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Integrated Portfolio Analysis: Return on Investment and Real Options Analysis of Intelligence Information Systems (Cryptologic Carry On Program)

30 September 2006

by

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Abstract

This paper introduces the Knowledge Value Added/Real Options (KVA+RO) valuation framework for use in information technology (IT) portfolio management within the Navy. KVA+RO is designed to support information technology (IT) portfolio investment decisions. It is intended to empower decision-makers by providing performance-based data and analyses like the Return On Investment (ROI) on individual projects, programs and processes within a portfolio of IT investments. Using KVA historical data as a platform, potential strategic investments are evaluated with real options analysis.

The first section discusses limitations of existing ROI approaches. The paper then presents KVA+RO methodology and framework, reviews core concepts, underlying assumptions, metrics and potential applications to the IT portfolio management problem in the DoD. In the final section, the KVA+RO valuation framework is applied to Naval Cryptologic Carry On Program (CCOP) systems, that are used in the Intelligence Collection Process (ICP), for evaluation of signal intelligence gathering system investments.

Keywords: Return on Investment in Information Technology, Real Options, Business Process Reengineering, Performance Accounting, ISR

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Dr. Tom Housel specializes in valuing intellectual capital and knowledge value measurement. He is currently a tenured Full Professor for the Information Sciences (Systems) Department. He won the prestigious Society for Information Management award for best paper in the field in 1986. His work on measuring the value of intellectual capital has been featured in a *Fortune* cover story (1994, October 3) and *Investor's Business Daily*, numerous books, professional periodicals, and academic journals (most recently in the *Journal of Intellectual Capital* (Vol. 2), 2005).

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Executive Summary

This paper introduces the Knowledge Value Added/Real Options (KVA+RO) valuation framework for use in information technology (IT) portfolio management within the Navy. It is intended to empower decision-makers by providing performance-based data and analyses like the Return On Investment (ROI) on individual projects, programs and processes within a portfolio of IT investments. Using KVA historical data as a platform, potential strategic investments are evaluated with real options analysis.

The first section discusses limitations of existing ROI approaches. The paper then presents KVA+RO methodology and framework, reviews core concepts, underlying assumptions, metrics and potential applications to the IT portfolio management problem in the DoD. In the final section, the KVA+RO valuation framework is applied to Naval Cryptologic Carry On Program (CCOP) systems, that are used in the Intelligence Collection Process (ICP), for evaluation of signal intelligence gathering system investments.

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I. Introduction

The United States has experienced dramatic changes in national security over the past 15 years, shifting away from the conventional threats posed during the Cold War era to the more unconventional threats evidenced by the tragic events of September 11 and the continuing global war on terrorism. To meet the challenges of the new national security environment, the Department of Defense (DoD) plans to spend $1.3 trillion between 2005 and 2009 for major programs ranging from new intelligence programs to homeland defense and military operations overseas.[1]

With lives at stake and billions of dollars at risk, difficult choices are made by the DoD on which projects to fund where tradeoffs occur. Should investments be made towards personnel or investments in new technology? Should more funding be allocated towards intelligence collection or processing? To evaluate and select projects returning maximum benefits, new measurement tools are critical to properly define, capture and measure the total value of investments. These tools must be capable of capturing data across a spectrum of organizations to compare processes, capabilities, costs, revenues and other benefits. In addition, they must incorporate elements of uncertainty and risk that are inherent in predicting the future. Understanding uncertainties and the potential impact of risks can significantly improve the likelihood of successful investment decisions. A team at the Naval Postgraduate School (NPS) applied the KVA+RO valuation framework to address those issues. .

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[1] GAO, *Better Support of Weapon System Program Managers Needed to Improve Outcomes*, November 2005, p. 17.

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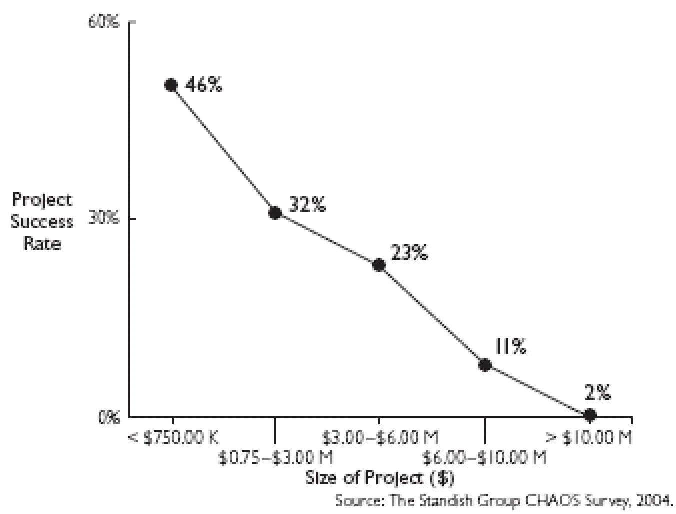
II. Return on Investment

DoD programs often experience large cost increases and extended delivery schedules, resulting in estimates of time and money being inaccurate by 20 to 50 percent or higher.[2] As a consequence, the ROI on DoD IT development programs has been unpredictable for decades. Statistics for the private sector are just as disconcerting (Figure 1), with large technology projects having a dismal success rate. According to research firm The Standish Group, IT projects with budgets exceeding $3 million have a 68 percent chance of failing.

Figure 1. Rate of Successful Project Delivery



(Source: The Standish Group, CHAOS Survey, Boston, 2004.)

High failure potential, shrinking revenues and smaller budgets have forced organizations to spend significant resources on measuring returns from the millions of dollars invested in technology. Various approaches have been adopted to

[2] Ibid.

measure ROI at corporate and sub-corporate levels. Corporate-level approaches seek to determine the contribution of human capital and IT assets on the overall performance of the organization. Sub-corporate-level approaches focus internally on the core processes involved in the production of organizational output and attempt to establish a measure for the benefits of assets within each process.

Some methodologies are traditional financial measures; others are heuristical methods supporting quantitative measures using subjective estimates. There are also probabilistic approaches using statistical and mathematical models to measure risk. Although methodologies differ, each has the common goal of providing managers with a metric of value for IT investments as summarized in Table 1.

Table 1. Approaches to Measuring Return on IT

Level of Analysis	Approach	Focus/Assumptions	Key Advantages	Limitations
Aggregate Corporate (firm) level	*Process of Elimination (i.e., Knowledge Capital)*	• Treats effect of IT on ROI as a residual after accounting for other capital investments	• Uses commonly accepted financial analysis techniques and existing accounting data	• Cannot drill down to effects of specific IT initiatives • ROI on IT difficult to measure directly
	Production Theory	• Determines IT effects through input/ output analysis using regression modeling techniques • Economic production function links IT investment input to productivity output	• Uses econometric analysis on large data sets to show contributions of IT	• "Black-box" approach with no intermediate mapping of IT's contributions to outputs
	Resource Based View	• Links firm's core capabilities with competitiveness • Uniqueness of IT resource = competitive advantage	• Uses strategic advantage approach to IT impacts	• Causal mapping between IT investment and firm competitive advantage difficult to establish
Corporate/ sub-corporate	*Option Pricing Model*	• Determines best point to exercise an option to invest in IT • Timing exercise option = value	• Predicts future value of IT investment	• No surrogate for revenue at sub-corporate level
Sub-corporate (Process) level	*Family of Measures (i.e., Balanced Scorecard)*	• Measures multiple indicators to derive unique contributions of IT	• Captures complexity of corporate performance	• No common unit of analysis/ theoretical framework • Multiple indicators required to measure performance
	Cost-Based (i.e., Activity Based Costing)	• Uses cost to determine value of IT • Derivations of cost ≈ value	• Captures accurate cost of IT	• No surrogate for revenue at this level; no ratio analysis
	Knowledge Value Added (i.e., KVA)	• Allocates revenue to IT proportionate to contributions to process outputs • IT contributions to output ≈ IT value-added	• Allocates revenue and cost of IT allowing ratio analysis of IT value-added	• Not directly applicable to highly creative processes

Source: Paul Pavlou, Thomas Housel, Waymond Rodgers and Eric Jansen. "Measuring the Return on Information Technology: A Knowledge-based Approach for Revenue Allocation at the Process and Firm Level," *Journal of the Association for Information Systems* 6, no. 7 (July 2005): 199-226.

Most ROI measures focus solely on financial returns at the corporate level and fail to capture complete benefit streams produced within organizational processes and the productive assets therein. Limitations with current attempts at ROI metrics include:

- ***Capturing IT-specific benefits.*** With the first wave of new technology, there was a clear distinction of benefits received from that specific technology. Inputs and outputs were clearly defined, but returns resulting from investments in mainframes to personal computers to client/server to enterprise resource planning suite to the Web were indistinguishable because there was no defensible way to allocate revenue to these IT assets. People, processes and technology have now become seamlessly integrated—further complicating efforts to develop ROI estimates for human capital assets and information technology assets.

- ***Quantifying intangible human capital assets (i.e., training, skills, knowledge).*** The average large company spends the equivalent of two percent on its total payroll on training, according to the management consult firm of Bain & Co.[3] How does that expenditure impact the final output in terms of creating shareholder value? How do training, knowledge, skill and education all contribute to the bottom-line of an output?

- ***Defining metrics for the public sector.*** Public sector organizations must evaluate investments on the overall "value" received. What does value translate to in the public sector? What capabilities deliver the greatest value? How can success be measured in the public sector? What is the resulting value to the public for each dollar invested? How can public sector value be calculated and quantified in common units such as money?

Measurement tools for assessing the performance of public funding investments, along with a common view of the benefits received are critical given increased regulations and pressures for better accountability and transparency. For example, DoD Directive 8115.01 issued October 2005 mandates the use of performance

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[3] Buchanan, Webster, *Human Capital Review*, Summer 2004, p. 1. <http://www.websterb.com/pdf/first_page/hcr_review_european_firstpage.pdf?PHPSESSID=7797d005f386063c964538906e8a060c>

metrics based on outputs, with ROI analysis required for all current and planned IT investments. NPS developed the KVA+RO framework to estimate the ROI on IT investments with an analytical tool set that also supports strategic, performance-based investment decisions.

III. Beyond ROI: The KVA+RO Valuation Framework

The KVA-+RO valuation framework measures operating performance, cost-effectiveness and return on investments. The framework also facilitates regulatory compliance and applies portfolio-management techniques to value programs, taking into account uncertainty and risk in estimating future benefits. The framework is useful for the DoD, not just private sector firms. Its focus on the outputs of core processes, sub-processes provides several benefits:

- Quantifies value of specific processes, functions, departments, divisions, or organizations in common units of output.
- Provides historical data on costs and revenues of specific processes and specific programs within organizations.
- Provides a methodology that will facilitate regulatory compliance in the public sector with legislation (such as the Clinger-Cohen Act of 1996) mandating portfolio management for all federal agencies. In the private sector, it can facilitate compliance with Sarbanes-Oxley by making performance among corporate entities more transparent.
- Highlights operational efficiencies/inefficiencies at any level of analysis, down to individual employees and IT systems.
- Leverages current and future portfolio investments by estimating the potential total value created.

Organizations can drill down to understand specific processes in terms of the cost of each process and its contribution to the bottom line with the KVA+RO framework. Government entities can use the framework to enhance existing performance tools. On the corporate side, the framework can be used to value any level of the organization from specific divisions or operating units down to individual employees and systems to determine profitability.

A. Overview of KVA+ RO Framework

The KVA+RO methodology, including the general data collection process, is summarized in Table 2 (see also Appendix 1).

Table 2. NPS Valuation Framework

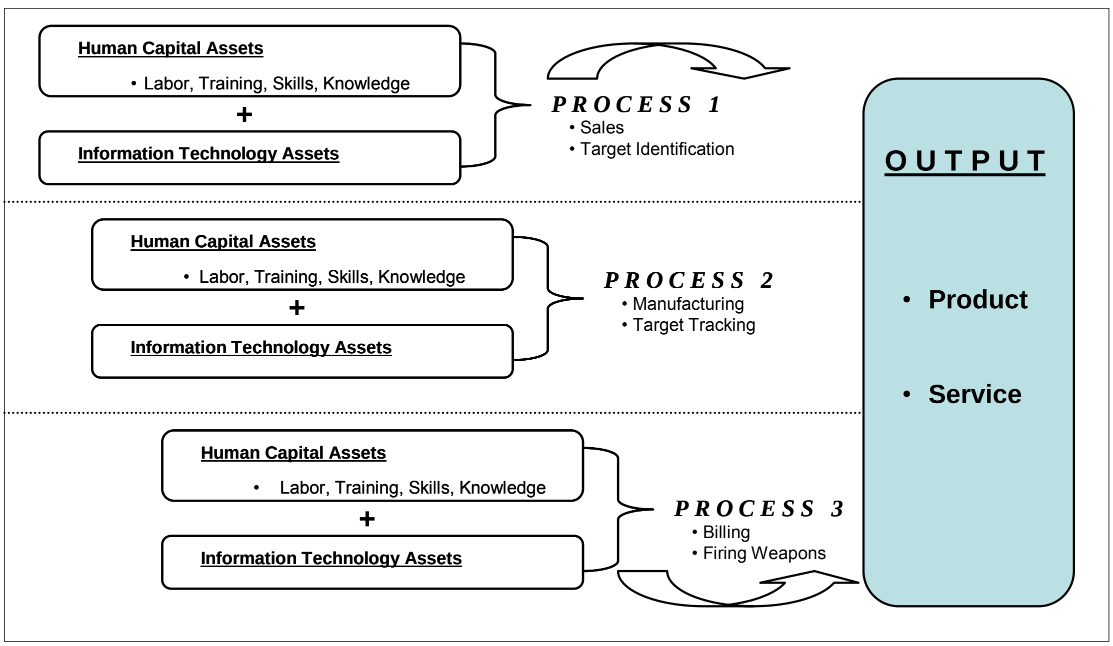
DATA COLLECTION	KVA METHODOLOGY	REAL OPTIONS THEORY
• Collect baseline data • Identify sub-processes • Research market comparable data • Conduct market analysis • Determine key metrics	**Step 1:** Calculate Time to Learn. **Step 2:** Calculate Value of Output (K) for each sub-process. **Step 3:** Calculate Total K for process. **Step 4:** Derive Proxy Revenue Stream. **Step 5:** Develop the Value Equation Numerator by assigning revenue streams to sub-processes. **Step 6:** Develop value equation denominator by assigning costs to sub-processes. **Step 7, 8, 9:** Calculate metrics: *Return on Investment (ROI)* *Return on Knowledge Assets (ROKA)* *Return on Knowledge Investment (RKOI)*	**Step 1**: **Risk Identification** List of projects and strategies to evaluate. **Step 2: Risk Prediction** Base case projections for each project. **Step 3: Risk Modeling** Develop static financial models with KVA data. **Step 4: Risk Analysis** Dynamic Monte Carlo simulation. **Step 5: Risk Mitigation** Framing real options. **Step 6: Risk Hedging** Options analytics, simulation & optimization. **Step 7: Risk Diversification** Portfolio optimization and asset allocation. **Step 8: Risk Management** Reports presentation and update analysis.

The first step under the framework is data collection on processes and sub-processes required to produce an output. Once all process data are accurately documented, they are supplemented by market research to compare cost and revenue data to establish baseline information. The KVA methodology is then applied to estimate value and costs for each process. Cost-per-unit of output calculated by KVA, in conjunction with price-per-unit of output estimates, provides raw data required for ROI analysis. In the final step of the framework, real options analysis is conducted to estimate the future value and risks of potential investments. Alternative scenarios are run, enabling decision-makers to assess risk, leverage uncertainty and limit downside risk. Principles of KVA and RO are discussed further in the next sections.

B. Knowledge Value Added Methodology

A new paradigm in sub-corporate performance analytics, 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 knowledge assets. By capturing the value of knowledge embedded in an organization's core processes, employees and IT, KVA identifies the actual cost and revenue of a product or service. Because KVA identifies every process required to produce an output and the historical costs of those processes, unit costs and unit prices of products and services are calculated. An output is defined as the end result of an organization's operations; it can be a product or service as shown in Figure 2 below.

Figure 2. Measuring Output



KVA has been applied in over 100 organizations in the public and private sectors, ranging in size from under 20 employees to thousands, for the past 14 years. The methodology has been applied in 35 areas within the DoD, from flight scheduling applications to ship maintenance and modernization processes.

As a performance tool, the methodology:

- Compares all processes in terms of relative productivity
- Allocates revenues 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
- Provides common unit measures for organizational productivity

Based on the tenets of complexity theory, KVA assumes that humans and technology in organizations add value by taking inputs and changing them into outputs through core processes.[4] The amount of change an asset or process produces can be a measure of value or benefit. Additional assumptions include:

- Describing all process outputs in common units (i.e., the time it takes to learn to produce the required outputs) allows historical revenue and cost data to be assigned to those processes at any given point in time.
- All outputs can be described in terms of the time required to learn how to produce them.
- Learning Time, a surrogate for the knowledge required to produce process outputs, is measured in common units of time. Consequently, Units of Learning Time = Common Units of Output (K).
- 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.

Describing processes in common units also permits market comparable data to be generated, particularly important for non-profit organizations such as the DoD. Market comparable data from the commercial sector can be used to estimate price

[4] Thomas Housel and Art Bell, *Measuring and Managing Knowledge* (Boston: McGraw-Hill, 2001), 92-93.

per common unit, allowing for revenue estimates of process outputs for non-profits. This also provides a common-units basis to define benefit streams regardless of process analyzed.

KVA differs from other ROI models because it allows for revenue estimates—enabling use of traditional accounting, financial performance and profitability measures, and prospective financial methods such as real options analysis. Figure 3 demonstrates how KV A compares to traditional cost accounting by providing costs per process instead of cost per category. Figure 4 provides a comparison of traditional corporate level revenue information while KVA provides this kind of information at the subcorporate level by taking the corporate level revenue and allocating it to subcorporate process outputs.

Figure 3. Comparison of Traditional Accounting versus Process Based Costing

Explains what was spent (Traditional Accounting) / *Explains how it was spent* (KVA Process Costing)

Traditional Accounting		KVA Process Costing	
Compensation	$5,000	Review Task	$1,000
Benefits/OT	1,000	Determine Op	1,000
Supplies/Materials	2,000	Input Search Function	2,500
Rent/Leases	1,000	Search/Collection	1,000
Depreciation	1,500	Target Data Acq	1,000
Admin. And Other	900	Target Data Processing	2,000
Total	**$11,400**	Format Report	600
		Quality Control Report	700
		Transmit Report	1,600
		Total	**$11,400**

Figure 4. Comparison of Outputs Traditional Accounting Benefits (Revenues) versus Process Based Value

Traditional Accounting/ Finance Measure	KVA Process Value Measure
Sales/Revenues	Common units of output
Product price	Market comparables: Price-per-unit of output
Total Revenues	Total units of output X price-per-unit = total revenue surrogate

KVA can rank processes in terms of the degree to which they add value to the organization or its processes. This assists decision-makers to identify what processes are value-added—those that will most likely accomplish a mission, deliver a service, or meet customer demand. Value is quantified in four key metrics: Return on Knowledge (ROK), Return on Knowledge Assets (ROKA), Return on Knowledge Investment (ROKI) and Return on Investment (ROI).

C. Real Options Analysis

Real options analysis incorporates strategic planning and analysis, risk assessment and management, and investment analysis. As a financial valuation tool, real options allows organizations to adapt decisions to respond to unexpected environmental or market developments. As a strategic management tool, real-options is a strategic investment valuation tool affording decision-makers the ability to leverage uncertainty and limit risk. Real-options can be used to:

- Identify different corporate investment decision pathways or projects that management can consider in highly uncertain business conditions;
- Value the feasibility and financial viability of each strategic decision pathway;
- Prioritize pathways or projects based on qualitative and quantitative metrics;
- Optimize strategic investment decisions by elevating different decision paths under certain conditions or determine how a different sequence of pathways can lead to the optimal strategy;
- Time effective execution of investments and find the optimal trigger values and cost or revenue drivers; and
- Manage existing or develop new options and strategic decision pathways for future opportunities.[5]

Different kinds of options are used in a variety of ways across a number of industries as portrayed in Figure 5.

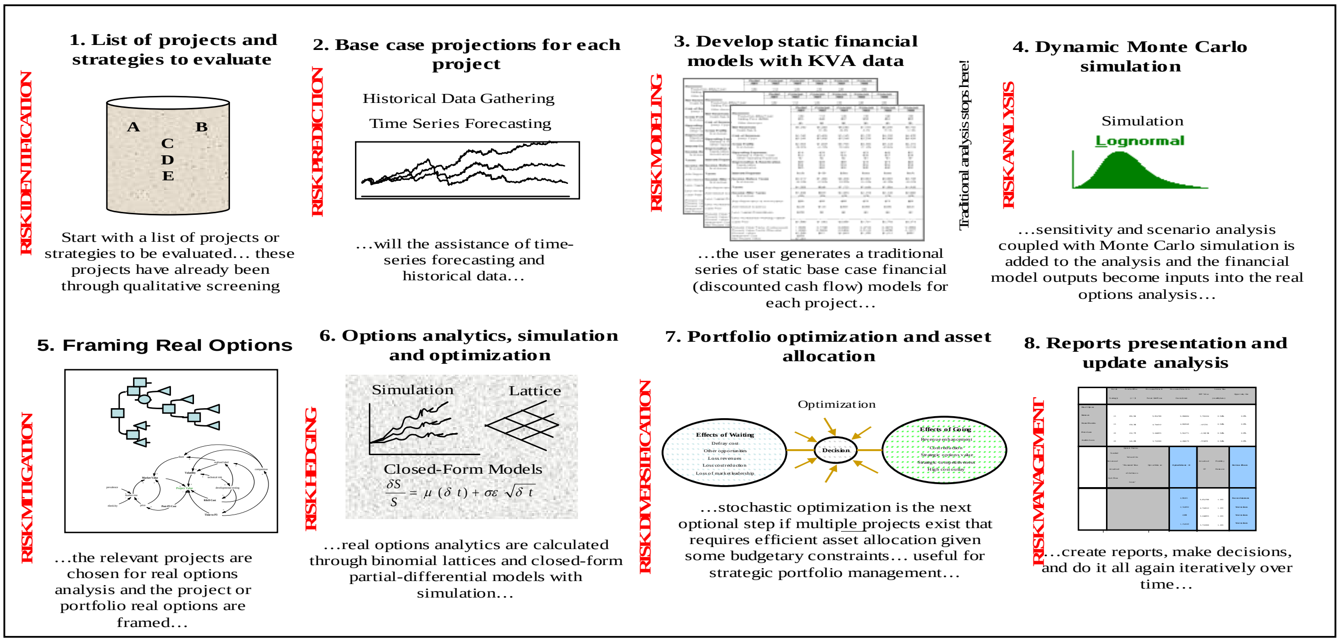
[5] Jonathan Mun, “Using Real-options Software to Value Complex Options,” *Financial Engineering Times* 27 (September/October 2002) pages 23-26.

Figure 5. Types of Real Options and 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

Although there are many approaches, the methodology used in the KVA+RO valuation framework is one developed by leading expert Dr. Johnathan Mun. Dr. Mun's real-options approach consists of eight steps visually represented in Figure 6.

Figure 6. Real Options Analysis Steps



D. Potential Applications of KVA + RO Framework

The strategic value of real options for the DoD is that it offers alternative paths to decision-makers. In a dynamic and uncertain environment where investment decisions must be flexible and fluid, real-options offers insights into alternative paths and how they relate to unique DoD requirements. A tool to augment existing performance tools, KVA+RO can be applied in many areas in the DoD as summarized in Table 3.

Table 3. Potential DoD Applications of KVA and Real Options

	Application
Activity Based Costing (ABC) Enhancement	• KVA provides a way to define common units of output of all processes. • RO/KVA provides a way to compare outputs per cost value flows (not just costs). • KVA provides a cost-per-common-unit of output across all processes.
OMB Circular A-76 Comparisons	• RO/KVA could enhance outsourcing comparisons between the Government's Most Efficient Organization (MEO) and private sector alternatives.
JCIDS and DAS	• RO and RO/KVA present themselves throughout JCIDS requirements generation and the Defense Acquisition System (e.g., DOTMLPF vs. New Program/Service solution, Joint Integration, Analysis of Material Alternatives (AMA), Analysis of Alternatives (AoA) and Spiral Development)
CCOPS Portfolio Analysis	• RO/KVA theory applies to Spiral Development and various organizational configurations, as well as the importance of how Integrated and Open Architectures become RO multipliers.

Source: Cesar Rios, Thomas Housel and Johnathan Mun, "Real Options and KVA in Military Strategy at the United States Navy," in *Modeling Risk: Applying Monte Carlo Simulation, Real Options Analysis, Forecasting, and Optimization Techniques*, ed. Johnathan Mun (New York: Wiley Finance, 2006) 441-452.

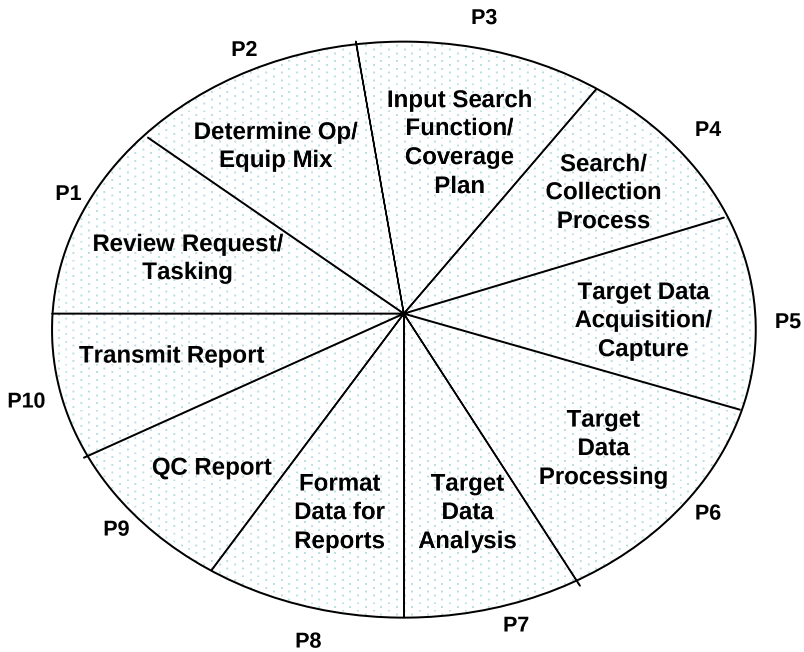
IV. Proof-of-Concept: USS Readiness Case Study

The valuation framework was applied to the fictitious US Navy warship, USS Readiness. Our case study focused on the Cryptologic Carry-On Program (CCOP) portfolio of intelligence information systems and, in particular, the ship-borne signals intelligence collection process. KVA+RO allows for analysis of existing and future CCOP systems on intelligence, search and rescue (ISR) activities, processes and operations for each system in the portfolio. Individual CCOP systems in the portfolio can be compared once baseline data is created, enabling decision-makers to make financial decisions and projections based on quantitative data.

A. Background

The USS Readiness is outfitted to conduct Intelligence, Surveillance, and Reconnaissance (ISR) missions and has a contingent of information warfare operators performing intelligence collection processes utilizing CCOP systems. Principal sub-processes in the ICP are shown in the Figure 7.

Figure 7. The Intelligence Collection Process



The warship is equipped with four CCOP systems: A, B, C, and D. CCOP systems may be used in a single sub-process or across sub-processes, and some systems such as CCOP A are highly complex with multiple subsystems as shown in Table 4 below. Each sub-process is further broken down into individual actions that may be required to perform the sub-process in the intelligence collection process. For example, sub-process "Target Data Processing" can be broken down into a number of human-based tasks requiring no automation.

Table 4. USS READINESS CCOP Systems

	SUB-PROCESS NAME	CCOP A	CCOP B	CCOP C	CCOP D
P1	Review Request/Tasking	X			
P2	Determine Op/Equip Mix	X			
P3	Input Search Function/Coverage Plan	X			
P4	Search/Collection Process	X	X		
P5	Target Data Acquisition/Capture	X	X		
P6	Target Data Processing	X	X	X	X
P7	Target Data Analysis	X		X	X
P8	Format Data for Report Generation	X			
P9	QC Report	X			
P10	Transmit Report	X			

B. Applying KVA Methodology

KVA methodology was applied to quantify the value added by CCOP systems, information warfare/cryptologic operators, and the enabling ship-borne system infrastructure with which they interact. Value provided by human capital elements were compared to IT elements to measure efficiency (productivity) and effectiveness (profitability). All assets, sub-processes, and outputs are first identified.

- ***Asset*** analysis encompasses all value and cost data related to each asset in the process, human capital or IT asset.
- ***Sub-process*** analysis includes a detailed breakdown of the ICP to include the time-to-learn, how to perform each sub-process, and number of executions for each sub-process.
- ***Process*** outputs are established via time-to-learn estimates, including the total number of aggregated process outputs and a surrogate revenue stream used to monetize the outputs.

Asset values and costs are then allocated throughout the sub-processes in which they contribute to the production of outputs. The time-to-learn (knowledge embedded in each sub-process) is multiplied by the number of executions of that sub-process, and the figure serves as a basis for revenue allocation at the sub-process level. Costs are calculated by multiplying the time it takes to produce the process output times the salary of those producing it and the cost per usage of the IT asset. Costing typically does not include the cost of fixed assets as these costs are typically used as a constant weighting factor. Therefore, these costs usually do not affect the relative performance estimates for the various sub-processes. Performance ratios such as ROKA and ROKI can be calculated after costs and benefits for each sub-process are defined.

C. KVA Results

KVA analysis was used to compare two example sub-processes: “Search and Collect” (P4) and “Format Data for Report Generation” (P8). Results are summarized in Tables 5 and 6; issues were identified at the portfolio, program and process levels. The data raises questions, as, noted for each process.

1. Program Level Issues

Table 5. USS READINESS Summary KVA Results
Return on Knowledge (ROK)

Sub-Process		CCOP A	CCOP B	CCOP C	CCOP D	ROK
Review Request/Tasking	P1	168.54%				168.54%
Determine Op/Equip Mix	P2	166.86%				166.86%
Input Search Function/Coverage Plan	P3	152.91%				152.91%
Search/Collection Process	P4	930.03%	148.15%			590.13%
Target Data Acquisition/Capture	P5	290.15%	147.71%			228.23%
Target Data Processing	P6	319.39%	162.59%	436.13%	28.18%	142.41%
Target Data Analysis	P7	149.98%		534.76%	34.55%	121.42%
Format Data for Report Generation	P8	143.34%				143.34%
QC Report	P9	315.88%				315.88%
Transmit Report	P10	148.75%				148.75%
ROK for Total Process		278.59%	152.81%	485.44%	31.37%	196.27%

- CCOP D is a cost-heavy system that executes very few times with negative ROKs throughout the sample period, as seen in Table 5.
  - Is CCOP D appropriate for this platform and mission?
  - What is a less expensive alternative to CCOP D?
  - Are all operators appropriately trained in the use of CCOP D?

2. Process Level Issues

Table 6. USS READINESS Summary KVA Results
Return on Knowledge Investment (ROKI)

Sub-Process		CCOP A	CCOP B	CCOP C	CCOP D	ROKI (ROI)
Review Request/Tasking	P1	68.54				22.11
Determine Op/Equip Mix	P2	66.86				20.89
Input Search Function/Coverage Plan	P3	52.91				-18.44
Search/Collection Process	P4	830.03	48.15			*239.01*
Target Data Acquisition/Capture	P5	190.15	47.71			47.28
Target Data Processing	P6	219.39	62.59	336.13	-71.82	36.67
Target Data Analysis	P7	49.98		434.76	-65.45	21.25
Format Data for Report Generation	P8	43.34				*-20.37*
QC Report	P9	215.88				79.19
Transmit Report	P10	48.75				-17.37
Metrics for Aggregated		178.59	52.81	385.44	68.63	109.9

- The Search and Collect process (P4) is knowledge-intensive, requiring IT and human capital asset investments to complete each sub-process in Table 6. Moreover, each sub-process output necessitates many executions of the sub-process.
  - Could an even higher return be achieved with further automated search and collection systems or more operators?
  - Should the amount of knowledge in humans and IT be adjusted?
  - Could a broader range of training allow operators to perform more functions?

- The Search and Collect process (P4) is a high performer, with an overall return of 239% compared to a -20.37% return for the Format Data for Report Generation process (P 8).
    - What accounts for the discrepancy in the returns received on each process?
- The Format Data for Report Generation process (P 8) only executes once per intelligence report (process output) with nearly one-third of all operators assigned to this sub-process one-fifth of the total human cost.
    - What causes this low efficiency level?
- The Format Data for Report Generation process (P 8) is more automated than P4.
    - Could this process be further automated or performed by other operators to yield higher efficiency and effectiveness levels?

Answers to these questions could help program managers allocate funds to new systems or to existing systems to improve CCOP products or to eliminate a system from the CCOP portfolio. Results could also be used to tailor manning and training requirements of ISR crews deploying CCOP systems.[6] (See Appendix 2 for possible limitations of this KVA analysis)

D. Real Options Analysis

Real options analysis was performed to determine the prospective value of three basic options (summarized in Table 7 below) over a three-year period using KVA data as input for the analysts. Three potential scenarios were identified.

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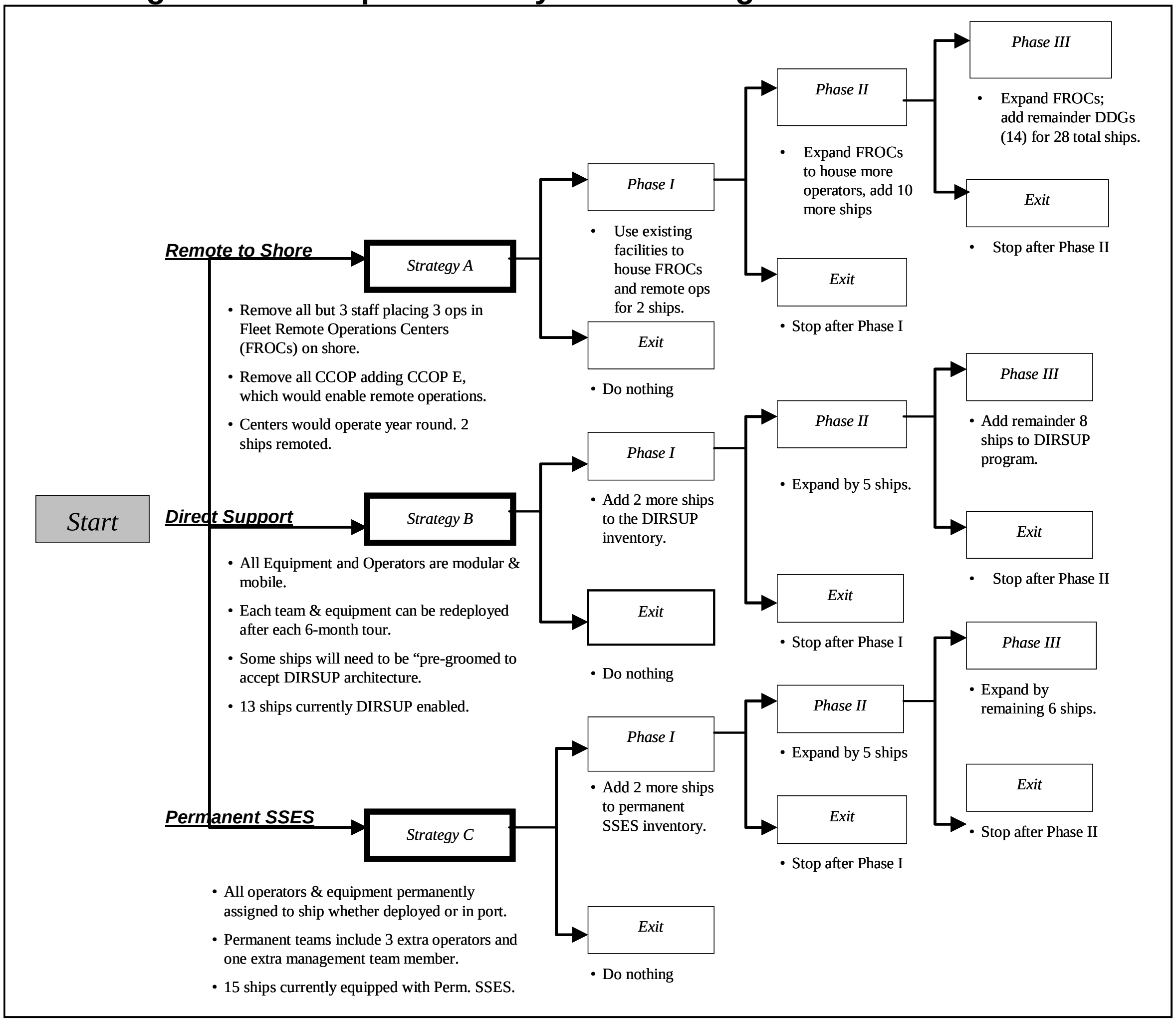
[6] This case study revealed a few limitations to implementation of KVA to the Intelligence Collection Process as modeled in for the USS READINESS. Please see Appendix 2 of the complete case study for limitations and issues being addressed.

Table 7. CCOP Strategic Scenarios

Option A **Remote to Shore**	**Option B** **Direct Support**	**Option C** **Permanent SSES**
• Data viewed from geographically remote center. • Intelligence collection processing from consolidated center requires less intelligence personnel on ships. • Consolidating capabilities into central center popular movement to cut costs and provide more shore based operations to support war-fighting capabilities. • Similar to consolidation of service operations in businesses into larger and fewer call centers.	• CCOP equipment & operators move from ship to ship whenever a ship came into port for maintenance, repair or modernization. • Fewer sets of CCOP equipment and operators required to service intelligence gathering needs of the fleet.	• CCOP systems and operators assigned to given ships at all times. • Requires more operators and CCOP systems. • Potential costs increases, provides more control of intelligence capability by the ships and fleet commanders.

Each strategic scenario is explored further, below in Figure 8.

Figure 8. Real Options Analysis of Strategic Scenarios



Results of the real options analysis in Table 8 below indicate that Option C delivers the highest value at $15.2 million. Although apriori, Options A and B were expected to have significant cost savings, it is possible to see greater total value (with much lower volatility, or risk), for Option C with RO analysis. Fleet and Ship Commanders who intuitively preferred Option C because it permitted greater control of intelligence assets for specific operations now have objective data to help them review their preferred option. This is not to say that the other options might provide greater strategic value in the long run once they are implemented with more productive CCOPs assets and lower volatility based on overcoming the initial decrements in the learning curve of a new process implementation. (See Appendix 3 for a list of companies, organizations using the real options analysis technique.)

Table 8. Summary, Real Options Analysis Results

	Option A	**Option B**	**Option C**
PV Option Cost (Year 1)	$348,533	$1,595,697	$1,613,029
PV Option Cost (Year 2)	$4,224,487	$3,043,358	$4,494,950
PV Option Cost (Year 3)	$3,688,994	$10,105,987	$8,806,643
PV Revenues	$24,416,017	$33,909,554	$38,820,096
PV Operating Costs	$16,220,188	$16,765,513	$9,951,833
PV Net Benefit	**$8,195,829**	**$17,144,041**	**$28,868,264**
PV Cost to Purchase Option	$425,000	$169,426	$72,611
Maturity Years	3.00	3.00	3.00
Average Risk-Free Rate	3.54%	3.54%	3.54%
Dividend Opportunity Cost	0.00%	0.00%	0.00%
Volatility	26.49%	29.44%	15.04%
Total Strategic Value with Options	**$1,386,355**	**$4,466,540**	**$15,231,813**

E. Conclusions and Recommendations

Applying the KVA+RO framework to the USS READINESS demonstrates how defensible and relatively objective metrics could be derived for analysis of each CCOP's ROI performance in the portfolio.[7] (See Appendix 4 that provides a teaching case study based on this research.)

Based on the results of our initial research, we make several recommendations:

- ***Expand scope of initial study***. KVA methodology should be applied and analyzed over a larger sampling period to accurately measure the impact of CCOP systems. A larger study should be conducted on CCOP systems at the Carrier Strike Group (CSG) or Expeditionary Strike Group (ESG) level over the course of one

[7] KVA analysis was conducted on a limited set of data. To obtain a more comprehensive picture of CCOP system contribution, multiple iterations of this analysis would have to be run across the Navy-wide enterprise of intelligence collection platforms to obtain a comprehensive understanding of CCOP program contribution.

deployment to begin establishing performance baselines for systems and processes.[8]

- ***Collect additional process data.*** Supplemental data on human and automated processes should be collected to attain near real-time performance data reporting. Automated logging of system utilization and performance are readily available in many business applications. Adapting such mechanisms for use with CCOP systems would facilitate the performance analysis.

- ***Implement KVA software for real-time analysis.*** Although several accounting software packages have included KVA analytical capabilities, the NPS research team has identified GaussSoft KVA software as the most comprehensive software platform for conducting the level of analysis required by DoD program managers. Implementing GaussSoft software allows real-time system and process inputs to be received, as well as proof-of-concept and a testing of the operational capabilities of the software to be performed. [9]

- ***Expand research study to include other public- and private-sector organizations.*** An extensive research study should be conducted on the Market Comparables Approach to include a valuation study of the intelligence products produced by private military corporations, along with competitive and business intelligence organizations, to achieve a baseline price-per-unit of output metric. One of the study's primary objectives would be to develop universally accepted descriptions of embedded knowledge and required learning time of each system and process.

- ***An external organization should be selected to maintain KVA databases for CCOP systems***. This organization would act as the central repository for system performance data to provide reports and analysis on a quarterly or semi-annual basis, thus enabling program managers to make informed acquisition decisions. This data could be expanded to include other systems and core processes to benchmark performance across the enterprise.

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[8] Currently in process with the Third Expeditionary Strike Group.

[9] Currently in process with the Third Expeditionary Strike Group.

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V. Conclusion

The national security environment of the United States has changed dramatically over the past several years. In addition, sweeping changes in the corporate landscape have mandated changes in the way government and corporations manage fiscal responsibilities, investments and mitigate risk. The KVA+RO framework is a powerful support tool for decision-makers in both sectors, assisting them to meet those challenges more effectively.

KVA is an analytic tool that monetizes the value, along with cost, of each process. It analyzes individual assets by asking ***how much*** an asset contributes to overall performance of the process. RO analysis estimates the total future value of a portfolio of options by leveraging uncertainty and limiting downside risk. Collectively, KVA and RO provide critical insights into the performance of the productive assets of organizations.

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Appendix 1. Calculation Steps in KVA Methodology

Step 1: Calculate Time-to-learn.

- ***Time required for average worker to learn sub-process (amount of knowledge required to produce a single aggregate sub-process output) is estimated.***

Step 2: Calculate Value of Output (K) for each sub-process.

- ***Calculate amount of output produced in sub-process, by asset type (human or IT) by counting the times an asset executes a sub-process.***
- ***Multiply that figure by the time required to learn sub-process.***

Step 3: Calculate Total K for process.

- ***Once** K **for each asset has been calculated, sum it to reveal total** K **for each sub-process.***

Steps 4 & 5: Derive Market Comparables Revenue surrogate and develop the Equation *Numerator by assigning revenue streams to sub-processes.*

- ***Under the market comparables approach, multiply total number of outputs by the average market price-per-unit to yield a Surrogate Revenue.***

Step 6: Develop the value equation denominator by assigning costs to sub-processes.

- ***Assign costs directly to each sub-process based on the assets producing outputs in each.***
- ***Divide cost of infrastructural assets assigned to multiple processes evenly throughout those sub-processes.***
- ***Sum costs of assets in each sub-process to yield the total cost per sub-process.***

Step 7: Calculate productivity, profitability and value ratios of ROI, ROKA or RKOI

- Calculate the value equations of ROK, ROKA and ROKI using revenues and costs assigned to sub-processes, people and IT.

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Appendix 2. Current Limitations of KVA Methodology

The case study revealed a few limitations to the implementation of KVA on the ISR process that are being addressed. These limitations are:

- With the raw data required for the analysis residing in multiple databases of varying classification levels, data-gathering mechanisms that are less human-intensive and more automated need to be created to extract the required information.
- Although the ICP in this case study was developed through the use of subject-matter experts, a standard description and definition of each sub-process should be reached through an Intelligence Community-wide consensus of process stake-holders.
- A more detailed research should be conducted to analyze the knowledge embedded in each IT system to accurately capture the benefits resulting from the execution of particular system processes.
- The Market Comparables approach to valuing the outputs of non-profit organizations, although used as a rough baseline to monetize outputs in this case study, requires a more in-depth look at comparable organizations utilizing similar processes to produce similar outputs. A broad database of such organizations is currently being created to benchmark industries by functional groupings and products.
- To provide a more powerful analysis of the ICP, a database of comparable historical KVA information should be created to benchmark future work or to provide a broader insight for current work.

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Appendix 3. Select List of Organizations Who Have Applied KVA Methodology

Airtouch

Arthur Anderson

Community Financial Resource Center (non-profit)

Courthouse Athletic Club

Direct TV

Department of Defense (numerous applications)

Earl Security

Financial Services Consultants LTD.

First Sierra Financial

First World Communications

Hughes Space and Communications Company

IBM GLOBAL SERVICES

Info. Technologies

Internet Productions

Lockheed Martin Telecommunications

Morey Bodyboard (Mattel Corp.)

Mullen

Nevada Bell

NOVA Chemical

Pacific Bell

Richwood Industries

AT & T (SBC, Inc.)

SpectraNet International

Stentor

Tokio Marine and Fire

Toyota Motors Sales

TRW

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Appendix 4. Case Study for Possible Use in Classes (Derived from the research study)

Operational Case Study: Acquiring and Deploying Information Technology

The proverbial $64 Billion dollar question is: “What investment in IT provides the best return and how should I deploy the IT for best effect?” Answering this two part questions involves estimating the kinds of return on investment (ROI) various IT investments options will provide as well as how best to deploy the IT to achieve the desire effects on operations.

This case study asks you to examine the various ROIs provided by four intelligence gathering (i.e., signal intelligence) IT systems in terms of how you would invest (or not invest) in each. It also asks you to identify the various options for deploying the systems. At the end of the day, what really matters is what the IT does for operators and their respective productivity.

Problem Overview

The United States has experienced dramatic changes in national security over the past 15 years, shifting away from the conventional threats posed during the Cold War era to more unconventional threats as evidenced by the tragic events of September 11 and the continuing global war on terrorism. To meet the challenges of the new national security environment, the Department of Defense (DoD) plans to spend $1.3 trillion between 2005 and 2009 for major programs ranging from new intelligence programs to homeland defense and military operations oversees.[10]

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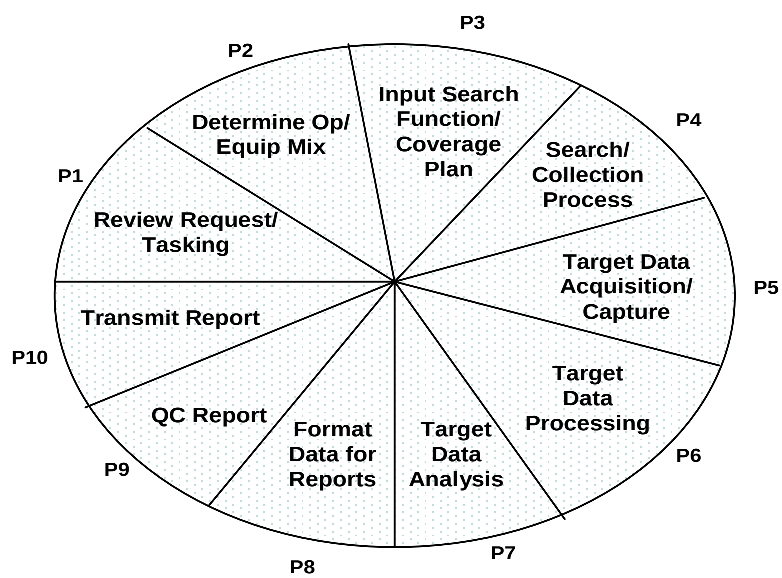
[10] GAO, “Better Support of Weapon System Program Managers Needed to Improve Outcomes,” Nov. 2005.

This case study focuses on the cryptologic carry-on program (CCOP) portfolio of intelligence information systems and in particular, the ship borne signals intelligence collection process. The USS Readiness is outfitted to conduct Intelligence, Surveillance, and Reconnaissance (ISR) missions and has a contingent of information warfare operators performing intelligence collection processes utilizing CCOP systems. Principal sub-processes in the ICP are shown in the following diagram.

The Intelligence Collection Process



The warship is equipped with four CCOP systems (A, B, C, and D). CCOP systems may be used in a single sub-process or across sub-processes, and some systems such as CCOP A are highly complex with multiple subsystems. Each sub-process is further broken down into individual actions that may be required to perform the sub-process in the intelligence collection process. For example, sub-process "Target Data Processing" can be broken down into a number of human-based tasks requiring no automation.

Table 1. USS READINESS CCOP Systems

	SUB-PROCESS NAME	CCOP A	CCOP B	CCOP C	CCOP D
P1	Review Request/Tasking	X			
P2	Determine Op/Equip Mix	X			
P3	Input Search Function/Coverage Plan	X			
P4	Search/Collection Process	X	X		
P5	Target Data Acquisition/Capture	X	X		
P6	Target Data Processing	X	X	X	X
P7	Target Data Analysis	X		X	X
P8	Format Data for Report Generation	X			
P9	QC Report	X			
P10	Transmit Report	X			

ROI Analysis

ROI analysis was used to compare two example sub-processes: "Search and Collect" (P4) and "Format Data for Report Generation" (P8). Results are summarized in the following tables.

Table2. USS READINESS Summary ROI Results

Sub-Process		CCOP A	CCOP B	CC OP C	C COP D	ROI
Review Request/Tasking	1	68.54%				22.1 1%
Determine Op/Equip Mix	2	66.86%				20.8 9%
Input Search Function/Coverage Plan	3	52.91%				- 18.44%
Search/Collection Process	4	830.03%	48.15%			*239. 01%*
Target Data Acquisition/Capture	5	190.15%	47.71%			47.2 8%
Target Data Processing	6	219.39%	62.59%	33 6.13%	-71.82%	36.6 7%
Target Data Analysis	7	49.98%		43 4.76%	-65.45%	21.2 5%
Format Data for Report Generation	8	43.34%				*- 20.37%*
QC Report	9	215.88%				79.1 9%
Transmit Report	10	48.75%				- 17.37%
Metrics for Aggregated		178.56%	52.81%	38 5.44%	- 68.63%	109. 90%

- CCOP D is a cost-heavy system that executes very few times with negative ROIs throughout the sample period, as seen in Table 2. Questions arising from this analysis include:
  - Is CCOP D appropriate for this platform and mission?
  - Are all operators appropriately trained in the use of CCOP D?

- The Search and Collect process (P4) is a high performer with an overall return of 239% compared to a -20.37% return for the Format Data for Report Generation process (P 8).
    - What accounts for the discrepancy in the returns received on each process?
    - What hurdle rate should be set for each process?
- The Format Data for Report Generation process (P 8) only executes once per intelligence report (process output) with nearly one third of all operators assigned to this sub-process (representing one fifth of the total human cost for the overall process).
    - What causes this low efficiency level?
- The Format Data for Report Generation process (P 8) is more automated than P4.
    - Could this process be further automated or performed by other operators to yield higher efficiency and effectiveness levels?

Answers to these questions could help program managers allocate funds to new systems or to existing systems for improve products or to eliminate a system from the CCOP portfolio. Results could also be used to tailor manning and training requirements of ISR crews deploying CCOP systems.

Strategic Level Questions

This case was focused on how the CCOPs manager

With lives at stake and billions of dollars at risk, difficult choices are made by the DoD on which projects to fund where tradeoffs occur. Should investments be made towards personnel or investments in new technology? Should more funding be allocated towards intelligence collection or processing?

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