NPS-AM-11-168

# ACQUISITION RESEARCH SPONSORED REPORT SERIES

**Analysis of ROI in Industry SOA Implementation**

**10 August 2011**

**by**


**Captain Russel G. Wolff, USMC**

Advisors: Dr. Thomas J. Housel, Professor,

Dr. Johnathan Mun, Research Professor, and

Dr. Dan C. Boger, Chair

Graduate School of Operational & Information Sciences

**Naval Postgraduate School**





Prepared for: Naval Postgraduate School, Monterey, California 93943



ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

The research presented in this report was supported by the Acquisition Chair of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

**To request Defense Acquisition Research or to become a research sponsor, please contact:**

NPS Acquisition Research Program
Attn: James B. Greene, RADM, USN, (Ret)
Acquisition Chair
Graduate School of Business and Public Policy
Naval Postgraduate School
555 Dyer Road, Room 332
Monterey, CA 93943-5103
Tel: (831) 656-2092
Fax: (831) 656-2253
E-mail: jbgreene@nps.edu

Copies of the Acquisition Sponsored Research Reports may be printed from our website www.acquisitionresearch.org

# ABSTRACT

The Department of Defense (DoD) is interested in acquiring systems that promote the use of open architecture (OA). Industry has successfully implemented service-oriented architecture (SOA) in its processes and may provide a benchmark for cost savings as well as examples of best practices for the DoD. The basic research question guiding this thesis is, what are the industry cost-saving benchmarks when transitioning to SOA from a proprietary system? The research supports the argument that OA in the DoD is similar to SOA in industry. This comparison is essential for the application of this thesis because this allows the outcomes of industry SOA implementation to be translated into what the DoD can expect from its OA implementations. This research also answers the research question by analyzing 34 industry reports—18 of which provided at least an overall ROI, and 10 of which broke out their ROI calculations into separate cost types. The reported costs were grouped into categories of cost savings, cost avoidance, or productivity improvements. The researcher concluded that the industry ROI for SOA implementation is 72%. Additionally, best practices in industry that are transferable to DoD were indentified, including ensuring system flexibility and implementing SOA incrementally.

**Keywords:** Service-oriented Architecture (SOA), Open Architecture (OA), Return on Investment (ROI), and Modular Open Systems Approach (MOSA)

THIS PAGE INTENTIONALLY LEFT BLANK

# ACKNOWLEDGMENTS

My wife, Anette, deserves recognition for her endless encouragement and countless sacrifices that allowed me to focus my efforts on this thesis. I am grateful beyond words.

.

THIS PAGE INTENTIONALLY LEFT BLANK

NPS-AM-11-168

# ACQUISITION RESEARCH SPONSORED REPORT SERIES

---

**Analysis of ROI in Industry SOA Implementation**

**10 August 2011**

**by**


**Captain Russel G. Wolff, USMC**

Advisors: Dr. Thomas J. Housel, Professor,

Dr. Johnathan Mun, Research Professor, and

Dr. Dan C. Boger, Chair

Graduate School of Operational & Information Sciences

**Naval Postgraduate School**

THIS PAGE INTENTIONALLY LEFT BLANK

# TABLE OF CONTENTS

# LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

# LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| API | Applications Programmer Interface |
| AWS | Aegis Weapons System |
| BTA | Business Transformation Agency |
| COTS | Commercial off-the-shelf |
| DoD | Department of Defense |
| DoN | Department of the Navy |
| FTE | Full-time Equivalent |
| GAO | Government Accountability Office |
| HP | Hewlett–Packard |
| IRM | Integrated Risk Management |
| IT | Information Technology |
| MOSA | Modular Open Systems Approach |
| NOA | Naval Open Architecture |
| NPV | Net Present Value |
| OA | Open Architecture |
| OAAM | Open Architecture Assessment Model |
| OAAT | Open Architecture Assessment Tool |
| OACE | Open Architecture Computing Environment |
| OAET | Open Architecture Enterprise Team |
| OPNAV | Office of the Chief of Naval Operations |
| PEO–IWS | Program Executive Office, Integrated Warfare Systems |
| PO | Portfolio Optimization |
| RO | Real Options |
| ROI | Return on Investment |
| SOA | Service-oriented Architecture |
| SOAP | Simple Object Access Protocol |
| USMEPCOM | United States Military Entrance Processing Command |
| WSDL | Web Service Description Language |
| XML | Extensible Markup Language |

THIS PAGE INTENTIONALLY LEFT BLANK

# I. INTRODUCTION

## A. PURPOSE

The purpose of this thesis is to analyze cost savings from various industries following the implementation of a service-oriented architecture (SOA). In order to accomplish this, the researcher analyzed cost implications that resulted from industries moving from a proprietary architecture to an SOA. The objective of this thesis is to establish a benchmark of performance outcomes, focusing on cost savings that were experienced in industry in order to determine what the government, or the Department of Defense (DoD) specifically, can expect to realize in its push to move to a more open architecture model. In addition, the researcher determined some industry best practices that may be used by the DoD as it moves to an open architecture model.

## B. BACKGROUND

Traditionally, the Navy has had rather inflexible acquisition strategies and has locked itself into single "stove-piped" systems that typically perform well but tend to be localized and prevent the sharing of information across different systems. In addition, because the Navy is locked into specific systems, the options of vendors that supply these systems become limited. In turn, there is little competition to drive down prices. The results are systems that have duplicative capabilities and are incompatible with other systems. Each system has become unique to the platform for which it was originally designed.

To combat this, in recent years the Navy has promoted the use of open architecture (OA) in acquisitions as a way to field systems faster and at a lower cost. Some of the systems that adopted OA early on are now being analyzed to determine whether they are achieving the promised benefits. However, there is no identified benchmark by which to compare the results of the analyses. By looking at private industry performance to identify a benchmark, the Navy can better determine the type of results it should be receiving from its investments.

One way to analyze benefits is through the use of the financial metric return on investment (ROI). ROI has long been accepted in industry as a way to measure the success of an investment, but it has more recently been promoted for use within the DoD. The Clinger–Cohen Act (1996) mandates the assessment of cost benefits for information technology investments. In addition, the Government Accountability Office's (GAO) *Assessing Risks and Returns: A Guide for Evaluating Federal Agencies' IT Investment Decision-Making,* Version 1, (1997) requires that information technology (IT) investments apply ROI measures. Finally, DoD Directive 8115.01 (Assistant Secretary of Defense for Networks and Information Integration, 2005), issued in October 2005, mandates the use of performance metrics based on outputs, with ROI analysis required for all current and planned IT investments. By analyzing the ROIs achieved in industry and comparing them to OA in the DoD, the DoD will take one more step to reaching the goals set forth in the documents described in this section.

## C. RESEARCH OBJECTIVES

The research conducted for this thesis encompassed several objectives. The first objective was to examine the relationships between OA and SOA. The second objective was to make a connection between Navy OA and industry SOA. This was necessary in order to apply the ROI achieved in industry as an applicable benchmark achievable in the DoD. The third research objective was to establish a cost-savings benchmark based on industry performance between the traditional proprietary architecture model and the SOA. The fourth and final objective was to determine some industry best practices that would work for the DoD as well as to identify some potential inhibitors that the DoD will need to carefully examine.

## D. RESEARCH QUESTIONS

In this thesis, the researcher attempts to provide decision-makers with answers to several questions as well as to provide recommendations for future studies. The research questions this thesis addresses are as follows:

1. What are the industry cost-saving benchmarks when transitioning to SOA from a proprietary system?

2. What are some industry best practices that may be used by the DoD?

## E. METHODOLOGY

The researcher analyzed industry published reports, focusing on the benefits provided by an SOA. Typically, these benefits were in the form of an achieved ROI. The achieved benefits were broken down as much as possible by the researcher to discover what percentage of the benefits was achieved due to cost savings, as well as other benefits. If detailed cost savings could not be determined, generalities were formed from surveys and overall ROI industry reports. This data was analyzed and used to form an industry average of typical cost savings achieved following an implementation of SOA. In addition, any correlations discovered were noted, as well as any patterns that pointed to methods of best practice.

## F. SCOPE

The scope of this thesis is primarily concerned with cost savings that can be achieved by SOA. However, other benefits also provide value, and these were analyzed as well. Some examples of these benefits are quicker response time, decreased error rate, and increased revenue. Some of these measures are somewhat subjective and difficult to quantify and were not included in calculating cost savings. Although these are mentioned as additional benefits, they were still analyzed because they contribute to the overall benefit of SOA implementation.

## G. THESIS ORGANIZATION

This thesis is organized to present a sequential flow of information, ending with conclusions and recommendations of the research. The chapters are organized in the following manner: In Chapter I, the researcher provides an overview of the thesis with regard to purpose, methodology, and scope. In addition, researched questions and objectives are identified. In Chapter II, the researcher provides a background for understanding Navy OA and SOA. Chapter III bridges the concepts from Chapter II. Differences and commonalities are analyzed and the conclusion is drawn that the principles observed in industry SOA are applicable to Navy OA. In this chapter, the researcher provides the foundation for the information needed to complete the research and draw conclusions. Chapter IV introduces ROI as it applies to IT investments. Chapter V is a detailed synopsis of the research conducted as well as of the findings and analysis of the data. This is the chapter that will ultimately answer the thesis question. Chapter VI presents conclusions, shortcomings of the study, and recommendations for future research.

# II. LITERATURE REVIEW

## A. CLOSED VERSUS OPEN SYSTEMS

There are generally two types of IT systems: closed systems and open systems. Closed systems are characterized by closely held, privately owned standards, protocols, languages, and data formats that are either unavailable to outsiders or are available only at a very high license fee (Azani, 2001). Closed systems typically contain proprietary software designed for the purpose of supporting a single system. When proprietary systems require upgrades or maintenance, their unique design makes upgrades costly and technically difficult, which leads to increases in the total life-cycle cost of the system. Since the systems are developed for a single purpose, interoperability with other systems suffers. Many times, additional *middleware* (software that connects two disparate and closed systems together through the use of defined interfaces) is inserted to achieve interoperability between systems. This adds another layer to the system and is potentially more costly to implement and maintain. However, when systems use the open architecture approach, middleware solves the interoperability issue.

The goal of systems is to have them perform better and be more cost efficient. Open systems can accomplish this task. In closed systems, upgrades that would provide greater processing capacity cannot be completed without overhauling the current systems. However, in an open system, the hardware and software can be modularized, making upgrades more efficient. Open systems take advantage of commercial advances by using commercial off-the-shelf (COTS) technologies to the fullest extent. This enables the most current technology to be used and allows for competition within industry (Uchytil, 2006). Closed systems tie the system owner to one sole-source contractor. Table 1 provides a comparison of some of the aspects of open versus closed systems.

**Table 1. Closed Systems vs. Open Systems**

(Azani, 2001)

| **Closed System Characteristics** | **Open System Characteristics** |
|---|---|
| Use of closely held, private interfaces, languages, data formats, and protocols (government or vendor unique standards) | Use of publicly available and widely used interfaces, languages, data formats, and protocols |
| Critical importance is given to unique design and implementation | Critical importance is given to interfaces management and widely used conventions |
| Less emphasis on modularity | Heavy emphasis on modularity |
| Vendor and technology dependency | Vendor and technology independence |
| Minimization of the number of implementations | Minimization of the number of types of interfaces |
| Difficult and more costly integration | High degree of portability, connectivity, interoperability, and scalability |
| Use of sole-source vendor | Use of multiple vendors |
| Expansion and upgrading usually requires considerable time, money, and effort | Easier, quicker, and less expensive expansion and upgrading |
| Higher total ownership cost | Lower total ownership cost |
| Slower and more costly technology to transfer | Technology transfer is faster and less costly |
| Components, interfaces, standards, and implementations are selected sequentially | Components, interfaces, standards, and implementations are selected interactively |
| Systems with shorter life expectancy | Systems with longer life expectancy |
| Use of individual company preferences to set and maintain specifications | Use of group consensus process to maintain interface specifications |
| Less adaptable to change in threats and technologies | More adaptable to evolving threats and technologies |
| Focuses mostly on development cost and meeting present mission | Focuses on total costs of ownership, sustainment, and growth |
| User as the producer of system | User as the consumer of components |
| Rigid and slow system of influence and control | Real-time and cybernetic system of influence and control |
| Adversarial relationship with prime contractors/supplier/vendors | Symbiotic relationship with prime contractors/suppliers/vendors |
| Mostly confined to traditional suppliers | Nontraditional suppliers can compete |
| Simple conformance testing | Very challenging conformance testing |

Many current legacy systems in the DoD, and the Navy in particular, follow the closed, proprietary system. The Navy's OA model was implemented to move the Navy away from the acquisition of closed systems to field open systems.

## B. OPEN ARCHITECTURE

### 1. Definition

An open architecture is an architecture that employs open standards for key interfaces within a system (Open Systems Joint Task Force [OSJTF], n.d.). This allows the components of a system to be interchangeable with other systems. One simple example of this is plug-and-play computer accessories. OA follows principles that enable modular, interoperable systems to adhere to open standards. Open standards are simply standards that are widely used, consensus based, published, and maintained by recognized industry standards organizations (OSJTF, n.d.). There are four primary types of standards: formal standards, industry standards, de facto standards, and proprietary standards. Formal standards are standards that are formally recognized by a standards committee. Industry standards are formal or de facto standards that are widely accepted and broadly implemented. De facto standards are standards that are not formal standards, but have gained widespread acceptance by users. Proprietary standards are standards that have been published, but the number of vendor implementations is limited.

The goals of OA are to increase reuse, increase flexibility, shorten delivery time to market, reduce costs, leverage competition, and improve interoperability. Of these, the key reasons the Navy is interested in OA are the decreased delivery time and the assumed reduction in total ownership costs.

As OA was gaining hold in the commercial sector, the Navy wanted to take advantage of the benefits that OA offered. In 2002, the Navy created the Program Executive Office, Integrated Warfare Systems (PEO–IWS), and put it in charge of implementing the Navy’s OA strategy. This included the adoption of standards, products, and best practices that allowed for systems integration and future technological upgrades. The PEO–IWS has since developed and implemented its own open architecture policy called Naval Open Architecture (NOA). The NOA policy is “a Navy initiative for a multi-faceted strategy providing a framework for developing joint interoperable systems that adapt and exploit open-system design principles and architectures” (Defense Acquisition University [DAU], 2006). NOA established a framework with a set of principles, including the following:

- provide more opportunities for competition and innovation,
- rapidly field affordable, interoperable systems,
- minimize total ownership cost,
- optimize total system performance,
- yield systems that are easily developed and upgradeable, and
- achieve component software reuse.

NOA is a systems design approach supported by governmental testing platforms such as the Open Architecture Computing Environment (OACE). The OACE is a standards-based computing infrastructure used by Surface Command and Control domain software applications that attempts to implement open specifications in interfaces and services. The OACE is a compatible set of standards-based COTS components that provides the framework for which support applications are built under the guidelines of OA (Department of Defense [DoD], NAVSEA, & PEO–IWS, 2004).

A few of the technologies that guide the OACE include the use of middleware and wrappers. Middleware is important in software development, particularly in the context of enterprise application integration. Middleware is a way of making separate applications communicate with one another without actually being integrated. It is the software infrastructure that is intended to support the deployment of core, mission-critical applications (Minoli, 2008). Middleware provides proven ways to connect the various software components in an application so they can exchange information using relatively easy-to-use mechanisms. Middleware is completely hidden from the perspective of the application user (Gorton, 2006). The term *middleware* is most often used to describe support software that facilitates interactions between major software components and that masks the differences in language, platform characteristics, message formats, communication protocols, data structures, and other factors (DoD, NAVSEA, & PEO–IWS, 2004).

A wrapper is software that is used to insulate applications from the applications programmer interface (API) of another set of software by exporting a different API. The wrapper exposes the legacy application's functionality or data to the SOA as a service. The wrapper provides all the security, quality of service, and service orientation principles that are provided by any other SOA service. Wrappers provide a way to reuse applications already delivering business value.

In order for the Navy to implement OA, it first had to develop an NOA strategy that included a vision statement, principles, goals, and supporting objectives. The NOA vision statement is to "transform our organization and culture and align our resources to adopt and institutionalize open architecture principles and processes throughout the naval community in order to deliver more warfighting capabilities to counter current and future threats" (PEO–IWS, 2007). Figure 1 describes the Department of the Navy (DoN) OA strategy.

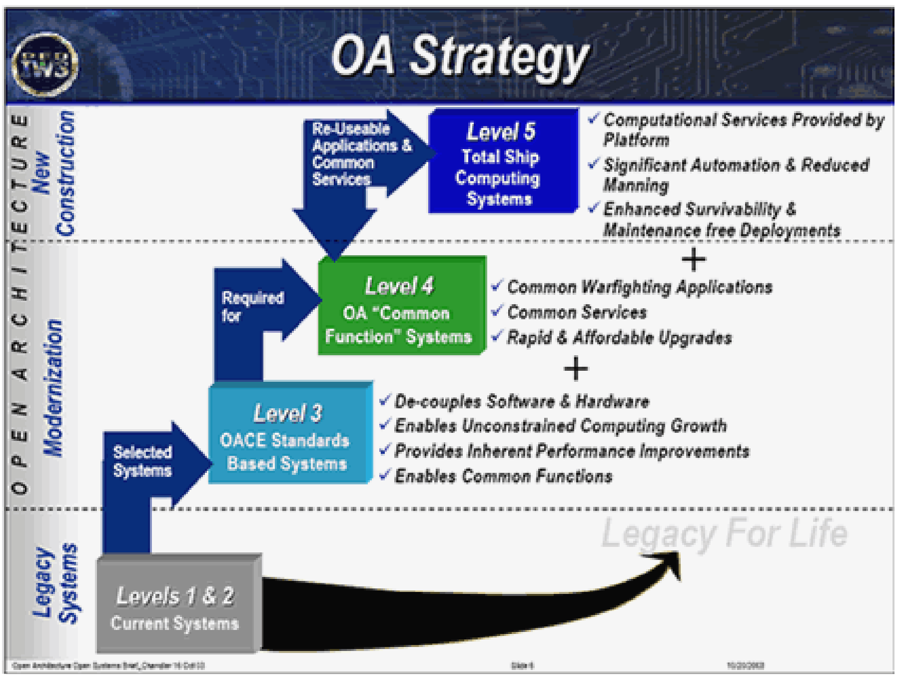


**Figure 1. DoN OA Strategy**
(Uchytil, 2006)

In order to implement NOA, a Naval Open Architecture Enterprise Team (OAET) was established. Since the PEO–IWS was assigned overall responsibility for the NOA implementation, it was designated as the OAET lead. One of the outcomes of the OAET was the development of the Open Architecture Assessment Model (OAAM). This model provides a program manager with a way to describe the "openness" of the current or proposed system.

In order to measure the openness, a program manager must use an Open Architecture Assessment Tool (OAAT), which is an analytical tool that assesses the openness of a system based on business and technical interrelated questions.

There are several benefits and drawbacks to OA. The one benefit most often discussed is the reduction in life-cycle costs. Costs could be reduced due to several of the attributes already described in this section, such as modularity and reuse. Because there is commonality between systems, maintenance costs could also decrease. In addition, competition from industry could increase and thereby drive down the cost of upgradable parts. Along with lower life-cycle costs, other advantages to OA include better system performance due to easier upgradability with the latest technologies as well as improved interoperability for joint warfighting.

Although there are several advantages, OA has its disadvantages as well. One of the biggest concerns is security. Although OA is already in use in industries such as banking, which requires a great deal of security, there is no industry comparison to the security required for a weapons system. In this case, careful testing would be required because there is no room for error in DoD weapons systems. Security and performance requirements are typically much higher in the DoD than in industry, so any COTS products used must be analyzed carefully before implementation to ensure that they do not leave the network vulnerable to outside attack. Furthermore, added security measures typically have a negative impact on performance, which may lead to the COTS products not performing as well as advertised.

Another major concern is cost. Although the life-cycle costs should decrease with OA, the up-front costs are very large. Because it would not be feasible to change the system overnight, much of the cost would occur during the transition period. Initially, there would be the cost of the new architecture. In addition, there would be the requirement to continue utilizing some of the existing legacy systems. This would mean the added cost of middleware to interface between the legacy and OA systems. Also, during the transition period, there would be maintenance costs incurred for both systems simultaneously. Eventually, the legacy systems would be phased out and replaced with OA systems, but this might take a while.

There are many theories as to how long the transition might take, but when the chief technical officer of the DoD Business Mission Area was asked how long the transition would take, he replied, “it will take a generation” (Bradley, 2007). Furthermore, training would need to be implemented in order to develop expertise in the new architecture. In all, although life-cycle costs would decrease, costs would most likely increase in the near term.

## C. PRINCIPLES OF NAVY OA

To achieve the vision of NOA, five principles were identified by the Office of the Chief of Naval Operations Staff (OPNAV), Warfare Requirements and Programs (N6/N7). These principles are as follows: encouraging competition and collaboration, modular design and design disclosure, reusable application software, interoperable joint warfighting applications and secure information exchange, and life-cycle affordability.

### 1. Encouraging Competition and Collaboration

OA naturally encourages competition and collaboration. Unlike systems that are acquired sole-source and restrict the full and open competition of resources, OA promotes competition among industries, leading to better products at a reduced price. In addition, because open standards are used, competition in industry can be leveraged when completing system upgrades or when fielding an entirely new but interoperable system.

### 2. Modular Design and Design Disclosure

Modularity is the concept of decomposing a system into subcomponents. These subcomponents do not rely on another aspect of the system. In that way, they can change quickly and allow for interactions with other systems. This would allow for the independent upgrade of subcomponents, instead of changing out an entire system.

### 3. Reusable Application Software

Reusable application software allows a system to use the same components and code that has been used in other platforms. Because the code has already been tested, certified, and approved, software reuse would save both time and money compared to developing new software independently.

### 4. Interoperable Joint Warfighting Applications and Secure Information Exchange

The principle of interoperable joint warfighting applications and secure information exchange involves using common services, common warfighting applications, and information assurance, and it requires these commonalities for the basic design elements of any new system (DoD, NAVSEA, & PEO–IWS, 2004).

### 5. Life-Cycle Affordability

This principle includes all life-cycle costs of system design, development, delivery, and support. Since this thesis is primarily concerned with cost savings, and it has been determined that initial costs increase at implementation, life-cycle affordability represents a key benefit of this thesis.

Along with the five principles listed previously, several key attributes are required when building an open architecture framework. An OA framework should enable open systems to be designed and to continually evolve throughout their life cycle. In order to accomplish this, OA provides a group of core concepts that must be addressed. These concepts provide the foundation for an OA framework. Although not entirely encompassing, four core concepts are modularity, reuse, scalability, and portability. Modularity and reuse have already been discussed.

### 6. Scalability

Scalability within OA refers to the ability to add new functionalities or resources without a major change or modification to the system. The ability to add new components, update current ones, or adjust the scale of the system with little disruption to the system's operations is the basic premise of the scalability attribute.

### 7. Portability

Portability refers to being able to move hardware or software from one platform to another. Proper implementation of portability into an OA would allow for easy transition between many hardware and software platforms (Uchytil, 2006).

These core concepts are especially critical in today's world, where the rate of technological advancement is higher than it has ever been.

In order to accomplish these principles, the Navy established three primary goals, each of which has several subsets. The three primary goals are as follows ("Naval OA Strategy," 2008):

1. Change naval process and business practices to utilize open systems architectures in order to rapidly field affordable, interoperable systems.
2. Provide naval OA systems engineering leadership to field common, interoperable capabilities more rapidly at reduced costs.
3. Change Navy and Marine Corps cultures to institutionalize OA principles.

## D. SERVICE-ORIENTED ARCHITECTURE (SOA)

In this section, the researcher offers several definitions of SOA, outlines SOA concepts and principles, and describes some benefits, as well as challenges, of SOA.

### 1. Definitions

The term *service-oriented architecture* has no centrally defined meaning. Several organizations have provided definitions, but no concrete definition has been agreed upon. Even though the exact definition of SOA is elusive in the information technology industry, there are some basic and useful concepts that are generally accepted.

- Hewlett–Packard (HP) offers this definition of SOA:

> an architectural approach—built upon the concept of software services—for designing, building, and managing the distributed computing infrastructure that an enterprise requires to execute and achieve business strategy and goals. This approach promotes the use of loosely coupled, reusable, standards-based, and well-defined services in a way that enables them to be discovered on the network and used by other applications or end users. (2005)

- IBM defines SOA in this way:

> an IT architectural style that supports the transformation of your business into a set of linked services, or repeatable business tasks,

> that can be accessed when needed over a network. This may be a local network, it may be the Internet, or it may be geographically and technologically diverse, combining services in New York, London, and Hong Kong as though they were all installed on your local desktop. These services can coalesce to accomplish a specific business task, enabling your business to quickly adapt to changing conditions and requirements. (n.d.)

- The Business Transformation Agency (BTA) defines SOA as "a way of describing an environment in terms of shared mission and business functions and the services that enable them" (Business Transformation Agency [BTA], 2009).

- The Government Accountability Office (GAO) describes SOA as an "approach for sharing functions and applications across an organization by designing them as discrete, reusable, business-oriented services" (GAO, 2006).

- Essential Software Architecture defines SOA as "an approach to building software systems from independent applications that communicate only by accessing the business-level services that each application provides" (Gorton, 2006).

Although there are various definitions of SOA, they all refer to services in one way or another. A definition of a service is "an implementation of a well-defined piece of business functionality, with a published interface that is discoverable and can be used by service consumers when building different applications and business processes" (O'Brien, Bass, & Merson, 2005, p. 1).

### 2. Principles

A common set of principles most often associated with SOA includes the following:

#### a. Services Are Reusable

Services are designed to support potential reuse, regardless of whether immediate reuse opportunities exist. By applying standards that allow reuse, the chances of accommodating future requirements with less development effort are increased (Erl, 2005a).

#### b. Services Share a Formal Contract

Service contracts provide a formal definition of service endpoint, each service operation, and every input and output message supported by each operation. Furthermore, service contracts include rules and characteristics of the service and its operations. In order for services to interact, a formal contract is needed to define the terms of information exchange. Therefore, service contracts define almost all the primary parts of an SOA. This information establishes the agreement made by a service provider and service requestors (Erl, 2005a).

#### c. Services Are Loosely Coupled

Loose coupling maintains that for services to interact, they must be aware of one another's existence. Awareness is achieved through service descriptions, which establish a name of the service, a description of the data expected by the service, and a description of any data returned by the service (Erl, 2005b). Additionally, loose coupling maintains that each service should be self-contained, adding a level of abstraction and service autonomy. Finally, due to low inter-module dependency, an advantage to loosely coupled systems is that they tend to have a shorter development time.

#### d. Services Abstract Underlying Logic

The service's description is the only part of a service that is visible to the outside world. In SOA, aside from what is expressed in the description and formal contract, the underlying logic is invisible and irrelevant to the service requestors.

#### e. Services Are Composable

Groups of services can be assembled to form composite services. This possibility allows logic to be represented at different levels of granularity and promotes reusability and the creation of abstract layers (O'Brien et al., 2005).

#### f. Services Are Autonomous

Services have control over the logic they encapsulate. The logic governed by a service resides within an explicit boundary. Within this boundary, the service has complete autonomy, and it is not dependent on any other service. This freedom of dependency eliminates ties that could inhibit its deployment and evolution (Erl, 2005a).

#### g. Services Are Stateless

Services should not manage state information because that may impede their ability to remain loosely coupled. Services should be designed to maximize statelessness (Erl, 2005b). A stateless condition for services is one that promotes reusability and scalability attributes.

#### h. Services Are Discoverable

Services should allow their descriptions to be discovered and understood by humans and service requestors so that they may be able to make use of their logic. Because each operation provides a potentially reusable piece of processing logic, the service needs to discover both the service's purpose as well as the functionality offered by its operations (Erl, 2005a). Services should be designed to be outwardly descriptive, so they can be found and accessed by availability discovery mechanisms. This service discovery can be facilitated by the use of a directory provider.

#### i. Services Are Modular

Although often covered under the principle of loosely coupled, modularity deserves its own description. Modularity allows the logic required to solve large problems to be better constructed, carried out, and managed if it is decomposed into a collection of smaller, related pieces (Erl, 2005a). Each piece addresses a specific part of the problem, but when coupled, solves the larger problem. An often-used analogy that distinguishes the traditional architectural approach from the loosely coupled, modular design offered by SOA is to think of traditional architecture as a jigsaw puzzle, tightly coupled, and SOA as a tangram puzzle, which is loosely coupled. Figure 2 provides an example of tight coupling versus loose coupling.

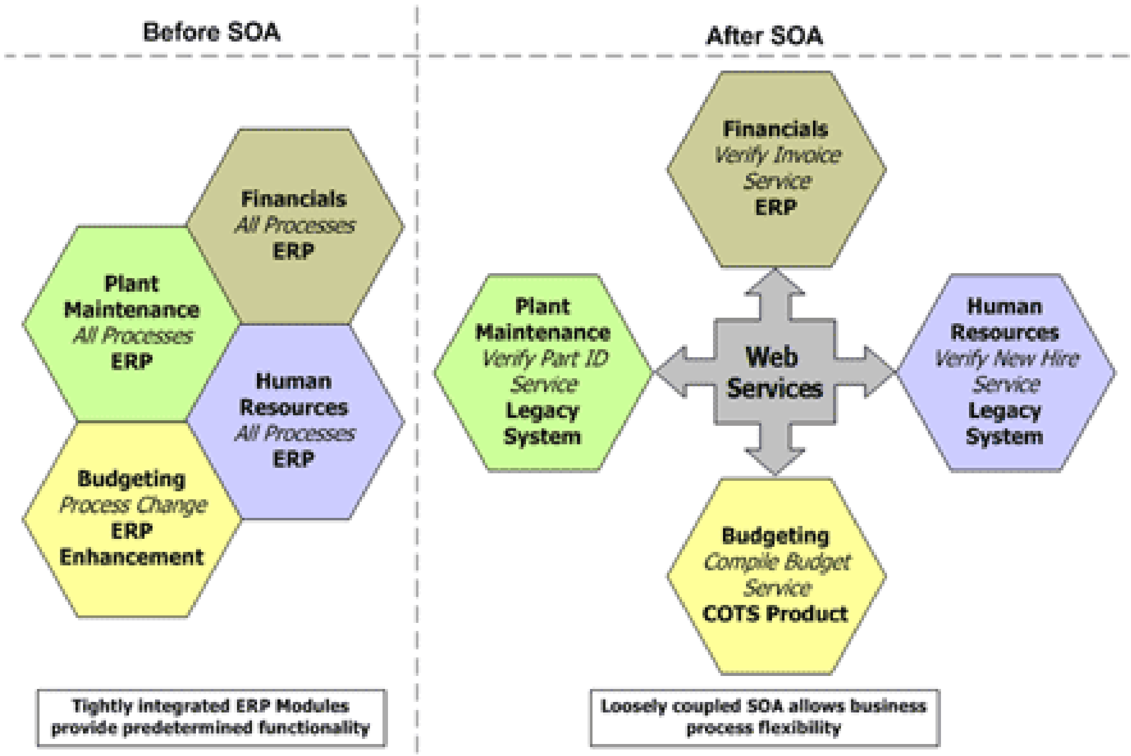


**Figure 2. Before and After SOA**
(Adler & Ahart, 2007)

Although all of the principles described in this section apply to SOA, autonomy, loose coupling, abstraction, and the need for a formal contract are often considered the core principles that establish the foundation of SOA (O'Brien et al., 2005).

### 3. Attributes

The principles described in the previous section lead to a set of quality attributes in the context of SOA.

#### a. Interoperability

Interoperability refers to the ability of a collection of communicating entities to share specific information and to operate on it according to an agreed-upon standard. In general, interoperability requires some form of interchange between two or more entities (Brownsword et al., 2004). This allows common services to interact between new and legacy systems, regardless of specific characteristics. In addition, products from various vendors are able to operate successfully with each other. SOA allows data sharing between systems that were unable to communicate previously. Increased interoperability is the most prominent benefit of SOA, especially when we consider web services technology (McGovern, Tyagi, Stevens, & Matthew, 2003). Finally, interoperability is directly related to the concept of reuse. As more services are reused, interoperability increases, providing a less burdensome IT structure.

#### b. Reliability

Simply stated, reliability is the ability of a system to keep operating over time (Clements, Kazman, & Klein, 2002). Many aspects related to reliability are important within SOA, particularly the reliability of the messages exchanged and the reliability of the services themselves. This can be of concern because different vendors may have different reliability requirements for their products, and, as the saying goes, a chain is only as strong as its weakest link.

#### c. Availability

Availability is the degree to which a system is accessible when it is required for use. SOA provides the advantage of constant availability because single components are responsible for compartmentalized data. However, because services are loosely coupled, if one service goes down, all other services that rely on that given service are affected. In this way, an entire system could be degraded. Therefore, when designing an SOA around critical systems, a backup should be considered (Brummett & Finney, 2008).

#### d. Usability

Usability is the measure of the quality of a user's experience in interacting with the service or information provided (O'Brien et al., 2005). A usable service is therefore one that provides a familiar feel and requires less training for a user to learn.

#### e. Security

Security within SOA is of vital concern to the DoD. Generally, security involves four main principles: confidentiality, authenticity, integrity, and availability. The system must provide a certain level of trust that the information being accessed is from an authorized user. In addition, stronger security mechanisms often have a negative impact on performance. For these reasons, security of SOA is considered a prime disadvantage and will be covered in the section titled Challenges at the end of this chapter.

#### f. Performance

Performance is related to response time (how long it takes to process a request), throughput (how many requests can be processed per unit time), and timeliness (the ability to process a request in an acceptable amount of time; O'Brien et al., 2005). With SOA, services may be spread over a vast area. This may affect performance of the system with respect to latency. Furthermore, latency is correlated with the number of times a service is invoked.

#### g. Scalability

Scalability is the ability of the system to be changed in size or volume to meet increased user demand without any degradation to other quality attributes.

#### h. Extensibility

Extensibility refers to the ease with which new services can be added. Extensibility becomes vital in today's rapidly changing technology environment. Furthermore, services should be able to be added without affecting the performance of other attributes or the user's interface, unless desired.

#### i. Adaptability

Adaptability is the degree to which existing services can be altered to better accommodate changing user requirements. As with extensibility, adaptability allows the system to stay current with rapidly changing technologies, changing environments, and changing missions.

#### j. Testability

Testability is the degree to which a service can be tested against a set of criteria, and the performance of that service against those set criteria. Testing can be complex for several reasons, including the fact that the service may act differently once coupled with other services. Trying to replicate all the issues a service may face in a test environment is extremely difficult. Within the DoD, testing of weapons platforms is done extensively in expensive testing facilities. As services move to connect formerly stove-piped platforms, testability becomes a critical attribute to ensure the systems remain functioning as they were meant to (O'Brien et al., 2005).

#### k. Modifiability

Modifiability is the ability to make changes to a system quickly and cost-effectively (Clements et al., 2002). Modifiability tends to be a by-product of other SOA attributes. Because services are loosely coupled, self-contained, and modular, they tend to be modified rather quickly, easily, and at a reduced cost.

### 4. Technology and Standards

SOA offers electronic services across the web, called web services. Web services do not expose their implementations to clients, only their capabilities. The client application invokes the functionality of a web service by sending it messages, receiving return messages, and using the results within the clients' applications. One key benefit of web services is that they are based on open standards. This allows web services to be implemented in any language and on any platform and still be compatible with client applications. With this in mind, it is necessary to define a few technical terms encountered in the core set of SOA standards.

### a. Extensible Markup Language (XML)

Extensible Markup Language (XML) is a language for marking up data so that information can be exchanged between applications and platforms. SOA is made possible by the widespread acceptance of open standards, and XML is the common language used by nearly all web services.

### b. Simple Object Access Protocol (SOAP)

For data to be transferred between computers, communication protocols must be established. Simple Object Access Protocol (SOAP) is a messaging protocol for transporting information and instructions within a distributed environment using XML as a foundation for the protocol. SOAP is the most commonly used transport protocol standard for moving messages between services.

### c. Web Service Description Language (WSDL)

Web Service Description Language (WSDL) is an XML-based language for describing web services and for publishing their interfaces to the network. WSDL enables a client application to determine the location of the web service, the functions it implements, and how to access and use each function. The WSDL serves as a contract between the web service and a consumer or potential consumer of that service. The WSDL file describes both the data to be passed and the method for passing the data.

### d. Web Service Stack

The web services stack shows the collection of computer networking protocols that define, locate, implement, and make web services interact with each other. The World Wide Web Consortium’s Web Services Architecture Working Group defined technical standards to ensure interoperability for SOAs.

## 5. Benefits

SOA has several key advantages as well as several challenges. The benefits are primarily the results of the principles that guide SOA. First, SOA promotes software reuse, which reduces design time and implementation time and results in an overall cost reduction. Since the applications are loosely coupled, testing of applications can be done independently on the application itself without affecting the entire system. In addition, service orientation attempts to solve problems of the past by using the following concepts (Erl, 2008):

- increased consistency in how functionality and data are represented,
- reduced dependencies between units of solution logic,
- reduced awareness of underlying solution logic design and implementation detail,
- increased opportunities to use a piece of solution logic for multiple purposes,
- increased opportunities to combine units of solution logic into different configurations,
- increased behavioral predictability,
- increased availability and scalability, and
- increased awareness of available solution logic.

### 6. Challenges

The following are some of the challenges that SOA systems face (Erl, 2008, p. 85):

- Increased performance requirements. Because multiple systems reuse a single service, system performance needs to increase to keep up with demand and prevent latency issues. Performance measures will need to be developed for each service based on intended usage.
- Reliability due to concurrent usage. A service may exhibit reduced reliability when more than one system is requiring that service's functions at the same time. Controls to mitigate the risk of reduced reliability must be introduced for critical systems.
- Single point failure. As an increasing number of systems rely on one service for a particular function or process, failure of the service will impact every system relying upon that service. Governance may aid in mitigating this risk. Backup systems are not ideal, but they should be considered for high-risk processes.
- Increased demand on hosting environments. As demand on hosting environments increases, runtimes may become excessive and lead to excessive latency issues.

Hosting environments will need to be scalable to mitigate increased demand. Concurrent requests from multiple applications must be addressed to reduce latency issues as a service processes these requests.

- Service contract versioning issues and redundant service contracts. Service contracts address how services will interface with various applications and describe their desired functionality. Versioning must be standardized to avoid confusion and redundant operations that may lead to increased runtime. Proper governance will reduce the likelihood of versioning issues and redundant service contracts.

- Security across the architecture. While the loose coupling of the network connections between the service requester and the service provider gives the global architecture resilience in recovery from intrusion, it also means that the system, much the same as the Internet, is virtually unbounded and the number of users accessing services is unknown. Unnecessary requests for service or unauthorized service requests could go undetected, using up valuable bandwidth and possibly compromising the confidentiality of information without the network owners discovering the loss until it is too late to recover (Teply, 2009, p. 38).

THIS PAGE INTENTIONALLY LEFT BLANK

# III. RELATIONSHIP BETWEEN OA AND SOA AND HOW SOA ACCOMPLISHES NOA STRATEGY

Many of the same principles of NOA defined in Chapter II are replicated in the principles of SOA used in industry. Table 2 compares some of the open systems characteristics from Table 1 with OA concepts used in the Navy and SOA concepts used in industry.

**Table 2. Comparison of Open Systems to OA and SOA**

| Open System Characteristics | Open Architecture Characteristics | Service-Oriented Architecture Characteristics |
|---|---|---|
| Heavy emphasis on modularity | Modular design and design disclosure | Services are modular |
| Lower total ownership cost and systems with longer life expectancy | Life-cycle affordability | Reliability and modifiability attributes decrease cost over the lifetime of the system |
| Easier, quicker, and less expensive expansion and upgrading | Easily upgradable systems | Adaptability, extensibility, and modifiability all contribute to ease of upgrading a system |
| High degree of portability, connectivity, interoperability, and scalability | Core concepts of scalability and portability, and stated goal of interoperability | Quality attributes of scalability and interoperability |
| Faster and less costly technology transfer | Goal to optimize system performance | Quality attribute of performance |
| | Reusable application software | Reusable services |
| | Interoperable joint warfighting applications and secure information exchange (common services and information assurance) | Quality attributes of usability (common services) and security |

*Note*: This table was adapted from a similar table in Azani (2001).

As many of the principles are similar, it is possible to treat them as like concepts for the purpose of this thesis. Therefore, successes and failures resulting from implementing SOA in industry should be similar to the expected outcomes of implementing OA in the Navy. Among the outcomes that can be compared is the potential for cost savings.

As shown in Table 2, SOA and OA are much alike. In fact, the principles laid out by the Defense Acquisition System, which guides the procurement of systems for the DoD, also resemble several of the same principles used in SOA. Furthermore, there is already a practice in place for implementing an open architecture in the DoD, whose goals also closely follow the goals of SOA. This is the Modular Open Systems Approach (MOSA). Both concepts are presented in the next sections.

## A. DEFENSE ACQUISITION SYSTEM

The Defense Acquisition System is a complex, multi-faceted system used by the DoD for the acquisition of its national security systems. As laid out in DoDD 5000.01 (USD[AT&L], 2003), five fundamental principles govern the Defense Acquisition System. The five principles are flexibility, responsiveness, innovation, discipline, and streamlined and effective management. Each policy directive can be supported by SOA and OA.

### 1. Flexibility

Flexibility is achieved by both SOA and OA through increased agility and the potential for reuse. The more open the system becomes, the more quickly the system can adapt to changing needs or requirements, thereby increasing overall flexibility.

### 2. Responsiveness

SOA and OA provide the necessary responsiveness by deploying systems to the warfighter in the shortest time practicable. Although a mature SOA or OA system is required for maximum responsiveness, the principle of responsiveness will be achieved through attributes such as modifiability and adaptability.

### 3. Innovation

Program managers should adopt innovative practices to include best commercial practices that reduce cycle time and cost. This can be accomplished by OA, since SOA practices are proven in commercial industry. OA is intended to reduce costs and development times. It will also reduce future costs through reuse and interoperability. Furthermore, cycle time will be reduced due to the reduction in redundant DoD systems.

#### 4. Discipline

The same level of discipline that applies to all acquisitions programs is required with OA. However, since these technologies are relatively new to the DoD, standard baseline parameters and exit criteria will need to be developed with data from programs using this technology.

#### 5. Streamlined and Effective Management

Streamlined and effective management refers to the management of an acquisitions program, ensuring credibility in cost, schedule, and performance reporting. SOA and OA can contribute to this because proven technologies have reduced risk, thereby enhancing the management of the overall program.

### B. MODULAR OPEN SYSTEMS APPROACH (MOSA)

MOSA is a way of implementing open architecture in the DoD. It is a strategy for developing a new system or modernizing an existing one. It uses widely supported commercial interface standards when developing systems. According to the Open Systems Joint Task Force (OSJTF, 2004), MOSA attempts to achieve the following:

- reduced acquisition cycle time and overall life-cycle cost,
- the ability to insert cutting-edge technology as it evolves,
- commonality and reuse of components among systems, and
- an increased ability to leverage commercial investment.

In order to achieve these benefits, MOSA adheres to five major principles: establishment of a MOSA-enabling environment, employment of modular design, designation of key interfaces, use of open standards for key interfaces, and certification of conformance (OSJTF, 2004). Figure 3 identifies the principles alongside the associated benefits provided.

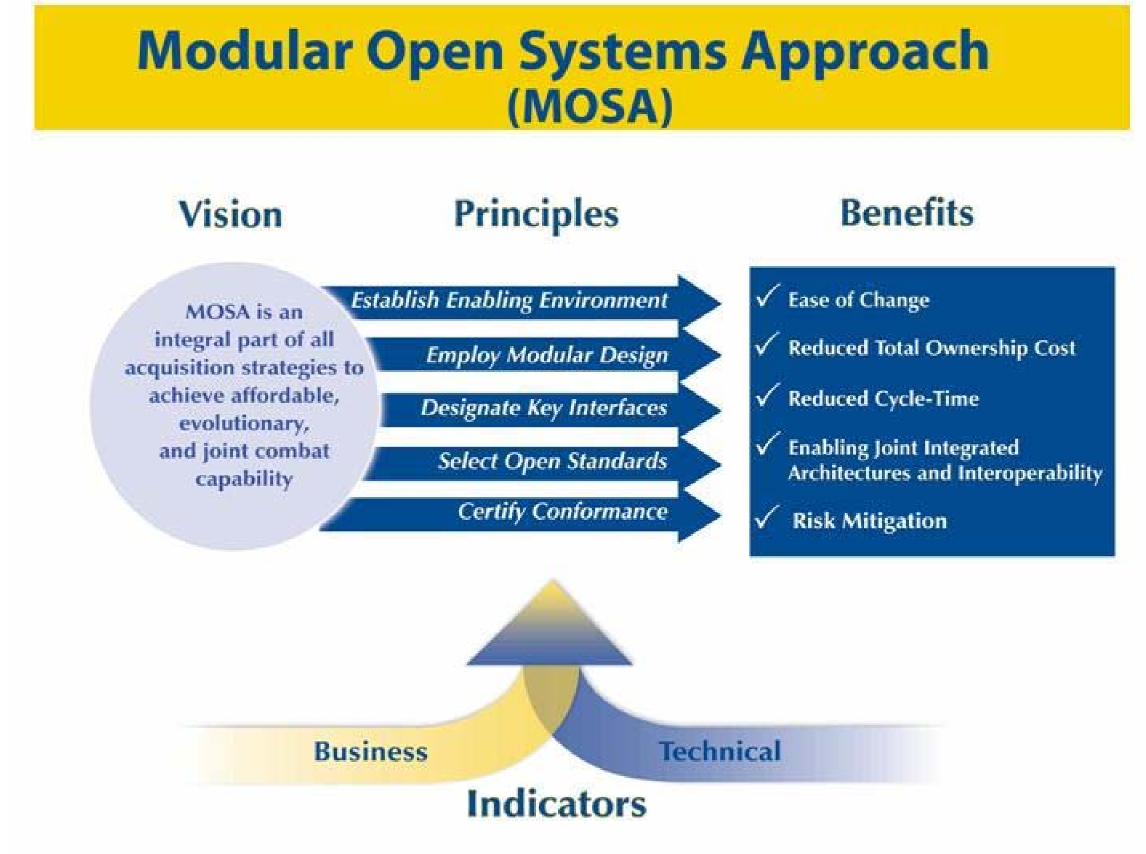


**Figure 3. MOSA Principles**
(OSJTF, 2004)

The goals of MOSA, along with the principles that guide MOSA, closely relate to those strategies that guide SOA. In addition, some of the underlying technical concepts relate MOSA principles to OACE and SOA, as seen in Table 3.

**Table 3. Comparison of MOSA Principles to OACE and SOA**

| MOSA Principles | OACE | SOA |
|---|---|---|
| 1. Establish an enabling environment—establish supportive requirements; business practices; technology development; acquisition, test and evaluation; and product support strategies. | Guidance concerning standards have already been published. | Already adheres to an enabling environment because many major companies are supporting SOA. |
| 2. Employ modular design—partitioned into scalable, reusable modules. Designed for ease of change. | Functional partitioning should support insertion of new functionality. | SOA services are modular. |
| 3. Designate key interfaces—identify interfaces that are highly reliable, technologically stable, and pass vital interoperability information. | Use structured programming within components and middleware technologies for interconnections and integration among components. | Use of wrappers to connect key interfaces that must interoperate. |
| 4. Use open standards—standards must permit interchangeability, interconnections, and compatibility. Standards must be well defined, mature, widely used, readily available, and allow for future technology insertion. | OACE encourages standards-based technologies. Recognizes XML and SOAP as standards. Programming language should support open standards. | Uses open standards such as XML, SOAP, and WSDL to ensure interoperability among services. |
| 5. Certify Conformance—modules must conform to open interfaces to allow plug-and-play and reconfiguration of mission capability in response to new threats and technologies. | Existing systems may see little if any change at the periphery, but changes are made at the interface. | Web services are based on open standards and only expose their capabilities to clients, not their implementations. |

*Note*. This table was constructed using information from the following sources: OSJTF (2004), and DoD, NAVSEA, and PEO–IWS (2004).

In this way, MOSA is a tool that guides the DoD in the use of OA in much the same manner as the principles that guide the use of SOA in industry, further amplifying the fact that they are similar and can be treated as such for the purpose of this thesis.

# IV. ROI CALCULATION FOR SOA

Since the IT boom of the 1990s, billions of dollars have been invested into IT with the goal of realizing significant returns. However, returns have not materialized as expected, leading to Nobel Prize–winning economist Robert Solow's "productivity paradox," which explains that even though IT is embedded in more business processes, returns are not showing up in productivity statistics (Atkinson & Court, 2010). Of the possible reasons leading to the productivity paradox, one is the fact that people cannot properly measure the returns produced by technology. One method frequently applied to IT systems is the ROI measurement. ROI is calculated as the revenue or benefits of an investment minus the investment cost, divided by the cost of the investment. This figure is expressed as a percentage and is interpreted as a productivity measure (Nelson, 2010). ROI is an important measure to businesses, as evidenced by the fact that 80% of companies surveyed by *ComputerWorld* and Ernst and Young said the financial justification of IT projects is important (Tian, Cao, Ding, Zhang, & Lee, 2007). However, of the companies surveyed, only 40% perform a financial business case analysis on a regular basis. Additionally, 65% of companies indicated they do not have the knowledge or tools needed to calculate ROI, and 75% said they have no formal process for measuring ROI for IT projects. Finally, 68% said they do not perform a follow-up ROI calculation six months after implementing the project (Tian, Cao, Ding, Zhang, & Lee, 2007).

The ROI for SOA is considered by many to be difficult, if not impossible, to calculate. This is because attributes such as efficiency are difficult to quantify. However, calculating the ROI is important because most businesses look for a tangible ROI when they evaluate or approve new or continuing investments. A British study (DiMare, 2009) found that 89% of companies use "intuition" or "guesswork" (p. 5) to calculate the ROI of their IT investments. According to ZapThink Research (Schmelzer, 2005), "only by understanding the full range of SOA value propositions can companies begin to get a handle on calculating the ROI of SOA" (para. 2). Furthermore, Gartner analyst Randy Heffner (as cited in McKendrick, 2007) has said, "any attempt to assign a specific ROI to SOA should be viewed with heavy skepticism" (para. 3). McKendrick (2007) further argued that SOA is a set of best practices that are relatively intangible. Some argue that not only should monetary values define ROI but also that return on closing capability gaps targeted by SOA implementation and nonmonetary valuations such as customer satisfaction and avoidance of loss of life should define ROI (Buck, Das, & Hanf, 2008). Figure 4 displays some nonmonetary considerations for analyzing ROI.

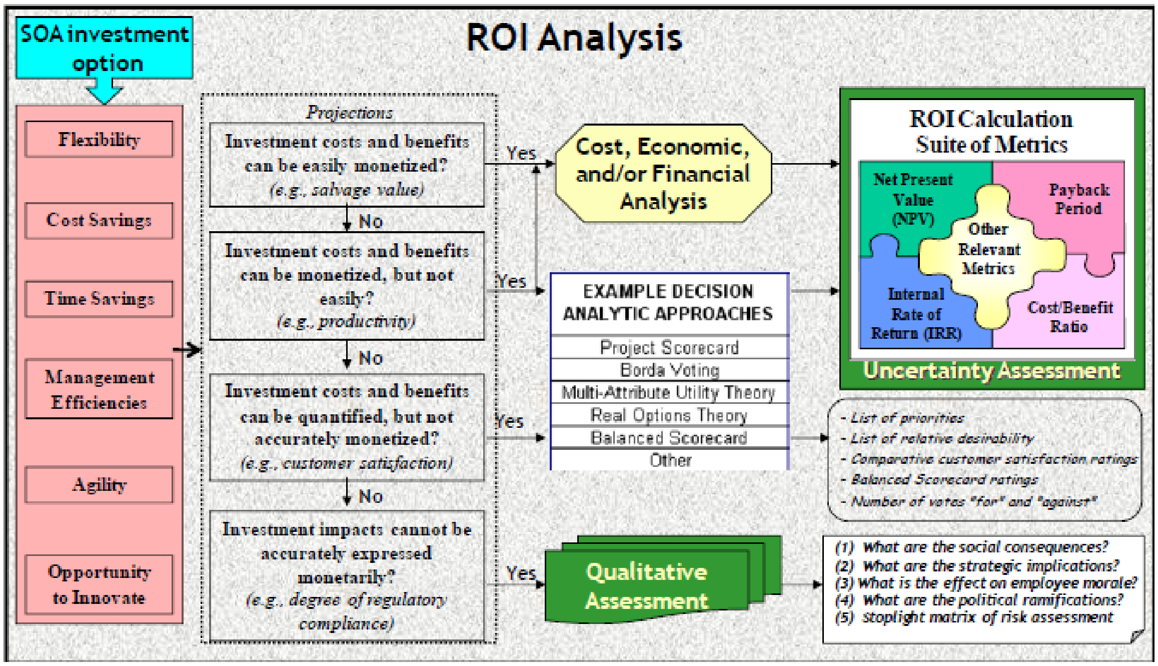


**Figure 4. ROI Analysis Considerations for SOA**
(Buck et al., 2008)

There is an old adage that you cannot manage what you cannot measure. Since SOA is made up of a variety of service components that only show their true value when working together, measuring the ROI for SOA can become quite convoluted. ROI is easier to calculate when using single-purpose applications. Each application can be measured and translated to an understandable ROI. According to Erl (2008), "this type of reasoning is what has led to the popularity of siloed application environments" (p. 257).

Service reuse adds to the complexity associated with calculating the ROI of SOA because the benefits may not be realized initially. As a service is reused, the ROI will continue to increase, as illustrated in Figure 5.

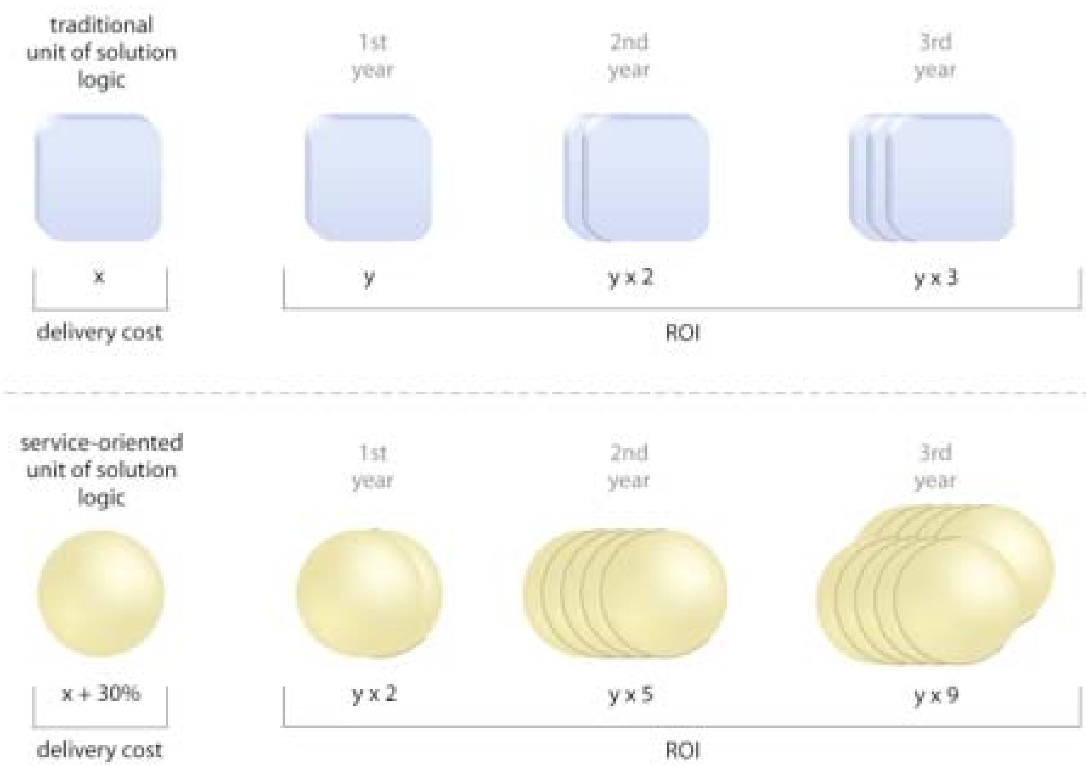


**Figure 5. Example of ROI for SOA Projects**
(Erl, 2008, p. 62)

Although there is a difference of opinion among experts as to how the ROI can be calculated within an SOA implementation, one recommendation is to divide SOA ROI calculations into three quantifiable benefits: "[1] Tactical ROI as a result of standards-based service oriented integration, [2] Operational ROI based on service and process reuse, and [3] Strategic ROI due to business and technology agility" (Gabhart, 2007, p. 2).

Tactical ROI focuses on reducing redundancy and on other initial cost reductions to provide justification for initiating an SOA. The following four steps describe the method for calculating tactical ROI (Gabhart, 2007, p. 2):

1. Compute the savings realized due to reduced middleware licensing costs.
2. Compute the savings afforded due to reduced development time.
3. Project savings due to reduced maintenance costs.

4. Add the results of Steps 1–3 together and fold that into whatever ROI formula your organization uses (i.e., net gain divided by investment).

Operational ROI provides feedback by analyzing the reuse of services, which extends implementation beyond the initial time frame. Two methods for calculating operational ROI for SOA are the iterative reuse model and the calculated reuse model. When using the iterative reuse model, the "investment return is measured based on the number of times a service or process is reused rather than an arbitrary time frame" (Gabhart, 2007, p. 3). Writing a program for reuse is not free. The relative cost of writing a program for reuse is approximately 1.5 times, or 50%, more than writing software for one-time use (Poulin, 1997). Although reusable components initially cost more than nonreusable components, they provide a cost savings each time the service is reused. The calculated reuse model requires that an organization compare current development costs with the costs required to develop reusable components. According to Gabhart (2007), the calculated reuse model is a "mathematical model [that] computes SOA value based upon a few key variables such as number of services available for reuse, degree of reuse, and service complexity" (p. 3).

Strategic ROI should be calculated to provide a complete analysis of the long-term benefits gained by implementing an SOA. Strategic ROI is described by Gabhart (2007) in the following way:

> Strategic ROI is manifested though cost controls, risk mitigation, and new revenue generation as a result of agility. … Strategic ROI is the ultimate expression of what SOA is all about. It's about making a strategic investment in an agile enterprise infrastructure and at the same time aligning the business and technology sides of the organization to work toward common, shared objectives. (p. 4)

Calculating strategic ROI is considered more an art than a science. The following are some examples from Gabhart (2007) on what should be accounted for when calculating strategic ROI:

- System development and maintenance costs saved due to the ability to modify information systems with little to no coding required (simply modify or rearrange the orchestration of several services).

- Estimated legal costs and fines avoided due to faster and more reliable responsiveness to regulatory changes.

- Revenue generated via the rapid creation of new services as well as the manipulation and reconfiguration of existing ones.

- Revenue generated due to the ability to expose internal capabilities as consumable services by business partners and clients (this potentially generates completely new streams of income. (p. 4)

In addition to Gabhart's method, other methods have been introduced, such as resource-consumption-based pricing, in which the consumption of services is metered (Denne, 2007). Although experts cannot decide on one method of calculating ROI for SOA, the previously mentioned methods are the current theories on how to proceed with calculating ROI for SOA.

Commercial industry methods for calculating ROI do not readily translate to the DoD because of the absence of profit in government. Since the motive is not profit, monetary values such as cost savings, cost reduction, and cost avoidance are typically measured (Phillips, 2002). However, some experts argue that nonquantifiable attributes must be analyzed as well. These attributes provide the overall value associated with implementing SOA and must be taken into account.

Nelson (2010) identified a few key concepts, which have been agreed on by professionals, that contribute to the difficulty of measuring the ROI in IT:

- the difficulty of defining the actual impact (benefits) of IT in terms of value because technology enhances an existing process or is embedded within many processes that are stand–alone, and

- the difficulty of assigning monetary value to intangible and tangible benefits (i.e., customer satisfaction, customer retention, or time savings). (p. 17)

There are several approaches for addressing these difficulties, with one such approach being the cost-based method. The cost-based approach was adopted to try to overcome the lack of a defined revenue and the difficulties of assigning monetary value to the impact that is provided by an IT investment. This method is used when a profit margin cannot be calculated because of the lack of a revenue stream. Instead, estimates of cost savings are used as a surrogate for revenue to calculate benefits. Cost savings can be defined as the resulting reduction in expenditures from the implementation of IT (Nelson, 2010). Methods for calculating cost savings include the following:

- Presuming that the cost to replace or outsource IT is, without proof, proportionate to the value it adds to process performance (Pavlou, Housel, Rodgers, & Jansen, 2005, p. 207).
- Utilizing the cost reductions that can be achieved through staff reductions, consolidation of facilities, elimination of software licenses, or other results that decrease current expenditures as cost savings (Brandon, 2010).
- Converting output data to monetary value by determining the amount of impact the technology had for each unit of cost reduction (Phillips & Phillips, 2002, p. 524).
- Calculating the cost of quality and directly converting quality improvements to cost savings (Phillips & Phillips, 2002, p. 524).
- Converting an employee's wages and benefits to cost savings by using them for the value of time when the employee's time is saved (Phillips & Phillips, 2002, p. 524).

All these cost savings or cost avoidances serve as a replacement for revenue in the ROI equation and are used to represent the net benefits or numerator of the ROI equation. The denominator of the ROI equation, the investment cost, is calculated by summing all the related costs of the IT. Sometimes, cost savings is the only measure used to calculate ROI. This assumes the net benefits did not change as a result of the cost reduction. When the net benefits, or numerator, are held constant while reducing costs, or the denominator, the result equates to a positive ROI. Essentially, every time cost is reduced, ROI is increased. Using this logic, the goal would be to decrease costs to zero, thereby resulting in an infinite ROI because a zero would be in the denominator. This is obviously unrealistic because a company cannot exist without producing some type of cost. Therefore, a major limitation of cost-based ROI approaches is that they rely on cost to determine value. This creates a major problem when estimating ROI because cost and revenue need to be derived independently in order to derive a true numerator. Cost-based approaches lack a surrogate for revenue (Pavlou et al., 2005).

One way to curtail the problems associated with the cost-based approaches is to use the knowledge value added (KVA) methodology. KVA provides surrogate revenue streams at the subprocess level that are uniquely derived from common units of output. This is accomplished by providing an objective method to estimate value in terms of common units of output, allowing allocation of surrogate revenue streams in the nonprofit sector by assuming a direct relationship between knowledge and the value stemming from it and describing all process outputs in common units (Housel, Kanevsky, Rodgers, & Little, 2009).

According to Housel and Mun (2010),

> KVA measures the value provided by human capital assets by analyzing an organization, process or function at the process level. It provides insights into each dollar of IT investment by monetizing the outputs of all assets, including intangible assets [e.g., assets produced by IT and humans]. By capturing the value of knowledge embedded in an organization's core processes [i.e., employees and IT], KVA identifies the actual cost and revenue of a process, product, or service. Because KVA identifies every process required to produce an aggregated output in terms of the historical process and cost-per-common-unit of output of those processes, unit costs and unit process can be easily calculated. Once cost and revenue streams have been assigned to sub-organizational outputs, normal accounting and financial performance and profitability metrics can be applied. (p. 7)

Although other methods of measuring value such as KVA exist, currently many companies use cost-based ROI analysis to choose a particular investment option, considering resource constraints, and to measure the ongoing performance of the investment. However, using only cost savings typically does not tell the whole story, and decision-makers must beware that analysis results can be readily manipulated (Buck et al., 2008).

THIS PAGE INTENTIONALLY LEFT BLANK

# V. DATA AND ANALYSIS

## A. METHODOLOGY

The researcher gathered data from a wide range of published reports and surveys. All reports were retrieved free of charge from various sites on the Internet, primarily from company white papers or case study reports that were accessible after subscribing to e-mail lists. The reports consisted primarily of industry-sponsored case studies, and they analyzed a particular business that was implementing a specific SOA solution to meet its unique objectives. The reports then assessed the success or failure resulting from implementing an SOA based on ROI. An example of such a case study is a report sponsored by Hewlett–Packard (HP) on the ROI realized by a company after incorporating one of HP's SOA services.

In all, 34 case studies from a variety of business domains were reviewed in detail. The method used to report ROI was not uniform in all of the reports. Some reports broke the cost savings into costs avoided or into productivity improvements, of which only a percentage was provided or could be calculated, and others simply stated a dollar amount of cost savings without including supporting figures. When feasible, the researcher broke costs out into the three quantifiable areas recognized in DoD financial management: (1) cost savings or actual reduction of cost in a current area; (2) cost avoidance, a reduction or elimination in a future requirement; and (3) productivity improvement, a reduction in future personnel time and effort (American Society of Military Comptrollers [ASMC], 2009). From the 34 case studies analyzed, 18 provided an overall ROI. From those, 10 were broken down into the various cost components. All reports were used to draw conclusions about benefits considered important to industry and to its best practices. The overall ROI from industry's implementation of SOA was found to be 305%, as shown in Table 4, while the ROI from cost savings and cost avoidance was calculated to be 72%, as shown in Table 5.

## B. ANALYSIS

Table 4 displays information taken directly from the case studies for the 18 selected companies with a reported overall ROI. Any column left blank indicates that the information was not presented in the report. Many companies declined to include their actual company name in the report and are instead referred to by their type of business. Because the case studies were conducted by different companies, their methods for calculating ROI varied as well. As shown in Table 4, ROI was calculated over a three- to six-year period. All companies calculated a net present value (NPV) with a discount rate of 12%. Furthermore, a payback period was calculated for most case studies. The authors of the reports said ROI was calculated under a process of measuring the benefits, calculating the total investment, and then projecting the investment and benefit over the time period designated. The reports did not provide details on exactly how benefits were measured.

### Table 4. Baseline Data—ROI Reported by 18 Selected Companies According to Case Study Reports

| Company | ROI | Benefit (discounted) | Investment (discounted) | NPV | Discount % | Discount Period (Years) | Payback (months) |
|---|---|---|---|---|---|---|---|
| Blue Cross Blue Shield of KC | 332% | 14,330,000 | 3,320,000 | 11,010,000 | 12% | 6 | 20 |
| Mobile Telecom | 625% | 10,120,000 | 1,400,000 | 8,720,000 | 12% | 3 | 5.6 |
| Real Time Services | 215% | 180,000 | 57,000 | 120,779 | | 5 | 0 |
| Global Provider for Info Mgmt Sys | 470% | 8,080,525 | 1,417,846 | 6,662,679 | 12% | 3 | 2.5 |
| Services and Fac Mgmt Co | 360% | 2,744,982 | 596,674 | 2,148,309 | 12% | 3 | 4.6 |
| European based telecom | 212% | 5,472,842 | 1,753,242 | 3,719,600 | 12% | 3 | 9 |
| International Finance Firm | 252% | $6,627,447 | $1,882,568 | $4,744,879 | 12% | 3 | 6.7 |
| Healthcare Provider | 356% | $13,475,631 | $2,952,633 | $10,522,889 | 12% | 6 | 6.7 |
| Global Media Consulting Firm | 244% | $1,541,718 | $447,938 | $1,093,780 | 12% | 3 | 8.2 |
| Healthcare Services Provider | 346% | $15,800,000 | $3,500,000 | $12,300,000 | 12% | 3 | 4.8 |
| Global Financial Services Firm | 472% | $37,140,000 | $6,490,000 | $30,650,000 | 12% | 3 | 3.9 |
| Carphone | 42% | $1,254,000 | $812,000 | | | 3 | 30.6 |
| Johnson Controls | 81% | $370,000 | | $143,547 | | 3 | 12 |
| Bank of India | 234% | | $23,000,000 | | | 5 | 24 |
| MoreDirect | 428% | $445,395 | $47,270 | $332,251 | | 5 | 5 |
| International Insurance Provider | 256% | $1,428,180 | $401,607 | $1,026,573 | 12% | 3 | 8 |
| Global Consumer Products Co | 265% | $1,118,547 | $306,370 | $812,176 | | 3 | 5.8 |
| Quicken Loans | 298% | | $183,000 | | | | |
| Average | **305%** | | | | | | 9.4 |

*Note*. This table was constructed using information from the following case studies: Case Study Forum (2009a, b), IDC Business Value Spotlight (2009a, b, c, d, e, 2010a, b, c), IDC ExpertROI® Spotlight (2010a, b, c, d), Shopping for SOA (n.d.), Nucleus Research (2007, 2008), and Thoughtfare Worldwide (2010).

Table 5 displays the calculated ROI for the 10 companies that broke out the benefits into categories. The researcher further broke down this data into either annual cost savings achieved by SOA implementation, annual cost avoidance, or annual productivity improvement. For the purposes of this thesis, cost savings was defined simply as the difference between the costs historically paid and the costs after implementing an SOA component. These costs were tangible benefits that could be recorded and programmed into a budget. Cost avoidance, on the other hand, were those costs that were planned, but because of the SOA implementation, did not need to be executed. A few examples of cost avoidance were not hiring additional workers, not outsourcing, or not making a planned purchase. In addition, if the case study stated the company saved some number of full-time equivalent (FTEs) workers, this was considered a cost avoidance because they no longer needed to hire those workers. Although still considered a cost benefit, cost avoidance savings were not considered true cost savings because it was unclear whether these future costs would ever have been realized.

All remaining quantifiable benefits fell into the productivity improvement category. Productivity improvement was considered the ability to accomplish more tasks in the same amount of time by the some number of workers. Two primary examples were staff efficiency and improved system availability. Staff efficiency was calculated as work hours saved. If the position was eliminated due to the efficiency, it was considered a cost savings; however, the majority of the time the worker was simply available to work on other projects and, therefore, was considered a productivity improvement. System availability or reduced downtime was also calculated on an hourly basis. The reduced downtime allowed workers to continue their jobs rather than stand idle while the system was unavailable.

To calculate the ROI from cost savings/cost avoidance, the average annual cost savings and average annual cost avoidance columns were summed. They were considered the benefit. Then, the ROI was calculated using Equation 1.

$$\text{ROI} = (\text{Benefit} - \text{Cost of Investment})/\text{Cost of Investment} \qquad (1)$$

The benefit and investment figures in the baseline Table 5 are discounted over a period of three to six years. However, since the cases used in this research are free, open-source cases, they did not contain detailed information on how the total discounted numbers were calculated. For example, the case studies provided an investment discounted over a number of years, but they did not identify when in time the investment was made. The investment may be assumed it occurred at time zero, but without detailed information, the researcher chose not to adjust it. Along the same lines, the cost savings, cost avoidance, and productivity improvements were provided as an average annual savings. Most SOA investments produce greater benefits the longer the systems are used, so it could be assumed that over a hypothetical period of 10 years, the ROI would be even greater. However, since the case studies did not report if the benefits were immediate, gradually grew, or gradually decreased over the time period, a determination could not be made. Additionally, the discount rate used in these cases was 12%, which is a common figure for commercial industries. The DoD, on the other hand, is not a revenue-generating company and, therefore, does not have competing investments that would warrant such a high discount rate. The DoD can use the risk-free U.S. Department of the Treasury rates as a more accurate measure of discount rates. The daily treasury yield rates for 2011 for three-year investments has fluctuated between 0.5% and 1.5% with the average rate for the first six months of 2011 being 1.05% (U.S. Department of Treasury, n.d.). A direct comparison to the investments presented in Figure 4 would be unfair because the exact calculations conducted in the case studies were not stated. However, in general, using a lower, more accurate discount rate for DoD investments would create a much higher ROI when compared to those realized in industry.

Table 5 also displays a calculated payback period. A payback period is a good measure for determining how long it will take to recoup an initial investment. To calculate the payback period, the annual cost savings/annual cost avoidance columns were summed to determine the net cash flow. The net cash flow calculated represents a periodic undiscounted cash flow. The payback period was calculated using Equation 2.

$$\text{Payback period} = (\text{investment}/\text{net cash flows}) * 12 \text{ months} \tag{2}$$

## Table 5. Calculated ROI From Cost Savings and Cost Avoidance

| Company | Reported ROI | Calcuated ROI from Cost Savings / Cost Avoidance | Average Annual Cost Savings | Average Annual Cost Avoidance | Average Annual Productivity Improvement | Benefit (discounted) | Investment (discounted) | NPV | Discount % | Discount Period (Years) | Payback (months) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blue Cross Blue Shield | 332% | 330% | $2,380,000 | $0 | $90,000 | $14,330,000 | $3,320,000 | $11,010,000 | 12% | 6 | 16.7 |
| Mobile Telecom | 625% | 136% | $1,100,000 | $0 | $3,570,000 | $10,120,000 | $1,400,000 | $8,720,000 | 12% | 3 | 15.3 |
| Global Provider for | 470% | -18% | $0 | $387,853 | $2,827,485 | $8,080,525 | $1,417,846 | $6,662,679 | 12% | 3 | 43.9 |
| Services and Fac Mgmt Co | 360% | -100% | $0 | $0 | $1,140,000 | $2,744,982 | $596,674 | $2,148,309 | 12% | 3 | |
| European based | 212% | -18% | $478,463 | $0 | $1,801,860 | $5,472,842 | $1,753,242 | $3,719,600 | 12% | 3 | 44.0 |
| International Finance Firm | 252% | -31% | $101,015 | $329,054 | $2,669,439 | $6,627,447 | $1,882,568 | $4,744,879 | 12% | 3 | 52.5 |
| Global Media Consulting | 244% | 107% | $111,609 | $198,140 | $332,626 | $1,541,718 | $447,938 | $1,093,780 | 12% | 3 | 17.4 |
| International Insurance | 256% | 7% | $143,839 | $0 | $427,328 | $1,428,180 | $401,607 | $1,026,573 | 12% | 3 | 33.5 |
| Healthcare Services | 346% | 146% | $0 | $2,870,000 | $3,720,000 | $15,800,000 | $3,500,000 | $12,300,000 | 12% | 3 | 14.6 |
| Global Consumer | 265% | 165% | $270,689 | $0 | $195,366 | $1,118,547 | $306,370 | $812,176 | 12% | 3 | 13.6 |
| Average | **336%** | **72%** | | | | | | | | | 27.9 |

### 1. Quantifiable Benefits

Table 6 identifies the commonalities of the associated costs that were identified as cost benefits from industry. These categories, or variations thereof, constituted the makeup of the cost savings, cost avoidance, and productivity improvement figures in Table 5.

**Table 6. Quantitative Benefit Categories**

| Benefit Categories | Examples of Quantitative Measurements | Benefit Metrics Examples |
|---|---|---|
| Cost Reduction | Reduced software upgrade costs, elimination of hardware and associated operations costs, and reduced personnel required. | Cost benefits are directly related to decreased software/hardware costs, licensing costs, or reduction in full-time equivalents. |
| Avoidance from Future Costs | Decreased staff, decreased power consumption, and elimination of outsourcing. | All costs can be calculated based on current rates, adjusted for inflation. |
| Avoidance of New Investment Costs | Purchase of new infrastructure or software. | Cost of replacing a modular service compared with replacing an entire system. |
| Increase IT Staff Efficiency | Reduced repair time for network services and security monitoring. | Calculate the difference between current maintenance costs and maintenance costs in an SOA project. |
| Improved Administrative Efficiency/Enhanced User Productivity | Improved quality of the help desk and customer satisfaction. | The help desk knows of the problem before users call to report, allowing them to answer the call quickly. |
| Increased Application Availability/Reduced Downtime | Downtime results in missed sales, trading opportunities lost, and a decrease in customer satisfaction and brand equity. | Downtime can be related to productivity of a user by an hourly rate of pay. Sales can be calculated per hour to determine revenue lost. |
| Software Reuse | Less development time, less testing time, and overall lower project costs. | Actual cost comparison of reused software to newly developed software. Training costs and productivity loss of users learning a new system. |
| Simplified User Interface | Decreased user learning time. | Reduced training costs and increased productivity. |

### 2. Nonquantifiable Benefits

In addition to monetary cost savings, the case studies listed several benefits that were not monetized or that the researcher removed because they did not correspond well to any of the three financial management characteristics of cost savings, cost avoidance, or productivity improvement. Table 7 lists these categories as well as briefly describes how they may impact the DoD.

**Table 7. Qualitative Benefit Categories**

| Benefit Categories | Examples of Qualitative Measurements | Relationship to the DoD |
|---|---|---|
| Business Staff Efficiency | Information delivered to managers more quickly and accurately improves decision-making. | Delivering timely and accurate information is vital to military leaders. |
| Business Credibility | Equates to more business because other companies view their system as available and reliable. | Availability and reliability of systems in the DoD is a productivity improvement. |
| Reduced Duplication of Effort | Information is entered once and available to all users. (This could be a productivity improvement as well but was listed separately as a qualitative benefit.) | Ensures accuracy and consistency of data. It also saves time inputting data or fixing mismatched data. |
| Faster Time to Market | Difference in the amount of time a product is available compared to the current time to market. | Faster delivery of vital intelligence or logistics when and where required. |
| Scalability | The ability to increase size or volume without degradation. | The ability of the service to be scaled in accordance with the changing mission. |
| Flexibility | Flexibility is achieved through increased agility and the potential for reuse. | Flexibility allows the system the ability to quickly adapt to changing needs or requirements. |

A case study for one company that was not included in the ROI calculations because an ROI was not provided, nor could it be calculated, was the one for the United States Military Entrance Processing Command (USMEPCOM). This case study is worth mentioning, however, because it deals directly with the DoD and because the USMEPCOM was so successful in its implementation of an SOA system that it was able to decrease the costs of a new project by $56 million, which won it the award for Best Return on Investment in the BPM Case Study Competition conducted by Object Management Group and BPTrends. One particular aspect of USMEPCOM's success was reusability. USMEPCOM was able to put reusability to work and complete a security project originally estimated at six months in only two weeks (Network Centric Operations Industry Consortium [NCOIC], 2010).

## C. PUBLISHED SURVEYS

In addition to specific case studies, the researcher analyzed published surveys in order to identify whether the data from the case studies were representative, to understand the perspective industry has on SOA, and to discover some best practices in industry. Finally, these perceptions and best practices were compared to the case studies to determine what, if any, of the concepts materialized.

The first aspect analyzed was to determine what industry perceived as value for its IT investments. In January 2008, Aberdeen Group published a report after surveying 4,600 business and IT decision-makers. The question the survey asked was what role participants thought IT would play in their businesses in the current year. The results of the survey are shown in Figure 6.

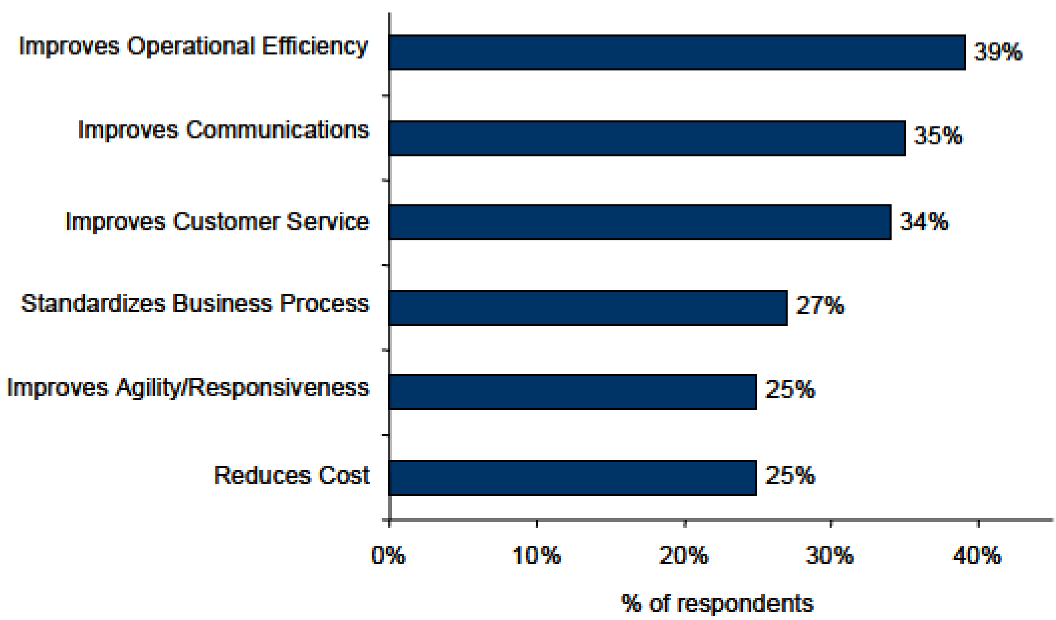


**Figure 6. Primary Roles of Business Technologies in 2008**
(Dortch, 2008)

Of the six most often cited categories in this survey, five of them were experienced by companies in the researcher's selected case studies. Only one category, improves communication, was not cited as a benefit.

Another survey of North American and European companies cited the categories improved customer service and faster time to market as the largest benefit participants expected from their IT investments. These benefits were also identified as benefits in the case studies. However, when these same companies were asked what the primary driver of the SOA vision within their organization was, IT cost savings was the most frequent answer, with 30% of respondents citing that reason, followed by customer service improvement and faster time to market at 23% and 21%, respectively (Ritter & Evans, n.d.). Aberdeen Group (2008) conducted a study of the SOA efforts of 400 companies, and among the companies identified as best-in-class, 62% reported improved business agility as their primary driver for SOA deployment. Reducing operating costs tied for third at 39% (Dortch, 2008). Forrester Research (Heffner & Fulton, 2008) claimed 81% to 84% of SOA users identified the drivers for SOA as improving business and application flexibility, while 70% to 75% of SOA users responded that lowering business and application costs were the drivers for SOA.

IBM conducted in-depth interviews with actual members of the project teams from 35 SOA implementations worldwide, spanning 11 industries. The benefits reported in these interviews are shown in Figure 7.

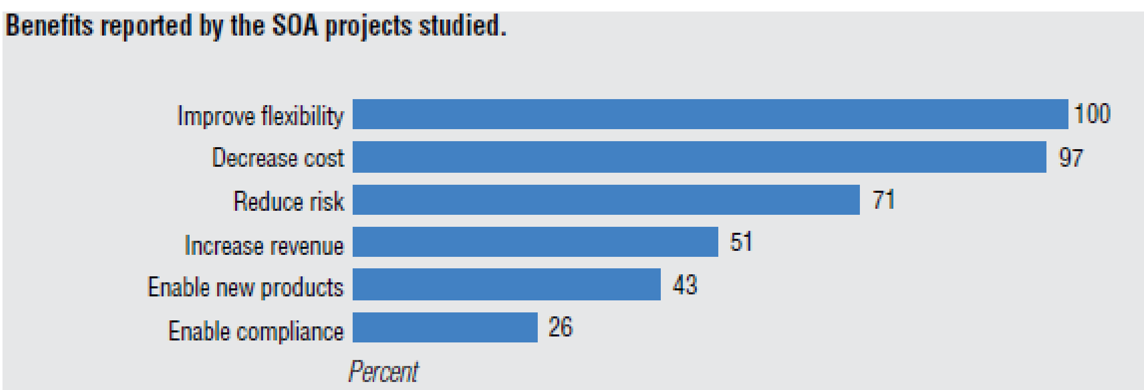


**Figure 7. Benefits Reported by the SOA Projects Studied by IBM**
(DiMare, 2009)

All but one company in the IBM study reported a decrease in costs as a benefit from SOA implementation (DiMare, 2009). In addition, in a study of over 900 IT and business decision-makers, over 60% who reported reducing cost as a major objective of SOA are currently meeting or exceeding their cost reduction objectives (IBM Global Technology Services, 2009).

The data described in Figures 6 and 7, as well as published surveys previously mentioned, support the fact that reducing costs is an important factor in industry, and most companies have been successful at achieving their cost-reduction goals. A report published in 2009 concluded that only 6% of organizations surveyed after adopting an SOA had a negative ROI. Of the remainder, 57% broke even and 37% experienced a positive ROI (Computer Economics, 2009). Furthermore, in a separate study, approximately 50% reported that their SOA investment had at least paid for itself. This seems to be representative of the findings in the case studies, as six of the 10 selected cases reported a positive ROI. However, a positive ROI of cost savings is not a foregone conclusion. In fact, cost reduction by itself does not encompass all the benefits offered by an SOA implementation. Furthermore, it is not always the primary driver in implementing SOA for industry, as has been seen in several published surveys. Many other factors play into the decision.

The next question is, if these are the reported outcomes, then is SOA still prevalent in industry? The researcher collected data to determine whether SOA implementation is on the rise, holding steady, or declining in industry. The results from the data indicate that SOA implementation is on the rise. One report showed that the percentage of organizations making the transition to a service-oriented model jumped from 18% in 2006 to 58% in 2008 (Computer Economics, 2009). In addition, in 2008, 70% of SOA users said they planned to increase their use of SOA, while only 3% planned to decrease their use (Heffner & Fulton, 2008).

Two primary benefits of SOA adoption are decreased risk and reusability. Risk mitigation encompasses many factors listed in the cases and surveys. These include flexibility that allows IT to more quickly react to changing demands, scalability to increase scope as needed, and reusability that implements proven technologies rather than attempting to develop a service from scratch. In addition, proven technologies increase the availability and stability factors of a system because they have already been tested and implemented previously. Risk mitigation is extremely important in the DoD because all too often systems are delivered late, over budget, and without the capability to perform as they were meant to.

As mentioned, an important quality of risk mitigation is reusability. Reusability is often considered as a necessary component to making SOA cost effective. One reason for this, as stated by DiMare (2009) of the IBM Institute for Business Value, is “increased reuse leads to reduced maintenance, which leads to decreased costs; or in another path, increased reuse leads to reduced integration time, which leads to reduced integration cost and thus to decreased costs” (p. 7). The true value of reuse is in the standardization of business processes (IBM, 2005). One survey concluded that 90% of organizations see reuse as a critical metric for success (Ritter & Evans, n.d.). Poulin and Himler (2006) suggested that the cost of reusing an SOA component is about half the cost of reusing traditional components. Forrester Research reported that SOA development can be almost twice the cost of traditional component development, but once the component is reused over and over, SOA becomes 30% more cost effective (Kobielus, 2005). As an example, Delta reported significant cost savings when reusing components (HP, 2010). Furthermore, AT&T claimed that reuse of a single service saved it between 50% to 85% of the cost of building custom interfaces (Erickson, 2006).

In conclusion, the reported surveys show that industry believes cost is an important facet of an SOA implementation and that industry would not move to an SOA if it did not provide some type of positive ROI. However, a straight-line cost reduction was typically not the objective of industry when implementing an SOA. Instead, industry focused primarily on efficiencies and providing a flexible business position. The objectives of an SOA implementation and the actual benefits realized that were identified in the surveys closely resembled those in the analyzed case studies. This allowed the researcher to conclude that the case studies provided an accurate representation of industry and that they can be used to arrive at an industry benchmark. Furthermore, the surveys, along with the case studies, formed the basis for the researcher’s conclusion of industry best practices.

## D. INDUSTRY BEST PRACTICES

The research provided two examples of best practices. These include ensuring that flexibility is built into the implementation and using an incremental approach. As evidenced by the surveys and case studies, flexibility was at or near the top of the list of objectives when implementing SOA. In addition, it was often recognized as a valued benefit as a result of implementing SOA. The ability to react and change course in a rapidly changing environment was considered an enormous benefit. In turn, any SOA project the DoD intends to implement must ensure flexibility. It is not only the business environment that is changing rapidly but also the military environment in terms of the threats faced by the various Services. No longer are mass armies attacking one another. The face of warfare has become terrorist groups who continue to adapt their tactics. The DoD acquisition strategy must be able to adapt and react to these changes, and flexibility is the key.

The second best practice drawn from the research is use of an incremental approach in implementing an SOA. First, it is very difficult to gather the resources to make an enterprise-wide conversion from legacy systems to SOA. A better practice for companies is to adopt SOA on an opportunistic basis such as when legacy system integration is required (Computer Economics, 2009). In the same way, the DoD should start small with near-term or easily implemented requirements and build from there. Furthermore, the DoD should initially attack the low-hanging fruit by introducing SOA services that will provide an immediate bang for the buck. When analyzing the best practices from all the case studies, one thing nearly all had in common was that they introduced a specific service to solve a specific problem; they did not attempt a massive replacement of all their systems at once. In addition to mitigating risk and being less expensive, this approach allows an organization to learn from the early implementations, thereby reducing the learning curve for future implementations.

## E. IMPLICATIONS OF RESEARCH FOR THE DOD

As discussed in the literature review, SOA and OA use many of the same concepts, which allowed them to be treated as similar in the framework of this thesis. Many of the objectives identified in the surveys were also identified in the analyzed case studies.

Furthermore, many of the outcomes reported in the surveys also closely matched the realized benefits found in the case studies. This means the DoD can expect similar outcomes to those achieved by industry. In addition, the DoD can learn from the industry best practices identified in this thesis and use that information in its own implementation of OA.

This research serves as a benchmark measure of what ROI the DoD can expect if it implements an OA. The baseline ROIs reported in Table 4 were rather high and offered a very quick payback period. In addition, when the ROI was calculated solely from cost savings, as shown in Table 5, the results were still respectable. This was encouraging since many companies were focused not on cost savings but on other areas, such as the flexibility to position their company competitively for the future. The DoD can benefit from this research in its acquisition of systems. The three primary areas of interest in DoD acquisitions are cost, schedule, and performance. Although cost was the focus of this thesis, schedule and performance were found to be very much impacted by SOA in industry. For example, companies want to ensure that a flexible system has a direct impact on schedule. The reason companies desire a flexible system is so they can shift gears quickly to take advantage of a changing environment. Although schedule impact may not be seen in the initial investment, it becomes evident in subsequent investments. There are several causes of this, such as the reusability factor, which allowed USMEPCOM to decrease the schedule time of a follow-on project from six months to two weeks.

In addition to improving schedule, increased performance was a benefit seen in the case studies. Often listed as staff efficiencies, workers were able to spend less time on issues such as maintenance and instead focus on other areas that would benefit the company. The schedule and performance aspects of SOA may be equally, if not more, beneficial than the potential cost savings. This is because just over half of the companies included in Table 5 experienced a positive ROI from cost savings and cost avoidance alone, but all of the companies analyzed experienced some sort of efficiency that they concluded had resulted in an overall positive ROI.

DoD acquisitions would also benefit from the risk mitigation offered by SOA projects. Some of the best practices learned from this research include reuse of technologies, use of an incremental approach, and use of a system that is built with a high level of flexibility and scalability, all of which equate to reduced risk. Because many acquisitions programs fail to meet their cost, schedule, and performance goals, implementing a methodology that reduces the associated risks would seem highly desirable. This thesis demonstrated the importance of flexibility in a system. With a stove-piped architecture, there is little flexibility. Not only is it inflexible during its useful life, but it is already inflexible at its inception. While in the development stage, the program may have already changed due to factors such as increased scope, technology obsolescence, and so forth. Even though the acquisition community requires a risk mitigation strategy for its projects, it is different than the risk mitigation offered by OA. Often, risk mitigation strategies for stove-piped systems are implemented early on. This would mean that the features and requirements of a system would be decided early in a program's development and would remain unchanged throughout the implementation phase. However, it is likely that requirements will change throughout the implementation because needs and technologies change, knowledge is incomplete at the start, and so forth (Campbell, 2010). In fact, locking in requirements too early in the process may lead to inflexibility in a program (Patterson, Ott, & Giglio, 2009), resulting in a program that does not achieve all its goals. One the other hand, OA offers the flexibility to adjust to this changing environment.

As a way ahead for the DoD, it is imperative that it develop a method of measuring the actual value of its investments, ensuring flexibility in its systems, as well as of implementing risk mitigation strategies. Although there are several ways of accomplishing this, one study has already proposed a method to solve these issues and could be used as a model going forward. The Naval Postgraduate School along with PEO-IWS conducted a pilot study to apply Knowledge Value Added + Real Options + Integrated Risk Management + Portfolio Optimization (KVA + RO + IRM + PO) to estimate the value created by inserting capabilities into the Aegis Weapons Systems (AWS) through the Advanced Capability Build process (Mun, Housel, & Wessman, 2010). The study looked at the 23 capabilities to be inserted into the AWS while considering issues such as value to the warfighter, risks, and a constrained budget. Using this toolset, the researchers were quickly able to estimate the effects of varying capability insertions. In addition, the researchers were able to quickly change the parameters, such as adding new capabilities or additional risk factors. This provides a great deal of flexibility to the decision-maker. Although not every system would require such an in-depth analysis, using a model such as this could be applied to most any investment and could provide the ability to better manage acquisition projects.

One concept that was proven successful in the AWS study was the use of KVA. The DoD could consider using KVA to measure the value of a project rather than ROI because it uses a derived value for the numerator. This would ensure benefits would be analyzed in objective, common units and would provide a more accurate measure of value. This is important because Mun et al. (2010) found little correlation between the actual cost of insertions and their military value when studying the AWS. In addition, the DoD should implement RO into its acquisition of OA systems. RO takes into consideration that projects have some amount of uncertainty and provides the decision-maker flexibility to exercise or abandon those options at different points in time when more information is known or the requirements change (Housel & Mun, 2010.) The use of RO would address the industry best practice of flexibility by allowing decisions to be made when more complete information is available. Furthermore, RO adheres to using an incremental approach, another industry best practice, by allowing for phased options and the option to wait or defer additional investments. Finally, since RO allows the decision-maker to assess the project at various points, it can be used to frame strategies to reduce risk.

THIS PAGE INTENTIONALLY LEFT BLANK

# VI. CONCLUSIONS AND RECOMMENDATIONS

## A. CONCLUSION

The main purpose of this thesis was to analyze cost savings from various industries following the implementation of an SOA. The research had several objectives. The first objective was to establish a benchmark of performance outcomes, focusing on cost savings experienced in industry in order to determine the benefits the government, or the DoD specifically, could expect to realize in its push to transition to a more open architecture model. The second objective was to determine some industry best practices that may be used by the DoD in this process.

The DoD can benefit from the use of an OA approach. The DoD is ready to implement OA, and the research findings in this thesis show that implementation of OA in the DoD would work. Guidelines outlining the acquisition of OA are already in place. In addition, guidelines for the use of MOSA and COTS are already published. Very little would need to change. However, the DoD cannot assume OA will solve all of its IT system needs, nor can it assume that OA will save the DoD a great deal of money. As seen in the cases and best practices from industry, the DoD must be cautious as to which projects it pursues by focusing on solving very specific issues. The DoD cannot look for the one-size-fits-all approach, but rather it must identify those projects that will provide the most bang for the buck and pursue those using OA systems.

SOA in industry and OA in the DoD can be considered similar concepts, and therefore the results seen from an SOA implementation in industry can be expected by the DoD. The industry cost-savings ROI calculation was 72%, and while this may seem attractive, many other factors must be weighed by the DoD before implementing an SOA project. The ROI is sensitive to many aspects, and there is no guarantee the outcome will always be positive. In fact, only six of the 10 case studies analyzed reported a positive ROI based on cost savings and cost avoidance alone. Therefore, actual ROI from cost savings could vary greatly. However, other benefits, including productivity improvements and nonquantifiable benefits, can more than make up the difference. The focus for the DoD, then, should not be solely on the cost savings SOA can provide, but on benefits such as flexibility and scalability that will allow for improvements in the long term. Furthermore, the DoD should assess the reusability factor of services when making plans to implement OA. Not only does reusability save money but also it decreases project risk. Finally, immediate mass implementation of SOA is not recommended. Instead, the DoD should take an incremental approach, focusing on particular needs and requirements, and implement SOA where it will have the greatest impact first.

## B. RECOMMENDATIONS FOR THE DOD

Based on these conclusions, the researcher has developed several recommendations that will benefit the DoD as it continues its push toward open systems. The first recommendation is to focus not only on cost savings but also on overall value offered by an open system. Many benefits such as flexibility, scalability, and reusability will position the DoD to rapidly adjust its systems to the changing combat mission and environment as well as to reduce future risk. Flexibility, specifically, was noted as an industry best practice, and the DoD should incorporate system flexibility to the greatest extent possible. Although these benefits may equate to cost savings in the future, they are not included in the current cost-savings calculations. Furthermore, making decisions solely on cost savings sends the message that the DoD is only concerned with reducing costs. This essentially means the goal is to reduce costs to zero, which is a fallacy in logic addressed in Chapter IV. In order to make a completely informed decision, the DoD should consider reducing the weight given to ROI as a result of cost savings in its decision-making process and instead attempt to incorporate all associated benefits.

The second recommendation for the DoD is to take an incremental approach and implement OA where results will be immediate. SOA is not a one-size-fits-all solution. Therefore, mass implementation of SOA is not recommended. Instead, the DoD should assess its current architecture and focus its efforts on particular needs and requirements. SOA should then be implemented where it will have the greatest impact first. The DoD should start small with near-term or easily implemented requirements, initially attacking the low-hanging fruit by introducing SOA services that will provide the most bang for the buck.

## C. RESEARCH SHORTCOMINGS

The primary shortcoming of this thesis is the validity of the data. Because the data was freely available, it was provided more as a marketing tool than as a qualitative representation of the typical outcome in industry. In this way, the companies sponsoring the case studies on the implementation of one of their SOA services most likely would report not on a failed SOA implementation, but on projects that succeeded. In addition, detailed information on how the research companies conducted their calculations was not available. This prohibited accurate calculations by the researcher because a determination could not be made as to when in time investments were made or when benefits were realized. More detailed information is available by purchasing the complete studies, but this was beyond the scope and economic feasibility of this thesis.

As an additional shortcoming, the ROI relating to cost savings and cost avoidance was calculated on 10 case studies that reported benefits in separate cost categories. In that respect, the use of only 10 case studies is not enough to be considered representative of the results of SOA implementation by industry in general. Also, many of the surveys listed cannot be considered representative. Several surveys provided a disclaimer stating that the results should not be considered representative of all SOA implementations. Also, surveys by their very nature are somewhat biased because typically only those respondents with a vested interest actually complete the surveys.

## D. RECOMMENDATIONS FOR FUTURE STUDIES

While conducting the research and writing of this thesis, the researcher identified several issues that could be developed and addressed in the future.

### 1. Research Complete Reports

The primary shortcoming of this thesis was the lack of access to complete company reports. Currently, detailed reports are only offered for a fee. If possible, future studies should assess detailed reports to understand the underlying meaning of what SOA is actually bringing to the company rather than rely on a brief synopsis whose primary use is as a marketing tool. This may include looking at several individual companies in great detail to better assess their success or failure in implementing SOA. Additionally, this may provide a more accurate depiction of when in time benefits were realized. Furthermore, nonprofit organizations should be analyzed because like the DoD, they lack the goal of revenue generation and, as a result, might be more representative of the results the DoD would experience.

### 2. Analyze Actual OA Implementations in the DoD

Analyzing actual DoD implementations on their successes or failures should be a focus of future research. However, the research should be conducted on the basis of overall value and not just on cost savings to determine the true value of the project. In that way, the research should not focus solely on ROI from cost savings or cost avoidance, but it should also make calculations for productivity improvements as well as the increased flexibility and scalability provided.

### 3. Assess the Viability of Reusability in the DoD

This thesis discussed the importance of reusability and the benefits it can provide in industry, but it is unclear whether these benefits can translate into the DoD due to restrictions on testing and security of the software. One of the primary benefits reusability offers is a proven technology that can be reused in a slightly different capacity over and over again. However, if testing and security restrictions apply to reused software, it is unclear whether the DoD would benefit from the reusability factor. One recommendation for future research is to look at reused software in the DoD that did go through the various testing and security checks and assess whether it was necessary. For example, new research could look at whether reliability was diminished or whether security was reduced in the reused software.

# REFERENCES


Aberdeen Group. (2008, January). Getting "business-class" performance from service-oriented architecture (SOA) investments. Retrieved from http://v1.aberdeen.com/launch/report/research_previews/4779-RP-service-oriented-architecture.asp?lan=US

Adler, J. R., & Ahart, J. L. (2007). *AEGIS platforms: Using KVA analysis to assess open architecture in sustaining engineering* (Master's thesis, Naval Postgraduate School). Retrieved from http://www.acquisitionresearch.net

American Society of Military Comptrollers (ASMC). (2009, October). *Enhanced defense financial management*. Alexandria, VA: Author.

Assistant Secretary of Defense for Networks and Information Integration. (2005, October). *Information technology portfolio management* (DoD Directive 8115.01). Washington, DC: Author.

Atkinson, R., & Court, R. (2010). Explaining the productivity paradox. Retrieved from http://www.neweconomyindex.org/prouctivity.html

Azani, C. (2001, September–October). The test and evaluation challenges of following an open system strategy. *ITEA Journal*, *22*(3). Retrieved from http://www.acq.osd.mil/osjtf/pdf/itea.pdf

Bradley, B. (2007, July 6). Business transformation at the Department of Defense. Retrieved from http://www.cio.com/article/print/122605

Brandon, D. (2010). Determining return on investment (ROI) in the public sector. Retrieved from http://pmi-ittelecom.org/pmtopics/determining-return-on-investment-roi-in-the-public-sector/

Brownsword, L., Carney, D., Fisher, D., Lewis, G., Morris, E., Place, P., … Meyers, B. (2004). *Current perspectives on interoperability* (CMU/SEI-2004-TR-009, ADA421613). Retrieved from http://www.sei.cmu.edu/library/abstracts/reports/04tr009.cfm

Brummett, C. S., & Finney, B. H. (2008). *Implications of services-oriented architecture and open architecture composable systems on the acquisition organizations and processes*

(Master's thesis, Naval Postgraduate School). Retrieved from http://www.acquisitionresearch.net

Buck, K., Das, P., & Hanf, D. (2008). Applying ROI analysis to support SOA information security investment decisions. In *Technologies for Homeland Security: 2008 IEEE Conference* (pp. 359–366). Retrieved from http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4534478&isnumber=4534402

Business Transformation Agency (BTA). (2009, February). Service-oriented architecture (SOA): An introduction to SOA—Definition. Retrieved from http://www.bta.mil/products/training/SOA/SOA-2/index.htm

Campbell, G. (2010, April). The illusion of certainty. Retrieved from http://www.acquisitionresearch.net/_beta/files/FY2010/NPS-AM-10-030.pdf

Case Study Forum. (2009a, August). MoreDirect builds a reliable, scalable storage network, gains $450,000 in benefits with HP LefHand P4000 SANs. Retrieved from http://www.cio.in/download?nid=4663

Case Study Forum. (2009b, October). RTS builds high-availability solutions, reduces costs, improves scalability, and gains US$123,000 in benefits with HP LeftHand P4000 SAN. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA2-8510ENW.pdf

Clements, P., Kazman, R., & Klein, M. (2002). *Evaluating software architectures: Methods and case studies*. Boston, MA: Addison–Wesley.

Clinger–Cohen Act, 40 U.S.C. § 1401(3) (1996).

Computer Economics. (2009, March). SOA adoption surges as organizations report positive ROI, but ownership costs exceed expectations. *Computer Economics Report, 31*(3), 1–9. Retrieved from http://web.ebscohost.com.libproxy.nps.edu/ehost/pdfviewer/pdfviewer?sid=05eb43ae-04f5-45df-a55d-5eea0fc18d78%40sessionmgr110&vid=6&hid=123

Defense Acquisition University (DAU). (2006). Open architecture terms & definitions. Retrieved from https://acc.dau.mil/CommunityBrowser.aspx?id=22108&lang=en-US

Denne, M. (2007). Pricing utility computing services. Retrieved from http://search.proquest.com/docview/290338501?accountid=12702

Department of Defense, NAVSEA, & PEO IWS. (2004). *Open architecture computing environment technologies and standards* (Version 1.0). Washington, DC: Authors.

DiMare, J. (2009, March). Service-oriented architecture: Measuring SOA's ROI in the new economic environment. Retrieved from ftp://ftp.software.ibm.com/common/ssi/pm/xb/n/gbe03202usen/GBE03202USEN.PDF

Dortch, M. (2008, February). Performance in a service-oriented architecture world. Retrieved from http://www.aberdeen.com/aberdeen-library/4198/RA-performance-service-architecture.aspx

Erickson, R. (2006, November 7). AT&T SOA experience. Retrieved from http://www.infoworld.com/event/soa/archive/2006/soa_resources.html

Erl, T. (2005a). *Service-oriented architecture: Concepts, technology, and design.* Boston, MA: Prentice Hall.

Erl, T. (2005b, April 6). *A look ahead to the service-oriented world: Defining SOA when there's no single, official definition*. Retrieved from http://weblogic.sys-con.com/node/48928

Erl, T. (2008). *SOA: Principles of service design*. Upper Saddle River, NJ: Prentice Hall.

Gabhart, K. (2007). SOA ROI, deconstructed. Retrieved from http://soamatters.com/blog/2007/04/03/soa-roi-deconstructed/

Gorton, I. (2006). *Essential software architecture*. Berlin, Germany: Springer-Verlag.

Government Accountability Office (GAO). (1997, February). *Assessing risks and returns: A guide for evaluating federal agencies' IT investment decision-making* (Version 1; GAO/AIMD-10.1.13). Retrieved from http://www.gao.gov/special.pubs/ai10113.pdf

Heffner, R., & Fulton, L. (2008, August). Topic overview: Service-oriented architecture for enterprise architects. Retrieved from http://www.forrester.com/rb/Research/topic_overview_service-oriented_architecture_for_enterprise_architects/q/id/46740/t/2

Hewlett–Packard (HP). (2005, November). Service-oriented architecture (SOA). Retrieved from http://h20338.www2.hp.com/services/downloads/soa-ww-4AA0-2398enw.pdf

Hewlett–Packard (HP). (2010, February). Delta soars with SOA. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA0-7978ENW.pdf

Housel, T., Kanevsky, V., Rodgers, W., & Little, W. (2009). *The use of modern portfolio theory in non-profits and their IT decisions*. Unpublished manuscript, Department of Information Sciences, Naval Postgraduate School, Monterey, CA.

Housel, T., & Mun, J. (2010). *A primer on applying Monte Carlo simulation, real options analysis, knowledge value added, forecasting, and portfolio optimization*. Monterey, CA: Naval Postgraduate School.

IBM. (2005). Five SOA projects that can pay for themselves in six months. Retrieved from http://www-03.ibm.com/industries/ca/en/retail/retail_docs/five_soa.pdf

IBM. (n.d.). New to SOA and web services. Retrieved from http://www.ibm.com/developerworks/webservices/newto/

IBM Global Technology Services. (2009, January). Enhancing your infrastructure in an uncertain economy to support your SOA business initiatives: Three actions IT executives can take now to cut costs, get more out of existing IT investments and increase productivity. Retrieved from ftp://ftp.software.ibm.com/common/ssi/sa/wh/n/msw03005usen/MSW03005USEN.PDF

IDC Business Value Spotlight. (2009a, August). Using HP Network Automation to improve network availability and reduce costs [Secure download]. Retrieved from https://h10078.www1.hp.com/cda/hpdc/display/main/secure/download_pdf_protected.jsp?zn=bto&cp=54_4000_14

IDC Business Value Spotlight. (2009b, August). Using HP Quality Center and HP Quick Test Pro to increase testing capacity and reduce costs. Retrieved from http://h20195.www2.hp.com/V2/GetPDF.aspx/4AA3-0222ENW.pdf

IDC Business Value Spotlight. (2009c, October). Using HP Quality Management Solutions to reduce costs and mitigate risks of application downtime. Retrieved from http://h20195.www2.hp.com/V2/GetPDF.aspx/4AA3-0223ENW.pdf

IDC Business Value Spotlight. (2009d, October). Using HP Service Manager to improve IT staff efficiency, increase application availability, and reduce costs for a global media consulting firm. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA3-0224ENW.pdf

IDC Business Value Spotlight. (2009e, October). Using HP SiteScope and HP Business Availability Center on HP SaaS to increase IT staff efficiency, improve administrative efficiency, and reduce costs. Retrieved from http://h20195.www2.hp.com/V2/GetPDF.aspx/4AA2-8670ENW.pdf

IDC Business Value Spotlight. (2010a, January). Using HP Network Management to improve IT staff efficiency and reduce costs for a global consumer products company. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA1-0307ENW.pdf

IDC Business Value Spotlight. (2010b, January). Using HP Operations Orchestration to increase system availability, improve staff productivity, and reduce costs for a global insurance provider. Retrieved from http://www.computerwoche.de/fileserver/idgwpcw/files/1929.pdf

IDC Business Value Spotlight. (2010c, February). Using HP Data Center Automation Center to improve staff efficiency and reduce costs for a Fortune 500 provider of information management systems and services. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA1-0304ENW.pdf

IDC ExpertROI™ Spotlight. (2010a, April). Using HP Client Automation Center to increase IT staff productivity and reduce costs for a global mobile telecommunications provider [Secure download]. Retrieved from https://h10078.www1.hp.com/cda/hpdc/display/main/secure/download_pdf_protected.jsp?zn=bto&cp=54_4000_14

IDC ExpertROI™ Spotlight. (2010b, April). Using HP Service Manager to integrate environments, increase IT productivity, and reduce user downtime for a leading United States-based healthcare services provider. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA1-6333ENW.pdf

IDC ExpertROI™ Spotlight. (2010c, May). Using HP Business Intelligence Solutions at Blue Cross And Blue Shield of Kansas City to reduce costs and increase competitiveness. Retrieved from http://h20195.www2.hp.com/V2/GetPDF.aspx/4AA1-6325ENW.pdf

IDC ExpertROI® Spotlight. (2010d, October). Using HP Client Automation at a leading global financial services firm to successfully convert acquired branches while increasing IT staff productivity and reducing costs [Secure download]. Retrieved from https://h10078.www1.hp.com/cda/hpdc/display/main/secure/download_pdf_protected.jsp?zn=bto&cp=54_4000_14

Kobielus, J. (2005, October). The ROI of SOA. Retrieved from http://www.networkworld.com/techinsider/2005/101005-roi-of-soa.html

McGovern, J., Tyagi, S., Stevens, M., & Matthew, S. (2003). *Java web services architecture*. San Francisco, CA: Morgan Kaufmann.

McKendrick, J. (2007, March). Analyst: ROI doesn't apply to SOA. Retrieved from http://blogs.zdnet.com/service-oriented/?p=831

Minoli, D. (2008). *Enterprise architecture A to Z.* Boca Raton, FL: Auerbach.

Mun, J., Housel, T., & Wessman, M. (2010). *PEO-IWS ACB insertion portfolio optimization.* Retrieved from http://www.acquisitionresearch.net/_beta/files/FY2010/NPS-AM-10-069.pdf

Naval OA strategy. (2008.) Retrieved from https://acc.dau.mil/adl/en-US/129676/file/40342/FY%202008%20OA%20Strategy%20Oct%2008%20FINAL.pdf

Nelson, M. (2010). *Information technology portfolio management proof of concept: Modern portfolio theory with KVA and ROI analysis* (Master's thesis, Naval Postgraduate School). Retrieved from http://www.acquisitionresearch.net

Network Centric Operations Industry Consortium (NCOIC). (2010, July). US Military Entrance Command (USMEPCOM) SOA case study. Retrieved from https://www.ncoic.org/apps/group_public/download.php/16921/CSC_case_study_USMEPCOM-rev%201.doc

Nucleus Research. (2007, December). ROI case study: Sterling Commerce Johnson controls power solutions. Retrieved from http://nucleusresearch.com/research/roi-case-studies/roi-case-study-sterling-commerce-johnson-controls-power-solutions/

Nucleus Research. (2008, July). ROI case study: HP SOA Systinet carphone warehouse. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA2-7330ENW.pdf

O'Brien, L., Bass, L., & Merson, P. (2005, September). *Quality attributes and service-oriented architectures* (Tech. Note CMU/SEI-2005-TN-014). Retrieved from http://www.sei.cmu.edu/publications/documents/05.reports/05tn014.html

Open Systems Joint Task Force (OSJTF). (2004, September). *A modular open systems approach to acquisition* (Version 2.0). Retrieved from http://www.acq.osd.mil/osjtf/pdf/pm_guide.pdf

Open Systems Joint Task Force (OSJTF). (n.d.). Terms and definitions. Retrieved from http://www.acq.osd.mil/osjtf/termsdef.html

Patterson, J., Ott, M., Giglio, E. (2009, April). *When instructions provide too much flexibility, establish rules defense acquisition performance assessment redux: Unpredictability, uncertainty and program failure: Implementing a rule-set can be the fix*. Retrieved from http://www.acquisitionresearch.net/_beta/files/FY2009/NPS-AM-09-046.pdf

Pavlou, P. A., Housel, T. J., Rodgers, W., & Jansen, E. (2005). Measuring the return on information technology: A knowledge-based approach for revenue allocation at the process and firm level. *Journal of the Association for Information Systems, 6*(7), 199–226. Retrieved from http://web.ebscohost.com.libproxy.nps.edu/ehost/detail?sid=f963bce4-d652-4a92-b5fd-6e1c5421a3e0%40sessionmgr114&vid=1&hid=110&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=bth&AN=18426893

Phillips, J. (2002). Measuring ROI in the public sector. In J. J. Phillips (Ed.), *In action* (pp. 1–21). Alexandria, VA: American Society for Training and Development.

Phillips, J., & Phillips, P. (2002, November). Advances in developing human resources: Technology's return on investment. *Advances in Developing Human Resources, 4*(4), 512–532. Retrieved from http://adh.sagepub.com/content/4/4/512.refs.html

Poulin, J. (1997). *Measuring software reuse*. Reading, MA: Addison-Wesley.

Poulin, J., & Himler, A. (2006). The ROI of SOA based on traditional component reuse. Retrieved from http://semanticommunity.info/@api/deki/files/2729/=ROI_of_SOA.pdf

Program Executive Office, Integrated Warfare Systems (PEO–IWS). (2007, January 5). *Naval OA strategy* (White paper). Retrieved from https://acc.dau.mil/adl/enUS/129676/file/40342/FY%202008%20OA%20Strategy%20Oct%2008%20FINAL.pdf

Ritter, T., & Evans, R. (n.d.). A survey of financial justification among SOA adopters in North America and Western Europe. Retrieved from http://www.scribd.com/doc/7056316/BEA-Costs-and-Benefits-GCR-Survey-Final

Schmelzer, R. (2005, January 27). The ROI of SOA. Retrieved from http://www.zapthink.com/report.html?id=ZAPFLASH-20050127

Shopping for SOA. (n.d.). *Mortgage Line*. Retrieved from http://web.ebscohost.com.libproxy.nps.edu/ehost/detail?vid=4&hid=107&sid=b6c79ac0-2411-44f7-b86d-19f034dbc905%40sessionmgr115&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=bwh&AN=L2D028027959706

Teply, J. F. (2009). *An investigation of network enterprise risk management techniques to support military net-centric operations* (Master's thesis, Naval Postgraduate School). Retrieved from http://www.acquisitionresearch.net

Thoughtfare Worldwide. (2010, August). The Bank of India partners with HP to improve customer experience and deliver anywhere, anytime banking—Realises a 234% ROI. Retrieved from http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA3-1024ENW.pdf

Tian, C., Cao, R., Ding, W., Zhang, H., & Lee, J. (2007, July). Business value analysis of IT services. In *2007 IEEE International Conference on Services Computing* (pp. 308–315). Retrieved from http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4278672&isnumber=4278610

Uchytil, J. (2006). *Assessing the operational value of situational awareness of AEGIS and ship self-defense system (SSDS) platforms through the application of the knowledge value added (KVA) methodology* (Master's thesis, Naval Postgraduate School). Retrieved from http://www.acquisitionresearch.net

Under Secretary of Defense for Acquisition, Technology, and Logistics (USD[AT&L]). (2003, May). *The defense acquisition system* (DoD Directive 5000.01). Washington, DC: Author.

U.S. Department of Treasury. (n.d.). Daily Treasury yield curve rates. Retrieved from http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yieldYear&year=2011

# 2003 - 2011 Sponsored Research Topics

## Acquisition Management

- Acquiring Combat Capability via Public-Private Partnerships (PPPs)
- BCA: Contractor vs. Organic Growth
- Defense Industry Consolidation
- EU-US Defense Industrial Relationships
- Knowledge Value Added (KVA) + Real Options (RO) Applied to Shipyard Planning Processes
- Managing the Services Supply Chain
- MOSA Contracting Implications
- Portfolio Optimization via KVA + RO
- Private Military Sector
- Software Requirements for OA
- Spiral Development
- Strategy for Defense Acquisition Research
- The Software, Hardware Asset Reuse Enterprise (SHARE) repository

## Contract Management

- Commodity Sourcing Strategies
- Contracting Government Procurement Functions
- Contractors in 21$^{st}$-century Combat Zone
- Joint Contingency Contracting
- Model for Optimizing Contingency Contracting, Planning and Execution
- Navy Contract Writing Guide
- Past Performance in Source Selection
- Strategic Contingency Contracting
- Transforming DoD Contract Closeout
- USAF Energy Savings Performance Contracts
- USAF IT Commodity Council
- USMC Contingency Contracting

## Financial Management

- Acquisitions via Leasing: MPS case
- Budget Scoring
- Budgeting for Capabilities-based Planning
- Capital Budgeting for the DoD
- Energy Saving Contracts/DoD Mobile Assets
- Financing DoD Budget via PPPs
- Lessons from Private Sector Capital Budgeting for DoD Acquisition Budgeting Reform
- PPPs and Government Financing
- ROI of Information Warfare Systems
- Special Termination Liability in MDAPs
- Strategic Sourcing
- Transaction Cost Economics (TCE) to Improve Cost Estimates

## Human Resources

- Indefinite Reenlistment
- Individual Augmentation
- Learning Management Systems
- Moral Conduct Waivers and First-term Attrition
- Retention
- The Navy's Selective Reenlistment Bonus (SRB) Management System
- Tuition Assistance

## Logistics Management

- Analysis of LAV Depot Maintenance
- Army LOG MOD
- ASDS Product Support Analysis
- Cold-chain Logistics
- Contractors Supporting Military Operations
- Diffusion/Variability on Vendor Performance Evaluation
- Evolutionary Acquisition
- Lean Six Sigma to Reduce Costs and Improve Readiness

- Naval Aviation Maintenance and Process Improvement (2)
- Optimizing CIWS Lifecycle Support (LCS)
- Outsourcing the Pearl Harbor MK-48 Intermediate Maintenance Activity
- Pallet Management System
- PBL (4)
- Privatization-NOSL/NAWCI
- RFID (6)
- Risk Analysis for Performance-based Logistics
- R-TOC AEGIS Microwave Power Tubes
- Sense-and-Respond Logistics Network
- Strategic Sourcing

## Program Management

- Building Collaborative Capacity
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Collaborative IT Tools Leveraging Competence
- Contractor vs. Organic Support
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to AEGIS and SSDS
- Managing the Service Supply Chain
- Measuring Uncertainty in Earned Value
- Organizational Modeling and Simulation
- Public-Private Partnership
- Terminating Your Own Program
- Utilizing Collaborative and Three-dimensional Imaging Technology

A complete listing and electronic copies of published research are available on our website: www.acquisitionresearch.org

THIS PAGE INTENTIONALLY LEFT BLANK

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL
555 DYER ROAD, INGERSOLL HALL
MONTEREY, CALIFORNIA 93943

www.acquisitionresearch.org