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The Challenge of Contracting for Large Complex Projects:
A Case Study of the Coast Guard's Deepwater Program

Contracting Series

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IBM Center for
The Business of Government

2008

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Cover photo: The Northrop Grumman Corporation-built National Security Cutter USCGC Bertholf was commissioned on August 4, 2008. Named to honor Commodore Ellsworth P. Bertholf, the first commandant of the U.S. Coast Guard, the ship is the most capable and technologically advanced maritime asset in the service's 218-year existence.

Source: *Icgsdeepwater.com. Photo courtesy of Northrop Grumman.*

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F O R E W O R D

On behalf of the IBM Center for The Business of Government, we are pleased to present this report, "The Challenge of Contracting for Large Complex Projects: A Case Study of the Coast Guard's Deepwater Program," by Trevor L. Brown, Ohio State University; Matthew Potoski, Iowa State University; and David M. Van Slyke, Syracuse University.

Albert Morales

One of the biggest challenges facing the new administration, as well as future administrations, is the effective acquisition of complex products. The federal government cannot eliminate the risks associated with complex products by simply avoiding procuring such products. As the difficulties confronting the federal government become increasingly complicated, so too will the types of goods and services needed to address those challenges.

David A. Abel

The federal government now spends about 40 percent of its discretionary budget to buy everything from office supplies to weapon systems. When the government buys simple products, like paper clips, they can turn to well-established acquisition strategies and practices and apply them to richly competitive markets. When government agencies buy complex products, like weapon systems, conventional acquisition approaches are often insufficient and markets are more challenging. The acquisition of complex products requires more sophisticated contracting approaches.

The research team of Brown, Potoski, and Van Slyke examines the contracting for a complex product or its components by reviewing the U.S. Coast Guard's experience with its Deepwater Program. The Deepwater Program was a major "system of systems" acquisition to upgrade and integrate the Coast Guard's sea and air assets (such as boats and airplanes). Based on their analysis of the Coast Guard experience, the authors offer lessons for the future as the government continues to face the challenge of acquiring complex products. We hope that this timely and informative report will be useful to both the new administration and Congress.

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EXECUTIVE SUMMARY

The U.S. federal government is increasingly acquiring products that have qualities that cannot be easily and clearly defined in advance and that are difficult to verify after the product or service has been delivered. These products are called complex products.

A federal government agency has three basic options for acquiring complex products:

- It can build the product itself.
- It can buy components of the product and then integrate them on its own.
- It can pay someone else—a general contractor—to buy the components and assemble them into the product.

This third option is often referred to as a system-of-systems (SoS) contracting approach in which a private firm serves as the product assembler, or lead systems integrator (LSI). In the second approach the government agency serves as the LSI.

The costs of building complex products are often out of reach for government agencies. Consequently, government agencies are left with the two assembly production options. In each case, the government agency relies on a contract (or contracts) to acquire the product and its component parts.

Contracts for complex products are risky for both buyers and sellers. With few competing vendors, the buyer—in this case a government agency—bears the risk that the seller will deliver a product that does not meet its needs or will request payment that exceeds the expected value of the product. And faced with a buyer who wants a very specialized product that few, if any, other buyers want, the seller bears the risk that it will invest time and effort to build a product for which it will not receive adequate compensation. These are difficult deals to negotiate.

This report highlights the risk of becoming locked in to or stuck in a contract with a vendor for a complex product or its components by examining the U.S. Coast Guard's Deepwater program, a major SoS acquisition to upgrade and integrate its sea and air assets (such as boats and airplanes). The Coast Guard is six years into a projected 25-year acquisition and production process for the Deepwater program, far enough along to examine options and tradeoffs at two initial stages: choosing whether to build, buy, or assemble the product, and designing the acquisition contract.

The Coast Guard initially elected to use a private firm to serve as the LSI and pursued a flexible contract design—an indefinite-delivery/indefinite-quantity (IDIQ) contract—to govern its relationship. The innovative contract design allowed production of many Deepwater assets to commence without decisions being made about every detail of the entire system, a task that would have been costly and challenging given the complexity of the system.

Because the initial results from the contract with the private LSI have been mixed, the Coast Guard has recently made a change in the Deepwater program. In response to the risks of becoming locked in to a relationship with the private LSI, the Coast Guard designed the contract so that at the five-year mark it could reassess the acquisition and exit the relationship if it was dissatisfied with the private LSI's production and delivery of the Deepwater system. Now, the Coast Guard is standing up its acquisition directorate to serve as the LSI so that it can purchase assets directly and integrate them into the Deepwater system.

The Coast Guard's experience with Project Deepwater suggests ways that government agencies can harness the benefits of complex contracting while avoiding its pitfalls. The Coast Guard experimented with a novel contracting approach and learned several lessons for future acquisitions of complex products:

- The effective acquisition of complex products requires an expanded and more highly skilled acquisition workforce.
- The effective acquisition of complex products requires a better understanding of risk.
- The effective acquisition of complex products requires an investment in learning.

Introduction

The Challenge of Acquiring Complex Products

The U.S. federal government spends around one-fifth of its budget buying everything from office supplies to weapon systems. When the federal government buys simple products, like paper clips, it can turn to well-established acquisition strategies, processes, and practices. When the federal government buys complex products, like weapon systems, conventional acquisition approaches are insufficient. Complex products require more sophisticated contracting approaches.

Contracts for complex products are risky for both buyers and sellers. With few competing vendors, the buyer—in this case a government agency—bears the risk that the seller will deliver a product that does not meet its needs or will request payment that exceeds the expected value of the product. And faced with a buyer who wants a very specialized product that few, if any, other buyers want, the seller bears the risk that it will invest time and effort to build a product for which it will not receive adequate compensation. These are difficult deals to negotiate.

This conundrum is by no means unique to weapon systems. Government agencies at all levels buy highly specialized products for which they are the only buyer. Examples are plentiful: massively integrated construction projects, such as the City of Boston's "Big Dig"; social service delivery systems that "wrap around" care for clients, such as Wisconsin's Wraparound Milwaukee; fencing systems that combine tactical infrastructure with sophisticated information technology to secure thousands of miles of border, such as the Department of Homeland Security's (DHS's) Secure Border Initiative Network.

One of the biggest challenges facing the next administration in Washington, DC, will be how to effectively acquire complex products. The federal government cannot eliminate the risks associated with complex products by simply not acquiring them. As the challenges facing the federal government become increasingly complicated, so too will the types of goods and services needed to address those challenges. Federal government agencies have three basic options for acquiring these types of complex products:

- It can build the product itself.
- It can buy components of the product and then integrate them on its own.
- It can pay someone else—a general contractor—to buy the components and assemble them into the product.

Under pressure to "do more with less," federal government agencies are increasingly turning to the third option by hiring a general contractor. A novel approach under this third option is to buy through a "system-of-systems" (SoS) strategy in which responsibility for designing, building, and integrating the assets into a coherent product, or system, is contracted to a private sector "lead systems integrator" (LSI)—the general contractor. The upsides of the SoS approach are lower costs by bundling related buys into a single acquisition and tapping technical capacity and expertise not available in-house. The downside is that the government agency is the only purchaser, and once the contract is let, the vendor is the only viable supplier. This situation leaves each party with no easy exit from the contract, limited information about costs and quality, and engagement with a partner relatively unconstrained by

Examples of Complex Projects

City of Boston's Big Dig: From 1985 to 2007, the City of Boston's Metropolitan Transportation Authority contracted with a private joint venture to design and construct a complex traffic system to reduce congestion into and out of Boston. The system comprises underground roads, bridges, ramps, and a tunnel under the Boston Harbor that is now integrated into the existing above-ground transportation infrastructure.

Milwaukee County's Wraparound Milwaukee: Beginning in 1995, Wisconsin's Milwaukee County Behavioral Health Division created an integrated social service system to provide individualized services to children with serious mental health, behavioral, and emotional needs. The network comprises community-based private service providers, health-care professionals, and public case managers who exchange patient information and deliver an array of coordinated treatment services.

DHS's Secure Border Initiative Network: To reduce illegal immigration and secure U.S. borders, in 2005 DHS commenced the design and production of an integrated system of more than 1,800 towers armed with cameras and heat and motion detectors along the U.S. northern and southern land borders. Through a contract with a private firm, advanced communication technology integrated into the fencing network will provide U.S. border security agents with precise information about their proximity to illegal aliens and other agents along the border.

competitive market pressures. With exit options limited, the risk is that each side will exploit contract loopholes and ambiguities, fearing the other side will do the same. The result can be a spiral of increasing rigidity, distrust, and conflict between the buyer and seller, risking cost overruns, quality lapses, missed deadlines and objectives, and ultimately a failed contract.

This report presents the Coast Guard's Deepwater program—a major SoS acquisition to upgrade and integrate its sea and air assets—to illustrate the options and challenges for acquiring complex products. The Coast Guard is six years into a projected 25-year acquisition and production process for the Deepwater program, far enough along to examine options and tradeoffs at two initial stages: choosing whether to build, buy, or assemble the product, and designing the acquisition contract.

This section continues with a distinction between simple and complex products. The next section of the report provides a brief background of the Coast Guard's Deepwater program to set up the illustrations and examples used throughout the report. The third section examines the production options—to build, buy, or assemble—and contract design options for complex products. The fourth section provides a case study of the Coast Guard's production choice in the Deepwater program, including an assessment of early results from the program, and an examination of the Deepwater contract. The report concludes by considering the future of federal procurement for complex products.

There are three main options for acquiring complex products; each comes with tradeoffs.

- **Building:** Reduces lock-in risks, but requires government agencies either to maintain or to grow production capacity that may be prohibitively expensive.
- **Buying:** Reduces costs but raises risks of getting locked in to a relationship with a single seller if significant specialized investments are required by the seller.
- **Assembly:** Reduces lock-in risks, but raises contracting costs and still may require investments in production capacity if the government agency serves as the assembler.

Simple vs. Complex Products

Sometimes government agencies buy or make goods or services whose important attributes can be easily and clearly defined in advance and unambiguously verified once they have been delivered. Such goods and services have clear-cut quality dimensions, specifications, and performance standards; market signals will tell agencies how much value they will get when they buy these products and how much the products will cost (Williamson 1985). As a result, before agencies commit to a purchase, they can determine whether the product will contribute

Simple versus Complex Products

Simple products have specifications, performance standards, costs, and mission impacts that are easy to describe before acquisition.	Complex products have specifications, performance standards, costs, and mission impacts that are difficult to describe before acquisition.
Examples	**Examples**
• Office supplies	• Weapons systems
• Data processing services	• Mental health services
• Parking garage operations	• Drug and chemical addiction services
• Fleet management services	• IT systems

positively to fulfilling the agency's mission at a price they can afford. These are called simple products.

Copy machine paper is a simple product. Its important qualities (size, color, and so on) are easily described and verified, it is simple to tell whether a particular box of paper fits the description, and it is easy to compare its costs across suppliers. Agency managers can determine before they buy whether one box of copy paper is better than another at achieving the agency's objectives (such as keeping costs low).

More complicated products have qualities that cannot be easily and clearly defined in advance and that are difficult to verify after the product or service has been delivered—government agencies do not fully know how much return on investment they will get from these products. Without specificity about the product's quality dimensions, specifications, and performance standards, the agency also does not know how much these products will cost. 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. These are called complex products.

Mental health services are an example of a complex product. It can be very difficult to specify in advance which services should be offered, in what amount, and through which processes, given uncertainty about patient needs, the severity of their illness, and the varying approaches to treatment and intervention across providers. In addition, the quality of mental health services is notoriously difficult to evaluate even after services have been delivered to patients. Agency managers cannot easily determine whether one mental health service is superior to another at achieving the agency's objectives (such as attenuating the negative impacts of a particular mental condition).

The Coast Guard's Deepwater Program

The U.S. Coast Guard's Deepwater program is an effort to upgrade and overhaul the Coast Guard's "deepwater" sea and air vessels and the command and control links among them.[1] The Deepwater program is used in this report to illustrate the options—and the tradeoffs among those options—in acquiring a complex product. This section provides a background of the Deepwater program and describes how it is a complex product.

Coast Guard's Mission

The Coast Guard began life in the late 1700s as the U.S. Revenue Cutter Service (RCS) and has been part of the federal government since the dawn of the nation, predating the Navy's creation in 1798. Early on, its primary responsibilities were to enforce tariff and trade laws, prevent smuggling, and defend the new nation's coastline along the northeastern seaboard. The RCS's early missions made it primarily a military organization.[2]

In 1915, the agency gained its familiar moniker—the Coast Guard—and formalized an expanded mission that included saving lives at sea. The Coast Guard's civilian responsibilities grew throughout the rest of the century to include aiding maritime navigation (such as lighthouses), determining merchant marine licensing, and ensuring merchant vessel safety. (See Figure 1 on page 12.)

The Coast Guard's dual military and civilian roles continue today. During times of peace, the Coast Guard finds its home in DHS[3]; during times of war, the Coast Guard can be directed to become part of the Department of the Navy. The present-day Coast Guard is a law enforcement, military, and life-saving organization with the following missions:

- Uphold the law (maritime security)
- Rescue the distressed at sea (maritime safety)
- Care for the environment (natural marine resources protection)
- Ensure safe marine transportation (maritime mobility)
- Defend the nation (coastal protection)

Coast Guard Acquisition

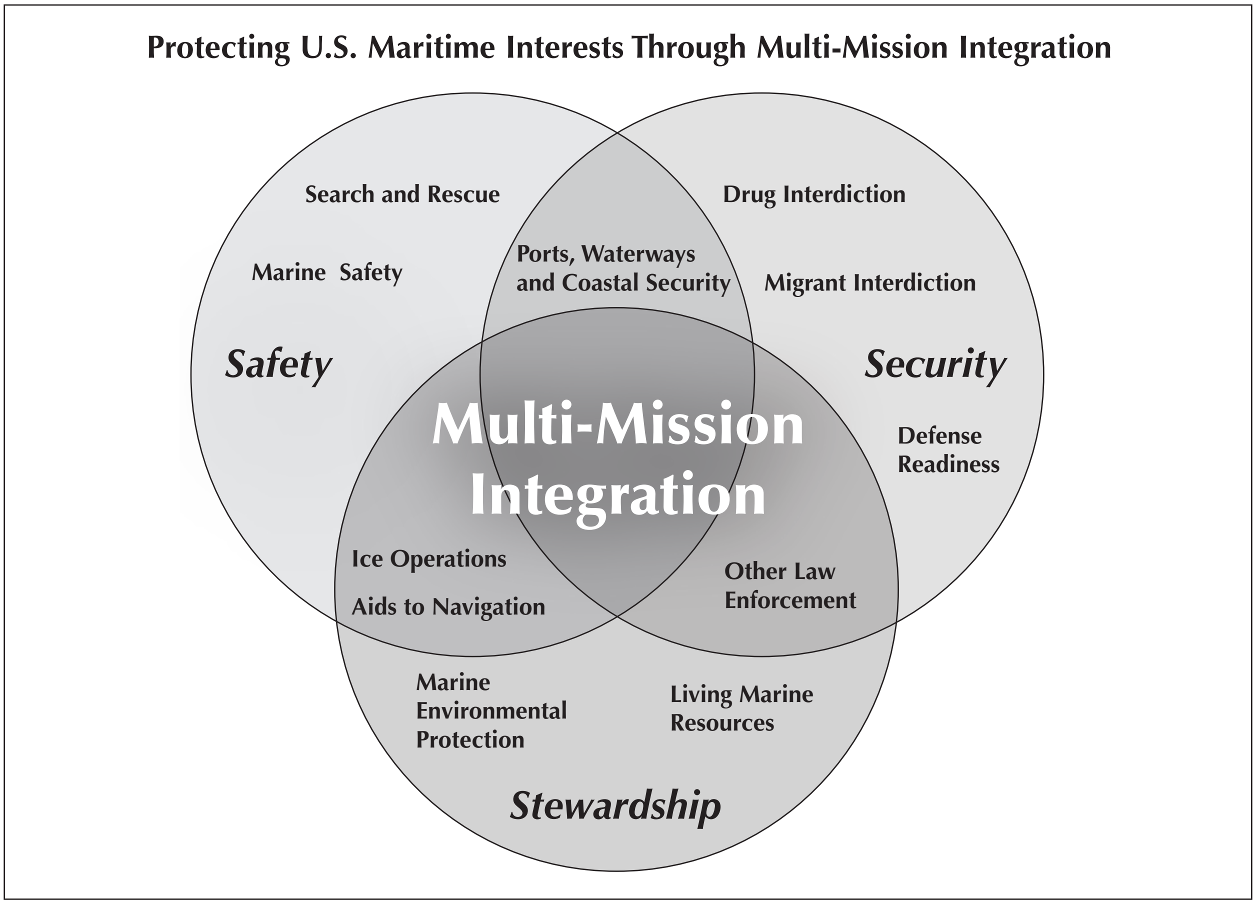
The Coast Guard maintains an array of assets to help pursue these missions, including ships and boats (such as cutters, buoy tenders, icebreakers, and lightships), airplanes and helicopters, shore stations, facilities, and lighthouses and navigation systems. The Coast Guard mostly buys these assets from private vendors. In recent history the Coast Guard's procurement practice has been to separately purchase individual classes of assets—ships, cutters, airplanes, and helicopters. When a class of ships was no longer seaworthy, the Coast Guard

Assets

Throughout this report the term *assets* refers to the physical resources that the Coast Guard uses to pursue its mission. The Coast Guard's Deepwater assets include:

- Boats
- Airplanes
- Helicopters
- Unmanned aerial vehicles
- Shore stations and facilities
- Lighthouses
- Communication infrastructure
- Navigation systems

Figure 1: Multiple Missions of the U.S. Coast Guard



Source: *www.uscg.mil*

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 smaller sellers. Without significant acquisition experience or capacity, and purchasing only infrequently in small quantities, the Coast Guard sometimes even acquired assets as part of larger Navy acquisitions.

By the early 1990s, the Coast Guard clearly needed a more targeted and strategic procurement approach.[4] Many of the Coast Guard's assets were reaching the end of their usable lifespan and were not ideally suited to the modern Coast Guard's missions. The Coast Guard's multiple missions and distributed global reach meant that its objectives 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 whose seamless communication and coordination would make the efficacy of the whole system greater than the sum of its parts.

The importance of interoperability is evident in how, for example, the Coast Guard might coordinate assets to rescue someone lost at sea. The objective would be to assign each air and sea asset an optimal search strategy and nautical range for locating the lost person, given sea and weather conditions, tides and drift, and the search strategies and technological capabilities of the other craft. As the search progressed, the search craft would need to

Interoperability

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. For example, sea assets must be able to coordinate their actions with air assets.

share data, refine its strategies in response to changing conditions, and once the person has been found, follow a coordinated rescue plan. Ideally, each search asset would operate independently, but in harmony with the other assets.

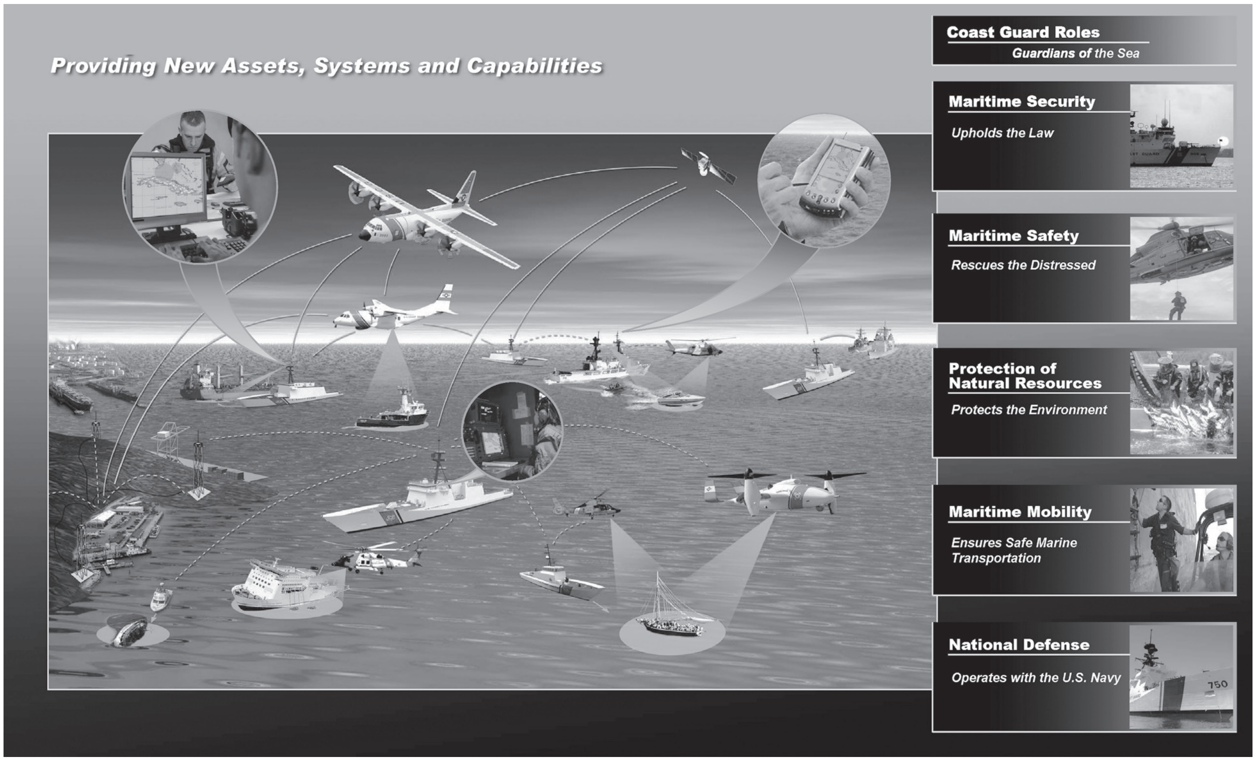
In 1998 Congress and the Clinton administration committed to a multiyear appropriation of $500 million a year to upgrade the Coast Guard's assets, an amount significantly more than the Coast Guard's historical acquisition line (GAO 2001). The result was the Deepwater program or "Project Deepwater." (See Figure 2.)

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 its assets and lower total ownership cost objectives.[5] The Coast Guard invited three industry teams (the Boeing Company, Lockheed Martin Naval Electronics and Surveillance Systems, and Science Applications International Corporation) to propose creative solutions and provided each team $20 million in seed funding.

After evaluating proposals from each team, 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 that the Coast Guard acquire five new sea vessels, two fixed-wing aircraft, two helicopters, and two unmanned aerial vehicles, and that they upgrade several of its existing assets. In addition, ICGS proposed to integrate all of the Coast Guard's Deepwater assets in a state-of-the-art command, control, communications, computers and intelligence, surveillance, and reconnaissance system, more commonly

Figure 2: Deepwater Program Overview



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

referred to as C4ISR. Figure 3 provides a timeline for Deepwater's contracting events.

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 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.

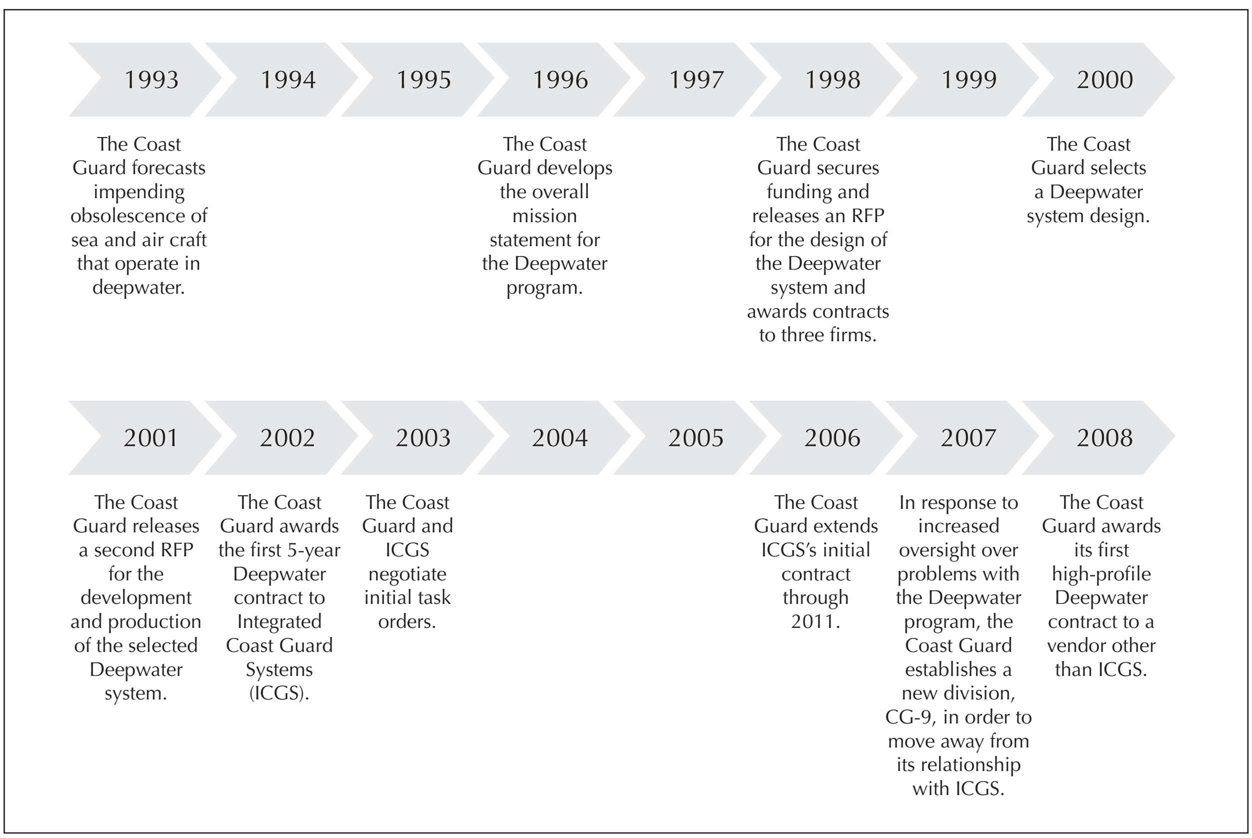
Although the Coast Guard had just entered into a five-year initial contract with ICGS, significant performance changes were imposed on the Deepwater program during the first year of the contract with the commencement of the War on Terror. These changes came after the initial contract and led to increased costs and time estimates that put the projected Deepwater acquisition at around $24 billion over a 25-year timeframe.

Project Deepwater as a Complex Product

With a hard cap on overall annual operating costs, the Coast Guard's challenge in the Deepwater program was to acquire a system of sophisticated interoperable assets—that is, they all had to be able to communicate with each other and seamlessly coordinate their activities in pursuit of various targets (such as armed speedboats running contraband, sailors lost at sea, and make-shift vessels porting illegal aliens). Because the Coast Guard chose to buy the system, the prospective seller would need to have the production capacity or purchasing ability to deliver very different kinds of assets—ships, cutters, helicopters, and airplanes—and the communications technology to integrate them.

The Deepwater program is a complex product because its specifications, performance standards, costs, and mission impacts were difficult to identify before acquisition of the system. At the outset, the Coast Guard understood its mission objectives, but it lacked information about the options for how different mixes of assets would help achieve them. The

Figure 3: Timeline of Deepwater's Major Contracting Events



Coast Guard knew the basic components that would ultimately compose its asset fleet—small and large boats, airplanes, and helicopters, tied together through communication and integration technologies. But the Coast Guard did not know the exact number of boats, airplanes, and helicopters to purchase, the performance specifications for each, and how the new assets would operate together in a system. For example, the Coast Guard did not know how many fewer aircraft would be needed if the performance of large cutters were increased by a certain percentage.

The Coast Guard was also highly uncertain about the costs of acquiring these assets. Although an initial cap was in place on overall operating costs, the lack of exact system arrangement and asset design specifications hampered any determination of the cost to deliver all 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.[6] Furthermore, once production began, the longer the Coast Guard took to make specification decisions about subsequent assets, the more costly the program would become as the production process lay idle.

By entering into a contract with ICGS to acquire the Deepwater program, the Coast Guard elected to buy a system of assets that it could not produce on its own, but in doing so exposed itself to some risk. The next section describes the tradeoffs between buying a complex product like the Deepwater program relative to other production options.

Understanding the Acquisition of Complex Products

This section provides a guide for the acquisition of complex products. First, it examines the production options for acquiring complex products: building, buying, or assembling. Second, given the increasing use of buying and assembling for complex products by government agencies, this section examines contract design options for complex products, focusing on the specificity of contract terms. This discussion provides a framework for analyzing the production and contract design decisions in Project Deepwater.

Production Options for Government Agencies in Acquiring Complex Products

Government agencies can use one of two basic options to acquire simple products: building or buying. When government agencies build products, public employees do the work, and when government agencies buy, they rely on vendors to produce the product. Government agencies acquiring complex products can also use a third option: assembly. Under one assembly option, government agencies contract with a vendor that buys the product components from other sellers and then assembles them into the final complex product. Under another assembly option, agencies buy product components from individual sellers themselves and then use government employees for final assembly. (See Figure 4.)

Basic Production Options

Each production option for complex products involves tradeoffs.

Glossary

Activities: Processes and steps used to transfer the inputs into the product.

Earned Value Management (EVM): A project management methodology used to measure actual versus planned technical, cost, and schedule performance for a given project.

Independent Verification and Validation (IV&V): An oversight process in which an independent third party performs monitoring, reporting, and/or evaluation tasks.

Inputs: Raw materials used to produce the product.

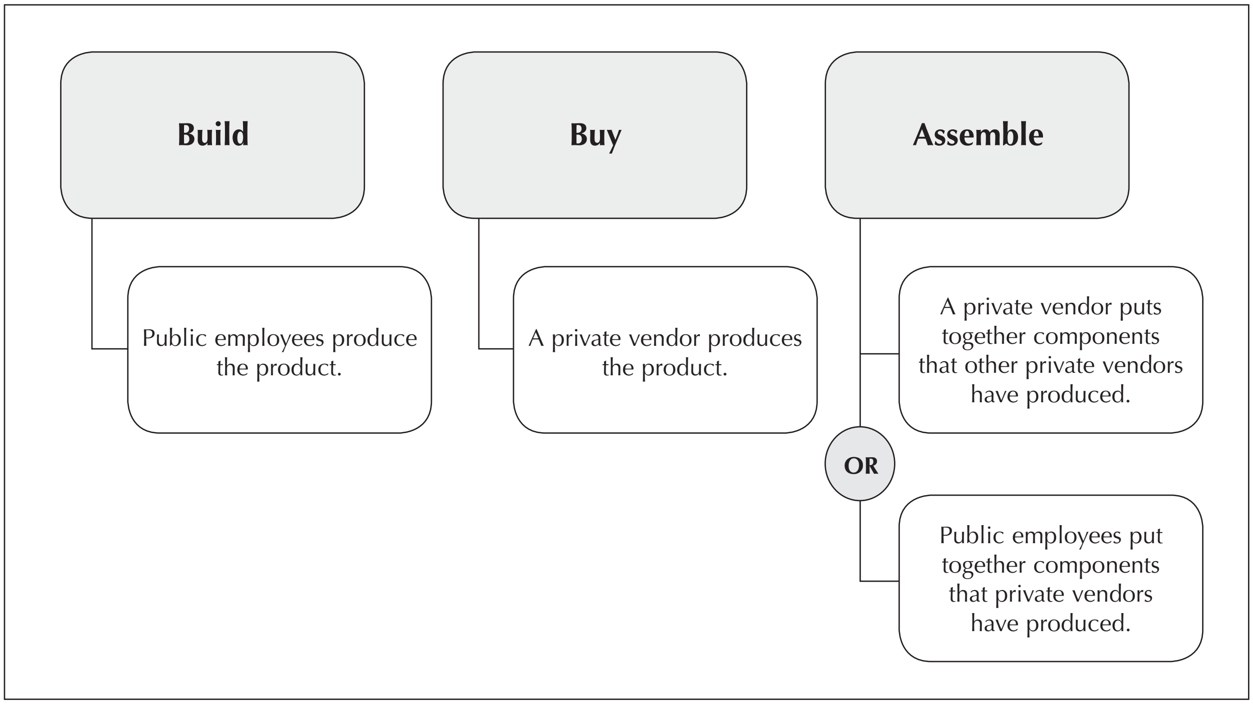
Lead Systems Integrator (LSI): An organization (such as a government agency or a private firm) that manages a network of subcontractors that produce the various components of a complex product and integrate them into the final product or system.

Outcomes: The ends to be achieved through the use of the product.

Outputs: The actual products produced.

System-of-Systems (SoS): An overall system comprising several discrete systems that perform independent functions that contribute to a goal regardless of the presence or absence of other component systems.

Figure 4: Production Options for Complex Products



Build It

The first option is to build it. Here a government agency uses its own employees to perform essentially all the activities needed to produce the product, including research and design, product specification, production and assembly, and testing and evaluation. The "build it" option means that the government agency has all the human resources and the fiscal and technical capacity to perform all these activities. Building complex products requires many specialized employees, including designers (architects, in the case of construction projects), systems engineers, and other expert laborers. Many of these talents, while essential for designing and building the product, have little value to the government agency once the product has been produced and brought on line. In instances where the product is acquired infrequently—a new road or building, for example—the government agency must have sufficient resource slack to allow employees with skills required only for the product acquisition to lay idle or have other activities to which they can be effectively deployed.

An example related to the Coast Guard's Deepwater program is when the U.S. Navy acquires a boat from its primary shipyard, the Norfolk Navy Yard in Portsmouth, Virginia. The Norfolk Navy Yard is the oldest and largest industrial facility that belongs to the U.S. Navy, and it employs Navy and civilian public personnel to build, remodel, and repair Navy ships.

Buy It

The second option is to buy a finished product from a single vendor. Here the government agency provides the specifications for what it wants (either before or after research and development) and contracts for the production, assembly, and sometimes even the testing and evaluation of the product from a fully integrated private vendor able to perform all these tasks. A reason for buying the product is that the government agency does not have employees with the specialized skills for designing and building the product. When government agencies are buyers, they instead need employees who are "smart buyers" who can specify products that meet the government's needs and scan the market to identify and cultivate viable suppliers (Kettl 1993). Smart buyers can also design bidding and contract arrangements and then effectively manage relations with the selected vendor. Although the government agency does not need the breadth of employees to perform all the functions associated with designing and producing the product, it does need a stable of employees—albeit a smaller, less costly stable—who can do the jobs necessary for buying the product.

As an example of buying, dating as far back as the 1790s, the Coast Guard has bought the vast majority of its assets from private firms. The Vigilant, the first commissioned Coast Guard cutter boat, was purchased in 1791 from a private shipyard in New York for service in New York waters.

Assemble It

Complex products are often made up of individual components that can be integrated into an interoperable system. This presents a third possible production option: assembly. In the first variation of this option, a government agency can turn to a private firm for final assembly. A contract for buying a complex system is often referred to as an SoS acquisition, and the selected vendor serves as the LSI whose job is to manage a network of subcontractors who produce the various components and assemble them into the system.

- **Option One:** Although debate continues about the value of SoS contracts and LSIs (see box), in a broad sense LSIs can be thought of as general contractors. Government agencies have long been in the business of buying fully integrated products that have been assembled by a vendor from pieces produced by subcontractors, just as many people buy houses that a general contractor has assembled from the labor of framers, plumbers, electricians, and so on. As discussed later in this section, the risks of buying complex products are not fundamentally driven by the fact that integration tasks are undertaken by a vendor, but rather by the underlying characteristics of the product—such as how well the buyer can evaluate product quality—and the competitiveness of the market for the product.
- **Option Two:** Instead of relying on a private firm, the government agency itself can perform the assembly (LSI) role, working as its own general contractor to manage subcontractors that produce the product components. This mixed approach to acquiring a complex product is a form of joint production. As such, the government agency needs employees who are smart buyers and adept contract managers, as when buying the product, but it also needs employees who can perform engineering, design, and integration tasks. This option might mean, for example, that government employees design the system while private vendors supply system components. Then government employees integrate the components that compose the system and, finally, rely on a combination of government employees and experts from other organizations to evaluate and test the system and its individual components.

Production Decision

The production decision is relatively straightforward for simple products. Markets for simple products tend to have large numbers of buyers and sellers who are well informed about each others' offerings. Buyers and sellers can easily enter and exit the market and can clearly define the terms of exchange. Government agencies can easily assess the costs of establishing or maintaining their productive capacity relative to buying the product or assembling it. Government agencies rarely contemplate making simple products themselves, and contracts are likely to produce win-win outcomes.

Choosing whether to build, buy, or assemble poses more of a challenge because the cost, quality, and quantity parameters of complex products cannot be easily defined or verified. Without strong information about product dimensions and costs, government agencies have difficulty determining what alternatives exist in the market relative to what they are capable of doing on their own. Although government agencies can reduce the uncertainty inherent in acquiring a complex product 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.

A related characteristic of complex products, specialized investments, further complicates the production choice.

Key Factor in the Production Choice for Complex Products: Specialized Investments

Complex products often require specialized investments. Investments are specialized to the extent that no market exists for the investment beyond the specific product being produced.[7] Only the purchaser for which the investment is being made wants the product. For example, some research in the U.S. space program found a market beyond the

System-of-Systems Contracting and Lead Systems Integrators

There is no single definition of an SoS contract or an LSI. The Federal Acquisition Regulation (FAR) does not mention either term. SoS refers to a general system comprising several discrete systems that perform independent functions that contribute to a goal regardless of the presence or absence of other component systems. This is not to say that the performance of a component system cannot be enhanced by working in conjunction with the other component systems, but rather that successful functioning of each component system does not require the operation of the other system components. The macro-system may serve as a force multiplier, augmenting the task performance of each component system.

For example, in the Deepwater SoS contract, boats, airplanes, and helicopters are each independent systems, capable of separately performing a task (such as interdicting an illegal ship at sea). However, the Deepwater system improves the ability of each boat, airplane, and helicopter to perform its assigned task because each is integrated with other system components.

Concerns about the SoS strategy have less to do with the approach and more to do with who is tasked with designing and producing the macro-system, namely the LSI. On the one hand, LSIs are simply general contractors, linking together system elements—the boats, airplanes, and helicopters—and ensuring that they are able to coordinate to form the system. In this way, governments buy from LSIs all the time. When the military acquires a fighter jet, for example, it does not typically order wings, landing gear, a cockpit, and other component parts from separate suppliers that arrive in boxes marked "some assembly required." Instead, the military turns to a vendor that delivers a fully functional fighter jet.

On the other hand, LSIs may move beyond simply performing product or system integration functions and take on a task and function that is inherently governmental, that is, the function "…is so intimately related to the public interest as to mandate performance by public employees" (OMB Policy Letter 92-1, September 23, 1992, http://whitehouse.gov/omb/procurement/policy_letters/92-1_092392.html). The boundaries on inherently governmental tasks are not clearly specified, but generally speaking involve exercising discretion through legal or financial decisions that involve value judgments (for example, the act of governing).

The Government Accountability Office (GAO) has expressed concern over LSIs that take on specifying the performance standards, or requirement definitions, of individual system components, if not the entire system. When LSIs make these requirement definition decisions, they begin to make value judgments for their client—in this case the government and its citizens—about what the system should be able to do. These types of decisions also potentially provide the LSI with influence over financial transactions, the overall costs of the system, and how much it receives in compensation.

In short, the SoS acquisition approach and the use of LSIs in and of themselves do not necessarily mean that too much discretion has been granted to vendors. The risk of an LSI encroaching on inherently governmental functions is driven more by the nature of what tasks have been assigned to it, the government's management of the acquisition, and the nature of what is being purchased.

National Aeronautics and Space Administration (Tang, for example), while other research found no market outside the contract (such as spacesuits, at least as of 2008). Examples of specialized investments include modifying a physical plant to produce components that can only be used by or sold to the government and training staff to handle procedures unique to the government. Vendors lose these specialized investments if they do not sell their product to the government. Government agencies can also make specialized investments in purchasing, such as training staff to use the software from a particular company.

For government agencies buying or assembling a product, the consequence of specialized investments and an unpredictable future is the classic "lock-in" problem (Williamson 1996). A party becomes locked in to a contract because it cannot deploy its specialized investments to other profitable endeavors, even when 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. The seller may look to opportunistically exploit contract ambiguities perhaps by "gold plating" the product with costly features that increase seller profits but add little value and considerable expense for the buyer. Likewise, because the seller has only one buyer for its products, the buyer may also opportunistically exploit contract terms for its own favor. The buyer may force a seller, for example, to make changes to a product that raise the seller's costs above the agreed upon price even though the buyer knows that a much cheaper product would meet its needs almost as well.

Absent lock-in problems, the buyer can simply replace an opportunistically behaving seller with a more suitable one, and a seller can likewise replace an opportunistic buyer. The presence of lock-in problems, however, weakens the disciplining power of markets.

Buying a complex product is likely to require specialized investments from the buyer and seller. This has important implications for government agencies considering the assembly option in which the agency serves as the LSI. Although a government agency that takes on integration responsibilities may eliminate the risk of exploitation by a vendor serving as the LSI, the government agency may still face considerable lock-in risks in buying the various system components should it require significant specialized investments. In this instance, the government agency is not locked in to a single general contractor, but may still be locked in to individual suppliers.

Making the Production Choice

Heightened lock-in risks from buying make building more attractive. If specialized investments are required to produce the product, government agencies run the risk of becoming locked in with whatever seller is chosen. The selected seller can then take advantage of the agency by reducing quality or increasing price in the future. As a result, a government agency may be wise to create or maintain production capacity instead of buying. This assumes, of course, that the agency either has the production capacity in place or can afford to develop it as needed.

When a product costs government agencies too much to build (for example, when the product is produced infrequently and the agency cannot afford the costs of maintaining an idle workforce and/or a physical plant), government agencies may have little alternative but to turn to the market, particularly if lock-in risks are not too severe. But as lock-in risks increase, government agencies may find assembly more attractive, particularly if they have sufficient contract management capacity to serve as the LSI. Assembly might allow the government agency to purchase components with low degrees of specialized investments while internally producing components that require significant specialized investments.

Tradeoffs Between Production Options for Complex Products

As discussed earlier, three primary tradeoffs exist between the build, buy, and assemble options.

- **Building:** Reduces lock-in risks, but requires the government agency either to maintain or to grow production capacity that may be prohibitively expensive.
- **Buying:** Reduces costs but raises risks of getting locked in to a relationship with a single seller if significant specialized investments are required by the seller.
- **Assembly:** Reduces lock-in risks, but raises contracting costs and still may require investments in production capacity if the government agency serves as the assembler.

Contract Design for Complex Products—How Specific?

Government agencies are increasingly using private firms as LSIs for complex products, as the Coast Guard did for the Deepwater program. The upside of buying a product that the government agency cannot build or assemble itself can outweigh the risk of becoming entrapped in a contract with little exit room, should the exchange not deliver on its promise. An important way to mitigate the downside risk is through the terms of agreement between the two parties. How well the contract is written can have a

Specificity

Specificity refers to how detailed the contract is about the terms of exchange (e.g., inputs, activities, outputs, and activities).

significant impact on the likelihood of mutual gains from the exchange.

The important design features of a contract are the following:

- Inputs, activities, outputs, and outcomes
- Compensation
- Delivery terms
- Decision rights and processes for negotiation
- Oversight
- Proprietary ownership

Most contracts include each of these features in some way, although the degree of specificity for each can vary considerably. Contracts for simple products tend to be more "specific" in that they identify clearly the buyer and sellers' exact obligations under all foreseeable conditions so that the sale can be executed safely. With simple products, not much could go wrong with the sale, so the contract can be relatively simple. Contracts for complex products are less specific relative to what is being purchased. Such contracts often contain relatively vague instructions for what the buyer and seller should do under various scenarios. Complex products tend be bought with less specific contracts because their very complexity means that a large number of scenarios and circumstances could occur and that defining them in advance would be too expensive for the buyer and seller.

The buyer and seller can negotiate which contract terms to write out in more detail and which can be relatively vague, considering how each term affects the risks of contracting.

Contract Design Options for Complex Products

Contracts govern the terms of exchange between buyers and sellers (for this report, a government agency and a private vendor). When negotiating the terms for assembling a product, the government agency may be inclined to specify as much as possible what it wants to buy. What are the product features and capabilities? What are the levels of performance? Who will use it and in what way? The vendor would like these specifics as well.

> **Flexibility**
>
> *Flexibility* refers to how adaptable the contract is to changing circumstances or new information that arises in the process of producing the product.

These details help the vendor decide how to make the product and forecast production costs. Armed with this information, the two parties can make the contract highly "specific," identifying the product's design, performance level, and expected costs, and defining buyer and seller rights and obligations across the most likely contingencies.[8]

Contracts for simple products are likely more specific. For these products, specifying each party's obligations in the exchange is relatively easy, including the price, qualities, and quantities of the product. The buyer's obligations typically include the payment terms and the terms under which the product is to be received (for example, the timing of delivery). The seller's obligations vary under price arrangements, but generally include some combination of output specifications, such as product qualities and quantities, and input characteristics, such as time and materials.

With a simple product and clear contract terms, determining whether one party has violated the terms of exchange is relatively easy. And if the seller does not live up to its obligations—if the product is of poor quality, for example—a competitive market is likely to offer attractive alternatives.

Complex products, however, are likely to have less specific contracts with ambiguous terms. The problem is that specifying the price, qualities, and quantities of the product across all likely future scenarios is very difficult. Events beyond the buyer and the seller's control can affect production, costs, and performance. Although the inclination of both parties may be to make the contract as clear and specific as possible, the costs of writing all these terms in advance of production may be so high that neither party would receive the desired value from the exchange.

Less specific contracts can be flexible, specifying some terms of exchange and leaving others to be negotiated later, once the buyer and seller know more about the product. The challenge for contract design for a complex product is to account for the product's inherent uncertainty by leaving some aspects of the product's dimensions unspecified, while taking steps to mitigate the risk of one or both parties exploiting lock-in problems stemming from the specialized investments required for the sale. The contract has to say enough to assure each party that it will not be taken advantage of, but not so much that they cannot afford to do business together.

The following are elements included in most contracts that establish the terms of exchange. Options are available to government agencies as they decide how specific to be about each element.

Inputs, Activities, Outputs, and Outcomes

Contracts specify what is being exchanged—the product to be purchased and at what price. Contracts can describe products in many ways, including specifying inputs, activities, outputs, and/or outcomes. Inputs refer to the assets (such as raw materials) used to produce the product. Activities refer to the processes and steps used to transfer the inputs into the product. Outputs are perhaps best defined as the actual product produced. Outcomes refer to the ends to be achieved through the use of the product.

Typically contracts specify outputs, such as a particular kind of boat to be delivered on a certain date. Some contracts instead specify inputs (such as a particular kind of boat with a steel hull) and activities (such as a production process with quality control steps at various stages) used to create the product. Performance-based contracts, however, specify the outcomes the product is to achieve (such as a means for intercepting drug runners at sea). In many cases, the contract states the basic product—a boat, in this example—but the specific details of the product and the means of production are left open. In this way, performance-based contracts are thought to be less specific.

The uncertainty surrounding complex products makes more complete task or output-based contracts difficult and costly to specify in advance, but they have some standards for judging whether the product meets what the buyer wants. Performance-based contracts may be less difficult and costly to specify in advance, but they leave some product details and prices to be resolved through post-contract negotiations.

Compensation

Another core element of a contract is the compensation terms—what is the price for the product. There are many forms of compensation. The two most prominent are:

- Fixed price contracts, which set compensation on the seller's outputs
- Cost reimbursement contracts, which set compensation on inputs, such as time and materials

Fixed price contracts might be thought of as more specific because they identify an actual cost in the contract. Cost reimbursement arrangements, however, are less specific because, although they usually identify allowable costs, they do not actually specify a unit cost.

The compensation arrangement determines whether the buyer or seller bears the risk of uncertainty about the product's costs (Bajari and Tadelis 1999). Fixed price contracts place the cost risk on sellers because the price is set at the time of contract award, while production costs may end up being higher than the price. Cost reimbursement contracts place more risk on the buyer because the buyer pays the difference if production costs end up higher than forecasted.

Complex product's cost uncertainty creates challenges for both compensation options. Sellers are adverse to pure fixed price contracts if they do not know exactly how to design, build, and assemble the product. The problems are even worse if specialized investments are required because the seller will not be able to redeploy the assets to some other profitable use. Buyers are likewise averse to shouldering the risk of a cost reimbursement contract because they are giving the seller greater discretion over how to produce the product and how much it ultimately will cost. A straight cost reimbursement contract raises the possibility of "gold-plating" because the seller's profits increase with the overall costs for the product. An answer to this dilemma is for the contract to contain some hybrid between fixed price and cost reimbursement payments. An example is when a seller is guaranteed some return on its investment, but the buyer has some protection from an open-ended cost commitment.

Delivery Terms

The timing of the product's delivery is fundamentally a function of the time needed to produce the product. In the simplest terms, when production time is clearly known in advance, the contract can specify a delivery date. When a product can be produced quickly—as with simple products—the contract term can be short, if not close to immediate in the case of a spot-market transaction.[9]

The production time for complex product is often unknown, and the challenges of assigning risks for time overruns are essentially the same as assigning risk for cost overruns. Moreover, the duration of the contract is in some respect the formalization of "lock-in." If a buyer agrees to a long-term—such as decades long—contract arrangement, it has ostensibly "locked" itself in with whatever seller it selects. The seller faces a similar risk because it becomes formally locked in as well, which reduces its ability to redeploy investments to other opportunities that might arise. A benefit here may be that a long-term contract signals a credible commitment by each party to deliver value to the other.

Decision Rights and Processes for Negotiation

Sometimes buyers and sellers disagree on how to interpret a contract—a more likely outcome when contracts are not specific. Buyers and sellers can specify in the contract the terms and conditions for how they will negotiate and resolve disputes and ambiguous contract terms. On the more specific side are formal procedures for adjudication and perhaps renegotiation of the contract itself. On the less specific side are contracts in the "partnership" mold that may define a venue for discussion or the broad outline of a mediation process. Contracts may also specify whether a joint decision arrangement is required to address questions that arise during production, rather than allowing one side to make decisions unilaterally. Perhaps the least specific contracts are those that provide no guidance on decision rights and renegotiation processes, basically saying "we'll figure it all out later."

Renegotiation procedures are likely to play an important role for complex products given their high uncertainty about product elements and costs; many important product details left unspecified will have to be figured out later in the production process. Less rigid procedures open the door for partnership relations in which the parties work things out less formally, perhaps at the managerial or task level, rather than through legal means. Partnerships work well if both sides look to partner; if not, less formal arrangements can be discordant. The seller in a cost reimbursement contract, for example, may choose product specifications that raise the costs of the product.

Oversight

Contracts often include oversight provisions that state how the buyer will monitor and evaluate the seller and how the seller will report to the buyer. More specific oversight provisions detail how the buyer can monitor the seller, the types of information on which the seller must report, and the means by which the product's quality and costs are evaluated. For complex products, there may be important reasons to consider alternative arrangements to this basic approach, such as when a government agency requires a general contractor to perform the monitoring and evaluation activities for its subcontractors.

There are risks in assigning monitoring and evaluation responsibilities to the seller, particularly if a high risk of lock-in exists. The seller may be inclined to shirk these responsibilities or at least cast the facts in its favor. The more specified the product's performance requirements, the easier it is for the buyer to hold the seller accountable for monitoring, reporting, and evaluation because the costs of validating the seller's efforts are low (Brown and Potoski 2006).

The less specified the product's performance requirements, the harder it is for the buyer to hold the seller accountable. One increasingly used approach for specifying performance requirements is earned value management (EVM), in which planned performance on technical, schedule, and cost objectives is compared with actual performance. The success of EVM in an acquisition will in part be a function of how easily planned performance can be identified clearly.

The uncertainty of complex products complicates detailing performance requirements, the very metrics by which vendor performance is evaluated. An alternative—or complement—is to require an independent third party to perform monitoring, reporting, and/or evaluation tasks. Independent verification and validation (IV&V) puts these contested tasks in the hands of a party that has significant experience performing these tasks for similar products but that is not party to the contract. IV&V is not without its costs, of course, as whatever entity is selected to perform these tasks will require compensation (GAO 2001, 2004, 2007 and 2007a; Acquisition Solutions 2001; Defense Acquisition University 2007; DHS Office of Inspector General 2007; O'Rourke 2008).

Proprietary Ownership

A final element is the degree to which the contract specifies proprietary ownership of the product. Important here is whether the contract indicates who "owns" the design of the product once it has been delivered. More specific contracts identify proprietary ownership, and less specific contracts do not. Again, the major risk at play is lock-in. If the seller enjoys proprietary ownership of the product and its design, it has effectively locked the buyer in to purchasing the product indefinitely from the seller. The seller has cemented its relationship as a monopolist. But if the buyer enjoys proprietary ownership over the product and its design, once the product's configuration becomes known, the buyer can take the design and solicit alternative sellers to produce the product.

Ownership is particularly important for complex products where so much is unknown at the outset about the product and its costs. If the buyer can exit the contract before the product is fully delivered, once the design specifications of the product become realized, it is less dependent on the initially chosen seller. Ownership of the design by no means ensures that the buyer can find a thick market for the product, but it gives the buyer a means to attempt to stimulate one.

Selecting the Degree of Contract Specificity for Complex Products

No contract can be completely specific because the future contains an infinite number of scenarios, not all of which can be identified in advance. Contracts for simple products are relatively specific; contracts for complex products are less specific because of the product's inherent uncertainty and the unknown future conditions for contract execution. At some point, the costs of writing contract terms for all future scenarios would exceed the mutual gains from the exchange and no contracting would occur.

The more the elements described previously are identified and detailed in the contract, the more specific the contract. For example, fixed price contracts that specify inputs, activities, and tasks are more specific than performance-based cost reimbursement contracts that specify only desired outcomes and identify allowable costs rather than the actual price. Although contracts for complex products are likely to be less specific, they need not be totally unspecific about contract elements. In fact, although specifying some contract elements can be costly, adding detail about other key elements may reduce risks for buyers and sellers. Specifying decision rights, negotiation procedures, and oversight requirements may not be too expensive given the problems they can mitigate. Approaches to designing contract arrangements for complex products include the following:

- The buyer and seller can address some of the risks of not specifying core contractual elements, such as product performance requirements and final costs, by specifying other contract elements, such as oversight requirements.
- Less specific contracts for complex products open the door for collaboration between buyer and seller when venues for informal negotiation are created. They run the risk, however, that one party may gain an advantage in these venues if roles and authorities are not specified.
- Contracts for complex products can be structured to space out decisions about a product's design standards, performance requirements, and costs to take advantage of learning through the process of producing the product, but such provisions do not eliminate the necessity of making these decisions.

A Case Study in Acquiring Complex Products: The Coast Guard's Project Deepwater

The Coast Guard's Deepwater program illustrates how production choices and contract design decisions can influence the success or failure of complex product acquisition. This section explores why the Coast Guard elected to pursue assembly through a private LSI, rather than perform the LSI role itself, or build the Deepwater system. It describes the contract that the Coast Guard used to begin Deepwater's acquisition. It provides a progress report on the acquisition of the first assets in the Deepwater system, before charting the changes to the Deepwater program, notably that the Coast Guard has taken steps to become the LSI.

Deepwater Production Decision

The Coast Guard chose to turn to a private firm to serve as the LSI for the acquisition of its Deepwater system. As described previously, the Deepwater program is a complex product, involving a high degree of uncertainty about the system's components, specifications, and costs. Specialized investments were required to produce and deliver the Deepwater system, and with those investments came lock-in risks for both the Coast Guard and ICGS. In spite of the risks, the Coast Guard opted to turn to a private LSI for assembly rather than build or assemble on its own.

Deepwater's Lock-In Risks

The assets in the Deepwater system vary in the degree to which they required specialized investments. On the low end are highly marketable assets, such as helicopter engines. On the high end is the development of new assets for which the Coast

Glossary

C4ISR: The command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) architecture designed to connect all the assets in the Deepwater system.

Indefinite-Delivery/Indefinite-Quantity (IDIQ) Contract: A contract vehicle that provides for an indefinite quantity of products or services over a fixed period of time.

Integrated Coast Guard Systems (ICGS): A co-equal partnership between the Lockheed Martin Corporation and the Northrop Grumman Corporation formed to serve as the LSI in the initial Deepwater contract.

Integrated Project Team (IPT): A team of multiple stakeholders—notably representatives from both the buyer and the seller—convened to collaborate and share information in order to determine product specifications and requirements in the midst of production.

Task Order: A formal agreement that specifies a period of performance and the minimum and maximum quantity of an individual product to be acquired under an IDIQ contract.

Undefinitized Contract Action (UCA): A contract action for which the terms of performance (such as product specifications, cost, and schedule) are not specified before production begins.

Guard is the only buyer, such as the National Security Cutter (NSC), the largest class of ships in the Coast Guard fleet. Northrop Grumman—the lead contractor on the NSC—developed a relatively specialized production process for the NSC because the Coast Guard requested such unique performance goals. The Coast Guard also made specialized investments for the Deepwater contract, such as creating a Deepwater acquisition office separate from its existing procurement infrastructure. This unit was to design procurement practices and systems exclusively for engaging with ICGS on Deepwater purchases.

Specialized investments such as the Deepwater acquisition office and the NSC production process created lock-in risks. For the Coast Guard, the risk was that ICGS would have an information advantage that it could exploit either by "gold plating" the overall system and its individual assets or by delivering a substandard system and assets. The Coast Guard would not have alternative sellers for comparing prices and quality for the system as a whole, or for some of the individual assets. For example, a highly specialized element of ICGS' Deepwater system is the logistics and communication system for integrating all the system components, known as C4ISR,[10] and its associated logistics system. ICGS has substantial research, development, modification, and adaptation costs invested in tailoring this system to the Coast Guard's needs. To secure returns on its investment, ICGS has a strong incentive to make this asset as proprietary as possible. Once the Coast Guard elected to use ICGS's logistics and communication platform, it raised the future costs of turning to other suppliers for logistics and communication capability enhancements, training, technical assistance, and standard operational maintenance and upgrades.

To meet the Coast Guard's request, ICGS had to make high up-front investments to design and build a product to meet the specific needs of this single client. The result was a real possibility that the client might walk away from its commitment at a later date. ICGS would then be left with a product, and perhaps a production process, for which there were few, if any, other buyers. From ICGS's perspective, there is not much of a market for the C4ISR system beyond the Coast Guard.[11] If the key logistics and communication elements of the C4ISR system were not proprietary, the Coast Guard might simply take the design specifications for these elements to a competing vendor, putting ICGS's investments at risk.

Why the Coast Guard Opted to Use a Private LSI for Assembly

In spite of Deepwater's risks, why did the Coast Guard opt to rely on a private firm as the LSI rather than build or assemble the system itself? The build option is easy to dismiss. The Coast Guard simply lacked the capacity to build the Deepwater system, nor was acquiring such capacity economically realistic. With the build option off the table, the more intriguing question is, why did the Coast Guard turn to a private LSI for assembly?

A simple answer is that the Coast Guard's leadership believed that "system" procurement would be more politically attractive than a collection of individually purchased assets. A fuller explanation is that the Coast Guard lacked the systems design and engineering capacity required for optimally assembling assets into an interoperable network system, and it lacked the acquisition, procurement, and oversight capability to manage the vast array of vendors needed to design and construct each component asset. If the Coast Guard wanted the Deepwater system, it needed to hire a general contractor to serve as system integrator, a role that the Coast Guard was not able to perform at the time.

The Deepwater program offered the Coast Guard a political opportunity, as well. Two factors are worth highlighting here. First, given its national defense and law enforcement missions, the Coast Guard was increasingly collaborating with the Navy. Under the newly deployed AEGIS combat system, the Navy's fleet was more interoperable and could make the case that the whole was greater than the sum of its parts. The Navy's AEGIS system presented a well-accepted blueprint for SoS programs. The Coast Guard could point to the Navy's experience with AEGIS as a best practice for the benefits of establishing an interoperable system, as well as a model for how to acquire one. Furthermore, the Coast Guard wanted to become more interoperable with the Navy through AEGIS and needed a complementary IT system to do so. Although the Coast Guard could point to the Navy's experience in acquiring an interoperable system, Deepwater was sufficiently novel that the Coast Guard could still argue that it would serve as a pilot for other complex systems development across government.[12] The C4ISR platform of integrated and interoperable technology and communication systems, in particular, was deemed to be a forerunner in achieving networked and interoperable mission capabilities.[13]

Second, the Coast Guard had just endured a period of downsizing and retrenchment during the Clinton administration.[14] At that same time, the Clinton administration was also interested in developing government–industry partnerships. Through Deepwater, the Coast Guard could serve as a model for engaging industry as a partner in lowering overall contracting costs by transferring more contract management responsibilities to the vendor.

Driven by need and opportunity, the Coast Guard's leadership recommended the SoS/LSI acquisition strategy. Through Deepwater, industry would be an equal "partner" in creating a platform of capabilities that would enhance the Coast Guard mission and operational effectiveness. Although the approach did not go unquestioned—some wondered whether the Coast Guard would be able to oversee its industry partner and manage the numerous risks associated with this endeavor—Coast Guard officials were nonetheless successful in selling this concept to a broad range of governmental stakeholders. That success was influenced by effective and charismatic leaders, substantial congressional goodwill toward the Coast Guard, effective industry lobbying of elected officials, and an acquisition strategy that took advantage of a political climate favorable toward innovation and public–private partnerships.

The Deepwater program catapulted the Coast Guard to the forefront of contracting and systems engineering practice and, in doing so, exposed the Coast Guard (and ICGS) to significant risk.

Deepwater Contract Design

Given the uncertainty faced by both the Coast Guard and ICGS in producing a complex product, or system of products, in this case, core elements of the Deepwater contract—notably the product's performance requirements and costs—were initially left unspecified. Other aspects of the contract, however, were specified to address the uncertainty about product qualities and costs. This section describes the overall architecture of the initial contract between the Coast Guard and ICGS. It then examines each of the five contract elements identified earlier to show how the two parties attempted to achieve a balance between flexibility and assurance given the uncertainty surrounding the Deepwater program's product specifications and costs.

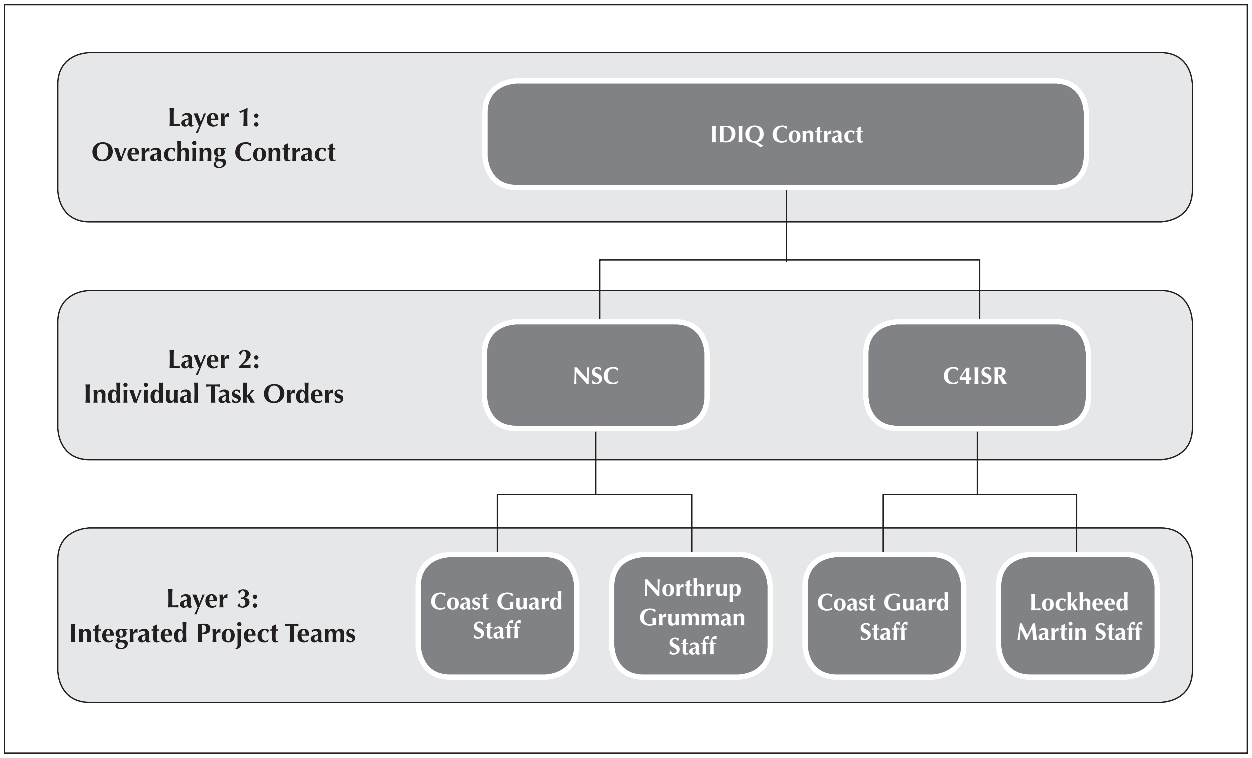
Deepwater Contract

In 2002 the Coast Guard and ICGS agreed to a three-tiered arrangement for the Deepwater contract (see Figure 5 on page 28).

- **IDIQ contract:** The top layer was a performance-based IDIQ contract.[15] In the simplest terms, an IDIQ contract does not specify a firm quantity of products or the tasks required to produce them; instead, the contract specifies the types of products that can be purchased by some determined end point.[16] The first Deepwater IDIQ contract established an arrangement in which the Coast Guard could buy specified system components without competitively bidding each one; instead, each purchase was negotiated with a single supplier, ICGS.
- **Individual task orders:** The middle layer of the contract further specified the terms of exchange. Each individual purchase under the IDIQ contract was to be negotiated through a task order between the Coast Guard and ICGS that specified basic terms, such as the number of units to be purchased in a class of assets and their delivery schedules. However, it left many dimensions indeterminate, such as the assets' exact design and performance specifications, cost schedules, and evaluation metrics.
- **Integrated project teams (ITPs):** Specifying the details of each task order occurred through a final contract layer that was intended to facilitate less formalized cooperation as the product was being designed, tested, and built. This process took place through IPTs, which brought together ICGS personnel, subcontractors, and Coast Guard officials to decide the important details about assets under their jurisdiction. Some of these decisions about important details were made before actual production of the asset, but other details were decided once production commenced.

After a decision was made about an important detail, ICGS and Coast Guard personnel would

Figure 5: Deepwater's Three Contract Layers



formally incorporate the specification and its cost into the task order. Because the fast tempo of the production process for each asset often required quick decisions, the Coast Guard and ICGS sometimes could not spend the time to formally negotiate these important elements into the task order. Instead, they turned to undefinitized contract actions (UCAs). UCAs are a legal vehicle that allows production to continue after a design change, even though the parties have not formally negotiated the full price and terms of that change. UCAs require that the parties formally resolve the specification and price within 180 days. Once these items become definitized—that is, once they are specified in contract—they operate like any formal contract.

Figure 6 depicts the process of negotiating, specifying, producing, and delivering each asset.

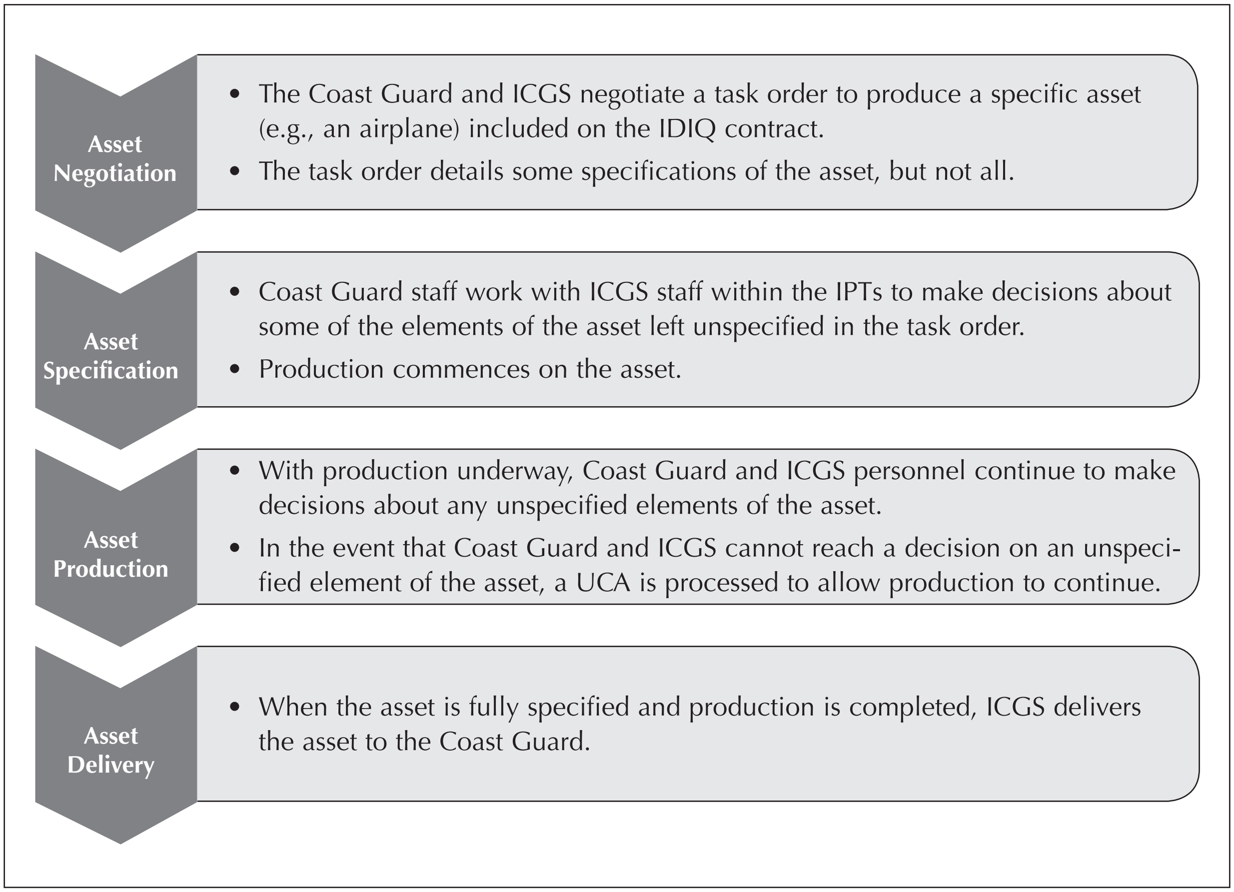
Inputs, Activities, Outputs, and Outcomes

In designing and producing an aerial or sea vessel, let alone an interoperable system of such assets, there is a set of almost infinite product specifications over which the buyer and seller could negotiate. Examples include the speed and lift of helicopters, the time at sea for boats, and the crew capacity for each surface asset. To specify each of these exactly requires forecasting across many variable future conditions (such as weather, terrorists, and drug runners). Given this uncertainty and lock-in risks, the Coast Guard and ICGS agreed to a contract that specified some aspects of the system, but left others unspecified.

The IDIQ contract provided the boundaries on options for the system by identifying different outputs that could be purchased to meet the overall system's performance goals. The IDIQ contract identified the boats, cutters, aerial vehicles, command-and-control centers, and communication technology to be purchased and integrated to form the Deepwater system.

Once these basic decisions were set, the second contract layer—the individual task orders—was designed to add specificity by laying out the number of various assets (or outputs) to be purchased (for example, eight NSCs). Finally, the more fine-grained details of each asset's design, performance specifications, and testing requirements were to be determined and incorporated into the formal tasks through decisions made within the IPTs.

Figure 6: Process of Negotiating, Specifying, Producing, and Delivering Deepwater's Assets



The structure of the Deepwater contract shows that the Coast Guard and ICGS essentially agreed to specify portions of the contract in stages rather than all at once at the front end.

Compensation

Reports in the press often suggest that the Deepwater program was a $24 billion contract.[17] This is partially true—this figure was a projection of the overall costs of the program. The projection did not mean that the Coast Guard entered into a contract that guaranteed a $24 billion payment to ICGS. Instead ICGS's compensation from Deepwater depended on what the Coast Guard purchased through individual task orders and as specified through the IPTs. The IDIQ was a menu of the base costs for various assets (such as a $400 million National Security Cutter), while the add-on features were neither specified nor priced (such as satellite technology, 50-inch guns, and a high-technology bridge). When buying assets through task orders, the Coast Guard got a sense of its base costs (a certain number of boats, a certain number of cutters), but a fuller cost picture would not become clear until the IPTs developed more precise performance requirements and cost schedules asset by asset.

The Coast Guard was making purchases without knowing the full costs of what it was buying. ICGS could not determine the time and materials needed to produce the product until performance requirements of each asset were specified, and the performance requirements of the assets could not be specified fully until some products had been built and tested. As a result, the first purchased unit of each asset (for example, the first-in-class, in the case of a boat) fundamentally put the cost risks in the hands of the Coast Guard, while the purchase of subsequent units shifted the cost risks to ICGS as costs became fixed.

Delivery Terms

The Deepwater program has also been incorrectly portrayed as a 25-year contract. Similar to compensation, this was a projection about the length of time the Coast Guard anticipated it would take to acquire all the elements to complete the system. The projection did not mean that the Coast Guard locked in to a 25-year contract with ICGS. Instead, the Coast Guard and ICGS agreed to an initial IDIQ contract for five years, renewable up to four times in increments as long as five years. Neither party was contractually locked in beyond the initial five years. There were multiple exit ramps throughout the contract.

Decision Rights and Processes for Negotiation

The IPTs were designed to facilitate low-cost cooperation over each asset's design, production, and evaluation. The Coast Guard's officials, ICGS personnel, and relevant subcontractors would meet in less formal venues to decide how the asset would fit in the overall mission requirements. The IPTs were modeled after similar mechanisms that had been pioneered by the Navy in its complex acquisitions, and were in many respects the primary manifestations of the Coast Guard and ICGS's desire to build a cooperative partnership.[18] Through the IPTs, the two parties could collaboratively and creatively work out details rather than resort to an adversarial and overly rigid decision-making process. Ultimately, though, any decision the two parties agreed to—or made unilaterally—became a feature of the formal contract arrangements. The Coast Guard still had to decide what it wanted to buy, and ICGS still had to determine costs. But under the Deepwater's contract structure, many of these decisions could be put off to later stages.

What the IPTs did not formally specify were the decision rights—the buyer and seller's roles, responsibilities, and authorities in these processes. The IPTs identified the participants in the negotiations, but did not indicate who had final decision-making authority or who could make unilateral decisions if the other party did not participate in the IPT. On the one hand, this created the possibility for a virtuous joint venture between equals. On the other hand, it suggested the opportunity for abuse if one party achieved an advantage over the other in the decision-making process. For example, the GAO repeatedly cautioned that a lack of specificity about IPT governance roles and responsibilities could leave the Coast Guard vulnerable to ICGS decision making. The concern was that ICGS and its subcontractors were making many critical decisions without input from the Coast Guard (GAO 2004, 12–16).

Even with this elaborate system, the Coast Guard and ICGS found additional ways to quickly specify asset details to keep production moving forward (cutters, for example, take years to produce). Once production for an asset was underway, rather than fully renegotiate each task order to reflect some design change or refinement, the Coast Guard and ICGS often used the previously described UCAs. Again, a UCA allows production to continue after a design change, even though the parties have not formally negotiated the full price and terms of that change. UCAs place the cost risk on the buyer because the seller has considerable discretion over the price charged for each revision.

Oversight

The Coast Guard embarked on an ambitious plan for overseeing ICGS's performance. The Coast Guard sought to use several standard contract management tools from the private sector, such as EVM, in which actual program costs are compared with baseline data to assess performance. This management tool is widely used in project management and government acquisition for tracking costs and performance reporting. The Coast Guard and ICGS had regular monthly and quarterly meetings to address contract issues face to face. Co-location of Coast Guard and ICGS personnel provided not only a vehicle for information exchange, but also for monitoring performance. The Coast Guard also had the option of drawing on third parties to provide IV&V of ICGS's decisions on a range of issues from hull design to tradeoffs among system capabilities. And of course, Deepwater performance was also evaluated by the GAO, DHS Inspector General, and House and Senate oversight committees, in addition to some fairly intense media scrutiny (GAO 2004, 2005 and 2005a, and 2007a; Defense Acquisition University 2007; DHS Office of Inspector General 2007; O'Rourke 2008).

Proprietary Ownership

From the outset, the Coast Guard sought a Deepwater system that limited the seller's proprietary ownership of assets as intellectual property. The initial RFP for the design of the Deepwater system included selection criteria designed to reduce any prospective seller's ability to lock the Coast Guard in through proprietary claims.

Proprietary elements were also incorporated in the formal contract arrangements.[19] First, the system was built on an open architecture that allowed for the addition, upgrade, and swap of many system components. Second, recognized industry and government design standards were used, allowing commercial off-the-shelf (COTS) technology. Third, core capabilities used on other government programs that have been identified as state-of-the-art were built into the system. For example, the integrated, interoperable logistics system on the Coast Guard's NSC is based on the COTS version of the Navy's AEGIS system and has integrated more than 100 COTS software components as part of its implementation. Fourth, the system was designed to provide the Coast Guard with the right to share the information used to develop the system across governmental programs other than Deepwater. These rights are often referred to as government purpose rights.[20]

Specificity of the Deepwater Contract and Lock-In Risks

The three contractual layers established the terms of the exchange and a process for the Coast Guard and ICGS to commence production on Deepwater assets without agreeing on every specific element of the asset and its total cost. These elements were determined at a point later in the production process. This governance arrangement was essential given the complexity of the Deepwater system. The IDIQ and the task orders could not specify at the outset every design and performance requirement for each asset in the system and how they would fit together. The specification challenge was exacerbated by the interoperability—and hence interconnectedness—of the system: A performance specification for one asset (such as the speed of a boat) had implications for other assets (such as the range of helicopters and airplanes). Because the acquisition of the total Deepwater fleet was sequenced over a 25-year period, the Coast Guard and ICGS were unable to forecast (and specify formally in a task order) every detail of the assets early in the acquisition because these would then cement performance specifications for all later assets, some of which had not yet been fully designed. In many cases, the Coast Guard could not know exactly all that it wanted each asset to do until it deployed its first-in-class and experimented with it under various conditions. Fundamentally, the contract was not completely specified.

This less specific contract agreement offered positive benefits for both the buyer and the seller. For one, the Deepwater contract arrangement created a mechanism for acquiring the component assets without both parties incurring the high costs of specifying the entire system at the front end, before research, development, and initial deployment revealed the assets' capabilities and costs. This open-ended arrangement allowed production of individual assets to begin and continue without full specification of each asset and its costs. This arrangement also addressed some of the risks associated with lock-in. The use of the IDIQ contract and the sequencing of the task orders created a means to make changes to the configuration of the system as production and asset use were underway. If the Coast Guard found that one of the early assets did not work as intended, it could select other assets for later task orders, make changes to planned assets, or buy from vendors other than ICGS. In addition, the five-year timeframes for the IDIQ contract and renewals offered exit ramps for both parties. The multistage nature of the contract meant that neither party was contractually locked in beyond the initial task orders.

These arrangements, however, did not fully resolve the lock-in risks. As noted previously, some of Deepwater's planned assets require specialized investments, while others do not. Although the Coast Guard may have a means of exiting the relationship with ICGS to pursue other providers, it may find a market with a limited number of buyers for some of the highly specialized assets. Because ICGS (or Northrop Grumman in the case of naval assets and Lockheed Martin in the case of aerial assets) has made the investments in some cases, it can deliver subsequent units at a lower cost than a potential new supplier that may have to make a high upfront investment to create the production facilities necessary to build the asset. The Coast Guard may find that, even though it may be dissatisfied with a particular asset, it simply cannot afford to purchase from other suppliers. Furthermore, less specific contract arrangements create opportunities for abuse of discretion by one party, particularly in the IPTs where roles, responsibilities, and authorities of participants were not well established. Finally, the contract was not clear about how awards and penalties would be assigned, what corrective action or sanctions would be required if design specifications were not certifiable, and what penalties or accommodations would be made for cost overruns or missed delivery dates.

Report on Project Deepwater Through 2008

The Coast Guard is now six years into the projected 25-year lifespan of the Deepwater acquisition program. It is premature to judge the overall success of the program, evaluate the performance of the Coast Guard and ICGS, or draw final lessons on the Coast Guard's original contracting strategy (the SoS approach with an LSI through an IDIQ contract). Important elements are missing from the Deepwater story, notably the impact of contract management and the behavior of each party within the IDIQ contract design. Still, the early signals from the first six years of the Deepwater program are worth reporting. Although Deepwater has garnered headlines for some of its stumbles, a more complete review of the early phases suggests a more mixed and balanced record. The following three early task orders show this balance: a success, a failure, and a mixed outcome.

Success: Maritime Patrol Aircraft[21]

An early acquisition that has received generally positive reviews is the HC-144A Ocean Sentry Medium Range Surveillance Maritime Patrol Aircraft (MRS MPA). This fixed-wing medium-range surveillance aircraft is tasked with performing search and rescue missions and enforcing maritime laws and treaties. The market for airplanes such as the MRS MPA is rich with sellers; if the Coast Guard were unhappy with the asset's current supplier (Lockheed Martin as an ICGS subcontractor), it can choose from several alternative suppliers. One of the airplane's features is that its C4ISR components can be loaded and unloaded on transferable missionized pallets, allowing easier maintenance and upgrades. These pallets function as a platform on which different types of workstations can be inserted or interchanged. Because the C4ISR pallet can be used across many Deepwater assets, the Coast Guard simply needs to buy an airplane that meets its basic performance and price requirements, knowing that the new asset will integrate straightforwardly with its other existing assets.

The Coast Guard has received the first five airplanes, and the sixth through eighth airplanes are under contract for a price $900,000 lower than the first five.[22] The MRS MPA has been delivered on schedule with only modest cost overruns on the initial orders and projected savings on future fixed price delivery task orders. Performance reviews of the HC-144A post-delivery have been positive, and the aircraft is meeting expectations.

Success: The HC-144A Aircraft

Photo: Deepwater Information & Solutions Center.

The HC–144A Ocean Sentry Medium Range Surveillance Maritime Patrol Aircraft.

Photo: Deepwater Information & Solutions Center.

One of the features of the HC–144A aircraft is that its C4ISR components can be loaded and unloaded on transferable missionized pallets.

Failure: 123 Island Class Patrol Boat

The conversion of 110-foot Island Class patrol boats to become 123-foot boats has by all accounts been a failure in the Deepwater program. Under the ICGS Deepwater proposal, the Coast Guard's existing 110-foot patrol boat was to receive a 13-foot extension to improve its capacities, such as allowing it to launch a short-range prosecutor (the chase boat) from the stern. Eight of 49 planned 123s were initially upgraded and delivered, and Coast Guard commanders spoke positively about the boat's C4ISR capabilities. The system's common operating picture provides the Coast Guard with information and tools it had not previously had on the 110.

However, after initial delivery, hull buckling and shaft alignment problems were discovered, raising safety and performance concerns. Subsequent modifications to fix these problems were deemed unsuccessful, and under a firestorm of controversy, the boats were eventually decommissioned and future orders were cancelled. The Coast Guard and ICGS are negotiating to resolve some remaining financial terms, but the program is effectively dead. The 110/123 has received perhaps the most media attention and congressional scrutiny of all the Deepwater assets because of its cost, poor performance, and safety issues. Only eight patrol boats were upgraded at a cost of $96 million, and even those were decommissioned.

Failure: The 123 Island Class Patrol Boat

Photo: Deepwater Information & Solutions Center.

After delivery, hull buckling and shaft alignment problems arose, and efforts to fix these problems were unsuccessful.

Mixed: National Security Cutter

The NSC, the largest class of ships in the Coast Guard fleet, is an example of an asset with mixed results. Northrop Grumman—the lead on the NSC—had to develop a relatively specialized production process to develop this class of assets because of unique performance attributes requested by the Coast Guard. This ship will be the first and largest Coast Guard cutter purchased in 30 years. The NSC is designed to be at sea for 230 days a year, have a 30-year lifespan, and be able to pursue a range of missions. It must be interoperable with the U.S. Navy on defense issues (given its comparable weapons and electronics systems) and respond to homeland security threats, such as nuclear, biological, and chemical exposure and containment.

Several issues associated with the NSC acquisition lead to classification of this asset acquisition as a mixed outcome. First, the task order left many performance requirements indeterminate, following the pattern of devolving these decisions to an IPT and later definitization.[23] The task order also did not identify the decision-making rights and obligations of either ICGS or the Coast Guard over these unspecified elements. Specifically, the task order did not identify the following: which party had decision-making authority over structural design specifications; the conditions under which an independent third-party assessment of the design would be necessary or which organizations would be qualified to perform this role (for example, the U.S. Navy's Surface Warfare Division); corrective action or sanctions if design specifications were not certifiable; criteria and evaluation process for paying award fees; and penalties or accommodations for cost overruns or missed delivery dates.

There has been criticism from parties and external overseers over a range of design issues with the NSC, how decisions were made or not made, the effectiveness of the IPT, and the relationship between the parties. To resolve these issues, the Coast Guard has engaged ICGS on a consolidated contraction action (CCA) "to resolve all outstanding contracting issues related to the NSC … include[ing] industry's Request for Equitable Adjustment and post-9/11 changes to the NSCs."[24] That CCA was signed August 2007 at a cost of $410 million to reflect changes to the first three NSCs. Based on interviews conducted for this report, congressional

Mixed: The National Security Cutter

Photo: Deepwater Information & Solutions Center.

The NSC is the largest class of ships in the Coast Guard fleet.

action, and the Coast Guard's own response to the contract, it is fair to characterize the relationship as one in which neither party is satisfied or sees the other as the partner they had at the outset of the Deepwater contract.

However, some positive outcomes lead to characterization of the NSC as a mixed case. First, the changes to the NSC as a result of 9/11, and the cost and time overruns associated with the effects on the Northrop Grumman shipyards as a result of Hurricane Katrina, make it surprising that the NSC was built at all. The first-in-class NSC—the Bertholf—was delivered 255 days after the projected delivery date and more than double the projected cost baseline. Yet, given the magnitude of the events beyond the Coast Guard's and ICGS's control, it is a testament to the work of the contract teams that the NSC was delivered with only a few issues (including a low number of starred trial cards at acceptance). These issues needed to be resolved before Coast Guard acceptance, but the ship is considered seaworthy. And notwithstanding structural fatigue issues that still need to be addressed on the first two of the eight cutters slated for production,[25] the reviews of the ship have been positive. The second NSC is 60 percent complete; the third is in production and funding; and as part of the Coast Guard 2009 Congressional Budget Submission has requested funds for the production of the fourth NSC. As a result of a first-in-class design for the largest Coast Guard cutter in the service's history and external events beyond either parties' control, the fact that the NSC was delivered and with only a few outstanding issues warrants characterizing the acquisition of this asset as a mixed outcome.

Project Deepwater: An Update

There have been positive, negative, and mixed returns from Deepwater's early performance. It is perhaps not surprising that the Deepwater program's early failures have dominated press reporting and oversight hearings. The failure of the 123-foot patrol boats in particular became the catalyst for heightened oversight and congressional inquiry. The intense controversy has left the Coast Guard and ICGS in a significantly tenser, and even acrimonious, relationship. The Coast Guard has renewed its Deepwater contract with ICGS for an additional 3.5 years. With this new contract, the LSI responsibility shifted to the Coast Guard. This change facilitates the purchase of Deepwater assets by Coast Guard personnel outside the IDIQ contract with IGS.

Under the IDIQ contract with ICGS, the Coast Guard has taken steps to enhance its contract management and systems integration capacity, primarily through the establishment in the summer of 2007 of a new administrative structure, the Coast Guard Acquisition Directorate, also known as CG-9.[26] The intent in creating CG-9 was to perform the acquisition and contract management functions previously performed by ICGS. In short, the Coast Guard still intends to pursue assembly as the production mode for the Deepwater system, but instead of relying on a private LSI, it will perform the role of LSI itself. This change has received support from Congress.

By assuming the LSI role, the Coast Guard is now better able to open competition to vendors outside the contract with ICGS. For example, one of CG-9's first responsibilities as the Deepwater LSI was to let a competitive tender for the Fast Response Cutter (FRC), the new boat to replace the decommissioned P-123 Island Class patrol boats. In September 2008, the Coast Guard awarded an initial $88 million fixed price contract to Bollinger Shipyards for the design and production of the FRC with plans to purchase a total of 34 boats. During this acquisition, CG-9 in its new role as the LSI was responsible for:

- Conducting an analysis of the FRC's operational requirements
- Conducting research on market providers and competing patrol boat designs
- Working with the Coast Guard's technical authorities and third-party independent reviewers to establish design standards
- Assessing designs submitted by private firms
- Selecting the winning bidder

As a result of this change, the Deepwater program today is different from when the initial contract with ICGS was awarded.[27] The Coast Guard now faces the challenge of serving as the LSI for Project Deepwater, with responsibilities including:

- Acquiring remaining Deepwater assets
- Performing contract management and oversight responsibilities
- Ultimately integrating all the assets to form the interoperable Deepwater system.

The Deepwater program is still a work in progress.

At a Glance: The Two Phases of Deepwater

2002–2007	2008–Present
• ICGS served as the LSI • All production of Deepwater assets done with ICGS subcontractors	• The Coast Guard begins to serve as LSI through CG-9 • The Coast Guard can solicit a wide variety of vendors (including ICGS) to produce Deepwater assets

A Look Ahead: The Federal Government's Challenge in Acquiring Complex Products

Acquiring complex products is not without risks. This report highlights the risk of becoming locked in to a contract with a vendor when products require highly specialized investments. Such risk is exacerbated when the government agency is the only purchaser of the product and there is only one seller. An agency may seek to eliminate such risks by building the product itself, but the costs of this option are often too high for many government agencies. Instead, government agencies are often left with two assembly production options:

- Buy the system's components from vendors and integrate them using government employees.
- Turn to a private vendor to both buy and integrate the components.

Project Deepwater's Lessons

The Coast Guard's Deepwater program highlights the risks and challenges of acquiring complex products. In assessing its aging deepwater fleet, the Coast Guard determined in the late 1990s that its multiple missions demanded an integrated and interoperable network of assets, a product that would require highly specialized investments and, as it turned out, prove difficult to specify.

Unable to design and build the system itself, the Coast Guard turned to the market. In markets for products that do not require specialized investments and that are easy to specify—simple products—a surfeit of sellers provide buyers with choices, and competition supplies information about tradeoffs between cost and quality. The market for complex products is likely to have few sellers, largely because specialized investments are required and the number of buyers is typically lower. The result is fewer options and less information for buyers. One of the risks of buying in a thin market is that buyers have more difficulty distinguishing good options from bad ones because they lack information on the tradeoffs between cost and quality. The Coast Guard's foray into the market for the design and production of the Deepwater system generated only three potential vendors.

Assembling complex products can be expensive. In the Deepwater case, not only did the Coast Guard find the costs of building the system too expensive, it also initially determined that it did not have the capability itself to serve as the LSI. The costs of managing the acquisition and integration of all the component parts were too high. Consequently, the Coast Guard elected to assemble the product through an SoS contract with a private LSI. In this way, the Coast Guard hoped to lower its administrative costs by transferring contract management tasks to ICGS, the selected LSI vendor. However, even with this production choice, the administrative costs of working with ICGS to specify the system and its components and acquire the system assets proved higher than either party initially anticipated. Furthermore, the Coast Guard faced the risk of locking itself in to a relationship with ICGS because of the highly specialized investments that were required to deliver the system. These circumstances jeopardized the win-win outcomes that successful contracting promised.

Deepwater's initial results have been mixed, to be certain, but the problems may have been overstated in the press. The Coast Guard has successfully acquired functioning assets through the IDIQ contract and is not contractually locked in to a relationship with ICGS. In fact, the innovative contract design used by the Coast Guard and ICGS allowed production to commence on many Deepwater assets in the absence of fully specifying the entire system, a task that would have likely been impossible to perform given uncertainty about the future. The flexible contract design also allowed the Coast Guard and ICGS to adapt the production process to incorporate new post-9/11 mission requirements.

Finally, the decision by the Coast Guard to let only a five-year contract to ICGS in the beginning created the opportunity for the Coast Guard to reassess the experience of the first five years and to exit the relationship if it was dissatisfied with ICGS's production and delivery of the Deepwater system.

Lessons for the Future

In response to future challenges, federal government agencies, much like the Coast Guard, will continue to need highly integrated systems of goods and services. The demand for complex products will not abate and will require many complex acquisitions. Without major public investments in the capacity of government agencies to build complex products themselves, government agencies will continue to rely on assembly as the primary means of acquisition. The Coast Guard's Deepwater experience offers several lessons for future acquisitions of complex products.

The Effective Acquisition of Complex Products Requires an Expanded and More Highly Skilled Acquisition Workforce.

Over a decade ago, Don Kettl (1993) highlighted the importance of effective contracting of "smart buyers"—acquisition personnel knowledgeable about market dynamics and skilled in engaging it. This call is perhaps even greater today given the increase in government contracting, particularly for complex products. The Partnership for Public Service projected that one of the fastest growing human resource needs across all federal agencies is acquisition personnel.[28] Many government agencies need an expanded and more highly skilled acquisition workforce. The Coast Guard's experience in Deepwater, for example, affirms the need for a large acquisition staff skilled in the following:

- Market dynamics and firm behavior
- The legal context of contracting
- Product specification and measurement
- Risk management
- Negotiation
- Contract design
- Incentive construction and implementation
- Contract management and oversight

Perhaps most important, as acquisition personnel perform their roles as smart buyers, they must be trained and given freedom to operate strategically. Smart buying of complex products is not simply an exercise in following procedures and punching checklists, but rather it requires personnel who can synthesize information, adapt quickly to changing circumstances, and selectively apply different tools and skills to match the dynamic challenges they face.

The Effective Acquisition of Complex Products Requires a Better Understanding of Risk.

As highlighted throughout this report, the acquisition of complex products incurs the risk of cost overruns, delays, less than desired product performance, and sometimes failed products. One of the challenges for public acquisition personnel (and their overseers) is to better understand risk so that it can be effectively managed and so that accountability can be appropriately assigned. Often overlooked but central nonetheless, the nature of the product is generally the primary source of contracting risk. Complex products are difficult to specify and require highly specialized investments that create the possibility of lock-in abuse. As a result, the buyer and seller's behavior determines win-win, win-lose, or lose-lose contract outcomes. However, the product is not the only source of risk. Uncertainty about the future and the impact of forces outside the control either party also drives complex product's risks. Buyers, sellers, and overseers can often misattribute contracting's outcomes to buyer and seller's behavior when in fact the impacts result from outside forces.

The Effective Acquisition of Complex Products Requires an Investment in Learning.

Contracting for complex products is by no means *terra incognita*. The Deepwater program is only one of several of ongoing complex product acquisitions within DHS, and there are others throughout the federal government. Less is known, however, about the effectiveness of different contracting tools, designs, and strategies for complex products than for simple products.

As government agencies continue trying different contract vehicles for acquiring complex products, these agencies (and their overseers) need to invest in creating acquisition units equipped as learning organizations to continually reassess and modify acquisition processes as they progress. Without knowing what does not work, agencies and their acquisition personnel will not be able to fully understand what does work and why.

When government agencies pursue contract strategies that allow for learning, as the Coast Guard did with the use of a flexible contract design, they should be allowed, if not encouraged, to change based on experimentation to some degree. The success of latitude, however, is conditioned on the establishment of processes and mechanisms for gathering lessons learned and incorporating them into future practice. In this way, the practice of contracting for complex product can be improved.

Acknowledgments

We appreciate the time shared by approximately 50 senior leaders from a range of vantage points and with specialized knowledge and expertise on the Coast Guard's Deepwater program. This report would not be possible without their cooperation. Those individuals were provided confidentiality in exchange for sharing information and their experiences with our research team. All errors and omissions remain the authors' responsibility.

Appendix: Research Methods

The authors conducted more than 50 interviews with individuals involved in the Deepwater program. The purposive sample was drawn from recommendations from experts involved in the program at various time periods over the course of the program to date. The sample included interviews with the following:

- 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. All interviews were conducted by a minimum of two members of the research team, and in some cases the entire team was present. No electronic recordings of the interviews exist.

The authors 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 the research team members.

Endnotes

1. The term "deepwater" refers to Coast Guard assets that operate in literal deepwater, 50 miles off shore.

2. To learn more about the history of the Coast Guard, see http://www.uscg.mil/history/.

3. In 2005, the Coast Guard was moved from the Department of Transportation to the newly created Department of Homeland Security.

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 37 out of 39 of the fleets worldwide (Acquisition Solutions 2001, 6).

5. See http://www.uscg.mil/directives/cim/4000-4999/CIM_4140_1.pdf. "Total ownership costs (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. First-in-class designs typically encounter cost overruns and schedule delays as the precise specifications for the product are worked out.

7. Economists typically refer specialized investments as asset specific investments (Williamson 2005).

8. All contracts are incomplete—not fully specified—to some degree because the future contains an infinite number of scenarios, not all of which can be specified in advance. Some, however, are less specific than others. For example, see Hart and Moore 2008, Tirole 1999, Bajari and Tadelis 2001, Heinrich 1999, Martin 2004, and O'Looney, 1998.

9. There are important caveats, of course. In the case of a quickly produced product, if the buyer makes the purchase frequently (for office supplies, for example), there may be cost advantages to entering into a long-term arrangement with a single seller. The seller may be able to offer a lower per unit price due to economies of scale of production. It may also lower the contracting costs for the buyer because it does not have to negotiate a new contract every time it makes a purchase. However, entering into a long-term arrangement for what is essentially a spot-market transaction may eliminate the cost savings associated with tapping market competition.

10. Lockheed Martin assumed the lead in development and production of this element because of its experience with the Navy's AEGIS system. For more information on the AEGIS system, see http://www.globalsecurity.org/military/systems/ship/systems/aegis.htm. This legacy system is the first generation predecessor to a more modern Coast Guard C4ISR system.

11. There is significant interest from overseas buyers for the C4ISR system, but because of national security concerns, ICGS is prohibited from selling comparable systems abroad.

12. The Coast Guard became designated as a government reinvention laboratory. See http://govinfo.library.unt.edu/npr/library/news/062999.html.

13. For more information about network-centric operations, see http://en.wikipedia.org/wiki/Network-centric_warfare.

14. See http://govinfo.library.unt.edu/npr/library/review.html.

15. See Federal Acquisition Regulation (FAR), section 16.500. http://www.arnet.gov/far/current/html/Subpart%2016_5.html or http://www.arnet.gov/far/current/pdf/FAR.pdf.

16. See, for example, FAR Subpart 16.5 Indefinite-Delivery Contracts http://www.arnet.gov/far/current/html/Subpart%2016_5.html#wp1093133.

17. See, for example, http://www.govexec.com/dailyfed/1207/121807kp1.htm, http://www.gao.gov/new.items/d07874.pdf, and http://www.uscg.mil/comdt/articles/docs/migration.pdf regarding the contract value, overall anticipated duration, and five-year IDIQs.

18. See http://nawctsd.navair.navy.mil/Resources/Library/Acqguide/teams.htm, http://www.stormingmedia.us/63/6336/A633683.html, and http://www.dau.mil/conferences/presentations/2004/B3C5Brown.pdf.

19. This information was shared by Lockheed Martin executives.

20. For more specific information about government purpose rights, see http://www.wifcon.com/anal/GPR_TD.doc.

21. Images were received from the Deepwater Information & Solutions Center, a joint Lockheed Martin and Northrop Grumman facility.

22. Department of Homeland Security, U.S. Coast Guard Statement of Admiral Thad W. Allen, Commandant, on Deepwater: 120 Days Later, Before the Subcommittee on Coast Guard and Maritime Transportation & Infrastructure, U.S. House of Representatives, June 12, 2007, page 2.

23. The design of the NSC occurred in two phases. In the phase 1 RFP, 85 percent of the design criteria and performance standards had been developed by the Coast Guard and the American Bureau of Shipping. In phase 2 of the contract, ICGS had discretion over what the remaining criteria and standards were going to be. However, the Coast Guard did not include a contractual mechanism that would ensure that the alternative standards would be consistent with the standards developed in the phase 1 RFP. (http://www.dhs.gov/xoig/assets/OIGtm_RLS_051707.pdf).

24. Department of Homeland Security, U.S. Coast Guard Statement of Admiral Thad W. Allen, Commandant, on Deepwater: 120 Days Later, Before the Subcommittee on Coast Guard and Maritime Transportation & Infrastructure, U.S. House of Representatives, June 12, 2007, page 10

25. The Coast Guard has indicated that these design changes will be included in the initial construction of NSCs #3–#8 and will be retrofitted during yard availabilities on NSC #1 and #2.

26. CG-9 refers to the Coast Guard's ninth directorate or division.

27. As of this writing, the Coast Guard has testified at congressional hearings that the only new work to be awarded under the existing ICGS contract will be for the NSC, MPA, and related C4ISR projects. All other former ICGS contracted projects are being migrated to other contracting vehicles.

28. See Roadmap to Reform: A Management Framework for the Next Administration. *Partnership for Public Service*, October 1, 2008, http://ourpublicservice.org/OPS/publications/viewcontentdetails.php?id=129. See also GAO 08-745, 18.

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