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A Methodology for Improving the Shipyard Planning Process: Using KVA Analysis, Risk Simulation and Strategic Real Options

30 September 2006

by

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Abstract

The U.S. Navy must be extremely diligent with its maintenance policies to ensure that ships and submarines meet national defense objectives. Maximizing the Navy's readiness requires continuous process improvement and innovation, and making information technology (IT) acquisitions that leverage technological advances to reduce costs and increase efficiency levels. Measurement tools are essential to define, capture, measure and evaluate the total value of potential IT acquisitions to ensure the likelihood of success.

This paper describes research conducted on the Knowledge Value Added/Real Options (KVA+RO) Valuation Framework. A comprehensive tool, KVA+RO was applied to Naval maintenance processes in a case study analyzing the potential impact of Commercial-off-the-shelf (COTS) technology on ship yard planning processes. Specific technology, including three-dimensional (3D) laser scanning and collaborative Product Lifecycle Management (PLM) solutions, were evaluated under three scenarios. Real Options analysis was also performed to determine the prospective value of strategic options over a three-year period.

Key Words: return on investment, real options, integrated risk management, value, cost

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I.0 Introduction

Defense leaders must maintain and modernize the United States Armed Forces to retain technological superiority while balancing defense budget constraints and wide-ranging military operational commitments, in addition to navigating an intricate information technology (IT) acquisition process. The Department of Defense (DoD) spends more than $63 billion annually—14% of its total budget—on defense maintenance programs spanning major depots, shipyards, and intermediate and organizational units throughout the world (Office of the Deputy Under Secretary of Defense (Logistics and Material Readiness), 2005). A broad range of defense maintenance capabilities and programs supporting approximately 280 ships, 14,000 aircraft, 900 strategic missiles and 330,000 ground combat and tactical vehicles are provided by nearly 680,000 personnel and several thousand commercial firms (Office of the Deputy Under Secretary of Defense (Logistics and Material Readiness), 2005).

To evaluate and select projects returning maximum benefits, measurement tools are essential to define, capture and measure the total value of IT acquisitions. These tools must capture data across a spectrum of organizations to compare processes, capabilities, costs, revenues and other benefits. Moreover, they must incorporate and analytically quantify elements of uncertainty and risks inherent in predicting the future, include ways to mitigate these risks through strategic options, and analytically develop and allocate budgets to optimize project portfolios. Understanding uncertainties and mitigating the potential impact of risks can significantly improve the likelihood of success in acquisition decisions.

The Naval Postgraduate School (NPS) developed the Knowledge Value Added/Real Options (KVA+RO) valuation framework to address these issues. KVA+RO analysis is designed to support IT portfolio acquisitions and to empower decision-makers by providing performance-based data and scenario analysis. Analyses like Return on Investment (ROI) on individual projects, programs and processes within a portfolio of IT acquisitions can be derived through KVA methodology. With historical data provided by KVA, potential strategic investments can then be evaluated with Real Options analysis. The analysis applied is a robust and analytical process incorporating the risk identification (applying various sensitivity techniques), risk quantification (applying Monte Carlo simulation), risk valuation (Real Options analysis), risk mitigation (Real Options framing), and risk diversification (analytical portfolio optimization).

This paper introduces the KVA+RO valuation framework. It begins with a discussion of the DoD's Portfolio Management mandate, requiring measurement of portfolio investments. It then briefly reviews performance measurement tools used by profit and non-profit organizations. In the third section, core concepts of the KVA+RO Valuation Framework, along with underlying assumptions, metrics and potential applications are presented. Section four applies KVA+RO Valuation Framework to Naval maintenance processes in a case study analyzing the potential impact of Commercial-off-the-shelf (COTS) technology. COTS technology could improve maintenance processes and substantially reduce costs over the 20-, 30- and 50-year lifecycle of Navy ships. In particular, 3Dimensional (3D) laser scanning technology and collaborative Product Lifecycle Management (PLM) solutions are evaluated under three scenarios: current "As Is," potential "To Be," and "Radical To Be." Results from our case analysis indicate that these technologies have the potential to:

- reduce maintenance costs for ships by expediting maintenance work in shipyards
- decrease maintenance costs by eliminating or reducing DoD planning yard labor costs
- provide an opportunity to improve fleet utilization and/or reduce fleet inventory requirements through reduced cycle-time
- improve productivity in current shipyard planning processes, allowing for increased shipboard modernization

Section four also identifies cost savings and areas of process improvements. In section five, Real Options analysis is conducted to determine the prospective value of the three strategic options over a 3-year period using KVA data as a platform. The paper concludes with specific recommendations.

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2.0 Defense Maintenance and Technology Acquisitions

The nation's leaders are committed to maintaining force operational readiness, superior technological edge, and quality material condition of military assets. DoD maintenance activities span a broad range of capabilities and programs, ranging from major depots and shipyards to intermediate and organizational level units throughout the world. Maintenance activities, performed at several levels of complexity, range from the rapid removal and replacement of components to complete overhaul or rebuilding of a weapon system.

The DoD has also been transforming itself towards capabilities-based planning, resource allocation and acquisition, based on principals of joint interoperability and network-centric warfare. IT resources were traditionally managed and acquired as stand-alone systems, resulting in duplicative investments in systems or platforms to deliver the same or similar capabilities, focusing on system or platform capabilities rather than on mission capabilities, and limiting the ability to share information. Legislation like the Clinger-Cohen Act of 1996 and the Information Technology Management Reform Act required federal agencies to implement an IT investment capital planning process. Directive 8115.01, issued in October of 2005, further mandates the management of IT investments as portfolios within the DoD enterprise. A portfolio is defined by the DoD as the group of capabilities, resources, management, and related investments required in accomplishing a mission-related or administrative outcome.[1] A portfolio includes outcome performance measures (mission, functional or administrative measures) and an expected return on investment (Department of Defense, 2005, October).

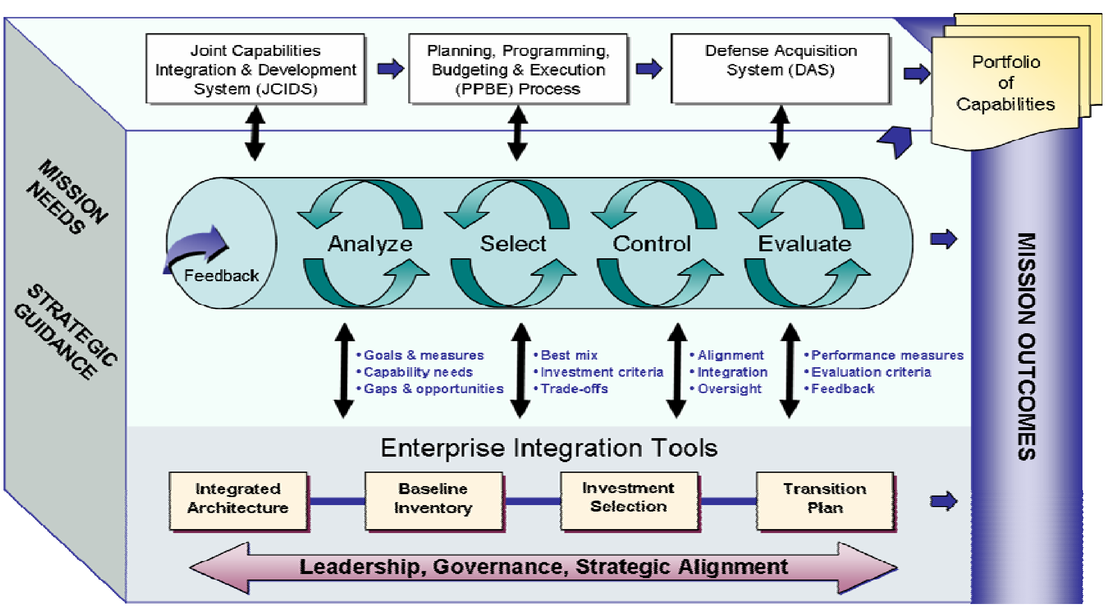
---

[1] "Resources" include people, money, facilities, weapons, information technology, other equipment, logistics support, services and information. "Management" includes strategic planning, capital planning, governance, process improvements, performance metrics/measures, requirements generation, acquisition/development and operations.

The Portfolio Management process emphasizes overall mission capability from individual systems and is a comprehensive strategy for making decisions based on enterprise strategic planning, integrated architectures, and outcome-based performance measures to achieve desired mission capabilities. It is an ongoing, collaborative, cross-cutting and flexible process that is performed by stakeholder teams representing all lifecycle activities (e.g., capabilities, resources, acquisition, operations, deactivation, and retirement/reutilization or demilitarization). Driven by mission outcomes to produce end-to-end IT capabilities, Portfolio Management provides the "glue" linking systems and the DoD's principal decision support processes: Joint Capabilities Integration and Development System (JCIDS), Planning, Programming, Budgeting and Execution (PPBE), and the Defense Acquisition System (DAS).

To manage IT portfolios, the DoD uses four continuous integrated and iterative activities: analysis, selection, control and evaluation. As an iterative process, results are fed back into the system to guide future decisions.

Figure 1. DoD IT Portfolio Management Decision-support Interactions



(Source: Department of Defense, 2005, October)

Each activity in the Portfolio Management process has a specific function:

- ***Analysis:*** performance goals established, gaps and opportunities identified; continuous improvement measures implemented; functional and technical options documented "as-is" and future architectures are further explored (Department of Defense, 2005, October); Addresses front-end requirements for legislation requiring strategic planning, performance and results management, benchmarking, elimination of unnecessary functions, process improvement, and definition of capabilities and gaps.

- ***Selection***: best mix of investments to achieve Enterprise, Mission Area, Sub-Portfolio, and Component outcomes to meet integrated strategic goals, architectures, programmatic and technical criteria, achieve results and maximize outcome.

- ***Control***: capabilities selected for portfolio are acquired. Consists of acquisition and oversight activities at the portfolio level complementing and supplementing traditional single-system, single-platform acquisition and oversight activities.

- ***Evaluation***: focuses on measuring and assessing outcomes of portfolio investments to determine whether expected benefits are achieved. Mechanisms for evaluation are post-implementation reviews and other operational assessments (e.g., after-action reports from military exercises). Evaluation results feed back into other phases of Portfolio Management to guide all investment decisions.

Key to the Portfolio Management process are tools measuring performance, outcomes and overall value. Yet, the DoD, as a non-profit organization, cannot measure returns in strictly monetary terms and must evaluate investments on the overall "value" received from investments. It cannot establish monetary benefits for the value added from combat effectiveness, operational readiness, and national defense.

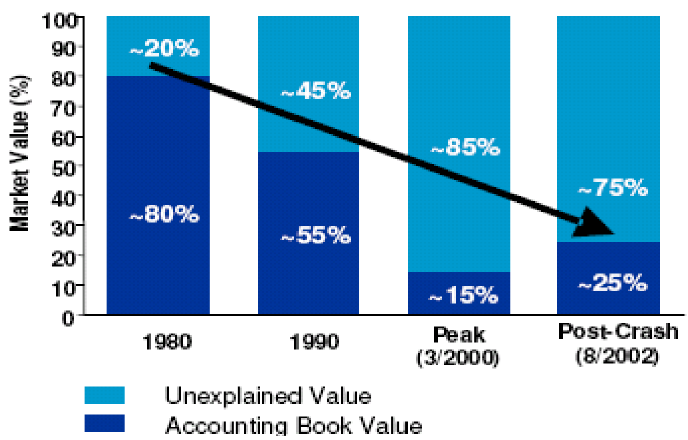
What does value translate into in the public sector? What capabilities deliver the greatest value in services provided to citizens? Government and industry-sponsored initiatives have been launched, over the past several years, to develop frameworks to define "value" in the public sector and identify high-performance capabilities enabling government agencies to create the greatest "value." Nearly 70% of public sector executives around the world plan to measure social returns on IT initiatives to its citizens and stakeholders over the next five years, according to a 2005 *Economist* study.

The consultancy firm Accenture created a Public Sector Value model to calculate the value of IT projects to government organizations in 2003. Market research firm Gartner established a consulting practice around the "Public Value of IT" to measure how government IT investments/programs contribute to improved operational efficiency, improved constituent service and political return. Computer software manufacturer SAP unveiled its collaborative "Public ROI" project to develop a methodology for defining, measuring, and communicating economic, social and political returns of government and public services programs in 2005. Beyond these specific corporate initiatives are models that have been developed to measure value derived from today's knowledge-based economy.

3.0. Measuring Value

Intangible assets have supplemented tangible assets as the key drivers in the economy during the past 25 years, according to Accenture. As one indicator, accounting book value of the S&P 500 declined from approximately 80% of total enterprise value in 1980 to approximately 25% in 2002 (Ballow, Burgman, & Burgoz, 2004, October). Figure 2 below shows unexplained market value (intangible value) is a long-term business trend transcending business cycles (Ballow, Burgman, & Burgoz, 2004, October).

Figure 2. Market Value vs. Book Value over Time (S&P 500)



(Source: Ballow, Burgman, & Burgoz, 2004, October; Adapted from Lev, 2001; Lev, 2003, September)

Further indicators include two of the largest corporate acquisitions in 2005, involving intangible assets valued at above 50% of the total purchase price (Neils, 2006, April 6). In SBC's $14.5 billion purchase of AT&T, $8.2 billion or 53% of the purchase price was allocated to intangible assets. With Proctor & Gamble's $53.5 billion acquisition of Gillette, $31.5 billion or 59% of the total purchase price was allocated to intangible assets (Neils, 2006, April 6).

Traditional accounting methods remain focused on tangible assets; therefore, a significant portion of corporate assets go unrecognized and underreported, as seen in Figure 3 (Ballow et al., 2004).

Figure 3. Classification of Assets

Asset Recognition	Asset Type				
	Traditional Accounting Assets		Intellectual capital Assets		
	Monetary	Physical	Relational	Organizational	Human
Tangible	• Cash • Investments • Receivables/ debtors • Payables/creditors	• Property • Plant • Equipment • Inventory – Finished goods – WIP – Parts/raw materials	• Customer contracts • Formal alliances, JVs, supply agreements	• Systems • Formalized processes • Codified knowledge • Patents • Brands	• Management contracts • Documented accessible skills inventories
Intangible	• Credit ratings • Undrawn facilities • Borrowing capacity (relative to like companies, based on character) • Receivables certainty • Accruals convertibility	• Plant flexibility • Plant modernity • Infrastructure surrounding plants • Access rights • Balance sheet strength • Inventory (good and usable, obsolete, redundant)	• Customer loyalty – Behavioral – Attitudinal • Quality of supply contracts • Right to tender, right to design • Strength of stakeholder support (including opinion leaders) • Networks	• Structural appropriateness • Informal processes • Organizational reputation • Productivity of R&D process • Quality of corporate governance • Tacit knowledge	• Top management quality • Top management experience • Ability to execute on strategy • Leadership capabilities • Problem-solving ability • Employee loyalty – Behavioral – Attitudinal • Personnel reputation • Workforce adaptability • Employee engagement

Traditional scope of accounting/ financial reporting (shaded: Tangible Monetary and Tangible Physical)

SOURCE: ASSETECONOMICS HOLDINGS, Accenture, 2004

Recognizing the significance of intangible assets to the overall value of an organization, the European Union recently implemented IFRS3 (International Financial Reporting Standards No. 3 on Business Combinations). IFRS3 stipulates that companies must measure, disclose and monitor intangible assets. It requires all acquired intangible and tangible assets be recognized on the balance sheet and priced at fair market values; intangible assets with indefinite lives also need to be tested annually for loss in value.

Given the economic importance of intangible assets, it is critical to properly report and manage them. A number of performance measurement models have been developed in an attempt to capture non-financial, intangible value, as seen in Table 1. Although valuable, these models have several limitations:

- revenues cannot be allocated at sub-corporate levels

- advanced techniques such as project flexibility as accounted for in Real Options cannot be conducted for further analysis
- risk and uncertainty quantification, mitigation, and management are not considered
- project and program interactions and interconnectivity within a portfolio are not considered

Performance measures often fail to capture the complete benefit stream produced by organizations, processes or assets to beneficiaries or stakeholders such as taxpayers, program managers and government sponsors. Measurement of ROI on how public monies are used, along with how benefits are received, is critical given increased regulations and pressures for increased accountability and transparency. DoD Directive 8115.0, as discussed earlier, mandates the use of performance metrics based on outputs with ROI analysis required for all current and planned IT investments.

How can the value of intangible assets be defined? How can any organization define the value of intangible assets, particularly hard-to-quantify intellectual capital assets? Benefits may result in many forms, including improved market competitiveness, expanded markets, new capabilities, or increased efficiency. NPS professors Dr. Thomas Housel and Dr. Johnathan Mun have developed an analytical tool to facilitate strategic, performance-based investment decisions. The KVA+RO Valuation Framework measures the value of intangibles provided by human capital assets like intellectual capital (e.g., training, knowledge, skills) critical to the completion of final outputs (yet difficult to quantify), as well as the risks and uncertainties involved with such assets; the Framework also includes ways to mitigate and manage these risks.

Table 1. Performance Measurement Models

MODEL	ORIGIN	RATIONALE	PURPOSE	APPROACH	ADVANTAGES	DISADVANTAGES
The Balanced Scorecard	Introduced in 1990s by Kaplan and Norton.	Companies need system of leading and lagging, internal and external indicators.	• Measures and manages execution of strategy • Includes financial and non-financial perspectives • Serves as a management tool reflecting the whole business (holistic)	• BSC organizes its measurement system into four perspectives: financial, customer, internal business, and growth • Cause-and-effect relationships link the four scorecard perspectives	• Powerful logic • Clear correlation between indicators and financial performance • Cause-and-effect linkages • Can be deployed into a system for managing intellectual capital • Well-developed and consistent literature • In practice, often used to formulate strategy and gain internal commitment	• Rigid; static; no consideration of dynamics • Four perspectives limiting; insufficient consideration of human assets and knowledge-creation processes • Limited treatment of external environment (i.e., focus exclusively on customers) • Internal use only; external comparisons are difficult
Economic Value Added	Introduced in 1994 by Stern, Stewart & Co., as a tool to assist corporations in pursing their prime financial directives by aiding in maximizing the wealth of their shareholders	The purpose of a company is to maximize shareholder value, and maximize the effective use of capital—a purpose that should be reflected in every decision, at all levels of the organization.	Develops a performance measure that properly accounts for all ways in which corporate value could be added or lost	EVA is net sales minus operating expenses minus taxes minus capital charges, where capital charges are calculated as the weighted average cost of capital multiplied by the total capital invested. In practice, EVA is increased if weighted average cost of capital is less than the return on net assets, and vice versa.	• Correlates well with stock price • Ties budgeting, financial planning, goal setting, and incentive compensation together • Provides a common language and benchmark for managers to discuss value creation	• Complicated adjustment procedures • Trade-off between accuracy and complexity • Based on net assets versus market value of assets • Weak additional explanatory power • Assumes governance structure in the interest of shareholders only
Intellectual Capital (IC) Approaches	Introduced in 1997 by Bontis, Edvinsson, Malone, Roos & Roos.	A good part of the value generated by a company comes from intangible resources, which also should be measured and monitored. However, intangibles do not obey conventional laws of diminishing returns and, therefore, needed a new approach to being measured, managed, and reported.	• Measures IC in an integrated framework • Combines financial capital with IC • Provides new insights into value creation by revealing and measuring the contribution of IC • Achieves innovative external reporting	• IC includes all the intangible resources that contribute to the creation of value for the organization (monetary, physical, human, relationship, and organizational) • Approach measures IC in conjunction with financial capital • Presents sophisticated methodology to calculate overall IC index	• Flexible • Dynamic model • Applicable to non-profit organizations • IC index could allow for external comparison between companies and across industries • Begins to address question of value creation being based on the use of resources (flows), not their mere existence (stocks)	• Elusive and complex • More metric development needed • Some argue too much emphasis on stocks versus flows • Diversity between organizations (and, thus, context specificity) hinders any possible comparison between companies • Provides measures of performance rather than absolute values—so lends itself to reporting of processes rather than value
Value Explorer®	Originated in 2000 by Andriessen & Tissen	Provides insight into the future potential of intangible assets by looking at: • Added value for customers • Competitiveness • Potential for new opportunities • Sustainability • Robustness	Helps organizations understand and measure value of core competencies	The core of the approach is a methodology to: • Identify core competencies/ intangible assets that are of strategic importance • Assess the relative strengths and weaknesses of intangibles with regards to future potential • Allocate the organization's income stream across the core competencies	• Identifies core competencies of the organization • Relatively simple and practical tool and process involved • Provides practical guidelines for strategic decision-making and prioritization of intangibles that help develop the strategic agenda • Concepts are similar to financial terminologies	• Dependent on subjective data for valuations • Provides a measure of value, not performance of underlying processes • Requires a thorough analysis of the hidden driving forces of the company
Human Resource Accounting	Since Hermanson's (1964) classic study several decades ago,	The value of human capital, as expressed in financial terms, should be capitalized on balance sheets	Quantifies economic value of people to organizations in order to provide	Researchers have proposed three types of HRA models: • Cost models that consider historical, acquisition replacement, or opportunity cost of human assets • HR value models that combine	• Calculated in financial terms • Extensive internal use in certain service industries	• Too many assumptions must be made, some of which cannot hold • Subjective and uncertain • Lacks reliability in that measures cannot be audited with any assurance

	the topic of how and whether to value human assets has been debated by accountants and human resource theorists	instead of expensed on the income statements.	input for managerial and financial decisions	non-monetary behavioral models with monetary economic models • Monetary emphasis models that calculate discounted estimates of future earnings or wages		
Value Chain Scoreboard	Originated in 2001 by Baruch Lev, Philip Bardes, Professors of Accounting and Finance with the Stern School of Business at New York University	As innovation becomes central to achieving a dominant competitive position, corporations will need to invest more heavily in intangible assets and monitor them closely. But, the amount of information available on intangibles lags behind. These information inefficiencies result in economic and societal damage.	Improves reporting on investments in innovation	• Scoreboard uses a "value chain" consisting of three phases: discovery of new products or services or processes, establishment of technological feasibility and commercialization of new products and services • Three categories in each phase that contain a number of indicators	• Based on thorough scientific research on the relationship between intangibles and company market value • Based on research of the information needs of analysts and other stakeholders • Simple and comprehensive	• Only focused at innovation • Seems primarily suitable for technology companies investing strongly in R&D • Strongly focused on external reporting • Weak additional explanatory power

(Source: KPMG, 2001. Adapted from materials developed by Bontis, N., Dragonetti, N.C., Jacobsen, K. & Roos, G., 1999; Andriessen, D. & Tissen, R., 2000; Lev, B., 2001)

3.1 Measuring Value: The KVA + RO Valuation Framework

The KVA+RO valuation framework measures operating performance, cost-effectiveness, return on investments, risk, Real Options (capturing strategic flexibility), and analytical portfolio optimization. The framework facilitates regulatory compliance and applies portfolio management techniques to evaluate programs and risks, taking into account uncertainty in estimating future benefits. Large, complex, organizations ranging from publicly traded *Fortune 500* firms to public-sector entities can use the KVA+RO framework. Its focus on core processes, sub-processes, and outputs provides several advantages:

- Quantifies value of specific processes, functions, departments, divisions, or organizations in common units,
- Provides historical data on costs and revenues of specific processes and tasks of specific programs or organizations,

- Facilitates regulatory compliance in the public sector (with legislation such as the Clinger-Cohen Act of 1996) mandating portfolio management for all federal agencies. In the private sector, facilitates compliance with Sarbanes-Oxley by making performance among corporate entities more transparent,

- Highlights operational efficiencies/inefficiencies, and

- Leverages current and potential portfolio investments by estimating potential total value created.

Organizations can drill down to understand specific processes involved in the production of an output, the cost of each process and its contribution to the bottom line with the KVA+RO framework. Government entities can use the framework to enhance existing performance tools—while on the corporate side, the framework can be used to value specific divisions or operating units to determine division profitability or shareholder value.

3.2 Overview of KVA+RO Framework

KVA+RO is designed to help organizations manage IT investments and mitigate risk. The framework's three components of data collection, KVA methodology, and Real Options analysis collectively provide performance-based data and analyses on individual projects, programs and processes within a portfolio of IT investments.

Figure 4. NPS Valuation Framework

KVA METHODOLOGY

Step 1: Calculate Time to Learn.

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

Step 3: Calculate Total K for process.

Step 4: Derive Proxy Revenue Stream.

Step 5: Develop the Value Equation Numerator by assigning revenue streams to sub-processes.

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

Step 7: Calculate metrics:
Return on Investment (ROI)
Return on Knowledge Assets (ROK)

+

REAL OPTIONS THEORY

Step 1: **Risk Identification**
List of projects and strategies to evaluate.

Step 2: Risk Prediction
Base case projections for each project.

Step 3: Risk Modeling
Develop static financial models with KVA data.

Step 4: Risk Analysis
Dynamic Monte Carlo simulation.

Step 5: Risk Mitigation
Framing real options.

Step 6: Risk Hedging
Options analytics, simulation & optimization.

Step 7: Risk Diversification
Portfolio optimization and asset allocation.

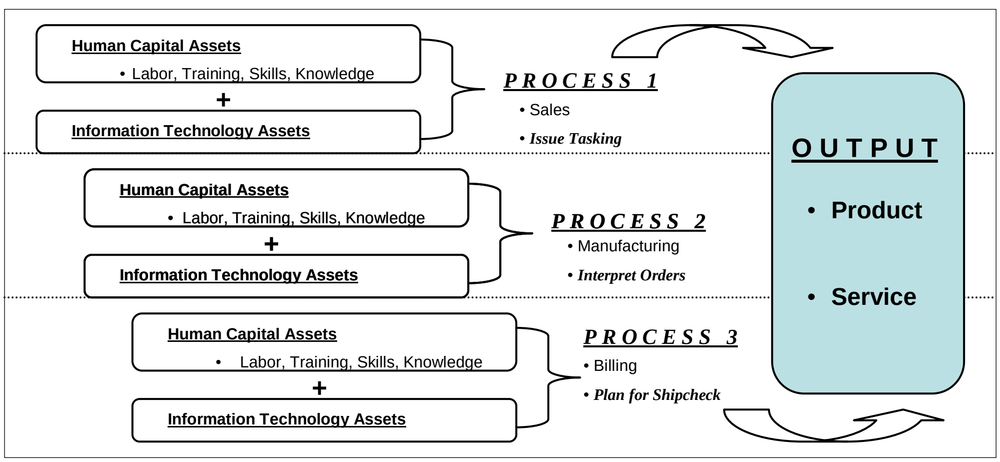
Step 8: Risk Management
Reports presentation and update analysis.

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

3.3 KVA+RO Framework: Knowledge Value Added Methodology

A new paradigm in sub-corporate performance analytics, KVA measures the value provided by human capital assets and IT assets by analyzing an organization, process or function at the process-level. It provides insights into each dollar of IT investment by monetizing the outputs of all assets, including intangible knowledge assets. By capturing the value of knowledge embedded in an organization's core processes, employees and IT, KVA identifies the actual cost and revenue of a product or service. Because KVA identifies every process required to produce an output and the historical costs of those processes, unit costs and unit prices of products and services are calculated. An output is defined as the end result of an organization's operations; it can be a product or service, as shown in Figure 5.

Figure 5. Measuring Output



KVA has been applied in over 100 organizations in the public and private sectors, ranging in size from under 20 employees to thousands, for the past 15 years. The methodology has been applied in 35 areas within the DoD, from flight simulation applications to maintenance and modernization processes. As a performance tool, the methodology:

- Compares all processes in terms of relative productivity,

- Allocates revenues to common units of output,
- Measures value added by IT by the outputs it produces,
- Relates outputs to cost of producing those outputs in common units, and
- Provides common unit of measures for organizational productivity.

Based on the tenets of complexity theory, KVA assumes that humans and technology in organizations add value by taking inputs and changing them into outputs through core processes (Housel & Bell, 2001, pp. 92-93). The amount of change an asset or process produces can be a measure of value or benefit. Additional assumptions include:

- Describing all process outputs in common units (i.e., the knowledge required to produce the outputs) allows historical revenue and cost data to be assigned to those processes at any given point in time.
- All outputs can be described in terms of the time required to learn how to produce them.
- Learning Time, a surrogate for procedural knowledge required to produce process outputs, is measured in common units of time. Consequently, Units of Learning Time = Common Units of Output (K).
- Common unit of output makes it possible to compare all outputs in terms of cost per unit as well as price per unit, because revenue can now be assigned at the sub-organizational level.
- Once cost and revenue streams have been assigned to sub-organizational outputs, normal accounting and financial performance and profitability metrics can be applied.

Describing processes in common units also permits market-comparable data to be generated, particularly important for non-profits like the US Navy. Using a Market Comparable approach, data from the commercial sector can be used to estimate price per common unit, allowing for revenue estimates of process outputs for non-profits. This also provides a common-units basis to define benefit streams regardless of process analyzed.

KVA differs from other nonprofit ROI models because it allows for revenue estimates, enabling the use of traditional accounting, financial performance and profitability measures at the sub-organizational level.

Figure 6. Comparison of Traditional Accounting versus Process-based Costing

Explains what was spent

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

Explains how it was spent

Figure 7. Comparison of Outputs Traditional Accounting Benefits (Revenues) versus Process-based Value

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

KVA can rank processes by the degree to which they add value to the organization or its outputs. This assists decision-makers in identifying what processes are really value-added—those that will best accomplish a mission, deliver a service, or meet customer demand. Value is quantified in two key metrics: Return-on-knowledge (ROK) and Return-on-knowledge Investment (ROI).

Table 2. KVA Metrics

Metric	Description	Type	Calculation
Return-on-Knowledge (ROK)[2]	Basic productivity, cash-flow ratio	Sub-corporate, process-level performance ratio	Outputs-benefits in common units/cost to produce the output
Return on Investment (ROI)	Same as ROI at the sub-corporate, process level	Traditional investment finance ratio	(Revenue-investment cost)/investment cost

KVA analysis can be conducted through three methods, as shown in the table below.

Table 3. Approaches to KVA Calculation

Steps	Learning Time	Process Description	Binary Query Method
1		Identify core process and its subprocesses.	
2	Establish common units to measure learning time	Describe products in terms of instructions required to reproduce them, and select unit of process description.	Create set of binary yes/no questions such that all possible outputs are represented as sequence of yes/no answers.
3	Calculate learning time to execute each subprocess.	Calculate number of process instructions pertaining to each subprocess.	Calculate length of sequence of yes/no answers for each subprocess.
4		Designate sampling period long enough to capture representative sample of core process's final product/service output.	
5	Multiply learning time for each subprocess by number of times subprocess executes during sample period.	Multiply number of process instructions used to describe each subprocess by number of times subprocess executes during sample period.	Multiply length of yes/no string for each subprocess by number of times this subprocess executes during sample period.
6		Allocate revenue to subprocesses in proportion to quantities generated by Step 5, and calculate costs for each subprocess.	
7		Calculate ROK, ROI, and interpret results.	

(Source: Housel & Bell, 2001)

[2] ROK was used extensively in the thesis research on which this white paper is based because market comparables had not been applied to derive revenue surrogates to enable generation of the ROI metric.

3.4 KVA+RO Framework: Real Options Analysis

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

- Identify different corporate investment decision pathways or projects that management can consider in highly uncertain business conditions;
- Value the feasibility and financial viability of each strategic decision pathway;
- Prioritize pathways or projects based on qualitative and quantitative metrics;
- Optimize strategic investment decisions by elevating different decision paths under certain conditions or determine how a different sequence of pathways can lead to the optimal strategy;
- Time effective execution of investments and find the optimal trigger values and cost or revenue drivers; and
- Manage existing or develop new options and strategic decision pathways for future opportunities (Mun, 2005).

Options are used in a variety of ways across a number of industries.

Table 4. Types of Real Options and Industry Applications

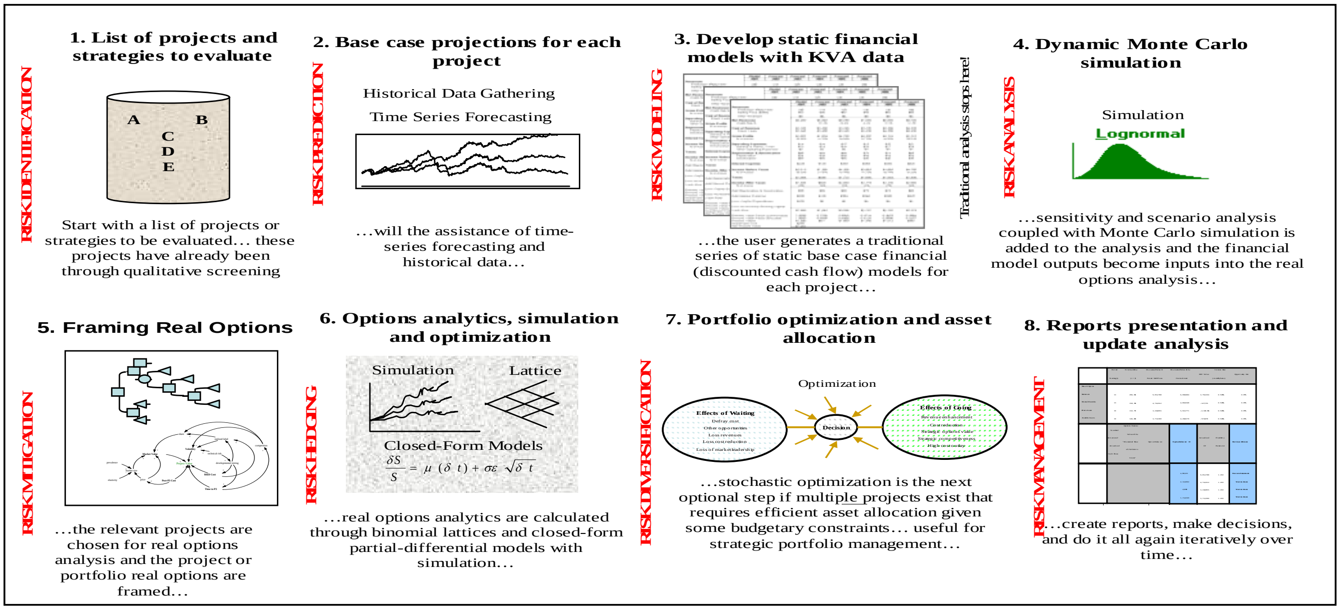
Types of Options	Industry Applications/Users
Option to Wait	**DoD/Acquisitions, Force Mix**
(Proof-of-concept, right of first refusal, getting more info)	Aeronautics/Boeing, Airbus
Option to Execute	Oil and Gas/BP, Shell
	High Tech/Intel
(Contracts in place which may/not be executed)	Pharmacology/Merck, Pfizer
Abandonment Option	R&D Portfolios/Motorola, Unilever
(When to exit and salvage or abandon a project to cut losses)	IT Infrastructure/Credit Suisse
Expansion Option	Electricity/Peaker-Plants
(Platform technologies, acquisitions, open architecture, providing a platform for future projects)	Acquisitions/Seagate
	Contracts/Syngenta, GM
Contraction Option	
(Outsourcing, alliances, joint ventures)	
Compound Option (platform options)	
Sequential Options (stage-gate development, R&D, phased options, proof-of-concept)	

Source: Johnathan Mun, "Real Options Analysis" (2nd Ed.) Wiley Publisher: New York, 2006 , Pages 15-40.

Although there are many approaches, the methodology used in the KVA+RO valuation framework is developed by leading expert Dr. Johnathan Mun. Dr. Mun's Real Options approach consists of eight steps, as shown in Figure 9, called the Integrated Risk Analysis Approach.[3]

[3] Dr. Johnathan Mun is a Research Professor at the Naval Post Graduate School and teaches public seminars on risk analysis, strategic real options, analytical portfolio management, forecasting and statistical analysis, where successful participants will obtain the Certified Risk Management (CRM) designation. For more information, visit www.realoptionsvaluation.com.

Figure 8. Integrated Risk Analysis



The Approach involves the following eight procedural steps:

1. Qualitative management screening
2. Forecasting and prediction
3. Base-case KVA net present value and ROI analysis
4. Risk-based Monte Carlo simulation
5. Strategic Real Options problem framing and courses of action
6. Real Options modeling and analysis
7. Analytical portfolio and resource optimization
8. Reporting and update analysis

Qualitative management screening is the first step in the integrated risk analysis process. Decision-makers have to decide which projects, assets, initiatives, or strategies are viable for further analysis, in accordance with the DoD's mission, vision, goal, or overall strategy. That is, the initial list of projects should be qualified in terms of meeting the DoD's overall agenda. The most valuable insight is often created as decision-makers frame the complete problem to be resolved. This is where the various risks to the organization are identified and fleshed out.

The future is then forecasted using time-series analysis, simulation, multivariate regression analysis, econometric models, or forecasting heuristics if historical or comparable data exist. Otherwise, other qualitative forecasting methods may be used (subjective guesses, growth-rate assumptions, expert opinions, Delphi method, and so forth). In a financial and KVA context, this is the step where future proxy benefits and cost drivers are forecasted.

For each project that passes the initial qualitative screens, a KVA-based discounted cash flow and ROI model is created. This model serves as the base-case analysis where a net present value (NPV) and ROI are calculated for each project, using the forecasted values in the previous step. This step also applies if only a single project is under evaluation. This ROI and NPV is calculated using the traditional approach of utilizing the forecast revenues and costs, and discounting the net of these revenues and costs at an appropriate risk-adjusted rate. The return on investment and other metrics are generated here.

Because the static KVA ROI and discounted cash-flow models produce only single-point estimate results, there is often little confidence in its accuracy given that future events that affect forecast cash flows are highly uncertain. To better estimate the actual value of a particular project, Monte Carlo simulation should be employed next. Usually, a sensitivity analysis is first performed on the model; that is, setting the ROI or net present value as the resulting variable, we can change each of its precedent variables and note the change in the resulting variable.

Precedent variables are those which ultimately flow through the model to affect the ROI or net present value figure. By tracing back all these precedent variables, we can change each one by a preset amount and see the effect on the resulting net present value. A graphical representation can then be created, which is often called a tornado chart (the Risk Simulator software is used to run simulation analysis as well as these sensitivity tornado charts and spider charts) because of its shape, where the most sensitive precedent variables are listed first, in descending order of magnitude. Armed with this information, we can then decide which key variables are highly uncertain in the future and which are deterministic. The uncertain key variables that drive the NPV and, hence, the decision, are called critical success drivers. These critical success drivers are prime candidates for Monte Carlo simulation using Risk Simulator.[4] Because some of these critical success drivers may be correlated, a correlated Monte Carlo simulation may be required. Typically, these correlations can be obtained through historical data. Running correlated simulations provides a much closer approximation to the variables' real-life behaviors.

The question now is that after quantifying risks in the previous step, what next? The risk information obtained somehow needs to be converted into *actionable intelligence*. Just because risk has been quantified to be such-and-such using Monte Carlo simulation, so what? And what do we do about it? The answer is to use Real Options analysis to hedge these risks, to value these risks, and to position the project to take advantage of or to mitigate the risks. The first step in Real Options is to generate a strategic map through the process of framing the problem. Based on the overall problem identification occurring during the initial qualitative management screening process, certain strategic optionalities would have become apparent for each particular project. The strategic optionalities may include among other things, the option to expand, contract, abandon, switch, choose, and so forth.

Through the use of Monte Carlo simulation, the resulting stochastic KVA ROI model will have a distribution of values. Thus, simulation models, analyzes, and quantifies the various risks and uncertainties of each project. The result is a distribution of the ROIs and the project's volatility. In Real Options, we assume that

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[4] Risk Simulator is a risk-based Monte Carlo simulation, forecasting, optimization, and statistical software used in the analysis, and was developed by Dr. Johnathan Mun (www.realoptionsvaluation.com). See Mun (2006) for details on using the software, applying the Integrated Risk Analysis approach, as well as multiple case studies.

the underlying variable is the future benefit minus the cost of the project. An implied volatility can be calculated through the results of a Monte Carlo simulation previously performed. Usually, the volatility is measured as the standard deviation of the logarithmic returns on the free net benefit stream. The Real Options valuation is then performed using the Real Options SLS software.[5]

Portfolio optimization is the next optional step in the analysis. If the analysis is done on multiple projects, decision-makers should view the results as a portfolio of rolled-up projects because the projects are, in most cases, correlated with one another; viewing them individually will not present the true picture. As organizations do not only have single projects, portfolio optimization is crucial. Given that certain projects are related to others, there are opportunities for hedging and diversifying risks through a portfolio. Because firms have limited budgets, time, people, and resources, in addition to requirements for certain overall levels of returns, risk tolerances, and so forth, portfolio optimization takes all such factors into account to analytically and robustly create an optimal portfolio mix. The analysis will provide the optimal allocation of investments across multiple projects. Portfolio optimization is performed using the Risk Simulator software.

The analysis is not complete until reports can be generated. Not only are results presented, but the process should also be shown. Clear, concise, and precise explanations transform a difficult black-box set of analytics into transparent steps. Top decision-makers will never accept results coming from black boxes if they do not understand where the assumptions or data originate and what types of mathematical or financial massaging takes place.

Risk analysis assumes that the future is uncertain and that decision-makers have the right to make midcourse corrections when these uncertainties become resolved or risks become known; the analysis is usually done ahead of time and,

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[5] The valuation is performed using the Real Options SLS software developed by Dr. Johnathan Mun (www.realoptionsvaluation.com).

thus, ahead of such uncertainty and risks. Therefore, when these risks become known, the analysis should be revisited to incorporate the decisions made or to revise any input assumptions. Sometimes, for long-horizon projects, several iterations of the Real Options analysis should be performed in which future iterations are updated with the latest data and assumptions. Understanding the steps required to undertake an integrated risk analysis is important because it provides insight not only into the methodology itself but also into how it evolves from traditional analyses, showing where the traditional approach ends and where the new analytics start.

3.5 Potential Applications of KVA + RO Framework

The strategic value of Real Options for the DoD is that it offers decision-makers alternative decision pathways or courses of action, something that the military has been accustomed to for decades. In a dynamic and uncertain environment where investment decisions must be flexible and fluid, strategic Real Options offers insights into alternative paths and how they relate to unique DoD requirements. A tool to augment existing performance tools, KVA+RO can be applied in many areas.

Table 5. Potential DoD Applications of KVA and Real Options

	Application
Activity-based Costing (ABC) Enhancement	KVA provides a way to define common units of output of former overhead functions. RO/KVA provides a way to compare outputs-per-cost value flows.
OMB Circular A-76 Comparisons	RO/KVA could enhance outsourcing comparisons between the Government's Most Efficient Organization (MEO) and private-sector alternatives.
JCIDS and DAS	RO and RO/KVA present themselves throughout JCIDS requirements generation and the Defense Acquisition System (e.g., DOTMLPF vs. New Program/Service solution, Joint Integration, Analysis of Material Alternatives (AMA), Analysis of Alternatives (AoA) and Spiral Development)
SHIPMAIN	RO/KVA theory applies to cost/benefits analysis for the various modernization options, as well as a way to measure the risks/valuation necessary in managing the portfolio of options.

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4.0 Methodology Proof-of-concept

Implementation of 3D laser scanning and collaborative PLM solutions has resulted in significant cost savings, optimized maintenance schedules, increased quality, improved safety and reduced re-work in several industries. In this proof-of-concept case study, we examine the hypothesis that if these technologies are applied to ship maintenance procedures, similar benefits could be derived:

- decreased cycle-time for US Navy ships by minimizing downtime in shipyards
- lowered maintenance cost by eliminating or reducing DoD planning yard labor costs
- reduced fleet inventory requirements through reduced cycle-time
- improved productivity (increased ROI) in current shipyard planning processes to facilitate faster and cheaper shipboard modernization.

To test our hypothesis, we apply the KVA+RO framework with data compiled from interviews and conversations with a select group of Subject Matter Experts (SMEs) from the Puget Sound Planning Yard (Puget Sound).[6] Using KVA methodology, we compared three scenarios on that one aspect of maintenance processes, ship planning yards:

- "As Is": Current labor-intensive process.
- "To Be": Introduction of 3D laser scanning and data capture and storage technology into the shipyard planning processes, enabling management and re-use of data. These technologies result in limited re-engineering.

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[6] Input from SMEs was analyzed and verified by independent sources; cost and process information was then aggregated to reflect data for all US public planning yard facilities.

- "Radical To Be": Several technologies introduced, including laser scanners, 3D digital imaging, data warehousing, a robust database management system (DBMS) and PLM. These technologies result in substantial redesign of current processes.

We also explore the question of how data capture and storage technologies, in conjunction with collaborative data-sharing technologies, could contribute to productivity of Navy organizations outside the planning yard. Could these technologies impact downstream processes, particularly in the public/private-sector shipyards performing maintenance, modernization and repair work on Navy vessels? Could reengineering the shipyard planning process affect the Navy's overall maintenance and modernization efforts?

4.1 The Challenge

The US Navy must be extremely diligent with its maintenance policies to ensure that ships and submarines meet national defense objectives. Maintenance Policy for Navy Ships delineates maintenance and modernizations efforts as those aimed "to define and manage the material condition requirements and the configuration of Navy ships." Consequently, maintenance and modernization policy is carefully designed to keep Navy ships operating at the maximum level of material readiness possible (OPNAVINST 4700.7K). This requirement is carefully balanced with the expectation of asset availability to Fleet Commanders since naval vessels undergoing repair, maintenance, or modernization in an industrial activity facility are unavailable for operational tasking until scheduled work is complete.

Maximizing the Navy's readiness requires continuous process improvement and innovation, as well as capitalization on technological advances to reduce costs and increase efficiency. Navy ships are expensive to operate, maintain and can remain in service for many years; the lifecycle for a small combatant is 20 or more years, 30 or more years for an attack submarine or larger surface combatant, and up to 50 years for an aircraft carrier (O'Rourke, 2005, June 23).

In fiscal year 2005, the Navy spent $3.9 billion on maintenance and modernization efforts. There are many challenges to maintenance activities, including labor-intensive and costly ship checks currently involving manual measurement methods. In addition, many of the Navy's ships were designed and fabricated in the 1970s and 1980s in primarily 2D work processes with no comprehensive, centralized source documenting all maintenance and modernization efforts (Greaves, 2005, October 11).

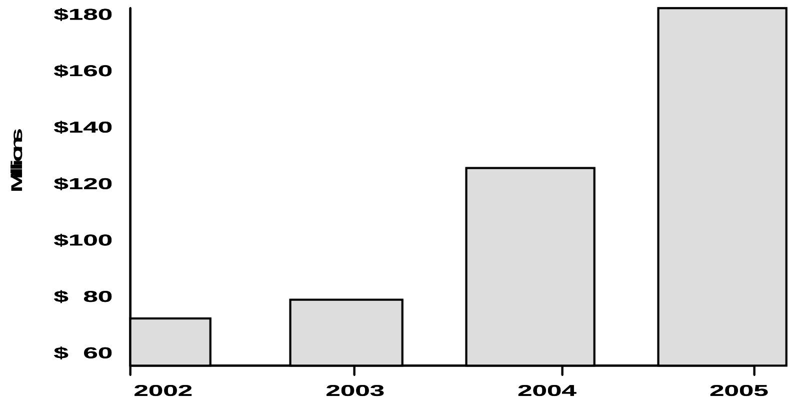
COTS like 3D terrestrial laser scanning and PLM technologies could improve maintenance processes and substantially reduce the costs of Navy ships. COTS could complement current Naval maintenance initiatives, including "one shipyard for the nation" and SHIPMAIN. Launched in 2002, SHIPMAIN's goal is to ensure that all shipyard processes are redesigned, with consistency among different maintenance facilities, to preserve ship quality and lifespan within schedule constraints. It is anticipated that SHIPMAIN will ultimately reduce the overall cost of ship maintenance and modernization by installing a common planning process for surface ship alterations. By installing a disciplined management process with objective measurements, SHIPMAIN strives to increase the efficiency of the process without compromising its effectiveness. Finally, the initiative will institutionalize the process, and implement a continuous improvement method.

4.2 Terrestrial Three-dimensional Technology

Terrestrial three-dimensional (3D laser) technology has moved from early adopter acceptance to mainstream markets since its introduction in the late 1990s. The terrestrial 3D laser scanning market is forecast to reach $180 million in sales in 2005, up 45% from the previous year (Greaves, 2005, October 11).[7]

[7] Based on estimates concluded from interviews conducted with software and service providers and laser scanner manufacturers, who report increasing activity in a wide variety of markets, including civil infrastructure, ship and boat building, and automobile manufacturing.

Figure 9. Terrestrial 3D Laser Scanning Market Forecast (Hardware, Software and Services)



Forecast October 11, 2005 (Source: Spar Pont Research LLC, 2005)

Use of 3D laser scanning technology has resulted in significant cost savings, optimized maintenance schedules, increased quality, improved safety and reduced re-work. Commercial applications range from maritime and space applications to manufacturing and production. Driving the industry's growth is increasing recognition that 3D aids in the design, fabrication, construction, operations and maintenance processes, according to industry analysts (Greaves, 2005, October 11).

The industry is poised for further growth with companies making large R&D investments. Laser-scanning solution providers offer every potential business model: software, hardware, software/hardware, hardware/services, software/services, software/hardware/services. Vendors include: CALLIDUS Precision Systems GmbH, FARO Technologies Inc., I-SiTE Pty Ltd., Leica Geosystems HDS, MDL (Measurement Devices Ltd.), Optech Incorporated, RIEGL Laser Measurement Systems GmbH, Spatial Integrated Systems, Inc. (SIS), Trimble Navigation Limited, Visi Image, Inc. and Zoller+Frohlich GmbH. Although the industry is dominated by a few large players, emerging companies like SIS are rapidly becoming key competitors. SIS develops and implements digital 3D data capture, imaging, modeling and visualization technologies integrated with commercial off-the-shelf software to provide engineering design, collaboration and PLM solutions.

Ship Check Data Capture 2005 Project

Recognizing the potential of new technologies on the ship check process on the US shipping industry, NSRP funded the Ship Check Data Capture project in 2005. Laser scanning, close-range photogrammetry and other technologies capturing as-built ship conditions in digital format to create 3D electronic models were evaluated. The project's goals were to: determine potential technology synergies producing cost effective solutions and prototype a ship check data capture process that could be used by the US shipbuilding industry. It is also anticipated that archived digital data would provide a cost-effective solution to the lifecycle cost management of ships.

With laser scanning technologies, preliminary results were encouraging, given a 32% cost savings over the traditional ship check process for a small ship; cost savings were even greater for a large ship at 44%.

Figure 10. NSRP Ship check Data Project Preliminary Results Cost/Time Savings

SMALL SHIP CHECK:

	Traditional	Laser Scanning	Realized Savings
Cost	$9,351	$6,398	32%
Labor Hours	112	72	36%

LARGE SHIP CHECK:

	Traditional	Laser Scanning	Realized Savings
Cost	$47,650	$26,465	44%
Labor Hours	660	336	49%

(Source: NSRP ASE, 2005, December 8)

Notes:
(1) Project time savings are close to project goal of 50%.
(2) Savings shown are only for first ship check and do not include elimination of future ship checks for the same space.
(3) Please see Appendices for full cost savings.

Specific benefits from the software and hardware tested include:

- Creation of as-built 3D models and validation of as-built models to design models
- Reduction of costly design changes, improved design capability
- Reduced construction rework
- Accurate factory-fabricate in lieu of field-fabricate
- Reduced ship check costs: fewer days, fewer personnel
- Elimination of return visits to the ship for missed measurements
- Obtaining measurements which are difficult or unsafe for human reach (NSRP ASE, 2005, December 8).

Spatial Integrated System (Case Example)

SIS's 3DIS (3DIS) is the solution used in the current case study. 3DIS is employed as a 3D image and data capture system (Figure 11). Upon its setup and execution, 3DIS works by scanning its predetermined environment: a compartment, or selected area within that compartment, with a pinpoint of laser light to quickly and accurately capture the digital space and distance information of that space or area. At the same time, an embedded wide-angle digital camera captures a photo image of the target.

Figure 11. SIS Laser Scanning Equipment

Source: Strategic Integrated Ssystems, Inc., http://www.sisinc.org/index.asp?id=12, 2006

Once data is captured, the technology automatically implements image-processing algorithms, and a digital point cloud results. The graphical user interface (GUI) of the system portrays this point cloud as faint lines outlining the images within that space. The actual file created is a long list of raw data in the form of (x,y,z) coordinates, and, as an added feature, each point retains its original color information. These data points can then be connected and enhanced to create a realistic, 3D model (Figure 12).

Figure 12. Sample Point Cloud Image (USNS Ship Exterior)

The file format used in the 3DIS system can be exported for further processing, such as 3D CAD analysis and modeling. The process for modeling the captured point cloud is more complex and can be accomplished several different ways. This path is typically used for a whole compartment or topside area. The complete process involves:

1. Point cloud captured and saved by 3DIS Imager, the scanner software.
2. Point cloud is viewed via 3DIS Viewer for quick check of data and point-to-point measurements.
3. Captured point clouds registered to one another using Imageware, point-processing application.
4. Surface model is constructed from the point-cloud data.
5. Surface model created is imported into CAD system and an assembly model of space and components is completed.
6. Files are exported to AUTOCAD, as required.

7. Detailed information, such as engineering notes and dimension call-outs added in AUTOCAD.[8]

Completion of this process provides a workable, 3D model of the captured area or compartment. From this model, prospective alterations can be visualized, accurate dimensions can be ascertained, and most importantly, the model may be reused many times over the lifecycle of the naval vessel, and for vessels of the same class. Figure 13 shows the completed 3D model created from a captured point cloud (Figure 12).

Figure 13. Digital 3D Model of USNS Superstructure

SIS technology has been used in several projects, including:

USS San Francisco damage assessment. Damaged areas of the USS San Francisco (SSN 711) were scanned when the submarine collided at high speed with an undersea mountain south of Guam.

USS Abraham Lincoln ship check. 3D laser scanning services were provided for ship check of a 3-story hangar bay on the USS Abraham Lincoln (CVN 72) in 2005. Hundreds of hours of labor were saved by scanning the HVAC, piping, fuel storage tanks and other structures. Engineers were also able to conduct multi-

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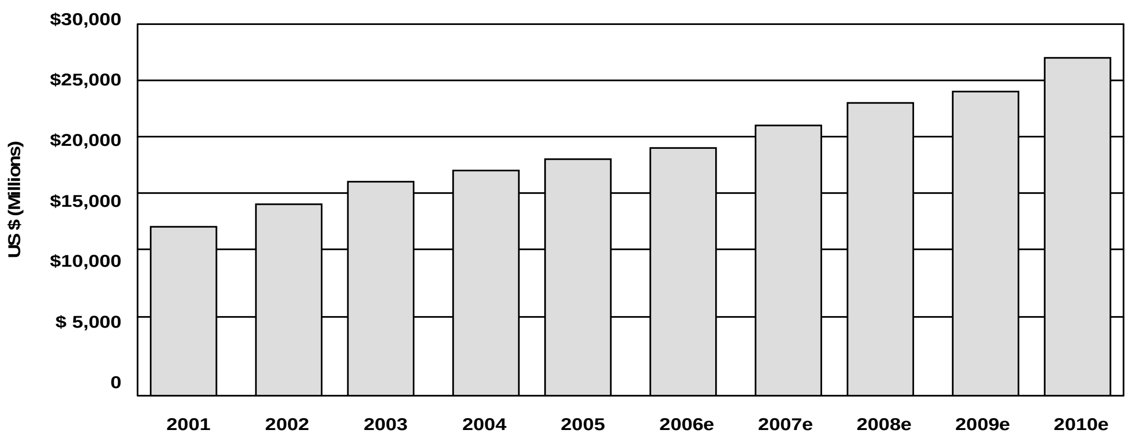
[8] Information on the operation of the laser scanning equipment and its proprietary software, including these seven steps listed here, was provided by Spatial Integrated Systems Subject Matter Experts.

discipline "what if" scenarios to avoid clashes in the installation of a new deck (Greaves, 2006, January 17).

4.3 Collaborative Technology

Product Lifecycle Management (PLM) is technology and a strategic approach applying business solutions to support collaboration, management, dissemination and use of product definition information across the extended enterprise from concept to end of life—integrating people, processes, systems and information.[9] Worldwide sales for PLM software and services in 2005 grew 8.7% to $18.1 billion, with sales estimated to reach $26.3 billion by 2010 (CIMdata, 2006, April 5).

Figure 14. Overall PLM Market Growth History and Forecast



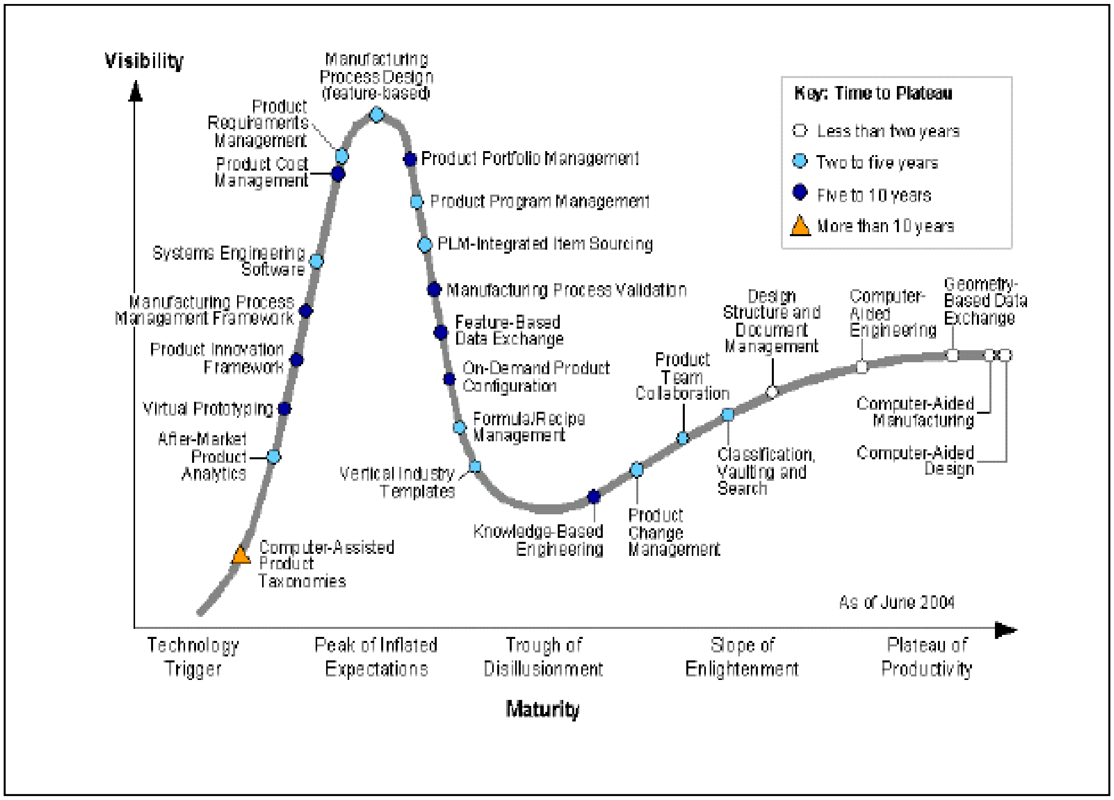
Estimates for 2005 to 2010. (Source: CIMdata, 2006, April 5).

The fastest growing sements of PLM solutions are collaboration, management and product-related sharing tools. These tools include technologies that support data exchange, portfolio management, digital manufacturing, enterprise application integration, and workflow automation. A range of industries have invested in PLM solutions, including those involved in aerospace and defense, automotive & other transportation, utilities, process manufacturing and high-tech

[9] For the purposes of this report, we are using CIMdata's definition of PLM.

development. The PLM market is poised for further growth with vendors expanding product offerings as the industry evolves. Figure 15 indicates the evolution of PLM applications, illustrating their stages before reaching the “plateau of productivity” in the mainstream market.

Figure 15. Evolution of PLM



Source: Gartner Group, Inc Report:; Halpern, Michael and Smith, Michael, “Total Value of Opportunity Analysis Exposes Value of PLM”, 29 December, 2004Some vendors in the PLM space are focused on specific niches within the marketplace, while a handful of companies are distinguishing themselves into “PLM Mindshare Leaders.” This select group, at the forefront of the market in terms or revenue or thought leadership, offers broad-based capabilities supporting full lifecycle-focused solutions.   PLM Mindshare Leaders include UGS, SAP, Agile and IBM/Dassault Systemes (CIMdata, 2006, April 5). UGS appears to be leading the segment by solidifying its leadership position with strategic acquisitions and key customer wins, including Northrup Grumman Ship Systems

(NGSS), in shipbuilding. After an extensive benchmarking study, NGSS selected UGS's solutions for digital manufacturing of ships (UGS, 2006, May 11).

4.4 Planning Yards

America's naval shipyards went through a major transformation during the 1990s, declining to four public-sector shipyards and six private-sector shipyards.[10] The Puget Sound Planning Yard in Washington State is one of the four public-sector Navy planning yards remaining in the US; other shipyards are situated in Virginia, Maine and Hawaii. Puget Sound is responsible for planning the maintenance and modernization ship alteration jobs scheduled for the aircraft carriers stationed on the West Coast and Japan, along with the minesweeper force based in Texas.

Planning Yards serve an essential role within the larger framework of the Navy's Fleet Modernization Program, supporting shipyards and other customers. For every ship maintenance or modernization task mandated by the Department of the Navy (DoN), the planning yard receives funding through the Design Services Allocation (DSA), along with technical guidance and tasking orders to prepare the shipyard to complete that task. The DSA is a funding line with provisions for design and SHIPALT development work, including Ship Alteration Requests (SAR), Ship installation drawings (SID), MDS, Liaison Action Requests (LAR), and Ship Service Request (SSR) update including Configuration Overhaul Planning (COP). SHIPALTS constitute an order mandating the introduction, design, or installation of changes to naval vessels.

Planning yards must compile all applicable data and job-related information for its end-users, which can then be used for some form of industrial activity. End-users may be the shipyard itself, a private-sector shipyard, or an entity independent of the planning yard and shipyard. This work is necessary so that physical work required to accomplish a SHIPALT may be planned and accomplished with minimal

[10] The remaining private-sector shipyards are owned by two companies.

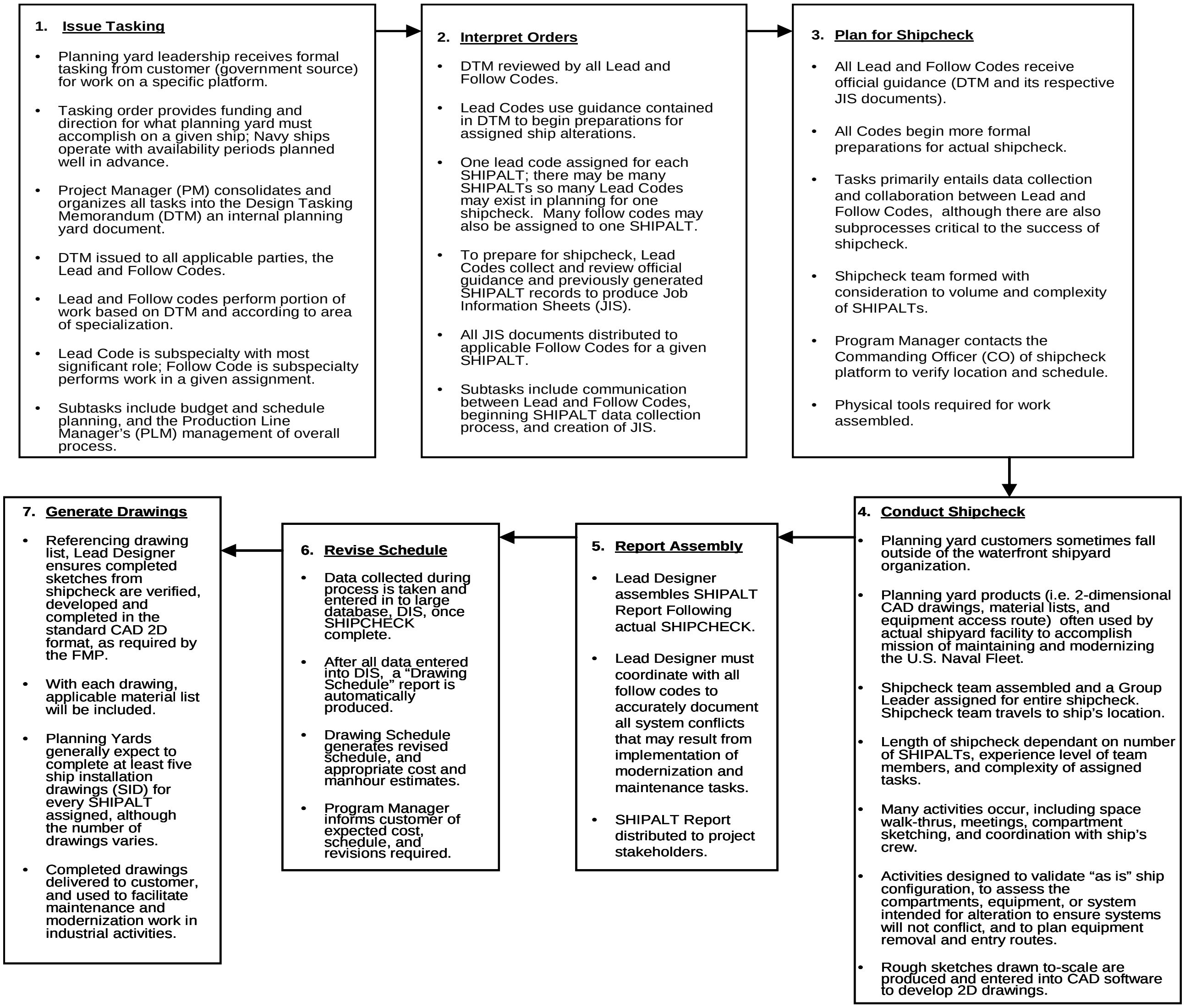
system or human conflict. All system interferences, problems, or conflicts relating to assigned SHIPALTS will be resolved by the planning yard. Planning yards strive to achieve these tasks, create quality installation drawings and retain experienced employees. Planning yards are overseen by a Chief Engineer and supported by staff in typically four divisions: Electrical/Electronics, Mechanical/Marine, Logistics/Material, and Structural/Naval.

Planning Yard Processes and Outputs

Planning yard activities involve essentially a chain of seven sequential core processes: issue tasking, interpret orders, plan for ship check, conduct ship check, report assembly, revise schedule and generate drawings.[11] This chain of core processes is executed for every naval vessel as it approaches its shipyard availability period and involves several sub-processes, as seen in Figure 16.

[11] The planning yard process chain was developed by conducting interviews with subject-matter expects at the Puget Sound Planning Yard. It is assumed that operations at alternate public planning yards are comparable in scope, duration, and knowledge requirements.

Figure 16. Planning Yard Core Processes



The schedule, timeline and location for ship availabilities are established by Navy leadership far in advance, but calendar dates and work assigned may be constrained by budget allowances and other prioritization factors. Availability schedules may also be affected by specific trigger events or unanticipated demand for operational naval assets. For example, the terrorist attacks of September 11, 2001, and Operation Iraqi Freedom prompted major changes in the deployment of naval forces. These events resulted in an ultimate surging to deploy seven carrier battle groups, and the largest Amphibious Task group assembled since World War II. The Navy implemented the Fleet Response Plan in May of 2003 to enhance its operational readiness, extending scheduled time between ship availabilities from 24 months to 27 months (www.gao.gov, 2004).

Standard documents considered to be planning yard products or "outputs" include 2-dimensional (2D) detailed AUTOCAD drawings of ship compartments or installation areas, equipment removal routes, and material lists. Less tangible outputs include ship's force/shipyard accord in regard to equipment configuration, and the assurance that alteration-specific capacities (such as sufficient chill water or electrical capacity for certain alterations) meet the requirements for a given SHIPALT.

The introduction of 3D laser scanning technology, in combination with the ability to improve collaboration among the multiple parties involved in the process, promised to greatly improve the overall performance of the processes. This study focused on estimating the potential of these two technologies in improving the return on investment (ROI) of these core processes and the value and risk of the options these technologies would provide Navy shipyard planning process leadership. For this purpose, we applied the KVA+RO Framework.

4.5 KVA Methodology: Data Collection

The first step in the KVA+RO Framework is to conduct KVA data-gathering meetings. As a result of these meetings, aggregated data was compiled based on input received from Subject-matter Expects (SME) as well as historical data presented at the meetings.[12] Interview data was augmented by additional research data to derive several key assumptions used for this case study.

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[12] Meetings were conducted in group settings. At the initial meeting, five planning yard SMEs with expertise in several areas and current Puget Sound employees were present. Each SME possessed over 20 years experience in the planning yard industry and a high degree of expertise in his/her affiliated discipline.

Table 6. Discussion of KVA Methodology Used in Case Study

- Learning Time method used to estimate value of subprocesses .
- SMEs achieved consensus on core planning yard processes, inputs and outputs of those processes, and frequency of subprocess iterations.
- SMEs subsequently defined seven subprocesses, describing each in great detail. Each subprocess requires a given level of knowledge in one or more of the following areas: administration, management, scheduling, budgeting, basic computer skills, drafting, engineering, shipboard systems, or AUTOCAD drafting and drawing development.
- SMEs analyzed amount of knowledge embedded in each subprocess and provided learning-time estimates for each.
- Established baseline level of knowledge for all estimates was a GS-7 employee with a college degree (no field specified).
- SMEs provided learning-time and rank-order estimates to establish reliability level on actual learning-time (ALT) figures.
- Preliminary analysis of initial learning time estimates resulted in an insufficient level of correlation between learning time estimates and rank order (based on difficulty to learn) estimates. Greater detail was gathered to evaluate each core planning yard process.
- To improve reliability of estimates, SMEs were asked to break each subprocess down into its component tasks and provide better estimates for the overall core process ALT by summing up new values.
- The resulting ALT estimates for the subprocesses were derived from the developed process instructions, and a correlation of greater than 80% was attained.

Table 7. Case Analysis—Baseline Data Assumptions

"As Is" Data Assumptions

Head Count

- Average ship check team is composed of 35 people (including all Lead and Follow Codes).

Times Fired

- Values derived from statistical information for fiscal years 2003, 2004, and 2005 and by SMEs.
- Fiscal year 2003 - 95 ship and submarine maintenance availabilities
- Fiscal year 2004 - 3 maintenance availabilities were funded, with additional funding granted to perform depot- and intermediate-level maintenance on 42 additional ships.
- Fiscal year 2005 - 85 planned availabilities.
- To remain conservative, and to properly account for planning yard work outsourced to private industry, this study approximates that work across the four public planning yards amounts to 40 planning yard process executions per year.
- 100 SHIPALTS occur per planning yard process:
  - 25 low-complexity alterations (a modification to a component or set of components)
  - 25 high-complexity alterations (a modification to a major system)
  - 50 medium-complexity alterations (a modification to a subsystem).
- Estimates for SHIPALTS are of medium-complexity, the likely mean and most common SHIPALT performed.

Actual Learning Time

One year = 230 work days. One month = 20 work days. One week=5 work days. One day = 8 hours.

Costs

- Salary figures based on midpoint average pay of GS-12 planning yard employees ($62,353/year) and GS-11 employees ($52,025/year).
- Because basic computing hardware and software is utilized in every scenario, IT cost is not included in the "as is" analysis. It is assumed that each employee in this process has an e-mail account, laptop or desktop computer with identical software, and access to a printer. Material, travel, and other miscellaneous costs are not included in this analysis in order for labor cost to be isolated.

Other

- 40 ship checks are accomplished between the four public-sector planning yards. Other naval ship checks are outsourced to private planning yards.
- The level of effort for each ship check is 100 SHIPALTS.
- All estimates assume a SHIPALT of medium-complexity.
- Each ship check team averages 35 personnel.

▪ Duration of a ship check is 10 workdays, with a travel day at each end. ▪ A minimal of five sketches/drawings are created for each SHIPALT. ▪ Approximately 10 digital photographs are captured for each SHIPALT. ▪ Each ship check will have five Lead Codes, and many Follow Codes.
"To Be" Data Assumptions **Cost of IT** ▪ Cost for laser scanning equipment and all applicable IT was provided by the Improved Engineering Design Process (IEDP) Project Manager for SIS. ▪ Cost for IT amortized for a 10-year period. ▪ Given an initial cost of $88,000 for one 3DIS scanner plus its applicable software suite, a maintenance/upkeep annual cost estimate of 20%, a use estimate of 200 days per year, and a lifespan estimate of 10 years, the resulting cost per day is: $132.00. ▪ For analysis of the "to be" KVA, this cost is absorbed by the actual scanning process, and not distributed evenly among the processes that utilize the software suite for modeling. This cost is based on the logistical ideal that one 3DIS scanner is shared between two planning yards.

4.6 KVA Analysis

To understand the value of technology on shipyard planning processes on US Navy fleet maintenance activities, KVA methodology was applied to three scenarios: "As Is," "To Be," and "Radical To Be." Although initial data estimates were compiled from Puget Sound Planning Yard sources, overall analysis and data values have been aggregated to reveal information relevant to all four public-sector planning yards. All estimates contained in this analysis are as conservative and accurate as possible. The following table summarizes KVA analysis for baseline data of current planning yard subprocesses.

Table 8. Core Planning Yard Process Overview

"AS IS" Planning Yard Process Overview														
Values Reflect Estimates for all U.S. Public-Sector Planning Yards														
Core Process	Process Title	# Org	Est. # Shipcheck per Org	Head Count per Shipcheck	Daily Salary	Times Fired per Shipcheck	Time (days)	ALT	K in IT	Total Learning Time	Rank Order	Total Benefits	Total Cost	ROI
1	Issue Tasking	4	10	2	$271.10	1	8	690	208	898	5	35984	$173,500.00	-69%
2	Interpret Orders	4	10	5	$226.20	100	10	470	66	536	4	2142000	$520,000.00	518%
3	Plan for Shipcheck	4	10	35	$226.20	1	6	238	12	250	3	9984	$1,655,000.00	-99%
4	Conduct Shipcheck	4	10	35	$271.10	1	10	1150	173	1323	6	11327940	$2,604,500.00	552%
5	Report Assembly	4	10	1	$226.20	1	6	405	21	426	2	1383240	$235,000.00	783%
6	Revise Schedule	4	10	1	$226.20	1	3	232	94	326	1	1288144	$131,000.00	1375%
7	Generate Drawings	4	10	110+	$226.20	500	18	750	80	830	7	16590000	$39,386,000.00	-37%
						"AS IS" PROCESS TOTALS:						32777292	$44,705,000.00	10%

The actual number of times each Planning Yard subprocess executes can be documented with historical data. The numbers used in this analysis are based on historical averages derived from SME estimates. Regardless of the actual number of overall process operations or firings per year, the relative orders of magnitude among the resulting ratios would be the same because the number of firings represents a constant across all estimates.

Under the "To Be" scenario, SIS's 3DIS laser scanner system and 3D data-capture technology was introduced in terms of the estimated impact on process parameters. Implementation of this system into the planning yard process would result in process outputs changing from static installation drawings delivered on paper to 3D digital images and models that are more accurate and precise. An added third dimension also provides greater value to end-users. To account for this added value, potential outputs of the "To Be" process affected by the technology were assigned a conservative increase of 20%.[13] In the final "Radical To Be" scenario, both 3D and collaborative information technology are fully maximized with

[13] An important note is that although the output is in 3D, the 2D drawing currently required by FMP policy is easily modified. Because appropriate stakeholders would still benefit from the 3-dimensional models, the value is conserved, while downstream shipyard processes which require 2D drawings would be supported until a new policy and IT-based infrastructure supporting 3D digital imagery is implemented.

deployment of laser scanners, 3D digital imaging, data warehousing, a robust database management system (DBMS), and PLM collaborative environments.

4.7 KVA Results

Results from KVA analysis reveal that digital 3D data capture with its high-quality, accurate, and reusable outputs, alongside the information storage and sharing capabilities of a PLM collaborative environment, may prove beneficial in naval ship maintenance and modernization planning and production efforts. Specific findings include:

Substantial Cost-savings

The DoD spends nearly $45 million to complete the shipyard planning process cycle an estimated 40 times per year.[14] With the introduction of 3D laser scanner system and 3D data-capture technology, costs would drop a substantial 84%—to nearly $8 million as seen in Table 9. Over the longer term, implementation of 3D and collaborative technologies could potentially reduce costs by $40 million per year.

[14] Cost estimate based solely on labor rates and excludes expenses such as travel and material. This figure consists of ship checkship checks conducted by only the four public-sector planning yards.

Table 9. KVA Results—Analysis of Costs

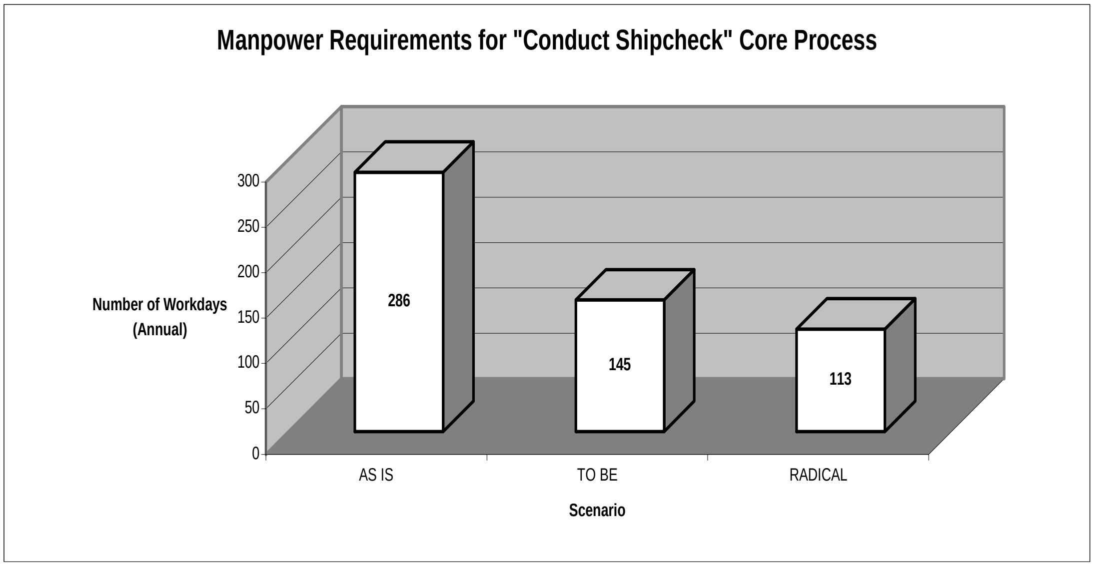
	Process Title	"AS IS"	"TO BE"	"RADICALTO BE"	*"AS IS" & "TO BE" Cost Savings*	*"AS IS" & "RADICAL" Cost Savings*
1	**ISSUE TASKING**	$173,500	$173,500	$173,500	***$0***	***$0***
2	**INTERPRET ORDERS**	$520,000	$520,000	$328,000	***$0***	***$192,000***
3	**PLAN FOR SHIP CHECK**	$1,655,000	$714,000	$374,500	***$941,000***	***$1,280,500***
4	**CONDUCT SHIP CHECK**	$2,604,500	$1,364,000	$1,041,000	***$1,240,500***	***$1,563,500***
5	**REPORT ASSEMBLY**	$235,000	$235,000	$122,000	***$0***	***$113,000***
6	**REVISE SCHEDULE**	$131,000	$131,000	$131,000	***$0***	***$0***
7	**GENERATE DRAWINGS**	$39,386,000	$4,716,000	$2,319,000	***$34,670,000***	***$37,067,000***
	TOTALS	**$44,705,000**	**$7,853,500**	**$4,489,000**	***$36,851,5000***	***$40,216,000***

Introduction of 3D technology in the "To Be" scenario results in cost-savings of nearly $37 million, derived through three subprocesses: process 3, 4 and 7. In the "Radical To Be" scenario, cost-savings of $40 million are anticipated from five of the seven subprocesses (process 2, 3, 4, 5 and 7)

Improved Process Performance

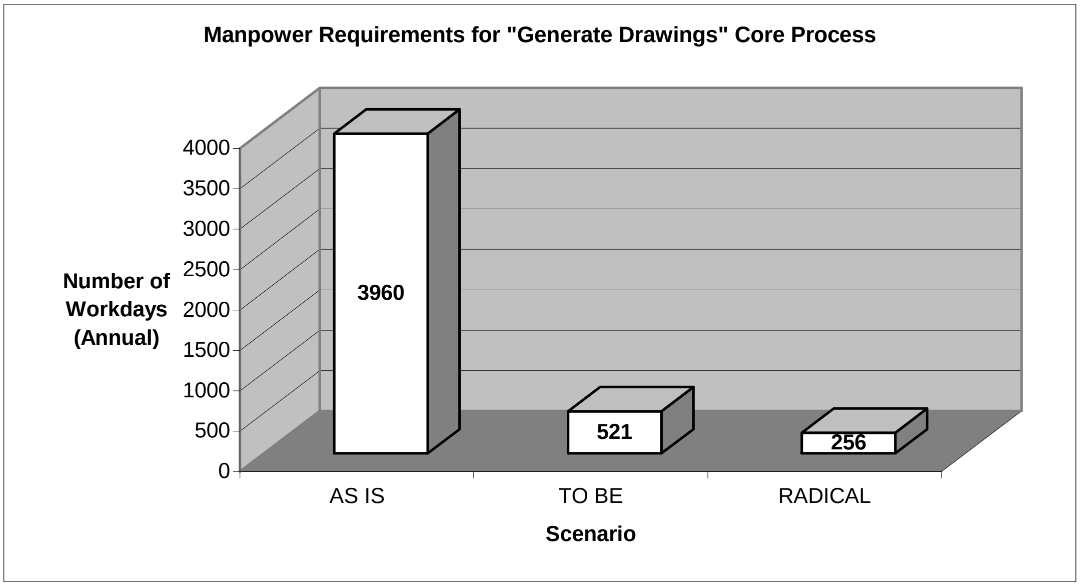
Several sub-processes that **will be** impacted greatly include "conduct ship check" and "generate drawing." The following graph shows the potential reduction from 286 days to 113 total workdays required between the four public-sector planning yards to complete 40 ship checks.

Figure 17. Potential Reduction of Workdays for "Conduct Ship check" Process



More dramatic manpower reductions are seen in the "generate drawings" core process. Because a once-manual effort is largely replaced by a more automated digital capture, and the subsequent creation of a 3D model capable of producing many, reusable 2D or 3D ship installation drawings, the requirement for a large work force is minimized. An annual requirement of roughly 20,000 installation drawings for 40 ship checks, with 100 SHIPALTS each, can be reduced from 3,960 paid work days (regardless of the number of workers) to only 256 paid work days. The following chart depicts this reduction.

Figure 18. Potential Reduction of Workdays for "Generate Drawings" Process



As currently executed, the "generate drawings" process is very labor-intensive because the majority of the process is manual, translating from a sketch on paper, or a pencil-marked revision to a previous SID, to a two-dimensional AutoCAD paper drawing. As evident in the above chart, through automation of the SID, manpower requirements are significantly reduced.

Optimized Operational Efficiency

The ROI metric identifies the productivity of specific processes. KVA analysis reveals that the implementation of new technology greatly impacts four of the seven core shipyard planning subprocesses.

Table 10. KVA Results—Analysis on ROI

Core Process	Process Title	"AS IS" ROI	"TO BE" ROI	"RADICALTO BE" ROI
1	Issue Tasking	-69%	-69%	-68%
2	Interpret Orders	518%	881%	1168%
3	Plan for Ship Check	-99%	-96%	-92%
4	Conduct Ship Check	552%	1785%	2530%
5	Report Assembly	783%	783%	1601%
6	Revise Schedule	1375%	1375%	1373%
7	Generate Drawings	-37%	2169%	4515%

Reduced Inventory & Expanded Capability

Expediting the planning yard process creates a ripple effect through all industrial activity for maintenance and modernization of naval assets. Reducing the duration of ship availabilities and providing more operational availability of naval assets could provide leadership options in deploying more ships or reducing the size of the Fleet. Leadership could schedule increased time gaps between new ship acquisitions or allow ship decommissioning to occur at an earlier, more realistic phase of its current expected lifecycle.

Reduced Navy Fleet Cycle-time.

The case study revealed that shipyard planning process duration could be reduced by 50%. Although this value is limited to a specific aspect of the availability process (the planning yard), if every operational Navy ship was available one additional week for tasking, over a two-year time-span, the DoN would have 280 additional weeks for tasking assignments, training, or crew rest and relaxation opportunities.

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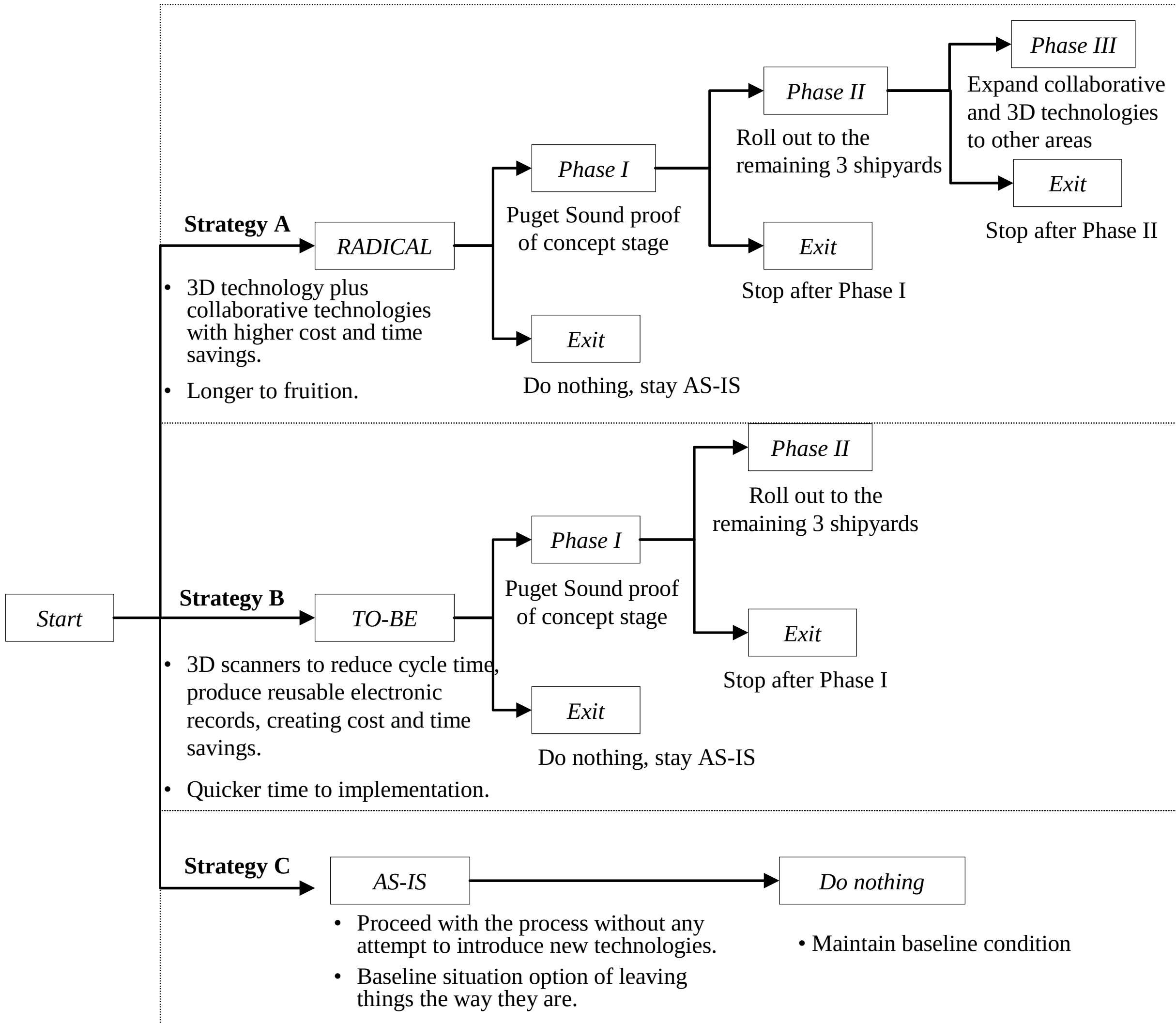
5.0 Real Options

Real Options analysis was performed to determine the prospective value of three basic options over a three-year period using KVA data as a platform. Figure 19 identifies the three potential strategies evaluated. A stage gate sequential compound option was analyzed, with implementation divided into several phases or stages. For example, instead of implementing a complete 3D scanning technology immediately, a proof-of-concept stage was first applied at the Puget Sound shipyard.

Only if the implementation is successful would the process be implemented at the remaining three shipyards; otherwise, the technology will be abandoned. These options to abandon and options to defer capital investments until more information is obtained and after the risks and uncertainties have been resolved over the passage of time, actions and events, creates a higher value than a direct risky implementation. The additional value exists as the risky, or downside, values in the implementation are mitigated (the maximum loss is the cost of a single implementation rather than 4 shipyard implementations simultaneously), thereby reducing the risks and enhancing the value of the project through a first-stage proof-of-concept.

Further, in the “Radical To Be” approach, the 3D scanning technology coupled with collaborative technologies can be applied to an additional 10 private shipyards across the US. These technologies can also be expanded into various other areas where 3D-collaborative efforts can be employed. This provides additional expansion and growth options that further increase the value of this strategic path.

Figure 19. COA Strategic Options



After running the different scenarios, “To Be” and “Radical To Be” provide highest overall total strategic value with little difference between the two (19.51 to 20.49 times improvement over the baseline “As Is” option). However, when considering all the downstream options available from collaborative technologies with 3D scanning capabilities, the “Radical To Be” course of action is the best, providing an overwhelming 68.88 times the returns from the existing “As Is” base case.

Table 11. Summary of Results

Maturity (Years)	5		
Risk-Free Rate (%)	5.00%		
Strategic Option Valuation			
	AS-IS	**TO-BE**	**RADICAL**
Benefits	$ 49,175,536.83	$ 93,344,192.00	$ 95,097,452.00
Costs	$ 44,705,033.48	$ 7,854,206.09	$ 4,488,887.70
Volatility	N/A	8.04%	9.81%
Total Strategic Value	$ 4,470,503.35	$ 87,227,330.00	$ 91,601,502.00
Factor Increase		19.51	20.49
Expansion Valuation on Stage-Gate Options			
Maturity (Years)	10	10	10
Factor Increase	3	3	10
	AS-IS	**TO-BE**	**RADICAL**
Benefits	$ 147,526,610.48	$ 280,032,576.00	$ 950,974,520.00
Costs	$ 134,115,100.43	$ 23,562,618.26	$ 44,888,876.96
Volatility	N/A	25.43%	31.02%
Long Term Total Strategic Value	$ 13,411,510.04	$ 265,742,275.00	$ 923,752,800.00
Factor Increase		19.81	68.88

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6.0 Recommendations

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

Expand scope of study to focus on SHIPMAIN. The KVA+RO methodology should be applied and analyzed over a larger sample to assess the impact of these technological assets in the context of SHIPMAIN due to the incredible number of potential applications. First, repair efforts would be enhanced because geographical constraints would be removed. If a ship or submarine is underway or overseas, repair processes could be expedited through a PLM collaborative interface with ship repair agencies, supply personnel, and other stakeholders using 3D digital models of the damage captured by a laser scanner. On vessels where maximum utility of space is critical, such as amphibious assault ships loaded out with Marine Corps equipment and aircraft, 3D models of storage areas would facilitate and improve planning. If new aircraft is introduced to the Fleet, such as the V-22 Osprey with its unconventional design, 3D models of hangar decks could aid Air Department's layout.

Implement KVA and RO software and training for real-time analysis. Although several accounting software packages have included KVA analytical capabilities, the NPS research team has identified GaussSoft Valuation Software as the most comprehensive KVA software platform for conducting the level of analysis required by DoD program managers. Implementing GaussSoft software allows: real-time system and process inputs to be received and proof-of-concept and test the operational capabilities of the software. In addition, software applications for forecasting, risk-based simulation, portfolio optimization and Real Options analysis like Risk Simulator and Real Options SLS can also be used in tandem with Microsoft Excel.. Also, the week-long Certified Risk Analyst (CRA) public training developed and run by Dr. Johnathan Mun is crucial to get decision-makers and analysts up to speed and able to perform the returns on investment, risk-based simulation, forecasting, and Real Options analyses described in this paper.

Create a common data repository that includes 3D images. A common data repository for planning yards, downstream industrial partners, and various stakeholders at all levels of the Chain of Command should be evaluated as an asset (the Navy Data Environment may serve this purpose). A large-scale database enabling interoperability should include a capacity to store and manage both 2D and 3D data. The database should be designed with the necessary tables and corresponding attributes for 3D so it would be ready for future growth into the 3D domain. The Database Management System (DBMS) must be capable of ensuring the integrity and availability of database information. It appears that UGS' PLM collaborative software can perform such functions and could be used for a proof-of-concept demonstration prior to widespread implementation in support of the SHIPMAIN approach.

7.0 Conclusions

This proof-of-concept case study reveals the potential value select IT resources may have on the Navy shipyard planning process. Digital 3D data capture, with its quality, accurate, and reusable product outputs, alongside the capabilities of PLM collaborative software appears beneficial to naval ship maintenance and modernization efforts. In particular, these technologies:

- reduce maintenance costs for ships by expediting maintenance work in shipyards
- decrease maintenance costs by eliminating or reducing DoD planning yard labor costs
- provide an opportunity to improve fleet utilization and/or reduce fleet inventory requirements through reduced cycle-time
- improve productivity in current shipyard planning processes, allowing for increased shipboard modernization

More importantly, these technologies could provide tremendous value in the US shipbuilding and repair industry. Given war-strained budgets, rising shipbuilding costs and fewer ship acquisitions by the Navy, industry consolidation and shrinkage will continue, which will greatly impact the nation's security strategy.[15],[16],[17] These technologies present an opportunity to help the US maintain its naval national security requirements and allow the industry to remain competitive in the global arena.

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[15] The Navy's 2006-2001 budget calls for cutbacks in various ship programs.
[16] There are six remaining private shipyards in the US, which are owned by two companies.
[17] In a 2005 analysis of Shipbuilding Programs, the GAO found that the Navy used "prior year completion" funding to pay for cost overruns. Increases in labor hour and material costs accounted for 77% of the cost growth of the eight ships studied. Design modifications, the need for additional and more costly materials, and human capital expenditures were the primary causes of cost growth.

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Appendix 1. Findings—Cost/Time Savings for a Small Ship Check

Table A-1. Traditional vs. Laser Scanning

	Traditional Ship Check					Ship Check with Laser Scanning						
		Total Labor Hours	Labor Cost	Expense Cost	Total Cost		Total Labor Hours	Labor Cost	Expense Cost	Total Cost	Total Cost Savings	Total Time Savings
Total Number of Design Personnel	4					3						
Estimated labor cost per hour $50												
Number of hours for ship check	12	48	$2,400		$2,400	8	24	$1,200		$1,200	$1,200	24
Travel time	16	64	$3,200		$3,200	16	48	$2,400		$2,400	$800	16
Total expense days	3					2						
Estimated Travel Expense: Airfare $400 Lodging $125 Car Rental $45 Per Diem $43				$1600 $1500 $135 $516	$3,751				$1200 $750 $90 $258	$2,298	$1,453	
Scanner/Software Investment & Maintenance									$500	$500	($500)	
Total Cost/Time		112	$5,600	$3,751	$9,351		72	$3,600	$2,798	$6,398	$2,953	40

(Source: NSRP ASE, 2005, December 8)

Appendix (cont.). Cost/Time Savings for a Large Ship Check

Table A-2. Traditional vs. Laser Scanning Continued

	Traditional Ship Check					Ship Check with Laser Scanning						
		Total Labor Hours	Labor Cost	Expense Cost	Total Cost		Total Labor Hours	Labor Cost	Expense Cost	Total Cost	Total Cost Savings	Total Time Savings
Total Number of Design Personnel	10					6						
Estimated labor cost per hour $50												
Number of hours for ship check	50	500	$25,000		$25,000	40	240	$12,000		$12,000	$13,000	260
Travel time	16	160	$8,000		$8,000	16	96	$4,800		$4,800	$3,200	64
Total expense days	6					5						
Estimated Travel Expense: Airfare $400 Lodging $125 Car Rental $45 Per Diem $43				$4,000 $7,500 $540 $2,580	$14,620				$2,400 $3,750 $225 $1,290	$7,665	$6,995	
Scanner/Software Investment & Maintenance									$2,000	$2000	($2000)	
Total Cost/Time		660	$33,000	$14,620	$47,620		336	$16,800	$9,665	$26,465	$21,155	324

(Source: NSRP ASE, 2005, December 8)

Appendix 2. Discussion of KVA Analysis "As Is"

"Issue Tasking" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of core process one:

Table A-3. Core Process One Findings

Core Process 1: Issue Tasking

1	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Fired per Shipcheck	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Rank Order	Total Benefits	Annual Cost	ROI
1a.	Plan SHIPCHECK budget allocations.	4	10	1	1	5	5	$271.10	30%	1	0	1	x	52	$54,220	-100%
1b.	Coordinate and build schedule.	4	10	1	1	3	3	$271.10	30%	1	0	1	x	52	$32,532	-100%
1c.	PLM oversee entire task.	4	10	1	1	8	8	$271.10	30%	690	207	897	x	35880	$86,752	-38%
	TOTALS	**4**	**10**	**2**	**1**	**8**	**16**	**$271.10**	**x**	**690**	**208**	**898**	**5**	**35984**	**$173,504**	**-69%**

Core Process One "As Is" KVA

As a management-based task, this process yields expected results. The total cost is relatively low, as very few employees are involved in the scheduling and budget aspects of delivering the DTM, the output of this core process. The overall cost was predictably low in relation to other processes because the rank structure of those employees involved in the included planning yard processes is more horizontally-oriented than most other organizations; the salaries used are that of either a GS-11 or GS-12, depending on the process. The ALT values contained in the "*plan ship check budget allocations*," and "*coordinate and build schedule*" were reduced to one day, because the knowledge which allows the PLM to oversee the task cannot overlap with these two activities. This reduction enabled proper application of KVA methodology.

"Interpret Orders" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of core process two:

Table A-4. Core Process Two Findings

Core Process 2: Interpret Orders																
2	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Fired per Shipcheck	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Rank Order	Total Benefits	Annual Cost	ROI
2a.	Coordinate and communicate with follow codes and outside organizations.	4	10	5	100	2.5	12.5	$226.20	5%	120	6	126	x	504000	$113,098	568%
2b.	Begins data collection pertaining to tasking.	4	10	5	100	5	25	$271.10	5%	230	12	242	x	966000	$271,100	434%
2c.	Create Job Information Sheet (JIS) for each unique "job."	4	10	5	100	2.5	12.5	$271.10	40%	120	48	168	x	672000	$135,550	644%
	TOTALS	4	10	5	100	10	50	$226.20	x	470	66	536	4	2142000	$519,748	518%

Core Process Two "As Is" KVA

Like the previous core process, the "Interpret Orders" core process has a predictable return-on-investment results, but it uses the knowledge assets of more personnel and is executed more often. Because creation of the JIS is already an automated process, and one which depends on user input and coordination among the Lead and Follow Codes, there is no evidence to suggest this process should be changed. However, there is potential for improvement in the work time required to "begin data collection pertaining to tasking."

"Plan for Ship Check" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of core process three:

Table A-5. Core Process Three Findings

Core Process 3: Plan for Shipcheck																
3	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Fired per Shipcheck	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Rank Order	Total Benefits	Annual Cost	ROI
3a.	Form shipcheck team.	4	10	1	1	0.5	0.5	$271.10	5%	2	0	2	x	84	$5,422	-98%
3b.	Get permission to go to ship.	4	10	1	1	0.25	0.25	$271.10	0%	5	0	5	x	200	$2,711	-89%
3c.	Gather data applicable to shipcheck: review guidance, drawings, schematics	4	10	35	1	5	175	$226.20	5%	230	12	242	x	9660	$1,583,370	-99%
3d.	Physically gather tools required for SHIPCHECK.	4	10	35	1	0.2	7	$226.20	0%	1	0	1	x	40	$63,335	-100%
	TOTALS	4	10	35	1	5.95	182.75	$226.20	x	238	12	250	3	9984	$1,654,837	-99%

Core Process Three "As Is" KVA

With an annual, aggregated cost of approximately $1.5 million, the ROI of this process is disproportionately low for all processes. Because this core process is focused on planning for the ship check, it requires a tremendous amount of knowledge in proportion to its output: an ensemble of tools and reference material needed by each member of the team for work on the ship check platform. Subject Matter Experts stated that finding the tools and reference materials required for each ship check executed requires knowledge and experience, because one must know what to look for, where to look for it, and how to acquire the resources needed (i.e., previous SID from ship check conducted on same ship class, lessons learned from previous SHIPALTs, etc.). There is no central repository that enables easy access to Navy-wide information beyond what has already been done "in house" at each Planning Yard facility. Information sharing and reuse is minimal.

"Conduct Ship Check" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of core process four:

Table A-6. Core Process Four Findings

Core Process 4: Conduct Shipcheck

4	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Fired per Shipcheck	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Rank Order	Total Benefits	Annual Cost	ROI
4a.	Travel time. Transport team to ship.	4	10	35	1	1	35	$226.20	0%	1	0	1	x	40	$316,674	-100%
4b.	Manage overall process.	4	10	1	1	9	10	$271.10	15%	1150	173	1323	x	52900	$97,596	-19%
4c.	Conduct in-brief and out-brief with ship's crew.	4	10	1	2	0.25	0.25	$271.10	15%	230	35	265	x	21160	$2,711	1071%
4d.	Liason with ship's crew, including conflict management and resolution.	4	10	1	75	4	4	$271.10	0%	460	0	460	x	1380000	$43,376	4672%
4e.	Conduct ship walkthru: identify and resolve interferences between new installations (one for each ALT).	4	10	5	100	4	20	$226.20	10%	690	69	759	x	3036000	$180,957	2417%
4f.	Determine alteration-pertinent capacities.	4	10	10	210	2.5	25	$226.20	10%	20	2	22	x	184800	$226,196	23%
4g.	Collect "removal data" for equipment and material to be removed, including temporary access routes.	4	10	10	25	2.5	25	$226.20	10%	120	12	132	x	132000	$226,196	-12%
4h.	Create rough sketches and schematic designs for SHIPALTS.	4	10	35	500	2	70	$226.20	5%	230	12	242	x	4830000	$633,348	1044%
4i.	Photograph images for SHIPALTS with digital camera.	4	10	3	1000	4	12	$226.20	75%	0.50	0.38	1	x	35000	$108,574	-52%
4j.	Create SHIIPALT material lists.	4	10	25	100	2	50	$226.20	20%	345	69	414	x	1656000	$452,391	449%
4k.	Travel time. Transport team from ship.	4	10	35	1	1	35	$226.20	0%	1	0	1	x	40	$316,674	-100%
	TOTALS	**4**	**10**	**35**	**40**	**10**	**286.25**	**$271.10**	**x**	**2097.5**	**371**	**3618**	**6**	**11327940**	**$2,604,692**	**552%**

Core Process Four "As Is" KVA

Simple observation of the large number of subprocesses executed to complete a typical ship check reveals that the "*conduct ship check*" core process requires significant knowledge-assets, a large budget, and significant manpower. Interestingly, reducing the time required to conduct a ship check provides the greatest opportunity to improve Navy ship cycle-time. Executing a ship check requires the second highest number of personnel workdays, outside of the "generate drawings" core process. Regardless of the number of personnel on the team, based on the subprocesses and work times estimated by the SME team, accomplishing one ship check consumes 286 workdays. This figure explains the relatively high annual cost of $2.6 million dollars for the completion of 40 ship checks. (Recall that planning yard duties outsourced to private industry are not included in this analysis.)

The ROI results indicate that the highest return on investment is achieved in the "*conduct ship walk-through*" and "*liaison with ship's crew*" subprocesses. The low cost of each and the high return on investment each allows indicate effective management for both processes. Conversely, one might also observe that the most expensive subprocess is "*create rough sketches and schematic designs*." This high cost, coupled with a ROI value of 1044%, implies that the investment in technology would greatly impact the manual labor involved in creating sketches.

"Report Assembly" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of core process five.

Table A-7. Core Process Five Findings

Core Process 5: Report Assembly																	
5	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Fired per Shipcheck	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Rank Order	Total Benefits	Annual Cost	ROI
5a.	Determine and list conflicts between subsystems.	4	10	5	100	5	25	$226.20	0%	345	0	345	x	1380000	$226,196	815%
5b.	Create SHIPALT Report.	4	10	1	1	1	1	$226.20	35%	60	21	81	x	3240	$9,048	-46%
	TOTALS	4	10	1	1	6	26	$271.10	x	405	21	426	2	1383240	$235,243	782%

Core Process Five "As Is" KVA

Before drafting a SHIPALT Report, the Lead Codes must confer with all Follow Codes and discuss any system conflicts relevant to SHIPALTS. Because much knowledge is used in determining system problems, this process results in a high ROI of 815%. Recalling the similar process of "*conduct ship walkthrough*" and its high ROI, it follows that determining system conflicts would have a similarly high ROI. In fact, many system conflicts are determined prior to this phase in the overall process. In this example, it is difficult to capture the instances where revisits to the ship for reassessment are necessary, as estimates for the percentage of cases in which this occurs were unavailable. As such, the total cost applied to this core process is likely much lower than reality.

"Revise Schedule" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of core process six.

Table A-8. Core Process Six Findings

Core Process 6: Revise Schedule																
6	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Fired per Shipcheck	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Rank Order	Total Benefits	Annual Cost	ROI
6a.	Organize data to update DIS.	4	10	10	100	1.25	12.5	$226.20	40%	230	92	322	x	1288000	$113,098	1608%
6b.	Develop drawing "list" or schedule.	4	10	1	1	1	1	$226.20	80%	1	1	2	x	72	$9,048	-99%
6c.	Expected manhours determined.	4	10	1	1	1	1	$226.20	80%	1	1	2	x	72	$9,048	-99%
TOTALS		**4**	**10**	**1**	**1**	**3**	**14.5**	**$271.10**	**x**	**232**	**94**	**326**	**1**	**1288144**	**$131,193**	**1373%**

Core Process Six "As Is" KVA

One of the primary objectives of planning yard work is to determine the budget and manhour requirements for each SHIPALT, so that the industrial activity can properly plan work execution. These estimates are achieved after the ship check by entering applicable data into an on-site database called DIS. Without question, allocating cost and time to each SHIPALT requires significant expertise and experience, reflected in the high ALT value for the "*organize data to update DIS*" Process. Within the DIS information system, estimates for cost and time are automatically generated once all SHIPALT information is submitted. Because it is a highly complex process and managed reasonably, the ROI for this process ranks higher than the others.

"Generate Drawings" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of core process seven.

Table A-9. Core Process Seven Findings

Core Process 7: Generate Drawings																
7	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Fired per Shipcheck	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Rank Order	Total Benefits	Annual Cost	ROI
7a.	Physically develop drawings to be redone in CAD.	4	10	110	500	18	1980	$226.20	5%	690	35	725	x	14490000	$17,914,696	21%
7b.	Draw and generate 2D drawing using AUTOCAD software.	4	10	110	500	18	1980	$271.10	75%	60	45	105	x	2100000	$21,471,120	-85%
	TOTALS	**4**	**10**	**1**	**500**	**18**	**3960**	**$271.10**	**x**	**750**	**80**	**830**	**7**	**16590000**	**$39,385,816**	**-37%**

Core Process Seven "As Is" KVA

Of any process, the subtasks completed in the "Generate Drawings" core process are executed most frequently, based on the SME input that at least five drawings are generated for every SHIPALT performed. In addition, a significant amount of knowledge is used per iteration, and the final output (the drawing) reflects that expertise. As mentioned in the "Report Assembly" process description, the task of generating drawings sometimes requires repeat visits to ships outside of the actual ship check period to validate sketches and ensure accuracy. As stated, an estimate to capture this percentage was unavailable. Similarly, the estimate of five drawings per SHIPALT is conservative, and it may be that in reality, many more drawings are required for complex SHIPALTS. As a result of these two notions, the total cost as calculated is presumably lower than reality. The impact on our analysis, however, is negligible, since conservative estimates are preferred.

Appendix 3. Discussion of "To Be" Data Analysis

Reengineering a notional, "to be" scenario presented several challenges. First, complete understanding of the current process was necessary before any alternate scenarios could be theorized. Second, to make reasonable and conservative estimates of a "to be" scenario, knowledge of the capabilities and limitations of the proposed IT resources and their place within that current process was required. Finally, the practicality of IT resources and usefulness of 3D models beyond planning yards was considered in each scenario.

For greater understanding, Core Processes three, four, and seven will be scaled down to each group of subtasks. Since no values changed in the other processes, they will not be included in this section.

a. "Plan for Ship check" "To Be" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of the notional "to be" revision of process three. Core process one and two are omitted because introduction of 3D data capturing technology had no influence on those tasks.

Table A-10. Core Processes Scaled Down

"To Be" Core Process 3: Plan for Shipcheck

3	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Times Fired per SC	Time (days)	Manhours (days)	Daily IT Cost	Daily Salary	%IT	ALT (days)	K in IT	TLT	Total Benefits	Annual Cost	ROI
3a.	Form shipcheck team.	4	10	1	1	0.5	0.5		$271.10	5%	2	0	2	84	$5,422	-98%
3b.	Get permission to go to ship.	4	10	1	1	0.25	0.25		$271.10	0%	5	0	5	200	$2,711	-89%
3c.	Gather data applicable to shipcheck: review guidance, drawings, schematics	4	10	15	1	5	75		$226.20	5%	230	12	242	9660	$678,587	-98%
3d.	Physically gather tools required for SHIPCHECK.	4	10	15	1	0.2	3		$226.20	0%	1	0	1	40	$27,143	-100%
	TOTALS	**4**	**10**	**15**	**1**	**5.95**	**78.75**		**$226.20**	x	**238**	**12**	**250**	**9984**	**$713,863**	**-98%**

KVA Analysis of "To Be" "Plan for Ship Check" Process

Several assumptions were made that account for the cost-savings reflected in the processes associated with planning a ship check. First, use of the laser scanning technology reduces the number of personnel necessary for the ship check team, because the process of manual hand-sketching has been superseded. The revised team size in this scenario consists of 15 personnel, reduced from the original “as is” size of 35. As such, only 15 personnel will need to gather information in preparation for each ship check. At the same time, access to stored digital information from previous ship checks will improve the data-collection process. Changed values are shown in red.

b. “Conduct Ship Check” “To Be” KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment(ROI) of the notional “to be” revision of process four.

Table A-11. KVA Estimates of Process Four Revision

"To Be" Core Process 4: Conduct Shipcheck

4	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Times Fired per SC	Time (days)	Manhours (days)	Daily IT Cost	Daily Salary	%IT	ALT (days)	K in IT	TLT	Total Benefits	Annual Cost	ROI
4a.	Travel time. Transport team to ship.	4	10	15	1	1	15		$226.20	0%	1	0	1	40	$135,717	-100%
4b.	Manage overall process.	4	10	1	1	9	9		$271.10	15%	1150	173	1323	52900	$97,596	-19%
4c.	Conduct in-brief and out-brief with ship's crew.	4	10	1	2	0.25	0.25		$271.10	15%	230	35	265	21160	$2,711	1071%
4d.	Liason with ship's crew, including conflict management and resolution.	4	10	1	75	4	4		$271.10	0%	460	0	460	1380000	$43,376	4672%
4e.	Conduct ship walkthru: identify and resolve interferences between new installations (one for each ALT).	4	10	5	100	4	20		$226.20	10%	690	69	759	3036000	$180,957	2417%
4f.	Determine alteration-pertinent capacities.	4	10	10	210	2.5	25		$226.20	10%	20	2	22	184800	$226,196	23%
4g.	Collect "removal data" for equipment and material to be removed, including temporary access routes.	4	10	10	5	2.5	25		$226.20	10%	120	12	132	26400	$226,196	-82%
4h.	**Scan & capture point cloud images for applicable areas and compartments.**	4	10	1	500	8	8	$132	$226.20	95%	276	262	538	10764000	$98,783	16245%
4i.	Photograph images for SHIPALTS with digital camera.	4	10	1	500	4	4		$226.20	75%	0.50	0.38	1	17500	$36,191	-27%
4j.	Create SHIPALT material lists.	4	10	10	100	2	20		$226.20	20%	345	69	414	1656000	$180,957	1273%
4k.	Travel time. Transport team from ship.	4	10	15	1	1	15		$226.20	0%	1	0	1	40	$135,717	-100%
	TOTALS	**4**	**10**	**15**	**40**	**x**	**145.25**		**$271.10**	**x**	**2143.5**	**622**	**3915**	**17138840**	**$1,364,396**	**1784%**

KVA Analysis of “To Be” “Conduct Ship Check” Process

Reducing the time required to complete this process will provide the greatest potential to both reduce the time required to conduct ship checks and to increase the time a Navy ship is available for operational tasking. Again, the ship check team size has been reduced from 35 to 15 personnel. In place of hand-sketched ship installation drawings, a laser scanner captures a point cloud image of the area or compartment specified in the SHIPALT. It is important to realize the fundamental change in this scenario: where a single sketch was once created for each required SID, the laser scanner can now capture a model from which an infinite number of 3D and 2D images, image redesigns, and the SHIPALT required installation drawings (SIDS), can be produced. For this exercise, it is assumed that 20 area or compartment scans are required to achieve the same level of output as the current "conduct ship check" scenario.

Laser Scanner Developers have documented performance times that reveal the time to capture a reliable, average quality point cloud is two to three hours for a low complexity space, such as a ship's fan room, four to six hours for a medium complexity space, such as a stateroom or office space, and eight to 12 hours for a high-complexity space, such as Combat Information Center (CIC) or a Main Machinery Room (MMR). These estimates are based on laser scanning work accomplished on 25 different Navy ships in recent years. The estimate used in this core process is four hours; that is, the time to capture a compartment of medium complexity. Experts agree that as experience and technology improve, the time required to capture a quality scan will be significantly reduced. In fact, the most recent 3DIS model created by Spatial Integrated Systems (SIS) reduces these documented scan times by 50%. For each compartment scanned, one system operator is sufficient. Obviously, the time required onboard is directly proportional to the number of scanners and scanner operators available to complete the required work.

For the specific subtasks reengineered to include 3D laser scanning or digital images, the ALT values were increased by a conservative 20% to reflect the additional knowledge embedded in a more valuable output. Three dimensions are inherently more complex than two dimensions. As is evident in the following table, the ROI of the "*scan and capture point cloud images*" process increased considerably. At the same time, the cost to execute this process is moderate, despite the cost of the laser scanner and software suite (price $132/day over 10 year period, not shown in table).

c. “Generate Drawings” “To Be” KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of the notional “to be” revision of process seven. Again, core processes five and six are omitted because introduction of 3D data capture technology had no influence on those tasks.

Table A-12. KVA Estimates of Process Seven Revision

"To Be" Core Process 7: Generate Drawings																	
7	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Times Fired per SC	Time (days)	Manhours (days)	Daily IT Cost	Daily Salary	%IT	ALT (days)	K in IT	TLT	Total Benefits	Annual Cost	ROI
7a.	~~Physically develop drawings to be redone in CAD.~~	4	~~10~~	~~110~~	500	~~18~~	~~1980~~		~~$226.20~~	~~5%~~	~~690~~	~~35~~	~~725~~	~~14490000~~	~~$17,914,696~~	21%
7b.	Conduct data processing for captured point clouds. (point processing)	4	10	10	500	7	70		$226.20	10%	828	83	911	18216000	$633,348	4214%
7c.	Model processed data to 3D.	4	10	10	500	45	450		$226.20	75%	828	621	1449	28980000	$4,071,600	968%
7d.	Generate 2D drawings.	4	10	10	500	0.125	1.25		$226.20	75%	690	518	1208	24150000	$11,310	320192%
	TOTALS	**4**	**10**	**1**	**500**	**5**	**521.25**		**$226.20**	**x**	**1380**	**552**	**1932**	**71346000**	**$4,716,258**	**2169%**

KVA Analysis of “To Be” “Generate Drawings” Process

As learned in analysis of the “as is” process to generate drawings, it is the most time-consuming task executed by planning yards. Experts note that on average, a typical AUTOCAD drawing requires approximately 40 hours of “thinking” and 40 hours of actual drawing in the software.[18] Of course, this depends greatly on the complexity of the drawing and the number of systems affected by the SHIPALT. Much of the “thinking” and “drawing” is actually done concurrently. With the introduction of 3D digital capture technology, the bulk of the drawing development task is no longer required since the laser scanner automatically captures the image; and with 3D imaging, engineering an alteration is simplified. With less problem-solving required to apply the mandated alteration to the current configuration, work time is significantly reduced.

Data processing is a necessary subprocess of this task. After an image point cloud is captured, data processing occurs. To accomplish this, a human operator

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[18] This estimate has two sources: personal e-mail received from an engineer (with 20 years planning yard and CAD experience) and agreement from a Branch Manager at Puget Sound Planning Yard.

establishes relationships between the "points in space" captured in the point cloud using point processing software. This step replaces the "as is" task of physically engineering and drawing a SID on paper to be recreated in a CAD or AUTOCAD application. Actual 3D modeling follows this step, which replaces the former step of drawing the 2D SID in AUTOCAD. While the "*model processed data to 3D*" has a high total cost, the downstream benefit is enormous, reflected in the considerable ROI of "*generate 2D drawings*." From a purely analytical vantage, the ROI figure is large because the work time is significantly reduced from the previous "as is" subtask which created 2D drawings in CAD. Using the 3D model generated in this "to be" scenario, however, creation of a 2D paper drawing may be likened to a snapshot within the software application. The improved return on investment in this notional scenario, particularly in the "*generate 2D drawings*" subprocess, is noteworthy.

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Appendix 4. Discussion of "Radical To Be" Data Analysis

This notional scenario presents the ideal state for Planning Yards, with maximum employment of laser scanners, 3D digital imaging, data warehousing, a robust database management system (DBMS), and collaborative environments. In reality, a reasonable transition to this state might take many years. The transition process is a tremendous undertaking requiring the following elements to achieve the state of readiness portrayed in our radical scenario: a revised policy, clearly articulated strategic goal, acquisition initiatives reflecting revised policy and strategies, appropriate test locations for gradual evaluation, and large-scale implementation in the planning yard environment.

Collaborative environment specialists at UGS Corporation were interviewed. The core processes and subtasks were reengineered appropriately to reflect the value added through a collaborative environment. Moreover, because the nature of technology is to evolve and improve, this scenario assumes ship 3D data is accessible to all stakeholders in the planning yard process. It also assumes minor decreases in laser scanner capture and required modeling work time. In this scenario, revisions to the FMP replace the requirement for 2D physical ship installation drawings with digital images, accessible via a network. As one indirect advantage, all stakeholders have instant access to all data generated by any planning yard or industrial activity. The most obvious advantages of collaborative environments are seen in those processes pertaining to planning.

As evident in the following table, the cost savings introduced in this scenario are significant. Following sections will explain each reengineered process in detail.

Table A-13. Cost Savings

Comparison between "As Is" and "Radical To Be" Cost and ROI Values

Core Process	Process Title	"As Is" Cost	"Radical To Be" Cost	Difference	"As Is" ROI	"Radical To Be" ROI
1	Issue Tasking	$173,500	$173,000	0	-69	-69
2	Interpret Orders	$520,000	$328,000	$192,000	518	1168
3	Plan For Ship Check	$1,655,000	$374,500	$1,280,500	-99	-92
4	Conduct Ship Check	$2,604,500	$1,041,000	$1,563,000	552	2530
5	Report Assembly	$235,000	$122,000	$113,000	783	1601
6	Revise Schedule	$131,000	$131,000	0	1375	1375
7	Generate Drawings	$39,386,000	$2,319,000	$37,067,000	**-37**	4515
	TOTALS	**$44,705,000**	**$4,489,000**	**$40,216,000**		

"As Is and "Radical To Be" Cost and ROK Comparison

3. **"Radical To Be" Data Analysis**

The following tables are theoretical interpretations built on the previous "as is" scenario iteration and portray how implementation of a planning-yard specific collaborative environment could affect the "as is" process by promoting interoperability, reusability of products, and knowledge sharing. Any "as is" or "to be" values changed are annotated in blue. Unaffected core processes are not discussed.

a. "Interpret Orders" Radical "To Be" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of the notional "radical to be" revision of process two.

Table A-14. KVA Estimates of Process Two "Radical To Be" Revision

"Radical To Be" Core Process 2: Interpret Orders															
2	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Times Fired per SC	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Total Benefits	Annual Cost	ROI
2a.	Coordinate and communicate with follow codes and outside organizations.	4	10	5	100	1.25	6.25	$226.20	50%	120	60	180	720000	$56,549	1810%
2b.	Begins data collection pertaining to tasking.	4	10	5	100	2.5	12.5	$271.10	50%	230	115	345	1380000	$135,550	1427%
2c.	Create Job Information Sheet (JIS) for each unique "job."	4	10	5	100	2.5	12.5	$271.10	40%	120	48	168	672000	$135,550	644%
	TOTALS	**4**	**10**	**5**	**100**	**6.25**	**31.25**	**$226.20**	**x**	**470**	**223**	**693**	**2772000**	**$327,649**	**1169%**

KVA Analysis of "Radical To Be" "Interpret Orders" Process

A primary assumption of this scenario is that a collaborative environment has been created, allowing all stakeholders and ship check-planners instant, real-time access to a database of reusable 3D images collected over time from various planning yard facilities. The collaborative environment also promotes effective coordination and communication between many engineers. As a result, communication and data collection tasks work times are reduced by 50%. Similarly, because of the amount of technology applied to a once manual process, the percentage of IT increased.

b. "Plan for Ship check" "Radical To Be" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of the notional "radical to be" revision of process three.

Table A-15. KVA Estimates of Process Three "Radical To Be" Revision

"Radical To Be" Core Process 3: Plan for Shipcheck															
3	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Times Fired per SC	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Total Benefits	Annual Cost	ROI
3a.	Form shipcheck team.	4	10	1	1	0.5	0.5	$271.10	5%	2	0	2	84	$5,422	-98%
3b.	Get permission to go to ship.	4	10	1	1	0.25	0.25	$271.10	0%	5	0	5	200	$2,711	-89%
3c.	Gather data applicable to shipcheck: review guidance, drawings, schematics	4	10	15	1	2.5	37.5	$226.20	75%	276	207	483	19320	$339,293	-91%
3d.	Physically gather tools required for SHIPCHECK.	4	10	15	1	0.2	3	$226.20	0%	1	0	1	40	$27,143	-100%
	TOTALS	**4**	**10**	**15**	**1**	**3.45**	**41.25**	**$226.20**	**x**	**284**	**207**	**491**	**19644**	**$374,570**	**-92%**

KVA Analysis of "Radical To Be" "Plan for Ship Check" Process

This core process is also focused on planning for a ship check. Consequently, the same assumptions from the "interpret orders" process may be applied here; engineers may find necessary SHIPALT data more quickly and easily through a collaborative interface. This assumption justifies the work time reduction to two and a half days per worker, rather than the "as is" work time of five days. With instant access to data from other Planning Yards and SHIPALTS, ship check teams will be more prepared for the work at hand. Constructive, time-saving, problem-solving discussion can occur among the Lead and Follow Codes and other outside organizations prior to the actual ship check.

c. "Conduct Ship check" "Radical To Be" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of the notional "radical to be" revision of process four.

Table A-16. KVA Estimates of Process Four "Radical To Be" Revision

"Radical To Be" Core Process 4: Conduct Shipcheck																
4	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Times Fired per SC	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Total Benefits	Annual Cost	ROI
4a.	Travel time. Transport team to ship.	4	10	15	1	1	15	$226.20	0%	1	0	1	40	$135,717	-100%
4b.	Manage overall process.	4	10	1	1	5	5	$271.10	15%	1150	173	1323	52900	$54,220	46%
4c.	Conduct in-brief and out-brief with ship's crew.	4	10	1	2	0.25	0.25	$271.10	15%	230	35	265	21160	$2,711	1071%
4d.	Liason with ship's crew, including conflict management and resolution.	4	10	1	75	4	4	$271.10	0%	460	0	460	1380000	$43,376	4672%
4e.	Conduct ship walkthru: identify and resolve interferences between new installations (one for each ALT).	4	10	5	100	2	10	$226.20	50%	690	345	1035	4140000	$90,478	6764%
4f.	Determine alteration-pertinent capacities.	4	10	10	210	2.5	25	$226.20	10%	20	2	22	184800	$226,196	23%
4g.	Collect "removal data" for equipment and material to be removed, including temporary access routes.	4	10	10	5	1	10	$226.20	50%	120	60	180	36000	$90,478	-40%
4h.	Scan & capture point cloud images for applicable areas and compartments.	4	10	2	500	2.5	5	$226.20	95%	276	262	538	10764000	$45,239	35590%
4i.	Photograph images for SHIPALTS with digital camera.	4	10	1	500	4	4	$226.20	75%	0.50	0.38	1	17500	$36,191	-27%
4j.	Create SHIPALT material lists.	4	10	10	100	2	20	$226.20	20%	345	69	414	1656000	$180,957	1273%
4k.	Travel time. Transport team from ship.	4	10	15	1	1	15	$226.20	0%	1	0	1	40	$135,717	-100%
	TOTALS	**4**	**10**	**15**	**40**	**x**	**113.25**	**$271.10**	**x**	**2143.5**	**946**	**4239**	**18252440**	**$1,041,281**	**2529%**

KVA Analysis of "Radical To Be" "Conduct Ship Check" Process

This process contains an assumption that scan times will be reduced. In reality, a scanner capable of the work time presented here already exists, but documented data is not yet available.[19] A ship compartment of medium-complexity can be scanned in two hours with one operator. In this scenario, two scanners are available, so the duration of the ship check may be reduced. Also, removal data information can be determined by looking at 3D ship models prior to going onboard, and time spent executing this process during the actual ship check will be for verification purposes only. Time required to complete the ship walk-through process has been reduced because the majority of system and subsystem conflicts were identified and resolved quickly and easily in the planning stage. As such, ship check walk-through procedures are also primarily for verification. If problems or unexpected difficulties arise during the ship check, they may be addressed through a collaborative interface, as access to many engineering experts is possible.

What is most notable about this "radical to be" reengineered process is the significant cost savings and impressive ROI improvements. Because of reduced manpower requirements, minimal ship check duration, and better utilization of knowledge assets, cost was reduced from the "as is" scenario by 50%, and the process ROI increased by 450%.

d. "Generate Drawings" "Radical To Be" KVA Analysis

The following table shows all KVA estimates used to determine the total process benefits, annual cost, and return on investment (ROI) of the notional "radical to be" revision of process seven.

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[19] SIS reports its new model, released in the Fall, 2005, reduces its predecessor's scan times by 50 percent.

Table A-17. KVA Estimates of Process Seven "Radical To Be" Revision

"Radical To Be" Core Process 7: Generate Drawings																
7	SUBPROCESS	# Units	Shipchecks per Unit	Head Count	Times Fired per SC	Time (days)	Manhours (days)	Daily Salary	%IT	ALT (days)	K in IT	TLT	Total Benefits	Annual Cost	ROI
7a.	~~Physically develop drawings to be redone in CAD.~~	4	~~10~~	~~110~~	~~500~~	~~18~~	~~1980~~	~~$226.20~~	~~5%~~	~~690~~	~~35~~	~~725~~	~~14490000~~	~~$17,914,696~~	21%
7b.	Conduct data processing for captured point clouds. (point processing)	4	10	10	500	3	30	$226.20	10%	828	83	911	18216000	$271,435	9967%
7c.	Model processed data to 3D.	4	10	10	500	22.5	225	$226.20	75%	828	621	1449	28980000	$2,035,800	2035%
7d.	Generate 2D drawings.	4	10	10	500	0.125	1.25	$226.20	75%	690	518	1208	24150000	$11,310	320192%
	TOTALS	4	10	1	500	5	256.25	$226.20	x	1380	552	1932	71346000	$2,318,545	4516%

KVA Analysis of "Radical To Be" "Generate Drawings" Process

It is assumed that as experience in 3D data processing and modeling matures and software improvements are made, work times for these related subprocesses will decrease. In this reengineered scenario, work times are decreased by 25%—reducing the work time for data processing to 2 days and model processing to 15 days. Object reuse in this process accounts for 25% of all SHIPALTS, reducing the demand to produce new models, decreasing work time further. Again, the improvement from the "as is" ROI value for this core process from -.37 to 4516 is phenomenal and highlights an impressive use of investment resources. Similarly, the cost reduction from the current process execution cost of $39 million dollars annually, to just over $2 million, is remarkable.

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