



ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

U.S. Coast Guard Cutter Procurement Lessons' Impacts on the Offshore Patrol Cutter (OPC) Program Affordability

December 2015

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ABSTRACT

The U.S. Coast Guard's upcoming acquisition of the Offshore Patrol Cutter (OPC) offers many opportunities to leverage recent procurement lessons to achieve the program's affordability requirement of \$310 million per hull. We explore the question of how lessons learned from the National Security Cutter (NSC) and Fast Response Cutter (FRC) procurement programs were applied to the OPC acquisition strategy to achieve affordability. We examine procurement lessons addressing management reforms, best practices in competition, contract structure, multiyear procurement, requirements generation, and test and evaluation. We employ a cost estimation model developed by Jeffrey Lineberry and first advanced in his 2012 work *Estimating Production Costs While Linking Combat Systems and Ship Design*. We validate the Coast Guard's OPC cost requirement of \$310 million per hull using notional design data. We further illustrate the impact that varying specific design characteristics (speed, personnel, and length/beam) have on ship production cost. Finally, we conclude that the U.S. Coast Guard has successfully incorporated lessons from the NSC and FRC procurement programs into the OPC acquisition strategy, and we present a trade-off analysis that program managers may use in future source selection processes.



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Disclaimer: The views represented in this report are those of the author and do not reflect the official policy position of the Navy, the Department of Defense, or the federal government.



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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alternatives Analysis
AC&I	Acquisition, Construction, and Improvement
ADA	Acquisition Decision Authority
ADE	Acquisition Decision Event
ALC	DHS Acquisition Life Cycle
AOR	Area of Responsibility
ARB	Acquisition Review Board
A/S	Analyze/Select Phase
BBC	Block Buy Contracting
BCA	Budget Control Act
BLS	Bureau of Labor and Statistics
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAE	Component Acquisition Executive
CAO	Chief Acquisition Officer
CAPE	Cost Assessment and Program Evaluation (Office within OSD)
CAQO	Chief Acquisition Officer (DHS)
CG-4	Coast Guard Engineering Logistics Directorate
CG-6	Assistant Commandant for C4ISR
CG-7	Assistant Commandant for Capability
CG-8	Assistant Commandant for Resources
CG-9	Coast Guard Acquisition Directorate
CG-9	Assistant Commandant for Acquisitions
CG-925	CG-9 Office of Strategic Planning and Communication
CG-932	CG-9 Assistant Program Executive Officer
CG-9321	CG-9 NSC Project Office
CG-9322	CG-9 OPC Project Office
CG-9324	CG-9 FRC Project Office
CIP	Capital Investment Plan
CLIN	Contract Line Item Numbers
COR	Contracting Officer's Representative



CONOPS	Concept of Operations
COTF	Navy's Commander Operational Test and Evaluation Force
COTS	Commercial Off-the-Shelf
CPIF	Cost Plus Incentive Fee
CPFF	Cost Plus Fixed Fee
CRS	Congressional Research Service
DAWIA	Defense Acquisition Workforce Improvement Act
DCMS	Deputy Commandant for Mission Support
DCO	Deputy Commandant for Operations
DD	Detailed Design
DD&C	Detailed Design and Construction
DHS	Department of Homeland Security
DHS OIG	DHS Office of the Inspector General
DOD	Department of Defense
DTC	Design to Cost
EOC	Executive Oversight Council
EOQ	Economic Order Quantity
EPA	Economic Price Adjustment
FAR	Federal Acquisition Regulation
FOUO	For Official Use Only
FPI	Fixed Price Incentive
FRC	Fast Response Cutter
GAO	Government Accountability Office
G-A	Coast Guard Acquisition Directorate
G-D	Integrated Deepwater System (IDS) Directorate
GFE	Government Furnished Equipment
HCA	Head of Contracting Activity
HII	Huntington Ingalls Industries, Incorporated
ICGS	Integrated Coast Guard Systems
ID/IQ	Indefinite Delivery, Indefinite Quantity
IDS	Integrated Deepwater System
IG	Inspector General
IOT&E	Initial Operational Testing and Evaluation



IRB	Institutional Review Board
FFP	Firm Fixed Price
FPI	Fixed-Price Incentive
FP/EPA	Fixed Price with Economic Price Adjustment
FY	Fiscal Year
GSE	Government-Supplied Equipment
HSAM	Department of Homeland Security Acquisition Manual
HSC	High Speed Connector
JHSV	Joint High Speed Vessel
KDR	Contract Design Review
KPP	Key Performance Parameter
LCC	Life-Cycle Cost
LCCE	Life-Cycle Cost Estimate
LCS	Littoral Combat Ship
LLTM	Long Lead-Time Materials
LRIP	Low Rate Initial Production
LSI	Lead Systems Integrator
MAR	Mission Analysis Report
MBSE	Model Based System Engineering
MDAP	Major Defense Acquisition Program
MIPR	Military Interdepartmental Purchase Request
MNS	Mission Needs Statement
MSAM	Major Systems Acquisition Manual
MYP	Multiyear Procurement
NAVSEA	Naval Sea Systems Command
NGSB	Northrop Grumman Shipbuilding
NGSS	Northrop Grumman Ship Systems
NVR	Naval Vessel Rules
NSC	National Security Cutter
OIG	Office of the Inspector General
OPC	Offshore Patrol Cutter
OPV	Offshore Patrol Vessel
ORD	Operational Requirements Document



ORT	Operational Requirements Team
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
P&CD	Preliminary and Contract Design
PARM	Program Accountability and Risk Management
PDR	Preliminary Design Review
PM	Project/Program Manager
PLCCE	Project Life-Cycle Cost Estimate
POR	Program of Record
PORD	Preliminary Operational Requirements Document
PPBE	Planning, Programming, Budget, and Execution
PTA	Point of Total Assumption
R&D	Research and Development
RDLP	Re-Procurement Data Licensing Package
REA	Request for Equitable Adjustment
RFP	Request for Proposal
SDT	Ship Design Team
SES	Senior Executive Service
SMDT	Ship Management Design Team
SOS	System of Systems
SWBSE	Ship Work Breakdown Structure Elements
TDP	Technical Data Package
TSV	Theater Support Vessel
USCG	U.S. Coast Guard
WBS	Work Breakdown Structure
WHEC	Hamilton-Class High-Endurance Cutter
WMEC	Medium-Endurance Cutter
WMSM	Maritime Security Cutter Medium
WPB	110 Foot Island-Class Patrol Boat
WSARA	Weapon Systems Reform Act



I. INTRODUCTION

The U.S. Coast Guard is nearly halfway through its roughly 25-year, \$24 billion major acquisition program of record, in which it plans to replace 90 older (legacy) Coast Guard cutters (some having been in service for nearly 50 years) with 91 planned new cutters (O'Rourke, 2015a). This multibillion-dollar major acquisition portfolio to recapitalize the Coast Guard's aging vessels and aircraft began in the late 1990s, and the Coast Guard has overcome many challenges in its management since then, including the establishment of the modern Acquisition Directorate (CG-9) in 2007. As the management of this portfolio continues with the acquisition of the offshore patrol cutter (OPC), "the largest cost-driver in the current recapitalization program" (Subcommittee on Coast Guard and Maritime Transportation, 2013, p. 2), the Coast Guard continues to face fiscal constraints in achieving its program of record (POR). The Government Accountability Office (GAO) (2011) has reported that "the Coast Guard is managing a portfolio, which includes many revised baselines approved by DHS, that is expected to cost more than what its annual budget will likely support" (p. 23). As the Coast Guard's existing fleet of 210' and 270' medium endurance cutters (WMECs) rapidly approach or have already passed their originally designed end of service life, and the Coast Guard continues to experience a decline in mission readiness in the service's Deepwater Area of Responsibility (AOR), the need to consider the OPC program's affordability has become one of the Coast Guard's highest priorities.

A. MOTIVATION AND GOALS

The OPC is a vital asset that is needed to bridge the capability gap between the national security cutter (NSC) and fast response cutter (FRC) to complete the system of surface assets. As such, it is imperative to understand the critical elements that influence what makes an acquisition program affordable, especially if recent lessons learned can be analyzed to harvest valuable insights that can be used to inform future decisions.

Our research efforts were designed with the following questions in mind: How do lessons learned from the U.S. Coast Guard's NSC and FRC procurement programs



contribute to the OPC acquisition strategy, and how do they impact the requirement of affordability?

B. COAST GUARD APPLICABILITY

We hope the conclusions and recommendations from our research will help decision makers plan and execute current and future Coast Guard acquisition programs that have affordability as one of their highest priorities. Our intent is to inform the next generation of acquisition professionals who will enter the complex world of management and oversight of major acquisition programs. The Coast Guard has made extraordinary progress in establishing its “policies, procedures, and organizations for acquisition program management and oversight” (Drezner, Arena, McKernan, Murphy, & Riposo, 2011, p. 1), and we hope the summary of this advancement will also inspire the next generation to sustain this growth.

C. SCOPE AND LIMITATIONS OF RESEARCH

Our research focuses on understanding the lessons learned from the recent NSC and FRC procurement programs, an analysis of how those lessons could be used to increase the affordability of future programs such as the OPC and attempts to provide academic support to inform future decisions made during recapitalization efforts. The results in this document are based on a research period from March to August of 2015.

We did not attempt to analyze the Coast Guard’s current mission analysis report (MAR), program of record (POR), fleet mix analysis, or DHS cutter study, or to make any conclusions about the adequacy of these studies in providing the Coast Guard with enough assets to execute all of its congressionally mandated missions. Our analysis assumed that existing versions of these reports define the constraints in which the managers of major acquisition programs should achieve affordability, and we recognize that these constraints may change as updated versions of these reports are published.

D. STRUCTURE OF THESIS

The background of recent Coast Guard acquisition programs and reforms and the current Systems Acquisition Structure and management processes are provided in



Chapter II. Chapter III describes the methods used to collect data and the format for interviews we conducted. Chapter IV includes an analysis of the data we collected and discussion of the results of this analysis. Finally, Chapter V provides a summary of our analysis, conclusions and recommendations that were informed by this analysis, and suggestions for future work.



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II. BACKGROUND

A. INTRODUCTION

The U.S. Coast Guard is nearly halfway through its major acquisition program of record, in which it plans to build 91 new cutters. The new cutters will be constructed in a mix of three different classes of vessels: the national security cutter (NSC), the offshore patrol cutter (OPC), and the fast response cutter (FRC).

The largest and most capable general-purpose cutter is the NSC. Eight NSCs are planned for procurement, with four already fully operational and executing Coast Guard missions, with the fifth having been delivered and commissioned. A contract for the eighth and final NSC was awarded in March 2015 (U.S. Coast Guard, 2015b). The total acquisition cost of the eight ships is currently estimated at \$5.559 billion in the Fiscal Year (FY) 2016 capital investment plan (CIP) (U.S. Coast Guard, 2015c).

The smallest of the new cutters will be the FRC. Fifty-eight FRCs are planned for procurement, with the 14th FRC delivered to the Coast Guard in October 2015 and the contract option for the 32nd FRC exercised in February 2015. The completion of 32 FRCs will be the end of phase 1 of the FRC acquisition strategy. As part of the FRC acquisition strategy, the Coast Guard issued a separate request for proposal (RFP) for the phase 2 construction of hulls 33 through 58 in February 2015 (U.S. Coast Guard, 2015a). This is part of the Coast Guard's strategy to keep industry competition involved throughout the acquisition and give other firms an opportunity to be awarded phase 2 using the re-procurement data licensing package (RDLP) purchased from the shipyard in phase 1. According to the FY 2016 CIP, the total acquisition cost of the 58 cutters is \$3.764 billion (U.S. Coast Guard, 2015c).

The third class of new cutters, the OPC, "are to be smaller, less expensive, and less capable than the NSC, but more capable than the FRC" (O'Rourke, 2015a, p. 1). The approved program of record calls for procurement of 25 OPCs, with the contract for phase 1 preliminary and contract design (P&CD) previously awarded to three firms in February 2014. "The FY 2016 CIP estimates the total acquisition cost of these 25 cutters



at \$10.523 billion. This makes the OPC program the most expensive project that the Coast Guard has ever taken on” (O’Rourke, 2015a, p. 4). O’Rourke (2015a) observes that the size of the program requires Congress to fund the Coast Guard’s acquisition, construction, and improvement (AC&I) account with at least \$1.9 billion each year, although the administration has proposed to cut the AC&I funding by 40% in recent fiscal years as a result of the sequester.

In order to meet the goal of constructing 25 new OPCs in a constrained budgetary environment, the Coast Guard has kept the requirement of affordability as the highest priority during the requirements development process of the two-phase OPC acquisition strategy, often making trade-offs to reduce the OPC capability for the purpose of affordability (O’Rourke, 2015a). The “lessons learned” from the acquisition strategies for the NSC and FRC have been vital to developing an affordable acquisition strategy for the OPC. This project explores how these lessons learned contributed to the OPC acquisition strategy and how they impacted the requirement of affordability.

B. INTEGRATED DEEPWATER SYSTEM BEGINS WITH INTEGRATED COAST GUARD SYSTEMS

The modern initiative to recapitalize the Coast Guard’s ships and aircraft began with an Integrated Deepwater System (IDS) acquisition plan that was created pre-9/11. According to historical information on the Coast Guard web page (U.S. Coast Guard, 1996),

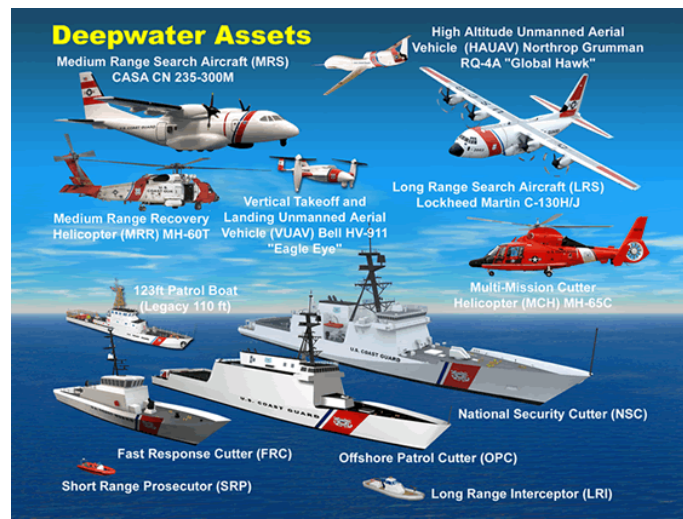
The Deepwater program was initiated in response to the Deepwater Mission Analysis Report (MAR), approved December 22, 1995 which defined missions and functional requirements for the missions for an integrated fleet and made an assessment against the current fleet by developing Demand Projections against legislatively mandated missions and derived Functional Requirements. (p. 11)

This early plan estimated the total acquisition cost at \$17 billion with a 20-year period of performance (Integrated Deepwater System Program, 2015). In 1998, under the pre-9/11 IDS acquisition plan, the Coast Guard distributed an RFP to industry to submit bids for an acquisition program that would replace legacy Coast Guard assets with a system-of-systems (SOS) acquisition approach, as opposed to historical approaches such



as within the Department of Defense (DOD), which used a series of smaller, independent acquisition programs. The vision for the SOS acquisition approach was to procure a single, integrated package of ships; aircraft; command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); and logistics support that would enable the project “to be optimized (i.e., made cost effective) at the overall, system-of-systems level, rather than sub-optimized at the level of individual platforms and systems” (O’Rourke, 2007, p. 6). Figure 1 depicts the Deepwater assets.

Figure 1. Coast Guard Deepwater Assets



Source: Fred Moosally. (n.d.) In *Wikipedia*. Retrieved November 5, 2015, from https://en.wikipedia.org/wiki/Fred_Moosally

In the late 1990s, the Coast Guard only had a small organic acquisition workforce that did not have very robust system-integration capabilities. To realize the size and complexity of the SOS acquisition approach, the Coast Guard elected to use a private-sector lead systems integrator (LSI) that would be, as O’Rourke (2007) stated, “responsible for designing, building, and integrating the various elements of the package to meet the Coast Guard’s [specifications] at the lowest possible cost” (p. 6). The Coast Guard selected Integrated Coast Guard Systems LLC (ICGS) as the private-sector LSI on June 25, 2002. ICGS was an industry joint venture of Lockheed Martin and Northrop Grumman Ship Systems (NGSS) that was awarded “an indefinite delivery, indefinite



quantity (ID/IQ) contract for the [SOS acquisition] program that included a five-year baseline term that ended in June 2007, and five potential additional award terms of up to five years (60 months) each” (O’Rourke, 2007, p. 7).

The Coast Guard continued with its IDS acquisition programs having ICGS as the private-sector LSI from 2002 to 2007. During that time, Congress, the GAO, and the Department of Homeland Security (DHS) Office of the Inspector General’s (DHS OIG) office widely criticized the Coast Guard’s management of ICGS as the LSI, often stating that the Coast Guard failed to exercise technical oversight over the design (Department of Homeland Security, Office of the Inspector General [DHS OIG], 2007), construction, and testing phases of the projects, and lacked the “in-house staff and expertise in program management, financial management, and system integration to properly oversee and manage [the large and complex acquisition effort]” (O’Rourke, 2007, p. 11). These claims were based on specific examples from the acquisition efforts for the NSC, FRC, and 110-foot patrol boat modernization effort, and included structural design flaws, the installation of nonconforming communications equipment, and the design of the FRC not meeting the Coast Guard’s mission requirements (DHS OIG, 2007). On March 25, 2005, the Coast Guard submitted a revised IDS acquisition plan to Congress that was updated based on the services’ analysis of its expanded missions post-9/11. This updated plan estimated the total acquisition cost at \$24 billion with a 25-year period of performance (POP) (O’Rourke, 2007). The criticisms, growing list of discrepancies, and expanded program were perhaps the impetus for the management restructurings that the Coast Guard implemented on April 17, 2007.

C. CONSOLIDATED ACQUISITION DIRECTORATE (CG-9)

The Coast Guard announced acquisition management reforms on April 17, 2007, that paved the way for the establishment of the modern Coast Guard Acquisition Directorate (CG-9) on July 13, 2007. This directorate merged the Integrated Deepwater System (IDS) Directorate (G-D) with the legacy Coast Guard Acquisition Directorate (G-A) under the leadership of the assistant commandant for acquisition and chief acquisition officer. As a result, “CG-9 became a single point of management, and acted as the



systems integrator for all Coast Guard Major Systems Acquisitions” (U.S. Coast Guard, 2013, pp. 1–2). Admiral Thad Allen, the commandant of the Coast Guard at that time, also described six fundamental principles that the Coast Guard and its industry partners would implement as a result of these reforms. The following list is a summary of the fundamental principles from the Congressional Research Service report by O’Rourke (2007):

- The Coast Guard assuming the LSI role for all IDS acquisition programs.
- The Coast Guard assuming responsibility for all life-cycle logistics functions within the IDS acquisition programs.
- An expanded role for the American Bureau of Shipping in assuring that all IDS acquisition programs were designed and constructed to established standards.
- Quick resolution with ICGS for all outstanding NSC issues.
- Future contracts for new assets would be directly awarded to the prime vendor by the Coast Guard if in the best interest of the government.
- Quarterly meetings between the Coast Guard and its industry partners until all IDS acquisition program issues were completely resolved. (p. 16)

According to the CG-9 history website (CG-9, 2012a), the new acquisition directorate was established and gained initial operating capability on July 13, 2007. The new directorate

brought together the Office of Procurement Management; the Office of Research, Development and Technical Management; the Research and Development Center; and the Head of Contracting Activity. Together, these offices helped to establish the foundation for a full-service acquisition and procurement management organization. (p. 1)

Additionally, this modernization initiative served to “enable the Coast Guard to execute more effective project management and acquisition governance, better aligns the Service with the DHS’s procurement organization, and ultimately enable[s] the Coast Guard to become the model for mid-size Federal Agency acquisition and procurement” (U.S. Coast Guard, 2007, p. 2). Reflecting the end of the Deepwater contract in 2011 and the Coast Guard’s actions to establish discreet acquisition programs with individualized



guidelines and documentation, GAO followed the Coast Guard in dropping the Deepwater name in reference to the Coast Guard’s acquisition portfolio.

D. BLUEPRINT FOR ACQUISITION REFORM

The Coast Guard’s first acquisition strategic plan, the “Blueprint for Acquisition Reform,” was based on four cornerstones of a successful acquisition function that were originally defined by the GAO in its publication *Framework for Assessing the Acquisition Function at Federal Agencies* (2005). The GAO’s framework both informed the Coast Guard’s strategy to consolidate its acquisition organizations and provided the foundation for CG-9’s first acquisition strategic plan with these four foundational tenets, as listed in the CG-9 (2014c) *Blueprint for Sustained Excellence*:

- Organizational alignment and leadership
- Policies and processes
- Human capital
- Information management and stewardship (p. 5).

This initial strategic plan focused on “an output-centric mechanism for accomplishing and tracking defined tasks” (CG-9, 2014c, p. 6), but as the new CG-9 achieved the intent of this blueprint, it began to update its strategic plan to include measuring performance across the directorate and key objectives and performance measures to track progress toward its goals. The current strategic plan, version 6.0, released in 2014, *Blueprint for Sustained Excellence*, “continues the transition from action tracking to performance management and aligns with higher level Coast Guard and Department of Homeland Security priorities” with the overarching vision that “the Coast Guard will be a model of acquisition excellence in government” (CG-9, 2014c, p. 7).

E. NSC ACQUISITION PROGRAM HISTORY

The NSC acquisition program was created and initiated within the ICGS framework in 2002, but then shifted to the Coast Guard as the system integrator starting with NSC 4 in 2010 (Johnson, 2011). The Coast Guard’s current POR published in 2004 outlined a planned procurement of eight NSCs as replacements for the 12 Hamilton-class



High-Endurance Cutters (WHECs). According to O’Rourke (2015a), “the Coast Guard’s FY 2016 five-year CIP estimates the total acquisition cost of the eight NSCs at \$5.559B, an average of \$695M per NSC” (p. 3). The detail design and construction (DD&C) of NSCs 1–3 was initially approved as part of the Integrated Deepwater System Acquisition plan dated May 21, 2001, and was awarded to ICGS. The contracts for the construction of NSCs 1–3 were cost-plus incentive (CPIF) contracts and awarded directly to ICGS between 2002 and 2007 (Johnson, 2011).

ICGS won the NSC 3 contract award on August 8, 2007; a three-year lapse in contract awards followed from NSC 3 to the award of NSC 4 (Johnson, 2011). The Coast Guard had announced its acquisition management reforms on April 17, 2007, which included the Coast Guard taking over as the system integrator. From then on, the Coast Guard would award contracts directly to the prime vendor (O’Rourke, 2007). On January 28, 2008, Northrop Grumman Ship Systems (NGSS) merged with its sister sector, Northrop Grumman Newport News, to form Northrop Grumman Shipbuilding (NGSB) (Huntington Ingalls Industries, 2015). On November 30, 2010, NSC 4 was the first NSC awarded outside of the ICGS private sector LSI framework with a fixed price incentive contract for \$480 million (Johnson, 2011). On March 31, 2011, NGSB transitioned to Huntington Ingalls Industries, Incorporated (HII), and through a memorandum of agreement conveyed all contract obligations to obligations between the Coast Guard and HII. The CG-9 Acquisition Newsroom website lists award contracts for each of the NSCs (CG-9, 2015). A summary of subsequent contract amounts, types, and dates for NSC 4–8 is shown in Table 1.

Table 1. NSC Contract Amounts, Types, and Dates

National Security Cutter	Contract Amount	Contract Type	Date
4	\$480M	Fixed-Price Incentive to HII	November 30, 2010
5	\$482M	Fixed-Price Incentive to HII	September 9, 2011
6	\$487.1M	Fixed-Price Incentive (firm target) to HII	April 30, 2013
7	\$497M	Fixed-Price Incentive (firm target) to HII	March 31, 2014
8	\$499.76	Fixed-Price Incentive (firm target) to HII	April 1, 2015

Source: U.S. Coast Guard Acquisitions Directorate (CG-9). (2015). Coast Guard acquisition newsroom. Retrieved from <http://www.uscg.mil/acquisition/newsroom/news2015.asp>



F. FRC ACQUISITION PROGRAM HISTORY

The FRC acquisition program was the first major acquisition program formerly contracted through the IDS Program to be brought in-house at the Coast Guard under the direct management of CG-9 (Steigman, 2008). The Coast Guard's current POR outlines a planned procurement of 58 FRCs as replacements for 49 110-foot Island-class patrol boats (WPB). O'Rourke stated, "The Coast Guard's FY 2016 five-year CIP estimates the total acquisition cost of the 58 FRCs at \$3.764B, an average of \$65M per FRC" (2015a, p. 8). The original plan to replace 49 existing WPBs with the FRC beginning in 2018 was accelerated by 10 years after the failed modernization effort of the WPB with ICGS.

The FRC acquisition program initially began in December 2006 when the Coast Guard issued a RFP to ICGS to execute the design phase of the FRC as part of the five-year base term contract awarded to ICGS in June 2002 (O'Rourke, 2007). However, according to the DHS OIG, the Coast Guard determined that although the ICGS cutter design "satisfied contract terms, [it] did not meet [the IDS] mission needs [in that] the composite hull weight and propulsion plant capacity were not consistent with in-service patrol boats of comparable length, speed, and range" (2009, p. 3). Due to these development risks, the Coast Guard canceled acquisition of the FRC within ICGS on April 19, 2007, and reassigned the program to its new CG-9 Acquisition Directorate as part of its acquisition management reforms that year (American City & County, Government Product News, 2007). The FRC acquisition program then continued under CG-9, with the contract for the design and construction of the lead FRC with options for 32 additional FRCs effectively awarded on January 15, 2009 (Steigman, 2008).

The FRC acquisition program is being conducted in two phases using a "parent-craft" design. The program uses a fixed price with economic price adjustment (FP/EPA) shipbuilding contract and includes the ability to purchase a RDLP at the end of each contract option period. The failed modernization effort of the WPB created an urgency to accelerate the FRC acquisition to reduce the increasing shortfall of patrol boat operational hours. This was one of the reasons for the Coast Guard selecting a parent-craft based on the Netherland's Damen Stan Patrol Boat 4708, a boat that has conducted missions for the Republic of South Africa similar to the approved FRC Concept of Operations



(CONOP). On January 15, 2009, the phase 1 contract for the design and construction of the lead FRC with options for 32 additional cutters was effectively awarded to Bollinger Shipyards Lockport, LLC for \$88 million and a POP through September 2019, with the options being worth an estimated additional \$1.5 billion (Steigman, 2008). On February 27, 2015, the Coast Guard exercised the last phase 1 shipbuilding contract option for FRCs 31 and 32, with a total number of 32 FRCs ordered from Bollinger Shipyards during phase 1 of the acquisition strategy.

CG-9 states that the RDLP option of the original contract award in January 2009 included the “required design data, drawings, materials list, technical and testing information, and licensing the government must have to competitively award the phase 2 shipbuilding contract as part of a planned second production phase” (2012b, p. 1). “The Coast Guard exercised this \$27.2 million contract option with Bollinger Shipyards on February 23, 2012. The RDLP reflected the FRC design maturity as of February 23, 2012, including modifications made to the original design prior to the February 10, 2012, delivery of the lead hull, Bernard C. Webber” (2012b, p. 1).

On February 27, 2015, the Coast Guard issued an RFP for phase 2 of the FRC acquisition. The phase 2 contract included options for the acquisition of up to 26 FRCs with FP/EPA contracts (U.S. Coast Guard, 2015a). The Coast Guard made the RDLP from phase 1 of the FRC contract available to interested offerors and plans to use this RDLP as the technical baseline for phase 2 of the acquisition. The phase 2 contract is planned for award in FY 2016 and has a POP of 2016–2024 (U.S. Coast Guard, 2015a).

G. OPC ACQUISITION PROGRAM HISTORY

The initial functional design for the OPC acquisition program was also introduced within the IDS/ICGS framework in 2001–2002 but then shifted to the Coast Guard as a separate project within CG-9 in 2007. The functional design was followed by a preliminary design for the OPC in 2004 with capabilities equivalent to the NSC. Within the ICGS framework, a PDR was scheduled for July 2006, detailed design was predicted to be complete by November 2006, and the first OPC was planned for delivery in 2010. The OPC was one of the costliest systems in IDS due to the number of cutters planned to



be built. However, the OPC program became a separate project within the new Acquisition Directorate (CG-9) in 2007. Within CG-9, the OPC project reached Acquisition Decision Event (ADE) 1 by the component acquisition executive (CAE) on January 28, 2008, and was approved as a DHS Major System (Level 1) Acquisition.

The Coast Guard reevaluated the Deepwater MAR from September 2007 to February 2008 (O'Rourke, 2007). This new alternatives analysis (AA) confirmed the OPC procurement plan, and with its release, the Coast Guard committed to conducting a new OPC design by initiating a new requirements analysis, draft CONOPS, and initial cost and schedule assessment. The new design and construction effort was projected to begin in 2013.

The Coast Guard's current POR outlines a planned procurement of 25 OPCs as replacements for 29 WMECs. According to O'Rourke, "the Coast Guard's FY 2016 five-year CIP estimates the total acquisition cost of the 25 ships at \$10.523 billion, or an average of approximately \$421 million per ship" (2015a, p. 4). The Coast Guard selected a two-phase OPC acquisition program that is being conducted in two phases with a down-select strategy. "Phase 1 entails full and open competition for [P&CD] awarded on a [firm fixed price] FFP basis to a maximum of three contractors" (Federal Business Opportunities, 2015). On February 11, 2014, the Coast Guard "awarded three FFP contracts for P&CD with a total value of \$65 million to Bollinger Shipyards Lockport LLC (Lockport, LA), Eastern Shipbuilding Group, Inc. (Panama City, FL), and General Dynamics, Bath Iron Works (Bath, ME)" (CG-9, 2014b, p.1). CG-9 stated, "Awarding multiple design contracts ensures that competition is continued through to a potential down-select for detailed design and construction, establishes a fixed-price environment for the remainder of the contract, and incorporates a strategy to maximize affordability" (2014b, p.1). There were two protests of this award, which the GAO reviewed, and on June 2, 2014, the GAO upheld the Coast Guard's award decision, enabling all P&CD contract work to continue (CG-9, 2014a).

The cover letter from Federal Business Opportunities (2015) for the OPC RFP indicates that



the phase 2 down-select decision will result in the exercising of an option with a single contractor for [detail design] DD with additional options for Long Lead Time Materials [LLTM], lead ship, up to ten follow ships and ancillary services and supplies. Phase 2 will predominately be a Fixed Price Incentive (Firm Target) with Economic Price Adjustment (EPA) plus a mix of FFP and Cost Plus Fixed Fee (CPFF) Contract Line Items (CLINs). (p. 1)

The Coast Guard's FY 2015 five-year CIP outlines the "annual funding levels and indicates that the first OPC is planned to be procured in FY 2018" (O'Rourke, 2015a, p. 4). Currently, the Coast Guard plans to procure one OPC for the first three years starting in FY 2018, then increase to procuring two OPCs per year starting with FY 2021 through FY 2024, until the first 11 ships are completed. Low rate initial production (LRIP) 1 has been defined as the first five ships. LRIP 2 has been defined as ships six through 11 (O'Rourke, 2015a).

H. U.S. COAST GUARD SYSTEMS ACQUISITION STRUCTURE

To fully understand how the Coast Guard OPC program utilized lessons learned from the procurement of the NSC and FRC, and how they impact affordability of the OPC program, it is necessary to address the Coast Guard acquisition process itself. Since inception, CG-9 has established fundamental policies and procedures to ensure the effective implementation of acquisition practices. The achievement of capable, supportable, affordable and sustainable systems is made possible by implementation of the Commandant Instruction Manual 5000.10C, *Major Systems Acquisition Manual* (MSAM) (U.S. Coast Guard, 2013).

1. Coast Guard Acquisition Directorate Objectives

The establishment of CG-9 provided the Coast Guard an opportunity to focus on providing the service a formal acquisition process with established guidance on how to successfully become the service's system integrator for all major systems acquisitions. DHS Acquisition Management Directive DHS 102-01 directed the Coast Guard to establish policy and procedures and implement the DHS Acquisition Management and Review Process (U.S. Coast Guard, 2013). As a result, the MSAM was implemented.



To provide the guiding force to the newly formed organization, the Coast Guard assistant commandant for acquisition and CAO defines the CG-9 mission and vision. The MSAM states, “Mission: Acquire and deliver more capable, interoperable assets and systems, and high quality, timely services that support Coast Guard forces in executing missions effectively and efficiently,” (U.S. Coast Guard, 2013, pp. 1–2) and “Vision: The Coast Guard will be a model of acquisition excellence in government” (U.S. Coast Guard, 2013, pp. 1–2).

With the mission and vision in mind, the MSAM established organizational objectives to achieve these goals. These objectives provide guidance to the acquisition workforce on how to plan, coordinate, and execute major systems acquisitions (U.S. Coast Guard, 2013, p. 13). The following is a list of objectives taken directly from the Coast Guard MSAM (2013):

- Reduce the duration of the acquisition cycle to field useable, affordable, sustainable, and technically mature discrete segments of capability.
- Manage major acquisition projects using a systems engineering approach that optimizes total system performance and minimizes total ownership costs.
- Develop cost estimates that document realistic life-cycle costs with sufficient accuracy, rigor and confidence to enhance Coast Guard credibility with the DHS, Congress, and the American taxpayer.
- Reestablish Coast Guard technical authority and practice to serve as system integrator for all acquisition projects.
- Develop major systems acquisition processes and procedures that are flexible and responsive, and allow [program manager] PMs to exercise innovation and creativity to deliver systems, products, and services to our customers in a timely manner.
- Align Coast Guard major acquisition process with the established DHS acquisition management policy (pp. 1–2).

Clearly, mission and vision statements are important to establish a primary foundation for the organization. However, without proper direction for the acquisition workforce from a capable leadership base, the organization would certainly encounter challenges. The MSAM addresses how CG-9 leverages the acquisition workforce and its



leadership corps by identifying acquisition team members and establishing guiding principles for all of the essential elements of the Coast Guard acquisitions team.

2. Coast Guard Leadership and Team

The MSAM outlines how CG-9 integrates the acquisition workforce and defines the responsibilities of each division. The MSAM identifies individuals that perform tasks that support any phase of the acquisition process. Anyone that is involved in the process of directly or indirectly supporting acquisitions is included in the acquisition “team” tasks that are addressed by the acquisition team and include requirements development, acquisition planning and strategy, contracting processes, business management, operational and technical authorities, and logistics support (to name only a few) (U.S. Coast Guard, 2013). To further support the identification of acquisition team players, key billets are defined in the MSAM. These key billets provide CG-9 the legitimacy within the Coast Guard personnel management structure to ensure the acquisition workforce is properly manned and billeted with the appropriate number of individuals that have the required skillset to perform their assigned tasks. The Coast Guard MSAM identifies the following as key billets (2013):

- Program and project management
- Systems planning, research, development, and engineering
- Procurement, including contracting
- Business, cost estimating, and financial management
- Industrial and contract property management
- Facilities engineering
- Life-cycle logistics
- Information technology
- Production, quality, and manufacturing
- Testing and evaluation
- Configuration management (pp. 1–4).



To support the Coast Guard mission needs, the MSAM further provides high level guidance on how the CG-9 leadership will successfully accomplish support of acquisitions.

According to the MSAM, the Coast Guard Acquisitions leadership team comprises the following (U.S. Coast Guard, 2013):

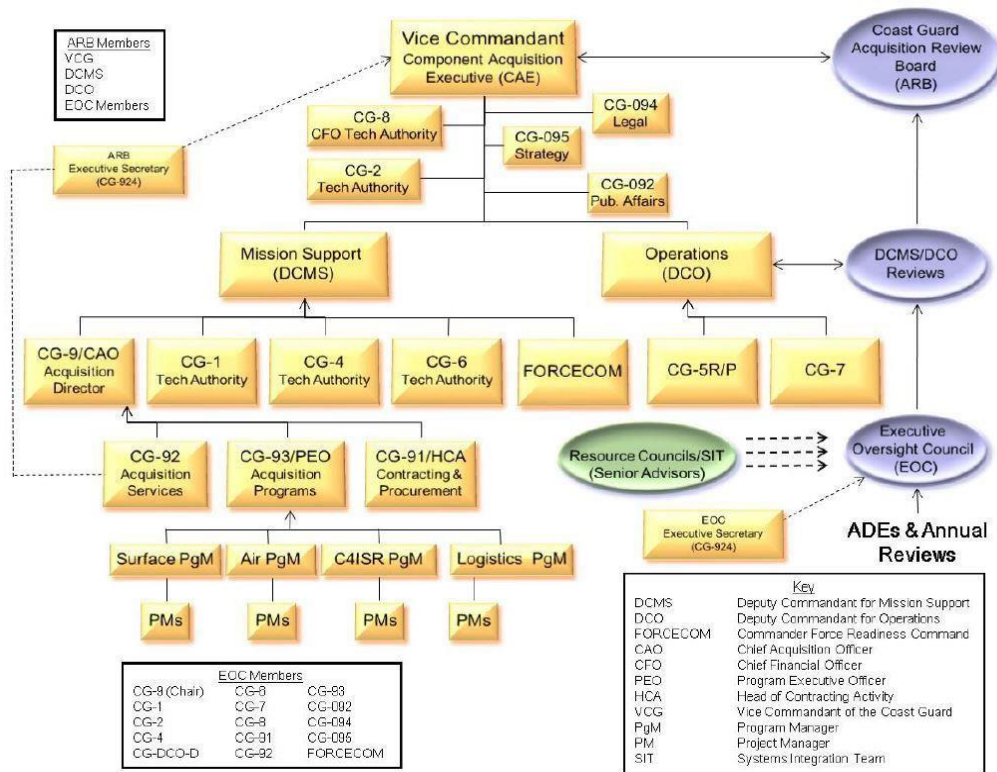
- Commandant of the Coast Guard
- Vice commandant acting as the component acquisition executive (CAE)
- Deputy commandant for mission support (DCMS)
- Deputy commandant for operations (DCO)
- Assistant commandants, the head of contracting activity (HCA)
- The senior staff of Coast Guard directorates, assigned field activities, and commands (pp. 1–5).

These leaders are the key component of the Coast Guard acquisitions system. The success or failure of the service ability to act as the system integrator for all major systems acquisitions is dependent on the ability of the Coast Guard leadership to manage the implementation of proven acquisition processes and practices.

The MSAM also describes how major systems ADEs and reviews are routed through the component chain of command. All ADE briefs are delivered to the acquisition team through the Executive Oversight Council (EOC) that consists of flag/Senior Executive Service (SES) level members, then to the deputy commandant for mission support (DCMS) for review (U.S. Coast Guard, 2013). Finally, the briefs are sent to the Coast Guard's Acquisition Review Board (ARB). Additionally, the ARB conducts annual review boards with the purpose of reviewing all major systems acquisitions, as well as allowing for the flow of vital information across all Coast Guard divisions (U.S. Coast Guard, 2013). Figure 2 shows the information flow within the Coast Guard acquisitions process. From this figure, the organizational hierarchy for the acquisition review process is apparent.



Figure 2. Coast Guard Acquisition Review Organization



Source: U.S. Coast Guard. (2013). *Major systems acquisition manual* (COMDNTINST M5000.10C). Washington, DC: Author.

The DHS established a specific training and certification requirement process to ensure a properly trained and educated leadership and acquisitions team.

3. USCG Acquisition Workforce Training and Certification

Commensurate with the DOD Defense Acquisition Workforce Improvement Act (DAWIA) training and certification standards, the Coast Guard along with the DHS, requires PMs to have the appropriate certification related to the total life-cycle cost estimate (LCCE) of the program they manage. Table 2 lists these specific requirements (U.S. Coast Guard, 2013, pp. 1–6).



Table 2. USCG PM Certification Requirements

Acquisition Level	Life-Cycle Cost Estimate (in dollars)	PM Certification Requirement
1	>\$1B	III
2	<\$1B ≥ \$300M	II
3	<\$300M	I

The table describes the program management requirements for all acquisition levels. Adapted from U.S. Coast Guard. (2013). *Major systems acquisition manual* (COMDNTINST M5000.10C). Washington, DC: Author.

The DHS is the approval authority for the certification process. The main areas of certification for the Coast Guard acquisitions team are Acquisition Program Managers (PM), Life-Cycle Logistics, Program Financial Managers, Systems Engineering, Test & Evaluation, and Contracting Officer’s Representative (COR). These certifications are managed by CG-9 in the Procurement Policy and Systems Division (U.S. Coast Guard, 2013). The MSAM further defines the authority and responsibility of each of the key positions previously listed in Table 2.

4. DHS Acquisitions Levels and Acquisition Decision Authorities

The DHS categorizes three levels of acquisition by measurement of the entire LCCE for the major or non-major systems acquisition. Additionally, the DHS defines program management requirements and authority requirements for each. Table 3 is an excerpt from the DHS Acquisitions Management Directive that defines the levels (Department of Homeland Security [DHS], 2010, p. 8).



Table 3. Program Acquisition Level

Acquisition Level	Life-Cycle Description (in dollars)
Level 1 (Major Acquisition)	Life-cycle cost: At or above \$1 billion ADA: Deputy secretary, or the chief acquisition officer (upon designation by the deputy secretary), or the undersecretary for management (upon designation by the CAQO)
Level 2 (Major Acquisition)	Life-cycle cost: \$300 million or more, but less than \$1 billion ADA: Chief acquisition officer, or one of the following officials as designated by the CAQO: undersecretary for management or the component acquisition executive
Level 3 (Non-Major Acquisition)	Life-cycle cost: Less than \$300 million ADA: Component head, or the component acquisition executive (upon designation by the component head)

Table 3 lists the acquisition levels and the associated life-cycle description. Adapted from Department of Homeland Security (DHS). (2010). *Acquisition management directive* (Directive 102-1; Revision No. 1.). Washington, DC: Author.

The OPC project falls into the Level 1 (Major Acquisition) category, and is the costliest program ever entered into by the Coast Guard.

I. U.S. COAST GUARD ACQUISITIONS MANAGEMENT PROCESS

1. Acquisition Management Interfaces

With the Coast Guard system acquisition structure discussed, including the acquisition leadership, team, certification requirements, and acquisition level, the acquisition process itself can be addressed. The MSAM (2013) defines “acquisition categories, acquisition phases, and principal decision milestones” (p. 2-1). With the overall goal of successful adherence to cost, schedule, and performance measures for each specific acquisition program, the PM should devise an acquisition strategy. The acquisition strategy includes three functional areas of focus: “major system acquisition management, requirements management, and capital investment planning” (U.S. Coast Guard, 2013, p. 2-1). Figure 3 shows the relationship between management interfaces and management areas.



Figure 3. USCG Acquisition Management Interfaces

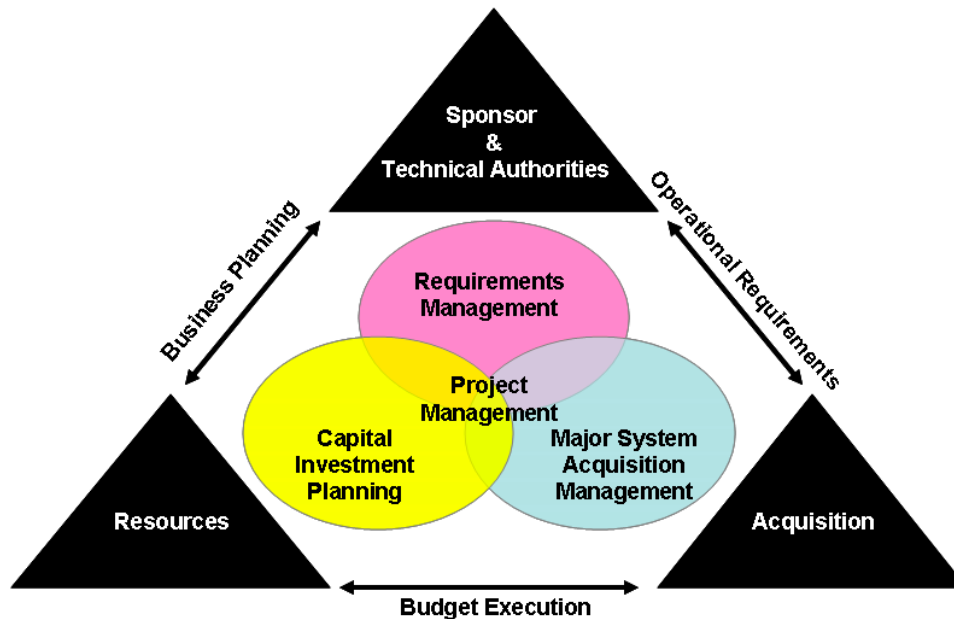


Figure 3 depicts the USCG acquisition management interfaces. Source: U.S. Coast Guard. (2013). *Major systems acquisition manual* (COMDNTINST M5000.10C). Washington, DC: Author.

The Coast Guard sponsor (CG-7 & CG-6) and the technical authority (CG-4) are responsible for the Requirements Management function. Once a mission need is identified, it is translated into a valid operational requirement by the Coast Guard Requirements Office (CG-77). Schofield (2010) states that “the Operational Requirements Framework provides both the operational requirements and design constraints necessary for the later design team to most effectively complete the functional allocation to design specifications” (p. 54). The technical authority validates the requirement to ensure that it meets technical standards.

Additionally, the sponsor will develop a mission needs statement (MNS). The MNS defines a capability gap and identifies a need to conduct a specific task. Concurrently, the business planning process identifies current capabilities in the Coast Guard and measures them against current or future missions to identify if any gaps exist. If a new material solution is required to fill the mission gap, the process continues. The sponsor will draft the CONOPS. The CONOPS describes in detail how the material solution will operate in all conditions of employment (U.S. Coast Guard, 2013). Finally,

the sponsor and the acquisition team will identify a potential solution to the capability gap and use the operational requirements framework to develop the preliminary operational requirements document (PORD) and operational requirements document (ORD) (Schofield, 2010, p. 54).

The Major Systems Acquisition Management phase of the interface process is managed by the PMs at CG-9. They manage the “cost, schedule, and performance parameters” of the system acquisition program (U.S. Coast Guard, 2013, p. 2–1).

The Capital Investment Planning process includes planning, programming, budget, and execution (PPBE) process management and is managed by the assistant commandant for resources (CG-8). The PM interfaces with CG-8 to manage the fiscal budget requirement for the program and coordinates with the sponsor to determine personnel requirements for the program (U.S. Coast Guard, 2013).

2. Major Systems Acquisition Process Structure

While the acquisition life-cycle framework phases are similar to the DOD’s, the DHS has adopted a slightly different process. Milestones are defined as ADEs and occur at each of the phases of the acquisition life cycle. As seen in Figure 4, the acquisition life-cycle phases include the following phases:

- Project Identification phase
- Need Development phase
- Analyze and Select phase
- Obtain phase
- Produce, Deploy, and Support phase (U.S. Coast Guard, 2013, pp. 2–4)



Figure 4. USCG Major Systems Acquisition Life-Cycle Framework



Source: U.S. Coast Guard. (2013). *Major systems acquisition manual* (COMDNTINST M5000.10C). Washington, DC: Author, pp. 2–4.

The acquisition framework consists of a number of ADEs, each at critical phases of the acquisition life cycle. At each ADE, the ARB reviews the program prior to submission to the DHS for approval. Each ADE should satisfy the requirements of the phase, as well as the exit strategy applicable to the ADE. Approval from the acquisition decision authority (ADA) must be obtained prior to entry into the next subsequent phase of the acquisition life cycle. The Coast Guard MSAM lists the following as brief descriptions of each ADE (2013):

- ADE-0: This event is at the beginning of the life cycle, and the determination of whether or not entry into the “Need” phase is justified. This phase identifies budgetary requirements for the annual PPBE process.
- ADE-1: This event “validates the need for the major acquisition,” supports the Coast Guard strategic needs, and facilitates the planning process for resources for the upcoming program.
- ADE-2A: This event allows for movement into the “Obtain phase.” Low Rate Initial Production (LRIP) quantity is approved in this phase.
- ADE-2B: This event support discrete segments of the acquisition if additional production phases for the program are required.
- ADE-2C: This event approves execution of LRIP for the quantities previously approved at ADE-2A.
- ADE-3: This event allows for full rate production after successful LRIP.
- ADE-4: This event is a Coast Guard–specific event. The program is transferred to the Support program once the material solution is delivered (pp. 2–4–2.5).

The OPC program is currently in the “design” phase post ADE-1. The remainder of this report focuses on the elements that lead up to the down select event from the



current contractors in the running and entry into the “obtain” phase. This report focuses on various elements of each phase up to the current state and analyzes lessons learned throughout all acquisition phases of both the NSC and FRC programs. With a good understanding of the successes and failures of both these programs, this report highlights how these lessons learned have shaped the acquisition plan for the OPC with “affordability” as the key requirement.



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III. METHODOLOGY

A. INTRODUCTION

In this chapter, we explain the investigative methods used to collect the data necessary for this research. We examine the methodology for collecting data and the reasoning behind the selection of the acquisition projects. We employed a literature review and phone interviews to develop a summary of the evolution of modern acquisition practices in the Coast Guard, compared those acquisitions to a similar project in the DOD, and worked to understand how each of the selected acquisition projects were managed at different stages of that evolution. We designed our interviews to give us a better understanding of how previous and similar acquisition projects have enabled the OPC acquisition project to have affordability as its highest priority. We reveal the selection of acquisition projects and interviewees. The acquisition projects selected were limited to those within the Coast Guard or that had similar strategies to the OPC project, and personnel interviewed were limited to those acquisition personnel who work or have worked in the project offices for the acquisition projects discussed.

B. METHODS

We researched the evolution of modern Coast Guard acquisition practices beginning with the conception of the Deepwater program in 1993 through present day where we summarize the status of the three major recapitalization investment programs in the surface vessel domain. Our research included literature from the Congressional Research Service (CRS), transcripts of congressional hearings, the GAO, the RAND Corporation, the DHS OIG, the CG-9 website, and various other online sources pertaining to acquisition and history related to this research. This literature provided us with many data points that were used in our analysis.

We established a partnership with the Coast Guard Acquisition Directorate's Office of Strategic Planning and Communication (CG-925). Through this relationship, CG-925 secured sponsorship and support for our research from the Coast Guard's assistant commandant for acquisitions CG-9/CAO. Along with the support and assistance



of CG-9/CAO, we had access to all assistant program executive officer (CG-932) surface acquisition program documents through the Coast Guard intranet portal. These documents included everything from the MAR to the deployment plan for all major recapitalization investment programs in the surface vessel domain. We reviewed the relevant documents for each of the acquisition programs that we were studying to obtain the data we used in our analysis.

We conducted an interview with the contracting officer's representative in the OPC Project Office (CG-9322). Our interview was designed with questions approved by the Institutional Review Board (IRB) at the Naval Postgraduate School to give us a better understanding of how previous and similar acquisition projects have enabled the OPC acquisition project to have affordability as its highest priority. The IRB determined that our interview questions were not designed to collect information about a living individual. The interview provided us with data that was used in our analysis.

We selected the NSC, FRC, Joint High Speed Vessel (JHSV), and OPC acquisition projects for analysis of lessons learned in making an acquisition program affordable. Although each of these projects were managed in different ways and through different stages of the Coast Guard's and Navy's evolution toward modern acquisition practices, they each contributed vital lessons learned that were essential to informing the Coast Guard's most recent acquisition decisions in procuring the OPC.

C. RESEARCH METHOD AND INTERVIEW QUESTIONS

In order to gather information and data regarding the OPC program, it was necessary to conduct an interview with the OPC program office. The interview centered on how the acquisition strategy was built and how the contracting strategy supported the goals of the acquisition plan related to affordability. The following questions were asked during our phone interview with CG-9322:

- What aspects of the OPC acquisition strategy contribute most to affordability?
- Does the OPC acquisition strategy use a multi-year or block-buy strategy?



- How will the OPC acquisition strategy procure data rights from the phase 1 contractor for phase 2?
- Has the Coast Guard considered the impacts of game theory (contractors coordinating strategies to reach a higher final price proposal) among shipbuilding contractors?
- How has the Coast Guard budgeted for the OPC in its budget requests for FY 2016–2020?
- How did the Coast Guard write the OPC requirements to be affordable?
- What does the \$310 million ceiling price include?
- How does the requirement of interoperability affect affordability?
- How does the Navy process for government furnished equipment (GFE) affect the Coast Guard acquisition time lines?

D. OPC COST MODEL TRADE-OFF ANALYSIS

In addition to the above listed methods, this report utilized research methods from the thesis titled *Estimating Production Cost while Linking Combat Systems and Ship Design*, developed by Jeffrey Lineberry (Naval Postgraduate School), to provide an estimate of the cost of the OPC given stated requirement objectives. Lineberry’s work used Model-based systems engineering (MBSE) to “develop and demonstrate a methodology to use the output analyses of the combat systems effectiveness as ship characteristic inputs for the ship design process.” Lineberry developed a “dashboard” using Microsoft Excel that used user-defined requirement inputs related to ship speed, helicopters/UAS, and weapons systems. Using MBSE, the dashboard estimated the cost per vessel based on a cost per pound relative to ship design functionality. His primary research was used for the Navy’s Offshore Patrol Vessel, a vessel that has similar characteristics to the Coast Guard’s OPC.

Using the dashboard, this report conducted a cost estimate for the OPC using notional design data. Additionally, this report conducted a requirements trade-off analysis for speed, personnel, and length/beam requirement objectives and thresholds. This data validates the Coast Guard stated objective of \$310 million per hull, as well as provides



OPC PMs executive trade-off analysis calculations respective to speed, personnel, and length/beam requirements.

E. SUMMARY

In this chapter, we identified the investigative methods used to collect the data necessary for this research and analysis. We examined the methodology for collecting data and described the primary literary sources that were examined. We revealed the partnerships that we fostered with CG-9, CG-925, and CG-932 and the resources that were available to us through our sponsorship and support by those parties. We outlined the process we used to conduct interviews over the phone and indicated the office that was interviewed. Finally, we examined the reasoning behind the selection of the acquisition projects we chose and why those projects provided us with the best data for our analysis.



IV. ANALYSIS/RESULTS

A. INTRODUCTION

Our research provides insight into the concerns that have been raised from recent procurement projects that should rightly be used to inform future Coast Guard acquisition programs in order to maximize their affordability. Our analysis attempted to classify these concerns into several major categories that could be further explored and developed to understand how the lessons learned from recent procurements could be incorporated into Coast Guard policy and implemented in future acquisition programs. We specifically focused on lessons learned from the NSC and the FRC and how those lessons could be used to inform the OPC acquisition program to maximize its affordability.

B. COMPETITION IN SHIP ACQUISITION

As the Coast Guard enters into the “middle stages” of the acquisition efforts initially planned under the legacy Deepwater program, the OPC project has found itself placed in a challenging environment within defense acquisition. Current budgetary restrictions have placed a high level of importance on the value and affordability of newly procured systems, and the OPC is no exception. Many functions within the acquisitions process can help reduce the overall costs of the system, including effective program management, sound and achievable requirements, and a well-structured competitive environment for the contract of the procured system. While there are many effective tools a PM can use to reduce costs of the overall project, competition can be very effective to reducing cost; however, it can also unintentionally add cost if not incorporated effectively.

The Weapon Systems Acquisition Reform Act (WSARA) of 2009 was introduced as a way to reform how the DOD issued contracts for major weapons systems procurement programs. The WSARA listed the following methods to help facilitate competition (2009):

- Competitive prototyping
- Dual-sourcing



- Unbundling of contracts
- Funding of next-generation prototype systems or subsystems
- Use of modular, open architectures to enable competition for upgrades
- Use of build-to-print approaches to enable production through multiple sources
- Acquisition of complete technical data packages
- Periodic competitions for subsystem upgrades
- Licensing of additional suppliers
- Periodic system or program reviews to address long-term competitive effects of program decisions (p. 19)

This section analyzed the OPC project in terms of how the acquisition plan (AP) incorporated some of the previously listed “best practices” to ensure affordability in the OPC procurement plan with respect to competition.

1. Competitive Prototyping and Funding of Next-Generation Prototype Systems or Subsystems

The OPC project decided not to use a design to cost (DTC) strategy. The OPC project hopes to achieve cost savings by using a multi-phase acquisition plan and incorporating competition in phase I for the detail design contract for a total cost of \$65 million. This “competitive prototyping” approach will potentially result in a number of positive aspects to the preliminary and detail design of the OPC. One of the most beneficial results is innovation. Gansler (2012) stated that effective competition “encourages innovation and higher quality” (p. 19). The potential upside for creating value in terms of affordability on the OPC project is how innovation forms efficient processes of shipbuilding, or develops technology to make ship design and production more effective. That cost savings can then be passed on to the government in terms of affordability.



2. Acquisition of Complete Technical Data Packages

Another key element in the potential success of the competitive approach to the OPC program is the government's ownership of the technical data package (TDP) to the OPC. By funding the prototypes during the phase I contract, the technical data rights belong to the Coast Guard. Ownership of the TDP will facilitate follow-on competition in subsequent phases of the program without the cost risk of attempting to acquire the data rights from a contractor that used their own research and development (R&D) funds to design the OPC.

C. RISK ON EFFECTS OF INCENTIVES IN ACQUISITION

The OPC program will use a fixed-price incentive (FPI) contract with hopes of increasing competitiveness of the contractor to achieve underrun costs on the program. According to the Federal Acquisition Regulation (FAR), "a fixed-price incentive contract is a fixed-price contract that provides for adjusting profit and establishing the final contract price by a formula based on the relationship of final negotiated total cost to total target cost" (FAR 16.204). Due to the FPI contract structure, the potential exists to provide value to the contractor in achieving FPI contract targets, increasing potential profit. However, if the program uses a poorly structured incentive plan, the incentive can become counterproductive. Novak and Levinson stated, "Misaligned incentives can unintentionally promote program outcomes which are in direct conflict with the stated intent of the acquisition system" (2012, p. 2). This report later stated that "misaligned incentives can lead to underbidding on a contract in hopes of recovering lost revenue from the underbid later in the acquisition" (Novak & Levinson, 2012, p. 6). By using the FPI approach, the OPC program mitigates some of the risk associated with incentives, because the contractor will give his or her "best effort" to achieve the fixed price of the contract. However, the incentive structure will have to apply a calculated approach in determining the point of total assumption (PTA), the most beneficial structure of the above target cost and below target cost proportion shared between the government and contractor. The PTA shows where the incentives do their intended job by actually incentivizing the contractor to stay under the target cost.



Three contractors will then compete for the contract to build hulls 1 through 9 in phase 2. The OPC project will use the affordability as a requirement strategy by establishing the cost per hull goals for hulls 4 through 9. In the RFP for the OPC, Section C.5 lists the affordability requirement as \$310 million per hull in “then-year-dollars” (Federal Business Opportunities, 2015, p. C-5).

D. CONTRACT STRUCTURE

Contract structure plays a large part in the effectiveness of the overall program specifically related to affordability. In the contract environment, the PM should analyze the type of acquisition measured against the expected risk to the government related to the contractor’s ability to meet the stated requirements of the contract. A simple acquisition of goods and services that rely on commercial-off-the-shelf (COTS) technology would use a fixed-price type of contract because there is little risk to the government. However, on a large technical program where the technology is immature, the government may risk more due to the required development of the technology and favor a cost type of contract. This reduces some of the risk to the contractor and assists the contractor in achieving the stated requirement of the acquisition.

Ship procurement is an extremely complex process. Mature ship designs with relatively low risk to the government may result in old technology and reduced capability in areas of ship’s endurance, speed, and C4ISR capabilities, whereas technologically advanced ship designs and new building processes can be more risky but result in a payoff of faster, more efficient hulls with robust information technology capability. The Coast Guard OPC program should analyze the desired capability for the OPC system, analyze lessons learned from prior ship procurement contracts, and decide the best course of action for how to construct the OPC contract with affordability as one of the main requirements. Lessons learned from prior shipbuilding contracts are discussed next.

1. National Security Cutter

The NSC was designed and initially constructed in a cost-plus incentive contract environment by ICGS. Although fair and open competition was used to select the private-sector LSI on a best-value basis for the IDS acquisition plan in 2002, once the LSI was



selected, competition was basically nonexistent in the acquisition program. The contracts for the construction of NSCs 1–3 were cost-plus incentive contracts and awarded directly to ICGS. After the Coast Guard began directly awarding contracts to the shipbuilder outside of the ICGS commercial LSI contract framework, the contracts for NSCs 4–8 were fixed-price incentive (firm target). With the addition of an incentive clause, the fee that the shipbuilder earned was linked directly to the actual cost performance. The final price of building the cutter was then used to determine how much fee the shipbuilder earned. “If the shipbuilder performed above target cost, the overrun was shared between the government and the shipbuilder. This new contract type provided a real disincentive for the shipbuilder to have overruns” (Keeter, 2007, p. 1). The LLTM for NSCs 4–8 were purchased using FFP contract line item options. The Coast Guard continued to use HII as the sole source shipbuilder to build NSCs 4–8 and therefore did not incorporate full and open competition throughout the acquisition strategy. The NSC is a DHS Level 1 investment.

2. Fast Response Cutter

The FRC design began within ICGS, but that program was canceled and reassigned to CG-9. Once the FRC project was within CG-9, the Coast Guard used a “parent-craft” design and a two-phase shipbuilding contract. The selection of a “parent-craft” reduced design costs by using a design that was already proven to execute similar missions. In the first phase, the Coast Guard used full and open competition to competitively award FP/EPA contracts to Bollinger Shipyards Lockport LLC for the design and construction of the lead ship with options for 32 additional ships. In addition, each contract option period in the first phase included the ability to purchase a RDLP, which the Coast Guard needs to competitively award the shipbuilding contract in the second phase. In the second phase, the contracts for FRCs 33–58 will leverage the cost benefits of full and open competition to re-compete the award with industry using the RDLPs purchased in the first phase.



3. Offshore Patrol Cutter

The Coast Guard is using a two-phase ship design strategy that consistently incorporates fair and open competition for the OPC acquisition program (U.S. Coast Guard, 2010). In the first phase, the Coast Guard used full and open competition to competitively award three FFP contracts for P&CD to Bollinger Shipyards Lockport LLC, Eastern Shipbuilding Group Inc., and General Dynamics, Bath Iron Works. In the second phase, the Coast Guard plans to down-select to a single design from these three firms and award a mainly fixed-price incentive (FPI; Firm Target) with an economic price adjustment (EPA) construction contract for DD&C with additional options for constructing the lead ship, LLTM, RDLP, eight to 10 follow-on ships and ancillary services and supplies (Federal Business Opportunities, 2015). Before the construction of the sixth OPC within the second phase, the Coast Guard will require the contractor to submit a fixed-price proposal for OPCs 6–11. The Coast Guard will then determine whether this proposal is fair and reasonable before proceeding with OPC 10 and 11. If the proposal is deemed to be not fair and reasonable, the contract will end with OPC 9 (Federal Business Opportunities, 2015). The contracts for OPCs 10–25 will again leverage the cost benefits of full and open competition to re-compete the award with industry using the RDLPs purchased in the first part of the second phase.

E. JOINT HIGH SPEED VESSEL

The two-phased procurement strategy that the Coast Guard is using for the OPC acquisition project has been previously used by the Navy for the Joint High Speed Vessel (JHSV). The JHSV program merged the previous Army Theater Support Vessel (TSV) with the Navy High Speed Connector (HSC) (Austal Limited, 2015). The JHSV is a 338-foot aluminum catamaran that provides high speed sea lift mobility for intra-theater personnel and cargo lift. The JHSV utilized commercial design and was certified based on American Bureau of Shipping (ABS) rules. As a noncombatant transport vessel, it was not required to meet Navy survivability or damage sustainment criteria and therefore had the advantage of using nondevelopmental or commercial technology (U.S. Navy, 2014). Austal USA was able to avoid substantial manufacturing and monetary uncertainty by



incorporating existing technology, using stable requirements, and restricting changes in an effort to reduce costs and increase efficiency (Austal Limited, 2015).

The Navy conducted the JHSV as a two-phased procurement. On February 1, 2008, the Navy awarded multiple FFP preliminary design contracts to three contractors: Austal USA, Incat Tasmania Pty Ltd, and Bath Iron Works (a subsidiary of General Dynamics) (Galrahn, 2008), with a period of performance not to exceed 180 days to submit a proposal for the DD&C contract. At the completion of phase 1, the Navy down-selected to a single contractor for phase 2, and on November 13, 2008, awarded Austal USA (located in Mobile, AL) a \$185 million FPI contract for DD&C of the lead JHSV “with contract options for the construction of up to nine additional ships and associated shore-based spares. All contract options have been awarded” (U.S. Navy, 2014, p. 1).

F. CONTRACT STRUCTURE LESSONS LEARNED

The lessons learned from the contract structure for the NSC and FRC have been vital to developing a contract structure for the OPC that makes the acquisition more affordable. Fixed-price contracts with incentive clauses that link the shipbuilder’s fee to their actual cost performance are extremely effective in making the shipbuilder conscious of cost overruns and therefore preventing cost growth on contracts. The migration from the cost-plus incentive contracts used on NSC 1–3 to the planned FPI/EPA contracts for the first phase of the OPC is a great improvement. The use of RDLPs and two-phase shipbuilding strategies gives the Coast Guard the ability to maintain fair and open competition further into the acquisition life cycle of the OPC. Shipbuilders awarded the first phase should be conscious that their proposal for the second phase will need to be competitive with other firms in the industry, and likewise other firms in the industry will work to ensure their proposals for phase two are more affordable than the incumbent’s. The migration from the sole source contracts used with HII on the NSC to the potential ability for the Coast Guard to competitively award FRCs 33–58 to a separate firm is a great improvement for the FRC and will likely greatly contribute to the affordability of the OPC.



G. BLOCK BUY CONTRACTING AND MYP

A potential contracting mechanism that could further increase the affordability of the OPC in the range of 5–10% is block buy contracting (BBC) or multiyear procurement (MYP). Currently, Congress authorizes the DOD to use these contracting mechanisms for “a limited number of defense acquisition programs” (O’Rourke & Schwartz, 2011, p. 1) that O’Rourke and Schwartz say “must meet several criteria to qualify” (p. 5). According to O’Rourke and Schwartz, the Navy has used BBC/MYP contracts for the DDG-51 destroyer, SSN Virginia-class submarine, LHD amphibious ship, and most recently the LCS.

The Department of Defense Authorization Act of 1981 is the permanent statute that dictates, “what criteria a program must meet to qualify for MYP” (O’Rourke & Schwartz, 2011, p. 5). O’Rourke and Schwartz suggest that these criteria include substantial savings, realistic cost estimates, stable need and design for the items, fixed-price type contract, and enough past completed products to illustrate if projected unit costs are accurate, and the program must not have had any Nunn-McCurdy critical cost growth breaches within the last five years. The OPC program cannot yet meet these criteria, and therefore BBC could be considered for use early in the DD&C phase.

“The standard or default approach [in government acquisitions is] annual contracting” (O’Rourke & Schwartz, 2011, p. 1). O’Rourke and Schwartz state that annual contracting involves one or more contracts that are used for each year’s worth of procurement of an item. They also argue that the advantage BBC or MYP introduces over annual contracting is the “use of a single contract for more than one year’s worth of procurement of multiple items” (p. 9). Unlike MYP, BBC is not covered by permanent statute, and therefore, programs do not have to meet as many criteria as they do for MYP. For this reason, BBC has been used in the beginning of new acquisition programs (for example SSN Virginia-class submarine) before these programs have fully matured to meet the criteria of MYP. BBC could potentially be used early in the DD&C phase of the OPC to reduce the combined procurement cost of the first batch of OPCs.



H. RECENT BBC AND MYP IN THE NAVY

The Navy's Littoral Combat Ship (LCS)/Frigate program recently used a pair of 10-ship BBCs for ships 5 through 25 in the program (out of 52 total planned) (O'Rourke, 2015b). O'Rourke (2015b) stated that these two contracts were awarded after the Navy changed from a down-select decision in December 2010 to instead using a dual-award strategy that it claimed would "reduce LCS procurement costs by hundreds of millions of dollars" (p. 38). According to O'Rourke, Secretary of the Navy Ray Mabus has stated that having two shipyards under the dual-award strategy has "driven cost down considerably" (2015b, p. 27). The original estimated average unit cost for each LCS was \$538 million, whereas the estimated average unit cost using the FPI block buy contracts is about \$440 million. "The Navy has not yet announced an acquisition strategy for ships 27-32" (O'Rourke, 2015b, p. 27).

I. BBC AND MYP IN THE COAST GUARD

The Coast Guard may have already missed potential cost savings by not using BBC or MYP for the NSC and phase 1 of the FRC. As O'Rourke (2015a) observed, the NSCs,

could have been acquired less expensively if they had been awarded on a more-even rate (such as a steady one ship per year) and if at least some of the ships had been acquired with a form of multiyear contracting (i.e., either multiyear procurement (MYP) or block buy contracting). The savings from such an approach might have been sufficient to pay for a substantial fraction of one of the eight ships in the class. (p. 5)

As the FRC enters phase 2 of its acquisition and the Coast Guard prepares to award another contract with options for hulls 33 through 58, the Coast Guard could consider an alternate approach to make the contract a multiyear contract (i.e., a BBC or MYP contract). O'Rourke stated that "an MYP or block buy contract might result in acquisition costs for FRC procured in FY 2016 and beyond that are lower than those possible under an options contract" (2015a, p. 5).



O'Rourke stated, "Section 215 of H.R. 4005, the Coast Guard and Maritime Transportation Act of 2014, provides authority for the use of MYP contracts for the OPC program" (2015a, p. 6). However, in order for the Coast Guard to use this authority, it would have to demonstrate that the OPC has a stable design, which may not be possible until the construction of the lead ship has been completed, since "completion of the lead ship has been the standard in Navy shipbuilding programs for demonstrating that the program has a stable design" (O'Rourke, 2015a, p. 6). In the interim, Congress could enable the Coast Guard to use multiyear contracts for the OPC program by authorizing block buy contracting with the ability to use Economic Order Quantity (EOQ), much like the Navy used for the first four Virginia-class attack submarine program (O'Rourke, 2015a).

MYP could be used once the OPC program meets the criteria to qualify for it to maximize the procurement cost savings that MYP achieves. MYP could increase affordability in giving shipbuilders confidence to make investments to optimize their workforce and production facilities with a guaranteed multiyear stream of business (O'Rourke & Schwartz, 2011). Additionally, MYP enables the ability to use EOQ purchasing to procure expensive or long lead-time materials in batch during the initial years of a five to six year contract. This allows the manufacturers "to take maximum advantage of production economies of scale that are possible with batch orders" (O'Rourke & Schwartz, 2011, p. 4).

Although MYP could potentially provide stability for the industrial base and yield significant cost savings that, according to Assistant Secretary of the Navy Sean Stackley (O'Rourke & Schwartz, 2011, p. 8), the government could ultimately put back into other programs, it should be noted that it could intrinsically reduce competition and the benefits thereof throughout the life cycle of a program. For this reason, the cost savings of MYP vice those of full and open competition throughout should be further analyzed to understand which strategy could make the OPC more affordable.



J. SOURCE SELECTION

Selecting a contractor that has proven experience in the design and production of complex ship systems, as well as ability to stay within program cost parameters, will be key. The OPC PM and the rest of the acquisition team should conduct extensive risk analysis during the source selection process. The phase I RFP, Coast Guard OPC RFP Part IV Section M states priority of specific requirements with objective and threshold values (Federal Business Opportunities, 2015, Section M):

- Speed
- Helicopter Hangar Storage (Aircraft Type)
- Operating Range
- Accommodations
- Patrol Endurance
- Small Boat Launch/Storage Capability (Number)
- 4-ft by 6-ft Pallet Storage Capability (Number)

Later, this report discusses requirement trade-off analysis related to the some of the evaluation factors that the PM may consider during the source selection process.

The RFP Section M.II goes on to identify the evaluation factors for selection as “All evaluation factors other than price, when combined, are approximately equal to price” (Federal Business Opportunities, 2015, p. M-3). Evaluation factors listed in the RFP are as follows (Federal Business Opportunities, 2015, p. M-3):

- Factor 1: Total Evaluated Price (Section M.II.6)
- Factor 2: Concept Design (Section M.II.4)
- Factor 3: Detail Design & Construction Approach (Section M.II.4)
- Factor 4: Production Capability (Section M.II.5)
- Factor 5: Organizational Management (Section M.II.5)
- Factor 6: Cost Management (Section M.II.5)



By setting these priorities, the contracting officer for the OPC program is stating that the price of the contract is very important. While total evaluated price and concept design approach are listed as the highest priority factors and play a large part of in determining the affordability of the design, the highest risk associated factors are organizational management, production capability, and cost management. It is evident that the CAE, acquisition leadership, and the acquisition team understand the potential risks and are mitigating the risk by placing a high priority on these factors.

K. OPC REQUIREMENTS AND OPERATIONAL TEST AND EVALUATION

The OPC program has the benefit of being the last cutter procurement project in the Coast Guard cutter recapitalization plan. Coast Guard leadership should take advantage of lessons learned from both the NSC and FRC acquisition programs and apply those lessons learned to the current OPC acquisition plan. Application of these lessons learned, coupled with an effective and strategic OPC acquisition plan, will reduce the risks associated with cost, schedule, and performance factors, and increase the potential for an affordable program. This report has discussed lessons learned from both programs regarding competition and contract structure. The following section addresses the fundamentals of the OPC requirements and how the AP addresses the operational test and evaluation (OT&E) activities of the OPC. Additionally, this section addresses how the AP applies lessons learned from the NSC and FRC requirements process and operational test and evaluation (OT&E) elements to facilitate an affordable program.

1. NSC and FRC Requirements Lessons Learned

Both the NSC and FRC programs have significant lessons learned relating to the design of the ship to operate effectively in its intended environments. Solid and specific requirements are essential during the Systems Engineering process to provide the contractor the ability to develop a work breakdown structure (WBS) based off the developed key performance parameters (KPPs) in order to meet the intended requirement. Use of architectures such as Naegle's Maintainability, Upgradability, Interoperability, Reliability & Security and Safety (MUIRS) (2006) during the design of ship and all of its subsystems could help to check that the product will meet the stated criteria.



Failure to address any of the MUIRS elements subjects the specific design to unnecessary risk. However, even if the design covers all elements of the MUIRS process, the element of “you don’t know what you don’t know” will always provide additional unknown risk to the design. Cost is one of the trade-offs in how complete the design is and how completely the design addresses every conceivable element of the MUIRS process. When designing to an affordable cost, the risks are in, first, failing to address all possible elements of the MUIRS requirements, and second, opening up the potential for significant issues to become apparent late in the design process and even post-production in the OT&E phase of the project.

a. NSC Requirements and Design Lessons Learned

The NSC had several significant design issues that degraded its ability to operate effectively in all the intended environments. The NSC requirements were that the cutter would conduct missions in all environments to include cold and warm climates. In the CRS cutter procurement report, O’Rourke (2015a) highlighted some issues that the Coast Guard encountered as a direct result of a poor design that significantly limited the NSC’s ability to operate in extreme climates.

These reports discuss several warm weather problems, including cooling system failures, excessive condensation forming “considerable” puddles on the deck of the ship, and limited redundancy in its air conditioning system—which, among other things, prevents the use of information technology systems when the air conditioning system needs to be serviced or repaired. In addition, according to operational reports, during a recent deployment, the commanding officer of an NSC had to impose speed restrictions on the vessel because of engine overheating when the seawater temperature was greater than 77 degrees. (p. 25)

Additionally, the NSC’s C4ISR system had significant changes as well. The system cost the Coast Guard \$413 million to develop and maintain (O’Rourke, 2015a). O’Rourke (2015a) stated that the system “was designed and built as a tightly integrated system bundling large commercial and government software programs with contractor-proprietary software, which made it difficult and costly to maintain—primarily due to its unique characteristics and large size” (p. 25). Ultimately, the Coast Guard replaced the costly C4ISR system with a more effective and easier to maintain system developed by



the Coast Guard. This change cost the Coast Guard an additional \$88.5 million (O'Rourke, 2015a, p. 25).

The problems with the NSC stem from the design and its ability to operate in these extreme environments, as well as implementing a complex C4ISR system that was too costly to operate and maintain. Ultimately, the life-cycle cost (LCC) will increase due to the redesign and corrections that have been made to the cutter for it to be able to operate in these extreme environments as stated in the requirements document.

b. FRC Requirements and Design Lessons Learned

One of the main drivers in the LCC of a program is the Produce/Deploy and Support efforts in ADE-4. Up to 75% of the total LCC can occur during this phase. In this phase, a significant cost driver is the cost of fuel. Both the NSC and FRC programs have encountered significant issues with the “fuel efficiency” of the hull design. The Coast Guard lists that part of the reason the requirements did not fully capture the importance of the endurance speed requirement is because the developers of the requirement did not fully understand the design drivers that would make the requirement achievable (CG-9, 2014d). The result was that fuel efficiency requirements were insufficient in the system engineering and design process. This design issue has the potential to have large negative budgetary impacts on the total LCC of the FRC program.

As the OPC program continues into the design phase, PMs should develop evaluation criteria that clearly define the metrics that make fuel consumption an important evaluation part of the deciding factor regarding the design of the hull. Clearly defining the fuel efficiency requirement could have huge savings in the operational and support phase of the total LCC of the OPC program.

Another design problem that had LCC implications was the FRC's small boat. GAO Report 14-450 pointed out that “initial testing of the small boat determined it to not be seaworthy in minimally acceptable sea conditions and—therefore—could not support the cutter's mission set” (2014, p. 14). Poor requirements are the cause of this issue. The systems engineering process did not have enough information to design an acceptable solution because the requirement was not specific enough when incorporated with the



stern launch design of the FRC. Systems integration is essential to ensure that all functions of the system as a whole are going to work as designed, and it takes solid requirements to which the contractor can design.

The OPC program learned this lesson by making a trade-off from its original design of a stern launch capability. By designing out the stern launch requirement, the OPC program adopted a mature side launch capability. This trade-off reduced the risk associated with trying to design to an immature technology. While there will be trade-offs in crew manning for small boat operations and an increased “time to deploy,” the ability for the small boat to support the OPC mission will be less risky and therefore could save LCC dollars.

2. Operational Test and Evaluation

In addition to a solid design, one of the key elements that significantly reduces the risk to a program’s LCC is how the program integrates the OT&E element. The only way to assess whether the program can meet its mission requirements is through OT&E. Ideally, OT&E occurs after the LRIP. If any issues with the design are identified, corrections can be made prior to full-rate production. If the program is delinquent in the testing of all of the functionality and the ability to meet stated KPPs, the LCC is at risk of adding costs that would otherwise have been avoided.

A lesson learned that could make the OPC more affordable is for it to “meet all key requirements during operational testing before being approved for full-rate production in order to avoid retrofits or design changes that add to the program’s cost” (GAO, 2014, p. 1). As observed by the GAO (2014), Coast Guard policy is

that representative units of major acquisition assets should be operationally tested by an independent test agency before they are approved for full-rate production. The results of these operational tests are used to evaluate the degree to which the capability or system being acquired meets its requirements and is able to operate in its intended environment, both before and often after full-rate production commences. (p. 8)



a. NSC Operational Test and Evaluation Lessons Learned

The NSC recently completed its initial OT&E, “although seven of eight vessels are completed or currently under construction” (GAO, 2014, p. 9). The GAO suggests that early assessments and mission performance of the first three NSCs acquired during operational deployments, preliminary test events and significant nonoperational tests and assessments indicated that design modifications costing at least \$140 million are essential for the NSC to meet its requirements. These changes included replacing the primary information system, structural enhancements, removal of aircraft handling tracks in the flight deck, and replacement of the gantry crane for small boat operations from the stern ramp. Currently, “additional changes may be needed because the Coast Guard has not fully validated the capabilities of the NSC” (GAO, 2014, p.1). The added costs of these retrofits and design changes have had negative impacts on the affordability of the NSC program.

As the GAO (2014) observed, “Continuing with full-rate production before ensuring that assets meet key requirements risks replicating problems in each new asset until such problems are corrected” (p. 13).

b. FRC Operational Test and Evaluation Lessons Learned

The GAO observes that the FRC completed initial OT&E but only met one of six key requirements throughout these tests. “The other five requirements did not meet minimum performance levels or were not tested” (2014, p. 15) due to a fuel leak, inaccurate fuel level indicators, warranty responsibilities, inadequate small boat, external unit availability, and delay in conducting repairs. Although the Coast Guard aggressively attempted “to test the [FRC] early in the acquisition process, [the early testing ultimately] limited the ability to fully examine the vessel” (GAO, 2014, p. 16) prior to full-rate production. As explained by DHS Inspector General John Roth (Assessing DHS’ performance, 2015),

We found that the USCG’s schedule-driven strategy allowed construction of the FRCs to start before operational, design, and technical risks were resolved. Consequently, six FRCs under construction needed modification, which increased the total cost of the acquisition by \$6.9 million and



caused schedule delays of at least 270 days for each cutter. This aggressive acquisition strategy also allowed the USCG to procure 12 FRCs before testing the lead cutter in actual operations. (p. 8)

The OPC program should meet and demonstrate all key requirements through OT&E prior to full-rate production. This will help avoid the risk for these cost increases and maintain affordability.

L. OPC AFFORDABILITY OF REQUIREMENTS

As with any shipbuilding endeavor, the requirements of the program play a large part in the overall affordability of the ship program. The OPC is a complex system. Risks are present in the engineering and ship design, integration of systems, and logistics and supply chains. The development of the requirements and the contractor's ability to meet KPPs will ultimately determine the outcome of the program in terms of affordability. One of the key components to the affordability of the OPC program is the affordability and completeness of the requirements. The OPC operational requirements document (ORD) contains detailed requirements as well as KPPs for the OPC. The ORD is a For Official Use Only (FOUO) document. Due to its FOUO designation, the details of the OPC ORD requirements or KPPs are not discussed in this report. To ensure unlimited distribution of this MBA report, all discussion of notional requirements or prospective KPPs for the OPC cost and requirements trade-off analysis are estimated or derived from publicly available documents.

One key element of requirements generation is early analysis of potential risks of having too technical of a requirement. If a requirement capability is not mature in its technical life cycle, this increases the risk of obtaining the requirement on schedule and at cost. According to the COR for the OPC project, Commander Jonathan Bates (J. Bates, personal communication, March 27, 2015) the OPC program has already executed trade-offs in the requirements generation phase by removing the stern launch capability requirement from the original design. This trade-off reduced the cost and risk associated with an immature technology in favor of a mature side launch capability and is an excellent example of identifying trade-offs during requirements generation that will reduce the LCC and maintain program affordability.

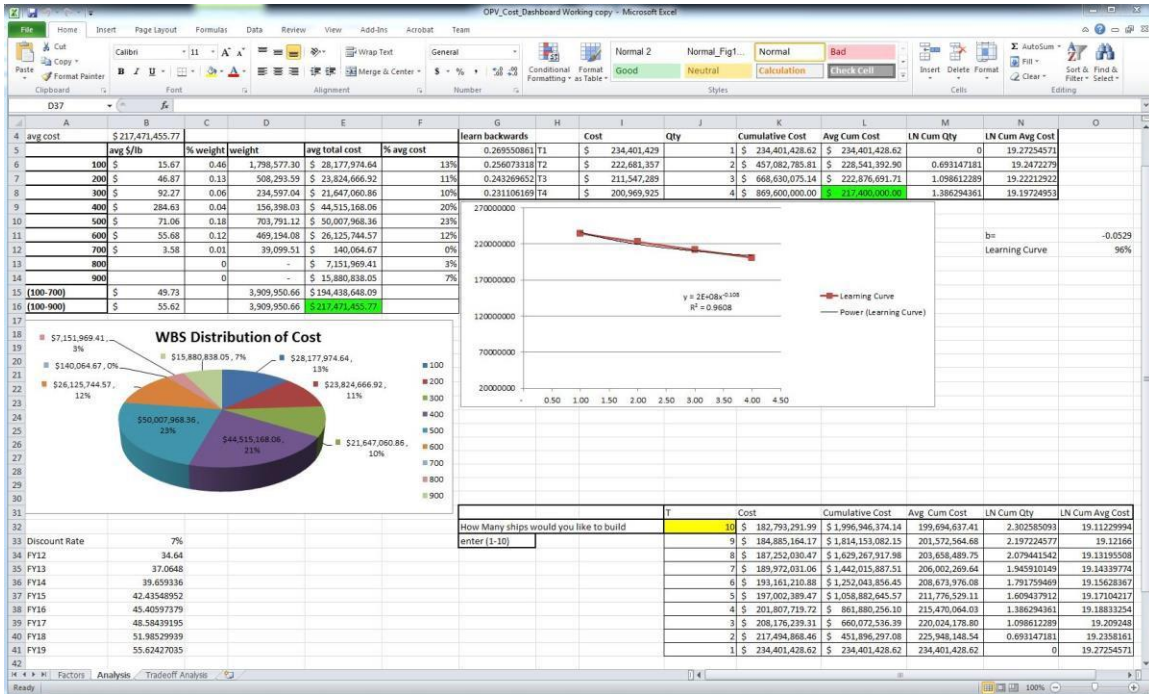


M. OPC COST ANALYSIS VALIDATION AND TRADE-OFF ANALYSIS

Due to the nature of the OPC contract being a full trade-off source selection, the PM and acquisition and contracting team should have a full understanding of the requirements areas they are willing to trade-off. Additionally, having \$310 million per hull as a requirement in and of itself and having full understanding of cost drivers in ship design process will be essential. With a full understanding of cost drivers in the ship systems engineering process, the PM and acquisition team will be able to determine which requirements areas are valued the highest to the Coast Guard, and what the expected relative cost per requirement will be. This section used work conducted by Lineberry (2012) in the area of cost estimation for the USN Offshore Patrol Vessel (OPV) through use of the OPV Cost Estimation Excel dashboard that he developed for his thesis, shown in Figure 5. Lineberry's OPV Cost Dashboard was used to estimate and validate the OPC cost estimate of \$310 million per hull. This was accomplished by analyzing the following three OPC requirements: speed, personnel, and length/beam. Additionally, we discuss the impact these requirements have on the associated trade-off costs. The results provide trade-off data in terms of the percentage change of these three requirements from stated thresholds to objectives, and the associated percent cost change for each. It is hoped that this information will add value during the source selection process and provide the PM and acquisition team with valuable insight into the trade-off process.



Figure 5. Lineberry's OPV Cost Dashboard



Source: Lineberry, J. (2012). Estimating production cost while linking combat systems and ship design. Retrieved from <http://oai.dtic.mil/oai/oai/?verb=getRecord&metadataPrefix=html&identifier=ADA578487>

1. OPC Cost Analysis Validation

Lineberry stated that generally “ship weight and cost are positively correlated, and regression analyses have been used to model their relationship” (2012, p. 11). He then gathered data from 41 OPVs worldwide (including Coast Guard NSC, WMEC Famous-and Reliance-class, and Hamilton-class cutters) to use as inputs for a modeling simulation. Lineberry used data from each element of the ship work breakdown structure elements (SWBSE) from the Coast Guard 270ft WMEC, which were provided by Naval Sea Systems Command (NAVSEA) Cost Engineering and Industrial Analysis Division (SEA 05C; 2012). Table 4 shows the SWBSE categories and associated percent of weight and cost for each category.



Table 4. Ship Work Breakdown Structure Elements (SWBSE) Categories

SWBSE	Category	% Weight	% Cost
100	Hull Structure	46%	13%
200	Propulsion Plant	13%	11%
300	Electrical Plant	6%	10%
400	Command and Surveillance	4%	20%
500	Auxiliary Systems	18%	23%
600	Outfit and Furnishings	12%	12%
700	Armament	1%	0%
800	Integration/Engineering	0%	3%
900	Ship Assembly and Support Services	0%	7%

Adapted from Lineberry, J. (2012). Estimating production cost while linking combat systems and ship design. Retrieved from <http://oai.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA578487>

It is interesting to note that hull materials, propulsion, electrical, and auxiliary systems comprise 57% of the overall cost of a ship.

Lineberry focused on “ship displacement, length, beam, and crew compliment” factors to analyze the OPV (2012, p. 14). His methodology conducted regression analysis to identify multicollinearity between dependent variables of the OPV data. With 45 different OPVs, Lineberry calculated the distribution of each of the variables including length, displacement, crew, beam, speed, and helicopter complement (2012). With this distribution, he calculated the average data point in each factor and then correlated those averages to provide SWBSE percentage data from the Coast Guard WMEC.

Lineberry estimated the price per pound of the ship by incorporating the Bureau of Labor Statistics calculations on shipbuilding labor costs, average material cost per ship, and “wrap rate” for overhead and administrative costs (2012). The average cost per



pound was estimated to be \$34.64 in 2012 dollars (Lineberry, 2012). Lineberry's estimate included learning curve savings and assumed a learning curve of 95%.

Lineberry's OPV dashboard also incorporated weapons systems into the calculation estimate. The cost estimation for the weapon systems used determines how many personnel are required for the system. For the purpose of the OPC estimation, we assume that while the weapon system used in the calculation is not exact to the planned OPC weapons systems, they are representative in terms of space and personnel requirements, and will be used in the cost estimate. The direct cost of the weapon system is considered government-supplied equipment and is not included in the cost estimate.

To normalize the cost per pound data from 2012 to 2019, we used a discount rate of 7%. This assumes that the delivery of the first OPC will occur between FY 2019 and FY 2020. The estimated cost per pound for this time frame is \$55.62 per pound. The OPV Cost Estimation Dashboard was altered to reflect the change in price per pound.

Drawing information from various publicly available documents that list potential design parameters of the OPC, we assumed the following parameters from a range of all publicly available estimates:

- Length: 360 feet
- Beam: 52 feet
- Speed: 25 knots
- Personnel: 126
- Full load displacement: 3,800 tons

The above listed data was entered into the OPV Cost Estimation Dashboard and calculated the following cost estimate of each SWBSE and as well as the total estimated cost per hull, shown in Table 5 and Figure 6.

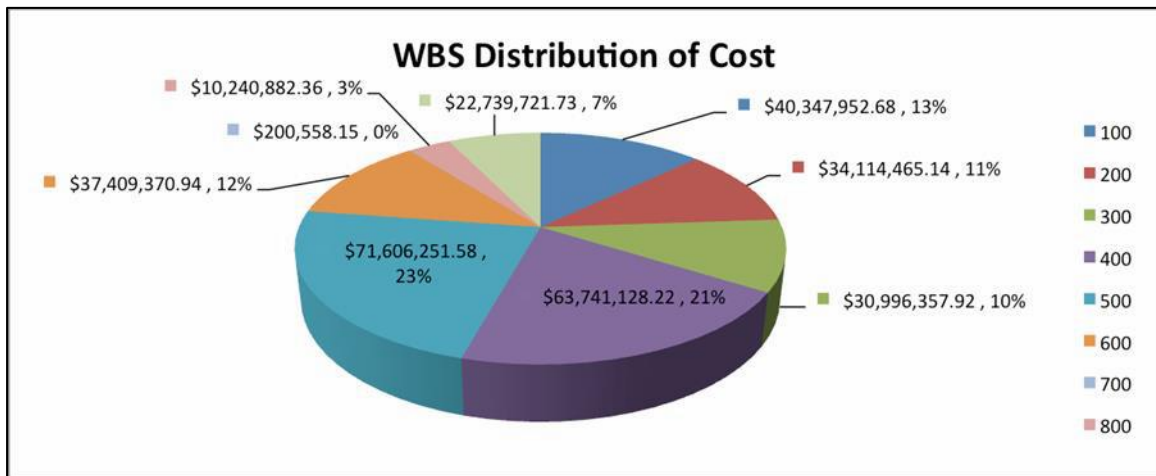


Table 5. OPC Cost Estimation Results

	avg \$/lb	% weight	weight	avg total cost	% avg cost
100	\$ 15.67	0.46	2,575,179.43	\$ 40,347,952.68	13%
200	\$ 46.88	0.13	727,768.10	\$ 34,114,465.14	11%
300	\$ 92.28	0.06	335,892.97	\$ 30,996,357.92	10%
400	\$ 284.65	0.04	223,928.65	\$ 63,741,128.22	20%
500	\$ 71.06	0.18	1,007,678.91	\$ 71,606,251.58	23%
600	\$ 55.69	0.12	671,785.94	\$ 37,409,370.94	12%
700	\$ 3.58	0.01	55,982.16	\$ 200,558.15	0%
800		0	-	\$ 10,240,882.36	3%
900		0	-	\$ 22,739,721.73	7%
(100-700)	\$ 49.73		5,598,216.16	\$ 278,416,084.63	
(100-900)	\$ 55.62		5,598,216.16	\$ 311,396,689.03	

Adapted from Lineberry, J. (2012). Estimating production cost while linking combat systems and ship design. Retrieved from <http://oai.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA578487>

Figure 6. Pie Chart Depiction of OPC WBS Cost Distribution



Adapted from Lineberry, J. (2012). Estimating production cost while linking combat systems and ship design. Retrieved from <http://oai.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA578487>

The estimated cost of a ship with similar characteristics to the OPC is \$311,396,689.03. This estimate is .45% more than the stated average cost requirement of \$310 million per hull. This estimate provided by the OPV Coast Dashboard validates the Coast Guard OPC cost requirement of \$310 million per hull given the assumptions in our model.



2. OPC Cost Trade-Off Analysis

There are many trade-offs that can occur in the OPC program. The program office will ultimately determine which requirement trade-offs will result in the best value to the Coast Guard during source selection. Given that Section M.II of the OPC request for information stated that the priority of specific requirements were speed, helicopter hangar storage, operating range, and accommodations (in that order), we used these four factors to estimate where the trade-off space may occur. Because all of these requirements together drive the naval systems engineering design and result in a length and beam for the hull, we focused on speed, personnel, and length/beam for trade-off analysis.

For our trade-off analysis, we used Lineberry's OPV cost dashboard to calculate trade-off estimates for three categories of requirements: speed, personnel, and length/beam. We used the dashboard default calculations and settings to estimate how change in speed, personnel, and length/beam relate to the relative change in cost. It is important to note, while the default calculations of the OPV dashboard are not exact to the OPC estimated design, they are representative of the cost behaviors a change in each requirement variable will produce. Additionally, because the dashboard calculates estimated cost based on five dependent variables, we chose speed (22 knots) and the number of helicopters and UAVs (two and one, respectively) as constants in the estimation of the cost calculations for personnel and length/beam. For speed, the constant was the number of Helicopters and UAVs (two and one, respectively). The weapons system variables were set to the default settings for all calculations. By selecting two of the five variables as constants, the cost estimates will result in more accurate estimate for each trade-off variable. We entered each requirement variable beginning with the threshold value for each category and included the objective value in the list of variables. Below is a summary of our findings of the analysis.

a. *Max Speed Trade-Off*

The default calculation speeds between 22 and 27 knots are listed in Figure 7. Using a default constant of 22 knots and two helicopters, an increase of three knots (12%) from 22 knots to 25 knots resulted in an increase of 14.15% in cost. Adding an additional

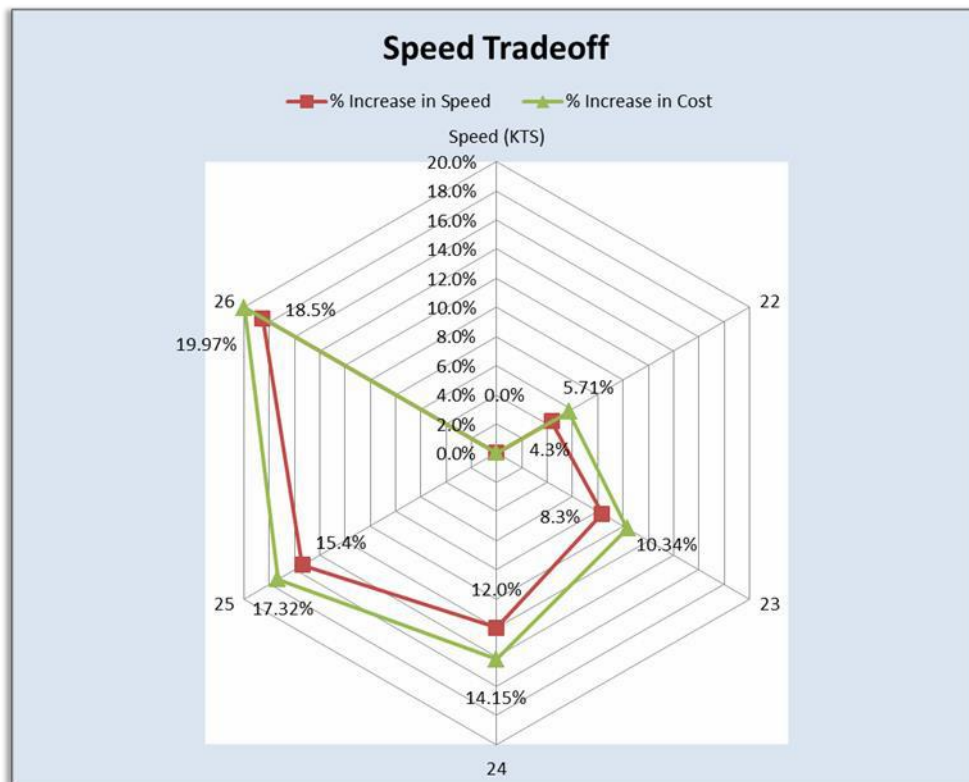


2 knots to 27 knot speed capability resulted in a 19.97% increase from the threshold value. Because speed is one of the main drivers in length and beam design, this trade-off is a significant cost driver. Table 6 and Figure 7 show the results of the max speed trade-off analysis.

Table 6. Max Speed Trade-Off Analysis

Max Speed Based Tradeoff Based on 22 kts					
Speed (KTS)	% Increase in Speed	Cost	Difference	% Increase in Cost	
22	0.0%	\$ 191,395,717.75	\$ -	0.00%	
23	4.3%	\$ 202,980,737.69	\$ 11,585,019.94	5.71%	
24	8.3%	\$ 213,467,021.28	\$ 22,071,303.53	10.34%	
25	12.0%	\$ 222,944,087.88	\$ 31,548,370.13	14.15%	
26	15.4%	\$ 231,484,316.00	\$ 40,088,598.25	17.32%	
27	18.5%	\$ 239,146,864.95	\$ 47,751,147.20	19.97%	

Figure 7. Max Speed Trade-Off Spider Chart



b. Personnel Trade-Off

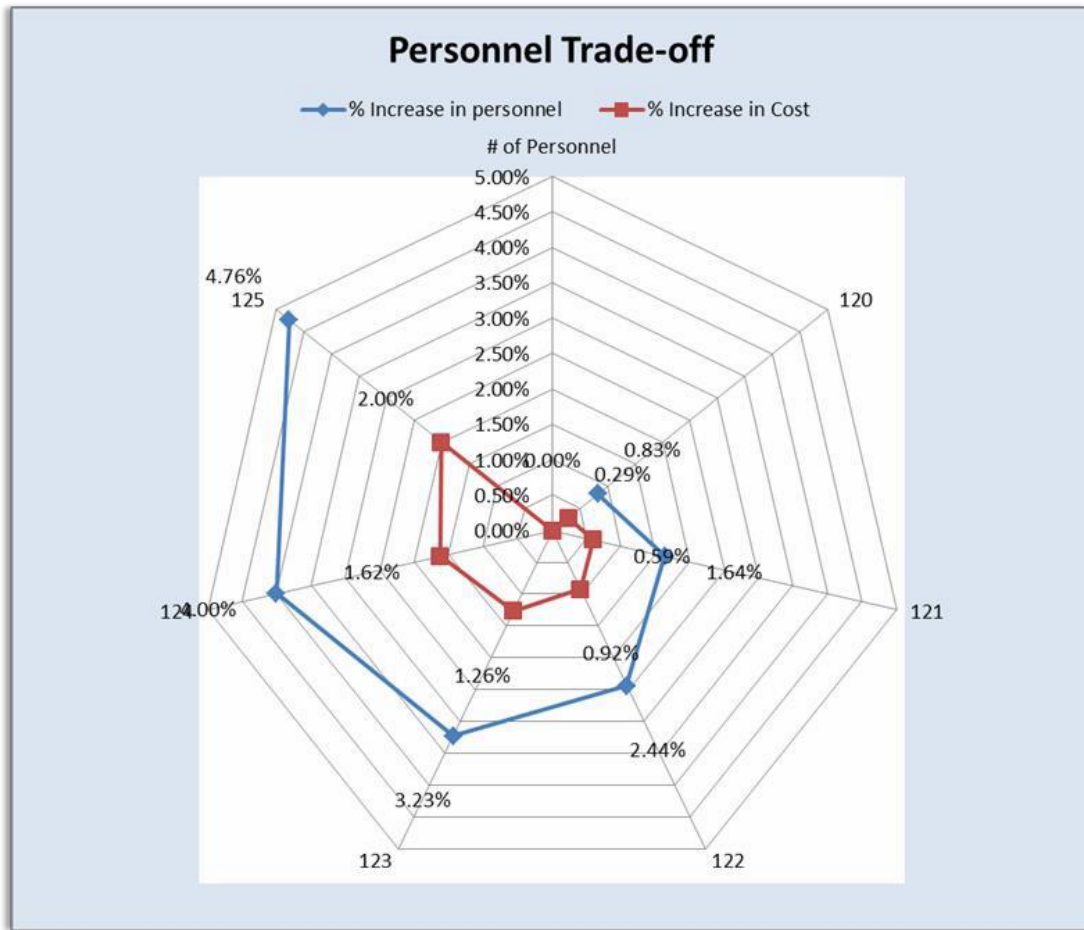
The default calculation personnel numbers between 120 and 126 are listed below in Table 7 and Figure 8. Using a default constant of 22 knots and two helicopters, an increase of six people (4.76%) from 120 to 126 resulted in an increase of just 2.0% in cost. The small increase in cost is related to the space footprint required to berth and support the additional personnel. This trade-off has the smallest impact on overall cost.

Table 7. Personnel Trade-Off

Personnel Tradeoff of 120				
# of Personnel	% Increase in personnel	Cost	Difference	% Increase in Cost
120		\$ 183,386,100.45	0	0.00%
121	0.83%	\$ 183,915,710.90	\$ 529,610.45	0.29%
122	1.64%	\$ 184,481,907.08	\$ 1,095,806.63	0.59%
123	2.44%	\$ 185,085,770.78	\$ 1,699,670.32	0.92%
124	3.23%	\$ 185,728,364.50	\$ 2,342,264.05	1.26%
125	4.00%	\$ 186,410,730.49	\$ 3,024,630.03	1.62%
126	4.76%	\$ 187,133,889.73	\$ 3,747,789.28	2.00%



Figure 8. Personnel Trade-Off Spider Chart



c. Length/Beam Trade-Off

One of the largest drivers in ship hull cost is length and beam. A number of factors determine length and beam of the ship. Requirements like speed, endurance, helicopter complement, propulsion, operability, seakeeping, and electrical systems, and personnel drive the design. The total expected weight displacement of all of the requirements put together determine how long and wide the ship will be. Using a baseline speed of 22 knots, the cost dashboard estimated the ship length and beam to be 320 feet and 45 feet, respectively. Using this as a starting point for the cost estimation, our calculations interpolated length and beam measurements to 370 feet and 53.8 feet, respectively. Because there is no threshold or objective length and beam, we included an estimated design length (360 feet) and beam (52 feet) as our anchor point for the interpolation calculation down to 320 feet and 45 feet.

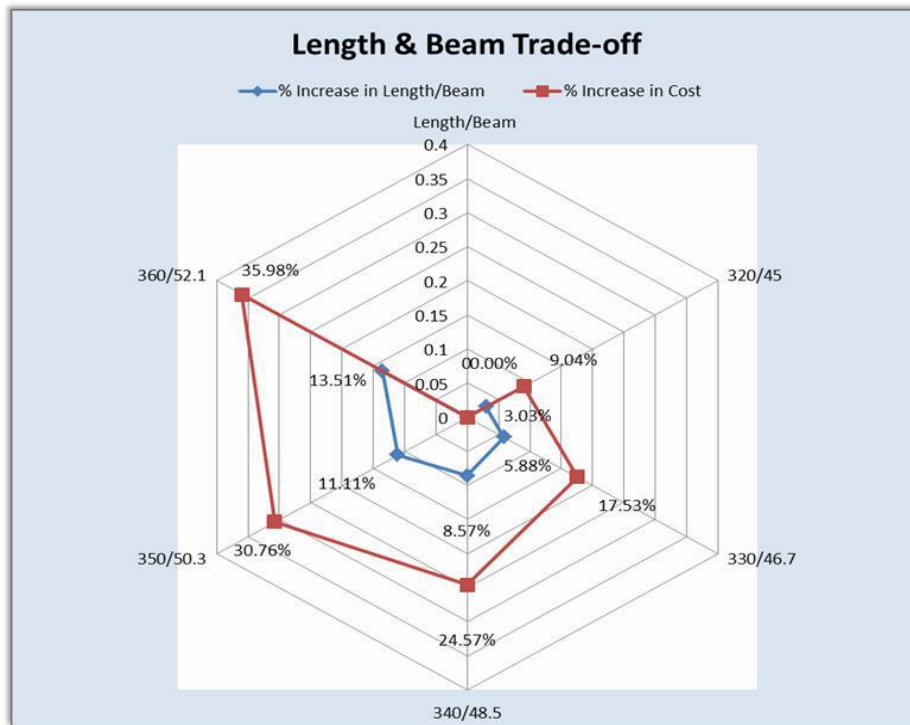


The calculation for an increase in length and beam are listed below in Table 8 and Figure 9. An 11.11% increase from 320 feet (length) and 45 feet (beam) to the estimated design of 360 feet (length and 52 feet (beam) resulted in a 30.76% increase in overall cost of the hull.

Table 8. Length/Beam Trade-Off

Length/Beam Tradeoff					
Length/Beam	% Increase in Length/Beam	Cost	Difference	% Increase in Cost	
320/45	0	\$ 216,623,677.46	0	0.00%	
330/46.7	3.03%	\$ 238,160,922.13	\$ 21,537,244.67	9.04%	
340/48.5	5.88%	\$ 262,676,615.62	\$ 46,052,938.16	17.53%	
350/50.3	8.57%	\$ 287,183,993.11	\$ 70,560,315.65	24.57%	
360/52.1	11.11%	\$ 312,867,140.94	\$ 96,243,463.49	30.76%	
370/53.8	13.51%	\$ 338,367,145.15	\$ 121,743,467.69	35.98%	

Figure 9. Length and Beam Trade-Off Spider Chart



3. OPC Cost Analysis Validation and Trade-Off Analysis Conclusion

This section conducted a validation of the \$310 million OPC cost requirement by using Lineberry's (2012) OPV Cost Dashboard. We found that given the stated



requirements for the OPC, the Coast Guard \$310 million cost requirement per hull for the OPC is an accurate cost estimate. While there are many variables in ship cost estimation and no one ship design will yield the same costs as another, Lineberry's (2012) work provides an accurate statistical framework to support his cost estimation calculations.

Additionally, this section conducted a trade-off analysis for three design areas of the OPC. Although there are many trade-off areas in shipbuilding that have a direct effect on the cost structure, the most critical cost drivers are those that will drive the design on the ship's length and beam. Hull materials, propulsion, electrical, and auxiliary systems comprise 57% of the overall cost of a ship and ultimately will determine the size of the ship based on the associated requirements. Understanding the cost drivers will assist PMs and the acquisition team in determining trade-off space during the source selection process.



V. CONCLUSIONS AND RECOMMENDATIONS

Our research focused on procurement lessons learned and the opportunities that the Coast Guard could leverage from these lessons in its upcoming acquisition of the OPC to maintain the program's affordability requirement of \$310 million per hull. Our research focused on procurement lessons including management reforms, best practices in competition, contract structure, multi-year procurement, requirements generation, and test and evaluation that may be applied to the OPC acquisition strategy to achieve the requirement of affordability. We employed a cost estimation model developed by Jeffrey Lineberry to validate the Coast Guard's OPC cost requirement of \$310 million per hull using notional design data. We further used this model to illustrate the impact that varying specific design characteristics (speed, personnel, and length/beam) has on ship production cost. Finally, we present a trade-off analysis that program managers may use in the source selection process.

The management reforms that the Coast Guard implemented in April 2007 in response to criticism that it failed to exercise technical oversight and lacked the in-house staff and expertise to oversee and manage large acquisition programs has yielded many positive results. The new Acquisition Directorate now serves as the system integrator for all Coast Guard major systems acquisitions and is well poised to perform this role for the OPC acquisition.

Incorporating competition throughout the life cycle of the acquisition is critical in achieving affordability. The NSC and FRC programs began within ICGS and did not benefit from having competition during the design phase. The OPC acquisition has already learned this lesson and has created a two-phase strategy. During the first phase, the Coast Guard awarded design contracts to three firms who will compete to be selected as the firm who will construct the lead ship and eight to 10 follow-on ships. The Coast Guard also included the purchase of the RDLP/TDP in phase 1 of the FRC and OPC, so that it could return to full and open competition to award phase 2 of the programs to any firm in the industry that could win the award with a lower bid. The use of competition throughout the process and the procurement of the RDLP/TDP demonstrate significant



progress in maintaining affordable procurement programs. We recommend that competition and the purchase of the RDLP/TDP continue to be used in future recapitalization efforts.

The transition in contract type from the NSC's initial cost-plus incentive contract to the FPI/EPA contracts used on FRC and OPC is a significant step in linking the shipbuilder's fee to their actual cost performance. This strategy provides real incentives for the shipbuilder to not have cost overruns, defines a share line between the government and contractor if there is an overrun, and is overall very effective at promoting innovation and keeping construction costs down. We understand that FPI contracts are currently favored by the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics and notwithstanding, assert that they have been crucial to keeping Coast Guard acquisitions affordable and should be used in future recapitalization efforts to incentivize the contractor and predetermine how cost overruns will be shared with the government.

Block buy contracting (BBC)—with the ability to use economic order quantity (EOQ) and the eventual use of multi-year procurement (MYP) once a stable design is demonstrated—could offer significant savings to current and future acquisition programs. The Navy has used BBC for the SSN Virginia-class submarine and LCS, and we recommend that further studies examine what cost savings have been realized as a result of using these approaches on these programs. Once a stable design is demonstrated for the OPC, we recommend that the Coast Guard explore the use of MYP to further achieve affordability on the OPC program.

Specific requirements, the use of mature technology, and an understanding of the design drivers enable the systems engineering process to maintain program affordability by ultimately keeping the LCC down. Structural design flaws, challenges operating in warmer climates, and the need to replace the C4ISR system on the NSC are examples of redesigns that were necessary after construction and became a cause of significant cost growth. The initial FRC design under ICGS had a composite hull weight and propulsion plant capacity that did not meet mission needs, and when the program was moved to CG-9, it was discovered that the requirements generation team lacked the technical and naval engineering understanding to develop obtainable endurance requirements. The OPC



program has already executed trade-offs in the requirements generation phase by removing the stern launch capability requirement from the original design. This trade-off reduced the cost and risk associated with an immature technology in favor of a mature side launch capability and is an excellent example of identifying trade-offs during requirements generation that will reduce the LCC and maintain program affordability. As the Coast Guard receives the P&CD proposals and begins the evaluation process, we recommend that technical improvements in requirement areas that increase the affordability of the design be considered as trade-offs in order to maintain a lower LCC.

Conducting operational test and evaluation early in the acquisition process allows any design changes necessary to meet mission requirements to be discovered and corrected prior to full rate production. Tests on the NSC and FRC revealed that \$140 million and \$6.9 million, respectively, in design changes were necessary for these platforms to meet their requirements. If discovered early enough in the acquisition program, retrofits and design changes that add to the program's cost can be avoided. We recommend that the Coast Guard fully test the OPC to ensure it meets all key requirements prior to commencing full rate production in order to maintain an overall affordable program.

The cost estimation model developed by Lineberry (2012) was used to validate the cost requirement of \$310 million per hull by analyzing the requirements of speed, personnel, and length/beam. We normalized the price per pound of Lineberry's model from 2012 to 2019 using a discount rate of 7% and used the model's assumption of a 95% learning curve. We assumed that the weapons system in Lineberry's model are representative of the OPC's weapons system and used the model's cost in our estimate. Our calculation yielded that a ship with similar characteristics to the OPC would cost \$311,396,689 and therefore validates the Coast Guard's cost estimation of each OPC hull. We recommend that PMs considering design trade-offs use a similar model to estimate how variations in speed, personnel, and length/beam will affect the cost of the proposed design.

The Lineberry (2012) model was also used to perform a trade-off analysis to estimate how variations in speed, personnel, and length/beam would affect the overall cost



of the design. Our calculations indicate that adding one knot of speed to the design approximately increases the cost by 3.6%, adding one additional personnel to the design approximately increases the cost by 0.34%, and increasing the length/beam of the design by 1% approximately increases the cost by 2.7%. We illustrated how changes in speed and length/beam have significant impacts to the overall cost of the hull and recommend that the Coast Guard perform a similar trade-off analysis during P&CD proposal evaluation to validate how the different design characteristics are affecting the overall cost.

Our research was extremely valuable in informing our thought processes on how to maintain affordability and technical oversight when managing a major acquisition program such as the OPC. Much of the information we provided is already old news to the acquisition leadership that leads today's acquisition workforce and has already boldly advanced the Coast Guard halfway through its major acquisition program of record. We do not claim to have made any insights that have not already been diligently incorporated into the acquisition process. Rather, we hope that our experience in conducting this research and our distinct privilege in participating in studies at the Naval Postgraduate School serve to reassure stakeholders that there is more to a successful acquisition than can be conveyed in this report. A successful acquisition should incorporate all of the components of a comprehensive acquisition plan with input from all stakeholders, early industry engagement, rigorous use of the systems engineering process, competition throughout, appropriate contract structure, stable requirements, early operational testing, and much more. The integration of all of these facets is a challenging job that demands a program manager who grows his team, leverages strategic partnerships and tirelessly champions their program and the capability it will bring to the user. In our opinion, the Coast Guard is doing all of this and more on the OPC acquisition, and we believe it will succeed in achieving program affordability and providing a much needed capability to the nation and the next generation of Cuttermen. Finally, we hope that our conclusions and recommendations provide academic support to inform future decisions made during recapitalization efforts.



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