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Business Case Analysis of Comprehensive Maritime Awareness

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December 2006**

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**BUSINESS CASE ANALYSIS OF COMPREHENSIVE MARITIME
AWARENESS**

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BUSINESS CASE ANALYSIS OF COMPREHENSIVE MARITIME AWARENESS

ABSTRACT

This research project develops a business case analysis model to evaluate the costs and benefits of utilizing the Comprehensive Maritime Awareness (CMA) system within the DoD. The business case analysis model was developed to conduct a detailed evaluation of the economic costs and benefits associated with CMA. The initial hypothesis favored CMA as a superior alternative to the existing system, Maritime Domain Awareness (MDA). Throughout the course of the research, this opinion was solidified and supported based on a series of factors. These factors are expressed and outlined in the observations, conclusions and recommendations.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym

| | |
|----------|--|
| ACTD | Advanced Concept Technology Development |
| Ad | Advertise |
| AIS | Automatic Identification System |
| AoA | Analysis of Alternatives |
| AOA | Agent Oriented Architecture |
| AOR | Area of Responsibility |
| BA | Battlespace Awareness |
| BCA | Business Case Analysis |
| C2 | Command and Control |
| C2PC | Command and Control Personal Computer |
| CATE | Computer Assisted Threat Evaluation |
| CDVD/IE | Common Distributed Virtual Database / Info Extraction |
| CENTRIXS | Combined Enterprise Regional Information Exchange |
| CIP | Common Intelligence Picture |
| CMA | Comprehensive Maritime Awareness |
| COCOM | Combatant Commander |
| COI | Community of Interest/ Contact of Interest / Critical Operational Issues |
| CONOPS | Concept of Operations |
| COP | Common Operating Picture |
| CSI | Container Security Initiative |
| DARPA | Defense Advanced Research Projects Agency |
| DCGS-M | Distributed Common Ground System-Navy |
| DDMS | Discovery Metadata Schema |
| DINK | Dedicated In-kind Funding |
| DMS | Defense Message System |
| ELINT | Electronics Intelligence |
| GALE | Generic Area Limitation Environment |
| GCCS-M | Global Command and Control System - Maritime |
| GSO | Ground Systems Operations |
| GWOT | Global War on Terrorism |
| HARTS | Harbor Craft Transponder System |
| IMO | International Maritime Organization |
| IR | Info Request |
| ISPS | International Ship and Port Facility |
| ISR | Intelligence, Surveillance, Reconnaissance |
| JC2 | Joint Command and Control |

| | |
|---------|---|
| JCTD | Joint Capability Technology Demonstration |
| JICPAC | Joint Intelligence Center Pacific |
| JWICS | Joint Worldwide Intelligence Communications System |
| KPP | Key Performance Parameter |
| LA/LB | Los Angeles/Long Beach |
| LEA | Law Enforcement Agencies |
| MDA | Maritime Domain Awareness |
| MIFC | Maritime Intelligence Fusion Center |
| MLS | Multi-level Security Guards |
| MOE | Measure of Effectiveness |
| MOP | Measure of Performance |
| MOS | Measure of Suitability |
| MSS | Modular Sensor System |
| MUA | Military Utility Assessments |
| NCES | Net-Centric Enterprise Services |
| NESI | Net-centric Enterprise Services for Interoperability |
| NIPRNET | Unclassified but Sensitive Internet Protocol Router Network |
| NMCC | National Military Command Center |
| NMIC | National Maritime Intelligence Center |
| NOA | Notice of Arrival |
| NRL | Naval Research Laboratory |
| NTM | Notice to Mariners |
| OM | Operational Manager |
| ONI | Office of Naval Intelligence |
| PACOM | Pacific Command |
| PANDA | Predictive Analysis for Naval Deployment Activities |
| ROI | Return on Investment |
| ROK | Return on Knowledge |
| RoS | Republic of Singapore |
| RWS | Ready Web Service |
| SBU | Sensitive but Unclassified |
| SCI | Sensitive Compartmented Information |
| SEI | Specific Emitter Identification |
| SII | Statements of Intelligence Interest |
| SIPRNET | Secret Internet Protocol Router Network |
| SOA | Service Oriented Architecture |
| SME | Subject Matter Expert |
| SOM | Straits of Malacca |
| SPAWAR | Space and Naval Warfare Systems Command |
| TADIX | Tactical Data Information Exchange Subsystem |

| | |
|------|-------------------------------------|
| TM | Technical Manager |
| TTPs | Tactics, Trends, Procedures |
| VOI | Vessel of Interest |
| VTIS | Vessel Tracking Information Center |
| WS | Web Services |
| XCOP | Extensible Common Operating Picture |
| XM | Transition Manager |

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I. INTRODUCTION

A. PURPOSE

A constant drive resides within the military and governments of the United States to identify, locate, and track all vessels on the seas throughout the world. This takes a combined effort of combat systems, intelligence resources, and the most recent technologies to build a complex vehicle that can accomplish full identification and tracking of all vessels. At this time, there is not any country in the world capable of attaining 100% identification and tracking of vessels on the seas. In fact, that is most likely impossible, but strides in this direction can be attained.

B. RESEARCH OBJECTIVES

The objective of this research is to analyze the current Maritime Domain Awareness (MDA) system in place, demonstrate what Continuous Maritime Awareness (CMA) is and show implementing CMA is a step in the right direction to accomplish maritime supremacy.

C. RESEARCH QUESTIONS

This research study will provide insight as to why CMA is a viable system, both systematically and economically. In particular, the research will apply a Cost Benefit Analysis approach to determine CMA's creditability in the current operating structure.

D. METHODOLOGY

This thesis will apply the Cost Benefit Analysis methodology to CMA in order to provide insight on CMA. The process will include process flow diagrams, conceptual documents, and literature review of pertinent documents. From this process, the CBA will be analyzed from an operational perspective to show advantages and disadvantages.

E. SCOPE

The scope of this thesis will be demonstrated in the operational value CMA provides to the US Navy. Providing the costs and benefits associated, the research process will focus on the inabilities of the current system and how CMA can improve upon the current capability.

F. THESIS ORGANIZATION

This thesis will be organized in the following manner:

Chapter I provides an overview of the thesis with regard to purpose and scope. Also, research objectives and questions will be addressed. Finally, the methodology used to generate the final conclusions will be provided.

Chapter II provides a background understanding of MDA, how the current system operates, and opportunities for future research. This chapter shares a foundation of information required to build understanding and draw conclusions in later chapters.

Chapter III describes CMA, its objectives, and how it can be applied to the current operating system.

Chapter IV outlines a basic business case analysis structure. The keys to this chapter reside in the benefits and costs associated with CMA.

Chapter V reveals conclusions, and recommendations based on the research provided.

II. MARITIME DOMAIN AWARENESS

A. DESCRIPTION OF MDA

In order to understand MDA, a definition of the actual maritime domain is required. The maritime domain is defined as:

All areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo, and vessels and other conveyances.¹

Essentially, everything associated with the earth's sea is part of the domain. Therefore, Maritime Domain Awareness (MDA) is having full and timely knowledge on everything within the maritime domain. The National Strategy for Maritime Security defines Maritime Domain Awareness as:

The effective understanding of anything associated with the global maritime domain that could impact the security, safety, economy, or environment of the United States. MDA is a key component of an active, layered maritime defense in depth. It will be achieved by improving our ability to collect, fuse, analyze, display, and disseminate actionable information and intelligence to operational commanders.²

MDA demands as much actionable intelligence as possible about everything that happens on the earth's water in order to protect our country from any harm which is the foundation of our counterterrorism program and maritime law enforcement operations. Figure 1 shows the interconnected network of how the MDA program intends to work. All parties involved are connected and working together to achieve maritime domain awareness.

¹U.S. Department of Homeland Security, National Plan to Achieve Maritime Domain Awareness for the National Strategy for Maritime Security, open-file report, 2 (October 2005).

²Ibid., 3.



Figure 1. MDA Network³

B. MDA OBJECTIVES

President Bush signed two directives on 21 December 2004; the National Security Presidential Directive-41 and the Homeland Security Presidential Directive-13 (NSPD-41/HSPD-13) established the Maritime Security Policy Coordinating Committee. This committee was responsible for the development of a National Strategy for Maritime Security and the eight supporting implementation plans outlined below.⁴

- **National Plan to Achieve Maritime Domain Awareness** lays the foundation for an effective understanding of anything associated with the Maritime Domain that could impact the security, safety, economy, or environment of the United States and identifying threats as early and as distant from our shores as possible.
- **Global Maritime Intelligence Integration Plan** uses existing capabilities to integrate all available intelligence regarding potential threats to U.S. interests in the Maritime Domain.
- **Maritime Operational Threat Response Plan** aims for coordinated U.S. Government response to threats against the United States and its interests in the Maritime Domain by establishing roles and responsibilities, which enable the government to respond quickly and decisively.

³U.S. Department of Homeland Security. Maritime Domain Awareness: Information Sharing, Processes and Partnerships. (April 19, 2005), accessed September 10, 2006. http://www.ndia.org/Content/ContentGroups/Divisions1/International/MDA_USCG.ppt#457.

⁴U.S. Department of Homeland Security, National Plan to Achieve Maritime Domain Awareness for the National Strategy for Maritime Security, open-file report, 2 (October 2005).

- **International Outreach and Coordination Strategy** provides a framework to coordinate all maritime security initiatives undertaken with foreign governments and international organizations, and solicits international support for enhanced maritime security.
- **Maritime Infrastructure Recovery Plan** recommends procedures and standards for the recovery of the maritime infrastructure following attack or similar disruption.
- **Maritime Transportation System Security Plan** responds to the President's call for recommendations to improve the national and international regulatory framework regarding the maritime domain.
- **Maritime Commerce Security Plan** establishes a comprehensive plan to secure the maritime supply chain.
- **Domestic Outreach Plan** engages non-Federal input to assist with the development and implementation of maritime security policies resulting from NSPD-41/HSPD-13.

The three primary plans are to develop a common operating picture, leverage partnerships within the MDA community and develop the infrastructure necessary to support MDA information management. These plans or objectives were implemented primarily to protect the United States from anyone that wants to do harm via the water. If achieved, these objectives should decrease the probability of another terrorist attack. One thing is almost certain, this will not stop all terrorist attacks but achieving MDA should make our borders more secure. The attack on 11 September 2001 alarmed many to the vulnerabilities that existed in the defense of our own country, and 95,000 miles of coastline was one of them.

The enemies our nation faces today are diverse, unpredictable, relentless and highly networked. With the increased concern over weapons of mass destruction and growing numbers of hostile states, the MDA program was established to counter such a threat. Our economy has become more globally connected through increased shipping, lower transaction costs and lower restrictions on trade, which has ultimately increased our reliance on foreign national goods. U.S. industry relies on just in time delivery of goods, creating tremendous pressures on inspectors and regulators to keep commerce flowing at all reasonable costs. Los Angeles/Long Beach (LA/LB) handles a third of west coast oil and almost half the west coast containers; no other U.S. port can accommodate the capacity if LA/LB closed. Houston is critical to production of petroleum products. Port Everglades is only port in South Florida capable of off-loading and refining oil. The ports of Boston and New York were closed at about 9:45 11

September 2001. We were forced to reopen these two ports by noon on 13 September 2001, not because it was safe to do so, but because New England had reached critically low inventory levels of gasoline and fuel oil.⁵ Reliance on oil is only one example, but all imported goods have a major impact on the price levels in our country, which makes the balance between national security and free trade more difficult.

Several other factors contribute to our concern over domain awareness. There are increased incidences of piracy and hijacking that pose a threat to the free flow of international commerce. There is ongoing use of commercial vessels for smuggling and trafficking in people, drugs and other contraband, including weapons. There is a growing concern over the potential use of commercial maritime vessels to support terrorist activities, including smuggling terrorists and weapons of mass destruction or hijacking a vessel for use in a terrorist attack against areas or assets of U.S. national interest, including sea lines of communication, U.S. Military forces or international ports.

On January 20, 2002, President Bush made the following statement:

The heart of the Maritime Domain Awareness program is accurate information, intelligence, surveillance, and reconnaissance of all vessels, cargo and people extending well beyond our traditional maritime boundaries.⁶

Recently, President Bush signed the \$7.4 billion Port Security Bill, which directs spending to new port security inspectors, nuclear weapons screening and developing an automated system to pinpoint high-risk cargo.⁷ This particular legislation shows bipartisan agreement on increased port security and the strength of the commitment by the \$7.4 billion dollar price tag. This bill does not, however, provide 100% screening of all ships exiting foreign ports en route to the United States. "One hundred percent screening of every container will shut down worldwide shipping overnight," said House

⁵CDR John Wood, USCG. Maritime Domain Awareness Brief. (November 9, 2006).

⁶U.S. Department of Homeland Security, National Plan to Achieve Maritime Domain Awareness for the National Strategy for Maritime Security, open-file report, 3 (October 2005).

⁷House Committee on Homeland Security website, accessed November 12, 2006.
http://homeland.house.gov/news/latestNews/20060504-SAFEPort/PR_SAFE_Port_Markup_042606.pdf.

Majority Leader John A. Boehner; so what about the percentage that do not get screened?
⁸ MDA intends to fill the gaps mentioned above by gathering intelligence from other agencies and sources to detect anomalies and possible threats. Can the current MDA program plug these holes and provide our country with 100% protection?

C. STATUS OF MDA PROGRAM

The MDA program has great intentions, objectives and looks great on paper. However, operationally, it lacks the effectiveness and efficiency required to keep our country safe. September 11, 2001 was an eye opener for many defense related agencies, but the MDA program would only be slightly better off by simply working harder. The maritime domain has become too complex for current systems, operations and processes. Figure 2 illustrates where we believe the program stands today. The MDA program today is highlighted in blue and shows how it has progressed from not knowing the identification and location of maritime vessels to knowing roughly 60%. The other 40% is intelligence the agencies involved in tracking and identifying need to know.

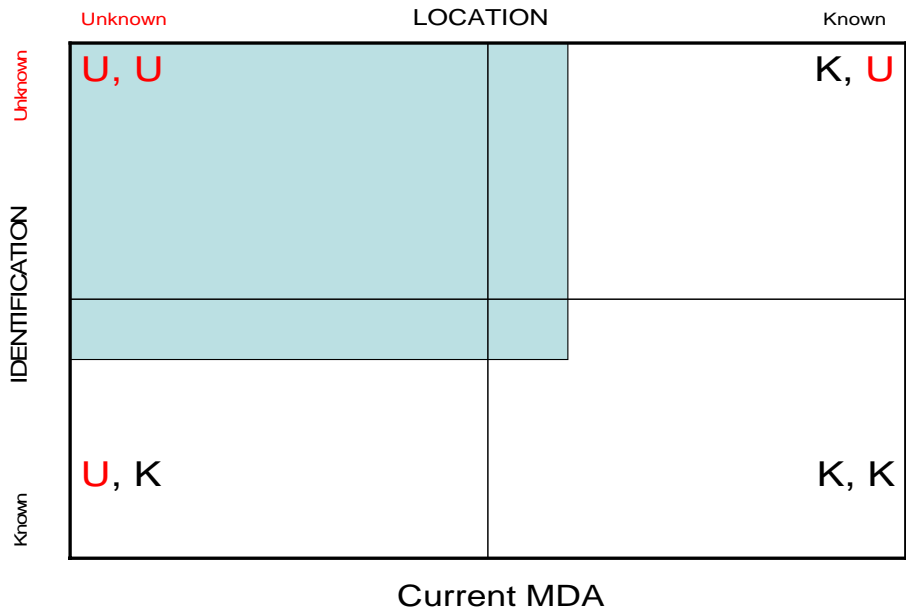


Figure 2. Current MDA Program

⁸Jonathan Weisman, “House Passes \$7.4 Billion Port Security Bill,” *Washington Post*, 5 May 2006, sec. A04.

The MDA program lacks the resources and tools necessary to provide timely and accurate maritime domain information to the correct agency. There are tools that are underutilized, some that are in production and others that are yet to be put on paper. One example of an underutilized tool is the Automatic Identification System (AIS). AIS is an unclassified broadcast system that acts like a transponder and sends/receives very important information via VHF maritime band. These units are commonly found on merchant vessels around the world but have the capability to be installed on land in choke points or along the coast, buoys, warships and any other place within line of sight range of a vessel. The International Maritime Organization (IMO) mandated in December, 2000 that AIS to be fitted aboard all ships of 300 gross tonnage and upwards that are engaged on international voyages, cargo ships of 500 gross tonnage and upwards that are not engaged on international voyages and passenger ships, irrespective of size, built on or after 1 July 2002.⁹ The information can be overlaid onto a radar screen; every contact on the screen will show course, speed, position, ship name, MMSI number, IMO number, call sign, type of cargo, ship dimension, destination, and ETA, provided it is equipped with AIS.¹⁰

To stress the importance of this data, here is an example. Ship ‘A’ gets underway from Spain saying it is en route to Canada. However, the ship is a rogue ship and is steaming towards the United States carrying a nuclear explosive. If a warship was in range, equipped with AIS, it could possibly detect the vessel not on the appropriate course needed to reach Canada and further interrogate the vessel as to why it was heading towards the United States. This information could then be transmitted to a processing center to decide if a threat exists.

Detecting the anomaly above is not as easy as it sounds because the water space is extremely vast; detecting a vessel in this scenario before it enters U.S. waters is the challenge. Currently, AIS is not required on U.S. Navy vessels, however it is used in the Coast Guard. It is also not required on all maritime vessels at this time nor is it installed

⁹International Maritime Organization web site, accessed September 14, 2006. http://www.imo.org/Safety/mainframe.asp?topic_id=155.

¹⁰USCG Navigation web site, accessed September 10, 2006. <http://www.navcen.uscg.gov/enav/ais/default.htm>.

on any buoys or along the coast. AIS is only one tool that would help identify the maritime picture if put into play more aggressively.

If the success of the MDA program was only about implementing additional tools then we would be able to make more technological recommendations as to what the program needed. Unfortunately, a big reason why the MDA program is deficient is also because of intangible reasons. MDA has too many cultural and sensitivity barriers between and across various agencies. Getting all agencies to fully cooperate and share information with one another is a major weakness. Agencies such as the U.S. Navy, USCG, DEA, CIA, FBI and the various other intelligence agencies are not working together to form the Common Operating Picture (COP) that the MDA program needs. This includes foreign countries that could also integrate their intelligence for the greater good. Many agencies and countries feel their information is too sensitive to share with other agencies and countries. There are hard classification issues that can not be compromised, but MDA lacks the ability to strip sensitive material in a timely manner to enter the information into the COP.

Timely information and decision making is the key to success in any battle. Having information and making a command decision before the enemy can is proven to be the most effective way to win a battle. MDA does not allow the information to flow in a timely matter to the appropriate agency. The barriers currently in place and the manual processes used to transfer the data will keep 100% MDA from being achievable. For the information to be timely there needs to be a COP into which all information can be fed for all agencies to view. MDA does not provide that capability.

Currently, agencies have to manually search for information on vessels of interest vice being fed or having the ability to access information from a common database. Furthermore, MDA lacks either an automated process which filters information to the right agency or more analysts to manually strip the data and then distribute.

The display currently in use for the U.S. Navy, USCG and other intelligence agencies is the GCCS-M system. GCCS-M claims to be near real-time but due to its manual nature it is often time late. Once a track is entered, the system tracks the contact

based on the operator's last entered course and speed. These contacts can sometimes be days time late, which is unacceptable for tracking today's threat. It will take time to transition towards another command and Control (C2) system with more automation because it is so widely used by the U.S. Navy, USCG and other intelligence centers. There are, however, more advanced C2 systems being designed.

Accuracy of the information is also deficient. The time and effort required to build a single track from the various agencies' informational databases is directly correlated to the accuracy of the data sometimes provided. Customers receive data from various resources and a common frustration is determining if a difference between external reports is an anomaly or operator error. Often it is the latter but we can not afford to not be 100% accurate in locating and identifying potential threats. For instance, if a GCCS operator onboard a U.S. Naval vessel reports vessel 'A' as having 21 crewmembers instead of 11 because the operator read the lookouts handwriting wrong, then the agency receiving this information would detect an anomaly. Vessel 'A' left port with 11 crewmembers, where did they pick up 10 extra crewmembers? This is a common problem because of operator error and the processes involved do not provide checks and balances. There are hundreds of resources and sensors available but if they are not interconnected, an accurate picture of a contact is not timely.

III. COMPREHENSIVE MARITIME AWARENESS (CMA)

A. DESCRIPTION OF CMA

Comprehensive Maritime Awareness (CMA) is the means to achieve MDA. CMA and MDA share the common goal of achieving full domain awareness, except CMA is all encompassing. CMA also separates itself because it is a new initiative to achieve maritime domain awareness by using more tools and resources in a more automated and streamlined fashion. MDA is achievable through CMA because of its service oriented architecture (SOA). SOA is the heart of CMA because it allows software services, processes, new and old technologies to be loosely connected. SOA is not one specific technology rather a network of technologies or independent services that work together to allow multiple users to benefit from each other's information. Through a SOA framework, CMA integrates the effort of joint forces, both foreign and domestic, along with every agency involved in tracking the threats we face today within the maritime domain.

CMA is an endless pool into which new tools and resources will be dumped. Each item, whether a physical system, new idea, critical eye, etc. put into this pool will allow CMA to come alive and achieve its plans. It is dynamic in every aspect because CMA evolves with the threat to be successful. CMA takes advantage of newer technologies because the customers involved in CMA are constantly looking for upgrades, new systems, sensors and more interagency communication. More communication allows for brand new ideas and information to flow more quickly.

In the first phase of CMA, customers will view information from displays like GCCS-M, Generic Area Limitation Environment (GALE-LITE), Command and Control Personal Computer (C2PC), and the Distributed Common Ground System-Navy (DCGS) which get fed information from where track fusion and dissemination occurs. The customers who draw on this information include Office of Naval Intelligence (ONI), MIFC, COCOMs, Republic of Singapore (RoS), USCG, Port Authorities and various Law Enforcement Agencies. Track fusion and dissemination occurs in the Joint World Wide Communications System (JWICS), the Secret Internet Protocol Router Network

(SIPRNet), the Unclassified but Sensitive Internet Protocol Router Network (NIPRNet) and the Common Distributed Virtual Database Information Extraction System (CDVD/IE). The network and systems draw upon seemingly endless multi-level data sources. The multi-level data sources include national data sources, ready web services (RWS) and sensitive but unclassified other web services (OWS SBU). RWS assets include sensors installed afloat and ashore, data we receive from the RoS and the Joint Maritime Information Extraction sight. OWS SBU assets include the AIS, ship position reports, advanced afloat and ashore sensors and law enforcement. The list of assets and resources are vast but each plays an integral role in painting the maritime picture.

The data is fused to form “Super Tracks” and is further disseminated with regards to classification level and relevance. JWICS is simply a communication path used by C2 to coordinate tracks and send information. It is capable of secure video/data within the defense intelligence community, which can come from a transmission of files to real time two-way video teleconferencing between sites. The SIPRNet is DoD’s largest interoperable command and control data network. It supports the GCCS, the Defense Message System (DMS), collaborative planning and numerous other classified warfighter applications. The NIPRNet provides seamless interoperability for unclassified combat support applications, as well as controlled access to the Internet. CDVD/IE is a new database that fuses intelligence data at multiple levels using a wide array of sensors and resources. CDVD/IE is a component of VTP and will be discussed later in the chapter.

B. CMA OBJECTIVES

The futuristic goal or final phase of CMA is to track 100 percent of maritime traffic, prioritize each track and identify the threats with flawless accuracy. After identification, the information will be sent to the involved DOD entity, government agency or coalition force for appropriate action. For the above process to happen at the level described, certain objectives need to be achieved. The objectives that CMA intends to achieve cover the shortfalls of the current MDA program. With CMA, the identification and location of all maritime vessels is known with a stronger level of confidence. Figure 3 shows how the lower right quadrant is closer to being filled in with

blue which means the identification and location of all maritime vessels is better known. The absolute final phase of this JCTD is to have the entire chart highlighted in blue so as to say that every single thing within the maritime domain is known.

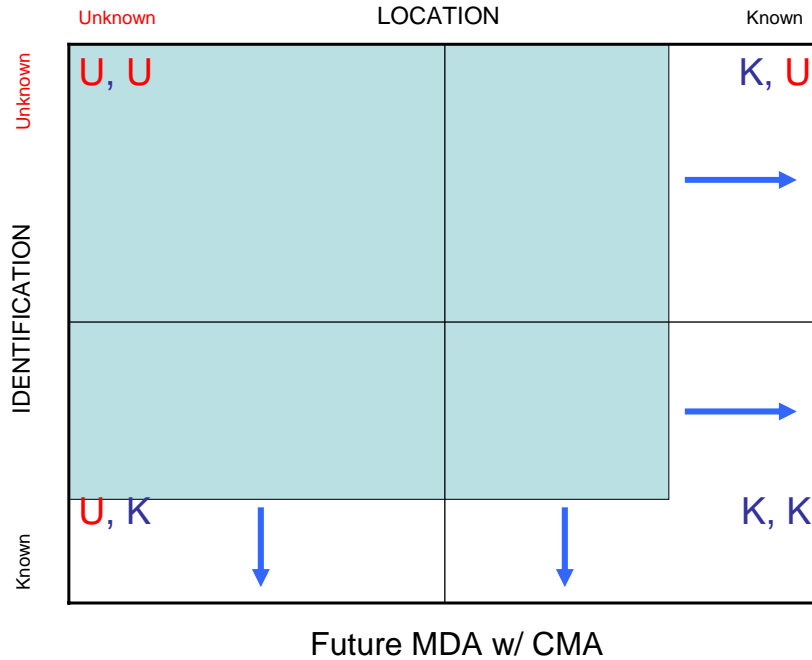


Figure 3. Future MDA Program with CMA

The first phase or step of CMA strives to lower the barriers between the different agencies and services involved by introducing this concept and its capabilities. Using a GCCS based system, information sharing will probably still be considered a manual process compared to the final phase of CMA, but the role of security guards will be emphasized. In the early phase, the placement of security guards or analysts will be needed to ensure sensitive material is not shared with the wrong people. With an increase of automation, there could be an increase in risk of leaking classified material so databases will be tailored to the user and have multiple levels of security access. As CMA evolves, however, systems like VTP intend to guard against security leaks while adding automation. Evolution depends on the researchers involved in not only determining the vulnerabilities that exist in our current system and ways to fix them. but which customers should be granted certain information.

Under CMA, new tools have emerged to automate the entire process and detect anomalies. These tools will greatly improve the ability to link vessel position information with possible threats. The automation will not only make the process faster, but it increases the efficiency and productivity of the analysts currently in place. It breaks down the barriers between each agency and shares the information they gather with everyone else. Once the information is able to flow more effectively and efficiently, customers like MIFC can build longer-duration tracks on surface vessels. It enables information to flow more effectively because it brings together nearly 200 multi-level data sources, classifies each source, enters it into multiple databases then makes it available to the various customers to access and use. This is a specific objective for automating the system. Automation will occur at many levels, but there is great value in automatically determining anomalies and vulnerabilities and immediately informing the right agency. Speed of information is only helpful if it is accurate, so CMA addresses accuracy by adding additional corroborative data sources to increase quality control.

C. TOOLS OF CMA

1. Current Tools

A benefit of CMA is that it can use old and new tools to achieve domain awareness. There are currently some very effective tools used in the MDA program that CMA will utilize. Some of these tools will become more effective and useful once certain objectives of CMA are achieved because fewer barriers will exist. Breaking down the barriers will allow more agencies to exploit other agencies' tools, spreading the benefit from one tool throughout all agencies by directly or indirectly sharing information. The data sources currently available are military and national and are fed from an array of sources and sensors.

The CMA concept is a joint effort and the key to its success is interoperability, coordination and cooperation. It incorporates sensor inputs from naval and space assets, those you find at chokepoints or ports and tag data. Sensor inputs are then correlated and

fused with intelligence from multiple sources as well as open commercial source information for use by the appropriate customer. The current process is manual but CMA intends to add more automation.

Each service or agency has their own tools to better achieve domain awareness. The Navy is an important asset because its nearly 300 ship fleet plays an integral role. On average, a third of that fleet is deployed and its sensors relay contact information to the necessary agencies ashore. Most U.S. Naval vessels and COCOMS are equipped with the GCCS-M system, which is the Navy's primary fielded Command and Control System. It enhances the operational commander's warfighting capability and aids in the decision-making process by receiving, retrieving, and displaying information relative to the current tactical situation. It is the common display system used by the USCG and MIFC as well.

The most common sensors aboard these vessels are surface radars and lookouts, which relay information to the track supervisor who enters the track into GCCS-M. This is the most manual of processes and can be followed up with a call for further information via bridge to bridge radio. Other sensors include electronics intelligence (ELINT) that fingerprints ships by reading their electronic emissions. Using the Tactical Data Information Exchange Subsystem (TADIX) and the Combined Enterprise Regional Information Exchange (CENTRIX) system, information is exchanged between ships worldwide. Coalition warships can also support CMA by adding their tracks to the common operating picture.

The USCG has a fleet of about 200 aircraft, over a thousand boats less than 65 feet and over 200 ships greater than 65 feet. The USCG is:

A military, multimission, maritime service within the Department of Homeland Security and one of the nation's five armed services. Its core roles are to protect the public, the environment, and U.S. economic and security interests in any maritime region in which those interests may be at risk, including international waters and America's coasts, ports, and inland waterways.¹¹

¹¹USCG website, accessed on 5 September 2006. <http://www.uscg.mil/top/missions/>

USCG responsibilities include patrolling the nation's 361 ports and 95,000 miles of coastline, boarding and inspecting tens of thousands of cargo ships and recreational boats, and reviewing security at the nation's commercial ports. In addition to the U.S. Navy, AIS is standard on most USCG vessels. AIS is a proven system that can be used to automatically identify vessels also AIS equipped. This sensor can be installed in chokepoints and harbor entrances, or on buoys and other navigational aids. USCG vessels are integral to our port security because they operate primarily along the coastline of the United States and communicate directly to shore-based facilities.

2. Future Tools

The first step to achieve Domain Awareness is to bring more tools into the system. The list of our current tools appears sufficient but more tools are needed to automate the entire process. Items that are currently being considered for CMA include the following:

- Vessel Tracking Program
- The Computer Assisted Threat Evaluation (CATE) Threat Assessment Tools
- Defense Advanced Research Projects Agency (DARPA) Tools for Maritime COP, FASTC2AP and Predictive Analysis for Naval Deployment Activities (PANDA), a behavior analysis resource.
- Extensible Tactical C4I Framework
- Extensible Common Operating Picture (XCOP)
- Combat Identification: Information Management of Coordinated Electronic (EC 06-01)

An objective of VTP is to decrease the time needed to process a track so it is possible to track 100 vessels per hour for ships greater than 100 GRT. This goal can be met by providing more accurate information and by automating the development of vessel tracks. Automation is expected in the data acquisition, validation, fusion, correlation and track generation phases, which will ultimately reduce manpower. VTP will create and associate actionable intelligence to “Super Tracks” by fusing data from

roughly 200 different sources. Fusing this data will be highly automated while still building detailed tracks. Anomaly detection will also occur once the track is entered. The information it produces will generate a classified picture for personnel with clearances and an unclassified picture for local law enforcement and other unclassified agencies to view.

VTP correlates multiple sensor capabilities in a MDA Layered Defense Concept, including non-cooperative vessel tracking. The sensors and tools included in this layered defense combine the sensors and tools currently used to track maritime traffic with additional advanced sensors specifically designed for VTP. The sensors for this layered defense include the following. First, VTP will leverage the technology already in use by extending the range on the AIS system, creating the AIS/ER system. In addition to installing AIS on all maritime vessels and strategically placing them in littoral areas or on buoys, VTP intends to install them on military and commercial aircraft. Installing them on aircraft will create a link of AIS transponders that has the potential to extend the range to roughly 2000nm. Second, a High Frequency Surface Wave Radar will be installed on various naval assets to track vessels greater than 25 feet, out to approximately 100nm. Third, a shore based transportable unit, called a Modular Sensor System (MSS), will be installed in various locations that house several subsystems. The MSS uses surface search radar with a range of about 24nm; it also has a Radio Frequency direction finder, a specific emitter identification system, and a local VHF AIS transponder. The sensors will also include acoustic data from coastal sonar buoys and optics from shore.

The cornerstone of the VTP project is the Common Distributed Virtual Database Information Extraction (CDVD/IE) system. The goal of this system is to process approximately 100 tracks per hour for ships greater than 100 GRT at higher confidence levels. At a remote local, intelligence information is collected & processed in this system component. The CDVD/IE system provides automation through alerts based on programmed rule sets, as well as any anomalies detected in the track data.

VTP expects to increase track capacity to 20,000 identified tracks, as opposed to roughly 200 high interest vessels that are manually tracked today. It is also expected to process tracks in less than .33hr, where the current process takes four to eight hours.

Automated systems like VTP are designed for the greater than 50,000 vessels over 300GRT that are engaged in international maritime commerce, but the final phase of CMA is to track all maritime vessels. VTP is only one stepping stone on the path to achieve full MDA; when it reaches its capability it will greatly enhance the maritime picture.

IV. THE BUSINESS CASE ANALYSIS (BCA)

One of the greatest hurdles that faces the Department of Defense is measuring the value associated with new technology systems and the processes that function within, and in conjunction with, these systems. During the research for this BCA, it was discovered that other studies have been done on new emerging systems such as Open Architecture and MDA. These studies were done using Knowledge Value Added (KVA) Methodology on these systems. (KVA was discovered late in this research and was not used in any calculations, but it will be discussed further in the conclusions of this research).

Building a business case on new technology or processes without revenue associated with the given output has been a difficult problem within the DoD and DON. In the commercial world, value can be measured through the revenue generated by a system, or by the cost savings that the system may achieve. However, within the Federal Government (specifically the Department of the Navy) and, for that matter, any non-revenue generating entity, monetary revenue is not always an easily interpreted measurement of value. It is not the goal of this research to assign value to the specific processes of MDA, but to determine if CMA is a course of action that is a sound business decision.

A. WHAT IS A BUSINESS CASE ANALYSIS (BCA)?

A Business Case Analysis (BCA) examines and compares the benefits, costs, and uncertainties of each alternative to determine the most cost effective means of achieving the objective. It is a systematic approach to the problem of resource allocation, comparing two or more alternatives in terms of cost and benefits. The standard steps in a BCA are below:

- Defining the objectives of the action being considered
- Specifying assumptions/constraints

- Identifying alternatives
- Listing the benefits for all feasible alternatives
- Estimating costs for each feasible alternative
- Ranking alternatives in terms of costs and benefits
- Analyzing risk/uncertainty
- Providing conclusions/recommendations

A BCA is a process for preparing a structured proposal that establishes sound business decisions for proceeding with an investment/project by providing decision makers with insight into how the investment/project supports business needs and strategic goals. The BCA structures the assessment by providing necessary information concerning the scope, alternatives considered, estimated costs, Return on Investment (ROI) and risks for decision makers to make an informed funding decision for the investment/project. Each BCA will be different depending on its application. However, a BCA structure should include the following, as a minimum.¹²

Introduction. It presents the objectives addressed by the subject of the case, and all the options, including the status quo, considered to achieve the objective.

Assumptions and Methods. Outlines the rules for deciding what belongs in the case, and what does not, along with the critical assumptions.

Business Impacts. The main business case results.

Sensitivity and Risk Analysis. Shows how results depend on the important assumptions (“what if”), as well as the likelihood for other results to surface.

Conclusions and Recommendations. Recommends specific actions based on business objectives and the results of the analysis.

¹² Acquisition Community Connection (ACC) [2004], Business Case Analysis.

1. The BCA Process

Figure 7 displays the BCA process consisting of four steps.

Definition is the first step in the BCA process and sets the scope of the problem. During this step, the assumptions and the constraints are formulated which will guide the BCA Team throughout the process. The alternatives to be considered are also identified in this step, as well as the metrics to compare alternatives.

Data Collection is the second step in the BCA process and involves identifying the source and types of data to be collected. Collecting data may be difficult because the data may be obscured in databases in remote locations or buried in budget documents.

Evaluation Analysis is the third step in the BCA process and includes the “number crunching”. In this step, the data that was collected in the second step is used to build a case for each alternative, using both qualitative and quantitative data. Each alternative is compared against each other, in an effort to identify a best alternative. It is important that analysts should not only seek to determine which alternative has the lowest cost, but which alternative provides the optimal combination of price and performance.

Results Presentation is the fourth step in the BCA process. This is a critical step because if the BCA Team is unable to effectively communicate the results to the decision makers, the analysis is worthless.

Conclusions are to be organized around the initial objectives stated in the case. The BCA could recommend staying with the status quo or adopting the alternative(s) being considered.

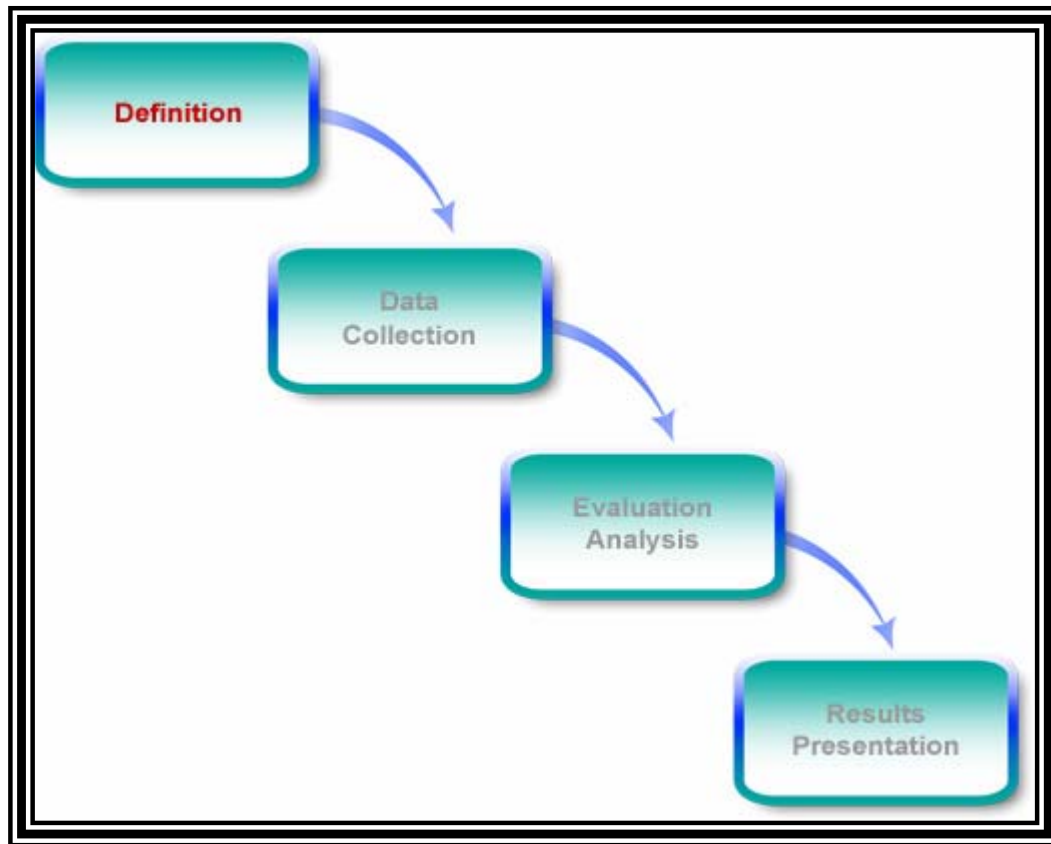


Figure 4. The BCA Process¹³

B. POTENTIAL INCURRED COSTS (MDA WITHOUT CMA)

One perspective to consider when valuing a successful CMA program is to compare the cost of programs like VTP, which are in the acquisition phase, to the cost to rebuild a major city. Estimating the cost to rebuild a city is extremely difficult, especially when you consider all the intangible and hidden costs associated with the loss of an entire city. The most current way to comprehend the loss of a city is to briefly analyze the natural disaster, Hurricane Katrina, and the destruction of New Orleans. The cost to rebuild New Orleans has been estimated to be roughly \$200 billion and is analogous to the destruction of a city caused by a nuclear bomb brought in on a ship.

There are many factors that should be considered when doing such an analysis. Cost figures range when estimating the cost of human life. Estimates range but the \$200

¹³Acquisition Community Connection (ACC) [2004], Business Case Analysis.

billion figure probably does not include the cost of life which has been estimated to be in the millions per person. The metropolitan New Orleans area had a population before the hurricane around 1.3 million, but a large number evacuated so many lives were saved.¹⁴ If a nuclear bomb went off in the city there would probably not be any warning. Aside from the loss of human life, there are many other costs to consider. There will be tremendous physical and emotional suffering of the survivors, increased medical costs, overfilled hospitals and inadequate living conditions for many years following the incident.

Direct costs associated with the loss of a city can be evaluated by insurance companies, but they do not cover all costs. There are obvious short-term costs, and then there are costs associated with long-term effects that are more difficult to estimate given the factor of time, inflation, energy costs, insurance company bankruptcy and housing reconstruction difficulties. These second order, longer term costs include the impact on city tourism, the cost to displace thousands of people to other cities and political/social unrest.

In retrospect, the city of New Orleans could have been protected from a category five hurricane at a fraction of the cost to repair the entire city after complete destruction. The cost to protect the city would have been primarily for reinforcing and/or replacing the levees used to keep flood water out. Building a flood protection system able to cope with a category five hurricane in New Orleans is a small investment given the potential benefit. However, concerning the low probability of a category five hurricane actually striking, the investment seemed much larger and not worth the cost.

So, why choose Hurricane Katrina? This scenario is presented because investing in CMA has the potential to avoid the destruction of major cities like New Orleans. CMA is global, meaning it simultaneously benefits more than one city, which makes valuing the benefit even more difficult. The probability of a terrorist attack and the probability it will occur within the maritime domain are factors that influence whether an

¹⁴The New Orleans Convention and Visitors Bureau website accessed 10 December, 2006. <http://www.neworleanscvb.com/faq/index.cfm/action/Cover>.

investment should be made. If CMA is implemented and VTP is acquired and performs to its designed capabilities at a cost of \$39 million, cost is potentially insignificant compared to destruction costs.

C. CMA COST (MDA WITH CMA)

On two research trips to the Coast Guard Maritime Intelligence Fusion Centers (MIFC) data was collected on the current MDA architecture, track management and track processes, information flow, intelligence system structure, hardware and software issues and various other topics of concern. Much time was spent on what new technologies were coming online and what impact a new MDA architecture would have on their track management processes. Over the years since 9/11, many improvements have been made to the current system and many new technologies have been brought online proving to be more effective than legacy systems. There is continuous improvement to MDA management, and adding the systems associated with the new CMA architecture will only further improve the watchstander's ability to manage and track the multitude of commercial vessels around the globe.

The first set of data we analyzed was taken from CMA JCTD program documents that details who is providing funds for the first four years of CMA testing and implementation. It is assumed that the majority of this funding is for the CDVD console, which is being fielded and tested at present. No other funding data was found on fielding or training for other MDA/CMA components. As previously discussed, most of the CMA architecture is pre-existing in the current MDA scheme of operations.

In Figure 5, the funding data for the CMA JCTD to cover four fiscal years shows a net cost of \$39M. This value includes funding trails from many different sources, including \$5.3M from the RoS (Republic of Singapore) for joint operational testing of CMA with the RoS.

shown in the table below.

| Funding (\$K) | Type | Program Element Number | FY06 | FY07 | FY08 | FY09 Transition BA4 | Total |
|---------------------------|------------|------------------------|-----------------|-----------------|----------------|---------------------|-----------------|
| Coalition Warfare Program | Cash | 0603923D8Z | \$250 | \$230 | \$0 | \$0 | \$480 |
| Singapore* | DINK | | \$2,500 | \$1,500 | \$1,300 | \$0 | \$5,300 |
| USN | Cash | 0604307N | \$4,410 | \$4,000 | \$3,220 | \$0 | \$11,630 |
| USN/N7F | Cash | 0603790N | \$0 | \$500 | \$500 | \$0 | \$1,000 |
| USN/ONR | DINK | | \$1,000 | \$700 | \$0 | \$0 | \$1,700 |
| PEOC4I&Space | Cash | 0604231N | \$0 | \$0 | \$0 | \$1,200 | \$1,200 |
| Sub-Total | | | \$8,160 | \$6,930 | \$5,020 | \$1,200 | \$21,310 |
| DUSD (AS&C) | CASH | 0603750D8Z | \$6,820 | \$5,910 | \$4,500 | \$1,000 | \$18,230 |
| TOTAL | <i>RMC</i> | <i>060364908Z</i> | \$14,980 | \$12,840 | \$9,520 | \$2,200 | \$39,540 |

Figure 5. CMA JCTD Funding¹⁵

Other funding data for CMA was pulled from the OSD RDT&E Project Justification (R2a Exhibit) for FY07. The CMA JCTD has been budgeted for \$6.5M in FY07 plans, which includes “baseline and demonstrate CMA technologies”.¹⁶ This value is comparable to the DUSD (AS&C) FY07 data in Figure 5.

The next set of data collected was from SME at the MIFCs that pertained to personnel numbers and cost of running a MIFC watchteam to conduct track management and provide intelligence information to the rest of the MDA architecture. This data is relevant to a BCA to calculate total cost of a system. Assumptions made for these calculations are as follows:

- Work Year = 52 Weeks
- Work Week = 42 Hours
- Watch = 12 Hours
- OJT = 6 Hours per Watch
- Avg Watchstander Annual Income (E-5 w/ 8 yrs) = \$28,825¹⁷

¹⁵Comprehensive Maritime Awareness (CMA) Joint Capabilities Technology Demonstration (JCTD) Implementation Directive. December 20, 2005.

¹⁶OSD RDT&E Project Justification, FY07.

¹⁷The Military.com web site, accessed October 25, 2006.
http://www.military.com/Registration/Pay_Chart?backURL=2006-military-pay-charts.

With this data, we can calculate the cost per track generation and figure this into an ROI equation for the BCA. As discussed in the MDA and CMA chapters, track generation in the current MDA system averages 200 vessels of interests (VOI) per day.

| MDA Threat ID Tracking Process (MIFC Pacific) | | | | | | |
|---|------------|-----------------|------------------------|--------------------------------------|------------|----------|
| Function | Tracks/Day | # Employees/Day | Cost/Employee Per Week | Cost/Week | Cost/Track | % Change |
| Track Gen (MDA) | 200 | 6 | \$554.33 | \$3,325.96 | \$2.38 | |
| Track Gen (CMA) | 2000 | 6 | \$554.33 | \$3,325.96 | \$0.24 | 900% |
| Assumptions | | | | | | |
| Work Year: | | | | 52 Weeks | | |
| Work Week: | | | | 42 Hours | | |
| Watch: | | | | 12 Hours | | |
| OJT: | | | | 6 Hrs/Watch | | |
| Watchstander (E-5 w/8yrs) Annual Income | | | \$28,825.00 | (This is the "average" watchstander) | | |
| Market Comparable Annual Income | | | \$37,472.50 | | | |

Figure 6. Track Cost Estimate

The current MDA track generation process allows a watchteam to generate and manage 200 VOI's per day at a labor cost of \$2.38 per track. Improving MDA to CMA architecture will allow the same watchteam to track up to 2000 VOI's per day, decreasing the labor cost to \$0.24 per track. This is a cumulative decrease of 900% in cost.

By improving technology and the system used to generate and manage tracks, the MIFC watchteam becomes significantly more effective. This has been an ongoing process over the last several years and will continue to improve with new equipment and technologies. Another variable to consider is the increased value gained from improved processes and what will be gained from improved intelligence gathering techniques, but this will be discussed in more detail in the final chapter.

D. THE BCA DILEMMA

Many problems surfaced in formulating the analysis and comparing the “as-is” to the “to-be” data. The first issue was the sparse data available regarding development and fielding dollar costs for the CMA JCTD. Many functions and components are already in place and there is no cost incurred to field hardware or train personnel on new equipment. Next, valuing improved technology in the DoD is next to impossible and considering the difficulty in assigning revenue and costs to different processes and functions.

Looking just at the improvements CMA will offer one MIFC could be enough to make a decision to pursue this added technology. However, that is not all that goes into a complete ROI analysis; more has to be considered.

As discussed in the previous sections, addressing the costs/rewards of MDA and a new CMA system, it is difficult to determine ROI given the huge rewards and gains from the new system. How is value placed upon saving 9/11 or Katrina type damage to a major U.S. city? What value is placed on preventing a dirty bomb or biological weapon from entering a major port of entry? These key variables are enormous and, unfortunately, can not be valued in a standard ROI calculation.

Another problem to consider is that CMA is not a completely new acquisition (like a new Joint Strike Fighter or DDX type program) but a continuation of existing technology with enhanced capabilities of legacy system. CMA does include some new hardware acquisitions (VTP/CDVD, MSS, etc.), but the cost of these acquisitions are relatively insignificant in the large scheme of MDA.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

From the start of this MBA project report, the architecture of MDA and the progression to CMA has been detailed as best as possible. The concepts and technology of the new thought progressions to CMA seem to be going in the right direction. Sometimes in the military acquisition process we add new systems or make changes/improvements to existing systems just for the sake of upgrading or adding new technology without first looking at the cost and benefits of these changes/additions. In the case of CMA, performing testing and integration of technologies while still in the JCTD process allows for actual field use and testing prior to pushing the system through the acquisition process. This allows for problems and issues to come forward prior to large amounts of funding and personnel time being wasted on a system that is un-proven or of little actual value to the military components.

On the other side, our thesis was unable to perform a detailed BCA due to the lack of hard financial data available. This is the case with many new systems in the pre-acquisition process and much research has been done on these systems both at the Naval Postgraduate School (NPS) and by other government agencies. Without financial numbers and hard data for analysis, the nature of our recommendations will be based on the knowledge gained and the value we deemed from that knowledge. We asked the question “is this a good decision?” and we believe we have found that answer. Our group is giving a strong recommendation to pursue advanced technologies to improve MDA capabilities. Further analysis can be done using other valuation methods that will solidify our recommendation.

In the course of this research, other methods were discovered that can be of great use when dealing with the problems that we had in building an adequate BCA. Previously mentioned KVA methodology has recently and is now being used by other research groups at this school and on ACTD and JCTD projects. KVA is a methodological approach to allow value to be assigned to processes in a system and assigns common output metrics to compare alternatives. Commercial or private

industries are using this methodology to value outputs of non-revenue producing entities in their organizations. This allows for comparisons and analyses to be conducted between different departments and divisions of an organization to determine their effectiveness and find areas of improvement, etc. A more complete description of KVA has been included in Appendix B of this research.

Another valuable tool discovered during this research was Real Options Analysis.¹⁸ This is a system produced by another NPS Professor, Dr Johnathan Mun, which includes methodology and software to conduct valuation and analysis of options based on risk and methods of valuation. The base software includes a Super Lattice Solver and Risk Simulator which runs similar to the basic solver add-ins to Microsoft Excel. The software is capable of conducting Real Options Analysis, Monte Carlo Simulation, Forecasting and Optimization. The Real Options Analysis system can be used with these types of projects to value and analyze processes and systems that do not produce revenue or do not have intrinsic value to the organization.

Subject Matter Experts at both sites visited were very helpful and insightful in the usefulness and the need for improved methods and technologies with MDA track management. Improvements in IT and intelligence data sharing within the DoD is a key factor in meeting the goals and directives of our leaders to improve and become masters of the Maritime Domain. With the valued insight of the SME's who manage and work in MDA on a daily basis, this group has found that any improvements, including large leaps to a CMA architecture, would be well worth the cost to the DoD. Saving ourselves from ourselves has become something of a norm in our line of work, and this system is no exception. Anything that can be done to prevent or possibly eliminate the chances of large scale destruction of a major port area or city would be welcomed. Our group and the many members of the community responsible for managing the data that can help accomplish what is required would welcome improvements to processes and systems that protect our citizens and infrastructure.

¹⁸Johnathan Mun, *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions*, ed. Arch G. Woodside, 2nd edition. (Wiley Publishers, 2006).

B. RECOMMENDATIONS

This thesis focused on the current MDA architecture and the need for improvements through new technologies and processes such as CMA. Our question for this thesis was “is this a sound course of action to pursue”. With the information and data collected by this group, the DoD should pursue the acquisition of technologies that will improve our capabilities in the MDA realm. Further analysis and research should be done with more detailed analysis of data to determine actual costs and benefits of the system. CMA is a step in the right direction for the U.S. to attain the desired goal of total Maritime Domain Awareness and fully protect our seas and borders from possible future incursions or attacks.

C. RECOMMENDATIONS FOR FUTURE RESEARCH

With a foundation being laid for the CMA JCTD project, there is still much to be learned and much research required in the area of measuring and determining the value of a CMA architecture for MDA. Using the methods mentioned in the previous sections, a more detailed analysis should be performed both on the macro and micro levels to determine the effectiveness and increased efficiencies of introducing new IT to the MDA process. A KVA methodology analysis should be performed on intelligence gathering watchteams (such as a MIFC, NORTHCOM Intel Center, etc) to fully demonstrate the use of CMA on a micro level within the organization.

There are several groups that we met with that are currently conducting research at NPS using these types of techniques to evaluate and analyze both MDA and CMA components. Their research, in conjunction with the results presented here, will further develop the business case for CMA, showing that this technology is a prudent investment.

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APPENDIX B: KNOWLEDGE VALUE ADDED (KVA) METHODOLOGY¹⁹

In 1996 the Clinger-Cohen Act (also ITMRA) was mandated to provide a measurement of performance of the federal governments information technology systems, and that measure would be determined by “how well the information technology supports the programs of the executive agency” (ITMRA). This was taken further by then Secretary of Defense Cohen to define a means of evaluation that will “utilize mission outcome based performance measurements as the cornerstone for information technology performance assessments” (Annual Defense Report, 1999). With the foundation set for the performance metrics, specific measurements and indicators are left to the program managers of system programs.

The KVA methodology applies the idea that the inherent knowledge in a process is a viable determinant of the process’ value. Through the application of the KVA methodology, knowledge within core processes of an organization can be measured and the resulting return on knowledge can be used to provide a means of evaluating multiple processes through common units of measurement.

This methodology does not require that the common units be reflected in the form of monetary or financial value. The processes within the operational context of a watch team can, through KVA, all be described in common units of output, the resulting productivity ratio (ROK) can then be evaluated to determine where efficiencies may be obtained.

Applying KVA methodology toward a business case analysis can show a given outcome with changes in inputs to a system. New technologic developments which cause improvements in the core processes of the system will display returns as ROK.

¹⁹Uchytel, Joseph. “Assessing the Operational Value of Situational Awareness for Aegis and Ship Self Defense Systems (SSDS) Platforms Through the Application of the Knowledge Value Added (KVA) Methodology.”

A. THE KVA SOLUTION

1. Knowledge Value-Added (KVA) Theory

Developed by Dr. Thomas Housel (Naval Postgraduate School) and Dr. Valery Kanevsky (Agilent Labs) over 15 years ago, KVA is a means to value the knowledge assets within an organization. Built upon complexity (measure of common unit of change) theory, the methodology asserts that core processes within an organization process inputs and add value to those inputs, changing the inputs into outputs through some application of change, thereby producing an output that has exhibited a transformation from the original input. The theory states that the difference (i.e., change) between the inputs from that of the outputs is the value provided by the organization's assets (i.e., people, processes or IT systems) which acted upon the inputs. In this manner, we can see that the knowledge within a process is proportional to the amount of change made to an input to produce the output. This knowledge value, measured in standard units of output, facilitates the analysis of multiple, differing processes throughout an organization, and empowers management to make more informed decisions concerning their core processes.

Knowledge embedded in core processes of an organization can now be evaluated and compared across the entire organization. KVA produces a common unit of knowledge that serves as a surrogate for units of output in a standard way (Housel and Bell, 2001), and in doing so, provides a decision support mechanism for those within the organization to make more informed decisions concerning the insertion of information technology into the processes. With a better understanding of where knowledge assets reside, a more in depth evaluation of an organization's processes can be achieved where efficiencies can be expanded upon and deficiencies can be rooted out and changed.

2. KVA Assumptions

With any methodology or framework there are certain assumptions that must be addressed so that a basic understanding can be agreed upon and the level of uncertainty can be mitigated. With KVA, the following assumptions apply:

1. There must be an input, a process that acts upon the input to produce an output.

2. The type of process (i.e., IT system, employees, procedures etc.) which acts upon the input is irrelevant to the measure of change.
3. Should the input equal the output, then there was no change, nor any value added from the process.
4. Value created by the process is relative to the change that the process applies to the input.
5. Change is measured by the amount of knowledge required to produce the change.
6. Accepting 4 and 5 above, value and knowledge are then related.
7. Knowledge can be defined as the amount of time it takes an average learner to acquire the knowledge.

These assumptions are visually represented in Figure 5, below.

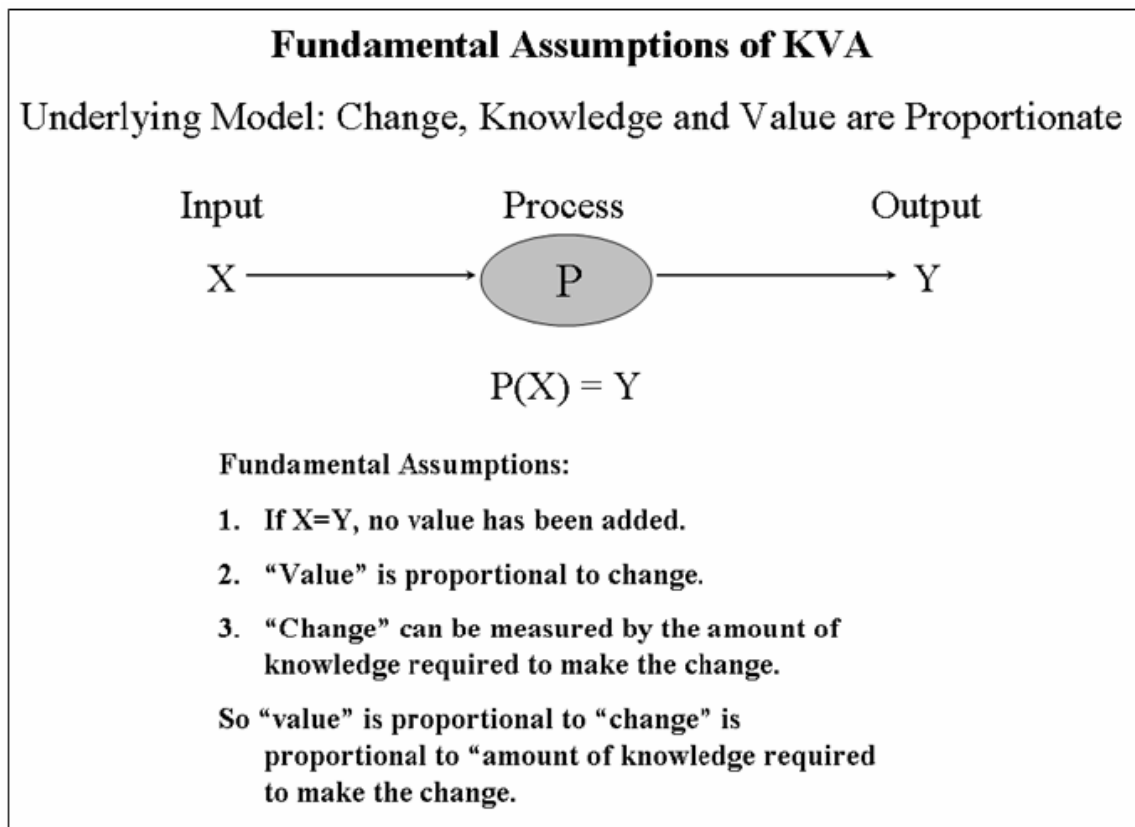


Figure 5. Assumptions of KVA (Housel and Bell, 2001)

3. KVA Approaches

The KVA methodology presents a very robust and dynamic framework that can use three different approaches for capturing the knowledge inherent in the core processes within an organization. While these approaches vary in application, neither is better or worse than the other, they simply present different collection means for deriving a result. It is important to note that once an approach is decided upon, it should be applied consistently throughout the organization. Processes cannot be correctly evaluated if they use differing approaches to determine their value. While the learning time approach is applicable to this thesis, each of the three methods is described in Table 4.

| Steps | Learning Time | Process Description | Binary Query Method |
|-------|--|--|--|
| 1 | Identify core process and its sub processes. | | |
| 2 | Establish common units and level of complexity to measure learning time. | Describe the products in terms of the instructions required to reproduce them and select unit of process description. | Create a set of binary yes or no questions such that all possible outputs are represented as a sequence of yes or no answers. |
| 3 | Calculate learning time to execute each sub process. | Calculate number of process description words, pages in manual, and lines of computer code pertaining to each sub process. | Calculate length of sequence of yes or no answers for each sub process. |
| 4 | Designate sampling time period long enough to capture a representative sample of the core processes final product or service output. | | |
| 5 | Multiply the learning time for each sub process by the number of times the sub process executes during the sample period. | Multiply the number of process words used to describe each sub process by the number of times the sub process executes during sample period. | Multiply the length of the yes or no string for each sub process by the number of times the sub process executes during sample period. |
| 6 | Calculate cost to execute knowledge (learning time and process instructions) to determine process costs. | | |
| 7 | Calculate ROK and ROP and interpret the results. | | |

Table 4. Three Approaches to KVA (Housel and Bell, 2001)

a. *Learning Time*

This approach uses a measurement based on the time it would take an average person to learn the process in question. The measurements must be in common units of time (i.e., hours, days, weeks etc.) and should be verifiably reliable. To obtain the learning time measurements, all time required to learn the process must be indicated. This may include training at a formal school, on-the-job-training (OJT), distance education and any other source of training that would be relevant to the generation of an output by means of the process indicated. Generally SME's, training manuals and standard operating procedures can provide a means for determining the actual learning time, although this type of information gathering can be prone to subjectivity. To avoid this and mitigate the risk of obtaining erroneous data, a correlation among two estimates can be calculated to ensure the most reliable and accurate data has been provided. Correlation can be achieved by obtaining an ordinal ranking based on the difficulty to learn each sub process within the organization. SME's are asked to rank order each sub process in order of difficulty to learn. This ranking is then correlated against the actual learning time data that was provided. Should the two provide a correlation of 80% or greater, the data can be considered to be reliable. A correlation below 80% assumes a discrepancy in either the rank order or the actual amount of learning time required for each process. This can occur when SME's do not completely understand the problem domain and provide learning time estimates that are faulty. Restructuring the learning time question or requesting a revalidation will normally be required.

b. *Process Description*

This approach measures the number of instructions needed to reproduce the outputs produced. Using the process description approach enables the KVA methodology to achieve a higher level of detail in the process description than does the learning time approach. It requires a more detailed and analytical description of each process and the amount of instructions needed to produce each output. The process instructions are calibrated in terms of their complexity.

c. Binary Query

Utilizing the binary query approach requires the creation of a set of binary yes/no questions such that all possible outputs are represented as sequences of yes/no answers (i.e., bits). These sequences can then be calculated and value can be attributed to the outcome.

B. RETURN ON KNOWLEDGE (ROK)

Return on Knowledge (ROK) is the ratio of revenue allocated to each core area compared to its corresponding expenses (Housel and Bell, 2001). The essence of KVA is found in the ROK ratio that the methodology provides. As stated earlier, knowledge is a surrogate for common unit outputs, so ROK provides a means for determining a 24 knowledge value to cost ratio for all processes within an organization. Proper application and analysis of ROK can provide an organization with a better understanding of the productivity of its knowledge assets, where they are located and how efficiently they are being applied throughout the organization. For non-revenue generating organizations this can be a force multiplier for validating processes and IT systems.

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