Contracted Versus Internal Assembly for Complex Products:
From Deepwater to the Acquisition Directorate in the U.S. Coast Guard

Contracting and Acquisition Series

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IBM Center for
The Business of Government

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Note: Author names are listed alphabetically.

Cover images courtesy of the U.S. Coast Guard.

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FOREWORD

On behalf of the IBM Center for The Business of Government, we are pleased to present this report, "Contracted Versus Internal Assembly for Complex Products: From Deepwater to the Acquisition Directorate in the U.S. Coast Guard," by Trevor L. Brown, Ohio State University; Matthew Potoski, Iowa State University; and David M. Van Slyke, Syracuse University.

Jonathan D. Breul

In many ways, this report is the sequel to the 2008 report by Professors Brown, Potoski, and Van Slyke. In that report, *The Challenge of Contracting for Large Complex Projects: A Case Study of the Coast Guard's Deepwater Program,* the authors used the Deepwater program to address the risks of acquiring complex products and identified how agencies can use effective contract design practices to mitigate those risks.

David A. Abel

This new report provides a timely update on what has happened to Project Deepwater since 2008, as it has transitioned to the U.S. Coast Guard itself serving as the lead system integrator (LSI), rather than a government contractor serving in that role. It is important to emphasize that the authors have not attempted to assess or evaluate the transition or Project Deepwater itself. Instead, the report focuses on providing lessons learned from the transition and offers three recommendations for contract management staff, agency executives, and congressional and executive-level policy makers.

A key message from the report is that the federal government will need to enhance its contracting capabilities (including the number of personnel working on acquisition) to manage the "assembly" of complex products. In the case of the U. S. Coast Guard, the last several years have been spent on enhancing both the capability and the size of CG-9, the Coast Guard Acquisition Directorate. One lesson from the Coast Guard experience is that federal agencies cannot easily turn the "switch" overnight from an external LSI to moving the LSI role in-house. The Coast Guard began the transition to CG-9 serving as the LSI in 2007, and it will not be completed until 2011. All new contracts for Deepwater assets, however, are now being awarded by CG-9.

The Coast Guard's Project Deepwater is still a work in progress, nearly 10 years after recognition by the Coast Guard that it needed an integrated procurement program to procure its future assets (helicopters, ships, information technology) and armaments. There is clearly much that the rest of the federal government can learn from the Coast Guard experience. In future years, an increased number of agencies will face the challenge of deciding whether to undertake "contracted versus internal assembly" for complex products. The report also concludes that the federal government now needs a new set of policies and tools to enable it to more effectively procure complex products.

It is clear that the federal government will continue to need to procure complex products (such as large information technology projects) in the years ahead. Lessons from the United States Coast Guard Deepwater Project, both positive and negative, can clearly be helpful to other agencies. We hope that this study will be useful and informative to leaders in both the executive and legislative branches of government as they wrestle with the challenge of acquiring complex products.

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EXECUTIVE SUMMARY

Many of the products the U.S. federal government buys require some assembly: Different component pieces have to be put together to produce the product. Government agencies face a choice:

- They can perform the task of assembling the product themselves; or
- They can turn to the market and hire an "integrator" or general contractor to assemble the product for them.

When a product is relatively simple—that is, the product's key attributes and performance requirements are easy to specify, and no specialized investments are required to produce the product—the decision is relatively straightforward. The acquiring agency can gather information about the costs and quality of different product components, along with the costs of internal assembly, relative to the costs and quality of fully assembled versions of the product. The agency can then decide whether to buy the complete, assembled product or buy the component parts and assemble them on its own.

When a product is complex, the decision is more complicated. The basic choice remains the same: Perform the assembly internally or buy it from the market. However, the characteristics of the product—difficult-to-specify attributes and performance standards and specialized investment requirements—impact not only the costs, but also the risk of a successful acquisition.

The upsides of hiring an organization—a "lead systems integrator"—to design, build, and integrate the product's assets into a coherent system are lower costs (by bundling related buys into a single acquisition) and access to technical capacity and expertise not available in-house. The downside is the "lock-in"—that is, the government agency may be the only purchaser of the product, and once the contract is let, the vendor is the only viable supplier, leaving each with no easy exit from the contract, limited information about costs and quality, and the engagement of a partner relatively unconstrained by competitive market pressures.

Alternatively, the government agency can buy the component parts and then integrate them into a coherent system on its own. The agency harnesses market competition to lower component costs, while still enjoying ownership of the process of tailoring the final product to meet its own specific needs. In this way, the agency eliminates the risk of lock-in to a lead systems integrator, but it does so at a price. Government assembly can be costly because it requires procurement staff to implement and manage contracts, along with integration staff to design the complex product and assemble the parts. This can be prohibitively expensive for a one-time purchase.

In this report, we identify the trade-offs between internal and contracted assembly through an analysis of the U.S. Coast Guard's Deepwater program—a major acquisition to upgrade and integrate the service's sea and air assets. Nine years into a projected 30-year Deepwater program, the Coast Guard has used both internal and contracted assembly approaches, first relying on a private sector lead systems integrator and more recently building its own internal public sector capacity to perform Deepwater program assembly.

The Coast Guard's experience with the Deepwater program offers several important lessons:

- The product's characteristics are the initial source of costs and risks.
- Contracting for assembly may be cheaper, but it also increases risk.
- Performing assembly internally may lower risk, but it also raises costs.
- The successful acquisition of any complex product is a function of lots of moving parts.

Our examination of the Coast Guard's Deepwater experience points to a trio of recommendations for different participants—namely, contract management staff, agency executives, and congressional and executive-level policy makers—for the acquisition of complex products.

For contract management staff:

- Agencies should match their acquisition approach to the characteristics of the product.

For agency executives:

- Agencies cannot move from contracted assembly to internal assembly (or vice versa) with the flip of a switch.

For congressional and executive-level policy makers:

- The effective acquisition of complex products requires new policies and tools.

Section 1: Introduction

Acquiring Complex Products

Many of the products the federal government buys require some assembly after purchase. A desktop computer usually comes shipped as a rectangular box intended to sit below the desk, with a monitor, keyboard, speakers, mouse, and the cables and software for connecting to the Internet. An agency could do its own assembly, perhaps through its information technology (IT) department, or it could hire an outside company for the job. Apple computers, for example, arrive "plug-in ready," with no assembly required, although they of course tend to cost more.

When a product is relatively simple, the decision about whether to hire an assembler or do it in-house is relatively straightforward. The acquiring agency can turn to the market to gather information about the costs and quality of different product components, along with the costs of internal assembly, relative to the costs and quality of fully assembled versions of the product. The agency can then decide whether to buy the assembled product itself or do its own assembly.

Not all assembled products, however, are as simple as desktop computers. Many products that government agencies acquire—weapons, transportation, and information technology systems—are complex, requiring the integration of numerous specialized parts, tailored in unique ways to the fit the agency's needs. Many agencies lack the capacity to build the complex products they need to do their jobs. Sometimes agencies buy the component parts and then do their own assembly to produce the final product. There are both upsides and downsides to this arrangement:

- **Upside:** The agency harnesses market competition to lower component costs, while still enjoying ownership of the process of tailoring the final product to meet its own specific needs.
- **Downside:** Government assembly can be costly because it requires procurement staff to implement and manage contracts, along with integration staff (e.g., systems engineers) to design the complex product and assemble the parts into the final whole product. Such assembly costs may be prohibitively expensive if the product is a one-time purchase.

Alternatively, governments can buy both the components and assembly. When done on a grand scale, this approach is sometimes referred to as a "system-of-systems" (SoS) strategy. In an SoS acquisition, the government hires a lead systems integrator (LSI) to perform the role of a general contractor, with the responsibility for designing, building, and integrating the assets into a coherent product or system. There are upsides and downsides to this approach:

- **Upside:** The SoS approach can lower costs by bundling related buys into a single acquisition and provide access to technical capacity and expertise not available in-house.
- **Downside:** The government agency may be the only purchaser of the product, and once the contract is let, the vendor is the only viable supplier, leaving each with no easy exit from the contract, limited information about costs and quality, and the engagement of a partner relatively unconstrained by competitive market pressures. With exit options limited, the risk is that each side will exploit contract loopholes and ambiguities, fearing the other side will do the same. The result can be a spiraling increase in rigidity, distrust and conflict between the buyer and seller—risking cost overruns, quality

lapses, missed deadlines and objectives, and ultimately a failed contract.

In this report, we identify the trade-offs between internal and contracted assembly through an analysis of the Coast Guard's Deepwater program—a major SoS acquisition to upgrade and integrate the service's sea and air assets. Nine years into a projected 30-year Deepwater program, the Coast Guard has used both internal and external (SoS) approaches, first relying on a private LSI and more recently building its internal capacity to perform Deepwater program assembly.

This report builds on our earlier IBM Center for The Business of Government report on the Coast Guard's Deepwater Program.[1] That report used the Deepwater program to highlight the risks of acquiring complex products and to help identify how agencies can use contract design to mitigate these risks.

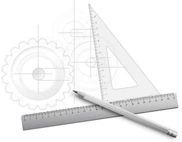
The remainder of Section 1's introduction summarizes the major takeaways from our earlier report, with an emphasis on the risks of acquiring complex products. Section 2 provides brief background information on the Coast Guard's Deepwater program and previews the illustrations and examples we will use later in the report. Section 3 reviews the costs and risks of internal and contracted product assembly, while Section 4 discusses how agencies can balance these costs and risks with their assembly decisions. Government agencies are increasingly contracting for assembly, but the upsides and risks of acquiring complex products under different assembly arrangements are not always clear. Section 5 provides a case study of the Coast Guard's assembly efforts, first under contracted assembly with a private LSI, and then under internal assembly. We conclude the report by identifying in Section 6 the lessons for mitigating risk under internal and contracted assembly for complex products.

Our report has practical implications for contract management staff, agency executives, and congressional and executive-level policy makers. We recommend that some audiences (e.g., contract management staff responsible for the acquisition of similarly complex systems) read the entire document, while other audiences (e.g., congressional and executive-level policy makers) skim through some sections. All readers should benefit from reading the remainder

Symbol Glossary

To simplify many of the concepts and ideas we describe in the text, we use a variety of symbols throughout the report. Here we identify the symbols we use in the first half of the report. Later, at the beginning of our case study of the Coast Guard, we introduce additional symbols that are more specific to the Deepwater program.

The U.S. Coast Guard, the acquiring government agency that is the focus of our case.



A "lead systems integrator," or general contractor hired by an acquiring government to design, procure, integrate, and deliver a complex product.

Helicopters, ships, and IT—examples of the assets that make up complex systems; in this case, the Coast Guard's Deepwater system.

Armaments, a ship engine, and radar equipment, or subcomponents of assets in a complex system; in this case, a ship in the Coast Guard's Deepwater system.

"Lock-In," or the phenomenon of creating a situation in which both an acquiring government agency and a vendor find no easy exit from a contract.

of this introduction and Section 2 of the report, as these provide an overview of our analysis and of the Deepwater case.

For those readers who want to understand the analytical building blocks that guide our analysis of Deepwater, Sections 3 and 4 are a must. For those readers who are most interested to learn about the Coast Guard's Deepwater experience, a skim of Sections 3 and 4 will provide a sufficient basis for understanding our analysis of Deepwater in Section 5. For those readers who are ultimately interested in the lessons and recommendations we derive from the Coast Guard's Deepwater experience to date, the focus should be on the concluding Section 6. Throughout the document, we insert arrow boxes with text suggesting who should read which section.

Complex Products and Their Risks

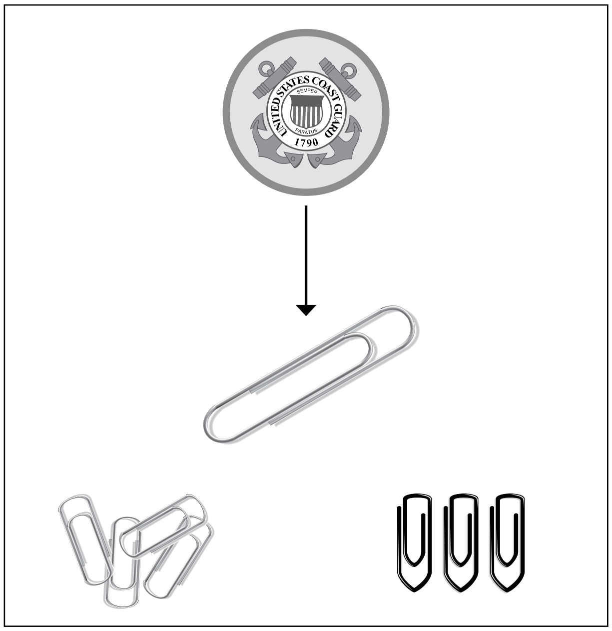
Sometimes government agencies buy or make goods and services with important attributes that can easily and clearly be spelled out in advance and can be unambiguously verified once they have been delivered. Such goods and services have clear-cut quality dimensions, specifications, and performance standards; agencies can know how much value they will get from their purchases, and markets signal how much the products will cost. As a result, before committing to a purchase, agencies can determine whether the product will contribute to fulfilling their mission at a price they can afford. We call these *simple* products.

Whether to produce or buy a simple product is a relatively straightforward decision. Markets for simple products tend to have large numbers of buyers and sellers who are:

- Well informed about one another's offerings
- Can easily enter and exit the market
- Can clearly define the terms of exchange

Government agencies can easily assess the costs of producing the product relative to buying or assembling it. In the end, agencies rarely even consider making simple products themselves, as contracts are likely to deliver win-win outcomes.

Figure 1: Contracting for Simple Products



The Coast Guard, for example, buys lots of paper clips every year. Paper clips are simple products: It's easy for buyers to specify what they want in a paper clip and it's easy for suppliers to produce them. Performance qualities and prices are clear to everyone. Consequently, if the Coast Guard ends up unsatisfied with the quality or cost of the paper clips it buys, it can easily switch to another producer. As Figure 1 shows, the market is rich with alternative paper clips.

More-complicated products have qualities that cannot be easily and clearly spelled out in advance and that are difficult to verify after the product or service has been delivered. Before purchasing such products, government agencies may not fully know how much of a return on investment will be realized from these products. Absent clarity about the product's quality dimensions, specifications, performance standards—and the trade-offs among them—the agency also may not know how much these products will cost to buy or maintain. As a result, agencies do not know at the time of purchase whether or precisely how a particular product will contribute to the agency's mission. We call these *complex* products.

Complex products are challenging to acquire because of two product characteristics. First, the cost, quality, and quantity parameters of complex products are not always easily determined, specified, and verified. Without strong information about product dimensions and costs, government agencies have a difficult time determining the alternatives that exist

A Complex Product's Key Characteristics

Product Specification Challenges

The product's cost, quality, and quantity parameters are difficult to specify.

Specialized Investment Requirements

The product requires investments that are unique to the product and cannot easily be used for other products.

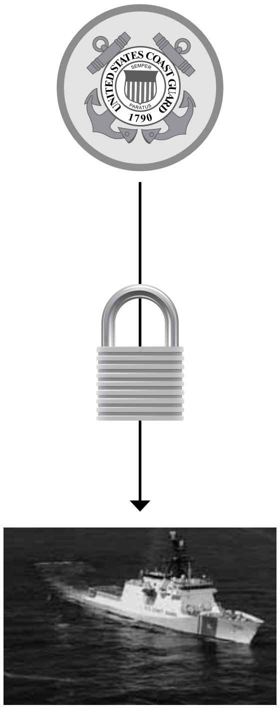
in the market relative to those they are capable of doing on their own. While government agencies can reduce such uncertainty through research and development, which they can do on their own or buy from a vendor, much of the information needed to make a fully informed decision will come through actual production of the product—learning by doing.

Second, complex products often require specialized investments. Investments are specialized to the extent that they are not able to generate value beyond the specific product being produced, perhaps because only a single purchaser wants the product.[2] Examples of specialized investments include the modification of a physical plant to produce components that can only be used by or sold to the government. Vendors lose these specialized investments if they do not sell their product to the government. Government agencies also can make specialized investments in purchasing, such as training staff to use the software from a particular company.

For government agencies buying or assembling a complex product, the consequence of uncertainty about the product and specialized investments is well known in academic circles as the "lock-in" problem (Williamson, 1996). A party becomes locked into a contract because it cannot deploy its specialized investments to other profitable endeavors, even if the other party exploits unforeseen events and contract ambiguities for its own gain. For the buyer, the lock-in risk is that, once a seller has been selected, no other potential sellers have made the necessary specialized investments, and the seller may perhaps "gold-plate" the product with costly features that increase the seller's profits, but which add little value and considerable expense for the buyer. Alternatively, the seller may add costs to the product by delaying delivery and charging for the additional time to complete the product. Likewise, because the seller has only one buyer for its products, the buyer also may opportunistically exploit contract terms for its own favor. The buyer may force a seller, for example, to make changes to a product which raise the seller's costs, even though the buyer knows that an unaltered product would meet the buyer's needs almost as well.

Absent lock-in problems, the buyer simply could replace an opportunistically behaving seller with a more suitable one, and a seller could likewise replace an opportunistic buyer. The presence of lock-in problems weakens the disciplining power of markets. Turning again to the Coast Guard example, ships, unlike paper clips, are complex products: It is difficult to specify all of their important attributes, and producers often have to make specialized investments to tailor the product to the buyer. As figure 2 shows, the risk is that the Coast Guard and whatever ship manufacturer it selects will become locked into a relationship, exposing both to the possibility of the other behaving opportunistically.

Figure 2: Contracting for Complex Products



Integrated Systems as Complex Products

With increasing frequency, many of the products purchased by government agencies like the Coast Guard are systems comprised of integrated goods and services (e.g., weapons systems, mental health services, IT systems). When government agencies purchase systems like these, the characteristics that make complex products risky ventures may be present across multiple levels. The creation of such a system requires both production—the manufacture of the component parts—and assembly—the integration of those parts into a functioning arrangement. In addition, many individual components of the system—for example, a ship or plane in the case of the Coast Guard—also can be thought of as its own "integrated system," since it often requires the production and assembly of its own component parts. It may be difficult to specify cost, quality, and quantity parameters at each of these levels—subproduction, production, and assembly—and the activities performed at each level may require specialized investments. In sum, the acquisition of an integrated system can make the task of managing the risks associated with complex products exponentially more challenging.

After a brief overview of the Coast Guard's Deepwater program, the basis for the examples used throughout the remainder of this report, the next section, Section 2, examines how government agencies acquiring complex products that take the form of integrated systems can use different acquisition approaches to manage lock-in risks. We compare the costs and risks of contracting with an LSI for the integration of the components of a complex product versus the performance of those functions internally.

Section 2: The Coast Guard's Deepwater Program

All readers will benefit from reading this section, as it provides background on the Deepwater case.

The Coast Guard's Deepwater program is a major, long-term effort to upgrade and overhaul the Coast Guard's "deepwater" sea and air vessels and the command and control links among them.[3] We use the Deepwater program in this report to frame the trade-offs of using different approaches for acquiring a complex product. In particular, we focus on complex product acquisition through internal and contracted assembly, basically integrating system components internally versus contracting with a general contractor, or lead systems integrator (LSI), to perform these functions. The Deepwater program serves as an illustrative example, because the Coast Guard has used both approaches over the life of the acquisition, first relying on an LSI and then performing assembly functions internally. Here, we provide a brief background of the Deepwater program and describe why it is a complex product. Later in the report, after we describe the trade-offs of internal versus contracted assembly, we return to the Deepwater program as a case study.

Coast Guard Acquisition

The Coast Guard maintains an array of assets to help pursue its multiple missions, including ships and boats (e.g., cutters, buoy tenders, icebreakers), airplanes and helicopters, shore stations, facilities, and lighthouses and navigation systems. The Coast Guard buys these assets from private vendors such as shipyards and defense contractors.

Assets

Throughout this report, we will use the term **assets** to refer to the physical resources the Coast Guard utilizes to pursue its mission. The Coast Guard's Deepwater assets include:

- Ships and boats
- Airplanes
- Helicopters
- Unmanned aerial vehicles
- Shore stations and facilities
- Communication infrastructure
- Navigation systems

In recent history, the Coast Guard's acquisition practice has been to purchase separately individual classes of assets—ships, cutters, airplanes, and helicopters. When a class of ships was no longer sea worthy, the Coast Guard bought a new one to replace it, perhaps with a modified design better suited to the Coast Guard's evolving missions. Because it bought fewer and smaller assets relative to other major naval buyers—notably, the U.S. Navy—the Coast Guard largely made purchases from a handful of small to midsized sellers. Without significant acquisition experience or capacity, and infrequent purchases of small quantities, the Coast Guard sometimes even acquired assets as part of larger Navy acquisitions.

By the early 1990s, it became clear that the Coast Guard needed a more targeted and strategic procurement approach.[4] Many of the Coast Guard's assets were reaching the end of their usable life spans and were not ideally suited to the modern Coast Guard's missions. The Coast Guard's multiple missions and global reach meant that its objectives

The United States Coast Guard At-A-Glance

The Coast Guard is a law enforcement, military, and life-saving organization. The Coast Guard's missions include:

- Upholding the law (maritime security)
- Rescuing the distressed at sea (maritime safety)
- Caring for the environment (protecting natural marine resources)
- Ensuring safe marine transportation (maritime mobility)
- Defending the nation (coastal protection)

The Coast Guard was created in 1790 as the Revenue Marine, later renamed the Revenue Cutter Service, within the Department of the Treasury. In 1915, the Revenue Cutter Service was combined with the U.S. Lifesaving Service to create the Coast Guard. In 1967, the Coast Guard was transferred to the Department of Transportation. In 2003, the agency was transferred to the Department of Homeland Security.

varied dramatically from location to location and changed frequently. The Coast Guard needed a new fleet of assets that could adapt quickly to changing circumstances in a decentralized decision-making environment. The Coast Guard's assets also had to work in concert; no single asset could perform its task without support or coordination from other assets. Any new or upgraded asset would have to be able to communicate and synchronize its capabilities with existing assets. The Coast Guard's goal was to acquire a system of interoperable assets with seamless communication and coordination that would make the efficacy of the whole greater than the sum of its parts.

Interoperability refers to the capacity to easily coordinate assets to carry out variable tasks across the Coast Guard's operational divisions and units, and sometimes in concert with the Department of the Navy and other federal, state, and local agencies. For example, sea assets have to be able to coordinate their actions with air assets.

In 1998, Congress and the Clinton administration committed to a multiyear appropriation of $500 million/year to upgrade the Coast Guard's assets—significantly more than the Coast Guard's historical acquisition funding (GAO 2001). The result was the Deepwater program, known as Project Deepwater.

Project Deepwater

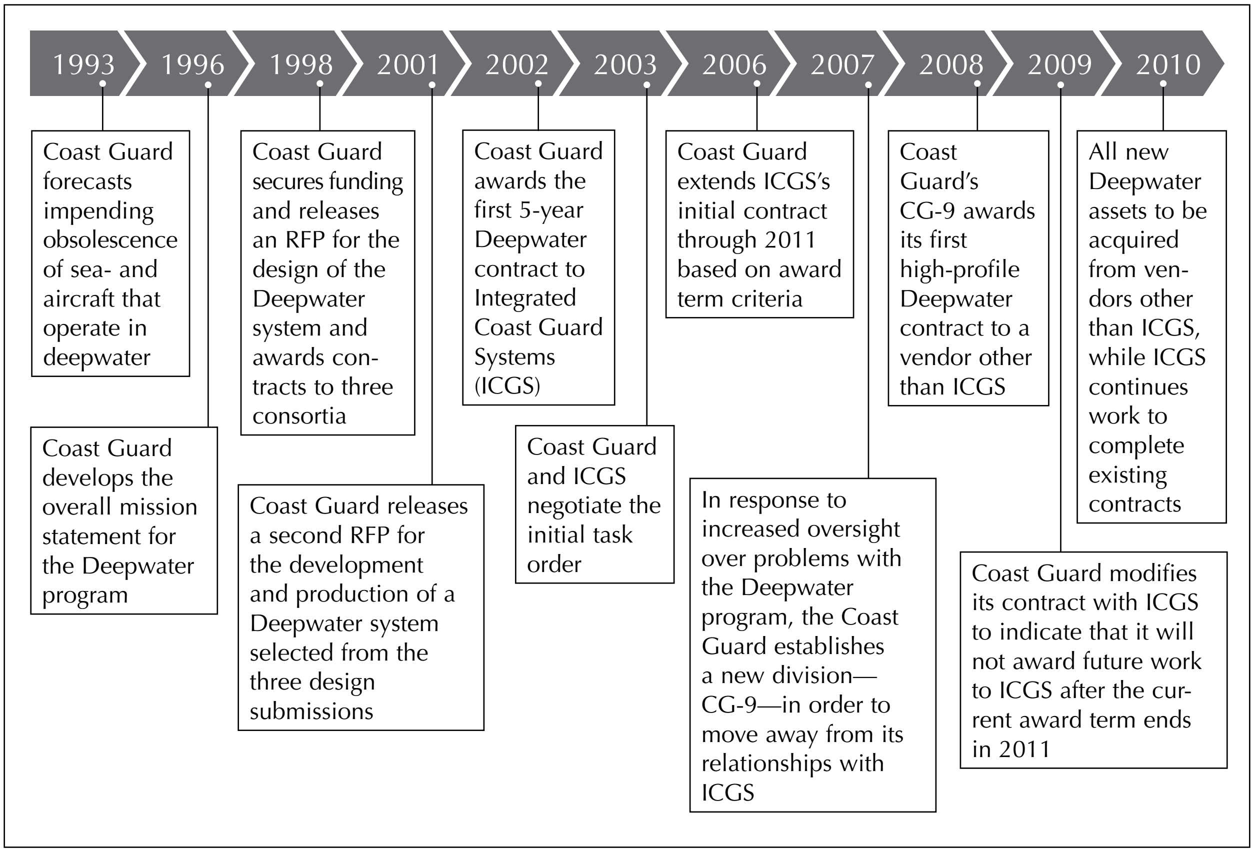
Toward the end of 1998, the Coast Guard issued a request for proposals (RFP), describing the mission needs and performance goals for the Deepwater upgrade, including the interoperability of the assets and total ownership cost objectives.[5] After evaluation proposals from three industry teams,[6] the Coast Guard selected a system design from Integrated Coast Guard Systems (ICGS, a 50/50 joint venture between Lockheed Martin and Northrop Grumman). ICGS proposed to integrate all of Coast Guard's Deepwater assets—some new and some upgraded—in a state-of-the-art command, control, communications, computers and intelligence, surveillance, and reconnaissance system, more commonly referred to as C4ISR.

In June 2002, the Coast Guard awarded ICGS an initial five-year contract for designing, building, integrating, and testing the assets in the Deepwater system. At this early stage, most of the Deepwater work was for design, capabilities and requirements determination, and testing, including specifying performance standards for the system and each of the planned assets. Under the contract terms, ICGS had full technical responsibility for designing and constructing all Deepwater assets, and for deciding whether contract components should be put out for competitive bids in second-tier contracts.

After entering into the initial five-year Deepwater contract with ICGS in 2002, there were new demands stemming from the "war on terror" that imposed significant performance changes to the program. These post-9/11 requirements changes came after the initial contract and have, to date, led to increased costs and time estimates that put the projected Deepwater acquisition at around $27.4 billion over a 30-year time frame.

While the Coast Guard extended the original ICGS contract by five years in 2006 to 2011 (based on the established award term criteria), by 2007 problems

Figure 3: Timeline of Deepwater's Major Contracting Events



Coast Guard forecasts impending obsolescence of sea- and aircraft that operate in deepwater

Coast Guard develops the overall mission statement for the Deepwater program

Coast Guard secures funding and releases an RFP for the design of the Deepwater system and awards contracts to three consortia

Coast Guard releases a second RFP for the development and production of a Deepwater system selected from the three design submissions

Coast Guard awards the first 5-year Deepwater contract to Integrated Coast Guard Systems (ICGS)

Coast Guard and ICGS negotiate the initial task order

Coast Guard extends ICGS's initial contract through 2011 based on award term criteria

In response to increased oversight over problems with the Deepwater program, the Coast Guard establishes a new division—CG-9—in order to move away from its relationships with ICGS

Coast Guard's CG-9 awards its first high-profile Deepwater contract to a vendor other than ICGS

Coast Guard modifies its contract with ICGS to indicate that it will not award future work to ICGS after the current award term ends in 2011

All new Deepwater assets to be acquired from vendors other than ICGS, while ICGS continues work to complete existing contracts

in several areas of the Deepwater program led the Coast Guard to take on responsibilities that, up to that point, ICGS had performed in its role as the LSI. The failed upgrade of an existing boat and significant cost overruns and delivery delays of a new ship for the Deepwater fleet spurred increased oversight by Congressional committees.[7]

In response to these issues, the Coast Guard began to develop its own capacity to perform assembly functions, moving initially to reorganize its acquisition programs and subsequently to create CG-9, Coast Guard's acquisition "directorate" with a status on par with that of other directorates such as Human Resources (CG-1) and Engineering and Logistics (CG-4). Starting in 2008, the Coast Guard began turning to CG-9 for the acquisition and integration of Deepwater assets. In 2009, the Coast Guard officially signaled that it would end its contractual relationship with ICGS at the end of the current award term in 2011.

Project Deepwater as a Complex Product

The Coast Guard's objective in the Deepwater program was to acquire a system of sophisticated interoperable assets with two overarching requirements: maximize operational effectiveness and minimize total operating cost. The assets all had to be able to communicate with one another and seamlessly coordinate their activities around different targets (e.g., armed speedboats running contraband, sailors lost at sea, makeshift vessels transporting illegal aliens), with a cap on overall annual operating costs. Since the Coast Guard initially elected to buy a fully integrated system, the prospective seller would need to have the production capacity or purchasing ability to deliver very different kinds of assets—ships, cutters, boats, helicopters, and airplanes—and the communications technology and human resource systems to integrate them.

The Deepwater program is a complex product, because performance standards, costs, and mission

Figure 4: Deepwater Program Overview

Source: *Deepwater Program Overview image courtesy of the Deepwater Information & Solutions Center, a joint Lockheed Martin and Northrop Grumman facility*

impacts were difficult to identify and clearly specify before acquisition of the system began. At the outset, the Coast Guard understood its mission objectives but lacked information about the options for how different mixes of assets would help to achieve them. The Coast Guard also knew the basic components that would ultimately comprise its asset fleet—ships and boats, airplanes, and helicopters, tied together through communication and integration technologies. But at the outset, the Coast Guard did not know the exact number of boats, airplanes, and helicopters to purchase; what each of their performance specifications should be; and how they would operate together in a system. For example, how many fewer aircraft would be needed if the performance of the large cutters were increased by a given percent?

The Coast Guard also had high uncertainty about the costs of acquiring these assets, specifically after the post-9/11 requirements were incorporated. While there was an initial cap on overall operating costs, the lack of exact system and asset design specifications made it difficult to determine how much it would cost to deliver all of these assets in a system that met the Coast Guard's objectives. Full cost information for each asset would not be available until the Coast Guard either specified performance standards with some precision or authorized a first-in-class design.[8] Furthermore, once production began, the longer it took for the Coast Guard to make specification decisions about subsequent assets, the more costly the program would become as production processes lay idle.

The Deepwater program also required specialized investments. First, ICGS would have to design a unique system to meet the needs of a single client. This system likely only would be valuable to the Coast Guard; much of the program would not have other buyers in the market. Second, ICGS would have to create a set of production processes tailored to deliver whatever interoperable system resulted from the design phase. While some components of the system could be sold to other clients, other system components and the system itself would only be valuable to the Coast Guard.

By entering into a contract with ICGS to acquire the Deepwater program, the Coast Guard elected to buy a system of assets that it couldn't produce on its own, but in doing so exposed itself to some risk. In the next section, Section 3, we describe the trade-offs of acquiring a complex product like the Deepwater program through different approaches. Fundamentally, we focus on the costs and risks of contracting for assembly functions, as the Coast Guard initially did by turning to ICGS—versus performing these functions internally, as the Coast Guard is doing now under its new acquisition enterprise.

Section 3: The Costs and Risks of Acquiring Complex Systems

Readers who want to understand the analytical building blocks of the Deepwater assessment will benefit from reading this section closely.

The acquisition of any product involves two basic functions: production and assembly. In the simplest terms:

- **Production** involves transforming raw materials into finished goods;
- **Assembly** involves putting those finished goods together into a complete, integrated product.

When government agencies acquire products made from a few easy-to-produce and easy-to-assemble components, one organization may be capable of performing both assembly and production. When government agencies acquire products made from difficult-to-produce and difficult-to-assemble components, one organization may not be capable of performing all of the tasks. Different types of organizations may be better suited for production tasks, while others are better suited for assembly tasks.

As we discuss below, government agencies enjoy some choices over how to arrange for the production and assembly of the things they want to buy. In the simplest terms, they can internalize production and assembly, basically doing both functions themselves, or they can turn to other organizations to perform one or both of these functions. The decision about how to make this choice is fundamentally informed by the trade-off between making costly internal capacity investments versus the risks of becoming locked in if the acquiring government agency turns to another organization to perform either or both of these functions. Buying helps harness the efficiencies of market discipline, but risks “lock-in” problems.

Production and Assembly Tasks and Costs

In this section, we describe the basic tasks involved with each function, as well as the accompanying types of costs. Then we take a simple example of a government agency that turns to another organization to perform both assembly and production to show how lock-in risks can exist for both functions.

Production Tasks and Costs

Two basic types of resources serve as the primary inputs into the production process: land and raw materials. The manufacture of any product typically takes place at a specific location or locations; the producer must pay the costs of either owning or renting the land. The raw materials that are transformed to create the product include naturally occurring goods such as water, air, soil, and minerals. Facilities, machinery, and tools—i.e., fixed assets—are used then to transform the raw materials into the finished product at the designated location. While the means of production for some products may involve high degrees of automation, human effort is typically needed to operate the fixed assets and transform the raw materials into the finished product. As such, production also incurs costs for people (labor) and equipment.

Production Costs

- Land
- Raw materials
- Fixed Assets
- Labor

Assembly Tasks and Costs

Assembly involves five categories of activities: design, requirements determination, purchasing, integration, and delivery.

Assembly Costs

- Design
- Requirements determination
- Purchasing
- Integration
- Delivery

- **Design:** The first stage of assembly is the design, or development of a plan for the overall product. This design plan includes identifying what component parts are necessary, and how and when they will be put together. In the case of a simple product, design is relatively straightforward because there is little to no uncertainty about the product's specifications. Complex systems, on the other hand, create more design challenges because uncertainty about the product's specifications means that it can be hard to sketch out exactly what component parts are needed and how different pieces are to fit together. In some cases, the purchaser of the system may request a flexible design, wherein different pieces can be combined in different ways to pursue objectives, some of which can be determined, but others which are yet to be fully specified.
- **Requirements Determination:** Design is followed by the requirements determination, or the identification of the specific performance requirements of the system and the component elements, given existing capabilities and needs. For example, this might mean specifying a boat's capabilities, like how fast it needs to go, and its attributes, like the thickness of its hull.
- **Purchasing:** The procurement of the raw materials or component parts of the product follows the requirements determination. Purchasing includes three tasks of its own: market research, contracting, and contract management. Market research entails gathering information about the costs and capabilities of potential parts or raw material producers, as well as information about the overall composition and dynamics of the market. This is necessary so that the purchaser can make the optimal decision about a particular supplier, balancing cost and quality.

  Contracting involves soliciting bidders (e.g., through requests for proposals), selecting from among them (e.g., through contract proposal assessment), and then negotiating a contract for various production tasks. Finally, contract management involves implementing the contract and managing relations with contracted producers, including monitoring and assessing performance, renegotiating, employing incentives, and providing compensation as tasks are completed and contract terms are fulfilled.
- **Integration:** Once the component parts are produced and purchased, the assembler returns to the design plan to figure out how to integrate the parts and put the finished product together. Like design, the task of integration is made more challenging to the degree that the product's specifications are unclear. The more that is specified about how to connect one component to another, the easier it is to put the product together. Complex products, like weapon systems, are often hard to integrate because it is difficult to specify in the design plan exactly how to connect one piece of the product with another.
- **Delivery:** The final assembly step is delivery, or bringing the fully integrated product to the acquiring government at the negotiated location. In the case of simple products, delivery may be nothing more than boxing up the product and shipping it to the consumer, or sending it to a store where a consumer can easily go purchase it. Complex products may, on the other hand, involve more complicated delivery arrangements in which the product actually has to be put together at the site of use [e.g., many components of information technology (IT) systems]. In this way, integration and delivery often occur simultaneously.

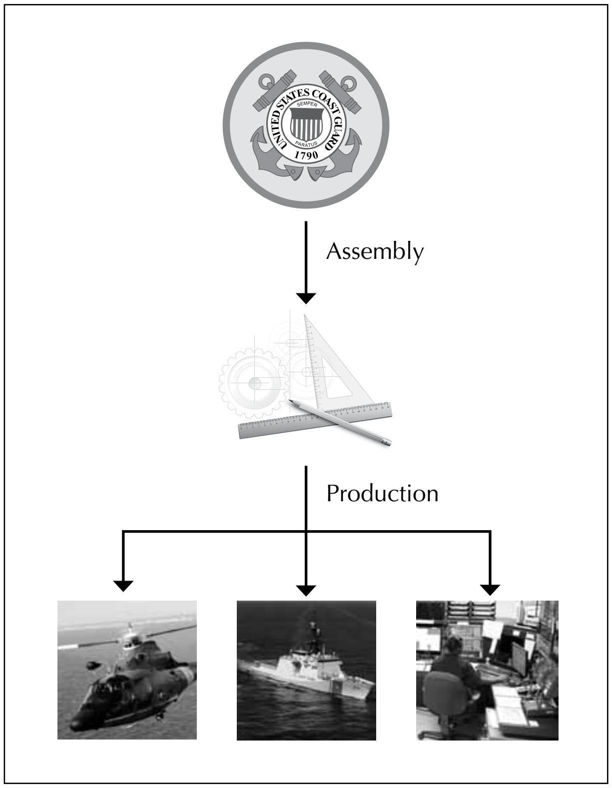
For some of the products that governments acquire, like the integrated systems that are the focus of this report, production and assembly costs can be high. For the Coast Guard to produce the ships, planes, helicopters, and IT for its Deepwater program, production costs were prohibitively exorbitant. And, because of the technical sophistication required to design the system, engage multiple supply markets, and integrate the various components into the final system, the Coast Guard's cost to assemble the assets into a final product were very high as well.

For organizations such as the Coast Guard, whose expertise and day-to-day activities operate across different domains, buying final individual products and fully assembled systems is much cheaper than making or assembling them internally. For government agencies that acquire integrated systems only periodically, it may be prohibitively expensive to maintain the assets, workforce, and accompanying systems and processes necessary to effectively perform production and assembly. In this case, it may be better to turn to other organizations that specialize in production or assembly and can perform the functions at a lower cost.

Production and Assembly Lock-In Risks

An important component of the trade-off in buying production and assembly functions rather than performing them internally is the lock-in risk that comes from acquiring a complex product. It may be difficult to specify cost, quality, and/or quantity of production and assembly tasks. Similarly, production and assembly may each require specialized investments. These characteristics create the potential for lock-in. To illustrate this possibility, we make things simple by assuming that the acquiring government agency opts to rely on other organizations to produce the components of the system; in this case, the Coast Guard relies on private firms to manufacture the IT, helicopters, ships, etc. that make up the Deepwater system. In addition, rather than perform assembly functions internally, we assume that the acquiring government agency turns to another organization for assembly; in the case of Deepwater, the Coast Guard selected Integrated Coast Guard Systems to serve as the lead systems integrator (see figure 5).

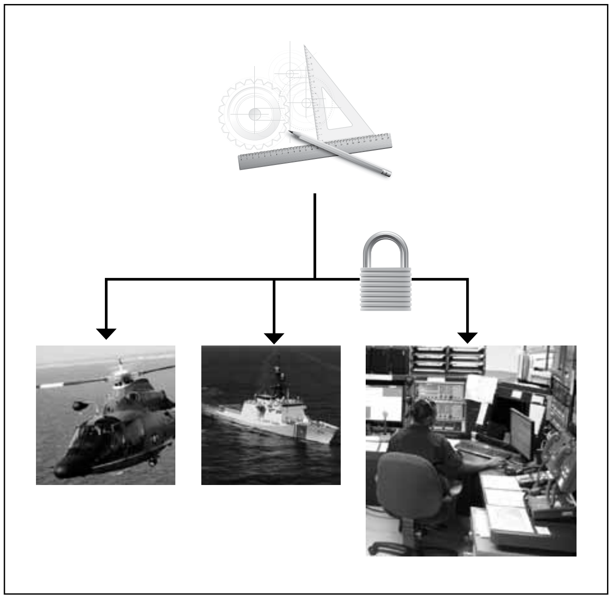
Figure 5: Acquiring a Complex System



At the production level, some system components are simple and others are complex. Complex components are difficult to specify (i.e., requirements definition is challenging) and require specialized investments, running the risk of lock-in, whereas simple components are relatively easy to specify, do not require specialized investments, and consequently create a low risk of lock-in. For example, imagine that each system component needs to be able to communicate with all of the other system components. To meet this requirement, a simple product could be used—say, a set of radios that all share the same frequency. In this case, the assembler faces little lock-in risk, since it can choose from a variety of radio manufacturers to make the communication system interoperable. However, a more complex communications product may be needed if the communication system requires not only simple voice communication but also computer, video, and other data transfer across multiple formats and platforms—and to be able to operate in multiple environments, including extreme weather, and have some security protections to prevent outsiders from listening in. Such were the requirements of the Coast Guard's communications systems for Deepwater. In a case like this, the assembler needs a vendor willing to make specialized investments to customize its production processes to make a unique, multifaceted product. An assembler for such a system runs the risk that it will become locked in to whatever communications vendor it selects, since it cannot turn to the competitive market for an alternative. The assembler might not be able to switch easily to another communications vendor if the original vendor delivers an ineffective communication system or increases the price in the future (see figure 6).

At the assembly level, when the tasks and processes required to integrate the components are easy to

Figure 6: Production Lock-In



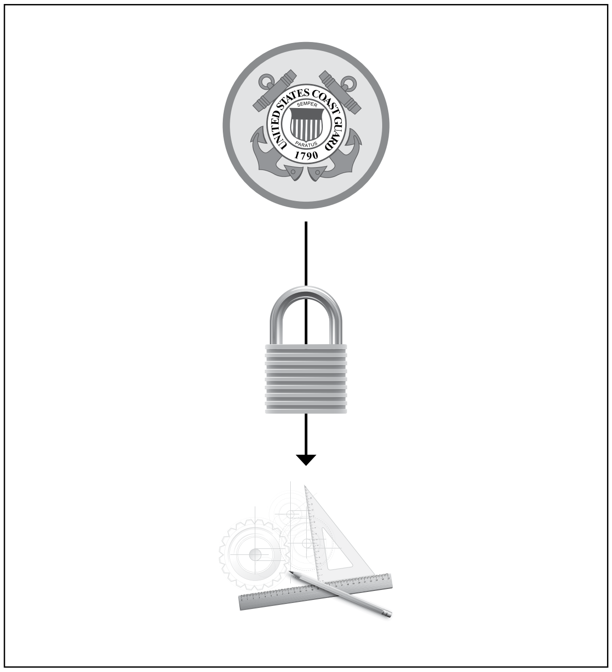
specify and do not require any specialized investments, the acquiring government agency faces little risk of lock-in when selecting an assembler. However, when the tasks are difficult to specify and either the acquiring government or the assembler has to make specialized investments, the risk of lock-in increases. Uncertainty about the product's dimensions, qualities, and costs may require each side to make investments in product research. For the acquiring government, these may be investments in learning about how the assembler proposes to make the product. For the assembler, these may be investments in learning about how each of the end users in the acquiring government might use the complex product. In addition, the assembler might make specialized investments to customize assembly processes for putting together the various component parts. It may be that the component parts are relatively easy to specify and easy to produce; the challenge may come in specifying how the component parts are to be put together, and the process required to do so may be unique.

For example, each of the ships, helicopters, and IT components that comprise the Deepwater system may be—on its own—a relatively straightforward, commercial off-the-shelf product, so that each can be purchased with low risks of lock-in. However, bringing these components into a system may be more challenging. When the Coast Guard executes a mission, it wants its assets to be integrated operationally and technologically. On the operational side, when a boat moves to a particular location at a particular speed, a helicopter may need to arrive at the same location in a similar time frame. Both of these crafts (and any other assets involved in a mission) have to be staffed with Coast Guard personnel.

As the assembler creates the design plan for the system as described above, successful integration will be contingent on highly specific knowledge of the staffing requirements for each asset as well as on the Coast Guard's overall staffing capacity. It may be that the Coast Guard cannot simultaneously deploy all of the assets needed for a mission because it lacks sufficient staff with the requisite skills and training to perform the mission. An assembler could deliver technically adequate assets, but fail to account for the personnel requirements necessary to connect the pieces operationally and thereby deliver an inadequate system. On the technical side, as noted earlier, all of these assets need to be able to simultaneously communicate and coordinate with one another. The communications platform the assembler acquires will have to be able to adapt to the different operating conditions of each asset (e.g., water versus air versus land). Here again, the assembler needs highly specific information; in this case, about the types of environments in which the Coast Guard will use each asset and how the Coast Guard intends to use the assets in combination to carry out specific missions. The IT must be adaptable to different conditions. Given these operational and technological requirements, the risk is not necessarily being locked in to a specific production process for each asset, but rather to a specialized assembly process (see figure 7). As was the case at the production level, the selected assembler may find itself with advantages in some dimensions of the assembly process.

To ensure receipt of a quality product within budget, government agencies have to balance the costs of performing production and assembly tasks internally versus the risks of lock-in at either the production or assembly levels when acquiring a complex product. In the following section, Section 4, we show how different choices about internal or contracted production and assembly impact the trade-off between costs and risks. First, though, we explain how the acquisition of a complex system rather than just a complex product adds further complications.

Figure 7: Assembly Lock-In



Mapping Production and Assembly Costs and Risks

In acquiring any product, government agencies must first make two basic decisions: Who is going to produce the component parts, and who is going to assemble those parts into a finished product? Both of these functions incur costs and carry risks of lock-in:

- Production costs include land, raw materials, fixed assets, and labor.
- Assembly costs include design, requirements determination, purchasing, integration, and delivery.
- When the tasks required to manufacture a product are difficult to specify or require specialized investments, the risk of lock-in at the production (or subproduction) level is high.
- When the tasks required to acquire component parts and integrate them into a finished product are difficult to specify, or require specialized investments, the risk of lock-in at the assembly level is high.

Complex Systems and Lock-In Risks

When governments acquire complex systems in which there are multiple component parts, there are additional levels of activity beyond production and assembly, and, hence, additional cost-versus-risk trade-offs. Notably, system components at the production level typically also require the manufacture of inputs and the assembly of those inputs into a finished product. For example, take the ships in the Deepwater system. In the way we've framed the discussion so far, ships are simply inputs manufactured at the production level. Ships, however, are complicated systems that require numerous inputs from different suppliers. We refer to this level below production as subproduction.

Just as lock-in risks can exist at the production and assembly levels, they can also exist at the subproduction level. System components at the production level may require inputs that are hard to define and sufficiently distinctive that they require specialized investments to manufacture them. That is, inputs to the production level which are manufactured at the subproduction level can also be complex and carry lock-in risks.

As in the proverb "for the want of a nail, the shoe was lost," subproduction lock-in problems can have consequences that spiral up the production chain to system assembly. Producers can become locked in to subproducers who manufacture complex inputs. Exploiting their advantaged position, a subproducer of a critical complex input can demand higher payments for the input or chose to cut corners on quality. In the absence of a market alternative, the manufacturer at the production level either has to pay the excessively high cost, which raises the costs of the system component, or accept a lower-quality input, which diminishes the quality of the system component. There may be a rich market for production-level components (e.g., ship manufacturers), but there could be a limited market for a key subproduction component (e.g., ship engines) due to the fact that lock-in problems have shrunk the field of potential suppliers. As a result, the lock-in risk resides at the subproduction level and not at the production level. Ultimately, the assembler and the acquiring government face higher costs or lower quality for some system component.

Section 4: Balancing Costs and Lock-In Risks Through Production and Assembly Choices

Readers who want to understand the analytical building blocks of the Deepwater assessment will benefit from this section.

In this section, we explain how different choices about production and assembly impact the trade-off between costs and lock-in risks in acquiring complex products. First, we lay out the production and assembly choices available to acquiring governments. Then we describe in detail contracted versus internal assembly, since this is increasingly the primary decision acquiring governments make. Finally, we identify the costs and risks associated with each assembly decision.

Production and Assembly Choices

There's nothing inherently "public" or "private" about production or assembly. Both can be performed by government or purchased from market suppliers. Some private firms specialize as manufacturers of component parts; others specialize as assemblers. For example, the Delphi Corporation, one of the world's largest automotive parts suppliers, is a producer of component parts for automotive companies—like the Ford Motor Company—who in turn serve as car assemblers. Similarly, governments can perform both functions as well. For example, NASA's Johnson Space Center Production Facility serves as a producer of components for the International Space Station. A public consortium of space agencies from the United States, Russia, Japan, Canada, and 10 European nations serves as the assembler, acquiring and integrating parts from different producers like the Johnson Space Center. As a result, government agencies acquiring complex products have the flexibility to mix and match production and assembly functions across public and private organizations.

An important choice for government agencies is to determine which production and assembly tasks they should perform themselves (internalize), and which production and assembly tasks they should purchase. There are essentially four basic options (see *Production and Assembly Combinations* box):

- Internal production and assembly
- Contracted assembly and internal production
- Internal assembly and contracted production
- Contracted production and assembly

For the vast majority of government agencies, the prevailing choice is between the final two options:

Production and Assembly Combinations

Internal Production and Assembly
The government agency performs all relevant tasks on its own.

Contracted Assembly and Internal Production
The government agency produces the component parts, but turns to another organization to assemble them into a finished product.

Internal Assembly and Contracted Production
Another organization produces the component parts, but the government agency assembles them into a finished product.

Contracted Production and Assembly
The government turns to other organizations to perform production and assembly tasks.

internal assembly and contracted production versus contracted production and assembly. The first option—internal production and assembly—corresponds to business sector decisions about whether the firm should vertically integrate production and assembly. Under complete vertical integration, the private firm owns and internally controls all production and assembly functions. It grows or gathers its own raw materials, transforms them into component parts, puts the parts together into a finished product, markets and retails the product, and then transports the product directly to the end consumer.

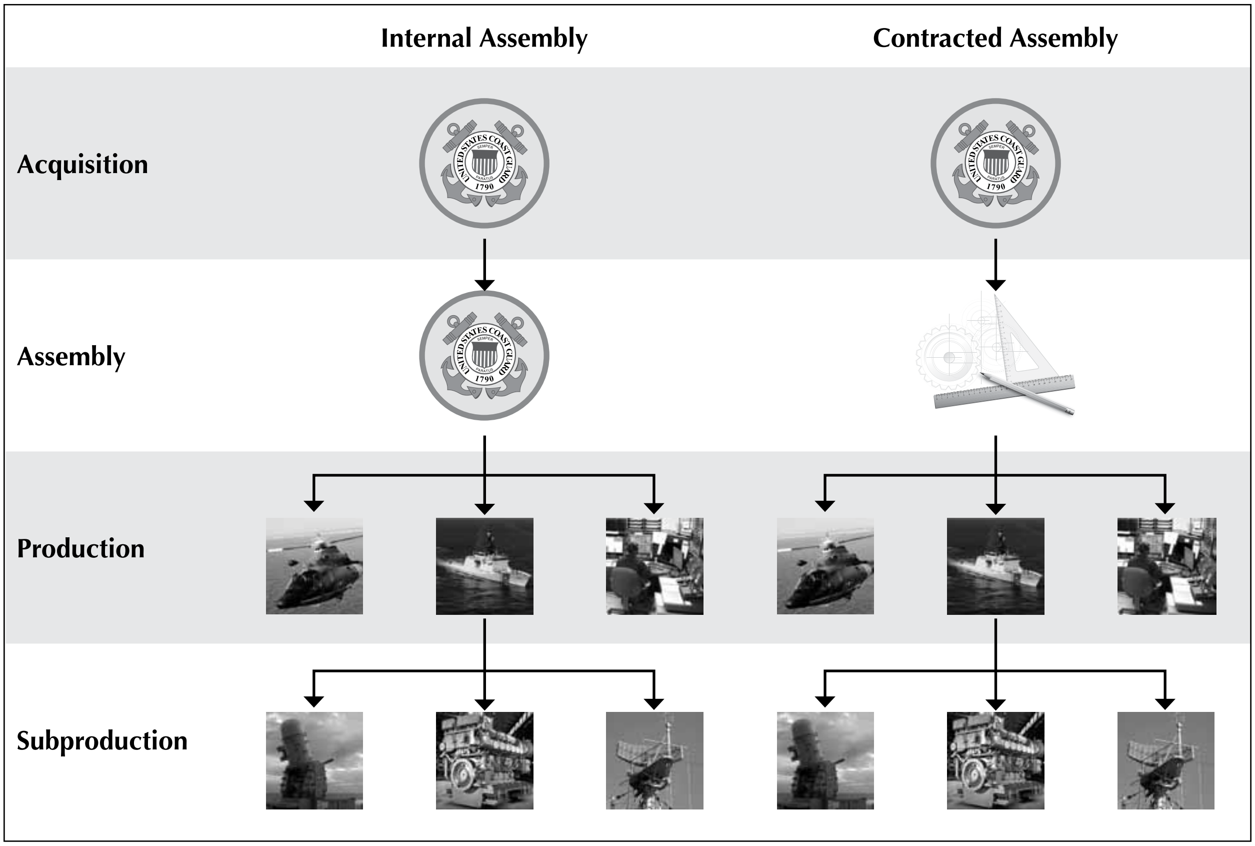
For complex products that incorporate many components (e.g., the ships, planes, helicopters, information technology (IT), etc. that make up the Coast Guard's Deepwater program), government agencies are unlikely to be able to maintain the capacity to internally produce and assemble all of them. The scale of operations for complex products, particularly "system-of-systems" (SoS) operations, makes complete vertical integration highly unlikely. Some of the same challenges make option two—contracted assembly and internal production—unlikely as well. While a government agency may be able to produce some components of a complex system like Deepwater, it will likely need to buy many components from other private or public contractors. It is for this reason we focus this report on the last two options. In both cases, the acquiring government relies on contracted production. The choice then often comes down to whether to internalize or contract for assembly.

Internal Assembly versus Contracted Assembly

Government agencies have flexibility over the internalization of assembly functions, choosing between internally performing assembly or contracting with an outside organization [either a public or private lead systems integrator (LSI) in the SoS model] to acquire the component parts and integrate them into a final product.

Figure 8 depicts the two basic options graphically, using the Coast Guard's Deepwater program as an example. Under internal assembly, the Coast Guard

Figure 8: Internal versus Contracted Assembly



contracts for various components—the helicopters, ships, and IT depicted here—from manufacturers at the production level, and then assembles those components into the Deepwater system. Because each of the component parts of the Deepwater program are themselves systems, manufacturers at the production level enter into contracts with subcontractors to produce those components at the subproduction level. For example, as the figure depicts, the manufacturer of a Coast Guard ship has to procure armaments, engines, and radar equipment from subcontractors.

Under contracted assembly, the Coast Guard contracts with another organization for assembly responsibilities. In the figure, an LSI takes over the assembly responsibilities that the Coast Guard would have performed under internal assembly; notably, purchasing the component assets and integrating them into an operational system.

Costs and Lock-In Risks Under Internal Assembly

The costs of internal assembly are primarily a function of labor requirements. Each of the various assembly tasks identified earlier in the report—design, requirements determination, market research, contracting, contract management, integration, and delivery—are sufficiently specialized that the government agency must make investments in different categories of employees to ensure that assembly is performed effectively. For example, a government agency acquiring a complex product needs staff to design the overall system as well as to specify the requirements of the system components. This might mean systems engineers to specify IT requirements for each component and the system as a whole, as well as staff with specialized product design skills (e.g., ship designers, helicopter designers). Since the assembling government agency will be acquiring multiple inputs from various supply markets (e.g., markets for ships, markets for helicopters), the agency will need staff with skills in market research, contracting, and contract management. The more distinct the components in the system, the more specialized the contracting staff needed by the acquiring government will be. Furthermore, when acquiring government agencies opt to build the staff capacity to perform assembly tasks, they essentially commit to this expense indefinitely even if they engage in assembly only periodically. In the event that the government agency acquires products that require assembly intermittently, the agency will have to find alternative uses for these specialized staff or incur the costs of having them be idle.

The benefit of these investments is that the government agency faces no lock-in risks at the assembly level, because it has taken on all assembly functions. Lock-in risks may remain, however, at the production and subproduction levels. Eliminating assembly-level lock-in risks does not eliminate production and subproduction lock-in risks. Instead, by taking on the assembly tasks, the acquiring government agency is now exposed to whatever lock-in risks exist at the production and subproduction levels. For example, in the case of the Deepwater program, when the Coast Guard performs assembly functions it may face production-level lock-in risks for IT if it demands a highly specialized communication arrangement to make the Deepwater system components interoperable. At the subproduction level, while the Coast Guard may find a rich market of ship manufacturers for certain classes of ships, it still may face lock-in risks at the subproduction level if all of the ship manufacturers in the market are reliant on a single producer of ship engines (see figure 9). One of the primary responsibilities of the government staff performing assembly functions is to manage and mitigate these lock-in risks.

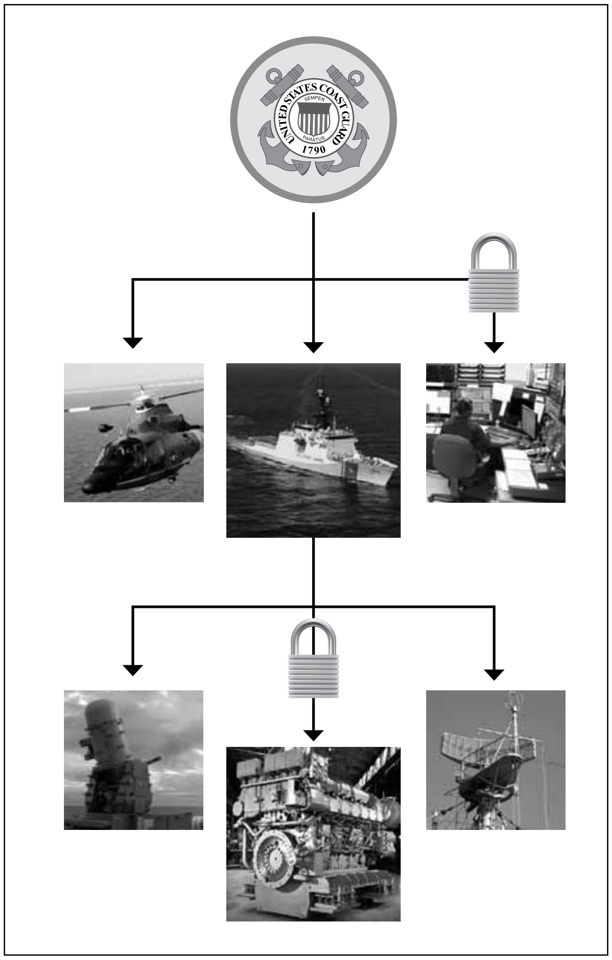
In sum, internal assembly:

- Eliminates assembly-level lock-in risks;
- Can mitigate production- and subproduction-level lock-in risks; and,
- Incurs long-term costs by making a permanent commitment to specialized staff capacity.

Costs and Lock-In Risks Under Contracted Assembly

As noted earlier, contracting for assembly may be cheaper than performing these tasks internally. This is the case for two reasons. First, a contracted assembler may be able to offer lower costs than can internal provision, because the assembler enjoys lower labor costs or can tap economies of scale by offering assembly services to a variety of clients. Second, even though many assembly contracts are for the long term (five years or more), they are not permanent financial commitments. Once the government agency acquires

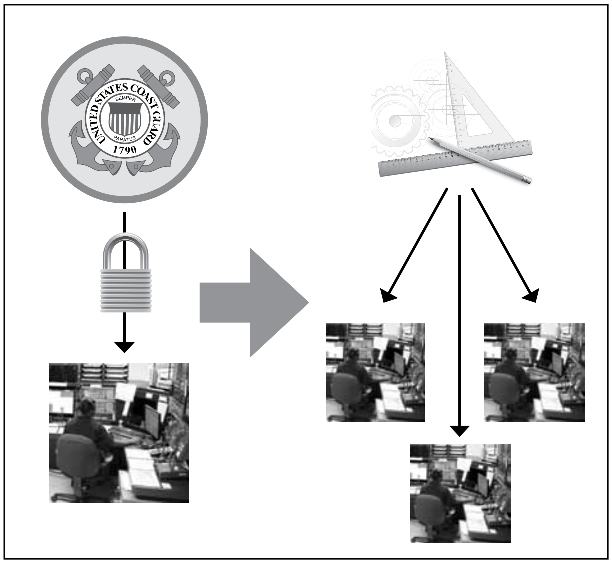
Figure 9: Lock-In Risks under Internal Assembly



the product, the agency isn't committed to continuing to fund staff to perform production or assembly tasks. In some instances, the government agency can opt to terminate the contract either by not exercising options for extension or by simply not funding the contract if it decides at a later date that it no longer needs the product.

Purchasing assembly tasks may also lower lock-in risks at the production and subproduction levels. One way to think about contracting for assembly is that the government agency is transferring the responsibility for managing lock-in risks at the production and subproduction levels to the assembler. An assembler may be able to better manage lock-in risks because it can better perform key assembly tasks that address the sources of the risk, notably reducing uncertainty about the product's qualities, quantities, and costs or minimizing the degree to which specialized investments are required to produce the product. For example, the acquiring government agency (e.g., the Coast Guard) may have only limited knowledge of a particular manufacturing sector and its products, like IT, and consequently only be aware of a single firm that can produce the type of product it desires. An LSI that provides assembly functions for multiple clients (e.g., the U.S. Navy, private merchant marine companies, foreign governments) may have considerably more experience and knowledge of the same manufacturing sector and the capabilities of firms unfamiliar to the acquiring government agency. With experience in managing and scanning supplier markets, the LSI may be better able than the government agency to identify potential manufacturers of products similar to the one desired by the government agency. A product that may have appeared to require specialized investments, given a narrow range of potential manufacturers, may not require such investments when the pool of potential manufacturers is broadened. Similarly, an LSI may be able to add value at the design phase by suggesting standardized alternatives to what might initially appear to require specialized investments. For example, in some industries standard products and services, or "commercial off-the-shelf" (COTS) technology, can be used for many production components. Having assembled similar systems for other clients, an LSI may have greater knowledge of both what COTS products exist and how they can be used in the assembly of various system components. In short, a contracted assembler may be able to reduce production and subproduction level lock-in risks in ways that the acquiring government agency cannot (see figure 10).

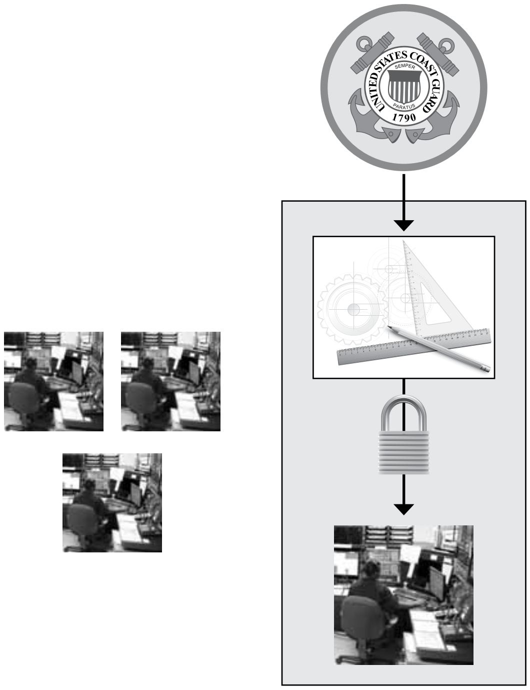
Figure 10: Reducing Lock-In Risks through Contracting for Assembly



The Special Case of Vertical Assembly

There is a special case in which contracting for assembly may not only incur lock-in risks for assembly tasks, but also for production and subproduction tasks. When the assembler vertically integrates production and assembly functions for highly complex products, it raises the possibility of lock-in at both production and assembly levels. On the one hand, vertical integration can lower costs by reducing the need for contract management staff, which can lower the cost the LSI charges the acquiring government. However, rather than enjoy the benefits of access to a wider market for products and system inputs described above, the opposite may occur as the assembler limits its search to only its own products. In this way, the government agency is now locked in to the LSI as a supplier of a unique product. For example, an assembler might vertically integrate assembly with the production of IT components. Even though comparable IT products may exist in the market, the assembler might incorporate its own highly specialized IT products into the system, thereby binding the acquiring government to these specific products on all future system components. On the one hand, this strategy may lower some costs—notably, the costs of market scanning and contracting—but raises the risk that the acquiring government becomes simultaneously locked in to the assembler and the producer.

Lock-In Risks that Result from Vertical Integration of Assembly and Production



When assembly is complex—the tasks are difficult to specify or are specialized investments—the risk of lock-in at the assembly level is high. In these instances, there are no COTS solutions; the contracted LSI will have to perform a unique set of assembly tasks. The assembler can then use its position of advantage to deliver an inferior system to save its own costs or unnecessarily “gold-plate” the system to raise the price it charges the acquiring government.

In sum, contracted assembly can:

- Lower the costs of assembly;
- Lower the risk of lock-in at the production and subproduction levels; and
- Raise the risk of lock-in at the assembly level.

Section 5: A Case Study in the Costs And Risks of Internal Versus Contracted Assembly

Readers interested in the Coast Guard's Deepwater experience will benefit from this section.

Deepwater to CG-9 in the Coast Guard

The Coast Guard's Deepwater program illustrates the trade-offs involved in contracting for assembly and in internally performing these functions. The Coast Guard began the Deepwater program in 2002 by contracting for assembly and production through a five-year contract with Integrated Coast Guard Systems (ICGS). Even though the Coast Guard had extended the initial contract with ICGS for an additional five years in 2006, a year later the Coast Guard began to move away from contracting for assembly with ICGS and to upgrade its internal capacity to perform assembly functions. This section explores why the Coast Guard elected initially to pursue contracted assembly through a private lead systems integrator (LSI) for the Deepwater system and then moved toward internal assembly. We identify the types of costs the Coast Guard saved or incurred, along with the risks of lock-in, first under contracted assembly with ICGS and then under internal assembly.

Production and Assembly Choices for the Coast Guard's Deepwater Program

Earlier in this report, we identified why the Deepwater system is a complex product—characterized by a high degree of uncertainty about the system's components, performance requirements and costs, as well as the necessity of specialized investments to produce some of the assets and the system as a whole.[9] Because of the high costs associated with establishing and maintaining production facilities, internally producing the system components was simply not an option for the Coast Guard. The fundamental question facing the Coast Guard was whether to internally perform assembly tasks—most notably designing the overall Deepwater system, conducting the capabilities and requirements determination, entering into contracts with multiple producers of system components, and then integrating them (see *Assembly of the Deepwater System* on page 30)—or contract for them.

Prior to 1998, the Coast Guard had performed assembly functions internally, contracting for the production of new boats, ships, helicopters, planes, and information technology (IT) as needed and as resources allowed, and determining how these assets would work together to perform varying missions. However, the Coast Guard had little experience contracting for anything as complex as the Deepwater system assembly process. In our previous report, we explained the Coast Guard's motivation for packaging all these assets into a "system of systems" (SoS) and turning to an LSI rather than continuing to contract asset by asset: In the late 1990s, the political authorization and funding environment supported the SoS/LSI approach and the Coast Guard lacked the internal capacity to perform assembly on the scale needed for the Deepwater program.

Not all supported the SoS/LSI approach. From the outset, some questioned whether the Coast Guard would be able to oversee its industry partner and manage the numerous risks associated with the project. After the project commenced, those in and around the Deepwater system with concerns about the

Symbol Glossary

Here we identify the symbols we use in the second half of the report to simplify the concepts and ideas we describe in the text. While some of the symbols we use in the first half of the report are generic, here we use symbols that are more specific to the Coast Guard's Deepwater program.

The Coast Guard's Acquisition Directorate, the unit exclusively responsible for acquisition prior to the Deepwater program as well as in the aftermath of the move away from the contracted LSI.

The Coast Guard's Integrated Deepwater Systems, the unit responsible for managing the Deepwater contract with the LSI.

CG-1 Human Resources; CG-4 Engineering and Logistics; CG-6 Command, Control Communications, Computers and IT; and CG-7 Capability; Coast Guard units responsible for working with the Acquisition Directorate.

Integrated Coast Guard Systems, the LSI for the Deepwater program and a consortium of Lockheed Martin, a logistics and avionics firm, and Northrop Grumman, a major ship manufacturer.

The American Bureau of Shipping, a nonprofit that provides the Coast Guard with independent validation and verification of shipping standards as the Coast Guard takes on assembly functions.

approach—notably, some Coast Guard and industry personnel involved in the production and assembly process—found an audience when Democrats swept to the majority in Congress after the 2006 elections. Congressional overseers honed in on press reports and whistleblower claims of problems connected to the acquisition of some assets in the first phase of the Deepwater program. As we noted in our previous report, there were both successes and failures under the initial SoS/LSI contract with ICGS, but given the changed political environment, the failures received more public attention and oversight scrutiny and ultimately carried more weight than the successes. Consequently, under mounting political pressure to terminate the contract with ICGS, the Coast Guard began to move away from the contracted assembly approach in 2007.

Viewed broadly, neither internal nor contracted assembly is inherently superior to the other. Depending on specification challenges and the degree to which specialized investments are required, each has costs and incurs risks of lock-in. These costs and risks vary, so that internal assembly may be better suited to the specific circumstances than is contracted assembly, or vice versa. While the Coast Guard and its political supporters enthusiastically championed the SoS/LSI approach in the late 1990s, the Coast Guard and ICGS failed to adequately invest in managing their partnership and fell prey to the downside of a series of lock-in risks. This doesn't mean that contracting for assembly is doomed to failure in all cases, but rather that the Coast Guard and ICGS efforts to mitigate risks, including lock-in risks, were unsuccessful. Now, the Coast Guard faces high costs in establishing its own internal assembly capacity and shoulders the risk of managing production and subproduction-level lock-in risks. Here, we describe the investments the Coast Guard (and ICGS, in the case of contracted assembly) made under contracted and internal assembly. Then we identify where the lock-in risks exist under contracted and internal assembly.

Acquisition Under Contracted Assembly: ICGS

Prior to the Deepwater program, the Coast Guard relied on internal contracting capacity to acquire assets. Specifically, the Coast Guard's Acquisition Directorate performed contracting functions for the

Assembly of the Deepwater System

The creation of the Deepwater system involves a complicated set of tasks across the five basic assembly functions.

Design
The plan for the system required gathering specific information on the operational requirements of end users—Coast Guard personnel who operated in “deep” water, so to speak—as well as the desired performance capabilities of different types of assets.

Requirements Determination
With an overall design, Coast Guard personnel then worked with other Coast Guard technical authorities to determine the capabilities and requirements for the system components. Translating requirements and linking them to testing and validation is what is referred to as the Fleet Mix Analysis. This is the specific combination of boats, ships, planes, and other assets needed to comprise the system and fulfill the performance goals of the Coast Guard’s various missions.

Purchasing
With the system design in hand, the assembler would then have to procure the component assets. Given the breadth of assets in the Deepwater system, this meant knowledge of a variety of markets (e.g., markets for boats, ships, helicopters, planes, IT, etc.). Effective contracting for complex products requires the establishment of a flexible yet clear set of guidelines and policies to guide contracting decisions (e.g., writing requests for proposals, writing contract specifications, establishing contractual incentives). Uncertainty about many of the Deepwater assets’ specifications required the establishment of contract management systems that promote collaboration between each asset’s producer (e.g., a vendor), the purchaser, and the ultimate end user, while also ensuring accountability.

Integration
As the assembler procured individual assets, it would also have to ensure that the assets could operate in conjunction with one another and ultimately be connected to form an integrated system. The interoperability requirement begins with the design of the system, but also includes the engineering of a functioning IT and communications system—referred to as C4ISR in the Deepwater program—and a scheme for deploying human personnel to operate the individual assets and connect the system.

Delivery
Not only does the Coast Guard undertake missions along the naval borders and in the interior waterways of the United States, but it often undertakes missions in waters overseas (e.g., in support of the Navy in the war in Iraq). Effective assembly requires delivering the Deepwater assets to locations around the globe and ensuring that, upon delivery, the assets can quickly be integrated into ongoing Coast Guard operations.

production of assets as necessary (see figure 11). During this period, the integration requirements for these assets were less sophisticated than those that would exist for Deepwater. Consequently, the Acquisition Directorate, in conjunction with other Coast Guard units, performed basic assembly functions.

With the advent of the Deepwater program, the Coast Guard began a process of organizational transformation that led to a more complicated acquisition structure. Rather than have the standing Acquisition Directorate manage the contract with ICGS, the Coast Guard created a new, separate contracting operation. This Deepwater acquisition office dealt directly with the LSI, ICGS’ Deepwater contract unit. ICGS’ Deepwater contract office had the responsibility to design the Deepwater system, purchase all the system components from producers, and then integrate them.

Some staff from the Coast Guard’s existing Acquisition Directorate were moved over to the Coast Guard’s Deepwater acquisition office; these staff members brought with them the institutional experience of prior Coast Guard acquisition practice, but they now operated within a wholly new entity engaging in new acquisition procedures for a highly complex product. The Coast Guard maintained the old Acquisition Directorate for the acquisition of assets outside the Deepwater program (e.g., aids to navigation), but was focused primarily on the major Coast Guard recapitalization programs. The separation was so significant that the Deepwater acquisition office was located in a separate space apart from the rest of the Coast Guard Acquisition Directorate staff and had little to no interaction with the other Coast Guard technical authorities. The Deepwater acquisition office was viewed by many within the Coast Guard as having taken many of the more experienced staff from the Coast Guard's existing Acquisition Directorate and separating them into a very hierarchical structure in which Deepwater staff were viewed as among the more innovative and better resourced. This led to resentment and undermined coordination, information exchange, and collaboration between staff in the Deepwater office and the technical authority personnel in the "rest" of the Coast Guard organization.

Coast Guard leadership denied that the intention was to create "first-class" and "second-class" acquisition offices. Instead, the leadership argued that the scope and scale of the Deepwater acquisition demanded new practices and policies, and that the best way to achieve this new approach was to create a separate entity. The overall approach of the Deepwater program was to view industry as a partner in the delivery of products to achieve the Coast Guard's mission, rather than simply as a supplier, and that such ends necessitated the organizational consolidation of Coast Guard staff based in the Deepwater program.

Coast Guard leadership maintained that contracting for assembly and this new organizational configuration with the Coast Guard lowered acquisition costs, since ICGS's Deepwater office was to perform the bulk of assembly tasks for the Deepwater system. ICGS was essentially a vertically integrated firm incorporating both production and assembly capacity. ICGS' constituent entities—Northrop Grumman and Lockheed Martin—are two of the largest producers of the specialized products and services the Coast Guard required for the Deepwater system. Northrop Grumman as a shipbuilding firm would be principally responsible for the acquisition and production of boats and ships, while Lockheed Martin, as an avionics and advanced technology firm, would be principally responsible for the acquisition and production of planes, helicopters, and IT systems. In this way, ICGS would be able to manage lock-in risks at the production and subproduction levels.

Figure 11: Coast Guard Acquisition Before and During the Deepwater Program

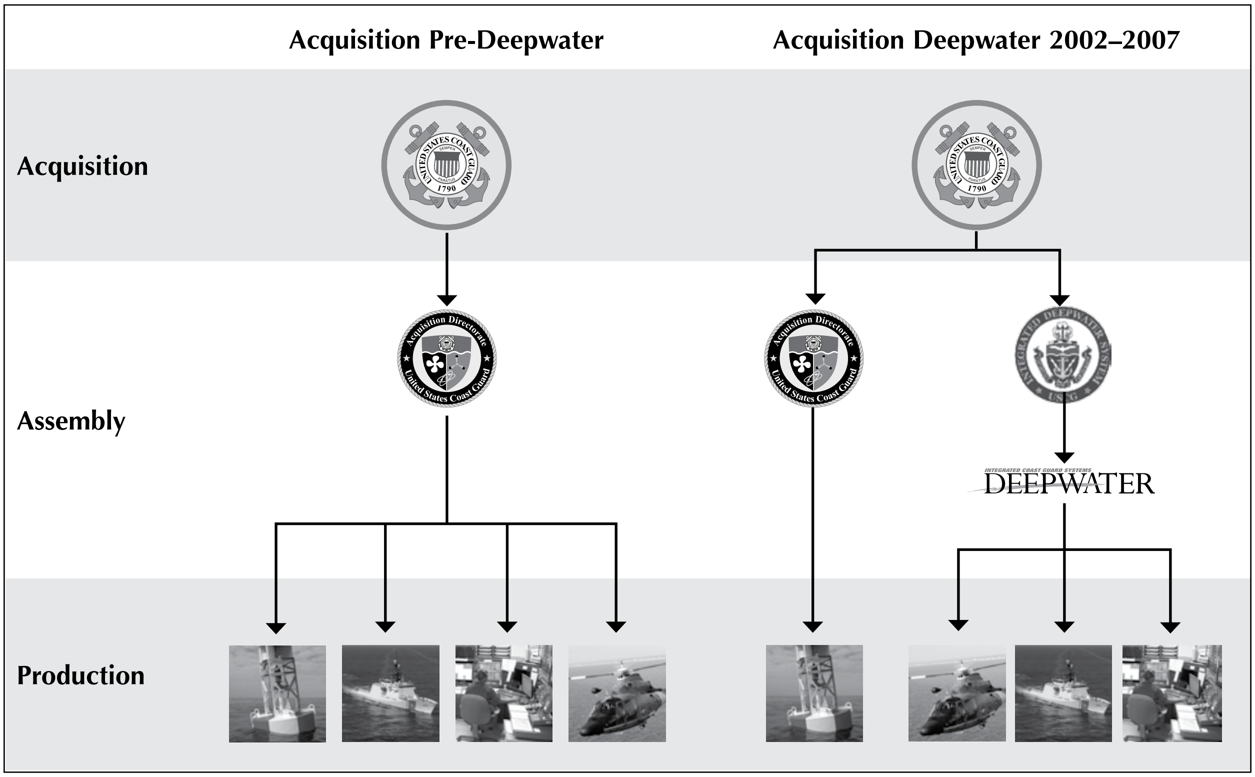
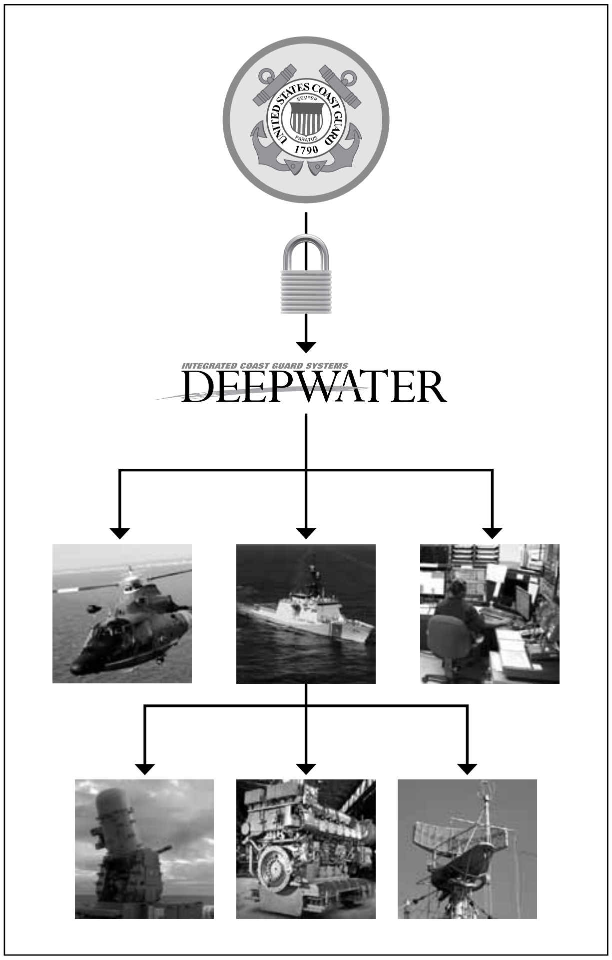


Figure 12: Assembly Lock-In



The risk under contracted assembly is that each side makes specialized investments that cannot be easily deployed for other purposes (see figure 12). ICGS made investments in designing a system that only one consumer—the Coast Guard—was interested in acquiring. ICGS also invested in specialized products and processes to integrate the system that were not easily deployable to other systems it might produce. In particular, ICGS contracted with Lockheed Martin to design, produce, and test the communications and IT infrastructure—C4ISR—that would be the foundational platform on which all assets were integrated to make the Deepwater system interoperable.

The Coast Guard's principal specialized investment was the establishment of the specialized Deepwater acquisition office. Unlike the existing Coast Guard Acquisition Directorate, which had developed contracting policies and procedures to deal with multiple vendors, this new Deepwater acquisition office was created to work with a single firm—ICGS. The contracting practices and procedures that were created for the Deepwater acquisition office would have to be altered to apply to other products and services the Coast Guard might acquire from other suppliers in the future.

The Coast Guard's experience with ICGS was mixed, as witnessed by the results of the Deepwater program. Although ICGS management of the Deepwater program garnered headlines for some of its stumbles, a comprehensive review suggests a more balanced record. Our earlier report highlighted three early task orders that illustrated successes, failures, and mixed outcomes (see *Outcomes Under ICGS*). Still, increasing pressure from Congress and a lack of satisfaction with the arrangement within the agency spurred the Coast Guard to move away from the contract with ICGS in 2007.

With its decision to move away from ICGS and take on assembly responsibilities for the Deepwater system, the Coast Guard faced two principal challenges:

- **How locked-in was the Coast Guard to the relationship with ICGS?** Both the Coast Guard and ICGS had made specialized investments to produce the Deepwater system as a whole, as well as specific assets. Would the Coast Guard remain reliant on ICGS for assembly functions? In addition, would the Coast Guard remain reliant on ICGS' component producers (i.e., Northrop Grumman and Lockheed Martin) for the production of major Deepwater assets? If the answer to both questions is yes, if the Coast Guard were to cancel the existing contract with ICGS, it may still be beholden to ICGS or Lockheed Martin and Northrop Grumman for key production and assembly tasks. In this way, the Coast Guard would be at a significant disadvantage in negotiating new contract terms, since it cannot seek out alternatives in a competitive market.
- **Would the Coast Guard be able to effectively build internal assembly capacity?** To serve as the assembler for the system would require investments in an array of sophisticated functions that the Coast Guard did not have before the Deepwater program. Would the Coast Guard be able to transform the contract management shop it set up to manage its relationship with ICGS into an LSI? Would the Coast Guard be able to

Outcomes Under ICGS

Success: Maritime Patrol Aircraft

The HC-144A Ocean Sentry Medium-Range Surveillance Maritime Patrol Aircraft (MRS MPA) was one of the first acquisitions under the assembly contract with ICGS. The Coast Guard received the plane on schedule, with only modest cost overruns on the initial orders and savings on subsequent fixed price delivery task orders. Performance reviews of the HC-144A post-delivery have been positive, and the aircraft is meeting the Coast Guard's expectations.

Failure: 123 Island Class Patrol Boat

Another earlier acquisition was the conversion of existing 110-foot Island Class patrol boats into 123-foot boats through the extension of the hull by 13 feet. While the first eight of 49 planned 123s had upgraded C4ISR capabilities that enhanced interoperability with other Coast Guard assets in the Deepwater system, hull buckling and shaft alignment problems raised safety and performance concerns. Ultimately, because of these safety and performance concerns as well as cost overruns, the entire acquisition was cancelled and the eight delivered boats were decommissioned.

Mixed: National Security Cutter

The largest acquisition in the Deepwater fleet, the 418-foot National Security Cutter (NSC), has been both negative and positive in outcome. On the negative side, cost overruns and delivery delays on the first-in-class NSC were significant. In addition, performance concerns were raised throughout the production process, although many of these issues have now been addressed. On the positive side, the NSC is now a fully operational ship that dramatically upgrades the Coast Guard's maritime capabilities. Furthermore, beyond the first three NSCs under contract with ICGS, subsequent high-endurance cutters will be acquired by CG-9 as the LSI under fixed-price contracts. They are anticipated to come in under the cost of the first NSC.

> effectively perform key assembly functions, notably design, requirements determination, procurement, integration, and delivery? This capacity becomes even more important if the Coast Guard finds itself locked-in with ICGS or its component producers for Deepwater components.

We turn to these questions in the following discussion.

Acquisition Under Internal Assembly: CG-9

In order to perform assembly functions internally, the Coast Guard needed to expand its capacity to perform core assembly tasks, notably design, requirements determination, procurement, integration, and delivery. The Coast Guard's move away from ICGS coincided with an effort to transform and modernize the entire Coast Guard using additional resources that became available post-9/11. Part of this reorganization involved elevating traditional support activities, like acquisition, to more central prominence within the Coast Guard, extending the reach of these activities across the service, and strengthening the connections with other support activities (e.g., human resource planning).

Under this modernization effort, the upgraded acquisition office, or CG-9, is led by the Assistant Commandant for Acquisitions, who reports to the Deputy Commandant for Mission Support.[10] This provides a direct relationship to the top-level leadership of the Coast Guard. In addition, CG-9 is to become more integrated with four other mission-support offices:

- CG-1 Human Resources

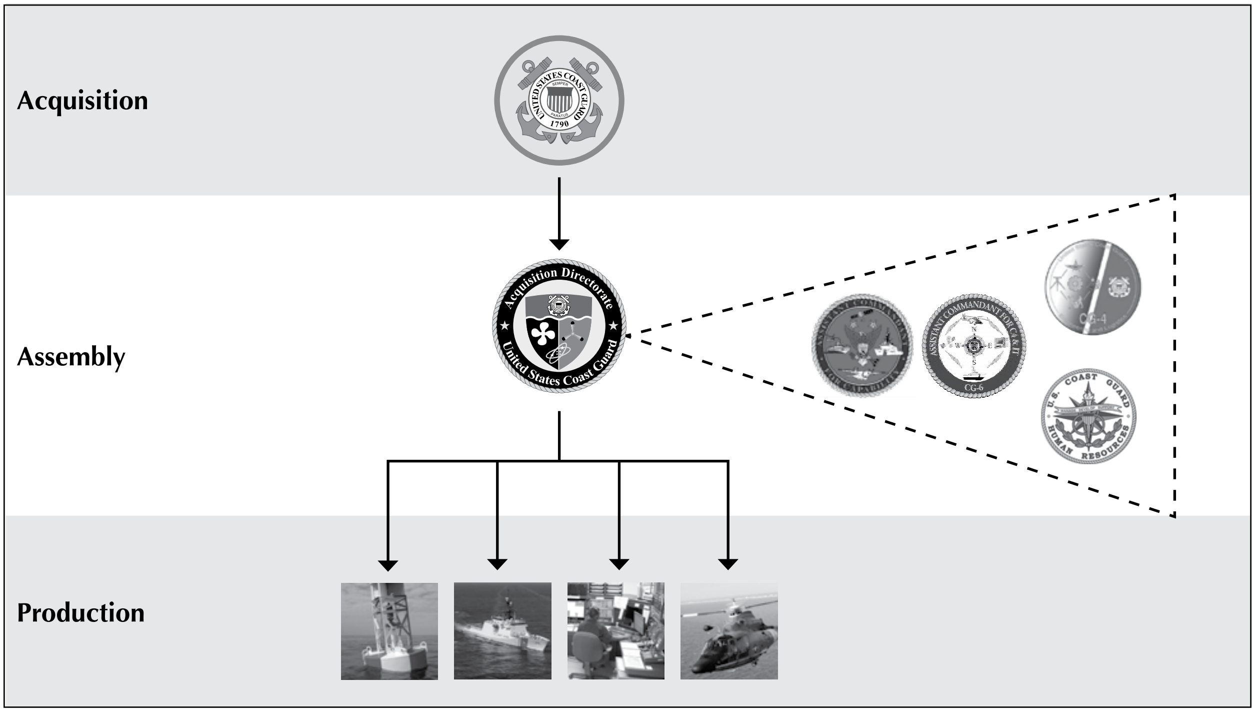
- CG-4 Engineering and Logistics
- CG-6 Command, Control Communications, Computers and Information Technology
- CG-7 Capabilities

Under internal assembly, when the Coast Guard acquires a new asset, rather than CG-9 making the purchase in isolation, these four units are to work in concert to both plan and execute the purchase of the product (see figure 13). CG-9 conducts the actual acquisition, taking the lead for market research, contracting, and contract management tasks. The other three units take the lead in developing the overall design of the asset, determining how it would best complement other assets to perform specific missions, as well as what key features and performance requirements it needed. CG-1 provides planning and design support for all human resource management elements of each asset. CG-4 provides planning and design support for the engineering, logistics, and maintenance of each asset. CG-6 provides planning and design support for all command, communication, and IT aspects of each asset. CG-7 provides planning and design support for determining capability needs and standards requirements.

For example, consider the development of the plan for the specific combination of boats, ships, planes, and other assets needed to comprise the Deepwater system. Under contracted assembly, ICGS, as the LSI, was responsible for conducting the analysis and proposing alternative combinations of Deepwater assets to the Coast Guard. Now, under internal assembly, the CG-9 is to work collaboratively with these other four units to perform this analysis, gathering information about trade-offs between cost and performance of the entire system under different combinations of assets.

The challenge for the Coast Guard in creating this new acquisition arrangement is that extricating itself from the previous arrangement with ICGS as the LSI is costly. The Coast Guard needs to acquire new permanent staff with the requisite skills in each of the four CG directorates, as well as set up offices, practices, and procedures to perform assembly tasks—all while continuing to acquire components of the Deepwater system. To that end, one of the Coast Guard's first steps in moving away from ICGS was to lay out what the leadership termed the Blueprint for Acquisition Reform in conjunction with an overhaul of its Major Systems Acquisition Manual (MSAM).[11] These documents provide guidance to acquisition staff in the

Figure 13: The Coast Guard's Desired Acquisition Approach



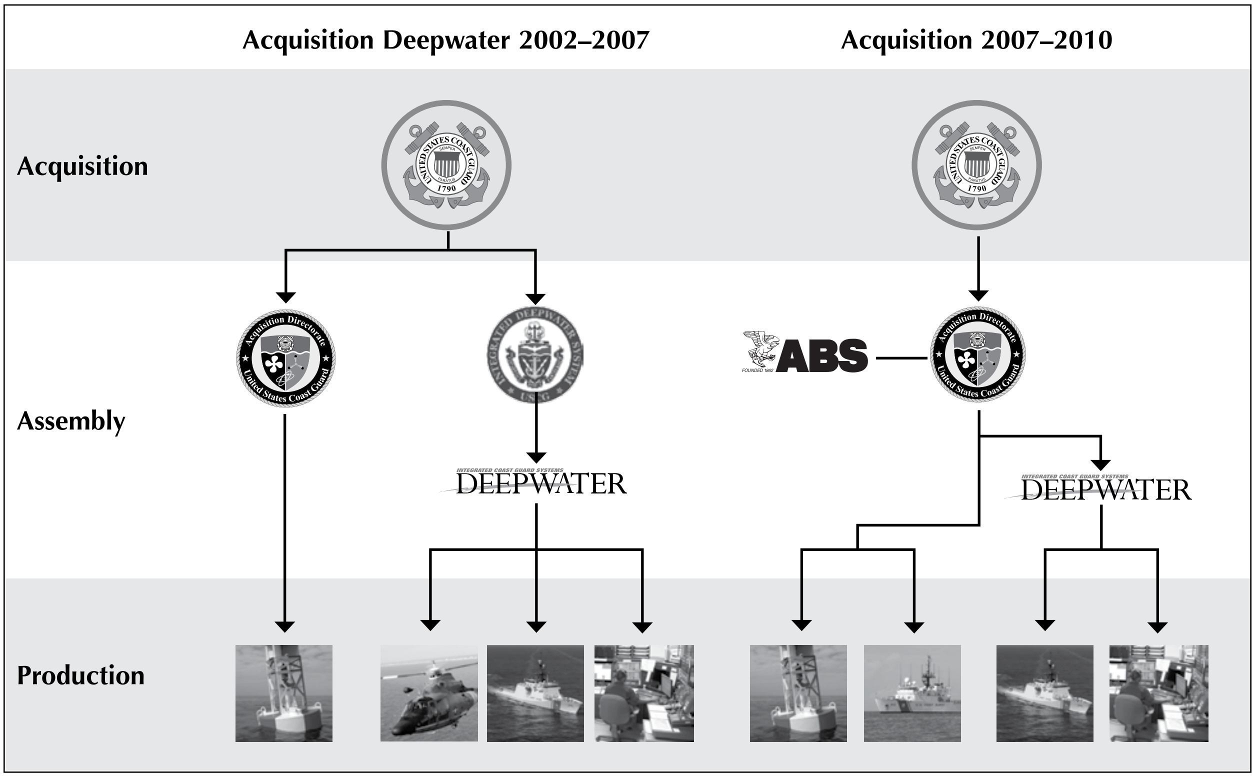
Coast Guard for conducting systems engineering and acquisition management functions. Recent General Accountability Office (GAO) testimony and reports cast doubt about the degree to which these documents are guiding the strategic direction and actions of the CG-9 Acquisition Directorate;[12] given the pace and magnitude of changes in the Coast Guard's mission over the last decade (e.g., post-9/11 homeland security requirements). The GAO's concern is that results are still lacking in the Coast Guard's efforts to integrate and link acquisition practices and procedures spelled out in the Blueprint for Acquisition Reform and the MSAM.

Part of the challenge is that the Coast Guard cannot jump immediately from the separate Deepwater office it had set up to manage its relationship with ICGS to a wholly new acquisition arrangement through which it performs all assembly functions internally. The Coast Guard has existing contracts for Deepwater components with ICGS (e.g., continued production of the National Security Cutters (NSCs) with the C4ISR systems, and the C4ISR "missionization" of the HC-130J). In addition, because the Coast Guard lacks adequate systems engineering, logistics, and C4ISR capacity, it has had to turn for support functions to other organizations—for example, to the Johns Hopkins University Applied Physics Laboratory to conduct the Fleet Mix Analyses or to the American Bureau of Shipping (ABS) to perform third-party validation of shipbuilding standards.[13] While the Coast Guard remains reliant on outside support for assembly functions, the GAO considers these arrangements with other organizations to be evidence of its continued progress in transitioning away from contracted assembly toward internal assembly. Figure 14 visually depicts the transition from ICGS performing assembly functions to an intermediary stage before the Coast Guard can fully internalize assembly.

In sum, to internalize assembly functions, the Coast Guard bears three types of costs:

- The one-time costs of dismantling the existing arrangement with ICGS;
- The one-time costs of putting transition support arrangements in place until the Coast Guard could fully internalize assembly functions; and
- The ongoing costs of establishing and maintaining internal assembly functions.

Figure 14: The Coast Guard's Acquisition Approach Through the Deepwater Program



The advantage of these investments is that, once the Coast Guard establishes the internal capacity to perform assembly functions, the risk of lock-in at the assembly level diminishes. Concerns about an advantaged vendor opportunistically raising costs or delivering low quality assembly are reduced. However, lock-in risks remain at the production and subproduction levels, risks that fall to the Coast Guard to manage. There are basically two types of production and subproduction lock-in risks for the Coast Guard under this new arrangement:

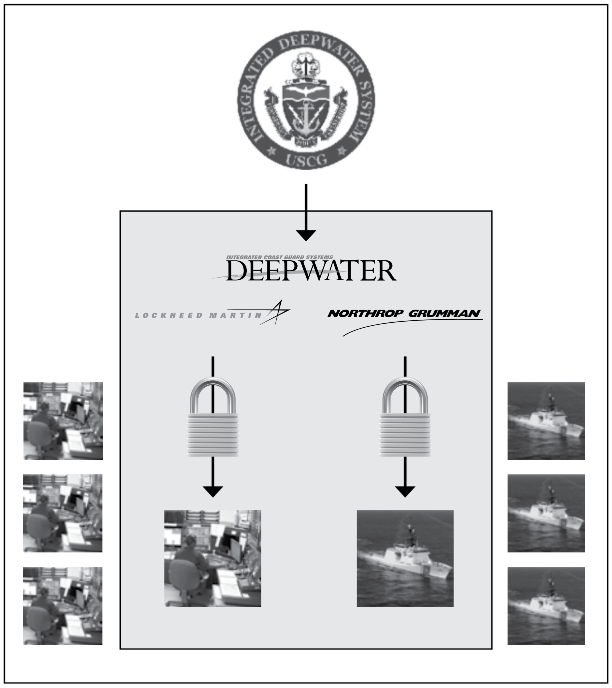
- Lock-in risks associated with new assets the Coast Guard acquires
- Lock-in risks that carry over from assets purchased under the contract with ICGS

The first type of lock-in risk is relatively straightforward to identify, although more challenging to mitigate and manage in practice. In the first instance, specification challenges and specialized investment requirements drive the risk of lock-in in the ways we've described earlier in this report. Our previous report discusses contracting and management strategies and tools that can be used to mitigate the risks associated with complex products.

The second type of lock-in risks—those that carry over from the previous arrangement—merit some explanation. Recall that the Coast Guard is still under contract with ICGS for some assets (notably, the production of three NSCs with C4ISR capabilities, and the C4ISR missionization of the HC-130J); it is contractually bound to acquire these pieces and cannot extricate itself from these arrangements without paying a steep financial penalty. However, the contract with ICGS concludes in 2011, so the Coast Guard is not indefinitely bound to ICGS or its constituent suppliers through legally enforceable contract arrangements. Rather, because of the nature of some of the assets the Coast Guard is acquiring under these contracts, they likely will remain bound to either Northrop Grumman or Lockheed Martin for a significant portion of the Deepwater program.

With Lockheed Martin, the carryover lock-in risk is for the foundational components of the C4ISR technology. When the Coast Guard processed the first task order for the C4ISR technology that serves as the interoperability backbone of the Deepwater system, ICGS opted to use Lockheed Martin to develop and produce the technology. The decision makes logical sense: ICGS lowers its market scanning, contracting, and contract management costs by drawing on in-house production capacity. However, there were alternative developers and producers of C4ISR technology in the market outside of Lockheed Martin (see figure 15). Because of the challenges in specifying the performance requirements of the C4ISR system and the specialized investments required to develop and produce it, whomever ICGS selected had an advantage in all future rounds of contracting for these elements of the system. Lockheed Martin, as the original designer of the foundational code of the system, will essentially remain the sole-source producer until the Coast Guard can gain mastery and proprietary ownership of the C4ISR programming. Under internal assembly, the Coast Guard can contract with other firms for components of the C4ISR system,[14] but remains locked into Lockheed Martin for core aspects of the C4ISR platform. There are other market suppliers of IT platforms that are like the C4ISR system, but the challenge for the Coast Guard remains acquiring the data rights to the current proprietary system, of which Lockheed Martin is the owner. Alternatively, the Coast Guard could purchase a commercial off-the-shelf (COTS) IT system with similar capabilities to that of the Lockheed

Figure 15: Lock-In Risks that Result from Vertical Integration of Assembly and Production



Martin C4ISR platform, and attempt to integrate the two systems in order to achieve interoperability. The costs of this second option are significant, as this requires an investment in Coast Guard-run design, development, and testing laboratories.

It's important to note that, because of the complex nature of the C4ISR system—its performance dimensions are difficult to specify, and design and production require specialized investments—there would be lock-in risks with whomever the Coast Guard selected to develop this component of the Deepwater system. However, had the Coast Guard either performed the task of negotiating the production of this asset on its own or turned to an LSI that was independent from the producer, more favorable contractual terms might have been negotiated.

With Northrop Grumman, the carryover lock-in risk is for the future acquisition of the NSC. While many of the boats and planes the Coast Guard buys are relatively standard COTS products, the NSC required significant research and development and specialized investments to produce the first-in-class vessel, the Bertholf.[15] The Bertholf is the most technologically advanced high-endurance cutter that the Coast Guard has ever acquired, equipped with a variety of features unique in the Coast Guard fleet, including: longer patrol endurance; more powerful weapons (e.g., a 57MM main gun; a larger flight deck; chemical-biological-radiological environmental hazard detection and defense systems; stern launch craft; and a sophisticated C4ISR suite). As a result, Northrop Grumman has an advantage over other shipyards when the Coast Guard looks into buying additional NSCs. The current contract with ICGS has Northrop Grumman delivering three NSCs by 2011. The Coast Guard plans to acquire five additional NSCs as part of the Deepwater program. Northrop Grumman has been asked to make a proposal for the fourth NSC. Northrop Grumman has the advantage of already having made the specialized investments in a facility specifically set up to produce the NSC, yielding lessons learned that are reflected in reduced man-hours to build succeeding ships, providing a sizable advantage in future NSC contract competitions.

As was the case with Lockheed Martin and its C4ISR work, ICGS was able to lower its assembly costs by internally producing the NSC, even though there were alternative shipyards that could have built the first-in-class vessel. An assembler independent from the producer might have been more vigorous in performing core assembly tasks, however, and thereby mitigated some lock-in risks. The first-in-class Bertholf had some serious problems. It arrived 22 months late and $256 million over budget, and was issued a number of performance-based trial cards that had to be corrected after the Coast Guard accepted the ship. The cost overruns and schedule delays were also attributed to a very significant number of requirements changes to the first-in-class vessel, along with other changes as a result of the Coast Guard's expanded mission, and new requirements post-9/11. Many of these problems were attributed to poor acquisition management on behalf of both ICGS and the Coast Guard.[16]

The complexity of these products by no means guarantees that the Coast Guard will receive inferior quality or face higher costs or delayed delivery. Instead, it simply means that the Coast Guard has to take steps to mitigate these risks. Along these lines, the Coast Guard has more actively involved and collaborated with technical and test authorities as well as with third parties to oversee the design and production of assets. Notably, the Coast Guard is now relying internally on its own Research and Development Center, and externally on the Navy's Surface Warfare Division and ABS to gain technical expertise, best-practice systems engineering and logistics design, and accreditation of design and production processes. By seeking this type of guidance, the Coast Guard is harnessing expert capacity and oversight after its own abilities in these areas had atrophied under the ICGS contract.

CG-9's Early Performance

A full assessment of how well the Coast Guard is performing the assembly function is premature. Still, it is possible to get an early gauge of how well the Coast Guard is performing assembly functions through the acquisition of the first Deepwater asset outside of the ICGS contract.

The workhorse of the Coast Guard fleet is commonly known as the Fast Response Cutter (FRC), a small but agile and fast patrol boat used in an array of Coast Guard missions (e.g., search and rescue, drug interdiction, illegal immigration prevention).

The FRC mission was to be shared with existing patrol boats to be upgraded and lengthened to 123 feet (the P-123s). As noted earlier in the document and in our previous report, hull structural failures and shaft alignment problems made the converted P-123s unseaworthy. The new FRCs were to be built in two classes: FRC-A, with new technology composite hulls, and FRC-B, with conventional steel hulls. On March 15, 2007, the Coast Guard terminated the ICGS FRC-A acquisition effort in response to congressional interest, and Commandant Thad Allen reassigned responsibility for the acquisition of the FRC-B to CG-9.

In the wake of these failed acquisitions under ICGS, CG-9 has continued with the more conventional and less risky procurement approach for what is now simply termed the FRC. The Coast Guard is seeking a boat with a less sophisticated hull structure than that of the originally planned FRC-A. This allowed CG-9 in June of 2007 to solicit proposals for a commercial off-the-shelf (COTS) craft based on a proven concept—or first-in-class parent craft design—for which there is evidence about the performance capabilities of the boat.[17]

After a review of six proposals using competitive and transparent criteria, CG-9 awarded the FRC contract to Bollinger Shipyards, Inc., in September 2008. Bollinger proposed a demonstrated COTS boat, based on a design from Dutch shipbuilder and designer Damen.[18] The primary modification to this COTS design is to add a stern launch capability, for a total of 58 vessels if all options are exercised; this will allow the Coast Guard to deploy small, fast interceptor craft easily and safely out of the rear of the cutter, rather than using the traditional, slower, and more dangerous approach of hoisting and lowering it off the side of the cutter.

This contract was for the production and testing of the first boat—the parent craft—under a firm fixed price with an economic price adjustment, in which the Coast Guard compensates Bollinger. CG-9 wisely structured the contract to include up to six options, in which the Coast Guard can purchase an additional 34 cutters under a fixed-price arrangement in which all of the boats purchased, after the first boat, cost a firm, set price.[19]

Section 6: A Look Ahead—Internal Versus Contracted Assembly in the Federal Government

Readers interested in the lessons and recommendations that flow from the Deepwater case will benefit from reading this section.

CG-9 Moving Forward

While the early signs on the acquisition of the Fast Response Cutter (FRC) are on balance positive, risks to the program remain. In particular, the larger question facing the Coast Guard centers on whether integrating its assets into a Deepwater system is a viable goal. The Coast Guard may upgrade its acquisition capabilities for purchasing individual assets, but this is only one aspect of the full range of functions required for effective assembly. The Coast Guard must also demonstrate success in the design, integration, and delivery of the full system. If the FRCs, for example, perform well individually, but fail to operate in tandem with other Deepwater assets, the Coast Guard will have failed to achieve the promise of interoperability, perhaps the signature performance dimension of the Deepwater program.

The early signs here are mixed. The GAO continues to express both optimism and concern about the Coast Guard's progress in revising its asset baselines to reflect new assumptions about asset capabilities and performance. The optimism is based on the Coast Guard's evolving modernization, involving in part stronger linkages between CG-9, the Acquisition Directorate, and the different technical authorities (e.g., CG-4 Engineering and Logistics). The concern centers around continued questions about the strategic direction of the Deepwater program post-ICGS, alignment issues between acquisition strategy and the MSAM, and perceived shortcomings in developing a systematic and disciplined approach to acquiring assets (GAO-09-682). The Coast Guard continues to experience acquisition workforce shortages, and its revised baselines point to higher costs and schedule slippages at the asset level.

These performance gaps have reverberated outside of the Coast Guard in important ways, as members of Congress have challenged the Coast Guard's operational and capital funding requests. While the Coast Guard has successfully taken steps to mitigate and reduce "lock-in" risks connected to contracting for assembly, the move to establish internal assembly capacity is both costly and fraught with its own risks.

Project Deepwater's Lessons

The Coast Guard's experience under Deepwater offers several important lessons.

- **The Product's Characteristics Are the Initial Source of Costs and Risks.** The Coast Guard has learned that acquisition of a complex product like the Deepwater system is both costly and risky, whether it has been done internally or through contract.
- **Contracting for Assembly May Be Cheaper, but It Also Increases Risk.** By contracting for assembly (and production) of the Deepwater system, the Coast Guard was able to acquire capacity it initially did not possess for performing these functions internally, but in doing so exposed itself to the risk of becoming "locked-in" to a private vendor.
- **Performing Assembly Internally May Lower Risk, but It Also Raises Costs.** As the Coast Guard

begins to move away from contracting for assembly, it lowers the risks associated with "lock-in," but in doing so is now incurring significant costs to create its own internal assembly capacity.

- **The Successful Acquisition of Any Complex Product Is a Function of Lots of Moving Parts.** The Coast Guard's Deepwater experience demonstrates that multiple aspects of the acquisition process impact acquisition success. In this report we've detailed the importance of the "assembly vs. production" choice, while our previous report highlighted the impact of contract design and contract management. All three of these phases of the acquisition process interact to influence performance outcomes.

Recommendations

The Coast Guard's Deepwater experience points to a trio of recommendations for different participants—contract management staff, agency executives, and congressional and executive-level policy makers—in the acquisition of complex products.

For contract management staff

Recommendation One: Agencies should match their acquisition approach to the characteristics of the product. Because simple products—like paper clips—are easy to specify and easy to produce, agencies can rely on standard approaches to acquisition (e.g., fixed-price contracts). More complex products—like new weapon and information technology systems—demand far more sophisticated acquisition strategies and systems. The successful acquisition of a complex product require both the purchasing agency and the vendor to work collaboratively to specify the product's attributes and performance requirements, and to invest in designing and building a specialized production process to deliver the product. Rather than treating the exchange like an off-the-shelf transaction, both the agency and the vendor benefit from approaching the exchange as if they were entering into a relationship in which there are risks for both parties. Systems and practices should be adopted that promote trust (e.g., vendor-agency workgroups that define product requirements collaboratively), but also hold both parties accountable (e.g., third-party validation and verification of product design and performance).

For agency executives

Recommendation Two: Agencies cannot move from contracted assembly to internal assembly (or vice versa) with the flip of a switch. The Coast Guard's experience transitioning from a contractor performing assembly functions to building the capacity to perform those functions internally highlights that the costs of changing modes in the midst of acquiring a complex product are high. New staff need to be hired and trained and new systems and practices need to be developed and implemented, all while still relying on contractors to perform assembly functions during the transition. The Obama administration's efforts to increase the size of the federal procurement workforce as well as convert contractors performing critical functions to federal employees are to be commended. Over the long run, these steps should improve agency capacity to internalize assembly functions. However, in the short run, the administration's guidance to agencies to in-source activities they currently acquire through contracts will likely prove challenging given the costs of transition. Agencies would be wise to meet this goal by initially in-sourcing simple rather than complex functions, while growing their internal capacity to effectively perform more complex functions, such as assembly and integration.

For congressional and executive-level policy makers

Recommendation Three: The effective acquisition of complex products requires new policies and tools. A central challenge in acquiring complex products is that conventional approaches to contracting (e.g., competitively bid fixed-price contracts) do not attend to the risks inherent in acquiring products that are difficult to specify and require specialized investments. In response to perceived acquisition failures for complex products (e.g., the Coast Guard's Deepwater program, the Department of Homeland Security's Secure Border Initiative, the Department of Army's Future Combat Systems), congressional and executive-level policy makers have taken several steps to try to improve contracting practices. Some of these steps may prove harmful in practice. For example, prohibiting agencies from using more flexible acquisition approaches, like "lead systems integrator" contracts, may cause agencies to rush to take on assembly functions before they have the capacity to do so. This will increase the risk of delivery delays and cost overruns. Instead of focusing on ways to constrain contracting practice, policy makers should instead foster efforts to provide procurement personnel with more information as they make contracting decisions, while simultaneously rewarding (and penalizing) procurement personnel and vendors for overall performance.

The Obama administration has taken some steps in the above direction. In particular, clarifying the definition of inherently governmental functions should provide procurement personnel with clearer guidance about which functions they can outsource and which functions should be performed internally. More could be done in this vein. In particular, procurement personnel need more comprehensive means of valuing the costs and risks associated with contracting for complex products or producing these products internally. Current accounting methodologies do not adequately account for the true costs of contracting or internal provision. Improved contracting performance is more likely to result from providing procurement personnel better information and clearer performance standards rather than regulating their behavior.

Appendix: Research Methods

We conducted over 125 face-to-face and telephone interviews with 100 individuals involved in the Deepwater program. The purposive sample was drawn from the recommendations of experts involved in the program at different time periods over the course of the program, to date. The sample included interviews with:

- Current and past Coast Guard officials
- Leaders from industry
- House and Senate committee and subcommittee staffers
- Representatives of oversight bodies
- Impacted third-parties
- Operational users of the modernized and upgraded Coast Guard assets

All interviewees were promised confidentiality in exchange for their participation. Therefore, no names, titles, or positions of the study participants will be released. All interviewees were told that they could withdraw from participation at any time. No electronic recordings of the interviews exist.

We reviewed thousands of pages of government reports, testimony, documents received under the Freedom of Information Act, and other materials. The references provided in terms of Deepwater-related materials represent only a fraction of the materials reviewed as part of this in-depth and objective analysis of the Coast Guard's Deepwater acquisition program.

This study met all the requirements from the respective university institutional review board guidelines for our research team members.

Endnotes

1. Trevor L. Brown, Matthew Potoski, and David M. Van Slyke. 2008. *The Challenge of Contracting for Large Complex Projects: A Case Study of the Coast Guard's Deepwater Program* (IBM Center for The Business of Government).

2. Economists typically refer to specialized investments as *asset-specific* investments (Williamson, 2005).

3. The term "deepwater" refers to Coast Guard assets that operate in literally deep water, 50 miles off shore.

4. As of 2001, 86 percent of the Coast Guard's assets, deepwater and air, had reached or were expected to reach the end of their planned service life within five years. The Coast Guard's fleet of assets was widely considered to be one of the oldest in the world, ranking at 37 out of 39 of fleets worldwide (Acquisition Solutions, 2001, p.6).

5. See www.uscg.mil/directives/cim/4000-4999/CIM_4140_1.pdf, page 5: "Total ownership cost (TOC), alternatively referred to as the total cost of ownership, is the sum of all costs associated with the research, development, procurement, personnel, training, operation, logistical support and disposal of an individual asset. This cost includes the total supporting infrastructure that plans, manages, and executes that asset's program over its full life, as well as the cost of requirements for common support items and systems that are incurred because of introducing the particular asset into the Coast Guard."

6. Three industry teams submitted proposals to the initial RFP: the Boeing Company, Lockheed Martin Naval Electronics and Surveillance Systems, and Science Applications International Corporation.

7. The failed boat upgrade was for the Coast Guard's P-123s, and the cost overruns and delivery delays occurred for the National Security Cutter. Later in this report, we provide more detail on the problems with the P-123 conversion. Our previous IBM report also details these problems and discusses some of the challenges associated with the production of the National Security Cutter.

8. First-in-class designs typically encounter cost overruns and schedule delays as the precise specifications for the product are worked out.

9. We also cover this in some detail in our previous report. *The Challenge of Contracting for Large Complex Project: A Case Study of the Coast Guard's Deepwater Program*. IBM Center for The Business of Government. 2008.

10. At this level within the Coast Guard, the Deputy Commandant for Mission Support integrates with the Deputy Commandant for Operations, the Commander of the Force Readiness Command and the Commander of the Operations Command. Together, these force-level units report directly to the Vice Commandant.

11. See www.uscg.mil/acquisition/newsroom/pdf/msam.pdf and www.uscg.mil/ACQUISITION/aboutus/blueprint_v3.pdf.

12. See GAO-07-446T, GAO-08-660, GAO-08-745, GAO-09-462T, GAO-09-497, GAO-09-530R, GAO-09-620T, and 09-682; CRS 2009.

13. In 2000, Booz Allen Hamilton conducted analysis and supported the Coast Guard in developing a conceptual design for an integrated Deepwater system. This began with an assessment of the Coast Guard's assets, C4ISR, and other support and technological components. The Booz Allen Hamilton contract at the time was referred to as the Deepwater Capability Replacement Analysis Project (see www.boozallen.com/consulting/industries_article/658190 and www.uscg.mil/comdt/speeches/docs/8feb_deepwater.pdf).

14. On Feb 25, 2009, L-3 Communications was awarded a subcontract by Bollinger, a ship manufacturer, for the installment of some C4ISR components on the most recent Deepwater acquisition, the Fast Response Cutter-B.

15. Northrop Grumman had to make significant specialized infrastructure and assembly process improvements to its shipbuilding production facility in Pascagoula, Mississippi.

16. See 09-462T, GAO 09-497, GAO 09-620T, GAO 09-682 and GAO 09-810T.

17. See www.uscg.mil/acquisition/newsroom/pdf/sentinelmediabrief.pdf and www.uscg.mil/ACQUISITION/sentinel/pdf/123sentinelcomparison.pdf.

18. This particular Damen design is currently being used by the South African Coast Guard.

19. The initial projection is that each additional cutter will cost between $45 million and $50 million. See www.navytimes.com/news/2008/09/defense_newcutters_093008/ and www.uscg.mil/acquisition/sentinel/faq.asp#2, point 35.

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