Right Sizing for Government Review

by

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ABSTRACT

The U.S. Navy has changed many of its acquisition practices. One of these changes is from performing the early design work primarily in-house, to contracting private shipyards to do the design. This change has shifted the government's role in design to a predominantly review function. Therefore, the government needs to decide what level of review should be performed, and how much this will cost in the future.

This research examines the Strategic Sealift acquisition program, which was one of the first programs that employed this new acquisition strategy. The costs of the design stages are identified, and the level of review is described. This research can be compared to later programs, and possibly used as a benchmark for future programs.

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Table of Contents

Acronyms

ABS	American Bureau of Shipping
ADM	Approval Decision Memorandum
AII	Avondale Industries, Inc
AOA	Analysis of Alternatives
APB	Acquisition Program Baseline
ASN	Assistant Secretary of the Navy
CAIV	Cost As an Independent Variable
CDRL	Contract Data Requirements List
CFE	Contractor Furnished Equipment
CNO	Chief of Naval Operations
COR	Circular of Requirements
CSE	Class Standard Equipment
DoD	Department of Defense
DTRC	David Taylor Research Center
FASA	Federal Acquisition Streamlining Act of 1994
FYDP	Future Year Defense Plan
GFE	Government Furnished Equipment
HM&E	Hull, Machinery and Electrical
ILS	Integrated Logistics Support
IPPD	Integrated Product and Process Development
IPPDT	Integrated Product and Process Development Team

IPT	Integrated Process Team
JROC	Joint Requirements Oversight Council
MDA	Milestone Decision Authority
MILSPEC	Military Specification
MNS	Mission Need Statement
MS	Milestone
NASSCO	National Steel and Shipbuilding Company
NAVSEA	Naval Sea Systems Command
NDSF	National Defense Sealift Fund
NNS	Newport News Shipbuilding
OGA	Other Government Agencies
OIPT	Overarching Integrated Product Team
OPNAV	Office of the Chief of Naval Operations
OR	Operational Requirements
ORD	Operational Requirements Document
PEO	Program Executive Office
PMS 385	Strategic Sealift Program Office
QFD	Quality Function Deployment
ROM	Rough Order-of Magnitude
RDT&E	Research, Development, Test and Evaluation
RFP	Request for Proposal
SASC	Senate Armed Services Committee
SCN	Ship Construction Navy

SECNAV	Secretary of the Navy
SHAPM	Ship Acquisition Project Manager
SUPSHIP	Superintendent of Shipbuilding
TOR	Tentative Operational Requirements

1 Introduction

The major shipyards in the United States are generally not competitive building commercial ships on the world market. Many suggestions for change in both the design and production processes have been offered by the maritime community. One common criticism is that the U.S. military did not do the shipyards any favors by being their sole customer. The shipyards became accustomed to designing and building ships the way the military wanted it, and this may have contributed to their downfall in the world market. The Navy is now beginning to change the way they acquire ships.

The world has changed greatly over the last few decades. With the fall of communism in Eastern Europe, the major threats have shifted from the superpowers to smaller countries. With these changes, the needs of the Navy have changed. In the 1980's, the U.S. was looking at building to a 600 ship Navy to prepare for the threats of the large superpowers. Now the Navy is under increasing pressure from budget reductions, and is looking to get more for its money. One movement within the government is to buy commercial off-the-shelf products when they will fulfill the mission need adequately. This movement has led to changes in the way the Navy acquires ships.

The main change in Navy acquisition has been the shift from in-house Navy designs, towards industry performing the majority of the design work. In this new paradigm, the government's role is shifting to a principally review function.

Many issues arise from these shifts in Navy acquisition. For instance, what is the right amount of review to perform? How much should the government budget for ship design in future programs? Would it make more sense to spend more money early in the program, in the design stages, and save more money later due to reduced design changes or producibility enhancements? How will the latest trends in acquisition (such as teaming arrangements, simulation-based design, etc.) change the costs associated with ship design?

All of these factors will affect the cost attributed to ship design. This paper investigates the design costs of the Strategic Sealift program as a basis for future comparison to other acquisition programs.

2 The Acquisition Process[1]

The ship acquisition process in the Navy is always changing. Most of these changes are small, but collectively these changes have altered the ship acquisition process substantially. In order to understand the direction the Navy is headed in ship acquisition strategy, it is important to understand the past.

2.1 Historical Perspective of the Ship Acquisition Process

The Navy has used several different ship acquisition strategies since World War II. In the 1950s, the Navy designed its own ships with in-house resources exclusively. This included naval shipyard personnel farmed-in for the process. The number of design deliverables was few compared with the designs of today, and the design timeframe was relatively short. The ship specifications were primarily engineering documents, as opposed to legal ones. The ships were not as fully integrated for a couple of reasons. First, different Navy organizations were responsible for the platform and weapons. In addition, the Preliminary Design and Contract Design were separate organizations within the Navy.

Construction in the 1950s occurred at both government (public) and contractor (private) shipyards. Most of the contracts were awarded without competition. The shipbuilders and the government did not have the same adversarial relationship that existed in later years. Claims were rare, and there was a substantial commercial

[1] Much of the content and wording of this section came from "Assessment of Options for Enhancing

shipbuilding market in the U.S. relative to today. However, this process for awarding major contracts on an allocation basis had some problems and could have utilized taxpayer money more effectively by requiring competition.

In the 1960s, the Total Package Procurement initiative became the standard in the Department of Defense (DoD). This concept included private shipbuilders designing the ships instead of the Navy. Competing contractors were required to submit binding price bids for the entire weapon-system program before contract award. This included the development costs in addition to the production costs. This was intended to allow the government a choice between competing products on the basis of commitments of performance, delivery schedule, and the price of the operation equipment. This method improved the system for generating requirements based on mission requirements. The problem with this method was that most total-package awards resulted in huge cost overruns. Once the shipbuilders began to lose money, large claims ensued and the adversarial relationship started. The government had to provide large bailouts or guaranteed loans to several of the contractors who faced bankruptcy. As a result, Congress passed legislation prohibiting this procurement approach. In addition, during this time the Navy stopped construction in government (public) shipyards.

In the 1970s a systems analysis and engineering approach was applied to all major systems, including ships. This arose out of a desire for better attention to cost-performance tradeoffs, and was called the Design to Cost initiative. The Navy re-established its central design team and once again was mostly responsible for ship design. The result of this systems approach was a large increase in design deliverables and design

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Surface Ship Acquisition", March 1996, pages 37-43 time as well. Staffing shortfalls led to the increased use of civilian shipbuilders and ship design agents for in-house Navy designs. The platform and weapons bureaus were combined, and program managers/platform directors were established. This added a layer between those who set the requirements, and those who design the ships.

In the 1980s, there were ample funds available for shipbuilding, as President Reagan was advocating a buildup to a 600-ship Navy. With this increase in funding, however, came a large concern regarding fraud, waste, abuse, competition and industrial base. The high cost and alleged low quality of defense systems paralleled many other industries in the U.S. One reason was that the defense industry had a customer who was forced to buy what the shipbuilding industry produced. This loss of competition and focus on Naval vessels led to the U.S. shipyards becoming highly uncompetitive on the global commercial sector. As a result of these developments, many of the small-medium sized shipyards went out of the business of building Naval ships; now there are six main shipbuilders competing for the one major customer of ships in the U.S. (the Navy).

The development contracts for ships were fixed price, which meant that the shipbuilders assumed more risk. In addition, dual sourcing for ships became commonplace. One can debate whether this was beneficial from a cost saving strategy point of view; however, it generally is accepted it was successful from an industrial base standpoint.

In the 1990s the U.S. Navy has been adjusting to changes in the world order. A reduction in the perceived threat of a major war has occurred with the breakup of the Soviet Union. This has made a large impact on the Defense budget for the U.S. The government is still struggling with what force level and type will be required in the future.

2.2 Acquisition Reform in the 1990s

Acquisition reform in the 1990s has centered on two areas of effort. The first is to use commercial products and processes in any application that does not require the additional cost and performance of military specification material. The adoption of commercial practices is made more difficult by the fact that the U.S. shipbuilders have little commercial business, so there is no model in the U.S. to compare the government business practices with. The second area of effort is to reduce non-value-added work, particularly in oversight and review. The government has implemented several changes to reflect these efforts.

2.2.1 Federal Acquisition Streamlining Act of 1994 (FASA)

This Act includes the following reforms:

- An increased dollar threshold (now $100,000) for using simplified small purchase procedures.
- A performance-based incentive-based approach to managing acquisition programs. DoD must approve cost, schedule, and performance goals for each major program and assess whether or not the goals are being achieved.

- Emphasis on streamlining the acquisition process and greater reliance on commercial products and processes.

2.2.2 Integrated Product and Process Development (IPPD) and Integrated Product Teams (IPTs)

The Concurrent Engineering concept was an impetus for starting IPPD and IPT. Concurrent Engineering is an effort to consider all aspects of the life cycle, especially production, in the early stages of the design process. The IPPD concept extends this idea by advocating that a good product requires a good process for designing, developing, producing, and maintaining it. IPTs are the teams of personnel from different backgrounds of design, manufacturing, and operation that participate in the process from the beginning. In addition, there is an effort to incorporate the oversight and review functions of the government into the IPTs. Rather than centering oversight on a finite set of review meetings, staff in charge of oversight are part of the team from the beginning and are continually updated. If an issue arises with the oversight team, it can be brought up, and resolved immediately. The hope is that these concepts will lead to a more producible design, with less rework involved, and ultimately reduce the cost of the ship.

2.2.3 Reduction of Specifications and Standards

The DoD has directed that military specifications and standards be used only when required. This is an effort to use commercial standards when at all possible. Performance specifications using commercial standards should be used to set requirements.

2.2.4 Quality Function Deployment (QFD)

QFD is an effort to introduce the customer requirements into design requirements. In general, the customer thinks more about the user's requirements than the design engineers do.

2.3 The Current Generic Ship Acquisition Process[2]

The generic ship acquisition process is difficult to describe, as all of the programs have some unusual features; however, the following describes the process on a high level. The program structure is organized into phases and milestone decision points for a given program. These phases and milestone decision points facilitate the translation of broad mission needs into system-specific performance requirements and a design that fulfills these requirements. The phases and milestones provide the framework within which a system is designed, developed, and deployed during its life cycle. The program structure is a fundamental building block of the program's acquisition strategy. At each milestone decision point, the status of program execution and plans for the next phase and remainder of the program should be assessed. The risks are addressed, in addition to the adequacy of risk management planning.

2.3.1 Pre-Milestone 0

[2] Defense Acquisition Deskbook, Sept. 30, 1997

In general, a program starts with a determination of mission need. This may be in response to an aging class of vessels that need to be replaced, or an effort to incorporate new technologies to our fleet to counter a new threat. These factors are reflected in the Future-Year Defense Plan (FYDP), which indicates the fiscal year a new ship will be procured. The first time the estimated cost for the procurement of a new ship will be estimated is in the last two to four years of a FYDP. Depending upon which of the two years this funding shows up, this allows for either a 4 or 5-year development cycle prior to contract award. The funding amount shown in the FYDP is usually determined by OPNAV and considers the type of ship to be procured, the previous cost of a similar type of ship, and the available SCN money in that fiscal year. Another factor taken into account is the mission characteristics and weapon system composition of the new ship. This initial planning results in a Mission Need Statement (MNS) document for a new ship, in addition to a threat assessment and an Acquisition Strategy Report. This constitutes a Milestone 0 approval.

2.3.2 Milestone 0

Milestone 0 signifies the initial formal interface between the requirements generation and the acquisition management systems. The Milestone Decision Authority (MDA) decides what action should be taken on the Mission Need Statement (MNS) at this decision point. For those MNS receiving favorable consideration, the MDA authorizes studies of a set of alternative concepts. A decision to proceed at this point does not establish a new acquisition program, but reflects approval to proceed with studies of concepts to satisfy the identified mission need. These studies may be performed either by in-house staff or contractors, or both.

The Milestone 0 Approval Decision Memorandum (ADM) approves the start of Phase 0. In addition, the ADM should define the minimum set of alternative concepts to be examined, identify lead organization for study efforts, identify the source of funding for the studies, and determine the exit criteria. A Ship Acquisition Program Manager (SHAPM) is either established, or designated to coordinate with the Navy Design Office (03) to perform ship feasibility studies.

2.3.3 Phase 0

Phase 0 is concept exploration. Concept exploration generally includes feasibility studies. These are competitive, parallel, short-term studies by the Government and/or industry to define and evaluate the feasibility of alternative concepts. They also include means for evaluating and ranking the relative merits of the concepts at Milestone I. Early life cycle cost estimates should be performed for each of the competing alternatives, in relation to the value of the expected increase in operational capability of each alternative. This Analysis of Alternatives (AOA) is intended to help compare alternative concepts.

The current scheme of acquisition results in tradeoffs between cost, schedule, and performance as a result of a Cost as an Independent Variable (CAIV) analysis. The new focus in Navy acquisition has shifted to a Total Cost of Ownership tradeoff. Some tradeoffs include hull forms, HM&E, combat systems, manning projections, Integrated Logistics Support (ILS) considerations, etc. The most promising concepts should be defined in terms of initial objectives for life cycle cost, schedule, performance, and acquisition strategy. Critical system characteristics and operational constraints (e.g., survivability, interoperability, transportability, etc.), projected surge and mobilization objectives, and infrastructure support requirements should be defined interactively with users. Establishing detailed performance requirements and mandatory delivery dates is avoided at this time, as premature detailed requirements are counter to evolutionary requirements definition and inhibit cost, schedule, and performance tradeoffs.

The acquisition strategy should provide for the validation of technologies and processes required achieving critical characteristics and meeting operational constraints. It should also address the need and rationale for concurrence and for prototyping, considering the results of technology development and demonstration. Plans for the next phase should also address risks. These studies usually take between 3 and 18 months to complete, and are typically performed using in-house personnel with support from contractors. The feasibility studies culminate in Milestone I review.

2.3.4 Milestone I

The MDA assesses the affordability of the proposed new acquisition program at Milestone I. This is the decision point that marks the first direct interaction between the planning, programming, budgeting, and acquisition management systems. A favorable decision at Milestone I establishes a new acquisition program. It also authorizes entry into Phase I, preliminary and contract design for ships.

2.3.5 Phase I

Preliminary Design phase begins at Milestone I approval. OPNAV issues Operational Requirements Document (ORD) which defines the options selected at the Milestone I decision point. Preliminary design further refines the ship. Ship characteristics, HM&E, and combat systems are finalized, while combat systems and manning estimates are refined. Simultaneously, the SHAPM develops the programmatic documents required to be completed during this phase of the acquisition. The Program Office, Design Office, contractors and Navy laboratories are all usually involved in the preliminary design phase. This phase usually takes between 6 and 12 months, and results in the start of Contract Design.

Contract Design involves preparation of the ship contract specifications and drawings, the contract statement of work, the Contract Data Requirements List (CDRL) and programmatic documentation. This phase usually lasts 9 to 15 months, and results in Milestone II review. The Request for Proposal (RFP) is issued either before or after Milestone II approval. After these steps happen, the government role generally shifts to programmatic functions, rather than design-oriented ones. Source selection occurs after Milestone II has been approved and the RFP has been issued. This step usually takes between 6 and 12 months, and is scheduled to occur during the first quarter of the fiscal year in which funding becomes available.

Multiple design approaches and parallel technologies are pursued within the system concept during this phase, when warranted. Supportability and manufacturing process design considerations should be integrated into the system design effort early. This is essential to preclude costly redesign efforts downstream in the process. Prototyping, testing, and early operational assessment of critical systems, subsystems, and components should be emphasized. This is essential to identifying and reducing risk, and assessing if the most promising design approaches will operate in the intended operational environment including both people and conditions. In fact, some people believe we should be spending more funding in these areas, and receiving the rewards later in the life cycle costs. There is a discussion of this later in the paper.

Cost drivers and alternatives are also identified and analyzed in this phase. In addition, the cost of the design approach should be analyzed as a function of risk and the expected increase in operational capability. The AOA should provide comparisons of the alternative design approaches and should be the principal basis for establishing or updating CAIV life cycle-based objectives.

Consistent with evolutionary requirements definition, the program manager works with the user to establish proposed performance objectives, identify production rate requirements for peacetime, contingency support, and reconstitution objectives, and develop proposed cost-schedule-performance tradeoffs for decision at Milestone II.

2.3.6 Milestone II

The MDA should rigorously determine the affordability of the program and establish a development Acquisition Program Baseline (APB) at this milestone. The Defense Planning Guidance, long-range modernization and investment plans, and internally generated planning documents of the DoD Components form the basis for making this assessment. This is critical due to the amount of funding that is associated with this decision. Establishing the development APB requires effective interaction among the requirements generation, acquisition management, and planning, programming, and budgeting systems.

Milestone II Acquisition Decision Memorandum (ADM) approves entry into Phase II (Engineering and Manufacturing Development). In addition, it approves the proposed or modified APB and acquisition strategy, and establishes life cycle cost objectives. Milestone II generally results in contract award.

Upon contract award, the emphasis of the program office shifts to contract administration through SUPSHIP and engineering support from the Navy Design Office.

Figure 1 illustrates the process of ship acquisition on a high level. This figure shows all the different relevant sub-processes, but no single sub-process is shown in detail.

Acquisition Process

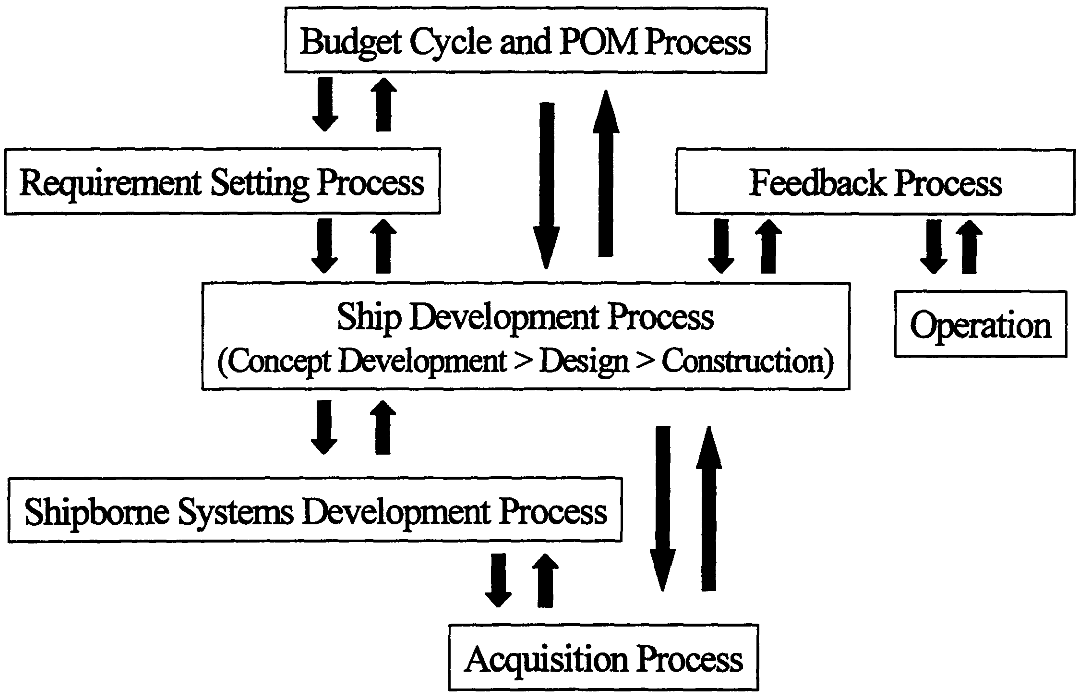


Figure 1.[3]

[3] Source: Improving the Ship Design, Acquisition and Construction Process: Strategic Plan, Vol. 1., June, 1991, page 2-4

3 The Acquisition Players

Figure 2 depicts the general players associated with Naval Ship Acquisition and the mechanisms by which they generate costs. This does not include players who are involved on the periphery, such as various review staff personnel, etc.

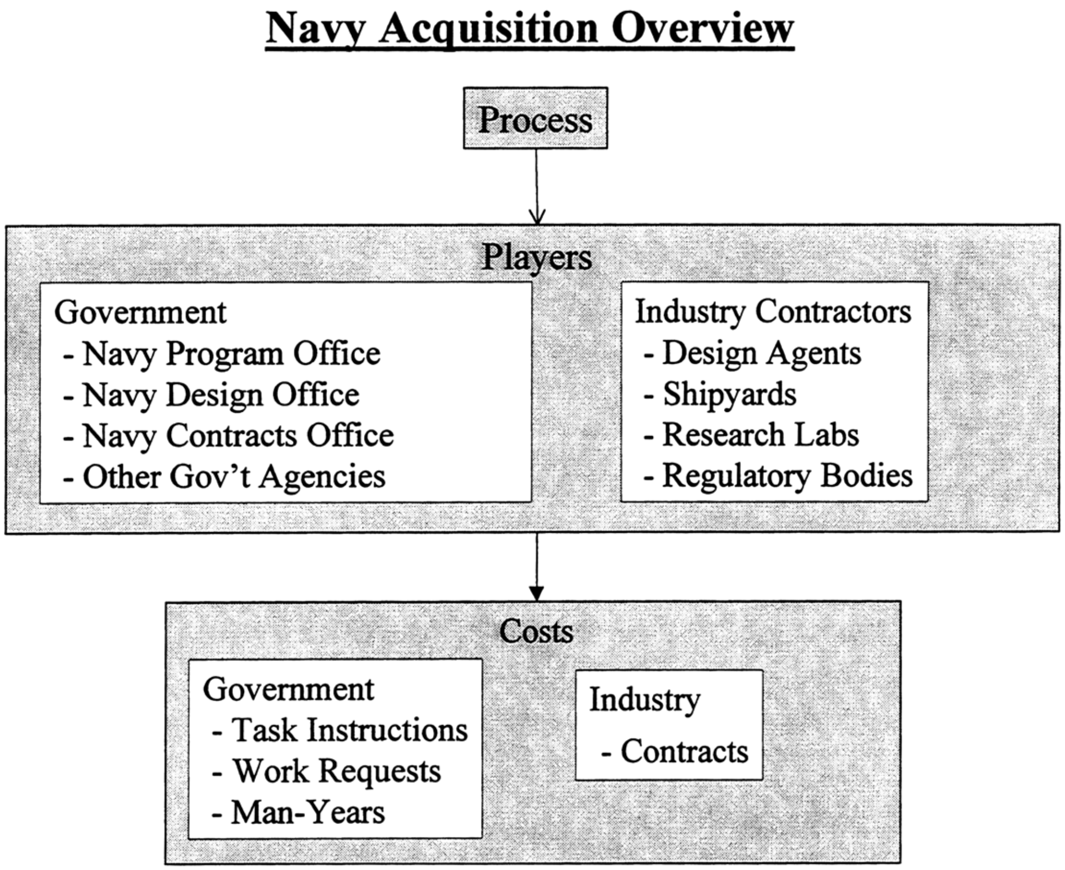


Figure 2.

The following sections will describe each of the players, and the role that each plays in Navy Ship Acquisition.

3.1 Government

The government functions in Naval Ship Acquisition can generally be divided into two groups; those who perform programmatic functions, and those who perform technical functions.

3.1.1 Navy Program Office

The Navy Program Office is run by the Ship Acquisition Program Manager (SHAPM). The SHAPM is responsible for developing an organization and planning to efficiently acquire the appropriate number and type of ships to meet the Navy's requirements. This management team, headed by a Program Manager, usually consists of a business/financial manager, a logistics manager, a technical manager/system engineer, a contracts officer, program engineers, and various specialists. This team is also responsible for the development of the acquisition plan, which is the overall strategy to attain an effective ship. The SHAPM is responsible for the planning, direction, control and utilization of assigned program resources. It is the job of the SHAPM to provide direction to the program support effort being performed by other organizations. They prepare technical specifications, contracts, and much of the paperwork required to move the program along. The funding for this Office up through Milestone II is through the Research, Development, Test and Evaluation (RDT&E) funds.

3.1.2 Navy Design Office

The Navy Design Office performs the technical engineering work to support the Program Office. The Program Office issues a ship's program directive, or task instruction, to perform technical work to the Design Office. The money that the Design Office spends to support the program is funded through the Program Office. In addition, the Design Office may hire outside contractors, or Navy Laboratories to help with this technical work. These contracts are funded through the Design Office.

3.1.3 Other Government Agencies (OGA)

The Design Office will often contract Other Government Agencies (OGA) to perform some technical work, especially in the development stages. One example of an OGA is David Taylor Research Center (DTRC), which often provides support of hull development, model tests, etc. These agencies are tasked through a document called a work request. The funds for these work requests also come through the Program Office.

3.2 Private Industry Contractors

Private Industry is involved throughout virtually all of the ship acquisition process. There has been a movement in the government to have private industry do even more of the work, with the government in primarily a review position.

3.2.1 Design Agents

Design Agents are involved throughout the design process. The government hires private design agents to help with the feasibility, preliminary, and contract designs. In addition, once shipyards become involved in the process, many hire private design agents to help with their design, all the way through detail design. One important distinction exists: if a design agent is hired by the government for work on any part of the design, that design agent is not allowed to support any shipyard in its design. This alleviates any conflict of interest arising from one firm developing both the requirements and baseline design for the government, and developing the design for the shipyard.

3.3.2 Other Contractors

For the purposes of this description of Navy ship acquisition, other contractors are those companies in private industry that are not included in any of the other functions. This is not a design company, shipyard, regulatory body, or research lab, but they provide services to the government. An example of this would be a company that supports the program management effort.

3.2.3 Shipyards

Shipyards receive the greatest percentage of the funds allotted for Navy acquisition. They are involved starting in developing the design, all the way until the ship has been accepted by the Navy and delivered. Traditionally, shipyards began to get involved after the RFP was issued, and a contract was awarded. Recently, the shipyards have started getting involved as early as exploratory design in pre-Milestone 0.

3.2.4 Research Labs

Research Labs perform some work for both the government and industry. Most of this work involves hull development early in the design stages.

3.2.5 Regulatory Bodies

Historically, regulatory bodies have not been heavily involved in Naval Ship Acquisition. Recently, however, there has been an effort to use commercial standard more extensively, rather than developing the designs to military specifications and standards.

4 A Case Study of the Sealift Program

The Sealift Program has been considered a successful Naval Acquisition Program by most people familiar with the program. This program has used some practices different from the norm of Naval Ship Acquisition.

4.1 History of the Sealift Program

The Strategic Sealift Program arose out of a need for suitable-size ships capable of fast sealift logisitical missions. The Senate Armed Services Committee (SASC) tasked the Secretary of the Navy to prepare program plans for the development of this type of ship in May 1988. The program was first funded in November 1989, when the FY90 defense appropriation bill approved $600 million in Ship Construction Navy (SCN) funds for sealift. This was later reduced to $375 million due to Gramm-Rudman-Hollings action and a Milpers transfer. The FY90-91 defense appropriation bill also authorized the Secretary of Defense to establish a fast Sealift ship program. In November 1990, the FY91 defense appropriations bill funded $900 million of SCN funds for Sealift acquisition, bringing the total SCN funds appropriated to $1.275 billion.

February of 1991 marked the date when SECNAV directed development of operational requirements for large, medium-speed Ro/Ro ships and the beginning of phased acquisition process. Later that month the CNO forwarded a draft of the Tentative Operational Requirements (TOR) to NAVSEA and directed conduct of feasibility studies. Two months following that, in April of 1991, NAVSEA forwarded Rough Order-of-

Magnitude (ROM) feasibility studies. These covered a range of new construction and conversion alternatives.

The summer months of 1991 marked significant activity for the Sealift program. In June the Assistant Secretary of the Navy (ASN) directed NAVSEA to commence preparation of documents to support the acquisition process, including appropriate streamlining measures. In July a draft of the Mission Need Statement was issued, and the SECNAV approved the general concept of the program. On August 2, 1991 NAVSEA issued an RFP for initial designs to U.S. shipyards. Later in August the Milestone 0 was scheduled and suggested the use of this program as a major defense acquisition pilot program. The Milestone 0 review was held August 30, 1991.

August 27, 1991, three days before Milestone 0 review, 9 U.S. shipyards responded to the RFP for initial design. On September 11, 1991 concept design contracts were awarded to these 9 shipyards. These contracts were worth $250,000 each. The initial designs were received from the shipyards on December 11, 1991, three months after the concept design contracts were awarded.

Meanwhile, in November 1991, the FY92 authorization bill specified that vessels constructed under the program would incorporate propulsion systems, bridge and machinery control systems, and interior communications equipment that are manufactured in the United States. In January of 1992 the Defense Mobility Requirements Study was completed, and it called for approximately 20 large medium-speed Ro/Ro vessels for prepositioning and surge.

In June 1992, the Mission Need Statement for Strategic Sealift was approved. In addition, the Operational Requirements Document (ORD) key ship characteristics was validated by the Joint Requirements Oversight Council (JROC). The Program Office, PMS 385, was also established at this time.

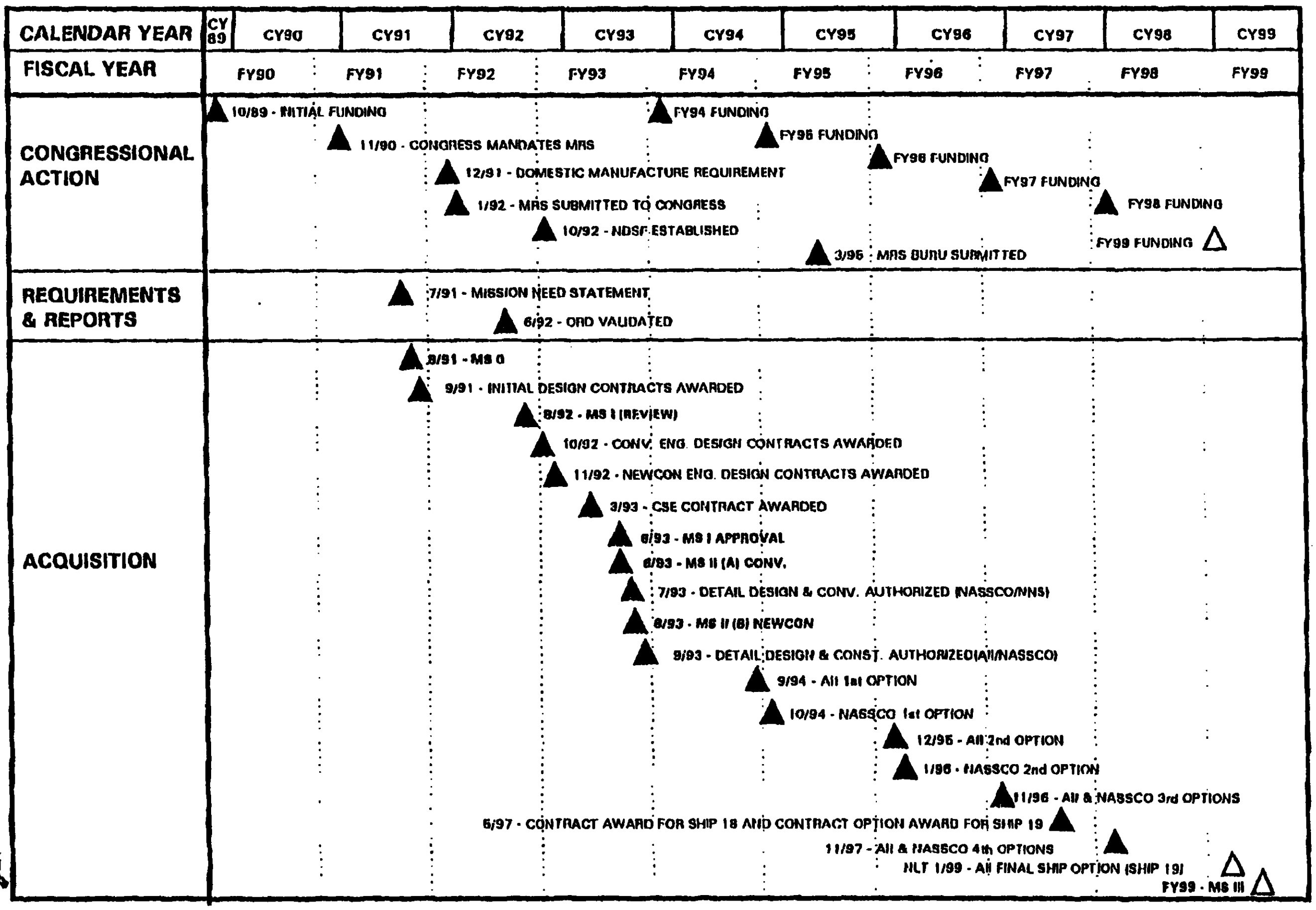
Milestone I occurred on August 17, 1992. Following this on October 30, 1992, the conversion engineering design contracts were awarded to 5 U.S. shipyards for $400,000 each. The new construction design contracts were awarded November 20, 1992 to 7 U.S. shipyards, for $1.2 million each.

The conversion program proceeded concurrently with the newbuilding program. The technical proposals were received for the conversion program on March 16, 1993. The pricing proposals for the conversions were received on March 30, 1993. This is when the discussions with the conversion offerors started. Detailed questions were sent to the shipbuilders regarding the detail design and conversion award at the end of April. The answers to these questions were due in late May. Milestone II meetings for the conversions occurred in June of 1993. On 30 July of 1993 National Steel and Shipbuilding Company (NASSCO) was authorized to convert three ships, and Newport News Shipbuilding (NNS) was authorized to convert two ships.

The new construction program followed the same pattern. Technical proposals were submitted on May 20, 1993, and the pricing proposals were due on June 21,1993. August 4, 1993 marked the Milestone II program decision meeting for the new construction. September 2, 1993, Avondale Industries, Inc. (AII) was authorized to construct one ship with options for five additional ships. On September 15, 1993 NASSCO was authorized to construct one ship also, with the options for five others.

The major events of the program are illustrated on the timeline in Figure 3.

INTEGRATED PROGRAM SCHEDULE



4.2 Unique Features of the Sealift Program

The Sealift Program had some very unique features to it. The function of the government in this program shifted from being one of design to one of essentially review and contractual functions. In addition, the design of this program occurred very quickly by government standards.

The most obvious difference between this program and most of the other Navy ship acquisition programs was the role of the shipyards. In most previous programs, the Navy did the feasibility studies, preliminary design and contract design in-house, with the support of design agents. The Sealift program involved the shipyards to do this work. Shortly after Milestone 0 the shipyards that responded to the RFP were contracted to perform the initial design studies. This means that industry comes up with the different designs that will satisfy the requirements that the government has set. The governments' role in design for this model is greatly reduced, with the bulk of the work being shifted to a design review function.

The other main difference between this program and other Navy ship acquisition programs is evident in the reduced cycle time for design. It was stated previously that a generic ship acquisition program usually takes between 3 and 18 months to complete feasibility studies. It can be seen that this program took approximately 12 months to complete this stage, from Milestone 0 to Milestone I. The preliminary design of a typical Navy ship acquisition program takes anywhere from 6 to 12 months. Contract Design generally consumes 9 to 15 months. So a typical program might take between 15 and 27 months to complete preliminary and contract design. These represent the events that take place between Milestone 1 and Milestone II. The Strategic Sealift program used 10 months to complete these activities for the conversion project, and 12 months for the newbuildings. Table 1 compares these time differences.

Table 1.[4]

Design Stage	Generic Ship	Strategic Sealift Program	
		Conversions	New Construction
Feasibility Studies	3-18 months	12 months	12 months
Preliminary and Contract Design	15-27 months	10 months	12 months
Total	18-45 months	22 months	24 months

4.3 Development Costs of the Sealift Program

The total design costs through Milestone II for the Strategic Sealift Program were $44.9 million. The total Sealift Program costs amount to approximately $5.9 billion. Obviously, the design is a small factor of those costs, approximately 0.8%. Figures 4 and 5 show the scope of these costs.

Figure 6 is an approximation of the timing of the design costs. Many of the funds that are appropriated can be spent in a multi-year period. It is difficult to tell which year these funds were actually spent, but Figure 6 is one estimate of the timing. You can see there is fairly significant funding in the first year, which then drops off some. The first year includes funding for the conceptual designs, feasibility studies, etc. After that stage,

[4] Improving the Ship Design, Acquisition, and Construction Process: Strategic Plan, Vol. 1, page 2-6 – 2-7

the spending drops off, and generally builds towards Milestone II. The engineering designs took place almost exclusively in FY 1993, which is reflected in Figure 6.

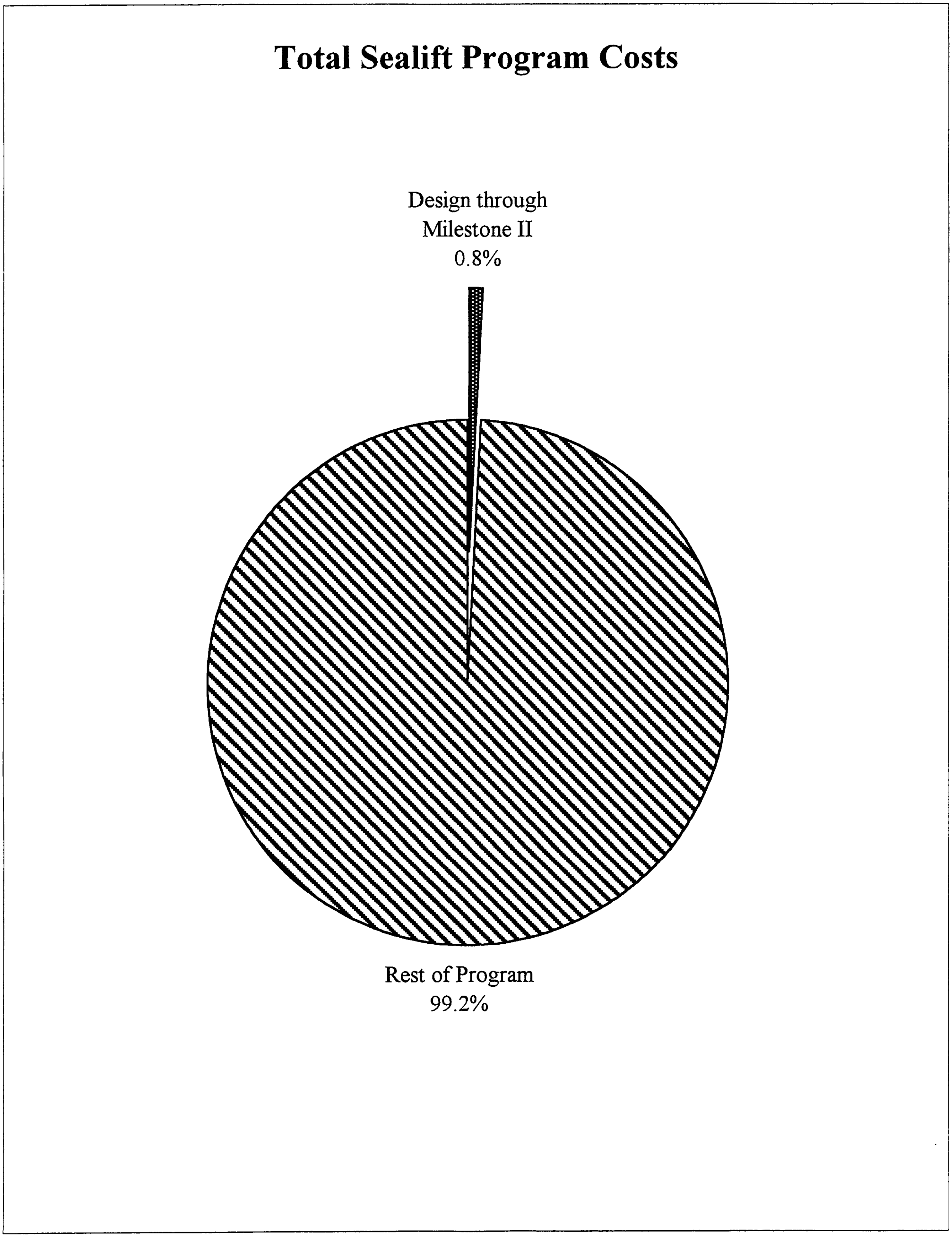
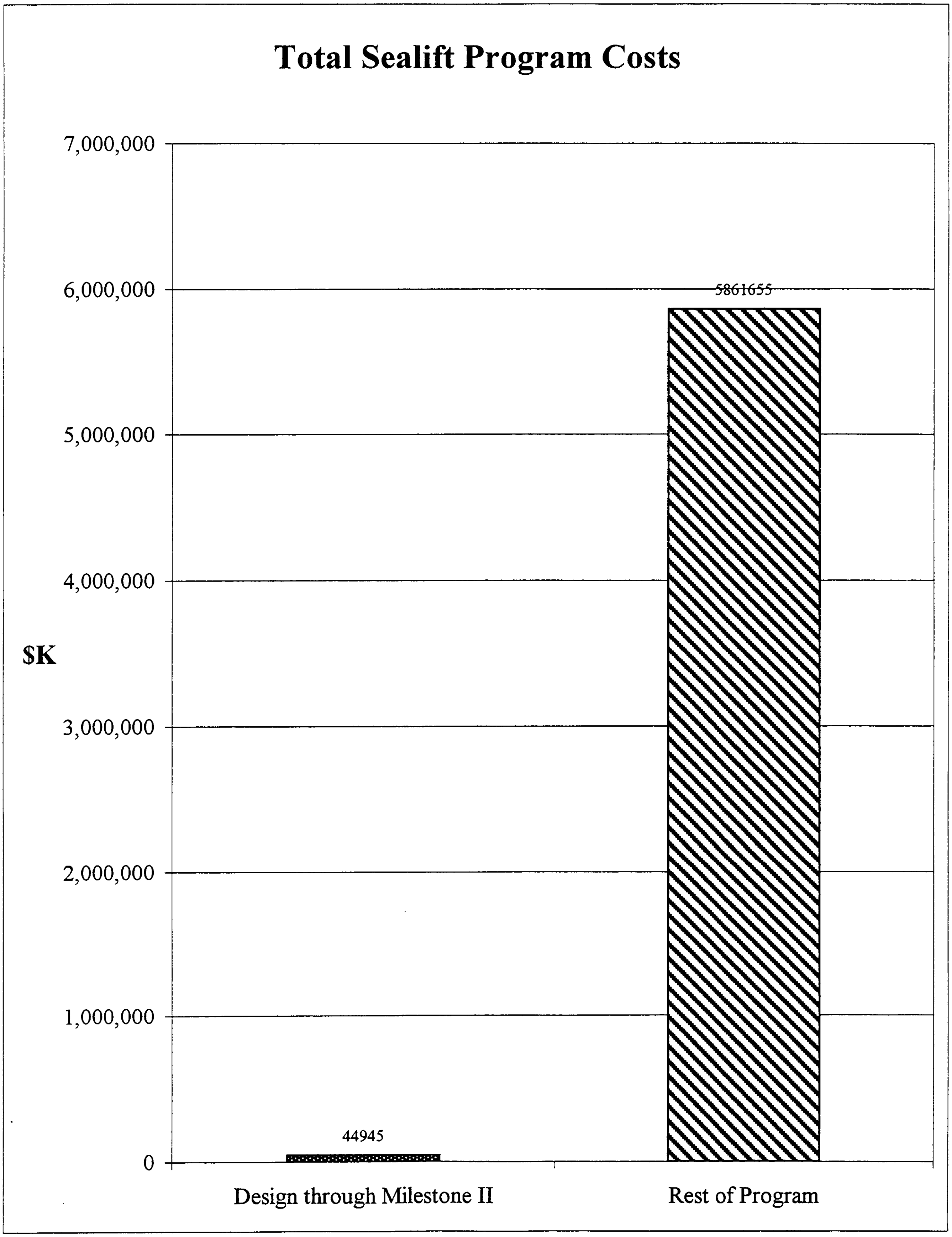

Total Sealift Program Costs
Design through
Milestone II
0.8%
Rest of Program
99.2%

Figure 4.



Total Sealift Program Costs
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
$K
5861655
44945
Design through Milestone II
Rest of Program

Figure 5.

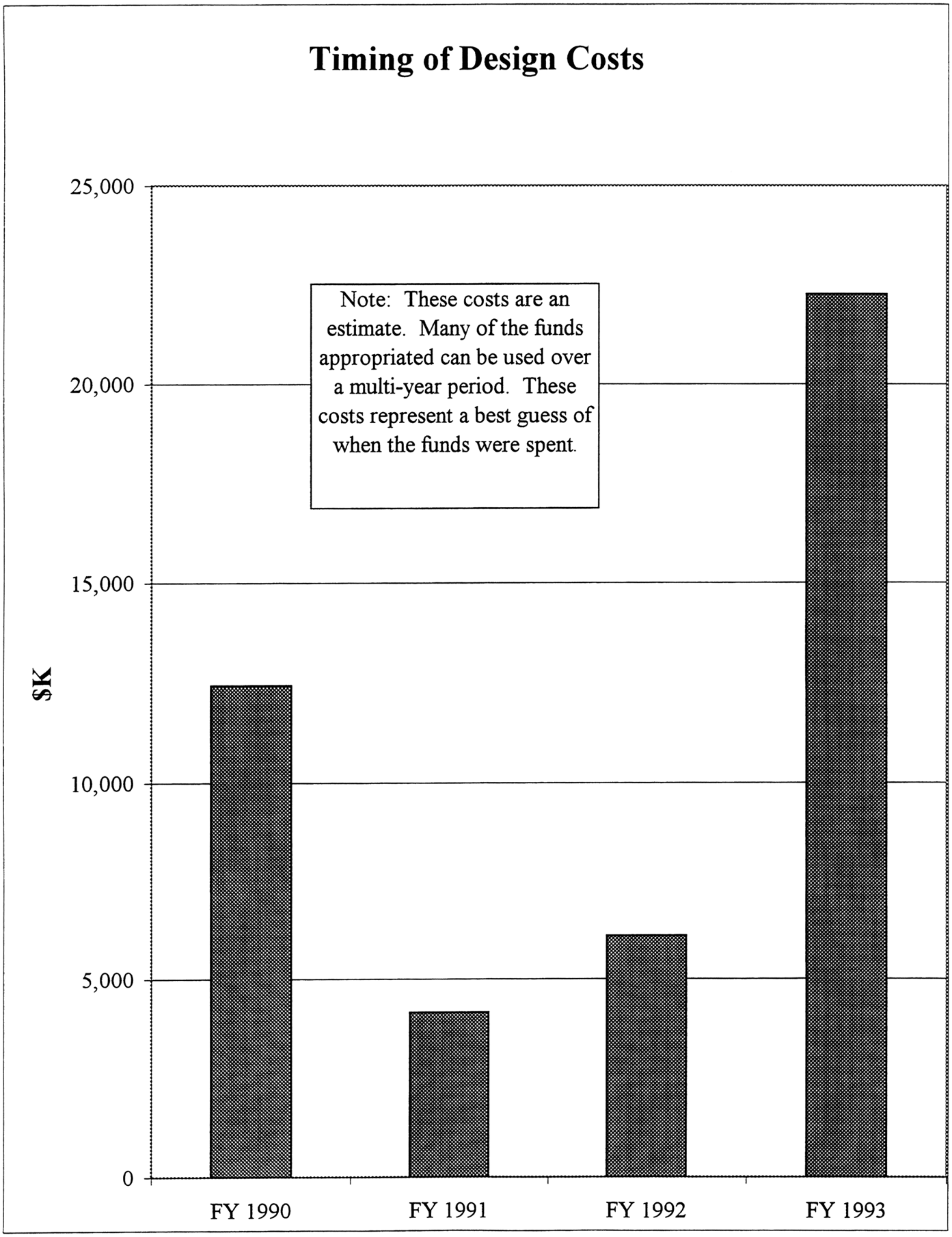

Timing of Design Costs
25,000
20,000
15,000
10,000
5,000
0
$K
Note: These costs are an estimate. Many of the funds appropriated can be used over a multi-year period. These costs represent a best guess of when the funds were spent.
FY 1990
FY 1991
FY 1992
FY 1993

Figure 6.

Of the design costs, Figure 7 shows that the government incurred 37% of the costs, while 63% were associated with private industry. The costs included in the government portion of that cost include the Program Office, the Design Office, and OGA. The industry segment included contractors that supported the program management and design effort, shipyards, and regulatory bodies.

It becomes apparent in Figure 7 that the majority of the design costs in the program were in industry. Figures 8 and 9 show the breakdown of costs for the various players in the Strategic Sealift design. These diagrams indicate the significance that industry had in the design of the Strategic Sealift program. The Program Office and the Design Office within the Navy made up only 11% of the total design costs, that were $44.9 million. The remainder cost of the design without these two players was $39.9 million. The majority of costs associated within the government came from OGA, which was constituted primarily of the cost of David Taylor Research Center (DTRC).

Figure 10 and 11 illustrates the cost of each of the steps of design. Obviously, the bulk of the design cost is associated with the contract design phase. Relatively little money is spent in the concept and feasibility design phase; only 6%. The preliminary design phase represents approximately 1/3 of the total design cost.

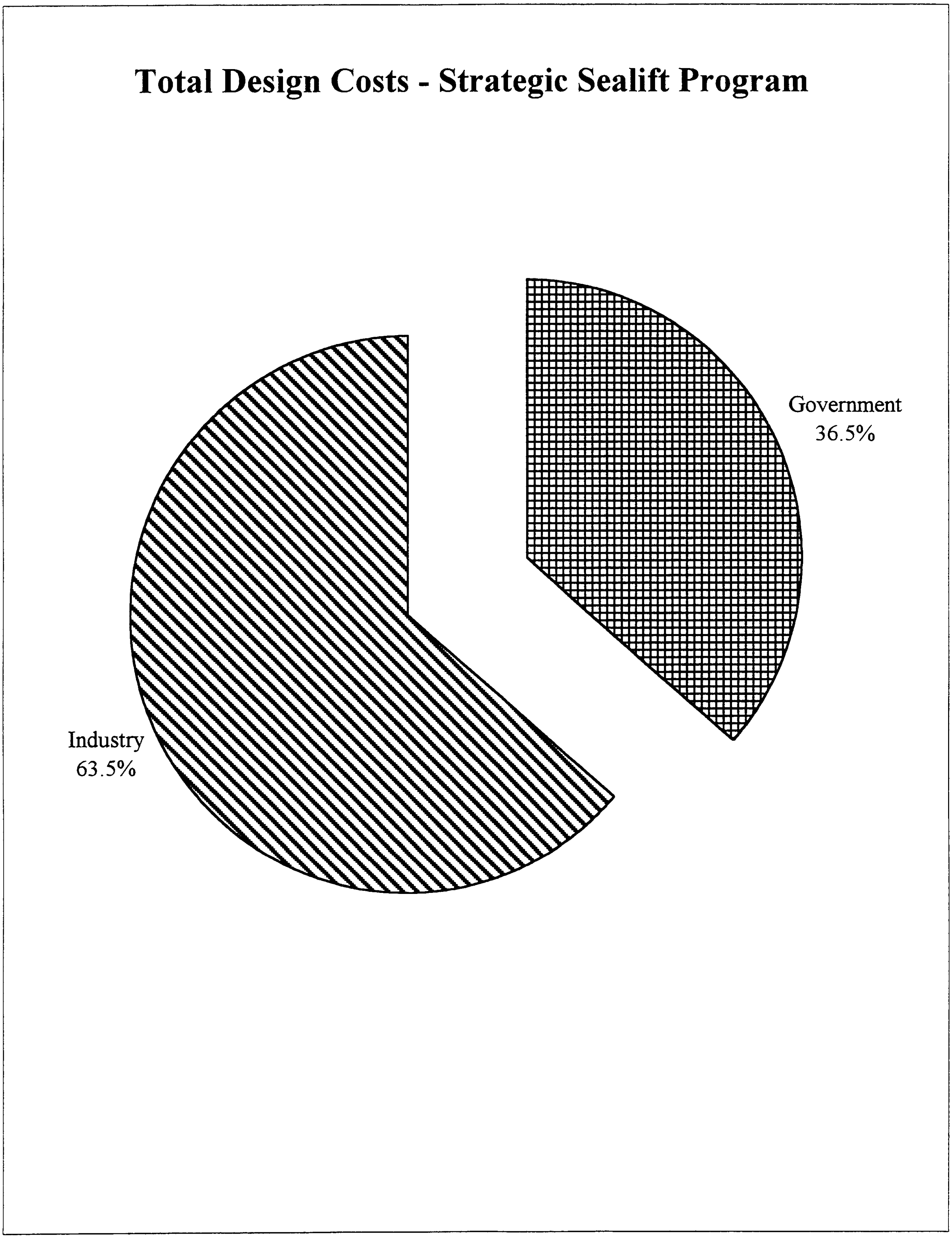
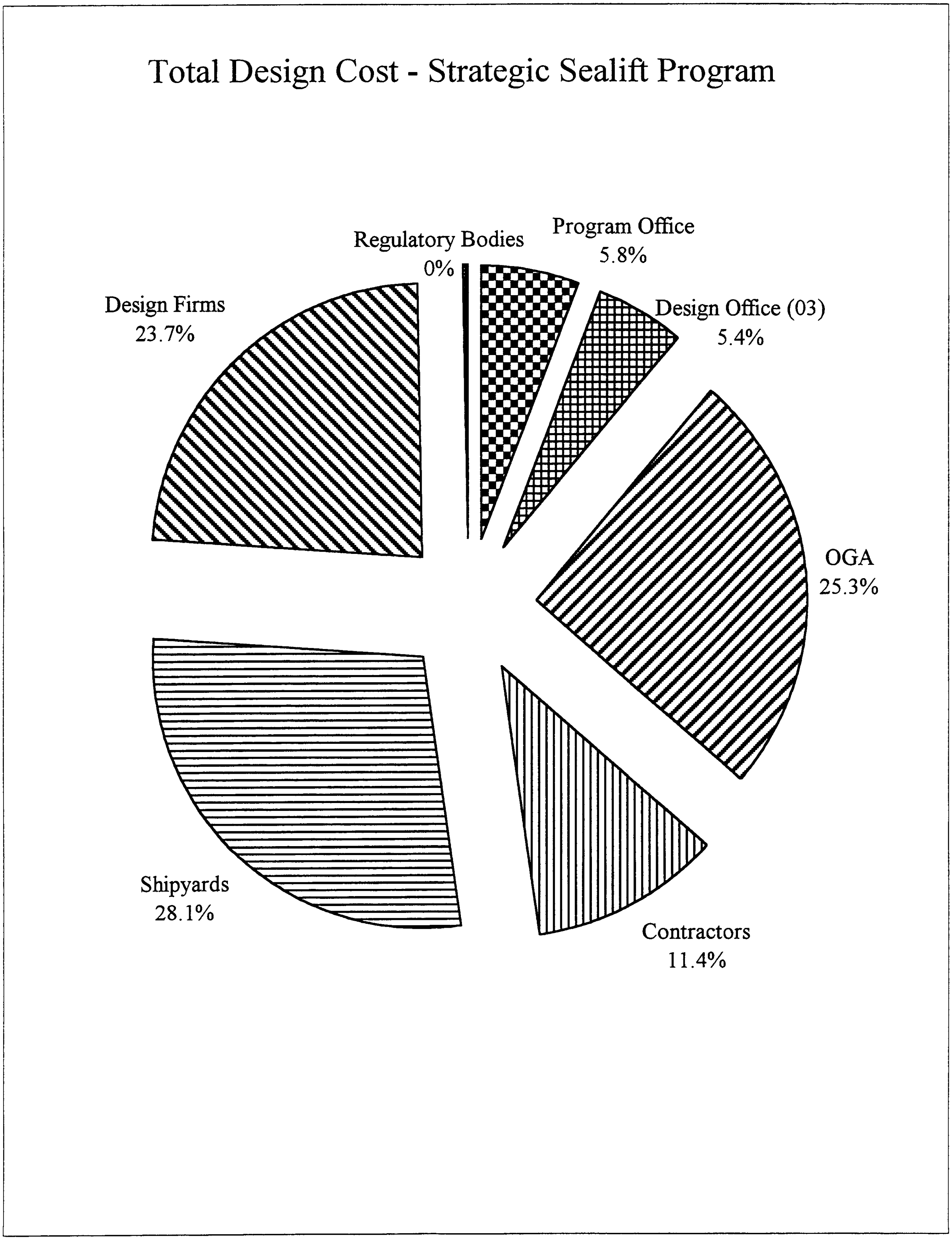

Total Design Costs - Strategic Sealift Program
Government
36.5%
Industry
63.5%

Figure 7.



Total Design Cost - Strategic Sealift Program
Regulatory Bodies
0%
Program Office
5.8%
Design Office (03)
5.4%
OGA
25.3%
Contractors
11.4%
Shipyards
28.1%
Design Firms
23.7%

Figure 8.

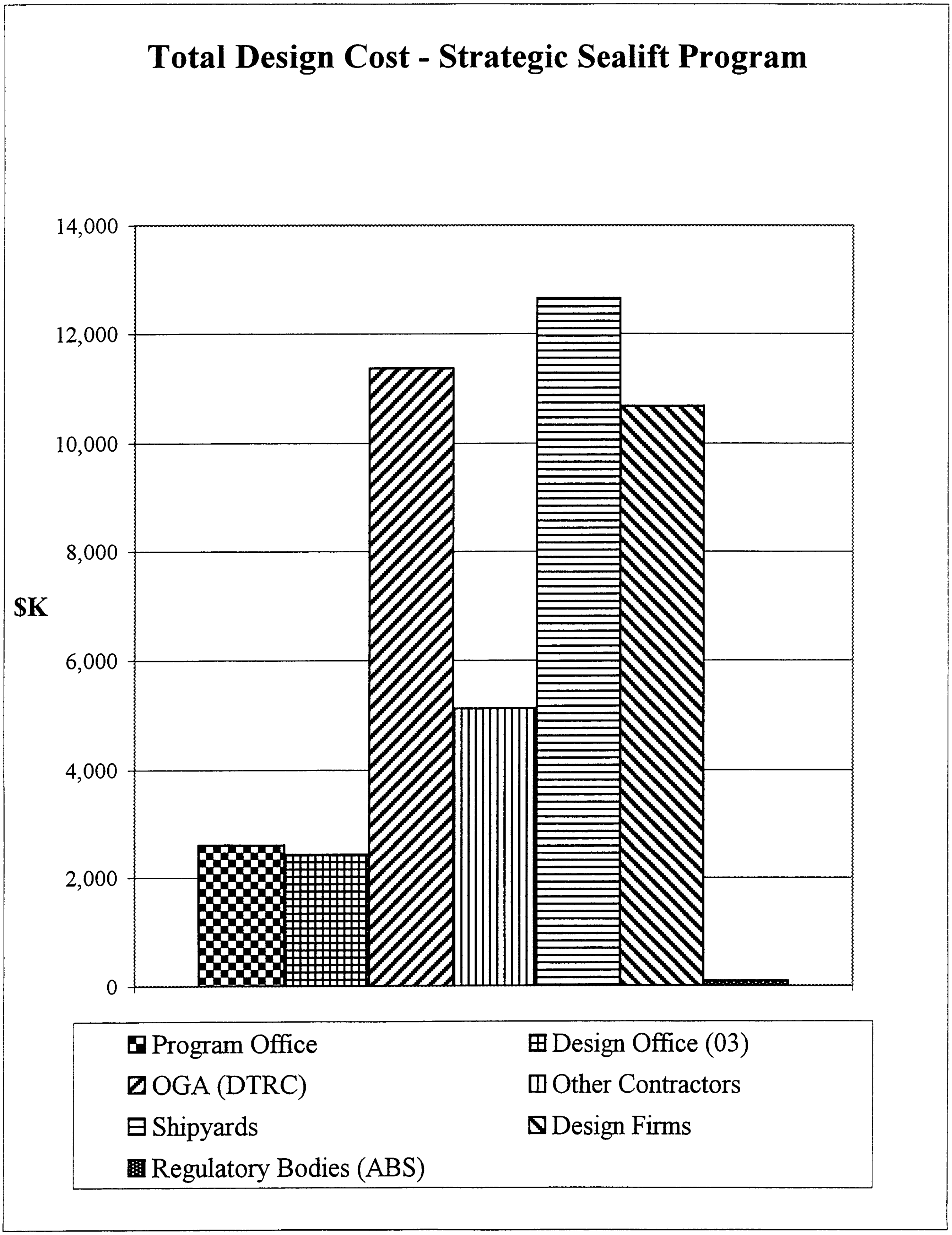

Total Design Cost - Strategic Sealift Program
14,000
12,000
10,000
8,000
$K
6,000
4,000
2,000
0
Program Office
Design Office (03)
OGA (DTRC)
Other Contractors
Shipyards
Design Firms
Regulatory Bodies (ABS)

Figure 9.

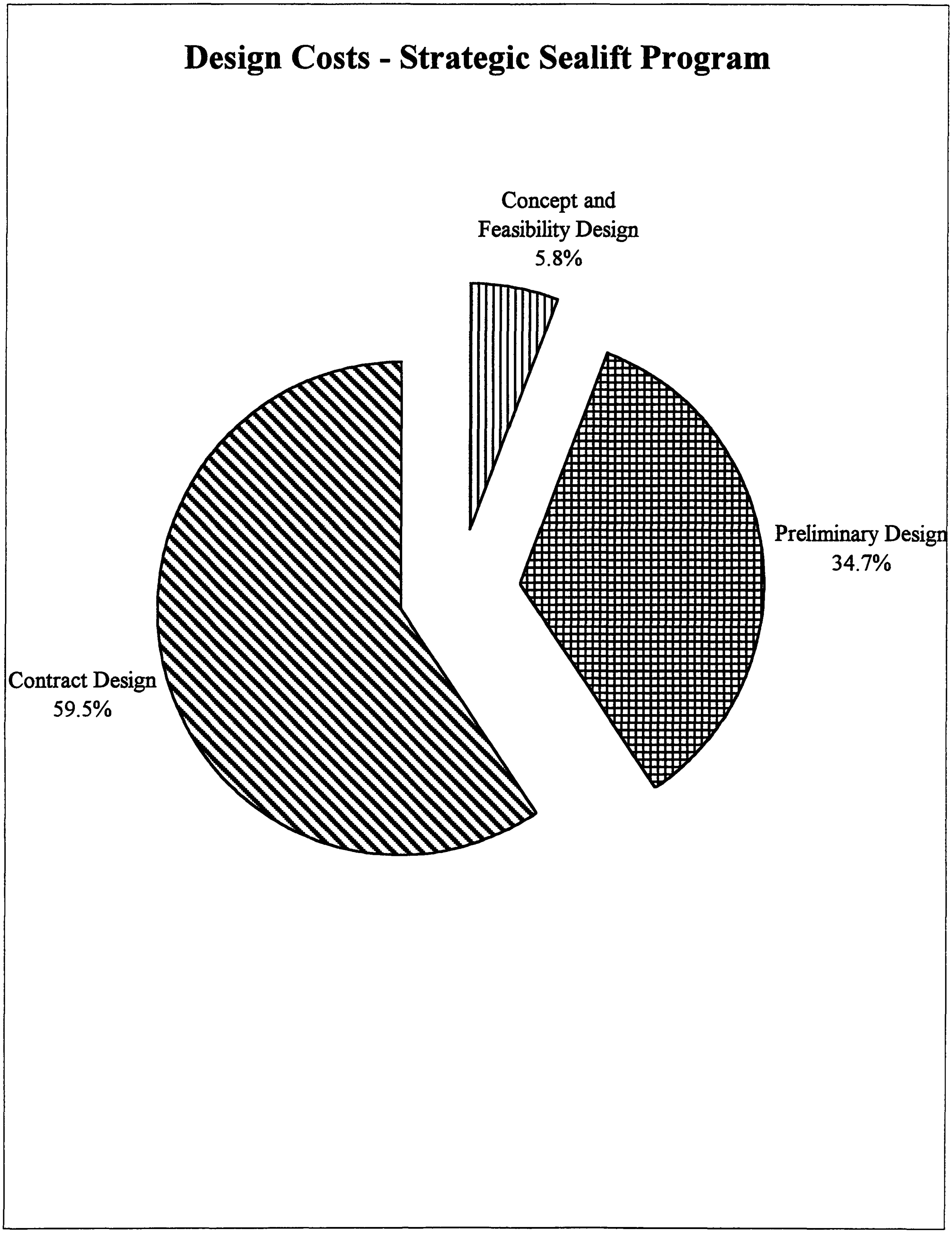

Design Costs - Strategic Sealift Program
Concept and
Feasibility Design
5.8%
Preliminary Design
34.7%
Contract Design
59.5%

Figure 10.

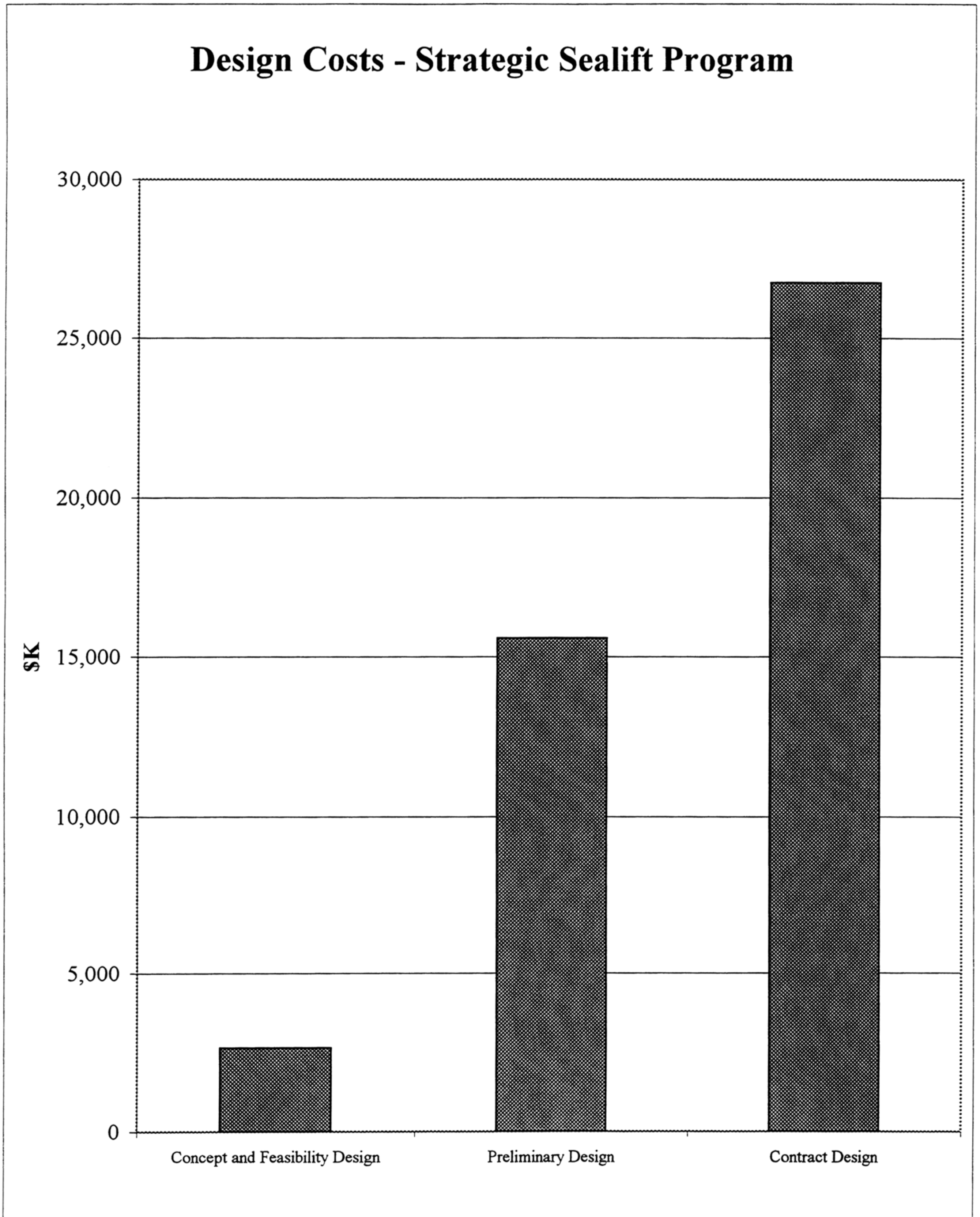

Design Costs - Strategic Sealift Program
$K
30,000
25,000
20,000
15,000
10,000
5,000
0
Concept and Feasibility Design
Preliminary Design
Contract Design

Figure 11.

4.3.1 Concept and Feasibility Design Costs

The concept and feasibility design phase of the program cost approximately $2.6 million. This is approximately 6% of the total design cost of $44.9 million. Figures 12 and 13 show the breakdown of costs within concept and feasibility design. The outside contractors spent the largest amounts of funds in this phase. Design firms constituted 44% of the costs of this design phase. The government costs were approximately 35% of the design. Obviously, the total costs of this design phase are relatively insignificant in comparison to the total design effort, and particularly with respect to the entire acquisition program.

4.3.2 Preliminary Design Costs

The preliminary design phase of the program cost approximately $15.6 million. This is approximately 35% of the total design cost. The cost allocation of this design phase is shown in Figures 14 and 15. The government had a larger role in this phase compared with the concept and feasibility stage; approximately 48% of the costs of this phase were associated with government organizations. The U.S. shipyards were not involved in the concept and feasibility studies but did become involved in preliminary design, with contracts worth $2.25 million, or approximately 14% of the costs of this phase. As in the concept and feasibility design stage, the design firms were allocated the largest piece of the pie, at 35%.

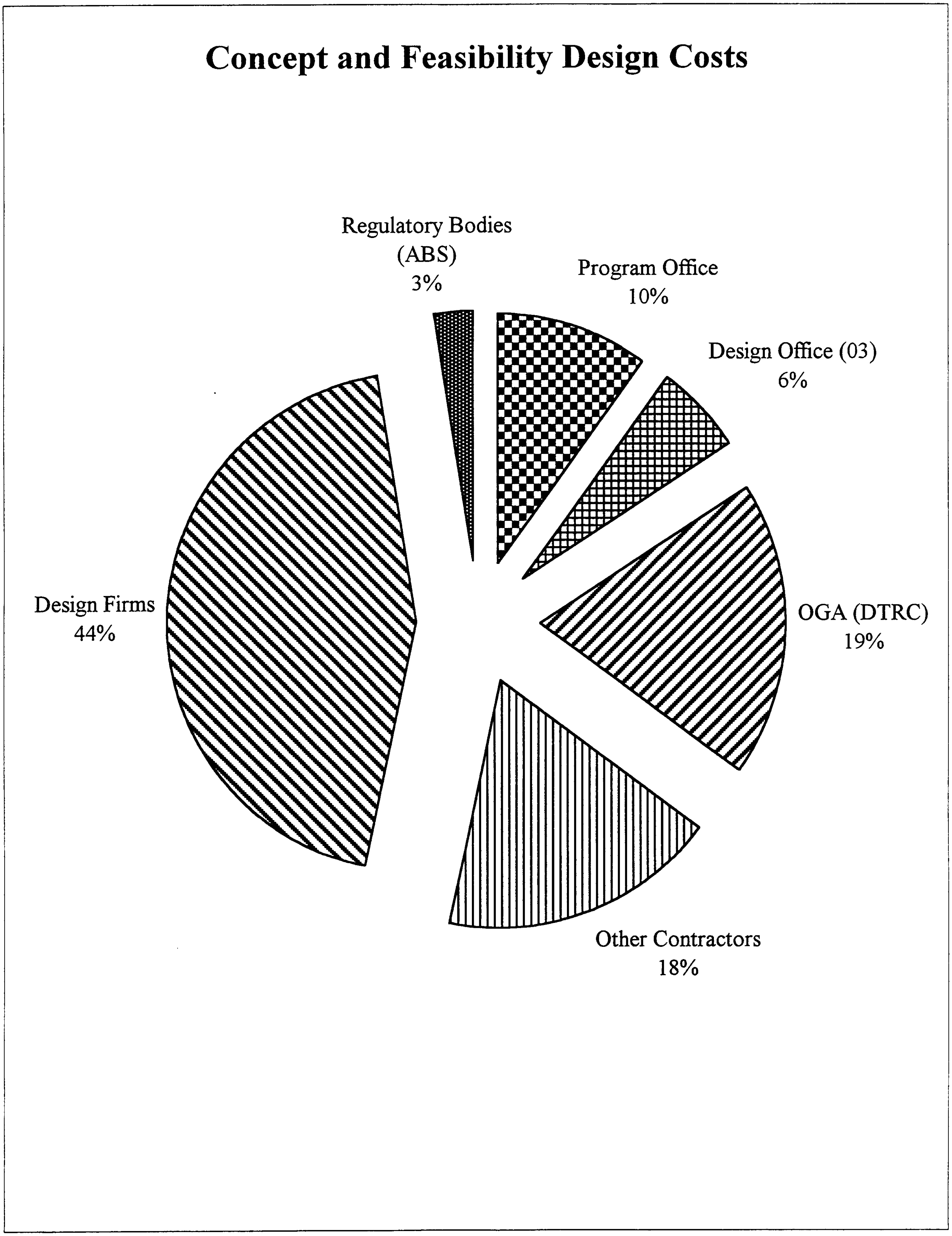

Concept and Feasibility Design Costs
Regulatory Bodies
(ABS)
3%
Program Office
10%
Design Office (03)
6%
OGA (DTRC)
19%
Other Contractors
18%
Design Firms
44%

Figure 12.

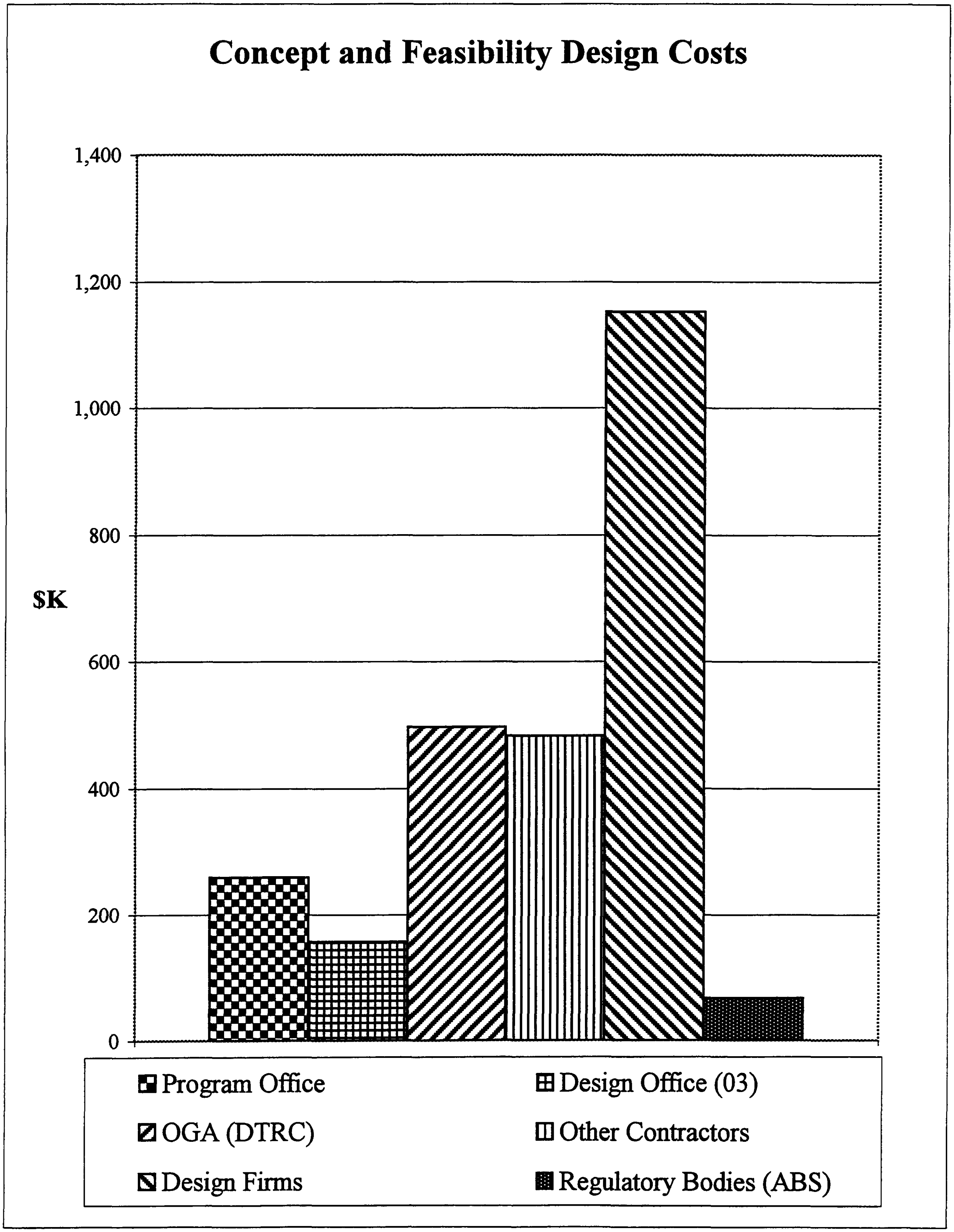

Concept and Feasibility Design Costs
1,400
1,200
1,000
800
$K
600
400
200
0
Program Office
Design Office (03)
OGA (DTRC)
Other Contractors
Design Firms
Regulatory Bodies (ABS)

Figure 13.

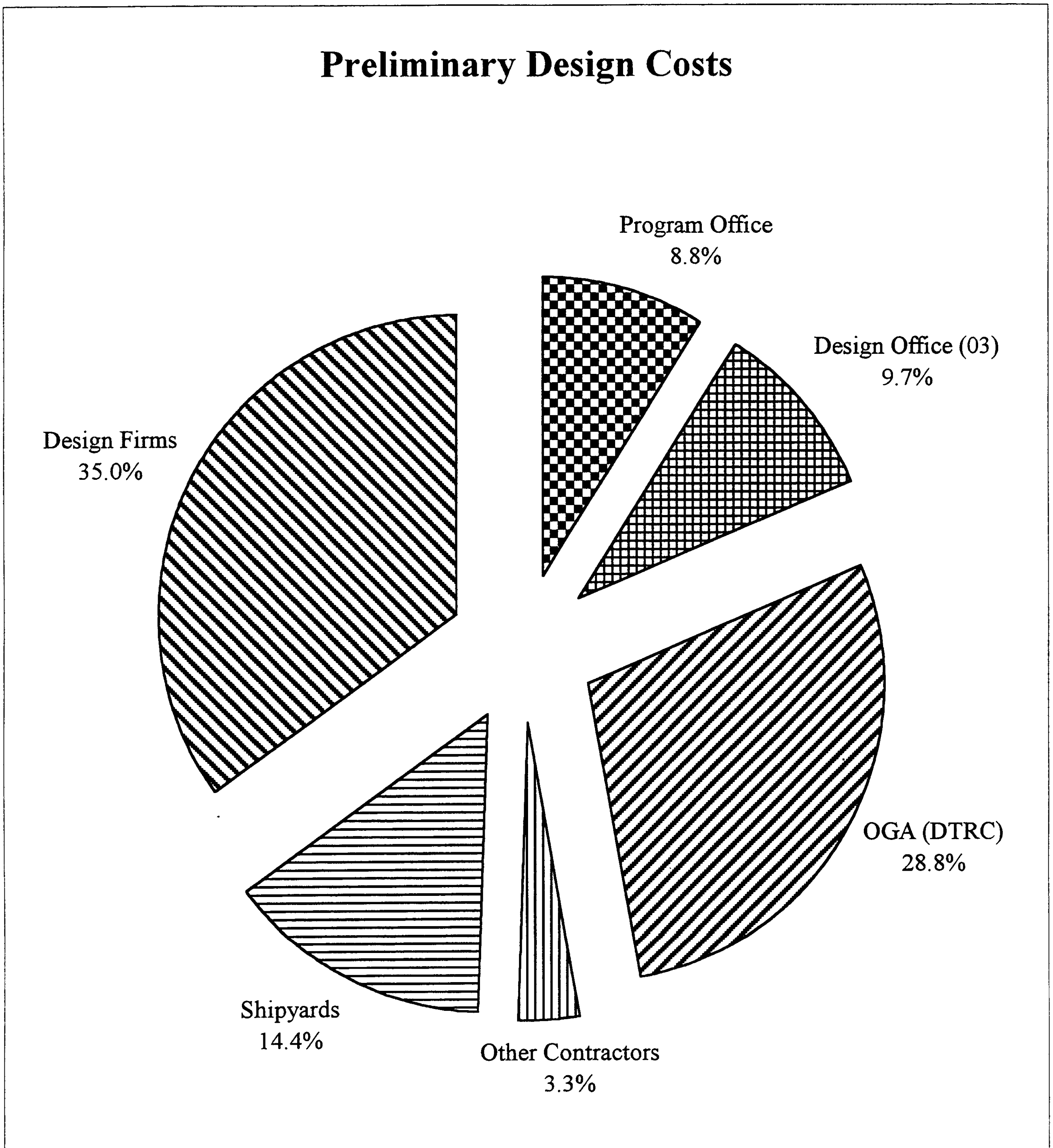

Preliminary Design Costs
Program Office
8.8%
Design Office (03)
9.7%
Design Firms
35.0%
OGA (DTRC)
28.8%
Shipyards
14.4%
Other Contractors
3.3%

Figure 14.

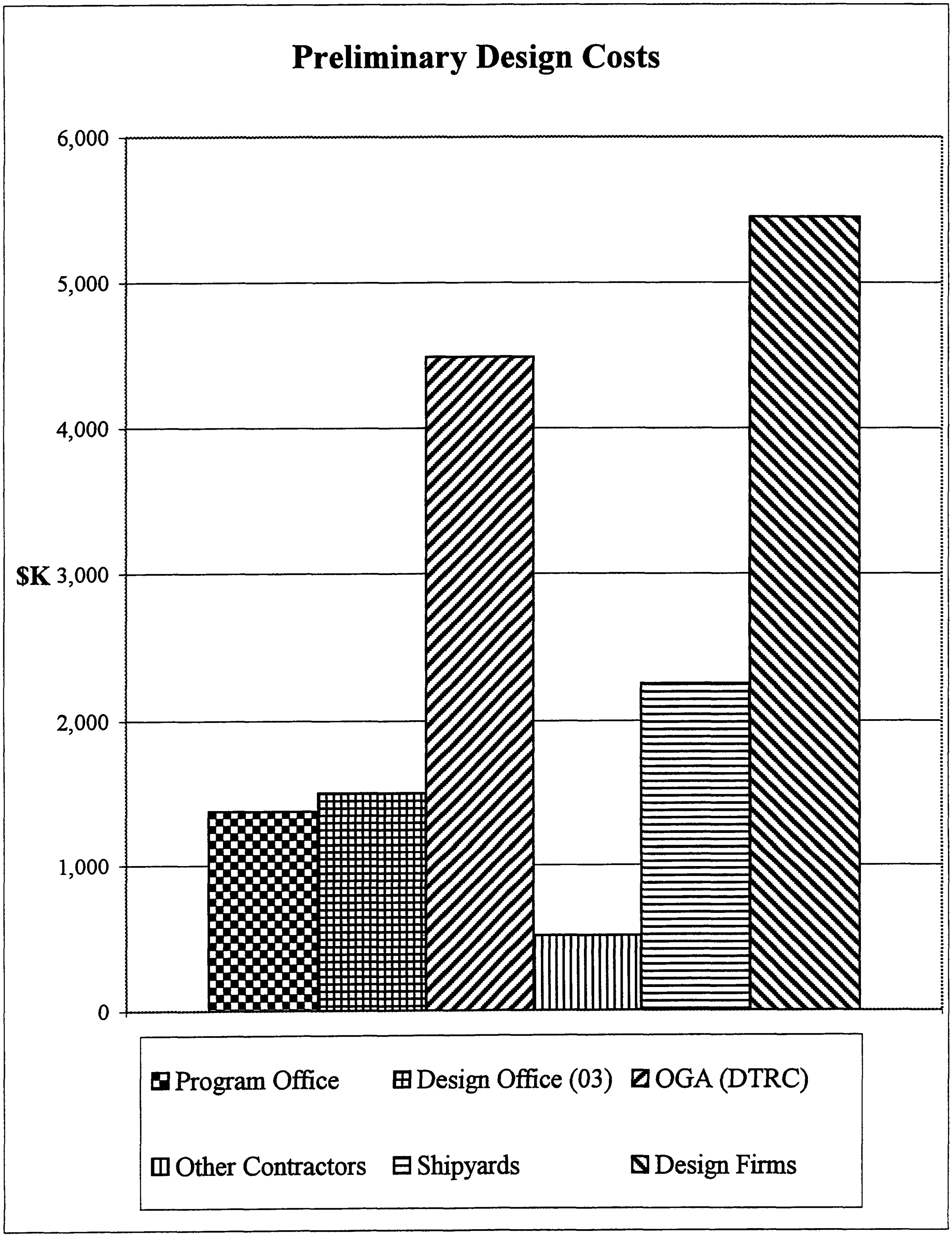

Preliminary Design Costs
6,000
5,000
4,000
$K 3,000
2,000
1,000
0
Program Office
Design Office (03)
OGA (DTRC)
Other Contractors
Shipyards
Design Firms

Figure 15.

4.3.3 Contract Design Costs

The contract design phase of the program cost over $26.7 million, or roughly 59% of the total design cost. Figures 16 and 17 show the breakdown of this design phase. The program office and design office had relatively small roles in this phase, at approximately 4% and 3%, respectively. OGA, however, consumed almost $6.4 million, or 24% of this phase. Shipyards did the largest proportion of work, with over $10 million dollars and 39% of the costs associated with this phase. The role of the design firms was diminished, at 15% of the costs, or approximately $4.1 million.

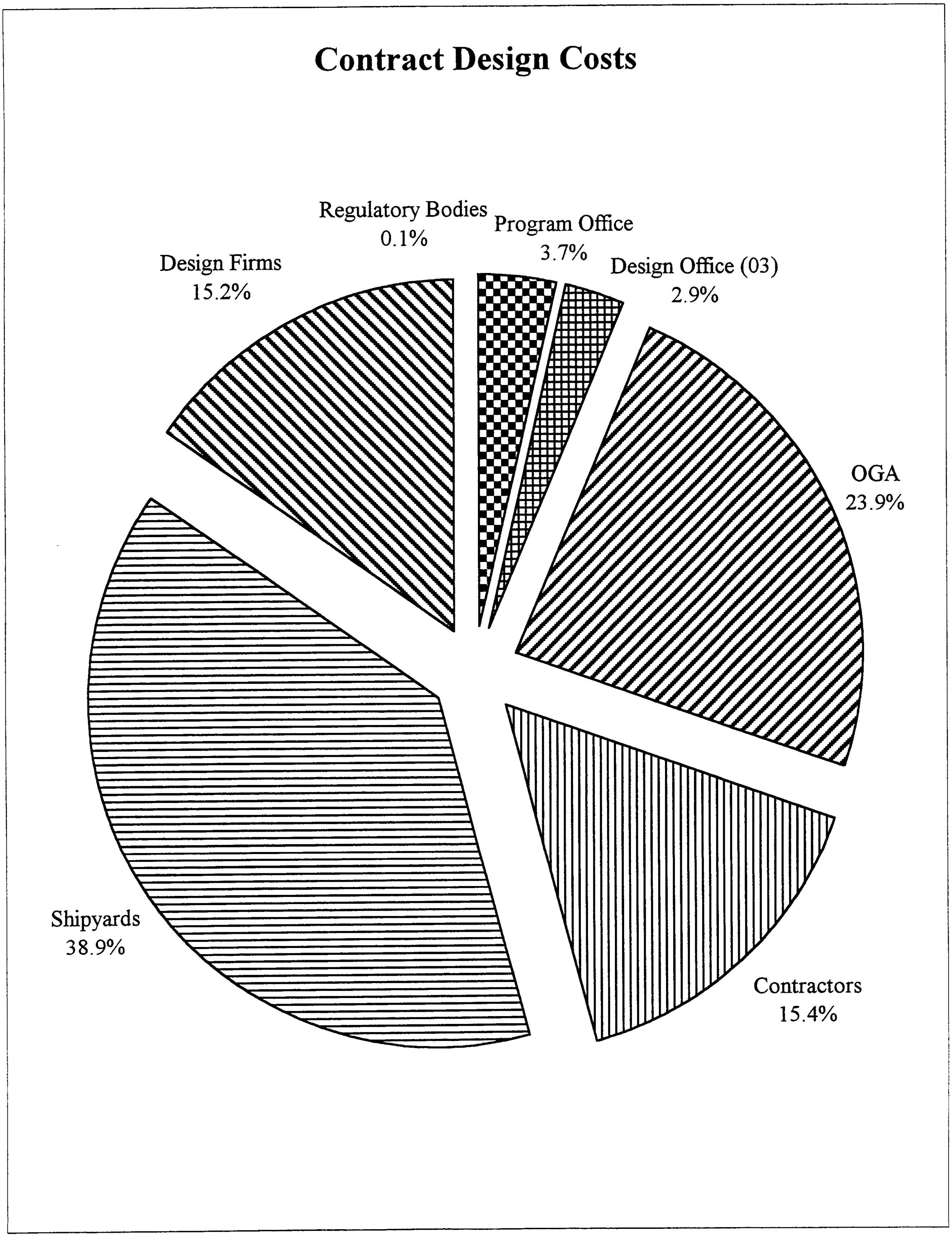

Contract Design Costs
Regulatory Bodies
0.1%
Program Office
3.7%
Design Office (03)
2.9%
Design Firms
15.2%
OGA
23.9%
Shipyards
38.9%
Contractors
15.4%

Figure 16.

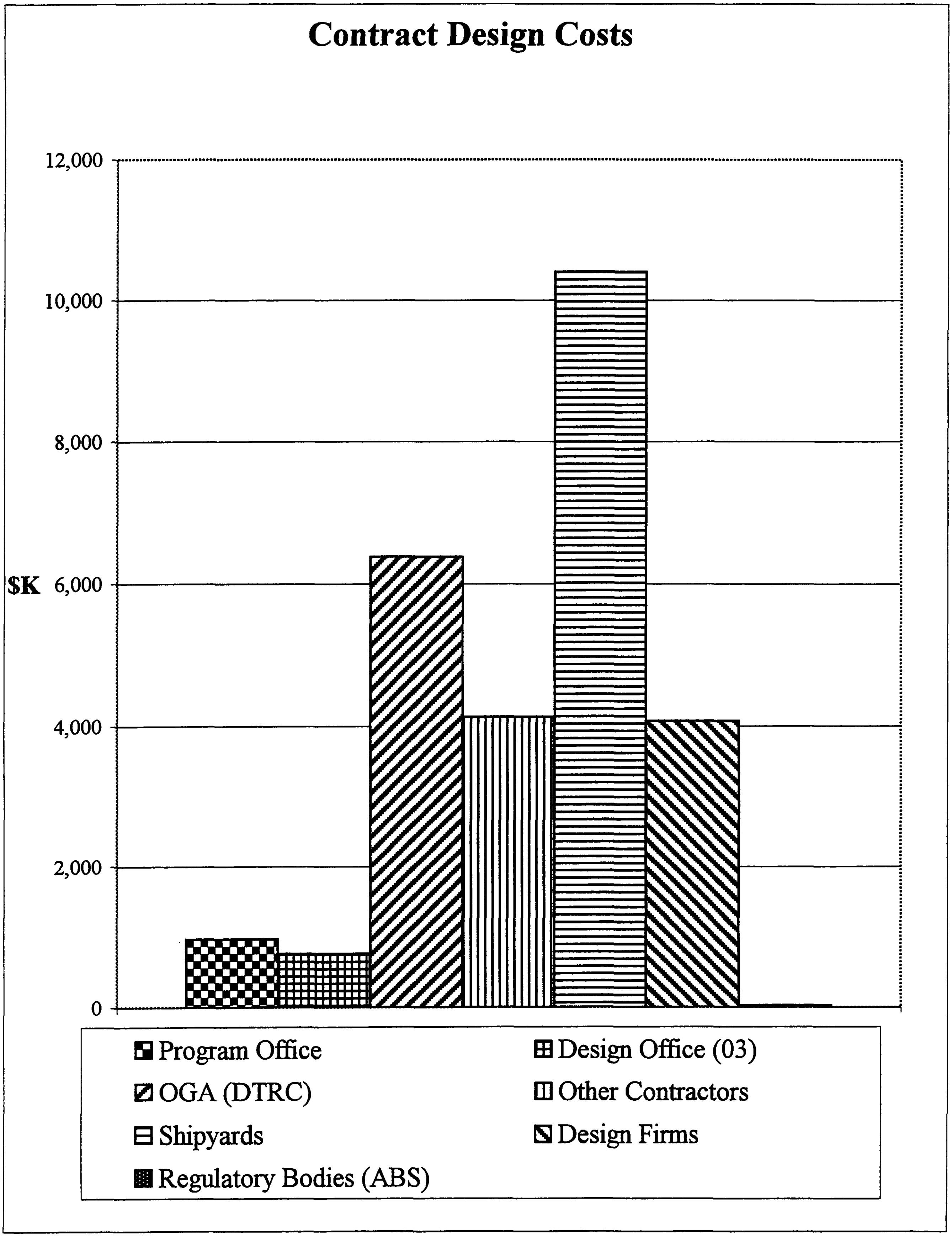

Contract Design Costs
12,000
10,000
8,000
$K
6,000
4,000
2,000
0
Program Office
Design Office (03)
OGA (DTRC)
Other Contractors
Shipyards
Design Firms
Regulatory Bodies (ABS)

Figure 17.

5 Role of Government Review[5]

5.1 Function of Government Review

The main objectives of the government in the design reviews of the Strategic Sealift program are the following:

- To assure that all the technical requirements are understood by the shipyards (and the government).
- To assist the shipyards in developing their technically acceptable design
- To facilitate dialogue with the shipyards as much as possible.
- To authorize detail design and construction (DD&C) options as quickly as possible

To ensure that the objectives were met, the Government Design Team adopted the following philosophy:

- To be flexible
- The goal is to have all designs technically acceptable and meeting the COR by the end of Engineering Design.
- To support and facilitate the shipyard design effort
- Communication with the each shipyard is to be free and open. Shipyard communications are proprietary between the shipyard and the government. COR changes are general and will not depict specific shipyard generated design solutions.
- To be open and agreeable to new, different or better ideas.

[5] Much of the content and wording of this section was taken from an unpublished paper on "Strategic Sealift Ship Engineering Design, Design Review Process and Quality Assurance Program," by Ron Nix

- No technical leveling will occur. The government will not give preferences, solutions, or ways to improve the design. If the design meets the COR, it is acceptable. If it does not meet the COR, the government will advise the shipyard of its concern.

5.2 Government Review in the Strategic Sealift Program

The Strategic Sealift program used the shipyards to develop the designs starting with the concept designs. This meant that the government's main role in the development of this design was its review function. Concept designs for the Sealift program were also referred to as initial designs.

The Navy gave 9 U.S. shipyards contracts for development of concept designs. Each shipyard had two face-to-face design reviews with the government.

The conversion engineering design contracts were awarded to 5 U.S. shipyards. These designs were reviewed face-to-face twice during the design process, in addition to one final government-only submittal review, for a total of three reviews. These were schedule driven reviews, approximately 6 weeks apart. The schedule for the reviews was identified in the Contract Data Requirements List (CDRL). The Navy received the deliverables 10 workdays before the formal review. Before the final review, the Navy Design team would do the following activities:

- Sort through the designs
- Attach the necessary forms
- Distribute the designs to the appropriate personnel

- Actually perform the review
- Format a package
- Make the necessary copies

Each formal review took approximately one day.

The new building design contracts were awarded to 7 U.S. shipyards. These designs followed essentially the same process, except they were reviewed face-to-face one additional time, for a total of four design reviews. As stated before, these reviews were for engineering compliance with the requirements, and were not ranked. The final submittal was then subject to the source selection process. This is where the designs were ranked for down selection.

The total number of design reviews for this program before Milestone II was 61. This includes 18 reviews in the concept design stage, 15 for the conversion designs, and 28 for the new construction designs. The government never stopped reviewing once the process started. The Navy Design office and design agents had a core of approximately 40 people associated with this task, and a peak of about 70 people.

The reviews were similar for both the initial and engineering designs; however, there were some changes. The reviews for both design stages included the following characteristics:

- They were formal reviews (required by contract)
- They were schedule driven reviews
- They were primarily technical reviews
- Design deliverables were required 10 work-days before the design review
- The reviews addressed the status of the design process

- The reviews were not linked to a formal acquisition milestone

The design reviews in the initial design phase gave the government invaluable experience with the review process. Some changes were made to the review process from this experience, and also because of the projected workload of 43 reviews in the engineering design phase. Some of these changes are reflected in Table 2.

Table 2. Design Review Changes

Design Review Aspect	Initial Design	Engineering Design
Business Sensitivity	Each design review was confidential between the government and shipyard.	Same, except for the Program Office Q&A's
Formality	Tended toward formal presentations by the shipyards	Tended towards less formal presentations.
Length	4 Hours	Entire day, or until shipyard felt satisfied
Depth of Review	Relatively top level	Relatively detailed
Review Feedback	Oral Only	Oral and written design review comments, in addition to Q&A's
End Product Use	Study phase, used as input to Engineering Design requirements and concept development	Design competition where a selected number of contracts would be authorized for conversion/construction

Three formal communication vehicles were used during the design reviews. They were Design Reviews, Q&A's, and specification reviews. To facilitate the three communication vehicles, the Government Design Team established five key product lines:

- Design Reviews
- Design Review Notebooks
- Specification Review Notebooks
- Q&A's
- COR Modifications

Each of these product lines is discussed in the following sections.

5.2.1 Design Reviews

The contract design review schedule was every four to six weeks. The exact dates were defined between the shipyards and the government as the project proceeded. The reviews on the New Construction and Conversion Engineering Design Contracts were scheduled to be 180 degrees out of phase with each other. Within each series of contracts (new construction or conversion) all the design reviews were back-to-back.

The general content of the reviews was established in the contract statement of work (SOW). Each shipyard chose their own style of presentation and the material that they wanted to address. The shipyards developed their own schedule for the reviews, and submitted it to the government. In some cases, the government would add items to the agenda.

The government personnel attending the reviews were essentially the same at each review to maintain consistency. The core consisted of nine people from both the

Program Office and the Design Office. Other guests were invited, including Army and Navy Sponsor representatives. The government did not have any support contractors at the design reviews. They did attend detailed session meetings when required to supplement the core government review team. The shipyards sent varying amounts of personnel depending on preference and the amount of work contracted out to design agents.

After the first design review where the government review team was working out of design review notebooks, the shipyard made it clear that they wanted copies of these notebooks. The government was under no contractual obligation to provide them with comments, but the Program Office decided to provide the review sheets out of the design review notebooks. The benefit was the following:

- It documented the design review in detail. Any government concerns were identified.
- It provided the shipyards documented feedback that they could share with their team.
- It provided the government with a documented performance measure from review to review. Repeat comments indicated a need to resolve design issues.

The main risk associated with providing the review sheets was allowing any inappropriate comments to slip through to the shipyard. An example would be comments that are directing change, or comments that may be inaccurate, out of scope, etc. This was a problem because the review sheets were turned over to the shipyard at the conclusion of the design review. Due to the fast-paced nature of this project, there was not time to carefully censor every sheet, with the review sheets still retaining their meaningfulness. The review sheets were the only part of the Design Review Notebooks that were given to the shipyards.

5.2.2 Design Review Notebooks

The design review notebook was a three-ring notebook divided into the following sections:

- Executive Summary
- Q&A's
- Data Delivery Status
- Regulatory Body Correspondence
- Shipyard Agenda
- Review Sheets
- Recommended changes to the COR

5.2.2.1 Executive Summary

The executive summary condensed the status of the design to a document that could be read and understood in minutes. It also summarized the governments concerns that were addressed further in the Design Review. The executive summary was the one integrated assessment of the review which did not occur elsewhere. The executive summary was divided into three parts; the synopsis, the standard presentation, and a Military Traffic Management Command – Transportation Engineering Agency (MTMC-

TEA) Computer Aided Deployment Embarkation System (CODES) cargo loadout summary.

The synopsis was approximately three pages, and consisted of an administrative header, a textual synopsis of the design, and questions for the shipyard. The synopsis was an assessment of the ship design against key system level requirements. This was organized by systems, not CDRL numbers. The synopsis was an excellent integration tool for the Government Design Team. Inconsistencies in the design and review sheets could be uncovered when preparing the synopsis. The questions for the shipyard were questions that were not obvious from the synopsis or the review sheets that needed to be emphasized. Oftentimes, no questions were listed. The synopsis was not provided outside the Government Design or Management Teams.

The standard presentation was an effort by the government to present the designs in a uniform and consistent manner. During the engineering design phase, the government had to keep track of 13 shipyard Sealift designs (one shipyard carried a sister ship as a separate design), all of which were being developed simultaneously. The shipyards each developed their own style of presentation, so the standard presentation provided homogeneity and consistency. This also helped to integrate the designs, and was effective to present to Government personnel not involved with the daily review process.

The CODES loadout primarily provided an independent viewpoint on the ships ability to carry the design cargo loads.

5.2.2.2 Q&A's

This section consisted of printouts of the Q&A's from both the Shipyard Q&A's and the PMS Q&A's. This was done for referral purposes during the design review, as well as to catch any discrepancies between the status of government and shipyard Q&A's.

5.2.2.3 Data Delivery Status

This was a printout of the CDRL Management Center (CMC) database. The CMC is a PMS 385 contractor where all headquarters data is sent. The CMC then distributes the appropriate documents to headquarters reviewers. The printout of the database was a way to access the status of a document during the Design Review.

5.2.2.4 Regulatory Body Correspondence

The Sealift ships are military ships designed to meet military requirements using commercial specifications and standards. As a result, ABS, USCG, and the Safety of Life at Sea (SOLAS) regulations were used extensively. These organizations, ABS and USCG, perform interpretation and application of these regulations. Any correspondence with these groups such as clarifications and approvals were included in this section.

5.2.2.5 Shipyard Agenda

This was simply a copy of what the shipyard intended to cover during the review. It was useful to have this information to prepare for the review.

5.2.2.6 Review Sheets

This section was the core of the Design Review. The review sheets are also known as checklists. The review sheets were prepared before the Engineering Design Phase, and incorporated different elements from various Navy acquisition programs.

Each drawing and calculation CDRL item required under the contract had a review sheet. Each review sheet had four parts; an Administrative Header, an Interface Check, Questions to Consider, and Comments. The Administrative Header contained the CDRL number and title, the submission number, date, shipyard name, and conversion or new construction information. The Interface check listed other CDRLs that interfaced with the particular CDRL under review. Three possible answers were provided for on the form; yes, no, or not applicable. If an interface was marked no, it was required to have a comment later on the review sheet.

The questions to consider part was formatted similarly to the interface check. The questions to consider were based on the COR, CDRL requirements, regulatory requirements, and the SOW. The comments were divided into three categories, basically according to severity. The most severe included undeniable failures of the shipyard to meet contract requirements, etc. The least severe could include the reviewers opinion, or mention of something that the reviewer considered as a marginal solution, but is within the contract.

5.2.2.7 Recommended Changes to the COR

This portion of the notebook summarized the recommended changes to the COR by the shipyards. It included a section for each recommendation for adjudication and justification.

Exhibit 1 is an example of a design review sheet. This review sheet is for CDRL number A005, which corresponds to Model Test Documentation.

Current Date: 6/15/95

CDRL No.: A005 **TITLE:** Model Test Documentation

SHIPYARD:____________________________ **NEW CONSTRUCTION**

Category:

1. COR deficiencies (include a reference to applicable COR Section):

2. Technical problems and/or unfulfilled CDRL requirements:

3. Other items (include general discussion):

This review sheet addresses the content of the model test report. The ability of the ship to meet spend requirements is addressed in CDRL A014.

Current Date: 6/15/95

CDRL No.: A005 **TITLE:** Model Test Documentation

SHIPYARD:___________________________ **NEW CONSTRUCTION**

Questions to consider:

	Yes	No	NA	Cat
10. Referring to 10.2.7, are predictions in accordance with the specified expansion methodology (using ITTC 78, C_A per DDS051, etc.) presented in the report for at least bare hull resistance, appended hull resistance, self-propulsion with stock propellers, and self-propulsion with design propellers, all for the ship in the Full Load Departure Condition?	____	____	____	____

Current Date: 6/15/95

CDRL No.: A005 **TITLE:** Model Test Documentation

SHIPYARD:____________________ **NEW CONSTRUCTION**

Questions to consider:

	Yes	No	NA	Cat
(n) Cavitation performance of design propeller simulating ship at speed corresponding to 100 percent MCR, in Full Load Condition.				
(o) Cavitation experiment of Design propeller simulating ship at one speed with no cavitation, in Full Load Condition.				
8. Referring to 10.2.6, 10.2.7, and 10.2.8 of CDRL A002, are the following items included in the test report(s)?				
(a) Wake harmonic analysis results?				
(b) Cavitation characteristics (photographs, sketches, verbal description) of design propeller, simulating ship at 24 knots, in Full Load condition?				
(c) Cavitation characteristics (photographs, sketches, verbal description) of Design propeller, simulating ship at 24 knots, in Ballast condition.				
(d) Cavitation characteristics (photographs, sketches, verbal description) of Design propeller, simulating ship at speed corresponding to 100 percent MCR, in Full Load condition.				
(e) Cavitation characteristics (photographs, sketches, verbal description) of Design propeller, simulating ship at speed corresponding to 100 percent MCR, in Ballast condition.				
9. Does the test report include descriptions of the models, test procedures and techniques, and test set-ups?				

Current Date: 6/15/95

CDRL No.: A005 **TITLE:** Model Test Documentation

SHIPYARD:______________________ **NEW CONSTRUCTION**

Questions to consider:

	Yes	No	NA	Cat
(o) Bilge keel location/extent shown on body plan?	___	___	___	___
(p) Definition of strut alignment angles, estimated from tests?	___	___	___	___
(q) Photographs of propeller cavitation model and test set up?	___	___	___	___
4. Is propeller direction of rotation noted for all self-propulsion tests?	___	___	___	___
5. Are test data extrapolation methods described?	___	___	___	___
6. Is tank water temperature recorded for each test?	___	___	___	___
7. Referring to 10.2.6, 10.2.7 and 10.2.8 of CDRL A002, are the required data (tabulated and plotted), applicable to the full-scale ship, presented in the report(s) for the following tests?				
(a) Bare hull resistance, Full Load.	___	___	___	___
(b) Bare hull resistance, Ballast.	___	___	___	___
(c) Appended hull resistance, Full Load.	___	___	___	___
(d) Appended hull resistance, Ballast.	___	___	___	___
(e) Appended hull resistance, Intermediate Load.	___	___	___	___
(f) Self-propulsion, stock propellers, Full Load.	___	___	___	___
(g) Self-propulsion, stock propellers, Ballast.	___	___	___	___
(h) Self-propulsion, design propellers, Full Load.	___	___	___	___
(i) Self-propulsion, design propellers, Ballast.	___	___	___	___
(j) Self-propulsion, design propellers, Intermediate Load.	___	___	___	___
(k) Wake survey.	___	___	___	___
(l) Open water, design propellers.	___	___	___	___
(m) Cavitation performance of design propeller simulating ship at 24 knots, in Full Load Condition.	___	___	___	___

STRATEGIC SEALIFT SHIP ENGINEERING DESIGN REVIEW

Current Date: 6/15/95

CDRL No.: A005 **TITLE:** Model Test Documentation

1st 2nd 3rd 4th SUBMISSION **Category:** 1. COR Deficiency
2. Technical Concern
3. Other

SHIPYARD:____________________ **NEW CONSTRUCTION**

	Yes	No	NA	Cat
Interface Check: Is the Model Test Data compatible with:				
1. Model Test Plan A002				
2. Hull Lines and Molded Offset Drawings A015-3				
3. Resistance and Powering Calculations A014				

Questions to consider:

	Yes	No	NA	Cat
1. Are model scale and model propeller dimensions acceptable?				
2. Are the principal hull dimensions and principal hull form parameter values, applicable to each test condition as listed in 10.2.6 of CDRL A002, included in the test report(s)?				
3. Do the test reports include:				
(a) Body plan?				
(b) Bow and stern profile lines drawings?				
(c) Sectional area curve offsets?				
(d) Section area curve plot?				
(e) DWL curve offsets?				
(f) DWL curve plot?				
(g) Stock propeller physical characteristics?				
(h) Stock propeller drawing?				
(i) Stock propeller open-water characteristics?				
(j) Design propeller physical characteristics?				
(k) Design propeller drawing?				
(l) Sketch(es) of all appendages?				
(m) Rake arrangement sketch?				
(n) Photographic records applicable to appendage alignment tests?				

5.2.3 Specification Review Notebook

Originally, the specifications and the drawings and calculations were to be addressed at the same design review. Slips in the specification development and review schedules did not permit this, however. Specification reviews had not been done at all in the Initial Design Phase, so the scope of this task was difficult to estimate originally. The specification reviews turned out to be quite time consuming. The specification review notebook basically consisted of the review sheets in specification order. The review sheets were created using the same systems as drawing and calculation review sheets.

5.2.4 Q&A's

One of the important lessons for the government from the Initial Design Phase was the need for a system of Q&A's. The government team was not prepared to handle specific questions during the reviews, and this was the best method to handle it. The Q&A's were for technical matters only. The Q&A's would be private between the shipyard and the program office; however, if in answering a question, a requirement was clarified that could significantly affect technical development, strategy, or cost, the Q&A would be shared with all the shipyards. The shared Q&A's were generic and did not identify the shipyard or reveal their approach. There were approximately 500 formal questions in the Engineering Design Phase.

5.2.5 COR Modifications

The conversion and new construction CORs were updated with modifications as the program proceeded. The updates included positively adjudicated recommended changes to the COR from the shipyards, implementing Q&A's, etc.

5.3 Effectiveness of Design Reviews

Most government personnel felt that this review process was effective in managing the acquisition product. This process was structured to review a large amount of information fairly and consistently. It is not a perfect system, though. The government learned many valuable lessons along the way, which improved the process. However, no statistics were kept to measure the quality of the process. Amount of feedback and cycle time are two examples of metrics which could help to identify weak areas in this process.

5.4 Role of Government Review in Future Navy Ship Acquisition Programs

The Strategic Sealift program has generally been regarded as a successful one. This then begs the question; is this a good model to follow? The fact remains that this is about as close to a commercial ship as the Navy buys. On other programs which have more combat systems, and are generally more complex, the government's role in the design process will most likely be greater. Should the amount of design review increase, decrease, or remain the same?

The amount of review that is required by government will depend on the amount of design work that is done by contractors. In addition, the amount of design review will depend on the complexity and performance requirements of the ship. The amount of design review will increase the more complex and advanced that the ship is. One possibility that could occur is that the design costs associated with a more complex ship will necessarily increase, but the amount of design review will remain the same percentage of the total design cost.

The Navy has clearly been moving towards having industry perform more of the design work in ship acquisitions. One way to determine if the Strategic Sealift program provides a good measure for this function is to see what happens in future programs, such as the LPD-17 and DD-21.

6 Acquisition Strategy Issues

There are several issues pertinent to acquisition strategy. These are discussed in the following sections.

6.1 Extent of Navy Involvement in the Early Design Stages

One issue related to design is the extent that the Navy should be involved. The early design stages are not a large proportion of the total ship acquisition cost; however, these stages are crucial in determining the cost, schedule, and performance of the delivered ship. By Milestone II, roughly 80 percent of the cost and performance of the ship is locked in. Obviously, the work done at these stages is very important and has a large impact on the success of the program.

The Strategic Sealift program did not use the Navy for a significant amount of early design work. The concept design work was tasked to 9 different shipyards shortly after Milestone 0. One disadvantage of this is that the government must support 9 different design staffs rather than one. The advantage of this process is that each works independently, and thus comes up with different solutions for the same requirements. This brainstorming (and extra initial cost) in the early stages could ultimately save large amounts of money in the long run if a better design is selected than one the government would have selected. This competition in the early stages does provide incentive for the shipbuilders to come up with innovative solutions. If the design is done by a single government team, the design may not be the most innovative, or the lowest cost. In addition, the Navy as designer and ultimate operator may not have a great incentive to reduce requirements.

The Sealift ships are not complicated ships. There are not any advanced combat systems. While the Sealift program has generally regarded as successful, there have been some reservations about using the same acquisition strategy for more complex ships. With more complex ships, the shipyards may have a very difficult time deciding between tradeoffs from an operational point of view. The Navy has a difficult time deciding what it wants, so how will the shipyards do that for them? There is a feeling that this strategy works if you are willing to accept what you get; however, this may not be what you were expecting. One alternative would be to use the shipyards for the concept and preliminary designs, at which point the Navy would select a design. The shipyards could then be guided by the contracted ship specification.

One issue related to this is the extent of the government staff. In recent years the government has concentrated on downsizing, so it is not clear whether the Navy will be able to continue the high level of involvement. One could argue that since the government has been doing the majority of the early design work for the past couple of decades, they have been doing the U.S. yards a disservice in terms of staying competitive in the commercial market by taking actions that result in reducing the experienced design staff at the shipyard.

6.2 Extent of Navy Involvement in Combat System Procurement and Integration

The Navy has been trying to determine whether ship systems are furnished by the Government (GFE) or by the contractor (CFE). This issue can affect ship affordability and acquisition incentives. Late arrivals or defects of GFE can lead to large claims against the government. If the shipyard was to assume the risk of this equipment, they could not sue the government for problems. The flip side, however, is that if the same combat system can be used on several classes of ship the government can usually acquire combat systems at lower cost than the shipbuilder can. This was the case in the Strategic Sealift program where the different classes of ships built at different yards shared the same stern ramps, cranes, etc. In addition, the government assumes the significant risks associated with combat system performance.

6.3 Competition versus Early Down-Selection

The Navy has primarily been using competition in the acquisition process; however, some of the other ways of cutting costs such as using IPTs, implementing build strategy in the design, etc. may be compromised by this. The major benefit of competition is lower prices, particularly if the shipyards believe they must compete to win an award. Competition prevents shipyard monopolies, and therefore limits price increases. Competition for design encourages innovative and effective design. One way this has been implemented in the past is through dual sourcing. This consists of awarding one class of ship to two separate shipyards. The contracts can consist of several options to buy more ships, and the government can choose whether to exercise these options or not. This results in lower prices, and the shipyards do their best so that the government exercises the options on the follow ships. Another advantage of dual sourcing is that it increases the surge potential for shipbuilding in the U.S., both for current and future programs.

The major disadvantage of full competition is that it makes early industry involvement in the IPT process more difficult. The optimum way to use these teams would be to involve the industry members at the earliest possible stage. If there are multiple yards involved in the acquisition process, there will need to be separate IPTs for each yard. One solution to this is to have early down-selection of the shipyard for the ship acquisition. It would still be possible to compete on sub-systems, and the prime contractor can participate in this process. In addition, the government avoids supporting several overhead structures on one project, such as in dual sourcing. The major impediment for early down selection is the escalation of costs for a given ship, from contract price to delivered price. If the award is sole source, the contract is critical. The government must be very careful how the contract is written. Different theories abound for the effectiveness of various types of contracts. Some argue that incentive fee and award fee contracts have the potential of being cost-effective.

6.4 Role of Concurrent Engineering, IPPD, and IPTs in Navy Ship Acquisition

Concurrent engineering is intended to consider all aspects of the life cycle in the early stages of the design process. The concept originated in industry, and has been used by several U.S. manufacturers, particularly in the auto and film industries. Instead of designing the product, and sending that to manufacturing to deal with it, concurrent engineering proposed considering manufacturing in the design process. Involving the manufacturers in the design process does this. This has now expanded to include many other players besides manufacturers in the process. One definition of current engineering is:

> *Concurrent Engineering is a systematic approach to the integrated development of a product and its related processes, that emphasizes responsiveness to customer expectations and embodies team values of cooperation, trust and sharing, in such a manner that decision making proceeds with large intervals of parallel working by all its life cycle perspectives, synchronized by comparatively brief exchanges to produce consensus.*[6]

The Navy has involved the shipbuilders in the early design phases during the past two decades. Concurrent engineering, however, goes beyond this level of involvement. The operators, support personnel, combat and support systems developers, and suppliers also should be involved to realize the benefits of a true systems engineering approach. The goal of concurrent engineering is to "produce products that meet given function and quality requirements in the shortest possible time and lowest cost." (Bennett and Lamb)

Integrated Product and Process Development (IPPD) is a management process that integrates all activities from product concept through production and field support, using a multi-functional team, to simultaneously optimize the product and its manufacturing and sustainment processes to meet cost and performance objectives. IPPD is defined as "an expansion of concurrent engineering utilizing a systematic approach to the integrated, concurrent development of a product and its associated manufacturing and sustainment processes to satisfy customer needs." (Perry memo) The key tenets of IPPD are as follows:

- Customer Focus – The primary objective of IPPD is to satisfy the customer's needs better, faster, and at less cost. The customer's needs should determine the nature of the product and its' associated process.
- Concurrent Development of Products and Processes – Processes should be developed concurrently with the products that they support. It is critical that the processes used to manage, develop, manufacture, verify, test, deploy, operate, support, train people, and eventually dispose of the product be considered during product development. Product and process design and performance should be kept in balance.
- Early and Continuous Life Cycle Planning – Planning for a product and its processes should begin early in the science & technology phase (especially advanced development) and extend throughout a product's life cycle. Early life cycle planning, which includes customers, functions and suppliers, lays a solid foundation for the various phases of a product and its processes. Key program events should be defined so that resources can be applied and the impact of resource constraints can be better understood and managed.
- Maximize Flexibility for Optimization and Use of Contractor Unique Approaches – RFP's and contracts should provide maximum flexibility for

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[6] J. Bennett and T. Lamb, "Concurrent Engineering: Application and Implementation for U.S. Shipbuilding," Journal of Ship Production, Vol. 12, No. 2, May 1996

optimization and use of contractor unique processes and commercial specifications, standards and practices.

- Encourage Robust Design and Improved Process Capability – Encourage use of advanced design and manufacturing techniques that promote achieving quality through design, products with little sensitivity to variations in the manufacturing process (robust design) and focus on process capability and continuous improvement.
- Event-Driven Scheduling – A scheduling framework should be established which relates program events to their associated accomplishments and accomplishment criteria. An event is considered complete only when the accomplishments associated with the event have been completed as measured by the accomplishment criteria. This event-driven scheduling reduces risk by ensuring that product and process maturity is incrementally demonstrated prior to beginning follow-on activities.
- Multidisciplinary Teamwork – Multidisciplinary teamwork is essential to the integrated and concurrent development of a product and its processes. The right people at the right place at the right time are required to make timely decisions. Team decisions should be based on the combined input of the entire team (e.g. engineering, manufacturing, test logistics, financial management, contracting personnel) to include customers and suppliers. Each team member needs to understand his/her role and support the roles of the other members, as well as understand the constraints under which

other team members operate. Communication within teams and between teams should be open with team success emphasized and rewarded.

- Empowerment – Decisions should be driven to the lowest possible level commensurate with risk. Resources should be allocated at levels consistent with authority, responsibility, and resources to manage their product and its risk commensurate with the team's capabilities. The team should accept responsibility and be held accountable for the results of its effort.
- Seamless Management Tools – A framework should be established which relates products and processes at all levels to demonstrate dependency and interrelationships. A single management system should be established that relates requirements, planning, resource allocation, execution and program tracking over the product's life cycle. This integrated approach helps ensure teams have all available information thereby enhancing team decision-making at all levels. Capabilities should be proved to share technical and business information throughout the product life cycle through the use of acquisition and support databases and software tools for accessing, exchanging, and viewing information.
- Proactive Identification and Management of Risk – Critical cost, schedule and technical parameters related to system characteristics should be identified from risk analyses and user requirements. Technical and business performance measurement plans, with appropriate metrics, should be developed and compared to best-in-class industry benchmarks

to provide continuing verification of the degree of anticipated achievement of technical and business parameters.

The Integrated Product Team (IPT), also called the Integrated Product and Process Development Team (IPPDT), is the implementing system for concurrent engineering and IPPD. An IPT is a multi-disciplinary team that is involved in the design and production process from the very beginning. The two most important characteristics of IPTs are the following:

- Cooperation – Cooperation is essential. Teams must have full and open discussions with no secrets. All the facts need to be on the table for each team member to understand and assess. Each member brings a unique expertise to the team that needs to be recognized by all. Because of that expertise, each person's views are important in developing a successful program, and these views need to be heard. Full and open discussion does not mean that each view must be acted on by the team. The team is not searching for "lowest common denominator" consensus. There can be disagreement on how to approach a particular issue, but that disagreement must be reasoned disagreement based on an alternative plan of action rather than unyielding opposition. Issues that cannot be resolved by the team must be identified early so that resolution can be achieved as quickly as possible at the appropriate level.
- Empowerment – Empowerment is critical. The functional representatives assigned to the IPT at all levels must be empowered by their leadership to

> give good advice and counsel to the Program Manager. They must be able to speak for their superiors, the "principals," in the decision making process. IPT members cannot be expected to have the breadth of knowledge and experience of their leadership in all cases. However, they are expected to be in frequent communication with their leadership, and thus ensure that their advice to the Program Manager is sound and will not be overturned later, barring unforeseen circumstances or new information. One of the key responsibilities of the leadership is to train and educate their people so they will have the required knowledge and skills to represent their organizations' leaders. As IPT members, people are an extension of their organizations and their leadership, and they must be able to speak for those organizations and leaders.

The purpose of IPTs is to make team decisions based on timely input from the entire team, including customers and suppliers. IPTs are generally formed at the Program Manager level and may include members from both Government and the system contractor. IPTs can be formed for ship design, contracting, and program management. Oversight for current NAVSEA programs is now being conducted by an Overarching IPT (OIPT). This function used to be done by the conventional milestone reviews.

The major challenge to implementing concurrent engineering is the change in management structure. If no one in the shipyard has ever used concurrent engineering, there will be no experience within the shipyard. Concurrent engineering is a change in management philosophy. Many of the traditional managers will be opposed to this method because of a loss of control. Management is the key. If the actions and behavior of management do not reinforce and support this change in philosophy, then any changes will be ineffective.

Concurrent engineering is not used to a great extent in shipyards overseas. Shipyards in the U.S., therefore, have been relatively unable to see the benefit of using concurrent engineering. Thus far any pilot programs have been inconclusive in demonstrating the perceived benefits of concurrent engineering. Without any examples showing the benefits, the U.S. shipbuilders have a difficult time knowing whether this is a good area to concentrate their efforts.

6.5 Most Effective Use of Acquisition Funding

One issue to consider is what the right allocation of funding is throughout the acquisition process. Some people in the industry believe that if more money was spent in the design stages, then much more money could be saved during the construction phases. Often times some of the tradeoffs involved in the design of a Naval vessel are not examined as thoroughly as they should be due to budget constraints. Designers will prefer to design conservatively, and err on the cautious side. This can lead to extra requirements or unnecessary equipment, and therefore added cost in the construction phase.

One example of this issue is illustrated with the side port ramps on the Strategic Sealift ships. Some who are familiar with the program feel that if more simulation work had been done with the loading and unloading of the vessel, then the side port ramps might have been eliminated. The reason more simulation work was not performed was budgetary and time constraints. If more money had been spent on simulation and the side port ramps were proved unnecessary, then much more money would have been saved by not buying the associated equipment. However, it is very difficult to take a piece of equipment out that that the customer has its mind set on; for instance, the U.S. Army with the side port ramps.

Another example that illustrates this point deals with the regulations imposed by the Coast Guard. If more money had been spent up front on the design, and communication with the Coast Guard had been better, perhaps some of the design changes later imposed may have been reduced. One particular aspect of the design that comes to mind is the fire-fighting system, which resulted in large design changes relatively late in the acquisition process. More money spent early in the design might have resulted in fewer design changes. In the Strategic Sealift program, design changes amounted to as high as 10% of the total cost of the ship. The budget for the conversion program was 10% for the lead ship, and 5% for the follow ships, while the budget for the new construction was 5% for the lead ship, and 3% for the follow ships. Figure 18 shows design changes are estimated to account for 5.5% of the total cost of the entire program. Figure 19 shows that the money spent on change orders accounted for approximately 7 times the amount of money spent on design through Milestone II. A huge portion of the costs are locked in by the time Milestone II occurs. Therefore, if a better, more complete design could be completed before Milestone II, possibly a large amount of savings may occur. Another way to understand this is the following: if double the amount of money was spent to obtain a better design before Milestone II, they would have needed to save

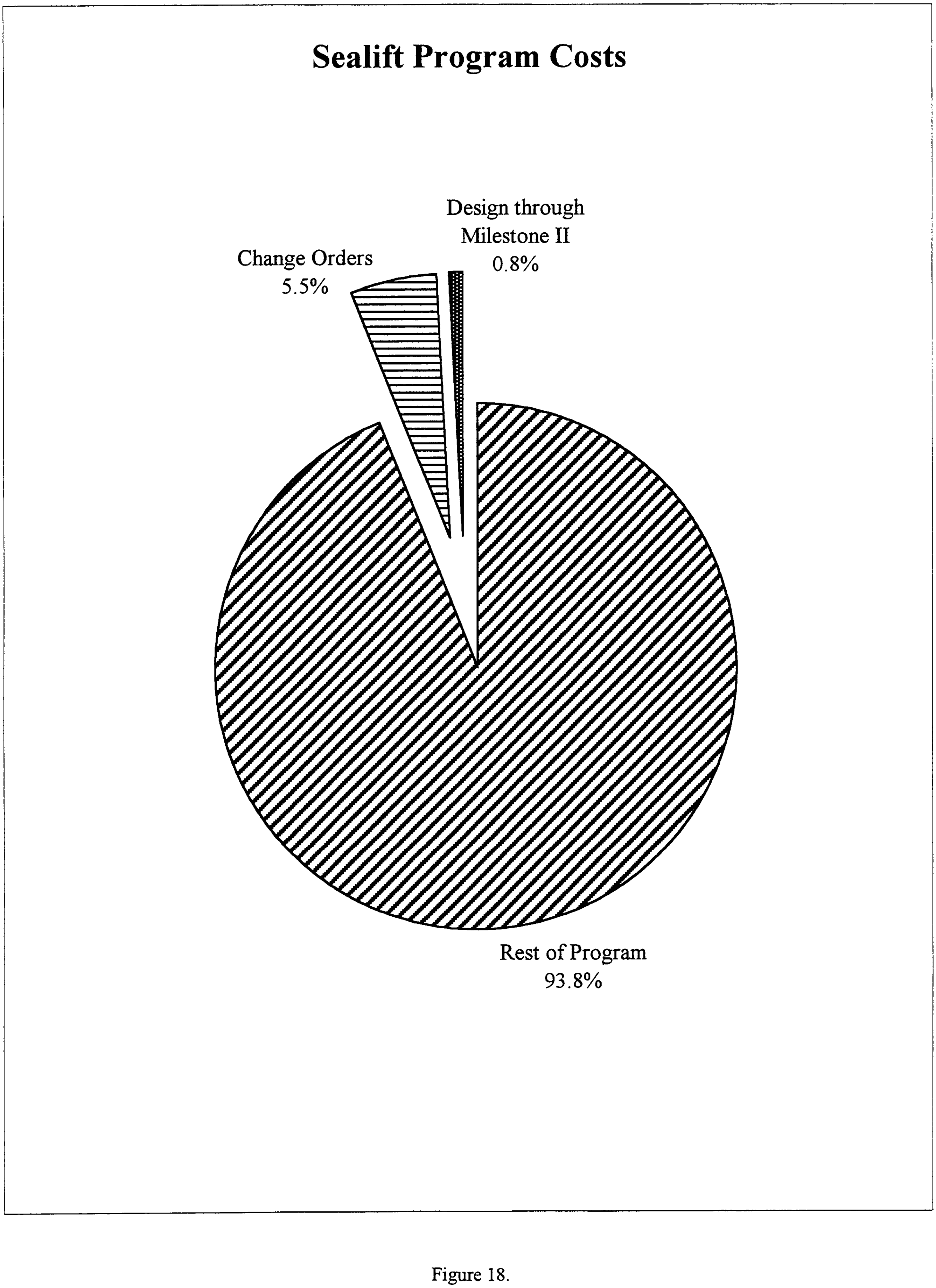
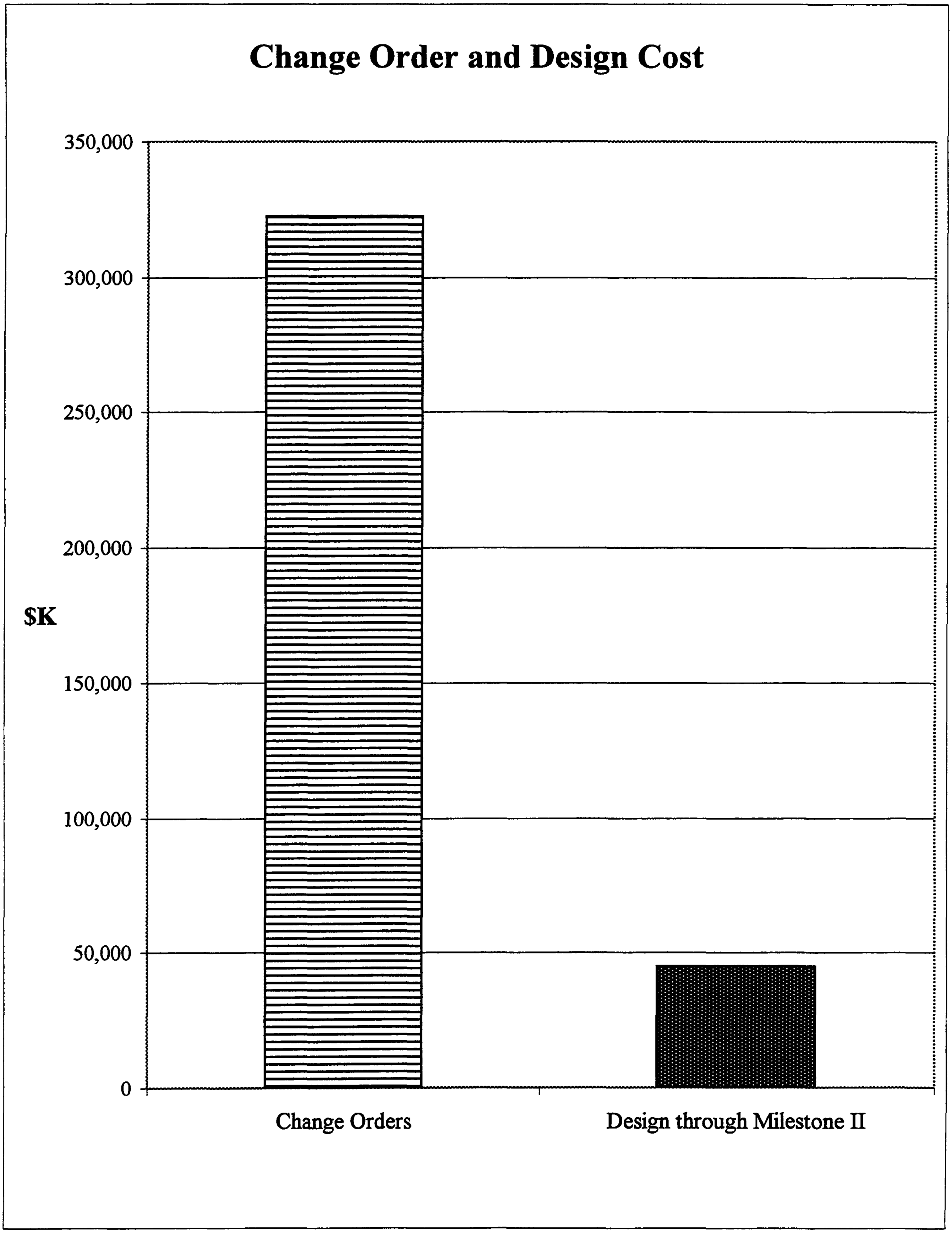

Sealift Program Costs
Design through
Milestone II
0.8%
Change Orders
5.5%
Rest of Program
93.8%

Figure 18.



Change Order and Design Cost
350,000
300,000
250,000
200,000
$K
150,000
100,000
50,000
0
Change Orders
Design through Milestone II

Figure 19.

approximately 14% of the change order cost for the program. Anything that they saved beyond that would be savings to the Navy and the taxpayers of the U.S.

However, the numbers are somewhat deceiving in this case. Because of the time pressures involved, the Navy began contracting for the standard equipment (e.g. ramps, etc.) before the design was complete. Later design work was included under the "Change Order" category. Therefore in this case the amount of money under the "change orders" is overstatement while "Design" may be understated.

Another word of caution is necessary at this point. It is too simplistic to think that more money spent up front by the government will always produce more savings later on. Money alone will not produce these results without the appropriate time to spend it and the needed cooperation among the parties involved.

Time is oftentimes more important than design maturity. In this project, the design happened so fast that the reviewers had a difficult time digesting all the designs. If they could have spent a little more time reviewing the designs without the potential dangers of personnel burn out, it is possible that the money would have been spent more effectively. The schedule of this design program did not permit that.

In addition, in many of these designs, the shipyard spent more to develop the design than the government funded them for. They did this in hopes of winning the contract and making the money back during the construction. It is the author's point of view that this is not a good practice to continue. If the government does not give enough money for a good design, then the only shipyards that will develop a good design are those that believe they are going to win the contract. The others will put in less effort, and the government will not get anything worthwhile out of them. The actual competition, and all the benefits that go along with that, will be gone. The government should fund what it believes is necessary to develop a solid design. Perhaps one way to do this is to determine what they traditionally spent on a design, and use that figure.

The major obstacle for spending more money up front on the design appears to be budgetary process itself. It is easier to get money in Congress to buy a physical structure such as a ship, compared to spending money on design. Many people believe that you could save money later on in the construction process by spending more on design, but that is tough to prove to Congress. Another consideration with this is to consider the program. The Strategic Sealift program was intended to be an essentially commercial-type acquisition program. That is, use off-the-shelf technology and basically accept the designs that come in. Most Naval ships are considerably more complex than the Sealift ships, so maybe it will be easier to fund more money early in the design stages of a more complex ship program.

In discussing Sealift program funding with current and past personnel, all agreed the amount of money spent by the Navy before Milestone II should not have been less than that utilized. There was a general feeling that another $10 million could have effectively been used on such areas as simulation and contractor activities.

7 Conclusions

Most people familiar with the Strategic Sealift Program consider it to be a successful acquisition program. This program used industry to develop the design to a greater extent than any previous Navy program. The effect of this was to shift the government's role in the acquisition from developing the design to a predominantly review function.

The government performed 61 reviews in the Sealift program. This is a major task, and as such required between 40 and 70 full-time employees to perform this function. Most government personnel feel this was the minimum amount of review that could be done and still receive an acceptable product. There were several benefits to having this many reviews, however. One major benefit of numerous reviews was the open dialogue that resulted from the face-to-face meetings. This led to clarifications of requirements, and hence a better design. While this review process was perceived to be good, there was no data taken to prove this. Some metrics need to be defined and used to evaluate and potentially improve the quality of the review process.

The benefits of this type of acquisition program are many. First and foremost, are the new and different ideas that arise out of independent design efforts. This competition can lead to a better design than the government may have come up with. The number of reviews that the government performed led to a sufficient amount of overview. The result was a good product that meets their performance objectives and requirements. Another benefit is that the shipyards begin to redevelop their engineering base for design, which may have dwindled in the 1980's, when the shipyards were not designing commercial vessels. Hopefully as the shipyards production processes improve, and their design capabilities increase, the shipyards will be able to compete for commercial vessels on a global level.

The design costs through Milestone II amounted to $44.9 million, or 0.8% of the total costs of the program. Even if another $10 million were added to this total (as some think would have been appropriate), this would only amount to 0.9% of the total costs. This is a very small percentage that this paper examines. This program was intended to be as "commercial" as possible. This resulted in minimizing the design costs in order to mimic a commercial acquisition program. Navy ships, however, are significantly more complex than a typical commercial ship. If the government had spent more on the design before Milestone II, when 80% of the costs are already locked in, then it is possible they would have enjoyed greater savings during the construction phase. One area where possible savings could occur are the design changes. Perhaps some of these changes could have been eliminated with more funding and time during design.

To judge whether this program is a good benchmark or not, will require comparison to other modern Navy acquisition programs, such as the LPD-17, DD-21, and CVX. These programs obviously have more combat systems, and are more complex. The true effects of the changes in acquisition strategy will be felt in these programs, if they continue to use a similar approach to the Sealift program. Hopefully these changes will lead to a less expensive, more effective Navy.

Selected References

Bennett, James G. and Thomas Lamb, "Concurrent Engineering: Application and Implementation for U.S. Shipbuilding," Journal of Ship Production, Vol. 12, No. 2, May 1996.

Defense Acquisition Deskbook, Sept 30, 1997.

Garver, Christopher M., Federal Acquisition Procedures, Masters Thesis, MIT, May, 1994.

Naval Sea Systems Command, "Improving the Ship Design, Acquisition and Construction Process: Strategic Plan." June, 1991.

Nix, Ron, "Strategic Sealift Ship Engineering Design, Design Review Process and Quality Assurance Program," Unpublished Paper.

Simmons, L. D., Assessment of Options for Enhancing Surface Ship Acquisition, Institute for Defense Analyses, March, 1996.

Tedesco, Matthew P., 1998. Strategic Change Management in Ship Design and Construction, Doctoral Thesis, MIT, June, 1998.