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MANPOWER IN THE DEVELOPMENT OF THE COAST GUARD NATIONAL SECURITY CUTTER: A HUMAN SYSTEMS INTEGRATION CASE STUDY

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THESIS

MANPOWER IN THE DEVELOPMENT OF THE COAST GUARD NATIONAL SECURITY CUTTER: A HUMAN SYSTEMS INTEGRATION CASE STUDY

by

Jesse C. Keyser

December 2022

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The National Security Cutter (NSC) is the U.S. Coast Guard's (USCG) largest acquisition program to date. Despite the NSC's significance, its acquisition (2002–present) has suffered numerous performance and cost-related setbacks ostensibly linked to Human System Integration (HSI) issues. In this thesis, we provide a historical HSI case study of the NSC program focusing on manpower, highlighting critical gaps in early concept analyses. While current USCG policy provides definitive guidance on HSI's inclusion in acquisition programs, little evidence exists linking HSI-related decisions to specific system performance and life-cycle cost outcomes. We use process tracing to systematically establish linkages between USCG HSI policy, NSC program decisions, and specific system performance and life-cycle cost outcomes, illustrating the importance of HSI's inclusion early in the acquisition life cycle. We produce a template for analyzing HSI decisions and outcomes in large-scale acquisition programs and provide a model for future systems engineering case studies. Our research will guide future program managers and HSI researchers in program management planning endeavors. Finally, our recommendations include the reinforcement of early and iterative HSI tradeoff considerations, organization and program-level integration of HSI in major program integrated product teams, strict adherence to USCG policy-defined HSI-related activities, and purposeful HSI case study taxonomy.

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ABSTRACT

The National Security Cutter (NSC) is the U.S. Coast Guard's (USCG) largest acquisition program to date. Despite the NSC's significance, its acquisition (2002–present) has suffered numerous performance and cost-related setbacks ostensibly linked to Human System Integration (HSI) issues. In this thesis, we provide a historical HSI case study of the NSC program focusing on manpower, highlighting critical gaps in early concept analyses. While current USCG policy provides definitive guidance on HSI's inclusion in acquisition programs, little evidence exists linking HSI-related decisions to specific system performance and life-cycle cost outcomes. We use process tracing to systematically establish linkages between USCG HSI policy, NSC program decisions, and specific system performance and life-cycle cost outcomes, illustrating the importance of HSI's inclusion early in the acquisition life cycle. We produce a template for analyzing HSI decisions and outcomes in large-scale acquisition programs and provide a model for future systems engineering case studies. Our research will guide future program managers and HSI researchers in program management planning endeavors. Finally, our recommendations include the reinforcement of early and iterative HSI tradeoff considerations, organization and program-level integration of HSI in major program integrated product teams, strict adherence to USCG policy-defined HSI-related activities, and purposeful HSI case study taxonomy.

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LIST OF ACRONYMS AND ABBREVIATIONS

AASP	Alternative Analysis Study Plan
ADA	Acquisition Decision Authority
ADE	Acquisition Decision Event
ADM	Acquisition Decision Memorandum
AP	Acquisition Plan
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CG-1B3	Coast Guard Human Systems Integration Program
CG-82	Coast Guard Budget and Programs
CG-9	Coast Guard Acquisitions Directorate
CG-9283	Coast Guard Acquisition Resource Management, Business Management, and Metrics
CPD	Capabilities Production Document
DHS	Department of Homeland Security
DOD	Department of Defense
GAO	Government Accountability Office
HEC	High Endurance Cutter
HSI	Human Systems Integration
HSIMP	Human Systems Integration Management Plan
HSIP	Human Systems Integration Plan
ICGS	Integrated Coast Guard System
IDS	Integrated Deepwater System
ILSP	Integrated Logistics Support Plan
INCOSE	International Council for Systems Engineering
LSI	Lead Systems Integrator
MEP	Manpower Estimate Report
MNS	Mission Needs Statement
MRA	Manpower Requirements Analysis
MRD	Manpower Requirements Decision
NSC	National Security Cutter

OA	Operational Assessment
ORD	Operational Requirements Document
PDA	Post-Delivery Activities
SELC	Systems Engineering Life cycle Plan
SES	Senior Executive Service
SOS	System-of-Systems
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
USCG	United States Coast Guard

EXECUTIVE SUMMARY

In the mid-1990s, the U.S. Coast Guard (USCG) experienced critical capability and availability gaps in asset and workforce infrastructures (U.S. Coast Guard, 1996). The USCG's aging fleet and updated National Defense requirements led to the Integrated Deepwater System (IDS) initiative. The large-scale, system-of-systems (SOS) acquisition resulted in the USCG's decision to outsource IDS asset production contracts to the Integrated Coast Guard System (ICGS), an external lead system integration (LSI) team fielded by Lockheed Martin and Northrop Grumman. This decision later proved controversial, as the service fell under extreme scrutiny by Congress, the Government Accountability Office (GAO), and the DHS Inspector General's Office for failing to exercise IDS technical and financial oversight (Skinner, 2009). Consequently, the USCG reformed its acquisition management processes in 2007 into the centralized CG Acquisition Directorate, CG-9 (Philpott & Weber, 2015).

The National Security Cutter (NSC) is a large part of the IDS SOS acquisition. Although we recognized Human Systems Integration (HSI) collaboration in some early NSC program documents, formal policy and authority guidance in acquisitions were unclear (Wright & Hall, 1994). Wright and Hall (1994) proposed an HSI management system and recommended establishing an office responsible for the HSI program (OHSIP). As a result, the USCG established the Office of Human Systems Integration (CG-1B3) in 2000, responsible for planning and executing all facets of the various HSI domains throughout every acquisition phase (Kudrick et al., 2019). Unfortunately, NSC design and production began before CG-1B3 fully integrated with the NSC program. As a result, the NSC program underestimated the HSI domain of manpower by inaccurately assigning too few crewmembers to carry out its assigned missions, thereby resulting in significant unplanned life cycle costs.

The NSC offers a unique case study opportunity to highlight HSI's impact on major acquisition programs. Our research focuses on the manpower HSI domain and utilizes process tracing to investigate linkages between USCG HSI policy, NSC program decisions, and specific system performance and life cycle cost outcomes. In the first part of the study, we analyze historical manpower-related NSC documents, identifying critical manpower-related decisions since the program's inception in 1996. Next, we present relevant documents that we transcribed and coded to visibly trace manpower-related documents to decision points. Finally, we represent the coded data on an NSC Manpower Life Cycle Wall Chart, comparing major system acquisition HSI best practices to actual NSC manpower-related events and program decisions.

Our results identified 18 manpower-related artifacts that led to manpower-related decisions, including three documented before the USCG's acquisition reform in 2007. With minimal USCG input, the contracted LSI, ICGS, drove those first three artifacts and the initial manpower estimate of 108 crewmembers for the NSC. The remaining 15 documents demonstrate a greater commitment to HSI with CG-1B3 input and directed a 16% increase in manpower over five years. Unfortunately, the updated manpower requirements were officially signed after three NSCs were produced and delivered, resulting in significant unplanned manpower, engineering, and logistical expenses.

The NSC program is and continues to be a complex system of systems within itself. The ship's operators, maintainers, and support personnel are as critical of an onboard system as any (e.g., fire control system, IS, etc.). Therefore, the program's success depends on appropriate requirements management, HSI-activity planning, and the continuous validation of meeting those requirements and needs of the users in an ever-changing socio-technical environment. The USCG has taken great strides in acquisition management strategies, including deliberate, early, and iterative CG-1B3 engagement. Clear evidence of improved processes and key policy show that HSI consideration is a priority for program managers and leadership. Our research reinforces that successful system acquisition requires HSI foresight provided by HSI domain leaders and practitioners in the field of study.

The resilience and adaptability of Coast Guard men and women often obscure poor HSI-related tradeoff decisions during the early phases of major system acquisitions. Conversely, even if a program adequately plans and integrates HSI-related activities, there is rarely direct evidence of its added value as the fruits of consideration tend not to be seen. In both cases, program leadership is left to trust the HSI process under both circumstances.

That phenomenon makes a dedicated HSI case study so valuable and why our research is warranted. Our recommendations include the reinforcement of early and iterative HSI tradeoff considerations, organization and program-level integration of HSI in major program integrated product teams, strict adherence to MSAM-defined HSI-related activities, and purposeful HSI case study taxonomy.

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I. INTRODUCTION

In the mid-1990s, the U.S. Coast Guard (USCG) experienced critical capability and availability gaps in asset and workforce infrastructures (U.S. Coast Guard, 1996). The USCG's aging fleet and updated National Defense requirements led to the initiation of the National Security Cutter (NSC) program in the early 2000s. Built to replace the legacy High Endurance Cutters (HECs), the NSC's unique design aimed to improve system capabilities, including improved "speed, endurance, sensors and aviation/small boat interdiction capabilities that are key to success in the transit zones off the coast of South America and in the Pacific, allowing the Coast Guard to focus on the departure and choke points which offer the best probability of detection and seizure" (Office of Cutter Forces, 2013, p. 5).

The USCG's acquisition program of record (2004) called for the procurement of eight NSCs, estimating an average of $670 million per ship (O'Rourke, 2012). In FY2018, Congress funded an additional three NSCs, bringing the planned total NSC acquisition to eleven (Frank Lobiondo Coast Guard Authorization Act of 2018, Pub. L. No. 115–282, 132 Stat. 4192, 2018). Nearing final program sustainment, the USCG's FY2022 budget overview includes $78 million for Post Delivery Activities (PDA) for the tenth and eleventh NSCs, program management, test and evaluation, program execution and support, and program close-out (U.S. Coast Guard Budget and Programs [CG-82], 2022). There are currently nine NSCs in service and two in construction, with expected delivery from Huntington Ingalls Industries Inc. in the next two to three years (Assistant Commandant for Acquisitions [CG-9], 2022).

Congressional Research Service (CRS) analyses continue to show increasing acquisition cost baselines as each subsequent NSC reaches operational service. CRS believes that lacking human-centered design considerations in the early acquisition phases results in unplanned life cycle costs and performance gaps (O'Rourke, 2012). Of note, poor USCG program oversight left government leadership wondering if the ships could sustain their entire 30-year intended service lives and if the Integrated Deepwater System (IDS) program budget included room for cost growth during subsequent builds (O'Rourke, 2012). Chapter II describes the IDS in more detail. During operational testing in 2010 and 2011 of the first and second NSC, the USCG identified six critical issues leading to required design changes. Figure 1 shows the resultant retrofit costs, which according to the Government Accountability Office (2011), were

> - reliability and maintenance problems with the crane on the back of the cutter,
> - an unsafe ammunition hoist for the main gun,
> - instability with the side davit for small boat launch,
> - insufficient power to a key system used for docking the cutter, and
> - an impractical requirement for using the side rescue door in difficult sea conditions…
>
> failure to reduce the number of people needed to secure the helicopter as the [Aircraft Ship Integrated Secure and Traverse] system was designed to do. (Government Accountability Office [GAO], 2011, pp. 23–24)

Figure 1. NSC Retrofits and Design Changes. Source: GAO (2016, p. 16).

Retrofits and design changes	**Estimated Cost (in millions)**
C4ISR upgrade	$88.5
Structural enhancements (National Security Cutters 1 and 2)	$38
Gantry crane that aids in launching cutter boats from stern ramp	$31
Single-point davit for cutter boat operations	$12.5
Upgrade communications system	$12.3
Update cutter monitoring system	$6.3
Upgrade two ammunition hoists	$6.3
Remove Aircraft Ship Integrated Secure and Traverse tracks in flight deck	$5.6
Breathing apparatus replacement	$1.6
Total cost	**$202.1**

Human Systems Integration (HSI) emphasizes the integration of humans and technology to optimize system performance and minimize cost across system life cycles (Naval Postgraduate School, 2022). According to the International Council for Systems Engineering (INCOSE), HSI is "the interdisciplinary technical management processes for integrating human considerations within and across all system elements" (Walden et al., 2015, p. 237). Additionally, Harold R. Booher, the author of *Handbook of Human Systems Integration* and the first Senior Executive (SES) Director of the Department of the U.S.

Army's HSI program, believes that focusing on the human element during system design (i.e., HSI) can lead to "dramatic reductions in waste and victims on the debit side of society's ledger and dramatic increases in system performance and productivity on the credit side" (Booher, 2003, p. 2). Unfortunately, a Government Accountability Office (GAO) report (2011) revealed programmatic risks to the NSC program included a significant lack of HSI considerations. Considering humans' diverse roles in the success of systems – supervision, operation, control, monitoring, maintenance, troubleshooting, etc. – and system usability requirements, integrating human considerations is essential throughout any system's acquisition life cycle. The NSC program was no exception.

In addition to sub-optimal performance and unplanned costs, the NSC manpower requirements have significantly changed since program inception. Booher (1990) defines the HSI manpower domain as "the number of human resources, both men and women, military and civilian, required and available to operate, maintain, and support military systems" (p. 4). A 2011 Manpower Requirements Analysis (MRA) of the NSC revealed that only 47% of NSC crewmembers were at optimal workload capacity while underway and only 16% while in port (Office of Human Systems Integration [CG-1B3], 2011). Workload capacity is defined by workload demand measured against crew size. Furthermore, the workload capacity was exceeded by 34% and 84%, respectively. The MRA (2011) recommended a crew size increase to 126 from the initial 108 defined by the NSC Capabilities Production Document (2006). The life cycle cost estimate (Figure 2) breaks down the 2012 individual cost estimates per rate (Acquisition Resource Management, Business Management, and Metrics, 2012). An additional 18 crewmembers would add substantial costs to the initial cost estimation.

Figure 2. AFC 1 and 20 Costs Per Cutter Per Year. Source: Office of Acquisition Resource Management, Business Management, and Metrics, (2012, p. 45).

Personnel	Grade	Quantity	AFC-01		AFC-20		Total
			Rate	Total	Rate	Total	
CAPT	O6	1	$165,901	$165,901	$8,698	$8,698	**$174,599**
CDR	O5	1	$142,225	$142,225	$8,401	$8,401	**$150,626**
LCDR	O4	2	$124,239	$248,478	$7,678	$15,357	**$263,835**
LT	O3	1	$104,445	$104,445	$6,893	$6,893	**$111,338**
LTJG	O2	3	$80,198	$240,594	$4,488	$13,463	**$254,057**
ENS, ENG4, ELC4, F&S4, BOSN4	O1	9	$62,885	$565,968	$3,143	$28,286	**$594,254**
E8	E8	3	$97,087	$291,261	$6,624	$19,873	**$311,134**
E7	E7	10	$84,663	$846,632	$5,981	$59,813	**$906,445**
E6	E6	17	$71,943	$1,223,023	$5,356	$91,057	**$1,314,080**
E5	E5	25	$60,931	$1,523,283	$4,228	$105,698	**$1,628,981**
E4	E4	33	$49,902	$1,646,764	$3,389	$111,828	**$1,758,591**
SN	E3	12	$37,697	$452,358	$2,149	$25,790	**$478,148**
FN	E2	6	$34,568	$207,407	$1,681	$10,085	**$217,491**
Total		***123***		***$ 7,658,338***		***$ 505,242***	***$ 8,163,580***

HSI is a relatively new concept in the USCG compared to other services. As an HSI case study, the NSC program represents a valuable opportunity to analyze how HSI considerations could save on life cycle optimization. The NSC program's conceptual design, beginning with the Deepwater Mission Needs Statement from 1996, straddles the USCG's HSI program established in the early 2000s (U.S. Coast Guard, 1996). The current USCG acquisition policy specifies required HSI-related activities throughout the acquisition life cycle (U.S. Coast Guard, 2021). However, despite being in the late stages of production, the NSC pre-dates the HSI requirements now inherent in the current policies, providing a natural basis for comparing current and previous acquisition practices that may have led to the program's unplanned costs.

A. RESEARCH QUESTIONS

Our research aims to answer four questions:

1. What manpower-related decisions occurred during the NSC program?
2. When did NSC staffing levels change during the NSC program?
3. Did manpower-related events, analyses, and decisions during the NSC program align with current HSI best practices?

4. Can linkages be drawn between manpower-related decisions and NSC program cost, schedule, and performance deficiencies?

B. HYPOTHESIS

Manpower-related decisions were not aligned with HSI best practices, contributing to NSC program cost, schedule, and performance deficiencies.

C. METHODOLOGY

While current USCG policy provides definitive guidance on HSI's inclusion in acquisition programs, little evidence exists linking HSI-related decisions to specific system performance and life cycle cost outcomes. We will use process tracing to systematically identify possible linkages between USCG HSI policy, NSC program decisions, and manpower-related performance and life cycle cost outcomes, illustrating the importance of HSI's inclusion early in the acquisition life cycle. Data collection includes archived NSC program records, acquisition documents, and HSI-related best practices from USCG acquisition policy and various agencies' HSI program guidance. If successful, we will produce a template for analyzing HSI decisions and outcomes in large-scale acquisition programs and provide a model for future HSI case studies.

D. SCOPE AND LIMITATIONS OF THE ANALYSIS

Our research focuses on the manpower HSI domain, defined by the crew size required to operate, maintain, and support the NSC during an operational readiness posture. The analysis does not attempt to blame or make hindsight conclusions regarding the adequacy of HSI-related decisions; we assume diligence on behalf of decision-makers given information at the time. Instead, the analysis serves as an example of how HSI considerations can positively impact current and future program acquisitions based on lessons learned from the NSC procurement program.

The systematic process tracing of USCG acquisition evolution and HSI-related decisions is limited by the availability of archived evidence and access to program representatives. Furthermore, many published documents have historic versions removed from any database and replaced by updated versions. In the absence of information regarding document evolution, we use deductive inference to present logical conclusions.

E. ORGANIZATION OF THESIS

Our research is organized into six chapters. Chapter I provides a brief background of the NSC program and introduces HSI's role in system performance and life cycle costs, specifically regarding the NSC's manpower requirements changes. Chapter II provides an in-depth evolutionary analysis of USCG acquisitions, a thorough background of HSI and the manpower domain, cognitive engineering and tracing, and case study methodologies. Chapter III describes the case study and process tracing methods used to collect, transcribe, code, and represent the data. Chapter IV provides the collected data results. Chapter V discusses our findings and inferences related to our research questions with a historical timeline depicting the NSC program with acquisition and HSI evolution overlay. Chapter VI summarizes the analysis, conclusions, recommendations for future work, and HSI case study research suggestions.

F. CHAPTER SUMMARY

In Chapter I, we presented some background on the NSC program and why the NSC provides a unique case study opportunity to highlight HSI's impact on major acquisition programs. The goal of HSI is total system optimization, including system cost, schedule, and performance, through the consideration and integration of human-centered design and technology. We aim to contribute to the success of current and future acquisition programs and HSI-related case study endeavors by producing a systematic process tracing of HSI-related decisions during the NSC acquisition linked to NSC manpower requirements changes. Highlighting the connection between HSI and system optimization will influence future major programs and ultimately save the USCG from future unplanned costs and sub-optimal system performance.

II. BACKGROUND

Although HSI collaboration was recognized in some early NSC program documents, formal policy and authority guidance in acquisitions were unclear (Wright & Hall, 1994). Wright and Hall (1994) proposed an HSI management system and recommended establishing an office responsible for the HSI program (OHSIP). As a result, the USCG established the Office of Human Systems Integration (CG-1B3) in 2000, responsible for planning and executing all facets of the various HSI domains throughout every acquisition phase (Kudrick et al., 2019). The following sections will describe the progression of USCG acquisitions, produce a brief history of HSI in the military, and discuss how qualitative data and case study research can improve programmatic decision-making.

A. COAST GUARD ACQUISITIONS

1. An Integrated Total-System Approach

William Hockberger, a naval architect with the Naval Sea Systems Command, published an article in the *Naval Engineers Journal* (1996) describing a "total-system approach" for optimizing a system of systems greater than the ship (Hockberger, 1996). Hockberger referred to his large system approach as a "supersystem." The supersystem concept focuses on integrated requirements of the entire system, requiring an open and unconstrained search for ways of accomplishing the mission.

The USCG established the IDS program in 1996 using the Hockberger-style total-system approach, viewing the NSC as a single asset contributing to IDS mission performance (Roden & Henke, 2002). The operational goals of the Deepwater program were to support the USCG's federally mandated missions with a recapitalization of the USCG's operational fleet and integration of C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) capabilities among Deepwater assets for a more efficient command and control structure (U.S. Coast Guard, 2017a). The initial acquisition strategy objectives were to improve operational effectiveness and reduce total ownership costs. However, rather than replacing assets through individual acquisition programs, the USCG elected an integrated, system-of-systems (SOS) acquisition approach (O'Rourke, 2012). In theory, compared to a single asset recapitalization, the opportunities for cross-asset integration should improve interoperability and save on total costs (Roden & Henke, 2002). Furthermore, the USCG realized the scope and complexity of an SOS approach and decided to use a private-sector lead systems integrator (LSI) to lead the IDS asset acquisition process known as the Integrated Coast Guard System (ICGS), fielded by Lockheed Martin and Northrop Grumman. The performance-based acquisition permitted the LSI significant latitude in determining how the various elements of the IDS would meet the original high-level requirements supplied by USCG leadership (O'Rourke, 2012).

Following 11 September 2001, new capability gaps for the USCG emerged, with a fixed focus on homeland security (U.S. Coast Guard, 2005). No longer would the service be predominantly reactive or response-based, but it needed to take a more proactive role in National Defense operations. Therefore, major system acquisition strategies changed, resulting in adjustments to initial IDS performance requirements, increasing costs, and delayed schedules (U.S. Coast Guard, 2017a). Additionally, the USCG underwent significant criticisms from Congress, the Government Accountability Office (GAO), and the DHS Inspector General's Office for failing to exercise IDS technical oversight (Skinner, 2009). These discrepancies and criticisms led to the demise of the LSI strategy, the introduction of a new acquisition management reform in 2007, and the modernization of USCG governance in IDS program oversight.

2. USCG Acquisition Program Reform

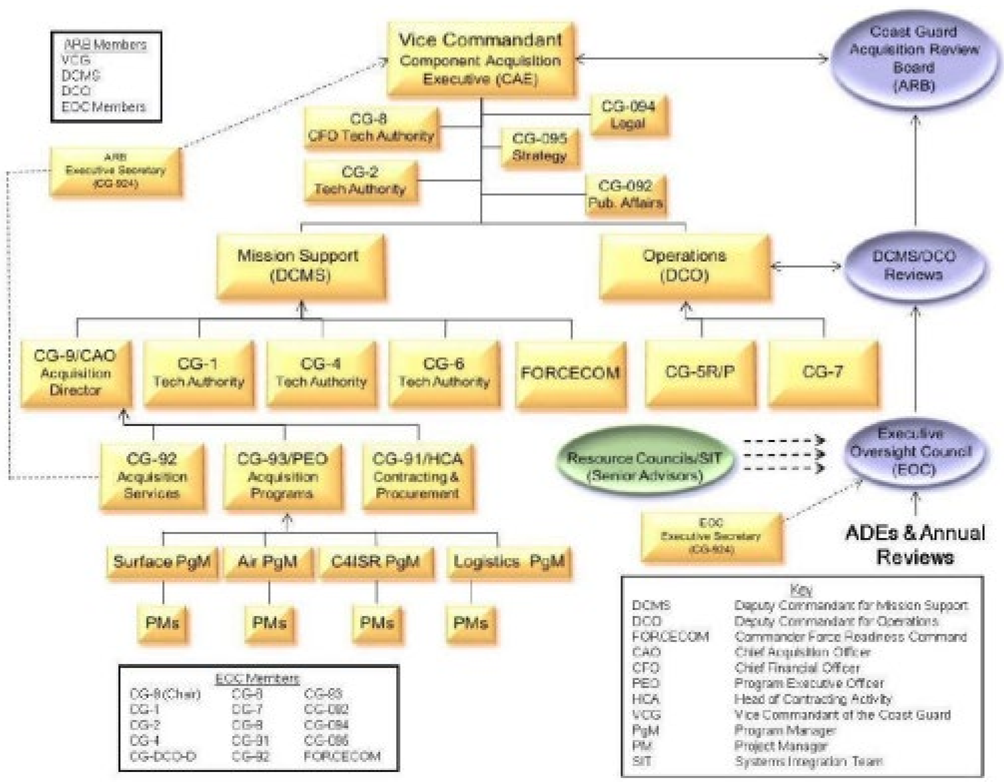
Based on their criticisms of the USCG's acquisition process, Congress updated Title 14, Chapter 11 of the U.S. Code, directing the Commandant of the Coast Guard to "establish an acquisition directorate to provide guidance and oversight for the implementation and management of all USCG acquisition processes, programs, and projects" (Acquisition Directorate, 2022). Additionally, Congress prohibited using private sector entities as LSIs. According to Title 14 USC 1101, the mission of the established acquisition directorate would be to:

(a) acquire and deliver assets and systems that increase operational readiness, enhance mission performance, and create a safe working environment;
(b) assist in the development of a workforce that is trained and qualified to further the Coast Guard's missions and deliver the best-value products and services to the Nation; and,
(c) meet the needs of customers of major acquisition programs in the most cost-effective manner practicable (Acquisition Directorate, 2022).

In July 2007, the USCG merged IDS with the legacy acquisition directorate to reform the USCG's acquisition program into the new CG Acquisition Directorate (CG-9) (Philpott & Weber, 2015). The USCG's Major Systems Acquisition Manual (MSAM) states that CG-9 "was established to provide a single point of management and act as the systems integrator for all USCG major acquisitions" (U.S. Coast Guard, 2021, p. 18). In addition, in 2008, the USCG published the first version of the MSAM with a vision to become a "model of acquisition excellence" in government (U.S. Coast Guard, 2021, p. 18). The manual would define the acquisition policies and procedures with updated guidance for Program Managers (PMs) and planning teams to plan, coordinate, and execute major systems acquisition programs (U.S. Coast Guard, 2021).

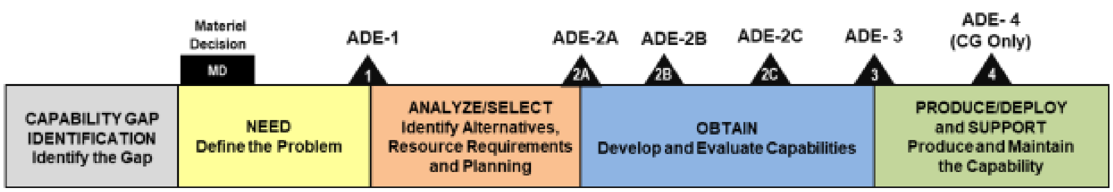
The MSAM further defines the acquisition leadership structure, key acquisition billets, and team member responsibilities. The manual describes how major systems acquisition decision events (ADEs) and reviews are routed through the leadership components. Figure 3 shows the acquisition hierarchy and the flow of acquisition information across the divisions.

Figure 3. USCG Acquisition Hierarchy & Review Flow Source: Philpott & Weber (2015, p. 19)



The USCG's major acquisition life cycle comprises "a pre-acquisition phase [Capability Gap Identification] and four distinct acquisition phases: Need, Analyze/Select, Obtain, and Produce/Deploy and Support" (U.S. Coast Guard, 2021, p. 2-7). Those familiar with the DOD acquisition life cycle will see some similarities. However, the DHS framework defines milestones as ADEs required to transition between acquisition phases. The DHS major acquisition framework is depicted in Figure 4.

Figure 4. Major Systems Acquisition Life Cycle Framework Source: U.S. Coast Guard (2021, p. 2-7)



ADEs ensure phase requirements are satisfied (exit criteria) before moving to the next phase. Once approved by the Acquisition Decision Authority (ADA), typically CG-9, via an Acquisition Decision Memorandum (ADM), the program can enter the next acquisition life cycle phase. The MSAM (2021) lists the following as brief descriptions of each ADE:

(a) Material Decision (MD): Recognition by the Sponsor and acquisition community that the USCG has elected, through the PPBE process, to request a resource allocation formally or has received funding to fill a capability gap.
(b) ADE-1: Validate the Need
(c) ADE-2A: Approve the Program and Initiate Obtain Phase Activities
(d) ADE-2B: Approve the APB and Continue Obtain Phase Activities
(e) ADE-2C: Approve Low-Rate Production or Incremental Delivery
(f) ADE-3: Produce and Deploy Program Products
(g) ADE-4: Acquisition Program Ends. Responsibility fully transferred to sustainment (U.S. Coast Guard, 2021, p. 2-7)

The last NSC milestone was ADE-3 in September 2014. The program anticipates a transition to sustainment (ADE-4) in FY27 upon completing and delivering the eleventh NSC (Nichols, 2022). Once again, HSI is most effective when integrated early in the acquisition life cycle. To better understand our research questions and support the foundation of HSI, the next section will review the practice focusing on the manpower domain.

B. HUMAN SYSTEMS INTEGRATION

Military design successes and failures are well documented throughout history and are readily available to the public (Booher, 2003). In the 20th century, technological advancements and a globalizing economy resulted in capability gaps and desires to ensure our warfighters have the best tools to keep our competitive advantage over our adversaries (Boy, 2017). However, military acquisition programs continuously defer human-centered requirements to measurable, tested technology requirements (O'Neil et al., 2015).

In 1984, the U.S. Army realized the significance of human factors considerations in system design. As a result, General Thurman, serving as the U.S. Army Deputy Chief of Staff for Personnel, initiated Manpower and Personnel Integration (MANPRINT), forcing a radical change in how the U.S. Army and contractors did business (Savage-

Knepshield et al., 2014). MANPRINT would require them to focus on the humans and design systems to fulfill warfighters' needs and capabilities (Skelton, 1997). However, the challenge was (and continues to be) determining when to implement human considerations during the acquisition process. Similarly, the U.S. Navy (USN) and Marine Corps created Hardware/Manpower Integration (HARDMAN), and the Air Force created the Integrated, Manpower, Personnel, and Comprehensive Training and Safety (IMPACTS) program (Clark & Goulder, 2002). These three programs evolved into the joint DOD term HSI as we know it today.

Realizing HSI's advantages, the Department of Defense (DOD) adapted its approach to Defense acquisitions. DOD Instruction 5000.95 (2022) requires all program managers to "formulate a comprehensive HSI program using an appropriate strategy to ensure HSI-related and human performance requirements are achieved" (Office of the Under Secretary of Defense for Research and Engineering [USD R&E], 2022, p. 6). The instruction also states that respective DOD component heads must "ensure that acquisition programs implement an HSI program early in the acquisition process that continues throughout the program life cycle" (USD R&E, 2020, p. 5).

The DHS defines HSI as "the discipline directed at addressing and optimizing human performance in complex work systems" (Department of Homeland Security [DHS], 2012, p. 1). Although there are many definitions of HSI and variants of HSI domains, DHS observes the following seven:

1. human factors engineering
2. manpower
3. personnel
4. training
5. environmental safety and occupational health (ESOH)
6. habitability
7. personnel survivability (Kudrick et al., 2019, p. 1)

Additionally, the 2012 DHS HSI Practitioner's Guide summarizes each domain outlined below (DHS, 2012).

> Human Factors Engineering encompasses the technical consideration and application of the integration of design criteria, psychological principles, human behavior, capabilities, and limitations as they relate to the design, development, test, and evaluation of systems. Manpower refers to the total workload considering job tasks, maintenance, operations, and other associated workloads. Personnel refers to the knowledge, skills, and abilities (KSAs) necessary to perform the job requirements successfully. Training is any activity that results in enabling users, operators, maintainers, leaders, and support personnel to acquire or enhance KSAs. ESOH factors are system design features that minimize the risk of injury, acute or chronic illness, or disability (reduced job performance) of personnel operating, maintaining, or supporting the system. Habitability factors are living and working conditions necessary to sustain the users' morale, safety, health, and comfort. Finally, personnel survivability consists of system design features that reduce the risk of fratricide, detection, and probability of being attacked, enabling the crew to withstand natural and man-made hostile environments without aborting the mission. (Kudrick et al., 2019, pp. 1–2)

One of the biggest challenges and contributors to total life cycle cost is manpower. In 2017, the GAO conducted a study highlighting the USN's manpower challenges resulting from its optimal manning initiative to improve workload deficiencies and reduce personnel costs. The USN concluded that the initiative had "adversely affected ship readiness," requiring restoration of crew sizes and unplanned costs (GAO, 2017, p. 2). Additionally, in 2018, the U.S. Army's recruitment efforts fell short of its intended enlistment goal by 7,600 volunteers, resulting in readiness, position gaps, and unprecedented enlistment bonuses (Laich, 2019). Finally, the 2020 Defense Manpower Requirements Report stressed a decline in the recruitment of next-generation warfighters with the requisite academic and physical skill set and aptitude to serve (Office of the Assistant Secretary of Defense for Manpower & Reserve Affairs, 2019). These and other military-based program manpower challenges pose significant risks to DOD and DHS component programs.

Along with directing acquisition reform in 2007, Congress used Title 14 of the U.S. Code to require the Commandant of the Coast Guard to "designate a sufficient number of positions to be in the Coast Guard's acquisition workforce to perform acquisition-related functions at USCG Headquarters and field activities" (Acquisition Directorate, 2022). As a result, the Commandant of the Coast Guard designated the Assistant Commandant for Human Resources (CG-1) as the Engineering Technical Authority (ETA) for HSI, including the incorporation of manpower design elements into the life cycle development and management of USCG systems (U.S. Coast Guard, 2021). ETAs have the "delegated authority, responsibility, and accountability to establish or assert technical engineering standards, tools, processes, and best practices" (U.S. Coast Guard, 2021, p. 1-18). Consolidation of all manpower-related analyses under CG-1 ensure applied standardization of the manpower requirement process.

The USCG's Manpower Requirements Manual (MRM), COMDTINST M5310.6, "prescribes the doctrine and policy to execute the Manpower requirements process to study an acquisition or a legacy organizational element" (U.S. Coast Guard, 2020, p. 3). Changes drive manpower requirements analyses to the mission, function, or task requirements. According to the MRM (2020), prompts to manpower requirements analyses include:

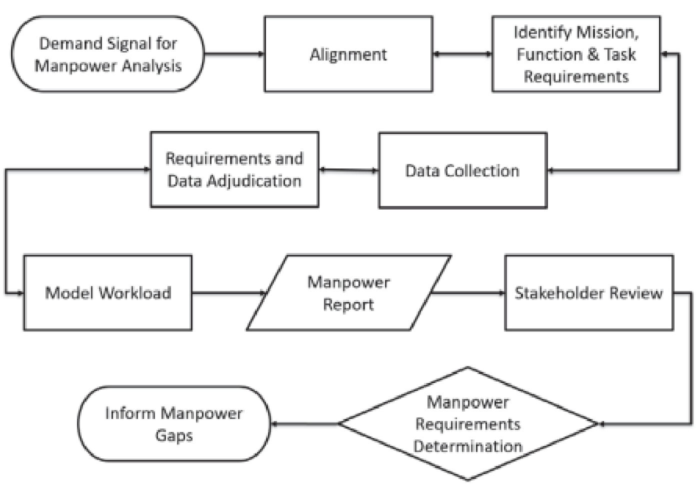
1. as required throughout the acquisition life cycle per the MSAM;
2. changes in mission capability and support requirements;
3. changes in law, regulation, or policy;
4. as directed by higher authority;
5. proposed changes to organizational structures;
6. establishment or change to an asset's operations, configuration, or maintenance; or
7. implementing or changing business processes, equipment, environment, or technological advances. (U.S. Coast Guard, 2020, pp. 1–1–1-2)

In addition to the manpower prompts listed, Booher's Handbook of Human Systems Integration (2003) states the "system characteristics that drive manpower requirements are all linked to the amount of attention that a system needs to remain operational," (i.e., operational tempo) (p. 383). The manpower elements required to remain operational (i.e., workload) include manning requirements driven by system design, maintenance manpower requirements driven by operational tempo, and "support manpower requirements driven by the geographic relationship between supply and operational units" (Booher, 2003, p. 384). Booher (2003) provides a relevant sample of the questions that a manpower requirements analysis can answer, including:

(a) How many maintainers do I need to achieve the required system availability at each maintenance level?
(b) Do I need two operators in my new system, or will advanced levels of automation allow me to reduce the crew size to one?
(c) Does the system require round-the-clock or sustained operations?
(d) Do sufficient human resources exist in the units that will receive the new system to conduct operations at the identified tempo? (Booher, 2003, p. 383)

The manpower requirements process guides program managers and representatives through translating mission-based requirements into manpower determinations. The detailed and iterative process is depicted in Figure 5, followed by a general explanation of each process step (U.S. Coast Guard, 2020):

Figure 5. Manpower Requirements Process Source: U.S. Coast Guard (2020, p. 1-2)



(a) Study Charter. The Study Charter is an agreement between the organizational element being analyzed and the manpower enterprise. It defines the scope of the study and the objectives of the analysis.

(b) Alignment. The Alignment meeting orients the program representatives to the manpower requirements process and aligns study expectations. Key goals, objectives, requirements, and milestones are discussed and agreed upon. The Project Plan, Work Breakdown Structure (WBS), and Alignment Meeting Report are developed, discussed, and finalized during the alignment phase.
(c) Familiarization Phase. During the familiarization phase, the analysts develop a detailed understanding of the organization's mission, functions, and tasks. This phase is used to define the work of the organization. The output of the familiarization phase is a Standard Work Document (SWD). The SWD lists the processes, tasks, and outputs to measure, analyze, and model. The SWD is a complete description of the organization's required work, which can be derived from various organizational documentation, including a process flowchart, narrative description, a functional statement, directed requirement, staffing pattern, or minimum manning.
(d) Data Collection Plan (DCP). This Data Collection Plan describes the type of work and workload data required to model the organization's manpower; the method intended to capture that information; the personnel requested to support the collection of data and information; the sites to be visited; and the schedule for those site visits.
(e) Workload, Constraints, and Assumptions (WCA) Report. The WCA report documents the organization's total workload requirements and the constraints and assumptions applied during modeling.
(f) Modeling & Distribution Phase. After all workload has been collected, measured, and calculated, the analysts must determine the manpower required to meet mission requirements. This is completed during the Modeling & Distribution Phase. The Manpower Report (MRA or MER) is the output of the Modeling & Distribution Phase.
(g) Manpower Requirement Determination (MRD). After the stakeholder review described in Chapter V, the MRD is produced and approved by either Commandant (CG-1) or the Manpower Engineering Technical Authority (U.S. Coast Guard, 2020, pp. 2–2 through 2–3).

A significant challenge to determining adequate manpower is identifying the total workload requirements. Familiarization and data collection are critical steps in determining workload information. During these two process steps, manpower requirement analysts collect and review documents that may contain mission, function, and task requirements. According to the MRM (2020), examples of these documents include:

(a) Laws, Treaties, and International Agreements;
(b) Department of Defense directives;
(c) Department of Homeland Security directives;
(d) Coast Guard directives;

(e) Coast Guard documents;
(f) Coast Guard publications;
(g) Capability Production Documents;
(h) Mission Needs Statement;
(i) Operational Requirements Document;
(j) Required Operational Capability / Projected Operational Environment;
(k) Concept of Operations;
(l) Integrated Logistics Support Plans and Maintenance Plans; and
(m) Previous manpower studies and existing staffing models. (U.S. Coast Guard, 2020, p. 3-1)

Manpower requirements analysts leverage the data to form total workload requirements that support a program's mission, functions, and goals. The workload is calculated based on several elements, such as task frequency, task accomplishment time, and team size. With an MRM-defined Manpower Availability Factor (appendix B), analysts can determine accurate manpower requirements measured against either current or planned staffing to find the manpower gap to make future program recommendations. Below are some of the reports produced by the process (U.S. Coast Guard, 2020):

(a) <u>Manpower Assessment</u>. A Manpower Assessment is a special study or initiative to determine required manpower or man-hours. An assessment is the lowest fidelity manpower study; however, its findings can help identify gaps in requirements and support early resourcing decisions. For example, Manpower Assessments may include workload reports and Engineering Technical Authority Determination Memos. However, due to their situational application, assessments may not follow the discipline or rigor of the more formal manpower determinant development process.
(b) <u>Manpower Estimate Report (MER)</u>. An MER is applied to a previously undefined mission requirement. This situation could be the result of a lack of established program requirements or the effect of an initial system or platform acquisition. Because the analysis is performed without firmly established requirements, the estimate often relies on parametric data and statistical inference drawn from similar systems or capabilities. Despite this limitation, an MER provides valuable analysis of the known operations, maintenance, and support to assist with early resource and design decisions. In addition, an MER serves as foundational extant data for a follow-on MRA, which would be conducted when mission requirements and workload are better defined.
(c) <u>Manpower Requirements Analysis (MRA)</u>. An MRA provides an analytical study that starts with reviewing all pertinent resources and doctrine and may be followed by surveys, OE site visits, interviews, and other data gathering techniques. The MRA analyst validates work, collects workload data, and reviews the OE's processes and operating

readiness conditions first-hand. This level of study provides the most in-depth data collection and analytical rigor and therefore consumes the most time and resources.

(d) Manpower Requirement Determination (MRD). An MRD establishes the final manpower requirements and addresses all stakeholder concerns except the availability or absence of resources. It contains relevant information which describes the quantity and mix of required manpower resulting from the MRA. An MRD is approved by CG-1 or the manpower ETA and can be used as the basis for resourcing decisions. (U.S. Coast Guard, 2020, pp. 2–1 through 2–2)

The manpower requirements process is a relatively objective and systematic approach to finding optimal manpower requirements. However, HSI demands taking the workload analysis one step further. As socio-technical systems become more complex, posing new challenges to workload demands, analysts must consider collaboration between humans and technology to determine accurate manpower numbers. Poor assumptions may result in an inaccurate work analysis without considering the cognitive workload. This multi-disciplinary endeavor is known as cognitive engineering and we discuss its applicability in the next section.

C. STUDYING COGNITIVE BEHAVIOR IN DECISION MAKING

According to Woods and Roth (1988), "Cognitive engineering is an applied cognitive science that draws on the knowledge and techniques of cognitive psychology and related disciplines to provide the foundation for the principle-driven design of person-machine systems" (p. 1). Specifically, design activity must include consideration of cognitive demands imposed by workplace environments and socio-technical complexities (Gersh et al., 2005). The goal of cognitive engineering is to understand issues involved in using complex devices, determine how to make better design choices, and measure tradeoffs when improvements in one HSI-related domain lead to deficits in another (Norman, 1986). Additionally, workplace environments are rapidly changing; therefore, cognitive engineering should be embedded within systems engineering (Halligan, 2016). Cognitive engineering is a proactive approach to human-technology design interaction. The overarching goal of HSI is to achieve optimal performance while minimizing total ownership costs, and cognitive engineering would substantially contribute to achieving that goal. Cognitive engineering shares the enhancing performance objective but approaches that goal by identifying sources of error that impair the current system's performance (Woods & Roth, 1988). Therefore, cognitive engineering can be used to understand where, how, and why interactions between humans and technology break down over a system's life cycle. Woods and Roth (1988) state that one error source is "buggy knowledge" – missing, incomplete, or erroneous information. An example would be a lack of HSI knowledge or consideration on the part of integrated product teams (IPTs). Furthermore, effective performance depends on adequately applying the information and subsequently observing, understanding, and collecting data on how and why program planners (i.e., IPTs) use the concepts and tools of their domains (Gersh et al., 2005).

There are many theories and approaches behind cognitive engineering efforts. However, there are generally two key concepts: human ecological (real-world) interactions and managing socio-technical change (Gersh et al., 2005). Just like HSI, cognitive engineering should be systematic and iterative in system design. We risk "continuing to field technology-focused systems without the standard inclusion of methods to support cognition across acquisition life cycles" (McDermott et al., 2017, p. 174). The following section discusses the implementation of HSI in major acquisitions and the relationship between cognitive engineering and HSI.

The underlying goal of most acquisition programs is to understand user needs and deliver an effective capability that fulfills a mission gap (McDermott et al., 2017). Even though the MSAM provides a structured framework for major acquisitions, there is rarely a single optimum program structure. Methods and practices used in traditional system design were developed when workplace policies and performance criteria operated under different circumstances (Vicente, 2009). IPTs should leverage HSI practitioners and MSAM-defined HSI-related activities to use cognitive engineering methods to elicit end-user input and feedback to understand system requirements, design prototypes, and verify products or systems iteratively. When transitioning from a legacy program to a new system design, programs should apply cognitive engineering methods across all program phases to capture and evaluate HSI-related changes based on the evolving nature of updated missions or dated procedures.

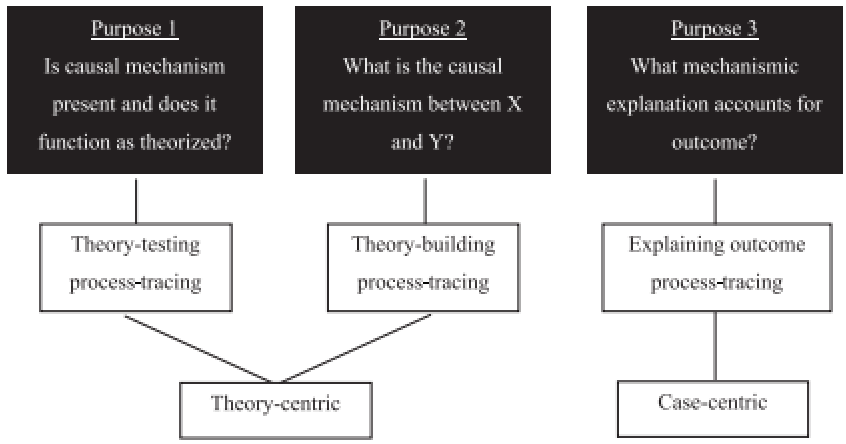
Cognitive engineering has emphasized observation and understanding to develop a cognitive task analysis that captures users' tasks and goals within their work domain (Gersh et al., 2005). However, studying cognitive behavior in complex situations is extremely difficult. According to Woods (1993), one way to manage complexity is to scope the problem and isolate one aspect within a dynamic process. Isolation allows researchers to understand one variable or subprocess at a time (for our research, the manpower HSI domain is isolated). Furthermore, studying historical accounts of cognitive engineering can highlight contributing factors to a program's overall success or failure.

D. PROCESS TRACING

Process tracing has become a popular taxonomy to analyze "cognitive activities during complex work tasks" (Patrick & James, 2004, p. 259). Notably, in historical accounts or unique case studies, process tracing can assist in the explanation of specific outcomes based on a presumed set of causal sequences (Yin, 2018). Despite its popularity, no single methodology has emerged from the literature.

According to Woods (1993), process tracing "maps out how incidents unfold, including available cues, those cues noted by participants, and participants' interpretation in both the immediate and in the larger institutional and professional contexts" (pp. 232–233). However, as processes like the DHS acquisition framework and variations to the work environment evolve, identifying a program's change of reasoning proves challenging. As a result, process tracing serves three distinct research purposes: theory testing, theory building, or explaining outcomes (Beach & Pedersen, 2019). Figure 6 presents the distinctions between the three research goals.

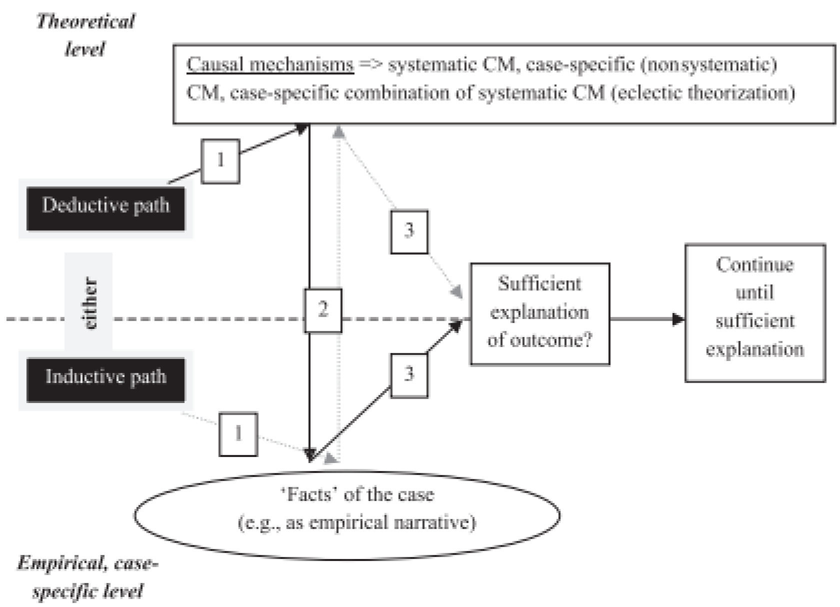
Figure 6. Process Tracing Methods. Source: Beach and Pedersen (2019)



Our research focuses on the third purpose – explaining the current state of the NSC program. According to Beach and Pedersen (2019), case-centric research does not aim to generalize, although one could utilize the information to make informed decisions based on case-specific causal relationships. Additionally, case-centric studies often broach theoretical ambitions beyond the case.

There are typically two approaches when building explanation accounts: deductive or inductive reasoning. Figure 7 is a foundational taxonomy for these two approaches. Creswell and Plano Clark (2007) state that "the deductive researcher works from the 'top-down,' from a theory to hypotheses to data to add to or contradict the theory" (Creswell & Plano Clark, 2007, p. 23). Conversely, "the inductive researcher is someone who works from the bottom-up, using the participants' views to build broader themes and generate a theory interconnecting the themes" (Creswell & Plano Clark, 2007, p. 23). Therefore, inductive research typically uses qualitative information (i.e., verbal reports, cognitive behaviors, retrospective analyses of critical incidents, etc.).

Figure 7. Process Tracing for Explaining Outcomes. Source: Beach and Pedersen (2019)



A critical takeaway is the grasping of "facts" as events unfold. Yet, the impossibility of observing a historical case can hinder the descriptive or explanatory components (Collier, 2011). Tannenwald's "Nuclear Taboo" article (1999) is an example of how one can use diverse primary and secondary sources (i.e., official documents, memoirs, and biographies) to describe events and produce causal inferences about a case. Further works on qualitative research and process tracing methodologies can be found in works by Collier (2011), Mahoney (2010), and Woods (1993).

E. HSI CASE STUDIES

Case studies can help strengthen a position or reinforce program requirements. According to Yin (2018), "the essence of a case study is that it tries to illuminate a decision or set of decisions" (Yin, 2018, p. 14). A case study assumes that, with much research and evidence, one can get closer to the why and the how (Thomas et al., 2020). The HSI practice continues to evolve, and practitioners face new challenges with socio-technical culture changes. Lessons learned based on case study research can help HSI practitioners acquire new knowledge, methods, or best practices in the growing field (Healy, 2020).

Unfortunately, there are very few HSI-related case studies available for exploration. A previous graduate of the Naval Postgraduate School, Chris Healy, surveyed case study literature and developed an encompassing case study outline to aid HSI practitioners attempting to produce a usable product (Healy, 2020). Figure 8 contains the recommended elements for structuring an HSI case study.

F. CHAPTER SUMMARY

In this chapter, we reviewed the historical progression of USCG acquisitions and the evolution of HSI in the military. We discussed how analyzing the decision-making process through an HSI lens can improve future program outcomes. We will capture many of these elements by systematically tracing NSC program documents and decisions linked to manpower requirements adjustments with relevant takeaways for HSI program improvements discussed in the following chapters.

Figure 8. Case Study Outline. Source: Healy (2020, p. 30)

Section	Purpose	Key Elements
Introduction	To provide an overview of the purpose, questions answered, and the scope of the study. Assists the reader in determining if the study supports the insights they are looking for.	The purpose of the study The scope of the analysis The point of view/position of the writer The questions answered
Background	This section builds the reader's understanding of the case study context. The HSI practitioner and other audiences will use this section to determine if this program is relatable to theirs.	Purpose of the Program or System Description of the operating concept Applicable life cycle phases Description of HSI team Applicable HSI Core Competencies
The Opportunity / Challenge	To describe the opportunity or issue and its relationship to the program, end-user, and HSI practitioner. This section frames the opportunity for HSI to provide value. It should address the equities of the Program, the End User, and the HSI practitioner.	Describe how the challenge relates to the affected HSI Domain. Risks to the program for implementation. Risks to the end-user for not addressing. Life Cycle Phase and where the problem was identified.
The HSI Approach	To describe the solution and how it was developed. This section should walk the reader through the process of developing a solution relative to the HSI opportunity.	Applicable HSI Core Competencies. Other engineering disciplines involved. Brainstorming techniques utilized.
Implementation Process	To describe the process of implementing the HSI solution.	Barrier to implementation Organizational Relationships TTAMs used to assist in the implementation Time and Cost to implement Implementation challenges faced by the HSI practitioner.
Key Outcomes / Lessons Learned	To describe successes and failures experienced throughout the process. The section should identify the key outcomes and takeaways for stakeholders relevant to the case study and not just the HIS team ROI and Lost Opportunities should be quantified in units such as Cost, Time, Effectiveness, Risk.	Success / Failures of the HSI Practitioner(s) Success / Failures of the Program Opportunities Lost (Quantified Units) Risk Reduction, Performance Enhancement Return on Investment (Quantified Units)

III. METHODOLOGY

A. INTRODUCTION

In Chapter III, we explain the investigative methodology used to collect, transcribe, codify, and represent historical NSC documents, decisions, and activities, and how these data points align with current HSI best practices. First, we completed a systematic background study of the USCG's major system acquisitions and the NSC's acquisition strategy. Practitioners from CG-1B3 and NSC program representatives were contacted to access the surface acquisition program's (CG-932) archived documents on the USCG intranet portal. We prioritized searches of IDS and NSC publicly releasable documents of record and compiled government reports from the public web domain and the USCG historians' office. Second, we transcribed the information to timeline the account of NSC program documents, focusing data collection efforts on specific manpower-related criteria. Third, we traced manpower-related decisions, and noted current HSI best practices with a binary coding system, further explained later in this chapter. Finally, we created an integrated timeline diagram of NSC program phases and milestones, hull production timelines, manpower-related documents, and life cycle cost estimates to make linkages more salient between manpower-related decisions and deficiencies to cost, schedule, and performance.

B. METHODS

1. Data Collection

Our detailed accounting of the USCG IDS program began with the conception of the USCG's IDS program and we established a baseline understanding of the initial SOS acquisition plan to replace the USCG's legacy surface fleet. Next, we analyzed early IDS mission needs documents from the CG-9 website. In addition, we reviewed reports from the GAO, CRS, DHS Office of Inspector General (OIG), and the USCG's historian website to gather historical records that corroborate the need and evolution of the USCG's acquisition reform. Finally, we collected all the published post-reform NSC program documents via the CG-932 intranet site to align with USCG's MSAM (2021) and MRM (2020) requirements.

2. Transcription

We chronicle each analyzed document on an Excel spreadsheet (Appendix A) to sequence and compare published dates to MSAM guidance. We also identify critical documents referenced but unavailable due to access restrictions or loss over time. We present the data in Appendix A, containing eight columns, each described below:

1. Date. The document or report publishing year
2. Document Name. The document or report name, including the version number
3. Manpower-relevant information. Is there a manpower-related discussion within the document?
4. Deviation from previous manpower-related information. Does the manpower-related discussion conflict with previous documentation?
5. Is this document traceable to previous documents? Does this document's manpower-related discussion relate to another document or decision (i.e., does it help tell the story)?
6. Currently prescribed HSI activity. Is this document mentioned in the MSAM (2021) as an HSI-related activity?
7. Is this document in the correct acquisition phase? Was this document published in the correct acquisition phase per MSAM HSI activity guidance?
8. Does this have a cost, schedule, or performance impact? If a manpower-related decision was made, can a linkage be drawn that infers impact to cost, schedule, or performance?

3. Coding Criteria

We code the transcribed data to streamline the interpretation of the complex, qualitative data pool. In addition, codifying the data helps visibly trace key documents and decision points. To focus the attention and scope on the manpower-related impacts on program cost, schedule, and performance, the documents highlighted in green meet further consideration criteria detailed below. Additionally, documents found in the incorrect acquisition phase per MSAM guidance received a "No," and red highlight to illustrate an analysis point in Chapter V. The unhighlighted cell blocks depicted the documents that did not meet the criteria, and we eliminated them from further analysis. Finally, we reference several documents from various sources not found during the historical document search. We annotate these missing documents with "Unable to locate this document" and a purple highlight. Appendix A illustrates the manpower-related decisions that evolved from binary results. Table 1 is an example of the color-coding key used in the data collection sheet, further described in the following few paragraphs.

Table 1. Document Coding Scheme Example

Operational Assessment (ref TEMP V3.0)	*Unable to locate this document*				Yes	Yes
Interim Manpower Requirements Analysis	Yes	Yes	Yes	Yes	Yes	Yes
Configuration Control Board Charter	No	No	No	No	No	No
Capability Production Document update (V2)	Yes	Yes	Yes	Yes	Yes	Yes

We presented the criteria for binary answers in columns 3–8 of Appendix A below:

(a) Manpower-relevant information. A "Yes" in this category indicates the document contains specific, searchable manpower-related terms. Table 2 provides the manpower-related terms that, if referenced within the document, assume manpower relevance.

Table 2. Manpower Search Terms

Manpower	Manning	Personnel
Staffing	Billet	Crew Size
Crew Compliment	Human Capital	Assigned crew

(b) Deviation from previous Manpower-related information. A "Yes" in this category indicates document contents contradict previous manpower-relevant documents.

(c) Is this document traceable to previous documents? A "Yes" in this category indicates the document references an exact crew size number for underway operations (e.g., 108, 111, 126, etc.). A crew size reference assumes relation to some previous manpower-related decision and, when cross-checked with conflicting information, can provide targeted insight into why the manpower requirements changed or existed initially.

(d) Currently prescribed HSI activity. The MSAM (2021) published guidance for HSI activities broken down by major system acquisition phases. While each activity may not be specific, we can make minor inferences regarding documentation requirements and deliverables. The criterion for receiving a "Yes" in this category includes an explicit reference to the document within the MSAM's HSI activities. To continue scoping our research, documents receiving a "No" in this category were removed from further study. The MSAM HSI activity documents include the following:

1) Need Phase
    i. Mission Needs Statement (MNS)
    ii. Concept of Operations (CONOP)
2) Analyze/Select (A&S) Phase
    i. Updates to MNS and CONOP
    ii. Operational Requirements Document (Capability Production Document)
    iii. Integrated Logistics Support Plan (ILSP)
    iv. Systems Engineering Life cycle Plan (SELC)

v. Test and Evaluation Master Plan (TEMP)
vi. Human Systems Integration Management Plan (HSIMP)
vii. Manpower Estimate Report (MER)
viii. System Safety Management Plan (SSMP)
ix. Human Factors Engineering Plan (HFEP)
x. Human Performance Support and Training (HPS&T) Plan
xi. Alternative Analysis Study Plan (AASP)
xii. Cost Estimating Baseline Document (CEBD)
xiii. Life Cycle Cost Estimate (LCCE).

3) Obtain Phase (ADE-2A through ADE-2B).
   i. Updates to previously mentioned plans
4) Obtain Phase (ADE-2B through ADE-2C).
   i. Updates to previously mentioned plans
   ii. Developmental Test Plan (as appropriate)
   iii. Operational Test Plan (OTP)
5) Obtain Phase (ADE-2C through ADE-3).
   i. Updates to previously mentioned plans
   ii. Manpower Requirements Analysis (MRA)
   iii. Manpower Requirements Determination (MRD)
   iv. Initial Operational Test & Evaluation (IOT&E)
   v. Operational Test Reports (OTR)
6) Produce/Deploy and Support (PD&S) Phase.
   i. Post Implementation Review (PIR)

(e) Is this in the correct acquisition phase? A "Yes" in this category indicates the alignment of the initial version of the published document date with the MSAM HSI activity phase requirements per the previous section. A document initially published before or after the designated phase received a "No" indication. Updates and newer document versions are assumed to be in the correct phase regardless of initial document publishing.

(f) Does this have a cost, schedule, or performance impact? A “Yes” in this category indicates a “Yes” in the deviation and traceability categories. We assume that any sub-optimal manpower estimation in the listed artifact would likely have unplanned impacts on cost, schedule, or performance.

4. Data Representation

Appendix B provides a visual representation of the NSC’s acquisition life cycle framework overlayed with NSC production timelines, manpower-related documents and activities, and programmatic changes, including AFC 1 and 20 (operator salary and permanent change of station) costs. This 20-year timeline overlays HSI activities with corresponding changes to NSC program cost, schedule, and performance.

The timeline begins in 2000 and encompasses two decades (through 2020) of documented references and comparison points, aligning MSAM-recommended HSI best practices to actual NSC manpower-related events and program decisions. The data representation design was inspired by the Defense Acquisition University’s (DAU) Defense Acquisition Life cycle Wall Chart. (Defense Acquisition University [DAU], 2020). Therefore, Appendix B is titled “NSC Manpower Life Cycle Wall Chart” to remain consistent with DAU Wall Chart terminology and simplify referencing information.

C. CHAPTER SUMMARY

In Chapter III, we described the process tracing methodology used to collect manpower-related data on the NSC program. Notably, the criteria for document selection and data representation provide our methods for using or excluding certain archived documents. The next chapter will break down the multiple swim lanes within the NSC Manpower Life Cycle Wall Chart to help draw linkages between manpower-related decisions and effects on NSC program cost, schedule, and performance.

IV. RESULTS

In Chapter IV, we discuss our findings of the historical data search to document NSC manpower-related decisions and the potential impacts of these decisions on NSC program cost, schedule, and performance. The first challenge was to review NSC-related acquisition artifacts and assess whether each was relevant to the NSC manpower case study. Artifacts deemed relevant to NSC manpower decisions were included on the NSC Manpower Life cycle Wall Chart. While we could not locate the most relevant artifacts of interest, several critical documents were either not for public release (NOTAL) or missing from program archives. In those cases, we noted their absence, and inferred their relevance from MSAM document descriptions.

A. HISTORICAL DOCUMENTS

Our work presented in this section provides a comprehensive search of 53 NSC program-related documents, assesses their relevance to HSI activities, and identifies impacts on the NSC's life cycle acquisition. Our assessment helps establish a timeline and build an objective approach to identifying manpower-related decisions, changes, and alignment with current HSI best practices.

We used an Excel spreadsheet table to document each NSC artifact examined. We categorized the results using current acquisition phase standards. For clarity, the documents produced in the Need and A&S phases were pre-acquisition reform, and the documents in the Obtain and PD&S phases were post-acquisition reform. This is an important distinction, as the decisions made before the 2007 acquisition reform contribute to our findings discussed later in our research. The tables below are excerpted from Appendix A for quick reference. Each column title reflects an acronym associated with the categories discussed in Chapter III, also specified here:

(Manpower relevance) Manpower-relevant information

(Deviation) Deviation from previous manpower-related information

(Traceability) Is this document traceable to previous documents?

(HSI activity) Currently prescribed HSI activity

(Correct phase) Is this in the correct acquisition phase?

(CSP impact) Does this have a cost, schedule, or performance impact?

Furthermore, we provide the columns in the depicted order to align with the initial research questions. Column (Man) answers the first research question, columns (Dev) and (Trac) answer the second, columns (HSI) and (Phase) answer the third, and column (CSP) answers the fourth. We reiterate the initial research questions here:

1. What manpower-related decisions occurred during the NSC program?
2. When did NSC staffing levels change during the NSC program?
3. Did manpower-related events, analyses, and decisions during the NSC program align with current HSI best practices?
4. Can linkages be drawn between manpower-related decisions and NSC program cost, schedule, and performance deficiencies?

1. Need Phase (Before 2002)

The historical document search reveals four NSC manpower-related program documents before 2002, depicted in Table 3.

Table 3. Need Phase Documents

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
1995	Mission Analysis Report	Yes	No	No	No	Yes	No
1996	IDS Mission Needs Statement V1.0	Yes	No	No	Yes	Yes	No
2001	Acquisition Plan	No	No	No	No	Yes	No
2002	Integrated Deepwater Report	Yes	No	No	No	Yes	No

After a thorough review of the four documents, while they make no prescriptive manpower decisions, they do reveal conflicting organizational priorities to NSC manpower expectations. However, the small number of referenced, publicly available documents and the lack of manpower-relevant information suggests minimal USCG oversight and HSI domain consideration during the early stages of NSC planning and production. In addition, the NSC's orienting concept of reducing manpower based on the USN's optimal manning strategy is a caveat to further manpower consideration (Spindel et al., 2000). Similar to the USN's optimal manning approach, the IDS Mission Needs Statement (MNS) prioritizes acquiring "state-of-the-art assets to reduce life cycle costs by allowing savings through significant reductions in crew sizes" (U.S. Coast Guard, 1996, p. 22). While evidence of manpower-related decisions in the MNS was limited, there is clear evidence of the USCG's orienting philosophy towards manpower.

2. Analyze/Select (A&S) Phase (2002-2007)

The historical search reveals seven NSC manpower-related program documents between 2002 and 2007, as depicted in Table 4.

Table 4. Analyze/Select Phase Documents

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
2005	IDS Mission Needs Statement V2.0	Yes	No	No	Yes	Yes	No
2005	Manpower Requirements Analysis (ICGS)	*Unable to locate this document*				Yes	Yes
2005	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No
2006	Capability Production Document	Yes	Yes	Yes	Yes	Yes	Yes
2006	NSC MX Manpower Requirements Analysis	Yes	No	Yes	Yes	Yes	No

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
2006	Staffing Standard for NSC	Yes	Yes	Yes	Yes	Yes	Yes
2006	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No

The objective criteria presented in Chapter III reveal three documents that require further consideration within this phase. The three documents are highlighted in green. The ICGS Manpower Requirements Analysis (MRA) was referenced in the Capability Production Document (CPD) and the Staffing Standard for the NSC. Unfortunately, we did not find the ICGS MRA after an extensive search, but its mention in the reference section of subsequent documents infers an impact on CPD and Staffing Standard decisions. The CPD and Staffing Standard for the NSC received further consideration for their deviation from previous manpower-related information and traceability.

The MSAM references all three documents as recommended HSI-related activities. The sections relevant to manpower decisions are summarized below. The impacts of these documents will be assessed in Chapter V.

1. ICGS was the LSI and lead author of the NSC's initial MRA. As mentioned in the previous paragraph, the MRA is not publicly available and cannot be analyzed further. However, ICGS determined that the optimal crew for the NSC was 108 to meet mission demands.

2. The CPD was published in 2006 and appeared to be the first document written in preparation for the acquisition reform, during which the LSI role would transition from ICGS to the USCG. The CPD references the ICGS MRA for an NSC crew of 108, implying no further manpower analysis between the initial MRA and CPD (Office of the Deepwater Sponsors' Representative [G-RCD], 2006).

3. The NSC Staffing Standard is the official USCG Commandant-mandated instruction establishing the preliminary operating crew of 108 for the NSC

(Papp [Chief of Staff], 2006). Again, the 108-crew projection is based on the ICGS MRA.

3. Obtain Phase (2007-2014)

The historical search reveals 26 NSC manpower-related program documents between 2007 and 2014, as depicted in green highlight in Table 5.

Table 5. Obtain Phase Documents

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
2007	Early Operational Assessment	*Unable to locate this document*				Yes	Yes
2008	IDS Alternative Analysis	Yes	No	No	Yes	No	No
2008	Acquisition Program Baseline	Yes	No	No	No	Yes	No
2008	NSC Risk Management Plan V1.0	*Unable to locate this document*				No	Yes
2008	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No
2009	Decision Memo - Staffing Standard Change NSC	Yes	Yes	Yes	Yes	Yes	Yes
2009	Alternative Analysis Study Plan	Yes	No	No	Yes	No	No
2009	Configuration Management Plan V1.0	*Unable to locate this document*				No	No
2010	DT&E Plan	Yes	No	No	Yes	Yes	No
2010	Operational Assessment (ref TEMP V3.0)	*Unable to locate this document*				Yes	Yes
2011	Interim Manpower Requirements Analysis	Yes	Yes	Yes	Yes	Yes	Yes
2011	Configuration Control Board Charter	No	No	No	No	No	No

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
2011	Capability Production Document update (V2)	Yes	Yes	Yes	Yes	Yes	Yes
2011	Capability Production Document V2.0 brief	Yes	Yes	Yes	Yes	Yes	Yes
2011	Deepwater GAO Report	Yes	No	No	No	NA	No
2012	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No
2012	Program Management Plan V1.0	*Unable to locate this document*				No	No
2012	Operational Requirements Document V2.0 (Initial ORD)	*Unable to locate this document*				Yes	Yes
2012	Life cycle Cost Estimate V1.0	Yes	Yes	Yes	Yes	No	Yes
2012	NSC Deployment Plan V1.0	Yes	Yes	Yes	Yes	Yes	Yes
2012	Systems Engineering Life cycle Plan (V1.0)	No	No	No	Yes	No	No
2012	CG-1 Manpower Requirements Document Memo	Yes	Yes	Yes	Yes	Yes	Yes
2013	Acquisition Decision Event - 3	No	No	No	No	Yes	No
2013	Integrated Logistics Support Plan V1.0	*Unable to locate this document*				No	Yes
2013	Configuration Management Plan V2.0	Yes	No	Yes	Yes	No	No
2013	WMSL Concept of Operations V1.0	Yes	No	No	Yes	No	No

Twelve documents published during the Obtain Phase warrant further consideration based on the criteria from Chapter III. Five of the twelve documents are missing from publicly available sources annotated with purple highlights. However, it is worth noting that later versions of these documents are available for analysis, with tracked changes annotating the previous versions' language. Additionally, three of the twelve documents were not published during the current MSAM's HSI-best practice phase recommendations annotated with red highlights. We summarize the sections relevant to manpower decisions below. The impacts of these documents will be assessed in Chapter V.

(a) In 2007, the USCG leveraged the USN's Operational Test and Evaluation Force to draft an Early Operational Assessment (EOA). Unfortunately, the document was not available for further analysis. However, the Defense Acquisition University (DAU) describes the EOA as an "evaluation of operational effectiveness and operational suitability that may be conducted any time using prototypes, mockups, engineering models, simulations, etc. The EOA will not substitute for OT&E required for full rate production" (Defense Acquisition University [DAU], n.d., para. 3). The relevance of the EOA to manpower decisions can be inferred from this definition.

(b) The initial NSC Risk Management Plan (RMP) is not available for analysis, but a later version of the plan was published in 2015. The later version requires Human Systems Integration (HSI) consideration by the Integrated Product Teams (IPT) (NSC Program Manager [CG-9321], 2015). It is unclear to what extent the IPTs considered HSI, but we infer the RMP tradeoff discussions are manpower relevant. The MSAM also recommends publishing an RMP during the Analyze and Select acquisition phase (U.S. Coast Guard, 2021). Hence, our research suggests this document is late and may impact cost, schedule, or performance.

(c) In an updated NSC Staffing Standard (2009), adding one additional crew member brings the total NSC crew size to 109 (U.S. Coast Guard, 2009). The Standard converted is:

    (i) One Boatswain's Mate Senior Chief (BMCS) billet to one Boatswain Chief Warrant Officer (BOSN);

(ii) One Food Specialist Chief (FSC) billet to one Food Specialist Third Class Petty Officer (FS3); and

(iii) One Financial and Supply Chief Warrant Officer (F&S) billet was added.

(d) The 2010 Operational Assessment supplements the 2007 EOA and contains similar information (Defense Acquisition University [DAU], n.d.). Unfortunately, the OA is unavailable for further analysis, so we assume manpower relevance.

(e) The 2011 Interim MRA was authored by CG-1B3 and appeared to be the first in-depth analysis of NSC rate-based functional workloads. The work by CG-1B3 provided leadership with a greater understanding of NSC requirements to meet mission demands, resulting in the recommendation to increase the NSC's crew size to 126 (CG-1B3, 2011).

(f) The next two documents are CPD updates and reflect much of the same information as the initial CPD, including information from the Interim MRA.

(g) The first version of the NSC Operational Requirements Document (ORD) replaced the CPD to align with DHS acquisition standards. Unfortunately, this version is unavailable, but later versions provided insight into the document's purpose. Here we find an unusual circumstance where initial requirements are being written and clarified after three NSCs are already delivered (Office of Cutter Forces, 2020).

(h) The NSC Life Cycle Cost Estimate (LCCE) provides another challenge faced by program managers. This is the first detailed estimate of NSC life cycle costs based on an empirical data search. A significant finding of our research is the LCCE includes extrapolation of the first three NSC costs and analogous factors, like T&E and procured additional equipment (Acquisition Resource Management, Business Management, and Metrics, 2012). The MSAM recommends LCCE preparation in the Analyze and Select acquisition phase, suggesting that this LCCE is late and decisions were made without appropriate cost estimation factors (U.S. Coast Guard, 2021).

(i) The MSAM requires the NSC Deployment Plan to document the resources required to operate and sustain the program (U.S. Coast Guard, 2021). The document discusses NSC operational costs but only calculates the total based on a crew size of 110, referencing the 2011 NSC Project Management Plan that has not been updated to reflect the 2011 Interim MRA (Office of Cutter Forces, 2012).

(j) The 2012 Manpower Requirements Decision is the official CG-1 recommendation to the Deputy Commandant of Operations (DCO) to update the NSC crew size to 126 (U.S. Coast Guard, 2012).

(k) The Integrated Logistics Support Plan (ILSP) outlines the NSC support activities to sustain the mission capability. The initial version of the ILSP is unavailable, but version two addresses crew accommodations to support 126 personnel (U.S. Coast Guard, 2017). This 2013 document is the first official reference to logistical accommodations and suggests a critical manpower consideration wasn't formalized before this date.

4. Produce/Deploy and Support (PD&S) Phase (2014-present)

The historical search reveals 17 NSC manpower-related program documents between 2014 and 2021, as depicted in green highlight in Table 6.

Table 6. PD&S Phase Documents

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
2014	Direct WMSL Support Manpower Requirements Analysis	Yes	No	Yes	Yes	Yes	No
2014	Program Management Plan V1.1	*Unable to locate this document*				Yes	No

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
2014	Initial Operational Test and Evaluation Plan	Yes	No	No	Yes	No	No
2014	Operational Test Report	Yes	No	No	Yes	No	No
2015	Direct WMSL Support Manpower Requirements Decision	Yes	No	Yes	Yes	Yes	No
2015	Risk Management Plan update	Yes	Yes	Yes	Yes	Yes	Yes
2015	Decision Memo - NSC crew increase	Yes	Yes	Yes	Yes	Yes	Yes
2016	NSC GAO Report	Yes	No	No	No	NA	No
2016	Test and Evaluation Master Plan V3.0	Yes	No	No	Yes	Yes	No
2017	Acquisition Program Baseline update	Yes	No	No	No	Yes	No
2017	Integrated Logistics Support Plan V2.0	Yes	No	Yes	Yes	Yes	Yes
2017	Program Management Plan V1.2	No	No	No	No	Yes	No
2020	Operational Requirements Document V3.0	Yes	No	Yes	Yes	Yes	No
2021	Cost Estimating Baseline Document V1.0	Yes	Yes	Yes	Yes	No	Yes
2021	Life Cycle Cost Estimate V3.0	Yes	No	Yes	Yes	No	No
2021	Post Implementation Review	Yes	No	Yes	Yes	Yes	No

Date	Document Name	(Manpower relevance)	(Deviation)	(Traceability)	(HSI activity)	(Correct phase)	(CSP impact)
2021	NSC Program Manager Charter	No	No	No	No	No	No

Three of the 17 documents met the criteria for further consideration within the scope of our study. In addition, all three documents are publicly available and discussed in Chapter V. The initial version of the Cost Estimating Baseline Document (CEBD) was not published during the HSI-related activity phase per MSAM guidance, depicted with a red highlight.

1. The updated RMP was referenced in the previous phase and contained similar information to the 2008 RMP with additional manpower-relevant information from the updated Interim MRA. Although this is a later version, it is essential to note that this risk tradeoff analysis is occurring beyond delivering 4 NSCs.

2. The 2015 NSC crew increase decision memorandum is DCO's final decision to increase the NSC's PAL to 126 based on the 2011 MRA and CG-1's 2012 recommendation (Michel [VADM, DCO], 2015).

3. The initial publishing date of the NSC's Cost Estimating Baseline Document (CEBD) is unclear, but the historical data search revealed a CEBD Version 1.0 dated 08 March 2021. The MSAM states that the CEBD "must be updated before each ADE and as necessary to support updates to the program's LCCE" (U.S. Coast Guard, 2021, p. 2). Therefore, we assume that without prior documentation of a previous CEBD, this cost estimating baseline was created after the recommended Analyze and Select acquisition phase.

B. NSC MANPOWER LIFE CYCLE WALL CHART

The NSC Manpower Life cycle Wall Chart (Appendix B) visually depicts the historical document results and is meant to supplement the analysis. We capture our critical findings in this single reference to encompass the multi-faceted research. We can extract several major takeaways from the wall chart demonstrating the misalignment between the NSC program acquisition process and current USCG acquisition HSI requirements. The visual comparison of NSC hull production timelines and NSC program documentation (or lack thereof) warrant focused discussion for consideration by future program managers and those with a vested interest in human performance in major acquisitions. Additionally, we can reflect on the timeline of evidence and make inferences about the importance of iterative manpower-related estimates and analyses on program life cycle costs.

We divide the chart into "swim lanes" stacked and compare them against a 20-year timeline of the NSC program's life cycle. Figure 9 is the first swim lane titled NSC Program Events, comprised of the NSC production and delivery milestones. The 2007 acquisition reform and the transition from ICGS to USCG as the LSI of the NSC program splits the initial production and delivery dates of the first three NSCs. We can deduce that the complete transformation of the USCG's acquisition process will critically impact the NSC's cost, schedule, and performance outcomes. The next chapter will discuss the production timeline of the first three NSCs and the relation to the USCG acquisition reform indicated by the red square in the figure.

Figure 9. NSC Production and Delivery Milestones

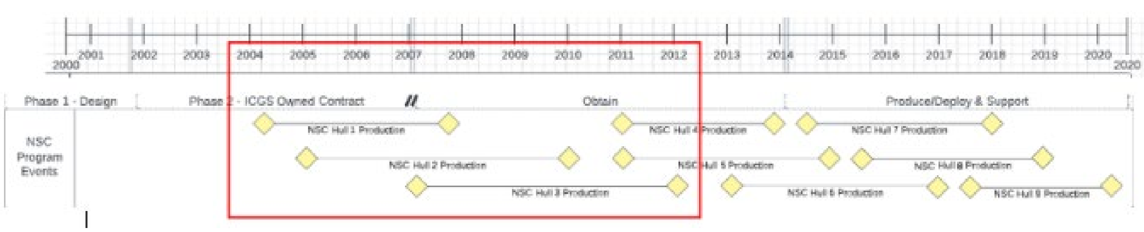


Figure 10 is the second swim lane titled Key NSC Program Documents and represents the historical documents referenced in the previous section for further consideration. When comparing the design and production timelines of the early NSCs, there is a substantial lack of tracing and documentation of NSC program events. The lack of documentation solidifies some negative oversight feedback discussed in previous chapters. Furthermore, after completing acquisition reform, there is a second gap in program documentation, suggesting little manpower validation has been performed in recent years to reconfirm manpower requirements. A critical focal point in the next chapter will discuss the lack of documentation found in the early phase of production and the current production phase indicated by the two red squares in the figure.

Figure 10. Key NSC Program Documents

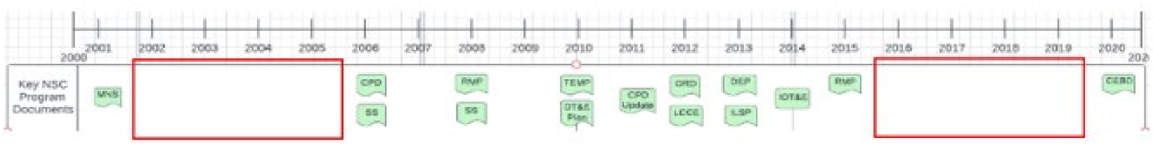


Figure 11 shows the comparison of manpower-related decisions against current manpower-related best practices. HSI best practices are taken from acquisition phase-related activities from the MSAM (2021). A retrospective analysis offers the opportunity to identify missed decision opportunities with more information than was readily available at the time of the decision. However, our research intends to capitalize on missed opportunities by comparing the published HSI best practices with incomplete or unperformed HSI-related activities. The critical takeaway discussed in the next chapter is the absence of several manpower-related activities that could have prevented unplanned changes during the NSC's acquisition life cycle. The red square in the figure indicates an example of one such absence.

Figure 11. Manpower Decisions Versus HSI Best Practices

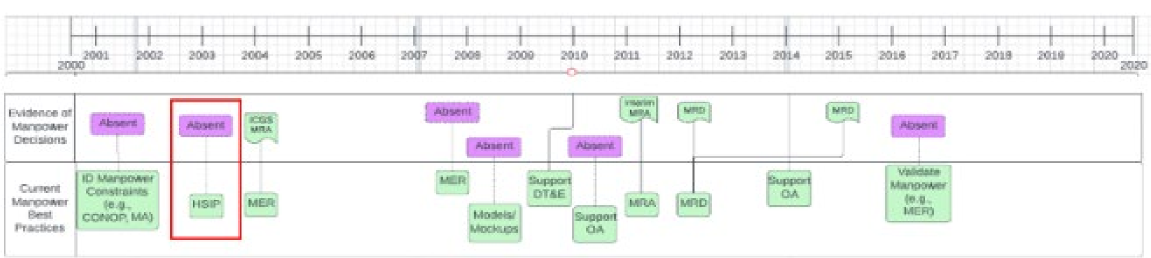
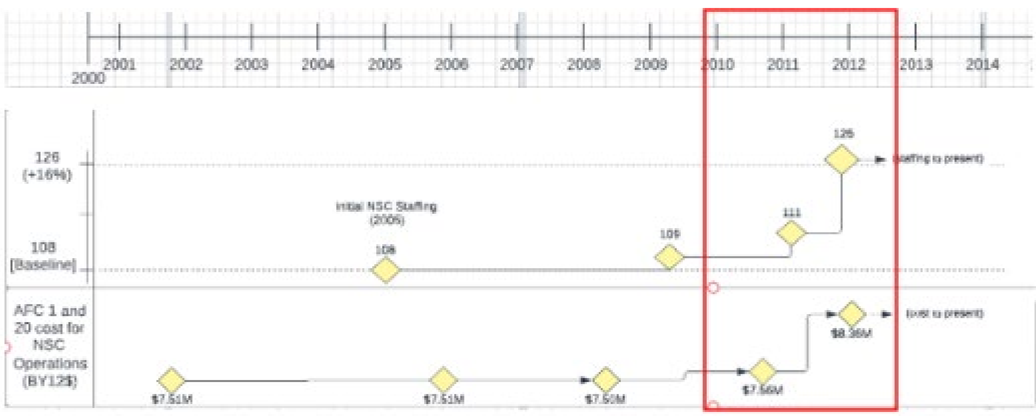


Figure 12 outlines the NSC manpower changes and the associated changes to AFC 1 and 20 costs for NSC operations. The wall chart shows an objective $1M annual increase in costs associated with manpower alone. However, the initial minimal manning tradeoff decision and the subsequent correction directly impact other HSI-related domain costs, like training and safety. Therefore, our discussion's focal point in Chapter V will be the significant cost increase linked to staffing changes, what caused the increase, and the cost impacts on other HSI domains.

Figure 12. NSC Staffing Level Changes



C. CHAPTER SUMMARY

In Chapter IV, we presented the results of the historical document search and described the methodological approach applied for further manpower-relevant consideration within the scope of our research. We briefly addressed each document, foreshadowing any manpower-related impacts on the NSC program life cycle. Furthermore, we presented snapshots from the NSC Life cycle Wall Chart (Appendix B) and introduced focus points in preparation for later discussion. We revisit our research questions and outline key takeaways in the next chapter.

V. DISCUSSION

The complexity of a multi-faceted system-of-systems acquisition can be a challenge for any program. Additionally, it's clear that during the early planning phases of IDS, the USCG identified the mission need to recapitalize an aging fleet of aircraft and surface vessels and realized the risks associated with such a large acquisition undertaking. At the time, the USCG perceived the best option was to outsource the IDS program to a proven LSI, giving way to Lockheed Martin and Northrop Grumman (previously referred to as ICGS). We found no evidence of purposive malintent. However, it does appear that oversight was minimal, and requirements developed by the USCG, particularly for the NSC, were general and vague. September 11, 2001, and the service's shift from the Department of Transportation to the Department of Homeland Security also introduced new mission requirements, altering the mindset from replacing old assets with similar capability assets to replacing old assets with technologically improved, more capable assets.

In reviewing NSC program documents while accounting for the evolution of USCG acquisitions and the adoption of an HSI program, we can see the value of HSI considerations based on significant program changes and impacts on life cycle costs. Identifying manpower updates provides one objective and measurable way to show why HSI considerations are essential. Next, we will review our research questions and discuss some of our critical findings of the historical data search compared to standard HSI guidance, and focuses on NSC manpower decision-based impacts.

A. RESEARCH QUESTIONS REVIEW

This section details the four research questions that our research sought to answer.

a. What manpower-related decisions occurred during the NSC program?

Two significant manpower decisions affected the NSC personnel allowance list (PAL). The first resulted from the ICGS MRA in 2005, and the second was the USCG's interim MRA in 2011. As previously mentioned, the ICGS MRA was not publicly accessible (NOTAL); therefore, we cannot analyze the MRA methodology. However, we assume that the driving factor behind NSC manpower-related decisions is some level of requirements or task analysis. A task analysis is critical in systematically calculating human interaction versus system demands (Lee et al., 2017). In their book, *Designing for People* (2017), Lee and colleagues provide the following taxonomy for conducting a task analysis:

1. Define the purpose and identify the required data;
2. collect task data;
3. interpret task data; and,
4. innovate from task data. (Lee et al., 2017, p. 27)

Program managers and IPTs can make informed tradeoff decisions during a program's early phases using successful task analyses. The Coast Guard's Offshore Patrol Cutter (OPC) program is a prime example of promoting task analyses to shape system requirements. Fortunately, OPC design and production efforts began in 2013 after the USCG established the new Acquisition Directorate, which entailed a revamped procurement plan, including the initiation of detailed requirements (i.e., task) analysis. (Philpott & Weber, 2015). Unfortunately, based on the original mindset of replacing legacy assets with similar ones and ambiguous requirements, ICGS's MRA was most likely developed based on observation without consideration of new applicable technology systems and post-9/11 mission-driven requirements.

Furthermore, there is no evidence of additional manpower analyses through production and delivery of the first three NSCs. Therefore, the original manpower estimate of 108 remained relatively the same until the USCG conducted its own MRA in 2011. The USCG's MRA analyzed the functional workloads of operational NSC crews and found that they significantly exceeded their workload capacities, resulting in a crew size increase to 126. There were several other minor manpower-related decisions, but the major changes stemmed from these two MRAs.

b. When did NSC staffing levels change during the NSC program?

Appendix C highlights the NSC staffing level changes. FY09 saw an increase in crew size from 108 to 109. This change was driven by two Chief Warrant Officer leadership opportunities and "optimal leadership-to-worker" ratios (U.S. Coast Guard, 2009, p. 1).

FY11 saw an increase from 109 to 111, adding two billets to support Sensitive Compartment Information Facility (SCIF) operations and maintenance (CG-1B3, 2011). The FY09 change was relatively insignificant, resulting from leadership desires, but the FY11 change was a little more forecasting of the NSC's manpower deficiencies. FY12 saw an increase from 111 to 126. The 2011 USCG MRA drove the 16% increase from FY11 to FY12 (CG-1B3, 2011).

c. *Did manpower-related events, analyses, and decisions during the NSC program align with current HSI best practices?*

The USCG acquisition management capabilities at the time of IDS inception were lacking simply due to a limited service size. The decision to outsource LSI for IDS to ICGS was most likely the right decision for the SOS acquisition. Unfortunately, NSC program documents were generated external to the USCG, and, with what seems to be limited USCG oversight, many of the early program documents are not archived. Therefore, the lack of evidence limits research efforts and traceability, which is essential to produce valuable lessons learned for future programs. Furthermore, any HSI best practices recommended during the early phases of the NSC program cannot be confirmed. For example, the first CPD detailing key performance parameter requirements wasn't drafted until 2006, after two NSCs were already in production. There is no evidence of HSI-related tradeoffs in the form of HSI planning, manpower estimates or constraints, or operational assessments that support NSC manpower design until the ICGS MRA was conducted during the same year the first NSC was produced. The evidence suggests that the NSC was designed without knowing the optimal crew size to support mission requirements.

After the USCG revamped its acquisition management program with the establishment of CG-9, the service took a round turn on dedicated policy guidance that supported HSI consideration early and iteratively throughout major program acquisition life cycles. Evidence suggests full investment from leadership, establishing the CG-1B3 HSI program and empowering technical authorities, and adopting a disciplined acquisition strategy grounded in systematic processes and transparency. However, there is still room for improvement, as manpower validation efforts are not evident since operational testing in 2014.

d. *Can linkages be drawn between manpower-related decisions and NSC program cost, schedule, and performance deficiencies?*

The lack of manpower-related evidence and deferred decision-making to ICGS during the early phases of the NSC program, particularly in analyzing and estimating NSC manpower requirements, provides a telling story of a small service with minimal large-scale acquisition experience. The trace for NSC program deficiencies starts with a concept of optimal manning perceived to save on long-term costs by supplementing performance requirements with new technology and automation. In addition, the need to replace aging assets during a time of heightened homeland security added pressure to a demanding schedule that promised near-term delivery of a modernized surface fleet. Based on the totality of circumstances at the time and what appears to be a hidden tradeoff of manpower performance for an immediate return on cost and schedule, the linkage of unforeseen requirements continued.

The Office of Cutter Forces (CG-751) prompted the 2011 Interim MRA, suspecting a suboptimal crew size compared to the required workload demands. The MRA found that workload demands exceeded capacity by 34%, suggesting suboptimal performance and overworked crew members (CG-1B3, 2011). Human factors and mishap analyses are beyond the scope of our research. However, evidence suggests a negative correlation between workload demands and performance in the maritime domain (Grech et al., 2008). What is made clear in our research is a significant annual increase in manpower costs. Appendix D shows an approximate $1M increase in annual NSC costs per ship based on manpower alone. This factor doesn't include logistical, training, and engineering changes required to support the additional manpower, but an increase in unplanned costs can be deduced. An accurate manpower estimate with USCG oversight and engagement may have assisted decision-makers in early HSI-related tradeoffs and prevented some of these cost factors that led to program cost overruns.

B. HISTORICAL DOCUMENT DISCUSSION

The previous section focused on the two MRAs found during our research. However, there are several other manpower-relevant documents worth discussing. The

CPD was initially part of the Joint Capabilities Integration and Development System (JCIDS) process used to identify requirements approved for production (AcqNotes, n.d.). Additionally, this document is typically prepared during the Engineering and Manufacturing Development (EMD) phase (Phase 3) of the DOD's Major Capabilities Acquisition pathway. However, the USCG appears to have drafted the CPD in place of the MSAM-directed Operational Requirements Document (ORD) that should be prepared during the Need and Analyze/Select phases (Phase 1 and 2) before production began on the first NSC. This discrepancy highlights the error in generating vague performance specifications for ICGS execution when designing the NSC, which resulted in production of the first three NSCs without clear requirements that would have been specified in the ORD. Furthermore, the initial ORD was published in 2012, after three NSCs were already delivered and operational. Therefore, we deduce that the first three NSCs were produced and delivered without specific quality requirements.

A second significant cost factor that led to NSC program deficiencies was a poor grasp of cost estimation. The Congressional Research Service reported substantial increases in annual budget requests for IDS from 2002–2011, increasing annually from \$320M to \$1,266M over the nine years (O'Rourke, 2012). Programs should develop an accurate Life Cycle Cost Estimate in the Analyze/Select phase to assist decision-makers in tradeoff discussions (U.S. Coast Guard, 2021). The NSC LCCE includes operating expenses like manpower (operations, maintenance, and training) which is a significant annual cost driver worth \$8.4M per ship (Acquisition Resource Management, Business Management, and Metrics, 2012). 2012 was the first year that the USCG published an LCCE, inferring a lack of budgetary oversight and manpower-related impacts.

Logistics management is a critical factor in performance and cost when increasing crew size post-NSC design. For example, a ship built to accommodate a crew of 108 may look significantly different than a ship built to accommodate a crew of 126. However, the USCG didn't establish an Integrated Logistics Support Plan (ILSP) supporting and sustaining crew activities until 2013. Accurate ISLP preparation and development may have alluded to some of the sustainment and workload capacity deficiencies identified in the 2011 MRA.

C. NSC MANPOWER LIFE CYCLE WALL CHART DISCUSSION

The NSC Manpower Life Cycle Wall Chart (Appendix B) provides an overview of NSC production timelines, manpower-related program documents, manpower-related best practices, and staffing changes. While its usefulness as a planning tool is limited, it can be analyzed and adapted to identify a timeline of linkages. Particularly interesting is the production timeline of the first few NSC hulls and the lack of manpower-related considerations. The two MRAs directly impact manpower-related decisions, with minimal manpower changes occurring beyond those two documents. Furthermore, we found no further evidence of official manpower estimates or manpower validation efforts. The lack of evidence could simply mean the 2011 Interim MRA was highly accurate, and no updates are necessary. However, according to the MSAM's HSI best practices, additional periodic manpower estimates should exist. Additionally, the lack of manpower changes since 2012 suggests that if a proper USCG-driven (end-user) MRA versus an ICGS MRA had been performed before the production of the first NSC, manpower-related changes may have been minimal. We can only speculate how the NSC events could have unfolded. Still, the NSC Manpower Life Cycle Wall Chart visually represents how the 2007 acquisition reform positively impacted the program and generates thoughtful insight into how early NSC program decisions may have been different if the new acquisition directorate had afforded guidance.

D. CHAPTER SUMMARY

In Chapter V, we reviewed our research questions and discussed our findings based on results from the historical data collection. While few identified causative factors directly impact NSC programmatic deficiencies, we present data to support a deductive inquiry that raises questions about the HSI process. Furthermore, the discussion applauds USCG leadership's embrace of acquisition reform and HSI insertion into MSAM activities. Finally, the overall successes of the NSC program in mission performance under current manpower requirements merit the service's ability to adapt and empower its technical authorities.

VI. SUMMARY, CONCLUSION, AND FUTURE RESEARCH

A. SUMMARY

The USCG's unprecedented attempt at large-scale replacement of multiple service assets using a system-of-systems approach proved beyond the USCG's pre-acquisition reform capabilities. With minimal experience and generalized baseline requirements before 2006, outsourcing the IDS program appeared on the surface as the USCG's best option to complete the acquisition and integration of a renewed fleet, including the focus of our research – the NSC. Unfortunately, the USCG's pre-2006 acquisition capabilities were not well-suited to undertake such an endeavor. Instead, they trusted much of the concept design and planning of the NSC to the outsourced lead systems integrator, ICGS, and provided little oversight as ICGS progressed through early design and production (Government Accountability Office, 2009).

According to the DHS OIG, IDS was a "$24 billion, 25-year acquisition program and the largest acquisition project in Coast Guard history" (Department of Homeland Security Office of Inspector General [DHS OIG], 2007, p. 2). As such, one can imagine how the sheer size of the IDS acquisition program would challenge even the most seasoned organizations. The USCG's HSI program took shape in the shadow of this massive undertaking and would take nearly a decade to become fully integrated in USCG acquisitions processes. As a result, IDS decision-makers likely made tradeoff decisions based on an incomplete understanding of NSC HSI issues, which may have contributed to a 200% increase in NSC production costs, from $322.2 million to $670 million, in less than five years (Brown et al., 2010).

Our historical case study of the NSC program focuses on the manpower HSI domain and identifies a critical gap in manpower analyses before ISLP preparation noted in Chapter V. The GAO underscored this gap in a 2009 report on the NSC:

> The Coast Guard has developed an interim support plan to guide logistics planning for the NSC until the Integrated Logistics Support Plan [ISLP], but the interim plan lacks MSAM-required details, such as maintenance planning and supply support, that are critical in determining the number of people and supplies the Coast Guard will

> need to support the NSC. (Government Accountability Office, 2009, p. 38)

As an orienting acquisitions artifact, the ISLP directs facilities and infrastructure planning assessments, including personnel berthing elements, service requirements for sewage, potable water, air conditioning, heat, etc. (U.S. Coast Guard, 2018). The ISLP also references the ship work breakdown structure (SWBS) that would have been defined early in the project's management and systems design process. An SWBS is the Navy shipboard design standard and includes outfits and furnishings to support living and working spaces, personal stowage space, and general purpose areas, e.g., galley (Naval Sea Command, 2014). Furthermore, the Naval Sea Command (NAVSEA) provides detailed habitability design criteria for new ships. While direct linkages between manpower assumptions and specific NSC design elements are elusive, we can safely deduce that the hotel services design for a ship supporting 108 crewmembers is significantly different from that of 126 crewmembers (Naval Sea Command, 2016). Critical design issues that arise from increased crew size include berthing and rack space, galley and messdeck size, food storage capacity, potable water tank size, reverse osmosis plant accommodations, etc. Manpower changes directly impact these types of habitability considerations. Finally, if engineering or design changes are required, a fixed NSC budget means these unplanned program costs present a critical challenge for NSC program sponsors.

A holistic assessment of the IDS acquisition strategy was beyond the scope of our research. However, the post-reform corrections in the NSC program offer essential evidence of improvement in acquisition processes, including HSI. Today, CG-9 claims that the USCG Acquisition Directorate "manages a multi-billion dollar investment portfolio to recapitalize the service's fleet of surface, aviation, and C4IT assets and capabilities" (*Acquisition Directorate History*, n.d., para. 1). Furthermore, the acquisition reform provided an opportunity for the service to publish HSI-related guidance and language in new acquisition policy used to build our research. Unfortunately, these changes did not occur until well into NSC production (i.e., NSC Hull 3).

B. CONCLUSION

Our research aims to reinforce that successful system acquisition requires HSI foresight provided by HSI domain leaders and practitioners rather than identifying NSC program failures or making hindsight judgments. As an organization, the USCG has taken great strides in acquisition management strategies, including deliberate, early, and iterative HSI engagement. Moreover, clear evidence of improved processes and key policy shows that HSI consideration is a priority for program managers and leadership.

At the acquisition enterprise level, the USCG and other organizations would be wise to leverage lessons learned from other services. HSI is a continued point of emphasis in the Department of Defense. This year, the DOD published Human Systems Integration in Defense Acquisition, DODI 5000.95, addressing HSI domains, integration, implementation, and reporting in defense acquisitions (Office of the Under Secretary of Defense for Research and Engineering, 2022). Before becoming a standalone instruction, the information in DODI 5000.95 was merely an enclosure to a separate DOD instruction, with vague guidance and general expectations to incorporate HSI into program acquisitions. The descriptive language in DODI 5000.95 now provides program managers with more explicit expectations to ensure that HSI is incorporated early and iteratively into all acquisition programs.

Specific to the manpower domain, the USCG can learn from the faults discovered in the USN's optimal manning strategy. For example, a 2017 GAO report underscored the adverse impacts of optimal manning on ship readiness and the importance of a rigorous manpower analysis. GAO stated the following:

> The Navy's process to determine manpower requirements—the number and skill mix of sailors needed for its ships—does not fully account for all ship workload. The Navy continues to use an outdated standard workweek that may overstate the amount of sailor time available for productive work. Although the Navy has updated some of its manpower factors, its instruction does not require reassessing factors to ensure they remain valid or require measuring workload while ships are in port. Current and analytically based manpower requirements are essential to ensuring that crews can maintain readiness and prevent overwork that can affect safety, morale, and retention. Until the Navy makes needed changes to its factors and instruction used in determining manpower

> requirements, its ships may not have the right number and skill mix of sailors to maintain readiness and prevent overworking its sailors. (Government Accountability Office, 2017, p. 1)

The U.S. Army, U.S. Air Force, and U.S. Navy have established HSI programs with pamphlets and handbooks that aid in planning and executing HSI activities, e.g., Army Pamphlet 602-2, the Air Force HSI Handbook, etc. The USCG utilizes these tools and leverages the MSAM to promote HSI activities, but these tools lack tailored DHS or USCG guidance. Therefore, we recommend establishing an HSI standalone doctrine aligning with sister service HSI program management practices.

At the program level, we recommend early integration of an HSI team to assist in developing an HSI strategy and drafting the HSI plan (HSIP). HSI team responsibilities include:

1. Identify high-cost drivers that increase life cycle costs and decrease system performance;
2. Identify HSI requirements and limitations;
3. Develop risk mitigation strategies;
4. Assist with HSI considerations in draft requests for proposals (RFPs);
5. Serve on source selection and IPTs;
6. Review relevant system documents;
7. Identify Manpower KPPs;
8. Identify measurable HSI KPPs and KSAs; and,
9. Draft and update HSIP for Acquisition Decision Events (ADEs). (U.S. Air Force, 2009, pp. 33–34)

The MSAM advises HSI Division engagement as early as the Need acquisition phase., i.e., post-materiel decision. However, we suggest future USCG program sponsors, PMs, and IPTs engage with the HSI Division as early as identifying a capability gap to stave-off strategies like "Optimal Manning." In addition, the HSI Division offers extensive expertise in tradeoff analyses, including Doctrine, Organization, Training, materiel, Leadership, Personnel, Facilities, and Policy (DOTmLPF-P) change considerations and aligning human capabilities and limitations with technological affordances and constraints.

The NSC program is and continues to be a complex system of systems within itself. Those who operate, maintain, and support the ship are as critical of a system as any technological system onboard. Therefore, the program's success depends on appropriate requirements management, HSI-activity planning, and the continuous validation of meeting those requirements and needs of the users in an ever-changing socio-technical environment.

C. RECOMMENDATIONS FOR FUTURE RESEARCH

The resilience and adaptability of Coast Guard men and women often obscure poor HSI-related tradeoff decisions during the early phases of major system acquisitions. Conversely, even if a program adequately plans and integrates HSI-related activities, there is rarely direct evidence of its added value as the fruits of astute HSI tradeoffs tend not to be seen. In both cases, program leadership is left to trust the HSI process with little feedback on its efficacy. What makes a dedicated HSI case study so valuable is the ability to draw out explicit links between HSI-related tradeoff decisions and their consequences to cost, schedule, and performance.

The first step in conducting an HSI case study is to realize that all HSI domains are intertwined and that the decisions in one domain will inevitably impact another (i.e., tradeoffs). As a result, an HSI case study can quickly expand beyond its intended scope. This is a microcosm of the challenge faced by HSI practitioners; there is a general belief that the HSI field has value, but explicitly linking an HSI action with a direct impact requires time and resources that are rarely available. Therefore, the first recommendation to future researchers is to carefully scope based on research constraints and attack 3–4 specific research questions that can be answered with data (i.e., interviews, archived research, walkthroughs, task analyses, etc.). Under typical circumstances in case study research, the data are captured in qualitative and quantitative forms. Both types of data are beneficial to case study research and "should be combined to compensate for their mutual and overlapping weaknesses" (Kelle, 2006, p. 294)

Once the data is in hand, the next step is to illustrate the focused takeaways from our research. This requires considerable time and thought, as the representation should be the most referenced part of the case study. There are myriad sources on conducting case study research and performing process tracing, introduced earlier. However, few taxonomies exist on performing an HSI-related case study and synthesizing quantitative and qualitative information in a useful way. Furthermore, in addition to our earlier defined research questions, the researcher must address the concept of descriptive inference. A researcher may not always have all the evidence to establish direct causality. Yet, sometimes, a lack of evidence can tell a story. The ability to compile artifacts and produce a timeline of events can lead to snapshots of missed opportunities. For future HSI researchers, the NSC Manpower Life cycle Wall Chart (Appendix B) provides a valuable tool that can be manipulated and reproduced to identify gaps or delays in HSI activities and infer impacts to program performance.

In conclusion, we hope that our research will guide future program managers and HSI researchers in program management endeavors. Follow on case study research on the NSC should include further examination of the financial impacts of NSC costs, schedules, and performance outcomes associated with other HSI domains. This evidence and our research efforts allowed logical connections, but a closer look at the SWBS and comparison with the NSC engineering changes might produce a monetary value of missed HSI activities. Additionally, the consequences of missed HSI activities reach beyond one domain. Retrospective case studies of the NSC's training, environmental safety and occupational health (ESOH), and habitability challenges would make interesting studies. They would undoubtedly overlap with some of the manpower issues presented in our study and provide further validation for HSI engagement.

Human integration in complex systems should not be taken lightly, especially as systems become more complex, capable, and autonomous. HSI practitioners are needed more now than ever to keep pace. The demand for early and iterative HSI involvement in systems design and acquisitions will persist as long as human operators, maintainers, and supporters are involved, which is why HSI must be employed proactively and continuously to optimize total system performance.

APPENDIX A. CHRONICLED DOCUMENTS

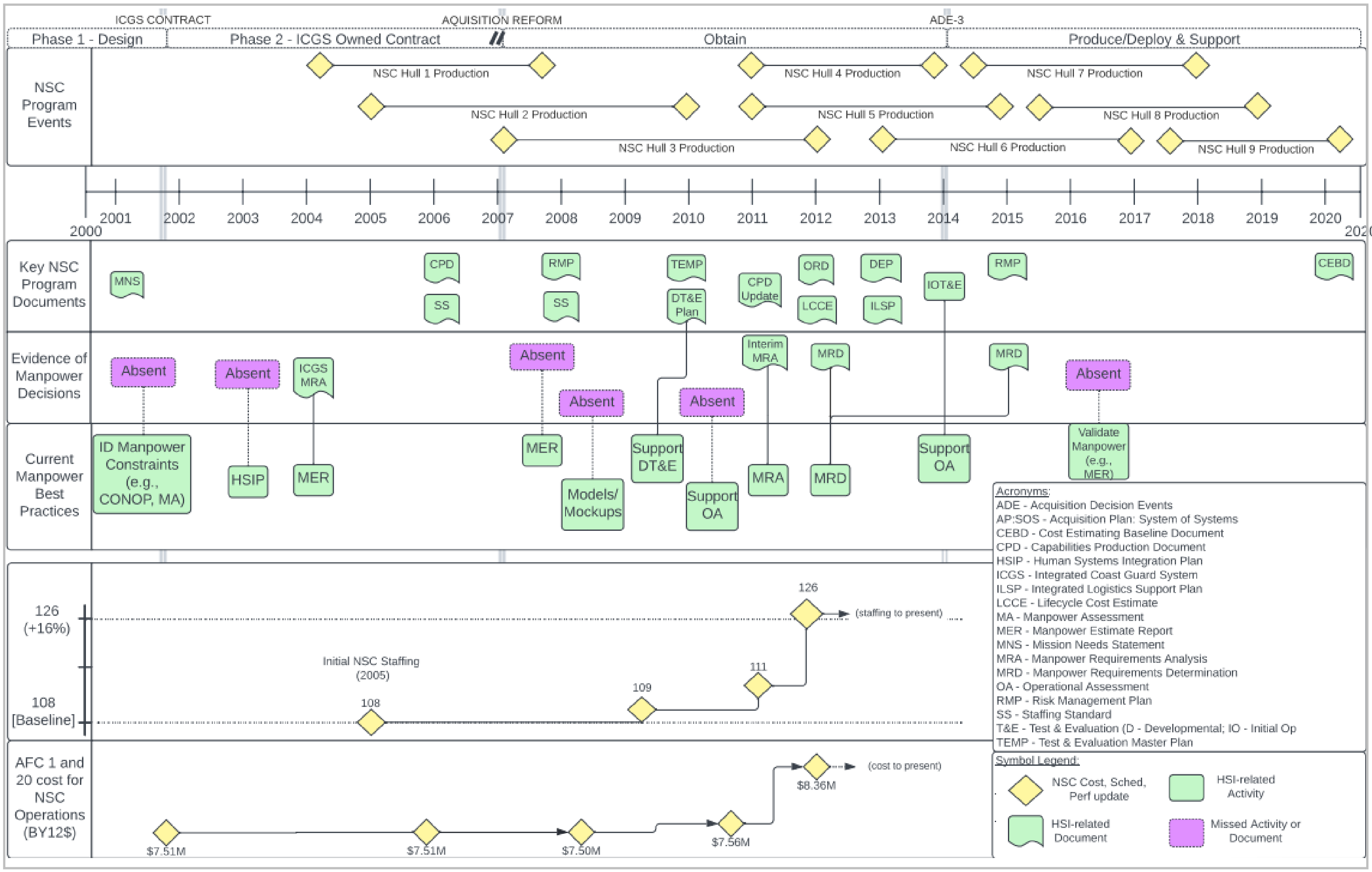
		Research Question 1	Research Question 2		Research Question 3		Research Question 4
Date	Document Name	Manpower-relevant information	Deviation from previous Manpower-related information	Is this document traceable to previous documents?	Currently prescribed HSI Activity	Is this in the correct acquisition phase?	Does this have a cost, schedule, or performance impact?
1995	Mission Analysis Report	Yes	No	No	No	Yes	No
1996	IDS Mission Needs Statement V1.0	Yes	No	No	Yes	Yes	No
2001	Acquisition Plan	No	No	No	No	Yes	No
2002	Integrated Deepwater Report	Yes	No	No	No	Yes	No
2005	IDS Mission Needs Statement V2.0	Yes	No	No	Yes	Yes	No
2005	Manpower Requirements Analysis (ICGS)	*Unable to locate this document*				Yes	Yes
2005	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No
2006	Capability Production Document	Yes	Yes	Yes	Yes	Yes	Yes
2006	NSC In-port MX Manpower Requirements Analysis	Yes	No	Yes	Yes	Yes	No
2006	Staffing Standard for NSC	Yes	Yes	Yes	Yes	Yes	Yes
2006	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No
2007	Early Operational Assessment	*Unable to locate this document*				Yes	Yes
2008	IDS Alternative Analysis	Yes	No	No	Yes	No	No
2008	Acquisition Program Baseline	Yes	No	No	No	Yes	No

		Research Question 1	Research Question 2		Research Question 3		Research Question 4
Date	**Document Name**	**Manpower-relevant information**	**Deviation from previous Manpower-related information**	**Is this document traceable to previous documents?**	**Currently prescribed HSI Activity**	**Is this in the correct acquisition phase?**	**Does this have a cost, schedule, or performance impact?**
2008	NSC Risk Management Plan V1.0	*Unable to locate this document*				No	Yes
2008	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No
2009	Decision Memo - Staffing Standard Change NSC	Yes	Yes	Yes	Yes	Yes	Yes
2009	Alternative Analysis Study Plan	Yes	No	No	Yes	No	No
2009	Configuration Management Plan V1.0	*Unable to locate this document*				No	No
2010	DT&E Plan	Yes	No	No	Yes	Yes	No
2010	Operational Assessment (ref TEMP V3.0)	*Unable to locate this document*				Yes	Yes
2011	Interim Manpower Requirements Analysis	Yes	Yes	Yes	Yes	Yes	Yes
2011	Configuration Control Board Charter	No	No	No	No	No	No
2011	Capability Production Document update (V2)	Yes	Yes	Yes	Yes	Yes	Yes
2011	Capability Production Document V2.0 brief	Yes	Yes	Yes	Yes	Yes	Yes
2011	Deepwater GAO Report	Yes	No	No	No	NA	No
2012	Deepwater Congressional Research Report	Yes	Yes	No	No	NA	No
2012	Program Management Plan V1.0	*Unable to locate this document*				No	No

		Research Question 1	Research Question 2		Research Question 3		Research Question 4
Date	**Document Name**	**Manpower-relevant information**	**Deviation from previous Manpower-related information**	**Is this document traceable to previous documents?**	**Currently prescribed HSI Activity**	**Is this in the correct acquisition phase?**	**Does this have a cost, schedule, or performance impact?**
2012	Operational Requirements Document V2.0 (Initial ORD)	*Unable to locate this document*				Yes	Yes
2012	Life cycle Cost Estimate V1.0		Yes	Yes	Yes	No	Yes
2012	NSC Deployment Plan V1.0	Yes	Yes	Yes	Yes	Yes	Yes
2012	Systems Engineering Life cycle Plan (V1.0)	No	No	No	Yes	No	No
2012	CG-1 Manpower Requirements Document Memo	Yes	Yes	Yes	Yes	Yes	Yes
2013	Acquisition Decision Event - 3	No	No	No	No	Yes	No
2013	Integrated Logistics Support Plan V1.0	*Unable to locate this document*				No	Yes
2013	Configuration Management Plan V2.0	Yes	No	Yes	Yes	No	No
2013	WMSL Concept of Operations V1.0	Yes	No	No	Yes	No	No
2014	Direct WMSL Support Manpower Requirements Analysis	Yes	No	Yes	Yes	Yes	No
2014	Program Management Plan V1.1	*Unable to locate this document*				Yes	No
2014	Initial Operational Test and Evaluation Plan	Yes	No	No	Yes	No	No
2014	Operational Test Report	Yes	No	No	Yes	No	No
2015	Direct WMSL Support Manpower Requirements Decision	Yes	No	Yes	Yes	Yes	No
2015	Risk Management Plan update	Yes	Yes	Yes	Yes	Yes	Yes
2015	Decision Memo - NSC crew increase	Yes	Yes	Yes	Yes	Yes	Yes

		Research Question 1	Research Question 2		Research Question 3		Research Question 4
Date	**Document Name**	**Manpower-relevant information**	**Deviation from previous Manpower-related information**	**Is this document traceable to previous documents?**	**Currently prescribed HSI Activity**	**Is this in the correct acquisition phase?**	**Does this have a cost, schedule, or performance impact?**
2016	NSC GAO Report	Yes	No	No	No	NA	No
2016	Test and Evaluation Master Plan V3.0	Yes	No	No	Yes	Yes	No
2017	Acquisition Program Baseline update	Yes	No	No	No	Yes	No
2017	Integrated Logistics Support Plan V2.0	Yes	No	Yes	Yes	Yes	Yes
2017	Program Management Plan V1.2	No	No	No	No	Yes	No
2020	Operational Requirements Document V3.0	Yes	No	Yes	Yes	Yes	No
2021	Cost Estimating Baseline Document V1.0	Yes	Yes	Yes	Yes	No	Yes
2021	Life Cycle Cost Estimate V3.0	Yes	No	Yes	Yes	No	No
2021	Post Implementation Review	Yes	No	Yes	Yes	Yes	No
2021	NSC Program Manager Charter	No	No	No	No	No	No

APPENDIX B. NSC MANPOWER LIFE CYCLE WALL CHART



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APPENDIX C. STAFFING CHANGES

Ship Crew Per NSC			*FY06*	*FY09*	*FY11*	*FY12*	*FY14*	*FY15*	*FY16*	*FY17*	*FY18*	*FY19*	*FY20*
NSC Officer Crew													
CAPT			1	1	1	1	1	1	1	1	1	1	1
CDR			1	1	1	1	1	1	1	1	1	1	1
LCDR			2	2	2	2	2	2	2	2	2	2	2
LT			1	1	1	1	1	1	1	1	1	1	1
LTJG			3	3	3	3	3	3	3	3	3	3	3
ENS			4	4	4	5	5	5	5	5	5	5	5
Warrant Officer Crew													
W4			2	4	4	4	4	4	4	4	4	4	4
NSC Enlisted Crew													
E8			4	3	3	3	3	3	3	3	3	3	3
E7			11	10	10	10	10	10	10	10	10	10	10
E6			18	18	17	17	17	17	17	17	17	17	17
E5			22	22	23	28	28	28	28	28	28	28	28
E4			28	29	30	33	33	33	33	33	33	33	33
SN			8	8	8	12	12	12	12	12	12	12	12
FN			3	3	4	6	6	6	6	6	6	6	6
Totals			108	109	111	126	126	126	126	126	126	126	126

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APPENDIX D. AFC 1 AND 20 COSTS FOR NSC OPERATIONS (BY12$)

AFC 1 (Salary) and AFC 20 (PCS) for NSC Operations (BY12$)										
Individual	**FY06**	**FY09**	**FY11**	**FY12**	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**
$174,599	$174,599	$174,599	$174,599	$174,599	$174,599	$174,599	$174,599	$174,599	$174,599	$174,599
$150,626	$150,626	$150,626	$150,626	$150,626	$150,626	$150,626	$150,626	$150,626	$150,626	$150,626
$131,917	$263,834	$263,834	$263,834	$263,834	$263,834	$263,834	$263,834	$263,834	$263,834	$263,834
$111,338	$111,338	$111,338	$111,338	$111,338	$111,338	$111,338	$111,338	$111,338	$111,338	$111,338
$84,686	$254,058	$254,058	$254,058	$254,058	$254,058	$254,058	$254,058	$254,058	$254,058	$254,058
$66,028	$264,112	$264,112	$264,112	$330,140	$330,140	$330,140	$330,140	$330,140	$330,140	$330,140
$66,028	$132,056	$264,112	$264,112	$264,112	$264,112	$264,112	$264,112	$264,112	$264,112	$264,112
$103,711	$414,844	$311,133	$311,133	$311,133	$311,133	$311,133	$311,133	$311,133	$311,133	$311,133
$90,644	$997,084	$906,440	$906,440	$906,440	$906,440	$906,440	$906,440	$906,440	$906,440	$906,440
$77,299	$1,391,382	$1,391,382	$1,314,083	$1,314,083	$1,314,083	$1,314,083	$1,314,083	$1,314,083	$1,314,083	$1,314,083
$65,159	$1,433,498	$1,433,498	$1,498,657	$1,824,452	$1,824,452	$1,824,452	$1,824,452	$1,824,452	$1,824,452	$1,824,452
$53,291	$1,492,148	$1,545,439	$1,598,730	$1,758,603	$1,758,603	$1,758,603	$1,758,603	$1,758,603	$1,758,603	$1,758,603
$39,846	$318,768	$318,768	$318,768	$478,152	$478,152	$478,152	$478,152	$478,152	$478,152	$478,152
$36,249	$108,747	$108,747	$144,996	$217,494	$217,494	$217,494	$217,494	$217,494	$217,494	$217,494
$1,251,421	**$7,507,094**	**$7,498,086**	**$7,575,486**	**$8,359,064**	**$8,359,064**	**$8,359,064**	**$8,359,064**	**$8,359,064**	**$8,359,064**	**$8,359,064**

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