***Year 1***	***Year 2***	**……**
Project Benefits (+)				
Project Cost (-)				

Alternative 2: Benefits and Cost Estimation

	Year 0	***Year 1***	***Year 2***	**……**
Project Benefits (+)				
Project Cost (-)				

Alternative N: Benefits and Cost Estimation

	Year 0	***Year 1***	***Year 2***	**……**
Project Benefits (+)				
Project Cost (-)				

Figure 8 Project Modeling

4.2.2 Phase II: Real Option Analysis

In phase II, the volatility (standard deviation) of the rate of return of the project will be derived using Monte Carlo simulations, where the inputs are the estimated cost and the estimated benefits of each project alternative (Figure 9).

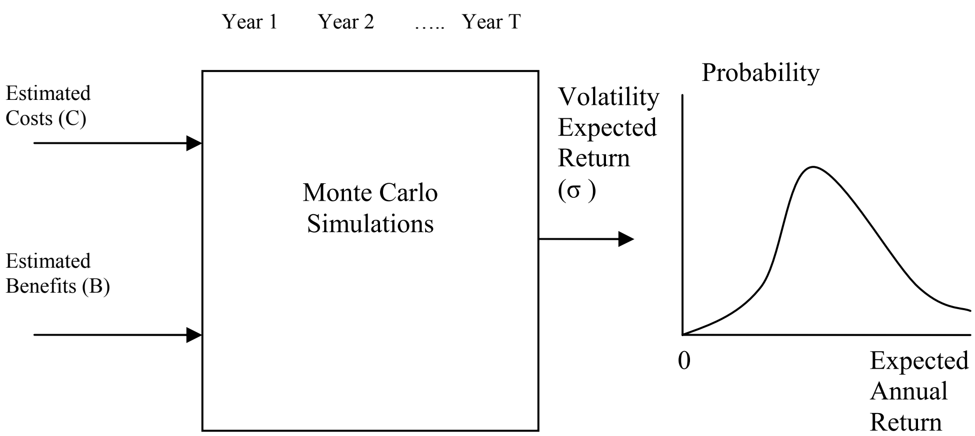


Figure 9 Monte Carlo Simulations for the Project Rate of Return

The variation rate for the estimated projects and benefits could be estimated, along with the probability that the variation will occur. The correlation coefficient between the variation in the estimated benefits and the project costs should be considered.

Once the volatility σ is determined, the modified Black-Scholes equation can be used to calculate the Real Option Value of each alternative during the different phases of the project life cycle (Table 13 and Table 14).

Table 13 Variation Rate for the Cost and Revenue of the Project

Real Option Value = $B * N(D_1) – C*N(D_2)$

Where: B = present value of the expected benefits of the project if it is undertaken today.

C = present value of the expected development cost of the project if it is undertaken today.

$D_1 = [\ln(B/C) + \sigma^2 * (t/2)] / [\sigma\sqrt{t}]$

$D_2 = D_1 – \sigma \sqrt{t}$

N(Di) = The cumulative normal probability function for Di , $i=_{1,2}$

σ^2 = variance of the ratio B/C $= \sigma^2_B + \sigma^2_C - 2 * \rho_{BC} * \sqrt{\sigma^2_B \sigma^2_C}$

σ^2_B= variance of the rate of change of benefits of the project

σ^2_C= variance of the rate of change of costs of the project

ρ_{BC} = Correlation between development costs and benefits

Table 14 Variation Rate for the Cost and Revenue of the Project

Real Option Parameter	**Description**	**Alternative 1**	**Alternative 2**
B	Present value of the expected benefits of the project if it is undertaken today.		
C	Present value of the expected development cost of the project if it is undertaken today		
σ^2	Variance of the ratio B/C = $\sigma^2_B + \sigma^2_C - 2 * \rho_{BC} * \sqrt{\sigma^2_B \sigma^2_C}$		
D_1	$D_1 = [\ln(B/C) + \sigma^2 * (t/2)] / [\sigma\sqrt{t}]$		
D_2	$D_2 = D_1 – \sigma \sqrt{t}$		
N(D1)	The cumulative normal probability function for D1		
N(D2)	The cumulative normal probability function for D2		
REAL OPTION SCORE	**B*N(D1) – CN(D2)**		

4.2.3 Phase III: Strategic Analysis

To obtain the priority vector "w" (weights) for each business factors, pair-wise comparisons between the four balanced scorecard business value categories are performed using the Saaty 1-9 scale of preferences (Saaty, 1983). The scales are presented in Table 15.

Table 15 Saaty 1-9 scale of preferences

Rating	Description
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very Strongly preferred
9	Extremely Strongly preferred

The next step, is to generate pair-wise comparisons for the four categories or perspectives of the balanced scorecard (Table 16).

Table 16 Pair-wise Comparison Matrix for Business Value Category

Business Category	Customer	Financial	Operational	Knowledge
Customer	$a_{11} = 1$	a_{12} = User/Financial	a_{13} = User/Operational	a_{14} = User/Knowledge
Financial	a_{21} = Financial/User	$a_{22} = 1$	a_{23} = Financial/Operational	a_{24} = Financial/Knowledge
Operational	a_{31} = Operational/User	a_{32} = Operational/Financial	$a_{33} = 1$	a_{34} = Operational/Knowledge
Knowledge	a_{41} = Knowledge/User	a_{42} = Knowledge/Financial	a_{24} = Knowledge/Operational	$a_{44} = 1$

In this matrix, every element $\mathbf{a_{ij}}$, is the result of a pair-wise comparison denoting the dominance of element "i" relative to element "j". The matrix is reciprocal, satisfying $\mathbf{aij} = \mathbf{1/a_{ij}}$. The matrix diagonal values are equal to 1 ($\mathbf{a_{ii}} = 1$) denoting the equal preference for the same business value category. For example, if the decision makers consider that the operational value is strongly preferred over the financial value to achieve the goal of maximizing the IT project investment, then the corresponding scale value is a_{32} = Operational/Financial = 7 , and the reciprocal value a_{23}= Financial/Operational = 1/7.

The pair-wise comparison matrix is denoted by A. Each value of the matrix A is normalizing by dividing the original value by the corresponding column sum. The new normalized matrix is denoted A* (Table 17). The weight for each balanced scorecard category corresponds to the average of each row in the normalized matrix A* (Table 18).

Table 17 Variation Rate for the Cost and Revenue of the Project

A=	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}
	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}
	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}
	a_{41}	a_{42}	a_{24}	a_{44}	a_{45}
	a_{51}	a_{52}	a_{35}	a_{25}	a_{55}

A*=	a^*_{11}	a^*_{12}	a^*_{13}	a^*_{14}
	a^*_{21}	a^*_{22}	a^*_{23}	a^*_{24}
	a^*_{31}	a^*_{32}	a^*_{33}	a^*_{34}
	a^*_{41}	a^*_{42}	a^*_{24}	a^*_{44}

Where,

$$a^*_{ij} = \frac{a_{ij}}{\sum_{i=1}^{4} a_{ij}}$$

Table 18 Business Category Weights

						Business Category Weights	
	a^*_{11}	a^*_{12}	a^*_{13}	a^*_{14}	a^*_{15}	$\sum_{j=1}^{5} a^*_{1j} \div 5$	**Customer**
	a^*_{21}	a^*_{22}	a^*_{23}	a^*_{24}	a^*_{25}	$\sum_{j=1}^{5} a^*_{2j} \div 5$	**Financial**
A*=	a^*_{31}	a^*_{32}	a^*_{33}	a^*_{34}	a^*_{35}	$\sum_{j=1}^{5} a^*_{3j} \div 5$	**Operational**
	a^*_{41}	a^*_{42}	a^*_{24}	a^*_{44}	a^*_{45}	$\sum_{j=1}^{5} a^*_{4j} \div 5$	**Knowledge**
WEIGHTS TOTALS						**1**	

For each of the four balanced scorecard categories, a pair-wise comparison of the business goals is done. The number of factors (K) is variable and specific for each category. The weight for each business goal, it is calculated using a procedure similar to the described for the categories but considering interrelations. The ROSS approach use super-matrix to analysis the inter-dependences and feedback. The effect of the interdependencies in the business goals is resolved by raising the super-matrix to the power 2k+1, where k is an arbitrary large number, until the matrix converges into "long term" stable weights values (Saaty, 2004).

The weight for each factor within a category corresponds to the average of each row in the normalized matrix A*. The tables 19 and 20 show the calculations to obtain the weight of the business goals for the four balanced scorecard categories.

Table 19 Business Goals Pair-wise Comparisons

CUSTOMER VALUE	Goal 1	Goal 2		Goal K
Goal 1	$a_{11} = 1$	$a_{12} =$ Goal1/Goal2		$a_{1k} =$ Goal1/GoalK
Goal 2	$a_{21} =$ Goal2/Goal1	$a_{22} = 1$		$a_{2k} =$ Goal2/GoalK
Goal K	$a_{41} =$ GoalK/Goal1	$a_{42} =$ GoalK/Goal2		$a_{kk} = 1$
FINANCIAL VALUE	Goal 1	Goal 2		Goal K
Goal 1	$a_{11} = 1$	$a_{12} =$ Goal1/Goal2		$a_{1k} =$ Goal1/GoalK
Goal 2	$a_{21} =$ Goal2/Goal1	$a_{22} = 1$		$a_{2k} =$ Goal2/GoalK
Goal K	$a_{41} =$ GoalK/Goal1	$a_{42} =$ GoalK/Goal2		$a_{kk} = 1$
OPERATIONAL VALUE	Goal 1	Goal 2		Goal K
Goal 1	$a_{11} = 1$	$a_{12} =$ Goal1/Goal2		$a_{1k} =$ Goal1/GoalK
Goal 2	$a_{21} =$ Goal2/Goal1	$a_{22} = 1$		$a_{2k} =$ Goal2/GoalK
Goal K	$a_{41} =$ GoalK/Goal1	$a_{42} =$ GoalK/Goal2		$a_{kk} = 1$
KNOWLEDGE VALUE	Goal 1	Goal 2		Goal K
Goal 1	$a_{11} = 1$	$a_{12} =$ Goal1/Goal2		$a_{1k} =$ Goal1/GoalK
Goal 2	$a_{21} =$ Goal2/Goal1	$a_{22} = 1$		$a_{2k} =$ Goal2/GoalK
Goal K	$a_{41} =$ GoalK/Goal1	$a_{42} =$ GoalK/Goal2		$a_{kk} = 1$

Table 20 Business Goals Weight

					Weights (Average)	$\mathbf{W_i}$	**Business Category**
A*=	a^*_{11}	a^*_{12}		a^*_{1k}	$\sum_{j=1}^{k} a_{1j} \div k$	w_{11}	**Goal 1**
	a^*_{21}	a^*_{22}		a^*_{2k}	$\sum_{j=1}^{k} a_{2j} \div k$	w_{12}	**Goal 2**
	a^*_{k1}	a^*_{k2}		a^*_{kk}	$\sum_{j=1}^{k} a_{kj} \div k$	w_{1k}	**Goal k**
WEIGHTS TOTAL					**100**		

The final weight for each business goal is found by multiplying the factor weight (**W_{ij})** for the weight of the corresponding category **(Wi**). (Table 21)

Table 21 Normalized Goal Weights

Business Goal	Weight	Normalized Goal Weight
1 User Value	**W_1**	
1.1 Goal	w_{11}	$W_{11} = w_{11} * \mathbf{W_1}$
1.2 Goal	w_{12}	$W_{12} = w_{12} * \mathbf{W_1}$
…..		
2 Financial Value	**W_2**	
2.1 Goal	w_{21}	$W_{21} = w_{21} * \mathbf{W_2}$
2.2 Goal	w_{22}	$W_{22} = w_{22} * \mathbf{W_2}$
……		
3 Operational Value	**W_3**	
3.1 Goal	w_{31}	$W_{31} = w_{31} * \mathbf{W_3}$
3.2 Goal	w_{32}	$W_{32} = w_{32} * \mathbf{W_3}$
……		
4 Knowledge Value	**W_4**	
4.1 Goal	w_{41}	$W_{41} = w_{41} * \mathbf{W_4}$
4.2 Goal	w_{42}	$W_{42} = w_{42} * \mathbf{W_4}$
……		
Normalized Weight Total		$\sum_{j=1}^{4} (\sum_{i=1}^{k} W_{ij}) = 1$

The next step is to rate the project alternatives with respect to each business goal. These rates can be found using pair wise comparisons. Tables 22 and 23 show the pair-wise comparison matrix for the project alternatives when considering a the customer perspective business category and one of the business goals for that category (e.g. 1.1 business goal).

Table 22 Project Alternatives Pair-wise Comparisons

1.1 Customer Goal	**Alternative 1**	**Alternative 2**		**Alternative N**
Alternative 1	$a_{11} = 1$	$a_{12} =$ Alt 1/Alt 2		$a_{1k} =$ Alt 1/Alt N
Alternative 2	$a_{21} =$ Alt 2/ Alt 1	$a_{22} = 1$		$a_{2k} =$ Alt 2/Alt N
Alternative N	$A_{n1} =$ Alt N / Alt 1	$a_{42} =$ Alt N/Alt 2		$A_{nn} =$ 1

Table 23 Project Alternatives Weights for Business Goal 1.1

					Weights for 1.1 Customer Goal	
	a^*_{11}	a^*_{12}		a^*_{1n}	$\sum_{j=1}^{n} a_{1j} \div n$	**Alternative 1** $P_1(S_{11})$
	a^*_{21}	a^*_{22}		a^*_{2n}	$\sum_{j=1}^{n} a_{2j} \div n$	**Alternative 2** $P_2(S_{11})$
A*=	a^*_{n1}	a^*_{n2}		a^*_{nk}	$\sum_{j=1}^{k} a_{kj} \div k$	**Alternative N** $P_n(S_{11})$
Weights Total					**1**	

The project alternative rate for each business goal is represented with the notation $P_i(Sik)$, where P_i represents the rating for project "i" considering business goal "jk".

The results of calculating the alternatives' ratings for each business goal are summarized in the Table 24.

Table 24 Project Alternatives Weights

Business Value Goals	Alternative 1 Rating	Alternative 2 Rating	Alternative N Rating
1 User Value			
1.1 Goal	$P_1(S_{11})$	$P_2(S_{11})$	$P_n(S_{11})$
1.2 Goal	$P_1(S_{12})$	$P_2(S_{12})$	$P_n(S_{12})$
…..			
2 Financial Value			
2.1 Goal	$P_1(S_{21})$	$P_2(S_{21})$	$P_n(S_{21})$
2.2 Goal	$P_1(S_{22})$	$P_2(S_{22})$	$P_n(S_{22})$
……			
3 Operational Value			
3.1 Goal	$P_1(S_{31})$	$P_2(S_{31})$	$P_n(S_{31})$
3.2 Goal	$P_1(S_{32})$	$P_2(S_{32})$	$P_n(S_{32})$
……			
4 Knowledge Value			
4.1 Goal	$P_1(S_{41})$	$P_2(S_{41})$	$P_n(S_{41})$
4.2 Goal	$P_1(S_{42})$	$P_2(S_{42})$	$P_n(S_{42})$
……			

Table 25 shows the final step to calculate the project alternative strategic scorecard values. Each goal weight W_{ij} is multiplied for the corresponding alternative rating $P_k(S_{ij})$. Then, the subtotals for each balanced scorecard category are obtained by adding the corresponding business goal project scores, and finally, the grand total strategic scorecard value is the sum of the business category subtotals.

Table 25 Strategic Scorecard Value Calculations

Business Value Goals	Goal Weight	IT Project Investment					
		Alternative 1 (P1)		Alternative 2 (P2)		Alternative N (PN)	
		Weight	Score	Weight	Score	Weight	Score
1 User Value	$\mathbf{W_1}$						
1.1 Goal	W_{11}	$P_1(S_{11})$	$P_1(S_{11})*W_{11}$	$P_2(S_{11})$	$P_2(S_{11})*W_{11}$	$P_n(S_{11})$	$P_n(S_{11})*W_{12}$
1.2 Goal	W_{12}	$P_1(S_{12})$	$P_1(S_{12})* W_{12}$	$P_2(S_{12})$	$P_2(S_{12})* W_{12}$	$P_n(S_{12})$	$P_n(S_{12})* W_{12}$
…..							
Subtotal 1 (User Value)			$\sum_{i=1}^{k} P_1(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} P_2(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} Pn(S_{1i})*W_{1i}$
2 Financial Value	$\mathbf{W_2}$						
2.1 Goal	W_{21}	$P_1(S_{21})$	$P_1(S_{21})* W_{21}$	$P_2(S_{21})$	$P_2(S_{21})* W_{21}$	$P_n(S_{21})$	$P_n(S_{21})* W_{21}$
2.2 Goal	W_{22}	$P_1(S_{22})$	$P_1(S_{22})* W_{22}$	$P_2(S_{22})$	$P_2(S_{22})* W_{22}$	$P_n(S_{22})$	$P_n(S_{22})* W_{22}$
……							
Subtotal 2 (Financial Value)			$\sum_{i=1}^{k} P_1(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} P_2(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} P_n(S_{1i})*W_{1i}$
3 Operational Value	$\mathbf{W_3}$						
3.1 Goal	W_{31}	$P_1(S_{31})$	$P_1(S_{31})* W_{31}$	$P_2(S_{31})$	$P_2(S_{31})* W_{31}$	$P_n(S_{31})$	$P_n(S_{31})* W_{31}$
3.2 Goal	W_{32}	$P_1(S_{32})$	$P_1(S_{32})* W_{32}$	$P_2(S_{32})$	$P_2(S_{32})* W_{32}$	$P_n(S_{32})$	$P_n(S_{32})* W_{32}$
……							
Subtotal 3 (Operational Value)			$\sum_{i=1}^{k} P_1(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} P_2(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} Pn(S_{1i})*W_{1i}$
4 Knowledge Value	$\mathbf{W_4}$						
4.1 Goal	W_{41}	$P_1(S_{41})$	$P_1(S_{41})* W_{41}$	$P_2(S_{41})$	$P_2(S_{41})* W_{41}$	$P_n(S_{41})$	$P_n(S_{41})* W_{41}$
4.2 Goal	W_{42}	$P_1(S_{42})$	$P_1(S_{42})* W_{42}$	$P_2(S_{42})$	$P_2(S_{42})* W_{42}$	$P_n(S_{42})$	$P_n(S_{42})* W_{42}$
……							
Subtotal 4 (Financial Value)			$\sum_{i=1}^{k} P_1(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} P_1(S_{1i})*W_{1i}$		$\sum_{i=1}^{k} P_1(S_{1i})*W_{1i}$
Total Strategic Score			$\sum_{j=1}^{4}$ **Subtotal j**		$\sum_{j=1}^{4}$ **Subtotal j**		$\sum_{j=1}^{4}$ **Subtotal j**

4.2.4 Phase IV: Project Selection

To guide the selection process, the research framework proposes to map the Real Option Score and the Strategic Score against the corresponding alternative cost (Figure 10)

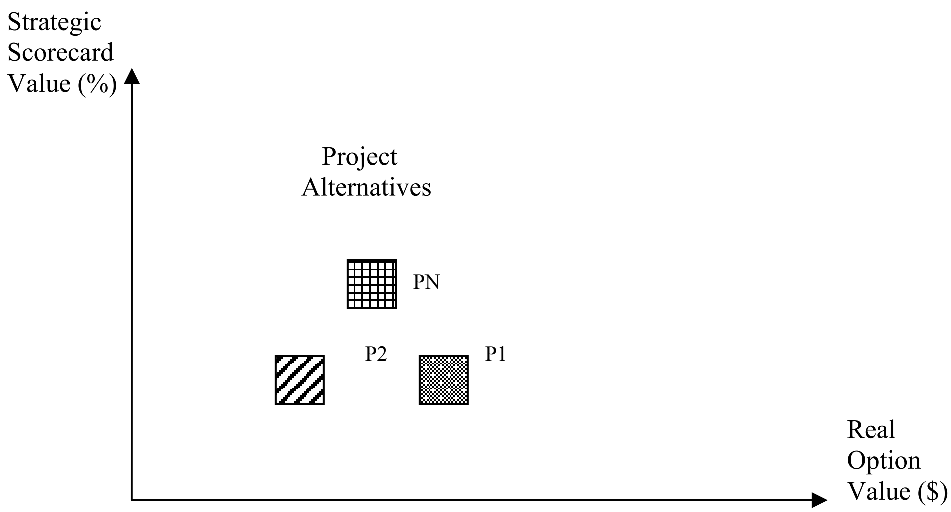


Figure 10 Strategic Scorecard Value and Real Option Value

Finally, in phase IV, The Real Option Value and the Strategic Scorecard Values are used to guide the selection decision. Using the ROSS approach managers can select the project with the best combination of Real Option and Strategic Scorecard values. The ROSS approach is a descriptive method to generate quantitative results and to guide the decision, but it is not a prescriptive method. The final decision should be made by the managers based on the specific trade-offs that are required for the current business conditions.

CHAPTER 5

CASE STUDY: SCINET PROJECT RETURN ON INVESTMENT

5.1 Introduction

This case study shows how the Real Option Strategic Scorecard (ROSS) framework can be applied to the analysis of e-government projects. In particular, this study discusses the return on investment for the Seminole County Integrated Network (SCINET) e-government project to replace the existing H.T.E. legacy information system.

Most local governments' agencies use a very ad-hoc approach to analyze the return on IT investment and select projects for their e-government portfolios. However, recent budget guidelines for the federal and local government require that new IT investments are justified with strong business cases.

For example, since 2005, the Federal Office of Management and Budget (OMB) is requiring that any IT investment of more than $500,000 dollars should satisfy the Exhibit 300 business case requirements. Exhibit 300 is a project application template for requesting federal government funds that requires a detailed project justification and plan including alternative analysis, cost and benefit analysis, acquisition plan, risk analysis, human resource management plan, enterprise architecture and security plan. After submission of the Exhibit 300 for the project, the Department's Capital Investment Technology Review Board (CITRB) assigns scores to the different items of Exhibit 300, and projects are funded based on the scoring results. The $60 billion federal IT budget managed by OMB is being assigned only to projects that provide a strong business case.

The new government business case requirements are increasing the awareness among federal and local officials about the need to adopt better decision frameworks to analyze and select IT projects. In this study, the different phases of the ROSS framework will be applied to analyze the return on investment of the SCINET project. An expected result is to demonstrate that the phases of the real option framework fit very well with the new government business case requirements to determine the value, cost and risk of projects. Furthermore, this case study demonstrates that the ROSS approach will help managers of the local and federal government to present better business cases to obtain funding for new e-government project investments.

This case study is organized as it follows. First, we provide a description of the Seminole County SCINET project being implemented to replace the existing H.T.E legacy system. Second, the ROSS decision framework is applied for the return on investment analysis of SCINET project. Finally, the conclusions of the case study are summarized.

5.2 The SCINET Project

Seminole County, located north of Orlando Florida, is one of the fastest growing counties in the United States. Its current population of 379,000 is expected to double over the next twenty years. The expected growth brings customer service challenges to Seminole County.

In order to improve the government services to this increasing population, the Seminole County Planning and Development Department decided to replace its current H.T.E. information system in 2003. The H.T.E. legacy application is provided by Sugard H.T.E. Inc, an international company serving municipalities since 1981 and with headquarters in Lake Mary, Florida. The H.T.E. system was bought by Seminole in 1998 and it is used to issue building permissions and other county transactions. The annual maintenance and operation costs to support H.T.E are around $200 dollar per year. During the years of operations, the H.T.E. legacy system has cost to the Seminole taxpayers more than $11 million dollars.

The Seminole County SCINET project objectives are to streamline service-delivery and integrate government services with the implementation of .NET based web services providing access to information anytime, anywhere. Through the portal, Seminole citizens can conduct business with the county from individual home computers, company's internet networks, and community kiosk centers.

For the SCINET project, Seminole County managers considered three different project alternatives. One option was to upgrade the system to a new H.T.E version provided by Sugard Inc. and based on proprietary software technology. A second project alternative was to develop the new system in-house using the Java programming language and using the internal resources of the IT department at Seminole. The third option was to implement the project in partnership with the Engineering Technology Department at the University of Central, using a joint development approach and Microsoft .NET tools. Table 26 summarizes the options considered by the Seminole County managers.

Table 26 Project Alternatives to replace H.T.E Legacy System

	Update H.T.E	**Joint Development with UCF**	**In-House Solution**
Cost	$1,000,000 (upgrade) $200,000 per year (maintenance)	$731,379 (development) $50,000 per year (maintenance)	$ n/a (increase of IT staff workload by 100%)
Technology	Proprietary	.NET	Java

In the summer of 2003, the Seminole County managers selected the partnership with the University of Central Florida to develop the new SCINET system to replace the H.T.E. legacy system. As a result of the joint development work with UCF, a string of new projects are being implemented including projects to migrate the current Lotus Domino e-mail system into Microsoft 2003 Exchange Server. However, there is a need to analyze the return on investment of these new projects using a systematic approach to quantify the costs, benefits, risks.

The Real Option Strategic Scorecard (ROSS) approach is applied in this case study to analysis the return on investment (ROI) of the SCINET e-government project. The ROSS approach uses a more comprehensive and axiomatic approach for the ROI analysis, measuring both the business value and the strategic implications of selecting implementing the SCINET project. The main benefit of applying the ROSS framework to the SCINET project, is providing guidelines to optimize the return on investment value of future IT e-government investments.

In the next section of this case study, we illustrate how the ROSS decision framework can be used to find out the return on investment of the SCINET project and to improve the decision process for future e-government investments at Seminole County.

5.3 Return on Investment Using the ROSS Approach

5.3.1 Phase I: Project Modeling

During this phase, the three steps of the project modeling ROSS approach were used to model the SCINET project. First, the strategic alignment of the

SCINET project initiative with the overall mission and vision of Seminole County was described using the four perspectives of the balanced scorecard. Priority weights for the customer, financial, operational and knowledge management perspectives were estimated using semi-structures and open-ended interviews. Second, the business goals were identified and the corresponding measurements and targets were estimated using interviews and surveys. Third, the costs and benefits for the SCINET project were estimated using expert opinion and benchmarking of similar strategic projects.

5.3.1.1 Balanced Scorecard Model

The first step for the project modeling is to describe the strategic alignment of the SCINET project initiative with the overall mission and vision of Seminole County, using the four perspectives of the balanced scorecard. Semi-structured and open-ended interviews were used to determine the relative importance of the customer, financial, operational and knowledge management perspectives of the balanced scorecard to achieve the overall mission of Seminole County of exceeding customer's expectations for services.

Seminole County managers and technical personnel were interviewed during the business analysis phase of the SCINET project, to determine the expectations and requirements for the project. For the *customer perspective*, the SCINET project is expected to provide a friendly user interface to access county services anytime, anywhere with outstanding quality and functionality. For the *operational perspective*, the SCINET project is expected to streamline processes to increase county effectiveness and efficiency. For the *financial perspective*, the SCINET project is expected to reduce costs and increase business opportunities with the Seminole and Florida community. Finally, for the *knowledge management* perspective, the SCINET project is expected improve information sharing and team work.

As a result of the discussions and interviews, the following weights were assigned to the four perspectives of the balanced scorecard (Table 27).

Table 27 Priority Weights for the Balanced Scorecard Perspectives

Balanced Scorecard Perspective	**Priority Weight (W)**
Customer	50%
Operational	20%
Financial	20%
Knowledge	10%

Figure 11 shows the corresponding strategic balanced scorecard map that was used to model and analyze the return on investment of the SCINET project.

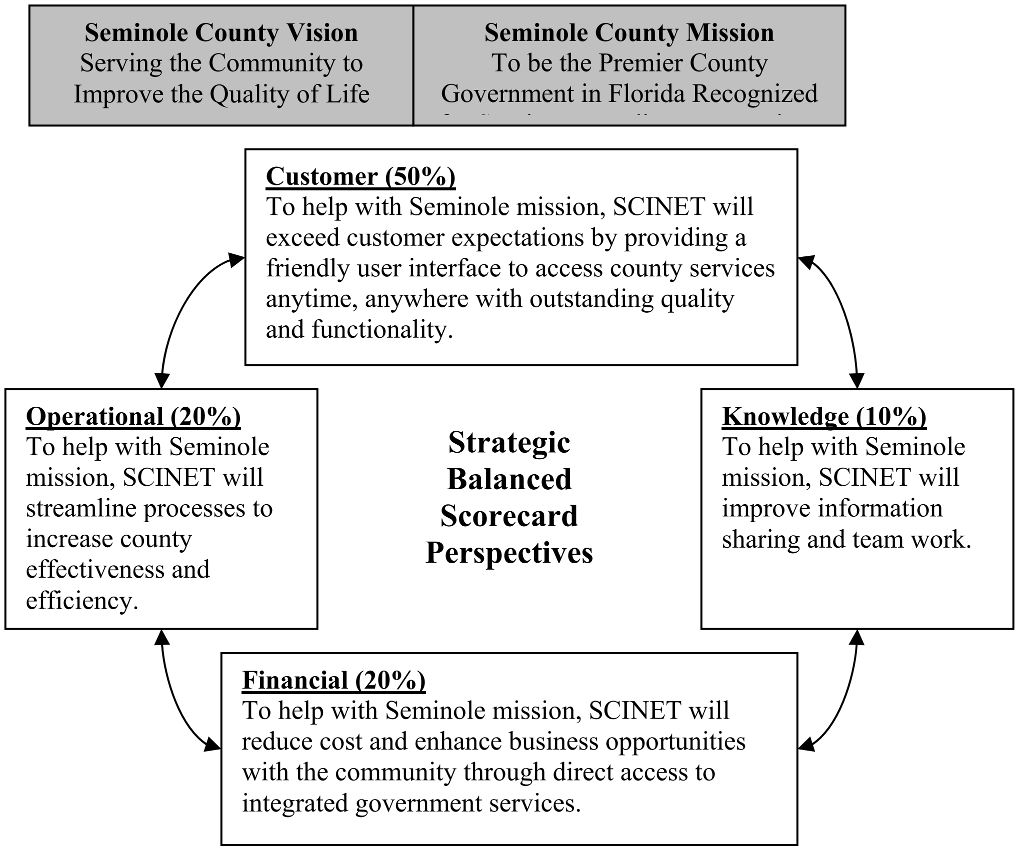


Figure 11 Balanced Scorecard Perspectives and Priority Weights

5.3.1.2 Business Goals, Measurement and Targets

The second step in the project modeling phase is to identify the business goals and the corresponding measurements and targets using the balanced scorecard perspectives. Several sessions were organized to find out the relevant elements and expectations for the SCINET migration project. These discussion sessions counted with the participation of Seminole managers, technical staff, users of the system, and representatives of the partners' agencies and the Board of commissioners. Figure 12 lists the business goals identified, measuring and targets.

Financial Perspective	How the SCINET project contributes to the business value?		
	FINANCIAL GOALS	MEASUREMENT	TARGET
	Reduce Cost	% Cost reduction per transaction	50%
	Profitability	% Increase of business transactions	10%
Customer Perspective	How the SCINET project contributes to customer satisfaction?		
	CUSTOMER GOALS	MEASUREMENT	TARGET
	Flexibility	% Customer satisfaction ratio	25%
	Reliability	% Reliability improvement	25%
	Responsiveness	% On-time delivery rate	98%
Operational Perspective	How the SCINET project contributes to the process operational excellence?		
	OPERATIONAL GOALS	MEASUREMENT	TARGET
	Capacity	%Capacity utilization increase	50%
	Efficiency	% Efficiency increase	50%
Knowledge Perspective	How the SCINET project contributes to the organization knowledge and learning?		
	KNOWLEDGE GOALS	MEASUREMENT	TARGET
	Learning Curve	% Decrease in user support	50%
	Team Collaboration	% Increase on cross functional collaboration	30%

Figure 12 Business Goals, Targets and Measurements for SCINET

5.3.1.3 Estimation of Costs and Benefits

The third step of the project modeling is to estimate cost and benefits. Identifying the business value of strategic investment like SCINET is a complex process, because the capabilities of this type of new system are seldom known in advance and it is difficult to predict the actual costs, benefits and the impact of uncertainty. In general, strategic investments have high initial investments and the returns are only seeing in the long term. For the SCINET project the benefits and costs were estimated based on expert opinion and benchmarking of similar projects. The estimation results are shown in Table 28.

Table 28 Estimation of Costs and Benefits for SCINET Project

SCINET PROJECT	**Analysis**	**Design**	**Development**	**Test**	**Release**	
Estimated Cost	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**
1.0 Software/ Hardware Licensing	$54,500	$54,500	$109,000	$109,000	$109,000	**$436,000**
2.0 Software Development	$104,000	$104,000	$208,000	$208,000	$208,000	**$832,000**
3.0 Consultant Support *	$75,945	$75,945	$151,890	$151,890	$151,890	**$607,560**
4.0 Seminole Employees	$55,359	$55,359	$110,717	$110,717	$110,717	**$442,868**
5.0 Training	$26,000	$26,000	$52,000	$52,000	$52,000	**$208,000**
6.0 Indirect Costs	$46,886	$46,886	$93,772	$93,772	$93,772	**$375,088**
7.0 Travel	$3,000	$3,000	$6,000	$6,000	$6,000	**$24,000**
Total Costs	**$365,690**	**$365,690**	**$731,379**	**$731,379**	**$731,379**	**$2,925,516**
Estimated Benefits	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**
1.0 Reduced Cost per Transaction	$0	$0	$500,000	$750,000	$1,250,000	**$2,500,000**
2.0 Reduced Maintenance Cost	$0	$0	$200,000	$200,000	$200,000	**$600,000**
Total Benefits	**$0**	**$0**	**$700,000**	**$950,000**	**$1,450,000**	**$3,100,000**
Net Cash Flow	**-$365,690**	**-$365,690**	**-$31,379**	**$218,621**	**$718,621**	

For the SCINET project, the costs included the initial investment of $731,379 for the first two years of analysis and design (2004-2005) and the additional costs of $731,379 per year during the there years of development and testing required to replace completely the legacy system and implement all the new functionality and features (2006-2008). In regard to the benefits, it is expected that the SCINET project will start reducing cost when the initial features of the system are released to the public on 2006. The benefits are expected to increase from $700,000 in 2006 to $1,450,000 in 2008

The total results indicate that the SCINET project estimated benefits will have a value of $3,100,000 and the overall project cost is $2,925,516. Because the expected costs and benefits are similar, the actual value of the project will not be self-evident, if we use the traditional return on investment analysis to justify the SCINET project investment. Therefore, in order to identify the actual business value of the SCINET project a real option analysis is required.

5.3.2 Phase II: Real Option Analysis

During Phase II, the real option analysis of SCINET project was done in a two step process. First, the real option analysis established a baseline for comparison calculating the return on investment without considering the uncertainty of costs and benefits. Second, the project returns are recalculated considering uncertainty conditions. The costs and benefits are estimated with a range of variability, and the corresponding volatility (standard deviation) of the project returns is estimated using the Black Scholes equation and Monte Carlo Simulations.

5.3.2.1 Baseline Scenario: Cost/Benefits without Uncertainty

The first step of the real option analysis is to establish a baseline for comparison calculating the return on investment without considering the uncertainty of costs and benefits. Table 29 shows the results with a typical estimated of 10% for the cost of capital rate. The net present value will be negative ($62,715) and the cost benefit ratio of the project will be $0.97 (for each dollar invested the benefit will be $0.97 cents). To get even (NPV=0), the cost of capital rate should be 6.63%.

Table 29 Baseline Case: Cost/Benefits without Uncertainty

SCINET PROJECT	**Analysis**	**Design**	**Development**	**Test**	**Release**	
	2004	**2005**	**2006**	**2007**	**2008**	**Total**
Total Costs	$365,690	$365,690	$731,379	$731,379	$731,379	$2,925,516
Total Benefits	$0	$0	$700,000	$950,000	$1,450,000	$3,100,000
Net Cash Flow	-$365,690	-$365,690	-$31,379	$218,621	$718,621	
Cost Present Value (C)	$2,137,834					
Benefit Present Value (B)	$2,075,119					
Net Present Value (NPV)	-$62,715					
Cost-Benefit Ratio (B/C)	$0.97					
Internal Rate of Return (IRR)	6.63%					

. However these baseline results are of limited value because they did not include the impact of uncertainty. The benefits or the cost can change over time, and this volatility will affect the return on investment of the project.

5.3.2.2 Real Scenario: Cost/Benefits with Uncertainty

The second step of the real option analysis is to calculate the impact of uncertainty. The assumptions for the uncertainty parameters (cost, benefits, and the variance of the benefit and cost ratio) are derived from benchmarking or expert opinion. Table 30 shows the results assuming that there that the project benefits for the SCINET project will fluctuate within a range of 60% above or below the expected value and that the that the cost will fluctuate within a range of 40% above or below the expected value during the considered project life cycle. The correlation coefficients for rates of variation between the benefits and the development costs are assumed to be 0.5.

The real option analysis shows that the SCINET project has a Real Option Value of $344,320, so with the assumed range of variation for the costs (40%) and benefits (60%), the SCINET project shows a positive return and business value, in contrast with results obtained with the traditional return on investment analysis that generated a slightly negative NPV ($62,715).

Table 30 Real Option Calculations for SCINET Project

SCINET PROJECT		
Real Option Analysis	**Variable**	**Value**
Cost Present Value	C	$2,137,834
Benefit Present Value	B	$2,075,119
Cost Standard Deviation	σ_B	0.40
Benefit Standard Deviation	σ_C	0.60
Cost Variance	σ^2_C	0.16
Benefit Variance	σ^2_B	0.36
B/C Correlated Coefficient	ρ_{BC}	0.50
B/C Variance		
$\sigma^2_B + \sigma^2_C - 2 * \rho_{BC} * \sigma_B * \sigma_C$	σ^2_{BC}	0.28
Project Time	t	5
D1 = [ln(B/C) + σ2 * (t/2)] / [σ√t]	D1	1.07
$D_2 = D_1 - \sigma \sqrt{t}$	D2	0.44
D1 cumulative normal probability	N(D1)	0.85779792
D2 cumulative normal probability	N(D2)	0.67161573
Real Option Value = B*N(D1) – CN(D2)	**RealOption**	**$344,230**

Figure 13 compares the traditional NPV results for the SCINET project and the Real Option Value derived from the real option analysis.

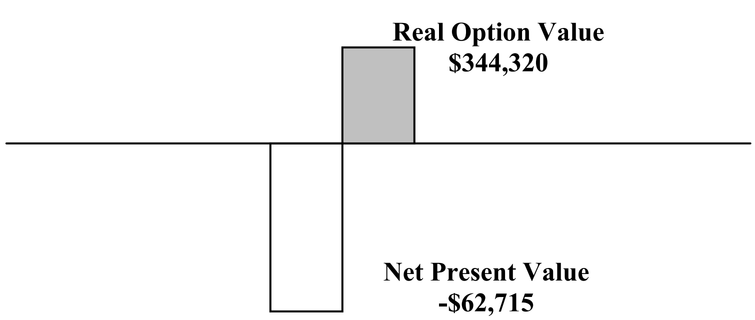


Figure 13 Comparing the Real Option and NPV Results for SCINET project

5.3.2.3 Monte Carlo Simulations

The third step of the real option analysis is to use Monte Carlo simulations to determine the volatility of the rate of return of the project. The inputs to the Monte Carlo simulations are the log normal distribution of the cost with a present value mean of $2,137,834 and a deviation standard of 40%, and log normal distribution of the benefits with a present value mean of $2,075,119 and a standard deviation of 60%. The output shows the mean, standard error and confidence interval for the Real Option Value (Figure 14).

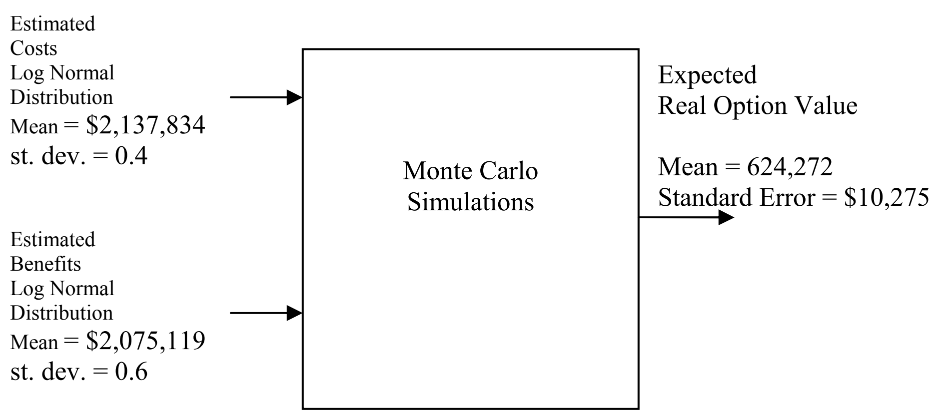


Figure 14 Monte Carlo Simulations Results

Based on the results of the Monte Carlo simulations, the Real Option Value for the SCINET project has a expected value E(x) = $624,272 and a standard error of $10,175 with a corresponding 95% confidence interval for the mean between $617,342 and 631,202.

5.3.3 Phase III: Strategic Analysis

The project business goal for the financial, customer, operational and knowledge perspective that were identified during the project modeling phase, are used as the input to start the strategic analysis of comparing the relative importance of each business goal. The output of this phase is the Strategic Scorecard Value that measures the strategic fit of the project with the overall mission and mission of Seminole County.

5.3.3.1 Estimation of Business Goals Priority Weights

The first step in the strategic analysis phase corresponds to finding the priority weights of the business goals using pair-wise comparisons. The pair-wise comparison values were estimated based on reports generated during the business analysis phase. The four perspectives of the balanced scorecard are used as the "control" criteria for the comparison. The pair-wise comparisons are conducted with respect to their relative importance toward each control criterion (financial, customer, operational, knowledge).

The results are tabulated in the pair-wise comparison matrices, where two business goals are compared at a time using the Saaty scale of 1 to 9, with 1 representing indifference between two components and 9 being overwhelming dominance of the component under consideration (row component in the matrix).

If a component has some level of weaker impact the range of scores will be from 1 to 1/9, where 1 represents indifference and 1/9 being overwhelming dominance by a column element over a row element. When scoring is conducted for a pair, a reciprocal value is automatically assigned to the reverse comparison within the matrix. That is, if a_{ij}, is a matrix value assigned to the relationship component "i" to component "j" m then a_{ji} is equal to $1/_{aij}$.

The strategic weights for the business goal are computed in two steps. First, the pair-wise comparison values for each balanced scorecard matrix are normalized by dividing each element in the column by the sum of the column elements. Then, the weight for each business goals correspond to the averaging the row values in the normalized matrix. The sum of priorities weights should be equal to 1.

Table 30 shows the results for the financial goals pair-wise comparisons. Reducing the cost is considered more important by the score of 7 (as shown in the cell at the intersection of the Reduce Cost row and Profitability column). Reciprocally, the intersection of the Profitability row and Reduce Cost column shows a score of 1/7 (0.14). The weighted priorities for the financial pair-wise matrix are 0.875 (for the Reduce Cost goal) and 0.125 (for the Profitability). Tables 31-34 were derived in the same fashion for the other operational, knowledge management and financial perspectives of the balanced scorecard.

Table 31 Financial Goals Pair-wise Comparisons

FINANCIAL GOALS			
Reduce Cost vs. Profitability In terms of the Financial Strategic Perspective for the SCINET project, which financial goal is more important : reducing the cost per transaction on 50% or increasing the profitability of business transactions by 10%. _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)			
FINANCIAL GOALS	**Reduce Cost**	**Profitability**	
Reduce Cost	1.00	7.00	
Profitability	0.14	1.00	
Total	**1.14**	**8.00**	
FINANCIAL GOALS	**Reduce Cost**	**Profitability**	**Weight**
Reduce Cost	0.875	0.875	**0.875**
Profitability	0.125	0.125	**0.125**
Total	**1.000**	**1.000**	**1.000**

Table 32 Operational Goals Pair-wise Comparisons

OPERATIONAL GOALS			
Capacity vs. Efficiency In terms of the Operational Excellence Strategic Perspective for the SCINET project, which operational goal is more important: increasing the capacity utilization by 50% or increasing the efficiency of the process by 50%. _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)			
OPERATIONAL GOALS	**Capacity**	**Efficiency**	
Capacity	1.00	0.20	
Efficiency	5.00	1.00	
Total	**6.00**	**1.20**	
OPERATIONAL GOALS	**Capacity**	**Efficiency**	**Weight**
Capacity	0.167	0.167	**0.167**
Efficiency	0.833	0.833	**0.833**
Total	**1.000**	**1.000**	**1.000**

Table 33 Knowledge Goals Pair-wise Comparisons

KNOWLEDGE GOALS			
Learning vs. Team Collaboration In terms of the Operational Excellence Strategic Perspective for the SCINET project, which operational goal is more important: decreasing user support by 50% or increasing cross functional collaboration by 30%. _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)			
KNOWLEDGE GOALS	**LearningCurve**	**Teamwork**	
LearningCurve	1.00	0.33	
Teamwork	3.00	1.00	
Total	**4.00**	**1.33**	
KNOWLEDGE GOALS	**LearningCurve**	**Teamwork**	**Weight**
LearningCurve	0.250	0.250	**0.250**
Teamwork	0.750	0.750	**0.750**
Total	**1.000**	**1.000**	**1.000**

Table 34 Customer Goals Pair-wise Comparisons

CUSTOMER GOALS				
Flexibility vs. Reliability vs. Responsiveness In terms of the Customer Strategic Perspective for the SCINET project, which customer goal is more important: increasing the customer satisfaction with the flexibility of the system by 25% or improving the reliability of the system by 25% or increasing the responsiveness of the system with a on-time delivery rate of 98%. _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)				
CUSTOMER GOALS	**Flexibility**	**Reliability**	**Responsiveness**	
Flexibility	1.000	0.111	0.143	
Reliability	9.000	1.000	5.000	
Responsiveness	7.000	0.200	1.000	
Total	**17.000**	**1.311**	**6.143**	
CUSTOMER GOALS	**Flexibility**	**Reliability**	**Responsiveness**	**Weight**
Flexibility	0.059	0.085	0.023	**0.072**
Reliability	0.529	0.763	0.814	**0.646**
Responsiveness	0.412	0.153	0.163	**0.282**
Total	**1.000**	**1.000**	**1.000**	**1.000**

5.3.3.2 Analysis of Business Goal Interdependencies

The second step of the strategic analysis is identifying interdependences among the business goals and recalculating the strategic weights for these interdependent components. For the SCINET project there is an interdependence between the Operational Perspective and the Knowledge Management Perspective. The operational goals of increasing capacity and efficiency depend on the increase on cross functional team collaboration and reducing the learning curve to work with new SCINET project features and functionality. Similarly, the knowledge management goals depend on the operational goals.

To fully describe the two-way interdependencies between the Operational Perspective and the Knowledge Management perspective, four pair-wise comparisons are required. At this stage, we use the Analytical Network Process (ANP) super-matrix for recalculating the business goal weights for the interdependent perspectives. The super-matrix is a partitioned matrix, where each sub-matrix corresponds to pair-wise matrix for each of the interdependent perspectives.

Table 35 shows the results of the super-matrix for the Operational-Knowledge interdependency. There are two sub-matrices representing the weight values found for the operational and knowledge perspective (see Tables 6 and 7).

Table 35 Super-matrix for the Operational/Knowledge Interdependency

OPERATIONAL/ KNOWLEDGE	Capacity	Efficiency	Learning Curve	Teamwork
Learning Curve	0.833	0.125	0.000	0.000
Teamwork	0.167	0.875	0.000	0.000
Capacity	0.000	0.000	0.100	0.125
Efficiency	0.000	0.000	0.900	0.875

The strategic weights considering interdependencies are calculated using the limiting power of the supermatrix: raising the super-matrix to the power 2k+1, where k is an arbitrary large number, until we obtain "long term" stable weights values (Saaty, 2004). For this case study, the values of the supermatrix converge when a power of 17 is used. The stable weights are shown in Table 36.

Table 36 Super-matrix Convergence to "Long Term" Weights at A^{17}

OPERATIONAL/ KNOWLEDGE	Capacity	Efficiency	Learning Curve	Teamwork
Learning Curve	0.429	0.429	0.000	0.000
Teamwork	0.571	0.571	0.000	0.000
Capacity	0.000	0.000	0.122	0.122
Efficiency	0.000	0.000	0.878	0.878

5.3.3.3 Estimation of Strategic Scorecard Values

The third step of the Strategic Analysis is to calculate the Strategic Scorecard Value for the project, using the weights found for the balanced scorecard perspective and the business goals and the corresponding ratings given for the SCINET project. Table 37 summarized these results.

Table 37 Strategic Scorecard Value for the SCINET Project

BALANCED SCORECARD PERSPECTIVE	Weight W	BUSINESS GOAL	Weight w	Normal Weight W * w	SCINET PROJECT Score S	STRATEGIC SCORECARD Value W*w*S
Financial	0.2	**Reduce Cost**	0.875	0.175	0.80	**0.140**
		Profitability	0.125	0.025	0.80	**0.020**
Customer	0.5	**Flexibility**	0.072	0.036	0.80	**0.029**
		Reliability	0.646	0.323	0.70	**0.226**
		Responsiveness	0.282	0.141	0.80	**0.113**
Operational	0.2	**Capacity**	0.122	0.024	0.60	**0.015**
		Efficiency	0.878	0.176	0.80	**0.140**
Knowledge	0.1	**Learning Curve**	0.429	0.043	0.90	**0.039**
		Teamwork	0.571	0.057	0.70	**0.040**
TOTALS	**1**			**1.000**		**0.761**

The SCINET project scores were estimated based on the report and meetings of the business analysis phase for the project. For each business goal, the SCINET project was assigned a score corresponding to the probability expectations that the project will satisfy the business goal. For example, there is an 80% probability (S=0.8) that the SCINET project will achieved the goal of reducing cost by 50%.

The Strategic Scorecard Value for each business goal is found by multiplying the corresponding weights for the balanced scorecard perspective (W), the business goal under consideration (w), and the expected score or probability or achieving the goal with the project (S). The Total Strategic Scorecard Value for the SCINET project is 0.761. This means that the strategic alignment of the project with the overall Seminole County mission and vision is 76.1%.

5.3.4 Phase IV ROI Analysis

The ROI analysis and selection phase presents the summary of final results for the Real Option Value and the Strategic Scorecard Value of the SCINET project. These results are represented graphically by Figure 15.

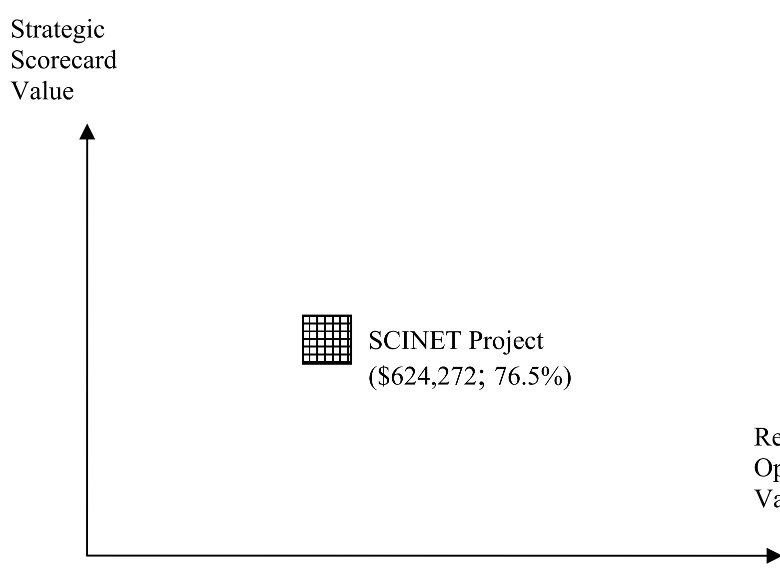


Figure 15 Return on Investment of the SCINET Project

These results show that the SCINET project has an expected Real Option Value of $624,227 and a Strategic Scorecard Value of 76.5% of alignment with the overall Seminole County mission of exceeding customer expectations for services. So applying the ROSS approach shows that SCINET project provides very attractive return on investment results for both the business value and strategy of Seminole County. Therefore, the project should be funded and fully supported by the managers.

5.4 SCINET Case Study Conclusions

The purpose of this case study was to show the applicability of the Real Option Strategic Scorecard (ROSS) framework to the analysis of the return on investment of e-government projects. In particular, the study focused in the ROI analysis of the SCINET project for Seminole County, Florida. The project is being developed in partnership with the Engineering Technology Department at the University of Central Florida (UCF).

This case study provides additional validation of the ROSS model and approach. The study helps to verify that the ROSS framework is an effective and efficient decision making tool that can be used by e-government managers for analyzing the return on investment of strategic decisions.

For the SCINET project, the Seminole County managers decided to adopt a strategic initiative to partnership with UCF and replace the existing legacy information system for a new web-based system developed using the Microsoft .NET technology. The SCINET project is an IT strategic investment that can improve the Seminole County strategic positioning and mission of being a premier county recognized for exceeding customer expectations for services.

SCINET is a strategic information system project with a great potential for returns on investment, but also a great inherent risk. In the case study, we show that to analyze the return on investment of a strategic investment is necessary to use a comprehensive analysis tool such as the ROSS framework that considers at the same time the benefits, costs and risks of the project.

Identifying the business value of strategic investment like SCINET is a complex process, because the capabilities of this type of new system are seldom known in advance and it is difficult to predict the actual costs, benefits and the impact of uncertainty. In general, strategic investments have high initial investments and the returns are only seeing in the long term.

For the SCINET project, the costs included the initial investment of $731,379 for the first two years of analysis and design (2004-2005) and the additional costs of $731,379 per year during the there years of development and testing required to replace completely the legacy system and implement all the new functionality and features (2006-2008). In regard to the benefits, it is expected that the SCINET project will start reducing cost when the initial features of the system are released to the public on 2006. The benefits are expected to increase from $700,000 in 2006 to $1,450,000 in 2008.

In the case study is shown that if we use traditional tools such as the net present value to analysis the return on investment of SCINET without risks considerations other than the cost of capital rate, the business value for the project will not be very attractive (the calculated NPV for SCINET is equal to -$62-715. However, we shown that this result is misleading, because did not include the impact of uncertainty. The benefits and cost can change over time, and this volatility will affect the return on investment of the project.

The four steps of the ROSS approach were used to calculate the business value and strategic alignment of the SCINET project considering uncertainty and risk. First, the business goals were identified using the financial, customer, operational and knowledge management perspectives of the balanced scorecard. Second, the Real Option Value of the project was estimated to have a corresponding mean of $624,272 based on the assumption that the cost and benefits will follow a normal distribution with a range of variability (standard deviation) of 40% and 60% respectively, and using the Black-Scholes equation and Monte Carlo simulations. Third, the Strategic Scorecard Value of the project was estimated to be 76.5% in alignment with the overall mission and vision of Seminole County. The strategic priorities weight representing the relative importance of the business goals were identified using pair-wise comparisons. The interdependencies among business goals were analyzed using the Analytical Network Process super matrix. For the SCINET project, individual scores were estimated for the level that the project is expected to satisfy each of the business goals. Finally, during the ROI analysis phase the results are summarized graphically and using the coordinates for the Real Option and Strategic Scorecard Values ($637,223; 76.5%).

The final conclusion of the case study is that applying the ROSS approach shows that the SCINET project provides very attractive return on investment for both the business value and strategic of Seminole County. Therefore, the project should be fully funded and supported by the Seminole managers. The case study demonstrates that the ROSS framework will help managers of the local and federal government to present better business cases to justify new e-government project investments.

CHAPTER 6

CASE STUDY: NASA GEOSPATIAL PROJECT SELECTION

6.1 Introduction

This case study shows the applicability of the ROSS approach to the analysis and selection of strategic information system (SIT) projects.   The study analyzes two different project alternatives for implementing Geospatial Interoperability Systems for the National Aeronautics and Space Administration (NASA). One project alternative uses open source interoperability standards and software to develop its entire geospatial system architecture. The other project alternative relies on proprietary, commercial off-the-shelf (COSTS) products to implement the system.

In this case study. the results of the Geospatial project selection analysis using the ROSS approach are compared with the results obtained by NASA using the value measuring methodology (VMM) developed by the Harvard University Kennedy's School of Government and the Booz Allen Hamilton consulting firm (NASA GIO Report, 2005).

The case study provides a scenario to refine and validate the ROSS approach using the standard eight critical success factors (Table 38) that are used by the research community for the validation of IT decision frameworks (Hazarding, 2003).

Table 38 Critical Success Factors for evaluation of IT decision frameworks

Critical Success Factor	
1	Providing a realistic description of the selection problem
2	Supporting group decision-making
3	Structuring the decision making problem
4	Incorporating both quantitative and qualitative factors
5	Expressing the relative importance of the factors
6	Analyzing alternatives
7	Comprehensibility of the methods
8	Applicability of the method

In this case study, the different phases of the research real option framework will be applied. An expected result of the case study is to demonstrate that the ROSS approach is appropriated to satisfy the steps required by NASA to determine the value, cost and risk of IT projects. Therefore, one of the significant benefits of this case study is to improve how NASA managers can present better business cases to obtain funding for new information system investments.

This case study is organized as it follows. First, the NASA Geospatial Interoperability project selection problem is presented. Second, the ROSS approach is used for analyzing the open source and proprietary alternatives to implement the NASA geospatial project. Third, the ROSS results are compared with the results originally obtained by NASA using the VMM methodology. Finally, the findings and conclusions are summarized.

6.2 The Geospatial Project Selection Problem

NASA is required to satisfy the business case specifications established in 2004 by the United States Federal Government. These business case requirements are defined in the Exhibit 300 used by the Federal Office of Management and Budget (OMB) to fund new e-government projects that top a $500,000 value. The Exhibit 300 (Table 39) is a document with a high level summary of the project justification and plan including alternative analysis, cost and benefit analysis, acquisition plan, risk analysis, human resource management plan, enterprise architecture and security plan.

Table 39 Office of Management and Budget Exhibit 300 Template

Exhibit 300 Office of Management and Budget		
Part I	Capital Asset Plan and Business Case	Score
	Summary of Spending	
	Project Description and Justification	
	Performance Goals and Measures	
	Program Management	
	Alternative Analysis	
	Risk Inventory and Assessment	
	Acquisition Strategy	
	Project and Funding Plan	
Part II	Additional Criteria for Information Technology	Score
	Enterprise Architecture	
	Security and Privacy	

After submission of the Exhibit 300, the Department's Capital Investment Technology Review Board (CITRB) assigns scores to the different items of Exhibit 300, and projects are funded based on the scoring results. The $60 billion federal IT budget managed by OMB is being assigned only to projects that provide a strong business case.

To facilitate the documentation of Exhibit 300, NASA is promoting the research and adoption of decision analysis frameworks. In 2004, for example, the NASA Geospatial Interoperability Office (NASA GIO) commissioned a study to the Harvard Kennedy School of Government and Booz Allen Hamilton consultants to determine the return on investment (ROI) of project alternatives to implement geospatial systems.

The geospatial systems are based on the terabytes of data that NASA daily collects from their 30 Earth-Sun System Spacecraft (E-SS) and 80 E-SS Sensors. This information is used to create planetary models, to make predictions, and to feed decision-support systems. Two alternatives were considered in the original NASA study. One project alternative uses open source interoperability standards and software to develop its entire geospatial system architecture. The other project alternative relied on proprietary, commercial off-the-shelf (COSTS) products to meet its needs.

In the original study, the analysis of the NASA Geospatial project alternatives was done using the Value Measuring Methodology (VMM) developed by Harvard and Booz Allen. However, the VMM results have some limitations. First, VMM is still based on one point estimates for the benefits and costs without considering the whole range of variability of these parameters and the impact of this variability in the return on investment of the projects. Second, in the VMM study interdependencies among the business factors were not considered. Third, the calculation of risk-adjusted values for the benefits and costs were based on a proprietary algorithm based on the risk categories used by Booz Allen.

In the present case study the ROSS approach is applied to overcome some of the limitations of the original VMM results.

The ROSS approach was used to analyze what will be the effects of considering interdependencies among the business goals and the impact of variability of cost and benefits in the return value of the project alternatives.

The ROSS approach uses Monte Carlo simulations and Real Options to find the probability distribution of the return on investment, and Strategic Balanced Scorecards to derive the strategic alignment of the project with the overall mission and vision of the NASA Geospatial Interoperability Office.

The next section of this case study present the results of analyzing the Geospatial project selection problem using the ROSS approach. These results are compared with the results of analyzing the project selection problem with the VMM methodology.

6.3 Project Selection Using the ROSS Approach

6.3.1 Phase I: Project Modeling

During this phase, the three steps of the project modeling ROSS approach were used to model the NASA Geospatial project selection problem.

First, the strategic alignment of the Geospatial project initiative with the overall mission and vision of NASA was described using the four perspectives of the balanced scorecard. The strategic importance of the customer, financial, operational and knowledge management perspectives were derived from NASA strategic plan reports, the benchmarking of previous NASA projects.

Second, using as a reference the original results of the Harvard Booz Allen study, the business goals identified by the NASA managers were mapped into the four perspectives of the balanced scorecard and the interdependences between business goals are modeled with caused and effect relationships.

Third, to outline the baseline scenario for the return on investment study, the NASA original cost and benefits estimation results are summarized using the net cash flows during the five year period of the project.

6.3.1.1 Balanced Scorecard Model

For this case study, The ROSS approach uses balanced scorecard models to provide the necessary structure to evaluate quantitative and qualitative information with respect to the NASA organization's strategic vision and goals.

Until 2002, NASA was organized into 12 regional centers each with its own strategic plan to document their respective vision, mission, and goals. During the administration of Sean O'Keefe (2001-2005) the concept 'One NASA' was introduced to create a truly unified space agency. A new unified mission was established and featured in all the budget and planning documents. NASA mission was "to understand and protect our home planet; to explore the universe and search for life; to inspire the next generation of explorers….as only NASA can".

In February of 2006 under the current NASA administration lead by Michael D. Griffin, the mission statement was changed to reflect the new focus in pursuing human spaceflight to the Moon and Mars. The new NASA mission is "to pioneer the future in space exploration, scientific discovery and aeronautics research".

NASA spends on information technology $2.2 billion a year. The new NASA administrations are trying to guarantee that the NASA research and project priorities are in alignment with the overall NASA mission. In this case study, the ROSS approach translated the NASA mission into the specific financial, customer, operational and knowledge management perspectives of the balanced scorecard. These balanced scorecard perspectives will be used as the control criteria for the evaluation of the geospatial project and measuring the strategic alignment of the open source and proprietary implementation alternatives. Figure 16 shows the description of the balanced scorecard perspectives for the NASA geospatial project.

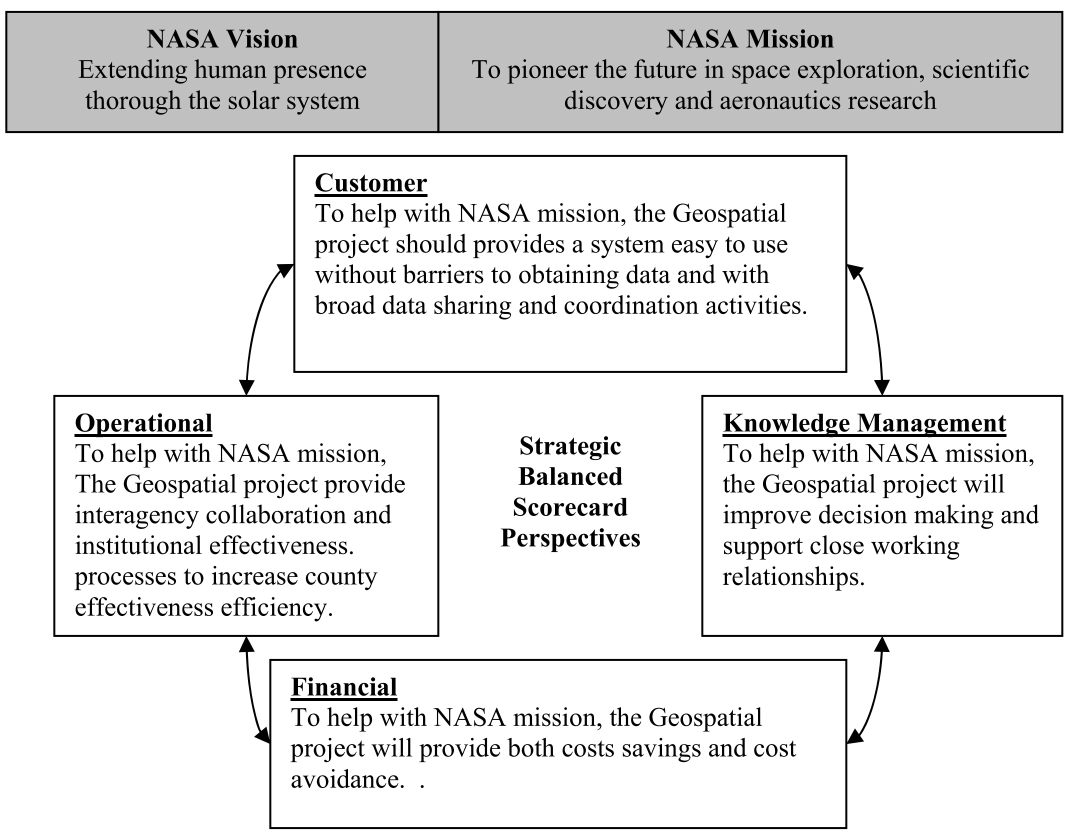


Figure 16 Balanced Scorecard for NASA Geospatial Project

6.3.1.2 Business Goals Identification

In this step, the original business factors identified from the managers of the NASA Geospatial Interoperability Office were mapped into the four perspectives of the balanced scorecard. Figure 17 lists the business goal classification.

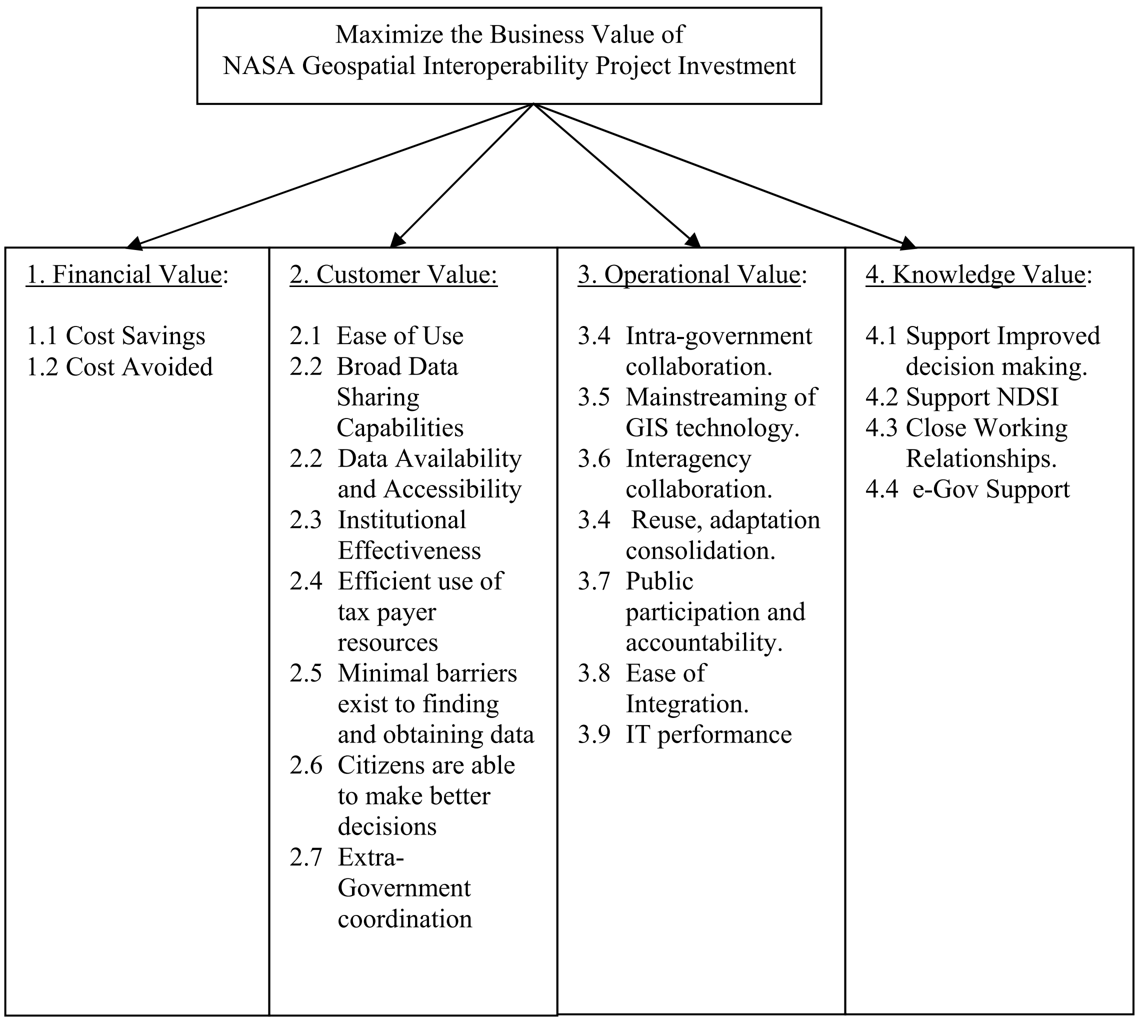


Figure 17 Business Goals for the NASA Geospatial Projects

6.3.1.3 Cost and Benefit Estimation

Tables 40 and 41 show the original manager estimation for the cost of the two project implementation alternatives (NASA GIO Report 2005). The project timeline considered is between 2004 and 2009. Both project alternatives have similar total costs. The open source alternative has a total cost of $7,316,479. The proprietary alternative cost is $7,347,252. Therefore, the monetary results do not show what alternative will be better and further analysis will be required considering the variability of the cost estimations

Table 40 Cost Estimation for Open Source Alternative

Project Alternative I (OPEN SOURCE)							
Estimated Cost	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Totals**
1.0 Design	$119,708	$125,694	$42,272	$44,386	$46,605	$48,935	$427,600
2.0 Implementation	$1,780,036	$1,869,038	$410,396	$430,915	$452,461	$475,084	$5,417,930
3.0 Maintenance	$374,368	$393,086	$163,219	$171,380	$179,949	$188,947	$1,470,949
Total Costs	$2,274,112	$2,387,818	$615,887	$646,681	$679,015	$712,966	$7,316,479

Table 41 Cost Estimation for Proprietary Alternative

Project Alternative I (OPEN SOURCE)							
Estimated Cost	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Totals**
1.0 Design	$46,075	$48,379	$50,798	$53,338	$56,004	$58,805	$313,399
2.0 Implementation	$68,400	$71,820	$75,411	$79,182	$83,141	$87,298	$465,252
3.0 Maintenance	$965,808	$1,014,098	$1,064,063	$1,118,043	$1,173,946	$1,232,643	$6,568,601
Total Costs	$1,080,283	$1,134,297	$1,190,272	$1,250,563	$1,313,091	$1,378,746	$7,347,252

6.3.2 Phase II: Real Option Analysis

During Phase II, the real option analysis of NASA Geospatial project selection problem was done in three steps. First, the real option analysis established a baseline for comparison calculating the total cost of the project without considering the uncertainty of costs for the design, implementation and maintenance phase of the geospatial project. Second, the project returns are recalculated considering uncertainty conditions. The costs for the different phases of the project are estimated with a range of variability, and the corresponding volatility (standard deviation) of the total cost for each implementation alternatives is estimated using Monte Carlo Simulations. Third, the results of Monte Carlo simulation are used as the input for the Black-Scholes equation to considerer further analysis involving the benefits of the project.

6.3.2.1 Baseline Scenario: Cost/Benefits without Uncertainty

To establish the baseline case study, the total costs are considered without uncertainty (variability = 0). Table 42 summarized the results.

Table 42 Total Cost for Geospatial Implementation Alternatives

	Total Cost (2004-2009
Open Source	$7,316,479
Proprietary	$7,347,252

Both projects have similar total costs (Open Source = $7,316,479 and Proprietary = $7,347,252). However, the cost profiles for the open source and proprietary alternatives are different. The Figure 18 shows the cost profile for both projects. During the design and implementation phases of the geospatial project, the total costs for the open source option shows a higher upfront spending in the first two years of the project (2004-2005). However, during the maintenance phase (2006-2009), the total costs of the open source are lower. The proprietary implementation shows a gradual increase of cost during the project timeline (2004-2009).

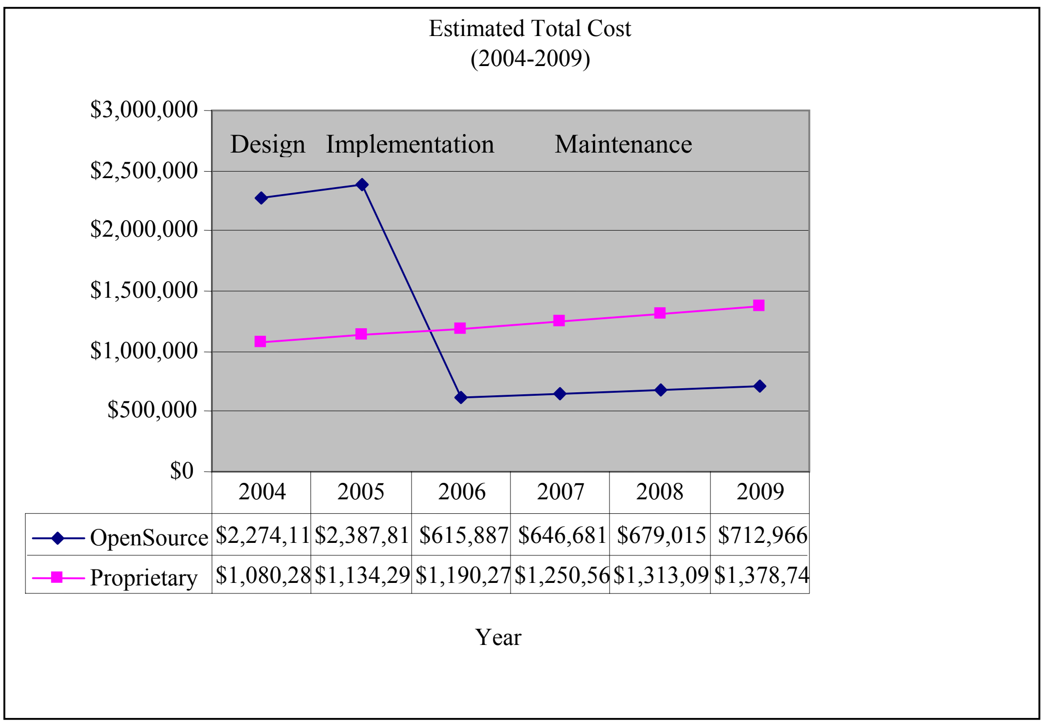


Figure 18 Baseline Case: Cost/Benefits without Uncertainty

6.3.2.2 Real Scenario: Cost/Benefits with Uncertainty

The next step of the ROSS approach is to analysis the returns of the project when the variability of the costs is considered.

In the original study (NASA GIO Report 2005), the following associated risks were reported: a risk of 24.4% for the total open source costs and a 56.6% for the total proprietary alternative costs. Appendix B presents the original NASA estimations using the risk-adjusted values of the VMM methodology. Table 43 summarizes these results. Thee original risk-adjusted total costs is obtained by multiplying the original total cost per the risk factor.

Table 43 Original Risk-Adjusted Total Costs

Geospatial Implementation	Total Cost	Risk	Risk-Adjusted Total Cost
Open Source	$7,316,479	0.244	**$9,116,130**
Proprietary	$7,347,252	0.566	**$11,505,555**

The results of the original study have the limitation of considering only the extreme worst case scenario for the calculation of the risk-adjusted total costs. In reality, the cost could vary between cost defined by the baseline case and the worst (risk adjusted) case. To overcome this limitation, in the present study the expected total costs are calculated using scenario analysis and Monte Carlo simulations to improve the accuracy of the estimations.

Using the original estimated risk of 0.246 for the open source and 0.566 for the proprietary implementation, the expected cost value is calculated assuming an equal probability for the baseline and worse case scenario. The expected cost results are shown in Figure 19.

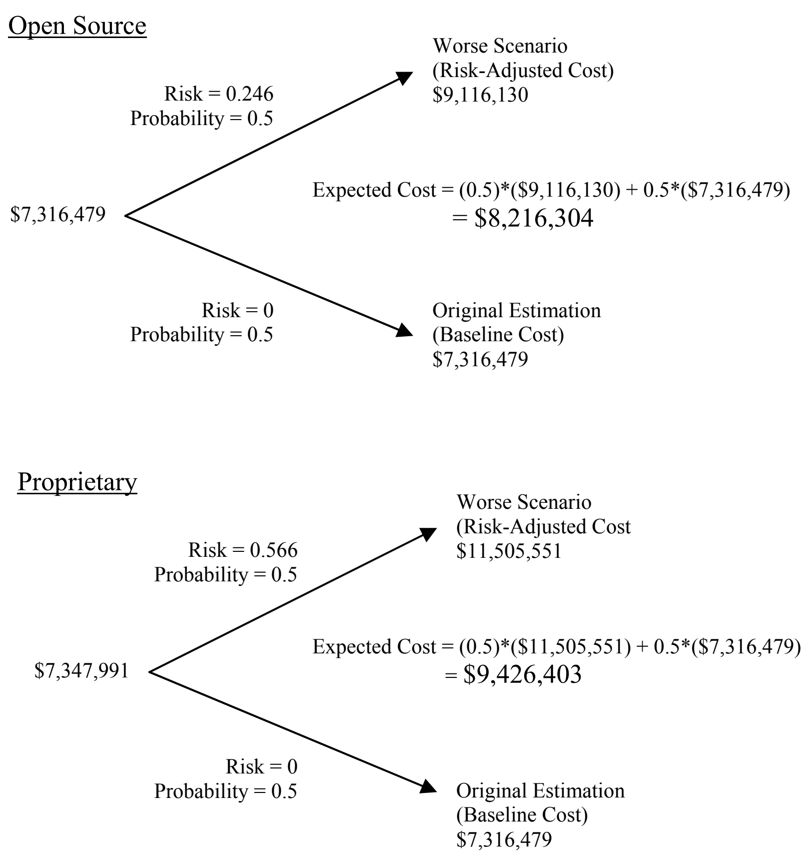


Figure 19 Expected Total Cost Results

In this case, the scenario analysis the results (open source costs = $8,216,304; and proprietary costs = $9,426,403) are a good reference for estimating the total costs, but a more realistic and accurate result is determined using Monte Carlo simulations.

For the simulations, the uncertain variable inputs are the costs for the design, implementation and maintenance phases. Table 44 shows the range of variation between the base case and worse values estimated by the NASA managers for each phase of the geospatial project.

Table 44 Project Phase Range of Variability

OPEN SOURCE	**Baseline Case (minimum)**	**Worst Case (Maximum)**
Design	$427,600	$488,705
Implementation	$5,417,930	$6,726,045
Maintenance	$1,470,949	$1,901,380
Total Cost	**$7,316,479**	**$9,116,130**
PROPIETARY	**Baseline Case (minimum)**	**Worst Case (Maximum)**
Design	$313,399	$399,228
Implementation	$465,252	$619,719
Maintenance	$6,568,601	$10,486,608
Total Cost	$7,347,252	$11,505,555

In the Monte Carlo simulations, the range of variability for the design, implementation and maintenance are represented using uniform distributions with a range of variation between the base case (minimum) and worse case (maximum) values estimated by the NASA managers. The total cost is expressed as the sum of the design, implementation and maintenance costs. The output of the simulation is the probability distribution of the total cost. Figure 20 summarizes the simulation results.

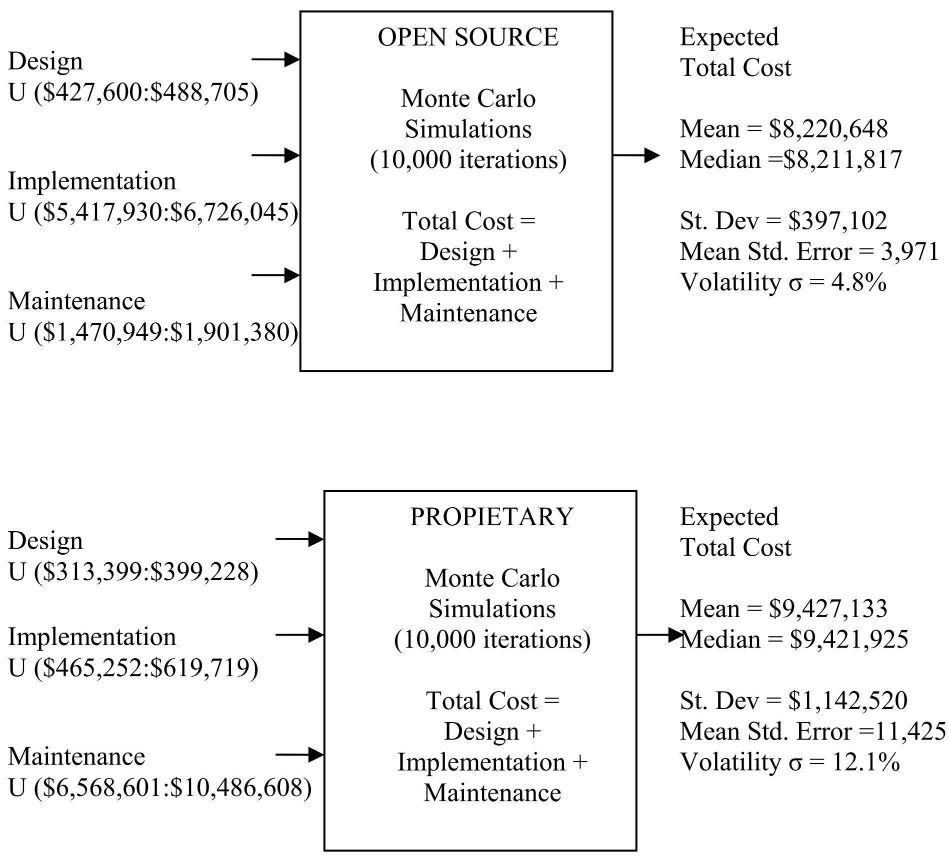


Figure 20 Monte Carlo Simulations Results

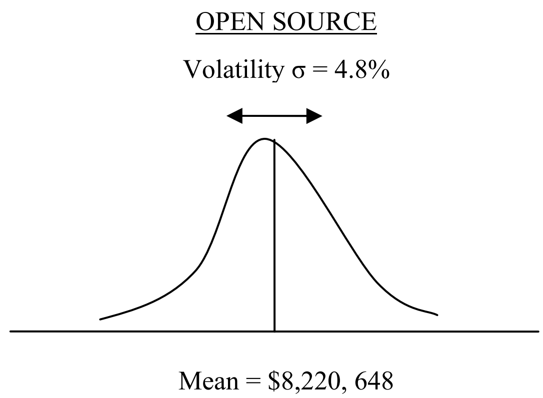
6.3.2.3 Real Option Value Results

The new results using the Monte Carlo simulations of the ROSS approach and the original results obtained by NASA using the VMM methodology are compared in Table 45.

Table 45 ROSS vs. VMM Comparison of Total Cost and Volatility

	New Results Using ROSS		**Original Results Using VMM**	
	Total Costs	**Volatility σ**	**Total Costs**	**Volatility σ**
Open Source	$8,220,648	4.8%	$9,116,130	24.4%
Proprietary	$9,427,133	12.1%	$11,505,555	56.6%

The ROSS approach shows more realistic values for the expected total costs and volatility. The open source alternative is expected to cost $8,220,648 with a risk or volatility of 4.8%. The proprietary solution is expected to cost $9,427,133 with a risk or volatility of 12.1. The volatility measures of the rate and magnitude of the change of cost (up or down) of project alternatives. Assuming a normal distribution, the total costs can be represented by Figure 21.



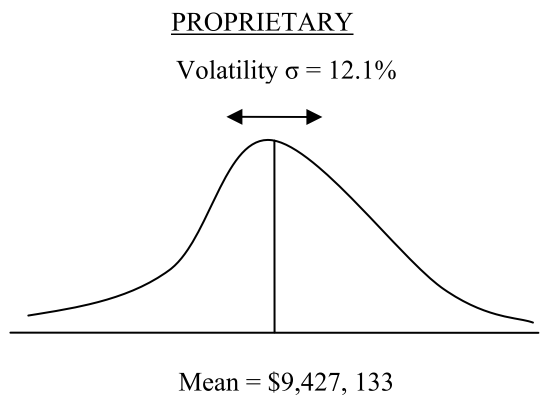


Figure 21 Total Cost Distribution, Mean and Volatility

Once the volatility of the costs and benefits are estimated, the Black-Scholes equation B*N(D1) – C*N(D2) can used to adjust the present value of the benefits (B) and costs (C) per the corresponding normal distribution of risks N(Di). Table 46 shows that parameters for finding the Black-Scholes adjusted returns. In the NASA original study the benefits were not estimated by the managers, so the benefit parameters are undefined. However, in further research the benefits could be considered to fully apply the Black-Scholes equation.

Table 46 Real Option Scores for Project Alternatives

Real Option Analysis	Variable	Open Source	Proprietary
Benefit Present Value	B		
Cost Present Value	C	$8,220,648	$9,427,133
Cost Volatility	σ_B		
Benefit Volatility	σ_C	0.048	0.121
Cost Variance	σ^2_C		
Benefit Variance	σ^2_B		
B/C Correlated Coefficient	ρ_{BC}		
σ^2_{BC} = B/C Variance =			
$\sigma^2_B + \sigma^2_C - 2 * \rho_{BC} * \sigma_B * \sigma_C$	σ^2_{BC}		
Project Period	t		
$D1 = [\ln(B/C) + \sigma^2 * (t/2)] / [\sigma\sqrt{t}]$	D1		
$D_2 = D_1 - \sigma \sqrt{t}$	D2		
D1 cumulative normal probability	N(D1)		
D2 cumulative normal probability	N(D2)		
Real Option= B*N(D1) – CN(D2)		**$8,220,648**	**$9,427,133**

6.3.3 Phase III: Strategic Analysis

During this phase, the project business goals for the financial, customer, operational and knowledge perspective that were identified during the project modeling phase, are used as the input to start the strategic analysis of comparing the relative importance of each business goal. The output of this phase is the Strategic Scorecard Value that measures the strategic fit of the project with the overall mission and mission of the NASA Geospatial Interoperability Office.

6.3.3.1 Estimation of Business Goal Interrelations Weights

The original NASA GIO report did not considered interrelations between the business goals for the Geospatial project. However, it is obvious that there are cause and effect relationships between operational goals and the knowledge management goals. For example, to achieve improved decision making is necessary to improve the inter-agency and intra-government collaboration. The e-government support depends on the IT performance (Figure 22).

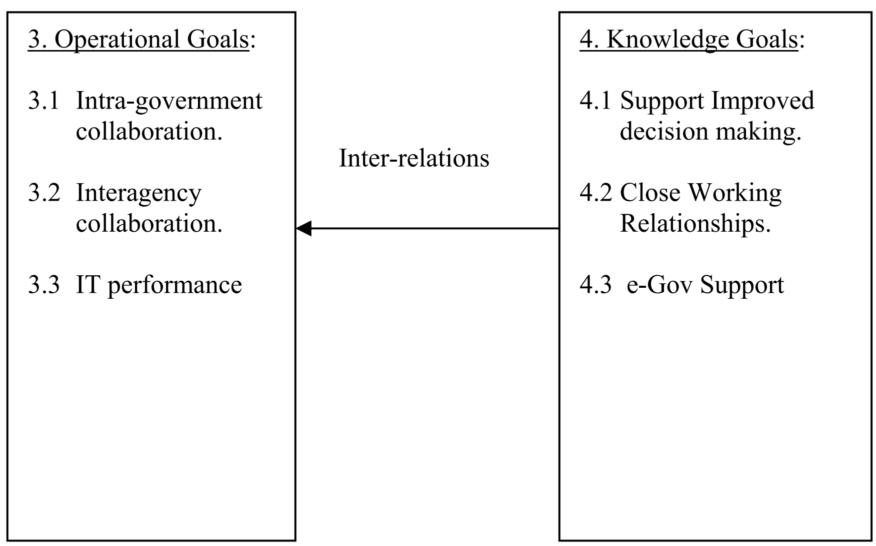


Figure 22 Business Goal Interdependencies

To illustrate the applicability of the ROSS approach, the interrelations between the operational and knowledge management goals are modeling using the pair-wise comparison for the interrelations (Tables 47 to 52).

Table 47 Intra-government Collaboration Pair-wise Comparisons

INTRA-GOVERNMENT COLLABORATION				
Decision Support vs. Close Relations vs. e-Gov Support In terms of intra-government collaboration, which knowledge management goal is more important: improving decisions close working relationships or the e-government support _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)				
INTRA_GOVERMENT COLLABORATION	**DecisionSupport**	**CloseRelations**	**e-gov. Support**	
DecisionSupport	1.000	0.111	0.143	
CloseRelations	9.000	1.000	5.000	
e-gov. Support	7.000	0.200	1.000	
Total	**17.000**	**1.311**	**6.143**	
CUSTOMER GOALS				**Weight**
DecisionSupport	0.059	0.085	0.023	**0.056**
CloseRelations	0.529	0.763	0.814	**0.702**
e-gov. Support	0.412	0.153	0.163	**0.242**
Total	**1.000**	**1.000**	**1.000**	**1.000**

Table 48 Inter-government Collaboration Pair-wise Comparisons

INTER-GOVERNMENT COLLABORATION				
Decision Support vs. Close Relations vs. e-Gov Support In terms of inter-government collaboration, which knowledge management goal is more important: improving decisions close working relationships or the e-government support _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)				
INTER_GOVERMENT COLLABORATION	**DecisionSupport**	**CloseRelations**	**e-gov. Support**	
DecisionSupport	1.000	0.111	7.000	
CloseRelations	9.000	1.000	5.000	
e-gov. Support	0.143	0.200	1.000	
Total	**10.143**	**1.311**	**13.000**	
CUSTOMER GOALS				**Weight**
DecisionSupport	0.099	0.085	0.538	**0.241**
CloseRelations	0.887	0.763	0.385	**0.678**
e-gov. Support	0.014	0.153	0.077	**0.081**
Total	**1.000**	**1.000**	**1.000**	**1.000**

Table 49 IT Performance Pair-wise Comparisons

IT PERFORMANCE				
Decision Support vs. Close Relations vs. e-Gov Support In terms of IT performance, which knowledge management goal is more important: improving decisions close working relationships or the e-government support _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)				
IT PERFORMANCE	**DecisionSupport**	**CloseRelations**	**e-gov. Support**	
DecisionSupport	1.000	7.000	0.111	
CloseRelations	0.143	1.000	0.143	
e-gov. Support	9.000	7.000	1.000	
Total	**10.143**	**15.000**	**1.254**	
CUSTOMER GOALS				**Weight**
DecisionSupport	0.099	0.467	0.089	**0.218**
CloseRelations	0.014	0.067	0.114	**0.065**
e-gov. Support	0.887	0.467	0.797	**0.717**
Total	**1.000**	**1.000**	**1.000**	**1.000**

Table 50 Decision Support Pair-wise Comparisons

DECISION SUPPORT				
Intra-Government Collaboration vs. Inter-Agency Collaboration vs. IT performance In terms of the decision support, which operational goal is more important: intra-government collaboration or inter-agency collaboration or IT performance? _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)				
DECISION SUPPORT	**Intra-Goverment**	**Inter-Agency**	**IT performance**	
Intra-Goverment	1.000	0.200	5.000	
Inter-Agency	5.000	1.000	7.000	
IT performance	0.200	0.143	1.000	
Total	**6.200**	**1.343**	**13.000**	
CUSTOMER GOALS				**Weight**
Intra-Goverment	0.161	0.149	0.385	**0.232**
Inter-Agency	0.806	0.745	0.538	**0.697**
IT performance	0.032	0.106	0.077	**0.072**
Total	**1.000**	**1.000**	**1.000**	**1.000**

Table 51 Close Working Relations Pair-Wise Comparisons

CLOSE WORKING RELATIONS				
Intra-Government Collaboration vs. Inter-Agency Collaboration vs. IT performance In terms of the close working relations, which operational goal is more important: intra-government collaboration or inter-agency collaboration or IT performance? _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)				
CLOSE WORKING RELATIONS	**Intra-Goverment**	**Inter-Agency**	**IT performance**	
Intra-Goverment	1.000	0.143	7.000	
Inter-Agency	7.000	1.000	7.000	
IT performance	0.143	0.143	1.000	
Total	**8.143**	**1.286**	**15.000**	
CUSTOMER GOALS				**Weight**
Intra-Goverment	0.123	0.111	0.467	**0.234**
Inter-Agency	0.860	0.778	0.467	**0.701**
IT performance	0.018	0.111	0.067	**0.065**
Total	**1.000**	**1.000**	**1.000**	**1.000**

Table 52 E-government Support Pair-wise Comparisons

E-GOVERMENT SUPPORT				
Intra-Government Collaboration vs. Inter-Agency Collaboration vs. IT performance In terms of the e-government support, which operational goal is more important: intra-government collaboration or inter-agency collaboration or IT performance? _ Equally Important (1) _Equally Important (1) _ Moderately More Important (3) _ Moderately Less Important (1/3) _ Strongly More Important (5) _ Strongly Less Important (1/5) _ Very Strongly More Important (7) _ Very Strongly Less Important (1/7) _ Extremely More Important (9) _ Extremely Less Important (1/9)				
E-GOVERNMENT SUPPORT	**Intra-Goverment**	**Inter-Agency**	**IT performance**	
Intra-Goverment	1.000	0.200	0.143	
Inter-Agency	5.000	1.000	0.143	
IT performance	7.000	7.000	1.000	
Total	**13.000**	**8.200**	**1.286**	
CUSTOMER GOALS				**Weight**
Intra-Goverment	0.077	0.024	0.111	**0.071**
Inter-Agency	0.385	0.122	0.111	**0.206**
IT performance	0.538	0.854	0.778	**0.723**
Total	**1.000**	**1.000**	**1.000**	**1.000**

The results of the pair-wise comparisons for the business goals with inter-dependencies are used to populate the super-matrix of interdependencies (Table 53).

Table 53 Super-matrix of Interdependencies

	Intra-Goverment	Inter-Agency	IT performance	DecisionSupport	CloseRelations	e-gov. Support
DecisionSupport	0.056	0.241	0.218			
CloseRelations	0.702	0.678	0.065			
e-gov. Support	0.242	0.081	0.717			
Intra-Goverment				0.232	0.234	0.071
Inter-Agency				0.697	0.701	0.206
IT performance				0.072	0.065	0.723

The super-matrix is a partitioned matrix, where each sub-matrix is composed of a set of relationships between the interrelated business goals. The values shown are the weighted priorities from the six pair wise comparisons involved.

The effect of the interdependencies in the business goals is resolved by raising the super-matrix to the power 2k+1, where k is an arbitrary large number, until the matrix converges into "long term" stable weights values (Saaty, 2004).

For this case study, the values of the super-matrix converge when a power of 33 is used. The stable weights are shown in Table 54.

Table 54 Super-matrix Convergence to "Long Term" at (Super-matrix)^{33}

	Intra-Goverment	Inter-Agency	IT performance	DecisionSupport	CloseRelations	e-gov. Support
DecisionSupport	0.197	0.197	0.197	0.000	0.000	0.000
CloseRelations	0.493	0.493	0.493	0.000	0.000	0.000
e-gov. Support	0.310	0.310	0.310	0.000	0.000	0.000
Intra-Goverment	0.000	0.000	0.000	0.203	0.203	0.203
Inter-Agency	0.000	0.000	0.000	0.608	0.608	0.608
IT performance	0.000	0.000	0.000	0.196	0.195	0.195

Finally, the original business goals weights and the interdependencies weights obtained using the super-matrix are multiplied to obtain the normal weight for each interrelated business goal (Table 55).

Table 55 Business Goal Weight Comparison

	Interdependent Weights (IW)	Original Weights (OW)	IW*OW	Normal Weight
OPERATIONAL GOALS				
Decision Support	0.197	0.3	0.059	0.179
Close Relations	0.493	0.3	0.148	0.447
e-government Support	0.310	0.4	0.124	0.375
			0.331	1.000
KNOWLEDGE GOALS				
Intra-Government	0.203	0.17	0.035	0.109
Inter-Agency	0.608	0.29	0.176	0.557
IT performance	0.196	0.54	0.106	0.334
			0.317	1.000

6.3.3.2 Strategic Scorecard Value Results

Table 56 shows the results for the Strategic Scorecard Values. The Strategic Scorecard Values are obtained by multiplying the balanced scorecard weights per the business goals weights and per the percentage assigned to each project alternative with respect to each business goal.

Table 56 Strategic Scorecard Values

			Alternative 1 Open Source		Alternative 2 Proprietary	
	Balanced Scorecard Weight (W_k)	Business Goal Weight (w_{ij})	Project Goal Score (S_{ij})	Strategic Score $W_k * w_{ij} * S_{ij}$	Project Score (S_{ij})	Strategic Score $W_k * w_{ij} * S_{ij}$
Customer	**55.20**	**1.000**		**49.87**		**29.18**
1.1 Easy to Use	55.20	0.178	0.83	8.14	0.52	5.10
1.2 Broad Data Sharing Capabilites	55.20	0.120	0.77	5.11	0.39	2.59
1.3 Data Availability and Accessability	55.20	0.182	0.95	9.57	0.40	4.03
2.1 Institutional Effectiveness	55.20	0.104	0.89	5.11	0.70	4.02
2.2 Efficient use of tax payer resources	55.20	0.068	0.99	3.69	0.91	3.39
2.3 Minimal Barriers exist to finding and obtaining data	55.20	0.104	0.96	5.51	0.56	3.21
2.4 Citizen are able to make better decisions	55.20	0.140	0.97	7.52	0.46	3.57
2.5 Extra-Government Coordination	55.20	0.104	0.91	5.22	0.57	3.27
Operational	**24.4**	**1.002**		**0.82**		**0.65**
3.1 Intra-Government collaboration	24.4	0.060	0.75	0.04	0.75	0.04
3.2 Mainstreaming of GIS technology	24.4	0.068	1.00	0.07	0.82	0.06
3.3 Interagency Collaboration	24.4	0.557	0.82	0.46	0.70	0.39
3.4 Reuse, Adaptation and Consolidation	24.4	0.087	0.99	0.09	0.88	0.08
3.5 Public Participation and Accountability	24.4	0.051	0.66	0.03	0.44	0.02
3.6 Ease of Integration	24.4	0.142	0.71	0.10	0.39	0.06
3.7 IT Performance	24.4	0.037	0.75	0.03	0.21	0.01
Knowledge	**8.8**	**0.995**		**0.88**		**0.43**
4.1 Supports improved decision making	8.8	0.179	0.91	0.16	0.52	0.09
4.2 Supports NSDI	8.8	0.263	0.85	0.22	0.39	0.10
4.3 Close Working Relationships	8.8	0.441	0.87	0.38	0.40	0.18
4.4 e-Gov Support	8.8	0.113	1.00	0.11	0.55	0.06
5 Government Financial	**11.60**	**1.000**		**6.92**	**4.87**	**4.87**
5.1 Total Cost Savings	11.60	0.620	0.60	4.31	3.60	3.60
5.2 Total Cost Avoided	11.60	0.380	0.59	2.60	1.28	1.28
TOTAL STRATEGIC SCORECARD VALUE				**58.48**		**35.14**

6.3.4 Phase IV: Project Selection

In this phase the results of the ROSS approach analysis are summarized in the Table 57. The best alternative for the Geospatial project selection problem is the open source implementation approach, because this alternative has the best combination of real option (-$8,220,648) and strategic scorecard values (58.48%). Figure 23 shows the results.

Table 57 ROSS vs. VMM Comparison of Results

	ROSS APPROACH Considering Interdependencies Using Monte Carlo Simulations			**VMM APPROACH** Without Considering Dependencies Using a Fixed Risk-Adjusted Factor		
	Real Option Costs	**Volatility σ**	**Strategic Scorecard Value**	**Original Total Costs**	**Original Volatility σ**	**Original Business Value**
Open Source	$8,220,648	4.8%	58.48 %	$9,116,130	24.4%	84.0%
Proprietary	$9,427,133	12.1%	35.14%	$11,505,555	56.6%	53.5%

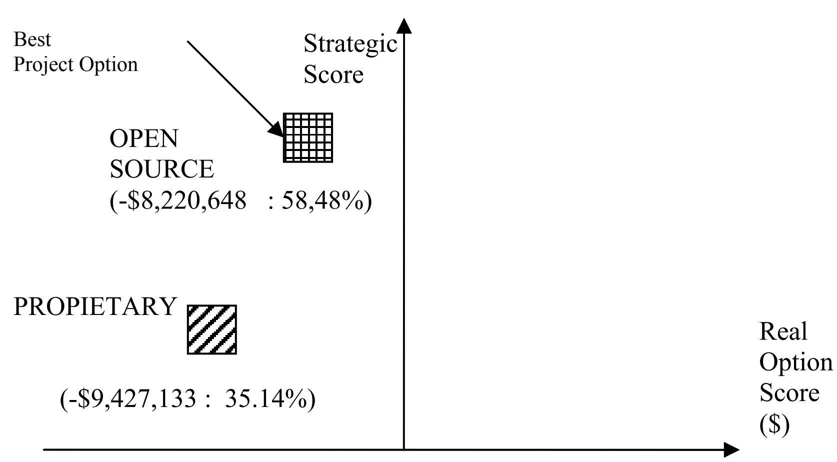


Figure 23 Strategic Scores and Real Option Values for the Project Alternatives

6.4 ROSS Decision Framework vs. VMM Methodology

In this part of the case study, a comparison between the ROSS approach versus the VMM methodology is presented. First, we compare ROSS and VMM regarding the cost/benefit estimation criteria and the tools used to obtain the return on investment (ROI). Second, we compare the differences between ROSS and VMM related to the strategic analysis criteria and the tools used to obtain the strategic weights.

. The ROSS approach and the VMM method differ in the evaluation of the impact of uncertainty in the cost, benefits and returns of the project. VMM uses one point estimations for the costs and benefits. These estimations are adjusted by a fixed risk factor which is calculated using traditional risk assessment where different risk elements are identified and assigned a high, medium and low probability and impact value. The total risk factor is the sum of products of probability per impact for the different risk elements. In contrast, the VMM approach uses range of variability for the estimations of cost and benefits. These estimations are adjusted by probability distributions representing the risk or volatility of the project. The risk factor is calculated using Monte Carlo simulations where the costs and benefits are the uncertainty input variables. The simulation output is the probability distribution of the returns for the project and the corresponding risk or volatility. Table 58 shows the results of comparing the ROSS approach versus VMM in terms of the cost, benefits, risks and ROI estimations.

Table 58 ROSS vs. VMM Cost/Benefit Analysis Differences

ROSS **Cost, Benefits, Risk Estimation**	**VMM** **Cost, Benefit, Risk Estimation**
Use range of variability estimations for the cost and benefits. Cost and benefits estimations are adjusted by probability distributions, N(D), representing the risk or volatility of the project. **B*N(D1) – C*N(D2)** The risk factor is calculated using Monte Carlo simulations where the costs and benefits estimated distribution are the uncertainty input variables. The simulation output is the probability distribution of the returns for the project and the corresponding risk or volatility. <u>Advantages</u> Return on investment analysis is more accurate considering all the possible scenarios of variation of the cost and benefits.	Use one point estimations of cost and benefits. Cost and benefit estimations are adjusted by a fixed risk factor. **$B*(Risk)_B – C*(Risk)_C$** The risk factor is calculated using traditional risk assessment where different risk elements are identified and assigned a high, medium and low probability (p) and impact (i) value. The total risk factor is the sum of the probability * impact products for the different risk elements. <u>Limitation</u> Return on investment analysis only considers the worse case scenario of variation of cost and benefits.
ROSS **Return On Investment: Tool**	**VMM** **Return on Investment: Tool**
Real Option + Monte Carlo Simulations <u>Advantage</u> Stochastic Approach considering different probability distributions. The mean and volatility of the project are used in the Black-Scholes equation to calculate the real option value of the managerial flexibility for the projects (options to defer, expand, and abandon the project)	Net Present Value <u>Limitation</u> Deterministic approach that does not consider probability distributions. Does not consider the managerial flexibility for the project. It is based on the deterministic net present value method for return on investment analysis.

The VMM methodology still relies on the traditional and deterministic net present value (NPV) analysis to generate the return on investment of (ROI) of the alternatives. Instead, the ROSS approach uses real option equations to calculate the ROI of the alternatives using a stochastic approach where probabilities distributions are considered.

Another difference between the ROSS framework and the VMM methodology is related to the strategic analysis approach. The methods differ in the assignment of the priority weights for the business goals of the project. The VMM requires managers to identify five business value factors (direct user, social, operational, political and financial value). This identification is time consuming and sometimes is difficult for managers to agree with the list of elements for each value factor. In contrast, the ROSS approach uses the balanced scorecard that most companies and government agencies had already implemented. Over 60% of the Fortune 1000 companies are using the balanced scorecard. The advantage of linking the balanced scorecard to the IT decision criteria is to leverage the familiarity that managers had with the process of identifying target and measurements for the four perspectives of the balanced scorecard (financial, customer, operational, knowledge management). The outcome is a strategy map that shows the alignment of the project with the overall mission and vision of the business. Table 59 shows the results of comparing the ROSS approach versus VMM regarding strategic analysis.

Table 59 ROSS vs. VMM Strategic Analysis Differences

ROSS **Strategic Weights : Criteria**	**VMM** **Strategic Weights: Criteria**
Strategy map with the four business perspectives of the balanced scorecard: • Financial • Customer • Operational • Knowledge Management <u>Advantages</u> Management is already familiar with the balanced scorecard criteria and measurements. Over 60% of the Fortune 1000 global companies have already implemented the Balanced Scorecard. Harvard Business Review considers the Balanced Scorecard one of the most powerful management ideas ever.	Five value factors: • Direct User (Customer) • Social Value • Operational • Politic Value • Financial Value <u>Limitation</u> Management is not familiar with the five value factors criteria. Considerable training and guidance by consultants is required. Few government organizations are using the five value factor criteria. VMM was developed by Booz, Allen and Hamilton using proprietary concepts of their consulting work.
ROSS **Strategic Weights: Tool**	**VMM** **Strategic Weights: Tool**
ANP (Analytical Network Process) <u>Advantage</u> Allow analyzing cause and effect inter-relations between business goals in different categories (balanced scorecard perspectives).	AHP (Analytical Hierarchical Process) <u>Limitation</u> Does not allow to consider cause and effect inter-relation between business goals in different categories (value factors)

Other limitation of the VMM is the use of the traditional analytical hierarchy process (AHP) approach to generate the priorities of the value factors. AHP does not considered the impact of cause and effect interrelation among factors. In the ROSS approach the cause and effect relationships are analyzed using analytical network processes (ANP) to do pair wise comparisons along the four business perspectives of the balanced scorecard to generate an overall Strategic Scorecard Value that measure the percentage of alignment of the project with the overall strategy of the firm.

In general, the ROSS decision framework provides more accurate and objective results as demonstrated with the results of the NASA Geospatial case study. The VMM methodology just considers the worst case scenario for the estimation of cost and benefits. Instead, the ROSS approach simulates many possible scenarios to find out the probability distribution of the returns of IT projects. The ROSS approach minimize the introduction of politics in the decision process by using the balanced scorecard as the control criteria and determining the weights using analytical network process pair-wise comparisons that consider all the possible interrelation between the business goals. The ROSS approach creates a balance between the financial (Real Option Value) and non-financial measures (Strategic Scorecard Value) to show the impact of IT projects in the overall mission and vision of the business.

6.5 NASA Case Study Conclusions

The goal of this case study was to show the applicability of the ROSS approach to the analysis and selection of strategic information technology (SIT) systems. The ROSS decision framework was applied to a NASA project selection problem to evaluate the best implementation alternative between using open source standard and software, or using proprietary commercial of-the-shelf applications.

In the original NASA geospatial analysis, identifying the best implementation alternative was difficult for the managers, because both options have practically the same net present value ($7,316,480 for the open source alternative and $7,347,991 for the proprietary alternative). Therefore, further analysis was required to compare both alternatives and select the best.

This case study shows that the ROSS approach provides more accurate results for the total costs, the volatility and the strategic alignment of the project alternatives. The results using the ROSS approach were compared with the original results obtained by NASA using the proprietary Value Measuring Methodology (VMM) developed by the Booz Allan and Hamilton firm in conjunction with the Harvard Kennedy School of Government. .

The ROSS approach allows to overcome some of the limitations of the VMM methodology. The ROSS decision framework integrates the use of Monte Carlo simulations and the Black Scholes equation for analyzing the whole range of variability for the cost of the NASA geospatial project alternatives. In this study, the output of these simulations is the probability distribution of the total cost. In contrast, VMM uses a traditional risk assessment and a fixed point estimations to calculate the risk adjusted total costs of the project.

Using the ROSS approach, the NASA geospatial open source implementation expected cost has a mean of $8,220,648 and a volatility of 4.8%. The proprietary solution estimated total cost was $9,427,133 with a volatility of 12.1%. The original VMM results for the geospatial project reported a total cost for the open source solution of $9,116,130 with a volatility of 24.4%. The total cost for the proprietary solution was $11,505,555 with a volatility of 56.6%.

For the strategy analysis, the ROSS approach results show that the NASA geospatial project has a Strategic Scorecard Value of 58.48% for the open source alternative and 35.14% for the proprietary alternative. Originally, the NASA VMM analysis reported a business value of 84.0% for the open source 84.0 and for the proprietary version 53.5%. The differences in results are explained by the consideration of interrelations between the business goals. VMM is based on the traditional Analytical Hierarchical Process (AHP) and do not support the pair-wise comparisons between business goal in two different categories. This limitation is resolved in the ROSS framework by integrating in the analysis the use of Analytical Network Processes (ANP) to map the cause and effect inter-relationships into a priority weights super-matrix of interconnections. The super-matrix is raised to a long power until the values for the weights converge. The case study shows that the ROSS approach results are an improvement and consistent with the results obtained using the current NASA value measuring methodology for project selection. NASA is committed to use the open source approach for further geospatial projects.

CHAPTER 7

CONCLUSIONS AND FUTURE RESEARCH

7.1 Conclusions

7.1.1 Implications for Research and Practice

Managers and engineers face several difficulties when trying to justify new strategic information technology (SIT) systems. The research literature shows that 79% of the companies require ROI analysis to be performed and that 50% of the strategic IT projects fail (MIT Center for Information Research, 2004). The traditional methods for project evaluation are inadequate for the analyses of risky IT investments because these methods are deterministic (uncertainty = 0) and do not consider risk.

The objective of this research was to develop a more comprehensive approach for the analysis of ROI analysis and selection of strategic information technology (SIT) systems in the presence of risk and considering business goal interrelations. During this research, a Real Option Strategic Scorecard (ROSS) decision framework was implemented and proposed as a better alternative for the project evaluation of SIT projects. In contrast with traditional methodologies and previous research work, the ROSS decision framework uses a multidimensional and axiomatic approach for systematically measuring both the business value and the strategic implications of IT projects.

The major research contribution of the ROSS approach is to be the first conceptual framework to fully integrate into a unified and comprehensive decision management system the best elements of real option theory, strategic balanced scorecards, Monte Carlo simulations and analytical network processes (ANP) to fully analyzes the effect of uncertainty and risk in the IT investment decisions.

The research provides value to practitioners by providing a generic model for ROI analysis and project evaluation of complex decisions and to researchers for demonstrating a new and novel hybrid application of real option and balanced scorecard to the analysis of IT strategic decisions. The ROSS decision framework optimizes the ROI analysis and selection of projects in the presence of risk, allowing managers to better compare and rank projects in the IT portfolio.

7.1.2 Advantages of the ROSS Approach

The real option strategic scorecard (ROSS) decision framework proposed in this dissertation has three important advantages over the current models present in the research literature and used by IT managers to select project investments. First, the ROSS framework guarantees the *strategic alignment* of the decision with the overall business mission and vision of the firm. Second, the ROSS approach *quantifies the impact of uncertainty* in the project decision. Third, the ROSS *minimizes the political bias in the decision process* by using a more objective methodology to compare project alternatives.

The ROSS decision framework guarantees the *strategic alignment* of the decision with the overall business mission and vision, by using the strategic plan and the corresponding balanced scorecard of the business as the guide and starting point to analyze any IT project investment decision. ROSS provides a more disciplined methodology to the IT project selection problem overcoming the empirical and subjective approach that currently IT managers use to quantify the business value of project investments. Instead of ad-hoc categories, ROSS uses the well defined business perspectives of the balanced scorecard. The project is studied in the context of the long term user perspective, financial perspective, operational perspective and knowledge management perspective.

The ROSS approach *quantifies the impact of uncertainty* in the project decisions using real option analysis and Monte Carlo simulations to determine the volatility of the expected return of the projects under different uncertainty scenarios. Therefore, the ROSS approach overcomes the limitation of the traditional deterministic models where decisions are considered static (now or never) and the impact of uncertainty is overlook.

The ROSS framework *minimize the political bias in the selection process*, using a more axiomatic approach to compare business goals and to assign the priority weights that IT managers assign to the different business factors under consideration. The project alternatives are compared using a more objective and systematic approach based on pair wise comparison matrices and analytical network processes.

The ROSS framework uses a four phase methodology for the return on investment analysis and selection of project alternatives. In Phase I, the business goals that are relevant to the project under consideration are identified and classified in the customer, financial, operational and knowledge categories of the balanced scorecard. In Phase II, the volatility of the rate of return of the project is used to calculate the real option score of the project using the Black-Scholes equation and Monte Carlo simulations. In Phase III, the strategic score is calculated by comparing the project alternatives with analytical network process and pair-wise comparisons. Finally, in Phase IV the decision is made using as criteria for selection the project alternative providing the best combination of real option and strategic scores.

7.1.3 Main Findings

A NASA Geospatial Interoperability project selection problem and the analysis of the return on investment (ROI) for the SCINET e-government project at

Seminole County in Florida were used as the cases studies to empirically validate that the ROSS approach.

The results of the case studies show that the ROSS framework satisfied the success factors for the validation of decision frameworks for project selection. The ROSS approach provides a realistic description of the selection problem, support group decision making, structure the decision problem incorporating both quantitative and qualitative factors, expresses the relative importance of the factors to analyze alternatives, and provides a comprehensive methodology to select the best alternative

The ROSS decision framework was applied to a NASA project selection problem to evaluate the best implementation alternative between adopting an open source approach or a proprietary approach to implement geospatial applications. In the original NASA geospatial analysis, identifying the best alternative was difficult for the managers, because both options have practically the same net present value ($7,316,480 for the open source alternative and $7,347,991 for the proprietary alternative). Therefore, further analysis was required to compare both alternatives and select the best.

In the NASA project selection case study, it was demonstrated that the ROSS approach provides more accurate results for the total costs, the volatility and the strategic alignment of the project alternatives. The results using the ROSS approach were compared with the original results obtained by NASA using the proprietary Value Measuring Methodology (VMM) developed by the Booz Allan and Hamilton firm in conjunction with the Harvard Kennedy School of Government. The ROSS approach allows to overcome some of the limitations of the VMM methodology.

The ROSS decision framework integrates the use of Monte Carlo simulations and the Black Scholes equation, for analyzing the whole range of variability for the cost of the geospatial project alternatives. In this study, the output of these simulations is the probability distribution of the cost and the generation of a more accurate estimation of the total cost. In contrast, VMM uses a traditional risk assessment and a fixed point estimated value for the risk to calculate the risk adjusted total costs of the project.

Using the ROSS approach the NASA geospatial open source implementation expected cost has a mean of $8,220,648 and a volatility of 4.8%. The proprietary solution estimated total cost was $9,427,133 with a volatility of 12.1%. The original VMM results for the geospatial project reported a total cost for the open source solution of $9,116,130 with a volatility of 24.4%. The total cost for the proprietary solution was $11,505,555 with a volatility of 56.6%.

In the NASA case study, the ROSS approach was used to consider the interrelations between business goals of operational and knowledge management perspectives of the balanced scorecard. VMM is based on the traditional Analytical

Hierarchical Process (AHP) and do not support the pair-wise comparisons between two different categories. This limitation is resolved in the ROSS framework by integrating in the analysis the use of Analytical Network Processes (ANP) that allow to consider cause and effect relationship in an analytical decision framework.

The ROSS approach in the NASA case study calculates the Strategic Scorecard Values using the new interrelation priority weights for the operational and knowledge management category. These priority weights are obtained by using a super-matrix of interconnections and raising the super-matrix to a long power until the values for the weights converge. The results for the geospatial project were a Strategic Scorecard Value of 58.48% for the open source alternative and 35.14% for the proprietary alternative. Originally, the values reported were for the open source 84.0 and for the proprietary version 53.5%..

These NASA study results using the ROSS approach are an improvement and consistent with the results obtained using the current NASA value measuring methodology for project selection. NASA is committed to use the open source approach for further geospatial projects.

The application of the ROSS decision framework was also discussed in a case study for the management of IT portfolios for Seminole County in Florida. In the Seminole case, the ROSS framework was used to analyze the return on investment of the migration of software from H.T.E legacy software to the new SCINET system.

SCINET is a strategic information system project with a great potential for returns on investment, but also a great inherent risk.   In the case study, we show that to analyze the return on investment of a strategic investment is necessary to use a comprehensive analysis tool such as the ROSS framework that considers at the same time the benefits, costs and risks of the project.

Identifying the business value of strategic investment like SCINET is a complex process, because the capabilities of this type of new system are seldom known in advance and it is difficult to predict the actual costs, benefits and the impact of uncertainty.

In the SCINET case study is shown that if we use traditional tools such as the net present value to analysis the return on investment of SCINET without risks considerations other than the cost of capital rate, the business value for the project will not be very attractive (the calculated NPV for SCINET is equal to -$62-715. However, we shown that this result is misleading, because did not include the impact of uncertainty. The benefits and cost can change over time, and this volatility will affect the return on investment of the project.

The four steps of the ROSS approach were used in the SCINET case. First, the business goals were identified using the financial, customer, operational and knowledge management perspectives of the balanced scorecard. Second, the Real Option Value of the project was estimated to have a corresponding mean of \$624,272 based on the assumption that the cost and benefits will follow a normal distribution with a range of variability of 40% and 60% respectively. Third, the Strategic Scorecard Value of the project was estimated to be 76.5% in alignment with the overall mission and vision of Seminole County. The interdependencies among business goals were analyzed using the Analytical Network Process super matrix. For the SCINET project, individual scores were estimated for the level that the project is expected to satisfy each of the business goals. Finally, during the ROI analysis phase the results were summarized graphically and using the coordinates for the Real Option and Strategic Scorecard Values (\$637,223; 76.5%).

The final conclusion of the SCINET case study is that applying the ROSS approach shows that the SCINET project provides very attractive return on investment for both the business value and strategic of Seminole County. Therefore, the project should be fully funded and supported by the Seminole managers. The case study demonstrates that the ROSS framework will help managers of the local and federal government to present better business cases to justify new e-government project investments.

7.1.4 Limitations

One of the limitations of the ROSS approach is the dependency on the expertise of the decision makers (the IT executives and managers). The initial estimation of cost and benefits and the values assigned during the pair-wise comparisons depend on the expertise of the particular manager taking the decision. There is some lack of accuracy on these estimations and there are some subjective opinions involved. For example, in 2004, the Congressional Budget Office estimates that a set of 72 programs executed by NASA since 1977 has been about 45 percent over the original estimated costs. So there is a need to improve the estimation of the original costs and benefits for IT projects (Bonkendour, 2006).

In general, as demonstrated by the Kenneth Arrow's (1963) impossibility theorem, it is not possible to design a decision framework that is 100% mathematical objective. Arrow won the Nobel Prize in 1971 for the mathematical demonstration that no voting system (a mechanism for extracting a decision from a multitude of voters' preferences) can possibly meet a certain set of reasonable criteria when there are three or more options to choose from. In non-mathematical terms, the Arrow's Theorem means that "no voting method is fair" or "every ranked voting method is flawed". In decision making, the Arrow theorem is used to show the limitations to make a rational choice based on several criteria.

The ROSS approach uses the Real Option Value and the Strategic Scorecard values to guide the selection decision. Using the ROSS approach managers can select the project with the best combination of Real Option and Strategic Scorecard values. The ROSS approach is a descriptive method to generate quantitative results and to guide the decision, but it is not a prescriptive method. The final decision should be made by the managers based on the specific trade-offs that are required for the current business conditions. The final choice is the alternative whose outcome is most preferred by the decision maker.

There is a limitation with all the project selection models including the ROSS approach, if the decision maker is indifferent to the outcomes, then a random choice is acceptable. The modern normative decision literature illustrates the random choice issue with the famous dialog in the Alice in Wonderland book (Hazelrigg, 2003):

> “ Would you tell me, please which way I ought to walk from here?”
> “That depends a good deal on where you want to get to” said the Cat.
> “I don’t care much where “ said Alice
> Then it doesn’t matter which way you walk” said the Cat
> “so long as I get somewhere” Alice added as an explanation
> “Oh, you’re sure to do that” said the Cat, “if you only walk long enough”

Therefore, applying the ROSS approach or any other decision analysis framework will provide good results as long as the IT managers provide good information about the business goals that they want to achieve. If the business vision and goal for the project are not clear, then any random outcome will be possible, as long they “walk long enough”.

7.2 Future Research

Real Option theory was developed based on the insight that the choice faced by a manager making a project decision is similar to the choice faced by a stock market investor. Recent research literature is extending the real option model using an emergent methodology called prediction markets and introduced by James Surowiecki's in the book “The Wisdom of Crowds” (Surowiecki, 2004).

Prediction markets are internal marketplaces created inside a company with the purpose of making collective predictions. Prediction markets behave similarly to the NASDAQ or the New York Stock Exchange market, with similar rules and outcomes. On an internal market, for example, any employee can propose new projects and estimate particular events such as the delivery date, the cost and benefits of the project. These proposals and events become stocks, complete with ticker symbols, discussion lists and e-mail alerts. Employees buy or sell the stocks, and prices changes to reflect the best guess estimation of the employees. After a period of trading, the current market prices can then be interpreted as predictions of the probability of the event or the expected value of the parameter.

Recent research papers (Bonkendour, 2006) had suggested the prediction markets can be integrated with the Black Scholes option pricing models. Bonkendour studied 72 programs executed by NASA to bring together fair valuation and real options for improving cost estimation accuracy.

In future research, the ROSS approach could be extended using the prediction market approach to estimate the initial values for cost and benefits, using the collective estimation of the marketplace instead of the isolate estimated of few project managers and engineers. A better cost and benefit estimation will improve the accuracy of the real option analysis using the ROSS approach.

. Prediction are being used as an alternative to deliver accurate forecasts and are being use to predict sales, rank projects, monitor industry trends or customer satisfaction. For example, Rita-Solutions, a software company that builds classified command and control systems for the Navy has fifty-five stocks listed on the company's internal market corresponding to information system projects. Each project stock begins trading at a price of $10. Every employee gets $10,000 in "opinion money" to allocate among the offerings, and employees invest in the project stock based on their best guess estimations. Employees share in the proceeds, if the project is delivered based on the collective estimations. Today, the product line, called Rite-View, accounts for 30 percent of the total sales. (New York Times, March 26, 2006).

Google is another example of a company using predictions market implemented inside of the company. Google's prediction markets were designed to forecasts project launch dates, cost and benefits. More than one thousand Google employees have bid in 43 projects. In the Google prediction market, the price of an event reflects a consensus probability that the event will occur. (Google, 2006)

The Google and Rita Solution examples shows the importance of using the collective wisdom of all the employees for the estimation of the cost and benefits of projects, instead of relying on the best guess estimation of a few upper manager and technical personnel.   Prediction market increase participation and provides more reliable results.

Another interesting and useful extension of the ROSS approach is to develop a software application to support the four phases of the ROSS decision framework. Currently, there are not commercial software applications that combine real option calculations, analytical network processes and balanced scorecard in the same package.   The most popular commercial packages only cover part of the decision analysis process. Expert Choice, for example, can be used for the Analytical Network Process pair-wise comparisons. Crystal Ball can be used for Monte Carlo Simulations and Real Options. The future research will create an integrated software solution using Excel scripts to implement the conceptual framework developed during this dissertation.   Several workshops about the ROSS conceptual framework and about the new supporting software system are being scheduled with universities in Latin America and the United States.

APPENDIX A:

TRADITIONAL MULTICRITERIA SCORING RESULTS

This appendix contains data to illustrate the application of the traditional multicriteria scoring method. The data was obtained from a Seminole County study to analyze the return on investment of the migration from the current Lotus Notes e-mail system to the Microsoft Exchange system. The data was compiled with the assistance of Seminole County staff. The appendix contains the cost and benefit comparison and the ad-hoc criteria used to rate the project alternatives. For each feature evaluated the project could get a NO satisfaction grade (-1) or a YES satisfaction grade. The points are discount from the assumed weight for each comparison criteria category. There major limitation of this approach is the lack of consideration of risk and variability, and the use of very subjective criteria for comparison.

Cost/Benefits Comparison

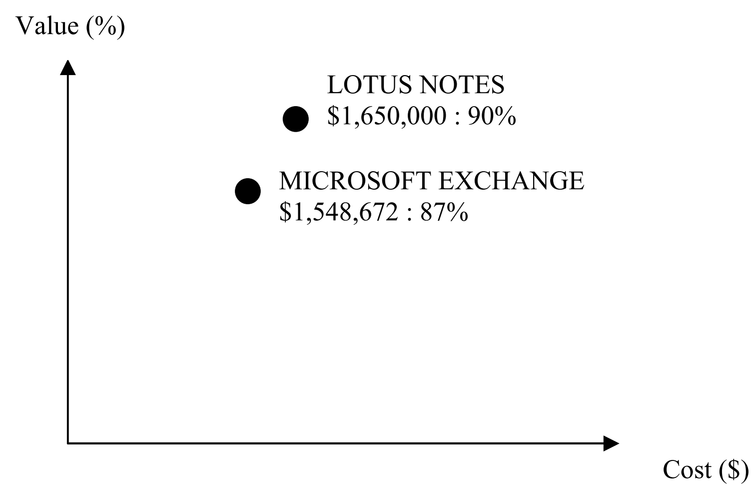
EXCHANGE COSTS							
Estimated Cost	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Hardware (Lease)	$200,897	$200,897	$200,897	$0	$0	$0	$602,691
Exchange Licensing	$68,317	$68,317	$68,317	$34,101	$34,101	$34,101	$307,254
3rd. Party Software	$251,706	$0	$0	$0			$251,706
Consultant Support	$445,000	$75,000	$50,000	$25,000	$10,000	$10,000	$615,000
Training	$20,000	$0	$0	$0	$0	$0	$20,000
Applications	$88,435	$0	$0	$0	$0	$0	$88,435
Reduce Hardware	-$1,532	-$8,673	-$13,039	$0	$0	$0	-$23,244
Reduce Lotus License	$0	-$62,634	-$62,634	-$62,634	-$62,634	-$62,634	-$313,170
Total	$1,072,823	$272,907	$243,541	$197,364	$182,364	$182,364	**$1,548,672**
LOTUS COSTS							
Estimated Cost	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Maintenance	$275,000	$275,000	$275,000	$275,000	$275,000	$275,000	$1,650,000
Total	$275,000	$275,000	$275,000	$275,000	$275,000	$275,000	**$1,650,000**

Ad-hoc Criteria

Features	WEIGHT	Microsoft Exchange	Score	Lotus Notes	Score
1.0 Interface Features	**10**		**8**		**10**
1.1 Local Folders		NO (-1)		YES	
1.2 Navigation Pane		NO (-1)		YES	
2.0 Messaging Features	**20**		**11**		**20**
2.1 Accept/Decline Appoint in Preview Panes					
2.2 Auto Address and Auto Name		NO		YES	
2.3 Display Unlimited Number of Messages		NO		YES	
2.4 Embed Document in Messages		NO		YES	
2.5 Add words to Dictionaries		NO		YES	
2.6 Track Delivery		NO		YES	
2.7 Rich Text Format (RFT) editing		NO		YES	
2.8 Reply in Same Format Received		NO		YES	
2.9 Search for Messages		NO		YES	
2.10 Organize Messages		NO		YES	
3.0 Calendar Features	**20**		**20**		**17**
3.1 Side by Side Viewing of Multiple Calendars		YES		NO	
3.2 Notification of Conflicting Appointment		YES		NO	
3.3 Send/Receive Calendar Attachment		YES		NO	
4.0 Contact Features	**10**		**10**		**7**
4.1 Contact Picture		YES		NO	
4.2 Print Address Card		YES		NO	
4.3 Exchange Virtual Business Cards		YES		NO	
5.0 Task Management	**10**		**10**		**7**
5.1 View Task by Category		YES		NO	
5.2 View by active/completed/overdue status		YES		NO	
5.3 Task Tracking		YES		NO	
6.0 Security (25%)	**30**		**28**		**29**
6.1 Kerberos Authentication		YES		NO	
6.2 Proprietary Security Protocol		NO		YES	
6.3 Less Vulnerability Against Virus		NO		YES	
TOTAL	**100**		**87**		**90**

Results Summary

	MICROSOFT EXCHANGE	LOTUS NOTES
Cost Score	**$1,548,672**	**$1,650,000**
Value Score	**87**	**90**



APPENDIX B:

VMM RESULTS

The appendix B summarizes the results of the original NASA Geospatial Return on Investment study (NASA GIO Report 2005, Foley 2006).

Cost/Benefits

CASE I (OPEN SOURCE)							
Estimated Cost	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Design	$119,708	$125,694	$42,272	$44,386	$46,605	$48,935	$427,600
Implementation	$1,780,036	$1,869,038	$410,396	$430,915	$452,461	$475,084	$5,417,930
Maintenance	$374,368	$393,086	$163,219	$171,380	$179,949	$188,947	$1,470,949
Total	$2,274,112	$2,387,818	$615,887	$646,681	$679,015	$712,966	$7,316,479
Risk Adjusted	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Design	$131,701	$141,190	$48,542	$52,065	$55,714	$59,493	$488,705
Implementation	$2,138,999	$2,290,127	$515,086	$553,582	$593,467	$634,784	$6,726,045
Maintenance	$465,114	$497,229	$211,054	$227,134	$241,814	$259,035	$1,901,380
Total	$2,735,814	$2,928,546	$774,682	$832,781	$890,995	$953,312	$9,116,130

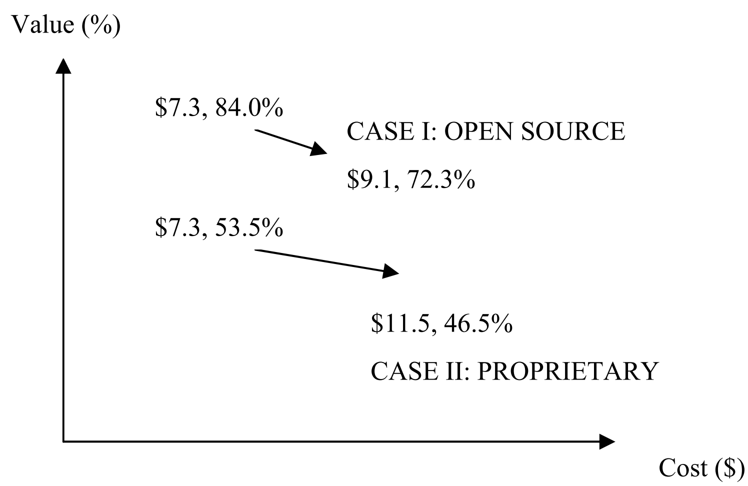
CASE II (PROPRIETARY)							
Estimated Cost	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Design	$46,075	$48,379	$50,798	$53,338	$56,004	$58,805	$313,399
Implementation	$68,400	$71,820	$75,411	$79,182	$83,141	$87,298	$465,252
Maintenance	$965,808	$1,014,098	$1,064,063	$1,118,043	$1,173,946	$1,232,643	$6,568,601
Total	$1,080,283	$1,134,297	$1,190,272	$1,250,563	$1,313,091	$1,378,746	$7,347,252
Risk Adjusted	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Design	$55,514	$59,379	$63,775	$68,330	$73,458	$78,772	$399,228
Implementation	$86,174	$92,173	$98,998	$106,068	$114,029	$122,277	$619,719
Maintenance	$1,458,197	$1,559,715	$1,675,195	$1,794,837	$1,929,545	$2,069,119	$10,486,608
Total	$1,599,885	$1,711,267	$1,837,968	$1,969,235	$2,117,032	$2,270,168	$11,505,555

Value Factor Criteria

Value Factors and Benefits	Weight	CASE I OPEN SOURCE Weight Score	CASE I OPEN SOURCE Risk Adjusted	CASE II PROPRIETARY Weight Score	CASE II PROPRIETARY Risk Adjusted
1 Direct User	**26.51**	**22.80**	**19.60**	**11.70**	**10.30**
1.1 Easy to Use	9.81	8.10	7.00	5.10	4.50
1.2 Broad Data Sharing Capabilities	6.63	5.10	4.40	2.60	2.30
1.3 Data Availability and Accessibility	10.07	9.60	8.20	4.00	3.50
2 Social Value	**28.70**	**27.00**	**23.10**	**17.50**	**15.20**
2.1 Institutional Effectiveness	5.74	5.10	4.40	4.00	3.50
2.2 Efficient use of tax payer resources	3.73	3.70	3.20	3.40	3.00
2.3 Minimal Barriers exist to finding and obtaining data	5.74	5.50	4.70	3.20	2.70
2.4 Citizen are able to make better decisions	7.75	7.50	6.40	3.60	3.10
2.5 Extra-Government Coordination	5.74	5.20	4.40	3.30	2.90
3 Government Foundation/Operational	**24.40**	**19.50**	**16.70**	**14.80**	**13.00**
3.1 Intra-Government collaboration	4.15	3.10	2.70	3.10	2.70
3.2 Mainstreaming of GIS technology	2.68	2.70	2.30	2.20	1.90
3.3 Interagency Collaboration	3.42	2.80	2.40	2.40	2.10
3.4 Reuse, Adaptation and Consolidation	3.42	3.40	2.90	3.00	2.60
3.5 Public Participation and Accountability	3.66	2.40	2.00	1.60	1.40
3.6 Ease of Integration	5.61	4.00	3.50	2.20	2.00
3.7 IT Performance	1.46	1.10	0.90	0.30	0.30
4 Strategic/Political Value	**8.80**	**7.90**	**6.70**	**4.20**	**3.70**
4.1 Supports improved decision making	2.64	2.40	2.00	1.30	1.10
4.2 Supports NSDI	2.46	2.10	1.80	1.70	1.50
4.3 Close Working Relationships	2.64	2.30	2.00	0.70	0.60
4.4 e-Gov Support	1.06	1.10	0.90	0.50	0.50
5 Government Financial	**11.60**	**6.90**	**6.00**	**4.90**	**4.30**
5.1 Total Cost Savings	7.19	4.3	3.7	3.60	3.10
5.2 Total Cost Avoided	4.41	2.6	2.3	1.30	1.20
Total		**84.10**	**72.10**	**53.10**	**46.50**

Results Summary

	CASE I (OPEN SOURCE)	CASE II (PROPIETARY)
Cost Risk Score	**24.6%**	**56.6%**
Original Cost	$7.3 million	$7.3 million
Risk Adjusted Cost	$9.1 million	$11.5 million
Value Risk Score	**-13.9%**	**-13.1%**
Value Score	84.0	53.5
Risk-Adjusted Score	72.3	46.5



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