Calhoun: The NPS Institutional Archive

Theses and Dissertations | Thesis Collection

Applying modern portfolio theory and the capital asset pricing model to DoD's information technology investments

VanOrden, Marc A.

Monterey, California. Naval Postgraduate School

http://hdl.handle.net/10945/4795

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

APPLYING MODERN PORTFOLIO THEORY AND THE CAPITAL ASSET PRICING MODEL TO DOD'S INFORMATION TECHNOLOGY INVESTMENTS

by

Sammie Pringle Jr.
Marc A. VanOrden

March 2009

Thesis Advisor: Thomas J. Housel
Second Reader: Johnathan Mun

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE		*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE March 2009	3. REPORT TYPE AND DATES COVERED Master's Thesis
4. TITLE AND SUBTITLE Applying Modern Portfolio Theory and the Capital Asset Pricing Model to DoD's Information Technology Investments		5. FUNDING NUMBERS
6. AUTHOR(S) Sammie Pringle Jr. and Marc A. VanOrden		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A		10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	12b. DISTRIBUTION CODE

13. ABSTRACT (maximum 200 words)

Program Managers (PMs) throughout the Department of Defense (DoD) were directed by the DoD Chief Information Officer to manage information technology (IT) investments as portfolios (to include Mission Areas, Subportfolios, and Components) within the DoD Enterprise. Managing portfolios of capabilities aligns IT with the overall needs of the warfighter, as well as the intelligence and business activities which support the warfighter. This thesis provides the detailed steps that PMs and Program Executive Officers (PEOs) should follow to closely manage their IT portfolios using the concepts described within Harry Markowitz' Modern Portfolio Theory. The first section will provide a demonstration of allocating revenue generated by a fictitious large corporation to the various sub-corporate levels and then applying Knowledge Value Added (KVA) in order to calculate a Return on Investment (ROI). The foundation of KVA analysis is that each subprocess output must be represented in common units of change; a price per unit of output is generated to allocate both cost and revenue at the subprocess level. The final section will apply a similar KVA analysis to the Naval Cryptologic Carry On Program (CCOP) systems to provide a public sector example.

14. SUBJECT TERMS CAPM, Capital Asset Pricing Model, KVA, Knowledge Value Added, Real Options, ROI, Return on Investment, MPT, Modern Portfolio Theory.			15. NUMBER OF PAGES 57
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU

THIS PAGE INTENTIONALLY LEFT BLANK

APPLYING MODERN PORTFOLIO THEORY AND THE CAPITAL ASSET PRICING MODEL TO DOD'S INFORMATION TECHNOLOGY INVESTMENTS

Sammie Pringle Jr.
Lieutenant Commander, United States Navy
B.S., Florida A & M University, 1996

Marc A. VanOrden
Lieutenant, United States Navy
B.S., San Diego State University, 2002

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 2009

Authors: Sammie Pringle Jr.
                   Marc A. VanOrden

Approved by: Dr. Thomas J. Housel
                   Thesis Advisor

                   Dr. Johnathan Mun
                   Second Reader

                   Dr. Dan C. Boger
                   Chairman, Department of Information Sciences

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Program Managers (PMs) throughout the Department of Defense (DoD) were directed by the DoD Chief Information Officer to manage information technology (IT) investments as portfolios (to include Mission Areas, Subportfolios, and Components) within the DoD Enterprise. Managing portfolios of capabilities aligns IT with the overall needs of the warfighter, as well as the intelligence and business activities which support the warfighter. This thesis provides the detailed steps that PMs and Program Executive Officers (PEOs) should follow to closely manage their IT portfolios using the concepts described within Harry Markowitz' Modern Portfolio Theory. The first section will provide a demonstration of allocating revenue generated by a fictitious large corporation to the various sub-corporate levels and then applying Knowledge Value Added (KVA) in order to calculate a Return on Investment (ROI). The foundation of KVA analysis is that each subprocess output must be represented in common units of change; a price per unit of output is generated to allocate both cost and revenue at the subprocess level. The final section will apply a similar KVA analysis to the Naval Cryptologic Carry On Program (CCOP) systems to provide a public sector example.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

THIS PAGE INTENTIONALLY LEFT BLANK

I.   INTRODUCTION

A.   PURPOSE / PROBLEM STATEMENT

On October 30, 2006, the Department of Defense (DoD) Chief Information Officer (CIO) directed that all information technology (IT) investments must be managed as a portfolio. "Managing portfolios of capabilities aligns IT with the overall needs of the warfighter, as well as the intelligence and business activities which support the warfighter" (DoD, *Information technology portfolio management implementation*, 2006, p. 3). This directive used some of the key terminology of Harry Markowitz' Modern Portfolio Theory without actually naming it specifically. The DoD CIO did not provide specific guidance on how to manage an IT investment portfolio, but only the necessity to manage the portfolio within a non-profit organization, i.e., the DoD. The objective of this research is to conduct a KVA analysis of a large corporation and a non-profit military organization. This paper will provide a detailed framework in order to adhere to this directive and will supply Program Managers with the necessary toolset to be able to make informed IT investment decisions.

The Clinger-Cohen Act (also known as Information Technology Management Reform Act of 1996) was signed into law in February 1996. The primary focus of this document was aimed at ensuring the hundreds of federal agencies (DoD, Federal Bureau of Investigation, National Security Agency, State Department, etc.) operated as economically responsible as possible. Acquisition, planning and management of IT must be treated as a "capital investment." This means that hardware and software cannot be purchased on an "impulse purchase" basis and installed without an overall plan. The Director of the Office of Management and Budget (OMB) is responsible for improving the acquisition, use, and disposal of IT by the Federal Government. His main goals were to better manage technology spending, achieve measurable improvements in federal agencies performance, and control system development risks.

According to the Office of Management and Budget (2000), the Clinger-Cohen Act was established to improve the way Federal agencies acquire and manage their IT resources by:

- Focusing information resource planning to support their strategic missions;

- Implementing a capital planning and investment control process that links to budget formulation and execution, and

- Rethinking and restructuring the way they do their work [(e.g., current processes)] before investing in information systems. (p. 2)

"Consistent with the Office of Management and Budget (OMB) Capital Planning and Investment Control guidance, the Department of Defense shall use four continuous integrated activities to manage its portfolios" (DoD, *Information technology portfolio management implementation*, 2006, p. 3). Figure 1 illustrates these four components of managing IT investments within the DoD.

- <u>Analysis</u> – "Activity in which Mission Areas and Subportfolios, in collaboration with Components, establish performance goals; identify gaps and opportunities; assess risks; provide for continuous improvement; and explore functional and technical options as documented in current capabilities and future integrated architectures" (DoD, *Information technology portfolio management implementation*, 2006, p. 14).

- <u>Selection</u> – "The process for selecting the best mix of investments to realize capabilities and achieve goals, satisfy measures, and comply with integrated architectures and transition plans" (DoD, *Information technology portfolio management implementation*, 2006, p. 18). The selection process focuses on a portfolio of IT investments with demonstrated ROI, benefit-cost analysis, proper planned oversight mechanisms, maximum usefulness, and other qualities aligned with the Enterprise Architecture (EA) and strategic plans as part of a managed investment portfolio.

- <u>Control</u> – "Activity is focused on developing and acquiring the capabilities selected in the portfolio… The purpose of control is to ensure that these capabilities will

be acquired in conformance with Mission Area and Subportfolio expectations …" (DoD, *Information technology portfolio management implementation*, 2006, p. 23).

- Evaluation - The results of the investment after implementation to assess the benefit-cost achieved compared to the benefit-cost expected, evaluate the ROI to make a continue/modify/terminate decision on continuing with the investment, document lessons learned, redesign processes where needed, reassess the business case, technical compliance and EA compliance.
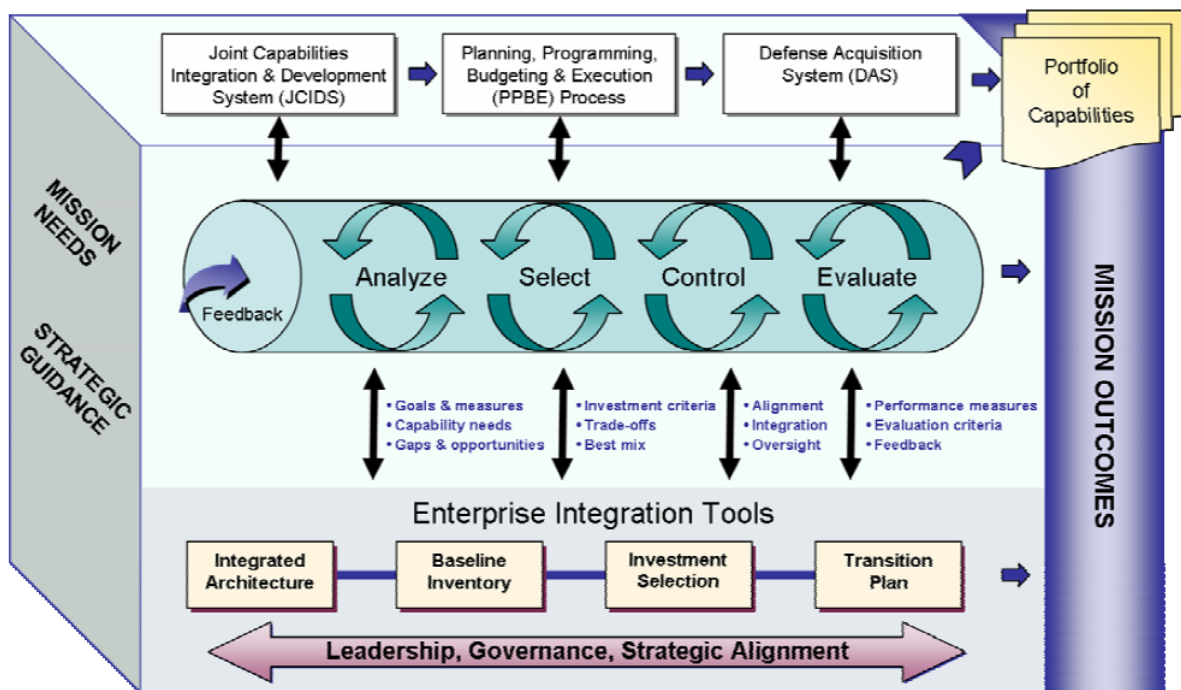
Figure 1. IT Portfolio Management Decision Support Interactions. (From: DoD, *Information technology portfolio management implementation*, 2006, p. 4)

In the spring of 2006, the Department of the Navy created the Program Executive Office for Enterprise Information Systems (PEO-EIS). The PEO-EIS primary assignment was designed specifically to oversee a portfolio of enterprise-wide IT programs. Their mission statement is to develop, acquire and deploy enterprise-wide information technology systems with full life-cycle support for the warfighter and business enterprise. All of the PEO-EIS programs are specifically designed to maximize

value to the warfighter by balancing cost with the capability delivered to the end user. The following is the list of programs which have been developed, implemented and are currently being managed by PEO-EIS:

a. BLII / ONE-Net: Base Level Information Infrastructure Program / OCONUS Navy Enterprise Network

b. NMCI: Navy Marine Corps Intranet

c. TFARS: Total Force Authorizations and Requirements System

d. NSIPS: Navy Standard Integrated Personnel System

e. Navy ERP: Navy Enterprise Resource Planning

f. GCSS-MC: Global Combat Support System – Marine Corps

g. Sea Warrior

h. NM&P: Navy Manpower and Personnel Systems

B.   BACKGROUND

This thesis represents the continuation of the work from two previous theses by LCDR Cesar Rios, in concert with Dr. Tom Housel in his thesis titled, "Return on Investment Analysis of Information Warfare Systems," and LT Ira Lambeth/LT Hubert Clapp in their thesis titled, "Using Knowledge Value Added (KVA) for Evaluating Cryptologic IT Capabilities: Trial Implementation." Both of these theses were conducted at the Naval Postgraduate School (NPS) in order to demonstrate the functionality and usability of the KVA methodology. Lambeth and Clapp conducted an operational example of six Navy Cryptologic Carry-On Program (CCOP) systems carried onboard the USS GONZALES (DDG 66).

LCDR Rios' thesis focused on creating a foundation for analyzing the CCOP system using KVA methodology. The research conducted by LT Lambeth and LT Clapp centered on providing a proof of concept example of several CCOP systems installed onboard USS GONZALES (DDG 66). The KVA methodology was applied to the CCOP systems used during an 18-month deployment of the USS GONZALES.

This thesis is the follow-on research which will provide the detailed steps that Program Managers and Program Executive Officers should follow to closely manage their IT portfolio using the concepts described within Harry Markowitz' Modern Portfolio Theory. The KVA methodology will be applied to two different companies (i.e., a for-profit large corporation and a non-profit military organization). The following background information will describe each company in further detail and the various concepts that will be applied throughout this thesis.

- **XYZ TELCOM:**

XYZ TELCOM is a fictitious telecommunication company based in Los Angeles with over 160,000 employees worldwide. There primary U.S. operating areas are California, Nevada, Texas, Kansas, Arkansas, Missouri, Michigan, Ohio, Illinois, Indiana, Wisconsin and Connecticut. This company is one of the largest providers of local and long distance telephone services in the United States. This company is fictional and is designed simply to be a proof of concept example to show that the KVA methodology can be used on any private sector company regardless of level of output or type of business organization (e.g., large corporation, sole-proprietor, partnership, etc.). KVA analysis can be performed on any company regardless of size or financial status. Using the KVA methodology, the Program Manager for XYZ TELCOM will be able to calculate the Return on Investment (ROI), Return on Knowledge (ROK) and the standard deviation of the IT systems in all the departments within the company. The steps detailed in this example will encapsulate the required tools necessary to be able to effectively manage any IT investment portfolio.

- **USS NEVERSAIL (DDG-22) Cryptologic Carry-On Program:**

The USS NEVERSAIL (DDG-22) is a fictional guided missile destroyer stationed in San Diego, CA. The ship carries six CCOP systems onboard during a routine six-month deployment. "The Cryptologic Carry-On Program (CCOP) is a product of the Advanced Cryptologic Systems Engineering program, which develops state-of-the-art Intelligence, Surveillance and Reconnaissance (ISR) capabilities in response to Combatant Command requirements for a quick-reaction surface, subsurface and airborne

cryptologic carry-on capability" (Rios, 2005, p. 2). CCOP supports Fleet Commander in Chief (FLTCINC) cryptologic Electronic Support (ES) requirements for Naval and Joint Operation including Counter-Drug operations. Its manning is provided by fleet Direct Support (DIRSUP) Augmentees and is staged at Fleet Electronic Support (FES) activities worldwide.

The CCOP systems are composed of several different subsystems, which for classification purposes will be referenced simply by a letter. The specifics of the system are outside the scope of this paper in order to keep this thesis at an unclassified level. All of the data presented is fictitious and will be used as a proof of concept example to illustrate how KVA analysis can be performed on any non-profit organization regardless of size.

The following concepts will be applied throughout this thesis:

1.   Return on Investment

Return on Investment (ROI), also known as rate of return, is the ratio of money gained or lost on an investment relative to the money invested. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio. ROI is a basic productivity ratio with profit (revenue minus cost) in the numerator and cost to generate the profit in the denominator.

$$\textbf{Percentage ROI} = \frac{\textbf{(Gain from Investment} - \textbf{Cost of Investment)}}{\textbf{Cost of Investment}}$$

For the above formula, the numerator is the difference between revenue and cost of the investment (or asset) and the denominator represents the cost of the investment (or asset) to the organization. "The ROI then produces a metric to determine how efficiently the investment is applied" (Lambeth & Clapp, 2007, p. 4). A positive value corresponds to capital growth, a negative value corresponds to capital decay and a value of 0% corresponds to no change.

Referring to revenues throughout this paper may seem imprudent due to the fact that the U.S. military is not a profit making business. This is the primary reason why the KVA methodology was chosen for this research. For non-profit organizations, especially in the military, Knowledge Value Added (KVA) is utilized to provide the required "benefits" or "revenue" proxy estimates to run ROI analysis. KVA generates ROI estimates by developing a market comparable price-per-common-unit of output multiplied by the number of outputs to achieve a total revenue estimate.

2.   Knowledge Value Added

"The Knowledge Value Added (KVA) methodology was created by Drs. Thomas Housel and Valery Kanevsky and has been published internationally in numerous articles and books about knowledge management and business process reengineering" (Housel & Kanevsky, n.d, p. 1). The KVA methodology provides a means to objectively allocate revenue to all corporate resources (e.g., materials, supplies and equipment) and organizational processes, even down to the individual employee level. It is based on the premise that businesses and other organizations produce outputs (e.g., products and services) through a series of processes and subprocesses which change the raw inputs (e.g., labor into services, information into reports).

Housel and Bell (2001) defined KVA as the following:

KVA is a methodology designed to estimate the value of the knowledge deployed throughout a company's core processes. KVA provides a performance ratio estimate that standardizes the output of all processes by describing the output in terms of the units of knowledge required to produce the output.

The goal of KVA methodology is to describe all organizational outputs in common units. Common units provide a means to compare all of the outputs for the organization's assets (e.g., human, machine, IT) regardless of the total quantity of outputs produced. An example within the military would be the process of planning for a ship alteration or gathering signal intelligence. KVA would allow a Program Manager to describe the outputs of both processes in common units and provide him the ability to compare their performance equally.

According to Housel & Mun (n.d.):

> KVA measures the value provided by human capital assets and IT assets by analyzing an organization, process or function at the process level. It provides insights into each dollar of IT investment by monetizing the outputs of all assets, including intangible assets (e.g., such as those assets produced by IT and humans). By capturing the value of knowledge embedded in an organization's core processes (i.e., employees and IT), KVA identifies the actual cost and revenue of a process, product, or service. Because KVA identifies every process required to produce an aggregated output in terms of the historical prices and costs-per-unit of output of those processes, unit costs and unit prices can be easily calculated.

As a performance tool, the KVA methodology:

- Compares all processes in terms of relative productivity
- Allocates revenues and costs to common units of output
- Measures value added by IT by the outputs it produces
- Relates outputs to cost of producing those outputs in common units. (p. 3)

3.   Modern Portfolio Theory

"In 1952, Harry Markowitz revolutionized the field of finance with his article written in the Journal of Finance entitled 'Portfolio Selection'" (Markowitz, 1987, p. ix). Modern Portfolio Theory (MPT) considers a method of resource allocation for the investor in the for-profit sector. Markowitz introduced the idea of a mean-variance efficient portfolio as one that (1) provides minimum variance for a given expected return and (2) provides maximum expected return for a given variance. The main idea is that investors should maintain a well-diversified portfolio in order to reduce their overall risk. "A 'portfolio' is a list of securities that belongs to an individual investor or a group of investors having certain goals" (Smith, 1971, p. 40).

MPT starts with the investors' set of probability beliefs regarding the expected return from each investment and the expected covariance between each pair of investments (based in turn upon expected standard deviations and correlation coefficients). Given these probability beliefs, the investor can chose between various

combinations of reward (expected return) and risk (variance of returns) depending on the construction of the portfolio (the identity and relative proportions of the investments). Of these combinations, those with the minimum variance for a given (investor-determined) level of risk or maximum return for a given variance correspond to a set of "efficient" portfolios. Thus, portfolio theory suggests a way of optimally allocating capital for the investor in the private sector.

McInish (2000) wrote in his book entitled "*Capital Markets: A Global Perspective*":

> A portfolio is efficient if it has the highest return for a given level of risk and the lowest risk for a given level of return. One portfolio dominates another if it has more return for a given level of risk or less risk for a given level of return. (p. 287)

Some PMs measure the amount of risk that their firm will tolerate. Then they examine a list of trade offs between more reward and lower risk. One of the components of MPT is the figure shown below which shows how much risk investors are willing to accept for a given return. If they are given an investment with a high potential return, investors are usually willing to accept a little more risk. If they are given an investment with much more certainty, they are willing to accept a lower return. This is expressed as a curve on the chart where risk and return are just barley acceptable. Figure 2 illustrates what someone's investment boundary might look like.
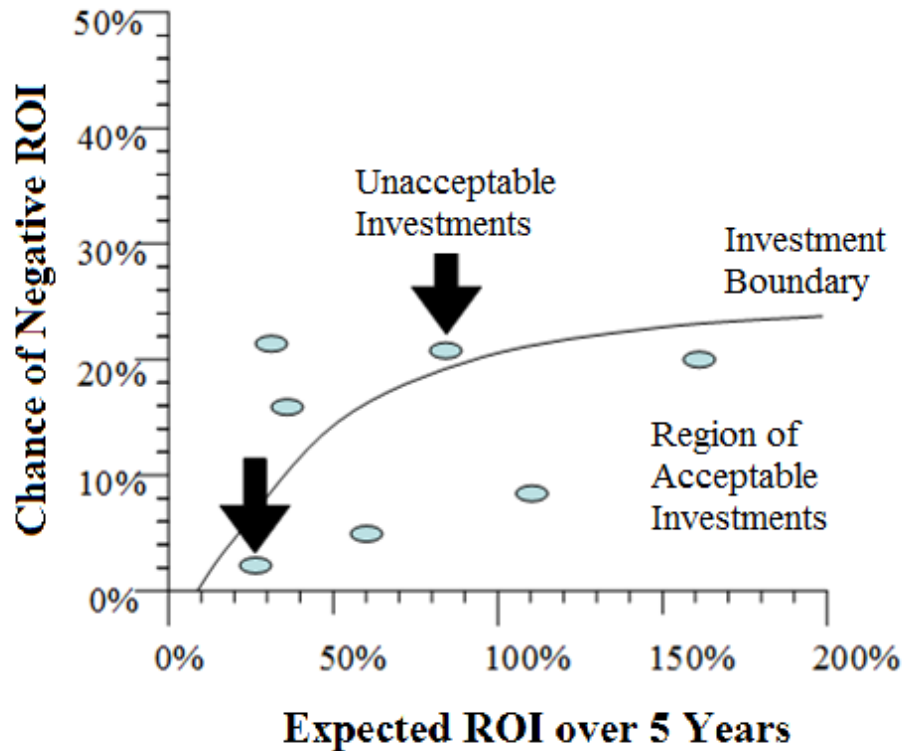
Figure 2.   The Investment Boundary. (After: Hubbard, 2007, p. 192)

This is a little different from the chart Harry Markowitz used. His risk axis was really historical volatility of the return on a particular stock (capital gains of losses as well as dividends). Markowitz's theory is an excellent tool for investors to use in order to be able to manage their investment portfolio. Modern Portfolio Theory is designed specifically for an investment portfolio of the stock market; however the principles can easily be tailored to work with any IT investment portfolio. In the stock market, the risk involved in a particular stock is determined by the historical volatility of the return. "But investments like IT projects or new product development don't typically have 'historical volatility.'   They do, however, share another characteristic of risk that is more fundamental than Markowitz's measure: They have a chance of a loss" (Hubbard, 2007, p. 193).

4. Capital Asset Pricing Model

According to McInish (2000):

> The Capital Asset Pricing Model is a major extension of the work of Markowitz. The CAPM has proved useful in a variety of contexts, including estimating the cost of capital, estimating risk for portfolios, and developing measures for ex post portfolio performance evaluation. The CAPM has also given rise to a significant movement to passively invest in portfolios designed to mimic indexes rather than trying to beat the market. (p. 281)

The CAPM is a model for pricing an individual security or a portfolio. The model is used to determine a theoretically appropriate required rate of return of an asset by taking into account the asset's sensitivity to non-diversifiable risk, the expected return of the market and the expected return of a theoretical risk-free asset.

The following excerpt was taken from "Capital Asset Pricing Model" (n.d.):

> For individual securities, we made use of the security market line (SML) and its relation to expected return and systemic risk (beta) to show how the market must price individual securities in relation to their security risk class. The SML enables us to calculate the reward-to-risk ratio for any security in relation to that of the overall market. Therefore, when the expected rate of return for any security is deflated by its beta coefficient, the reward-to-risk ratio for any individual security in the market is equal to the market reward-to-risk ratio, thus:
>
> $$\frac{E(R_i) - R_f}{\beta_i} = E(R_m) - R_f$$
>
> The market reward-to-risk ratio is effectively the market risk premium and by rearranging the above equation and solving for E(Ri), we obtain the Capital Asset Pricing Model (CAPM).
>
> $$E(R_i) = R_f + \beta_i(E(R_m) - R_f)$$
>
> Where:
>
> $E(R_i)$ = the expected return on the capital asset
>
> R_f = the risk-free rate of interest such as interest arising from government bonds
>
> β_i = the sensitivity of the asset returns to market returns,

$E(R_m)$ = the expected return of the market

5. Tracking Stocks

In the late 1990s, several companies were conducting research on ways to track the value of one segment of the organization. Many companies issued "tracking" stocks in addition to their traditional common stock. "Tracking stock, also known as 'targeted' or 'lettered' stock in the financial press, is a class of common stock that is linked to the performance of a specific business group within a diversified firm" (Elder & Westra, 2000, p. 1). A tracking stock was a type of common stock that "tracks" or depends on the financial performance of a specific business unit or operating division of a company. The advantage of this type of stock was based on the concept that when the unit or division does well then the value of the tracking stock may increase even if the company as a whole performs poorly.

According to Elder & Westra, companies like Walt Disney Co., AT&T and Sprint Corporation are some of the few companies who decided to issue tracking stocks. These companies attempted to track the value of one particular division within their large organization. Unfortunately there were several disadvantages associated with tracking stocks such as: (1) the lack of a separate board of directors to oversee the division; (2) tracking stocks tended to perform about as well as the company's common stock; (3) tracking stock shareholders usually have limited or no voting rights. Based on the poor performance of tracking stocks over the years there are very few tracking stocks in existence today. However, the concept of allocating and tracking the value of the sub-corporate levels within an organization is highly sought after by most companies and of significant relevance to this paper.

C. RESEARCH OBJECTIVES

The objective of this research is to conduct a KVA analysis on a for-profit large corporation and a non-profit military organization. This thesis will build upon previous research to provide the detailed framework that Program Managers and Program Executive Officers should follow to closely manage their IT portfolio. The fundamental

concepts which are described within Harry Markowitz' Modern Portfolio Theory will be the foundation for this research. The goal of this research is to provide PMs the necessary toolset to make informed IT investment decisions and effectively manage their IT projects.

D. METHODOLOGY

The Knowledge Value Added (KVA) methodology will be used to analyze two different types of companies. The first KVA analysis will be conducted on a fictional large corporation named XYZ TELCOM which is designed to represent any private sector company. The second analysis will be conducted on the Navy's Cryptologic Carry-On Program carried onboard the fictitious USS NEVERSAIL (DDG 22) during a routine six-month deployment. These two analyses are proof of concept examples in order to demonstrate the various steps involved with KVA. The KVA methodology can be easily tailored to fit a non-profit organization such as the U.S. government or a private sector company. The cost and price per unit of output will be estimated using the KVA methodology which describes all outputs in common units. The benefit to a PM of utilizing the KVA analysis is the fact that the final results will produce a Return on Investment (ROI) value and a standard variation percentage which can be used to manage a portfolio of various IT investments.

THIS PAGE INTENTIONALLY LEFT BLANK

II.   KVA ANALYSIS XYZ TELCOM

A.   INTRODUCTION

The fictitious XYZ TELCOM company provides telecommunications services to consumers and businesses in the United States and internationally. It provides wireless services, including local wireless communications, long-distance, and roaming services with various postpaid and prepaid service plans. The company also supplies various handsets and personal computer wireless data cards, as well as accessories comprising carrying cases, hands-free devices, batteries, battery chargers, and other items. XYZ TELCOM's wireline services comprise voice services comprising local and long-distance services, integrated network connections, traditional long distance and international long distance, calling card, 1-800 services, conference calling, and wholesale switched access service, as well as calling features, such as caller ID, call waiting, and voice mail. Its wireline data services consist of switched and dedicated transport, Internet access and network integration, and data equipment. The company's other wireline services include managed Web hosting, application management, security service, integration services, customer premises equipment, outsourcing, directory and operator assistance services, government-related services, and satellite video services.

B.   APPLYING KVA METHODOLOGY

1.   KVA Assumptions

According to Rios, Housel & Mun (2006):

Based on the tenets of complexity theory, KVA assumes that humans and technology in organizations add value by taking inputs and changing them (measured in units of complexity) into outputs through core processes. The amount of change an asset produces within a process can be a measure of value or benefit.

The additional assumptions in KVA include:

• Describing all process outputs in common units (e.g., using a knowledge metaphor for the descriptive language in terms of the time it

takes an average employee to learn how to produce the outputs) allows historical revenue and cost data to be assigned to those processes historically.

- All outputs can be described in terms of the time required to learn how to produce them.

- Learning Time, a surrogate for procedural knowledge required to produce process outputs, is measured in common units of time. Consequently, Units of Learning Time = Common Units of Output (K).

- A common unit of output makes it possible to compare all outputs in terms of cost-per-unit as well as price-per-unit, because revenue can now be assigned at the sub-organizational level.

- Once cost and revenue streams have been assigned to sub-organizational outputs, normal accounting and financial performance and profitability metrics can be applied. (p. 9)

2. KVA Steps

KVA steps should be followed by Program Managers and Program Executive Officers when managing their IT portfolios. By closely monitoring the IT portfolio in this manner it will provide the PM with greater insight into determining whether to continue to fund a particular system, upgrade the system or possibly even abandon the IT system altogether. These KVA steps encompass the combined works of Drs. Housel & Kanevsky (n.d.) and Lambeth & Clapp (2007).

a. Step One: Identify Core Process and Its Subprocesses

- Determine periphery of the core processes.

- Achieve consensus on the description of the complex and basic processes.

- Utilize current descriptions, found in diverse places (e.g., in historical records, activity based costing efforts or quality management efforts).

- Apply any of the workflow modeling tools to generate a document that includes comprehensive examples of the core and subprocesses, to include process diagrams that have a clear input and output.

- Explain the tasks for the subprocesses and core process.

b. Step Two: Determine Learning Time

Learning Time (Lt) is the time required for the average worker to learn how to produce a single process output is estimated.

c. Step Three: Determine How to Execute a Process

Executions (Ex) are the number of times all process assets, human or IT, produced the process outputs in a given time-period. Compute the amount of process commands that are essential to generate the outputs of each process.

d. Step Four: Calculate Value of Output (K) and Total Value of Output (K) for each Process

Knowledge (K) is the term used to describe common units of output estimated by KVA. The formula for calculating knowledge is to multiply the executions by the learning time. $K = (Ex) (Lt)$.

Calculate the sum of K for each of the sub-processes, the result will be the Total K for the sub-processes. **Total $K = \Sigma (K)$.**

e. Step Five: Determine Revenue per Knowledge Unit and Establish the Numerator by Assigning Revenue Streams to Processes

Revenue per Knowledge Unit (RKU) is the price per unit designated for the outputs for the profit organizations based on the market price per unit of the comparable outputs of a similar commercial organization.

Revenue (R) is allocated to each process by multiplying the common units of output (K) of each process by the RKU. **$R = (RKU) (K)$.**

f. Step Six: Calculate Process Cost

The expenses show the cost associated with producing the output of each process. Sum the costs of assets in each process to yield the total costs of all outputs of a process for a given time period.

g.   *Step Seven: Calculate the Value Ratios of ROI and ROK*

"As knowledge initiatives take hold and mature, it becomes essential to conduct true cost/benefit analysis to determine the proper level of investment for knowledge management and the expected return on investment" ("Measuring the Return on Knowledge," 2006). The Return on Knowledge (ROK) provides a ratio of how the cost and revenue are associated with producing an output within each sub-process. The ROK is calculated by dividing the revenue by the expenses. ROK can be compared among processes to determine which processes may need closer analysis when the result is a low ROK. **ROK = Revenues / Expenses.**

The Return on Investment (ROI) is a return ratio that compares the net benefits of a process verses its total costs. The ROI is calculated by the taking the numerator minus the denominator and then dividing the resultant by the denominator. ROIs can be compared among processes to determine which processes may need to be changed in order to improve efficiency. **ROI = (Revenues – Expenses) / Expenses.**

h.   *Step Eight: Calculate Standard Deviation (If Applicable).*

Calculating standard deviation provides the PM with an indication of the volatility of an asset. Volatility is a degree of uncertainty that exists in a program. The steps are only applicable if historical ROI data is present. Standard deviation is the square root of the variance and can be derived by the steps indicated below:

Population Mean (μ)

$$\mu = \frac{\sum x}{N}$$

μ is the average value of the population.

$\sum$ is the total of or sum of variable 'x'

x is the values of the Historical ROIs (Q1, Q2,....)

N is the number of values or data points

Variance (σ^2)

$$\sigma^2 = \frac{\sum(x-\mu)^2}{N}$$

Standard Deviation (σ)

$$\sigma = \sqrt{\sigma^2}$$

i.   Calculate the Population Mean

      1. Add the values of the historical ROIs.

      2. Divide the sum of historical ROIs by N.

ii.   Calculate the Variance

      1. Subtract the mean from each variable of 'x'.

      2. Square each result.

      3. Sum all the squares.

      4. Divide the sum of squares by N. The result is the variance.

iii. Calculate the Standard Deviation

      1. Square root of the variance.

C. KVA RESULTS

Department	Learning Time	Executions	Knowledge (K)	Expenses	Revenues	ROK	ROI	STD DEV	% of Rev.
Accounting	15	800,000	12,000,000	$ 1,100,000	$ 1,200,000	109.09%	9.09%	4.0%	12.00%
Human Resources	10	1,000,000	10,000,000	$ 900,000	$ 1,000,000	111.11%	11.11%	2.8%	10.00%
Manufacturing	0.5	110,000,000	55,000,000	$ 5,000,000	$ 5,500,000	110.00%	10.00%	2.6%	55.00%
IT	30	500,000	15,000,000	$ 1,200,000	$ 1,500,000	125.00%	25.00%	7.6%	15.00%
Sales	5	1,600,000	8,000,000	$ 650,000	$ 800,000	123.08%	23.08%	6.4%	8.00%
Totals			100,000,000	$ 8,850,000	$ 10,000,000	112.99%	12.99%	3.84%	100.00%
Revenue per Knowledge Unit:	$ 0.10								

Table 1.   KVA Analysis for XYZ TELCOM

Table 1 illustrates the implementation of using the KVA methodology on five major processes: Accounting, Human Resources, Manufacturing, Information Technology and Sales. The results of the KVA analysis for each of these processes for XYZ TELCOM are shown in Table 1. This analysis makes possible the allocation of IT resources based on the amount of knowledge embedded within each segment's core processes. Given a periodic application of the KVA methodology, the company can build an historical record of sub-corporate revenues and arrive at a variance (shown as standard deviation) and correlations between the earnings of the various segments. In effect, the PM has all the information needed to extend the notion of portfolio theory as applied to investments in companies down to a sub-corporate market.

D. ANALYZING KVA RESULTS

The KVA analysis produces a Return on Knowledge (ROK) which is a ratio to estimate the value added by given knowledge assets. By comparing the expenses and revenues associated with the knowledge asset, the results can be computed to compare efficiency in performance of the processes. In the example in Table 1, XYZ TELCOM's ROK for each of the five processes generated positive net revenue, which is indicated by an ROK of greater than 100%.

ROI can be used by a Program Manager or a Program Executive Officer to determine whether current or prospective IT investments should be funded or changed in order to improve efficiency. According to the Department of the Navy's IT Capital Planning Guide (2001), investments must have an ROI greater than "1.0" to be considered for funding. In this example, Table 1 shows that all of the core processes for XYZ TELCOM have an ROI greater than 1.0. Therefore the PM would make favorable recommendations based on the ROI results for the IT investment. Periodic applications of the KVA methodology can provide a PM with a historical record of an IT assets past performance. The PM can evaluate the major segments' ROI to determine whether to reallocate resources based on his analysis.

At this point in the ROI process, the Program Manager's recommendations are heavily influenced by the historical data that has been collected over a measured period of time. It is the recommendation by the authors of this thesis that PMs collect and analyze quarterly ROI data in order to have sufficient historical data to better determine volatility. The PM assigns the weights to each metric and then he determines if the metric is following a positive or negative trend. It is imperative that the PM ascertains solid metrics before making an investment decision so that he can better analyze the ROI process. If the historical data is not present, then the PM can still define the metric based on the current ROI analysis.

The next step is to use real options analysis to assess the IT processes of XYZ TELCOM. According to Mun (2006), real options is defined as "a systematic approach and integrated solution using financial theory, economic analysis, management science, decision sciences, statistics, and economic modeling in applying options theory in valuing real physical assets ..."

Figure 3 is a list of the various types of options and their industry applications.

Types of Options	Industry Applications/Users

• Option to Wait
    (Proof of concept, right of first refusal, getting more info)
• Option to Execute
    (Contracts in place which may/not be executed)
• Abandonment Option
    (exit and salvage)
• Expansion Option
    (platform technologies, acquisitions, open architecture)
• Contraction Option
    (outsourcing, alliances)
• Compound Option (platform options)
• Sequential Options (stage-gate development, R&D, phased options)
	• DoD/Acquisitions, Force Mix
	• CCOPS Portfolio Analysis
	• Aeronautics/Boeing, Airbus
	• Oil and Gas/BP, Shell
	• High Tech/Intel
	• Pharmacology/Merck, Pfizer
	• R&D Portfolios/Motorola, Unilever
	• IT Infrastructure/Credit Suisse
	• Electricity/Peaker-Plants
	• Acquisitions/Seagate
	• Contracts/Syngenta, GM

Figure 3.   Types of Real Options and Industry Applications (From: Rios, Housel, and Mun, 2006)

The eight steps of the real-options approach are illustrated in Figure 4.
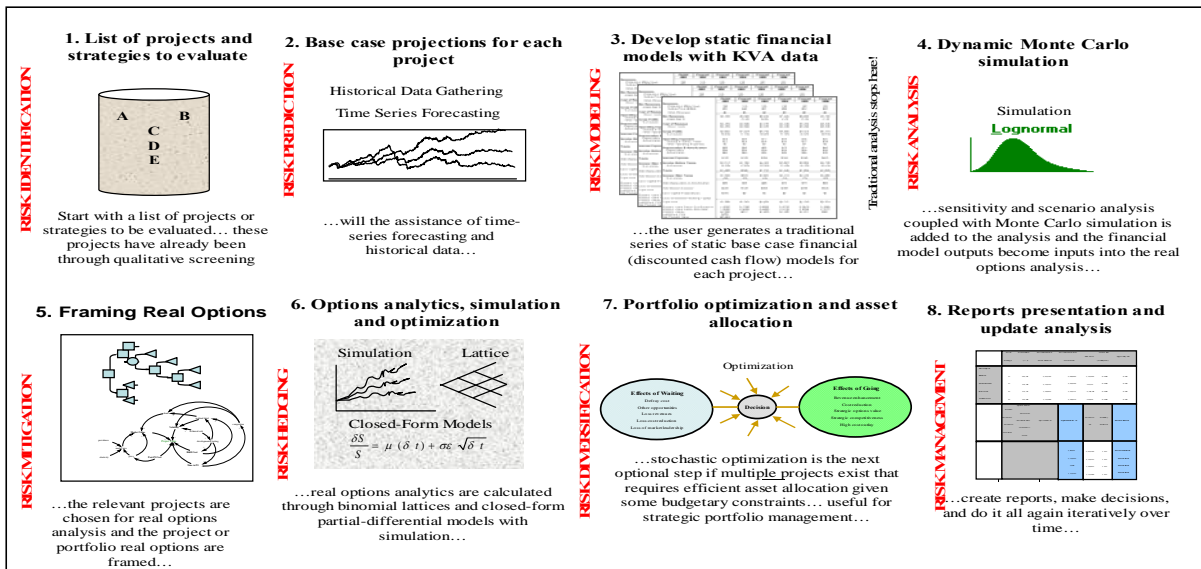

Figure 4.   Real Options Analysis Steps (From: Mun, 2006, p. 29)

According to Mun (2006), real-options can be used to:

- Identify different corporate investment decision pathways or projects that management can navigate given the highly uncertain business conditions;

- Value each of the strategic decisions pathways and what it represents in terms of financial viability and feasibility;

- Prioritize the pathways or projects based on a series of qualitative and quantitative metrics;

- Optimize the value of your strategic investment decisions by evaluating different decision paths under certain conditions or determining how using a different sequence of pathways can lead to the optimal strategy;

- Time the effective execution of your investments and finding the optimal trigger values and cost or revenue drivers; and

- Manage existing or developing new optionalities and strategic decision pathways for future opportunities.

Due to the positive trends in the ROI analysis for Table 1, the PM for XYZ TELCOM should consider one or more of the following real options: option to wait; option to execute; or expansion option. The option to wait would probably be the best option due to the fact that the PM could use more historical ROI data to get a better assessment of the volatility of the IT portfolio.

A PM can get real options implemented by understanding that real options analysis is a decision-making process that improves and balances the decision analysis approaches. Real options take financial methodologies and change them to analytical techniques. A PM must have the right tools, resources, and senior management buy-in to successfully implement a real options analysis.

THIS PAGE INTENTIONALLY LEFT BLANK

III. KVA ANALYSIS USS NEVERSAIL (DDG-22)

A. INTRODUCTION

The first KVA analysis performed on a U.S. military system was conducted by Lieutenant Ira Lambeth and Lieutenant Hubert Clapp. Their focus was centered on performing a proof of concept study to utilize KVA methodology to measure the ROI of six different Cryptologic Carry-On Program (CCOP) systems. This methodology was applied to the CCOP systems in use during an 18 month deployment of the USS GONZALES (DDG 66). The ROI data was analyzed and modeled using GaussSoft KVA Performance Accounting Modeling Software. A detailed analysis was conducted on the performance of each CCOP system, each stage of the Intelligence Collection Process (ICP) and the individual operators themselves. The results served as inputs for analysis for decision makers to study alternative courses of action (COAs) for the future deployment of CCOP systems.

Using this initial KVA analysis as a baseline, an example was created using a fictional guided missile destroyer USS NEVERSAIL (DDG-22). In this example, the ship has six CCOP systems carried onboard during a routine 6-month deployment. All of the data is merely used as a proof of concept example and the figures do not represent any real-world values. The analysis should be used by Program Managers and Program Executive Officers to better understand how to properly manage their IT investment portfolios.

B. APPLYING KVA METHODOLOGY

1. KVA Assumptions

"KVA uses a knowledge-based metaphor as a means to describe units of change in terms of the knowledge required to make the changes" (Lambeth & Clapp, 2007, p. 14). The fundamental assumptions of KVA have not changed and are exactly the same as the example in the previous chapter. Figure 4 illustrates the underlying assumptions of KVA analysis.
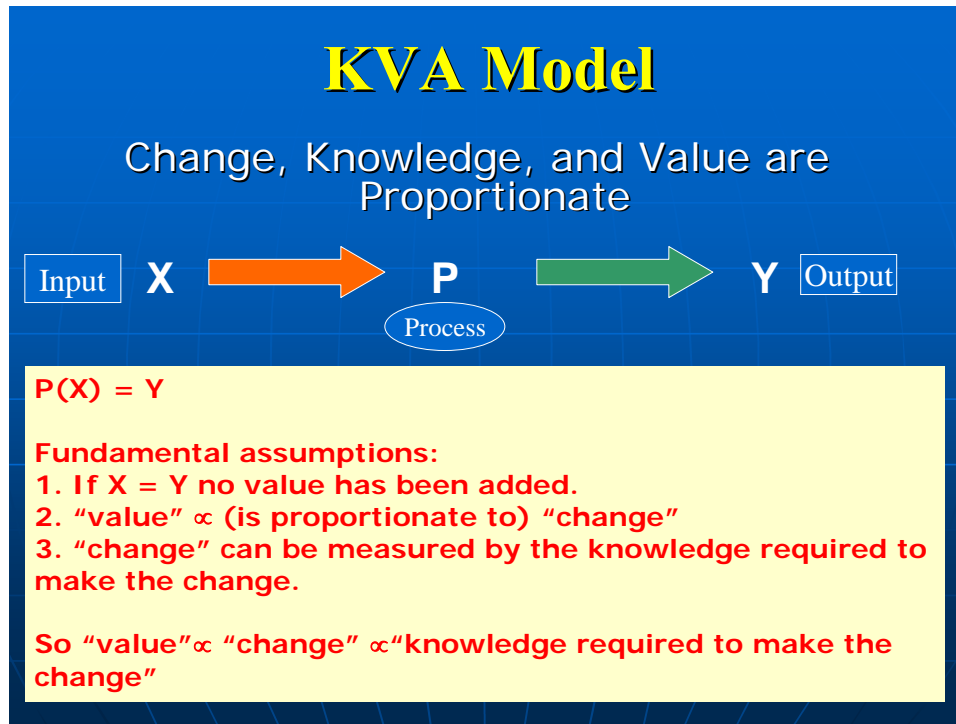
Figure 5.   Underlying KVA assumptions model (From: Cook, Slide 6).

These original assumptions are further broken down in order to demonstrate the principle concept that KVA can be used on any type of organization even when no revenue is generated. These universal assumptions are:

a.   Cost and Revenue Assumptions

Describing all process outputs in common units (e.g., using a knowledge metaphor for the descriptive language in terms of the time it takes an average employee to learn how to produce the outputs) allows historical revenue and cost data to be assigned to those processes historically.

According to Lambeth & Clapp (2007):

Having a common unit of output makes it possible to compare all outputs in terms of cost-per-unit as well as price-per-unit, since revenue can now be assigned at the sub-organizational level. Once cost and revenue streams have been assigned to sub-organizational outputs, normal accounting and financial performance and profitability metrics can be applied to them. (p. 15)

b. *Learning Time*

There are inherent similarities and differences between knowledge and learning. Both may be explicit or tacit; however, learning time is more about "How" and less about the "Why". All outputs can be described in terms of the time required to learn how to produce them. Knowledge and learning are defined differently:

- Knowledge may be specific or general.

- Knowledge may be in people or IT.

- Learning is the process (time) to gain knowledge.

- Learning is related to task specific activities.

- Learning Time is measured in common units of time.

2. Case Study Assumptions and Data

a. *Assumptions*

Lambeth & Clapp (2007) wrote the following concerning market comparable revenue assumptions:

> The [market comparable] revenue assumption states that not for profit agencies can derive certain inferences from comparable outputs of commercial entities. They are:
>
> - First, if the processes used to produce the outputs of both organizations are comparable, then the outputs of the two must also be comparable.
>
> - Second, if market forces have placed a "value" or price-per-unit to the comparable commercial outputs yielding a revenue stream for the commercial entity, that price-per-unit can also be applied to the not-for-profit case.
>
> - Lastly, the derived price-per-unit can be used to develop an analytical or hypothetical revenue stream for the not-for-profit organization. (p. 15)

b.   Data

Length of Sample Period: The sample period for this analysis was the normal 6 month deployment period. Annual cost data have been adjusted to reflect this time frame.

Learning Time: The learning time for this example is estimated and reflects how long it would take the average person to learn how to produce the outputs of each CCOP system.   Learning time can be obtained by conducting a face-to-face interview with the senior leadership within the organization. A secondary interview can also be conducted with the actual users of the various systems and then comparing the results with the data obtained with the interview previously performed.   However, be advised that achieving a consensus between top executives and the individual employees is often difficult to obtain. The users of the system sometimes do not fully comprehend all the subprocesses that comprise the total amount of learning time to produce the final output. Typically, senior leaders have greater insight and a broader understanding as to all of the various complexities involved in order to produce the required level of output. Learning time includes formal training (class work), on-the-job training and hands-on apprenticeship work. Learning time is "time spent learning" and not elapsed time.

Executions: This value is a measure of the number of times a process executes or knowledge is used to perform a step in a process. The data for the USS NEVERSAIL (DDG-22) was manufactured for the purposes of simplifying the calculation process only and is not attributable to any actual real-world source.

Cost and Revenue Assumptions: Detailed cost and revenue information was estimated for the USS NEVERSAIL CCOP systems. Cost data was derived from annual budget estimates.   Revenue data was derived from market comparables to commercial units of the same common units of output as the six CCOP systems. Cost and revenue data is displayed in the following table:

Element	Avg. Annual Unit Costs	Avg. Annual Unit Revenue
CCOP A	$158,333	$102,530
CCOP B	$29,167	$103,154
CCOP C	$54,545	$94, 072
CCOP D	$40,000	$61,768
CCOP E	$35,000	$53,033
CCOP F	$58,000	$45,442
TOTAL IT	$330,898	$460,000

Table 2.   USS NEVERSAIL Systems Cost and Revenue Data.

3.   KVA Results

The KVA steps are detailed in Chapter II of this thesis. To simplify this example the steps will not be demonstrated. Program Managers must realize, however, that KVA analysis cannot be performed without first performing all the required steps and calculating all the necessary data. Table 3 contains the results of the KVA analysis for each of the six CCOP systems on USS NEVERSAIL (DDG 22).

Element	Learning Time	Executions	Knowledge (K)	Expenses	Revenues	ROK	ROI	STD DEV	% of Rev.
CCOP A	34	87	2958	$ 158,333	$ 102,530	64.76%	-35.24%	4.0%	22.29%
CCOP B	93	32	2976	$ 29,167	$ 103,154	353.67%	253.67%	2.8%	22.42%
CCOP C	59	46	2714	$ 54,545	$ 94, 072	172.47%	72.47%	2.6%	20.45%
CCOP D	18	99	1782	$ 40,000	$ 61,768	154.42%	54.42%	7.6%	13.43%
CCOP E	85	18	1530	$ 19,833	$ 53,033	267.40%	167.40%	12.0%	11.53%
CCOP F	57	23	1311	$ 29,000	$ 45,442	156.70%	56.70%	6.4%	9.88%
Totals			13271	$ 330,878	$ 460,000	139.02%	39.02%	3.70%	100.00%
Revenue per Knowledge Unit:	$ 34.66								

Table 3.   KVA Analysis for USS NEVERSAIL (DDG 22)

C.   ANALYZING KVA RESULTS

The results of the USS NEVERSAIL KVA calculation are purely fictitious and are merely shown as a public sector example. The main focus should be placed on the ROI and Standard Deviation columns. These columns represent the amount of Return on Investment and the volatility (risk) for each of the six different CCOP processes. The PM

would be able to make recommendations to the Navy PEO based on the various real options available. Most of the values contain positive ROI percentages, although the calculation of CCOP A resulted in a negative ROI. This negative ROI will need to be examined and analyzed further.

There is a fundamental difference between managing an individual information technology (IT) portfolio and managing a large aggregated IT portfolio of several individual investments. A Program Manager in charge of a small IT portfolio is only concerned with his individual system(s), but a Program Executive Officer in charge of a large portfolio that encompasses several individual IT portfolios would be have a broader focus. The PM of the USS NEVERSAIL (DDG-22) is concerned about the negative ROI for CCOP A while also noticing that the standard deviation is 4.0% (meaning that the volatility of the system is low and relatively stable). An ROI less than 1.0 indicates a negative trend of an IT portfolio and therefore should be closely monitored by the PM. The PM realizes that due to the low volatility of CCOP A the ROI will remain negative without some type of process re-engineering. The Navy PEO in charge of all the CCOP systems has a broader focus. His job is to calculate the ROI data for every CCOP system in the entire Navy. He is not greatly concerned with the single USS NEVERSAIL portfolio, but is focused on the total ROI of the larger portfolio made up of all CCOPs in the Navy. Each PM must realize that there are two separate points of view that at times may differ from one another.

The PM for the USS NEVERSAIL must never develop tunnel vision while managing his IT portfolio. A Program Manager's overall goal is to effectively manage his IT portfolio to the utmost of his abilities. One of his primary concerns would be to reduce expenses as much as feasible while continuing to increase revenue thus creating a positive ROI. The term "revenue" in this example is not literal given that this is a public sector organization. An effective manager would also strive to reduce learning times to streamline the process. However, the PM needs to understand that his efforts to successfully manage his individual IT portfolio could have a positive or negative affect to the aggregated portfolio of the organization.

Using the USS NEVERSAIL as the primary example to illustrate these possible side effects, the PM notices that the calculation in the first row of Table 3 resulted in a negative ROI for CCOP A. This can be easily explained by the fact that the expenses greatly outweigh the revenue generated by the process. The PM immediately analyzes the data and determines solutions in order to produce a positive ROI. One of the possible viable solutions would be to increase the amount of executions of CCOP A in order to thereby increase revenue. In this particular case, a positive ROI would result when the number of executions was increased from 87 to 145. Even though the CCOP A process is 95% automated by computer there would still be an increase of $7,000 in expenses. Table 4 below contains the revised calculated totals that would result from this increase in executions of CCOP A system (changes are highlighted in yellow).

Element	Learning Time	Executions	Knowledge (K)	Expenses	Revenues	ROK	ROI	STD DEV
CCOP A	34	145	4930	$ 165,333	$ 170,874	103.35%	3.35%	4.0%
CCOP B	93	32	2976	$ 29,167	$ 103,154	353.67%	253.67%	2.8%
CCOP C	59	46	2714	$ 54,545	$ 94,072	172.47%	72.47%	2.6%
CCOP D	18	99	1782	$ 40,000	$ 61,768	154.42%	54.42%	7.6%
CCOP E	85	18	1530	$ 19,833	$ 53,033	267.40%	167.40%	12.0%
CCOP F	57	23	1311	$ 29,000	$ 45,442	156.70%	56.70%	6.4%
Totals			15243	$ 337,878	$ 528,322	156.36%	56.12%	3.70%
Revenue per Knowledge Unit:	$ 34.66							

Table 4.   Revised KVA Analysis for USS NEVERSAIL (DDG-22).

At first glance it appears that the decision to increase the number of executions was highly advantageous. The expenses, revenues and ROK to the system increased while the ROI changed from a negative to a positive value. The PM of the USS NEVERSAIL is undoubtedly feeling a sense of pride for a job well done. However upon closer review the PM is now faced with the situation in which the CCOP A system is now producing more output than it was previously. This may cause an adverse effect to other systems that were already operating at maximum capacity and are only able to process a select amount of data. This increase of output from CCOP A may cause a backlog and

additional expenses (e.g., processing time, labor costs) to the systems that require this data as input. Don't use both e.g., and etc. in same sentence.

This simple example demonstrates the concept that Program Managers for an individual IT portfolio need to be cognizant of the fact that their actions could impact the larger aggregated IT portfolio of the entire organization. The implications of a PM's actions may have serious consequences (e.g., cost of storage the excess inventory, old inventory passing its expiration (if applicable), or costs associated with the production of inventory/output). While the PM of USS NEVERSAIL simply wanted all the ROIs in his IT portfolio to be positive, his actions caused a backlog of output and additional expenses to related systems. Bottom line is that PMs simply need to be aware that their IT portfolio management must have a holistic view with regards to the entire organization.

IV.   CONCLUSIONS AND RECOMMENDATIONS

A.   CONCLUSIONS

This thesis provides the steps that Program Managers and Program Executive Officers need to follow to effectively manage their IT portfolios. Using KVA analysis and ROI on IT systems provides the defensible metric of value.   Applying this methodology to track the value-added of a technology in a core process provides leadership of any IT portfolio the ability to make sound investment decisions for any system. There are several reasons that using the KVA methodology to manage an IT investment portfolio is a viable solution to the directive issued by the DoD CIO. Here are some of the key benefits:

- Financial: The economical benefit is the ability to evaluate the Return on Investment to determine whether or not the cost of the investment was money well spent. The Department of Defense spends billions of dollars every year on developing and acquiring new technology. Conducting a KVA analysis on the IT investment portfolios would provide greater insight into determining if this money was not spent frivolously.

- Managerial: Another benefit that is closely related to economics is the ease of management. Using the KVA steps detailed in this thesis allows PMs and PEOs the ability to calculate the standard deviation (i.e., volatility) of an IT portfolio. For the purposes of this thesis: Standard Deviation = Volatility = Risk. Using the standard deviation the PM will be able to identify the volatility of each of the subprocesses within the portfolio. This data along with the ROI information can be an excellent managerial tool to identify the IT systems that have higher risk. Systems with a large amount of volatility tend to indicate a high level of instability and may require the PM to conduct further analysis.

- Real Options: After conducting a thorough KVA analysis of an IT investment portfolio the PM now has a better understanding of how each subprocess performs historically over time. The PM will be able to allocate more resources (e.g.,

time and money) to those areas that require greater attention. Additionally, the PM will be able to make real options decisions such as: expanding the system, upgrading the system or recommending the abandonment of the system.

B.   RECOMMENDATIONS

Program Managers and Program Executive Officers should start using the concepts of Harry Markowitz's Modern Portfolio Theory to manage their IT investment portfolios.   This theory was designed for an investment portfolio of the stock market; however the principles can easily be tailored to work with any IT investment portfolio. Department of Defense PMs and PEOs must understand the importance of the underlying principles of MPT and the risks involved in order to properly manage any IT investment portfolio (i.e., large or small).

This thesis has demonstrated the benefits (e.g., financial, managerial, real options) of utilizing the KVA methodology on a portfolio of IT investments. Therefore, the Department of Defense should implement a policy that mandates the use of the KVA steps provided in this thesis. These steps illustrate the detailed framework that should be followed in order to effectively manage any IT investment portfolio. This policy should be strictly enforced to ensure that all PMs and PEOs use the KVA methodology on all current and future IT investment portfolios. These KVA steps will provide the PMs and PEOs with the necessary toolset to be able to make informed IT investment decisions.

V. FUTURE RESEARCH AREAS

A baseline has been set in this research for the value of applying the KVA methodology to a private and public sector IT investment portfolio. There is still further research that can be conducted using actual real-world data. True historical data could be collected which would provide a greater understanding of the economical and managerial benefits of KVA and ROI. Additionally, the potential would exist for a more detailed analysis of the calculated data and available real options.

While conducting this research, one of the fundamental assumptions made was that the individual subprocesses had already been fully optimized to the greatest extent possible. A KVA analysis of an IT portfolio in conjunction with a thorough examination of Business Process Re-Engineering (BPR) could be conducted in a future study. The key to BPR is for organizations to look at their business processes from a "clean slate" perspective and determine how they can best construct these processes to improve how they conduct business. Conducting further research using KVA methodology and BPR would provide further insight into not only managing an IT portfolio, but the benefits of optimizing each subprocess in order to produce its maximum output.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Capital Asset Pricing Model. (n.d.). Retrieved February 24, 2009, from Wikipedia:
    http://en.wikipedia.org/wiki/Capital_asset_pricing_model.

Cook, Glenn. (2008). *Lecture 4: Evaluation of Output (KVA) [PowerPoint slides].*
    Retrieved December 15, 2008, from course IS4220, 4th Qtr/2008, Naval
    Postgraduate School, Monterey, CA.

Department of Defense. (1997). *Guide for Managing Information Technology as an
    Investment and Measuring Performance*. Version 1.0. Prepared by Vector
    Research, Inc.

Department of Defense. (2006a). *Information technology portfolio management
    implementation*. DODINST8115.02.

Department of Defense. (2006b). *DoD Chief Information Officer strategic plan*.
    Version 1.

Department of the Navy Information Technology Capital Planning Guide. (2001).
    Retrieved February 5, 2009, from http://www.doncio.navy.mil/download.aspx?
    attachid=493.

Elder, J. & Westra, P. (2000). The reaction of security prices to tracking stocks
    announcements. *Journal of Economics and Finance*.

Elton, E. J. & Gruber, M. J. (1979). *Portfolio theory, 25 years after*. New York, NY:
    North-Holland Publishing Co.

Fabozzi, F. J., Markowitz, H. M., Kostovetsky, L. (2004). *The theory and practice of
    investment management workbook: Step-by-step exercises and tests to help you
    master the theory and practice of investment management*. Hoboken, NJ: John
    Wiley & Sons, Inc.

Hagin, R. (1979). *The Dow Jones-Irwin guide to modern portfolio theory*. Homewood,
    IL: Dow Jones-Irwin.

Housel, T. J. & Bell, A. H. (2001). *Measuring and managing knowledge*. New York,
    NY: McGraw-Hill Companies, Inc.

Housel, T.J. & Kanevsky, V. (n.d.). *Knowledge Value-Added (KVA) Methodology*.
    Retrieved January 25, 2009, from
    http://www.iec.org/online/tutorials/kva/index.html

Housel, T. J. & Mun, J. (2007). *A primer on applying Monte Carlo simulation, Real Options analysis, Knowledge Value Added, forecasting, and portfolio optimization [White paper].* Retrieved February 23, 2009, from Naval Postgraduate School, Monterey, CA.

Hubbard, D. W. (2007). *How to measure anything.* Hoboken, NJ: John Wiley & Sons, Inc.

Lambeth, I. D. & Clapp, H. N. (2007). *Using Knowledge Value Added (KVA) for evaluating cryptologic IT capabilities: Trial implementation.* Monterey: Naval Postgraduate School.

Markowitz, H. M. (1952). Portfolio selection. *The Journal of Finance, 7(1)*, 77-91.

Markowitz, H. M. & Perold, A. F. (1981). Portfolio analysis with factors and scenarios. *The Journal of Finance, 36(4)*, 871-877.

Markowitz, H. M., Todd, G. P., Sharpe, W. F. (1987). *Mean-variance analysis in portfolio choice and capital markets.* Hoboken, NJ: John Wiley & Sons, Inc.

Markowitz, H. M. (1991). *Portfolio selection: Efficient diversification of investment.* Hoboken, NJ: John Wiley & Sons, Inc.

Measuring the Return on Knowledge. (2006). Retrieved January 25, 2009, from http://www.knowledgeboard.com/download/3887/Measuring-the-Return-on-Knowledge.pdf

McInish, T. H. (2000). *Capital Markets: A Global Perspective.* Oxford, England: Blackwell Publishing.

Mun, J. (2005). *Real options analysis: Tools and techniques for valuing strategic investments and decision.* Hoboken, NJ: John Wiley & Sons, Inc.

Office of Management and Budget. (2000). *Management of Federal Information Resources.* Circular No. A-130.

Rios, C. (2005). *Return on investment analysis of information warfare systems.* Monterey, CA: Naval Postgraduate School.

Rios, C., Housel, T., & Mun, J. (2006). *Integrated portfolio analysis [electronic resource] : Return on investment and real options analysis of intelligence information systems (cryptologic carry on program).* Monterey, CA: Naval Postgraduate School.

Sharpe, W. F. (1970). *Portfolio theory and capital markets.* New York, NY: McGraw-Hill Book Co.

Smith, K. V. (1971). *Portfolio management: Theoretical and empirical studies of portfolio-making.* San Francisco, CA: Holt, Rinehart and Winston, Inc.

United States Code. (1996). *Clinger-Cohen Act (Formerly Information Technology Management Reform Act).* Division E of Pub L. 104-106.

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
    Ft. Belvoir, Virginia

2. Dudley Knox Library
    Naval Postgraduate School
    Monterey, California

3. Tom Housel
    Naval Postgraduate School
    Monterey, California

4. Jonathan Mun
    Naval Postgraduate School
    Monterey, California

5. Dan Boger
    Naval Postgraduate School
    Monterey, California