CASE STUDY: U.S. COAST GUARD INTEGRATED DEEPWATER SYSTEM

October 2014

A Systems Engineering Perspective

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Table of Contents

The Integrated Deepwater System

The Integrated Deepwater System (IDS) was a program to recapitalize the U.S. Coast Guard assets (surface, air, etc.) as a system-of-systems. The program formally began in 2002 when a contract was awarded to a joint venture formed by Lockheed Martin and Northrop Grumman. The program suffered from severe problems affecting cost, schedule, and performance. These problems can be traced to a variety of causes. The system-of-systems approach to system design is still not well understood, and it has many associated risks. The Coast Guard did not have a mature acquisition capability, and consequently they opted for a lead systems integrator (LSI) model, further introducing risk into the program. The Coast Guard was transferred from the Department of Transportation to the Department of Homeland Security (DHS) in early 2003. The newly formed DHS did not have the organizational maturity to assist the Coast Guard or to provide meaningful oversight. Many of the requirements developed by the Coast Guard were flawed and lacked engineering rigor. All of these problems resulted in approximately ten years of churn, flawed deliverables, missed deadlines, and cost over-runs totaling billions of dollars.

This monograph will examine the IDS Program from several perspectives: program management, requirements management, risk management, and cost management. This examination relied on data from multiple sources, but priority was given to data and reporting from the Coast Guard and the General Accountability Office.

The Integrated Deepwater System (IDS) Mission Need Statement (MNS) of 2004 identifies the needs associated with the U.S. Coast Guard (USCG) IDS Program.[1] This MNS was updated twice in order to respond to changes in the national security environment. The original MNS approved in 1996 was an "asset capability replacement program."[2] In other words, ships, aircraft, and other assets were simply to be replaced with newer versions of the same capabilities. The MNS was updated in 2000 during an Interagency Task Force on Roles and Missions for the USCG.[3] The work of this Task Force resulted in a baseline System Performance Specification (SPS) for the Integrated Deepwater System.[4]

The second update to the MNS in 2004 was the result of the terrorist attack of 11 September 2001. As a result of that attack the national security environment changed, and many of those associated changes had an impact on the USCG and the Deepwater Program. Shortly after the attack, the USCG intelligence element was admitted to the

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[1] "*Mission Need Statement (MNS), Integrated Deepwater System, Update (Revision 1.0),*" 2004, *United States Coast Guard*, URL: <http://www.uscg.mil/history/docs/2004_USCG_revisedmns.pdf>, accessed on 22 August 2014, cited hereafter as IDS MNS.

[2] IDS MNS, Executive Summary, 2.

[3] IDS MNS, 1.

[4] "*System Performance Specification for the Integrated Deepwater System*," 1 August 2000, *United States Coast Guard*, URL: <https://www.uscg.mil/history/docs/2000_USCG_systemperformancespecification.pdf>, accessed 27 August 2014, cited hereafter as IDS SPS.

national Intelligence Community (IC).[5] Another significant change occurred on 1 March 2003 when the USCG was transferred from the Department of Transportation to the Department of Homeland Security (DHS).[6] (The Office of Homeland Security became the Department of Homeland Security on 1 March 2003.)[7]

In June 2001 Lockheed Martin and Northrup Grumman Ingalls Shipbuilding formed a joint venture company, Integrated Coast Guard Systems (ICGS), to bid on the Integrated Deepwater Systems contract.[8] This contract reflected the requirements documented in the IDS SPS of August 2000. The ICGS joint venture was awarded the primary contract for the IDS on 25 June 2002.[9] The following month, the Office of Homeland Security published the National Strategy for Homeland Security in July 2002.[10] This strategy assigned the USCG the role of "lead federal agency for Maritime Security."[11]

The IDS MNS was updated in 2004 in response to all of these changes resulting from the attack of 11 September 2001:

- USCG membership in the IC
- USCG transfer to DHS
- USCG missions aligned with the National Strategy for Homeland Security

This updated IDS MNS provides an over-arching vision for the Integrated Deepwater System. The assets described in this vision are illustrated in the following figure.

> "The System-of-Systems IDS design is intended to improve the capability to detect, intercept, and interdict potential threats in the maritime domain using a layered defense of major cutters, patrol boats, helicopters, unmanned aerial vehicles (UAV) and maritime patrol aircraft all connected using a single command and control architecture. The further away from our shores that these threats are interdicted, the safer the country will be."[12]

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[5] IDS MNS, 4.

[6] IDS MNS, 2.

[7] "Creation of the Department of Homeland Security," *Department of Homeland Security*, URL: <http://www.dhs.gov/creation-department-homeland-security>, accessed 27 August 2014.

[8] Melanie D. Scott, "Lockheed Martin bids on Coast Guard jobs," *The Philadelphia Inquirer*, 8 July 2001, URL: <http://articles.philly.com/2001-07-08/news/25315323_1_joint-venture-naval-electronics-integrated-coast-guard-systems>, accessed 27 August 2014, cited hereafter as Scott.

[9] IDS MNS, 8.

[10] IDS MNS, 6.

[11] IDS MNS, Executive Summary, 1.

[12] IDS MNS, 1.

Figure 1 Deepwater Assets

Source: "U.S. Coast Guard's Deepwater Efforts Sink," Defense Industry Daily, 14 December 2011, URL: <http://www.defenseindustrydaily.com/us-coast-guards-deepwater-effort-hits-more-rough-sailing-02863/>, accessed 27 August 2014.

Management Approach

In June 2001 Lockheed Martin and Northrup Grumman Ingalls Shipbuilding formed a joint venture company, Integrated Coast Guard Systems (ICGS), to bid on the Integrated Deepwater Systems contract.[13] This contract reflected the requirements documented in the IDS Systems Performance Specification (SPS) of August 2000. The ICGS joint venture was awarded the primary contract for the IDS on 25 June 2002.[14]

The Coast Guard did not have the expertise or the manpower required to manage such a large acquisition program, so it chose to assign to ICGS the role of lead systems integrator (LSI):

[13] Scott.

[14] IDS MNS, 8.

> "At the start of Deepwater, the Coast Guard chose to use a system-of-systems acquisition strategy that would replace its assets with a single, integrated package of aircraft, vessels, and communications systems through Integrated Coast Guard Systems (ICGS), a system integrator that was responsible for designing, constructing, deploying, supporting and integrating the assets to meet Coast Guard requirements."[15]

In 2004 an ICGS executive speaking at a symposium outlined some management practices implemented: a Joint Program Management Team (JMPT) charter was signed Jan. 16, 2003; an integrated product team (IPT) structure organized 23 teams reporting to the JMPT; an Integrated Product Data Environment (IPDE) was established *across the Enterprise* [emphasis added]; integrated earned value management system (EVMS) and integrated master schedule (IMS) were established and managed *across the entire Enterprise* [emphasis added].[16] These management practices established *across the Enterprise* proved to have unintended consequences that jeopardized the success of the program.

Specifically, bundling of all assets into a single system-of-systems acquisition package did not provide the Coast Guard with an appropriate level of insight into cost and performance. The Congressional Research Service documented this assessment in 2007:

> "Some observers have expressed the view that using an LSI to implement the Deepwater program made a complex program more complex, and set the stage for waste, fraud, and abuse by effectively outsourcing oversight of the program to the private sector and by creating a conflict of interest for the private sector in executing the program. Other observers, including the DAU and GAO, have expressed the view that the LSI approach is basically valid, but that the contract used to implement the approach for the Deepwater program was flawed in various ways, *undermining the Coast Guard's ability to assess contractor performance, control costs, ensure accountability and conduct general oversight of the program*."[17] [emphasis added]

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[15] U.S. Government Accountability Office, *Deepwater Program Management Initiatives and Key Homeland Security Missions. Testimony Before the Subcommittee on Homeland Security, Committee on Appropriations, House of Representatives, Statement of John P. Hutton, Director Acquisition and Sourcing Management and Stephen L. Caldwell, Director Homeland Security and Justice*, GAO-08-531T, 2008, 3-4, URL: <http://gao.gov/assets/120/119205.pdf>, accessed 10 September 2014, cited hereafter as GAO-8-531T.

[16] Gerry Moorman, *Deepwater: DoD Maintenance Exhibition & Symposium – 2004*, SAE International, PowerPoint Slides, URL: <http://www.sae.org/events/dod/presentations/2004partmoorman.pdf>, accessed on 11 September 2014.

[17] Ronald O'Rourke, Congressional Research Service, *Report to Congress: Coast Guard Deepwater Program: Background, Oversight Issues, and Options for Congress*, CRS-10, 30 April 2007, URL: < http://www.uscg.mil/history/docs/CRS/CRSDeepwater19901.pdf>, accessed 11 September 2014, cited hereafter as O'Rourke.

Roles of Acquisition Agents, Developers, and Users

When the Deepwater Program began the USCG did not have the necessary expertise, infrastructure, or manpower required to manage a large acquisition program. The Coast Guard opted to contract ICGS as LSI in order to free itself from the need to make decisions about every program detail, which would have been costly given the complexity of the system. [18] In this LSI model, ICGS acted as a general contractor for the system-of-systems (SoS) with responsibility to design, build, and integrate all assets into a coherent system.[19] This approach had both advantages and disadvantages:

> "The upsides of the SoS approach are lower costs by bundling related buys into a single acquisition and tapping technical capacity and expertise not available in-house. The downside is that the government agency is the only purchaser, and once the contract is let, the vendor is the only viable supplier. This situation leaves each party with no easy exit from the contract, limited information about costs and quality, and engagement with a partner relatively unconstrained by Introduction competitive market pressures. With exit options limited, the risk is that each side will exploit contract loopholes and ambiguities, fearing the other side will do the same. The result can be a spiral of increasing rigidity, distrust, and conflict between the buyer and seller, risking cost overruns, quality lapses, missed deadlines and objectives, and ultimately a failed contract."[20]

The Deepwater Program did in fact experience this "spiral of increasing rigidity, distrust, and conflict" throughout the period 2003-2007. Finally, on 17 April 2007 Admiral Allen, USCG Commandant, announced that the USCG would relieve ICGS and assume responsibility as LSI for the Deepwater Program. The following timeline summarizes the move from ICGS as LSI to USCG as LSI.[21]

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[18] Trevor Brown, Matthew Potoski, and David M. Van Slyke, *The Challenge of Contracting for Large Complex Projects: A Case Study of the Coast Guard's Deepwater Program*, 6, 2008, IBM Center for the Business of Government, URL: <http://www.businessofgovernment.org/sites/default/files/CoastGuard%20DeepPrgm.pdf>, accessed 10 September 2014, cited hereafter as The Challenge.

[19] The Challenge, 8.

[20] The Challenge, 8-9.

[21] "U.S. Coast Guard's Deepwater Efforts Sink," Defense Industry Daily, 14 December 2011, URL: <http://www.defenseindustrydaily.com/us-coast-guards-deepwater-effort-hits-more-rough-sailing-02863/>, accessed 27 August 2014, cited hereafter as Deepwater Sinks.

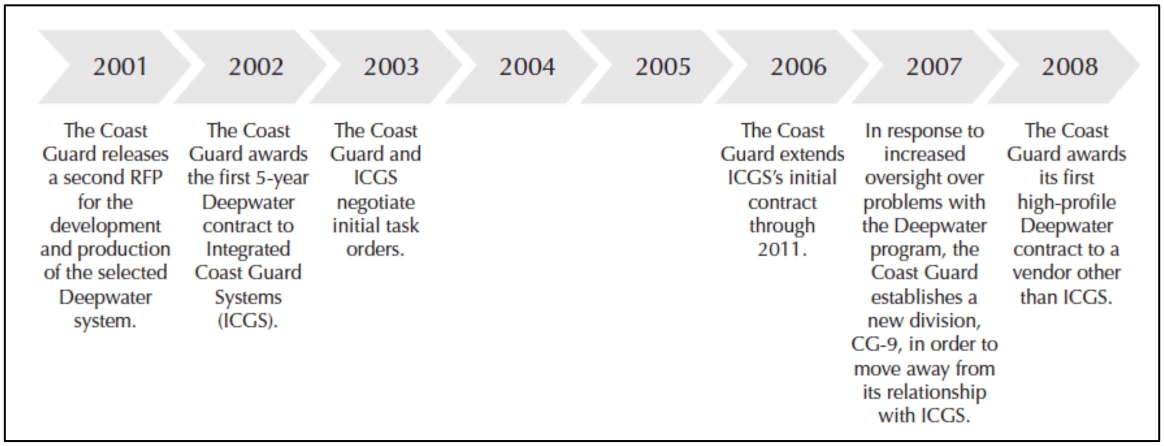

Figure 2 USCG Moves Away from LSI Model
Source: The Challenge, 14

In order to execute Admiral Allen's directive, the USCG needed to modify its infrastructure to support a large acquisition effort. As a result, on 13 July 2007 the USCG established a new Acquisition Directorate, CG-9, with responsibility for Deepwater.[22] The following figure illustrates the original ICGS acquisition structure compared with its replacement by CG-9.

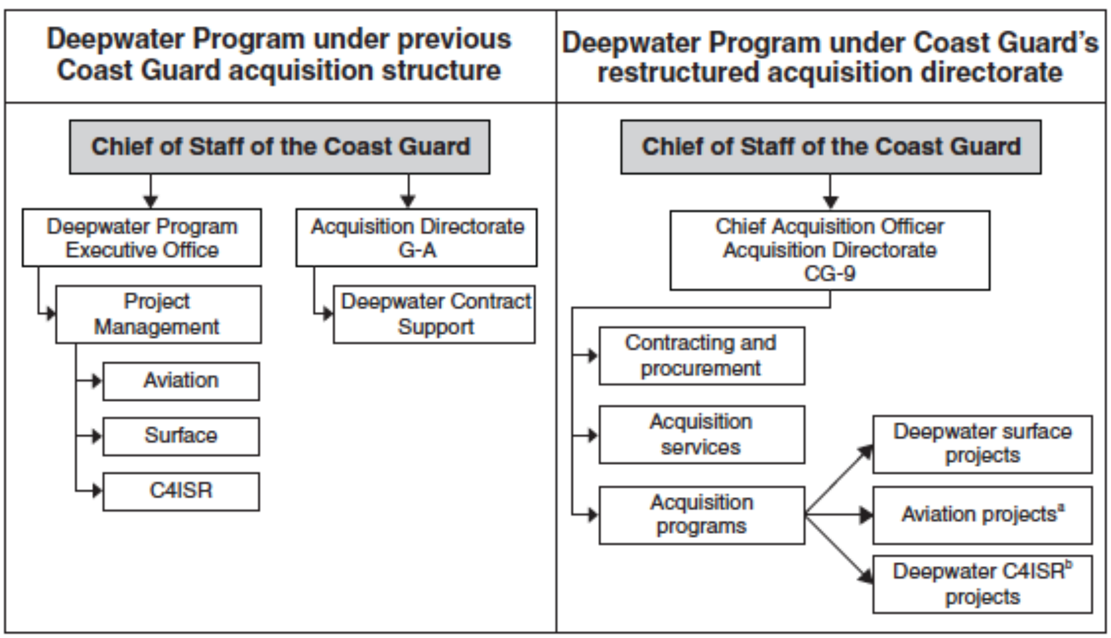

Figure 3 Change in Deepwater Program Management
Source: GAO-08-531T, 5, URL: <http://gao.gov/assets/120/119205.pdf>.

[22] Deepwater Sinks.

Motivations to Support the Effort

All stakeholders were motivated to support the Deepwater Program. Following the attack of 11 September 2001, the Department of Homeland Security (DHS) had made maritime security a top priority, as reflected in the Mission Need Statement of 2004:

> "The System-of-Systems IDS design is intended to improve the capability to detect, intercept, and interdict potential threats in the maritime domain using a layered defense of major cutters, patrol boats, helicopters, unmanned aerial vehicles (UAV) and maritime patrol aircraft all connected using a single command and control architecture. The further away from our shores that these threats are interdicted, the safer the country will be."[23]

Similarly the Coast Guard, a component of DHS, was motivated to recapitalize all of its assets, since they had been neglected by congressional appropriations for many years. Following is an assessment of the aging assets of the Coast Guard at the inception of the Deepwater Program, with assets more than thirty years old:

> "Of 39 similar navy and coast guard fleets surveyed around the world, the U.S. Coast Guard's vessel fleet is the 37th oldest. The Coast Guard's twelve 1960's era Hamilton class cutters are among the service's aging fleet slated for replacement under the Deepwater contract. The 378-foot Hamilton class are the largest multi-mission, helicopter capable ships operated by the Coast Guard. Other existing ships that would be replaced include fourteen 1960's vintage 210-foot Reliance class, and a variety of other ships, some dating back from World War II. Aircraft readiness has also been a recurring problem in recent years with expenditures for repairs on the rise, and some of the Coast Guard's existing helicopters cannot operate from the flight decks of some older cutters."[24]

Finally, ICGS was motivated to execute the contract because if successful it had the potential to provide twenty-five years of continued work for the joint venture. Additionally, the ICGS was motivated to prove itself as an LSI in order to win similar contracts in the future.

Lifecycle Development Model

The Deepwater Program was initially structured as a system-of-systems, executed by a sole-source lead systems integrator (LSI): Integrated Coast Guard Systems. The goal of the system-of-systems was to provide the Coast Guard with the assets required to complete all assigned missions. This system-of-systems demanded interoperability among assets afloat, assets airborne, and assets land-based. Further, interoperability was required with U.S. Navy assets and those of the law enforcement and intelligence

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[23] IDS MNS, 1.

[24] "Coast Guard awards $16.95 billion Deepwater contract," *Marine Log*, URL: <http://www.marinelog.com/DOCS/NEWSMMIIa/MMIIJun26.html>, accessed 10 September 2014.

communities. Individual systems and sub-systems conformed to the traditional "Vee-Model" of systems engineering, but the system-of-systems development relied heavily on modeling and simulation to support systems engineering of interoperability between and among assets.

Diamond Taxonomy

The Diamond Taxonomy has been proposed as a technique to characterize a project in four dimensions: novelty, technology, complexity, and pace (NTCP).[25] The novelty dimension is a measure of innovation: derivative, platform, and breakthrough. The Deepwater Program is clearly an example of platform innovation; existing assets were being replaced with improved assets providing new and improved functionality.[26] The technology dimension is a measure of uncertainty: low-tech, medium-tech, high-tech, and super high-tech. The Deepwater Program is characterized, for the most part, as high-tech, using proven technologies.[27] In a few cases Deepwater projects ventured into the realm of super high-tech (unproven technologies), resulting in undesirable consequences. The complexity dimension is a measure of system scope: assembly, system, and array. The Deepwater Program was by definition a system-of-systems, and therefore considered an array.[28] The pace dimension is a measure of urgency: regular, fast/competitive, time-critical, and blitz. The Deepwater Program is characterized as fast/competitive. The program had ambitious deadlines, but they were determined by schedules, not by external events.[29]

The following figure illustrates the four NTCP dimensions characterizing the Deepwater Program. This figure is applicable to the program both at the beginning and the end. In other words, the NTCP dimensions did not change during the execution of the Deepwater Program.

[25] Aaron J. Shenahar and Brian Sauser, "Systems Engineering Management: The Multidisciplinary Approach," in *Handbook of Systems Engineering and Management*, ed. Andrew P. Sage and William B. Rouse, (Hoboken, NJ: Wiley, 2009), 123-124, cited hereafter as SEM.

[26] SEM, 124-125.

[27] SEM, 125-126.

[28] SEM, 126-127.

[29] SEM, 127.

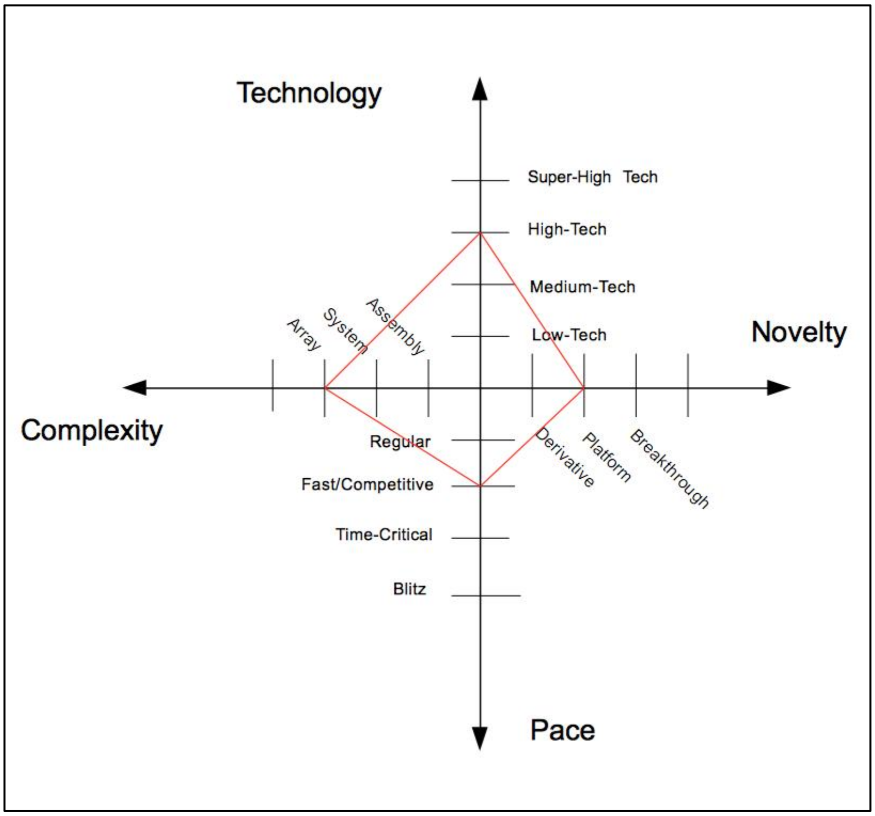

Figure 4 "Diamond Taxonomy" for the Deepwater Program
Source: Author's Analysis

These dimensions can provide the systems engineering manager (SEM) with insight into roles and functions required for a "conventional" project.[30] In the case of the Deepwater Program, this model is not readily applicable given the unique contract arrangement of ICGS as lead systems integrator (LSI) with extraordinary authority to make decisions on behalf of the USCG.

Comparison of Performance at the End with that Envisioned Early in the Development Lifecycle

The multitude of problems resulting from the "spiral of increasing rigidity, distrust, and conflict" described elsewhere in this paper had real impact on the quality and utility of the assets developed.

The Coast Guard has 49 110-foot Island-class Patrol Boats that were to be replaced by Deepwater Fast Response Cutters (FRCs). ICGS proposed to provide additional capabilities and extend the life of the patrol boats until the FRCs became available. To do this, ICGS lengthened the eight of the patrol boats from 110-feet to 123-feet at a cost of nearly $100 million. The Coast Guard halted continued work on the patrol boats, determining the eight delivered in 2005 did not meet their operational

[30] SEM, 131-144.

requirements. In February 2007, the DHS Inspector General confirmed the existence of design flaws alleged by a Lockheed Martin systems engineer. Also in 2007, the Coast Guard determined these eight "modernized" patrol boats had serious structural flaws. The patrol boats were decommissioned and cannibalized for parts and equipment.[31]

Owing to the problems with the patrol boats, the Coast Guard decided to accelerate acquisition of the Fast Response Cutters (FRCs). However, the Coast Guard discovered design flaws in the FRC and in February 2006 they suspended continued work on the cutters.[32]

The National Security Cutters (NSC) originally conceived to be the pride of the recapitalized Coast Guard fleet, and yet they too were flawed. The DHS Inspector General noted the following:

> "The NSC, as designed and constructed, will not meet performance specifications described in the original Deepwater contract. Specifically, due to design deficiencies, the NSC's structure provides insufficient fatigue strength to be deployed underway for 230 days per year over its 30-year operational service life under Caribbean (General Atlantic) and Gulf of Alaska (North Pacific) sea conditions. Coast Guard technical experts believe the NSC's design deficiencies will also increase the cutter's maintenance costs and reduce its service life."[33]

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[31] O'Rourke, 7-9.

[32] O'Rourke, 9-10.

[33] Department of Homeland Security, Office of Inspector General, *Acquisition of the National Security Cutter*, 1, OIG-07-23, January 2007, URL: < http://www.oig.dhs.gov/assets/Mgmt/OIG_07-23_Jan07.pdf>, accessed 10 September 2014, cited hereafter as DHS OIG.

Comparison of Original Schedule with Actual Results

The multitude of performance problems during the Deepwater Program development, including those associated with the patrol boat modernization, the Fast Response Cutter, the National Security Cutter, had an impact on the program schedule as well. The following table identifies the schedule delays between the 2007 baseline and the revised assessment of July 2010. In the case of the FRC, final asset delivery was delayed by **five years**!

	Initial operational capability (FY)			Final asset delivery (FY)		
Asset	2007 baseline	Current baseline	Change	2007 baseline	Current baseline	Change
National Security Cutter	2008	2009	12 months	2014	2016	24 months
Fast Response Cutter[a]	2010	2013	27 months	2016	2021	60 months
Medium Endurance Cutter Sustainment	2006	2006[b]	0 months	2016	2017[b]	17 months
Patrol Boat Sustainment	2009	2007[b]	(18 months)	2013	2014[b]	17 months
Maritime Patrol Aircraft	2008	2009	21 months	2016	2020	57 months
HC-130J	2008	2009	3 months	2009	2011	21 months
HC-130H	2013	to be determined		2017	to be determined	
HH-65	2009	to be determined		2013	to be determined	
HH-60	2014	to be determined		2019	2020	12 months

Figure 5 Changes in Initial Operational Capability and Final Asset Delivery from 2007 Baseline for Selected Deepwater Assets as of July 2010
Source: GAO-10-790, 22, "Revisions to Asset Baselines Show Further Schedule Delays"

IDS Requirements Management

The Deepwater Program was plagued by a great number of serious problems during its period of performance. Poor or imprecise requirements were undoubtedly a contributing factor to the source of those problems. The following examination of a sample of Deepwater system requirements reveals the majority of them are flawed based on the quality factors defined by Davis.

In June 2001 Lockheed Martin and Northrup Grumman Ingalls Shipbuilding formed a joint venture company, Integrated Coast Guard Systems (ICGS), to bid on the Integrated Deepwater Systems contract.[34] This contract reflected the requirements documented in the IDS Systems Performance Specification (SPS) of August 2000.[35] The ICGS joint venture was awarded the primary contract for the IDS on 25 June 2002.[36]

> "A performance specification states requirements in terms of the required results and the criteria for verifying compliance, without specifically stating how the results are to be achieved. A performance specification describes the functional requirements for an item, its

[34] Scott.

[35] IDS SPS.

[36] IDS MNS, 8.

capabilities, the environment in which it must operate, and any interface, interoperability, or compatibility requirements. It does not present a preconceived solution to a requirement."[37]

According to Davis, a good system requirements specification (SRS) exhibits thirteen quality factors.[38] Of these thirteen quality factors, the following five apply to the SRS document as a whole: complete, consistent, modifiable, traceable, and organized. Applying these criteria to the IDS SPS provides the following insights into the Deepwater Program.

Complete. A requirements document is complete, according to Davis, if it captures everything the system is supposed to do.[39] The SPS meets that test at a conceptual level, but not at a detailed level. Associated Deepwater artifacts, such as the Test and Evaluation Master Plan (TEMP) and the Technical Feasibility Factor Requirements and Standards, do provide those details. Those artifacts are not discussed here.

Consistent. According to Davis, the requirements document is consistent only if requirements do not conflict with each other.[40] The requirements identified in the SPS are levied on the entire system-of-systems: "3.1 Functional Capabilities. The capabilities in this specification shall be met by the entire IDS (individual assets may not necessarily be capable of meeting all of the requirements)."[41] No individual SPS requirements appear to conflict with any others.

Modifiable. According to Davis, the requirements document is modifiable if changes "can be made easily, completely, and consistently."[42] The SPS is lacks a table of contents and an index, but it does provide some cross-references. The document clearly could be improved in terms of this quality factor.

Traceable. This quality factor, according to Davis, enables stakeholders to reference requirements easily and efficiently.[43] The SPS begins with a recapitulation of the fourteen USCG missions required by statute, but the individual requirements listed in the SPS are not traced back to those missions. The individual paragraphs are numbered for ease of reference, but individual paragraphs include more than one requirement in a number of cases, such as the following:

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[37] "*Guide for Performance Specifications*," 24 August 2009, Defense Standardization Program, 2, URL:< http://www.navair.navy.mil/nawctsd/Resources/Library/Acqguide/SD_15%202009.pdf>, accessed 15 September 2014, cited hereafter as Guide.

[38] Gulu Gambhir, "Requirements Engineering" (presented at the PhD Cohort, George Washington University, 13 September 2014), 104, cited hereafter as RE Presentation.

[39] RE Presentation, 106.

[40] RE Presentation, 108.

[41] SPS, 4.

[42] RE Presentation, 110.

[43] RE Presentation, 112.

> "3.2.5 Surveillance, Detection and Monitoring. The IDS shall be capable of determining what and whom resides, enters, and exits any selected zone(s) within the Deepwater AOR. In addition to material targets, this requirement includes other mission triggers or events such as maritime pollution or national marine sanctuary violations, closed area incursions, collisions, etc."[44]

Organized. The SPS co-locates related requirements, such as "3.3 Information Exchange Capabilities," and numbers the individual paragraphs, so at a basic level it satisfies Davis' quality factor for organization.[45]

Davis maintains that a good individual requirement must exhibit the following quality factors: correct, unambiguous, verifiable, understandable by the customer, traced (rationale), design independent, annotated (priority & relative stability), and concise.[46] The SPS is assumed to be correct and understandable by the customer, because the customer, the USCG, prepared it. In general, the SPS does not provide any rationale for the requirements: they are not explicitly traced to specific missions. Nor does the SPS provide any annotation regarding priority or relative stability. With regard to being verifiable, the SPS does provide some verification guidance for individual requirements, but in general it defers to the Lead Systems Integrator:

> "4.1 Classification of Verifications. Verification classifications shall be proposed by the contractor. These classifications shall identify acceptable verification approaches to field the IDS and sub-systems of the IDS. Each approach shall contain the various methods (analysis, demonstration, examination, and/or test) of verification."[47]

The following table identifies forty requirements included in the SPS. The requirements are extracted from the following categories in the SPS:

- 3.3 Information Exchange Capabilities
- 3.4 Information Support Capabilities
- 3.5 Decision Support Capabilities
- 3.6 Prosecution

The numbered columns correspond to the following quality factors.

1. Correct
2. Unambiguous
3. Verifiable
4. Understandable by customer
5. Traced (rationale)

[44] SPS, 5.

[45] RE Presentation, 114.

[46] RE Presentation, 115.

[47] SPS, 19.

6. Design independent
7. Annotated (priority & relative stability)
8. Concise

For the reasons already noted, the quality factors (1) correct, (3) verifiable, (4) understandable by customer, (5) traced, and (7) annotated generally require no further comment. The other quality factors are applied to the extracted requirements and are flagged with **C** (comment) if a comment is appropriate. The comments also address *driving requirements*, when applicable. The application of the judgment of *driving* is subjective in terms of Deepwater, because all requirements are (in theory) traced back to the fourteen missions that are **mandated by statute**. In that regard, statutory missions are by definition driving: the USCG does not have the option to trade-off one mission in order to better perform another. All of them drive the design and development of the system of systems. Following are those fourteen missions[48]:

- 1.4.1 Alien Migrant Interdiction Operations (AMIO)
- 1.4.2 Port Operations, Security and Defense (POSD)
- 1.4.3 Drug Interdiction
- 1.4.4 Environmental Defense Operations
- 1.4.5 Foreign Vessel Inspection
- 1.4.6 General Defense Operations
- 1.4.7 General Law Enforcement
- 1.4.8 International Ice Patrol (HP)
- 1.4.9 Lightering Zone Enforcement
- 1.4.10 Living Marine Resources Enforcement (LMR)
- 1.4.11 Maritime Intercept Operations (MIO)
- 1.4.12 Maritime Pollution (MARPOL) Enforcement and Response
- 1.4.13 Search and Rescue (SAR)
- 1.4.14 Peacetime Military Engagement (PME)

[48] SPS, 2-4.

Table 1 Deepwater Program Requirements

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.3.1 Exchange Information with Other Coast Guard Assets. The IDS shall maintain simultaneous real time voice, video and data communications between all Coast Guard assets.		C							2. Unambiguous (and Traceable): The requirement states "all Coast Guard assets." How can IDS maintain real time voice communications with a UAV, one of those assets? Voice, video, and data communications should be treated as three separate requirements. **This requirement can be considered driving.**
3.3.2 Embarked Staff. The IDS shall provide command and control support for an embarked staff without negative impact on any unit's independent communication, command and control functions.		C							2. Unambiguous: What constitutes a "negative impact"? What is meant by a "unit's independent" C3 functions?
3.3.3 Exchange Information with External Organizations. The IDS shall maintain simultaneous real time voice, video and data communications with DOD, other Federal agencies, state and local government, North Atlantic Treaty Organization (NATO), similar coalitions and potential partners, the maritime public, and private sector in accordance with applicable standards.		C	C						2. Unambiguous (and Traceable): Who are "similar coalitions and potential partners"? Voice, video, and data communications should be treated as three separate requirements. 3. Verifiable: What are the "applicable standards"? **This requirement can be considered driving.**

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.3.4 Dissemination. The IDS shall disseminate processed intelligence to operational units and the general public as required.	C	C							1. Correct: Processed intelligence is generally classified, so how can it be disseminated to "the general public"? 2. Unambiguous (and Traceable): The intelligence is to be disseminated "as required," but it is unclear what constitutes required dissemination. Operational units and the general public should be treated as two separate requirements.
3.3.5 Protect Information Exchanges at Appropriate Level of Security. The IDS shall properly safeguard and handle secure and non-secure information exchanges up to a level of security that ensures interoperability with U.S. and allied forces.		C							2. Unambiguous (and Traceable): This requirement conflates secure (classified) and non-secure (unclassified) information exchanges. These should be treated as separate requirements. **This requirement can be considered driving.**
3.4.1 Access Data Bases and Data. The IDS shall access Coast Guard, multiple agency, and national information and informational data bases needed to accomplish missions.		C							2. Unambiguous: Does "shall access" mean provide an interface to exchange data or does it mean simply to have the authority to read and use the data?

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.4.1.1 Target Information. The IDS shall access information which provides position, course, speed, and description of the target and specifies the age and accuracy of the information.	C	C							1. Correct: Course and speed are not applicable when addressing a stationary target. 2. Unambiguous (and Traceable): This requirement conflates two requirements. The age and accuracy of the target information may not be known, so this should be treated as a separate requirement.
3.4.2 Store and Archive Information. The IDS shall store and archive both corporate and locally maintained information.		C							2. Unambiguous (and Traceable): Some information is non-digital (i.e., paper). Does this information fall within the scope of IDS? Corporate data and local data should be treated as two separate requirements.
3.4.3 Preserve Data Integrity. The IDS shall prevent loss, corruption or conflict of stored information.	C								1. Correct: IDS can alert users to the existence of conflicting stored information, but it cannot prevent the occurrence of conflicting stored information in all cases.
3.4.4 Preserve Data Security. The IDS shall prevent, detect and counteract network intrusions.									
3.4.5 OPSEC. The IDS shall implement Operations Security (OPSEC) measures.									
3.4.6 OPDEC. The IDS shall conduct deception operations (OPDEC).		C							2. Unambiguous: A system cannot conduct deception operations, but it can provide the capability to conduct them.

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.5.1 Determine High Interest Grids and Assess Threats. The IDS shall determine and track activity in High Interest Grids.		C							2. Unambiguous (and Traceable): This requirement conflates determining high interest grids and assessing threats, two separate requirements.
3.5.2 Develop Plans. The IDS shall provide decision support capabilities to develop operational and management plans, logistics plans, mission plans, crisis action plans, and unit operational and support plans.		C						C	2. Unambiguous (and Traceable): Is this list of plans representative or exhaustive? Each type of plan should be addressed as a separate requirement. 8. Concise: Should the requirement read instead, “The IDS shall provide decision support capabilities to assist planners”?
3.5.3 Allocate Resources. The IDS shall provide decision support capabilities to develop plans to prioritize and adjust the use of available assets and those of other organizations to accomplish Coast Guard missions, to include National Emergency Response Operations (NERO).		C				C			1. Unambiguous (and Traceable): How can the IDS adjust the use of available assets belonging to “other organizations”? Or do they mean assets transferred to the USCG from other organizations? Prioritize and adjust should be treated as two separate requirements. 2. Design Independent: The stipulation to “prioritize and adjust” may be an over-specification impinging on the real requirement to provide decision support capabilities to accomplish Coast Guard missions.

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.5.4 Direct and Oversee Operations. The IDS shall exercise command and control of multiple Coast Guard surface and air assets, and in U.S. and multi-national operations (DOD, other government agencies, NATO and similar coalitions and potential partners).		C							2. Unambiguous: Isn't IDS required to provide C2 over ALL Coast Guard assets, vice "multiple" assets? The additional text regarding DoD, NATO, etc., is completely unclear. **This requirement can be considered driving.**
3.5.5 Navigate. IDS assets shall determine navigational position as required to prosecute Deepwater missions, as verified in Section 4.8.		C							2. Unambiguous: Does "determine navigational position" mean navigate?
3.5.6 Maintain Situation Awareness. The IDS shall maintain awareness of the operating environment, to include fusion of local tactical information with database information in near real time.		C				C			2. Unambiguous: How does "local tactical information" differ from local information? 6. Design Independent: The stipulation to fuse local data with "database information" seems to cross the line from "what" to "how." **This requirement can be considered driving.**
3.5.6.1 Ocean Surface Current. The IDS shall determine ocean surface current speed and direction.		C							2. Unambiguous: Does IDS have to determine the speed and direction of water currents or of USCG assets on the surface of the ocean?

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.5.6.2 Oceanographic and Meteorological Observations. The IDS shall determine oceanic bathythermographic profiles and meteorological observations to include wind velocity, wind direction, sea temperature, sea state, visibility, air temperature, etc.		C							2. Unambiguous (and Traceable): The use of "etc." at the end of the requirement is not sufficiently specific. Wind velocity, direction, sea state, visibility, air temperature should each be treated as a separate requirement.
3.5.6.3 Drift Rate Determination. During the response to events involving mariners in distress, the IDS shall continuously sense the wind and ocean currents in designated search areas for the calculation of drift rates of distressed craft and survivors.						C			6. Design Independent: This requirement is stating **how** to locate distressed craft and survivors.
3.5.7 Evaluate and Adjust Operations. The IDS shall provide the capability to evaluate and adjust operations to ensure routine operations and crisis taskings are properly executed without mission degradation.		C							2. Unambiguous (and Traceable): Evaluate and adjust operations should be treated as two separate requirements. This requirement also conflates routine operations and crisis taskings. They should be separated. **This requirement can be considered driving.**
3.5.8 Direct and Oversee Sustainment Actions. The IDS shall provide the necessary planning support to ensure assets are able to accomplish assigned missions.		C							2. Unambiguous: How does this requirement differ from 3.5.3?

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.6.1 Enforcement. The IDS shall compel compliance of cooperative, uncooperative and evasive targets using the minimum force necessary, including effective non-lethal means.		C							2. Unambiguous (and Traceable): Why would IDS need to compel compliance from a cooperative target? Cooperative, uncooperative, and evasive targets should be treated as three separate requirements. **This requirement can be considered driving.**
3.6.2 Response Time (Distress). The IDS shall be capable of arriving on-scene and rendering assistance, as verified in Section 4.9.		C							2. Unambiguous (and Traceable): Arriving on-scene and rendering assistance should be treated as two separate requirements.
3.6.3 Response Time (NERO). The IDS shall respond to a NERO, as verified in Section 4.10.									
3.6.4 Intercept and Interdict. The IDS shall intercept and interdict TOT anywhere in the Deepwater AOR.		C							2. Unambiguous (and Traceable): Intercept and interdict should be treated as two separate requirements. **This requirement can be considered driving.**
3.6.5 Conduct Boardings. The IDS shall safely and effectively launch and recover multiple, simultaneous boarding teams with equipment to and from vessels at sea, as verified in Section 4.11.		C							2. Unambiguous (and Traceable): Launch and recover should be treated as two separate requirements. **This requirement can be considered driving.**
3.6.5.1 Pathogens. The IDS shall protect boarding team personnel and dispatching asset from food-borne, water-borne, air-borne, and blood-borne pathogens on-board target vessels.		C							2. Unambiguous (and Traceable): Protecting the boarding team and protecting the dispatching asset should be treated as two separate requirements.

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.6.5.2 Hazardous Atmospheres. The IDS shall detect vessel compartments containing hazardous atmospheres or potential hazardous atmospheres.		C							2. Unambiguous: The use of "potential" is a poor word choice. Every vessel compartment has the potential to be a hazardous atmosphere. "Suspected" would be a better word choice.
3.6.6 Command Presence. The IDS shall provide a command presence/cover for multiple, simultaneous boarding teams.		C							2. Unambiguous: Does "command presence/cover" imply command presence and cover are one thing or two separate things?
3.6.7 Transfers. The IDS shall conduct transfers of equipment and people to and from vessels, as verified in Section 4.12.		C							2. Unambiguous (and Traceable): Transfers of equipment to vessels and transfers of people to vessels should be treated as two separate requirements.
3.6.8 Escort. The IDS shall be capable of escorting vessels of any size.									**This requirement can be considered driving.**
3.6.9 Towing. The IDS shall tow vessels, as verified in Section 4.13.									**This requirement can be considered driving.**
3.6.10 Transport. The IDS shall have the capability to rapidly transport mission specific equipment and personnel to scene (i.e. IIP, Marine Environmental Response, Law Enforcement Operations, and Search and Rescue) as verified in Section 4.25. Locations for transporting equipment and personnel may include crossing international boundaries and/or use of facilities damaged or impacted by natural disasters.		C							2. Unambiguous (and Traceable): Transports of equipment and transports of people to scene should be treated as two separate requirements.

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.6.11 Port Security. The IDS shall provide for the safe and efficient operation of all vessels transiting designated harbors anywhere in the Deepwater AOR, including protection of port assets and coastal patrols to enforce security perimeters during NERO.		C							2. Unambiguous (and Traceable): Transiting designated harbors, protecting port assets, and protecting coastal patrols should be treated as separate requirements. **This requirement can be considered driving.**
3.6.12 HAZMAT Response Capabilities. The IDS shall provide Level A Hazardous Material (HAZMAT), per 29 CFR 1910.120 Appendix B, response up to 200 NM offshore.									
3.6.13 Divert or Seize Vessels. The IDS shall divert or seize vessels as required and provide custody crews and security for seized vessels.		C							2. Unambiguous (and Traceable): Divert vessels, seize vessels, provide custody for seized crews, and provide custody for seized vessels should each be a separate requirement. **This requirement can be considered driving.**
3.6.14 ESM/ECM. The IDS shall conduct Electronic Surveillance Measures (ESM) and Electronic Countermeasures (ECM) operations in support of own unit.		C							2. Unambiguous (and Traceable): ESM and ECM should be treated as two separate requirements.
3.6.15 EMCON. The IDS shall conduct Emission Control (EMCON) operations in support of own unit.									

REQUIREMENT	1	2	3	4	5	6	7	8	COMMENTS
3.6.16 Hazards to Navigation. The IDS shall mark, remove, sink or destroy hazards to navigation.		C							2. Unambiguous (and Traceable): Mark, remove, sink, and destroy hazards to navigation should each be treated as a separate requirement. **This requirement can be considered driving.**

IDS Risk Management

The Deepwater Program mission was the recapitalization of major U.S. Coast Guard (USCG) assets, with the National Security Cutter designed as the flagship of the USCG fleet. As with many of the recapitalized assets in the Deepwater Program, the first National Security Cutter (NSC-1), *Bertholf*, exhibited a number of design flaws resulting in schedule delays and cost overruns.

This paper examines thirteen risks identified in a formal NSC-1 risk briefing presented on 30 August 2007.[49] That briefing identified the risks, proposed mitigation strategies, and estimated both the likelihood of occurrence and the resulting impact. In this paper the Risk Matrix developed by MITRE is used to analyze that data.[50] The *Risk Matrix User's Guide* provides detailed information regarding use of the matrix.[51]

Following is a brief description of the *Bertholf*, providing an overview of its sophistication and complexity as a system:

> "The *Berthölf* is a complex ship, with capabilities that surpass those of the current fleet's high endurance cutters. The NSC features increased patrol endurance (60–90 day patrol cycles); more powerful weapons (including the Mk110 57mm main gun); a larger flight deck; chemical-biological & radiological environmental hazard detection and defense; and improved command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) equipment. With a suite of modern air and surface search radars and target classification optics, the NSCs' sensor range and capabilities also are extended and augmented by aircraft, such as the modernized MH-65C Dolphin helicopter."[52]

Risk is probably greatest in any first-in-class system, but then risk is reduced in subsequent product deliveries, owing to lessons-learned, etc.[53] The *Bertholf* was the first in the Legend-class of National Security Cutters, and the attendant risks associated with its development and deployment resulted in a number of delays and cost overruns. These

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[49] NSC Risk Brief, United States Coast Guard, Acquisition Directorate, Program Executive Officer, 30 August 2007, Project on Government Oversight, URL: <http://pogoarchives.org/m/wi/deepwater/risk-brief-20070830.pdf>, accessed 22 September 2014, cited hereafter as Risk Brief.

[50] *Risk Matrix*, version 2.20, Excel, Risk Management (Bedford, MA: MITRE, 1999), URL: <http://www2.mitre.org/work/sepo/toolkits/risk/ToolsTechniques/RiskMatrix.html>, accessed 22 September 2014.

[51] Pamela Engert and Zachary Lansdowne, "Risk Matrix User's Guide" (MITRE, November 1999), URL: <http://www2.mitre.org/work/sepo/toolkits/risk/ToolsTechniques/RiskMatrix.html>, accessed 22 September 2014, cited hereafter as User's Guide.

[52] Hunter Keeter, "Coast Guard, Industry Team Put Finishing Touches on Cutter Bertholf & Apply Lessons Learned to Sister Ship, Waesche," U.S. Coast Guard, Acquisition Directorate Feature Article, URL: <http://www.uscg.mil/acquisition/newsroom/feature/nscupdate.asp>, accessed 23 September 2014, cited hereafter as Keeter.

[53] Keeter.

problems were no doubt exacerbated by the troubled Deepwater acquisition model. The U.S. Government Accountability Office reported the following regarding the delays in the delivery of the *Bertholf* and the impact of the delays on the USCG:

> "Regarding the National Security Cutters, delays in the delivery of National Security Cutters and the support assets of unmanned aircraft and small boats have created operational gaps for the Coast Guard that include the projected loss of thousands of days in National Security Cutter availability for conducting missions until 2018, as we reported in July 2009. The first vessel (USCGC *Bertholf*) was initially projected for delivery in 2006 but was not delivered to the Coast Guard until May 2008. We reported in July 2009 that this first vessel was undergoing final trials as the Coast Guard prepared it for full operational service in the fourth quarter of fiscal year 2010. The Coast Guard deployed this first National Security Cutter without its planned support assets."[54]

Figure 6 USCG Bertholf,
Source: USCG, URL: <http://www.uscg.mil/history/webcutters/WHEC_Photo_Index.asp>, accessed 23 September 2014

[54] "COAST GUARD: Observations on the Requested Fiscal Year 2011 Budget, Past Performance, and Current Challenges, Statement of Stephen L. Caldwell, Director Homeland Security and Justice Issues" (GAO, February 25, 2010), 15, Government Accountability Office, URL: <http://gao.gov/assets/130/124071.pdf>, accessed 23 September 2014, cited hereafter as GAO-10-411T.

MITRE Risk Matrix Tool

The following tables provide the Risk Matrix populated with data extracted from the Risk Brief of August 2007. The Risk Matrix (Excel) uses that data to calculate the Borda Rank (column O) and the Risk Rating (column P), both columns highlighted in yellow. The Action Plan, Figure 2, identifies specific mitigation tasks that had been completed already at the time of the Risk Brief. The remaining figures provide insights into the Borda calculations, computed by the Risk Matrix, both with and without the Action Plan.

A	B	F	G	H	J	K	O	P	U
Risk No.	**Related Risk No.**	**RISK**	**Timeframe Start**	**Timeframe End**	**I**	**Po (%)**	**Borda Rank**	**R**	**Manage/Mitigate**
1	2	TEMPEST: If NSC 1 does not meet TEMPEST requirements of IA 5239.3 1, IA 5239.22 and NSTISSAM TEMPESTI2-95 by delivery, then the cutter will be unable to process classified information.			S	70%	1	M	Conduct early Visual TEMPEST Inspection (VTI) Conduct Pre-Instrumented TEMPEST survey (ITS) on cabinets CCA clarified TEMPEST contract requirements Work-Off identified TEMPEST discrepancies Charter Working Group to provide execution focus on design issues PMRO will conduct periodic inspections to ensure discrepancies are addressed Conduct VTI after discrepancies are addressed Conduct Full Ship ITS
2	1	Information Assurance: If the NSC is not granted IATO/ATO by the DAA before delivery, then it will not be able to connect to SIPRNET or CGDN+. IATO/ATO is heavily dependent on DIACAP and FISMA requirements.			S	70%	1	M	CG-6 identify DAA/CA Add contract scope for HM&E systems Charter IA Leadership Team to provide visibility and mgmt oversight Charter IA Working Group to provide execution focus on design issues Break out from Test Cert Schedule an IA POA&M to focus on: Identifying requirements and architecture Developing SSAA documentation Scanning and hardening information systems

4	3		CGC2 Performance: If the CGC2 system is unable to perform consistently by delivery, then the NSC will not be able to execute all mission requirements.			Mo	60%	5	L	Mitigate Shipboard Integration risk at MDAC & TRACEN Adjust software build process from lessons learned at D7 and -123 Establish USCG insight and oversight through IPTs and ECB/CCB Conduct rigorous oversight of Shipboard Testing Program Review and revise management approach and contracting vehicle of software fixes, upgrades and security maintenance
5	4	5	External Communications: If the External Coinmunications (ExComms) change proposals are not completed at PSA, then the NSC will be unable to meet multiple circuit capability requirements in HF, UHF (including UHF MILSATCOM) and VHF bands.			Mo	60%	5	L	Partner with NS WCDD-ITD to conduct topside analysis Develop technical solution for ExComms Upgrades Develop or modify ECP for consideration by NSC CCB Schedule SCIF design review with CG2/3/4/6 representatives

6	5	1,2	Interior Communications: If the Internal Vessel Communication System (IVCS) is not accredited by delivery, then the crew of the NSC will be unable to discuss classified information over this system and the Interior Communication system will need to be modified.			Mo	60%	5	L	Submit Type Accreditation Package Partner with the USN on accreditation of the IVCS Monitor NSA evaluation and provide amplifying information as needed Await results of the NSA accreditation
7	6		NSC 1 Schedule: If the Builder's and Acceptance Trials of NSC 1 do not occur on time, then the ship may not be delivered by the end of February 2008			Mo	70%	0	M	Program Office monitoring progress carefully Pushing ICGS for a revised, realistic schedule to DD-250 PMRO adjusting staff resources to support aggressive schedule and ensure QA is not compromised Program Office established teams to focus on IA issues Coordinate with INSURV revised AT date once known to ensure INSURV can support

8	7		Stern Launch and Recovery: If any remaining safety and engineering concerns cannot be resolved at PSA, then the NSC may not be able to safely and effectively launch and recover its small boats from the stem ramp			Mi	50%	10	L	Side launch davit was added to mitigate stem launch risk situations 2 SRP's have been modified for use in both stem launch and side launch davits L/R Working group established Near term focus on test planning, training and safety Post Delivery effort to develop operational guidance and expand operational envelope Long term focus R&D planning with CG-926 Develop confidence building measures with trials during increasing sea states. Any required modifications will be scheduled for PSA
9	8		NSC Weight Growth: If weight growth cannot be offset with a corresponding increase in limiting displacement at PSA, then the NSC will have less weight margin reserved for service life growth.			Mi	30%	3	L	Performing the inclining experiment and dead-weight survey prior to Builder's trials will provide opportunity to reassess further weight growth V-line structural modifications to NSC 1/2 will increase the max displacement to 4,700 LT, bringing the service life margin to 278 LT NSC 3 will include max displacement at 4,700 LT at delivery Future ECPs must be weight neutral

0	9		Vital Space Access/Egress: If effective access and egress routes from certain vital spaces on the NSC are not created, then the NSC will not meet Navy GENSPEC requirements.			Mi	30%	3	L	Initiate Safety Assessment Evaluate ECPs to modify NSC 1 post delivery Explore ECP's for NSC 213 during construction
1	10		Flight Deck Certification: If essential ship modifications are not accomplished at PSA, then the NSC will not achieve hll NAVAIR certification as required by the CPD.			Mi	30%	10	L	Active involvement of NAVAIR, CG-933, Ship-Helo Branch in aviation facilities working group 2 changes planned for PDA to achieve Interim Certification NAVAIR-certified MORIAH wind indicating system Flight Deck AFFF Sprinkling for landing armed helicopters Add De-ionized Water for HH-65C engine washdown
2	11		HH65C Helo Unavailable: If the HH65C helicopters are not modified to accommodate the ASIST probe at PSA, then the NSC will not be able to deploy with an ASIST equipped aircraft and will require additional personnel to conduct flight operations.			Mo	40%	5	L	Aviation Community planning on default pitch/roll limits pending DI Testing with ASIST Working with USN to test ASIST using Navy H-60 until USCG HH-65C is available Reprogrammed NSC funds to support aircraft modification ARSC will modify the first two HH65C's Conduct Shipboard Flight Testing

3	12		VUAV: If replacement maritime surveillance capability is not found by delivery, then the NSC will fail Surveillance Critical Test Parameter.			Mo	80%	5	L	R&D Center working on Surveillance alternatives Phase 1 Study Phase 2 Study Phase 3 Study; pends funding Implementation of surveillance solution
4	13		NVG Operations: If an NVG compatible system is not provided by delivery, then the NSC will not be able to conduct night helicopter operations without illuminating the flight deck.			Mi	30%	10	L	Align with USN Next Generation VLA development Work with NAVAIR to define ASIST mod Address legacy capability post delivery and implement an ECP, if needed Implement ASIST mod during PSA, if needed

	A	B	C	D	E	
1	Risk No.	Task	OPR	Exit Criteria	Assessment	Discussion
2	1	Conduct early Visual TEMPEST Inspection (VTI)			Blue	
3	1	Conduct Pre-Instrumented TEMPEST survey (ITS) on cabinets			Blue	
4	1	CCA clarified TEMPEST contract requirements			Blue	
5	2	CG-6 identify DAA/CA			Blue	
6	2	Add contract scope for HM&E systems			Blue	
7	3	Mitigate Shipboard Integration risk at MDAC & TRACEN			Blue	
8	3	Adjust software build process from lessons learned at D7 and -123			Blue	
9	3	Establish USCG insight and oversight through IPTs and ECB/CCB			Blue	
10	4	Partner with NS WCDD-ITD to conduct topside analysis			Blue	
11	4	Develop technical solution for ExComms Upgrades			Blue	
12	5	Submit Type Accreditation Package			Blue	
13	5	Partner with the USN on accreditation of the IVCS			Blue	
14	6	Program Office monitoring progress carefully			Blue	
15	6	Pushing ICGS for a revised, realistic schedule to DD-250			Blue	
16	6	PMRO adjusting staff resources to support aggressive schedule and ensure QA is not compromised			Blue	
17	6	Program Office established teams to focus on IA issues			Blue	
18	6	Coordinate with INSURV revised AT date once known to ensure INSURV can support			Yellow	
19	7	Side launch davit was added to mitigate stem launch risk situations			Blue	
20	7	2 SRP's have been modified for use in both stem launch and side launch davits			Blue	
21	7	L/R Working group established			Blue	
22	7	Near term focus on test planning, training and safety			Blue	
23	10	Active involvement of NAVAIR, CG-933, Ship-Helo Branch in aviation facilities working group			Blue	
24	11	Aviation Community planning on default pitch/roll limits pending DI Testing with ASIST			Blue	
25	11	Working with USN to test ASIST using Navy H-60 until USCG HH-65C is available			Blue	
26	11	Reprogrammed NSC funds to support aircraft modification			Blue	
27	12	Phase 1 Study			Blue	
28	12	Phase 2 Study			Blue	
29	13	Align with USN Next Generation VLA development			Blue	
30	13	Work with NAVAIR to define ASIST mod			Blue	
31						

Figure 7 Action Plan, Many of the Mitigation Tasks Completed (Blue)

Borda Rank Computed by the MITRE Risk Matrix Tool

The MITRE Risk Matrix tool automatically computes the Borda Rank based on the data populated into the matrix. This computation is affected by the presence (or absence) of an action plan.

Risk No.	Borda Rank	Impact
1	1	S
2	1	S
3	5	Mo
4	5	Mo
5	5	Mo
6	0	Mo
7	10	Mi
8	3	Mi
9	3	Mi
10	10	Mi
11	5	Mo
12	5	Mo
13	10	Mi

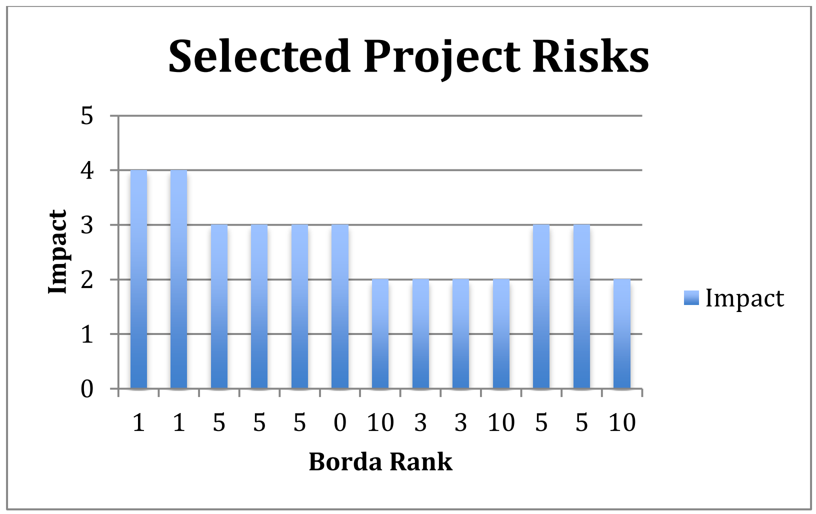

Figure 8 Impact by Borda Rank: Computed by Risk Matrix

Risk No.	Borda Rank	Impact
1	0	S
2	0	S
3	4	Mo
4	4	Mo
5	4	Mo
6	3	Mo
7	8	Mi
8	9	Mi
9	9	Mi
10	9	Mi
11	7	Mo
12	2	Mo
13	9	Mi

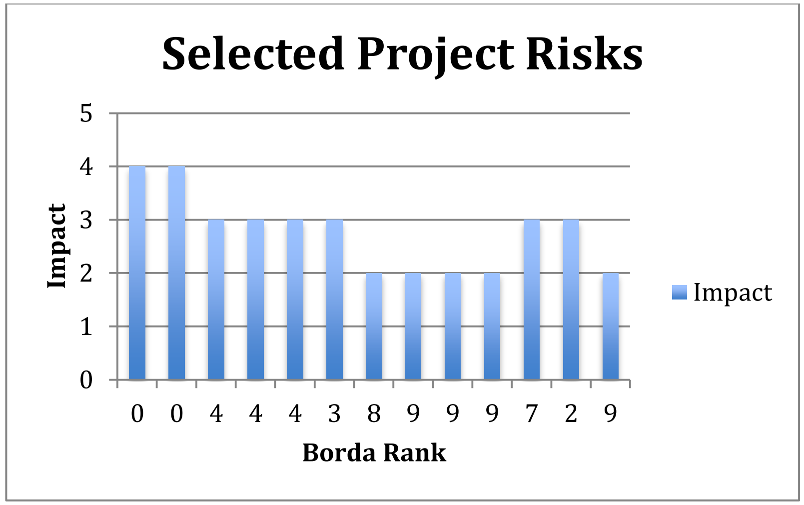

Figure 9 Impact by Borda Rank, Computed <u>Without</u> Action Plan

Risk No.	Borda Rank	Po
1	1	70%
2	1	70%
3	5	60%
4	5	60%
5	5	60%
6	0	70%
7	10	50%
8	3	30%
9	3	30%
10	10	30%
11	5	40%
12	5	80%
13	10	30%

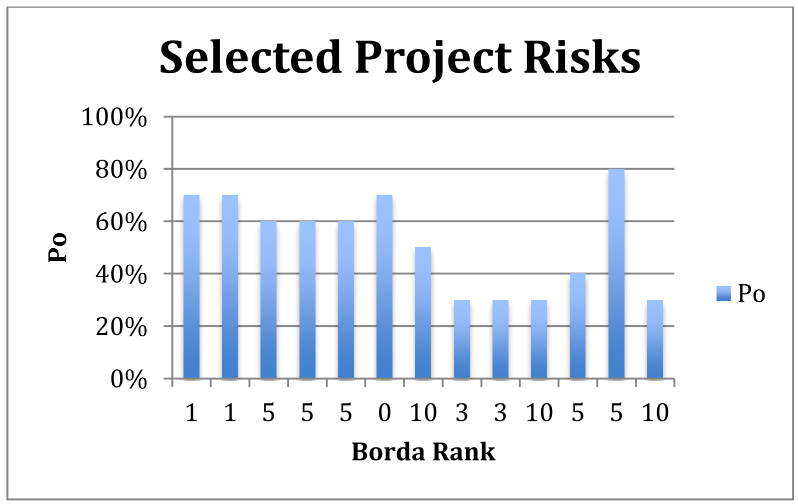

Figure 10 Probability of Occurrence by Borda Rank, Computed by Risk Matrix

Risk No.	Borda Rank	Po
1	0	70%
2	0	70%
3	4	60%
4	4	60%
5	4	60%
6	3	70%
7	8	50%
8	9	30%
9	9	30%
10	9	30%
11	7	40%
12	2	80%
13	9	30%

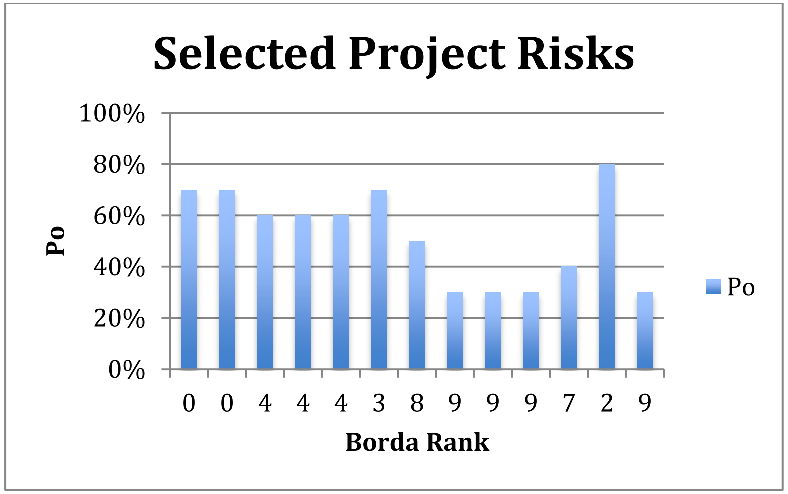

Figure 11 Probability of Occurrence by Borda Rank, Without Action Plan

Risk No.	Borda Rank	Ponm
1	1	0%
2	1	0%
3	5	0%
4	5	0%
5	5	0%
6	0	35%
7	10	0%
8	3	30%
9	3	30%
10	10	0%
11	5	0%
12	5	0%
13	10	0%

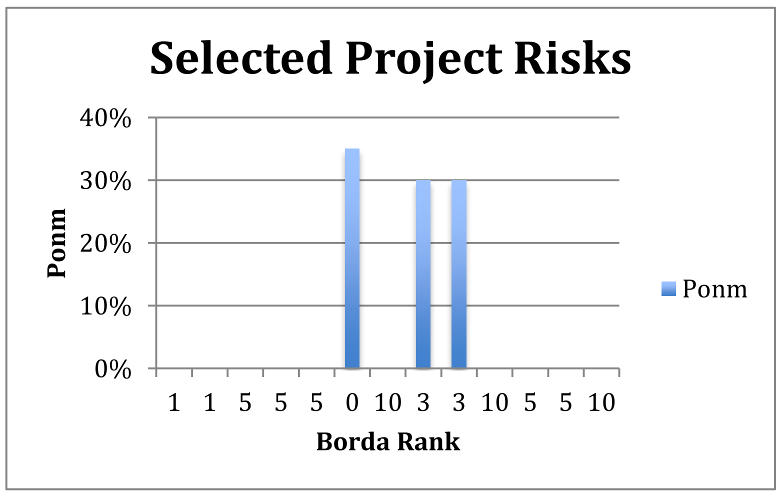

Figure 12 Ponm by Borda Rank, Computed by Risk Matrix
Note: "Formally, Ponm is the joint probability that the risk occurs and the action plan fails to mitigate it," User's Guide, 24.

Risk No.	Borda Rank	Ponm
1	0	70%
2	0	70%
3	4	60%
4	4	60%
5	4	60%
6	3	70%
7	8	50%
8	9	30%
9	9	30%
10	9	30%
11	7	40%
12	2	80%
13	9	30%

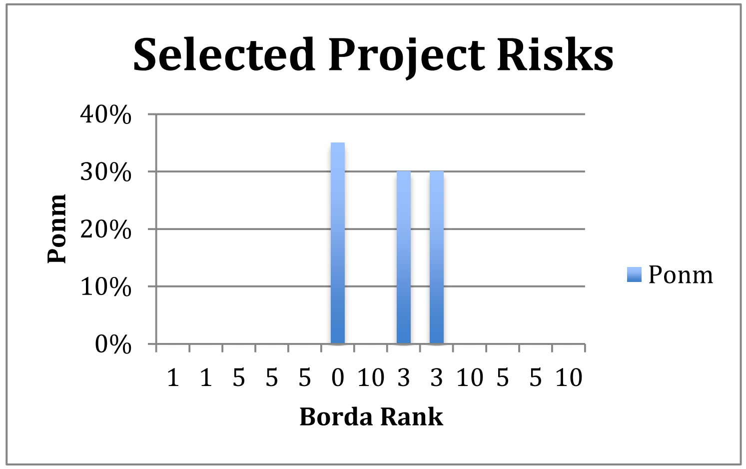

Figure 13 Ponm by Borda Rank, <u>Without</u> Action Plan

IDS Cost Management

Deepwater program cost estimates fluctuated greatly, and the USCG had tremendous difficulty providing DHS and the U.S. Congress with accurate data. This paper relies heavily on cost estimates generated by the General Accountability Office (GAO). Those estimates are used here to approximate a bottoms-up lifecycle cost estimate for the Deepwater program. The following GAO observation from 2010 provides an overview of the difficulties in computing accurate Deepwater estimates.

> "Regarding total acquisition cost, the Coast Guard has determined that some of the assets will significantly exceed anticipated costs in the 2007 Deepwater baseline. Due to this growth, the total cost of the Deepwater Program is now expected to be roughly $28 billion, or $3.8 billion more than the $24.2 billion that DHS approved in 2007, an increase of approximately 16 percent. For the assets with revised baselines this represents cost growth of approximately 35 percent. Further growth could occur, as four Deepwater assets currently lack revised cost baselines. Among them is the largest cost driver in the program, the 25 cutters of the Offshore Patrol Cutter class which, in the 2007 baseline, accounted for over 33 percent of the $24.2 billion total acquisition cost."[55]

Figure 14 Deepwater SOS Concept
Source: GAO-11-743[56]

[55] John P. Hutton, *Coast Guard: Deepwater Requirements, Quantities, and Cost Require Revalidation to Reflect Knowledge Gained* (GAO, 2010), 15, URL: <http://www.gao.gov/new.items/d10790.pdf>, accessed 30 September 2014, cited hereafter as GAO-10-790.

[56] John P. Hutton et al., *Coast Guard: Action Needed As Approved Deepwater Program Remains Unachievable* (GAO, 2011), 31, URL: <http://www.gao.gov/new.items/d11743.pdf>, accessed 30 September 2014, cited hereafter as GAO-11-743.

Bottoms-Up Lifecycle Cost Estimate

The bottoms-up lifecycle cost estimate identifies three major categories of costs: RDT&E (research, development, testing and evaluation); procurement; and operations & maintenance.[57] This estimate is based on an engineering buildup approach beginning with a work breakdown structure (WBS) to identify the major deliverables.[58] The following WBS identifies the Deepwater System-of-Systems elements down two levels. Assigning costs to these elements results in a cost breakdown structure (CBS). The aggregation of the elements in the CBS provides a cost estimate for the entire system.

RDT&E costs frequently reduce over time during a program execution as technology, design, and implementation matures. Also, the program does not incur O&M costs until the system is fielded. Detailed information about Deepwater RDT&E costs and O&M costs is not readily available. The GAO sources used in preparing the following estimates appear to include RDT&E costs in the cost of acquisition of Deepwater assets. Further, the GAO sources focus on acquisition costs and total life-cycle costs, with little detailed information regarding O&M. The estimates produced in this paper assume that O&M costs for each asset can be approximated by subtracting acquisition costs from total life-cycle costs.

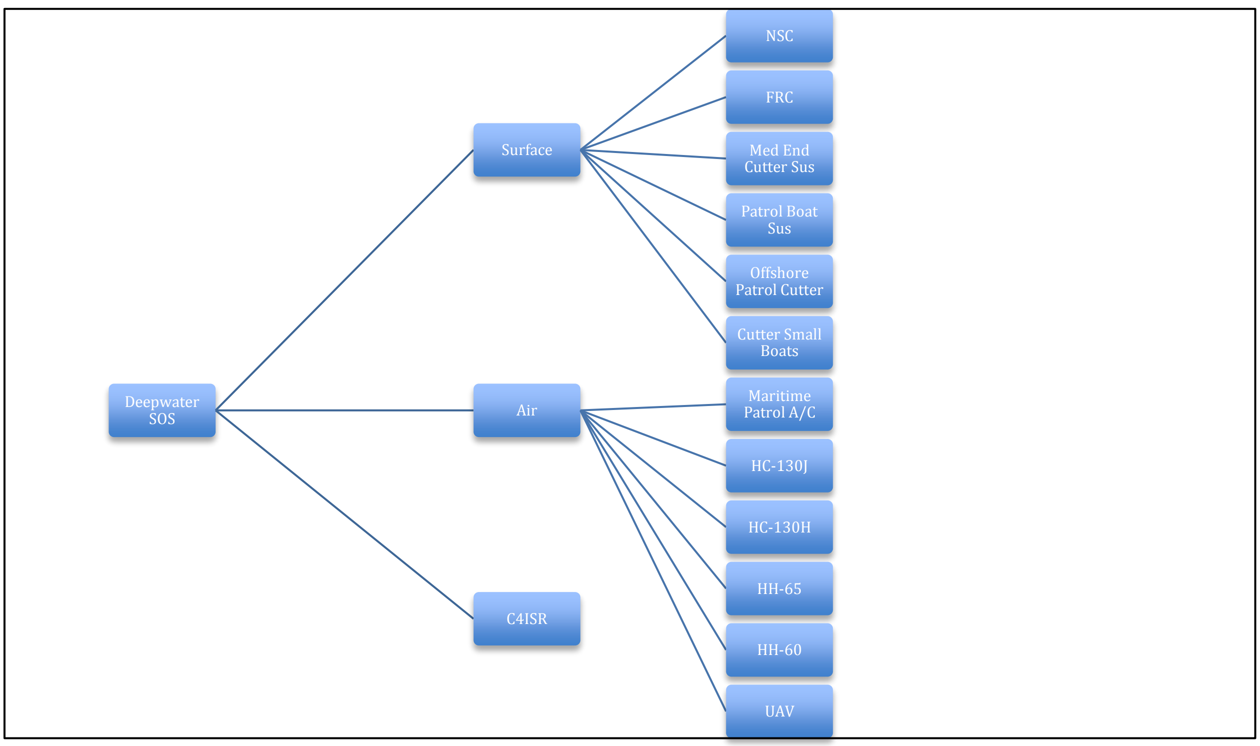

Figure 15 IDS WBS
Source: Author's Analysis

[57] S. Gulu Ghambir, "Lifecycle Cost Estimation," 16, (Lecture presented at the PhD Cohort, George Washington University, September 27, 2014), cited hereafter as LCE Presentation.

[58] LCE Presentation, 20.

RAND Cost Estimates

Granularity of cost data for Deepwater assets is not readily available, however the GAO has investigated many aspects of the program during the past ten years, and that agency has produced a number of cost estimates that are used in this paper. The RAND Corporation developed one of the earliest cost estimates for Deepwater in 2004. These estimates would eventually prove to be very inaccurate. They estimated total acquisition costs during a 20-year program as $8.2BIL (1998 dollars).[59] Adjusted for inflation, that estimate becomes $11.97BIL (2014 dollars).[60] They estimated total operating and support costs (O&M) for the same 20-year period as $23.4BIL (1998 dollars).[61] Adjusted for inflation, that estimate becomes $34.15BIL (2014 dollars).[62] These figures yield an approximate total lifecycle cost estimate (LCCE) of $46.12BIL.

GAO Cost Estimates

A GAO report of July 2010 provides data regarding both the 2007 cost baselines and the 2010 revised baselines. These data can be used to gain insights into the costs of the Deepwater program. The following table provides estimates for total acquisition costs of the Deepwater assets.

Table 3: Increased Total Acquisition Costs for Deepwater Assets with Approved Baselines as of July 2010 (then-year dollars in millions)

Asset	2007 Baseline	Revised baseline	Change
National Security Cutter	3,450	4,749	1,299
Fast Response Cutter[a]	3,206	4,243	1,037
Medium Endurance Cutter Sustainment	317	321[b]	4
Patrol Boat Sustainment	117	194[b]	77
Maritime Patrol Aircraft	1,706	2,400	694
HC-130J	11	176	165
HC-130H	610	745	135
HH-65	741	1,041[c]	300
HH-60	451	487	36
C4ISR	1,353	Baseline submitted to DHS January 2009	
Offshore Patrol Cutter	8,098	Baseline in development	
Cutter Small Boats	110	Baseline in development	
Unmanned Aerial System	503	Baseline in development	

Figure 16 Deepwater Estimated Acquisition Costs
Source: GAO-10-790, 16.

[59] J. L Birkler et al., *The U.S. Coast Guard's Deepwater Force Modernization Plan: Can It Be Accelerated? : Will It Meet Changing Security Needs?* (Santa Monica, CA: Rand, 2004), 49, cited hereafter as RAND.

[60] "US Inflation Calculator," *US Inflation Calculator*, accessed October 1, 2014, URL: <http://www.usinflationcalculator.com/>, cited hereafter as Inflation Calculator.

[61] RAND, 52.

[62] Inflation Calculator.

The same report also provides data regarding lifecycle costs for the associated Deepwater assets.

Table 4: 2007 and Revised Life-cycle Cost Baselines for Deepwater Assets (then-year dollars in millions)

Asset	2007 Life-cycle cost baseline	Revised baseline	Change
National Security Cutter	22,998	24,277	759
Fast Response Cutter[a]	22,256	15,634	(6,622)
Medium Endurance Cutter Sustainment	7,157	4,515[b]	(2,642)
Patrol Boat Sustainment	897	847[b]	(50)
Maritime Patrol Aircraft	22,773	13,267	(9,506)
HC-130J	6,551	430[c]	(6,121)
HC-130H	16,582	16,662	80
HH-65	53,433	6,298[c]	(47,135)
HH-60	26,075	902[c]	(25,173)
C4ISR	1,353	Baseline submitted to DHS January 2009	
Offshore Patrol Cutter	47,601	Baseline in development	
Unmanned Aerial System	17,753	Baseline in development	

Figure 17 Lifecycle Costs for Deepwater Assets
Source: GAO-10-790, 17.

These data are captured in an Excel workbook in order to calculate O&M costs and to produce graphs illustrating the costs.

	A	B	C
1		2007 Acquisition Baseline (2007 dollars in millions)	2007 Life-cycle Cost Baseline (2007 dollars in millions)
2	National Security Cutter	3,450	22,998
3	Fast Response Cutter	3,206	22,256
4	Medium Endurance Cutter Sustainment	317	7,157
5	Patrol Boat Sustainment	117	897
6	Maritime Patrol Aircraft	1,706	22,773
7	HC-130J	11	6,551
8	HC-130H	610	16,582
9	HH-65	741	53,433
10	HH-60	451	26,075
11	C4ISR	1,353	6,713
12	Offshore Patrol Cutter	8,098	47,601
13	Cutter Small Boats	110	
14	Unmanned Aerial System	503	17,753
15			
16	TOTALS	20,673	250,789
17			

Figure 18 Deepwater 2007 Baseline Data
Source: Author's Analysis

Impact of Inflation on Cost Estimates

These data are adjusted for inflation from 2007 dollars to present value of 2014 dollars.[63] Subtracting acquisition costs from the total life-cycle costs approximates the O&M costs.

A	B	C	D
	2007 Acquisition Baseline (2014 dollars in millions - rounded up)	O&M Costs (estimated by subtracting Acq Costs from LCCE)	2007 Life-cycle Cost Baseline (2014 dollars in millions - rounded up)
National Security Cutter	3,958	22,424	26,382
Fast Response Cutter	3,678	21,853	25,531
Medium Endurance Cutter Sustainment	364	7,846	8,210
Patrol Boat Sustainment	134	895	1029
Maritime Patrol Aircraft	1,957	24,167	26,124
HC-130J	13	7,502	7,515
HC-130H	700	18,322	19,022
HH-65	850	60,446	61,296
HH-60	517	29,395	29,912
C4ISR	1,552	6,149	7,701
Offshore Patrol Cutter	9,280	45,325	54,605
Cutter Small Boats		0	
Unmanned Aerial System	577	19,788	20,365
TOTALS	23,580	264,112	287,692

Figure 19 Deepwater 2007 Baseline Data Adjusted for Inflation
Source: Author's Analysis

[63] Inflation Calculator.

The following graph illustrates the estimated costs associated with acquisition, O&M, and LCCE.

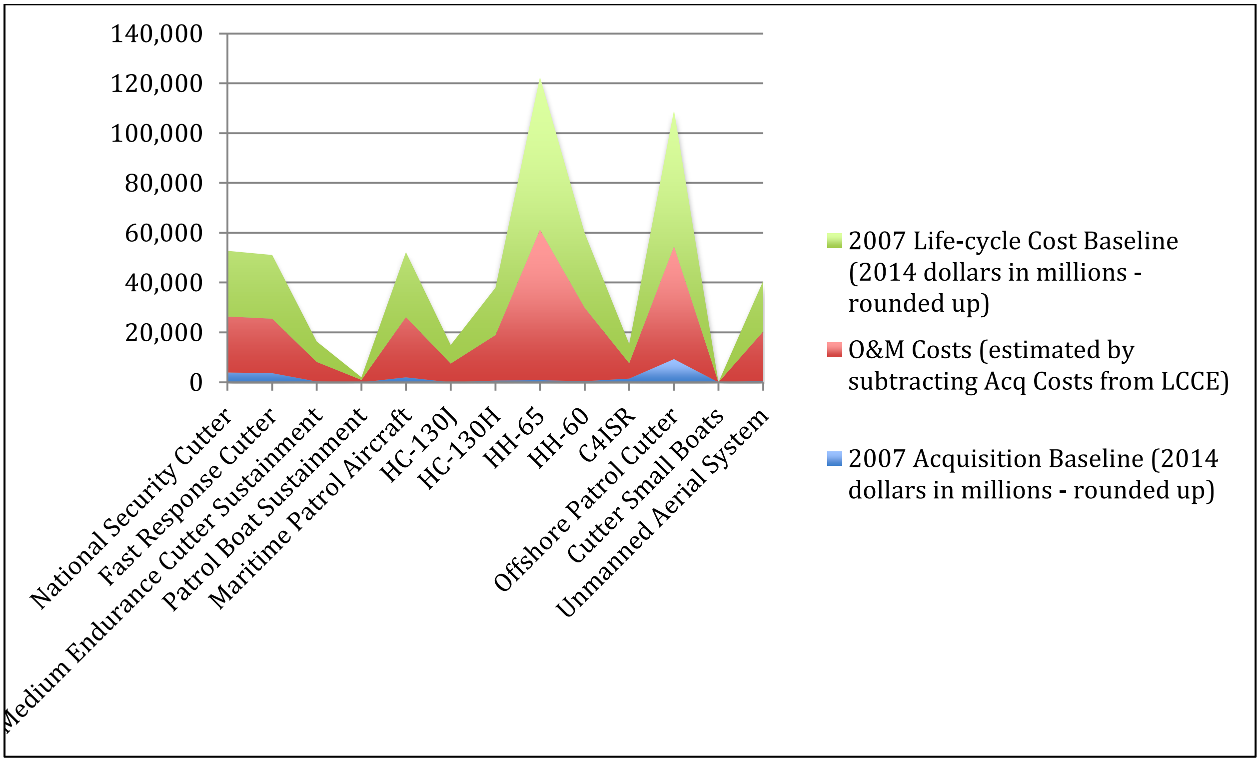

Figure 20 2007 Deepwater Baseline Costs
Source: Author's Analysis

The GAO provides data regarding the revised life-cycle cost estimates as of July 2010.

Table 5: Revised Life-cycle Cost Baselines and Current Life-cycle Cost Estimates for Deepwater Assets (then-year dollars in millions)

Asset	Revised baseline	Current estimate[a]	Difference
National Security Cutter	24,277	16,859	(7,419)
Fast Response Cutter[b]	15,634	13,174	(2,460)
Medium Endurance Cutter Sustainment	4,515[c]	4,427	(88)
Patrol Boat Sustainment	847[c]	861	14
Maritime Patrol Aircraft	13,267	25,493	12,226
HC-130J	430[d]	1,705	1,275
HC-130H	16,662	Estimate in development	
HH-65	6,298[d]	8,173	1,875
HH-60	902[d]	Estimate in development	
C4ISR	Baseline submitted to DHS January 2009	6,713[e]	5,360[e]

Figure 21 2010 Revised Deepwater Life-cycle Cost Estimates
Source: GAO-10-790

The acquisition data and life-cycle data for 2010 are adjusted for inflation from 2007 dollars to present value 2014 dollars, and the O&M costs are approximated.[64]

A	B	C	D
	2010 Revised Acquisition Baseline (2014 dollars in millions - rounded up)	2010 O&M Costs (estimated by subtracting Acq Costs from LCCE)	2010 Revised Life-cycle Cost Baseline (2014 dollars in millions - rounded up)
National Security Cutter	5,448	13892	19,340
Fast Response Cutter	4,867	10246	15,113
Medium Endurance Cutter Sustainment	368	4710	5,078
Patrol Boat Sustainment	223	765	988
Maritime Patrol Aircraft	2,753	26491	29,244
HC-130J	202	1754	1,956
HC-130H	855	18259	19,114
HH-65	1,194	8182	9,376
HH-60	559	476	1,035
C4ISR	1,552	6149	7,701
Offshore Patrol Cutter	9,290	45315	54,605
Cutter Small Boats		0	
Unmanned Aerial System	577	19788	20,365
TOTALS	27888	156027	183915

Figure 22 2010 Revised Deepwater Baseline Costs
Source: Author's Analysis

[64] Inflation Calculator.

The following graph illustrates the 2010 revised baseline costs associated with Deepwater assets.

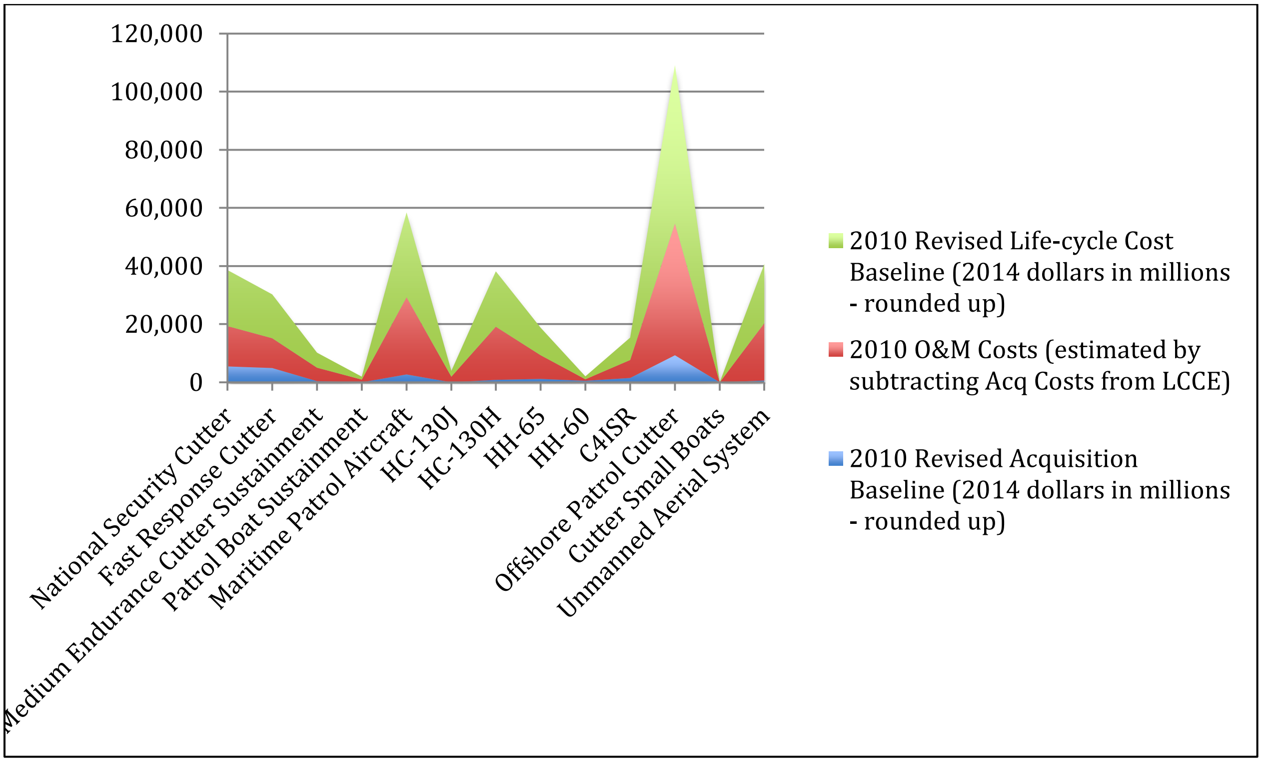

Figure 23 Deepwater 2010 Revised Cost Estimates
Source: Author's Analysis

The following information from a GAO report of July 2011 notes that accurate cost estimates remain a challenge.

GAO: "True Cost and Schedule of Deepwater Program Is Not Known"

> "The Deepwater Program as a whole continues to exceed the cost and schedule baselines approved by DHS in May 2007, but several factors preclude a solid understanding of the true cost and schedule of the program. The Coast Guard has developed baselines for some assets, most of which have been approved by DHS, that indicate the estimated total acquisition cost could be as much as $29.3 billion, or about $5 billion over the $24.2 billion baseline. But additional cost growth is looming because the Coast Guard has yet to develop revised baselines for all the Deepwater assets, including the Offshore Patrol Cutter (OPC)—the largest cost driver in the Deepwater Program. In addition, the Coast Guard's most recent 5-year budget plan, included in DHS's fiscal year 2012 budget request, indicates

further cost and schedule changes not yet reflected in the asset baselines."[65]

This report notes that total acquisition costs for the Deepwater program "could be as much as $29.3 billion." The 2010 revised acquisition estimate produced in this paper is $27.88BIL. Given the nature of the Deepwater program, that could be considered a reasonably accurate estimate. It should be noted too that the difference in the two estimates could be attributed to programmatic expenses.

The July 2010 CBS for Deepwater assets, adjusted for inflation, provides a LCCE for the Deepwater program of approximately $184BIL. However, for the reasons noted elsewhere in this paper, LCCE estimates for Deepwater assets do not inspire confidence.

Growth in Estimates of Acquisition Costs

This final graph illustrates the growth in the estimated cost of acquisition alone during the period 2004-2010. RDT&E was assumed to be included in the acquisition costs. Accurate O&M estimates are needed in order to compute an accurate LCCE.

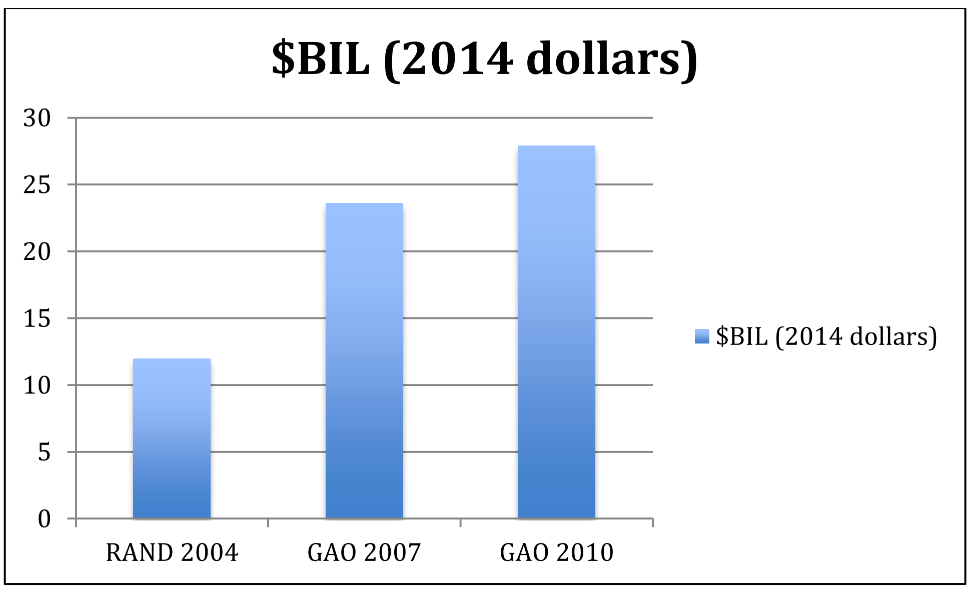

Figure 24 Growth in Cost Estimates for Deepwater Acquisitions
Source: Author's Analysis

[65] GAO-11-743, 10.

Concluding Remarks

This monograph has identified the causes of many of the problems observed during the Deepwater Program execution. One additional cause that was not addressed in this monograph can be attributed to the sense of urgency the federal government exhibited in the period immediately following September 11th, 2001. Following that attack the U.S. government was suddenly focused on anything and everything that would protect the homeland from additional terrorist attacks. The Coast Guard, as the lead agency for maritime defense of the homeland, was given nearly *carte blanche* to acquire a complex Deepwater system of systems. While the sense of urgency was justifiable, the lack of required oversight for this critical program is inexcusable.

BIBLIOGRAPHY

Birkler, J. L, United States, Coast Guard, Rand Corporation, and National Security Research Division. The U.S. Coast Guard's Deepwater Force Modernization Plan: Can It Be Accelerated? : Will It Meet Changing Security Needs?. Santa Monica, CA: Rand, 2004.

Engert, Pamela, and Zachary Lansdowne. "Risk Matrix User's Guide." MITRE, November 1999. URL: <http://www2.mitre.org/work/sepo/toolkits/risk/ToolsTechniques/RiskMatrix.html>. Accessed 22 September 2014.

"COAST GUARD: Observations on the Requested Fiscal Year 2011 Budget, Past Performance, and Current Challenges, Statement of Stephen L. Caldwell, Director Homeland Security and Justice Issues." GAO, 25 February 2010. Government Accountability Office. URL: <http://gao.gov/assets/130/124071.pdf>. Accessed 22 September 2014.

"Creation of the Department of Homeland Security." *Department of Homeland Security.* URL: <http://www.dhs.gov/creation-department-homeland-security>. Accessed 27 August 2014.

Gambhir, Gulu. "Requirements Engineering." Presented at the PhD Cohort, George Washington University, 13 September 2014.

--------. "Lifecycle Cost Estimation." Lecture presented at the PhD Cohort, George Washington University, September 27, 2014.

"GAO: Deepwater Program Costs Still Unclear." Navy Times. Accessed September 30, 2014. URL: <http://www.navytimes.com/article/20110729/NEWS/107290318/GAO-Deepwater-program-costs-still-unclear>.

"Guide for Performance Specifications," 24 August 2009. Defense Standardization Program. URL: <http://www.navair.navy.mil/nawctsd/Resources/Library/Acqguide/SD_15%202009.pdf>. Accessed 15 September 2014.

Hutton, John P. Coast Guard: Deepwater Requirements, Quantities, and Cost Require Revalidation to Reflect Knowledge Gained. GAO, 2010. URL: <http://www.gao.gov/new.items/d10790.pdf>.

Hutton, John P., Michele Mackin, Molly Traci, William Carrigg, Tisha Derricotte, Jennifer Echard, Laurier Fish, et al. Coast Guard: Action Needed As Approved Deepwater Program Remains Unachievable. GAO, 2011. URL: <http://www.gao.gov/new.items/d11743.pdf>.

Keeter, Hunter. "Coast Guard, Industry Team Put Finishing Touches on Cutter Bertholf & Apply Lessons Learned to Sister Ship, Waesche." U.S. Coast Guard. Acquisition Directorate Feature Article. URL:

<http://www.uscg.mil/acquisition/newsroom/feature/nscupdate.asp>. Accessed 23 September 2014.

Leonard, Barry. GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs. GAO, 2009. http://www.gao.gov/assets/80/77175.pdf.

"Mission Need Statement (MNS), Integrated Deepwater System, Update (Revision 1.0)," 2004. *United States Coast Guard*, URL: <http://www.uscg.mil/history/docs/2004_USCG_revisedmns.pdf>. Acccessed on 22 August 2014.

"Risk Brief." 30 August 2007. Project on Government Oversight, URL: <http://pogoarchives.org/m/wi/deepwater/risk-brief-20070830.pdf>. Accessed 22 September 2014.

"System Performance Specification for the Integrated Deepwater System," 1 August 2000. *United States Coast Guard*. URL: <https://www.uscg.mil/history/docs/2000_USCG_systemperformancespecification.pdf>. Accessed 27 August 2014.

"U.S. Coast Guard's Deepwater Efforts Sink." Defense Industry Daily, online ed., 14 December 2011. URL: < http://www.defenseindustrydaily.com/us-coast-guards-deepwater-effort-hits-more-rough-sailing-02863/>. Accessed 27 August 2014.

"US Inflation Calculator." US Inflation Calculator. Accessed October 1, 2014. URL: <http://www.usinflationcalculator.com/>.

Risk Matrix (version 2.20). Excel. Risk Management. Bedford, MA: MITRE, 1999. URL: <http://www2.mitre.org/work/sepo/toolkits/risk/ ToolsTechniques/RiskMatrix.html>. Accessed 22 September 2014.

Scott, Melanie D. "Lockheed Martin bids on Coast Guard jobs." *The Philadelphia Inquirer*, online ed., 8 July 2001. URL: < http://articles.philly.com/2001-07-08/news/25315323_1_joint-venture-naval-electronics-integrated-coast-guard-systems>. Accessed 27 August 2014.

U.S. Government Accountability Office. *Deepwater Program Management Initiatives and Key Homeland Security Missions. Testimony Before the Subcommittee on Homeland Security, Committee on Appropriations, House of Representatives, Statement of John P. Hutton, Director Acquisition and Sourcing Management and Stephen L. Caldwell, Director Homeland Security and Justice*. GAO-08-531T. 2008. URL: <http://gao.gov/assets/120/119205.pdf>. Accessed 10 September 2014.