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Return on investment analysis of information warfare systems

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THESIS

RETURN ON INVESTMENT ANALYSIS OF INFORMATION WARFARE SYSTEMS

by

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September 2005

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The United States Navy's Cryptologic Carry-On Program Office manages a portfolio of Information Warfare (IW) systems. This research and case study demonstrate how the Knowledge Value Added (KVA) Methodology can be used to formulate a framework for extracting and analyzing performance parameters and measures of effectiveness for each system. KVA measures the effectiveness and efficiency of CCOP systems and the impact they have on the Intelligence Collection Process (ICP) on board U.S. Navy Ships. By analyzing the outputs of the subprocesses involved in the ICP in common units of change, a price per unit of output can be generated to allocate both cost and revenue at the subprocess level. With this level of financial detail, a return on investment (ROI) analysis can be conducted for each process, or asset.

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RETURN ON INVESTMENT ANALYSIS OF INFORMATION WARFARE SYSTEMS

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ABSTRACT

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I. INTRODUCTION

A. PURPOSE / PROBLEM STATEMENT

Millions of dollars are spent each year on quick reaction capability (QRC) Information Warfare (IW) and intelligence collection systems. These information technology (IT) systems are used to fill existing capability gaps at the Fleet, theater and strategic level. Managing these portfolios of equipment as an investment requires that program managers be able to maximize the benefits of the systems in a systematic manner while considering the impact of cost throughout the enterprise. To successfully accomplish this task, it is essential to develop a means and methodology to measure the performance of the IT investments in an objective manner. As of yet, no acceptable measure of their performance or benefit has been developed to determine whether the systems are yielding an adequate level of performance or return on investment (ROI).

B. BACKGROUND

Intelligence, as stated in the National Security Strategy (NSS) of the United States, is the nation's first line of defense against terrorists and other hostile nations. The document calls for innovation within the armed forces to transform intelligence and exploit the country's advantages in science and technology, stating the following:

> Innovation within the armed forces will rest on experimentation with new approaches to warfare, strengthening joint operations, exploiting U.S. intelligence advantages, and taking full advantage of science and technology […] We must transform our intelligence capabilities and build new ones to keep pace with the nature of these threats.[1]

According to the NSS, intelligence capabilities must be transformed and new capabilities must be built to keep pace with emerging threats. Intelligence systems must be appropriately integrated with defense and law enforcement systems as well as Allied systems. The NSS calls for hard choices to "ensure the right level and allocation of government spending on national security."[2] It also calls for an investment in future intelligence capabilities and a strong security infrastructure to prevent the compromise of

[1] United States. President. The National Security Strategy of the United States of America. Washington, White House, 2002. p. 30. <http://www.whitehouse.gov/nsc/nss.pdf> [1 June, 2005].

[2] Ibid. pp. 30-31.

those capabilities. Lastly, the NSS acknowledges the managerial changes that must be made stating that "[w]e must also transform the way the Department of Defense is run, especially in financial management."[3]

Transformation of the business practices internal to the Department of Defense (DoD), to include financial and program management, is a key enabler for achieving the intelligence goals of the NSS.[4] With this mandate, the DoD established the Defense Acquisition System, DoD Directive 5000.1, dated 12 May 2003, to manage the technological investments, resources and programs required to accomplish the NSS and support the Armed Forces. The primary objective of the DoD 5000 Series is to acquire "quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price." [5] To realign the individual services' intelligence efforts with the DoD transformational practices, coordinative mechanisms such as the Joint Intelligence Surveillance and Reconnaissance (ISR) Operational Concept and the Joint ISR Operational Architecture (ISR JOC/JOA), have been created.[6]

1. Navy ISR

The Naval Transformation Roadmap of 2003 calls for the reengineering of maritime ISR to align with the DoD's 5000 Series and joint warfighting concepts with the goal of redefining standards and metrics and ensuring interoperability, while providing the warfighter required capabilities in a timely, cost-effective and efficient manner.[7] Maritime ISR lies at the core of the Naval Operational Doctrine and is an essential element in improving the speed and effectiveness of naval and joint operations. It is necessary, with today's threat, to expand the range of ISR options available to the commander and ensure decision superiority across the range of military operations in accordance with the NSS. From a program management point of view, there are several

[3] United States. President. The National Security Strategy of the United States of America. Washington, White House, 2002. p. 30. <http://www.whitehouse.gov/nsc/nss.pdf> [1 June, 2005].

[4] Ibid. 31.

[5] Department of Defense. DoD Directive 5000.1. "The Defense Acquisition System." 12 May 2003. p. 2.

[6] Department of the Navy. Naval Transformation Roadmap 2003: Assured Access & Power Projection…From the Sea. Washington: Dept. of the Navy, 2003. pp.68-69.

[7] Ibid. 69.

challenges in meeting future requirements. First, program mangers must create a requirements management program that will thoroughly capture the joint warfighters' seemingly intangible inputs and translate them as accurately as possible to ensure the system will satisfy the user requirements. Next, needs and requirements must be transformed into a comprehensive set of product and process system descriptions to "solve" the ISR problem in a top-down manner by applying the Systems Engineering Process (SEP). The requirement for the integration of cutting-edge technology and limited resources must be leveraged with the use of Commercial Off-The Shelf and Government Off-The-Shelf (COTS/GOTS) systems in an Open Architecture (OA) that will integrate seamlessly with existing systems. Lastly, innovative techniques to metricize Key Performance Parameters (KPPs) must be developed to facilitate integrated Testing and Evaluation of Navy and Joint ISR programs.

With this backdrop, the goal of Navy ISR program managers is to develop an investment strategy for maritime ISR systems consistent with validated warfighter requirements and within the framework of approved architectures. The strategy should adhere to a national-level strategic view, and balance the development of new intelligence collection capabilities, modernization of current systems, and sustainment of existing infrastructures, as well as move toward robust interoperability. The DoD 5000 Series and the Joint Capabilities Integration and Development System (JCIDS), delineated in the Chairman Joint Chiefs of Staff Instruction (CJCSI) 3170.01E, dated 11 May 2003, and other governing documents such as the Government Performance and Results Act (GPRA), and the Information Technology Management and Results Act (ITMRA) serve as a guidelines for addressing these challenges.

2. The Cryptologic Carry-On Program

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. CCOP systems have broad scope and functions. There are approximately 100 cryptologic capable surface ships in the current Navy inventory. Each of these ships is a potential user of carry-on equipment. In addition, there are numerous subsurface and air platforms that are also potential users. CCOP provides the necessary resources to enable a rapid transition of available Commercial off the Shelf (COTS) and Government off the Shelf (GOTS) technologies that apply ISR system functionalities. These technologies typically require various levels of integration to leverage on-board capabilities that provide system and mission management, product reporting and data analysis support. COTS/GOTS systems usually require some level of adaptation or modification to meet fleet requirements. Before deployment for operational use, systems must be systematically tested to ensure suitable and reliable operation. They must also be tested for network vulnerabilities (if connected to Navy or Joint networks), and tested against joint interoperability requirements. [8]

3. Acquisitions Implications

The Department of Defense Directive 5000.1, 12 May 2003, states that advanced technology shall be integrated into producible systems and deployed in the shortest time practicable to address "capability gaps" between stated national security threats and the ability to properly address them with current capabilities.[9] Evolutionary Acquisition (EA) is the preferred DoD strategy for rapid acquisition of mature technologies. An evolutionary approach delivers capability in increments, recognizing, up front, the need for future capability improvements.[10] The CCOP shares this objective of EA, which is to balance needs and available capabilities with resources, and to put capability into the hands of the user quickly.

a. COTS/GOTS and Open Architectures

The DoDD 5000.1 also states "A modular, open systems approach (MOSA) shall be employed, where feasible." Historically, cutting-edge ISR systems were costly and often "stovepiped." They were not readily adaptable or reconfigurable for a rapidly changing global threat. The DoD mandated use of MOSA and a migration to open systems architectures that incorporate commercial solutions to address the fast-

[8] Department of Defense. "The Advanced Cryptologic Systems Engineering Program: Budget Item Justification." Washington: February,2004. <http://www.dtic.mil/descriptivesum/Y2005/Navy/0204574N.pdf#search='Advanced%20Cryptologic%20Systems%20Engineering%20program'> [April 2005]

[9] DoDD 5000.1, 12 May 2003. p. 2.

[10] Department of Defense. DoD Instruction 5000.2. "Operation of the Defense Acquisition System." 12 May 2003. p. 3.

paced threat. A number of information systems architectures, policies, procedures and standards have been developed and implemented to enable the interoperability of these new systems and facilitate the migration.[11] MOSA enables CCOP systems to be designed for affordable change with reduced life cycle costs. It also facilitates the employment of evolutionary acquisition with more opportunities for technology insertion and shortens the total acquisition time.

b. Risk Management

The Risk Management Guide for DoD Acquisition (June 2003) defines risk management as "the art and science of panning, assessing, and handling future events to ensure favorable outcomes. The alternative to risk management is crisis management." The use of COTS/GOTS and MOSA in the CCOP all provide a level of risk, which must be managed. The increasing system technological complexities, the reliance on complex software, along with shortened acquisitions timelines and funding instability all contribute to this risk. Modeling and simulation (M&S) tools should be used to mitigate some of the risk in the CCOP. In particular, cost models should be employed to determine projected lifecycle costs along with manpower and performance M&S tools. The Defense acquisition Guide Book (Nov 2004) suggests that alternatives to the traditional cost estimation need to be considered because legacy cost models tend not to adequately address costs associated with information systems.[12]

C. RESEARCH OBJECTIVES

The objective of this research is to develop a decision support model and methodology to assist in the budgeting process for the United States Navy's Chief of Naval Operations (OPNAV) CCOP Program Office (OPNAV N201) acquisition of information warfare systems. The model will assess the effectiveness and efficiency of the CCOP portfolio of IW systems in support of the achievement of the Navy ISR mission. The methodology will be used to develop quantitative objectives that are based on measurable data and quantifiable criteria. Once measures are defined, an objective performance baseline for each system in the portfolio can be created with which to

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[11] Department of Defense. Maritime SIGINT Architecture Technical Standards Handbook v. 1.0. Ft. George G. Meade, MD: NSA/CSS, 23 August 1999. p. 6.

[12] Department of Defense. The Defense Acquisition Guidebook. The Defense Acquisition University. Sect. 4.5.7.2

compare the impact of existing and future CCOP systems on individual activities, processes and operations. The resulting information can then be utilized to make sound financial decisions and projections in the acquisition and deployment of these systems.

D. METHODOLOGY

This thesis will attempt to model the intelligence collection process (ICP), as it applies to shipborne signals intelligence (SIGINT) collection, and measure the impact of CCOP Systems on the process utilizing the Knowledge Value-Added (KVA) methodology. First, all assets, subprocesses, and outputs will be identified. The analysis of assets will encompass all cost data related to each asset in the process, human and IT. The subprocess analysis will contain a detailed breakdown of the ICP to include the time-to-learn and number of executions for each subprocess. The process outputs will also be analyzed to include the total number of process outputs and a surrogate revenue stream that will be used to monetize the outputs. Next, asset costs will be allocated throughout the subprocesses in which they contribute to the production of outputs. The time-to-learn, or knowledge embedded in each subprocess will be multiplied by the number of executions of that subprocess. The resulting figure will be used as a basis for the KVA Approach for allocating revenue at the subprocess level. Once a cost and benefit for each subprocess has been determined, performance ratios such as ROA and ROI can be calculated.

Comparing performance measures of various configurations of CCOP systems within the shipborne ICP can assist program managers in identifying targets of transformation, which will aid in making higher-level acquisition strategy decisions.

II. RETURN ON INVESTMENT

A. WHAT IS ROI?

While there are many forms of "return" such as return on equity (ROE), return on performance (ROP) and return on assets (ROA), the focus of this research is the overarching concept of Return on Investment (ROI).

1. ROI Defined

Return on Investment or ROI has been defined in many ways, but it has generally been known to encompass the quantification of the past, present, and potential future performance of an organization or business. More specifically, the return on investment in assets is a measure of performance that is determined by the percentage relationship of earnings to assets.[13] Many companies and organizations view ROI both as a goal as well as a measure of profit and asset performance. In its most generic form, it is characterized by the following equation:[14]

$$PercentageROI = \frac{Earnings}{Investment}$$

In this equation, earnings, or the net operating income of an organization or business is the difference between revenue and expenses. Investment can also carry a wide connotation, but in a general case, the amount of investment is determined by an examination of an organization's original capital and its assets, both financial and physical. Thus, a higher return, or percentage ROI, indicates a more efficient and effective use of those assets and capital.

Another view of ROI, by Clarence Nickerson, a Professor of Business Administration Emeritus at the Harvard University Graduate School of Business Administration, recognizes that "the value of a business property is dependent on what it

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13 Nickerson, Clarence B. Accounting Handbook for Nonaccountants. 3rd Ed. New York: Van Nostrand Reinhold Co., 1986. p. 73.

14 Ibid. 632.

can produce."[15] He also states, "in order to judge the value of the wealth created, we should take into account the property required to produce it."[16]

As a practical mater, ROI can be used to determine the potential benefit of a single investment strategy or of multiple strategic investment options. Forecasting revenue streams and comparing them with the expected capital investment and operating costs of a single strategy over the course of time, or of multiple strategies can accomplish this. ROI yields valuable insight for managers and investors making high-level business strategy decisions. But what if an organization produces no measurable "revenue," in the business sense of the word?

B. ROI IN THE PUBLIC SECTOR

As the budgets of public sector organizations are coming under increased scrutiny, stakeholders, managers and taxpayers are all demanding a higher level of accountability and transparency of the public investment in those organizations. Additionally, regulations such as the Government Performance Results Act of 1993 (GPRA), require the establishment of strategic planning and performance measurement in programs for the accountability of their expenditures. Faced with these challenges, public sector organizations have been, for many years, searching for a defensible means of producing the metrics required to measure the value of the services and products they provide. In some cases, an organization may produce outputs that are similar to those of a commercial organization or business, allowing that organization to directly place a value to its products and services based on the market price or value of the commercial products. But many public sector organizations are inherently different, and require a different approach to the determination of their ROI.

1. The Public Sector Problem

There are several issues that must be considered when conducting an ROI analysis in the public sector. First, the frequent absence of measurable revenues and profits make it a challenge to determine the overall benefit stream produced by the organization. Secondly, hard data is often difficult to collect amidst an abundance of seemingly

[15] Nickerson, Clarence B. Accounting Handbook for Nonaccountants. 3rd Ed. New York: Van Nostrand Reinhold Co., 1986. p. 652.

[16] Ibid.

intangible, soft data. Also, ROI depends on the notion of costs and benefits. In the public sector though, the recipients of the benefits or stakeholders are not easily identifiable; potential beneficiaries could be program participants, managers of participants, sponsors of the program or even taxpayers who are concerned about their tax-dollars. Another problem lies at the very nature of public-sector organizations and government services in particular, whose services are "essential" and must be provided, regardless of the accountability or cost. Lastly, public-sector organizations do not often have the range of flexibility or options to correct problems and make radical changes.[17]

2. The Public Sector Reality

The reality of public-sector organizations is that they do provide benefits, although in most cases these are presented in the form of cost savings resulting from improved quality, increased productivity or timesaving initiatives. Monetizing the benefits directly may be difficult, but new approaches to the problem are currently being developed. The issue of hard data is also one that can be overcome; output, quality, cost and time are all usually measurable in private as well as public-sector organizations and represent viable categories of hard data. The notion that services provided by government organizations are essential and above scrutiny is also being dispelled; regulations such as the GPRA are requiring all agencies to undergo evaluation to ensure they are operating effectively and efficiently.[18] And finally, identifying flexibility or options in public-sector organizations is not only possible, but required if a desire exists to improve the effectiveness of public programs and services.

This research focuses on public sector ROI as it applies to the Department of Defense and a portfolio of information technology (IT) assets. Because of the variable nature of IT and their benefits, determining ROI on them poses some unique challenges.

C. IT ROI

Organizations, public and private, make investments in information technology with the goal of improving the efficiency, timeliness, quality and effectiveness of their

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17 Phillips, Patricia P. "ROI in the Public Sector." Ed. Patricia Phillips. Alexandria, VA: American Society for Training and Development, 2002. <http://www.astd.org/NR/rdonlyres/779B0547-EB1F-48E5-8776-7808107FD010/0/Whitepaper.pdf#search='ROI%20in%20the%20public%20sector'> [August 2005]

18 Ibid.

services, products or processes. The problem these organizations face though, is discerning the amount of value contributed by their IT investments on the processes in which they are meant to operate.

1. Current Approaches

There have been numerous approaches to assessing the impact of IT on an organization's fiscal performance at the corporate and sub-corporate levels of aggregation. Table 1 summarizes some of the most common approaches to measuring the return on IT and the advantages and limitations of each.

Level of Analysis	Approach	Focus	Example	Key Assumption	Key Advantage	Limitation
Aggregate Corporate (firm) level	Process of Elimination	Treats effect of IT on ROI as a residual after accounting for other capital investments	Knowledge capital	ROI difficult to measure directly	Uses commonly accepted financial analysis techniques and existing accounting data	Cannot drill down to effects of specific IT initiatives
	Production Theory	Determines the effects of IT 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 at firm level	"Black-box" approach with no intermediate mapping of IT's contributions to outputs
	Resource-Based View	Linking firm core capabilities with competitiveness		Uniqueness of IT resource = competitive advantage	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 the best point at which to exercise an option to invest in IT		Timing exercise option = value	Predicting the future value of an IT investment	No surrogate for revenue at sub- corporate level

Sub-corporate (Process)	Family of Measures	Measure multiple indicators to derive unique contributions of IT at sub-corporate level	Balanced score-card	Need multiple indicators to measure performance	Captures complexity of corporate performance	No common unit of analysis/ theoretical framework
	Cost-Based	Use cost to determine value of information technology	Activity-based costing	Derivations of cost ≈ value	Captures accurate cost of IT	No surrogate for revenue at sub- corporate level -- no ratio analysis
	Knowledge Value Added	Allocating revenue to IT in proportion to contributions to process outputs	Housel & Kanevksy KVA Methodology	IT contributions to output ≈ IT value-added	Allocates revenue and cost of IT allowing ratio analysis of IT value-added	Does not apply directly to highly creative processes

Table 1. Common Approaches to Measuring Return on IT. [19]

These approaches are subdivided into two distinct levels of analysis, the corporate level and the sub-corporate level. Corporate-level approaches seek to determine the contribution of the assets, both knowledge and IT, on the overall performance of the organization. The sub-corporate-level approaches look internally at the sub-processes which are involved in the production of organizational output and attempt to establish a measure for the benefits of knowledge and IT assets within each sub-process. The goal of each approach is to provide managers with a metric of value for their organization's investment in IT and knowledge assets.

D. MANAGING IT INVESTMENTS IN THE DOD

It is the stated goal of the Department of Defense (DoD) that all information technology (IT) programs within the organization be managed as investments rather than acquisitions. To accomplish this, and to fall within the framework of regulations and legislation such as the Government Performance and Results Act (GPRA) and the Information Technology Management and Results Act (ITMRA), the DoD has made it its goal to establish performance measures in the IT investment process.

[19] Housel, T., Jansen, E., Pavlou, P. & Rodgers, W. "Measuring the Return on Information Technology: A Knowledge-Based Approach for Revenue Allocation at the Process and Firm Level." Monterey, CA: Naval Postgraduate School, August 2005.

1. Defining IT Performance Measures in the DoD

The Department of Defense Guide for Managing Information Technology (IT) as an Investment and Measuring Performance v.1.0 (10 February 1997), defines IT performance measure as:

> the assessment of effectiveness and efficiency of IT in support of the achievement of an organization's missions, goals, and quantitative objectives through the application of outcome-based, measurable, and quantifiable criteria, compared against an established baseline, to activities, operations, and processes […] Performance Measurement is the means by which an organization measures it effectiveness and efficiency in the pursuit of its missions, goals, and objectives.[20]

Effectiveness implies accomplishing the required mission tasks and goals while ensuring customer satisfaction and high quality. Efficiency implies that the best possible use of available resources was employed to improve quantity or work, reduce costs and improve timeliness of the overall project.

2. Steps for Effective Performance Measurement

To assist managers in maximizing the benefits of IT investments, the guide outlines six steps in effective performance measurement:[21]

- *Define mission, key result areas, and business functions.*
- *Develop mission related goals.*
- *Generate performance measures/indicators.*
- *Validate and verify performance measures.*
- *Implement the performance measures and collect data.*
- *Monitor and assess the results and repeat the process as needed.*

3. Levels of Management

The DoD also recognizes that managers at different levels of any organization require different types of information from which to base their investment and business

[20] Department of Defense. Guide for Managing Information Technology (IT) as an Investment and Measuring Performance. Version 1.0. Arlington, Virginia: Vector Research Inc., 10 February 1997. ES-i.

[21] Ibid.

strategies on. The guide identifies three management levels: Enterprise, Functional, and Program/Project Level.[22] At the Enterprise Level, managers are focused on policy and mission decisions to guide the strategic direction of acquisition decisions. The Functional Level managers focus on unit results and improving the operational processes which produce them, mission related outcome measures are also developed at this level. At the Program/Project Level, managers and project leaders focus on the activities and tasks critical to making and executing tactical and management decisions. Program managers and project leaders are also the focal point from which the other levels receive detailed performance and valuation data for individual systems, projects, processes and activities. This is the level where the CCOP Program Office functions and where this research was primarily focused.

4. Performance Measurement at the Program/Project Level

Program/Project-Level managers and leaders capture and generate the information required by managers at the other two levels. It is necessary, at this level, to determine what key information is needed to develop defensible, accurate and meaningful performance measures. Among these measures is Return on Investment, ROI.

At a minimum, ROI consists of both a return (i.e., benefit) component and an investment (i.e., cost) component. The cost component measures the number of investment dollars management has placed into the human, infrastructure and IT assets of the program or project; this information is generally documented in detail. Benefit measures are much more complex. The DoD guide defines "the accomplishment of functional missions and goals,"[23] as a measure of benefit. How a program, project, process or asset contributes to overall mission accomplishment is normally a matter of efficiency and effectiveness. The question often raised though is "how is efficiency and effectiveness measured and how do they translate into dollars?"

To be mathematically sound, ROI requires that benefits AND costs be monetized. While mangers or analysts can directly measure the benefits of some investments in monetary terms (e.g., cost savings or lower overhead), oftentimes they cannot be directly

[22] Department of Defense. Guide for Managing Information Technology (IT) as an Investment and Measuring Performance. Version 1.0. Arlington, Virginia: Vector Research Inc., 10 February 1997. p. 3-4.

[23] Ibid. 6-9.

measured monetarily. Such is usually the case with many IT systems, projects and programs. The DoD Guide summarizes 12 approaches to measuring the performance of IT that are similar to those in Table 1, but recognizes that the list is not complete.[24] The following chapters outline an alternative method and approach.

24 Department of Defense. Guide for Managing Information Technology (IT) as an Investment and Measuring Performance. Version 1.0. Arlington, Virginia: Vector Research Inc., 10 February 1997. p. 8-1.

III. THE KNOWLEDGE VALUE ADDED METHODOLOGY

A. THE COMPARABILITY AND VALUE PROBLEM

There are several situations the realm of business and non-profit organizations that can benefit from a method for measuring the value of knowledge assets both human and IT. The first hurdle in solving the problem is defining what is meant by "value". The simplest measure of value, as presented by Dr. Myron L. Cramer, is dollars: how much is earned or saved. The metric of dollar-value is primarily used in assessing contributions in a commercial or business context.[25] A problem exists though, when applying dollar-value in the DoD case where different methods are used to assess how systems or people contribute "value" to combat effectiveness or mission completion. These methods often fail to capture the benefit stream produced by organizations, processes or assets in standard or comparable units of measure. And oftentimes, the only metric that is measured with any level of standardization and accuracy is cost. Benefits, while measured in terms of varying degrees of contribution, are seldom represented in the monetized fashion required by traditional accounting methods for extracting a value or Return on Investment.

Another problem present in the DoD case is the translation of outputs into monetary benefits. Whereas in the commercial case, a price per unit is assigned to the outputs, there is no equivalent pricing mechanism in the DoD or non-profit case. This presents a problem when conducting empirical financial analysis and in particular when seeking a baseline from which to formulate sound fiscal decisions.

B. THE KVA SOLUTION

1. Knowledge Value-Added (KVA) Theory

Knowledge Value-Added (KVA) created by Dr. Tom Housel (Naval Postgraduate School) and Dr. Valery Kanevsky (Agilent Labs). Initiated almost 15 years ago, KVA was built on tenets of complexity and entropy theory, and was developed in response to business process reengineering efforts of organizations that, with no other method

[25] Cramer, Myron. "Measuring the Value of Information." Atlanta, GA: Georgia Tech Research Institute. <http://iw.gtri.gatech.edu> [20 July 2005]. p. 2

available, focused primarily on cost cutting measures to determine the "value" of a process or knowledge asset. KVA is based on the assumption that humans and technology in organizations add value by taking inputs and changing them into outputs through core processes.[26] The amount of change an asset or process produces can, in fact, be a measure of value or benefit.

KVA is a general theory for estimating the value added by knowledge assets, human and IT, using a methodology that is analytic and tautological. 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, in some manner, the raw inputs (i.e., labor into services, information into reports). KVA explains the changes made on the inputs by organizational processes to produce outputs in terms of the equivalent corresponding changes in entropy. The concept of entropy is defined in the American Heritage Dictionary as a "measure of the degree of disorder [or change] in a closed system." In the business context, it can be used as a surrogate for the amount of changes that a process makes to inputs to produce the resulting outputs. [27]

2. KVA Assumptions

KVA uses knowledge-based metaphor to operationalize the relationship between change in entropy and value added. The units of change induced by a process to produce an output are described in terms of the knowledge required to make the changes. More specifically, the time it takes the average learner "to acquire the procedural knowledge required to produce a process output provides a practical surrogate for the corresponding changes in entropy."[28] This concept is illustrated in Figure 1.

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[26] Housel, T. and Bell, A. Measuring and Managing Knowledge. Boston: McGraw-Hill, 2001. pp. 92-93.

[27] Housel, T. El Sawy, O., Zhong, J., and Rodgers, W. "Models for Mearsuring the Reutrn on Information Technology: A Proof of Concept Demonstration." 22nd International Conference on Inormation Systems. December, 2001. p. 13.

[28] Ibid.

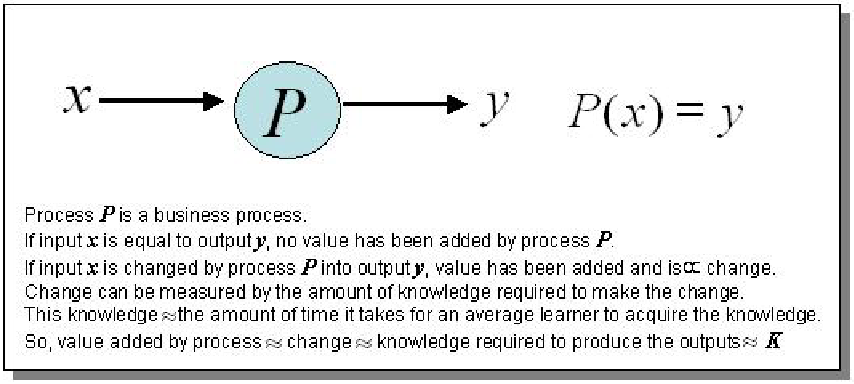

Figure 1. The Housel-Kanevsky Value-Added Cycle.[29]

KVA theory also assumes that all process outputs can be described in equivalent units (e.g., the time required to learn how to produce outputs). The advantages of this level of process output description include:[30]

- The ability to compare all processes in terms of their relative productivity
- The ability to allocate revenue to a common unit of output
- The ability to describe the value added by IT in terms of the outputs it produces
- The ability to relate outputs to the cost to produce those outputs in common units
- A common unit of measure for organizational productivity

By describing all process outputs in common units it is possible for managers and analysts to assign revenue, as well as cost, to those units at any given point in time. With the resulting information, traditional accounting and financial performance and profitability metrics can be applied at the sub-organizational level.

Other assumptions include the concept of *Learning Time*. Learning Time is measured in common units of time and is a surrogate for the procedural knowledge required to produce process outputs. Units of Learning Time represent common units of output which are described by the variable ***K***. Procedural knowledge can be embedded in process assets such as IT, employees, training manuals, etc. A single execution of a process is equivalent to a single unit of output, represented by a given number of

[29] Housel and Bell. 2001.

[30] Housel, et al. December 2001. p. 11.

common units, ***K***. Additional levels of detail in process descriptions provide additional levels of accuracy in the estimation of the number of knowledge units comprising those processes.

3. Three Approaches to KVA

In addition to the Learning Time approach for calculating KVA, Table 2 illustrates two other methods which can be used.

Learning Time Approach	**Process Description Approach**	**Binary Query Method**
Identify compound process and its component processes.	Identify compound process and its component processes.	Identify compound process and its component processes.
Establish common units to measure learning time.	Describe the products in terms of the instructions required to reproduce them and select unit of process description	Create a set of binary YES/NO questions such that all possible outputs are represented as a sequence of YES/NO answers.
Calculate learning time to execute each component process.	Calculate number of process description words, pages in manual, lines of computer code pertaining to each process.	Calculate length of sequence of YES/NO answers for each component processes.
Designate sampling time period long enough to capture a representative sample of the compound processes' final product/service output.	Designate sampling time period long enough to capture a representative sample of the compound processes' final product/service output.	Designate sampling time period long enough to capture a representative sample of the compound processes' final product/service output.
Multiply the learning time for each component process by the number of times the component executes during sample period.	Multiply the number of process words used to describe each component process by the number of times the component executes during sample period.	Multiply the length of the YES/NO string for each component process by the number of times this component executes during sample period.
Allocate revenue to component processes in proportion to the quantities generated by previous step.	Allocate revenue to component processes in proportion to the quantities generated by previous step.	Allocate revenue to component processes in proportion to the quantities generated by previous step.

Calculate the cost to execute each component process, calculate return on investment per process by dividing revenue allocated to component process by cost of component process.	Calculate the cost to execute each component process, calculate return on investment per process by dividing revenue allocated to component process by cost of component process.	Calculate the cost to execute each component process, calculate return on investment per process by dividing revenue allocated to component process by cost of component process.

Table 2. Three Approaches of KVA.[31]

The procedural steps of KVA as applied in this research are outlined in the following case study.

[31] Walsh, David. "Knowledge Value Added: Assessing both Fixed and Variable Value." Business Process Audits.Com. White Papers. Business Process Audits.Com, 13 August 1998. <http://www.businessprocessaudits.com/kvawalsh.com> [06 June 2005]

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IV. METHODOLOGY CASE STUDY: USS READINESS

A. INTRODUCTION

In late 2004, the staff of the United States Navy's Chief of Naval Operations (OPNAV) directed its Cryptologic Carry-On Program Office (OPNAV N201) to focus on three goals for the following fiscal year: Efficiencies, Metrics, and Return on Investment.[32] Measuring efficiencies, developing proper metrics, and determining return on investment of the CCOP portfolio of Information Warfare (IW) systems had, for many years, seemed a bridge too far. Faced with this challenge and with the yearly challenge of deciding how to allocate precious funding dollars to the twelve IW systems which currently make up the CCOP portfolio, Lieutenant Commander Brian Prevo, the CCOP program officer had to answer some fundamental questions. Should he merely give each an equal amount of continuous funding? Should he ask which ones needed the most funding to continue or upgrade? Should he ask the users which ones they liked? None of these questions really went to the heart of the problem from his perspective. He really wanted a relatively objective estimate of the contribution of performance of each. The simple question for him to answer before he made his next moves was, "What is the return on investment of each CCOP system?" Further, he wanted to know the best strategic "options" for the employment and deployment of his systems. He wanted to know where his investments might provide the best future performance in supporting the Navy's Global Intelligence, Surveillance, and Reconnaissance (ISR) mission.

LCDR Prevo turned to a team from the Naval Postgraduate School's (NPS) Graduate School of Operations and Information Sciences, Dr.'s Tom Housel and Johnathan Mun, to help him devise a way to allocate his limited funding resources. He also enlisted the help of a fellow Naval Cryptologist and Information Warfare Officer who happened to be a student at NPS, LCDR Cesar Rios. Rios had operated CCOP systems and other IW systems while conducting ISR missions from various Navy platforms, to include ships and aircraft. As team lead and subject matter expert, LCDR Rios sought advice from Dr.'s Housel and Mun about how to structure this problem in a

[32] Department of the Navy. CCOP Program Briefing. Power Point. Washington: Dept. of the Navy, CCOP Program Office (OPNAV N201C), 25 April 2005.

way that would provide the ROI and options information that the CCOP Program Office needed to make resource allocation decisions. Mun would provide the real options (RO) analysis approach which would be conducted in follow-on to this research. The Knowledge Value Added (KVA) approach provides the raw data necessary for this kind of analysis. Housel is an expert in the KVA methodology. KVA provides a method for describing the output of all process assets (human and information technology) in common units. Market comparables can then be generated from the commercial world to estimate the price per common unit, which allows revenue estimates for the process outputs of non-profit organizations such as the U.S. Navy. It also allows a cost per unit of output that, when combined with the revenue estimates, provides the raw data for ROI analysis.

Armed with these methodologies, the team began the process of collecting the data required to provide LCDR Prevo with the analysis he needed to support is CCOP resource allocation decisions. The following is a synopsis of the research, including the use of new software that provides KVA and RO analysis.

1. Objective

The overall objective of the research was to develop a model and methodology to assist in the CCOP Program Office's budgeting process for the acquisition of information warfare systems. The model was to assess the effectiveness and efficiency of the systems in support of the achievement of the Navy Intelligence, Surveillance, and Reconnaissance (ISR) mission. The methodology had to be capable of producing measurable objectives that were reliable and based on clearly defined criteria. Once measures were defined, an objective performance baseline for each system in the portfolio could be created with which to compare the impact of existing and future CCOP systems on ISR activities, processes and operations. The resulting information could then be utilized to make grounded and defensible financial decisions and projections in the acquisition and deployment of these systems.

2. Method

This case study demonstrated the operationalization of the Knowledge Value Added (KVA) Methodology's ability to extract the measurable and quantifiable data required to develop a performance baseline for valuing the impact of CCOP systems on the process in which they are employed, the Intelligence Collection Process (ICP). In particular, this case focused on the shipborne ICP and the performance of the human and information technology (IT) components that comprise the process.

B. HYPOTHESIS

The Performance metrics of CCOP systems operating within the ICP can be derived by applying the Knowledge Value Added Methodology. These metrics can be used to apply financial estimates for the determination of Return on Investment, Return on Assets and Return on Performance.

C. ANALYSIS AND DATA COLLECTION

1. The ICP and CCOP

To accurately measure the performance of CCOP systems it is necessary to observe the systems as they operate within the overall ICP along with the fixed infrastructure and human operators. Although the ICP differs slightly between the multiple collection platforms (i.e., aircraft, destroyers, cruisers, etc.), the process will be described at a general-enough level to achieve an aggregate view of the process elements and their outputs.

CCOP systems have a broad scope of capabilities and functions. Within the ICP, they may be used to perform operations in a single subprocess or in multiple subprocesses simultaneously. CCOP systems may be used in a stand-alone manner, or they may augment existing infrastructure or capabilities onboard the ISR platform. The systems are also capable of performing fully automated functions as well as human-enabled functions. It is this particular mix of dynamic behaviors that makes analyzing CCOP systems a challenge.

2. The Data Collection Challenge

The ISR Mission is generally conducted at a highly classified level. Many particulars of the ICP and the CCOP systems and their outputs are closely guarded information. Deriving the information required to perform analysis at the unclassified level is difficult, and at times, impossible. For the purpose of academic research, much of the data was estimated or inferred based on realistic sampling of unclassified process information. Information on human capital, such as salaries and operator training, are public information and were gathered from sources such as the Stay Navy Website and the Center for Information Dominance (CID) training documentation. The equipment data was also derived or inferred from documentation provided by the OPNAV N20 staff and the Space and Naval Warfare Command (SPAWAR). Other information such as number of process outputs and executions were extrapolated from samples gathered via interviews with ISR crews currently operating onboard, deployed U.S. Navy surface ships.

D. MODELING THE USS READINESS ICP

The intelligence collection process (ICP) is the means by which tactical Navy intelligence, surveillance and reconnaissance (ISR) units (i.e., ships, aircraft and other platforms) receive requests for intelligence or intelligence collection tasking and apply various human disciplines and IT technologies to search, acquire, process and report results back to tactical users (i.e., fleet staffs and strike groups), and national-level consumers (i.e., NSA). The following table is a brief description of the generalized process:

	Sub-Process Name	Sub-Process Description
P1	Review Request	• Determine if collection capability is available • Determine if further direction or info required
P2	Determine Op/Equip Mix	• Review directives and target information to determine type/category of target
P3	Input Search/Function into CCOP	• Assign search blocks and allocate system resources to each target
P4	Search/Collection Process	• Targeted or full spectrum search • Observe sensor data for target cues
P5	Target Data Acquisition/Capture	• Audio Routing • Record/Capture Data
P6	Target Data Processing	• Demodulate, decrypt, direction find (DF), or Geo-locate • Translate
P7	Target Data Analysis	• Human or IT-based analysis of captured data
P8	Format Data for Report Generation	• Input data into required reporting formats
P9	QC Report	• Check format, accuracy and adherence to tasking, regulations and laws
P10	Transmit Report	• Transmit via secure voice radio, secure internet relay chat, US Message Traffic Format

Table 3. The Intelligence Collection Process (ICP).

Each sub-process can be further broken down into individual actions that may be required to perform the subprocess. Below is the breakdown of sub-process ***P6 Target Data Processing***:

P6	Target Data Processing
	Human-based (no automation required)
	Manual copy directly into report
	Human translation & processing
	IT-based
	Direct transfer into report
	Demodulate
	All IT-based
	Human-enabled
	Decrypt
	All IT-based
	Human-enabled
	Direction finding
	Automatic - Local Line Of Bearing (LOB)
	Human-enabled - local LOB
	Human-enabled - B-rep request
	Geolocation
	Special processing

Table 4. Process P6 Activities.

1. USS READINESS

USS READINESS is a fictitious U.S. Navy warship which has been outfitted for conducting ISR missions. Along with the general manning, the ship has a contingent of Information Warfare operators who perform the ICP utilizing CCOP systems that interconnect with a pre-existing IT infrastructure. For the purpose of this research, it is assumed that the ship is on a typical six-month deployment and receives daily tasking for ISR collection from higher authorities as well as intelligence requirements from the commanding officer and group commanders. In response to tasking, the ISR crew onboard USS READINESS produces a variety of reports which include raw-intelligence reports, technical reports, analyst-to-analyst exchanges and daily collection summaries. The table below illustrates the ISR crew and the subprocesses within the ICP in which they perform:

IW Operator	Assigned to ICP Processes
Division Officer	1,2,9
Division Leading Petty Officer	1,2,9,7
Signals Operator 1	3-7,9
Signals Operator 2	3-7
Signals Operator 3	4-7
Signals Operator 4	4-7
Signals Operator 5	4-7
Comms Operator 1	8,10
Comms Operator 2	8,10
Comms Operator 3	8,10

Table 5. USS READINESS ISR Crew.

USS READINESS is outfitted with four CCOP systems (A, B, C, and D) which operate in the following subprocesses:

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

Table 6. USS READINESS CCOP Systems.

As shown in Table 6, CCOP systems may be used in a single subprocess or across multiple subprocesses along with the existing infrastructure available in each particular platform. Additionally, some systems such as CCOP A are highly complex and comprised of multiple subsystems. Below is a breakdown of CCOP A and its related components.

CCOP A (Example)	
Component	**Description/Functions**
Radio Frequency Management System	• RF management
Signal Acquisition System	• Energy Search
Audio Distribution System	• Audio Routing & Recording
Intermediate Frequency Signal Processing System	• Spectrum Display Operations • Signal Processing Applications
Control & Processing System	• Coverage Plan Creation/Management
Common Cryptologic Workstation (CCWS)	• Database Operations • JMCIS Applications • Cryptologic Unified Build Applications • Microsoft Applications • Signal Processing Applications

Table 7. CCOP A Components.

To accurately capture the contribution of CCOP systems across subprocesses it is necessary to break down each system to its individual components and functions, analyze the attributes of each, and insert them into the appropriate subprocess of the ICP.

E. APPLYING KVA

As described in the previous chapter, KVA uses a knowledge-based metaphor as a means to describe units of change in terms of the knowledge required to make the changes. The analysis is accomplished by extracting historical data to build metrics that are structured in the same manner as common financial metrics. The difference between KVA and other financial models though, is that KVA provides the means to analyze the metrics at a sub-organizational level and allows for the allocation of cost and revenue across subprocesses for accounting purposes.

1. KVA Assumptions

The underlying assumptions of KVA are that:

- Human and technology in organizations take inputs and change them into outputs through core processes
- By describing all process outputs in common units (i.e., the knowledge required to produce the outputs) it is possible to assign revenue, as well as cost, 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 is measured in common units of time and is also a surrogate for knowledge. Thus, units of Learning Time can also be called Common Units of Output (**K**).

- 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 stream have been assigned to sub-organizational outputs, normal accounting and financial performance and profitability metrics can be applied to them.

2. Case Study Assumptions and Data

The following assumptions and data apply to the USS READINESS – KVA proof of concept case study. Figures and results are estimates only, and should not be viewed as projections of actual capabilities.

a. Assumptions

Length of Sample Period: The sample period for this analysis was one deployment period (6 months). For this reason, some annual cost data is adjusted to reflect the sample period.

Cost Assumptions: Cost of human capital assets was derived from annual U.S. Navy salary information available on the Stay Navy website for Fiscal Year 2005 with allowances calculated for a crew home ported in San Diego, CA. Operator rank and bonus level information was estimated based on a typical shipborne ISR crew. Equipment costs were derived from annual cost data provided by the OPNAV N20 staff. While equipment costs reflect installation and training costs, they do not reflect amortization or the total operational cost of the program.

Proxy Revenue Assumptions: Proxy revenues are based on the following assumption: if a commercial entity or organization produces comparable outputs as a not-for-profit organization such as the Department of Defense, and the processes required to produce those outputs are comparable, certain inferences can be derived. First, if the processes are comparable, the outputs of the commercial case are comparable to the outputs of the not-for-profit case. 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. For this research, the price-per-report of nine competitive/business intelligence organizations and private military corporations were averaged to yield a notional market comparable price-per-unit of the outputs of the USS READINESS ICP. Figure 2 illustrates two of the corporations sampled in the Intelligence Price-per-Unit study.

IHL Consulting Group

IHL Consulting Group is a global research and advisory firm specializing in technologies for the retail and hospitality industries. The company, generates timely data reports, offers advisory services and serves as the leading retail technology spokesperson for industry and vendor events. IHL provides customized business intelligence for retailers and retail technology vendors, with particular expertise in supply chain and store level systems. Their customers are retailers and retail technology providers who want to better understand what is going on in the overall technology market, or wish to identify specific equipment needs for the retail market.

IHL's price per report ranges from $1,495 to $3,295

J.C. Owens Global Consulting, LLC

J.C. Owens Global Consulting, LLC is a subsidiary of J. C. Owens Group Worldwide. It has been established to provide international investigation, business intelligence and risk consulting services to corporate organizations and government agencies worldwide in 182 countries around the world. Their specific areas of capability include: Global Corporate Investigations; Global Business Intelligence; Intellectual Property/Copyright Trademark Investigations; Background/Pre-employment/Due Diligence/Litigation Support; Insurance Fraud & Claim Investigation.

The firm presently covers a total of 182 countries in Africa, North/South America, Middle East, Central America, Europe, Asia, and the Caribbean. It maintains an office in Bloomfield, New Jersey, United States of America, from where it covers the world; and an office in Lagos, Nigeria, which handles its African operations.

Price per Global Intelligence Report/Assignment is approximately $5,000 (US)

Figure 2. Intelligence Price-per-Unit Benchmarking Sample.[33]

Output Assumptions: Although the ICP onboard the ISR unit produces a variety of reports, only raw-intelligence reports (also known as ***Klieghlights*** or KL) were counted as outputs for this research. It was also assumed that each report was of equal tactical value/weight and importance, in essence, all outputs were similar.

Other Assumptions: *IT Learning Time.* It was assumed that the knowledge embedded in information technology (IT) systems can be derived by averaging the time it would take an average learner to learn how to produce the outputs produced by the IT systems in a single subprocess output cycle. CCOP systems are

[33] Data for IHL Consulting Group was gathered from the 2005 IGL Consulting Group Research Price List which is available from www.ihlservices.com

Data for J.C. Owens Global Consulting, LLC was furnished by Mr. Israel Mbachu, CFE, CII, Principal Partner at J.C. Owens Global Consulting, LLC. Email dated 09 September 2005.

highly complex and at times, comprise multiple components with varying functions. To estimate the time to learn of a single CCOP system, the components were analyzed individually. Academic authorities on the functions performed by each were consulted to determine the length of time it would take an average learner (assuming at least a Bachelor's of Science (B.S.) degree in Electrical Engineering or in a field related to the component) to learn how to produce the IT outputs. In this case, subject matter experts in the functional fields of each system were consulted to estimate the IT time to learn. Figure 3 illustrates one such interview.

CCOP C Learning Time Derivation Example

To determine the learning time of CCOP C, the team first dissected the system into its basic functional components. CCOP C is the AN/SSQ-120(V) Transportable-Radio Direction Finder (T-RDF). T-RDF provides a low-cost Medium/High/Very High/Ultra High Frequency (MF/HF/VHF/UHF) Direction Finding (DF) capability to selected U.S. Navy ships. T-RDF has two major components, the receiving equipment and the processing unit.

To analyze the system and determine its time to learn, the team consulted Dr. Richard Adler, an authority on signals intelligence (SIGINT) systems and antenna technologies. It was assumed that, as a baseline, the "average learner" to be taught the functions of T-RDF would have an undergraduate degree in a related technical field such as Electrical Engineering. Dr. Adler suggested that the underlying disciplines that would have to be learned are:

–Basic RF Theory (66 days)
–EM Theory/Formal EM (198 days)
–Basic Communications Theory (132 days)
–Propagation Theory (66 days)
–Antenna Theory (66 days)
–Basic Radio Direction Finding (66 days)

Aggregating the results, an estimate of 594 days of learning time would be required for the average learner to learn how to produce the outputs of CCOP C.

Figure 3. CCOP C Learning Time.[34] [35]

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[34] Department of the Navy. Vision…Presence…Power: A Program Guide to the U.S. Navy – 2002 Edition. Washington: Dept. of the Navy, 2002. Chapter 3.

35 Dr. Richard Adler is a Research Associate Professor in Department of Electrical and Computer Engineering at the Naval Postgraduate School. He also holds positions in the Research Committee and is the Supervisor of the Signal Enhancement Lab. Dr. Adler has 31 years of experience in undergraduate and graduate teaching and thesis advising, 29 years in design and analysis of VLF-UHF tactical, strategic, DF and broadcast antennas, 31 years in EM numerical analysis of the effects of platforms and environment on the performance of antennas, and 26 years Hands-On-Workshops on Numerical Antenna Modeling for wire antennas, reflector antennas and general scattering shapes. He is a Registered Professional Engineer in California.

b. *Human Capital Data*

Individual data sheets were created for each member of the fictitious USS READINESS ISR crew. The information included the typical rank and subspecialty designators or Navy Education Codes (NEC) of afloat-IW operators. Military pay was collected along with NEC-specific bonus pay for each operator. Figure 4 illustrates the amount of job specific schooling and on-the-job training received by each.

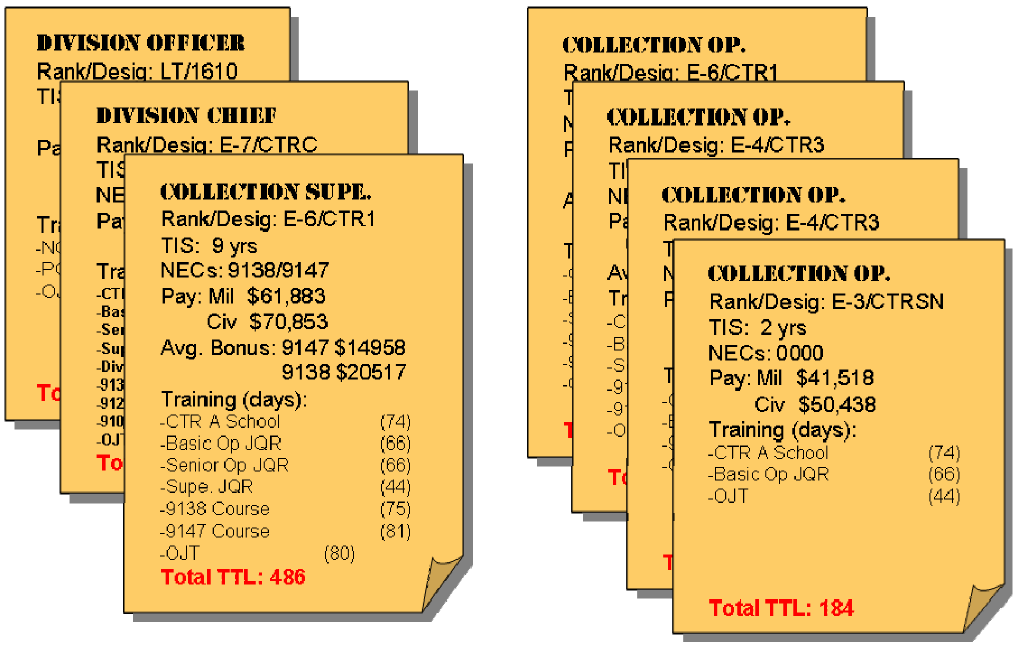

Figure 4. Sample Operator Data Sheets.

The following tables contain the actual case data for the cost of human assets used in this research:

Element	Annual Unit Cost (avg)	Annual Unit Bonuses (avg)	Budget (Cost) per Sample Pd
Div Officer	$ 79,298	$ -	$ 39,649
Div LPO	$ 79,298	$ -	$ 39,649
SigOp 1	$ 61,883	$ 35,475	$ 48,679
SigOp 2	$ 58,190	$ 14,958	$ 36,574
SigOp 3	$ 44,391	$ 17,177	$ 30,784
SigOp 4	$ 43,397	$ -	$ 21,699
SigOp 5	$ 41,518	$ -	$ 20,759
ComOp1	$ 44,391		$ 22,196
ComOp2	$ 43,397		$ 21,699
ComOp3	$ 41,518		$ 20,759
Total Human			$ 302,446

Table 8. USS READINESS Human Capital Cost Data.

The total amount of days of on-the-job training and job experience of the human assets are shown in Table 9.

Operator	Time in Service (Days)	Pre-Deployment Training (Days)	On-Job Training (Days)	Totals
Div Officer	1,825	15	292	2,132
Div LPO	4,380	15	524	4,919
SigOp 1	3,285	30	486	3,801
SigOp 2	2,190	30	366	2,586
SigOp 3	1,095	30	325	1,450
SigOp 4	730	30	219	979
SigOp 5	730	30	184	944
ComOp1	2190	20	325	2,535
ComOp2	1096	20	219	1,335
ComOp3	730	20	184	934

Table 9. USS READINESS Operator Training Time (Days).

c. Information Technology Data

Detailed information was also gathered for the USS READINESS CCOP systems and fixed infrastructure analyzed in this research. Cost data, shown below, was derived from annual budget estimates.

Element	Avg Annual Unit Costs	Budget (Cost) per Sample Pd
CCOP A	$ 193,500	$ 96,750
CCOP B	$ 44,643	$ 22,322
CCOP C	$ 24,000	$ 12,000
CCOP D	$ 126,923	$ 63,462
Total CCOP		$ 194,533
Fixed IT Infrastructure		$ 102,500
TOTAL IT		**$ 297,033**

Table 10. USS READINESS Systems Cost Data.

To obtain the time-to-learn of CCOP systems, each was analyzed at the component or subsystem-level. The learning-time for each component was then estimated by interviewing subject matter experts and deriving how many days it would take the average IW operator to learn how to perform the component operation. The table below contains the aggregated estimations used for each system.

System	Time to Learn (days)
CCOP A Aggregated Time to Learn =	4,092
CCOP B	1,460
CCOP C	514
CCOP D	1,825

Table 11. CCOP System Learning-Time.

3. KVA Steps

The following is a summarized synopsis of the steps in using the KVA method once the required data has been gathered. Two of the USS READINESS ICP subprocesses are used to illustrate the computations, subprocesses P4 and P8. Appendix A contains the actual analysis. Each step also contains the definitions of variables and relevant formulas used.

a. Step One: Estimate Process Time- to-Learn

(1) Definitions:

Time to Learn (t_L) is the time it would take the average learner to learn how to produce a single subprocess output.

Human Time to Learn (t_{LH}) is the time it would take the average learner to learn the human-specific portions of the subprocess required to produce a single subprocess output. In this case factors such as time-in-service, schooling, on the job training, and pre-deployment training of each operator were used to estimate the human time to learn.

IT Time to Learn (t_{LIT}) is the time it would take the same average learner to learn how to produce the outputs produced by the IT systems in a single subprocess output cycle. In this case, subject matter experts in the functional fields of each system were consulted to estimate the IT time to learn as exampled in Figure 3.

% Automation is the percent of a process that is automated by information technology (IT) over and above human contribution.

(2) Description: First, the time it takes an average Information Warfare operator to learn one whole subprocess is estimated. This represents the amount of knowledge required to produce a single aggregate subprocess output. Time to Learn (**t_L**) is estimated by summing the average time spent in training the process (pre-deployment training), the combined training experience of each operator performing the process (Table 9.), and the learning time embedded in each IT system multiplied by the

percent automation of the particular subprocess. The time to learn of CCOP systems operating in more than one subprocess is divided equally across the subprocess in which they operate.

	Sub-process Name	CCOP Assigned	Process Training t_{LH} (days)	Other Relevant t_{LH} (days)	Tot t_{LH} (days)	CCOP t_{LIT} (days)	Avg % Automat'n	Tot t_{LIT} times % Automat'n (days)	Tot t_L for 1 Process Output (days)
P4	**Search / Collection Process**	A,B	**35**	9760	9795	896	46.25%	414.34	10,209.34
P8	**Format Data for Report Generation**	A	**10**	4804	4814	409	71.67%	293.27	5,107.27

Table 12. P4 and P8 Time to Learn.

b. Steps Two and Three: Calculate the K Produced by IT and Human Assets. Find the Total K for Each Subprocess

(1) Definitions:

K is the descriptive term chosen for the common units of output estimated by KVA.

Executions (Ex) are the average number of times a process asset, human or IT, produced an individual subprocess output.

$\mathbf{K_H}$ is the common units of output attributed to human-asset contribution.

$\mathbf{K_{IT}}$ is the common units of output attributed to IT-asset contribution.

$\mathbf{K_P}$ is the total common units of output for each subprocess.

(2) Formulas:

Total subprocess-asset output: $\mathbf{K_{Asset} = (Ex_{Asset})\ (t_L)}$
Total subprocess output: $\mathbf{K_P = K_H + K_{IT}}$
Total process output: $\mathbf{K_{TOT} = \Sigma(K_P)}$

(3) Description: The number of times an element, human or IT, executes a subprocess is tallied and then multiplied by the time to learn of the particular subprocess. The resulting number is the amount of output, by asset, used in the execution of the subprocess. Once the **K** for each asset has been calculated, it is summed to reveal the total **K** for each subprocess.

Total Output per Subprocess for Sample Period - Including Automation					
# of each asset per Posi-tion	Asset	# executns by Asset *P4*	Total K *P4*	# executns by Asset *P8*	Total K *P8*
1	Div Officer	0.00	0.00	0.00	0.00
1	Div LPO	0.00	0.00	0.00	0.00
1	SigOp 1	135.00	1378260.68	0.00	0.00
1	SigOp 2	144.00	1470144.72	0.00	0.00
1	SigOp 3	162.00	1653912.81	0.00	0.00
1	SigOp 4	152.00	1551819.43	0.00	0.00
1	SigOp 5	158.00	1613075.46	0.00	0.00
1	ComOp1	0.00	0.00	78.00	398367.34
1	ComOp2	0.00	0.00	78.00	398367.34
1	ComOp3	0.00	0.00	79.00	403474.62
1	CCOP A	751.00	7667213.09	235.00	1200209.31
1	CCOP B	92.00	939259.13	0.00	0.00
1	CCOP C	0.00	0.00	0.00	0.00
1	CCOP D	0.00	0.00	0.00	0.00
1	IT Fixed Infrastructure	235.00	2399194.51	235.00	1200209.31
		K_P	18672879.81		3600627.92

Table 13. P4 and P8 Total K by Asset.

Subprocess Name		K_{IT} (automation & infras)	K_H	K_{TOT}
P4	Search/Collection	10,909,092.30	7,599,933.50	18,509,025.80
P8	Format Data for Report Generation	2,342,721.41	1,171,360.71	3,514,082.12

Table 14. P4 and P8 IT/Human Total K.

c. ***Steps Four and Five: Derive Proxy Revenue Stream and Develop the Value Equation Numerator by Assigning Revenue Streams to Subprocesses.***

(1) Definitions:

Market Comparable Price per Unit is the notional price per unit allocated to the outputs of non-profit organizations based on the market price per unit of the comparable outputs of a similar commercial organization.

% K is percent of the total K produced by an individual subprocess or asset.

(2) Formulas:

Proxy Revenue: $\mathbf{R_{TOT}}$ **= (Total # of Process Outputs) (Market Comp. Price per Unit)**

% of Total **K** per Subprocess: $\mathbf{\% K_P = (K_P / K_{TOT}) \times 100\%}$

Subprocess Revenue Allocation: $\mathbf{R_P = \%K_P \times R_{TOT}}$

(3) Description: First, utilizing the Market Comparables approach, the total number of ICP outputs is multiplied by the average market price-per-unit to yield a Proxy Revenue for the USS READINESS ICP.

Proxy Revenue Assumptions	
Market Comparable Price Per Unit (avg)	**$ 3,800**
Avg# Reports executed/sample pd	**235**
Avg Proxy for Revs - Sample Pd (R_{TOT})	**$ 893,000**

Table 15. USS READINESS ICP Proxy Revenue Assumption.

Next, the percent of the total process **K** produced by each subprocess is calculated.

	Subprocess Name	K for IT (automation & infras)	K for Humans	Total K	% of Total K per sub-process
P4	**Search/Collection**	10,909,092.30	7,599,933.50	18,509,025.80	24.5398%
P8	**Format Data for Report Generation**	2,342,721.41	1,171,360.71	3,514,082.12	4.6591%
		52,659,382.55	22,765,206.13	75,424,588.68	100.0000%

Table 16. P4 and P8 Percent K.

Revenues can now be assigned to subprocesses, people and IT based on their individual **%K**:

	Subprocess Name	K for Humans	Total K	% of Total K per sub-process	Proxy Revenue Assigned to Sub-process ($US)	% of Total K for Human per Sub-process	Proxy Revenue Assigned to Human K ($US)
P4	**Search/ Collection**	7,599,933.50	18,509,025.80	24.5398%	$ 219,140	10.0762%	$ 89,980
P8	**Format Data for Report Generation**	1,171,360.71	3,514,082.12	4.6591%	$ 41,605	1.5530%	$ 13,868
		22,765,206.13	75,424,588.68	100.0000%	$ 893,000	30.1827%	$ 269,532

Table 17. P4 and P8 Proxy Revenue Allocation for Human Contribution.

	Subprocess Name	K for IT (automation & infras)	Total K	% of Total K for CCOP A	Proxy Revenue Assigned to CCOP A Process K ($US)	% of Total K for CCOP B	Proxy Revenue Assigned to CCOP B Process K ($US)
P4	**Search/ Collection**	10,909,092.30	18,509,025.80	10.08%	$ 89,980	1.23%	$ 11,023
P8	**Format Data for Report Generation**	2,342,721.41	3,514,082.12	1.55%	$ 13,868	0.00%	$ -
		52,659,382.55	75,424,588.68	30.18%	$ 269,532	3.82%	$ 34,110

Table 18. P4 and P8 Proxy Revenue Allocation for CCOP A & B Contribution.

	Subprocess Name	% of Total K for CCOP C	Proxy Revenue Assigned to CCOP C Process K ($US)	% of Total K for CCOP D	Proxy Revenue Assigned to CCOP D Process K ($US)	% of Total K for Fixed IT Infrastructure	Proxy Revenue Assigned to Fixed Infras Process K ($US)
P4	**Search/ Collection**	0.00%	$ -	0.00%	$ -	3.15%	$ 28,156
P8	**Format Data for Report Generation**	0.00%	$ -	0.00%	$ -	1.55%	$ 13,868
		6.52%	$ 58,253	2.23%	$ 19,906	27.06%	$ 241,667

Table 19. P4 and P8 Proxy Revenue Allocation for CCOP C & D, and IT Fixed Infrastructure Contribution.

d. Step Six: Develop the Value Equation Denominator by Assigning Costs to Subprocesses

(1) Description: Costs are assigned directly to each subprocess based on the assets producing outputs in each. The cost of human and IT assets that are assigned to multiple processes are divided evenly throughout those subprocesses. The cost of human and IT assets are summed in each subprocess to yield the total cost per subprocess ($\mathbf{C_P}$).

	Subprocess Name	Proxy Revenue Assigned to Sub-process ($US)	Cost Assigned to Sub-process ($US)	Proxy Revenue Assigned to Human K ($US)	Cost Assigned to Human K ($US)
P4	**Search/Collection**	$ 219,140	$ 64,642	$ 89,980	$37,276.47
P8	**Format Data for Report Generation**	$ 41,605	$ 52,252	$ 13,868	$32,326.50
		$ 893,000	$ 622,607	$ 269,532	$ 292,533

Table 20. P4 and P8 Total Cost Allocation & Human Cost Allocation.

	Subprocess Name	Proxy Revenue Assigned to CCOP A Process K ($US)	Cost Assigned to CCOP A Process K ($US)	Proxy Revenue Assigned to CCOP B Process K ($US)	Cost Assigned to CCOP B Process K ($US)
P4	**Search/ Collection**	$ 89,980	$ 9,675	$ 11,023	$ 7,441
P8	**Format Data for Report Generation**	$ 13,868	$ 9,675	$ -	
		$ 269,532	$ 96,750	$ 34,110	$ 22,322

Table 21. P4 and P8 Cost Allocation for CCOP A & B.

Proxy Revenue Assigned to CCOP C Process K ($US)	Cost Assigned to CCOP C Process K ($US)	Proxy Revenue Assigned to CCOP D Process K ($US)	Cost Assigned to CCOP D Process K ($US)	Proxy Revenue Assigned to Fixed Infras Process K ($US)	Cost Assigned to Fixed Infras Process K ($US)
$ -		$ -		$ 28,156	$ 10,250
$ -		$ -		$ 13,868	$ 10,250
$ 58,253	$ 12,000	$ 19,906	$ 63,462	$ 241,667	$ 102,500

Table 22. P4 and P8 Cost Allocation for CCOP C, D, and Fixed IT Infrastructure.

e. Steps Seven, Eight and Nine: Calculate the Value Equation (ROI)

(1) Definitions:

ROK is the Return on Knowledge, a productivity ratio
ROKA is the Return on Knowledge Assets, a profitability ratio
ROKI is the Return on Knowledge Investment, the value equation

(2) Formulas:

Total Return on Knowledge: **ROK = Revenue / Cost**

Subprocess ROK (as percentage): $\mathbf{ROK_P = (R_P / C_P) \times 100\%}$

Subprocess ROKA: $\mathbf{ROKA_P = (R_P - C_P) / (\%K_P \times R_{TOT})}$

Subprocess ROKI: $\mathbf{ROKI_P = (R_P - C_P) / (C_P)}$

(2) Description: The revenues and costs assigned to subprocesses, people and IT are used to calculate the value equations.

KVA Metrics for Total K					
	Subprocess Name	**ROK as Ratio**	**ROK *as %***	**ROKA**	**ROKI**
P4	**Search/Collection**	3.39	339.01%	70.50%	239.01%
P8	**Format Data for Report Generation**	0.80	79.63%	-25.59%	-20.37%
Metrics for Aggregated		14.10	1410.20%	157.31%	410.20%

Table 23. P4 and P8 KVA Metrics.

Note: For Human and IT ROK, ROKA, and ROKI, the Cost and Revenue of each asset is substituted for subprocess cost and revenues in the value equations.

4. KVA Results for USS REDINESS ICP with Actual Case Data Iputs

Historical KVA for USS READINESS for Intelligence Collection Process
Total K Contribution and Human K

	KVA Metrics for Total K						KVA Metrics for Human K				
	Subprocess Name	ROK as Ratio	ROK *as* %	ROKA	ROKI		Subprocess Name	ROK as Ratio	ROK *as* %	ROKA	ROKI
P1	Receive/Review Request/Tasking	1.22	122.11%	18.10%	22.11%	*P1*	Receive/Review Request/Tasking	0.71	70.50%	-41.84%	-29.50%
P2	Determine Op/Equip Mix	1.21	120.89%	17.28%	20.89%	*P2*	Determine Op/Equip Mix	0.70	69.80%	-43.26%	-30.20%
P3	Load Search Func/Coverage Plan	0.82	81.56%	-22.62%	-18.44%	*P3*	Load Search Func/Coverage Plan	0.96	95.89%	-4.29%	-4.11%
P4	Search/Collection	3.39	339.01%	70.50%	239.01%	*P4*	Search/Collection	2.41	241.39%	58.57%	141.39%
P5	Target Data Acquisition/Capture	1.47	147.28%	32.10%	47.28%	*P5*	Target Data Acquisition/Capture	0.75	75.31%	-32.79%	-24.69%
P6	Target Data Processing	1.37	136.67%	26.83%	36.67%	*P6*	Target Data Processing	0.83	82.90%	-20.63%	-17.10%
P7	Target Data Analysis	1.21	121.25%	17.52%	21.25%	*P7*	Target Data Analysis	0.63	62.75%	-59.35%	-37.25%
P8	Format Data for Report Generation	0.80	79.63%	-25.59%	-20.37%	*P8*	Format Data for Report Generation	0.43	42.90%	-133.09%	-57.10%
P9	QC Report	1.79	179.19%	44.19%	79.19%	*P9*	QC Report	0.98	97.82%	-2.22%	-2.18%
P10	Transmit Report	0.83	82.63%	-21.02%	-17.37%	*P10*	Transmit Report	0.45	44.52%	-124.62%	-55.48%
Metrics for Aggregated		14.10	1410.20%	157.31%	410.20%		Metrics for Aggregate	8.84	883.79%	-403.52%	-116.21%

Please note that the floor for ROKA is -100% (e.g., zero return on knowledge ass Please note that the floor for ROKA is -100% (e.g., zero return on knowledge assets)

KVA Metrics for CCOP A K

	Sub-Process Name	ROK as Ratio	ROK *as* %	ROKA	ROKI
P1	Receive/ Review Request/ Tasking	1.69	168.54%	40.67%	68.54%
P2	Determine Op/Equip Mix	1.67	166.86%	40.07%	66.86%
P3	Load Search Func/ Coverage Plan	1.53	152.91%	34.60%	52.91%
P4	Search/ Collection	9.30	930.03%	89.25%	830.03%
P5	Target Data Acquisition/ Capture	2.90	290.15%	65.54%	190.15%
P6	Target Data Processing	3.19	319.39%	68.69%	219.39%
P7	Target Data Analysis	1.50	149.98%	33.33%	49.98%
P8	Format Data for Report Generation	1.43	143.34%	30.24%	43.34%
P9	QC Report	3.16	315.88%	68.34%	215.88%
P10	Transmit Report	1.49	148.75%	32.77%	48.75%
Metrics for Aggregated		27.86	2785.86%	503.50%	1785.86%

Please note that the floor for ROKA is -100% (e.g., zero return on knowledge assets)

	KVA Metrics for CCOP B K				
	Sub-Process Name	ROK as Ratio	ROK *as %*	ROKA	ROKI
P1	Receive/ Review Request/ Tasking				
P2	Determine Op/Equip Mix				
P3	Load Search Func/ Coverage Plan				
P4	Search/ Collection	1.48	148.15%	32.50%	48.15%
P5	Target Data Acquisition/Capture	1.48	147.71%	32.30%	47.71%
P6	Target Data Processing	1.63	162.59%	38.50%	62.59%
P7	Target Data Analysis				
P8	Format Data for Report Generation				
P9	QC Report				
P10	Transmit Report				
Metrics for Aggregated		4.58	458.44%	103.29%	158.44%

	KVA Metrics for CCOP C K				
	Sub-Process Name	ROK as Ratio	ROK *as %*	ROKA	ROKI
P1	Receive/ Review Request/ Tasking				
P2	Determine Op/Equip Mix				
P3	Load Search Func/ Coverage Plan				
P4	Search/ Collection				
P5	Target Data Acquisition/Capture				
P6	Target Data Processing	4.36	436.13%	77.07%	336.13%
P7	Target Data Analysis	5.35	534.76%	81.30%	434.76%
P8	Format Data for Report Generation				
P9	QC Report				
P10	Transmit Report				
Metrics for Aggregated		9.71	970.88%	158.37%	770.88%

Please note that the floor for ROKA is -100% (e.g., zero return on knowledge assets)

	KVA Metrics for CCOP D K				
	Sub-Process Name	ROK as Ratio	ROK *as %*	ROKA	ROKI
P1	Receive/ Review Request/ Tasking				
P2	Determine Op/Equip Mix				
P3	Load Search Func/ Coverage Plan				
P4	Search/ Collection				
P5	Target Data Acquisition/ Capture				
P6	Target Data Processing	0.28	28.18%	-254.86%	-71.82%
P7	Target Data Analysis	0.35	34.55%	-189.41%	-65.45%
P8	Format Data for Report Generation				
P9	QC Report				
P10	Transmit Report				
Metrics for Aggregated		0.63	62.73%	-444.28%	-137.27%

	KVA Metrics for Fixed Infrastructure K				
	Sub-Process Name	ROK as Ratio	ROK *as %*	ROKA	ROKI
P1	Receive/ Review Request/ Tasking	1.95	194.72%	48.64%	94.72%
P2	Determine Op/Equip Mix	1.93	192.78%	48.13%	92.78%
P3	Load Search Func/ Coverage Plan	1.77	176.65%	43.39%	76.65%
P4	Search/ Collection	2.75	274.70%	63.60%	174.70%
P5	Target Data Acquisition/ Capture	2.74	273.88%	63.49%	173.88%
P6	Target Data Processing	3.01	301.48%	66.83%	201.48%
P7	Target Data Analysis	3.70	369.66%	72.95%	269.66%
P8	Format Data for Report Generation	1.35	135.30%	26.09%	35.30%
P9	QC Report	2.98	298.16%	66.46%	198.16%
P10	Transmit Report	1.40	140.41%	28.78%	40.41%
Metrics for Aggregated		23.58	2357.73%	528.36%	1357.73%

Table 24. KVA Results for USS READINESS

E. ANALYZING THE KVA RESULTS

KVA provides a unique and insightful means of measuring the contributions of Information Technology and human assets to the production of process outputs. By analyzing an organization, process or function at the subprocess-level, this methodology allows military leaders and program managers to structure a problem and solution set in an empirical manner. The results can then be used to conduct comparative analyses of multiple human and IT configurations of similar processes with the final goal of ensuring the best possible posturing of people, equipment and the increasingly limited funding-dollars within the organization and the Department of Defense.

While profitability is not the goal of the DoD, and other non-profit organizations, it is their goal and responsibility to the individual taxpayer, to ensure that the limited resources are managed in a reasonable, accountable and transparent manner. In this case, KVA was used to quantify the value added by Cryptologic Carry-On Program systems, Information Warfare/Cryptologic operators, and the enabling shipborne infrastructure with which they interact. The result is an assessment of the efficiency (productivity) and effectiveness (profitability) of human-system performance within the Intelligence Collection Process. 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. That is not to say though, that analyzing a single process yields no value. Looking at the USS READINESS case study on its own, it is possible to interpret the KVA analysis results and identify targets of transformation within the subprocesses of the Intelligence Collection Process. It is possible to look at the individual assets and ask "why?" an asset contributes more or less than others, and "how?" the performance of assets impacts the overall output of the process.

1. Case Example Results

Looking back at the two subprocesses detailed in the case study, P4 and P8, a few questions can be asked:

- What makes P4 such a high performer, with an overall return of 239% versus a return of -20.37% for P8?
- P8, Format Data for Report Generation, only executes once per KL report (process output), yet almost a third of all the operators (ComOp 1, ComOp2, ComOp3) in this particular case are assigned to this subprocess for almost a fifth of the total human cost.
- P8 is more automated than P4. Could P8 be further automated or could it be performed by the other operators in lieu of the three communications operators to yield higher efficiency **and** effectiveness?

- P4, Search and Collect, is a knowledge-intensive function requiring a high system and human capital asset investment. Each process output requires many executions of P4. Could an even higher return be achieved with automated search and collection systems or more operators?

Other observations of this case example could include:

- Should the amount of knowledge in humans and IT be adjusted?
- Is a broader range of training required to allow all operators to perform more functions?
- CCOP D is a cost-heavy system but executes very few times, comparatively, throughout the sample period. Is CCOP D appropriate for this platform and mission? Is there a cheaper alternative to CCOP D? Are all the operators appropriately trained in the use of CCOP D?

These are the kinds of questions CCOP program mangers and other stake-holders can begin to ask. The answers to these questions can help CCOP program managers allocate funds to new systems or to existing systems for product improvement, or if further study deems it so, to cut a system all together from the portfolio. The results can also be used to tailor the manning and training requirements of ISR crews deploying with CCOP systems.

Finally, KVA also provides the structured data required to perform various methods of risk analysis and performance projections such as Real Options Analysis. The combination of KVA historical performance metrics and real options analytic tools will enable the CCOP Program Office and the U.S. Navy to estimate and compare the future value added of different mixes of humans and systems as well as a range of new initiatives for the deployment and employment options of both.

2. Current Limitations of Knowledge Value Added

This case study revealed a few limitations to the implementation of KVA to the Intelligence Collection Process as modeled in for the USS READINESS, which are currently being addressed. They 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

subprocess should be reached through a 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. The creation of a broad database of such organizations is currently being conducted to benchmark industries by functional groupings and products.
- Lastly, 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.

V. CONCLUSIONS

Maritime ISR will remain at the core of the Naval Operational Doctrine and will continue to be an essential element in improving the speed and effectiveness of naval and joint operations. Innovations resulting from the transformation of the DoD's business practices must be refined to meet the unique challenges posed by Intelligence, Surveillance, and Reconnaissance programs. It is the responsibility of program managers and DoD officials to do their very best to create realistic objectives, clear guidance and an effective organization when executing the resources of the United States in defense of the nation. Dwight D. Eisenhower once said:

> Every gun that is made, every warship launched, every rocket fired, signifies in the final sense a theft from those who hunger and are not fed, those who are cold and are not clothed.
>
> -Dwight D. Eisenhower

The citizens of the country are entitled to see standards for performance so they can judge whether the national objectives are being met in a responsible manner.

Congress recently criticized the DoD's acquisition and testing and evaluation of Intelligence, Surveillance and Reconnaissance (ISR) systems, stating that there has been "inadequate data to compare systems' capabilities and costs across the spectrum of intelligence programs, an imbalance between collection and analysis programs, and an intelligence effort that does not reflect an optimal allocation of resources."[36] Section 355 of the FY2004 Intelligence Authorization Act (P.L. 108-177) required a report from the Director of Central Intelligence (DCI) and the Secretary of Defense assessing progress in the development of "a comprehensive and uniform analytical capability to assess the utility and advisability of various sensor and platform architectures and capabilities for the collection of intelligence ... [and] the improvement of coordination between the Department [of Defense] and the intelligence community on strategic and budgetary planning."[37]

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[36] Best, Richard. Intelligence, Surveillance, and Reconnaissance: Issues for Congress. CRS Report for Congress (RL 32508). Washington: Congressional Research Service, 22 Feb 2005. p. 2.

[37] Ibid.

Assessing the impact and overall value of information technology investments, such as ISR systems, has been a continuing challenge, both in business and in the DoD. The solution to the valuation of IT systems has been referred to as one of the "holy grails of the Information Systems (IS) field," most notably, at a May 2005 presentation of this case study at the DoD's *2nd Annual Acquisitions Symposium* in Monterey, California. But even skeptics of the various methodologies proposed for measuring the value of IT acquisitions agree that a common framework must be created for understanding, evaluating, and in the end, justifying the impact of government investments in information technology on the overall successful completion of the national security mission of the United States.

The challenges in determining the value and risk associated with ISR systems acquisitions are plenty. In this particular case, the use of Commercial of the Shelf and Government off the Shelf (COTS/GOTS) systems and open systems architectures in ISR systems provide a level of risk, which must be managed. Technological complexities, the reliance on evolving software and systems, shortened acquisitions timelines and funding instability all contribute to this risk in Navy ISR systems such as the Cryptologic Carry-On Program (CCOP). Although the DoD has instituted rigorous types of testing and evaluation (T&E) for all of its programs and projects to mitigate risk, metrics for IT systems have lacked the requisite depth for meaningful valuation. Crucial to successful T&E is the development of measurable Key Performance Parameters (KPPs) and Measures of Effectiveness (MOEs) to provide accurate projections of system performance in a variety of operational environments.

It was the goal of this research to provide the means to extract measures of value and effectiveness to the CCOP Program office through the use of the Housel-Kenevsky Knowledge Value Added (KVA) Methodology. Applying KVA to the USS READINESS Case Study showed that the program managers could build metrics that are meaningful and useful in performing sound financial analysis of each system's performance at the process and subprocess level. KVA analysis also identified a new category and source of raw data which can provide insights into the relationship of cost and value of organizations, processes, and asset investments. This new data allows managers and senior decision makers to discuss the "value" of seemingly intangible assets in a defensible, empirical and replicable manner. Lastly, KVA facilitates the transformation and continuous process improvement of the DoD's global intelligence mission. Through KVA analysis, the operational value of CCOP systems can be measured and managed to ensure a responsible stewardship of the nation's resources and ensure that the soldiers and sailors who use these systems are receiving the right tools with the right capabilities required to perform their duties in defense of the nation.

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VI. RECOMMENDATIONS

The quest for the holy grail of information technology is far from over. An accurate valuation of Cryptologic Cary-On Program systems will come through an organizational transformation and operational transformation as well.

The Knowledge Value Added (KVA) Methodology, as any other methodology, is only as effective and meaningful as the data used to apply it. As indicated in the case study, data collection challenges remain. It is recommended that processes, both human and automated, be created to gather the required performance data in near-real-time. Automated logging of system utilization and performance are readily available in many business applications. Adapting such mechanisms directly into CCOP systems would facilitate the analysis of their performance. Human activity and performance mechanisms have also been used in the past, both in business and in the DoD.

KVA is a robust methodology, when applied throughout an enterprise with the appropriate inputs, it is capable of analyzing the data and returning defensible, quantifiable results in near-real-time. Although several accounting software packages have included KVA analytical capabilities, the research team at the Naval Postgraduate School identified the GaussSoft Valuation Software as the most capable software platform for conducting the level of analysis required by DoD program managers for valuing IT systems and processes. A brief overview of GaussSoft and screen shots of the multi-faceted reports produced by the software package are provided in Appendix B. It is recommended that this software package be deployed to receive real-time system and process inputs from deployed units operating CCOP systems as a proof-of-concept and operational test of the software capabilities.

A true measure of the impact of CCOP systems will require that the methodology and data gathering be analyzed and refined over a larger sampling of time. KVA, in its current form is ready for deployment; it is recommended that a study be conducted on CCOP systems at the Carrier Strike Group (CSG) or Expeditionary Strike Group (ESG) level over the course of one deployment to begin establishing performance baselines for systems and processes. It is also recommended that a community-wide effort be enacted along with the system developers to determine a universally accepted description of the embedded knowledge and required learning time of each system and process. A more in depth and extensive research should be conducted on the Market Comparables Approach to include a valuation study of the intelligence products produced by private military corporations (PMCs) as well as competitive and business intelligence organizations to achieve a common baseline which can be applied directly to DoD intelligence products. A KVA baseline should also

Lastly, it is recommended that an organization be identified to maintain KVA databases for CCOP systems. Such organization could be a central repository for system performance data as well as a ready source of performance and valuation reports which can be tapped quarterly or yearly by program managers wishing to make informed acquisition decisions.

APPENDIX A. USS READINESS KVA ANALYSIS

Historical Learning Time and Automation Data - 6 Month Deployment Sample Period
USS READINESS

Operator	Time in Service (Days)	Pre-Deploy-ment Training (Days)	On-Job Training (Days)	Totals	Assigned to Processes
Div Officer	1,825	15	292	2,132	1,2,9
Div LPO	4,380	15	524	4,919	1,2,9,7
SigOp 1	3,285	30	486	3,801	3-7,9
SigOp 2	2,190	30	366	2,586	3-7
SigOp 3	1,095	30	325	1,450	4-7
SigOp 4	730	30	219	979	4-6
SigOp 5	730	30	184	944	4-6
ComOp1	2190	20	325	2,535	8,10
ComOp2	1096	20	219	1,335	8,10
ComOp3	730	20	184	934	8,10

CCOP A Aggregated Time to Learn =	4,092
CCOP B Time to Learn =	1,460
CCOP C Time to Learn =	500
CCOP D Time to Learn =	1,825

Assumptions:

Subprocesses over which both IT Infras spread = 10

(CCOP System Time to Learn is divided evenly over subprocesses in which they operate)

	Sub-Process Name	CCOP Assigned	Process Training t_{LH} (days)	Other Relevant t_{LH} (days)	Tot t_{LH} (days)	CCOP t_{LIT} (days)	Avg % Automat'n	Tot t_{LIT} times % Automat'n (days)	Tot t_L for 1 Process Output (days)
P1	Review Request/Tasking	A	20	7051	7071	409	25.00%	102.30	7,173.30
P2	Determine Op/Equip Mix	A	10	7051	7061	409	10.00%	40.92	7,101.92
P3	Input Search Function/Coverage Plan	A	35	6387	6422	409	21.00%	85.93	6,507.93
P4	Search/Collection Process	A,B	35	9760	9795	896	36.25%	324.75	10,119.75
P5	Target Data Acquisition/Capture	A,B	16	9760	9776	896	35.00%	313.55	10,089.55
P6	Target Data Processing	A,B,C,D	340	9760	10100	2058	48.89%	1,006.34	11,106.34
P7	Target Data Analysis	A,C,D	50	12756	12806	1572	51.67%	812.10	13,618.10
P8	Format Data for Report Generation	A	10	4804	4814	409	41.67%	170.51	4,984.51
P9	QC Report	A	30	10852	10882	409	25.00%	102.30	10,984.30
P10	Transmit Report	A	14	4804	4818	409	86.67%	354.65	5,172.65
					83545			3,313.36	86,858.36

	Subprocess Name	Total t_{LIT} times % Automat'n (days)	Total t_{LH} (days)	Total t_L for 1 Process Executns (days)	Range of Values for Non-Routine t_L: Upper	Range of Values for Non-Routine t_L: Lower
P1	Review Request/Tasking	102.30	7,071.00	7,173.30		
P2	Determine Op/Equip Mix	40.92	7,061.00	7,101.92		
P3	Input Search	85.93	6,422.00	6,507.93	10.00%	-10.00%
P4	Search/Collection Process	324.75	9,795.00	10,119.75	20.00%	-20.00%
P5	Target Data	313.55	9,776.00	10,089.55	20.00%	-20.00%
P6	Target Data Processing	1,006.34	10,100.00	11,106.34	10.00%	-10.00%
P7	Target Data Analysis	812.10	12,806.00	13,618.10	10.00%	-10.00%
P8	Format Data for Report	170.51	4,814.00	4,984.51	15.00%	-15.00%
P9	QC Report	102.30	10,882.00	10,984.30	All other t_L cannot vary,	
P10	Transmit Report	354.65	4,818.00	5,172.65	since processes are	
		3,313.36	83,545.00	86,858.36	routine.	

ASSUMPTIONS

	Sample Pd	Prior Pd	Range of Values: Upper	Range of Values: Lower
Avg # Reports during sample period	235			
Length of sample period as %	100.00%	0.00%		
Avg # Reports executed/sample pd	235	-	20.00%	-20.00%
# Ships in this period =	1			
# SigOps/Category/Ship =	1			
# SigOp Categories/Ship =	4			
# CCOPs/Category/Ship =	1			
# CCOP Categories/Ship =	4			
# Command Teams/Ship =	1			
# units of time =	365			

Knowledge in Use for Sample Period - Including Automation

Asset	# executns by Asset *P1*	Total K *P1*	# executns by Asset P2	Total K *P2*	# executns by Asset P3	Total K *P3*	# executns by Asset P4	Total K *P4*
Div Officer	92.00	659943.60	92.00	653376.64	0.00	0.00	0.00	0.00
Div LPO	100.00	717330.00	100.00	710192.00	0.00	0.00	0.00	0.00
SigOp 1	0.00	0.00	0.00	0.00	100.00	650793.20	135.00	1366166.48
SigOp 2	0.00	0.00	0.00	0.00	92.00	598729.74	144.00	1457244.24
SigOp 3	0.00	0.00	0.00	0.00	0.00	0.00	162.00	1639399.77
SigOp 4	0.00	0.00	0.00	0.00	0.00	0.00	152.00	1538202.25
SigOp 5	0.00	0.00	0.00	0.00	0.00	0.00	158.00	1598920.76
ComOp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ComOp2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ComOp3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCOP A	192.00	1377273.60	192.00	1363568.64	192.00	1249522.94	751.00	7599933.50
CCOP B	0.00	0.00	0.00	0.00	0.00	0.00	92.00	931017.15
CCOP C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCOP D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IT Fixed	235.00	1685725.50	235.00	1668951.20	235.00	1529364.02	235.00	2378141.64
Infrastructure		4440272.70		4396088.48		4028409.91		18509025.80

# executns by Asset P5	Total K *P5*	# executns by Asset P6	Total K *P6*	# executns by Asset P7	Total K *P7*	# executns by Asset P8	Total K *P8*	# executns by Asset P9	Total K *P9*	# executns by Asset P10	Total K *P10*	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	856775.40	0.00	0.00	
0.00	0.00	0.00	0.00	24.00	326834.34	0.00	0.00	78.00	856775.40	0.00	0.00	
56.00	565014.99	56.00	621954.79	28.00	381306.73	0.00	0.00	79.00	867759.70	0.00	0.00	
63.00	635641.86	63.00	699699.13	30.00	408542.92	0.00	0.00	0.00	0.00	0.00	0.00	
45.00	454029.90	45.00	499785.10	8.00	108944.78	0.00	0.00	0.00	0.00	0.00	0.00	
35.00	353134.37	35.00	388721.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
36.00	363223.92	36.00	399828.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	78.00	388792.06	0.00	0.00	78.00	403466.98	
0.00	0.00	0.00	0.00	0.00	0.00	78.00	388792.06	0.00	0.00	78.00	403466.98	
0.00	0.00	0.00	0.00	0.00	0.00	79.00	393776.58	0.00	0.00	79.00	408639.64	
235.00	2371045.03	235.00	2609988.83	90.00	1225628.77	235.00	1171360.71	235.00	2581310.50	235.00	1215573.61	
92.00	928238.91	92.00	1021782.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	199.00	2210160.76	199.00	2710001.38	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	68.00	755230.81	68.00	926030.62	0.00	0.00	0.00	0.00	0.00	0.00	
235.00	2371045.03	235.00	2609988.83	235.00	3200252.89	235.00	1171360.71	235.00	2581310.50	235.00	1215573.61	
	8041374.01		11817140.93		9287542.42		3514082.12		7743931.50		3646720.82	75424588.68

Historical KVA for USS READINESS for Intelligence Collection Process

Total K Contribution and Human K

Assigned to Processes	Asset	Avg Annual Unit Costs	Avg Annual Unit Bonus	Budget (Cost) per Sample Pd	Cost per Operator per Sub-process
1,2,9	Div Officer	$ 79,298	$ -	$ 39,649	$13,216.33
1,2,9	Div LPO	$ 79,298	$ -	$ 39,649	$9,912.25
3-7,9	SigOp 1	$ 61,883	$ 35,475	$ 48,679	$8,113.17
3-7	SigOp 2	$ 58,190	$ 14,958	$ 36,574	$7,314.80
4-7	SigOp 3	$ 44,391	$ 17,177	$ 30,784	$7,696.00
4-6	SigOp 4	$ 43,397	$ -	$ 21,699	$7,232.83
4-6	SigOp 5	$ 41,518	$ -	$ 20,759	$6,919.67
8,10	ComOp1	$ 44,391		$ 22,196	$11,097.75
8,10	ComOp2	$ 43,397		$ 21,699	$10,849.25
8,10	ComOp3	$ 41,518		$ 20,759	$10,379.50
	Total Human			$ 302,446	
1-10	CCOP A	$ 193,500		$ 96,750	
4-6	CCOP B	$ 44,643		$ 22,322	
6,7	CCOP C	$ 24,000		$ 12,000	
6,7	CCOP D	$ 126,923		$ 63,462	
	Total IT			$ 194,533	
1-10	Fixed IT Infrastructure			$ 102,500	
1-10	Other Fixed Costs			$ -	
	GRAND TOTALS			$ 599,479	

Proxy Revenue & Cost Assumptions	
Market Comparable Price Per Unit (avg)	$ 3,800
Avg# Reports executed/sample pd	235
Avg Proxy for Revs - Sample Pd =	$ 893,000
Avg cost for IT Fixed Infrastructure (annual) =	$ 205,000
All other fixed costs (annual) =	$ -
Length of Sample Pd as % of Year =	50.00%
	$ -

Historical KVA for USS READINESS for Intelligence Collection Process

Total K Contribution and Human K

	Subprocess Name	K for IT (automation & infras)	K for Humans	Total K	% of Total K per sub-process	Proxy Revenue Assigned to Sub-process ($US)	Cost Assigned to Sub-process ($US)	% of Total K for Human per Sub-process	Proxy Revenue Assigned to Human K ($US)	Cost Assigned to Human K ($US)
P1	Receive/Review Request/Tasking	3,062,999.10	1,377,273.60	4,440,272.70	5.8870%	$ 52,571	$ 43,054	1.8260%	$ 16,306	$23,128.58
P2	Determine Op/Equip Mix	3,032,519.84	1,363,568.64	4,396,088.48	5.8285%	$ 52,048	$ 43,054	1.8079%	$ 16,144	$23,128.58
P3	Load Search Func/Coverage Plan	2,778,886.96	1,249,522.94	4,028,409.91	5.3410%	$ 47,695	$ 58,482	1.6567%	$ 14,794	$15,427.97
P4	Search/Collection	10,909,092.30	7,599,933.50	18,509,025.80	24.5398%	$ 219,140	$ 64,642	10.0762%	$ 89,980	$37,276.47
P5	Target Data Acquisition/Capture	5,670,328.97	2,371,045.03	8,041,374.01	10.6615%	$ 95,207	$ 64,642	3.1436%	$ 28,072	$37,276.47
P6	Target Data Processing	9,207,152.10	2,609,988.83	11,817,140.93	15.6675%	$ 139,911	$ 102,373	3.4604%	$ 30,901	$37,276.47
P7	Target Data Analysis	8,061,913.65	1,225,628.77	9,287,542.42	12.3137%	$ 109,961	$ 90,692	1.6250%	$ 14,511	$23,123.97
P8	Format Data for Report Generation	2,342,721.41	1,171,360.71	3,514,082.12	4.6591%	$ 41,605	$ 52,252	1.5530%	$ 13,868	$32,326.50
P9	QC Report	5,162,621.00	2,581,310.50	7,743,931.50	10.2671%	$ 91,685	$ 51,167	3.4224%	$ 30,562	$31,241.75
P10	Transmit Report	2,431,147.21	1,215,573.61	3,646,720.82	4.8349%	$ 43,176	$ 52,252	1.6116%	$ 14,392	$32,326.50
		52,659,382.55	22,765,206.13	75,424,588.68	100.0000%	$ 893,000	$ 622,607	30.1827%	$ 269,532	$ 292,533

Historical KVA for USS READINESS for Intelligence Collection Process Total K Contribution and Human K											
KVA Metrics for Total K						KVA Metrics for Human K					
	Subprocess Name	ROK as Ratio	ROK *as* %	ROKA	ROKI		Subprocess Name	ROK as Ratio	ROK *as* %	ROKA	ROKI
P1	Receive/Review Request/Tasking	1.22	122.11%	18.10%	22.11%	*P1*	Receive/Review Request/Tasking	0.71	70.50%	-41.84%	-29.50%
P2	Determine Op/Equip Mix	1.21	120.89%	17.28%	20.89%	*P2*	Determine Op/Equip Mix	0.70	69.80%	-43.26%	-30.20%
P3	Load Search Func/Coverage Plan	0.82	81.56%	-22.62%	-18.44%	*P3*	Load Search Func/Coverage Plan	0.96	95.89%	-4.29%	-4.11%
P4	Search/Collection	3.39	339.01%	70.50%	239.01%	*P4*	Search/Collection	2.41	241.39%	58.57%	141.39%
P5	Target Data Acquisition/Capture	1.47	147.28%	32.10%	47.28%	*P5*	Target Data Acquisition/Capture	0.75	75.31%	-32.79%	-24.69%
P6	Target Data Processing	1.37	136.67%	26.83%	36.67%	*P6*	Target Data Processing	0.83	82.90%	-20.63%	-17.10%
P7	Target Data Analysis	1.21	121.25%	17.52%	21.25%	*P7*	Target Data Analysis	0.63	62.75%	-59.35%	-37.25%
P8	Format Data for Report Generation	0.80	79.63%	-25.59%	-20.37%	*P8*	Format Data for Report Generation	0.43	42.90%	-133.09%	-57.10%
P9	QC Report	1.79	179.19%	44.19%	79.19%	*P9*	QC Report	0.98	97.82%	-2.22%	-2.18%
P10	Transmit Report	0.83	82.63%	-21.02%	-17.37%	*P10*	Transmit Report	0.45	44.52%	-124.62%	-55.48%
Metrics for Aggregated		14.10	1410.20%	157.31%	410.20%		Metrics for Aggregate	8.84	883.79%	-403.52%	-116.21%
Please note that the floor for ROKA is -100% (e.g., zero return on knowledge ass						Please note that the floor for ROKA is -100% (e.g., zero return on knowledge assets)					

Historical KVA for USS READINESS for Intelligence Collection Process IT Contribution								
Proxy Revenue & Cost Assumptions			CCOP A K	CCOP B K	CCOP C K	CCOP D K	Fixed Infras K	Total IT K
Market Comparable Price Per Unit (avg)	$ 3,800	*P1*	1,377,273.60				1,685,725.50	3,062,999.10
Avg# Reports executed/sample pd	235	*P2*	1,363,568.64				1,668,951.20	3,032,519.84
Avg Proxy for Revs - Sample Pd =	$ 893,000	*P3*	1,249,522.94				1,529,364.02	2,778,886.96
Avg cost for IT Fixed Infrastructure (annual) =	$ 205,000	*P4*	7,599,933.50	931,017.15			2,378,141.64	10,909,092.30
All other fixed costs (annual) =	$ -	*P5*	2,371,045.03	928,238.91			2,371,045.03	5,670,328.97
		P6	2,609,988.83	1,021,782.86	2,210,160.76	755,230.81	2,609,988.83	9,207,152.10
Length of Sample Pd as % of Year =	50.00%	*P7*	1,225,628.77		2,710,001.38	926,030.62	3,200,252.89	8,061,913.65
		P8	1,171,360.71				1,171,360.71	2,342,721.41
		P9	2,581,310.50				2,581,310.50	5,162,621.00
		P10	1,215,573.61				1,215,573.61	2,431,147.21
			22,765,206.13	2,881,038.92	4,920,162.14	1,681,261.43	20,411,713.93	52,659,382.55

Subprocess Name		K for IT (automation & infras)	K for Humans	Total K	% of Total K for CCOP A	Proxy Revenue Assigned to CCOP A Process K ($US)	Cost Assigned to CCOP A Process K ($US)	% of Total K for CCOP B	Proxy Revenue Assigned to CCOP B Process K ($US)	Cost Assigned to CCOP B Process K ($US)
P1	Receive/ Review Request/ Tasking	3,062,999.10	1,377,273.60	4,440,272.70	1.83%	$ 16,306	$ 9,675	0.00%	$ -	
P2	Determine Op/Equip Mix	3,032,519.84	1,363,568.64	4,396,088.48	1.81%	$ 16,144	$ 9,675	0.00%	$ -	
P3	Load Search Func/ Coverage	2,778,886.96	1,249,522.94	4,028,409.91	1.66%	$ 14,794	$ 9,675	0.00%	$ -	
P4	Search/ Collection	10,909,092.30	7,599,933.50	18,509,025.80	10.08%	$ 89,980	$ 9,675	1.23%	$ 11,023	$ 7,441
P5	Target Data Acquisition/ Capture	5,670,328.97	2,371,045.03	8,041,374.01	3.14%	$ 28,072	$ 9,675	1.23%	$ 10,990	$ 7,441
P6	Target Data Processing	9,207,152.10	2,609,988.83	11,817,140.93	3.46%	$ 30,901	$ 9,675	1.35%	$ 12,098	$ 7,441
P7	Target Data Analysis	8,061,913.65	1,225,628.77	9,287,542.42	1.62%	$ 14,511	$ 9,675	0.00%	$ -	
P8	Format Data for Report Generation	2,342,721.41	1,171,360.71	3,514,082.12	1.55%	$ 13,868	$ 9,675	0.00%	$ -	
P9	QC Report	5,162,621.00	2,581,310.50	7,743,931.50	3.42%	$ 30,562	$ 9,675	0.00%	$ -	
P10	Transmit Report	2,431,147.21	1,215,573.61	3,646,720.82	1.61%	$ 14,392	$ 9,675	0.00%	$ -	
		52,659,382.55	22,765,206.13	75,424,588.68	30.18%	$ 269,532	$ 96,750	3.82%	$ 34,110	$ 22,322

	Subprocess Name	% of Total K for CCOP C	Proxy Revenue Assigned to CCOP C Process K ($US)	Cost Assigned to CCOP C Process K ($US)	% of Total K for CCOP D	Proxy Revenue Assigned to CCOP D Process K ($US)	Cost Assigned to CCOP D Process K ($US)	% of Total K for Fixed IT Infrastructure	Proxy Revenue Assigned to Fixed Infras Process K ($US)	Cost Assigned to Fixed Infras Process K ($US)
P1	Receive/ Review Request/ Tasking	-	$ -		-	$ -		0.022350	$ 19,958	$ 10,250
P2	Determine Op/Equip Mix	-	$ -		-	$ -		0.022127	$ 19,760	$ 10,250
P3	Load Search Func/ Coverage	-	$ -		-	$ -		0.020277	$ 18,107	$ 10,250
P4	Search/ Collection	0.00%	$ -		0.00%	$ -		3.15%	$ 28,156	$ 10,250
P5	Target Data Acquisition/ Capture	0.00%	$ -		0.00%	$ -		3.14%	$ 28,072	$ 10,250
P6	Target Data Processing	2.93%	$ 26,168	$ 6,000	1.00%	$ 8,942	$ 31,731	3.46%	$ 30,901	$ 10,250
P7	Target Data Analysis	3.59%	$ 32,085	$ 6,000	1.23%	$ 10,964	$ 31,731	4.24%	$ 37,890	$ 10,250
P8	Format Data for Report Generation	0.00%	$ -		0.00%	$ -		1.55%	$ 13,868	$ 10,250
P9	QC Report	0.00%	$ -		0.00%	$ -		3.42%	$ 30,562	$ 10,250
P10	Transmit Report	0.00%	$ -		0.00%	$ -		1.61%	$ 14,392	$ 10,250
		6.52%	$ 58,253	$ 12,000	2.23%	$ 19,906	$ 63,462	27.06%	$ 241,667	$ 102,500

KVA Metrics for CCOP A K					
	Sub-Process Name	ROK as Ratio	ROK *as* %	ROKA	ROKI
P1	Receive/ Review Request/ Tasking	1.69	168.54%	40.67%	68.54%
P2	Determine Op/Equip Mix	1.67	166.86%	40.07%	66.86%
P3	Load Search Func/ Coverage Plan	1.53	152.91%	34.60%	52.91%
P4	Search/ Collection	9.30	930.03%	89.25%	830.03%
P5	Target Data Acquisition/ Capture	2.90	290.15%	65.54%	190.15%
P6	Target Data Processing	3.19	319.39%	68.69%	219.39%
P7	Target Data Analysis	1.50	149.98%	33.33%	49.98%
P8	Format Data for Report Generation	1.43	143.34%	30.24%	43.34%
P9	QC Report	3.16	315.88%	68.34%	215.88%
P10	Transmit Report	1.49	148.75%	32.77%	48.75%
Metrics for Aggregated		27.86	2785.86%	503.50%	1785.86%

Please note that the floor for ROKA is -100% (e.g., zero return on knowledge assets)

	KVA Metrics for CCOP B K				
	Sub-Process Name	ROK as Ratio	ROK as %	ROKA	ROKI
P1	Receive/ Review Request/ Tasking				
P2	Determine Op/Equip Mix				
P3	Load Search Func/ Coverage Plan				
P4	Search/ Collection	1.48	148.15%	32.50%	48.15%
P5	Target Data Acquisition/Capture	1.48	147.71%	32.30%	47.71%
P6	Target Data Processing	1.63	162.59%	38.50%	62.59%
P7	Target Data Analysis				
P8	Format Data for Report Generation				
P9	QC Report				
P10	Transmit Report				
Metrics for Aggregated		4.58	458.44%	103.29%	158.44%

	KVA Metrics for CCOP C K				
	Sub-Process Name	ROK as Ratio	ROK as %	ROKA	ROKI
P1	Receive/ Review Request/ Tasking				
P2	Determine Op/Equip Mix				
P3	Load Search Func/ Coverage Plan				
P4	Search/ Collection				
P5	Target Data Acquisition/Capture				
P6	Target Data Processing	4.36	436.13%	77.07%	336.13%
P7	Target Data Analysis	5.35	534.76%	81.30%	434.76%
P8	Format Data for Report Generation				
P9	QC Report				
P10	Transmit Report				
Metrics for Aggregated		9.71	970.88%	158.37%	770.88%

Please note that the floor for ROKA is -100% (e.g., zero return on knowledge assets)

	KVA Metrics for CCOP D K				
	Sub-Process Name	ROK as Ratio	ROK as %	ROKA	ROKI
P1	Receive/ Review Request/ Tasking				
P2	Determine Op/Equip Mix				
P3	Load Search Func/ Coverage Plan				
P4	Search/ Collection				
P5	Target Data Acquisition/ Capture				
P6	Target Data Processing	0.28	28.18%	-254.86%	-71.82%
P7	Target Data Analysis	0.35	34.55%	-189.41%	-65.45%
P8	Format Data for Report Generation				
P9	QC Report				
P10	Transmit Report				
Metrics for Aggregated		0.63	62.73%	-444.28%	-137.27%

	KVA Metrics for Fixed Infrastructure K				
	Sub-Process Name	ROK as Ratio	ROK as %	ROKA	ROKI
P1	Receive/ Review Request/ Tasking	1.95	194.72%	48.64%	94.72%
P2	Determine Op/Equip Mix	1.93	192.78%	48.13%	92.78%
P3	Load Search Func/ Coverage Plan	1.77	176.65%	43.39%	76.65%
P4	Search/ Collection	2.75	274.70%	63.60%	174.70%
P5	Target Data Acquisition/ Capture	2.74	273.88%	63.49%	173.88%
P6	Target Data Processing	3.01	301.48%	66.83%	201.48%
P7	Target Data Analysis	3.70	369.66%	72.95%	269.66%
P8	Format Data for Report Generation	1.35	135.30%	26.09%	35.30%
P9	QC Report	2.98	298.16%	66.46%	198.16%
P10	Transmit Report	1.40	140.41%	28.78%	40.41%
Metrics for Aggregated		23.58	2357.73%	528.36%	1357.73%

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APPENDIX B. GAUSSSOFT OVERVIEW

[GAUSS Overview provided courtesy of GaussSoft, Inc. <http:www.gaussoft.com>]

GAUSS is a line of software created by GaussSoft, Inc., a privately held US corporation founded in 1993, with headquarters in San Jose, California and an extended presence with offices and partners in NorthAmerica, Europe and Latin America.

GaussSoft delivers scalable Enterprise Performance Intelligence solutions. GaussSoft products enable large and medium-sized companies to control and reduce the cost of enterprise operations, increase profitability and improve organizational productivity by providing flexibility, scalability and ease of use.

GaussSoft's solutions are built on an integrated suite of high performance products for Profit and Cost Analysis, Multidimensional Query, and Activity Reporting that are scalable, function-rich, and easy to use.

GaussSoft has installed performance intelligence solutions in over 200 enterprise and consulting companies all around the world, including telecommunication, banking, manufacturing and agribusiness firms and government organizations. They have been implemented in customer premises by leading consulting firms including Deloitte, KPMG and Price.

GaussSoft suite includes:

Gauss - Profit and Cost Allocation Engine: This strategic decision-making and analysis solution enables companies to know which products, services, and customers are making profits and which aren't. Using different value and costing methodologies this solution helps reduce and control the cost of enterprise operations, increase profitability and improve organizational productivity.

Gauss - KVA: Knowledge Value Added (KVA) is a methodology that allows any organization to calculate the economic performance of core processes by providing an objective way to allocate revenue to the processes at any level within the organization. Knowing how much revenue corporate knowledge is producing, allows organizations to dramatically improve their effectiveness and efficiency.

Gauss - Planning: This enterprise collaborative solution allows thousands of users to perform corporate enterprise planning, including financial planning, budgeting and forecasting up to 10 times faster. When used with Gauss Profit and Gauss KVA, an organization can create plans optimized for profitability and value.

Gauss - Radial Viewer: This is a Business Intelligence (BI) front-end with graphical interaction. This tool enables all End Users to create their own queries and professional looking reports from scratch -in seconds-.

Figures 5-7 are graphical outputs of GaussSoft products.

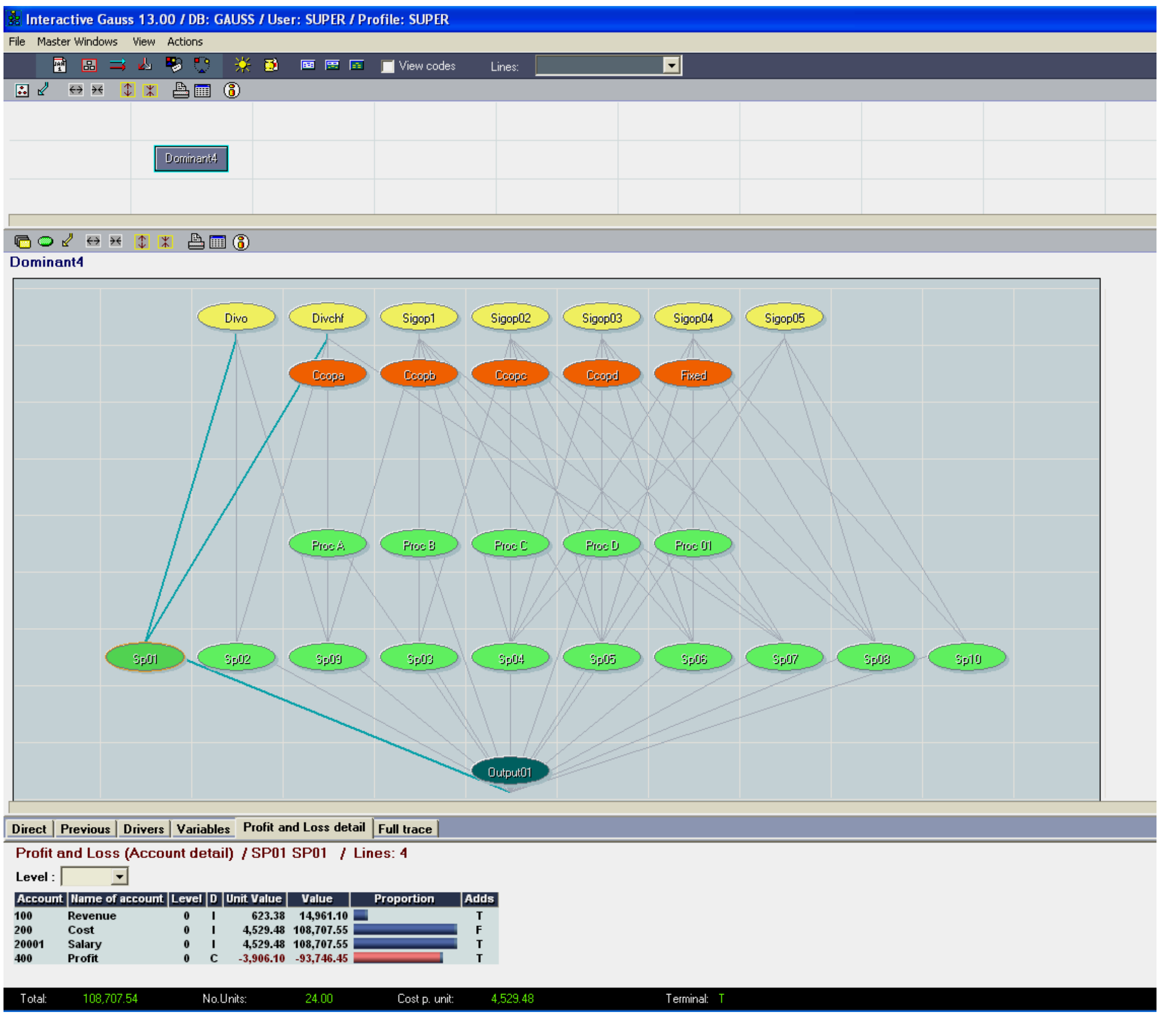


Figure 5. GaussSoft Accumulator View for KVA Case Study.

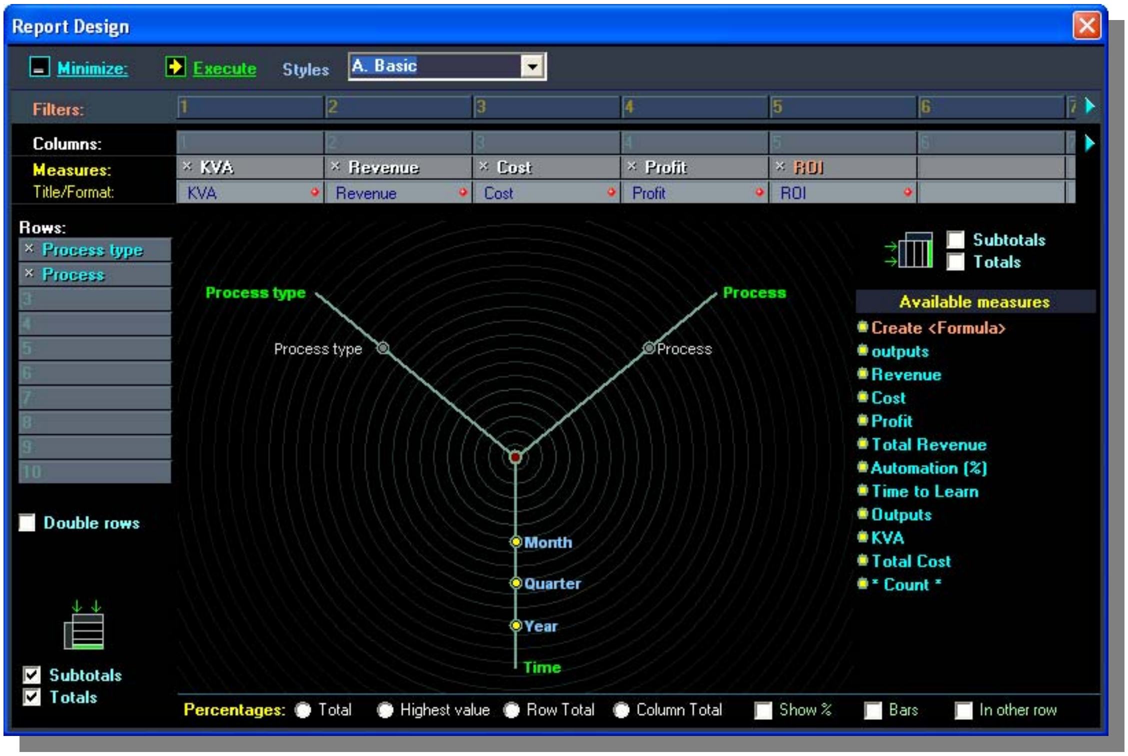
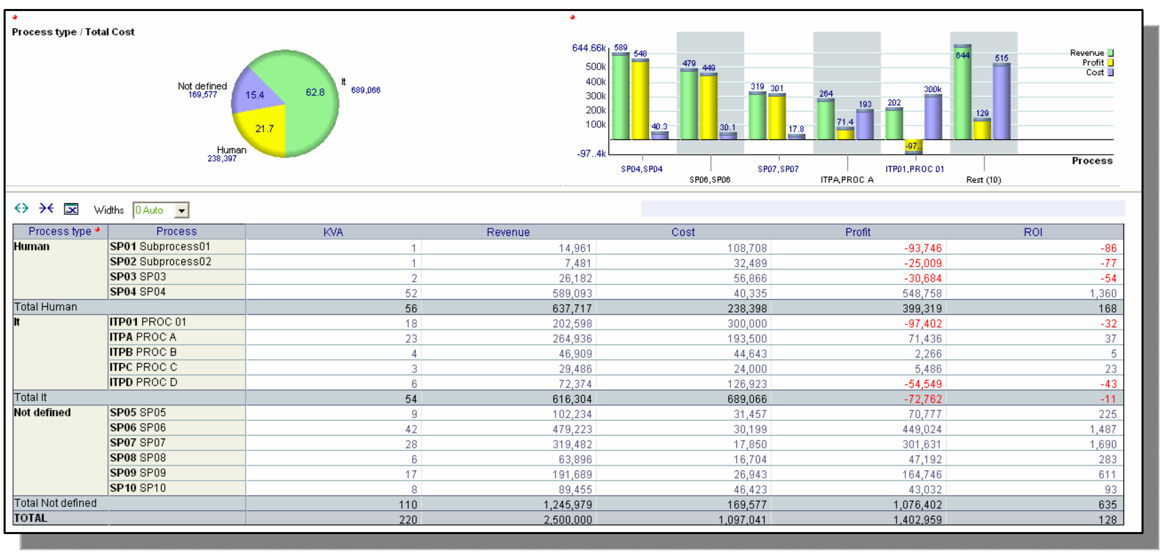


Figure 6. GaussSoft Radial Viewer Report Design Screen.



Process type	Process	KVA	Revenue	Cost	Profit	ROI
Human	SP01 Subprocess01	1	14,961	108,708	-93,746	-86
	SP02 Subprocess02	1	7,481	32,489	-25,009	-77
	SP03 SP03	2	26,182	56,866	-30,684	-54
	SP04 SP04	52	589,093	40,335	548,758	1,360
Total Human		56	637,717	238,398	399,319	168
It	ITP01 PROC 01	18	202,598	300,000	-97,402	-32
	ITPA PROC A	23	264,936	193,500	71,436	37
	ITPB PROC B	4	46,909	44,643	2,266	5
	ITPC PROC C	3	29,486	24,000	5,486	23
	ITPD PROC D	6	72,374	126,923	-54,549	-43
Total It		54	616,304	689,066	-72,762	-11
Not defined	SP05 SP05	9	102,234	31,457	70,777	225
	SP06 SP06	42	479,223	30,199	449,024	1,487
	SP07 SP07	28	319,482	17,850	301,631	1,690
	SP08 SP08	6	63,896	16,704	47,192	283
	SP09 SP09	17	191,689	26,943	164,746	611
	SP10 SP10	8	89,455	46,423	43,032	93
Total Not defined		110	1,245,979	169,577	1,076,402	635
TOTAL		220	2,500,000	1,097,041	1,402,959	128

Figure 7. GaussSoft Radial Viewer Sample Report

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