Navy Design Spending in an Era of Acquisition Reform

by

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ABSTRACT

An evolutionary change is taking place within the government with the ultimate goal being a shift in ship design responsibility from "in-house" to "industry." Eventually, it is predicted that the government would take on an advisory role as overseer and reviewer of the design, much the way a customer acts in a commercial endeavor. This evolution will not happen overnight, nor will it happen within one program. However, efforts towards achieving this end can be seen in several recent Navy programs, to varying degrees. These programs include the Icebreaker, Sealift, and LPD-17 programs. Further efforts are currently being made in the DD-21 program.

The DDG-51, Icebreaker, Sealift, and LPD-17 programs will be presented in this thesis. Each of these programs will serve as a unique case study in Navy ship acquisition. The focus of these investigations will be the timeframe leading up to contract award at Milestone II when approximately 80% of the final design is set. Of particular interest will be the distribution of costs between government and industry for varying stages in each program, the timing of these phases, as well as the point at which control of the design has passed out of the government's hands and into the hands of industry.

This analysis will provide insight into predicting the design cost of the government's efforts to get to Milestone II in future acquisition programs as the role of the Navy continues to change. Examination of key government personnel on hand as each program develops will prove useful in developing a generic team of core professionals for future Navy programs as the government steps away from the design front and focuses on its role of design review.

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The NAVSEA Chair for the Professor of Ship Acquisition supported this thesis.

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ACRONYMS

ACAT	Acquisition Category
ADM	Approval Decision Memorandum
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
ASR	Acquisition Strategy Report
CaIV	Cost as an Independent Variable
CBD	Commerce Business Daily
COEA	Cost and Operational Effectiveness Analysis
COTS	Commercial off the Shelf
CPS	Competitive Prototyping Strategy
DAC	Design, Acquisition, and Construction
DoD	Department of Defense
DoT	Department of Transportation
DMS	Determination of Mission Need
DTRC	David Taylor Research Center
EDB	Engineering Design Baseline
FASA	Federal Acquisition Streamlining Act of 1994
FSC	Full Service Contractor
ICE	Independent Cost Estimate
ILS	Integrated Logistics Support
IPDE	Integrated Product and Data Environment

IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
HM&E	Hull, Machinery, and Equipment
LRIP	Low Rate Initial Production
MDA	Milestone Decision Authority
MILSPECS	Military Specifications (and Standards)
MNS	Mission Needs Statement
MoE	Measures of Effectiveness
MS	Milestone
NAVSEA	Naval Sea Systems Command
NDI	Non-Developmental Item
OGA	Other Government Agencies
OMB	Office of Management and Budget
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
P-spec	Performance specifications
RFP	Request for Proposals
ROM	Reliability, Operationability, and Maintainability
SCIB	Ships Characteristics and Improvement Board (Navy)
SCN	Ship Construction and Conversion, Navy
SDM	Ship Design Manager
SHAPM	Ship Acquisition Program Manager

SOR	System of Operational Requirements
SRRC	Specification Reading and Review Conference
TOC	Total Ownership Costs
USCGC	United States Coast Guard Cutter

1 INTRODUCTION

In 1990, the Chief Engineer of NAVSEA undertook a major self-examination of the warship design, acquisition, and construction (DAC) process. He found that the time required to design and construct warships had been steadily increasing over the past twenty years. Several reasons for this were offered. Among them were the increased complexity of ships and their systems, the wider range of alternatives studied, longer decision-making process, and shrinking industrial base. As Tibbits and Keane put it, "revolutionary changes in the DAC process were needed to achieve dramatic reductions in total cycle time, and these process changes needed to start with design" (Reference 1).

The United States Navy acquisition process has entered a new arena with the passing of the Federal Acquisition Streamlining Act of 1994 (FASA). With this act, emphasis is placed on the increased use of commercial "off-the-shelf" (COTS) products and processes when possible. In addition, an evolutionary change is taking place within the government with the ultimate goal being a shift in design responsibility from "in-house" to "industry." Eventually, it is predicted that the government would take on an advisory role as overseer and reviewer of the design, much the way a customer acts in a commercial endeavor. The DoD imperative was to reduce the cost of new systems by going to industry for their design and development (Reference 1). This evolution will not happen overnight, nor will it happen within one program. However, efforts towards achieving this end can be seen in several recent Navy programs, to varying degrees.

These programs include the Icebreaker, Sealift, and LPD-17 programs. Further efforts are currently being made in the DD-21 program.

The DDG-51, Icebreaker, Sealift, and LPD-17 programs will be presented in the following sections. Each of these programs will serve as a unique case study in Navy acquisition. The focus of these investigations will be the timeframe leading up to contract award at Milestone II when approximately 80% of the final design is set. Of particular interest will be the distribution of costs between government and industry for varying stages in each program, the timing of these phases, as well as the point at which control of the design has passed out of the government's hands and into the hands of industry.

This analysis will provide insight into predicting the design cost of the government's efforts to get to Milestone II in future acquisition programs as the role of the Navy continues to change. Examination of key government personnel on hand as each program develops will prove useful in developing a generic team of core professionals for future Navy programs as the government steps away from the design front and focuses on its role of design review.

2 ACQUISITION REFORM

The Navy is making strides in the acquisition community towards acquisition reform. They have laid out a "new way of doing business" in the DoD 5000 revision. The intent of the new instruction is to streamline the acquisition process by eliminating unnecessary regulation, delegate authority to the lowest possible organization level, eliminate non-essential military specifications and standards where commercial specifications will suffice, and encourage maximum use of Commercial-off-the-Shelf (COTS) equipment. High on the list of reform priorities is the management of programs with a focus on reduced total life cycle costs. This includes designing platform systems with an open-system architecture that will allow for follow-on technology insertion. Several systems developed in this manner, such as the AN/SQS-53A EC-16 sonar and the Air Combat Electronics Program (ARC 210), have resulted in reduced life cycle costs and program manager man-hours, as well as in reduced system weight requirements.

The Navy also established an Acquisition Reform Office in January 1995 to show their continued commitment to achieving improvements in acquisition reform. This office is responsible for driving the acquisition reform agenda, including the development of the Acquisition Center of Excellence. This center contains a virtual library open to all Program Executive officers and Program Managers for use in developing acquisition strategies, obtaining up-to-date acquisition information, reviewing lessons learned, and testing acquisition ideas to support enhanced productivity and reduced costs.

2.1 THE PROCESS

The following section briefly describes the current, generic-ship acquisition process. Figure 2.1 illustrates the four major milestone decision points and four phases of the acquisition process. These typically provide a basis for comprehensive management and the progressive decision-making associated with program maturation. Much of the information here has been obtained from the 1998 MIT thesis, Right Sizing for Government Review by A. Speirs as well as the Defense Acquisition Deskbook (References 2,3). This section is provided to help the reader grasp the basic timeframe and level of effort for various stages in the ship program leading up to the award of contract. A clear understanding of the concepts presented here, as well as in Figure 2.1, is necessary to interpret the examinations undertaken in this thesis.

2.1.1 Pre-Milestone 0

As Figure 2.1 shows, the acquisition process begins with the Determination of Mission Need (DMS). This is the process by which DoD personnel determine deficiencies in the Navy's planned capabilities. These deficiencies could take the form of an aging fleet in need of replacement or in the lack of technology to counter a new threat. Funding is allocated toward efforts that seek a solution to these specific military problems. Funding is allocated based on the type of ship to be acquired, the previous cost of a similar type of ship, and the available Shipbuilding and Conversion, Navy (SCN) money in that fiscal year. Mission characteristics and weaponry requirements are also considered. These steps lead up to the issuance of a Mission Needs Statement (MNS)

Ship Acquisition and the Design Process

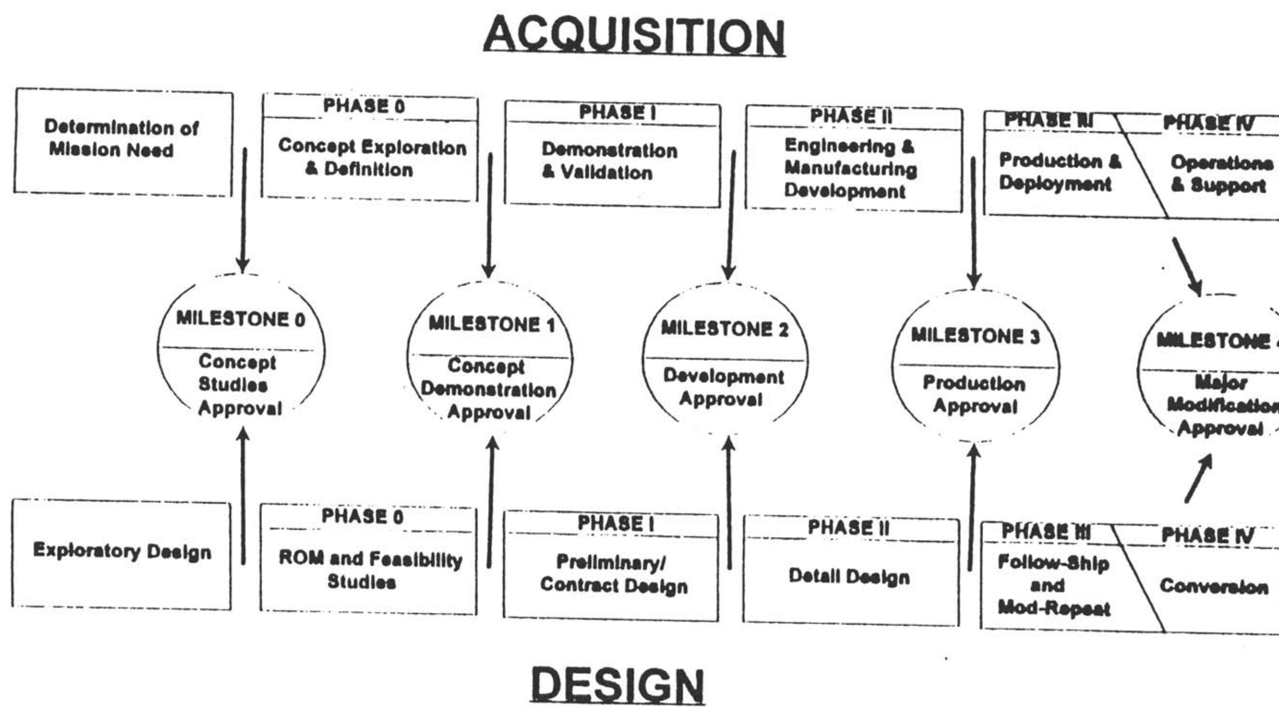


FIGURE 2.1

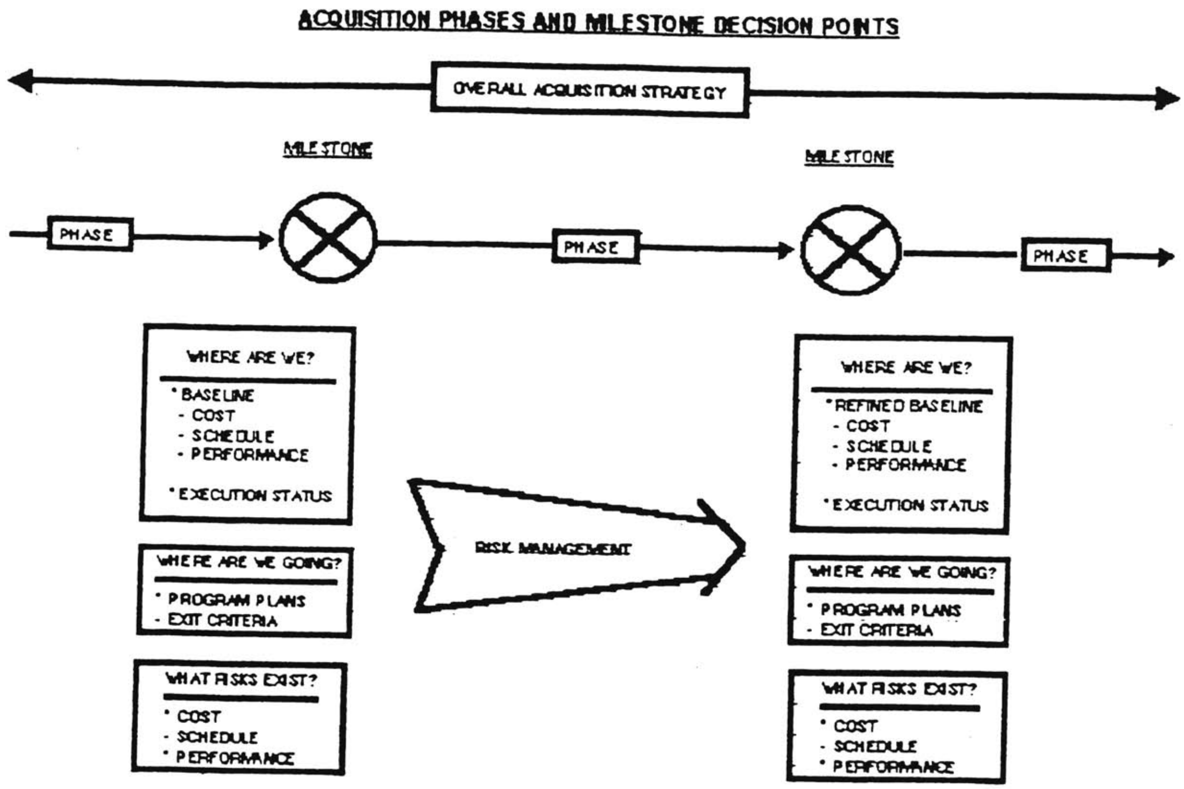
for a new vessel, as well as a threat assessment and Acquisition Strategy Report (ASR), which signifies Milestone 0 approval.

2.1.2 Milestone 0

A milestone can be considered the point at which a recommendation is made and approval is sought regarding further action within the acquisition process. Milestone 0: Concept Direction marks the initial formal interface between the requirements generation and the acquisition management systems. At this point, the Milestone Decision Authority (MDA) may choose to approve further action be taken to study alternative concepts. Or, the MDA may decide to cancel all further efforts at this time. Figure 2.2 illustrates the type of assessments made at each milestone regarding the status of the program execution and next-phase planning. The program is evaluated based on the risk levels regarding cost, schedule, and performance. Exit criteria, as shown in the figure, pertain to program-specific results that are required in the next phase. These criteria are established and approved during the milestone review, before the next phase begins. Major points of consideration by the MDA at Milestone 0 include:

- Validation of the MNS
- Satisfaction of need with non-material solution
- Allocation of funds to support study efforts, given this need is of sufficient importance.

Assuming that the MDA grants further investigation into the MNS with the issuance of the Milestone 0 Approval Decision Memorandum (ADM), efforts are carried out either by in-house staff, contractors, or a combination of the two. In general, the


ACQUISITION PHASES AND MILESTONE DECISION POINTS
OVERALL ACQUISITION STRATEGY
MILESTONE
MILESTONE
PHASE
PHASE
PHASE
WHERE ARE WE?
* BASELINE
- COST
- SCHEDULE
- PERFORMANCE
* EXECUTION STATUS
WHERE ARE WE GOING?
* PROGRAM PLANS
- EXIT CRITERIA
WHAT RISKS EXIST?
* COST
- SCHEDULE
* PERFORMANCE
RISK MANAGEMENT
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- PERFORMANCE
* EXECUTION STATUS
WHERE ARE WE GOING?
* PROGRAM PLANS
- EXIT CRITERIA
WHAT RISKS EXIST?
* COST
- SCHEDULE
* PERFORMANCE

FIGURE 2.2

ADM documents the decisions made as a result of the milestone review and includes the following:

- Definition of minimum set of alternatives to be examined
- Identification of funding source(s)
- Determination of exit criteria.

In addition, a Ship Acquisition Program Manager (SHAPM) is established. As Figure 2.1 showed, issuance of the ADM approves the start of Phase 0.

2.1.3 Phase 0

Phase 0 is referred to as Concept Exploration and Definition. This is a directed, funded effort designed to provide a new, or improved, material capability in response to a validated need. During this time, the acquisition strategy is developed, system alternatives are proposed and examined, and the systems program requirements document is expanded to support subsequent phases.

The acquisition strategy is a framework for planning, directing, and managing the program to ensure objectives are met while operating within the imposed resource constraints. Strategies regarding testing and evaluation, acquisition, competition, and prototyping are often included. Government, industry, or a teaming of the two undertakes competitive, parallel, short-term feasibility studies to determine the advantages and disadvantages of proposed concepts. These studies investigate the Reliability, Operationability, and Maintainability (ROM) of each concept and include a first estimate on life-cycle costs. These combined efforts are known collectively as the Analysis of Alternatives (AoA) or as the Cost and Operational Effectiveness Analysis (COEA.)

Tasks carried out during Phase 0 include the following:

- Creation of validated assessment of military threat
- Consideration of technology and technical risk
- Assessment of merits of each alternative
- Identification of an acquisition strategy
- Identification of cost, schedule, and performance for approval
- Identification of potential environmental consequences
- Identification of program-specific accomplishments to be completed during next phase
- Analysis of major technology and industrial capability issues
- Identification of cooperative opportunities
- Compliance with international arms control agreements
- Creation of proposed oversight and review strategy to include description of milestone decision
- Development of system requirements concerning measures of effectiveness (MoE).

These studies provide the basis for assessing relative merits of alternative concepts at Milestone I, New Acquisition Program approval. The conclusion of these studies, which require 3 to 18 months of effort, prompts the issuance of Milestone I review.

2.1.4 Milestone I

At Milestone I: New Acquisition Program approval, the MDA assesses the affordability of the proposed new acquisition program. Interaction between planning, programming, budgeting, and acquisition management systems takes place for the first time. At Milestone I, MDA considers the following:

- Threat assessment
- Acquisition strategy
- Phase 0 exit criteria status and Phase I exit criteria plans
- Acquisition Program Baseline (APB)
- AoA and studies supporting needs of new program
- Environmental consequences
- Adequacy of resources (manpower and funding)
- Hierarchy of material alternatives

- Affordability assessment

A favorable decision at Milestone I authorizes the beginning of Phase I, Demonstration and Validation, during which time the preliminary and contract designs are carried out.

2.1.5 Phase I

Preliminary and contract designs are carried out during Phase I of the acquisition program. Modern day ship design and acquisition processes do not separate preliminary design from contract design. These are seamless design activities and are both conducted between MS I and II. An Operational Requirements Document (ORD) is issued which documents the user's objectives and minimum acceptable requirements for operational performance of a proposed concept. DoD 5000 has standardized the format for this document. This phase, commonly referred to as Concept Demonstration and Validation, consists of steps necessary to resolve or minimize logistic problems identified during Phase 0: Concept Exploration. Ship characteristics, HM&E, and certain systems are finalized while others are further refined. Supportability and manufacturing process design considerations should be integrated into the system design effort early to preclude costly redesign efforts downstream in the process. As will be discussed in further detail in subsequent sections, the program office, design office, contractors, and Navy laboratories are all usually involved in this phase of the program. These entities are involved in the following efforts:

- Creation of updated assessment of the military threat
- Consideration of technology and technical risk
- Refinement of cost objectives and affordability assessment
- Identification of major cost, schedule, and performance tradeoff opportunities

- Refinement of acquisition strategy and determination of initial, low-rate production
- Identification of a test and evaluation strategy and appropriate testing
- Assessment of the industrial capability to support the program
- Identification of proposed cost, schedule, and performance objectives and thresholds for approval
- Assessment of potential environmental impacts
- Verification that adequate resources have been programmed to support production, deployment, and support
- Identification of cooperative opportunities
- Ensuring of compliance with international arms control agreements
- Creation of a proposed oversight and review strategy to include a description of mandatory program information
- Refinement of Cost as an Independent Variable (CaIV) objectives
- Analysis of any major technology and industrial capability issues
- Creation of Independent Cost Estimate (ICE) and Manpower Estimate

The preliminary design typically takes 6-12 months and leads to the start of contract design. The contract design usually requires 9-15 months. In the past, the contract design has been the engineering development of the technical and contractual definition of the ship design (including ship specifications and drawings) to a level of detail sufficient for prospective shipbuilders to make a sound estimate of the construction cost and schedule. The contract design package has traditionally provided the technical baseline from which the Navy selects the shipbuilder who then develops the detail design package required supporting the construction and eventual delivery of the ship.

Under the Acquisition Reform for new design ships, traditional distinct phasing of the design process has been replaced with a continuous, concurrent engineering, Integrated Product and Process Development (IPPD) process extending through and after contract award. This serves to maintain the focus of multi-discipline teams consisting of the government, shipbuilder, system programs, and suppliers. Government/Industry Integrated Product Team(s) (IPTs) will utilize the IPPD process to develop the design in an Integrated Product and Data Environment (IPDE.) The design approach is part of an acquisition strategy that is based on commercial practices and incorporates a phased technical definition.

A primary goal of this phase is to validate the choice of alternatives and to provide the basis for determining whether to proceed into Phase II: Engineering & Manufacturing Development. This is decided at the Milestone II review. Typically, an RFP is issued during this phase to potential bidders. According to the current, generic ship acquisition model, the transition of government personnel from design mode to review mode takes place at this time. However, as will be discussed with the Sealift program, this transition happened earlier in the process.

2.1.6 Milestone II

At this decision milestone, MDA should rigorously assess the affordability of the program and establish a development Acquisition Program Baseline (APB.) The Defense Planning Guidance, long-range modernization and investment plans, and internally generated planning documents form the basis for making this assessment. Risks of the program should be assessed, as should risk management plans. Considerations at this point include:

- Acquisition strategy
- APB
- Phase I exit criteria status and Phase II exit criteria plans
- Validated threat assessment
- Low Rate Initial Production (LRIP) quantities
- Prototyping/demonstration results
- Potential environmental consequences
- Adequacy of resources (manpower and funding)
- ICE and manpower estimate

Milestone II approves the proposed or modified APB and acquisition strategy, establishes life cycle cost objectives and exit criteria, identifies Low Rate Initial Production (LRIP), and approves entry into Phase II: Engineering and Manufacturing Development.

2.2 Final Comments

It is important to realize that the acquisition process described above is in its generic form. The MDA can tailor the milestones and phases to support a specific acquisition situation. "Tailoring" is one of the major themes of DoD 5000 as are the ideas that, "one size does not fit all" and "there is no reason to expect to treat every program identically." These phases and milestone decision points simply facilitate the orderly translation of broadly-stated mission needs into system-specific requirements and a stable design that can be produced efficiently.

Chapters 3-6 present the four programs included in this thesis. The acquisition process undertaken as well as the total program spending leading up to Milestone II will be included. All costs are shown in terms of actual dollars, unadjusted for inflation. Chapter 7 provides a comparative analysis for these programs and evaluates several hypotheses on acquisition reform based on findings in this thesis. Conclusions are made in Chapter 8.

3 DDG-51 ACQUISITION PROGRAM

The ARLEIGH BURKE Class of AEGIS-equipped guided missile destroyers is designed as a replacement for the 15-year old LEAHY and BELKNAP Class cruisers in conducting anti-air warfare, anti-submarine warfare and surface-to-surface warfare. The DDG-51 Program is a 29-ship buy with the first ship operational in 1989 and the last ship delivered in 1997. Bid price for the lead ship was $1,173,400,000 (1985 dollars). The design effort began with Feasibility Studies in 1979 and ended with Contract Design package signature on June 29, 1984. Principal particulars for the class are provided in Table 3.1.

Table 3.1: Principal Particulars for ARLEIGH BURKE Class

Displacement, full load (approx.)	8,300 tons
Length between perpendiculars	466 feet
Beam	59 feet
Draft, navigational	20.7 feet
Complement	21 officers, 286 men
Propulsion	4-LM2500 GTs, 2-CP propellers 40,000 SHP each

3.1 Design Strategy

In many ways, the DDG-51 program represents "the old ways of doing things." The DDG-51 is a Navy design. The New Design, Conventional Approach was used. Since this design departed from the basic DD963 hull and machinery plant, the DDG-51 design strategy was much closer to being a "clean sheet of paper design" and numerous feasibility and producibility studies were undertaken early on. Although the early stages of the DDG-51 design were completed at the contractors' site (in terms of feasibility and producibility studies) and the concept of collocation was applied to this project in the contract design phase, the Navy maintained entire control over the design until contract award at MS II. Representatives from prospective bid yards were on hand during discussions to ensure that the design could be executed by several competing yards; however, no funds were allocated for this purpose. During the early stages of the DDG-51 design, viewpoints on the use of collocated teams conflicted. Most agreed that there were obvious advantages to applying it; however, some felt that other programs might suffer. In the end, the DDG-51 project was deemed of sufficient importance and visibility to require collocation.

For all phases, the fraction of work performed by NAVSEA personnel was assumed to be less than 20%. (In hindsight, the fraction of work actually performed by in-house personnel in terms of man-days was only 12%.) Contractor support for this program included multi-design agents by functional code. Management support was also provided from outside NAVSEA. Table 3.2 presents the program's overall schedule. Table 3.3 highlights key dates. Figure 3.1 also illustrates these time frames and important dates.

Table 3.2: Overall Schedule for DDG-51 Acquisition Program

	START DATE	COMPLETION DATE	TOTAL LENGTH
Feasibility Study	August 1978	March 1982	44 months
Conceptual Design	February 1980	March 1982	26 months
Preliminary Design	March 1982	December 1982	10 months
Contract Design	May 1983	June 1984	14 months
		Total	**68 months**

Table 3.3: Key Dates in DDG-51 Acquisition Program

EVENT	FEAS/CONCEPT STUDY	PRELIMINARY DESIGN	CONTRACT DESIGN
SCIB	N/A	October 1982	N/A
Senior Review	February 1982	December 1, 1982	May 15, 1984
Command Review	February 1982	December 15, 1982	May 29, 1984
CD Circulation	N/A	N/A	March 28, 1984
CD Reading Session	N/A	N/A	May-June, 1984
CD Signature	N/A	N/A	June 29, 1984

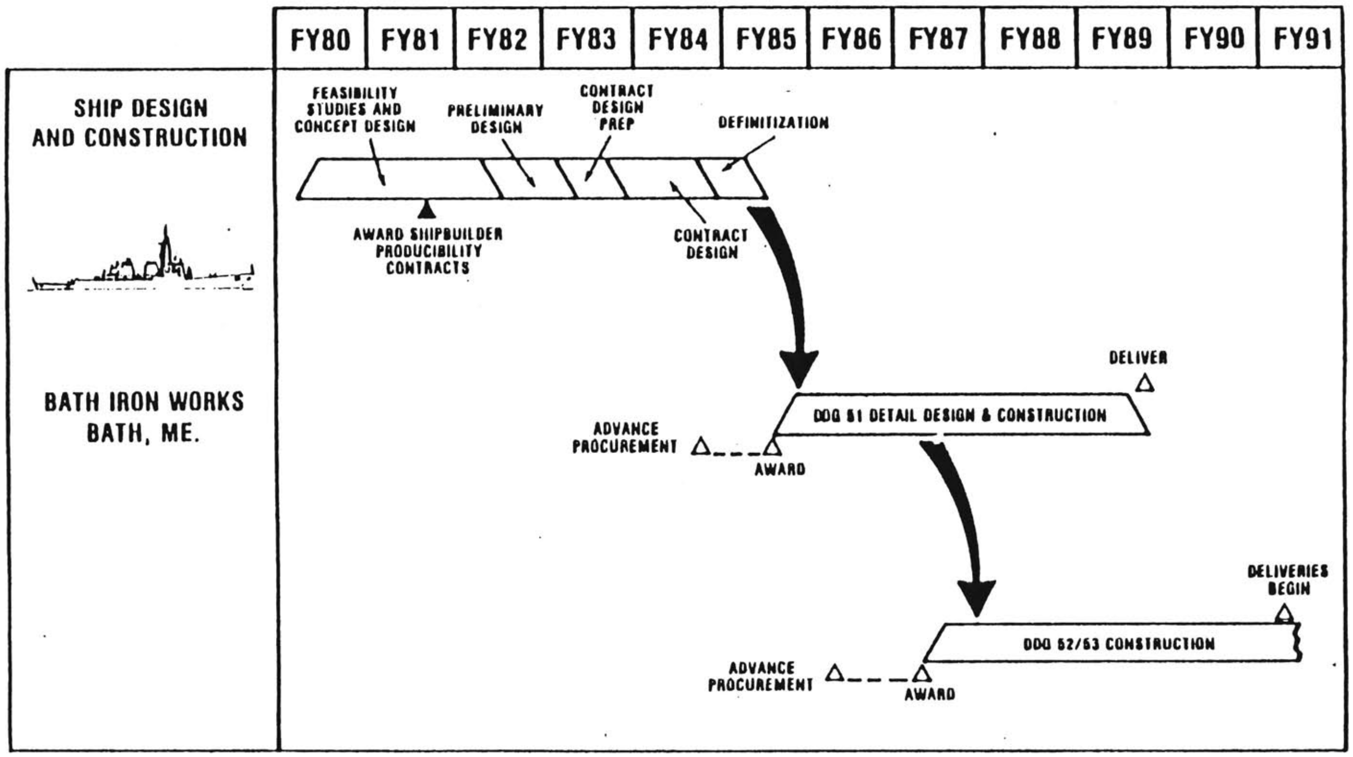

Figure 3.1 GUIDED MISSILE DESTROYER (DDG 51 CLASS) ACQUISITION PROGRAM SCHEDULE

3.2 Key Personnel

As the program progressed through its stages, the number of key government personnel on hand increased. Table 3.4 provides a list of key personnel for each phase. New personnel in each phase are shown in bold.

Table 3.4: Key Personnel in DDG-51 Acquisition Program

Feasibility Studies	Conceptual Design Phase	Preliminary Design Phase	Contract Design Phase
4 personnel	Ship Design Manager Deputy SDM Dsg'n Integration Mngr TGM-Hull TGM-Machinery TGM-C.S. Integration	Ship Design Manager Deputy SDM Dsg'n Integration Mgr TGM-Hull TGM-Machinery TGM-C.S. Integration **Head Systems Eng'r**	**Director of Design** Ship Design Manager Deputy SDM Dsg'n Integration Mgr TGM-Hull TGM-Machinery TGM-Specifications TGM-C.S. Integration TGM-ELEX Systems Head Systems Eng'r **Computer Apps Mng'r** **Producibility Manager** **CPS Engineer** **SSES Engineer** **DNSRDC Liaison** **Design Budget Manager** **Business Manager**

3.3 Development Costs of the DDG-51 Program

As was mentioned previously, the total design program ran from February 1980 to March 1985. The program was awarded in July 1984; however, a definitization phase took place until March 1985 that included proposal preparation and evaluation as well as contract negotiation and award support. The total design costs through March 1985 for the DDG-51 Program (including the definitization phase) were $58.6 million.[1]

Information on annual monies spent was not available. However, Figure 3.2, which shows in-house participation in design phases, was available. Using this figure as well as the information on total spending by phase as guides, an estimate on fiscal year spending is made in Figure 3.3.

Figure 3.4 shows the distribution of costs between government and industry through Milestone II. In this figure, government represents the program office, design office, and OGA. The design office will often contract Other Government Agencies (OGA) to perform some technical tasks, especially in developmental stages. The David Taylor Research Center (DTRC) is an example of an OGA, which often provides support of hull development, model testing, etc. All numbers shown from this point on will not include monies spent during the definitization phase for ease of comparison since all programs in this thesis do not include this phase. Through Milestone II (i.e.-through contract award), approximately 57% of the money ($27.8 M) was spent by industry with the remaining 43% allocated to government effort.

Figures 3.5 and 3.6 show the breakdown of government into OGA and in-house which would include the program office and design office. Of the 43% allocated to government, in-house personnel spent 23% ($11.2 M); almost 20% ($9.5 M) was spent

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[1] One source reported total design costs at $62.2 M. However, this value could not be justified and was not used.

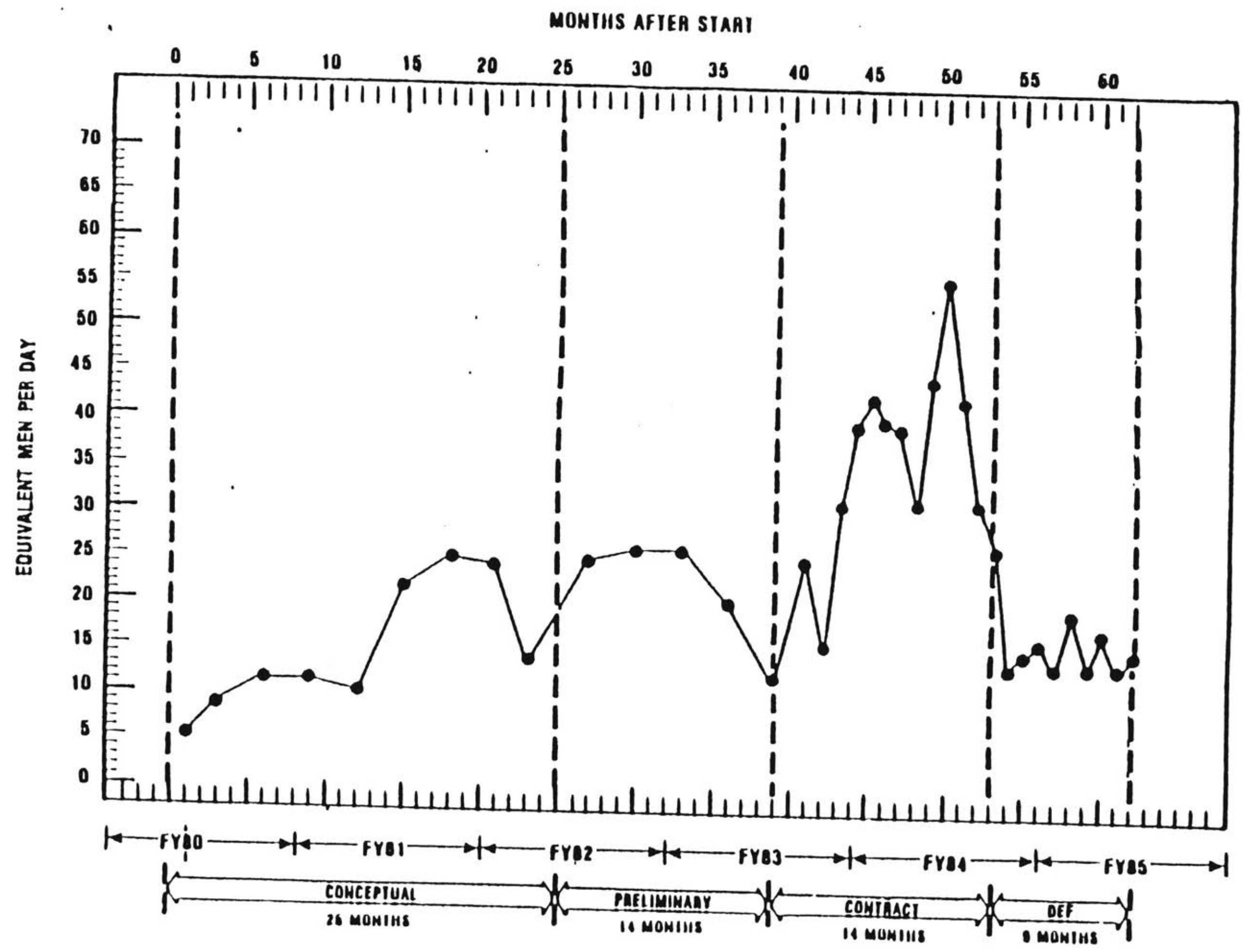

Figure 3.2 GUIDED MISSLE DESTROYER (DDG 51) NAVSEA PARTICIPATION IN DESIGN PHASES

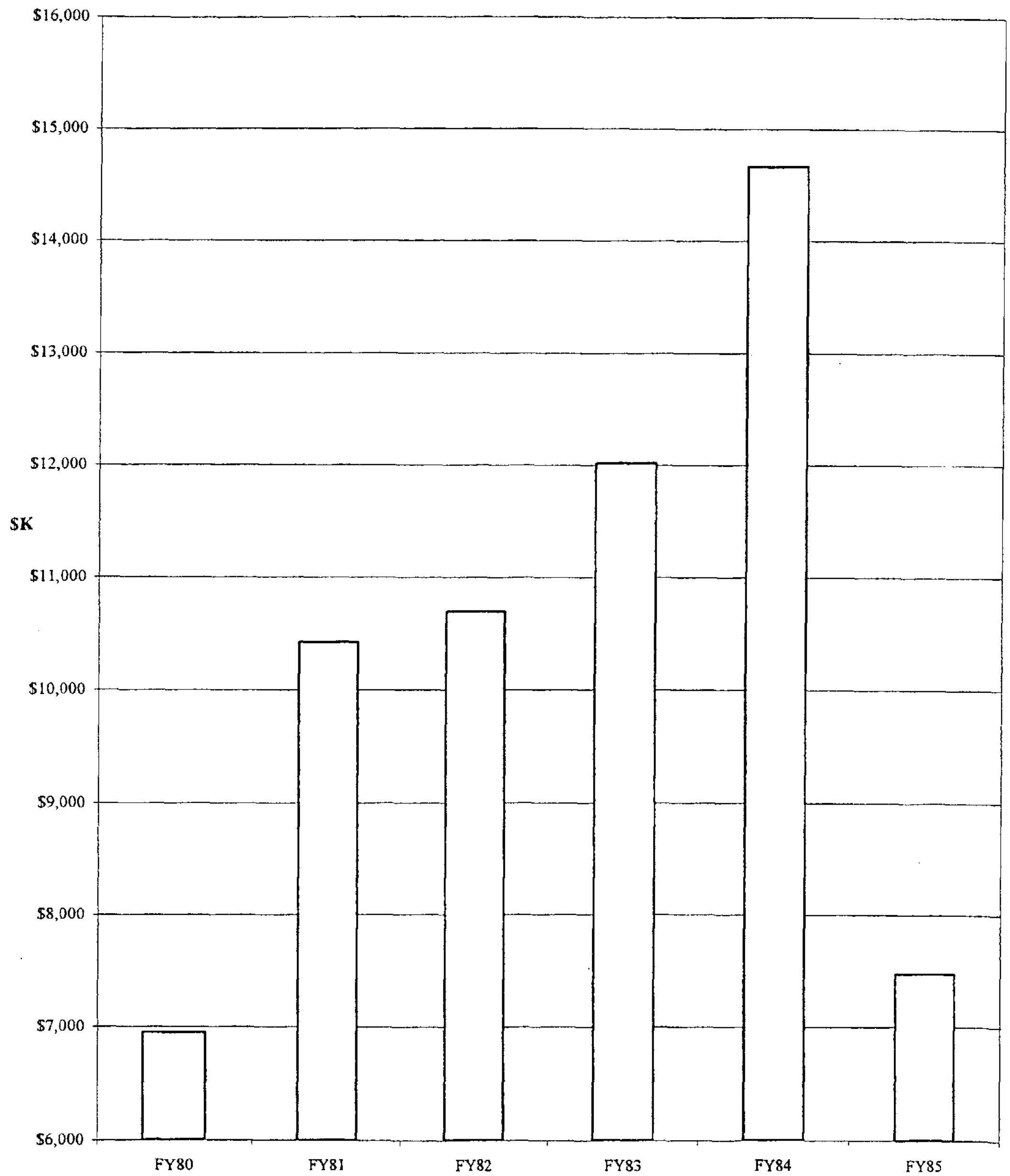

Figure 3.3: Estimated Timing of Design Spending

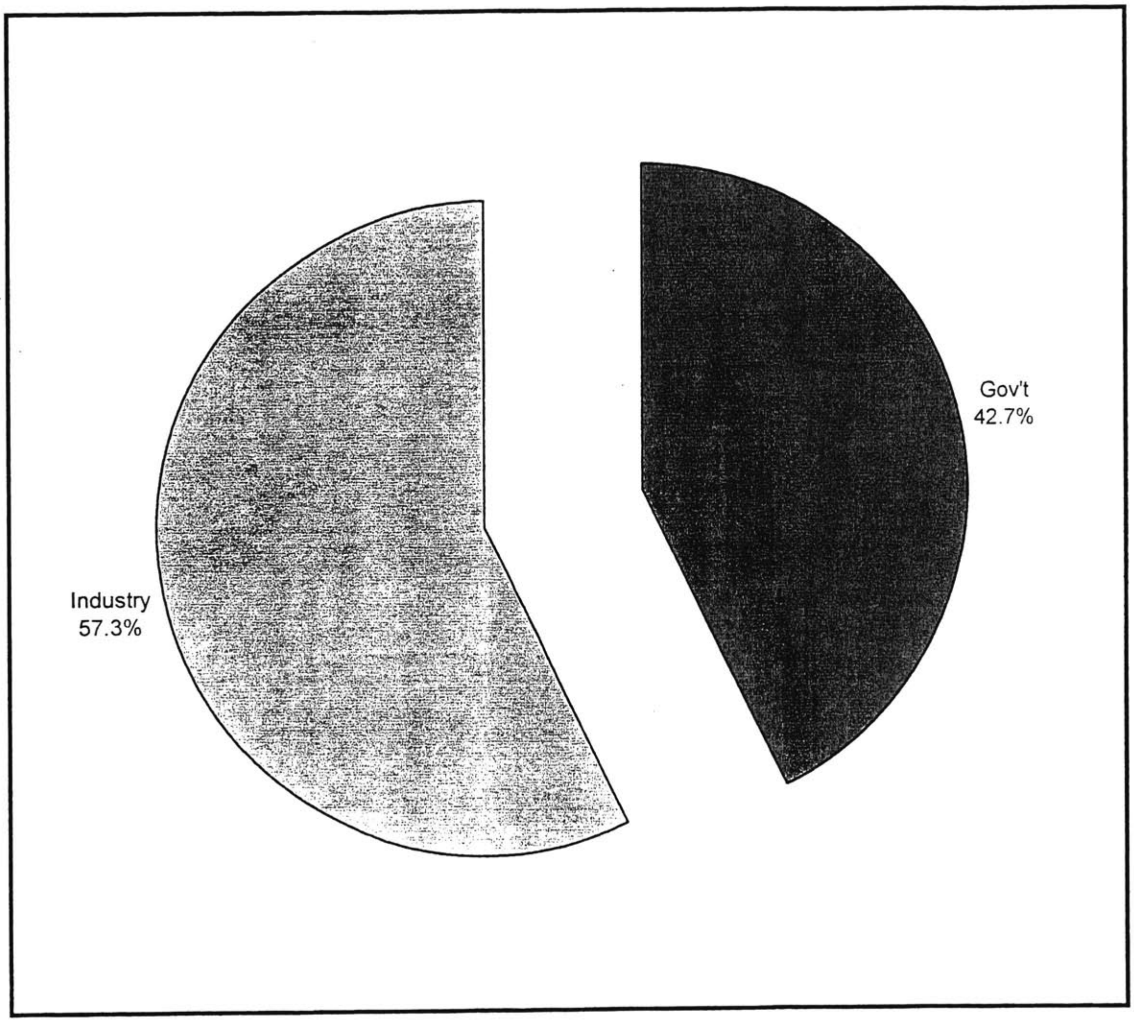

Figure 3.4: Total Design Costs for DDG-51

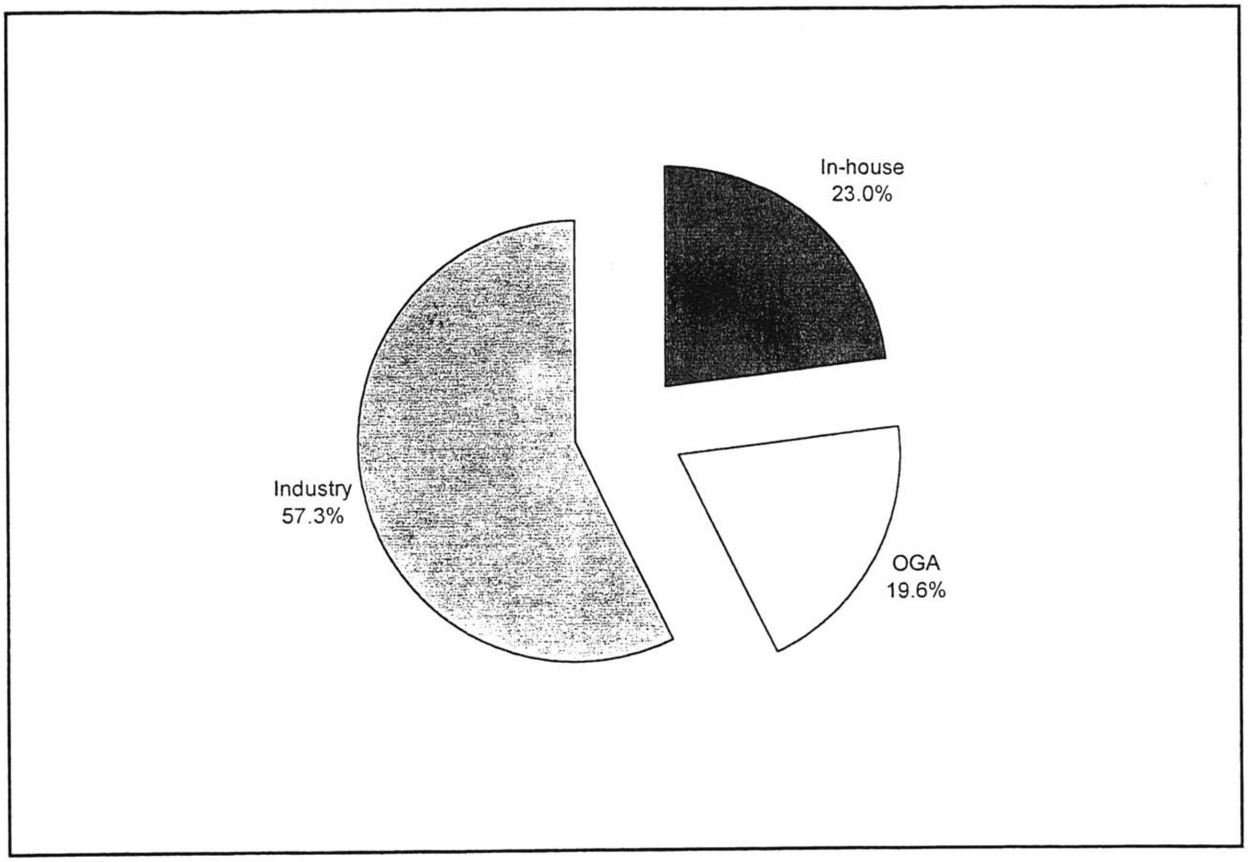

Figure 3.5: Total Design Costs by Performing Activity for DDG-51

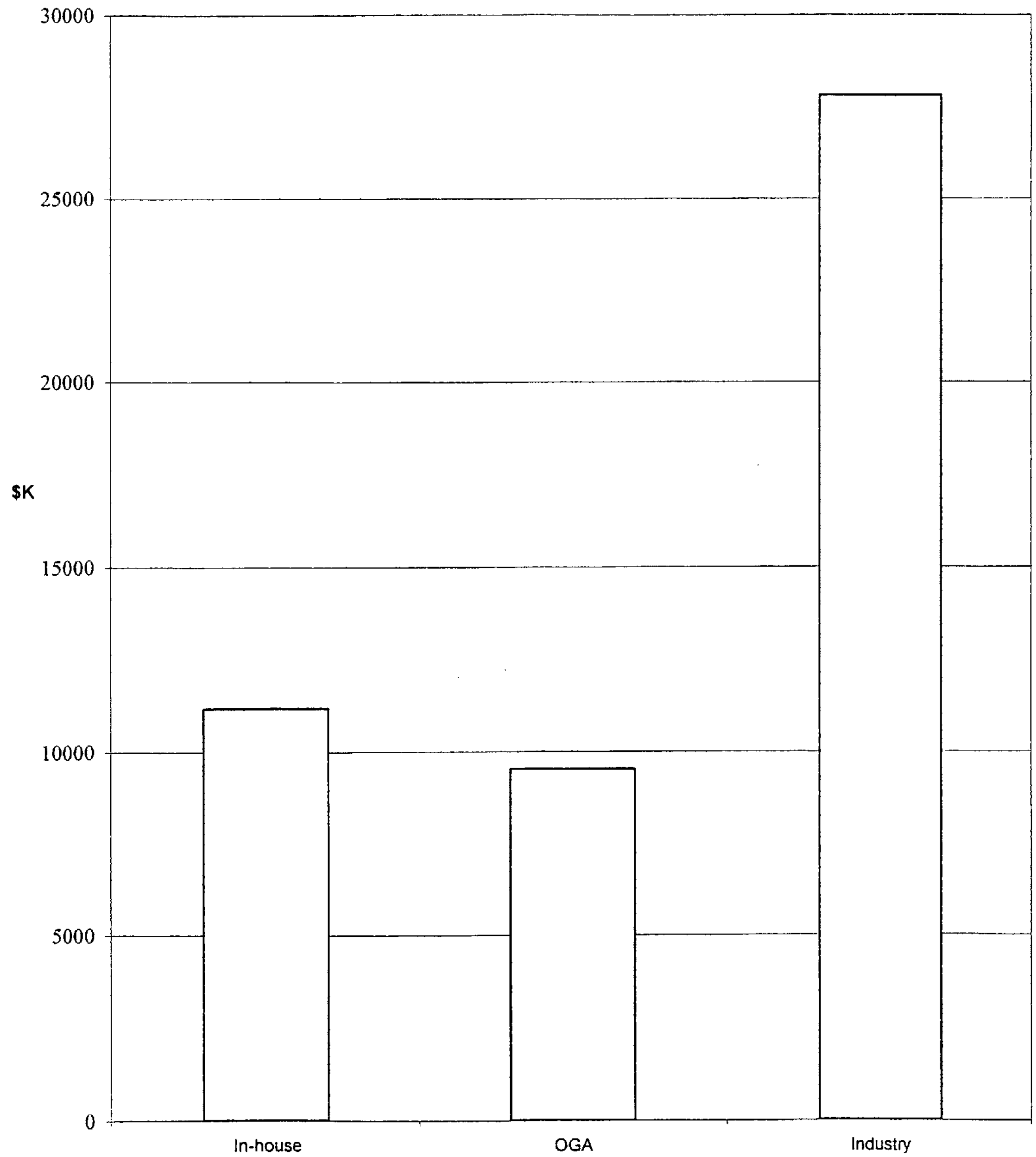

Figure 3.6: Monies Spent Though MS II for DDG-51

by OGA activities. It must be noted here that since consistent numbers were not provided for in-house spending, an alternate method was used. The full-time in-house personnel numbers in mandays were provided for each phase. These values were converted to dollars spent using deflation from the assumed rate of $150K/man-year in FY96. A table of these values is found in Appendix 1.

Figures 3.7 and 3.8 show the cost breakdown by phase. The contract design represented the bulk of the costs with 53%; concept studies represented only 12% of the total costs, even though this phase lasted 44 months of the 68 months it took to get to Milestone II. The preliminary design phase represented about one-third (35%) of the total design costs.

3.3.1 Concept and Feasibility Design Costs

Costs for the concept and feasibility design phase of the program (Phase 0) were just over $6 million as was shown Figure 3.8. Another source shows total spending during this phase of $17.3 M. No further data existed to substantiate this value. It is the estimation of NAVSEA personnel that this value may have included all activities not directly related to the design of the DDG-51. Therefore, the value shown in Figure 3.8, based on the method described previously, is used.

Figures 3.9 and 3.10 show the breakdown of these costs into different activities. During this phase approximately 73% ($4.4 M) went to industry. This is consistent with the fact that a wide range of concepts was investigated during this phase, the majority of which was done by industry. In-house efforts represented almost 19% ($1.1 M) while OGA represented 8% ($0.5 M.)

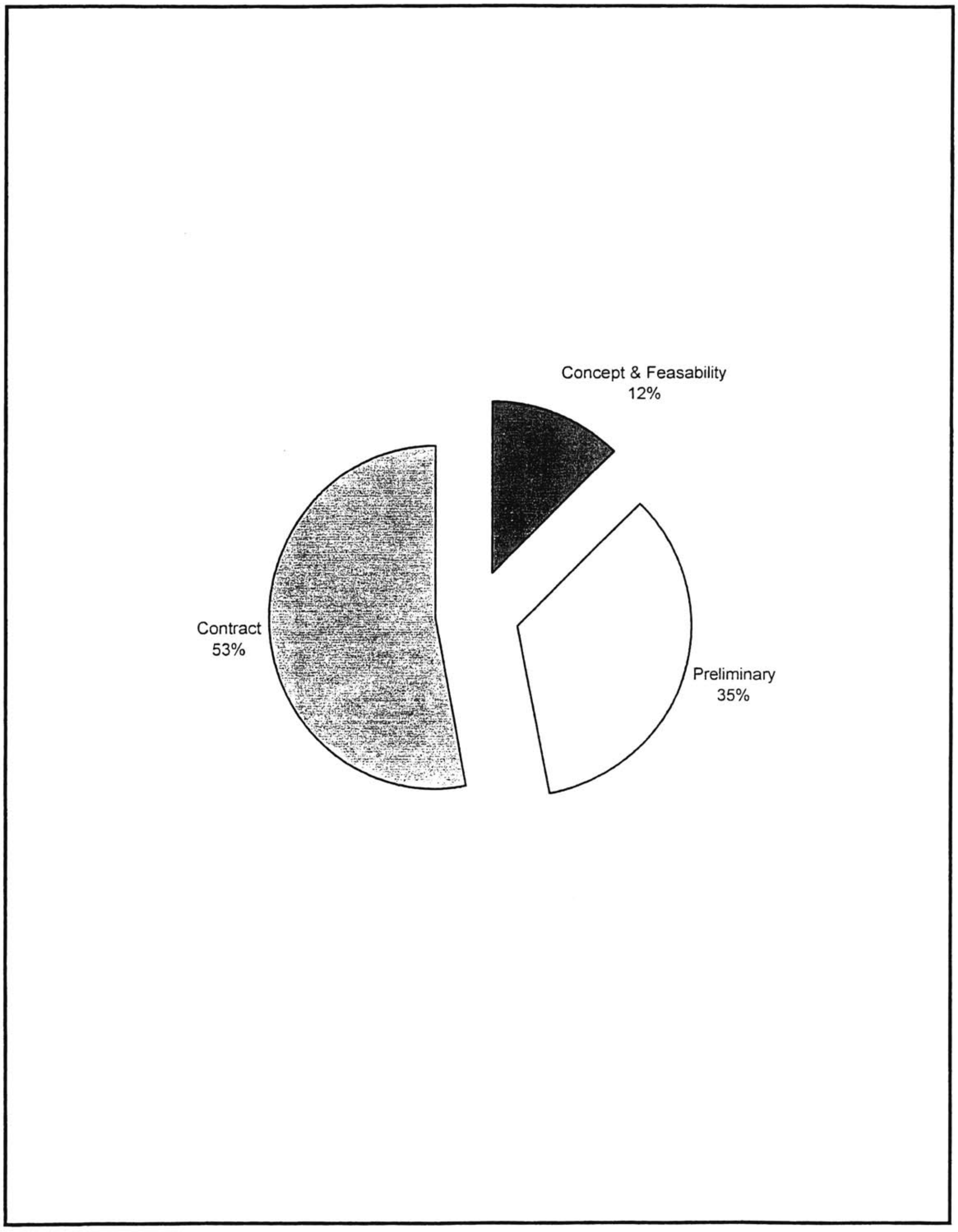

Figure 3.7: Design Phase Allocation for DDG-51

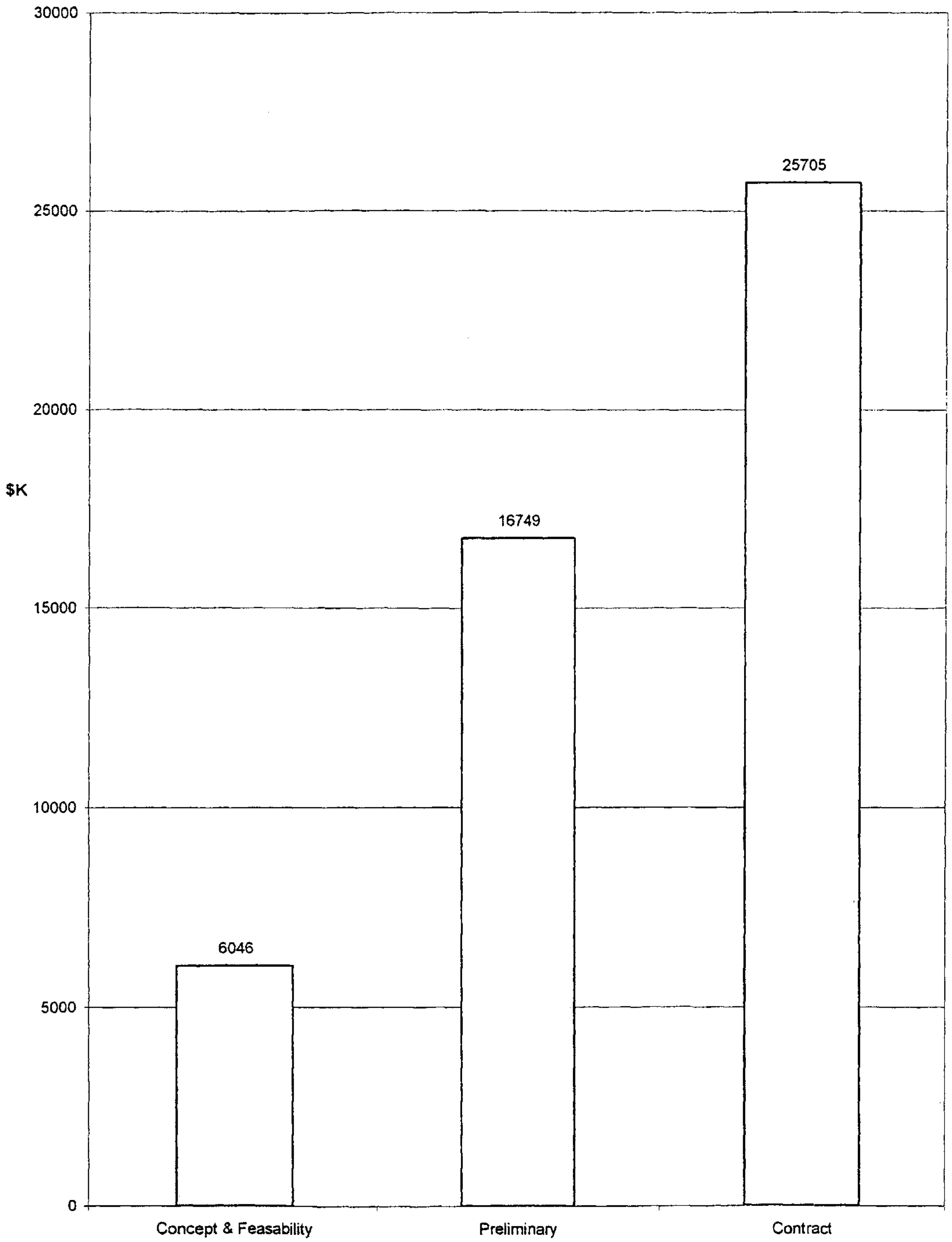

Figure 3.8: Monies Allocated by Phase for DDG-51

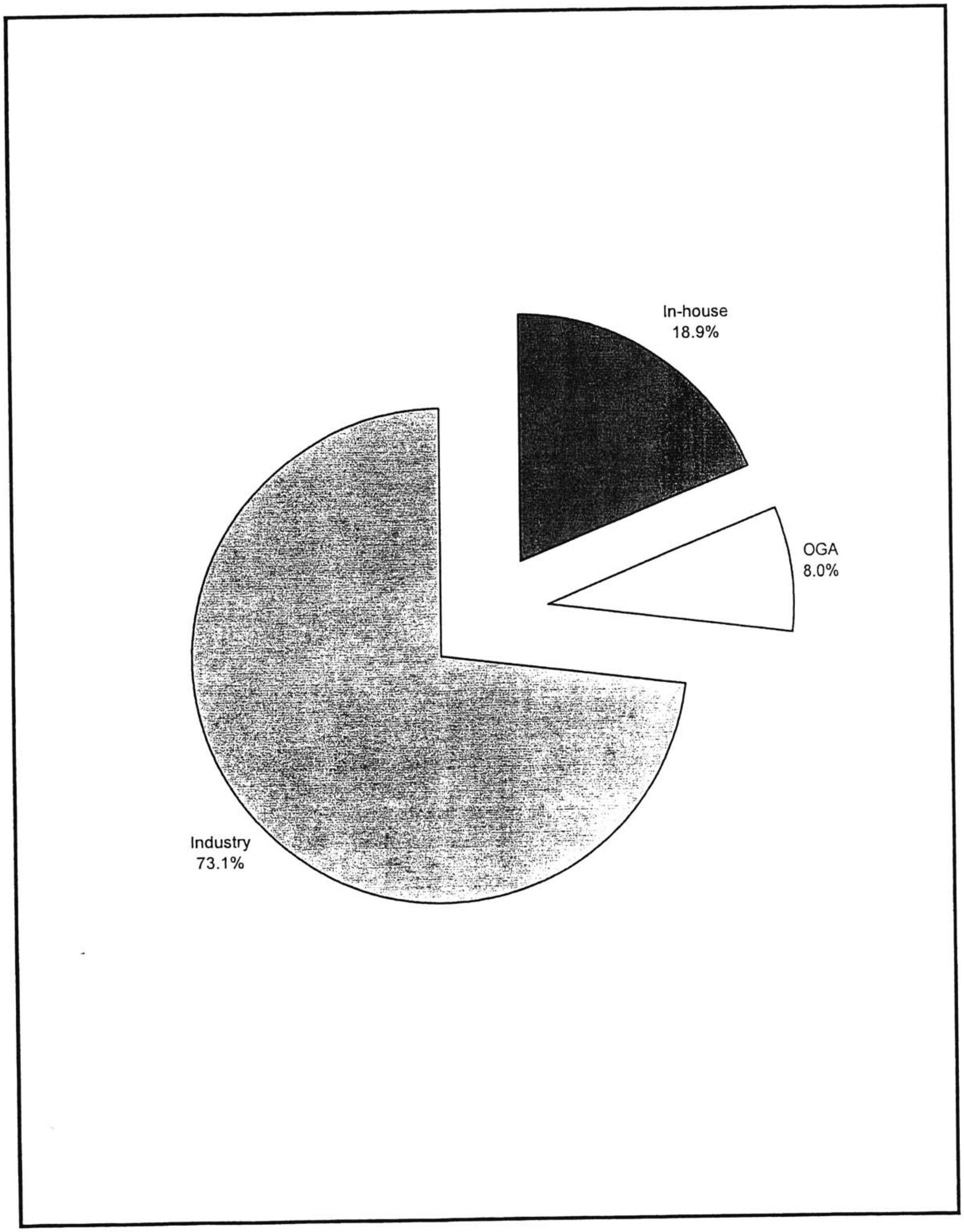

Figure 3.9: Concept & Feasibility Effort for DDG-51

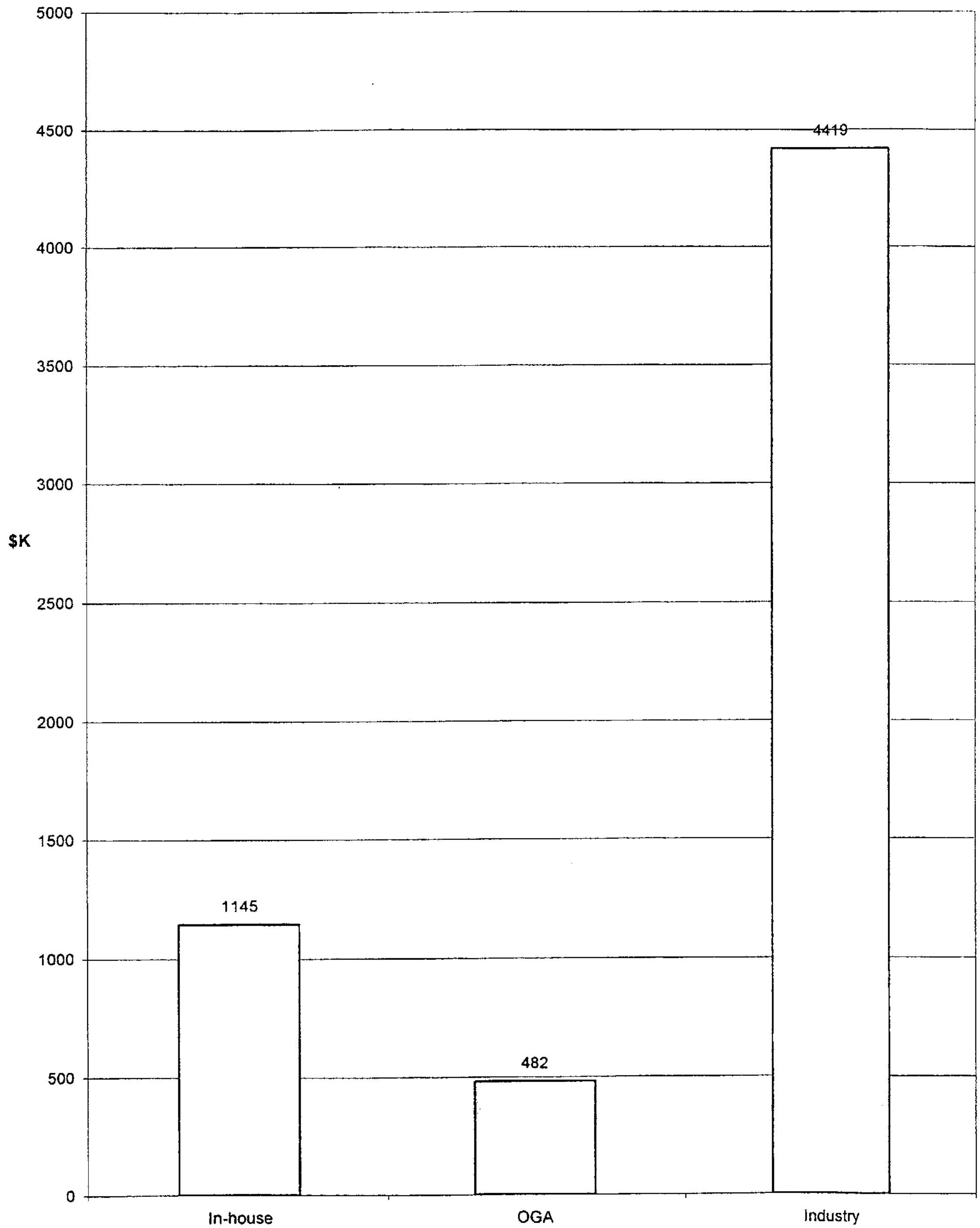

Figure 3.10: Concept & Feasibility Costs for DDG-51

3.3.2 Preliminary Design Costs

Figures 3.11 and 3.12 show total costs to all parties during the Preliminary Design. The total monies spent during this phase ($16.7 million) account for approximately one-third of the total design costs. Both sides of government, in-house and OGA, played a much greater role in this phase than in the concept and feasibility phase. In-house effort totaled $3.8 M, roughly 23%, while OGA spent almost $5 M or 30% of total preliminary design monies. Industry still put forth the majority of effort at 48%, which totaled $8 M. As was the case in the concept and feasibility phase and will be shown in the contract design phase, industry effort typically exceeds in-house effort significantly. This has been the Navy approach toward design over the past twenty years. Several reasons offered for this include:

- The desire to approach industry for solutions as it continues to incorporate new technology
- The shrinking of government agencies
- The need to keep a stable design group

3.3.3 Contract Design Costs

The Contract Design phase amounted to approximately $29.7 million or 53% of the total costs to Milestone II. Figures 3.13 and 3.14 illustrate the breakdown for these costs. In-house effort was approximately equal to the preliminary design phase while the OGA efforts decreased from almost 30% to about 15%. Total monies spent by these activities were $6.2 M and $4.1 M respectively. As was just discussed, the majority of monies went to industry making up $15.4 M or 60% of total contract design costs.

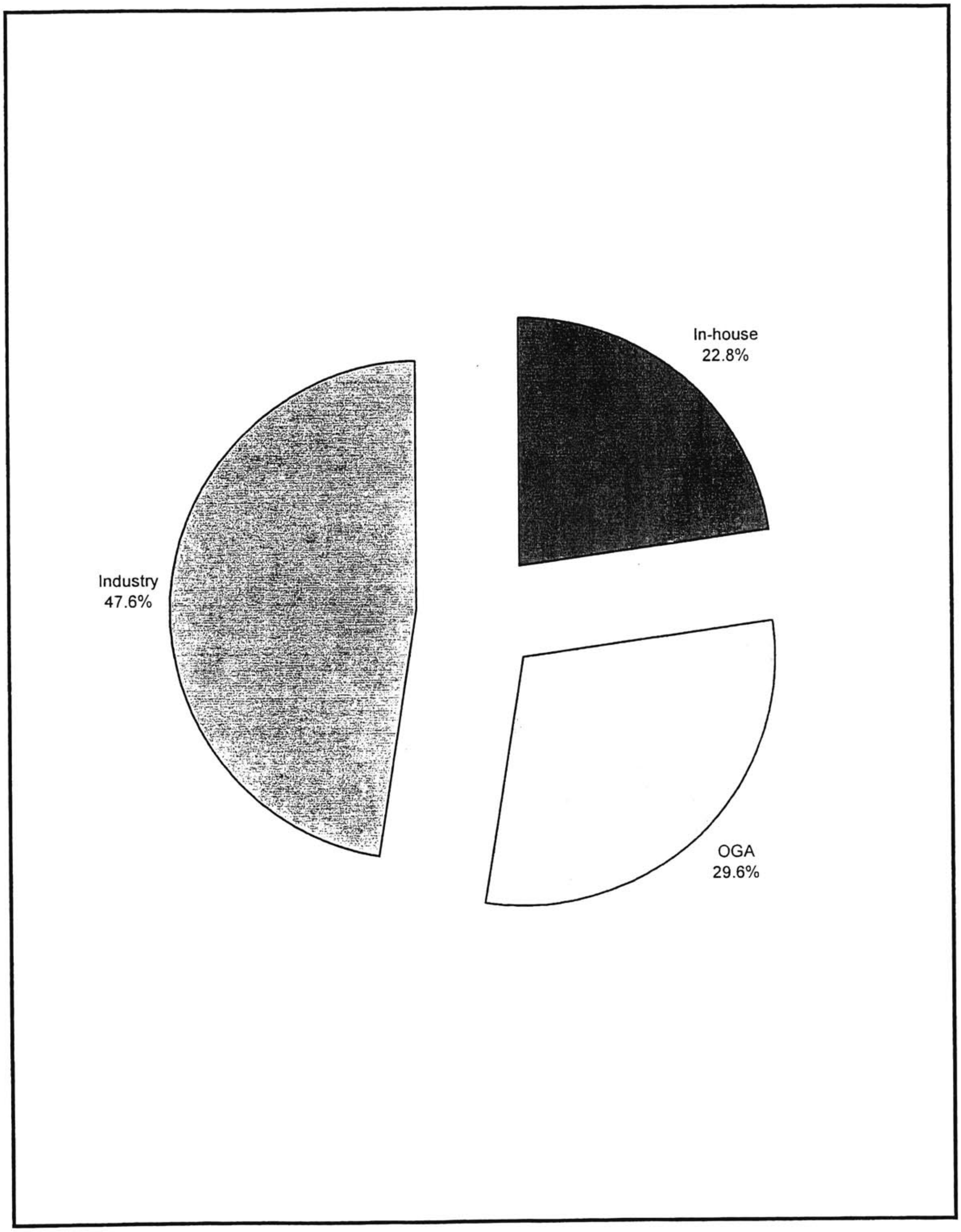

Figure 3.11: Preliminary Design Effort for DDG-51

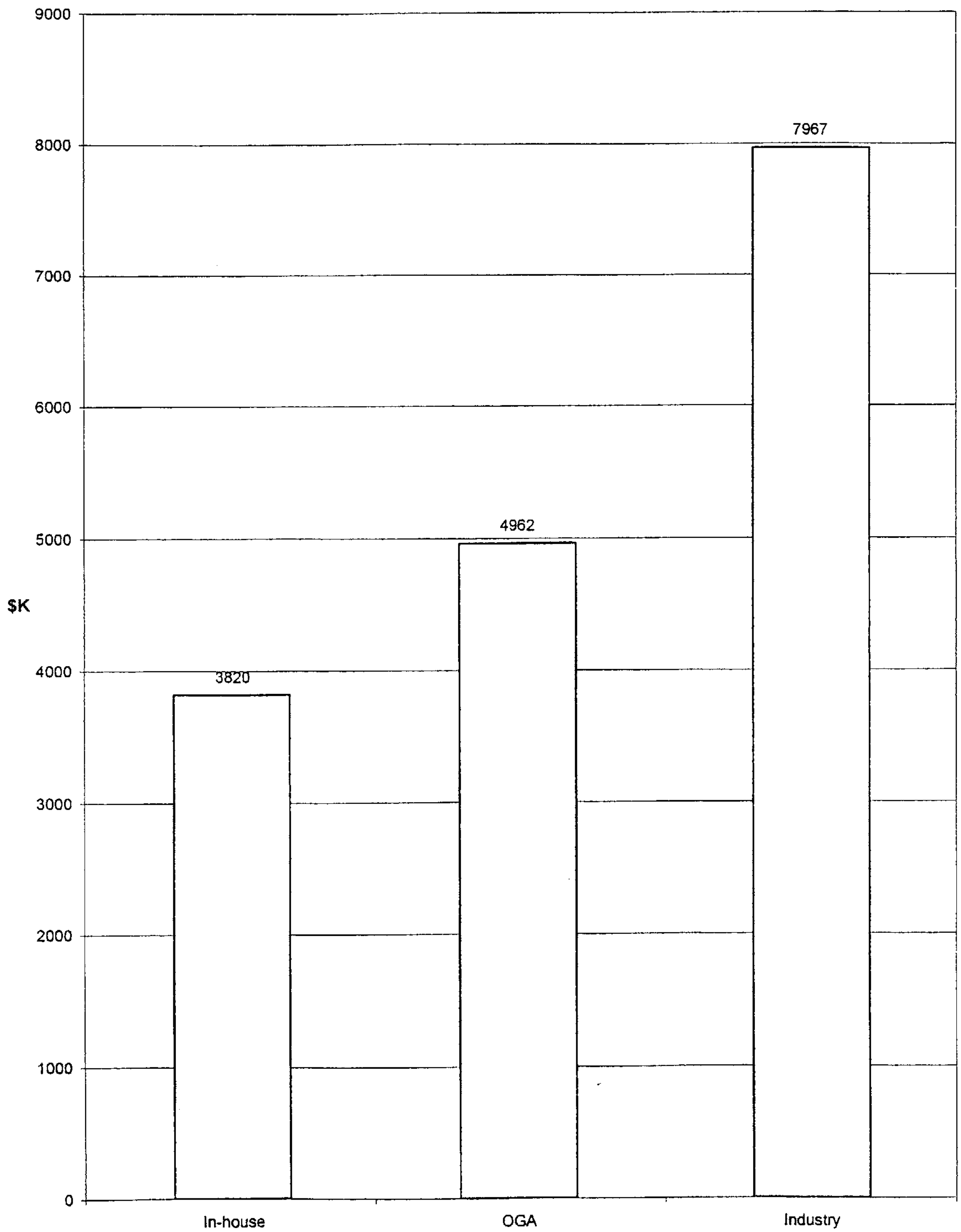

Figure 3.12: Preliminary Design Costs for DDG-51

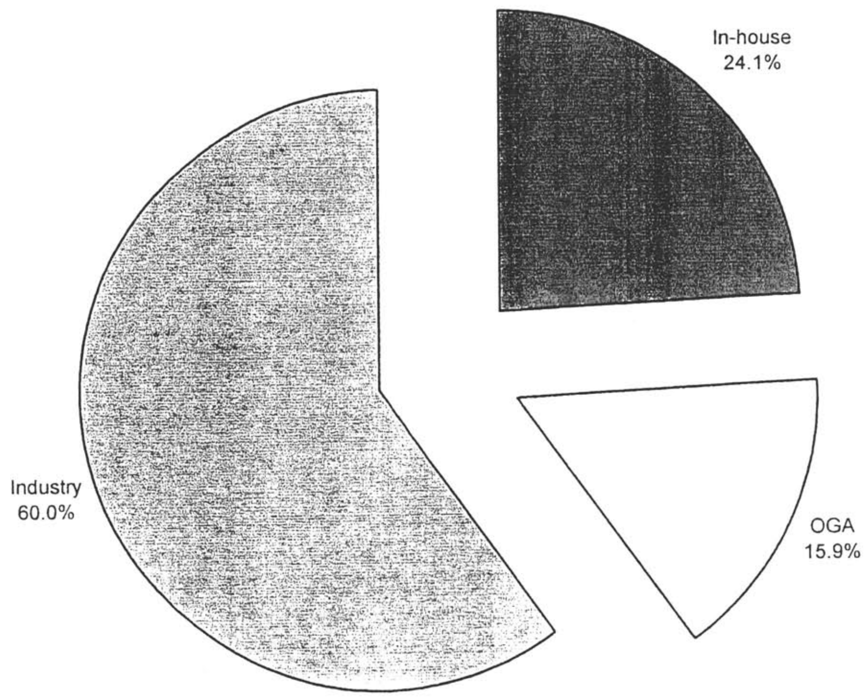

Figure 3.13: Contract Design Effort for DDG-51

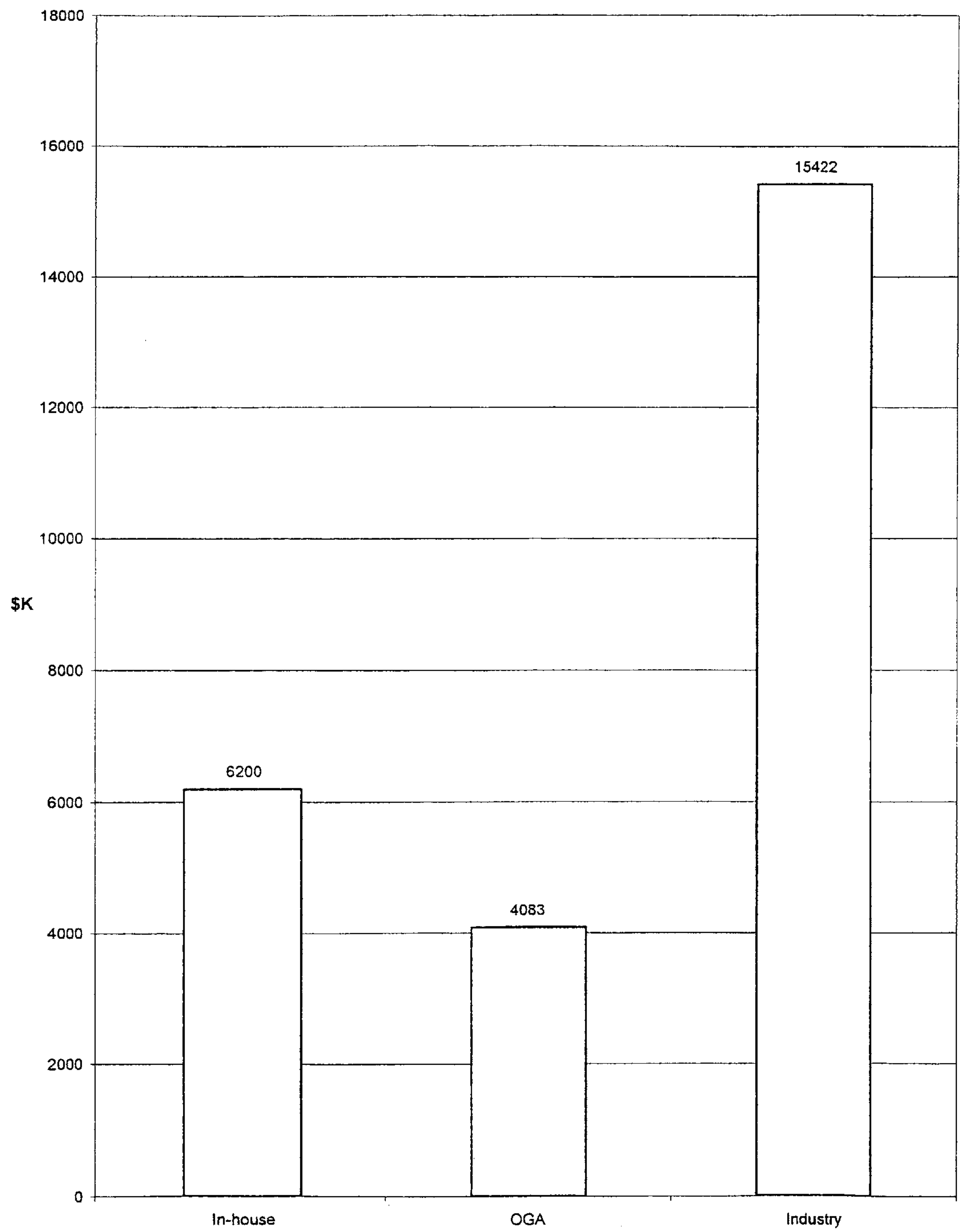

Figure 3.14: Contract Design Costs for DDG-51

3.3.4 Task Group Funding

Key personnel brought on during the each phase in the DDG-51 design were shown in Table 3.4. Figures 3.15 and 3.16 show effort levels by task group for the design. The task groups were broken down into the following: Program Management, Systems Engineering, Hull Engineering, Machinery, and Combat Systems Integration. As was expected, the hull and machinery systems task groups made up the greatest effort with 33% ($19.3 M) and 28% ($16.4 M) respectively. Program Management was the third largest group with 21% or $12.3 M. One surprise for this type of warship was the relatively small amount of monies spent by the combat systems integration group. This group represented only 10%, less than $6 M. Approximately $4.7 M (8%) was spent by the systems engineering group.

Due to the lack of consistent in-house data, effort levels by task group for each phase in the design are not available. However, all task groups were allocated funds as early as concept design.

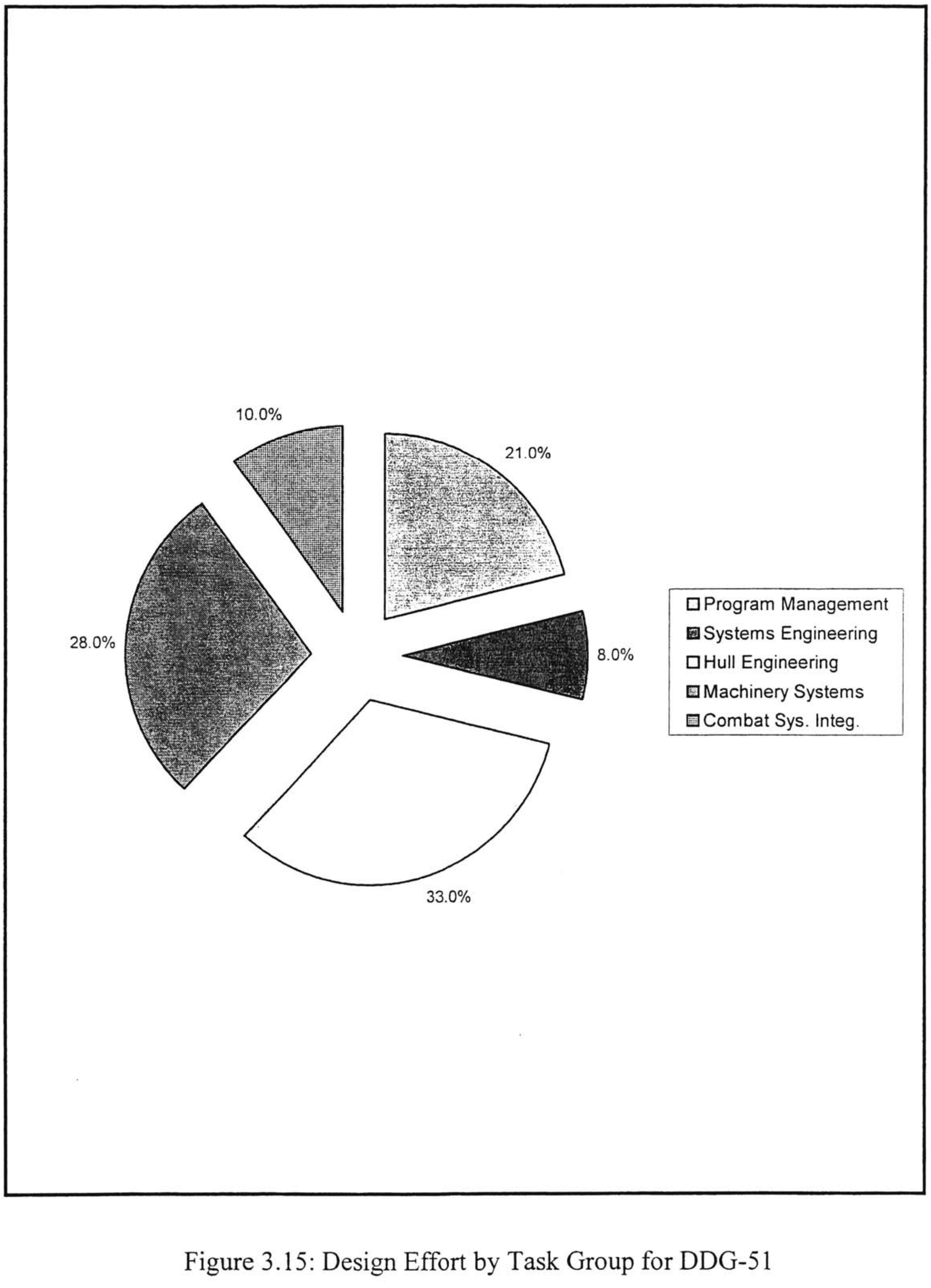

Figure 3.15: Design Effort by Task Group for DDG-51

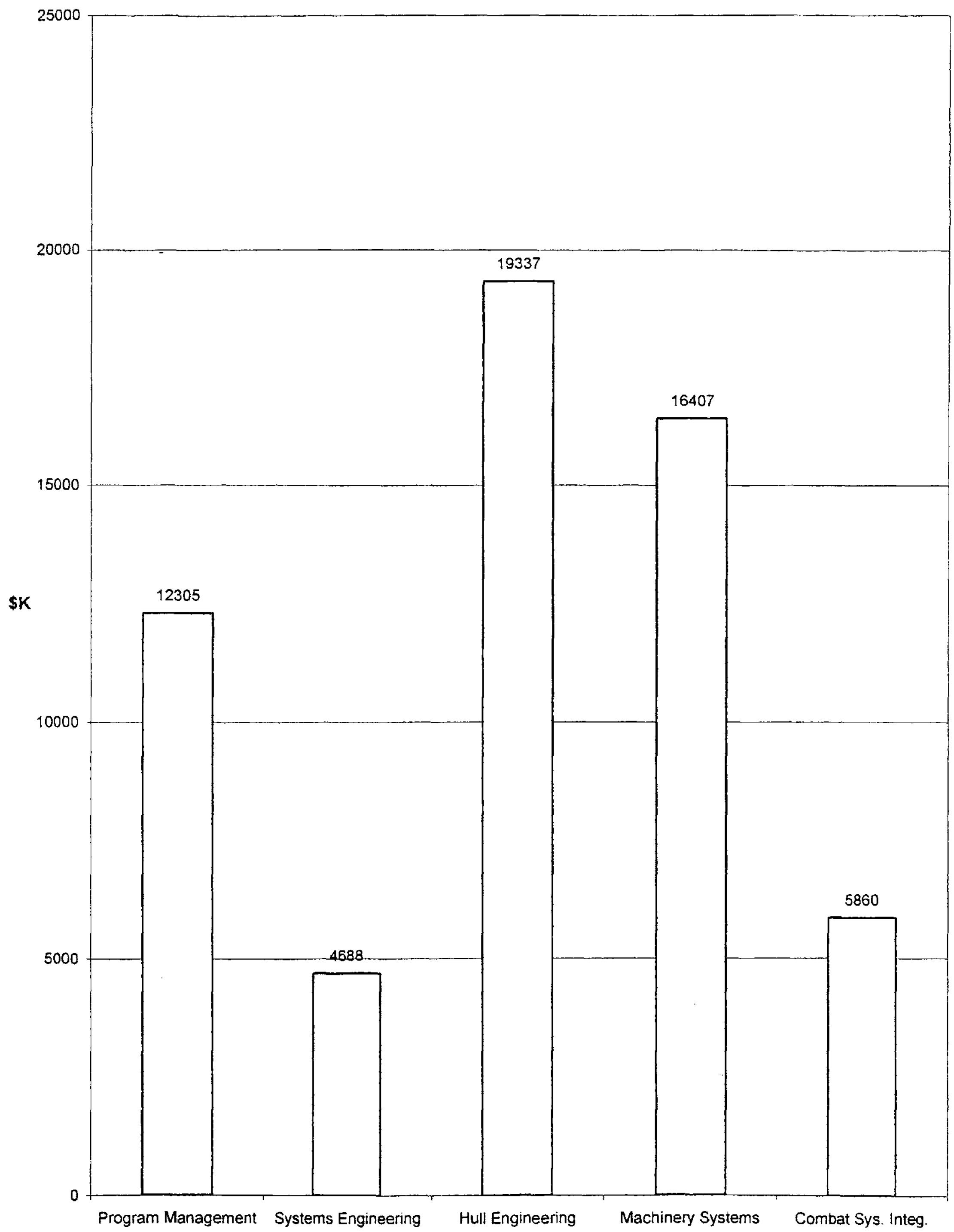

Figure 3.16: Task Group Costs for DDG-51

4 USCGC ICEBREAKER ACQUISITION PROGRAM[2]

Following the Polar Icebreaker Requirements Study in 1984 and issuance of a Mission Needs Statement in September 1984, the Coast Guard initiated the Polar Icebreaker Replacement Program for building the USCGC Polar Icebreaker/Research Vessel, the *USCGC Healy*. Subsequently, the Coast Guard prepared a preliminary design and designated it the WAGB 20 Polar Icebreaker. Its characteristics are provided in Table 4.1. The Coast Guard received the Department of Transportation's approval to continue through the contract design phase.

Table 4.1: Principal Particulars for 460-Ft Contract Design Polar Icebreaker

Displacement, full load (approx.)	17,710 tons
Length overall	459' 6"
Beam	94' 6"
Draft, navigational	32'
Complement	30 scientists + 133 Crew & Avdet
Propulsion	Diesel/Electric (AC-AC Cyclo Converter) 30,000 SHP, 2 screws

Congressional Authorization was provided in FY90 for the construction of one ship with the appropriation of $350 million. Funding for the ship came from Shipbuilding and Conversion, Navy (SCN) funds. As a result, representatives from OMB, DOT, OSD, Navy, and the Coast Guard decided to direct the Navy to procure the ship. PMS373 was chartered to carry out the program and was jointly staffed with seven

[2] Parts of this chapter were taken from J. Tuttle's and H. Marcus's case study, USCGC Healy (Reference 4.)

Navy and six Coast Guard personnel, managed by a Coast Guard captain. The Coast Guard captain was there to ensure the Coast Guard's goals were not compromised. His primary functions were to balance costs, schedules, and performance.

4.1 Original Acquisition Strategy

The acquisition strategy for the *USCGC Healy* had two distinct parts. The first attempt reflected the "old way of doing things," similar to the DDG-51 program where the Navy developed a contract design, sought sources for detailed design and construction through a Commerce Business Daily (CBD) announcement, issued RFPs, and awarded the contract. However, in the spring of 1992 the Naval Sea Systems Command was forced to cancel the solicitation due to affordability issues. Nevertheless, there was still enormous support for the program from the Navy, Coast Guard, and Congress. In April of 1992 a team was organized to rethink the technical and programmatic approach for this acquisition. As a result, the contract for detailed design and construction of a Polar Icebreaker was awarded to Avondale Industries in July of 1993. The following sections discuss the failures of the first solicitation, regrouping efforts, and the revised, and successful acquisition approach.

Shortly after the formation of PMS373, the Coast Guard contract-design package for the WAGB 20 Polar Icebreaker was reviewed by NAVSEA to determine whether it met Navy standards as buildable, biddable, and ready for release as part of an RFP. In March 1991, over a dozen RFPs for detailed design with an option for construction were sent to prospective shipyards. Only two shipyards submitted proposals, Avondale

Industries, Inc. and Ingalls Shipbuilding Division of Litton Industries. The limited response was due to the perceived risk on behalf of the shipyards for only one contract, the lack of space available at some yards to construct a vessel of this size, and a loss of interest by one yard after learning it had to use the government's design instead of its own.

In August the Assistant Secretary of the Navy (ASN) gave Milestone II approval and in September 1991 the Under Secretary of Defense for Acquisition approved the contract type, Fixed Price Incentive. Proposals were received in October 1991, and the source selection process commenced shortly thereafter. Discussions were initiated in December and closed January 31, 1992. At that time, Best and Final Offers were requested. The original procurement time line is shown in Figure 4.1.

4.2 Design Strategy

The preliminary and contract design for the *USCGC Healy* were developed in-house by a USCG design team, with additional support from the joint USCG/Navy team under PMS373 to bring it up to Navy standards. This was a major reason why the first solicitation failed. Prominent American shipbuilders had grave reservations about the producibility of the 460-ft ship. They stated that the design had little shipbuilder influence; therefore, they believed it seriously lacked modern producibility considerations. They cited the expensive use of compound curvature in the hull, and the

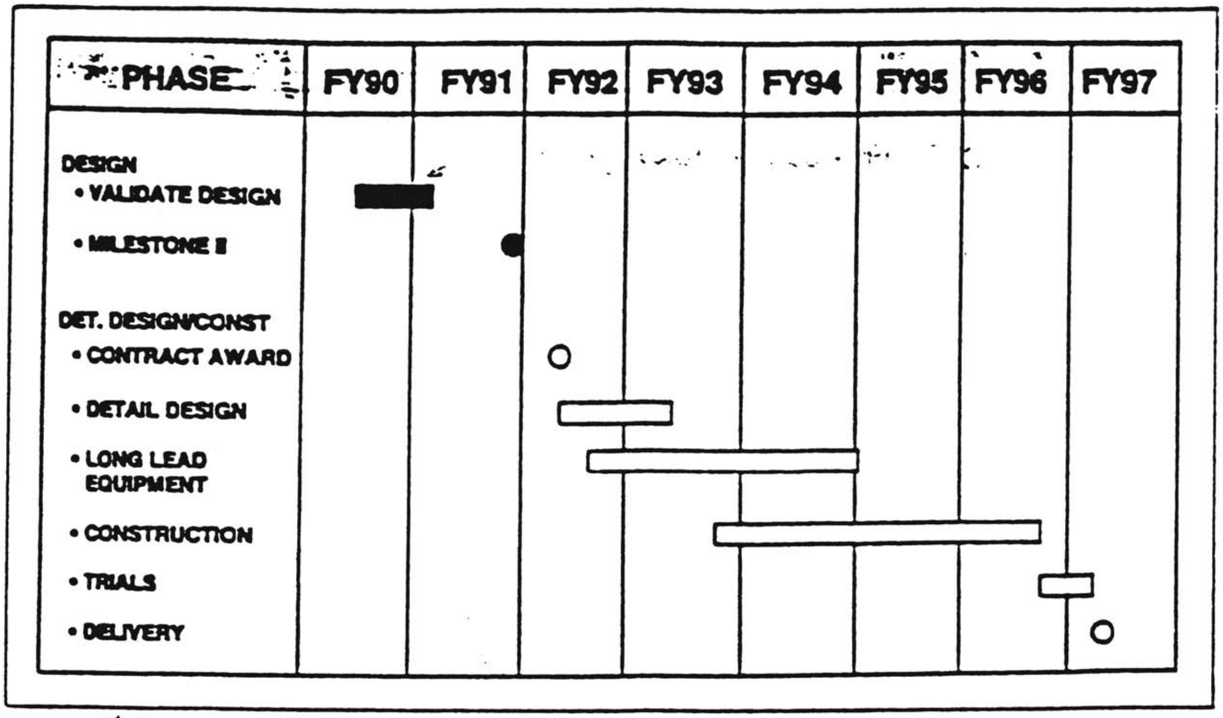

FIGURE 4.1 Original Procurement Timeline

fact all major ship's distributive system diagrams, provided as contract guidance, were unsized. They believed the production would be painful and very expensive. As a result, bid prices received exceeded the appropriated funding. Since money was limited, a recommendation was made to cancel the solicitation. The official notice was issued in March 1992.

Additional failures related to the design strategy include the perceived risk by the shipbuilders in building a one-of-a-kind ship with technology not in common use in the American marine industry. Documentation requirements in the solicitation such as the requirement for finite element analysis were viewed as indicators of higher risks than normal. Finally, a large number of major components were virtually sole-sourced which stifled competition between vendors.

4.3 Second Acquisition Strategy

In April 1992, it was determined that the project's cost, as represented by the average of the two responsive bids previously received, had to be reduced by approximately $100 million to make the ship affordable with the available funds. Further pressure came from the DoD's reissuance of the policy 5000 series instructions that would require further documentation. In addition, the need to reduce the operating tempo of the two operational polar icebreakers, USCGC's *Polar Sea* and *Polar Star* also added pressure.

A team approach was developed to rework the Coast Guard Sponsor's Requirements, rewrite the specifications, and develop an acquisition strategy. Members of the three teams were all in-house personnel. Senior members of one team would also be members of other teams. The organization of these teams is shown in Figure 4.2.

One interesting note is that, compared to a normal USCG acquisition program, the program manager had an unusual amount of freedom to choose, and later remove, team members. A "core" team of eight persons met almost daily to discuss progress on the three interlocking teams.

The new acquisition strategy focused on cost reduction and time compression. In order to achieve these goals, competition was limited to Avondale and Ingalls since these were the only yards that sent proposals for the 460-ft icebreaker and, therefore, had expended considerable effort already. Furthermore, another full and open competition would likely result in no additional competitors and would be fatal to the program. Figure 4.3 illustrates this point. In addition, it was decided that on-site government personnel during early stages of design development were important. These personnel were organized into Specification Reading and Review Conference (SRRC) teams.

The contracting approach was also unique in this program. In rewriting the contract, two options were considered: option 1, the standard contract design approach; option 2, a modified "quick-time" approach. The main reason supporting the standard design approach, which would involve full and open competition, was that the shipyards' main experience was in detail design and construction. Furthermore, presenting the yard with a design to build gave PMS373 significant leverage. However a highly detailed

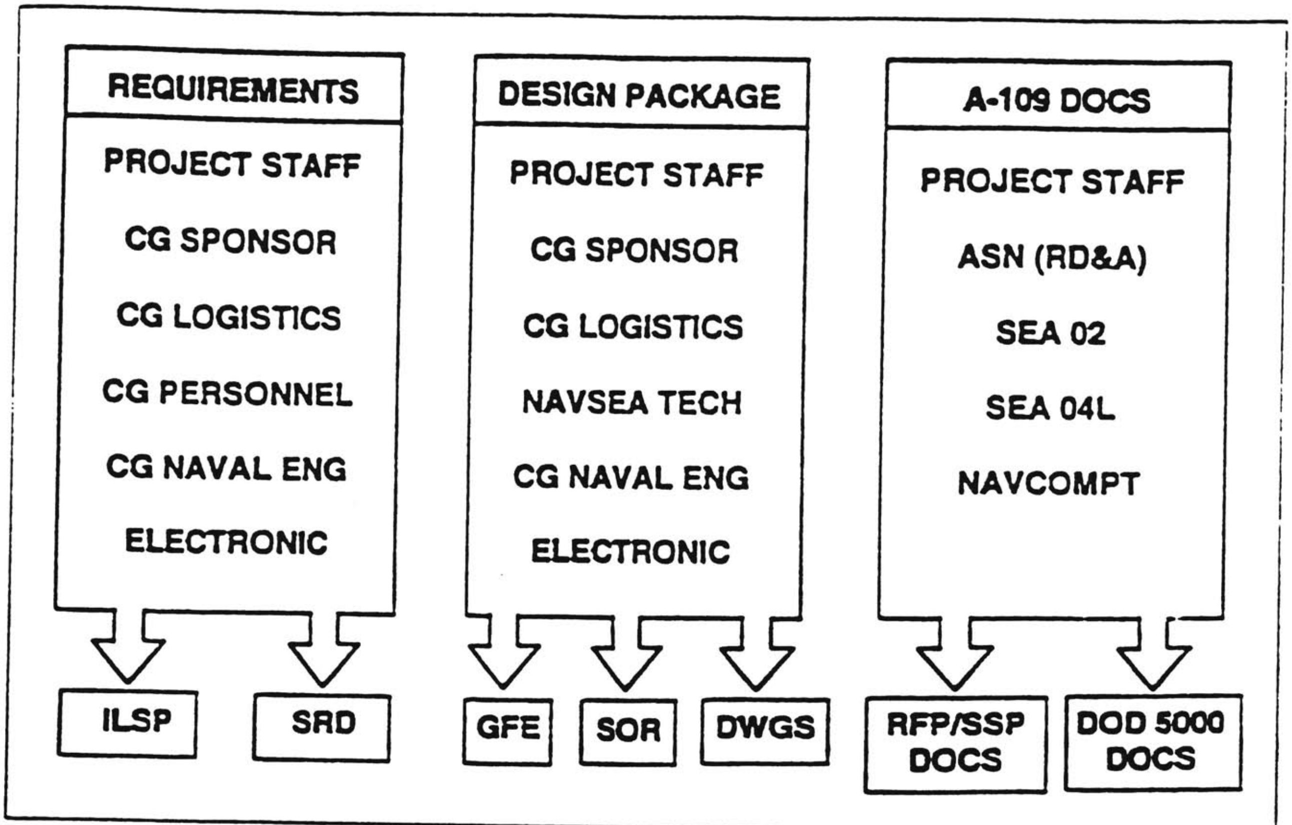

FIGURE 4.2 Polar Icebreaker Team Approach and Support Matrix

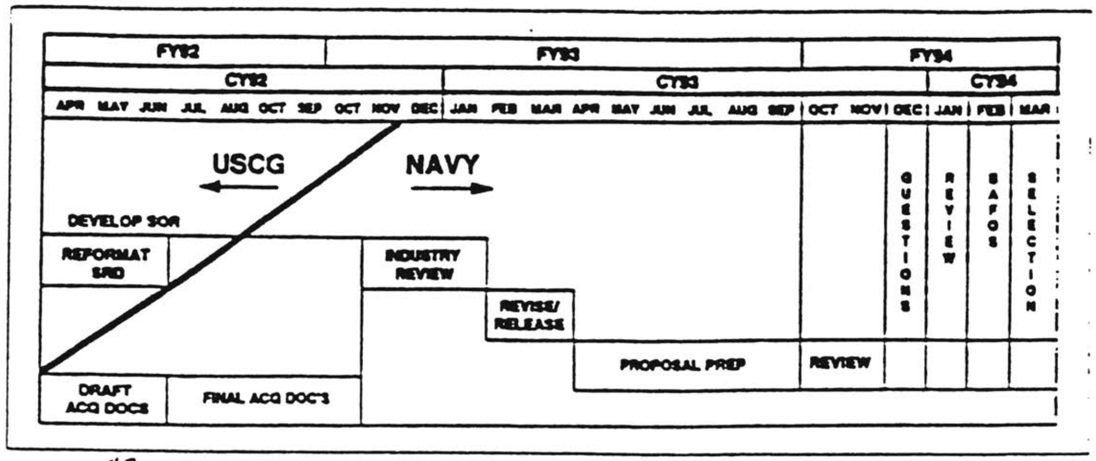

FIGURE 4.3 Full and Open Competition Schedule

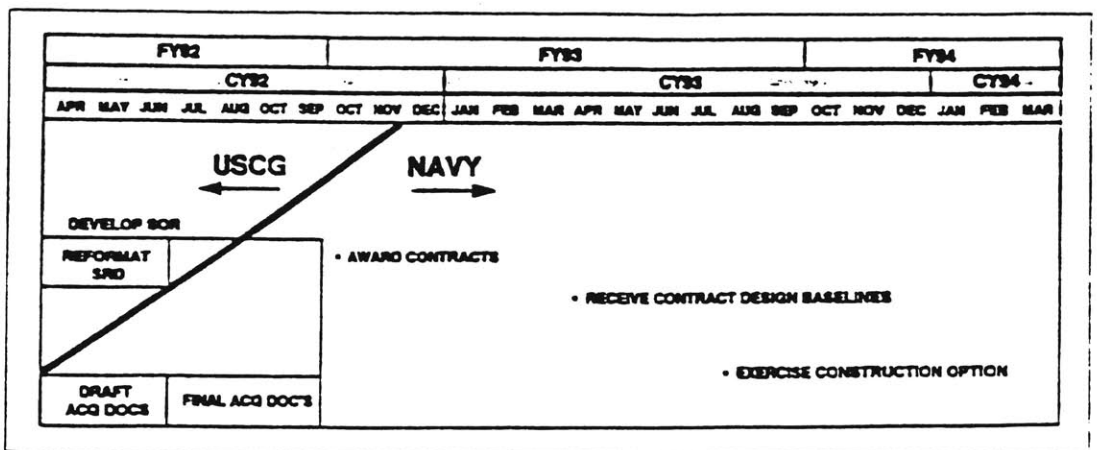

FIGURE 4.3 Limited Competition Schedule

design issued by PMS373 may overburden the shipbuilder financially. The alternative was to allow the yards to come up with a design based on a government proposal. This meant PMS373 would have to clearly define their needs (in terms of performance-based requirements) to guarantee a desirable final product.

There were two major drawbacks to the contract design approach. First, time was playing against them. It was estimated that 12-19 months would be required to execute a new contract design. Second, there was no assurance that the costly producibility problems from the first solicitation would be overcome.

The alternative contracting method used two phases. The first phase of the contract included awarding each yard $200K to develop an Engineering Design Baseline (EDB) which was roughly between preliminary design and contract design. The government planned to review the EDBs during source selection to insure the EDBs could meet requirements. Each yard was then invited to submit a proposal for the Detail Design and Construction option for an EDB-based vessel. The second phase would begin after exercising the contract option of the successful yard.

Instead of opting for the lowest bidder, as has been done historically, the EDB competition proposals were rated from a "Best Value" perspective. This meant the best technical design and price combination. Thus, proposal reviewers could exercise judgment and score on a descriptive rather than a numeric scale. The downside to this approach was that it required more documentation of the evaluation process. In reality, the contractors did not like the Best Value approach since they did not know whether technical or cost standards were more important to the government.

As was mentioned earlier, the SRRC approach was considered a cornerstone to this acquisition strategy. On-site teams of government personnel were available to answer technical questions, clarify requirements, and evaluate proposed technical solutions. Technical personnel at NAVSEA controlled the flow of information to both yards without compromising design ideas from either. This was risky, but highly effective. The presence of on-site teams had several advantages. First, open discussions allowed quick solutions to simple problems of interpretation. Second, both the government and contractor had opportunities to influence the design process early on and head off problems that could cause delays later. Third, it promoted good working relationships and reduced the adversarial process that often occurs.

This approach, however, had its shortcomings. First, a significant amount of technical personnel at NAVSEA were needed to ensure both teams got the same information without compromising the competitive design of either yard. In this process, government personnel from one team were not allowed to discuss progress with their colleagues working on another team. They also took no part in the final design selection for contract award. In addition, skilled government personnel were needed at "headquarters" to oversee progress for both teams and protect against unfair informational advantages. Finally, it was vital that all elements of the shipyard's organization participated in the early stages. Otherwise, lack of commitment could become a problem in the next phase.

Reading sessions on the revised SOR took place in late August. The revised SOR had an emphasis on commercial standards as opposed to MilSpecs and Standards. Time constraints prohibited the reading of the whole specification. Approximately one-third was read with an emphasis on the sections that either changed during the rewrite or had the most operational impact. In hindsight, this was a serious error since many inconsistencies were found in later phases of the project. The review process was slow, but was really the only way to properly perform a review. The process was also an excellent way for SRRC team members to come up to speed on sections which they were not directly involved with rewriting.

After a post-award conference in Gulfport, Mississippi where the yards were given the official SOR, the two SRRC teams were dispatched to each yard. The speed with which questions were fielded, reviewed, and forwarded and responded to was crucial for this process. Responses were communicated in less than 10 days. The SRRC process was superior to the standard clarification scheme since it allowed the government to help open communication and sped up the design process. Both shipyards asked more than 1200 questions overall; 600 of these were common. Approximately 400 changes were made to the SOR due to these questions. The SRRC averaged twenty-two questions per day and on some days as many as fifty. One shipyard believed it was able to lower its bid by $35 million because better understanding of requirements reduced their risk.

Designs and pricing proposals came in April 1993 and review started almost at once. An award was made on July 15, 1993. Information on the change in bid price from the original offer is shown in Table 4.2.

Table 4.2: Change in Bid Price from Winning Shipyard

	ORIGINAL BID	FINAL BID
Length	460 feet	420 feet
Light Ship Displacement (less all margins)	11,547 LT	10,909 LT
Total Costs	$276.9 Million (1991)	$229 Million (1991)

4.4 Development Costs of the USCGC Icebreaker Program

Due to the unique circumstances of the USCGC Icebreaker program, the format of the new acquisition reform divisions has been applied in the following way:

Pre-Phase 0: 1973-1978

Phase 0: 1978-March 1992

Phase I: April 1992 – August 1992

Phase II: September 1992 – August 1993

Under this format, costs incurred during the first acquisition attempt are included in Phase 0. Pre-Phase 0 costs included feasibility studies from the first acquisition attempt. Phases I and II are as described above.

Figures 4.4 and 4.5 illustrate total costs up to contract award, relative to the total program budget for the acquisition of one ship. The total ship budget was $350 M. Total costs up to contract award were $12.5 M. Design costs represented less than 4% of the total acquisition budget. Thus, as is the case with most surface ship acquisition programs, the design is a small factor of the total program costs. However, it is important

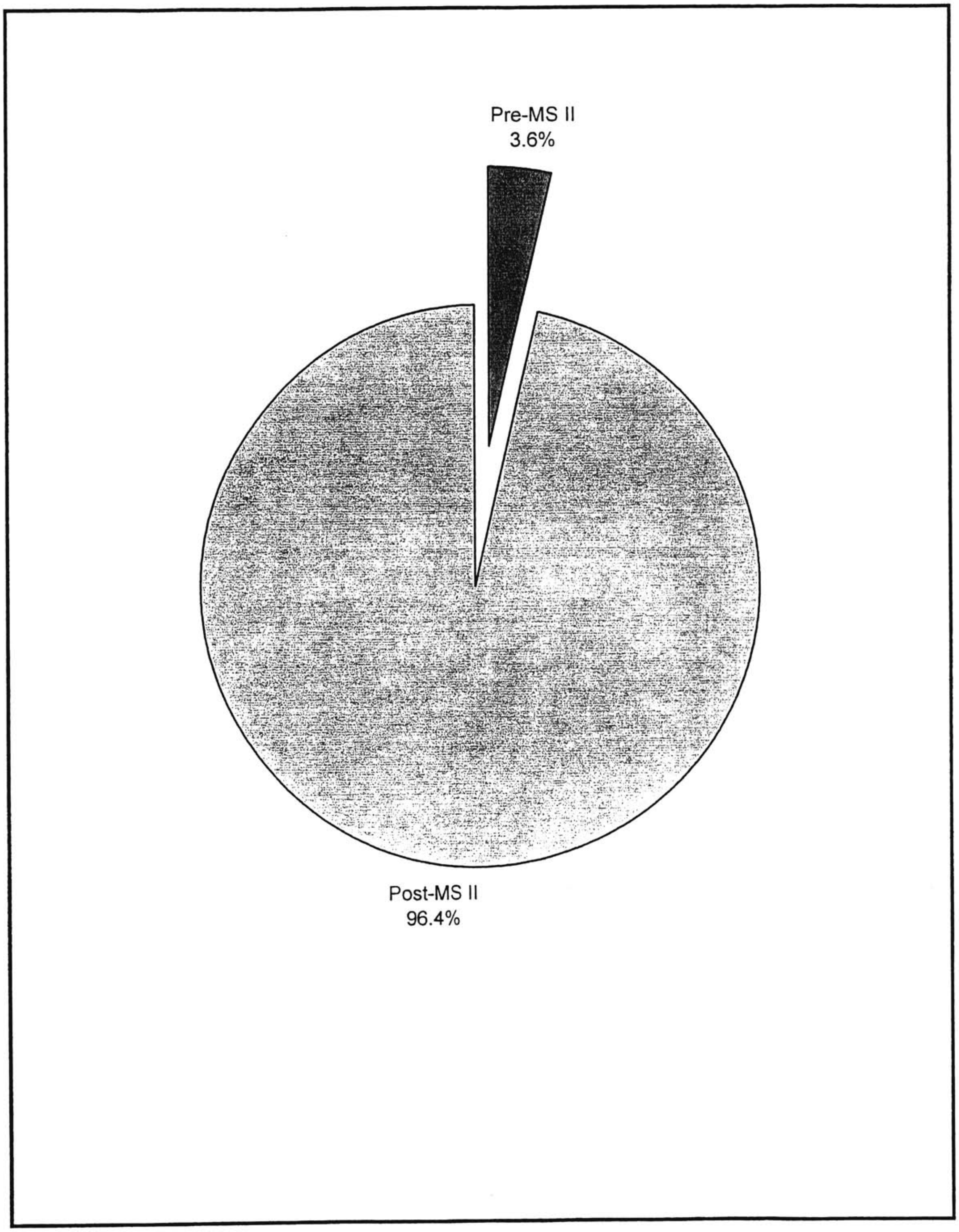

Figure 4.4: Icebreaker Design Costs as Percent of Total Program Costs

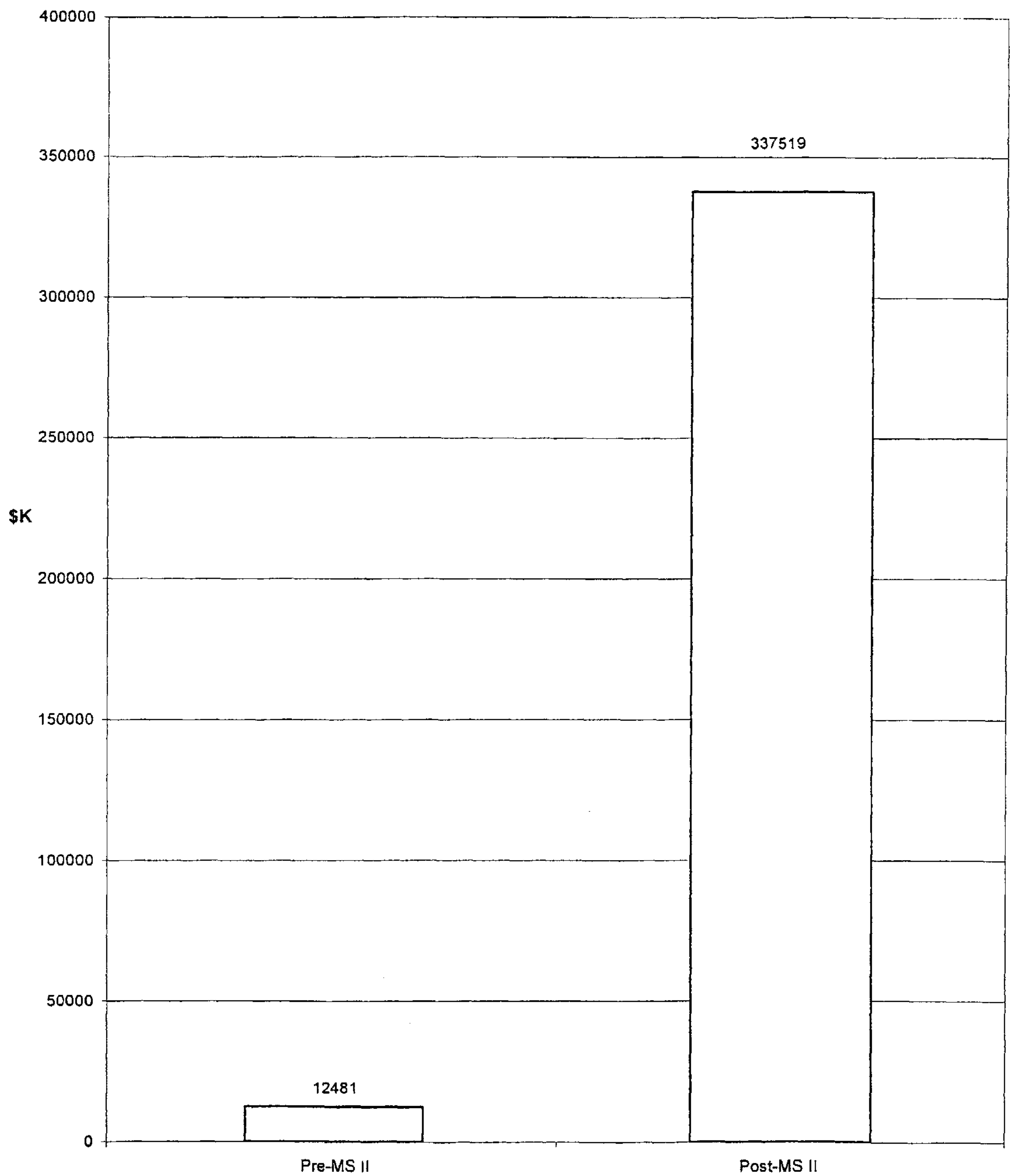

Figure 4.5: Total Design Costs for Icebreaker

to keep in mind that by Milestone II approximately 80% of total costs for the remainder of the program are fixed. Therefore, greater efforts made during the initial phases, and therefore a greater slice of the pie, may in fact reduce the overall size of the pie.

This was seen to a certain extent during the second attempt at acquisition. By involving the shipyards in the design of the vessel, a design that was easier to produce resulted, and the shipyard was able to shave $48 M from the bid price thus reducing the overall size of the pie.

Figures 4.6 and 4.7 show the cost breakdown according to the assumed phasing. One item to note is that there are significantly higher costs up front because this represents a total attempt at acquisition by applying "the old way of doing things" that was ultimately unsuccessful. Ignoring the Phase 0 costs for a moment, the trends illustrated by the other phases are consistent with other programs examined in this thesis. More money is spent as the program moves closer to the award date.

One lesson learned here, that will be brought up again later, is the fact that in the initial acquisition program, approximately $9.5 M was spent but did not result in a contract award despite the overwhelming support from all sides. As a result, the government needed to spend an additional $3 M to have a successful contract award. By spending a little more up front, the end result was a vessel that was indeed biddable and buildable. This additional $3 M resulted in a cost savings of $48 M. That is a significant return on investment!

Figures 4.8 and 4.9 illustrate the cost breakdown between government and industry. In this case, government included PMS 373, Acquisition Icebreaker (AIB)

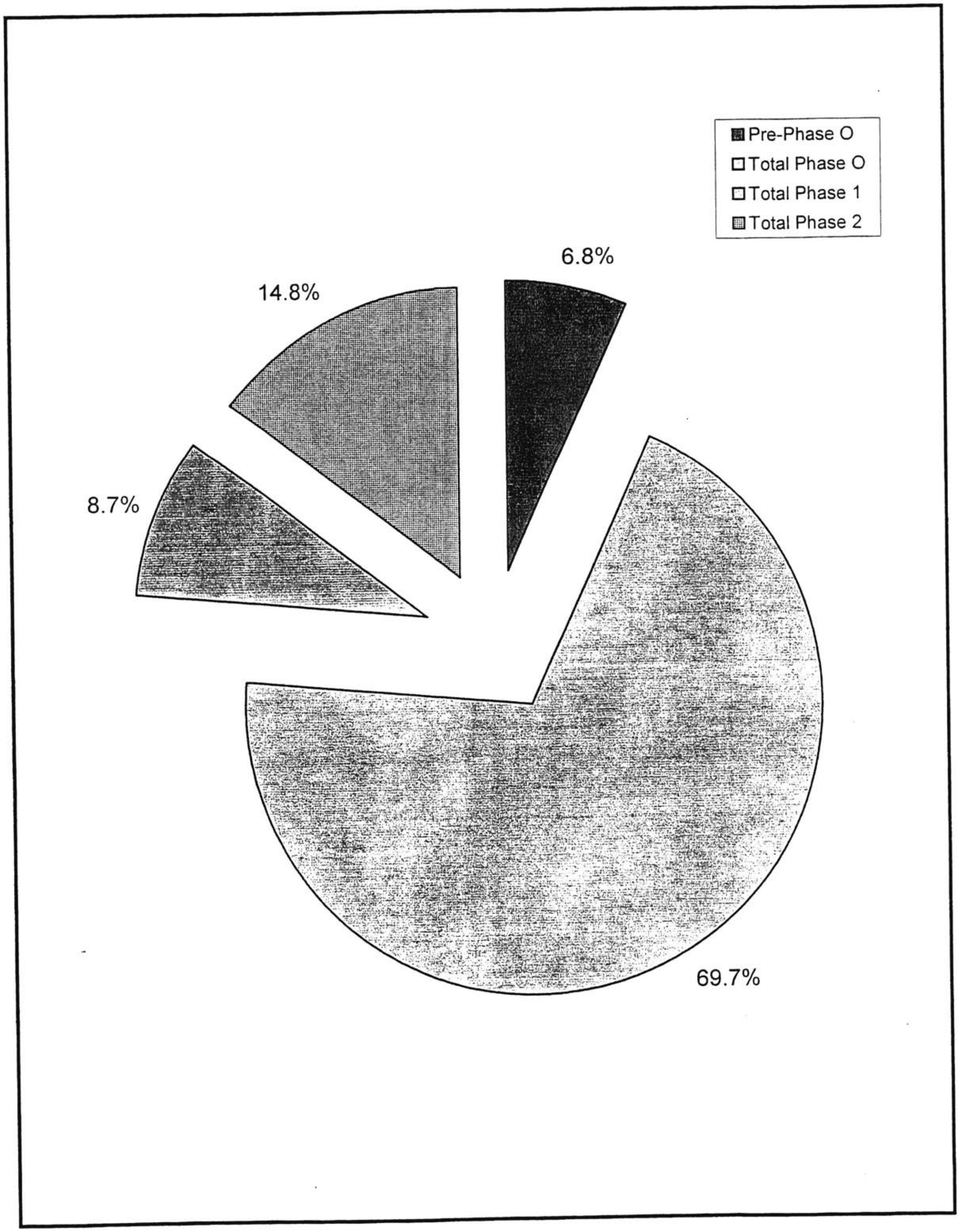

Figure 4.6: Phase Breakdown for Icebreaker

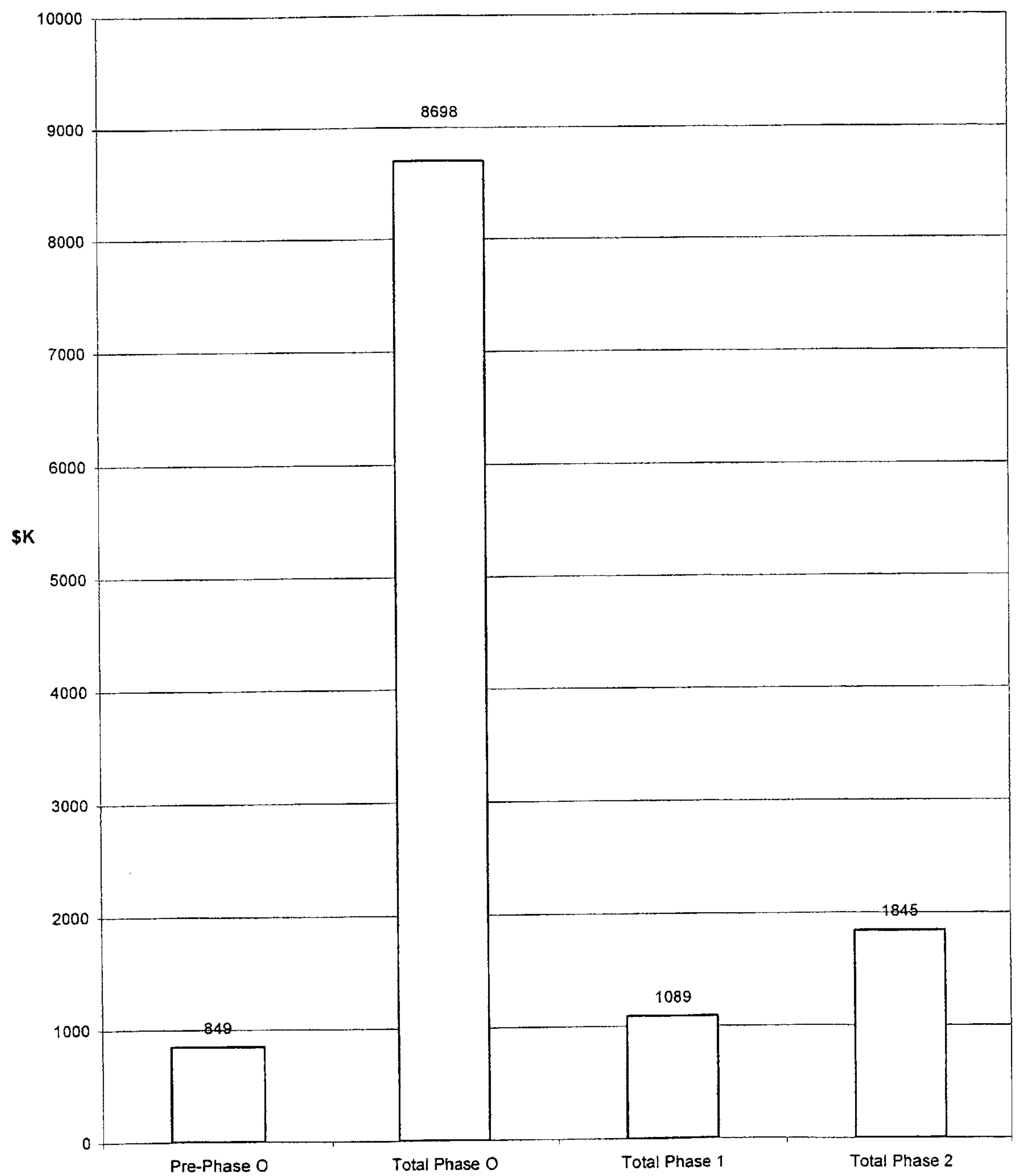

Figure 4.7: Costs by Phase for Icebreaker

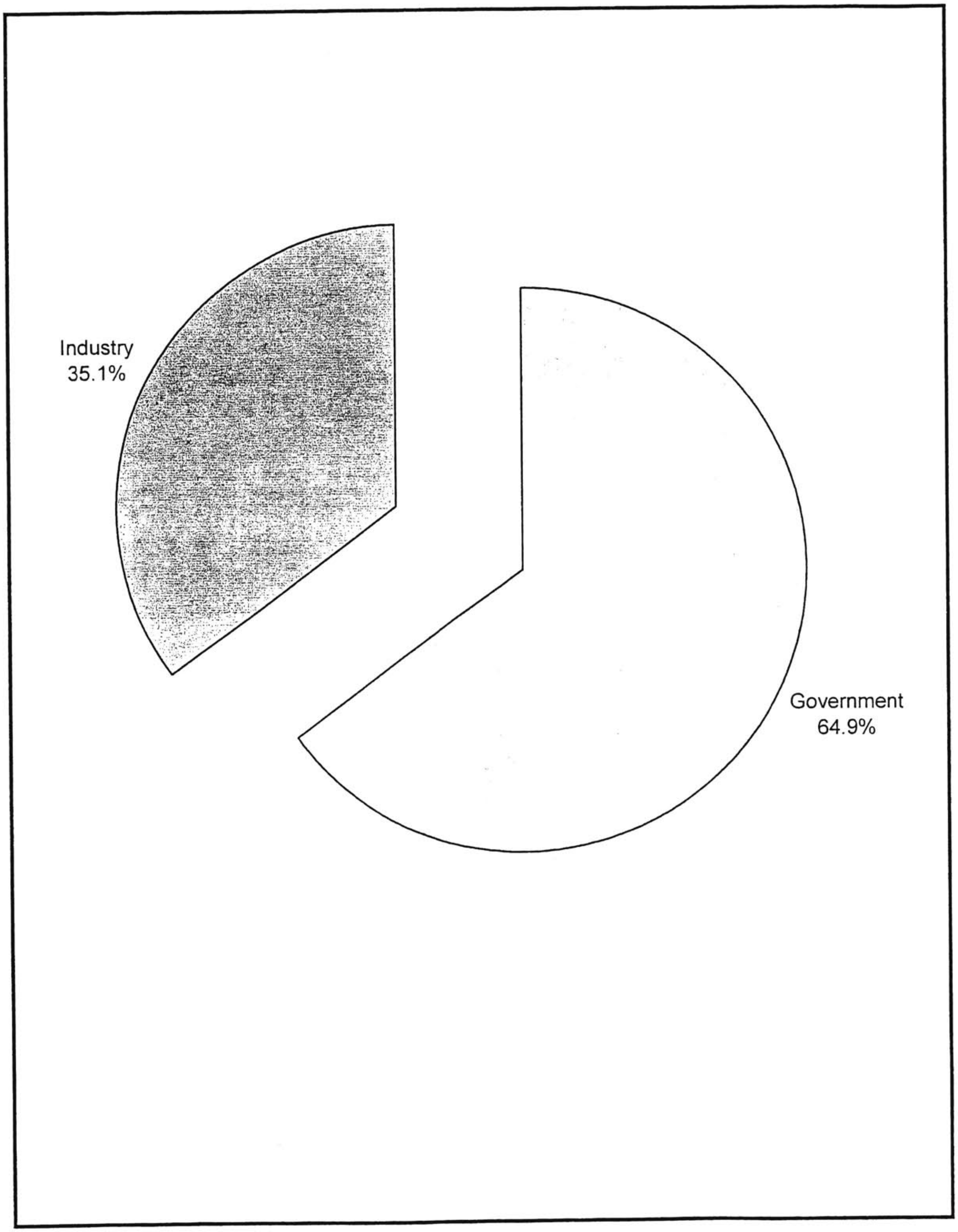

Figure 4.8: Total Design Effort of Icebreaker

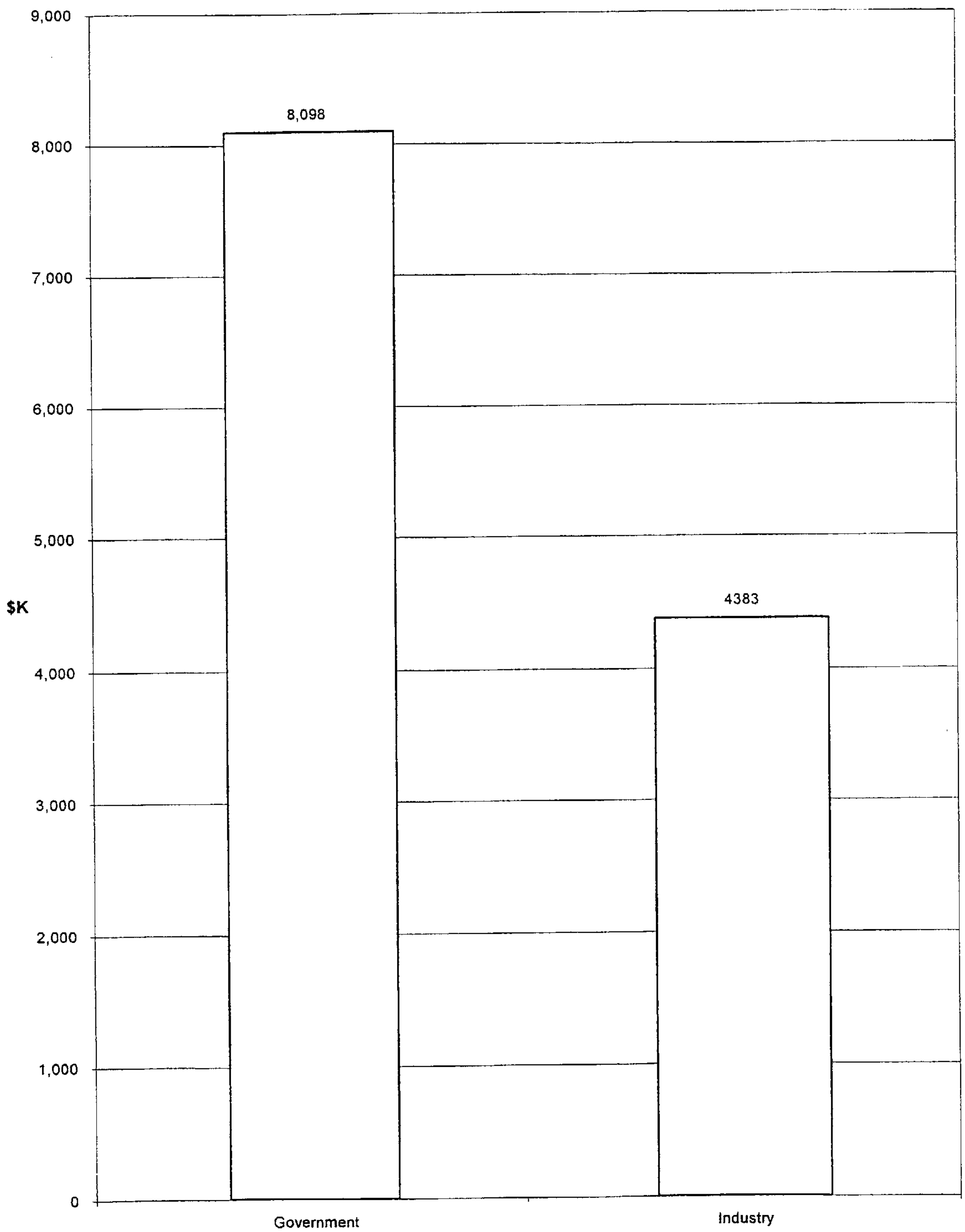

Figure 4.9: Total Design Costs for Icebreaker

team, Coast Guard Engineering (ENE), NAVSEA 03, and to a small extent, Supship. Industry consisted primarily of shipyards and design firms. Government effort totaled $8.1 M (65%) while industry represented only 35%, $4.4 M. This represents a deviation from typical Navy acquisition programs in recent years. Again, we can see the lesson learned from this type of cost breakdown. The lesson is this: without sufficient involvement from industry at an early point in the process, the probability of successfully making it to contract award and having an acceptable vessel at the end of the acquisition process is significantly reduced. This will be discussed again later.

At the time of this publication, no data was available on task group efforts.

5 STRATEGIC SEALIFT ACQUISITION PROGRAM[3]

Andrew Speirs prepared a thorough case study on the Sealift Acquisition program in his thesis, Right Sizing for Government Review (Reference 2). Since this section will only partially summarize the work he did, readers interested in a detailed analysis on the program should obtain a copy of this source.

The T-AKR 310 class Strategic Sealift Program arose out of a need for suitable-size ships capable of fast sealift logistical missions. Following the Gulf War, a mobility requirements study for the US DoD resulted in the creation of a $2.4 billion budget for an additional 19 sealift ships. Sealift ships are essential to military forces in the deployment of military cargo in both the pre-positioning of forces for deterrence or coercion and also in the surge of military intervention. Responsibility for the US Army, Navy, and Air Force sealift operations lies with the Military Sealift Command of the US Navy. The mission of the Strategic Sealift ships is the deployment of military cargoes to anywhere in the world. Table 5.1 shows the principal particulars for the new construction Strategic Sealift vessels.

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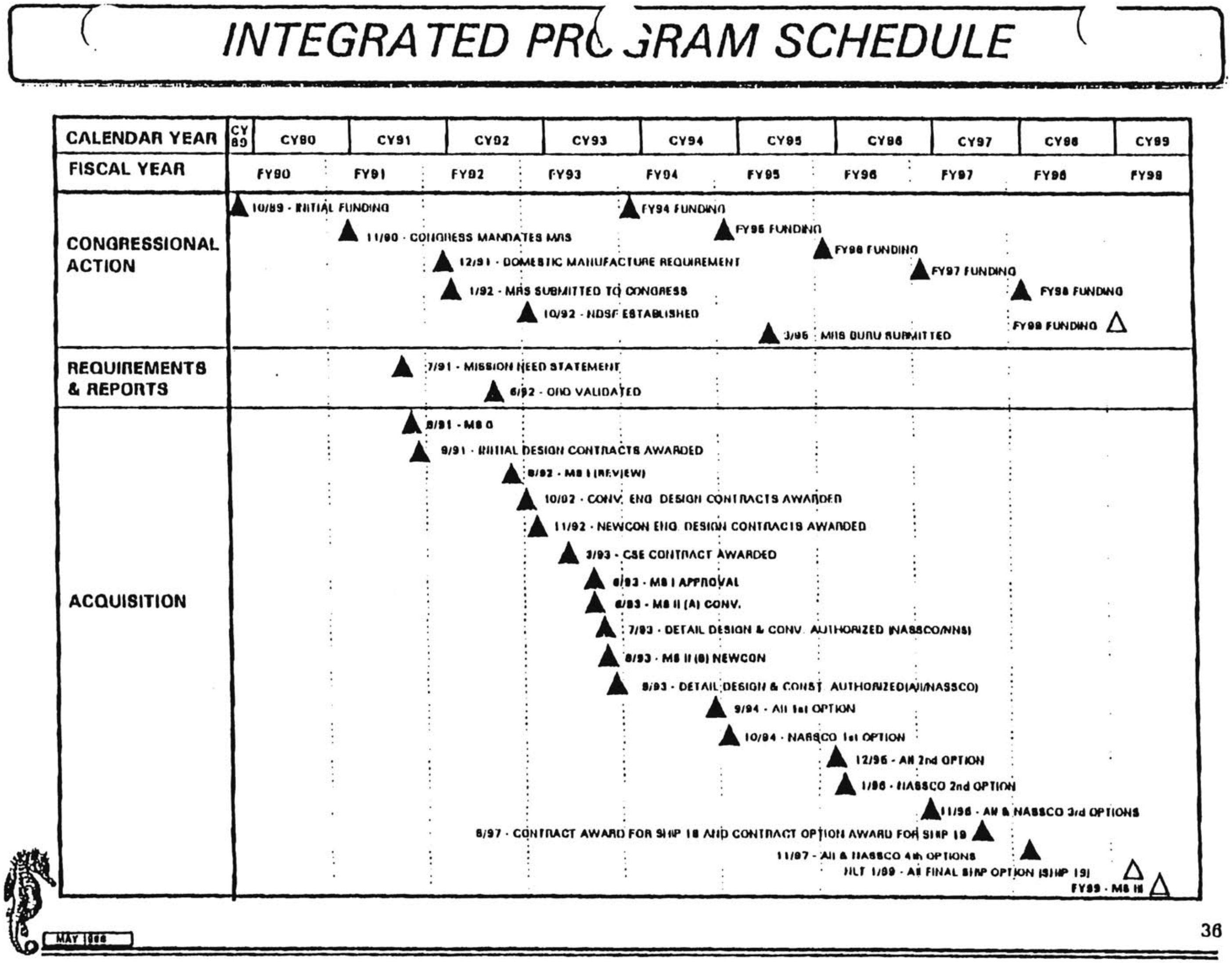
[3] Much of the content and wording of this section came from A. Speirs' thesis Right Sizing for Government Review June 1998, pages 30-53 (Reference 2).

Table 5.1: Principal Particulars for Strategic Sealift

Displacement at design draft	62,700 LT
Length between perpendiculars	905 feet
Beam, molded	105 ft. 9 in.
Draft, design	34 feet
Complement	13 officers, 32 unlicensed
Propulsion	2-LM2500 GTs, 2-CP propellers 32,000 BHP each

5.1 Acquisition Strategy

The program was first funded in November 1989, when the FY90 defense appropriations bill approved $600 million in Ship Construction and Conversion, Navy (SCN) funds for sealift. Figure 5.1 shows a timeline of major events occurring in this program. This program consisted of both new construction and conversion; however, for purposes here, only monies spent toward new construction are of interest. 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 Needs Statement (MNS) was issued, and the SECNAV approved the general concept of the program. In August, NAVSEA issued an RFP for initial designs to US shipyards. Later that month, the MS 0 was scheduled and suggested the use of this program as a major defense acquisition pilot program. Nine shipyards responded to the RFP for initial design. The MS 0 review was held August 30, 1991. In September, concept design contracts were awarded to these nine shipyards.



INTEGRATED PROGRAM SCHEDULE
CALENDAR YEAR
CY 89
CY90
CY91
CY92
CY93
CY94
CY95
CY96
CY97
CY98
CY99
FISCAL YEAR
FY90
FY91
FY92
FY93
FY94
FY95
FY96
FY97
FY98
FY99
CONGRESSIONAL ACTION
10/89 - INITIAL FUNDING
11/90 - CONGRESS MANDATES MRS
12/91 - DOMESTIC MANUFACTURE REQUIREMENT
1/92 - MRS SUBMITTED TO CONGRESS
10/92 - NDSF ESTABLISHED
FY94 FUNDING
FY95 FUNDING
FY96 FUNDING
FY97 FUNDING
FY98 FUNDING
FY99 FUNDING
3/96 - MRS BURU SUBMITTED
REQUIREMENTS & REPORTS
7/91 - MISSION NEED STATEMENT
6/92 - ORD VALIDATED
ACQUISITION
8/91 - MS 0
9/91 - INITIAL DESIGN CONTRACTS AWARDED
8/92 - MS I (REVIEW)
10/92 - CONV. ENG DESIGN CONTRACTS AWARDED
11/92 - NEWCON ENG DESIGN CONTRACTS AWARDED
3/93 - CSE CONTRACT AWARDED
6/93 - MS I APPROVAL
6/93 - MS II (A) CONV.
7/93 - DETAIL DESIGN & CONV. AUTHORIZED (NASSCO/NNS)
8/93 - MS II (B) NEWCON
9/93 - DETAIL DESIGN & CONST AUTHORIZED(AH/NASSCO)
9/94 - AH 1st OPTION
10/94 - NASSCO 1st OPTION
12/95 - AH 2nd OPTION
1/96 - NASSCO 2nd OPTION
11/96 - AH & NASSCO 3rd OPTIONS
6/97 - CONTRACT AWARD FOR SHIP 18 AND CONTRACT OPTION AWARD FOR SHIP 19
11/97 - AH & NASSCO 4th OPTIONS
NLT 1/99 - AH FINAL SHIP OPTION (SHIP 19)
FY99 - MS III
MAY 1994
36

FIGURE 5.1

In June 1992, the MNS for Strategic Sealift was approved. The Program Office, PMS 385, was also established at this time. MS I occurred in August 1992. New construction design contracts were issued to 7 of the 9 initial shipyards on November 1992. August 1993 marked the MS II program decision meeting for new construction. On September 2, 1993 Avondale Industries, Inc. 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. Table 5.2 shows the duration of acquisition phases in the Strategic Sealift program.

Table 5.2: General Schedule for Strategic Sealift Program

	START DATE	END DATE	DURATION
Concept & Feasibility	FY90	FY91	12 months
Preliminary Design	FY91	FY92	3 months
Contract Design	FY92	FY93	9 months

5.2 Design Strategy

The Sealift program was one of the first Navy programs to break from the traditional mold of Navy in-house design. In this program, transitional steps were taken to change the role of government from being one of design to one of essentially review and contractual functions.

This program marked a change in 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 MS 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. This reduced the government's role in design, and shifted the bulk of the work to a design review function.

This change toward government as review body, although not easy to implement, was considered by most to be an effective way to manage the acquisition product. This process was structured to review a large amount of information fairly and consistently. Approximately 18 concept design reviews were held in addition to 28 new-construction design reviews. This required a core of forty government personnel and design agents with as many as seventy at times. This review process varied from the Icebreaker program in that the government personnel attending the reviews were essentially the same at each review to maintain consistency. A core of nine people was established for this task. Support contractors were not present for these reviews.

Further variation on the Icebreaker theme was the fact that government personnel were not involved as part of the shipyard teams. Thus, all government personnel could communicate with each other on the development of various designs. All questions and answers were private between the shipyard and the program office; however, if in answering a question, the requirement was clarified and could significantly affect technical development, strategy, or cost, it would be shared with other yards. Approximately 500 formal questions were asked in the Engineering Design Phase.

Another difference between this program and other Navy acquisition programs was the reduced cycle time for the design. A generic ship acquisition program usually takes 3 to 18 months to complete feasibility and concept studies. Table 5.2 shows this phase lasted only took 12 months. Preliminary design and contract design of a typical Navy ship acquisition program can last anywhere from 6 to 12 months and 9 to 15 months, respectively, combining to a total of 15 to 27 months. Table 5.2 shows this combined process took only 12 months in the Strategic Sealift program. Of course, it should be kept in mind that this is a non-combatant vessel.

5.3 Development Costs of the Strategic Sealift Program

The total design costs through MS II for the Strategic Sealift program were $44.9 million. The total Sealift program costs amount to approximately $5.9 billion. Thus, total design costs represented less than 1% of total program costs. Figure 5.2 is an approximation of the timing of the design costs according to Speirs, 1998. There is significant funding in the first year, which then drops off. The first year includes funding for the conceptual designs, feasibility studies, etc. After that stage, the spending drops off, and generally builds towards MS II. The engineering designs took place almost exclusively in FY 1993, which is reflected in the figure.

Of the design costs, Figure 5.3 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, Design Office, and OGA.

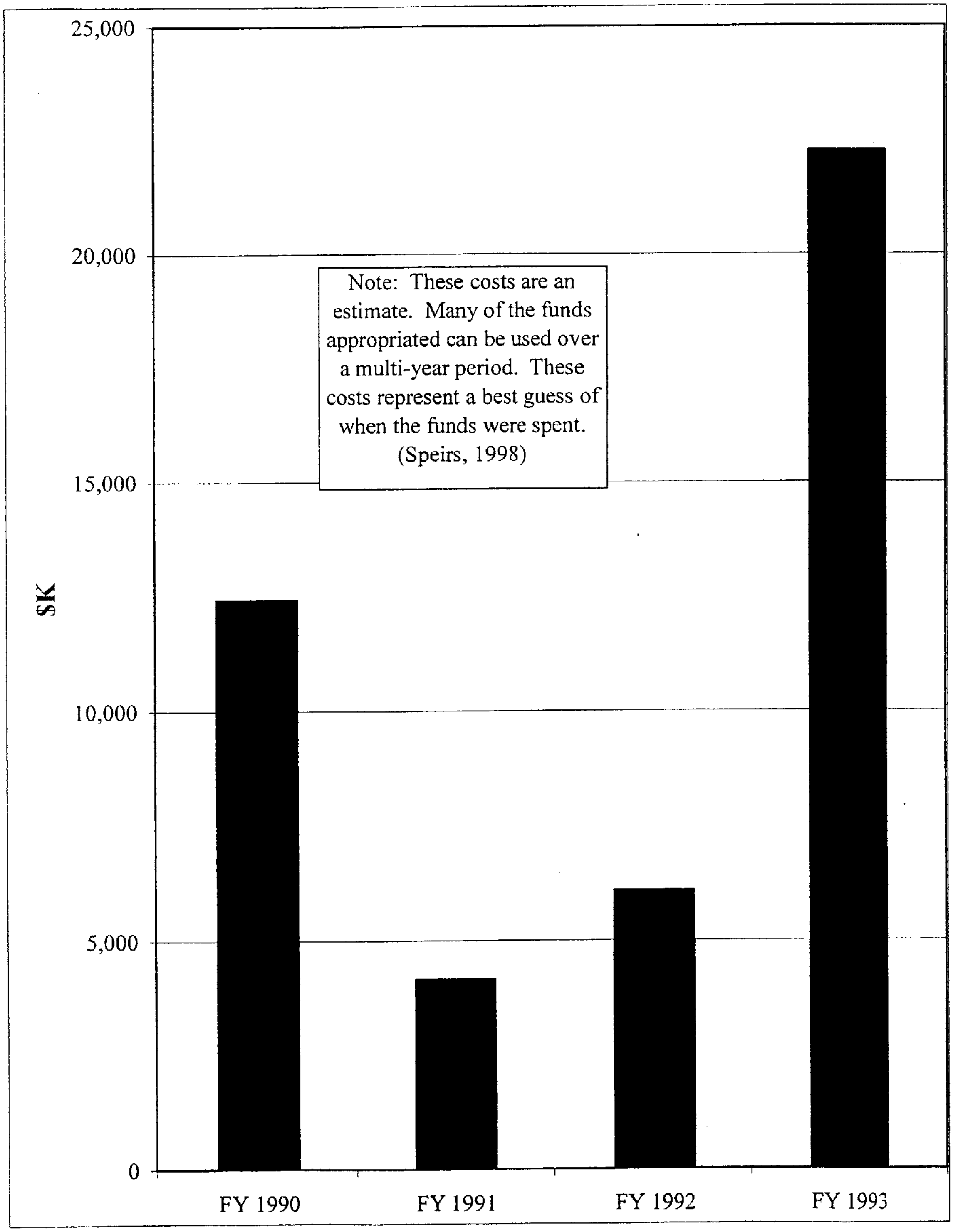


Figure 5.2: Timing of Design Costs for Sealift Program

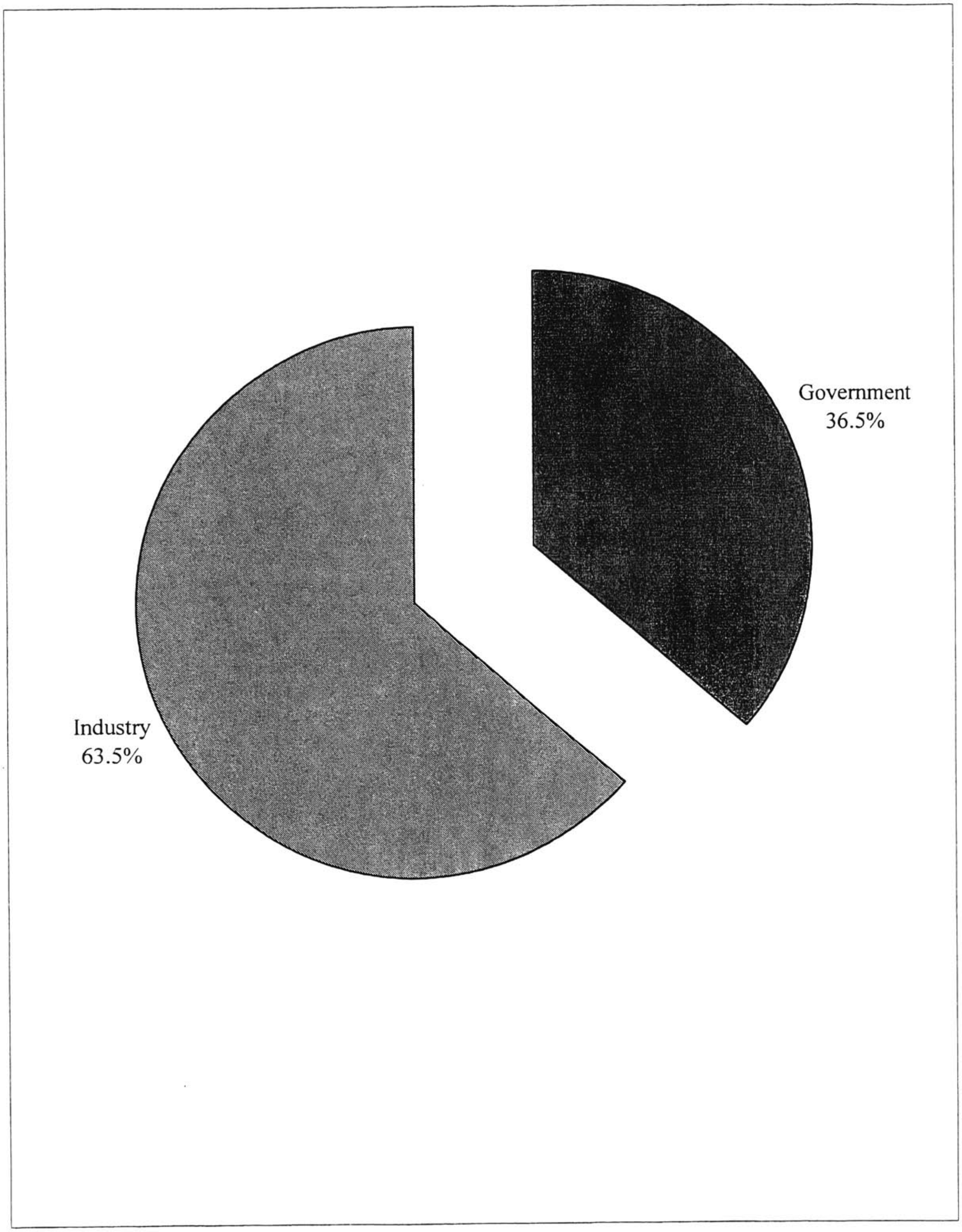


Figure 5.3: Total Design Effort for Sealift Program

The industry segment included contractors that supported the program management and design effort, shipyards, and regulatory bodies.

It becomes apparent in Figure 5.3 that the majority of the design costs in the program were in industry. Figures 5.4 and 5.5 illustrate the breakdown of costs for various players in the Strategic Sealift design. These diagrams indicate the significance that industry had in the design of the Strategic Sealift program. The Navy's Program Office and Design Office, synonymous with the term "in-house," made up only 11% of the total design costs, or $44.9 million. The remaining 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).

Figures 5.6 and 5.7 illustrate the cost of each phase in the design. The bulk of the design cost for the Sealift program, similar to most Navy programs, was during the contract design phase. Relatively little money was spent in the concept and feasibility design phase, only 6%. The preliminary design phase represented approximately 1/3 of the total design cost.

5.3.1 Concept and Feasibility Design Costs

The concept and feasibility design phase of the program cost approximately $2.6 million. Again, this was approximately 6% of the total design cost of $44.9 million. Figures 5.8 and 5.9 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. Obviously, the total costs of this design phase

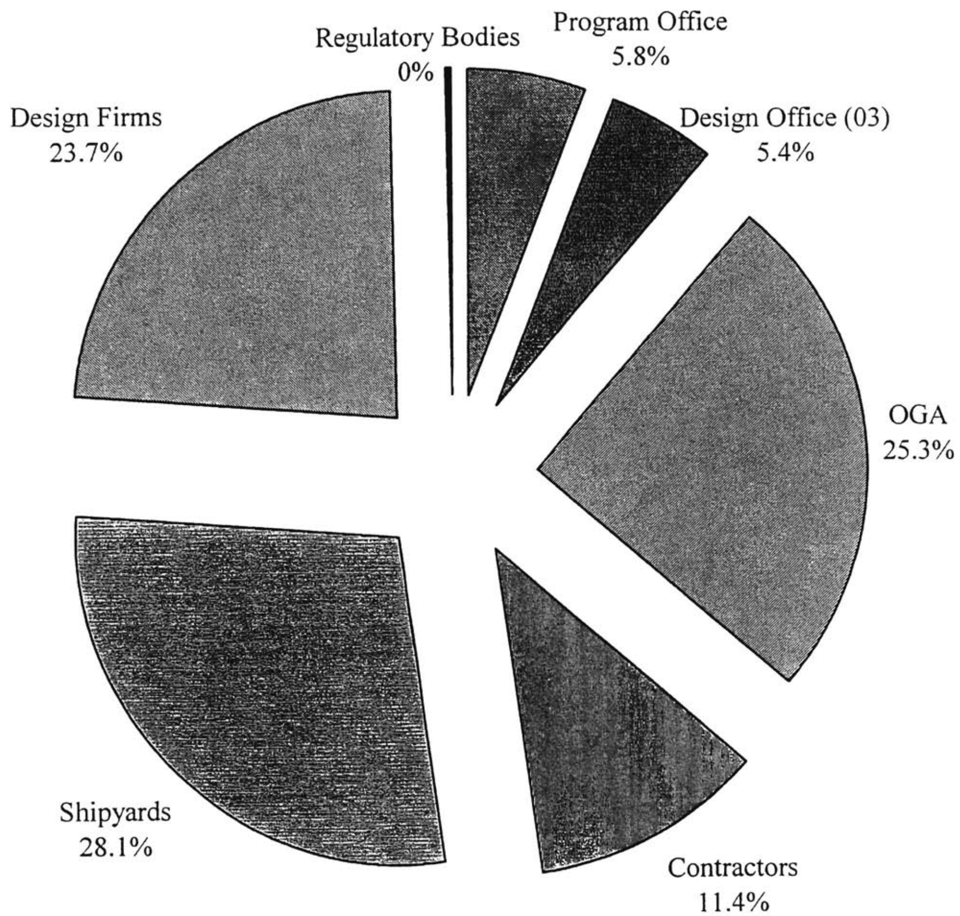


Figure 5.4: Total Design Effort (Detailed) – Sealift Program

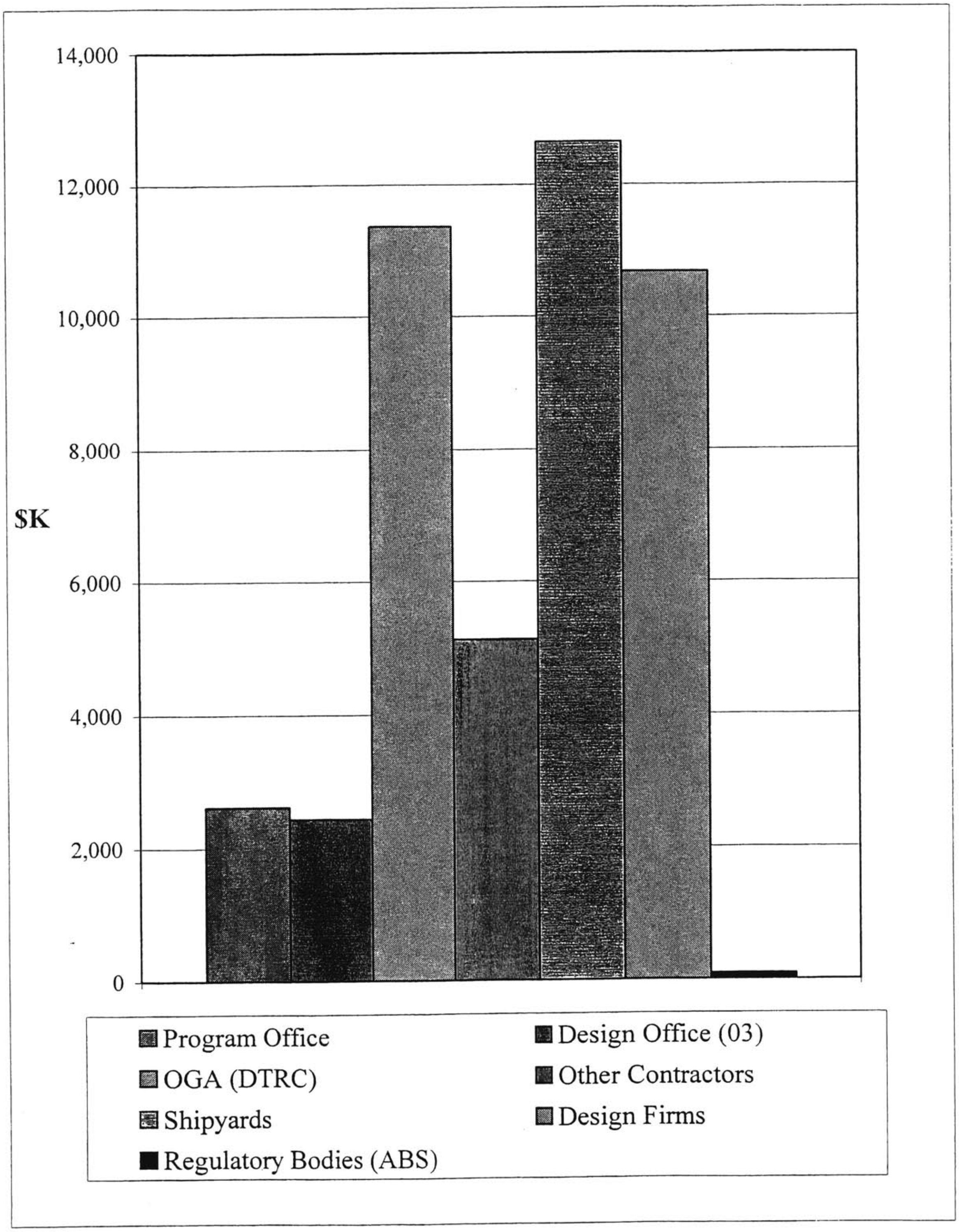


Figure 5.5: Total Design Costs (Detailed) – Sealift Program

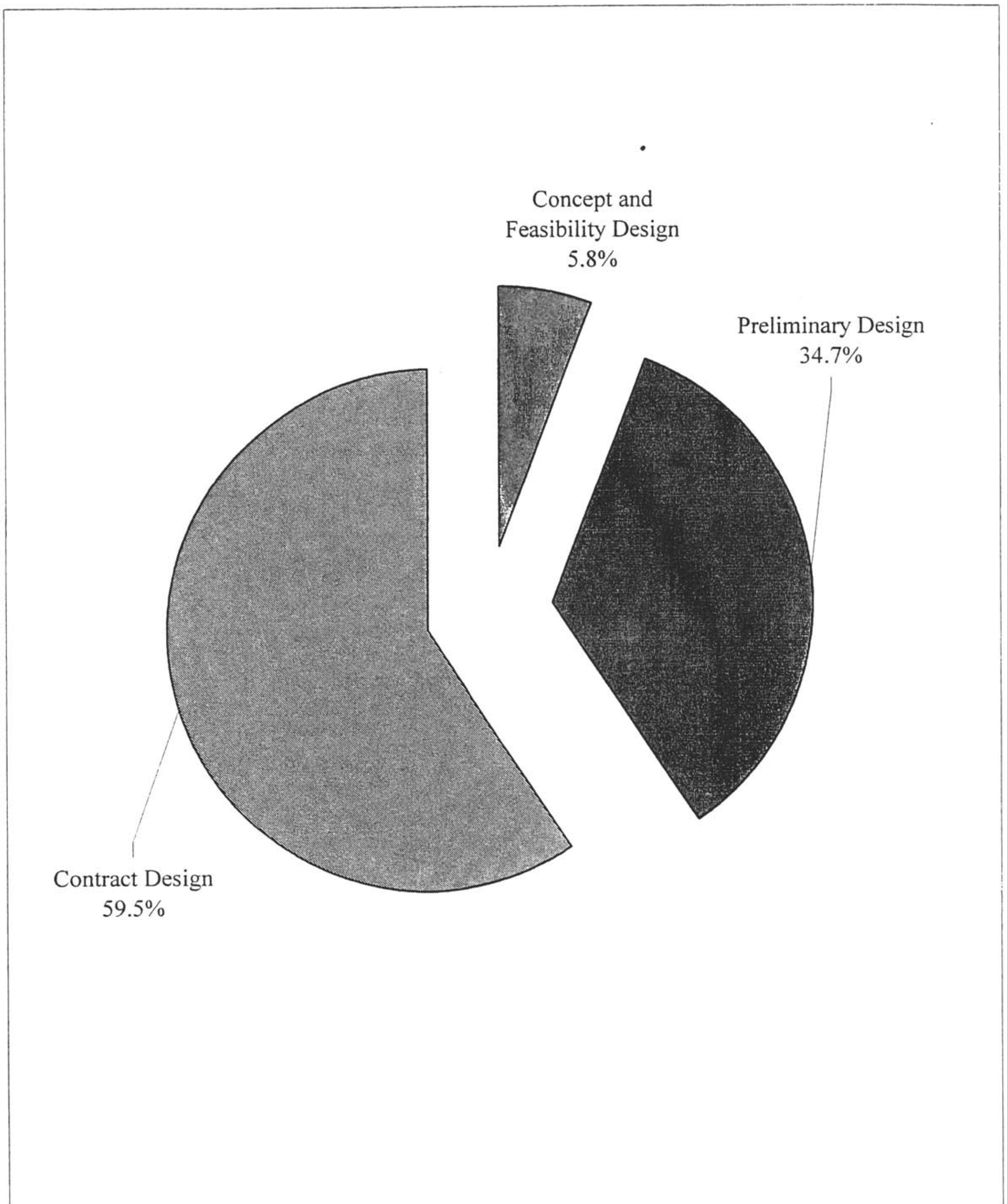


Figure 5.6: Total Design Effort by Phase for Sealift Program

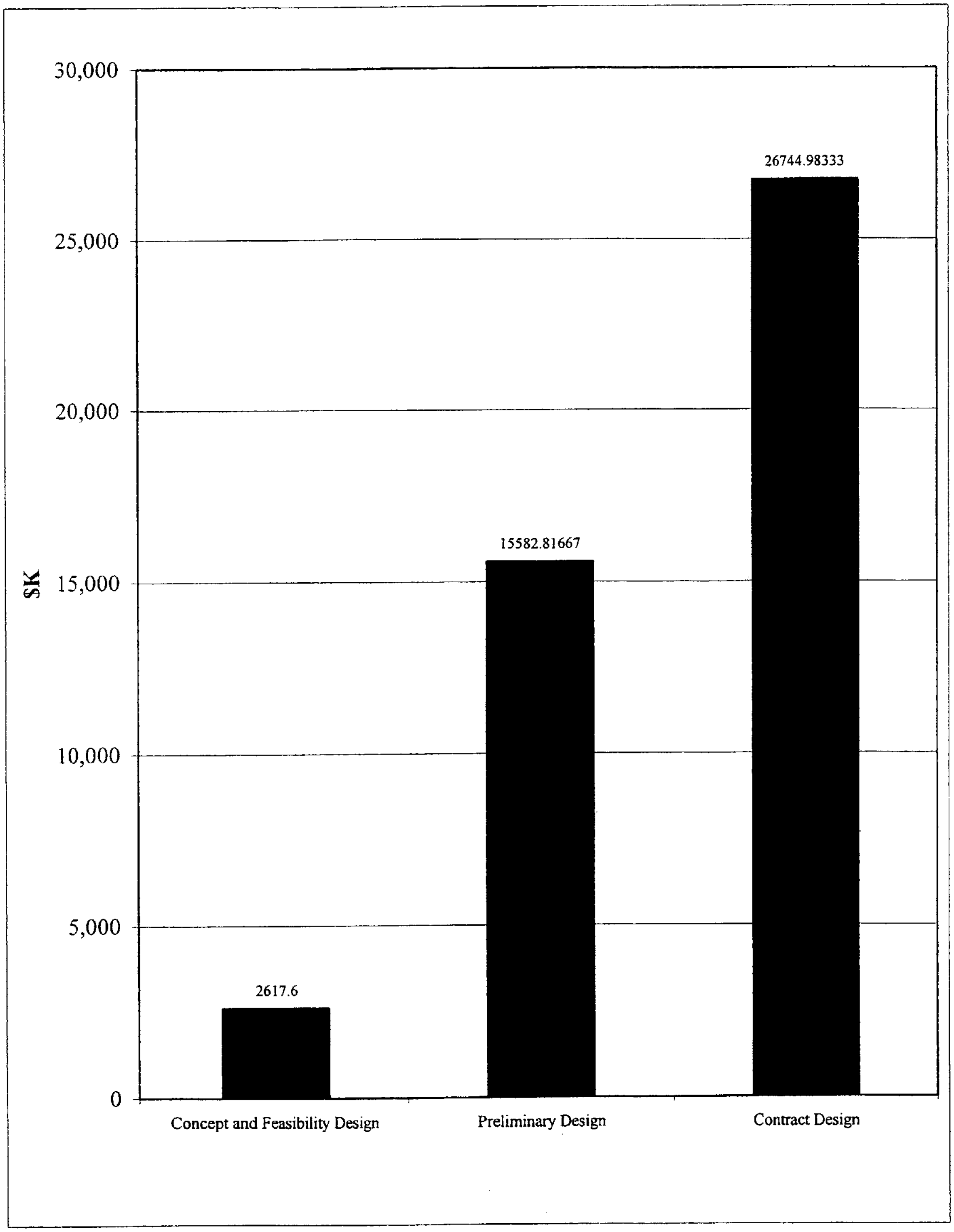


Figure 5.7: Total Design Costs by Phase for Sealift Program

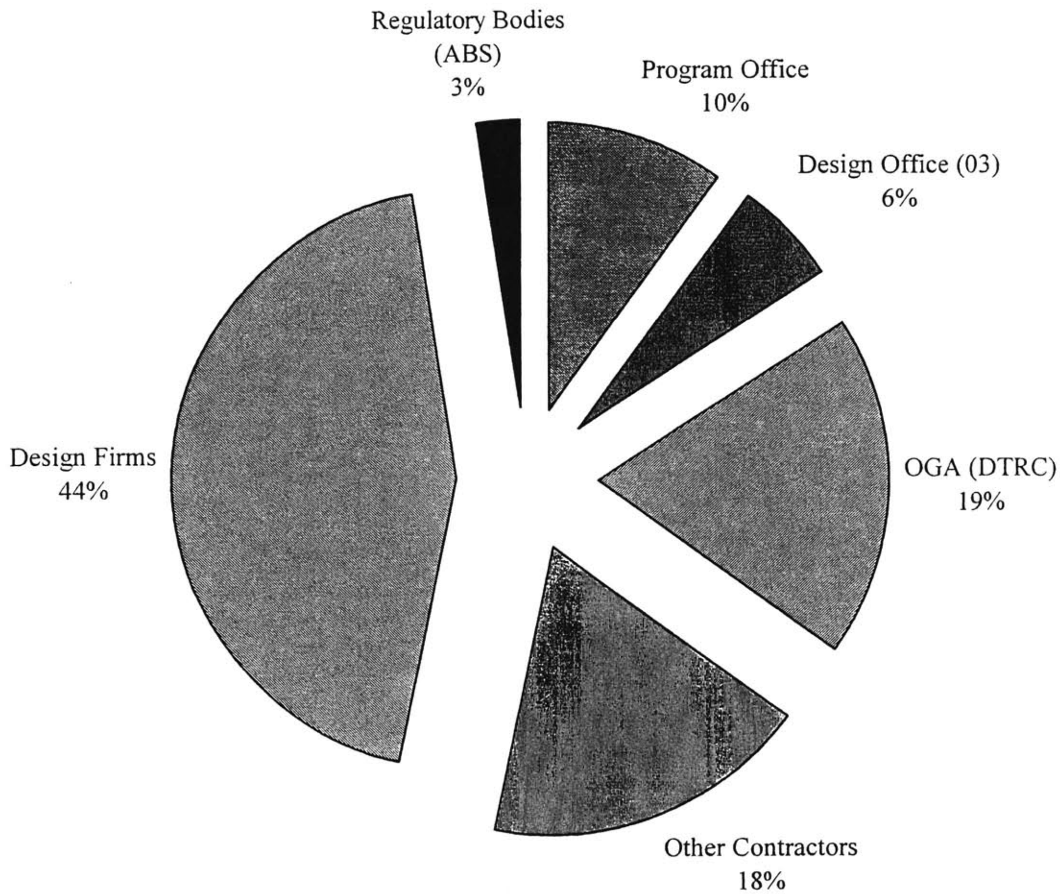


Figure 5.8: Concept & Feasibility Design Effort for Sealift Program

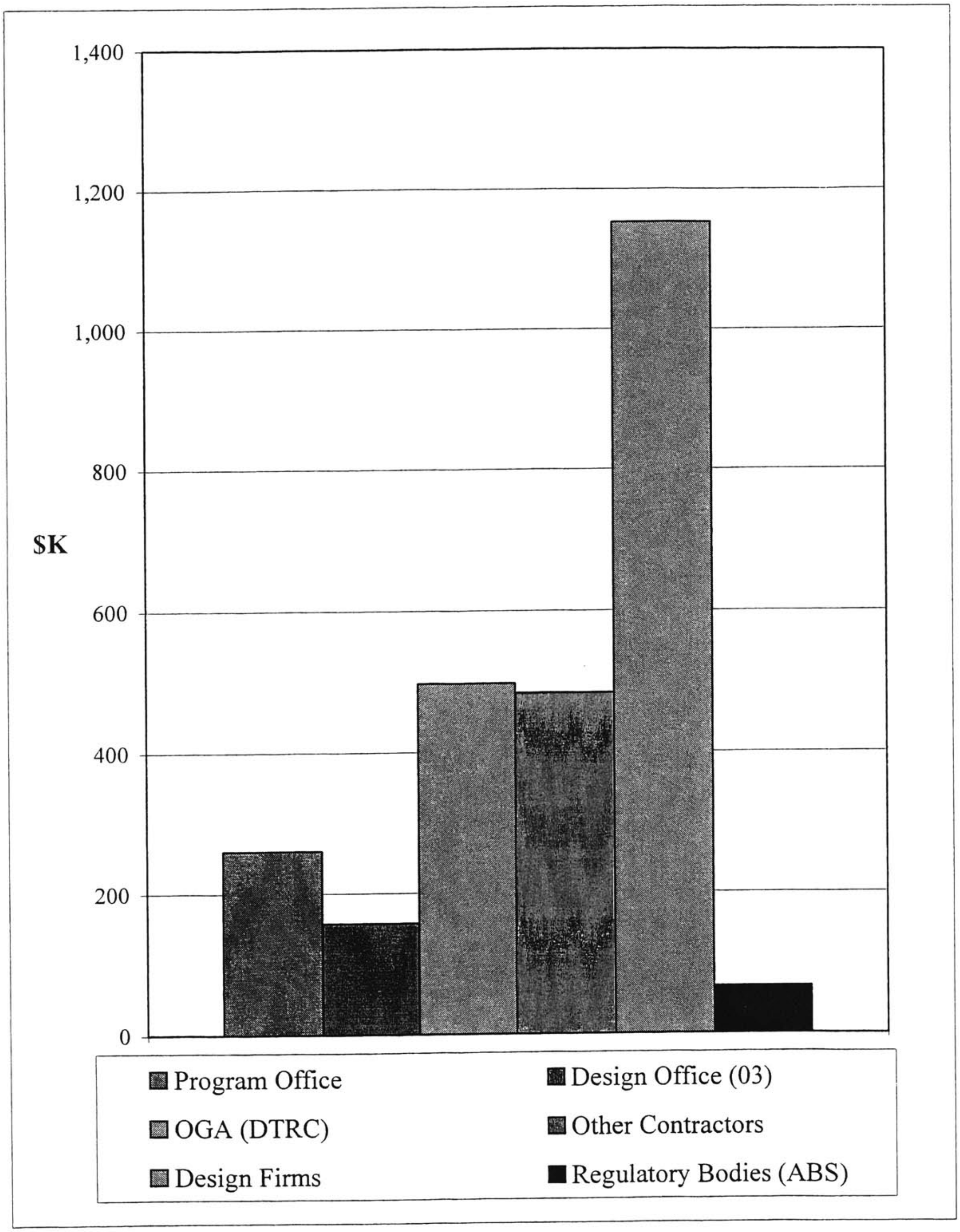


Figure 5.9: Concept & Feasibility Costs for Sealift Program

were relatively insignificant in comparison to the total design effort, and particularly with respect to the entire acquisition program.

5.3.2 Preliminary Design Costs

The preliminary design phase of the program cost approximately $15.6 million, or 35% of the total design costs. The cost allocation of this design phase is shown in Figures 5.10 and 5.11. 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 US shipyards were not involved in the concept and feasibility studies, but did become involved in the 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 least 35%.

5.3.3 Contract Design Costs

The contract design phase of the program cost over $26.7 million, or roughly 59% of the total design costs. Figures 5.12 and 5.13 show the breakdown of this design phase. The Navy's 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 portion 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.

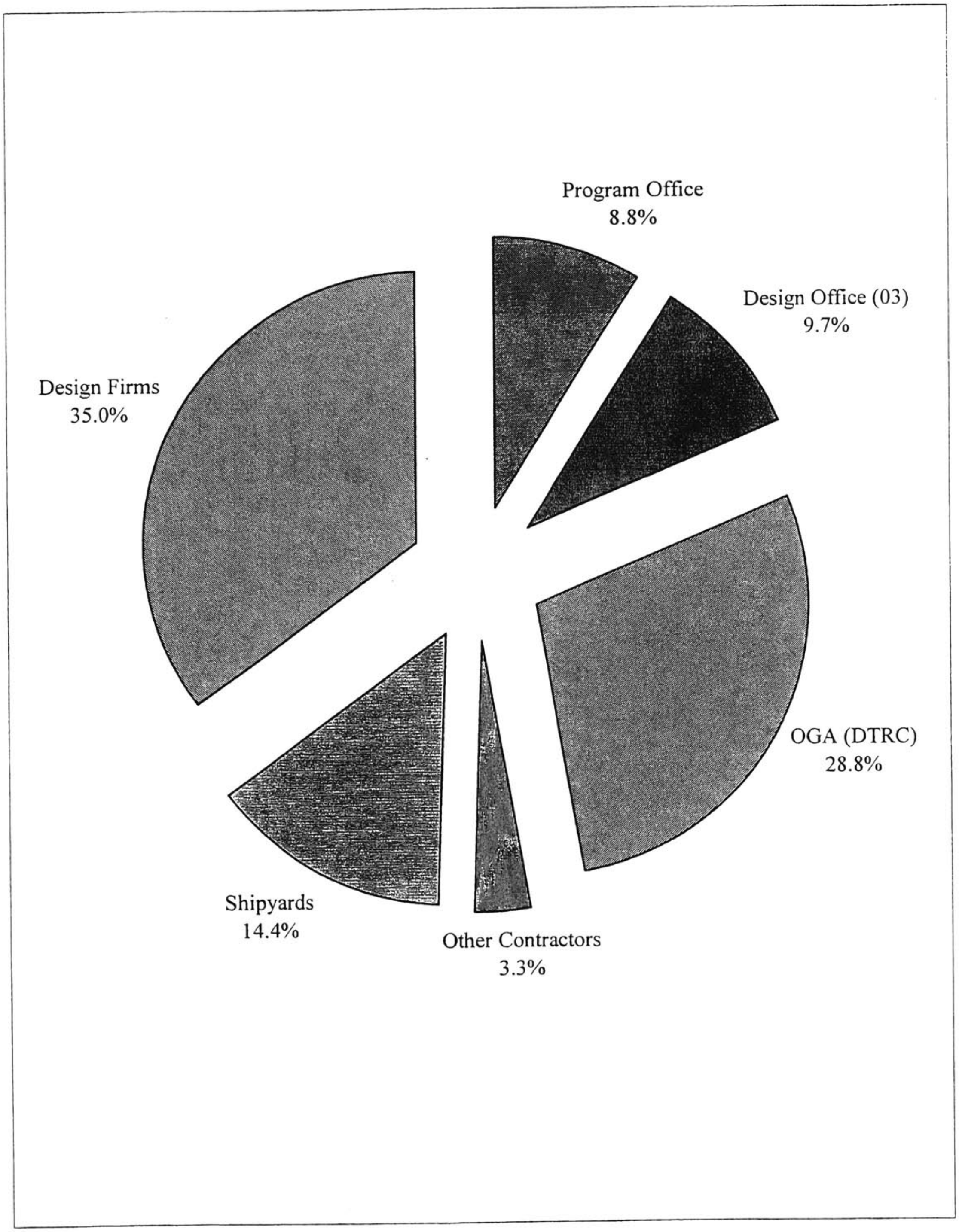


Figure 5.10: Preliminary Design Effort for Sealift Program

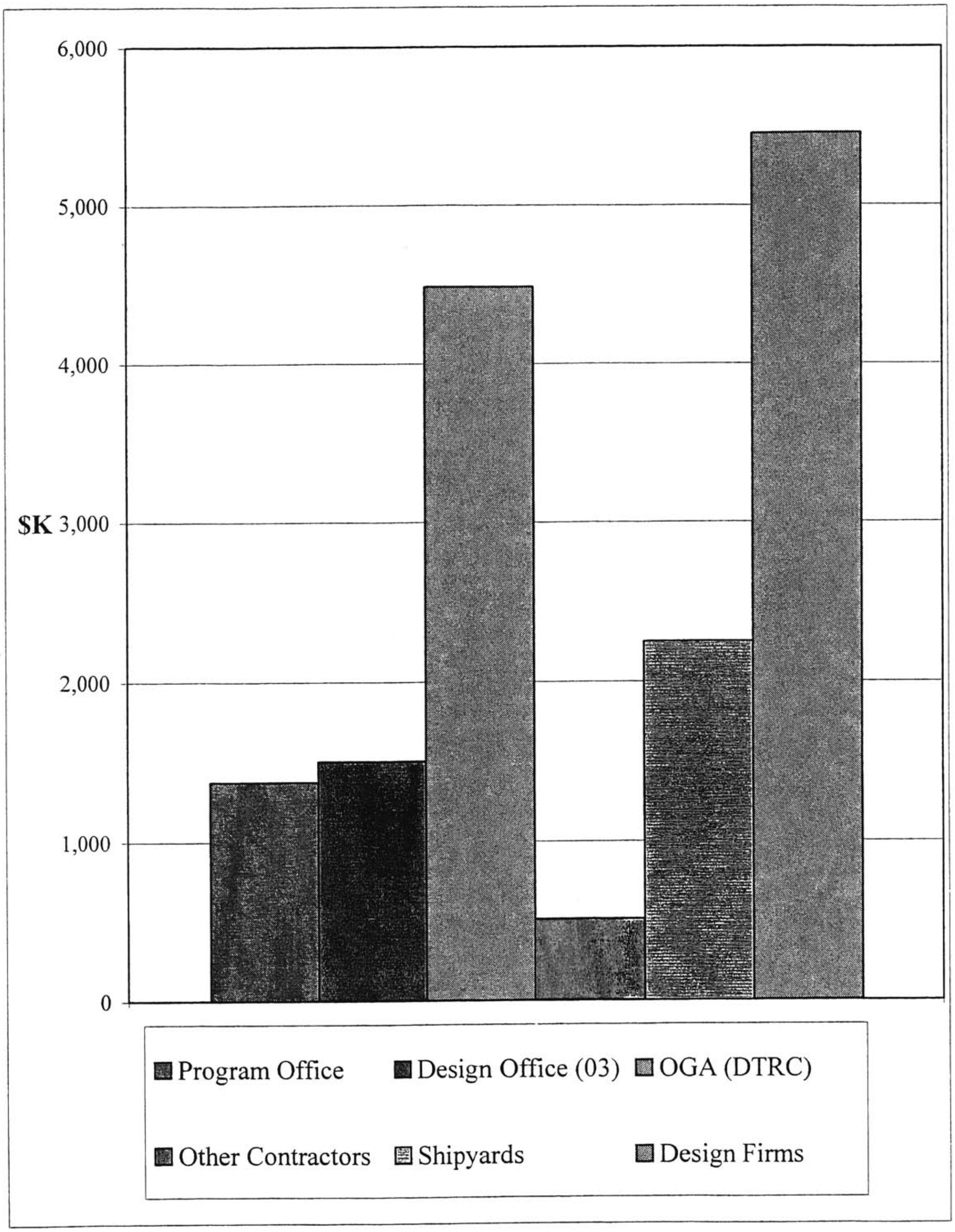


Figure 5.11: Preliminary Design Costs for Sealift Program

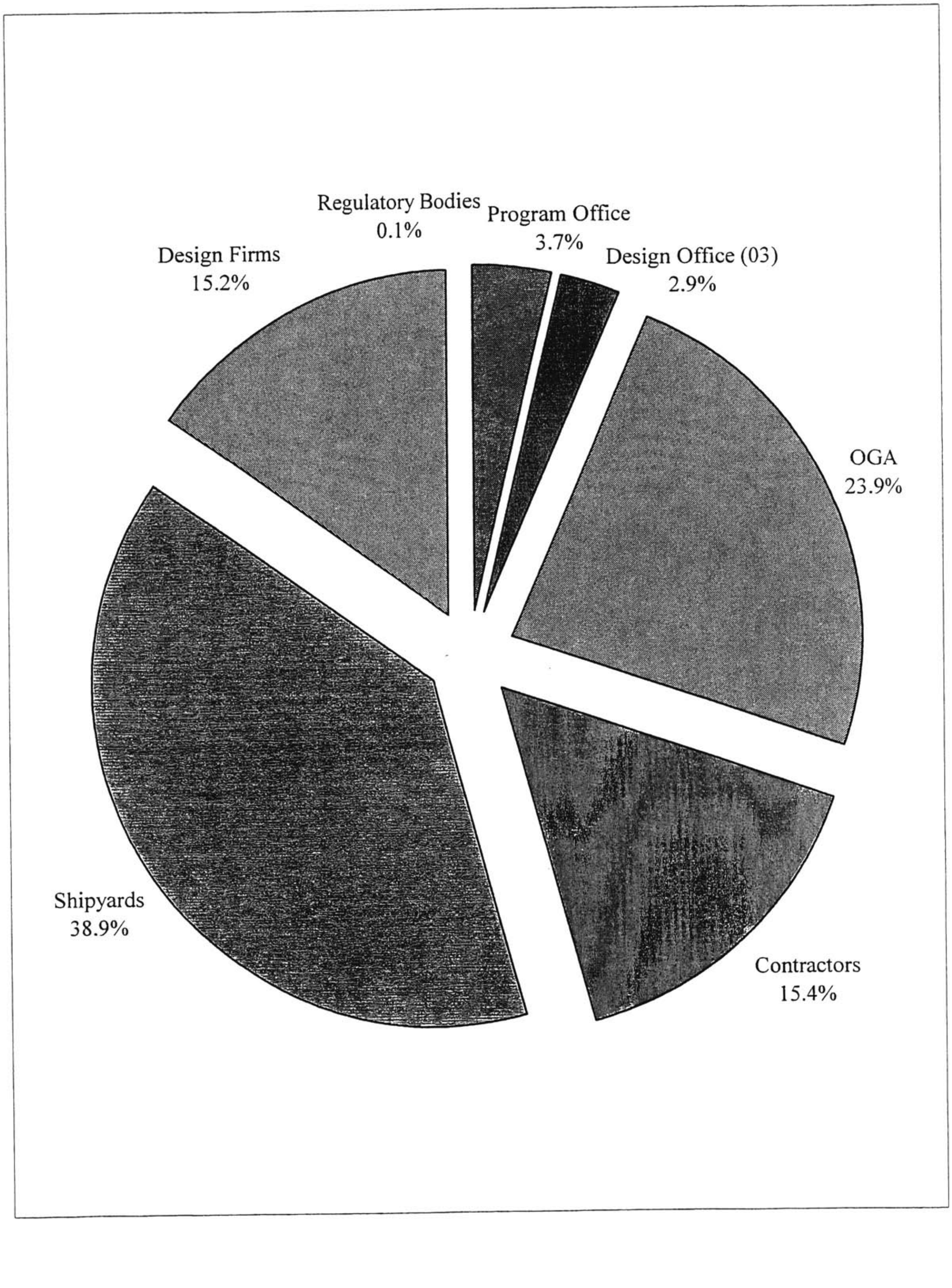


Figure 5.12: Contract Design Effort for Sealift Program

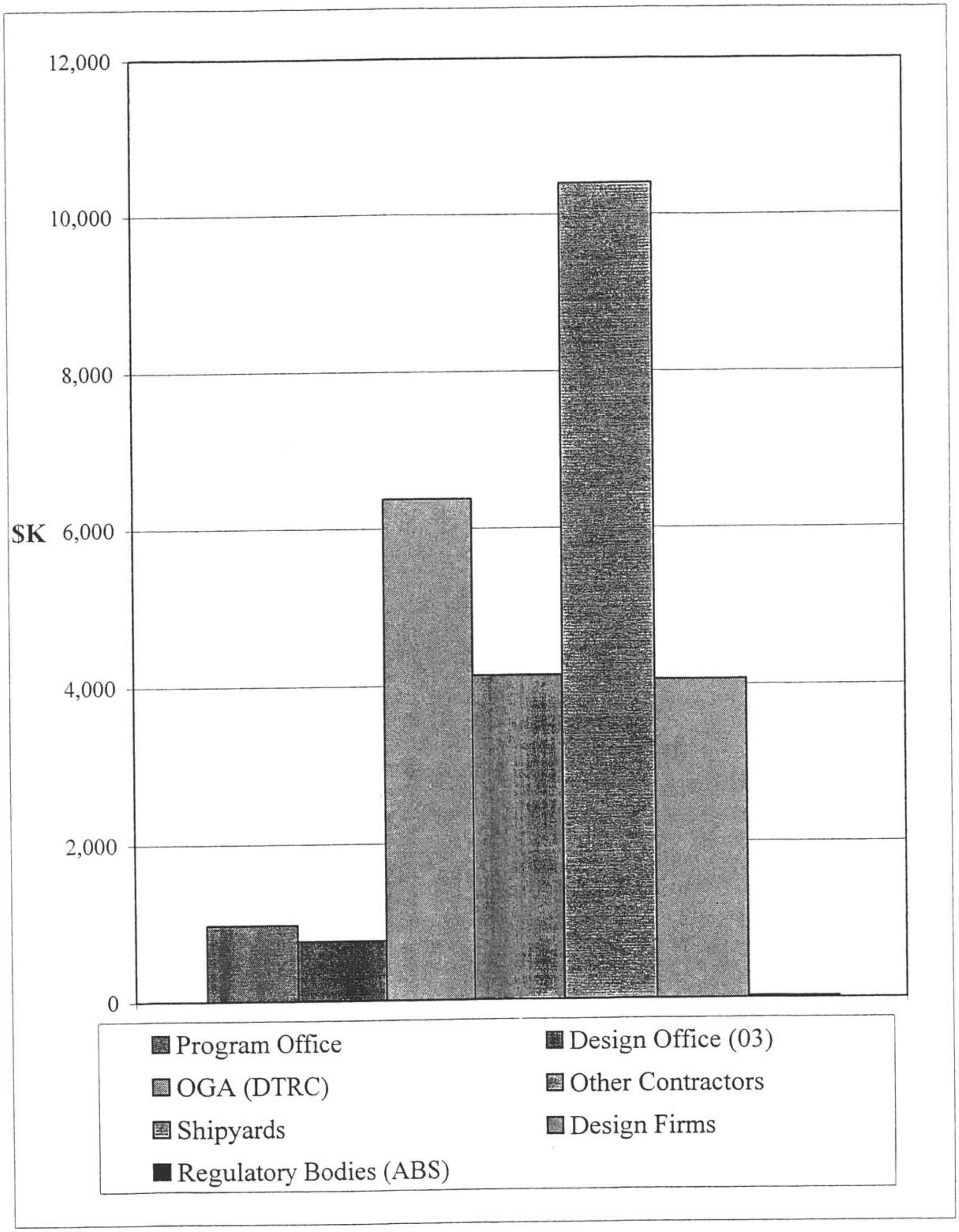


Figure 5.13: Contract Design Costs for Sealift Program

6 LPD-17 ACQUISITION PROGRAM

In 1990, the Navy and Marine Corps completed a joint study on amphibious operations. This study revealed the following:

1) several of the Amphibious Force ship classes today are reaching the end of their service lives (27 ships are projected to reach the end of their service lives by FY2000)

2) other classes are no longer capable of fully performing their original mission.

As a result, the LPD-17 class of amphibious transport dock ships is a functional replacement of four amphibious ship classes: LPD, LSD, LST, and KLA classes. This study also defined the optimum size (lift capacity) for the LPD-17 ship class that would make up the projected lift shortfall resulting from the retirement of these other amphibious ship classes. This new class will be capable of accommodating a wide range of deployment scenarios. In size and mission, the LPD-17's closest relative in today's fleet is the LPD-4 class. Principal particulars for the LPD-17 class are provided in Table 6.1.

Table 6.1: Principal Particulars for LPD-17 Class

Displacement, full load (approx.)	24,800 tons
Length between perpendiculars	656 feet
Beam	105 feet
Draft, navigational	23 feet
Complement	32 officers, 34 CPO/NCO, 429 enlisted
Propulsion	4-geared diesels, 2-CP propellers 40,000 SHP

Ships in this class will be the most highly technical and advanced amphibious ships ever built. Combining key war fighting and command, control, communications, computer, and intelligence capabilities, this class is an integral element in executing the Navy's "Forward ... From the Sea" strategy beyond the turn of the century. The LPD-17 ship class will embark, transport, land, and support amphibious assault forces of the United States Marine Corps. It will be capable of supporting littoral operations across the full spectrum of potential conflict.

6.1 Acquisition Strategy

The LPD-17 class program is the first Navy shipbuilding effort aimed at minimizing military specifications and standards (MILSPECS) that allow contractors to take advantage of cost-reducing commercial-off-the-shelf (COTS) technologies and non-developmental items (NDI.) This is also the first major ship-acquisition program to employ a totally electronic proposal evaluation process; the Navy's formal request for proposal (RFP) was issued electronically by posting it on the Naval Sea System Command's Contract Directorate home page. In addition, it is the first surface ship program to be covered under the 1991 Defense Systems Acquisition Policy, as an ACAT ID Major Program. It is required to be reviewed at all levels within the Navy and DoD up to and including the Defense Acquisition Board (DAB) in the Office of the Secretary of Defense.

The first ship in the class, *USS San Antonio*, and its 11 projected follow-on ships are predicted to be models of the Navy's ongoing efforts in acquisition reform, making efforts to improve the way in which the Navy designs, builds, acquires, and operates its fleet. The objective of this acquisition approach is to ensure that the most capable ships are introduced into the fleet while simultaneously ensuring life-cycle affordability. Tibbits and Keane point out that, “although the “feedback loop” for efforts made in ship design and acquisition may be ten years, the trends are in the right direction” (Reference 1).

A key element of the new acquisition process was the requirement for a Cost and Operational Effectiveness Analysis (COEA.) The COEA was performed during Phase O (Feasibility Studies), after passing MS 0 in November 1990, and must be updated prior to each subsequent acquisition milestone. The COEA is an independent evaluation of the effectiveness of each alternative against current and projected threats and an assessment of capability versus cost of the program associated with acquiring each alternative.

On January 19, 1993, the Undersecretary of Defense for Acquisition approved the LPD-17 program to proceed into Phase I: Demonstration and Validation. This phase included all preliminary design and contract design activities leading up to lead ship award. On June 29, 1994, the Secretary of Defense directed the use of performance specifications. This policy further authorized the use of non-government standards and allowed the use of MilSpecs and Standards as a last resort. This policy was adhered to and the LPD-17 contract specifications were released for proposals with approximately 150 MilSpecs and Standards.

In November 1994 a new program manager was appointed to the LPD-17 program with the designation PMS 317 (separate from the existing Amphibious Warfare Program.) This new program manager implemented the Integrated Process and Product

Development (IPPD) Team approach in early 1995 for the contract design phase. The IPPD approach integrated Program Management, Ship Design, and Industry (potential shipbuilders) for the final phases of design.

This innovative acquisition strategy was the first major ship program to blend shipbuilding with a total ship systems integrator in the same contract. The result was a Full Service Contractor (FSC) – two shipbuilding firms, a ships systems integrator, and an IPDE systems developer. Most previous shipbuilding programs separated the entities contractually with the Navy managing the interface. This new acquisition strategy required the FSC to manage these interactions while the Navy management team focuses on top level strategic direction.

There are several advantages to this strategy. First, it leaves the program office free from the work-intensive efforts of refereeing between the prime contractor and its sub-contractor integrators. This way, government talent can be dedicated to key decision-making and top-level management issues. The values of concurrent engineering where design and integration occur simultaneously were recognized. The relationships between prime, sub-contractor and government incorporate efficiencies and facilitate process execution that will ensure successful integration. This method emphasizes the need to work side-by-side with both the owners and operators of the vessels.

In December 1995 the procurement year was accelerated to FY96. Contract Design was signed in March 1996. A full and open competition was held for this procurement and two proposals were received. In December 1996, Avondale Industries, Inc. was awarded a $641.4 million cost-plus-award-fee contract for detail design, integration and construction of *USS San Antonio* (LPD-17) with options for construction of LPD-18 and LPD-19. Teaming with Avondale on this contract were General Dynamics/Bath Iron Works, Hughes Aircraft Company and Intergraph Corporation. Bath Iron Works was to participate in the detail design and will construct the LPD 19. The contract included options that, if exercised, would bring the cumulative value of the entire contract to $1.5 billion. Work was to be performed in Avondale, La (48%); Bath, Maine (32%); Fullerton, Calif. (16%); and Waynesboro, Va. (4%.) The expected delivery of LPD 17 was 67 months after contract award. Contract funds would not expire at the end of the current fiscal year.

The acquisition strategy also envisioned a long-term relationship with the FSC. "Full Service" does not just apply to the first ship construction contract, but continues through subsequent construction under two separate contracts for follow-on ships. The acquisition strategy anticipated the FSC would be tasked with life-cycle support and planning yard responsibilities for the entire class for the duration of the LPD-17's lifetime.

In August 1998, Avondale was awarded a $9.7 million modification to a previously awarded contract for research, development, test and evaluation of new technologies potentially applicable to the LPD-17 class ship. This modification covered the exploration of various emerging innovative production processes, shipboard automation techniques, and system design concepts with emphasis on reduced maintenance, manning, and radar cross-section and improvements of structural design concepts, electronics integration and habitability. Work was to be performed within

Bath, Maine (38%), San Diego, Calif. (32%), and New Orleans, La.(30%) and is expected to be completed in July 1999. Table 6.2 illustrates the approximate timing for the LPD-17 design phase.

Table 6.2: General Design Schedule for the LPD-17 Program

	START DATE	END DATE
Concept & Feasibility	FY91	FY92
Preliminary Design	FY93	FY94
Contract Design	FY94	FY96

6.2 Design Strategy

A multi-disciplinary, collocated NAVSEA design team under PMS 317 designed the LPD-17. There were team members "representing the broad total ship 'disciplines' such as producibility, cost, human engineering, computer-aided design, and reliability, maintainability, and availability, as well as the more traditional system disciplines such as hull, propulsion, and combat systems" (Reference 1). NAVSEA support contractors and other Navy activity support were provided as required.

Collocation of the design team began very early on during the feasibility studies. This was driven in part by the need to develop a large number of ship concept alternatives to support the COEA/AoA decision-making process.

Direct shipbuilding industry involvement in the LPD-17 design began during the contract design phase. At this time, five competitively selected shipbuilders were brought onboard to help review the specifications, develop additional producibility improvements, and comment on the implications of several aspects in the design. An advantageous spin on this program was the teaming of shipbuilders and combat systems integrators that took place to allow for a pooling of organizational strengths through implementation of IPPD strategy.

Contractor personnel was available to the local representatives and the Design Team at-large to support detailed design studies covering a wide range of technical and management issues. Contractor and Navy activity support was obtained by the use of RDT&E funds provided by the Ship Design Manager.

6.3 Development Costs of the LPD-17 Program

The total design costs through Milestone II for the LPD-17 Program were $67.7 million. Figure 6.1 illustrates the timing of the funding through Milestone II. As was stated earlier, the bid price for the first ship was $641 million. The total design effort through MS II represents only 10% of the bid price. The majority of the funding for concept and feasibility studies was spent in FY91 ($6.5 million) with the remaining monies spent in FY92 ($2.9 million.) Preliminary design costs of $11 million were expended in FY93, leading to the contract design. The majority of funds through Milestone II were spent in FY94 ($21 million), on contract design. Additional funds were spent in FY95 and FY96 on contract design and activities leading to contract award ($28 million.)

Figure 6.2 shows the distribution of costs between government and industry through Milestone II. In this figure government represents the program office, design

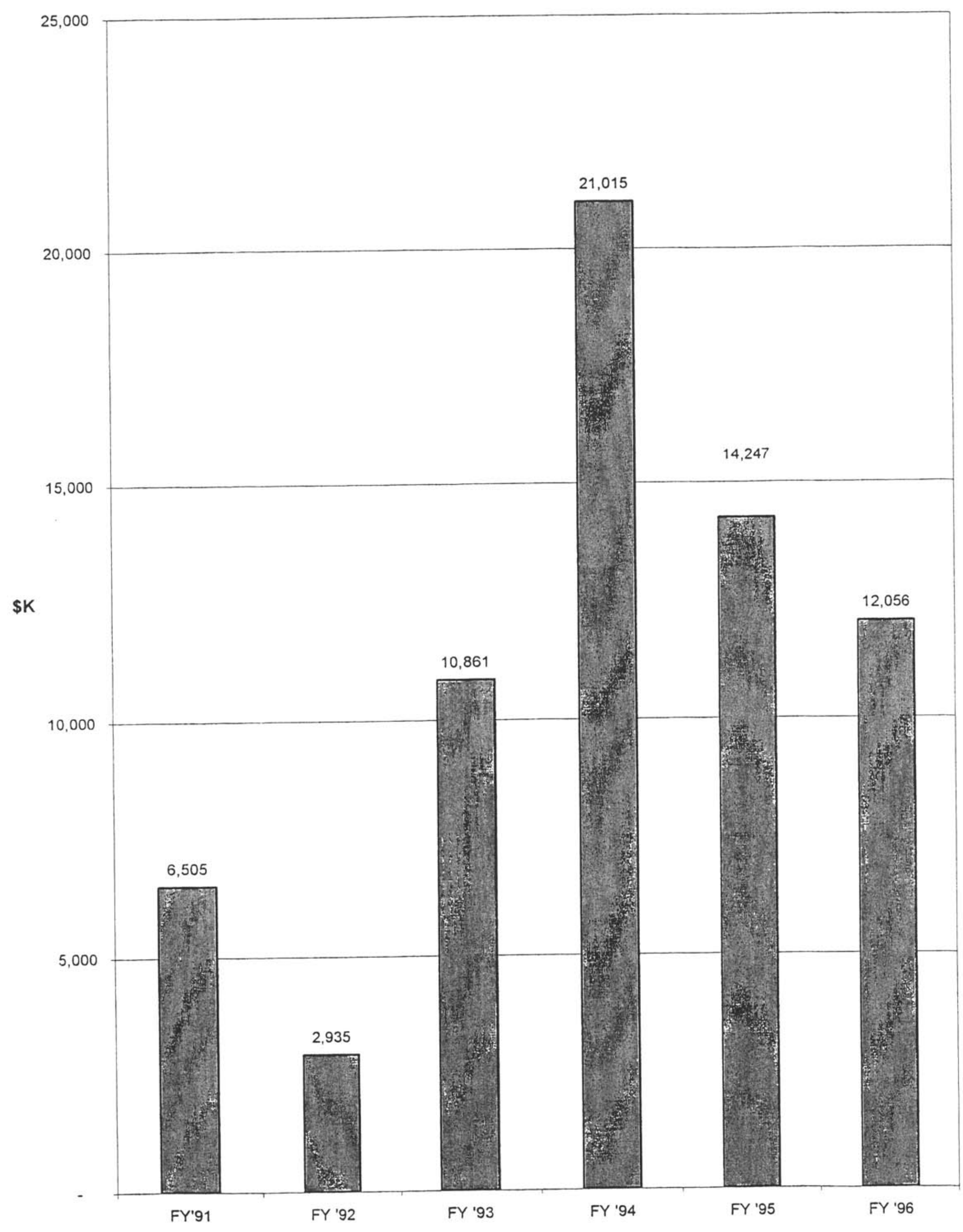


Figure 6.1: Timing of Costs for LPD-17 Program

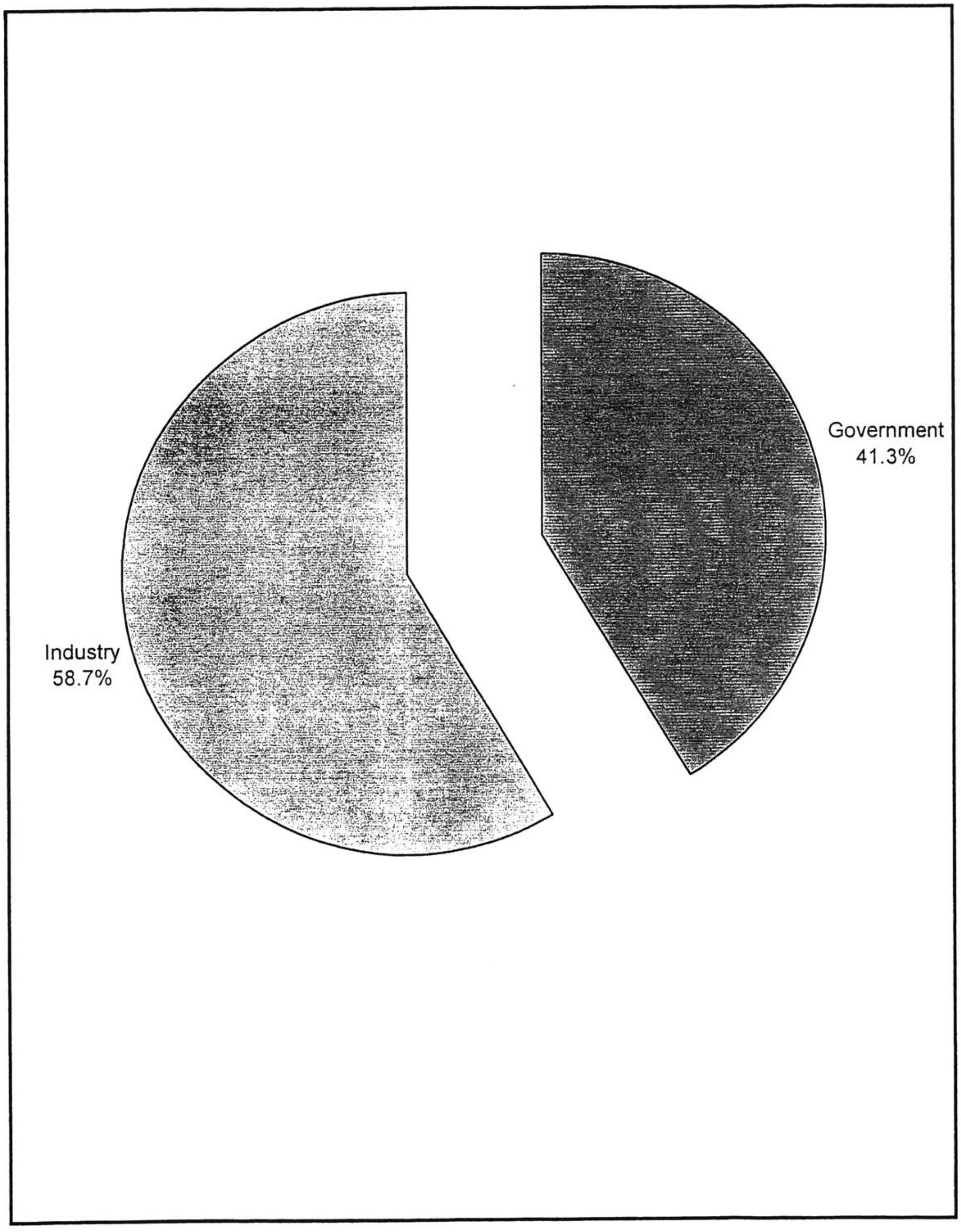


Figure 6.2: Total Design Effort for LPD-17 Program

office, and other government agencies (OGAs.) Through Milestone II, it is apparent that industry represented the majority of design costs (58.7%.) Of the remaining 41.3% allocated to the government, costs between the program and design offices totaled almost 23% and costs to OGAs totaled just over 18% (see Figure 6.3). Funds allocated to industry through MS II totaled $39.7 million as shown in Figure 6.4. Funds to OGA totaled $12.3 million; funds allocated to the program and design offices totaled $15.5 million.

Figures 6.5 and 6.6 show the cost breakdown by phase. As was stated earlier, the majority of funds (70%) for the LPD-17 program were allocated to the contract design phase. Funds for the contract phase totaled $47 million. Fourteen percent was spent on concept and feasibility studies; the preliminary design phase represented the remaining 16% of total design costs up through Milestone II.

6.3.1 Concept and Feasibility Design Costs

The concept and feasibility design phase of the program cost was just under $9.5 million as was shown in Figure 6.6. Figures 6.7 and 6.8 show the breakdown of these costs into different activities. During this phase, shipyards did yet have an active role in the design process. Therefore, it is fair to say that the great majority of funds spent by industry were to design agents and contractors. This cost totaled $4.7 million, representing 50% of the budget for this phase. Twenty-nine percent, or $2.7 million, was spent in-house with the remaining 21% ($2 million) spent by OGAs.

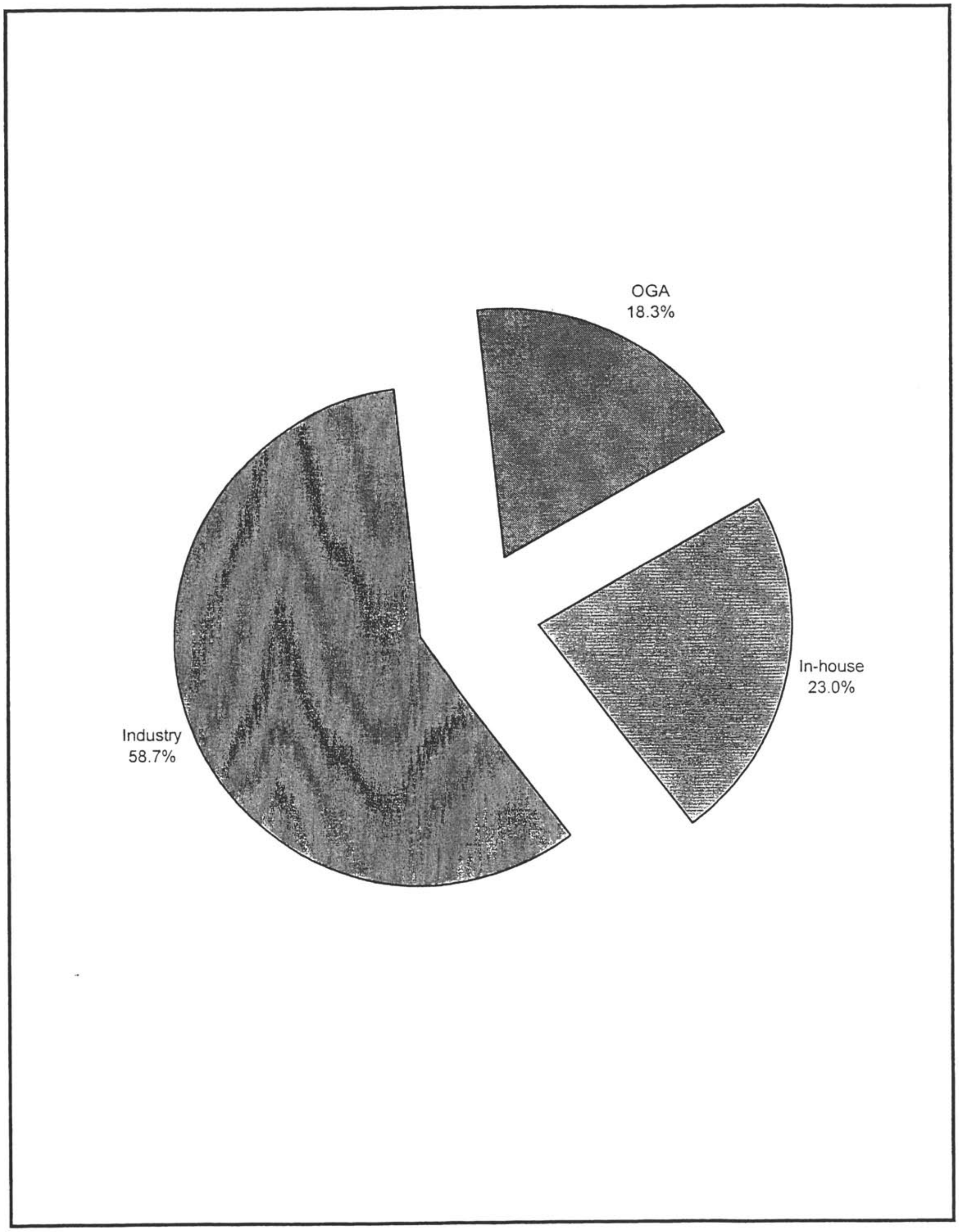


Figure 6.3: Total Design Effort (Detailed) for LPD-17 Program

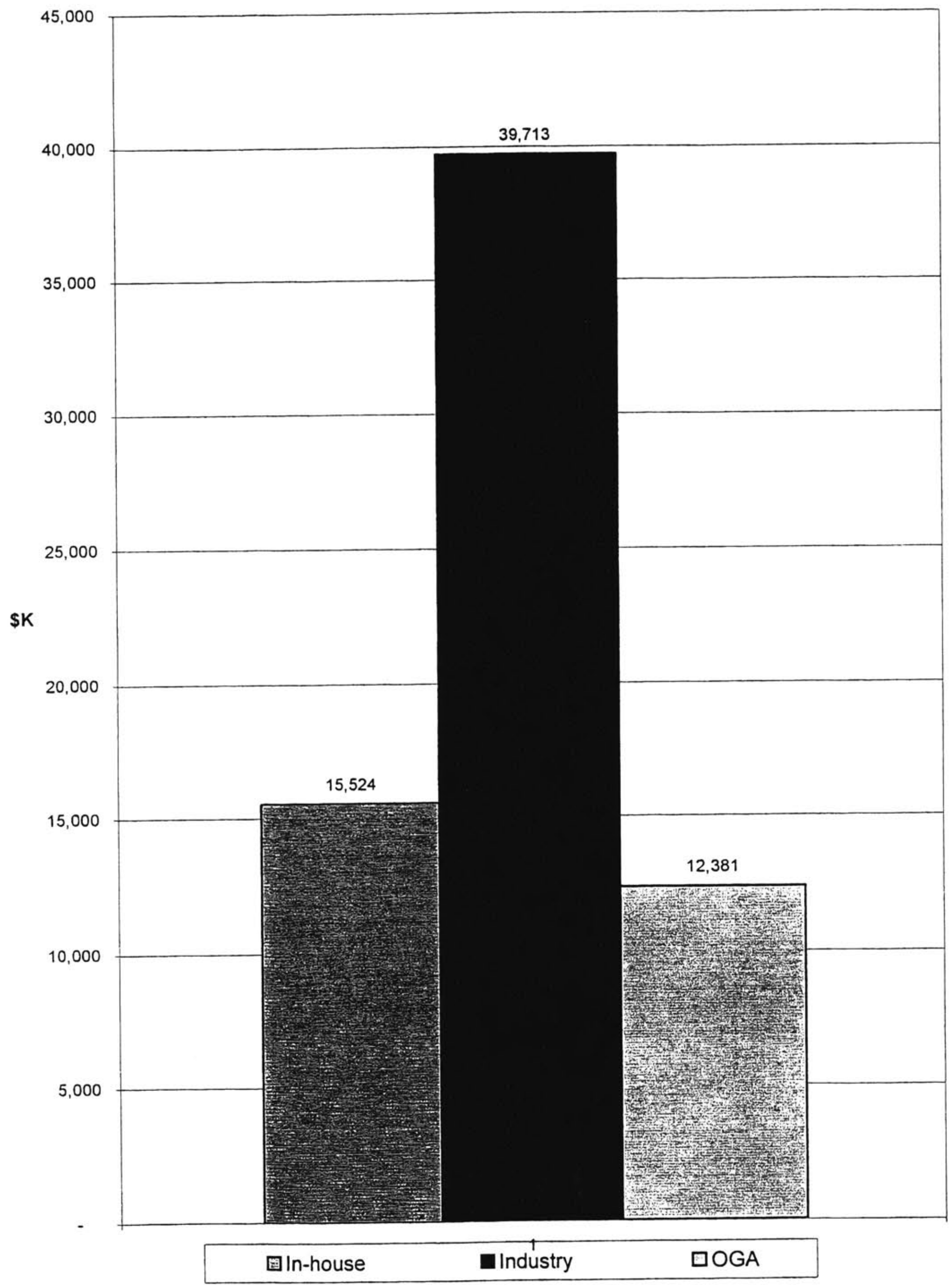


Figure 6.4: Total Design Cost for LPD-17 Program

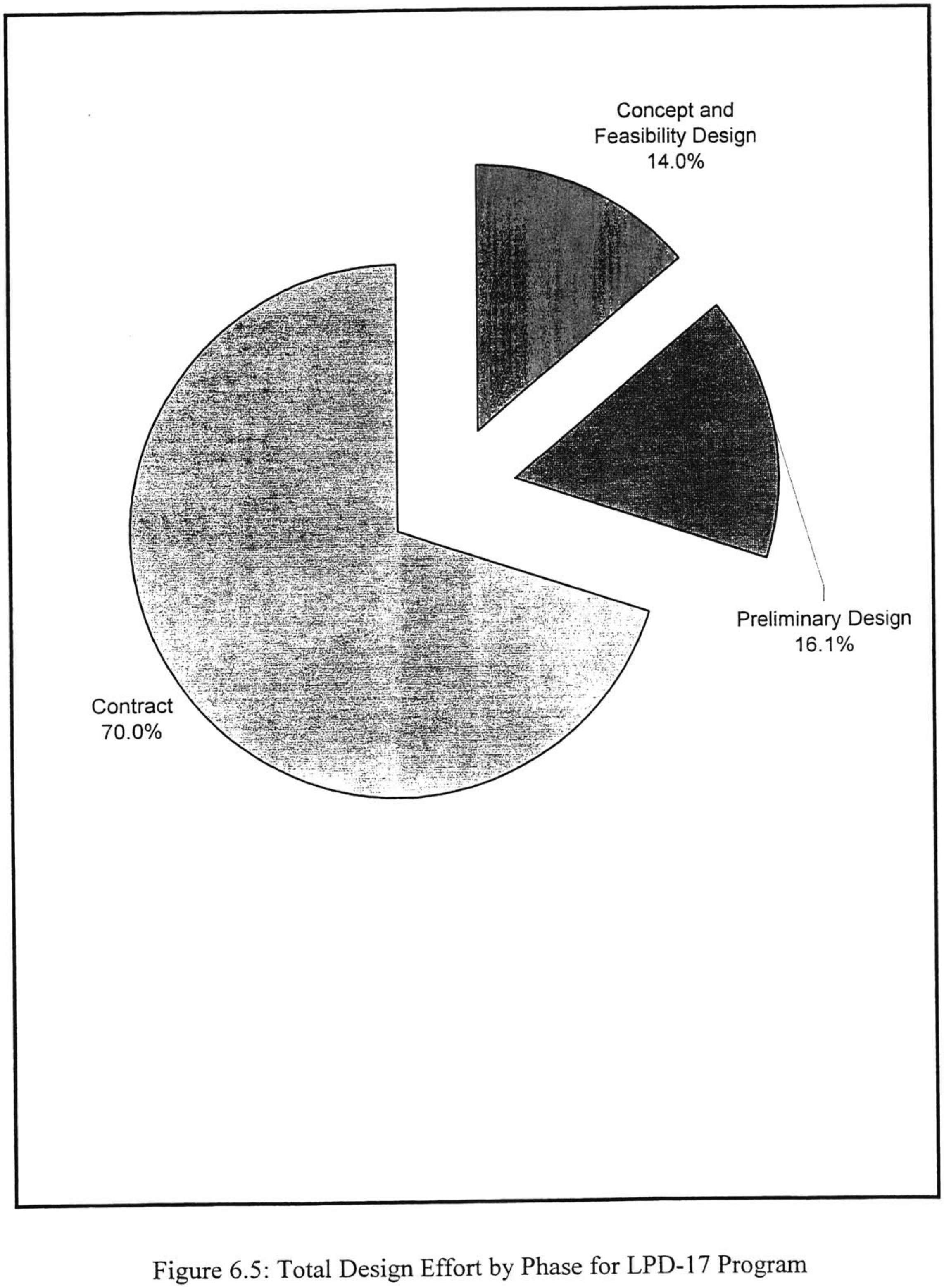


Figure 6.5: Total Design Effort by Phase for LPD-17 Program

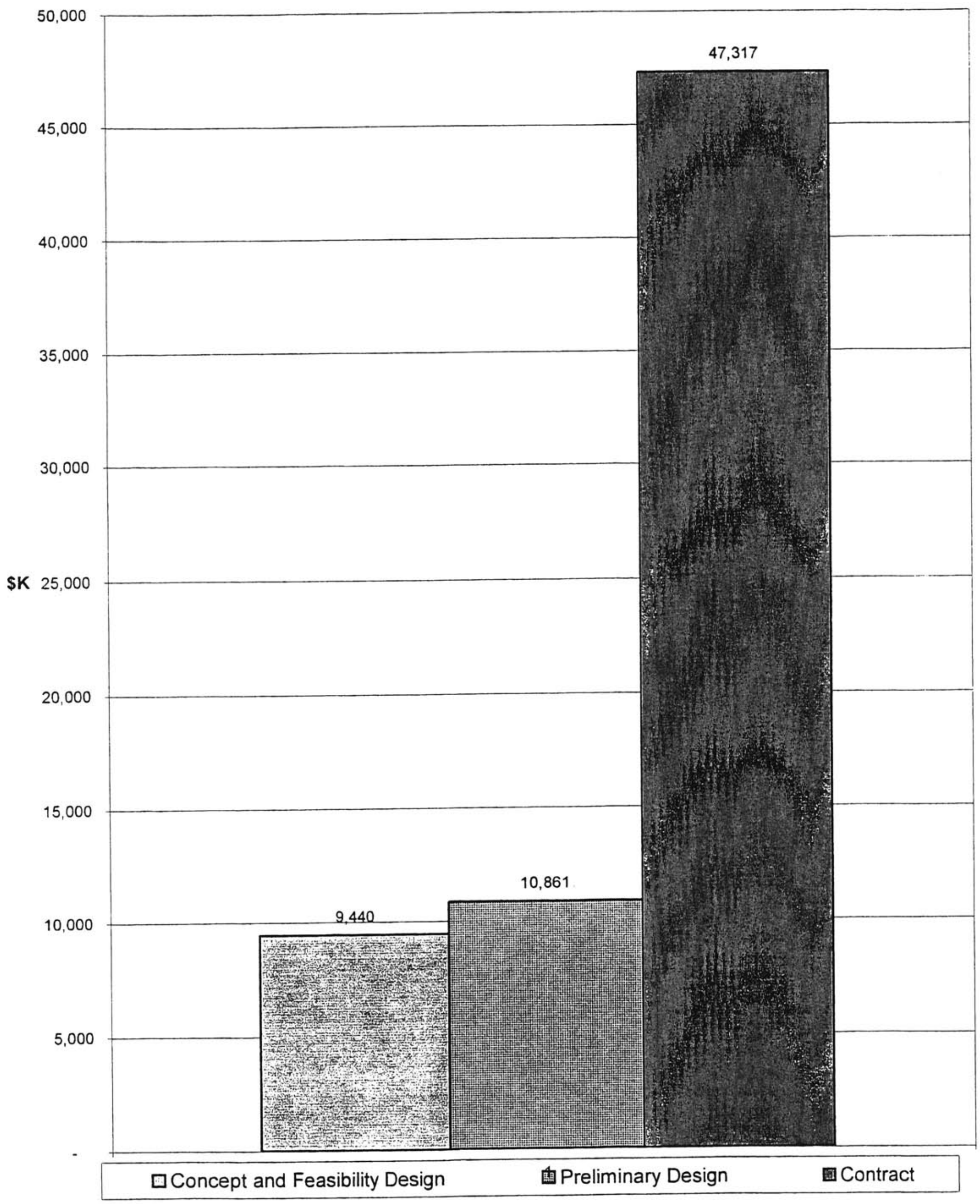


Figure 6.6: Total Design Costs by Phase for LPD-17 Program

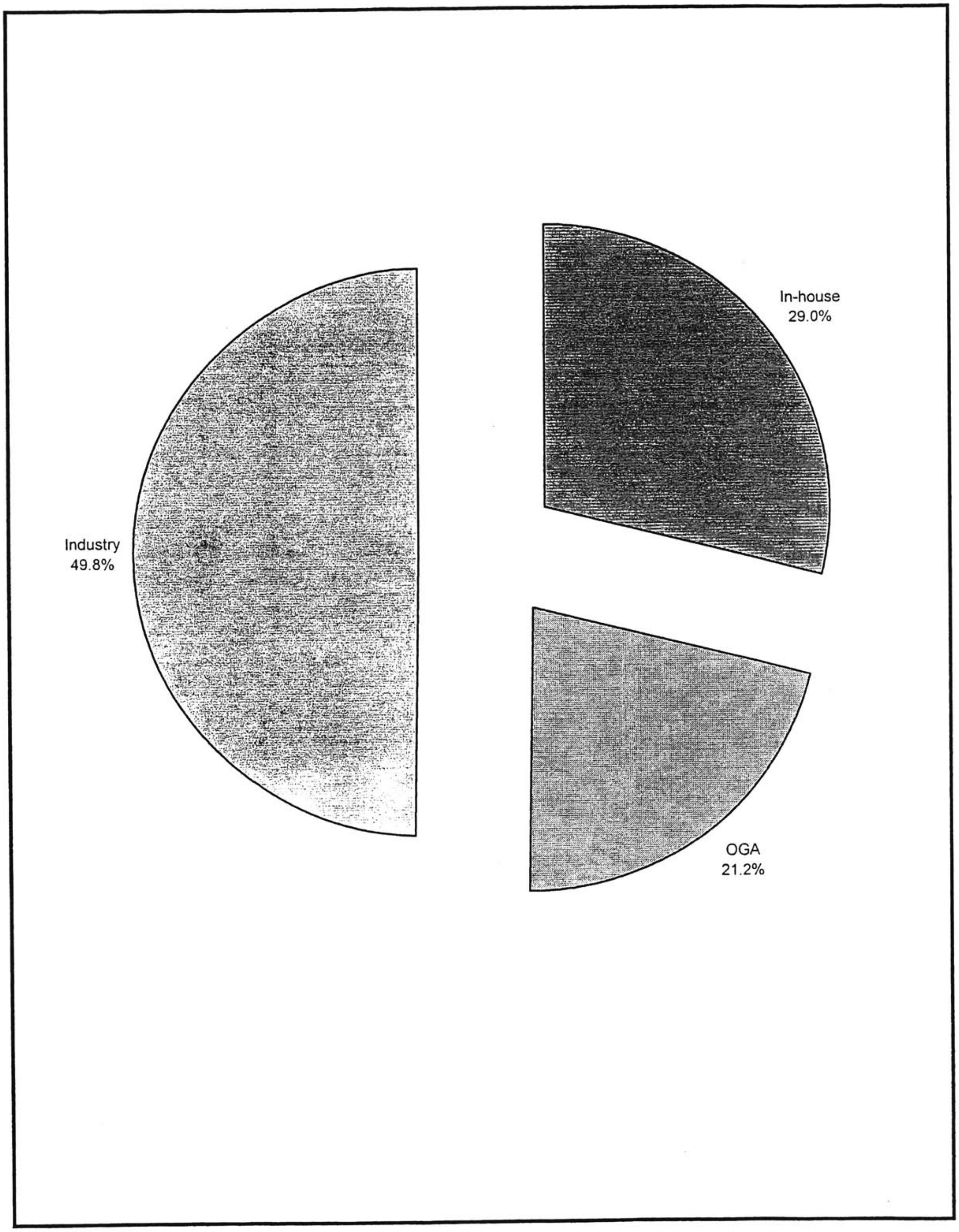


Figure 6.7: Concept & Feasibility Design Effort for LPD-17 Program

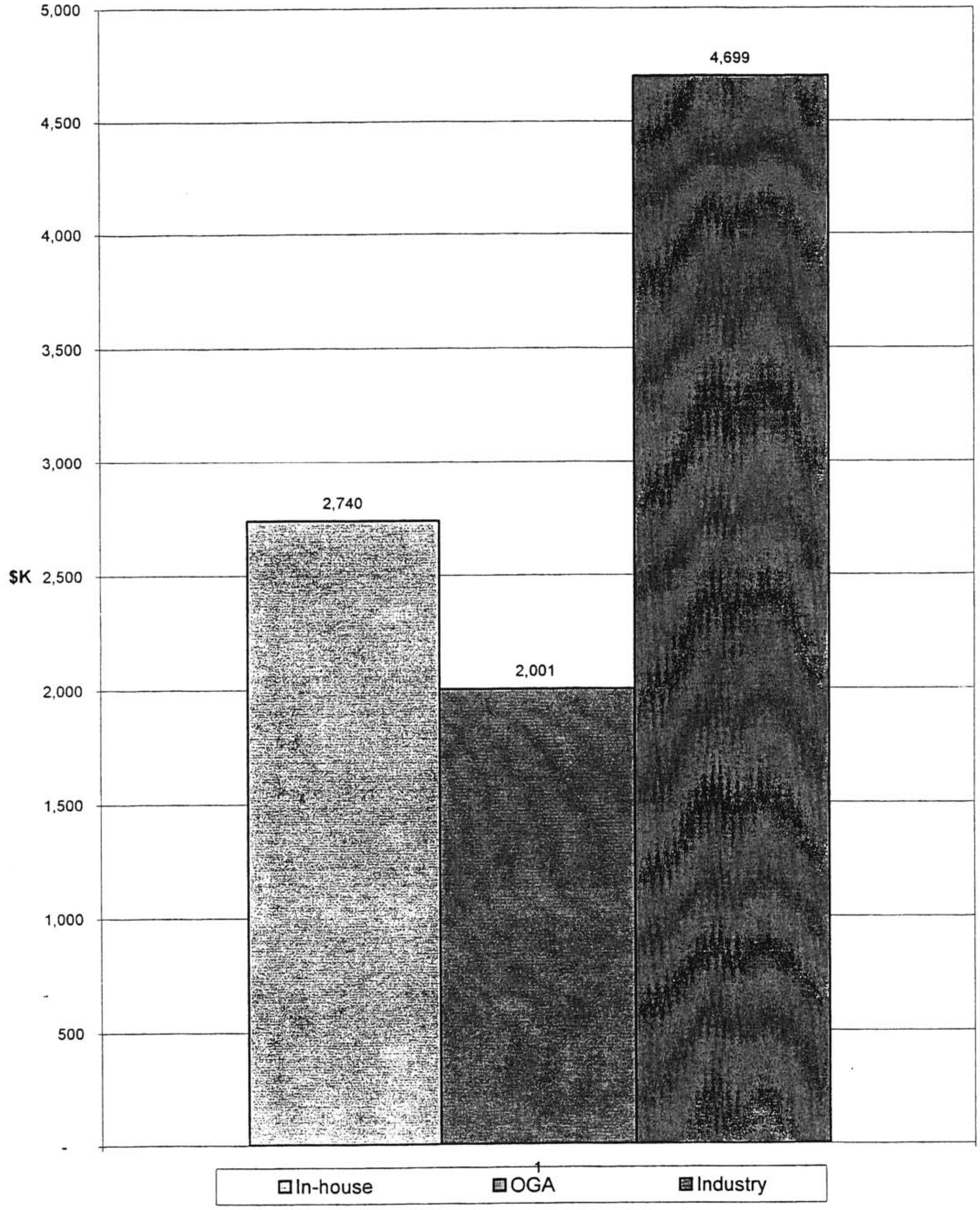


Figure 6.8: Concept & Feasibility Design Costs for LPD-17 Program

6.3.2 Preliminary Design Costs

Figures 6.9 and 6.10 show the total costs to all activities during Phase 0: Preliminary Design. The total monies spent during this phase, almost $11 million, accounted for 16% of the total design costs for the LPD-17 program. Industry played a much bigger role in this phase (63%) than in the concept and feasibility phase and accounted for approximately $7 million. Total government effort for this phase (in terms of monies spent) decreased. Both in-house and OGA spending accounted for approximately $2 million each.

6.3.3 Contract Design Costs

Please recall that the IPPD teams between government and industry were established between the preliminary and contract design phases. Shipbuilders had an active role in the design process for the first time and accounted for a significant amount of total industry spending. According to Figures 6.11 and 6.12, total spending by industry in this phase amounted to $28 million, 60% of total monies spent during the contract design phase. In-house spending totaled almost $11 million, or 23%. The remaining 18%, or $8.3 million went to OGA.

6.3.4 Funding Distribution

As was seen in the DDG-51 analysis, an attempt is made here to understand the personnel required by phase. Figures 6.13, 6.14, and 6.15 show the cost breakdown by task group for each phase in the program. During the Concept and Feasibility Phase, the Ship Design Management and System Engineering task groups play a very large role,

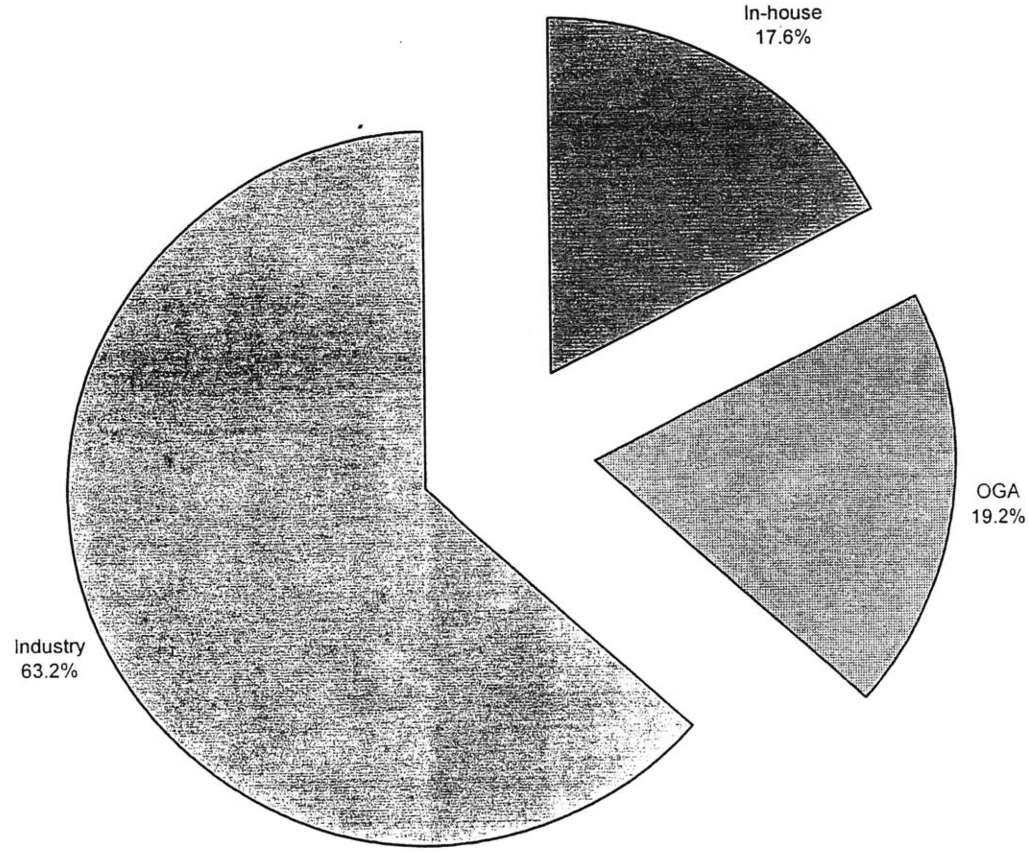


Figure 6.9: Preliminary Design Effort for LPD-17 Program

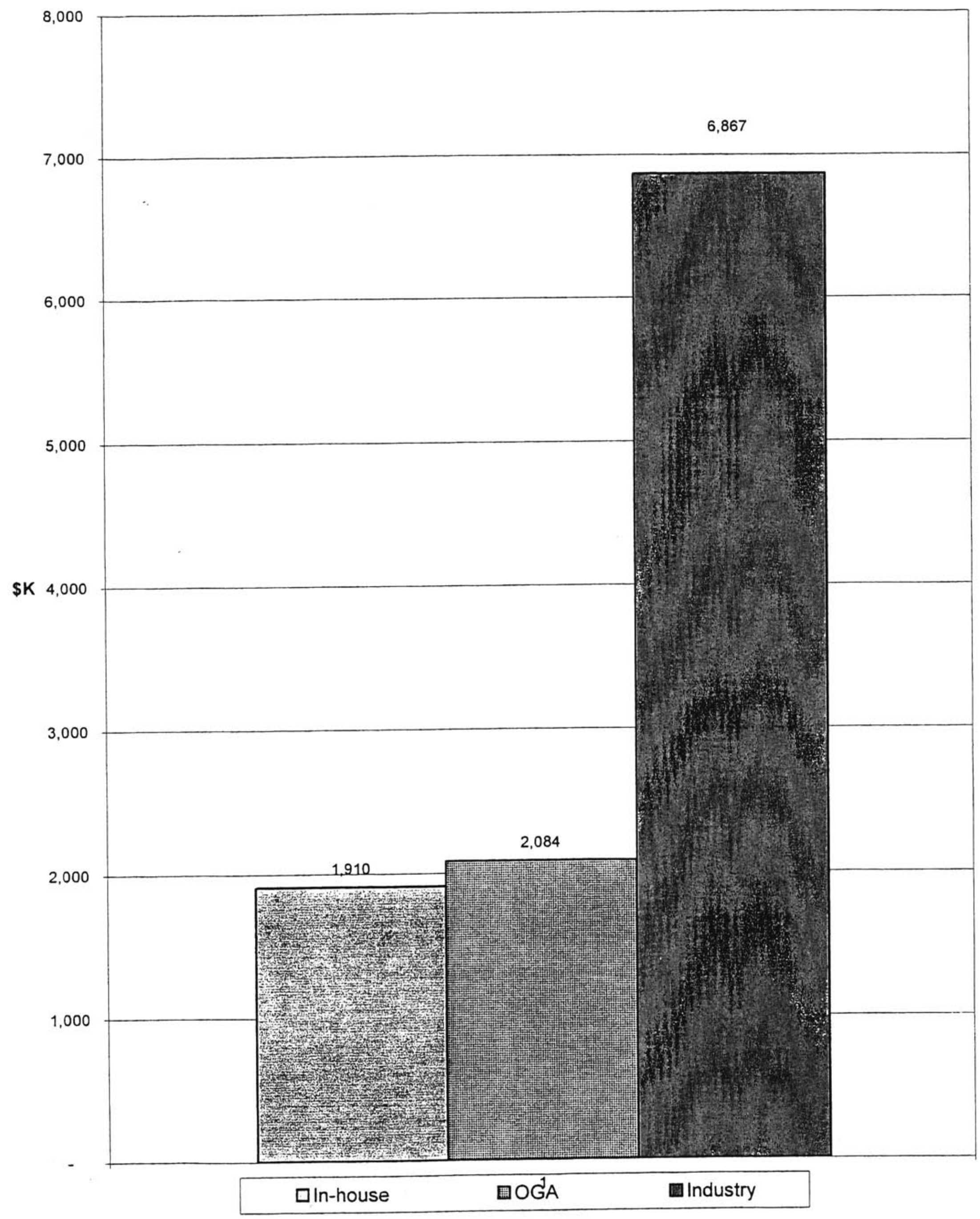


Figure 6.10: Preliminary Design Costs for LPD-17 Program

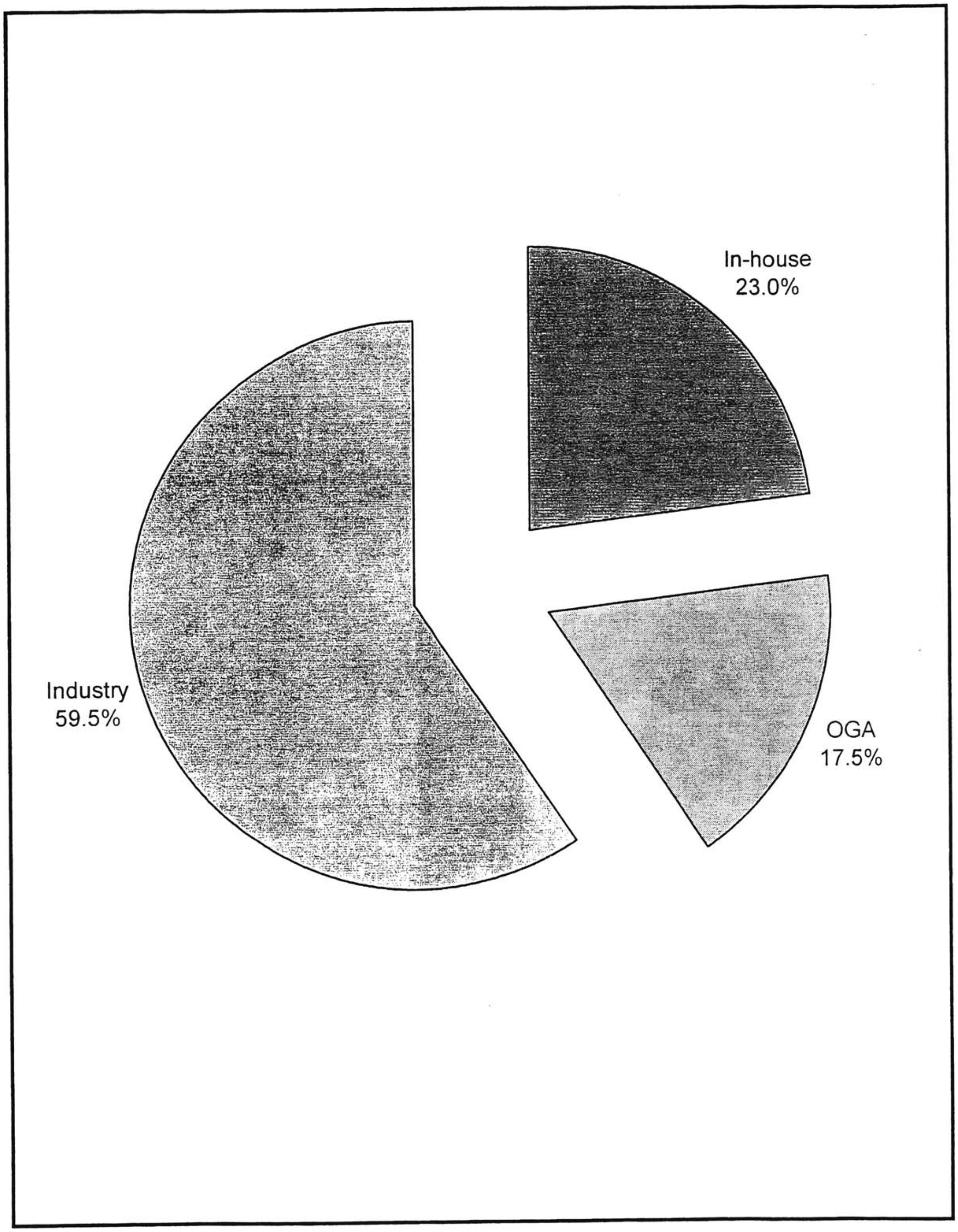


Figure 6.11: Contract Design Effort for LPD-17 Program

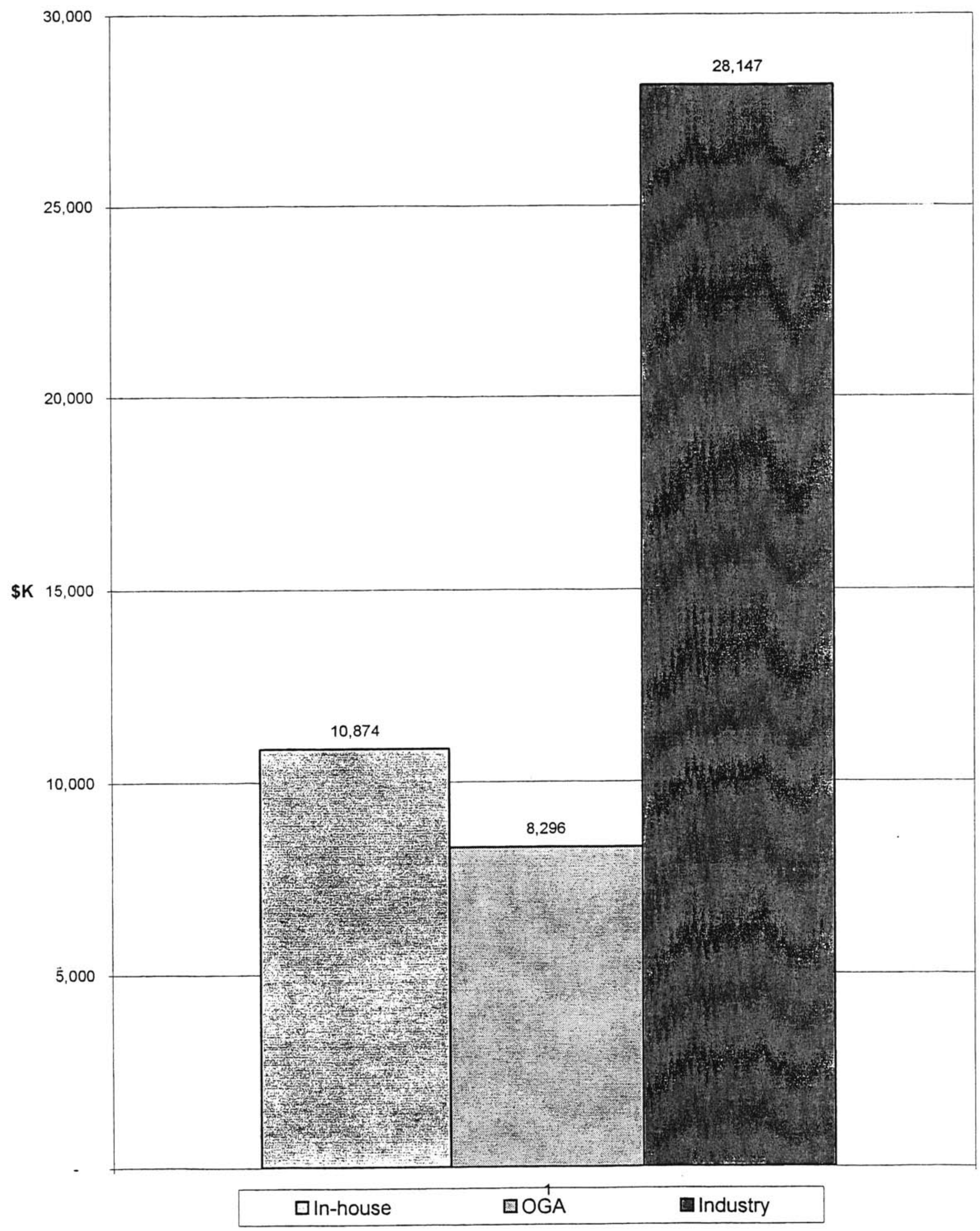


Figure 6.12: Contract Design Costs for LPD-17 Program

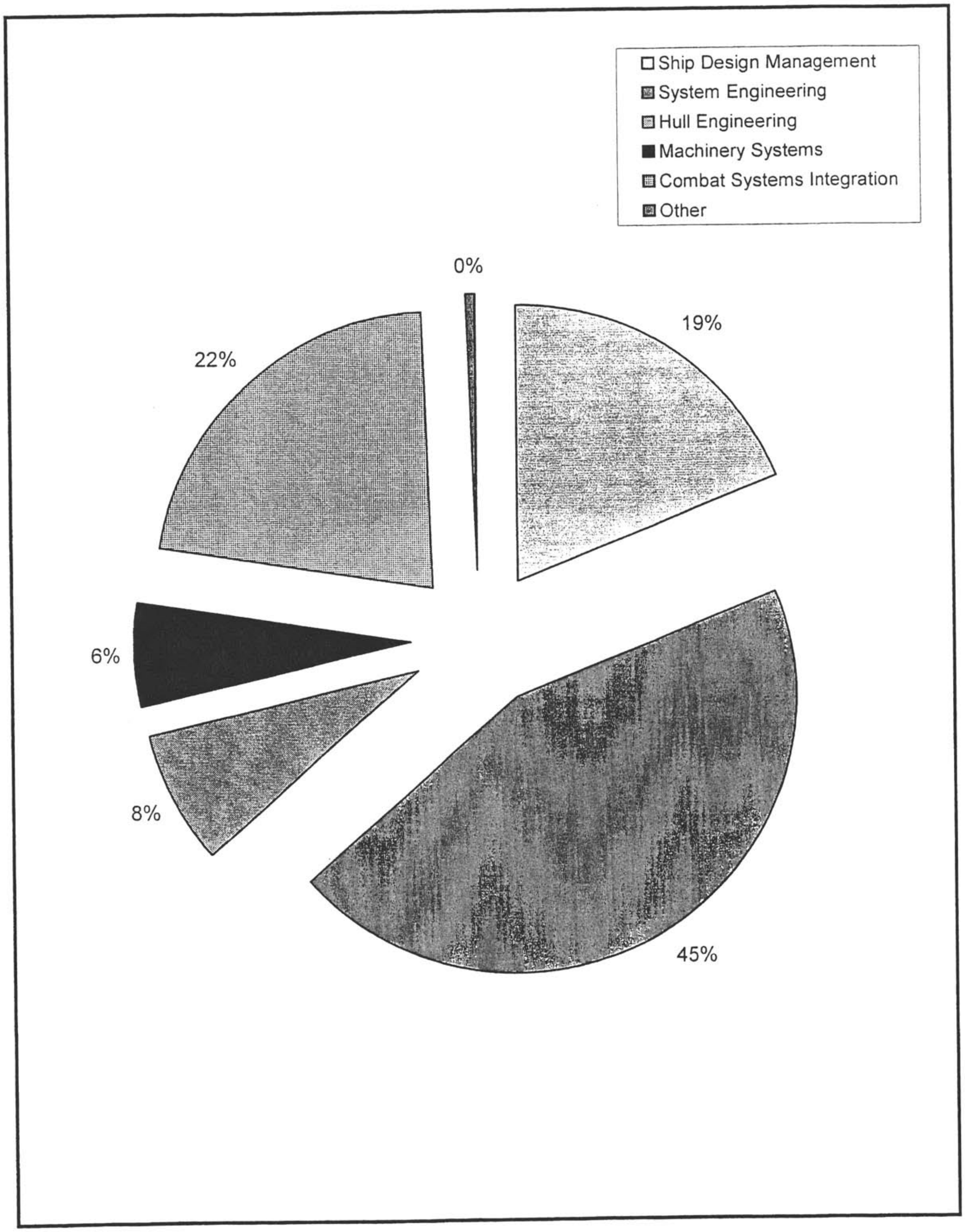


Figure 6.13: Concept Design Task Group Effort for LPD-17 Program

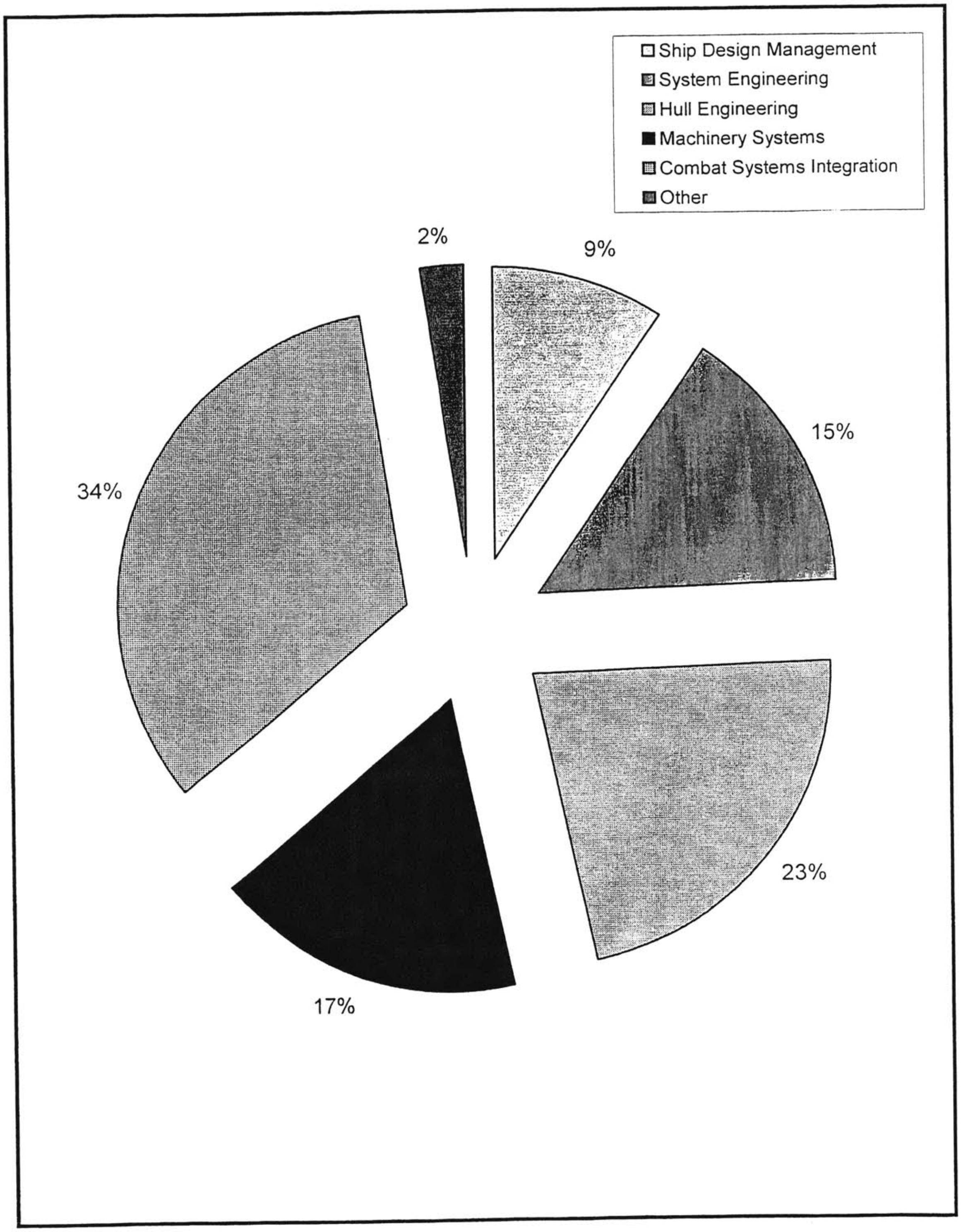


Figure 6.14: Preliminary Design Task Group Effort for LPD-17 Program

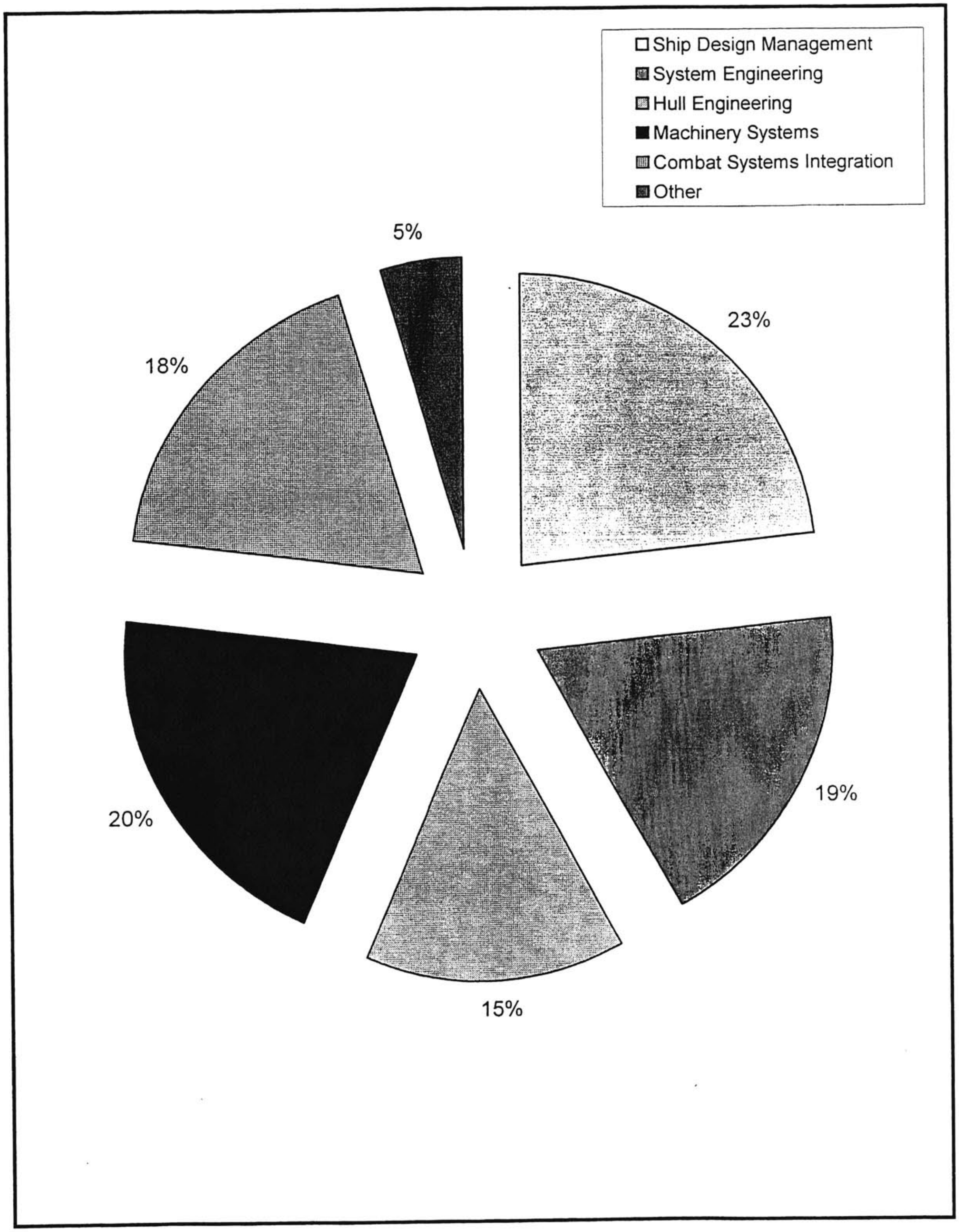


Figure 6.15: Contract Design Task Group Effort for LPD-17 Program

19% and 45% respectively. Specific tasks under the heading System Engineering include design integration, producibility, and reliability, maintainability, and availability studies. A third large contributor is the Combat Systems Integration group.

During the Preliminary Design phase, a slightly different distribution took place. All six task groups accounted for at least 10% of total funds for the phase, with the exception of groups consolidated in "other." These groups include ILS, materials, and ship specifications groups. The Hull Engineering group spent 23% of the funds; Machinery accounted for 17%; and the Combat Systems group made up 34% of costs for this phase.

The Ship Design Management task group made up one-quarter of total costs spent during the Contract Design phase. Other major task groups contributed between 15% and 20% each. We see in this phase that the government's role during this phase takes on a greater focus toward management than in previous phases.

7 COMPARATIVE ANALYSIS

In the previous sections of this thesis, four acquisition programs were presented on their own, with total design costs shown unadjusted for inflation. This section will present these programs together, in terms of 1998 dollars. Although it is impossible to get a perfect "apples-to-apples" comparison among different programs, each unique in its own way, several general hypotheses addressing total spending during the design process leading up to MS II will be presented. Conclusions and recommendations will be drawn from these hypotheses based on the approaches used in these four programs.

7.1 Total Design Costs

Total design costs for the four new-construction acquisition programs presented in this thesis are shown in Table 7.1. Values shown in Table 7.2 have been adjusted to 1998 dollars using the Wharton Econometric Forecasting Associates (WEFA) Group, Gross Domestic Product (GDP) inflation chart found in Appendix 1.

Table 7.1: Total Design Costs, uninflated, in $000's

	CONCEPT & FEASIBILITY		PRELIMINARY DESIGN		CONTRACT DESIGN		TOTAL
	$K	% of total	$K	% of total	$K	% of total	$K
DDG-51	$6,046	12.5%	$16,749	34.5%	$25,705	53.0%	$48,500
Icebreaker	$9,547	76.5%	$1,089	8.7%	$1,845	14.8%	$12,481
Sealift	$2,618	5.8%	$15,583	34.7%	$26,745	59.5%	$44,945
LPD-17	$9,440	14.0%	$10,861	16.1%	$47,317	70.0%	$67,618

Table 7.2: Total Design Costs (Inflated to 1998 dollars)

	CONCEPT & FEASIBILITY		PRELIMINARY DESIGN		CONTRACT DESIGN		TOTAL
	$K	% of total	$K	% of total	$K	% of total	$K
DDG-51	$11,437	14.5%	$27,328	34.6%	$40,233	50.9%	$78,998
Icebreaker	$15,399	82.3%	$1,247	6.7%	$2,058	11.0%	$18,704
Sealift	$3,080	6.1%	$17,842	35.2%	$29,833	58.8%	$50,754
LPD-17	$ 10,955	15.1%	$11,972	16.5%	$49,708	68.4%	$72,635

These numbers are also illustrated in Figure 7.1.

One trend to note is that the type of vessel to be designed drives total design spending. DDG-51 and LPD-17 have extensive combat capability and cost a significant amount more to design than the Icebreaker and Sealift. The Sealift, still with a relatively high level of complexity, costs $20 M less to design. Finally, the Icebreaker, as expected, was the least costly program reviewed in this thesis. Reasons for this are the fact that the Icebreaker is a smaller vessel, single vessel program. It is no combat capability and its systems are not as complex as the other ship programs.

Judging from Figure 7.1, it would be possible to say that some percentage of the $6.5 M difference between DDG-51 and LPD-17 is due to the acquisition approach taken, although the actual breakdown is difficult to discern. Finally, Figure 7.2 shows total spending through MS II as a percentage of first ship cost.

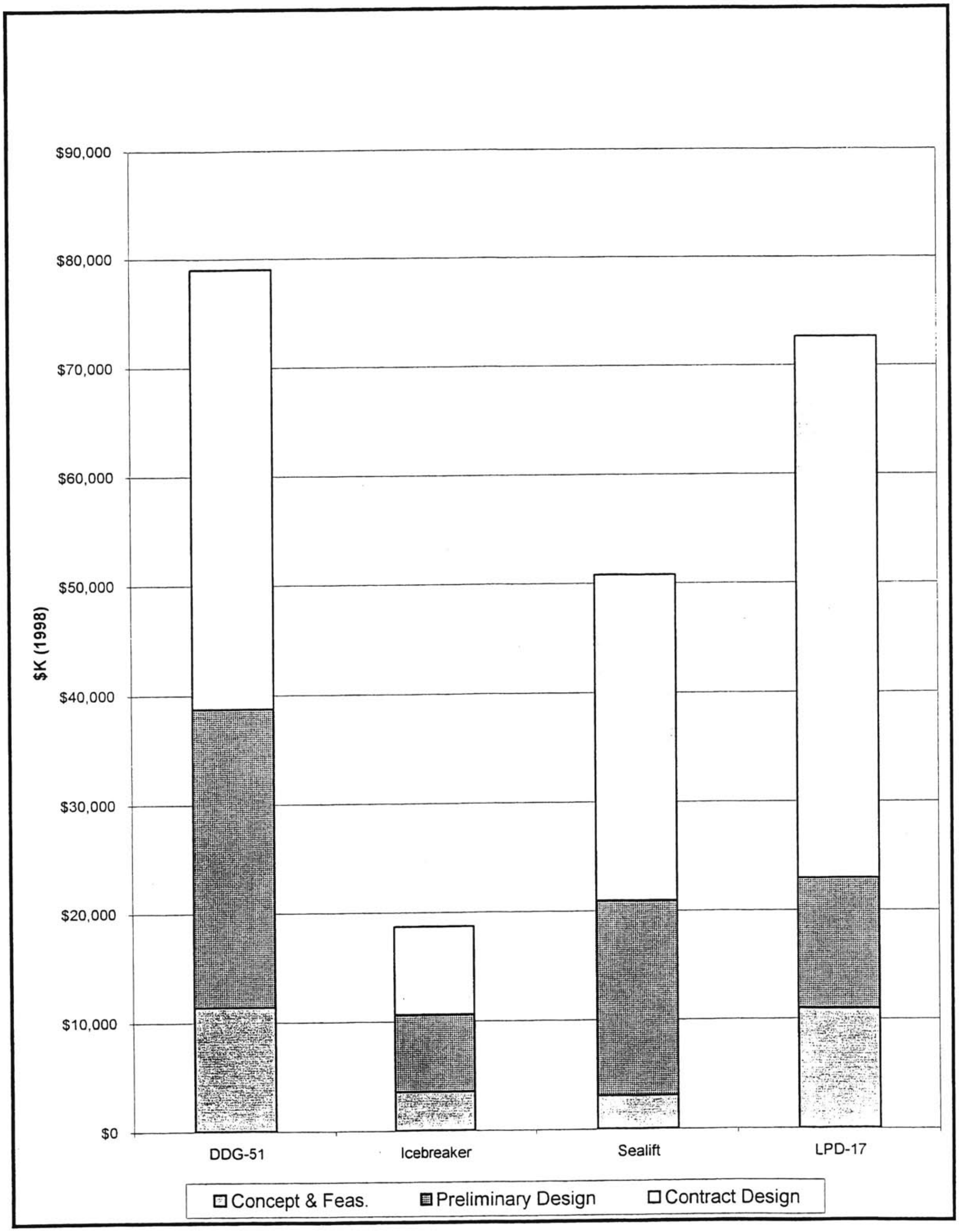


Figure 7.1: Total Design Costs for Several Navy/USCG Programs

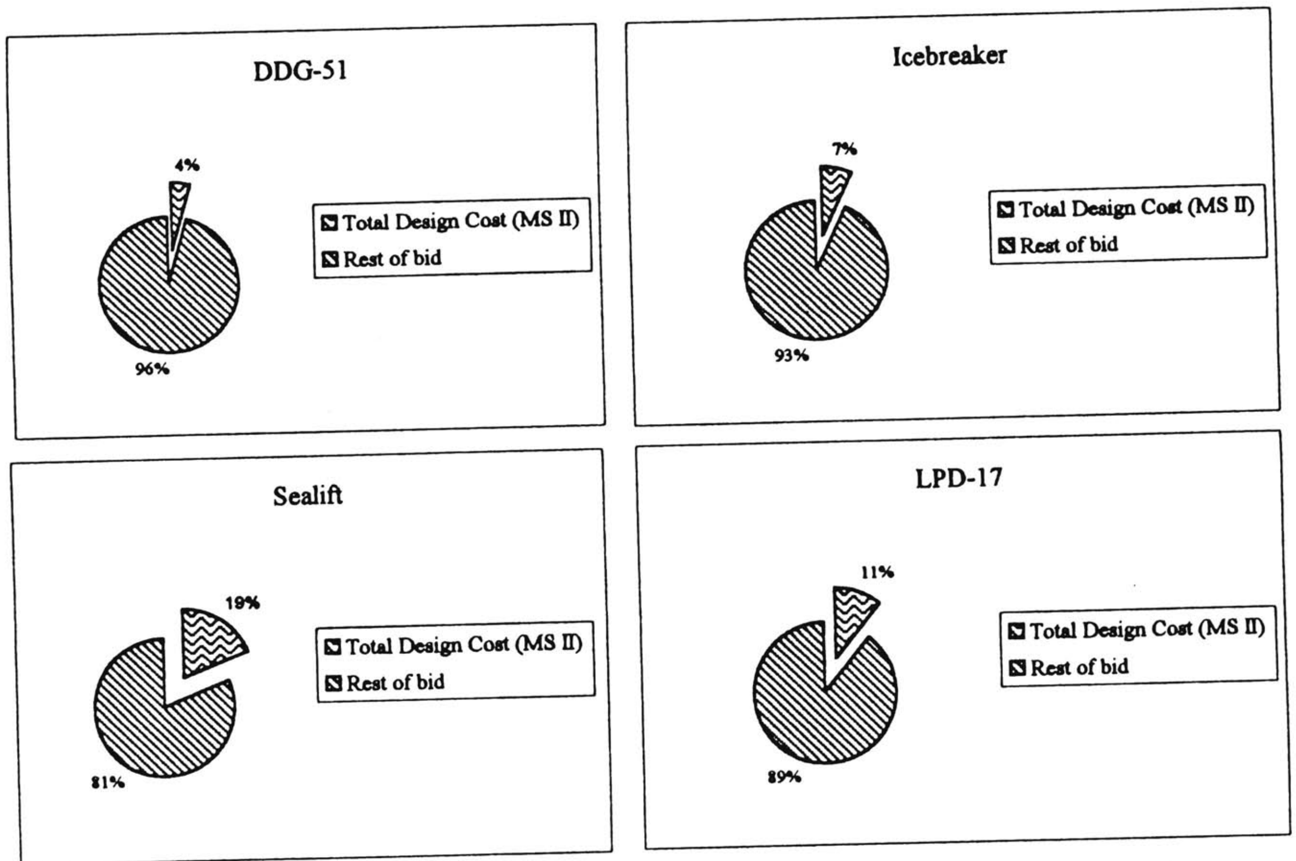


Figure 7.2: Total Design Costs as Percent of Bid for Lead Ship Detailed Design and Construction

7.2 Concept Design Spending

The concept design cost breakdown by activity group is shown in Figure 7.3 for the DDG-51, Sealift, and LPD-17 programs. The Icebreaker program, primarily because it is not a military ship and because design costs may be understated since money was spent on design prior to the official acquisition program began, is not included in the comparison. In all three of these programs, industry contributions during this phase are primarily from design agents and not from shipyards. Regardless of how industry is represented during this phase, it is clear that the majority of funds during this phase were allocated to industry. The participation by OGA varied. With the exception of LPD-17 where it accounted for 29%, in-house typically represented less than 20% of total design costs.

7.3 Preliminary Design Spending

Figure 7.4 illustrates activity group spending during preliminary design. In-house contributed about 20% for all three programs; OGA efforts ranged from 20% to 30%. During the DDG-51 preliminary design, the majority of industry funding was spent on design agents rather than on shipbuilders. In the Sealift program, shipyards accounted for roughly 14% with design firms contributing 35%. Industry represented over 60% of LPD-17 preliminary design spending. It is difficult to break out design agents versus shipyards for this program. However, it is estimated that the majority of these costs associated with industry were still for design agents during this phase. Please recall that

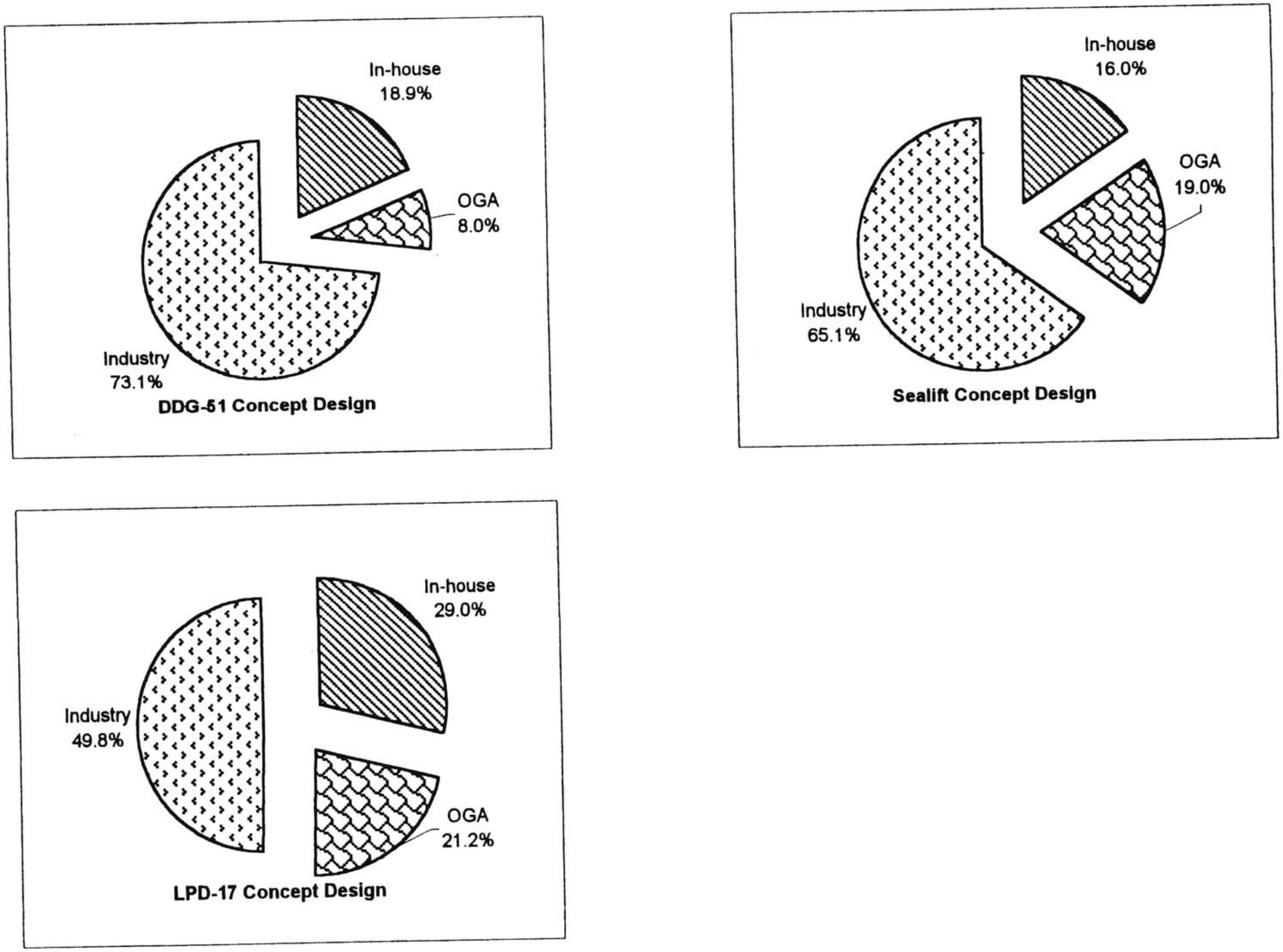


Figure 7.3: Concept Design Spending Breakdown for Several Navy Programs

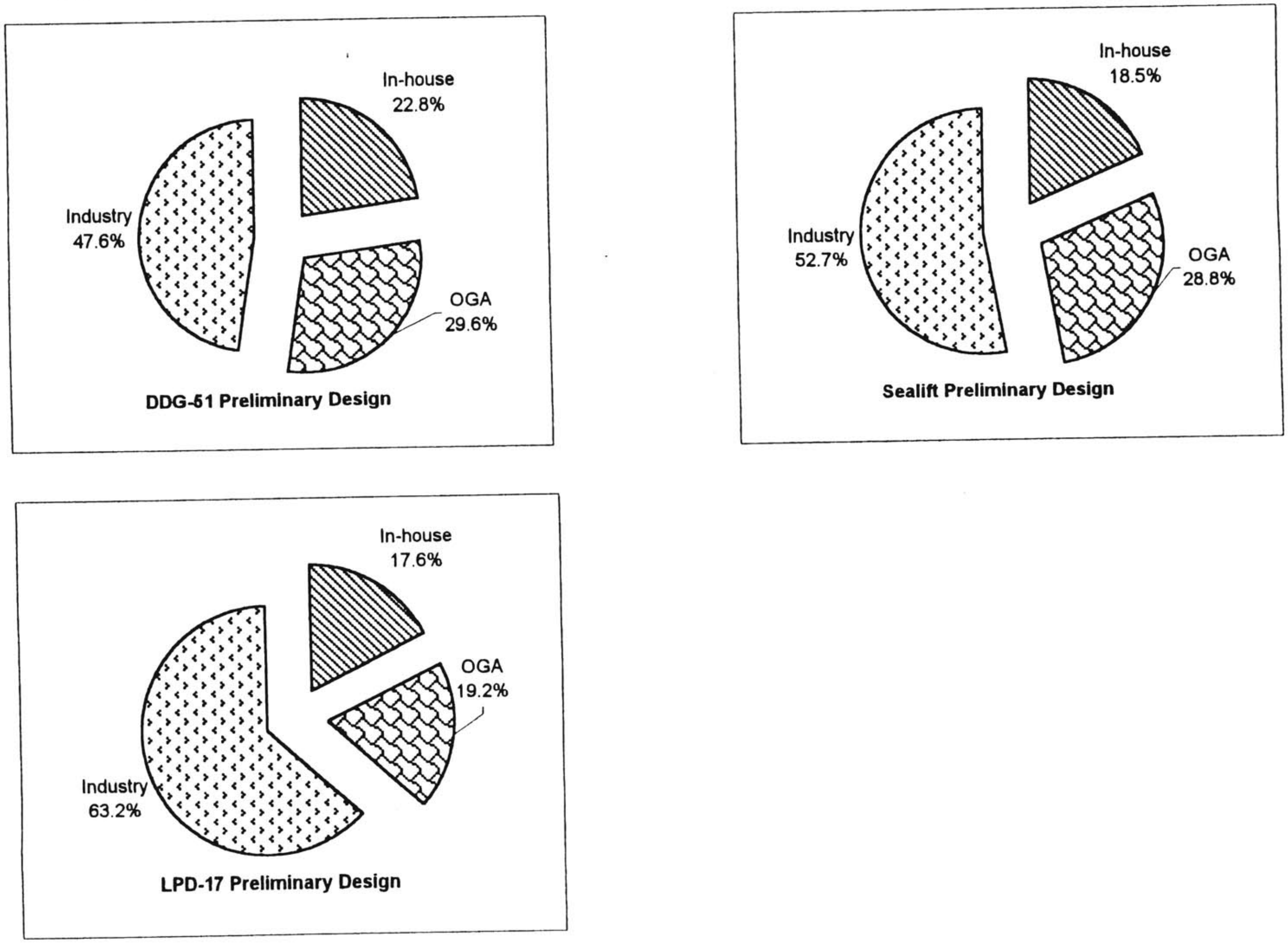


Figure 7.4: Preliminary Design Spending Breakdown for Several Navy Programs

in the Sealift program, seven shipyards were contracted to develop preliminary designs while in-house personnel maintained an arm's length approach as reviewer. In the LPD-17 program, shipyards were involved in the preliminary design, but IPPD teams (which included NAVSEA personnel assigned to each team) were not created until the beginning of contract design.

7.4 Contract Design Spending

Contract design spending for the DDG-51, Sealift, and LPD-17 is shown in Figure 7.5. Again, the majority of industry funding was spent on design agents rather than shipyards in the DDG-51 program. In the contract design phase, 60% of spending went to industry. Based on the acquisition approach taken in the DDG-51 program, the "old way of doing things," the effort by in-house and OGA are consistent, 24% and 16% respectively. Likewise, based on the type of approach implemented for the Sealift program, of competitive, industry-based contract designs, the70% level of effort by industry, with shipyards accounting for 40% and design agents only 15%, is consistent. With in-house maintaining the role of reviewer at 6.5%, OGA makes up the difference with 24%. What is very interesting is the comparison between the DDG-51 and LPD-17 programs for industry spending. The amount of industry effort for both programs is about 60%; however, there has been a transition over time from the majority of the money spent on design agents to the majority of the money being spent on shipyards. This trend continues in the DD-21 program currently underway.

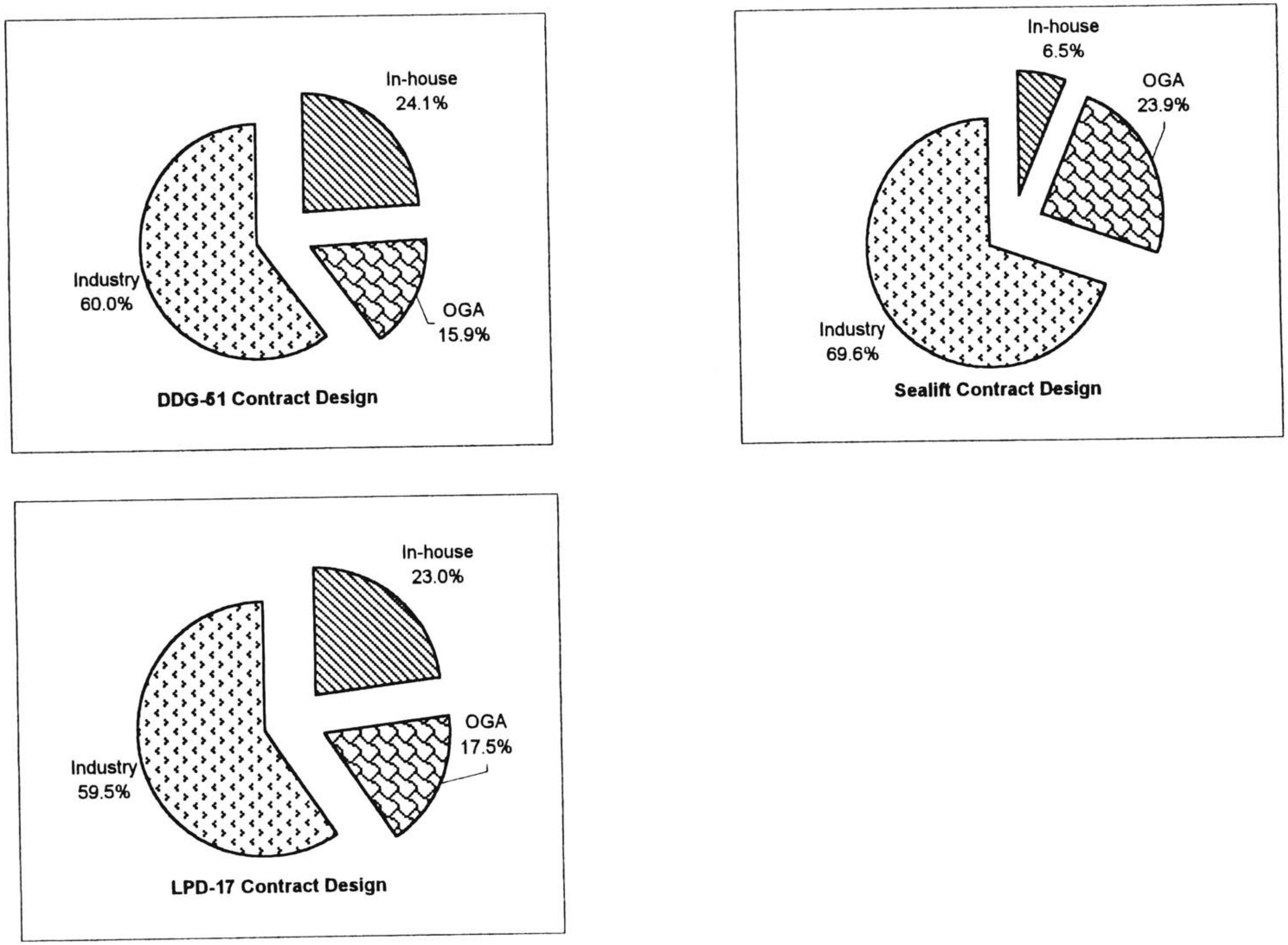
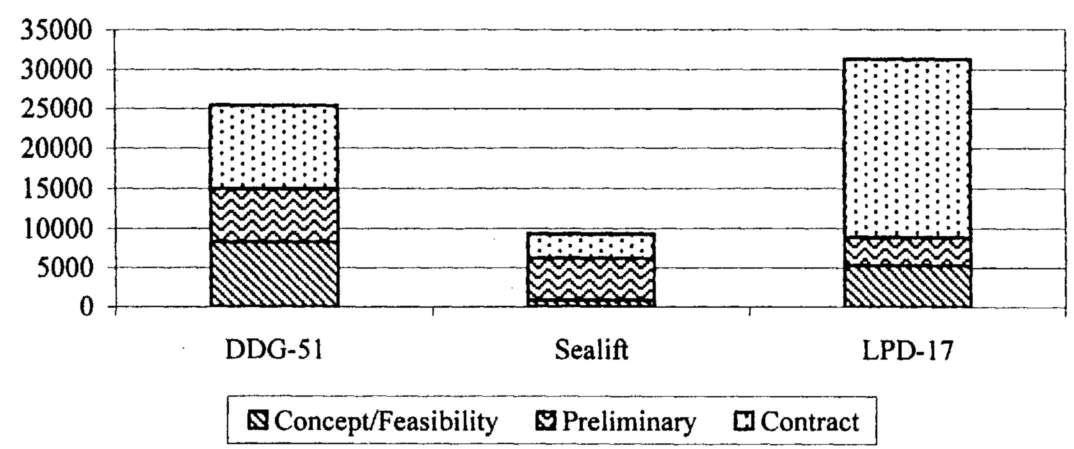


Figure 7.5: Contract Design Spending Breakdown for Several Navy Programs

In-house Mandays by Phase

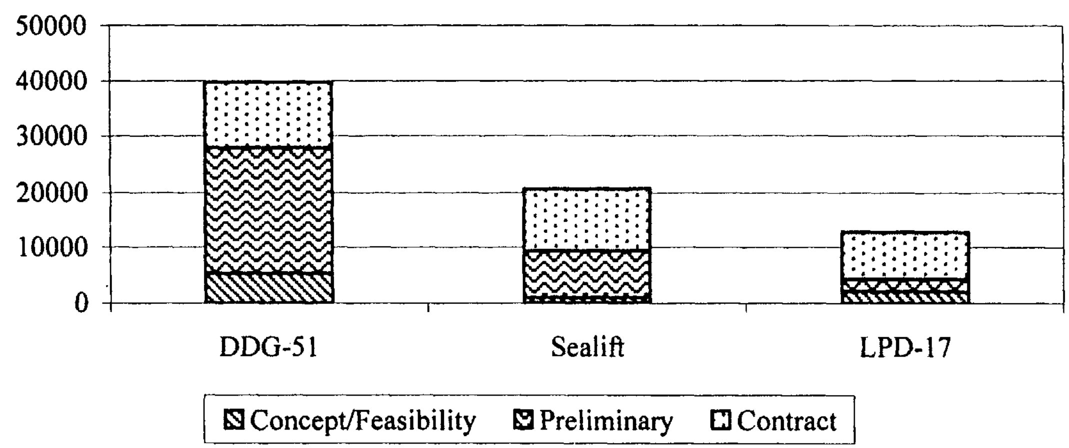
	DDG-51	Sealift	LPD-17
Concept/Feasibility	8298	819.5	5312
Preliminary	6674	5378.4	3551
Contract	10469	3122.7	22465

Figure 7.6: In-house Mandays



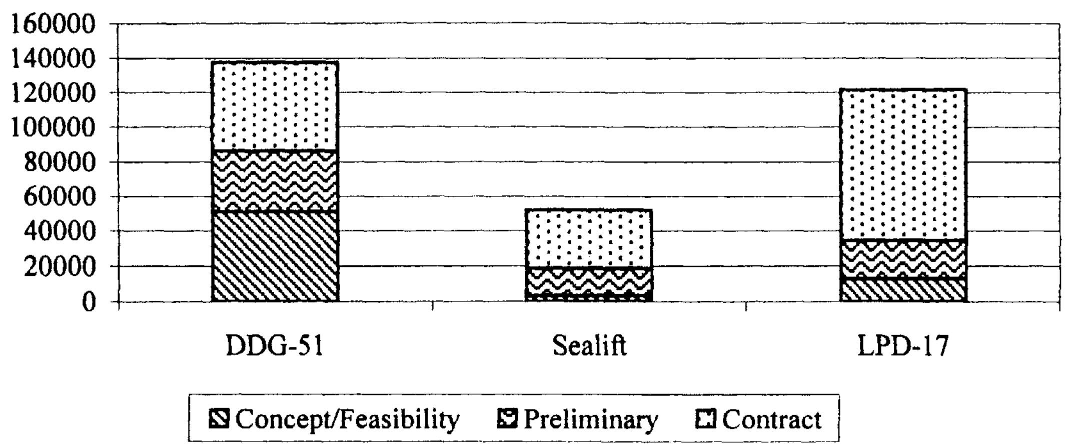
OGA Mandays by Phase	DDG-51	Sealift	LPD-17
Concept/Feasibility	5321	975.3	2084
Preliminary	22555	8367.9	2171
Contract	11893	11415.7	8644

Figure 7.7: OGA Mandays



Industry Mandays by Phase	DDG-51	Sealift	LPD-17
Concept/Feasibility	50961	3341.8	13010
Preliminary	35256	15326.1	21460
Contract	51435	33323.0	87208

Figure 7.8: Industry Mandays



7.5 Manpower Levels

Total mandays for each program, by phase and activity, are shown in Figures 7.6, 7.7, and 7.8. Mandays for the Icebreaker program were not available. The most obvious conclusion from Figure 7.6, In-house Mandays, is that the complexity of combatant programs requires much greater effort than non-combatant programs and are, therefore, much more expensive. Furthermore, once the effort has evolved into a major program, with multiple ships, absolute mandays are relatively constant. Design costs, expressed as a function of bid, will vary as the price of the bid varies. In-house mandays for DDG-51 made up 12% of total mandays as opposed to 17% for LPD-17. Total mandays are determined from summing mandays in Figures 7.6–7.8. When comparing DDG-51 and LPD-17 programs, the type of work done by in-house personnel has evolved from designer to program reviewer. However, this increase from 12% to 17% seems inconsistent with recent downsizing efforts within governmental agencies. This increase could be due to the added time needed for IPPD team set-up and training, software developments, program delays, as well as the focus on TOC in the LPD-17 program. Programs in the past have not focused on TOC reductions. Furthermore, although there have been manning cutbacks within NAVSEA, there have also been fewer large programs. Thus, personnel are able to shift between programs. Finally, the total length of the DDG-51 program was 50 months whereas the LPD-17 program was 74 months. Thus, on a per year basis, the average number of personnel for the LPD-17 program is less than for the DDG-51 program. This is shown in Figure 7.9.

n-house Manyears by Phase per year (=personnel/year			
	DDG-51	Sealift	LPD-17
Concept/Feasibility	15	3	10
Preliminary	32	86	7
Contract	36	17	43

Timing of Design Stages (months)					
	DDG-51	Icebreaker	Sealift	LPD-17	Generic Ship*
Concept	26	29	12	26	3-18
Preliminary Design	10	5	3	23	6-11
Contract Design	14	11	9	25	9-16
Total	50	45	24	74	18-45

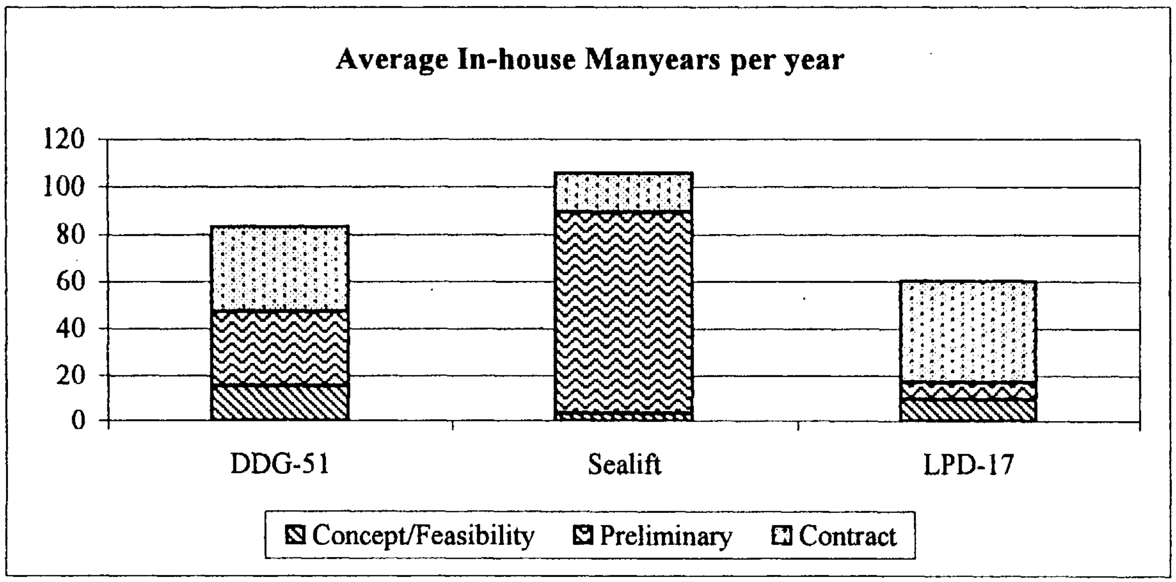


Figure 7.9: Data for Determining Average In-house Manyears per year

Figure 7.7 illustrated OGA mandays. It is difficult to make conclusions from this information. Figure 7.8 showed industry mandays. Industry includes design agents as well as shipyards. From this graph, one conclusion is that there is a trend toward increased industry involvement. As was mentioned earlier, there is also a definite trend toward earlier shipyard involvement, which has led to a greater role played by shipyards than by design agents. The effects of the IPD team for the LPD-17 program are shown in the fact that industry involvement during contract design has increased significantly. Although there was a significant amount of industry participation during the designing of the Sealift program, the lower level of complexity for this non-combatant required fewer mandays overall.

7.6 Task Group Effort

Task group effort for total design through MS II is shown in Figure 7.10 for the DDG-51 and LPD-17 programs. These numbers were not available for either the Icebreaker or Sealift programs at the time this thesis was published. Program management effort was much greater for the LPD-17 program than for the DDG-51 program. This was also the case for hull engineering and machinery systems. Systems engineering and combat systems integration task groups played a smaller role for the LPD-17 program than for the DDG-51 program.

7.7 Hypotheses on Acquisition

In the remainder of this chapter, the author presents several hypotheses concerning the Navy acquisition process. These hypotheses are evaluated based on the

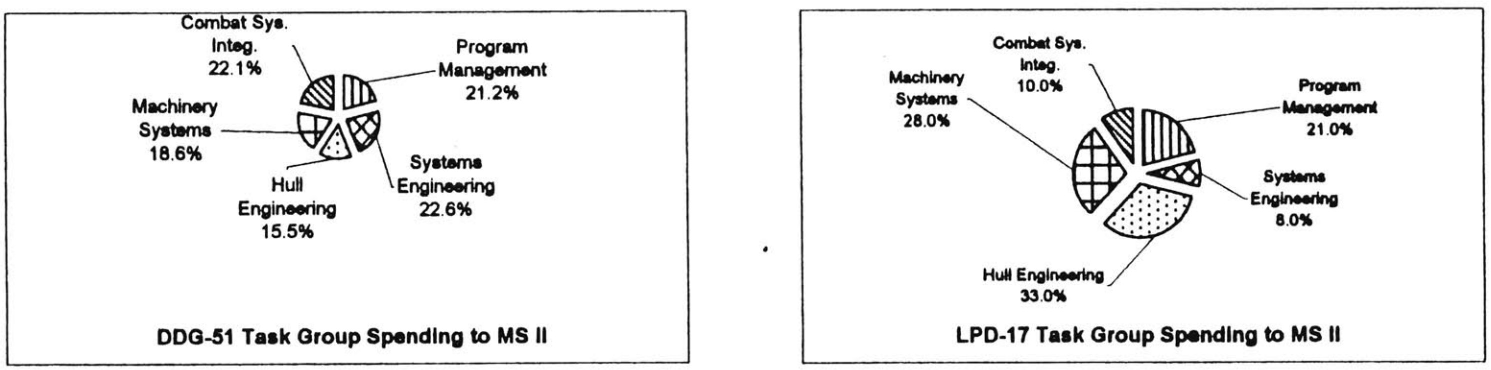


Figure 7.10: Total Task Group Spending through Milestone II.

data presented previously as well as the knowledge the author has gained from performing this thesis. Hypotheses directly relating to the data provided are discussed first. Subsequent hypotheses are consistent with literature reviewed on this topic, and while may not be either proved or disproved by data collected here, are nonetheless enlightening.

Hypothesis 1: Although there have been great changes in the acquisition process, the changes in design cost, in-house mandays, and industry effort have been minor.

Great strides have been made in, among other areas, streamlining the total acquisition process, increasing industry involvement, and focusing on total ownership costs (TOC). However, despite these changes, the procedure of acquiring a new combatant, especially a multi-ship program like the DDG-51 and LPD-17, requires an enormous amount of effort. Total design costs as a percent of lead ship costs may vary as a function of the bid, however; Table 7.2 illustrated that, in terms of 1998 dollars, total design costs to MS II for both the DDG-51 and LPD-17 were roughly $75 million. Regardless of whether in-house personnel are performing the design, acting as reviewers, or a hybrid of the two, a pool of qualified government personnel existed to sustain the program. Finally, the transition in industry involvement from design agents to shipyard (and design agents) has been seen over time and will continue through the current DD-21 program and beyond. This transition has not greatly changed industry costs for these programs.

Hypothesis 2: Design costs are minor relative to first ship bid and, moreover, are insignificant compared to total costs of a multi-ship program. Thus, more money invested up front should result in significant savings to total design.

This relates to the philosophy of concurrent engineering taught by Huthwaite (Reference 5). Concurrent engineering applies the precept that the successful designer considers all product life-cycle aspects from the beginning of a design, all the way through to disposal.

It recognizes that a product is the sum of its life-cycle processes, not just the sum of its individual parts (Reference 1).

He states there are three truths that form the basis for concurrent engineering. The first truth is that,

Design is the primary driver of quality, cost, and time.

As was previously stated in this thesis, and is shown in Figure 7.11, most would agree that the design drives approximately 70% to 80% of the total life-cycle cost. As Figure 7.12 shows, the cost incurred through contract award at MS II, the time period reviewed by this thesis, represents only a small fraction of total cost to develop a new warship (or any commercial item.) This figure further points out that by MS II, the amount of cost and performance "locked in" is enormous. Consequently, greater efforts made during the initial phases, and therefore a greater slice of the pie, may in fact reduce the overall size of the pie.

Certainly, as was seen in Figure 7.2, design costs are very small compared to the bid price for the first ship. The Icebreaker program only included one ship; however, design costs represented only 5% of the total program costs. Furthermore, for multi-ship

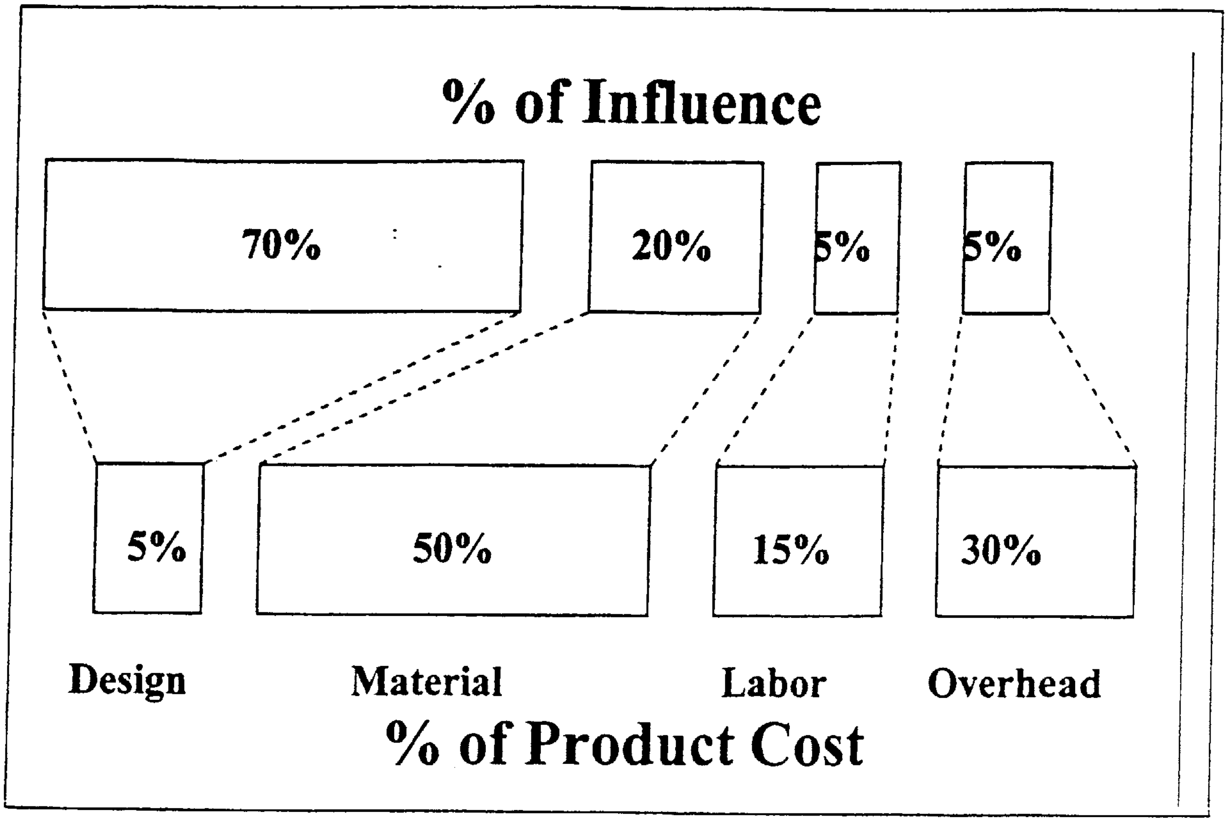


FIGURE 7.11 (REF. 1)

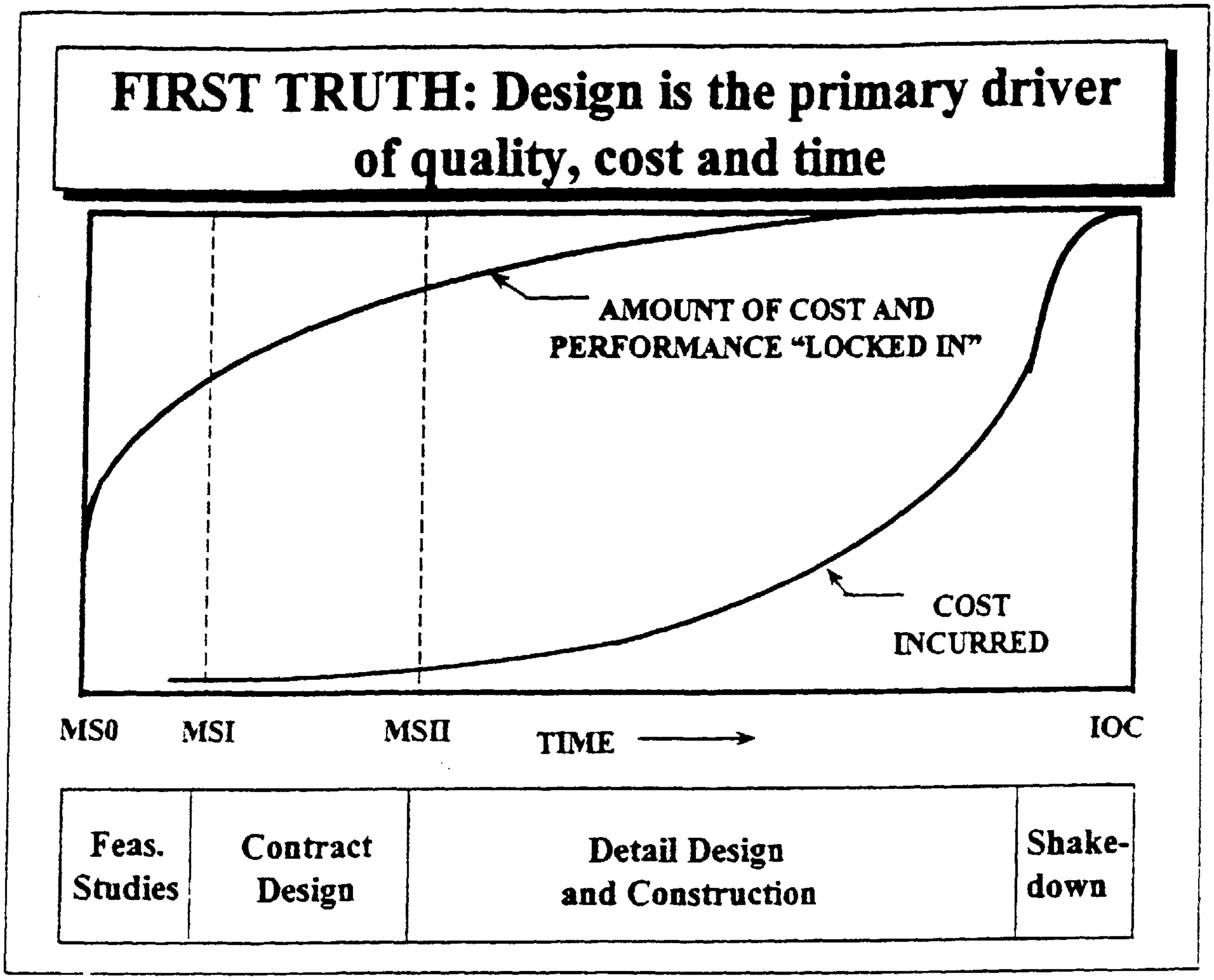


FIGURE: 7.12 (REF. 1)

programs, the design costs are insignificant when compared to the total costs for the program. The figure shows design costs as 5%of total program costs. Design costs for the programs reviewed here were even less. For both the DDG-51 and Sealift programs, design costs through MS II represented less than 1% of total program costs. The LPD-17 program is still underway, but there is no doubt that this trend will also prove true for the LPD-17 program. The reference to the majority of costs "locked in" by MS II is seen in a more qualitative sense than with actual numbers. By MS II, there exists not only a concept to be further developed but also an actual design requiring only further massaging through detailed design to prepare for construction. This statement has also held true for the programs reviewed here.

There are three effective measures to test this hypothesis on the programs presented here. First, the amount of change-order costs required, with the exception of changes made at request of customer (and not driven by discrepancies in design), gives a good indication on the quality of the design by MS II. Second, time overruns against the projected delivery date could also, to a lesser extent, measure whether enough time and money was invested in the design phase. Certainly, events out of the control of designers, schedulers, and planners such as a labor strike or other delays in yard operations, would need to be extracted. The third measure focuses on total ownership costs.

Change-order costs on the lead ship for the DDG-51 program were $87.6 million in real dollars ($124.5 M in 1998 dollars). This is almost $10 million greater than design costs through MS II. As of the print date for this thesis, change order costs for the LPD-

17 program were not publicly available. Change-order costs for the Icebreaker, approximately $23 M, totaled 6.6% of the total program budget. The design phase of the Icebreaker represented only 3.6% of the total budget. Change-order costs for the Sealift program totaled $324 M, 5.5% of the total budget. However, the design phase represented less than 1% of the program budget. In layman's terms, if double the amount of money was spent to obtain a better Sealift design before MS II, the government would need to save only 14% of the change-order costs. Savings beyond this would be savings to the Navy and US taxpayer! (Reference 2).

Total Ownership Costs (TOC) was a key tenet in the LPD-17 program. In today's environment, the Navy cannot afford to operate as in the past. TOC reductions focus on all cost drivers, combining research and development, design and traditional ship construction costs with life cycle operating and support costs. The TOC process is integrated with the total ship development process and is a component of all team activities. Figure 7.13 depicts the relative relationship of initial design, acquisition, and operating and support costs as viewed from a TOC perspective. The LPD-17 program would consider paying a premium in acquisition, within budget constraints, to obtain significant savings during the 40-year life of each ship of the class.

Hypothesis 3: Greater industry involvement early on will result in a "better" end-product (in terms of producibility, affordability, and operationability.)

This is really at the heart of why concurrent engineering and IPPD theory should be successful. In order to see the big picture, team members must represent a broad

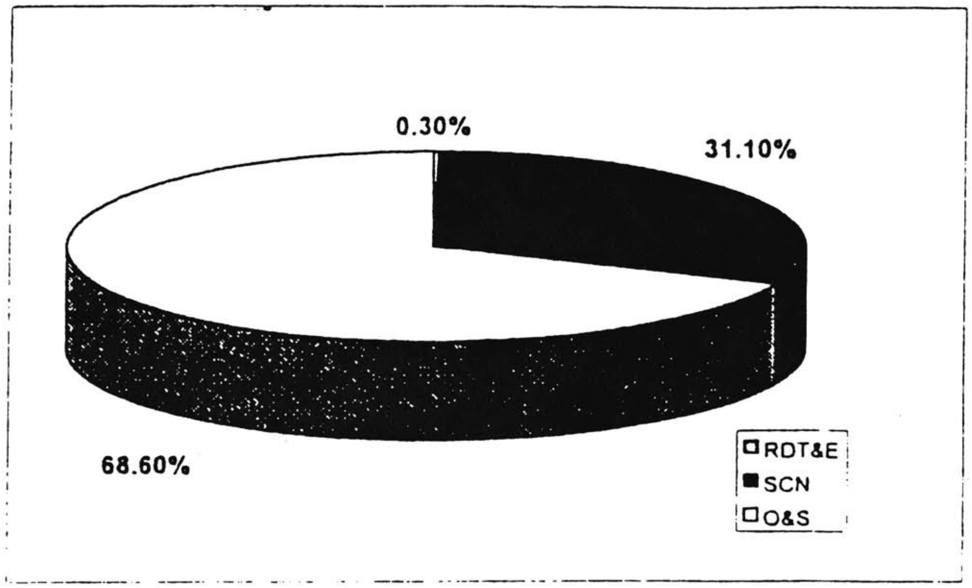


Figure 7.13 LPD 17 TOC Breakout

spectrum of knowledge to bring to the design table. The third truth of concurrent engineering is,

Multi-functional teams are the keys to solving the total design equation.

Tibbits and Keane expand on Huthwaite's third truth in saying "basic concurrent engineering is best carried out by multi-functional teams, led by a strong product manager (like NAVSEA Ship Design Managers)." Furthermore, life cycle "process owners" need to participate from the earliest stages in the design. These concepts are relayed in Figure 7.14.

In the past, warship design/acquisition strategies have tended to be "bi-polar" in the sense that the choices were either a Navy design or an industry design. Since the DDG-51 program, when the idea of collocation was first applied, to the present time, NAVSEA has continued to pursue earlier and closer relationships with industry. As a general rule, many believe that contract design will always be too late to bring the shipbuilders in because most of the critical design decisions have been made by then. Ideally, the shipbuilders should actively participate in the design process, not serve as after-the-fact reviewers.

We saw in the USCGC Icebreaker program that one of the major reasons why the first contract attempt failed was the lack of involvement from the shipyards. Thus, the design was perceived as not producible, among other things. In the USCGC Icebreaker program, government effort totaled $8.1 M (65%) while industry (primarily shipyards but also design firms) represented only 35%, $4.4 M. This represents a deviation from

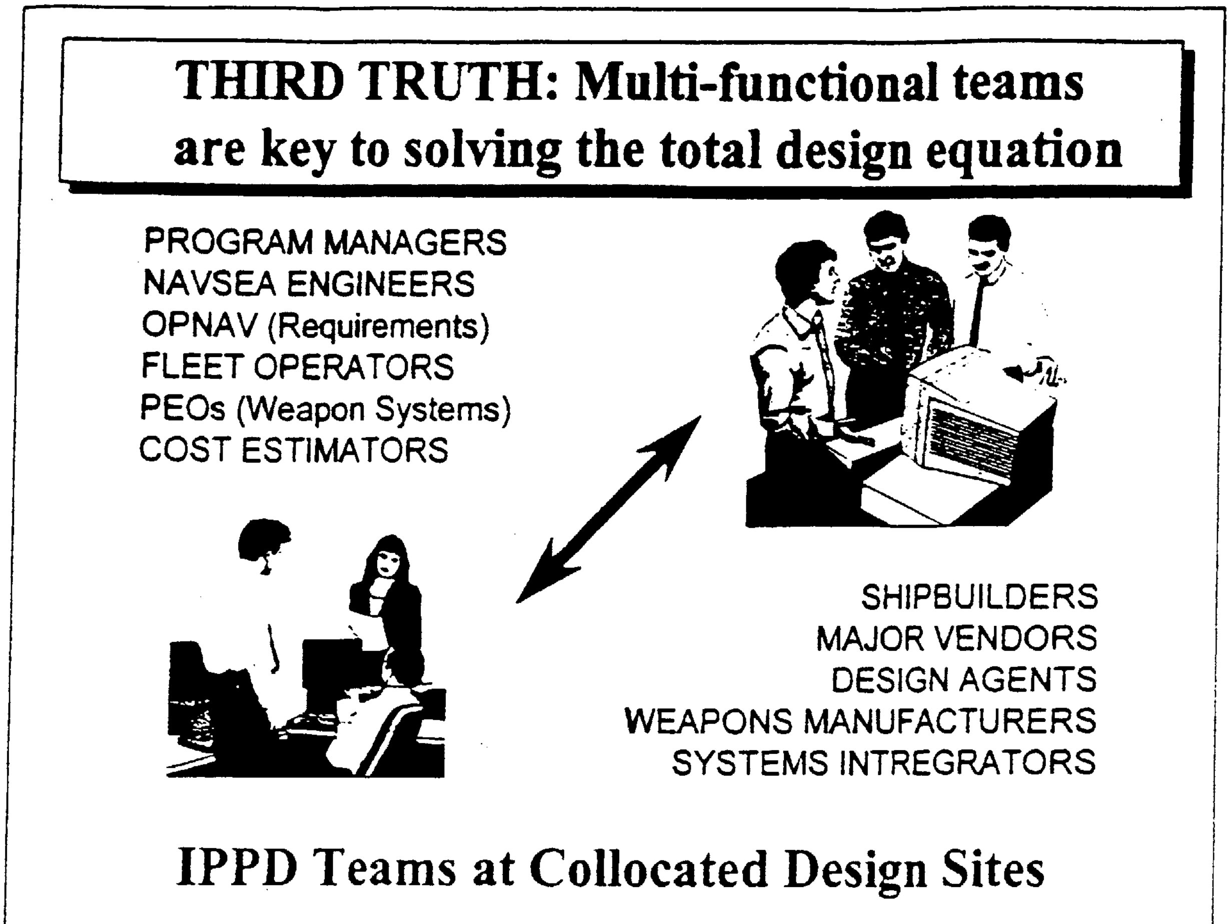


FIGURE 7.14 (REF. 1)

typical Navy acquisition programs in recent years. The lesson was learned here from this type of cost breakdown. Without sufficient involvement from shipyards at an early point in the process, the probability of making it to contract award and having an acceptable vessel at the end of the acquisition process is significantly reduced.

Another example of the success of early involvement with shipbuilders was also seen in the Icebreaker. After the original program failed, the shipyards were consulted on the design and allowed to develop their own design to submit, one yard reported a savings of $35 M on the vessel bid price. Thus, early industry involvement can be a win-win situation.

The effect of early shipyard involvement was demonstrated in the Sealift program. Although this level of competition will most likely not be seen again, the effort on behalf of the various shipbuilders resulted in a quality product in a significantly shorter time frame than most Navy acquisition programs. Again, since this vessel is a non-combatant, it is difficult to pull out the timesaving directly resulting from early shipyard involvement. However, it is felt that some portion of the timesaving is a function of the unique acquisition process undertaken in the Sealift program.

Several "early involvement" efforts to date for the LPD-17 have brought about expected TOC savings in terms of cost, manpower, space, and weight. Examples include manning reductions, equipment substitutions, paint coating systems, and self-cleaning filters.

Hypothesis 4: As shipbuilder responsibility increases and occurs at an earlier stage in the design, the role of the "contractor" will change.

The term "contractor" refers to the technical support NAVSEA receives during the design phase in terms of design agents, shipyards, and non-governmental research labs. Figure 7.1 illustrated this point when comparing the total industry effort for the DDG-51 program to that of the LPD-17 program. In the DDG-51 program, shipbuilders were not heavily involved until after MS II. During LPD-17, shipbuilders were brought in for the contract design phase on joint Navy-industry IPD teams. From this figure, we see that although the industry spending remains 60% for both programs, design agents were doing the majority of the work in DDG-51 whereas shipbuilders were doing the majority of the work for the LPD-17 program.

Industry mandays were shown in Figure 7.8. In comparing the two combatant programs, although mandays for DDG-51 and LPD-17 are about the same, industry effort represented 68% of total mandays for the DDG-51 program and 74% of total mandays for the LPD-17 program.

Another trend that could act as a metric for this hypothesis is the move from Navy providing definitive ship specifications (MILSPECS) as it has done for decades, towards the implementation of performance specifications. Therefore, during Phase O (COEA/AoA studies phase) potential shipyards and systems integrators would participate at Navy collocated design sites. We know that a key tenet for the LPD-17 program was a focus on reduced MILSPECS whenever possible.

Hypothesis 5: On-site teaming of NAVSEA personnel with shipbuilders should become the "norm."

The presence of on-site teams had several advantages during both the Icebreaker and LPD-17 programs. First, open discussions allowed quick solutions to simple problems of interpretation. Second, both the government and contractor had opportunities to influence the design process early on and head off problems that could cause delays later. Third, it promoted good working relationships and reduced the adversarial process that often occurs. However, to have a lot of competition, it often takes longer to thoroughly review and compare each team's proposal. This was seen in the LPD-17 program. It also requires a relatively large pool of highly technical in-house personnel both for distribution to individual teams as well as in the program office to maintain consistency between the teams.

It is difficult to measure the effectiveness of this hypothesis other than by word of mouth. It is the general feeling for both programs that the use of the teaming concept was a great asset to the design process and should be continued. One metric for this hypothesis could be the turn-around time in getting answers to shipyards' questions or in adjudicating changes. According to Fireman (Reference 6), a common theme among previous acquisition programs is the inordinately long process of Q&A as well as change-orders. This was a key factor in determining that an on-site Government team was a necessity. Traditionally, the full service contractor (FSC) would formally draft and forward questions about the ship specifications to the Program Office. Typically, after 45 days or so the Program Office would respond in a letter. More time would elapse as the contractor would request additional clarification via successive cycles of letter writing. This process might consist of hundreds of letters in the first two years of a major shipbuilding program.

For LPD-17, no Navy program office letters were generated over the first 8 months. Day-to-day and face-to-face interactions have completely eliminated previous cycle time delays. Decisions are made and solutions obtained within days instead of the historic months that often slowed traditional programs.

Hypothesis 6: Despite best efforts, there is always the possibility that external forces and factors will alter the planned acquisition process.

The above discussions shed light on certain trends taking place across several Navy acquisition programs, as well as lessons learned and what steps still need to be taken. However, despite best efforts by all interested parties the success of the acquisition is often times at the mercy of forces outside of these parties' control. These forces include the nature of the political arena where budgets are allocated and schedules are planned, the economic health of different regions of the country where several yards exist, the timing of the entire process, as well as the funding (or lack thereof.)

The Icebreaker program, although a success the second time around in terms of awarding a contract within the allocated budget, was also pressured to cut the design process short to alleviate stress on the fleet, to make use of a "pre-acquisition reform" window, and because of an ever-present fear of losing funding. Furthermore, one of the big change orders for this program was a mission change that had nothing to do with the time or quality of the design effort. The bottom mapping sonar dome represented about

25% of the total changes. This design change was a political decision driven by NSF scientists.

Hypothesis 7: A "shorter" design phase does not guarantee a "better" product.

This hypothesis relates to the fact that efforts in the past have sometimes been made to reduce the length of the design phase in order to shorten the overall acquisition process. Tibbits and Keane make the general statement that while this may have led to an earlier award of contract for some programs, it failed to achieve its basic objective. In other words, problems that should have been resolved during the design phase were not discovered until construction, resulting in costly, and timely, design changes. Huthwaite relays this message in his second truth on concurrent engineering (see Figure 7.15),

The power of design needs to be leveraged earlier, broader, and deeper.

Similar to the first truth, two metrics of this truth are the change-order costs and construction schedule overruns. Taking the necessary time during the design phase, with an eye toward problem prevention, can potentially result in reduced change-orders, rework, and total cycle time.

Timing of phases for each program is listed in Table 7.3. In addition, a "generic ship" acquisition program is included for comparison taken from the article, "Improving the Ship Design, Acquisition, and Construction Process" (Reference 6). Again, it is important to remember that the Sealift is a non-combatant. Thus, its design schedule is expected to be quite shorter than combatant vessel design schedules. The preliminary design phase should last 9-16 months according to this source. The LPD-17 preliminary design lasted for 23 months (due in part to changing requirements for amphibious lift.)

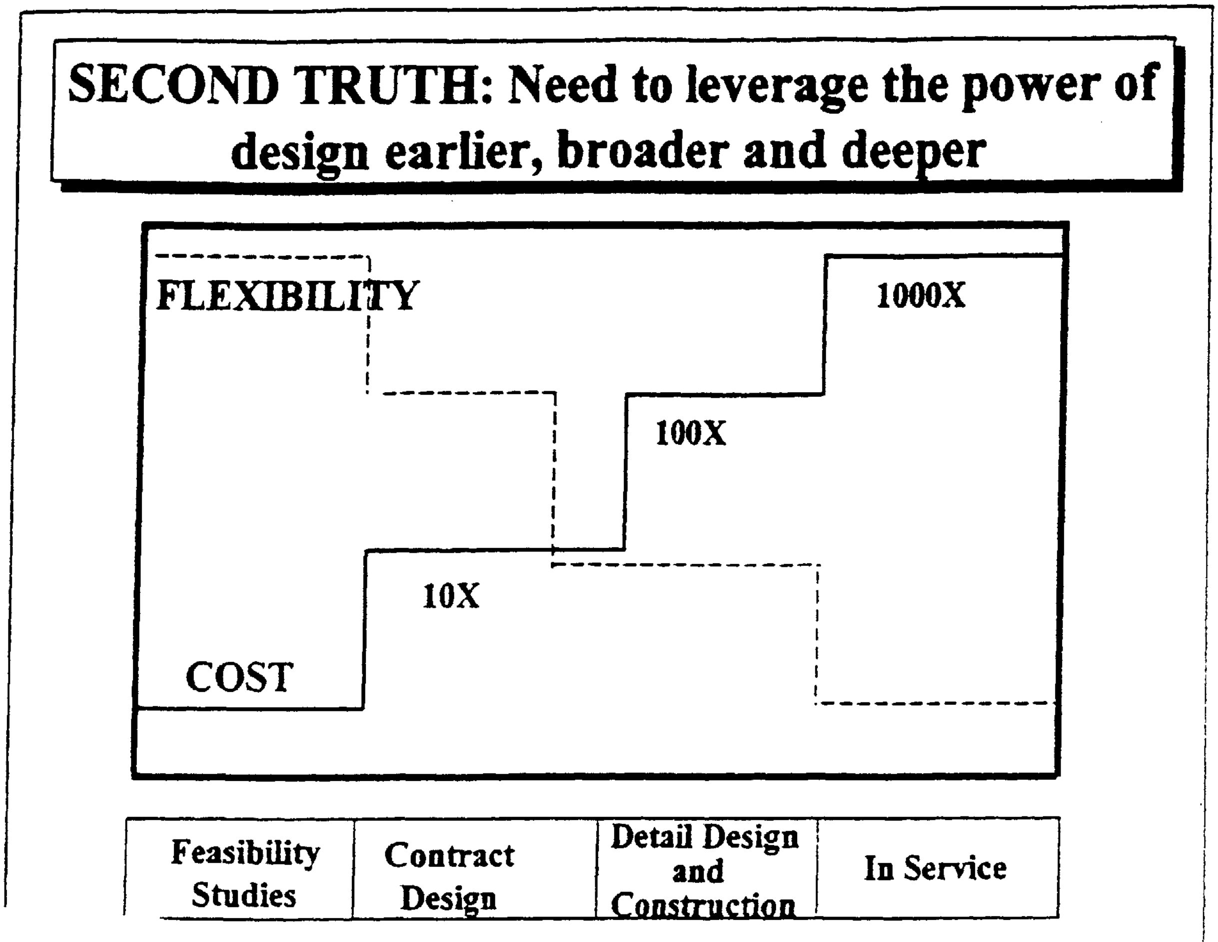

SECOND TRUTH: Need to leverage the power of design earlier, broader and deeper
FLEXIBILITY
1000X
100X
10X
COST
Feasibility Studies
Contract Design
Detail Design and Construction
In Service

FIG. 7.15 (REF 1)

Again, in the contract design phase, the LPD-17 lands outside the boundary by 9 months. Overall, in comparing the total months for DDG-51 versus the total time for LPD-17, we see the DDG-51 design phase takes two years less (24 months) than the LPD-17 program. Does this mean that moving toward a greater industry focus will increase the design time? Or perhaps, since the LPD-17 implemented so many new innovations in concurrent engineering, acquisition reform, and IPD teaming, some additional time was necessary to shift paradigms. Only time will tell whether this process can then take advantage of its implementation tools to reduce total cycle time and TOC, despite the increase in design time.

Table 7.3: Timing of Design Phases (months)

	DDG-51	Icebreaker	Sealift	LPD-17	Generic Ship
Concept	26	29	12	26	3-18
Prelim. Design	10	5	3	23	6-11
Contract Design	14	11	9	25	9-16
Total	50	45	24	74	18-45

Hypothesis 8: The focus of Navy responsibility should be on early design stages. Industry responsibility should focus on the construction stage. Intermediary stages should be a joint effort in responsibility.

During the naval buildup of the 1980s, the Navy's shipbuilding program and shipbuilding industrial base was enormous. Now, in the 1990s and leading into the 21st century, these resources have been greatly reduced; this trend is likely to continue. One solution to the question of how to adapt would be to change the role and focus of both Navy and industry as shown in Figure 7.16. The Navy, with its limited design resources, would focus its efforts up front, prior to MS I. Their responsibilities would include

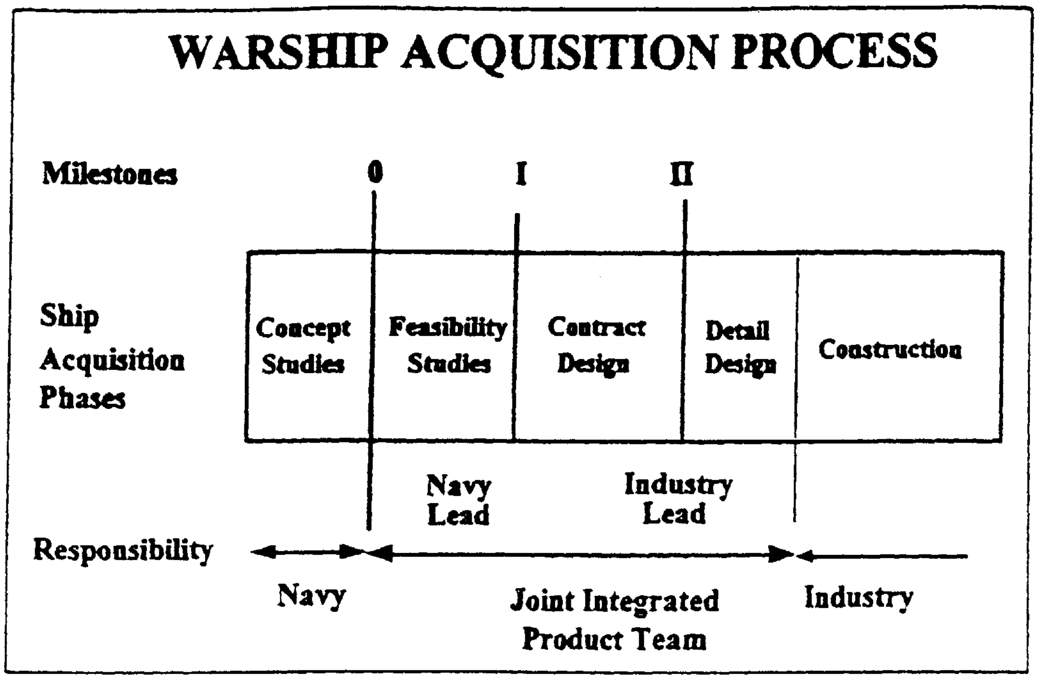

WARSHIP ACQUISITION PROCESS
Milestones
0
I
II
Ship Acquisition Phases
Concept Studies
Feasibility Studies
Contract Design
Detail Design
Construction
Navy Lead
Industry Lead
Responsibility
Navy
Joint Integrated Product Team
Industry

FIG. 7.16 (REF 1)

concept studies, leading up to MS O approval and issuance of the MNS, as well as feasibility studies (ie-COEA/AoA) leading up to MS I approval and the formal establishment of a program. Hereafter, the Navy's role on industry IPTs would vary.

The major challenge facing this new Navy role is in insuring that the level of concept definition is sufficient to support the COEA/AoA process and to develop the ORD and performance specifications.

After MS I, industry's new role will be to carry out functions previously performed by the Navy. First, a design needs to be developed based on the ORD and performance specifications (P-spec.) Trade-off analyses with regard to risk, cost, performance, and schedule would be performed. Issues regarding survivability, signatures, manning, and ILS must be performed. This approach with regard to Navy IPT members would incorporate the skills possessed by Navy employees regarding specialized knowledge and lessons learned, relationships with other government organizations, and risk management. The first attempt toward this proposed strategy is being implemented in the LPD-17 program. The success of this method is yet to be seen. Further efforts are currently being pursued for the DD-21 program.

Hypothesis 9: Full and open competition of the 1980s should be replaced with early down-selection to one or two Navy-Industry teams.

Under the above-mentioned proposal, the Navy would be responsible for early ship concept studies leading to a MS 0 approval (typified by the MNS.) Navy would also be responsible for feasibility studies leading to MS I approval to formally establish a program. Thereafter, the Navy has two options on involving industry.

1) down select to a single shipbuilder/systems integrator team

2) award design competition contracts to a small number of teams (given the mergers in the shipbuilding industry, two teams may be appropriate)

Option 1 maximizes the benefits of cooperation and is recommended by Tibbits and Keane. The implementation of option I would ideally result in a continuous design development, acquisition, and construction process without any major interruptions. The risk is that, once a contract is awarded, there is no further competition to drive down costs.

In contrast, the benefits of competition are realized in option 2. Certainly, the feasibility of supporting two Industry-Navy IPTs during a competition is a disadvantage to option 2. When looking at the total life-cycle costs of the product, Tibbitts' and Keane's statement that option 2 requires additional funds is questionable; if looking only at design costs, it is probably the case. They further point out that "deferring the final down-selection until MS II has obvious political advantages and appears to be the approach favored by senior officials."

Based on current trends toward consolidation and mergers in today's economy there will probable only be two, at the most three, bidders. Based on trends in the defense industry, these bidders will most likely take the form of teams consisting of at least one shipyard as well as systems integrators (typically, combat/weapons systems manufacturers.) As a result of government downsizing, there will be limits on the number of qualified NAVSEA personnel available to multiple teams. The approach taken in the Icebreaker program, and currently in DD-21 program, involved two teams with NAVSEA personnel assigned. This approach would retain the competitive nature of the process. However, steps must be taken to avoid overtaxing the NAVSEA personnel base.

This approach to teaming between shipyards results in the consolidation of individual yard's specialties. For instance, perhaps yard A, although competent in detailed design and construction, feels its competitive advantage lies in its innovative thinking at the during the design stage. On the other hand, yard B may feel its designs are not as innovative, but it has made significant capital investments in converting its operations to being highly automated and efficient. Thus, the teaming of these two yards results in a competitive advantage for both of them and a better bid for the Navy.

8 CONCLUSIONS

In conclusion, the examination of design spending through MS II on four distinct naval acquisition programs has proved to be quite insightful. The evolutionary nature of acquisition reform is conceptualized as the reader steps through each of the four ship programs: DDG-51, USCGC Icebreaker, Strategic Sealift, and LPD-17. Acquisition reform is truly a "work in progress." Many lessons have been learned; many issues remain unanswered, and certainly Navy acquisition continues to evolve.

The first conclusion drawn from the undertaking of this thesis is that, despite changes to the acquisition process, the procedure of acquiring a new combatant, especially a multi-ship program like the DDG-51 and LPD-17, will always require an enormous amount of effort. Regardless of whether in-house personnel are performing the design, acting as reviewers, or a hybrid of the two, the need exists for a pool of qualified government personnel to sustain the program. Finally, the transition in industry involvement from design agents to shipyard (and design agents) has been seen over time and will continue through the current DD-21 program and beyond. This transition has not greatly changed industry design costs for these programs.

Secondly, design costs through MS II are relatively insignificant compared to total program costs, yet 70% to 80% of the design is "fixed" by this point. Thus, sufficient effort (in terms of money and mandays) should be taken during the design phase. This can result in reduced change-order costs as well as a reduction in total cycle time and TOC, despite a possible rise in design time.

In addition, there has been a trend toward concurrent engineering and implementation of the IPD philosophy, particularly in the LPD-17. Ultimate success in this program remains to be seen. However, this methodology was quite successful in the USCGC Icebreaker program.

There has been an evident move toward greater industry involvement, particularly shipbuilders, during early stages. In the non-combatant Sealift program, this resulted in significant cycle time reductions as well as a better understanding of challenges involved in its implementation. In comparing the DDG-51 program with the LPD-17 program, we see that although total effort by industry is approximately equal, the role that design agents play versus the role that shipyards play has dramatically shifted toward the later. This trend is expected to continue through the DD-21 program and beyond.

The debate remains on competition versus sole-sourcing. The reduced source of qualified in-house personnel as well as the possible increase in time required for review may work against those in support of competition. However, the Navy has less leverage with sole-sourcing, and the inherent advantages to competitive bidding of ideas is lost. The trend in industry today is toward consolidation of shipbuilding efforts to maximize competitive advantage in addition to bringing in outside expertise in order to market themselves as a "Full Service Contractor" (FSC). Having, say, two FSC teams, along with NAVSEA personnel, future operators, and others as team members, will provide for a competitive bidding process. Therefore, the Strategic Sealift program, which had 9 yards in competition, was an interesting approach, but a unique one that probably will not be repeated.

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DATA SOURCES

Design history for DDG-51

Red book for DDG-51

Red book for LPD-17

WEFA for inflation chart

APPENDIX: MAN-YEAR INFLATION TABLE

Manyear Inflation Table

Year	Adjustment rate	$K/manyear
FY 98	100	155.83
FY 97	98.17	152.98
FY 96	96.26	150.00
FY 95	94.12	146.67
FY 94	91.79	143.03
FY 93	89.65	139.70
FY 92	87.34	136.10
FY 91	85.00	132.45
FY 90	81.76	127.40
FY 89	78.36	122.11
FY 88	75.19	117.17
FY 87	72.54	113.04
FY 86	70.39	109.69
FY 85	68.59	106.88
FY 84	66.31	103.33
FY 83	63.89	99.56
FY 82	61.29	95.51
FY 81	57.66	89.85
FY 80	52.70	82.12
FY 79	48.24	75.17
FY 78	44.43	69.23
FY 77	41.42	64.54
FY 76	38.91	60.63
FY 75	36.75	57.27
FY 74	33.61	52.37
FY 73	30.83	48.04

WEFA GDP Inflation Table used to estimate manyear rates (assuming $150K in FY96.)