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Defense Porftolio Analysis

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Abstract.

This is a Portfolio Management Analysis assessment, the focus of which is to identify and assess current Commercial Off-the-Shelf (COTS) Portfolio Analysis (PA) software products and solutions—with attention to market positioning, market share, product features, and other features. Two products (Risk Simulator and Palisades @Risk) were used to develop Portfolio Models ([1]). These models were populated with relevant data, and then run through an appropriate number of simulation iterations to assess candidate projects with respect to risk and Expected Military Value (EMV).

This document discusses Portfolio Management Analysis (PMA) during various stages of project management and system engineering. The goal for Portfolio Management Analysis is realized after the entire project design infrastructure is implemented from agency heads to managers, and the end users instruments are provided for implementation.

The results of this analysis will be synthesized, documented and recommended to Defense military organizations, and agency heads for consideration. The intent is to identify approaches and tools to incorporate PMA net-centric strategies to meet war fighter and business operations requirements, while continuing to maintain current levels of service, ensuring conservation of manpower and meeting infrastructure resource requirements.

Keywords: Defense portfolio analysis, decision-support process, resource allocation.

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1. Introduction

This study defines and describes Portfolio Analysis (PA); where it started, what it measures, how other industries are utilizing it, why it is important today, and what the Department of Defense (DoD) is doing and planning for the future.

Modern Portfolio Theory was introduced by Harry Markowitz with his paper "Portfolio Selection," which appeared in the *Journal of Finance* (1952). He demonstrated that a portfolio of individual securities composed of consistently good risk- reward characteristics (e.g., stocks of all rail companies), could well be foolish. He detailed the mathematics of diversification, which focused on selecting portfolios based on their overall risk-reward characteristics. He felt that investors should create portfolios of dissimilar securities rather than purchase and hold only individual securities (e.g., only shares of IBM). Portfolio theory provides a broad context for understanding the interactions of systematic and non-systematic risk and reward.

Portfolio Analysis (PA) is the art and science of allocating scarce resources to satisfy strategic objectives, or determining how to best spend limited dollars ([1]). PA also provides tools for organizing and managing a set of projects in a portfolio of projects to meet its goal ([4]). Portfolio Management begins with an enterprise-level identification and definition of market opportunities and then prioritization of those opportunities within resource constraints ([20], p. 9). A set of projects tracked across the entire portfolio in a timely and effective manner helps senior leadership make sound decisions, data-based decisions supported by analysis of cost, schedule and performance risks ([1]). These future projects will have a National strategic impact as situations and partners change. The ability of senior leadership to adjust portfolios to meet Defense needs now and in the future is critical.

Portfolio Analysis (PA) is used by businesses to measure everything from money to performance. In the finance industry, it is used to measure the strength of a group of investments to make appropriate tradeoffs of expected return on investment and risk. Using the Markowitz Efficient Frontier ([23]), a ratio of the expected return for each asset, the standard deviation of each asset's logarithmic relative returns (measure of risk), and the correlation matrix between these assets, sets of portfolios with expected returns greater than any other with the same or lesser risk, and lesser risk than any other with the same or greater return could be identified (MVO, 2009). In the Information Technology (IT) sector, PA is used to manage priorities for resource allocation. Based on limited resources (budget), which projects should we keep while increasing profits and which are failing to perform and losing money? Whatever is being measured during the analysis, it is a key factor in the success or failure of the business. Companies commonly use Net Present Value (NPV) analysis, which can show, in today's dollars, the relative cash flow of various alternatives over a long period of time ([20], p. 15).

In general, successful companies take a disciplined approach to prioritizing needs and initiating a balanced mix of executable development programs ([20], p 7). hey begin with an enterprise level approach to identifying market opportunities and then prioritize them based on strategic goals, resources available, and risk. The market opportunities with the greatest potential to succeed are included in the portfolio.

But, what is the DoD currently doing? The DoD is using individual program managers to manage specific programs/systems, without regard to the overall strategic goal of the U.S. Each program is its own entity, with little or no interaction with other programs and program managers are not held responsible for minimizing the risks associated with their particular programs. The DoD's service-centric structure and fragmented decision-making processes are at odds with the integrated, portfolio management approach used by successful commercial companies to make enterprise- level investment decisions ([20], p 18).

In 2004, the Defense Finance and Accounting Service (DFAS) implemented portfolio management in an effort to help prioritize initiatives and more closely link budget to agency strategy, while answering a presidential call for improving financial management. In doing this, they developed an approach which not only governs technology investments but includes all high-value initiatives ($250,000 or more). As a decision-making tool, Portfolio Management requires essential data about all initiatives o be entered into a central database and requires those initiatives to be scored against basic criteria and risk (decision analysis). Portfolio Management treats existing and new initiatives as assets to be managed instead of costs. The process is dynamic and iterative so that the Portfolio reflects changing agency goals and priorities. The key to assessing portfolio effectiveness is measuring the right things. Because of the importance of performance measures in completing the portfolio requirements, it is crucial for DFAS to agree on the appropriate measures early in the Portfolio Management process. Each initiative receives a weighted score on three dimensions: Mission, Financial and Benefits, and Risk ([20], p 21).

In the U.S. Military context, risk analysis, real options analysis, and portfolio optimization techniques are enablers of a new way of approaching the problems of estimating ROI and the risk-value of various strategic real options ([26], p. 1). This analysis can be performed by running various risk modelling programs including, Monte Carlo Simulations, Stochastic Forecasting, Real Options Analysis (ROA), and Portfolio Optimization using Knowledge Value Added (KVA). These methodologies help in making the best possible decisions, allocating budgets, predicting outcomes, creating portfolios with the highest strategic value and ROI, and so forth, where the conditions surrounding these decisions are risky or uncertain ([11]; [26], p 2).

What are these modelling programs? Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to compute their results. Monte Carlo methods are often used when simulating physical and mathematical systems. Because of their reliance on repeated computation and random or pseudorandom numbers, Monte Carlo methods are most suited to calculation by a computer. Monte Carlo methods are useful for modelling phenomena with significant uncertainty in inputs, such as the calculation of risk in business. In Stochastic Forecasting, the objective is to minimize a given cost function that depends on a large number of discrete or continuous variables. ROA applies financial options valuation techniques to real physical assets and capital budgeting decisions ([4]). ROA itself is the right, but not the obligation, to undertake some business decision; typically the option to make, or abandon, a capital investment ([17]). PA provides decision makers with an efficient set of portfolios, based on minimizing risk subject to a particular return ([31]). Risk modelling refers to the use of formal econometric techniques to determine the aggregate risk in a financial portfolio. Risk modelling is one of many subtasks within the broader area of financial modelling. Risk modelling uses a variety of techniques including market risk, VaR, Historical Simulation, or Extreme Value Theory in order to analyze a portfolio and make forecasts of the likely losses that would be incurred for a variety of risks. Such risks are typically grouped into credit risk, liquidity risk, interest rate risk, and operational risk categories ([17]).

As part of the project background, we must include a short discussion about risk. So what is risk? Risk is any uncertainty that affects a system in an unknown fashion and its ramifications are unknown, but it brings great fluctuation in the value and outcome.

We have talked about both PA and portfolio management a great deal up to this point. To clarify, this paper focuses on PA, but in doing so, we must also discuss portfolio management. There are similarities, such that in both portfolio (decision) analysis and portfolio management one must analyze and practice risk management. PA, using the Markowitz Efficient Frontier ([23]) optimization approach, provides decision makers with an efficient set of portfolios based on minimizing risk subject to a particular return.

Portfolio Management provides guidance as to what level of risk-taking is appropriate. PA alone does not provide managerial guidance about which efficient portfolio is best for the organization. Combining PA and portfolio management can improve the overall decision process, and could ultimately improve organizational performance ([31]).

2 System Engineering

2.1. Requirements

2.1.2 Objectives

System Engineering (SE) begins with the capture of requirements. For this research project, several sources were used to establish requirements. In understanding the requirements provided from different organizations, it is necessary to understand how each organization defines PA. The Project Management Institute defines:

Portfolio as “a collection of projects and programs and other work that are grouped together to facilitate effective management of that work to meet strategic business objectives. The projects or programs of the portfolio may not necessarily be interdependent or directly related.”

Portfolio Management (PfM) as “The centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs and other related work to achieve specific strategic business objectives.”

PfM, in the context of this research paper, views each program investment from an enterprise level as contributing to the collective whole, rather than an independent and unrelated program investment. With this enterprise perspective, Portfolio Managers can effectively:

a. Identify and prioritize opportunities, and

b. Apply available resources to potential products to select the best mix of products to exploit the highest-priority and/or most promising— opportunities ([20]).

This type of approach depends on strong enterprise governance with committed leadership; it also depends on information tools which provide the ability to visualize complex data relationships in a comprehensible manner.

A PfM approach begins with an enterprise-level framework and definition of market opportunities and then the prioritization of those opportunities within resource constraints. At each review gate, programs are assessed against available resources, established criteria, competing programs, and the goals and objectives of the DoD as a whole. As alternatives pass through each review gate, the number is expected to decrease, until only those alternatives with the greatest potential to succeed make it into the product portfolio ([20], Figure 1).

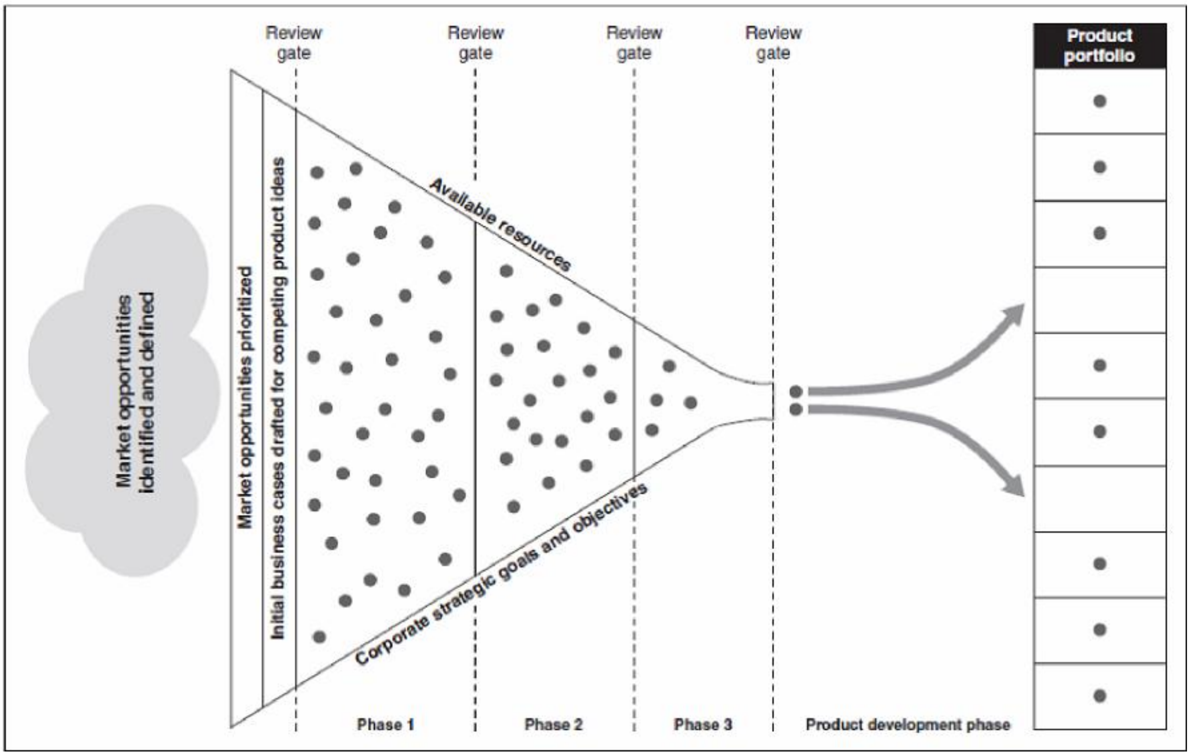

Figure 1. PfM Approach to Product Investments

In support of the framework identified as a best practice by the GAO ([20]), a fundamental premise of this paper is the need to identify COTS systems that can provide the capabilities identified in the Requirements section.

This project analyzes applicable PA tools, systems and underlying methodologies in terms of relevancy to identification of viable requirements and technical alternatives.

2.1.2 Scope

This research project encompasses PA pertaining to the DoD, as identified in the requirements provided, both explicit and derived. Some interpretation of requirements is needed as requirements are decomposed into functional capabilities. These interpretations, in terms of this paper, have not been presented to, nor vetted with the authors and agencies that provided the top-level requirements. The research scope fully explores the applicability of PA systems, vis-a-vis the requirements, using a System Engineering approach.

2.1.3 Identified Needs and Best Practices

This section begins to address the research questions in terms of performance, functional requirements, and system requirements. As outlined in the Project Methodology, a Literature Review was conducted to examine the current PA landscape from a requirements perspective..

2.1.4 Capability Requirements

The Cost of Capability Concept must also be considered, but may be viewed as a pre-expenditure, or constant plus a fixed fee for changes. The capability concept document is pre-portfolio selection, and assembly of capabilities as portfolios to meet the mission need should be based on this concept document. Inflation over time is a constant for any capability selection from the portfolios and is not considered a major factor in selection.

2.2 Analysis

2.2.1 Portfolio Capability Evaluation

From the DoD acquisition perspective, capabilities to meet identified requirements that satisfy mission gaps in execution of military strategies are tied to cost, schedule, and performance. In turn then, it is logical to view portfolios in a manner that optimizes these values. Let us consider that, for an optimum identified capability requirement, the following is true, regardless of whether it is from existing legacy, evolutionary, or new development (Figure 2):

$$\sum_{concept}^{operating} Capability = \sum_{Capability-}^{Capability+} Capability$$

Capability Concept + Capability Development + Capability Equipment + Capability Interfaces + Capability Installation + Capability Logistics

Figure 2. Capabilities Equation ([1])

The summation of sub-folders in a notional capability portfolio will result in a final capability that matches the DoD mission gap requirement, is better than the requirement, or is somewhat less than the requirement, but is good enough to serve as an interim solution (a lower threshold must be established to know when a sub-folder must be discarded as not useful). In turn, each of the pieces of this notional capability (let us call them $K or notional constant dollars for the baseline) portfolio may be further decomposed such that (Figure 3):

$$\$K_{cc} + \$K_{cd}^{+/0} + \$K_{ce}^{+/0/-\Delta} + \$K_{cif}^{+/+\Delta} + \$K_{cin}^{+/+\Delta} + \$K_{log}^{+/+\,log\,\Delta}$$

Where:

$\$K_{cc}$	Is cost of capability concept
$\$K_{cd}$	Is cost of capability development
$\$K_{ce}$	Is cost of capability equipment/components
$\$K_{cif}$	Is cost of capability interfaces
$\$K_{cin}$	Is cost of capability installation
$\$K_{log}$	Is cost lifecycle logistics for the capability including contract, initial administration, training (T), publications (P), spare parts kits (Spk), design changes (Sys) for the installation, software packages, etc.

$$T\Delta + P\Delta + Spk\Delta + Sys\Delta = log\,\Delta$$

Figure 3. Summation of Capabilities ([1])

As shown above, changes (or the +/- deltas) to the notional baseline capability result in increases/decreases for cost, schedule and/or performance. At the enterprise level, then, these parameters may be used to graphically show advantages and disadvantages for various options within each of the portfolio sub-folders (we will examine the individual parameters graphically later on). This same rationale may be used for evaluating schedule and performance. When numerical values are assigned, portfolios of capabilities and their components may be evaluated to select those most favourable within cost, schedule and performance desired to meet the capability gap. Note that risk is not an issue in capability parameter selection at this point. Risk is an integral part of sub-folder or technology evaluation that may make a specific capability option within the portfolio infeasible. Risk may be evaluated at each enterprise level calculation and at each subsequent parent-child decomposition, such that risk is always a consideration throughout the selection process.

Evaluation of the portfolio must also consider the desired timeframe for fielding the capability. If technologies or equipment within the selected sub-folders have low probability of reaching the fielding date, they must be shelved until they are mature enough for consideration. Schedules for the selected comparison parameters must use arbitrary weighted earned values. Depending upon the capability requirement, there are several types of scheduling software products that may be used. Regardless of the scheduling tool, as long as it is consistent, a reasonable comparison may be made between portfolio sub-folders that meet notional Earned Value Management System and Integrated Defense Acquisition, Technology, and Logistics management framework milestone and alternative decision point requirements.

Although the capability performance may be measured by several criteria, it may be best measured via established criteria, as set forth in a Technology Readiness Assessment and/or Manufacturing Readiness Assessment. These criteria are well- recognized throughout the DoD and other government activities. Because of the expandable nature of the requirements for each level of performance, each of the parameters for evaluating a sub-folder within the portfolio may be tailored to fit the criteria of technology and manufacturing readiness. When compared with one another, using the same criteria, selection of the most promising sub-folders for the capability can be accomplished.

Because sub-folders consider existing, evolutionary, and new developments, use of this method allows the evaluator to be able to inject capabilities into the performance versus time chart at the current level and select those that may be more mature and, therefore, have the best chance of success, all other weighted factors being near equal. The evaluator must be attuned to the pitfalls of selecting mature technologies, even though they meet a current need, which cannot evolve and remain interoperable with other capabilities in the battle space in the out years.

2.2.2 Threat Environments (Based on the 2008 National Defense Strategy (NDS)

Today's current environmental threat is: Global struggle against violent extremist ideology seeking to overturn the international state system, asymmetrical/irregular warfare.

2.2.3 Gartner Group's COTS PA Product Landscape

Applications for project, portfolio and resource management boost team performance and enable IT management and others to access real-time data via dashboards for prioritization and quick decision making.

2.2.4 Forrester Research COTS PA Product Landscape

The Forrester WaveTM Project Portfolio Management Tools, Q4 2007 report established CA as the PPM leader in 2007, according to an article published 18 December 2007, by Mr. Lewis Cardin et al. (p. 8). Forrester evaluated fourteen leading PPM vendors across ninety-five criteria and found that CA and Planview established PPM leadership within the field thanks to their wide choice of mature features and functions. Forrester's COTS PA product research uncovered a market environment in which:

- CA, Planview, HP, Primavera, and IBM lead the pack
- Compuware, Oracle, Serena, and Microsoft offer competitive options
- SAP and Daptiv lack the expected full suite of out-of-the-box offerings

This evaluation of the COTS PPM Suite market is intended to be a starting point only. Readers are encouraged to view detailed product evaluations and adapt the criteria weightings to suit their individual needs through the Forrester™ Wave Excel-based vendor comparison tool.

2.2.5 Real Options Valuation's Risk Simulator

Real Options Valuation's Risk Simulator software package will help to identify, quantify, and evaluate risk in projects and decisions. Risk Simulator, a powerful Excel add-in application, is used for applying simulation, forecasting, statistical analysis, and optimization in existing Excel spreadsheet models. It contains four different modules: Monte Carlo Simulation, Optimization, Statistical and Analytical tools, Time Series and Cross-Sectional forecasting. Risk simulator is also integrated with the Real Options Super Lattice Solver software, for solving strategic real options, financial options, and employee stock options.

2.2.6 Palisade @RISK (http://www.palisade.com/)

Palisade @RISK performs risk analysis using Monte Carlo simulation to show you many possible outcomes using Microsoft Excel spreadsheets, and tells you how likely outcomes are to occur. You can then decide which risks are worth taking and which ones to avoid, allowing for improved decision making under uncertainty. @RISK uses simulation to answer questions like:

a. "What is the probability of profit exceeding $10 million?"

b. "What are the chances of losing money on this venture?"

c. "What is the probability that the project will be delivered within budget?"

d. "How much contingency (management reserve) should be included?"

@RISK is an add-in to Microsoft Excel, integrating completely with the spreadsheet. All @RISK functions are Excel functions, and behave exactly the same as native Excel functions. @RISK windows are all linked directly to cells in your spreadsheet, so changes in one place are carried over to the other. @RISK graphs point to their cells via callout windows.

2.2.7 Shortcomings of COTS Products

The drive to incorporate COTS software and hardware is often based on incomplete or inaccurate information. Clearly identified requirements that cannot incorporate COTS software and hardware need additional research, cost, and development within their product design. However, using PPM COTS products does offer many advantages and disadvantages. For instance, many of these shortcomings are described by engineers who are reluctant to move to COTS, if for no other reason than a general resistance to change. Many engineers display the attitude "if we did not make it; the product design is no good." It is basically that type of mentality that promotes a general distrust of COTS products.

a Advantages of COTS

The advantages associated with the use of COTS are:

- Immediately available and shorter development schedule
- Reduced cost
- Increased portability
- Improved Quality (resulting from more efficient testing)

b Disadvantages of COTS

The disadvantages associated with the use of COTS are:

- Hard to meet special requirements
- Continual investment in COTS product
- Bad interoperability.

2.3 Model Development

2.3.1 Model Data

Using the basic data depicted in Figure 33 below, our research team attempted to develop a model in (1) Real Options Valuation's Risk Simulator and (2) @RISK that would analyze the data and provide usable output as measures of EMV. We also attempted to model this data with the Program Management (PM) software but were unable to do so. The EMV measures for this model were developed by our team. However, in practice, the EMV measures should be developed by Budget, Strategic, and Acquisition professionals to ensure their accuracy.

Program	ENPV	NPV	Cost	Strategy Ranking	Military Score	Tactical Score	FTE Resoucres
Program 1	$501.60	$102.30	$443.50	1.94	2.51	1.77	3.91
Program 2	$726.30	$121.30	$358.80	3.75	3.84	3.56	2.73
Program 3	$932.40	$354.20	$925.90	2.34	3.12	3.24	5.24
Program 4	$620.50	$265.80	$512.10	1.36	5.14	5.1	3.41
Program 5	$420.80	$271.20	$524.50	1.32	3.22	1.62	3.29
Program 6	$2,087.50	$345.90	$1,868.70	4.68	6.37	6.21	4.56
Program 7	$3,264.90	$594.10	$1,602.10	10.59	8.69	7.53	4.23
Program 8	$2,563.40	$421.50	$2,133.40	2.83	2.64	4.12	5.61
Program 9	$5,468.10	$1,032.20	$2,712.30	7.68	6.94	7.99	4.68
Program 10	$3,248.90	$775.40	$2,502.80	5.74	5.53	6.23	6.43
Program 11	$125.90	$32.80	$28.60	15.26	9.84	9.17	5.47
Program 12	$235.10	$85.60	$109.50	6.42	4.25	3.65	3.91
Program 13	$4,163.50	$325.10	$3,054.20	5.26	3.41	6.21	5.23
Program 14	$4,468.70	$594.10	$1,673.80	10.54	8.46	7.54	4.23
Program 15	$587.60	$421.50	$409.00	2.81	2.74	3.52	5.34
Program 16	$1,698.40	$431.90	$658.30	11.92	8.45	8.87	4.26
Program 17	$758.40	$134.20	$485.50	4.65	4.52	4.35	6.32
Program 18	$1,248.30	$301.50	$331.50	4.85	6.13	5.62	3.57
Program 19	$389.90	$26.10	$159.00	7.98	7.65	8.62	4.98
Program 20	$3,864.70	$1,257.60	$1,458.70	15.46	9.48	9.34	12.64
			$21,952.20	127.38	112.93	114.26	100.04
		Maximize	<=$10,500	<= 100			<= 80

Objective: *Maximize Total Portfolio Returns times the Portfolio Comprehensive Score*
Decision Variables: *Allocation or Go/No-Go Decision*
Restrictions on Decision Variables *Binary decision variables (0 or 1)*
Constraints: *Total Cost is less than $10,500 (in thousands or millions of dollars)*
Less than or equal to 10 projects selected in the entire portfolio
Full-time Equivalence resources have to be less than 80
Total Strategic Ranking for the entire portfolio must be less than 100

Figure 4. Base Evaluation Model ([1])

Earned Net Present Value is an enhancement of the NPV that explicitly addresses uncertainty. NPV compares a single stream of cash flows in today's dollars to the value of that same dollar in the future. Cost is the actual cost listed in the 2009 Defense Procurement Budget Request. Strategic Ranking, Military Score, and Tactical Score are EMV measures developed by evaluating the NDS and then scoring the programs based on how they meet the NDS. FTE resources equates to the amount of actual resources used as a percent. One hundred percent means that all resources are fully utilized all the time. The goal is to maximize the portfolio returns without exceeding an arbitrary budget of $10,500 while keeping the strategic ranking below 100 and the FTE below 80.

In evaluating this model, we plan to verify that PA and Defense budget decision making can be improved using COTS software.

2.3.2 Real Options Valuation's Risk Simulator

Figure 5 is the model developed using the Real Options Risk Simulator. The task was to run an optimization/simulation to determine which ten of the following twenty programs best meet the requirements outlined in the NDS. Only ten programs will go forward. These are real programs in the FY 2009 budget with the real costs included. The names of the real programs will be revealed later in the analysis section. The ranking and military/tactical scores, along with the FTE resources, are based on the NDS and the President's goals are located: http://www.whitehouse.gov/agenda/defense/.

Because our thesis is based on PA, we will attempt to run this through PPM programs as well as risk simulators. For the purpose of this model, the military score, comprehensive score, and tactical score are all measures of EMV.

After running the discrete (static) optimization on this model with the original budget of less than $10,500, and a strategy rank of less than 100, no more than ten programs, and FTE resources not to exceed 80.

Military Portfolio Optimization

Project Name	ENPV	NPV	Cost	Strategy Ranking	Return to Rank Ratio	Profitability Index	Selection	Military Score	Tactical Score	FTE Resources	Comprehensive Score
Project 1	$501.60	$102.30	$443.50	4.26	117.75	1.23	1	2.51	1.77	3.91	1.40
Project 2	$726.30	$121.30	$358.80	5.61	129.47	1.34	1	3.84	3.56	2.73	1.77
Project 3	$932.40	$354.20	$925.90	2.34	398.46	1.38	1	3.12	3.24	5.24	2.12
Project 4	$620.50	$265.80	$512.10	3.21	193.30	1.52	1	5.14	5.10	3.41	2.46
Project 5	$420.80	$271.20	$524.50	1.32	318.79	1.52	1	3.22	1.62	3.29	1.60
Project 6	$2,087.50	$345.90	$1,868.70	4.58	446.05	1.19	1	6.37	6.21	4.56	2.98
Project 7	$3,264.90	$594.10	$1,602.10	10.59	308.30	1.37	1	8.69	7.53	4.23	3.43
Project 8	$2,563.40	$421.50	$2,133.40	2.83	905.80	1.20	1	2.64	4.12	5.61	2.31
Project 9	$5,468.10	$1,032.20	$2,712.30	7.68	711.99	1.38	1	6.94	7.99	4.68	3.46
Project 10	$3,248.90	$775.40	$2,502.80	5.74	566.01	1.31	1	5.53	6.23	6.43	3.16
Project 11	$125.90	$32.80	$28.60	15.26	8.25	2.15	1	9.64	9.17	5.47	4.13
Project 12	$235.10	$85.60	$109.50	6.42	36.62	1.78	1	4.25	3.65	3.91	2.00
Project 13	$4,163.50	$325.10	$3,054.20	5.26	791.54	1.11	1	3.41	6.21	5.23	2.77
Project 14	$4,468.70	$594.10	$1,673.80	10.54	8.46	7.54	1	8.46	7.54	4.23	3.41
Project 15	$587.60	$421.50	$409.00	2.81	209.11	2.03	1	2.74	3.52	5.34	2.13
Project 16	$1,698.40	$431.90	$658.30	11.92	142.48	1.66	1	8.45	8.87	4.26	3.74
Project 17	$758.40	$134.20	$465.50	4.65	163.10	1.28	1	4.52	4.35	6.32	2.60
Project 18	$1,248.30	$301.50	$331.50	4.85	257.38	1.91	1	6.13	5.62	3.57	2.66
Project 19	$389.90	$26.10	$159.00	7.98	48.86	1.16	1	7.65	8.62	4.98	3.73
Project 20	$3,864.70	$1,257.60	$1,458.70	15.46	249.98	1.86	1	9.46	9.34	12.64	5.21
Total	$37,374.90		$21,952.20	133.41			20	**112.93**	**114.26**	100.04	**57.08**
Profit/Rank	$280.15										
Profit*Score	$2,133,370.83	Maximize	<=$10500	<=100			x<=10			<=80	

Figure 5. Real Programs in the FY09 Budget with Costs ([1])

2.3.3 Real Options Valuation's Risk Simulator Data Analysis

The analysis of the risk simulator model shows, without a doubt, that there is a definite efficient frontier in which there is a substantial ROI limit in the profile used in this model. As shown in Figure 6 below, from $9,500 to $10,500 there is actually a decrease in the ROI maximization objective. From $10,500 to $12,500 there is a substantial increase in the EMV and ROI objectives with a rapid slow down in ROI above that threshold. Note that by increasing the budget by $2,000 and allowing for additional programs, decision makers are given the "opportunity" to increase the Defense capabilities outlined in the NDS. This "opportunity" is one of the options available to Defense decision makers. The option does not have to be exercised, but it is available if needs dictate and funding is available from Congress. Other options include using eleven programs or thirteen programs, if funding becomes available, or even using nine programs in the case of budget cuts. Note that using nine programs provides an even better ROI than the baseline.

			Static Efficiency Frontier				
Budget	Comprehensive Score	Tactical Score	Military Score	Allowed Projects	ROI-RANK Objective	Percent Change ROI	
$9,500.00	32.37	69.03	70.16	9	$689,082.38	1.97%	
$10,500.00	32.32	69.57	70.46	10	$675,768.93	0.00%	Baseline
$11,500.00	35.82	72.59	73.34	11	$810,419.62	19.93%	
$12,500.00	39.27	81.77	80.68	12	$984,108.39	45.63%	
$13,000.00	40.59	84.01	82.20	13	$998,868.72	47.81%	

Figure 6. Efficient Frontier ROI from Baseline

This tells the decision makers in Washington that, based on the NDS, a budget of $10,500 is not the most optimal to provide for our Defense needs. If more funding were allotted, the most optimal solution, based on strategic value, would be a budget of $12,500 and twelve programs. Anything more would be a waste of taxpayers' money by funding a low ROI, and anything less would decrease the value of the Defense plan and make the budget less effective, while decreasing Defense capabilities.

3. Conclusions

3.1 Comparing the Evaluation Model with Reality

After developing the evaluation model, running simulations, and performing data analysis, the research team has concluded that Risk Simulator is a very capable Microsoft Excel plug-in which can evaluate program risk, evaluate EMVs, and optimize budgeting and programming constraints, all within the scope of the NDS. This software also has hundreds of risk models built in, including the military model. These models are easily modifiable to fit any number or programming requirements. To verify this assessment, refer to Figure 7, the original model with the real program names.

	Program	ENPV	NPV	Cost	Strategy Ranking	Military Score	Tactical Score	FTE Resoucres
P1	CH-47 Helicopter	$501.60	$102.30	$443.50	1.94	2.51	1.77	3.91
P2	Armed Reconnaissance Helicopter	$726.30	$121.30	$358.80	3.75	3.84	3.56	2.73
P3	Blackhawk Helicopter	$932.40	$354.20	$925.90	2.34	3.12	3.24	5.24
P4	Patriot Missle System	$620.50	$265.80	$512.10	1.36	5.14	5.1	3.41
P5	Patriot Modifications	$420.80	$271.20	$524.50	1.32	3.22	1.62	3.29
P6	F/A 18 E/F Fighter	$2,087.50	$345.90	$1,868.70	4.68	6.37	6.21	4.56
P7	Joint Strike Fighter	$3,264.90	$594.10	$1,602.10	10.59	8.69	7.53	4.23
P8	V22 Osprey	$2,563.40	$421.50	$2,133.40	2.83	2.64	4.12	5.61
P9	Carrier Replacement Program	$5,468.10	$1,032.20	$2,712.30	7.68	6.94	7.99	4.68
P10	DDG-1000 Program	$3,248.90	$775.40	$2,502.80	5.74	5.53	6.23	6.43
P11	Marine EOD Systems	$125.90	$32.80	$28.60	15.26	9.84	9.17	5.47
P12	Marine High Mobility Rocket Systen	$235.10	$85.60	$109.50	6.42	4.25	3.65	3.91
P13	Air Force F-22 Fighter	$4,163.50	$325.10	$3,054.20	5.26	3.41	6.21	5.23
P14	Air Force Joint Strike Fighter	$4,468.70	$594.10	$1,673.80	10.54	8.46	7.54	4.23
P15	V22 Osprey	$587.60	$421.50	$409.00	2.81	2.74	3.52	5.34
P16	Global Hawk Remote UAV	$1,698.40	$431.90	$658.30	11.92	8.45	8.87	4.26
P17	C5A Cargo Plane	$758.40	$134.20	$485.50	4.65	4.52	4.35	6.32
P18	C17 Cargo Plane	$1,248.30	$301.50	$331.50	4.85	6.13	5.62	3.57
P19	Defense Space Recon Program	$389.90	$26.10	$159.00	7.98	7.65	8.62	4.98
P20	Special Operations Command	$3,864.70	$1,257.60	$1,458.70	15.46	9.48	9.34	12.64

Figure 7. Evaluation Model with Real Program Names ([1])

3.2 Modeling Using Costs Products

Gartner and Forrester identified several PPM software suites which can be used to develop and manage project models. However, these models do not offer robust simulations which account for a range of probability distributions while accounting for risk across model scenarios. These products excel at providing graphical representations of complex data in the form of digital “dashboards,” bubble-charts, and efficient frontiers. When used in conjunction with PA modelling software, these PPM suites are excellent at helping to efficiently manage large projects while helping to mitigate risk.

The authors of this paper found that the Real Options Valuation’s Risk Simulator and @RISK were better suited for the research being conducted in accordance with the intent of this research paper. Risk Simulator was by far the superior product evaluated and provided hundreds of readymade models including; Military models, Efficient Frontier Models, multiple simulations. These modelling tools leverage the capabilities of Microsoft Excel and Monte-Carlo simulation to develop a range of statistical probability distributions using an array of variable inputs. This provides the ability to look at the best, worst and most likely scenarios.

3.3 Research Limitations

The authors found that the "boil the ocean" approach to evaluating products was beyond the scope that was executable in a (1) distributed team environment (i.e., team not collocated), and (2) without a central laboratory environment with configuration control of the products being evaluated. Additionally, it was difficult to codify all the numerous requirements and variables from multiple sources. The model was developed using only a few of the variables and requirements identified in the present study. More complex models could be developed using the work in this document as a starting point.

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