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# THESIS

**AN ANALYSIS OF RETURN ON INVESTMENT OF THE CONSOLIDATED AFLOAT NETWORKS AND ENTERPRISE SERVICES (CANES) PROGRAM**

by

Aleron B. Rognlie

June 2010

Thesis Co-Advisors:    Kenneth Euske
                       Douglas Brinkley

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The thesis focuses on quantifying the possible benefits of upgrading the current shipboard network system to the CANES system, and determining whether those benefits are likely to be realized in actual operations.

The researcher calculated a CANES ROI of 73 percent. A sensitivity analysis was performed to examine how ignoring cost avoidance affects the calculated value of ROI, along with how much other input factors would have to change in order to make the CANES investment unattractive.

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**AN ANALYSIS OF RETURN ON INVESTMENT OF THE CONSOLIDATED
AFLOAT NETWORKS AND ENTERPRISE SERVICES (CANES) PROGRAM**

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Submitted in partial fulfillment of the
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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACS | Afloat Core Services |
| ADNS | Automated Digital Network System |
| AoA | Analysis of Alternatives |
| BY | Base Year |
| C4ISR | Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance |
| C&E | Consolidate and Enhance |
| CANES | Consolidated Afloat Network and Enterprises System |
| CCE | Common Computing Environment |
| CDS | Cross-Domain Solutions |
| CENTRIXS | Combined Enterprise Regional Information Exchange System |
| CND | Computer Network Defense |
| DCGS-N | Distributed Common Ground System – Navy |
| DMS | Defense Messaging System |
| DoD | Department of Defense |
| EA | Early Adopter |
| FL | Force Level Ship |
| FOC | Full Operational Capability |
| FY | Fiscal Year |
| GCCS-M | Global Command and Control System – Maritime |
| HM&E | Hull, Mechanical, and Electrical |
| ISNS | Integrated Shipboard Network System |
| IP | Internet Protocol |
| IT | Information Technology; Information Systems Technician |
| LAN | Local Area Network |
| LCCE | Life Cycle Cost Estimate |
| MOE | Measures of Effectiveness |
| MOP | Measures of Performance |
| MTBF | Mean Time Between Failures |

| | |
|---|---|
| NAVMACS II/SMS | Navy Modular Automated Communications System II – Single Messaging Solution |
| NCES | Net-Centric Enterprise Service |
| NTCSS | Naval Tactical Command Support System |
| OSD | Office of the Secretary of Defense |
| PA&E | Program Analysis and Evaluation |
| POR | Program of Record |
| PV | Present Value |
| ROI | Return on Investment |
| SCI LAN | Sensitive Compartmented Information Local Area Network |
| SI | Special Intelligence |
| SOA | Service Oriented Architecture |
| SQ | Status Quo |
| SUB | Submarine |
| SUBLAN | Submarine Local Area Network |
| SVDS | Ships Video Distribution System |
| UL | Unit Level Ship |
| VIXS | Video Information Exchange Systems |
| VTC | Video Teleconference |

# EXECUTIVE SUMMARY

The purpose of this thesis is to calculate a value for the return on investment (ROI) of the Consolidated Afloat Networks and Enterprise Services (CANES). CANES is the next generation of computer networks for U.S. Navy ships, which is meant to replace the aging system of networks currently deployed throughout the fleet. It is comprised of three elements, Common Computing Environment (CCE), Cross Domain Solutions (CDS), and Afloat Core Services (ACS).

The researcher examined previous work performed by the CANES team in the development of a business case for CANES. This thesis also includes a section discussing some of the intangible benefits of CANES and the difference between cost savings and cost avoidance.

The thesis focuses on quantifying the possible benefits of upgrading the current shipboard network system to the CANES system, and determining whether those benefits are likely to be realized in actual operations. Table 1 is a summary of the discounted benefits of CANES and the discounted net investment required to run the CANES program.

| ROI CALCULATION (BY10$, in thousands) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Total |
| Discounted Benefits | 492 | 1489 | 3969 | 7079 | 9717 | 9267 | 8734 | 32913 | 30823 | 28826 | 27046 | 25294 | 23687 | 22135 | 20754 | 19422 | 271647 |
| Discounted Investment | 84273 | 189227 | 235475 | 216807 | 240766 | -22860 | -21423 | -20426 | -79244 | -66066 | -31075 | -98215 | -79163 | -45131 | -88105 | -44096 | 370744 |

Table 1.    Summary of Yearly CANES Benefits and Investment

The researcher calculated a CANES ROI of 73 percent. A sensitivity analysis was performed to examine how ignoring cost avoidance affects the calculated value of ROI, along with how much other input factors would have to change in order to make the CANES investment unattractive. The researcher concluded, based on the sensitivity analysis, that the ROI is sensitive to changes

in manpower cost reductions and insensitive to changes in CANES installation costs, operational software maintenance costs, phase out costs for legacy networks, and costs to perform technical refreshment.

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# I.    INTRODUCTION

## A.    PURPOSE

The researcher develops a value for return on investment (ROI) for the Consolidated Afloat Networks and Enterprise Services (CANES) program. Lawmakers and U.S. Navy leadership would like to know how this program will impact future costs, so that informed decisions can be made regarding upgrades to the current state of shipboard information technology (IT) networks.

## B.    BACKGROUND

### 1.    Primer on Networks

In order to understand what CANES is supposed to accomplish for the U.S. Navy's shipboard network environment, a foundation in the basic operation of computer networks is necessary.  A local area network, or LAN, is a collection of computers or other devices connected via some sort of communications channel (wired or wireless) that allows users to communicate and share resources with other users.[1]

For large enterprise-scale LANs of the type the U.S. Navy deploys on ships, these computers are organized in a client-server relationship.  A server is typically a powerful computer that runs specialized software that allows it to "serve" information requests from the computers users are operating, called clients.  Often servers will simply share files or other data with the clients, but they can also run e-mail systems, Internet sites, or host applications for the client

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[1] Tracy V. Wilson and John Fuller, "How Home Networking Works," HowStuffWorks, http://computer.howstuffworks.com/home-network5.htm (accessed March 3, 2010).

computers to access.[2]   Microsoft's Windows Server 2003, Sun Microsystems' Solaris 10, and Novell's NetWare 6.5 are all examples of operating systems that run on computers acting as servers.

To get servers to communicate with client computers, they need to be connected by switches.  Switches are hardware components that control the flow of information between different sections of the network that are connected to each other, called "nodes."  The switches quickly send information from one node to the correct node instead of every node in the network, which greatly speeds up data transmission.[3]

When data are exchanged between networks, instead of within different nodes of the same network, the data must be sent through a router.  The router is a specialized piece of network equipment that will examine the destination address of the data, determine where the information is supposed to go, and use that address to do two main jobs—make sure information does not travel where it is not needed, and make sure information gets to its proper destination.[4] Essentially, any time information must flow between two different networks, the router tells it where to go and how to get there.

The final piece of hardware to get a LAN connected to the Internet is a modem.  A modem (modulator-demodulator) takes the digital information that is being sent on a network, and changes it into a form that can be transmitted by satellite, cable television line, phone line, or some other transmission media.

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[2] PC World Staff, "Server Operating Systems," PC World, http://www.pcworld.idg.com.au/article/151491/server_operating_systems/ (accessed March 5, 2010).

[3] Jeff Tyson, "How LAN Switches Work," HowStuffWorks, http://computer.howstuffworks.com/lan-switch4.htm (accessed March 5, 2010).

[4] Linksys, "How Routers Work," http://www.linksysbycisco.com/static/us/Learning-Center/Network-Basics/Network-Hardware/How-Routers-Work/index.html (accessed March 4, 2010).

Likewise, a modem will take signals from the external transmission media and convert them to digital form to use in the network.[5]

All these components can be combined to make most types of networks found in both home and business environments. The U.S. Navy is no different—it just has to use more specialized components suited for shipboard use. In its most basic form, a shipboard computer network uses a client-server approach with several powerful computers acting as servers. All the workstations that sailors use act as clients. The computers are connected across the various network nodes by switches to ensure fast data flow, and a router controls the flow of data between networks (there are often several different networks on each ship). The router also interfaces with the modem (or is integrated with the modem) to handle the flow of data on and off the ship via satellite or radio communications. Figure 1 illustrates a very basic shipboard LAN configuration.
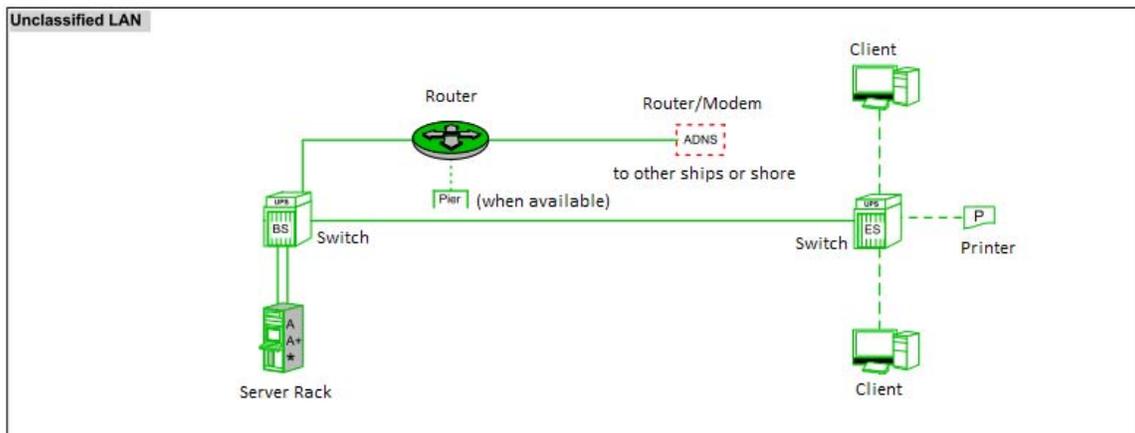


Figure 1.    Basic Shipboard LAN[6]

Although the layout of a shipboard network is similar to most other computer networks, there is a difference in that the hardware used must be adapted to an at-sea environment. One example of this equipment is the

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[5] Marshall Brain, "How Modems Work," HowStuffWorks, http://computer.howstuffworks.com/modem.htm (accessed March 10, 2010).

[6] PMW 165 Naval Afloat Networks, "DDG-51 Class," *Functional Baseline Configuration Integrated Shipboard Network System*, August 21, 2001.

Automated Digital Network System (ADNS). ADNS is the router that allows the shipboard network to communicate off-ship. It provides ship-to-ship and ship-to-shore Internet Protocol (IP) connectivity by efficiently using whatever off-ship communication bandwidth is available. The terminals (shown in Figure 2) automatically and dynamically consolidate outgoing voice, data, and video into a standard IP stream that can be sent via satellite or line-of-site communications systems modems.[7]



Figure 2.    Typical shipboard ADNS terminal[8]

The major shipboard network systems that CANES promises to integrate are the Integrated Shipboard Network System (ISNS), Submarine Local Area Network (SUBLAN), Combined Enterprise Regional Information Exchange

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[7] U.S. Navy, "Vision Presence Power 2005: A Program Guide to the U.S. Navy," U.S. Navy, http://www.navy.mil/navydata/policy/vision/vis05/top-v05.html (accessed April 3, 2010).

[8] Ibid.

System-Maritime (CENTRIXS-M), the Sensitive Compartmented Information Local Area Network (SCI LAN), and the Video Information Exchange Systems (VIXS) and Ships Video Distribution System (SVDS). These network systems are described in the following section:

### a.    ISNS

ISNS is a system of hardware and software that together make up the legacy network infrastructure on surface ships throughout the fleet. It is derived from a combination of even older programs of record (POR) in order to provide basic LAN services across all U.S. Navy ships. It supports all classification levels (Top Secret to Unclassified) via separate hardware (i.e., computer terminals, network switches, servers, and associated cabling) for each network level.[9]

### b.    SUBLAN

SUBLAN is essentially the submarine variant of ISNS. It handles the same classification levels and serves a similar function, just for U.S. Navy submarines.[10]

### c.    CENTRIXS-M

The CENTRIXS-M network was developed to enable IP communications (e-mail, Web, and chat) between U.S. Navy and allied ships. This separate communications network interfaces with ADNS, enabling high-speed data transfer among seven different allied groups, including Japan, South Korea, NATO, and the Global Counter-Terrorism Task Force.[11]

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[9] U.S. Navy, "Vision Presence Power 2005: A Program Guide to the U.S. Navy," http://www.navy.mil/navydata/policy/vision/vis05/top-v05.html (accessed April 3, 2010).

[10] Ibid.

[11] Ibid.

#### d. SCI LAN

The SCI LAN provides a separate network for receipt and transmission of Special Intelligence (SI) and SCI data that satisfies the U.S. Navy's criteria for computer security. The network architecture is able to handle secure voice, video, and data transfer among SCI-capable platforms.[12]

#### e. VIXS/SVDS

The Video Information Exchange Systems (VIXS) and Shipboard Video Distribution System are add-on networks installed on ships to support video exchange, streaming video distribution, and Video Teleconferences (VTC). As of 2008, there were approximately 100 such systems in the fleet, with five different variants.[13]

### 2. Current Fleet Network Status

The U.S. Navy fleet has over 640 legacy systems that comprise the shipboard IT network environment. These systems continue to be used because they still meet the U.S. Navy's current needs, even though they do not do the job as well as a newer system and will not be able to meet the needs of the Navy in the future. There are over 17 variants for hardware, 6 separate operating system variants, and 380 application versions of the software sailors use scattered throughout the fleet.[14]

A typical U.S. Navy large surface combatant, such as a Ticonderoga-class cruiser or Arliegh Burke-class destroyer, has at least thirteen separate local area

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[12] U.S. Navy, "Vision Presence Power 2005: A Program Guide to the U.S. Navy," http://www.navy.mil/navydata/policy/vision/vis05/top-v05.html (accessed April 3, 2010).

[13] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

[14] Kevin Clarke, "Consolidated Afloat Networks and Enterprise Services (CANES) Overview: CANES Top 100 – Part 1 – Program Overview" (PowerPoint Presentation for PEO C4I PMW 160, August 21, 2009).

networks (LANs).[15] These networks do not "talk" to each other—each one has separate hardware (including cabling) and separate software, which effectively creates "stovepipes" of information. In addition, each one of these networks is managed separately. Each one has its own update process for hardware and software, as well as its own system for security updates.[16]

The concern over duplicate infrastructures and applications currently fielded on ships has reached the top levels of the U.S. Navy. At the Annual Fleet N6 Conference at the Naval Network Warfare Command in 2006, the FY07 Numbered Fleet Top Ten C4 Requirements were laid out, in part stating:

> The deployment of many Service-Oriented Programs (Maintenance, Administration, QOL, etc.) have (sic) resulted in unique networks deployed on ships that adversely load the existing ISNS backbone. These systems are neither accounted for nor integrated with existing shipboard networks, except as required to allow off-ship connectivity. All IP Networks, regardless of purpose, must be consolidated under the future network consolidation program, CANES, to ensure warfighting networks are not adversely affected and to allow a common view into the IP shipboard architecture.[17]

It is estimated that the U.S. Navy spends $1.6 billion every year in legacy costs for this current system of shipboard networks.[18] That figure is only expected to increase as components need to be replaced. The mean time between failures (MBTF) rate is getting worse as the networks age. Current shipboard networks operate with a 95 percent readiness, but even that is not

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[15] Clarke, "Consolidated Afloat Networks and Enterprise Services (CANES) Overview."

[16] Ibid.

[17] Commander U.S. Navy Second Fleet, "COMSECONDFLT FY07 NUMBERED FLEET TOP TEN C4 REQUIREMENTS" (Naval Message 071908ZSEP06, September 7, 2006).

[18] Rita Boland, "Ideas Become Reality As New Strategies Unfurl," *Signal* (May 2008): 45.

good enough.  To fully support mission critical applications, a shipboard network must have a threshold of 99 percent readiness, with an objective readiness of 99.9 percent.[19]

### 3. CANES

The CANES program is being developed to address the issues of the legacy shipboard network situation.  The stated goals of the CANES program are:

1. Build a secure afloat network required for Naval and Joint operations.

2. Consolidate and reduce the number of afloat networks through the use of mature cross-domain technologies and Common Computing Environment (CCE) infrastructure.

3. Reduce the infrastructure footprint and associated costs for hardware afloat.

4. Provide increased reliability, application hosting, and other capabilities to meet current and projected Warfighter requirements.

5. Federate Net-Centric Enterprise Service (NCES) Afloat Core Services (ACS) to the tactical edge to support overall DoD (Department of Defense) Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) applications migration to a Service Oriented Architecture (SOA) environment.[20]

CANES is separated into three elements, which will function together to meet the project's stated goals:

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[19] Clarke, "Consolidated Afloat Networks and Enterprise Services (CANES) Overview.").

[20] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Acquisition Plan (January 2009).

### a.   CCE

The first element is the Common Computing Environment (CCE), which effectively consolidates a ship's network hardware into a common networked core, instead of operating as many separated groups of dissimilar hardware.  This way the hardware and operating software for shipboard networks will all fall under a single POR for centralized management instead of the scattered duplication of infrastructures that exist today.  CCE allows the core network to host virtual versions of legacy applications, without the redundant hardware that the legacy programs required.  It will also standardize the delivery of security updates, and allow for a more managed approach to fleet-wide hardware and software updates to ensure shipboard networks remain relatively modern.[21]

### b.   CDS

The second element is Cross Domain Solutions (CDS), which allows different levels of security classification systems to all run together on the same client workstation.  CDS also allows users to set permission levels on data so that the same information could be accessed between security levels, while still maintaining the ability to prevent the flow of information across security domains on a case-by-case basis.[22]

### c.   ACS

The final element is Afloat Core Services (ACS), which takes a service oriented architecture (SOA) approach to decouple the hardware from dedicated software, and instead allow software developers to avoid having to re-write duplicate functionality and use existing plug-in solutions to supply or

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[21] Clarke, "Consolidated Afloat Networks and Enterprise Services (CANES) Overview."

[22] Ibid.

transform data.[23]  For example, if an application writer wants to include the ability to display information collected from a ship's sensors on a map, he or she wouldn't have to write detailed code for each part—both the map display functionality and the sensor information aggregation would already exist as services, so the application writer could take those standard services and focus on providing enhanced features rather than on re-writing code that already exists.

Figure 3 shows how CANES is an evolution of the current shipboard network environment.  The CCE will replace the separate ISNS, SUBLAN, SCI LAN, and CENTRIXS-M networks while maintaining their capabilities via CDS and ACS.  The CCE will then interface with ADNS to enable ship-to-ship and ship-to-shore IP connectivity.  CANES is not designed to replace the hull, mechanical, and electrical network (HM&E) that controls shipboard equipment at a low level, nor will it replace the combat systems networks that control the weapons, navigation, and fire control systems.

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[23] David Perera, "CANES to consolidate shipboard networks," Federal Computer Week, http://fcw.com/articles/2009/02/23/ngen-canes-to-consolidate-shipboard-networks.aspx, February 19, 2009 (accessed April 5, 2010).
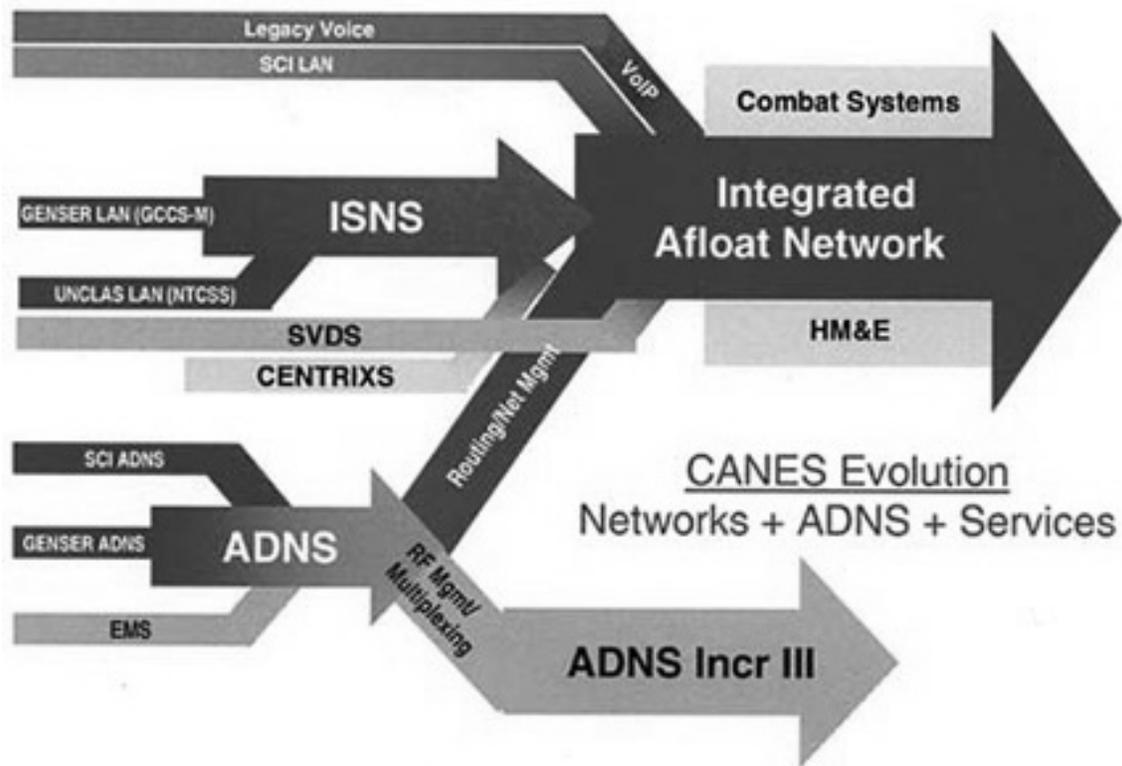
Figure 3. CANES Evolution[24]

CANES promises several benefits to U.S. Navy ships over the current system of installed networks. It will use fewer physical server racks, lowering overall ship weight and freeing up space for other uses. CANES will provide for centrally managed security management by remotely applying security patches, which could lead to improved shipboard network security. Ships that upgrade to CANES are also expected to have a higher network availability than current network systems, by increasing the mean time between failures while reducing time required to recover from a failure.[25]

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[24] Clarke, "Consolidated Afloat Networks and Enterprise Services (CANES) Overview."

[25] Ibid.

## C.    RESEARCH QUESTIONS

Primary Research Question:

What is the value for a comprehensive ROI for the CANES program?

Secondary Research Questions:

1.    What are the savings for the CANES program (versus cost avoidance)?

2.    Which predicted benefits can be monetized?

# II.    PRIOR WORK

## A.    CANES ANALYSIS OF ALTERNATIVES

### 1.    AoA Process

During the procurement process for Department of Defense (DoD) programs, an agency is required to conduct an analysis of alternatives (AoA) to determine the scope and requirements of the program per DoD instruction 5000.02. For the CANES program, this was completed on October 31, 2008.

Under DoD guidelines, the AoA is separated into two phases.  The first phase has four tasks:

- Identify the operational imperative for change, along with any new requirements that imperative brings

- Identify possible risks for the planned technologies

- Using the requirements and risks, identify viable alternatives

- Determine appropriate Measures of Effectiveness (MOE) and Measures of Performance (MOP) that are objective and can be quantified

The second phase of the AoA has two tasks: establish the status quo, or baseline, and then evaluate the alternatives identified in the first phase.  The evaluation consists of an effectiveness analysis, a risk analysis, and a cost estimation analysis.  Those factors are combined into an overall cost-effectiveness analysis to determine which alternative best meets the required need.

### 2. Viable Alternatives

Three alternatives were considered in the first phase of the AoA process that met the material effectiveness requirement. The first of these alternatives is called Consolidate and Enhance (C&E), which involves collapsing the existing shipboard networks into three network backbones, separated by their security domains (Unclassified, Secret, and SCI). The management of the three combined networks would fall under a single POR that would encompass the CANES program's three elements (CCE, ACS, and CDS). The second alternative is called Consolidate and Enhance with Two PORs (C&E 2 POR), which is materially the same as Consolidate and Enhance, but separates CCE and ACS as two separate functional areas, each with its own POR for acquisition. The third alternative is called Consolidate and Enhance With Two Sub-Programs (C&E 2 Sub-Prog), and again it is materially the same as the first two alternatives, but CCE and ACS would be treated as separate increments (or sub-programs) within the same POR. The system could then be fielded in parts in a phased deployment to mitigate the risk if the ACS element is not technically mature when the CCE element is ready for installation in the fleet.

### 3. Analysis

Although the performance of an AoA requires risk, effectiveness, and cost analysis, the researcher examined only the cost analysis portion of the AoA. The cost analysis was based on developing a complete Life Cycle Cost Estimate (LCCE) for the three identified alternatives. The life cycle of each alternative was defined as from "the initial implementation period through Full Operational Capability (FOC) plus ten years of operation."[26] For the three viable alternatives, then, the period to be analyzed was from FY2010–FY2026.

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[26] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

The cost analysis produced full LCCEs for each alternative as well as one for the status quo, which are all included in the Appendix (Tables 22–25). Some of the important assumptions used in developing the LCCEs are:

- January 2008 Office of the Secretary of Defense (OSD) inflation indices were used.

- For the status quo, a technical refresh (shipwide network improvement) was assumed to occur every three years for software and every six years for hardware.

- Technical refresh for the viable alternatives was assumed to occur every two years for software and every four years for hardware.

- Any ship within five years of decommissioning was not included in the technical refresh plans.

- All costs were estimated based on available data.

- Costs to migrate applications to CANES were estimated using five programs (called Early Adopters) as a representative sample. The five Early Adopter (EA) programs were:

  - Global Command and Control System-Maritime (GCCS-M)

  - Distributed Common Ground System-Navy (DCGS-N)

  - Naval Tactical Command Support System (NTCSS)

  - Computer Network Defense (CND)

  - Navy Modular Automated Communications System II-Single Messaging Solution (NAVMACS II/SMS) Defense Messaging System (DMS) Proxy programs

The reason these assumptions are highlighted is that the researcher used similar assumptions for the ROI calculations in this thesis. The researcher's assumptions are addressed in the Analysis section.

The equation (Figure 4) the AoA team used to calculate each alternative's ROI is based on the Office of the Secretary of Defense (OSD) Program Analysis and Evaluation (PA&E) recommended cost difference model, which compares the costs to maintain the status quo to the costs of each alternative.

$$ROI = \frac{B + \sum\limits_{t=EOI}^{N} \dfrac{Cost_{SQ}^{t} - Cost_{ALT}^{t}}{(1+d)^{t}}}{\sum\limits_{t=0}^{t=FY26} \dfrac{ALT_{1}^{t}}{(1+d)^{t}}}$$

Figure 4.    AoA ROI Equation[27]

The numerator for the formula is the present value (PV) of the differences in the cost between the each alternative and the status quo, where d is the discount rate for the period, t is the time, EOI is the end of the increment, N is the period of interest (in this case, FY 2026), and B is intangible benefits.  Any intangible benefits that could not be monetized were ignored for the purposes of the AoA, which set B equal to zero.  The denominator is the PV of the amount of funds invested to deploy and operate the alternative.

Based on the results of the LCCE for the three alternatives, compared to the estimated costs of the status quo, the AoA team generated a summary table (Table 2) showing the estimated ROI for each alternative.

| Alternative | Consolidate and Enhance | Consolidate and Enhance With 2 Sub-Programs | Consolidate and Enhance With 2 PORs |
|---|---|---|---|
| Discounted ROI | 99% | 95% | 74% |

Table 2.    AoA ROI Results[28]

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[27] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

[28] Ibid.

Also based on the same cost estimates, the AoA team developed a break-even analysis graph (Figure 5), which shows the point where the viable alternative's total costs are less than the status quo. Note that the curves for C&E and C&E 2 Sub-Prog are difficult to distinguish because the spending profiles for those alternatives are so similar.
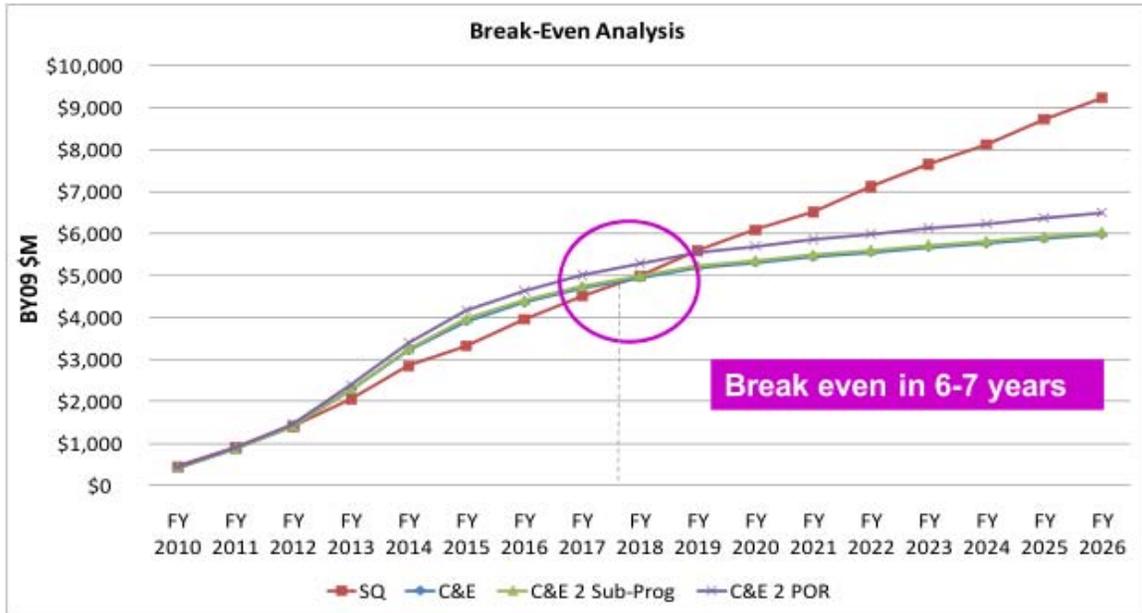


Figure 5.    AoA Break-Even Analysis[29]

The analysis shows that the alternatives should have a break-even point approximately 6–7 years after Initial Operational Capability in FY2011.

### 4.    Result of AoA

The preferred alternative that the CANES AoA team chose was the Consolidate and Enhance with 2 Sub-programs, for the following reasons:

- It provides for separate visibility of CCE and ACS acquisitions under one Program of Record (POR).

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[29] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

- CCE would be able to proceed if ACS was delayed.

- It delivers a much-needed technology refresh to aging legacy systems.

- It reflected the best cost/utility in support of warfighter requirements.[30]

## B. PRELIMINARY COST SAVINGS

Since the publication of the AoA, a trial version of CANES has been installed on two ships for testing and evaluation, USS ABRAHAM LINCOLN (CVN 72) and USS CAPE ST GEORGE (CG 71). The CANES team was able to use cost information from the hardware and software installation while the ships were in shipyards in FY 2009 to generate more detailed data on how much it would cost to deploy CANES throughout the fleet. First, the CANES team determined the cost to procure and install the legacy network system on the two ships being upgraded. Then, they calculated the costs to procure and install the Early Adopter (EA) version of CANES being used for testing, which hosts 22 applications as services on USS ABRAHAM LINCOLN and 16 applications on USS CAPE ST GEORGE. The cost summaries that the CANES team generated from these new data are included as Tables 3 and 4. Items that are highlighted in grey are estimates from the CANES team; all other numbers are actual costs. Note that ISNS has a higher cost under CANES. The reason for the increased cost is due to higher server requirements on the core ISNS system for the virtualization requirements to host all the other installed systems under CANES.

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[30] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

| System | Initial Network Installation ($K) | Early Adopter ($K) |
|---|---|---|
| AIS | $93 | $24 |
| NITES/VNE-NCS | $237 | $0 |
| GCCS-M | $2,600 | $305 |
| NTCSS | $767 | $153 |
| CfN | $726 | $108 |
| CND | $518 | $71 |
| USW-DSS | $500 | $20 |
| NIAPS | $726 | $70 |
| ARRS - CAS | $363 | $75 |
| ARRS - MRAS | $363 | $75 |
| ARRS - CASREP | $363 | $75 |
| ARRS - IRRI | $363 | $75 |
| TMIP-M | $726 | $15 |
| MCMS | $726 | $237 |
| OOMA | $726 | $18 |
| MEDAL | part of GCCS-M | part of GCCS-M |
| AMSRR | $726 | $237 |
| CV Sharp | $726 | $237 |
| DCGS-N BLK I ECP | $3,420 | $2,455 |
| DIOS-S | unknown | unknown |
| ISNS | $11,467 | $18,643 |
| Total: | $26,137 | $22,893 |

Table 3.    USS ABRAHAM LINCOLN Early Adopter Cost Comparison[31]

[31] PEO C4I PMW 160, "Early Adopters ROI.xls" (Excel Spreadsheet data for PEO C4I PMW 160, May 6, 2010).

| System | Initial Network Installation ($K) | Early Adopter ($K) |
|---|---|---|
| NITES/VNE-NCS | part of ISNS | part of ISNS |
| GCCS-M | $525 | $90 |
| NTCSS | $229 | $95 |
| CND | $352 | $25 |
| USW-DSS | $400 | $20 |
| NIAPS | $726 | $70 |
| ARRS - CAS | $363 | $75 |
| ARRS - MRAS | $363 | $75 |
| ARRS - CASREP | $363 | $75 |
| ARRS - IRRI | $363 | $75 |
| TMIP-M | $726 | $15 |
| MCMS | $726 | $237 |
| MEDAL | $726 | $237 |
| NEURS | $726 | $237 |
| DIO-S | unknown | unknown |
| ISNS | $3,328 | $6,152 |
| **Total:** | **$9,917** | **$7,477** |

Table 4.    USS CAPE ST GEORGE Early Adopter Cost Comparison[32]

According to the CANES team ROI brief, as more legacy systems are moved to a hosted environment (from 17 and 22 hosted applications for Early Adopters to 42 hosted applications with CANES), the cost savings would be even higher.

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[32] PEO C4I PMW 160, "Early Adopters ROI.xls" (Excel Spreadsheet data for PEO C4I PMW 160, May 6, 2010).

# III. METHODOLOGY

## A. OVERVIEW

The researcher used the framework of the AoA to guide the generation of a ROI.  The basic calculation of the ROI from the AoA is the same, but with the addition of updated information available since the AoA was published in 2008, along with some estimates made using case studies to monetize benefits that were not addressed in the AoA.

The first step was to determine the time period for the analysis.  The AoA used a period of 17 years, from FY 2010 to FY 2026.  The researcher used a similar time period, but chose to ignore FY 2010 and only focus on FY 2011 to FY 2026 because anything prior to FY2011 is a sunk cost and is not relevant to the ROI.

Next, the researcher collected cost data and estimates relevant to the initial ship installs and upgrades portion of the CANES project.  The most recent data and schedules were used wherever possible, with the actual cost data coming from the AoA or CANES project team.

To monetize the benefits of CANES, the researcher used case studies from private industry and the government to quantify the less tangible benefits of the CANES program.  For example, when examining the possible savings on manpower, the 2009 study by the RAND Corporation on the effects of the CANES project provided valuable information on how manpower requirements might be impacted by the use of CANES in the fleet.  These case studies were then used to develop estimates for the different benefits examined.

Once all the data and estimates were collected, the researcher adjusted the values to ensure they were all stated in Base Year (BY) 2010 thousands of dollars, by using the appropriate inflation tables provided by OSD.  This step insured that any comparison of costs would be valid across different years.

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After converting all values to BY 2010 amounts, the researcher used the same calculation for ROI as the AoA team (detailed in the Prior Work section, Figure 4) to allow for ease of comparison between the researcher's results and the AOA team's results, which is presented in the conclusion. Once the base ROI calculation was made, the final step was to perform a sensitivity analysis by adjusting various inputs to the formula to see how they affected the ROI.

## B. COST AVOIDANCE VERSUS COST SAVINGS

Cost avoidance and cost savings are related terms that are sometimes used interchangeably, but it is useful when doing cost estimations to recognize that the terms are not synonymous. Cost avoidance, for the purposes of this thesis, is defined as a possible reduction in money laid out in future periods.[33] An example of a cost avoidance would be a process improvement to reduce future costs in one area or reduce workload of a company's support staff, but the potential benefits may not be realized because they are dependent on cost or workload reductions in other areas being made. The problem is that cost avoidance may be intangible or unrealized.

Cost savings is defined as a method that will meet the project's objectives, but at a lower cost than what was paid historically or quoted by the supplier.[34] Examples of cost savings would be a lowered energy cost by converting an office from incandescent to fluorescent light bulbs—the savings are not dependent on cost reductions in other areas, and are likely to be realized. Cost savings are tangible benefits that can be recorded and programmed in a budget.

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[33] NASPO Benchmarking Workgroup, "Benchmarking Cost Savings and Avoidance," NASPO, http://www.naspo.org/documents/Benchmarking_Cost_Savings__and_Cost_Avoidance.pdf (accessed April 4, 2010).

[34] Penn State Auxiliary & Business Services, "Purchasing," Penn State Auxiliary & Business Services, http://www.purchasing.psu.edu/glossary.shtml (accessed March 24, 2010).

Any benefits identified in this thesis that have an estimated value were identified as either a cost savings or a cost avoidance. The researcher then examined what the ROI would be if all benefits identified as cost avoidances were excluded compared to the standard ROI that includes benefits identified as cost avoidance.

## C.     INTANGIBLE BENEFITS

Potential benefits of CANES that were not possible to monetize are considered intangible benefits for the purposes of this thesis. Multiple benefits fall into this category; for example, the space and weight saved on ships due to consolidating servers onto fewer racks was not monetized. There is a definite benefit to freeing up space and reducing weight on U.S. Navy ships so that extra spare parts could be stored onboard or extra equipment that adds more warfighting capabilities could be installed. However, assigning a specific value to the benefits that could be realized from such factors of CANES is highly subjective, so those benefits are ignored for the ROI calculation.

Any benefits of the CANES program identified in the ROI analysis or introductory CANES description that could not be monetized in this thesis are discussed in the conclusion as items to consider in conjunction with the ROI estimate.

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# IV. ANALYSIS

## A. ASSUMPTIONS

The researcher made the following assumptions to calculate the ROI for the CANES program:

- December 2009 OSD inflation indices were used.

- Technical refresh for CANES was assumed to occur every two years for software and every four years for hardware.

- Any ship within five years of decommissioning was not included in the analysis.

- The only ships considered in the analysis are Aircraft Carriers, Large Surface Combatants, Attack Submarines, Ballistic Missile Submarines, and Amphibious Warfare Ships.

- All costs were estimated based on available data.

The ship type and decommissioning assumptions were chosen to limit the number of ships analyzed to ones that either have cost data available or are similar enough to the ships analyzed so that estimates could be made. The technical refresh assumption is based on the CANES fielding plan that explains the technical refresh schedule, and is necessary to estimate the costs associated with updating shipboard hardware and software. All other assumptions were made to ensure the most recent data were being used.

## B. CANES PROCUREMENT AND INSTALLATION COST

The LCCE for the status quo from the CANES AoA was used as the data source for legacy system costs. These data are presented in the Appendix (Tables 22–25).

For initial CANES installs on ships to be built within the identified time period (FY 2011 to FY 2026), a combination of the Long-Range Naval Construction Plan for FY 2011 (Table 5) and the newest cost information the CANES team developed from the Early Adopters was used.

| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aircraft Carrier | | | 1 | | | | | 1 | | | | | 1 | | | |
| Large Surface Combatant | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 2 |
| Attack Submarine | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| Ballistic Missile Submarine | | | | | | | | | 1 | | | 1 | | 1 | 1 | 1 |
| Big-Deck Amphibious Ships | 1 | | | | | 1 | | | | | 1 | | | | 1 | |
| Small Amphibious Ships | | 1 | | | | | 1 | | 1 | | 1 | | 1 | | 1 | |

Table 5.    FY 2011–2026 Long-Range Naval Construction Plan[35]

According to the Long-Range Naval Construction Plan, Large Surface Combatants include Destroyers (DDG) and Cruisers (CG).  Amphibious warfare ships are not broken down into "Big-Deck Amphibious Ships" (LHA/LHD) and "Small Amphibious Ships" (LPD/LSD) in the Construction Plan chart that Table 5 was based on, but the text of the report describes the sequencing plan for those ships and was used to generate Table 5.[36]

The researcher took the ships from the construction plan and sorted them into three groups: Force Level (FL), Unit Level (UL), Submarines (SUB), as shown in Table 6.  The ships in each group all have similar computer network layouts and capabilities, so the costs for CANES installation are assumed to be identical within the group.  This is the same assumption used by the CANES team, so the data they collected could be used in this analysis.

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[35] Director, Warfare Integration (OPNAV N8F), Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011 (February 2010).

[36] Ibid.

| FL Ship Types | UL Ship Types | Submarine Ship Types |
|---|---|---|
| Aircraft Carriers (CVN) Big-Deck Amphibious Ships (LHA, LHD) Amphibious Command Ships (LCC) | Destroyers (DDG) Cruisers (CG) Small Amphibious Ships (LPD, LSD) | Attack Submarines (SSN) Ballistic Missile Submarines (SSBN) |

Table 6.    Ship Classification Breakdown

The initial installation cost for CANES on each group of ships was based on the data from the CANES team Early Adopters study, which included hardware and software procurement and system installation.  The researcher also included estimated costs the CANES team identified to install 40 hosted applications rather than the limited number from the Early Adopters study in order to get a more representative number for the cost to install the full CANES suite.  An Early Adopter study for submarine platforms could not be identified, so to determine the initial CANES installation cost for submarines, the researcher determined that submarines cost 8.1 percent less to upgrade than UL class ships based on AoA cost data.[37]   Therefore, the cost to perform an initial install of CANES on a submarine could be approximated as being 8.1 percent less than an initial CANES installation for a UL ship.  The initial CANES installation costs used for the ROI calculation are summarized in Table 7.

| CANES Installation Costs (BY10$, in thousands) | | |
|---|---|---|
| FL Install Cost | UL Install Cost | SUB install Cost |
| 33,795 | 10,321 | 9,485 |

Table 7.    Initial CANES Installation Costs[38]

[37] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

[38] PEO C4I PMW 160, "Early Adopters ROI.xls" (Excel Spreadsheet data for PEO C4I PMW 160, May 6, 2010).

The cost to perform initial installs of the legacy shipboard network systems was taken from the same CANES Early Adopter study. Again, submarine legacy installation costs were assumed to be 8.1 percent less than legacy installation costs for UL ships. The initial legacy installation costs are summarized in Table 8.

| Legacy Installation Costs (BY10$, in thousands) | | |
|---|---|---|
| FL Install Cost | UL Install Cost | SUB install Cost |
| 49,373 | 18,630 | 17,121 |

Table 8.     Initial Legacy Installation Costs[39]

Current U.S. Navy ships that required upgrades to CANES used cost data from the AoA based on the amount of work required for the upgrade (major, medium, or minor), which was converted to BY10$ and is summarized in Table 9.

| CANES Upgrade Costs (BY10$, in thousands) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ship Type | FL | | | UL | | | SUB |
| Upgrade Type | Major | Medium | Minor | Major | Meduim | Minor | Medium |
| Cost | 32,635 | 24,795 | 22,901 | 8,875 | 8,105 | 8,074 | 7,446 |

Table 9.     CANES Upgrade Costs[40]

The upgrade cost information was combined with the CANES upgrade schedule from the CANES team (Table 10). Note that all upgrades are due to occur by the end of FY 2016.

| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FL - Major | 0 | 2 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FL - Medium | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FL - Minor | 0 | 0 | 3 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UL - Major | 0 | 1 | 3 | 6 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UL - Medium | 2 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UL - Minor | 0 | 1 | 6 | 9 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SUB - Medium | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 10.     CANES Fleet Upgrade Schedule[41]

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[39] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

[40] Ibid.

The researcher combined all the cost data for initial installations and fleet upgrades to create a summary table of all costs associated with CANES procurement and installation (Table 11) for each year in the analysis.

| CANES Procurement and Installation Cost Summary (BY10$, in thousands) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | TOTAL |
| Initial Installation | 49933 | 39612 | 73407 | 29291 | 39612 | 63086 | 49933 | 53601 | 59418 | 29291 | 83728 | 38776 | 74243 | 29291 | 73407 | 39612 | 826241 |
| Upgrade | 16210 | 98430 | 233357 | 279627 | 277027 | 22901 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 927551 |
| Total | 66143 | 138042 | 306764 | 308918 | 316639 | 85987 | 49933 | 53601 | 59418 | 29291 | 83728 | 38776 | 74243 | 29291 | 73407 | 39612 | 1753792 |

Table 11.    CANES Procurement and Installation Cost Summary

## C.    SOFTWARE COSTS AND BENEFITS

To determine the possible software savings that could be realized with a fleet-wide adoption of CANES, the researcher used three case studies that examined the effect of adopting a Service Oriented Architecture (SOA) by several companies.

The first case study was conducted by IBM in 2006, to determine how businesses were able to use SOA to lower their costs.  The results of the study show companies that transitioned to SOA from their legacy systems were able to reduce their software development cost by 25 percent as well as reducing the time it took to develop the software.[42]

The second case study, by Joshua Greenbaum of Enterprise Applications Consulting from 2006, examined benefits of changing to a SOA by studying how

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[41] Clarke, "Consolidated Afloat Networks and Enterprise Services (CANES) Overview."

[42] Luba Cherbakov et al., "SOA in action inside IBM, Part 1: SOA case studies," IBM, http://www.ibm.com/developerworks/webservices/library/ws-soa-in-action/ (accessed April 10, 2010).

much software code could be reused.  This study determined that businesses could expect a software development cost to be from 13 to 35 percent lower by taking a SOA approach.[43]

The final case study was conducted by LogicLibrary in 2006, and surveyed businesses that implemented large-scale SOAs.  The responses indicated that software development costs using SOA were approximately one-half what was required for traditional software development.  An important finding of the case study was that the cost for the companies to maintain their software applications was reduced by 90 percent when using SOA versus traditional software environments.[44]

Based on the results of the three case studies, the researcher used a value of 25 percent for the expected level of savings that could be realized for software development due to CANES.  The researcher chose a value of 25 percent for software development savings because it was a lower boundary of the estimated savings realized in similar projects identified in the three case studies.  To apply that expected level of savings to the ROI model, the researcher used the status quo costs for software development, testing, and evaluation from the AoA, and lowered those costs by 25 percent.  Table 12 summarizes the expected costs for CANES software, which are used for the software refresh for ships with CANES that occurs every two years.

| CANES Software Refresh Cost Summary (BY10$, in thousands) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | TOTAL |
| Software Refresh Costs | 1075 | 1042 | 751 | 1307 | 857 | 608 | 580 | 526 | 526 | 526 | 526 | 526 | 526 | 526 | 526 | 526 | 10954 |

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[43] Joshua Greenbaum, "Return on Investment for Composite Applications and Service Oriented Architectures: A Model for Financial Success and Enterprise Efficiency," Enterprise Applications Consulting, www.eaconsult.com/articles/SOA_ROI_EACReport.pdf (accessed April 15, 2010).

[44] Jeffrey Poulin and Alan Himler, "The ROI of SOA Based on Traditional Component Reuse," LogicLibrary, www.logiclibrary.com/pdf/wp/ROI_of_SOA.pdf (accessed April 28, 2010).

Table 12.    CANES Software Refresh Cost Summary

The CANES program will reduce the operational costs of software maintenance by an estimated 90 percent, based on the findings of the LogicLibrary case study. The researcher calculated how such a reduction would impact CANES by first converting the status quo costs for operational software maintenance to BY10$ (Table 13).

| Status Quo Operational Software Maintenance costs (BY10$, in thousands) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| Software Maintenance | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5654 | 5607 | 5607 | 5607 |

Table 13.    Status Quo Operational Software Maintenance Cost[45]

The researcher then used the percentage of ships that had transitioned to CANES (from the CANES fleet upgrade schedule) along with the 90 percent expected reduction in operating cost to develop the yearly cost reduction in operational software maintenance due to CANES (Table 14).

| CANES Operational Software Maintenance Cost Reduction (BY10$, in thousands) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Total |
| Software Maintenance Savings | 134 | 536 | 1674 | 3348 | 5022 | 5089 | 5089 | 5089 | 5089 | 5089 | 5089 | 5089 | 5089 | 5046 | 5046 | 5046 | 66563 |

Table 14.    CANES Operational Software Maintenance Cost Reduction

The operational software maintenance cost reduction is considered a cost avoidance for the purposes of this thesis, because the cost reduction cannot be tied to any one cost element for budgeting purposes and may not ever be realized.    The effects of ignoring this cost avoidance are examined in the Sensitivity Analysis section of the thesis.

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[45] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

## D.    POWER SAVINGS

One of the possible benefits of CANES is a reduction in energy use for cooling network hardware, as well as lowered energy use to power all the servers that run the network due to less physical hardware required.  To quantify the savings that could be seen from the reduced energy use, the researcher determined how much fuel would be saved on ships that were not nuclear-powered.  Submarines and aircraft carriers were not included in the analysis because it is difficult to quantify how much nuclear fuel is used for cooling and electricity generation, and how much a given unit of fuel would cost.  The calculations for conventionally fueled ships are more straightforward.  The researcher also assumed that the fuel savings for all ships analyzed could be approximated based on the fuel consumption of an Allison AG9140 Gas Turbine Generator, which generates electricity on destroyers and cruisers and accounts for the generator used on the majority of ships being analyzed.[46]

The CANES team estimated that, for a full CANES install, approximately 22 fewer racks of servers would be required for a FL class ship, and 8 fewer for a UL ship.[47]   Each rack uses 3.3 kilowatts (kw), according to the AoA Cost Effectiveness Report.[48]   Given the fuel usage rate of the Allison Gas Turbine Generators of 15,375 BTU/kw-hr[49], and the energy content of U.S. Navy fuel (Diesel Fuel Marine) of 138,700 BTU/gallon[50], the researcher calculated that each rack that could be removed from a ship would save over 3,204 gallons every year assuming full operation.  Since 50 percent of ships are away from

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[46] Rolls-Royce, "Allison AG9140 and AG9140RF Ship Service Generators Fact Sheet," http://www.rolls-royce.com/Images/MMS%20FS%2053%2008%201%20Allison%20AG9140%20and%20AG9140RF%20_tcm92-9324.pdf (accessed April 13, 2010).

[47] PEO C4I PMW 160, "Early Adopters ROI.xls" (Excel Spreadsheet data for PEO C4I PMW 160, May 6, 2010).

[48] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

[49] Rolls-Royce, "Allison AG9140 and AG9140RF Ship Service Generators Fact Sheet,"

[50] U.S. Department of the Interior, "BTU Conversion Table," www.doi.gov/pam/eneratt2.html (accessed April 15, 2010).

their homeport at any given time[51], the researcher assumed that the ships are operational 50 percent of the time, so each rack removed per ship would therefore save 1,602 gallons of fuel every year.

The Defense Energy Support Center established the standard price for Diesel Fuel Marine as of January 1, 2010, to be $2.81 per gallon.[52] The researcher combined the price of fuel with the yearly amount of fuel saved per rack and the number of racks saved for FL and UL ships, along with the CANES upgrade schedule to produce a yearly breakdown of anticipated fuel savings by transitioning to CANES across the fleet (Table 15).

| Expected CANES Fuel Savings (BY10$, in thousands) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Total |
| Fuel Savings | 181 | 498 | 1303 | 2290 | 3213 | 3349 | 3457 | 3493 | 3602 | 3638 | 3846 | 3883 | 3991 | 4027 | 4199 | 4272 | 49242 |

Table 15.    Expected CANES Fuel Savings

The fuel savings expected due to CANES are classified as cost savings for the purposes of this thesis because the reduced fuel use is directly tied to a reduction in racks installed on ships, making it possible to reflect in a budget process.

Fuel savings are not the only benefit of lowering the number of racks installed on U.S. Navy ships. Each rack weighs 845 pounds, so a FL ship would see a reduction of 18,590 pounds in weight, plus any additional weight reduction due to an expected decrease in required network cabling.[53] This weight reduction and associated space savings from rack removal could allow the ship to carry more spare parts or supplies for extended deployments. The U.S. Navy

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[51] U.S. Navy, "Status of the Navy," http://www.navy.mil/navydata/navy_legacy_hr.asp?id=146 (accessed April 23, 2010).

[52] Defense Energy Support Center, "FY 2010 Standard Prices," https://www.desc.dla.mil/DCM/Files/JAN.01.2010.pdf (accessed April 23, 2010).

[53] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

could install more damage-control equipment for combating ship disasters, or increase the habitability of spaces around the ship by giving the sailors extra room.  Since there are so many possibilities for the resulting space and weight savings, any quantification would be speculative, and those benefits are considered intangible.

## E.    MANPOWER REDUCTION

The RAND Corporation conducted a case study in 2009 that examined the effect of CANES on shipboard IT manning.  The study noted the issues surrounding possible shipboard manpower reduction, including the fact that any reduction may be less than calculated because sailors may still be required to fill other roles on a ship such as for damage control.  The study concludes that a manpower reduction of 6–12 percent per ship could be possible, depending on manning requirements for the rest of the ship.[54]

Several alternatives are presented based on the data from the RAND case study.  The scenario the researcher chose to use for the CANES ROI calculation is that manpower requirements could be reduced by 6 percent compared to the status quo, as this was the most conservative assumption that still showed a benefit to manning reduction.  Because of the uncertainty level in realizing any savings from a manpower reduction, this factor is classified as a potential cost avoidance for the purposes of this thesis.  The possibility that ship manning might not be able to be reduced at all or that a higher than expected manning reduction of 12 percent could be seen is explored later in the sensitivity analysis section.

Based on the assumed 6 percent manpower reduction, the manpower cost avoidance was calculated by multiplying the status quo operational manpower costs by the expected percent reduction and percentage of the fleet converted to CANES, which gives yearly manpower savings in Table 16.

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[54] RAND National Defense Research Institute, Consolidated Afloat Networks and Enterprise Services (CANES) Manpower, Personnel, and Training Implications (RAND Corporation, 2009).

| Expected CANES Manpower Cost Avoidance for 6% Reduction (BY10$, in thousands) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Total |
| Personnel Savings | 114 | 460 | 1467 | 2935 | 4402 | 4461 | 4461 | 44169 | 44169 | 44169 | 44169 | 44169 | 44169 | 44169 | 44169 | 44169 | 415821 |

Table 16.    Expected Yearly CANES Manpower Cost Avoidance


## F.    CALCULATION

The researcher used the same equation to calculate CANES ROI that was used in the AoA report (Figure 4).  To recap, the ROI is the discounted benefits of CANES, divided by the discounted net investment to install and maintain CANES over the status quo.  The researcher chose a discount rate of 7 percent, which is the official discount rate used for evaluating government projects.[55] Because all the cost data is already in BY 2010 dollars, inflation is already taken into account, so the 7 percent discount represents the real discount rate vice a nominal rate.

In addition to the costs and savings identified earlier in the analysis, additional costs must also be included to address the costs to implement and run the CANES program.  These costs include the Program Management costs for both the CCE and ACS, and the hardware refresh costs to update shipboard network hardware every four years.  Table 17 is a summary of costs from the AoA (C&E with 2 Sub-Prog) that have been adjusted to BY10$ and must be included in the ROI calculation.

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[55] Office of Management and Budget, "Circular No. A-94 Revised," www.whitehouse.gov/omb/rewrite/circulars/a094/a094.html (accessed April 22, 2010).

| Summary of Additional CANES Costs (BY10$, in thousands) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Total |
| CCE Management | 13497 | 10463 | 5617 | 6139 | 5176 | 5024 | 1998 | 2037 | 2169 | 2212 | 2257 | 2301 | 2348 | 2394 | 2442 | 2491 | 68564 |
| ACS Management | 1419 | 1099 | 590 | 645 | 545 | 528 | 210 | 214 | 228 | 233 | 237 | 242 | 246 | 252 | 257 | 262 | 7207 |
| CCE Tech Refresh | 0 | 14 | 1990 | 12771 | 39053 | 59528 | 102842 | 91244 | 111644 | 75015 | 111320 | 98765 | 120847 | 81198 | 114380 | 106906 | 1127515 |
| Total | 14916 | 11576 | 8197 | 19554 | 44773 | 65080 | 105050 | 93496 | 114040 | 77460 | 113814 | 101308 | 123441 | 83844 | 117079 | 109659 | 1203286 |

Table 17. Summary of Additional CANES Costs[56]

If CANES were to be implemented, there would be costs associated with phasing out the status quo, such as severing contracts and closing production lines. These costs are taken from the AoA report and adjusted to BY10$, and presented as Table 18.

| Status Quo Phaseout (BY10$, in thousands) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Total |
| Status Quo Phaseout | 385293 | 341764 | 427328 | 470276 | 201737 | 240415 | 157215 | 93706 | 79625 | 24179 | 0 | 0 | 0 | 0 | 0 | 0 | 2421539 |

Table 18. Status Quo Phaseout[57]

The ROI calculation is summarized in Table 19. The discounted benefit of $271,647,000 was calculated by summing yearly manpower savings, fuel use savings, and software savings, and then discounting by 7 percent. The net discounted investment of $370,744,000 was calculated by summing all earlier costs identified in the analysis (installation/upgrade, hardware and software tech refresh, and program management costs), adding in the phaseout costs for the status quo, subtracting out the total investment costs for the status quo, and then applying the 7 percent discount rate.

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[56] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

[57] Ibid.

| ROI CALCULATIONS (BY10$, in thousands) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Total |
| Benefits | 492 | 1593 | 4544 | 8672 | 12737 | 12998 | 13107 | 52851 | 52959 | 52996 | 53204 | 53240 | 53349 | 53342 | 53514 | 53586 | 533184 |
| **Discounted Benefits** | **492** | **1489** | **3969** | **7079** | **9717** | **9267** | **8734** | **32913** | **30823** | **28826** | **27046** | **25294** | **23687** | **22135** | **20754** | **19422** | **271647** |
| | | | | | | | | | | | | | | | | | |
| CANES investment | 105609 | 150660 | 315712 | 329779 | 362268 | 151675 | 155564 | 147623 | 173984 | 107277 | 198067 | 140610 | 198210 | 113661 | 191012 | 149797 | 2991507 |
| + SQ Phaseout | 385293 | 341764 | 427328 | 470276 | 201737 | 240415 | 157215 | 93706 | 79625 | 24179 | 0 | 0 | 0 | 0 | 0 | 0 | 2421539 |
| - SQ Investment | 406629 | 289951 | 473445 | 534458 | 248410 | 424152 | 344929 | 274128 | 389764 | 252915 | 259197 | 347339 | 376499 | 222420 | 418194 | 271460 | 5533890 |
| Investment (net) | 84273 | 202473 | 269596 | 265597 | 315595 | -32062 | -32150 | -32799 | -136156 | -121459 | -61130 | -206728 | -178289 | -108759 | -227182 | -121663 | -120844 |
| **Discounted Investment** | **84273** | **189227** | **235475** | **216807** | **240766** | **-22860** | **-21423** | **-20426** | **-79244** | **-66066** | **-31075** | **-98215** | **-79163** | **-45131** | **-88105** | **-44096** | **370744** |

Table 19.    Summary of ROI Calculation

The ROI for CANES was calculated by dividing the total discounted benefits by the total discounted net investment, and resulted in a value of 73 percent.

## G.    SENSITIVITY ANALYSIS

The researcher used two different methods to examine how the CANES ROI would change if different inputs or cost assumptions were used.  The first method was to adjust the calculated ROI value of CANES by removing benefits that were identified as cost avoidances. The second method calculated how much different cost factors would have to change to lower the ROI to 20 percent, which is the minimum acceptable ROI for IT projects  identified in a survey of 100 companies.[58]

For the first sensitivity analysis method, the cost avoidances identified earlier in the Analysis section were manpower benefits and operational software maintenance.  The researcher explored the effect on ROI for the following variations:

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[58] Anthony Cresswell, "Return on Investment in Information Technology: A Guide for Managers," University of Albany, www.ctg.albany.edu/publications/guides/roi/roi.pdf (accessed May 13, 2010).

- Removing all benefits identified as cost avoidances, since those values may never be realized

- Removing only the manpower cost avoidance

- Removing only the operational software maintenance cost avoidance

- Increasing manpower cost avoidance to 12 from 6 percent, based on the high end of the RAND study results

The results of the variations are summarized in Table 20.

| Variation | ROI |
|---|---|
| Remove All Cost Avoidances | 7.7% |
| Remove Manpower Avoidance | 17.8% |
| Remove Software Maintenance Avoidance | 63.1% |
| Increase Manpower Avoidance to 12% | 128.7% |

Table 20.    Summary of ROI Variations

The results of the first sensitivity analysis method shows the relative impact of manpower cost to the estimated CANES ROI. If ship manning cannot be lowered after CANES is implemented, the ROI will drop from 73 percent to 17.8 percent.  However, if ship manning can actually be reduced even more than the 6 percent the RAND study estimated, the CANES ROI could be higher.

The inputs the researcher examined for the second sensitivity analysis method (to see what it would take to lower ROI to 20 percent) were CANES installation costs (both upgrades and initial installations), status quo phaseout costs, and technical refresh costs (both hardware and software).  The results are summarized in Table 21.

| Variation | Required Increase |
|---|---|
| SQ Phaseout Cost | 49.0% |
| Installation Cost | 75.5% |
| Tech Refresh Cost | 165.0% |

Table 21.　Summary of Required Cost Increases to Lower ROI to 20%

Note that installation costs, technical refresh costs, and status quo phaseout costs would have to increase by a minimum of 49 percent in order to lower the ROI to 20 percent. It appears that it would take a large cost increase in any of those areas to make the project unattractive, which shows that the CANES project is relatively insensitive to changes in the aforementioned costs.

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# V.    CONCLUSION AND RECOMMENDATIONS

The calculation of a value for ROI of the CANES program is complex and depends on many factors.  Any attempt to estimate the overall savings for a project as far reaching and long lasting as CANES necessitates making assumptions and will therefore include some uncertainties.  The researcher made every attempt to use the most up-to-date information and use estimates where no data were available to ensure the calculated ROI was reasonable and reflected the real value of the CANES program.  These estimates were based on the lower bounds of values from case studies that examined benefits that could be realized with network consolidation and a SOA environment.

The calculated ROI value for the CANES program is 73 percent. This value, while attractive, is dependent on the U.S. Navy being able to reduce manning associated with shipboard network operation.  While this reduction may be possible, naval personnel planners will actually need to reduce the IT billets required for the savings due to the implementation of CANES to be realized.

While the ROI is sensitive to manpower reductions, the calculated value is relatively insensitive to changes in installation costs, phaseout costs of the status quo systems, and costs associated with the planned technical refresh for hardware and software on CANES ships.  It would take an increase of 49 percent in status quo phaseout costs to reduce the CANES ROI to a minimum acceptable value of 20 percent.

Compared to the ROI value of 95 percent the AoA team calculated, the value of 73 percent the researcher calculated may seem low.  However, the AoA team used a discount rate of 5 percent, while the researcher used a discount rate of 7 percent.  By recalculating the CANES ROI with a 5 percent discount rate, a 117 percent ROI for CANES is obtained, which is even more attractive than the value obtained by the AoA team.  The main reason for the observed difference is the net investment for CANES in this thesis is lower due to the lower cost to

install CANES on a new ship compared to install the legacy network systems for Force Level, Unit Level, and Submarine class ships.

The numerical ROI value for CANES is important, but it should not be the only consideration taken into account when deciding whether to fund the CANES program.  The CANES program has several intangible benefits that provide real value to the U.S. Navy, but could not be quantified in this thesis.  Examples of these benefits are increased network availability, reduction of network space and weight, and improved network security management.  These factors, combined with the 73 percent ROI, make CANES even more attractive.

# APPENDIX. AOA COST ESTIMATES

| Status Quo | ICE Concept WBS Costs Report - Constant Year Dollars | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cost Summary by Year | All costs are in Base Year 2009 $K | | | | | | | | | | | | | | | | | |
| | FY 2010 | FY 2011 | FY 2012 | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | FY 2023 | FY 2024 | FY 2025 | FY 2026 | Total |
| Concept WBS Costs | 387,967 | 387,983 | 357,305 | 492,768 | 624,788 | 319,660 | 463,571 | 397,059 | 314,180 | 440,792 | 342,089 | 262,353 | 435,593 | 378,633 | 311,740 | 438,374 | 341,620 | 6,696,475 |
| 1.0 INVESTMENT | 286,579 | 283,211 | 250,442 | 383,369 | 511,237 | 209,271 | 352,979 | 286,467 | 204,290 | 330,903 | 232,200 | 152,564 | 325,783 | 268,822 | 201,976 | 328,610 | 232,116 | 4,840,820 |
| 1.1 Program Management | 12,021 | 11,584 | 13,773 | 10,489 | 27,126 | 12,459 | 12,459 | 12,240 | 12,240 | 12,240 | 12,240 | 12,240 | 12,240 | 12,240 | 12,240 | 12,240 | 12,230 | 222,305 |
| 1.1.1 Personnel | 11,821 | 11,384 | 13,573 | 10,289 | 26,926 | 12,259 | 12,259 | 12,040 | 12,040 | 12,040 | 12,040 | 12,040 | 12,040 | 12,040 | 12,040 | 12,040 | 12,040 | 218,914 |
| 1.1.4 Other | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 190 | 3,391 |
| 1.3 Development | 12,460 | 12,419 | 12,698 | 11,021 | 18,870 | 11,159 | 10,831 | 9,015 | 8,943 | 8,943 | 8,943 | 8,943 | 8,943 | 8,943 | 8,943 | 8,943 | 7,649 | 177,664 |
| 1.3.1 System Design and Specification | 10,997 | 10,997 | 11,321 | 10,027 | 17,143 | 10,027 | 10,027 | 8,248 | 8,248 | 8,248 | 8,248 | 8,248 | 8,248 | 8,248 | 8,248 | 8,248 | 6,954 | 161,727 |
| 1.3.3 Software Development | 372 | 495 | 451 | 67 | 310 | 437 | 109 | 72 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,313 |
| 1.3.8 Test and Evaluate | 1,090 | 926 | 926 | 926 | 1,417 | 695 | 695 | 695 | 695 | 695 | 695 | 695 | 695 | 695 | 695 | 695 | 695 | 13,623 |
| 1.4 System Procurement | 114,309 | 114,018 | 100,745 | 160,281 | 205,590 | 86,657 | 148,001 | 132,574 | 94,716 | 150,142 | 104,655 | 68,578 | 139,748 | 124,748 | 92,402 | 147,988 | 104,952 | 2,090,102 |
| 1.4.1 Deployment Hardware | 100,563 | 102,535 | 90,704 | 151,831 | 183,380 | 80,845 | 141,972 | 128,169 | 90,704 | 145,915 | 100,563 | 65,070 | 136,056 | 120,282 | 88,732 | 143,943 | 100,563 | 1,971,828 |
| 1.4.2 System Deployment Software | 8,471 | 7,272 | 6,633 | 6,792 | 7,831 | 3,996 | 4,475 | 3,276 | 3,516 | 3,596 | 3,596 | 2,877 | 3,196 | 3,836 | 3,196 | 3,436 | 3,916 | 79,912 |
| 1.4.3 Initial Documentation Requirements | 1,869 | 2,072 | 2,252 | 1,531 | 5,854 | 1,531 | 1,396 | 1,081 | 495 | 630 | 495 | 630 | 495 | 630 | 473 | 608 | 473 | 22,517 |
| 1.4.5 Initial Spares | 3,407 | 2,139 | 1,157 | 127 | 8,524 | 285 | 158 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15,845 |
| 1.6 System Initiation, Implementation, & Fielding | 147,789 | 145,191 | 123,226 | 201,578 | 259,650 | 98,996 | 181,688 | 132,639 | 88,391 | 159,578 | 106,362 | 62,803 | 164,852 | 122,891 | 88,391 | 159,439 | 107,285 | 2,350,749 |
| 1.6.1 Initial Training | 3,087 | 1,873 | 2,092 | 979 | 7,525 | 118 | 118 | 118 | 118 | 118 | 118 | 118 | 118 | 118 | 118 | 118 | 17 | 16,871 |
| 1.6.2 System Integration Site Test/Acceptance | 74,999 | 71,428 | 57,142 | 81,249 | 152,677 | 44,642 | 58,035 | 45,535 | 25,893 | 46,428 | 32,143 | 16,071 | 43,750 | 38,393 | 25,893 | 46,428 | 32,143 | 892,850 |
| 1.6.3 Common Support Equipment | 11,098 | 10,682 | 9,295 | 7,353 | 22,613 | 7,353 | 7,630 | 6,243 | 6,382 | 6,243 | 6,382 | 6,243 | 6,382 | 6,243 | 6,382 | 6,104 | 6,104 | 138,729 |
| 1.6.4 Site Activation and Facilities Preparation | 58,603 | 61,208 | 54,697 | 111,998 | 76,836 | 46,883 | 115,905 | 80,743 | 55,999 | 106,789 | 67,720 | 40,371 | 114,602 | 78,138 | 55,999 | 106,789 | 69,022 | 1,302,299 |
| 2.0 OPERATION & SUPPORT | 101,387 | 104,772 | 106,863 | 109,399 | 113,551 | 110,389 | 110,592 | 110,592 | 109,890 | 109,890 | 109,890 | 109,789 | 109,811 | 109,811 | 109,764 | 109,764 | 109,503 | 1,855,655 |
| 2.1 System/Material/Item Management | 69,813 | 71,919 | 72,621 | 74,025 | 74,025 | 74,025 | 74,025 | 74,025 | 73,323 | 73,323 | 73,323 | 73,323 | 73,323 | 73,323 | 73,323 | 73,211 | 73,211 | 1,244,271 |
| 2.1.1 Personnel | 67,611 | 69,716 | 70,418 | 71,822 | 71,822 | 71,822 | 71,822 | 71,822 | 71,120 | 71,120 | 71,120 | 71,120 | 71,120 | 71,120 | 71,120 | 71,120 | 71,120 | 1,206,938 |
| 2.1.4 Other | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,203 | 2,091 | 37,333 |
| 2.2 Annual Operations Investment | 6,073 | 6,376 | 6,680 | 6,984 | 7,186 | 7,389 | 7,591 | 7,591 | 7,591 | 7,591 | 7,591 | 7,490 | 7,490 | 7,490 | 7,490 | 7,490 | 7,490 | 123,587 |
| 2.2.3 Replenishment Supplies and Consumables | 6,073 | 6,376 | 6,680 | 6,984 | 7,186 | 7,389 | 7,591 | 7,591 | 7,591 | 7,591 | 7,591 | 7,490 | 7,490 | 7,490 | 7,490 | 7,490 | 7,490 | 123,587 |
| 2.3 Hardware Maintenance | 2,482 | 2,726 | 3,080 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,346 | 3,346 | 3,346 | 3,346 | 3,346 | 54,930 |
| 2.3.1 Organic Hardware Maintenance | 2,482 | 2,726 | 3,080 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,324 | 3,346 | 3,346 | 3,346 | 3,346 | 3,346 | 54,930 |
| 2.4 Software Maintenance | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,557 | 5,557 | 5,557 | 95,123 |
| 2.4.2 Application/Mission Software (non-COTS) | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,604 | 5,557 | 5,557 | 5,557 | 95,123 |
| 2.6 Data Maintenance | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,477 | 26,372 |
| 2.6.1 Mission Application Data | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,556 | 1,477 | 26,372 |
| 2.7 Unit/Site Operations | 15,860 | 16,591 | 17,322 | 17,907 | 21,856 | 18,492 | 18,492 | 18,492 | 18,492 | 18,492 | 18,492 | 18,492 | 18,492 | 18,492 | 18,492 | 18,492 | 18,423 | 311,373 |
| 2.7.7 Recurring Training | 14,492 | 15,223 | 15,954 | 16,539 | 20,488 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 17,124 | 288,188 |
| 2.7.8 Miscellaneous Support | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,368 | 1,298 | 23,185 |

Table 22.   AoA Status Quo Life Cycle Cost Estimate[59]

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[59] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

| Consolidate & Enhance (C&E) — Cost Summary by Year | FY 2010 | FY 2011 | FY 2012 | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | FY 2023 | FY 2024 | FY 2025 | FY 2026 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0.0 GRAND TOTAL** | 422,493 | 447,392 | 540,606 | 874,601 | 950,206 | 708,843 | 431,797 | 339,735 | 248,789 | 229,126 | 130,282 | 131,419 | 111,778 | 124,002 | 86,898 | 113,312 | 103,103 | 5,994,380 |
| **1.0 INVESTMENT** | 34,043 | 63,303 | 191,445 | 436,945 | 464,642 | 486,671 | 169,045 | 157,183 | 128,161 | 124,905 | 83,463 | 111,219 | 93,825 | 108,908 | 71,804 | 98,320 | 88,111 | 2,911,993 |
| 1.1 Program Management | 12,973 | 12,272 | 9,327 | 4,979 | 5,260 | 4,418 | 4,278 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,473 | 70,127 |
| 1.1.1 Personnel | 12,973 | 12,272 | 9,327 | 4,979 | 5,260 | 4,418 | 4,278 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,683 | 1,473 | 70,127 |
| 1.3 Development | 840 | 4,024 | 3,316 | 3,117 | 3,847 | 3,847 | 3,117 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22,110 |
| 1.3.8 Test and Evaluate | 840 | 4,024 | 3,316 | 3,117 | 3,847 | 3,847 | 3,117 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22,110 |
| 1.4 System Procurement | 8,162 | 21,478 | 75,752 | 202,769 | 221,910 | 208,836 | 24,465 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 763,372 |
| 1.4.1 Deployment Hardware | 5,494 | 14,066 | 50,110 | 133,847 | 145,477 | 136,675 | 16,483 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 502,153 |
| 1.4.2 System Deployment Software | 1,634 | 4,782 | 16,246 | 43,838 | 49,187 | 46,607 | 4,975 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 167,270 |
| 1.4.5 Initial Spares | 1,033 | 2,631 | 9,395 | 25,084 | 27,245 | 25,554 | 3,006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 93,949 |
| 1.6 System Initiation, Implementation, & Fielding | 9,462 | 20,737 | 89,225 | 193,814 | 188,987 | 198,434 | 68,330 | 50,096 | 36,746 | 16,849 | 10,855 | 7,707 | 5,102 | 1,954 | 0 | 0 | 0 | 898,298 |
| 1.6.1 Initial Training | 791 | 3,163 | 1,885 | 3,588 | 12,528 | 4,257 | 4,196 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30,409 |
| 1.6.2 System Integration Site Test/Acceptance | 0 | 2,727 | 14,090 | 37,043 | 45,452 | 37,043 | 32,043 | 35,225 | 20,680 | 2,954 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 227,258 |
| 1.6.3 Common Support Equipment | 42 | 42 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 208 |
| 1.6.4 Site Activation and Facilities Preparation | 7,978 | 13,829 | 71,271 | 148,924 | 123,926 | 146,797 | 19,147 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 531,873 |
| 1.6.7 Initial Logistical Support | 651 | 977 | 1,954 | 4,233 | 7,056 | 10,312 | 12,918 | 14,871 | 16,065 | 13,894 | 10,855 | 7,707 | 5,102 | 1,954 | 0 | 0 | 0 | 108,551 |
| 1.7 Upgrade/Preplanned Product Improvement | 0 | 0 | 194 | 2,318 | 12,835 | 37,835 | 56,358 | 94,018 | 80,409 | 97,692 | 64,973 | 94,018 | 80,409 | 97,692 | 64,973 | 89,725 | 80,409 | 953,858 |
| 1.7.2 Life Cycle Upgrades Procurement | 0 | 0 | 194 | 2,318 | 12,835 | 37,835 | 56,358 | 94,018 | 80,409 | 97,692 | 64,973 | 94,018 | 80,409 | 97,692 | 64,973 | 89,725 | 80,409 | 953,858 |
| 1.9 Risk Reserve | 2,606 | 4,791 | 13,631 | 29,948 | 31,803 | 33,300 | 12,498 | 11,385 | 9,323 | 8,681 | 5,952 | 7,811 | 6,631 | 7,579 | 5,148 | 6,912 | 6,230 | 204,228 |
| **2.0 OPERATION & SUPPORT** | 102 | 2,226 | 10,438 | 14,130 | 19,473 | 22,230 | 24,476 | 26,735 | 27,756 | 25,306 | 22,855 | 20,200 | 17,953 | 15,094 | 15,094 | 14,992 | 14,992 | 294,051 |
| 2.7 Unit/Site Operations | 102 | 2,226 | 10,438 | 14,130 | 19,473 | 22,230 | 24,476 | 26,735 | 27,756 | 25,306 | 22,855 | 20,200 | 17,953 | 15,094 | 15,094 | 14,992 | 14,992 | 294,051 |
| 2.7.1 System Operation Personnel | 102 | 306 | 1,225 | 3,574 | 6,229 | 8,986 | 11,233 | 13,684 | 14,705 | 12,254 | 9,803 | 7,148 | 4,902 | 2,042 | 2,042 | 1,940 | 1,940 | 102,117 |
| 2.7.8 Miscellaneous Support | 0 | 1,919 | 9,213 | 10,556 | 13,243 | 13,243 | 13,243 | 13,052 | 13,052 | 13,052 | 13,052 | 13,052 | 13,052 | 13,052 | 13,052 | 13,052 | 13,052 | 191,934 |
| **3.0 ALTERNATIVE PHASE OUT** | 388,348 | 381,864 | 338,722 | 423,525 | 466,091 | 199,942 | 238,275 | 155,816 | 92,872 | 78,916 | 23,964 | 0 | 0 | 0 | 0 | 0 | 0 | 2,788,336 |
| 3.1 System Management | 12,066 | 11,426 | 13,071 | 9,049 | 20,201 | 7,769 | 6,398 | 4,753 | 3,565 | 2,194 | 914 | 0 | 0 | 0 | 0 | 0 | 0 | 91,406 |
| 3.1.1 Personnel | 12,066 | 11,426 | 13,071 | 9,049 | 20,201 | 7,769 | 6,398 | 4,753 | 3,565 | 2,194 | 914 | 0 | 0 | 0 | 0 | 0 | 0 | 91,406 |
| 3.2 Phase Out Investment | 274,883 | 267,696 | 224,065 | 320,044 | 361,338 | 122,960 | 174,916 | 107,663 | 57,071 | 56,806 | 15,777 | 0 | 0 | 0 | 0 | 0 | 0 | 1,983,220 |
| 3.2.1 Deployment Hardware | 259,592 | 253,907 | 212,221 | 306,963 | 346,754 | 117,480 | 168,640 | 104,216 | 54,950 | 54,950 | 15,159 | 0 | 0 | 0 | 0 | 0 | 0 | 1,894,831 |
| 3.2.2 Software (non-developmental) | 15,291 | 13,789 | 11,844 | 13,082 | 14,584 | 5,480 | 6,276 | 3,447 | 2,121 | 1,856 | 619 | 0 | 0 | 0 | 0 | 0 | 0 | 88,389 |
| 3.3 Phase Out Operations and Support | 101,400 | 102,742 | 101,586 | 94,432 | 84,552 | 69,213 | 56,961 | 43,401 | 32,236 | 19,916 | 7,273 | 0 | 0 | 0 | 0 | 0 | 0 | 713,710 |
| 3.3.1 Hardware Maintenance | 75,376 | 76,430 | 75,376 | 70,105 | 60,617 | 51,129 | 42,168 | 32,153 | 23,720 | 14,759 | 5,271 | 0 | 0 | 0 | 0 | 0 | 0 | 527,105 |
| 3.3.2 Software Maintenance | 10,116 | 10,049 | 9,709 | 8,894 | 7,672 | 6,450 | 5,296 | 4,006 | 3,055 | 1,833 | 815 | 0 | 0 | 0 | 0 | 0 | 0 | 67,896 |
| 3.3.3 Unit/site Operations | 15,907 | 16,263 | 16,501 | 15,432 | 16,263 | 11,634 | 9,497 | 7,241 | 5,461 | 3,324 | 1,187 | 0 | 0 | 0 | 0 | 0 | 0 | 118,710 |

ICE Concept WBS Costs Report - Constant Year Dollars

All costs are in Base Year 2009 $K

Table 23.    AoA C&E Life Cycle Cost Estimate[60]

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[60] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

C&E with 2 PORs — ICE Concept WBS Costs Report - Constant Year Dollars

Cost Summary by Year — All costs are in Base Year 2009 $K

| Concept WBS Costs | FY 2010 | FY 2011 | FY 2012 | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | FY 2023 | FY 2024 | FY 2025 | FY 2026 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Concept WBS Costs** | 430,196 | 459,141 | 570,396 | 931,365 | 1,009,152 | 776,047 | 467,138 | 377,469 | 280,413 | 258,884 | 150,819 | 156,602 | 132,825 | 147,216 | 102,588 | 134,238 | 121,995 | 6,506,483 |
| **1.0 INVESTMENT - CCE** | 35,817 | 64,584 | 202,244 | 455,202 | 474,065 | 502,467 | 182,862 | 172,973 | 142,097 | 137,504 | 91,149 | 121,780 | 103,880 | 119,516 | 78,039 | 106,999 | 97,465 | 3,088,643 |
| 1.1 Program Management | 14,593 | 13,805 | 10,491 | 5,601 | 5,916 | 4,970 | 4,812 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,657 | 78,883 |
| 1.1.1 Personnel | 14,593 | 13,805 | 10,491 | 5,601 | 5,916 | 4,970 | 4,812 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,893 | 1,657 | 78,883 |
| 1.3 Development | 945 | 4,526 | 3,731 | 3,507 | 4,327 | 4,327 | 3,507 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24,870 |
| 1.3.8 Test and Evaluate | 945 | 4,526 | 3,731 | 3,507 | 4,327 | 4,327 | 3,507 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24,870 |
| 1.4 System Procurement | 6,932 | 19,171 | 72,405 | 193,685 | 209,957 | 195,927 | 23,509 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 721,585 |
| 1.4.1 Deployment Hardware | 5,494 | 14,066 | 50,110 | 133,847 | 145,477 | 136,675 | 16,483 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 502,153 |
| 1.4.2 System Deployment Software | 404 | 2,474 | 12,900 | 34,754 | 37,235 | 33,698 | 4,019 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 125,483 |
| 1.4.5 Initial Spares | 1,033 | 2,631 | 9,395 | 25,084 | 27,245 | 25,554 | 3,006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 93,949 |
| 1.6 System Initiation, Implementation, & Fielding | 10,748 | 22,423 | 101,859 | 219,546 | 207,773 | 222,161 | 77,629 | 56,311 | 41,304 | 18,939 | 12,202 | 8,663 | 5,735 | 2,196 | 0 | 0 | 0 | 1,007,489 |
| 1.6.1 Initial Training | 889 | 3,555 | 2,119 | 4,033 | 14,083 | 4,785 | 4,717 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34,181 |
| 1.6.2 System Integration Site Test/Acceptance | 0 | 3,065 | 15,838 | 41,638 | 51,090 | 41,638 | 36,018 | 39,595 | 23,246 | 3,321 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 255,450 |
| 1.6.3 Common Support Equipment | 37 | 37 | 22 | 22 | 22 | 22 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 187 |
| 1.6.4 Site Activation and Facilities Preparation | 9,090 | 14,667 | 81,683 | 169,093 | 134,647 | 164,124 | 22,351 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 595,654 |
| 1.6.7 Initial Logistical Support | 732 | 1,098 | 2,196 | 4,759 | 7,931 | 11,592 | 14,520 | 16,716 | 18,059 | 15,618 | 12,202 | 8,663 | 5,735 | 2,196 | 0 | 0 | 0 | 122,017 |
| 1.7 Upgrade/Preplanned Product Improvement | 0 | 0 | 50 | 2,223 | 13,647 | 40,788 | 60,918 | 102,901 | 89,238 | 107,290 | 70,796 | 102,901 | 89,238 | 107,290 | 70,796 | 97,771 | 89,238 | 1,045,087 |
| 1.7.2 Life Cycle Upgrades Procurement | 0 | 0 | 50 | 2,223 | 13,647 | 40,788 | 60,918 | 102,901 | 89,238 | 107,290 | 70,796 | 102,901 | 89,238 | 107,290 | 70,796 | 97,771 | 89,238 | 1,045,087 |
| 1.9 Risk Reserve | 2,599 | 4,659 | 13,708 | 30,640 | 32,445 | 34,294 | 12,488 | 11,868 | 9,660 | 9,382 | 6,258 | 8,323 | 7,014 | 8,136 | 5,350 | 7,334 | 6,570 | 210,728 |
| **2.0 OPERATION & SUPPORT - CCE** | 115 | 2,245 | 10,499 | 14,472 | 20,119 | 23,221 | 25,748 | 28,315 | 29,464 | 26,707 | 23,950 | 20,963 | 18,435 | 15,219 | 15,219 | 15,104 | 15,104 | 304,896 |
| 2.7 Unit/Site Operations | 115 | 2,245 | 10,499 | 14,472 | 20,119 | 23,221 | 25,748 | 28,315 | 29,464 | 26,707 | 23,950 | 20,963 | 18,435 | 15,219 | 15,219 | 15,104 | 15,104 | 304,896 |
| 2.7.1 System Operation Personnel | 115 | 345 | 1,379 | 4,021 | 7,008 | 10,110 | 12,637 | 15,394 | 16,543 | 13,786 | 11,029 | 8,042 | 5,514 | 2,298 | 2,298 | 2,183 | 2,183 | 114,881 |
| 2.7.8 Miscellaneous Support | 0 | 1,900 | 9,121 | 10,451 | 13,111 | 13,111 | 13,111 | 12,921 | 12,921 | 12,921 | 12,921 | 12,921 | 12,921 | 12,921 | 12,921 | 12,921 | 12,921 | 190,015 |
| **1.0 INVESTMENT - ACS** | 5,903 | 10,199 | 17,764 | 36,559 | 46,641 | 47,837 | 17,392 | 17,218 | 12,707 | 12,790 | 9,095 | 11,530 | 8,461 | 10,791 | 7,639 | 10,458 | 7,748 | 290,730 |
| 1.1 Program Management | 1,621 | 1,534 | 1,166 | 622 | 657 | 552 | 535 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 184 | 8,765 |
| 1.1.1 Personnel | 1,621 | 1,534 | 1,166 | 622 | 657 | 552 | 535 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 184 | 8,765 |
| 1.2 Concept Exploration | 1,599 | 1,871 | 1,559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5,029 |
| 1.2.1 Engineering Analysis and Specification | 1,599 | 1,871 | 1,559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5,029 |
| 1.3 Development | 105 | 503 | 415 | 390 | 481 | 481 | 390 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,763 |
| 1.3.8 Test and Evaluate | 105 | 503 | 415 | 390 | 481 | 481 | 390 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,763 |
| 1.4 System Procurement | 1,230 | 2,307 | 3,347 | 9,084 | 11,953 | 12,909 | 956 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41,787 |
| 1.4.2 System Deployment Software | 1,230 | 2,307 | 3,347 | 9,084 | 11,953 | 12,909 | 956 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41,787 |
| 1.6 System Initiation, Implementation, & Fielding | 1,059 | 3,466 | 9,573 | 22,512 | 28,256 | 25,667 | 7,706 | 6,257 | 4,589 | 2,104 | 1,356 | 963 | 637 | 244 | 0 | 0 | 0 | 114,389 |
| 1.6.1 Initial Training | 99 | 395 | 235 | 448 | 1,565 | 532 | 524 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3,798 |
| 1.6.2 System Integration Site Test/Acceptance | 4 | 341 | 1,760 | 4,626 | 5,677 | 4,626 | 4,002 | 4,399 | 2,583 | 369 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28,383 |
| 1.6.3 Common Support Equipment | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 |
| 1.6.4 Site Activation and Facilities Preparation | 875 | 2,604 | 7,331 | 16,507 | 20,131 | 19,218 | 1,564 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 68,629 |
| 1.6.7 Initial Logistical Support | 81 | 122 | 244 | 529 | 881 | 1,288 | 1,613 | 1,857 | 2,007 | 1,735 | 1,356 | 963 | 637 | 244 | 0 | 0 | 0 | 13,557 |
| 1.7 Upgrade/Preplanned Product Improvement | 0 | 0 | 182 | 546 | 1,689 | 4,417 | 6,418 | 9,432 | 6,834 | 9,432 | 6,834 | 9,432 | 6,834 | 9,432 | 6,834 | 9,432 | 6,834 | 94,584 |
| 1.7.2 Life Cycle Upgrades Procurement | 0 | 0 | 182 | 546 | 1,689 | 4,417 | 6,418 | 9,432 | 6,834 | 9,432 | 6,834 | 9,432 | 6,834 | 9,432 | 6,834 | 9,432 | 6,834 | 94,584 |
| 1.9 Risk Reserve | 289 | 518 | 1,523 | 3,404 | 3,605 | 3,810 | 1,388 | 1,319 | 1,073 | 1,042 | 695 | 925 | 779 | 904 | 594 | 815 | 730 | 23,414 |
| **2.0 OPERATION & SUPPORT - ACS** | 13 | 249 | 1,167 | 1,608 | 2,235 | 2,580 | 2,861 | 3,146 | 3,274 | 2,967 | 2,661 | 2,329 | 2,048 | 1,691 | 1,691 | 1,678 | 1,678 | 33,877 |
| 2.7 Unit/Site Operations | 13 | 249 | 1,167 | 1,608 | 2,235 | 2,580 | 2,861 | 3,146 | 3,274 | 2,967 | 2,661 | 2,329 | 2,048 | 1,691 | 1,691 | 1,678 | 1,678 | 33,877 |
| 2.7.1 System Operation Personnel | 13 | 38 | 153 | 447 | 779 | 1,123 | 1,404 | 1,710 | 1,838 | 1,532 | 1,225 | 894 | 613 | 255 | 255 | 243 | 243 | 12,765 |
| 2.7.8 Miscellaneous Support | 0 | 211 | 1,013 | 1,161 | 1,457 | 1,457 | 1,457 | 1,436 | 1,436 | 1,436 | 1,436 | 1,436 | 1,436 | 1,436 | 1,436 | 1,436 | 1,436 | 21,113 |
| **3.0 ALTERNATIVE PHASE OUT** | 388,348 | 381,864 | 338,722 | 423,525 | 466,091 | 199,942 | 238,275 | 155,816 | 92,872 | 78,916 | 23,964 | 0 | 0 | 0 | 0 | 0 | 0 | 2,788,336 |
| 3.1 System Management | 12,066 | 11,426 | 13,071 | 9,049 | 20,201 | 7,769 | 6,398 | 4,753 | 3,565 | 2,194 | 914 | 0 | 0 | 0 | 0 | 0 | 0 | 91,406 |
| 3.1.1 Personnel | 12,066 | 11,426 | 13,071 | 9,049 | 20,201 | 7,769 | 6,398 | 4,753 | 3,565 | 2,194 | 914 | 0 | 0 | 0 | 0 | 0 | 0 | 91,406 |
| 3.2 Phase Out Investment | 274,883 | 267,696 | 224,065 | 320,044 | 361,338 | 122,960 | 174,916 | 107,663 | 57,071 | 56,806 | 15,777 | 0 | 0 | 0 | 0 | 0 | 0 | 1,983,220 |
| 3.2.1 Deployment Hardware | 259,592 | 253,907 | 212,221 | 306,963 | 346,754 | 117,480 | 168,640 | 104,216 | 54,950 | 54,950 | 15,159 | 0 | 0 | 0 | 0 | 0 | 0 | 1,894,831 |
| 3.2.2 Software (non-developmental) | 15,291 | 13,789 | 11,844 | 13,082 | 14,584 | 5,480 | 6,276 | 3,447 | 2,121 | 1,856 | 619 | 0 | 0 | 0 | 0 | 0 | 0 | 88,389 |
| 3.3 Phase Out Operations and Support | 101,400 | 102,742 | 101,586 | 94,432 | 84,552 | 69,213 | 56,961 | 43,401 | 32,236 | 19,916 | 7,273 | 0 | 0 | 0 | 0 | 0 | 0 | 713,710 |
| 3.3.1 Hardware Maintenance | 75,376 | 76,430 | 75,376 | 70,105 | 60,617 | 51,129 | 42,168 | 32,153 | 23,720 | 14,759 | 5,271 | 0 | 0 | 0 | 0 | 0 | 0 | 527,105 |
| 3.3.2 Software Maintenance | 10,116 | 10,049 | 9,709 | 8,894 | 7,672 | 6,450 | 5,296 | 4,006 | 3,055 | 1,833 | 815 | 0 | 0 | 0 | 0 | 0 | 0 | 67,896 |
| 3.3.3 Unit/Site Operations | 15,907 | 16,263 | 16,501 | 15,432 | 16,263 | 11,634 | 9,497 | 7,241 | 5,461 | 3,324 | 1,187 | 0 | 0 | 0 | 0 | 0 | 0 | 118,710 |

Table 24.    AoA C&E 2 POR Life Cycle Cost Estimate[61]

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[61] PEO C4I PMW 160, Consolidated Afloat Networks and Enterprise Services (CANES) Analysis of Alternatives (AoA) Detailed Report (October 31, 2008).

Table header area (rotated):

C&E with 2 Sub-Programs

ICE Concept WBS Costs Report - Constant Year Dollars

Cost Summary by Year

All costs are in Base Year 2009 $K

Table 25.    AoA C&E 2 Sub-Prog Life Cycle Cost Estimate[62]

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