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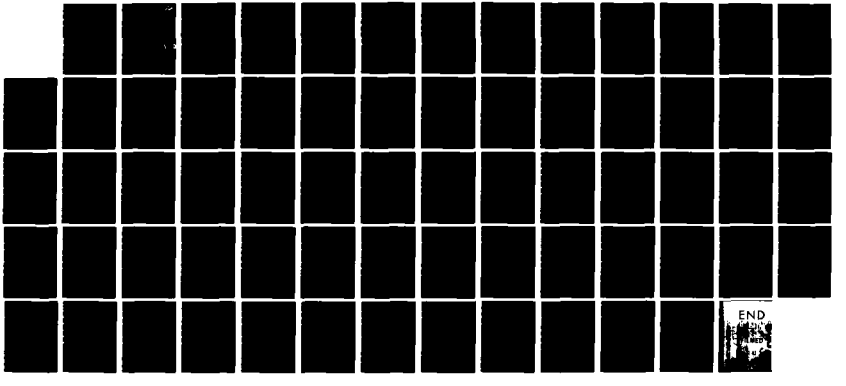

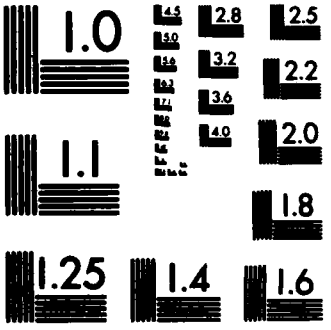

MANAGEMENT COSTS OF DOD MILITARY CONSTRUCTION PROJECTS

April 1983

Paul F. Dienemann
Joseph S. Domin
Evan R. Harrington

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LOGISTICS MANAGEMENT INSTITUTE
4701 Sangamore Road
P.O. Box 9489
Washington, D.C. 20016

We conclude that C-E and NAVFAC costs for managing military construction projects are generally consistent with costs of other government agencies and private sector organizations.

EXECUTIVE SUMMARY

The Army Corps of Engineers (C-E) and Naval Facilities Engineering Command (NAVFAC) provide construction support services for about 900 new military construction projects each year. Services include the supervision, review and administration of design contracts and the supervision, inspection and administration of construction contracts. Criticisms have been raised that C-E and NAVFAC costs for these services are too high. We find that not to be the case. When differences in project complexity and size are accounted for, C-E and NAVFAC costs of construction support services compare favorably with five other government agencies and three large corporations providing the same type services.

Total design and construction phase costs for a 50/50 mix of average and above average complexity projects in the $5 million range are 9.5 percent of construction contract costs in C-E and 9.2 percent in NAVFAC. Design phase costs are 3.0 percent in C-E and 1.3 percent in NAVFAC. Construction phase costs are 6.5 percent in C-E and 7.9 percent in NAVFAC.

Design phase costs in three corporations and a state government fall between C-E and NAVFAC. Veterans Administration and General Services Administration (GSA) costs are somewhat higher. Construction phase costs in the Federal Aviation Administration, a local government and one corporation are about the same as C-E and NAVFAC. Construction phase costs in a state government and two corporations are somewhat lower than those in C-E and NAVFAC. In this last comparison, we attribute the cost differences to the higher level of complexity of C-E and NAVFAC construction projects and not to management differences.

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CHAPTER 1. INTRODUCTION

In the 1982 hearings before the committee on appropriations of the U.S. House of Representatives, concern was expressed about the in-house support costs incurred by the Corps of Engineers (C-E) and the Naval Facilities and Engineering Command (NAVFAC) in the planning and design phase of construction projects. A question was asked whether in-house support costs in the military had ever been compared to in-house support costs in the private sector. The Director of Construction in the Office of the Secretary of Defense stated that such a comparison was needed and was planned for the coming year. The Office of the Director of Construction tasked the Logistics Management Institute to make this comparison as part of a review of all construction support activities of C-E and NAVFAC.

The objective of the current study is to assess the reasonableness of costs incurred by C-E and NAVFAC for supervision, review and administration of design contracts and for supervision, inspection and administration of construction work. The approach used to accomplish this objective was to compare costs on military construction projects to similar costs experienced by private firms and other government agencies.

Review of past research in this area disclosed a 1972 study by the General Accounting Office (GAO) titled "Comparative Costs to Design, Supervise, and Inspect Military Construction Projects." Although the GAO report contained some cost data for the military, Government Services Administration (GSA) and architectural and engineering (A-E) firms, it was admitted that comparisons may not be meaningful because the study did not consider the influence of project size and complexity, as well as the types of

services provided, on the costs of design and construction services. No conclusion on the relative efficiency of the military construction agencies could be made. Our study does adjust cost data for the effects of project size, complexity and services provided to allow for more meaningful comparisons.

In the course of this study, information was gathered from the following organizations:

- C-E headquarters
- NAVFAC headquarters
- C-E Southwest Division Headquarters
- C-E Fort Worth District Office
- NAVFAC Atlantic Engineering Field Division
- C-E Baltimore District Office
- C-E Bay Area Office
- Government Services Administration
- Federal Aviation Agency
- Office of the State Architect, California
- Veterans Administration
- General Services Department, City of Los Angeles
- Airports Construction Authority, City of Los Angeles
- Construction Divisions of four large corporations
- American Consulting Engineers Council

A special data call for C-E and NAVFAC was processed. Additionally, a survey of 24 firms was conducted under the auspices of the American Consulting Engineers Council.

The types of construction support services provided by C-E and NAVFAC, large corporations, A-E firms, and other federal, state and city government agencies were identified and data were collected on the costs of providing construction support services. Regression analysis was used to relate costs of providing construction support services to the size and complexity of construction projects. Comparisons were then made with costs for private firms and other government agencies providing essentially the same services as C-E and NAVFAC for facilities projects of comparable size and complexity.

This analysis covered activities of C-E, NAVFAC, private firms and other government agencies in the contiguous United States. Only new facility

projects, as distinguished from facility maintenance, repair or modification projects, are compared since the scope of the latter group of projects can vary widely, thereby inhibiting the validity of a comparative analysis.

Two principal adjustments were made to the cost information provided by government agencies and private firms. First, all costs reported by federal government agencies were increased by 13 percent to include full costs of civilian retirement and other benefits which are only partially included in organizational budget and accounting data. Second, estimated indirect and overhead costs were added where necessary to the source data of organizations that do not routinely include full overhead costs in their cost accounting information. The adjustments were made to enhance comparability of cost data among the construction agencies. They are fully documented in this report.

We summarize the comparative analysis and the major study findings in Chapter 2. Chapter 3 provides a discussion of construction support services and the size and complexity factors and other issues that affect construction cost comparisons. Appendices A through D present the comparative cost information gathered from the military, other government agencies, and large corporations. Appendix D also contains the results of the survey of consulting engineering firms. The cost data used in the comparisons are provided in Appendix E. Appendix F is a glossary of terms.

CHAPTER 2. COMPARATIVE ANALYSIS AND STUDY FINDINGS

CONSTRUCTION SERVICES

In the private sector, a new facility construction project usually involves the joint efforts of three interested parties -- the customer, the designer, and the builder. The customer specifies the characteristics of the needed facility and all other aspects of the project scope; contracts for predesign, design and construction services; oversees and/or inspects the design and construction work; and administers design and construction contracts, including maintenance and processing of contract documents, change orders, modifications and required reports. In the military, C-E and NAVFAC perform all of these customer functions.

The functions of the designer, usually an A-E firm, are defined by the customer. Basic A-E services include technical advice to the customer on the need for surveys, foundation and materials investigations and other predesign services; production of designs, plans, specifications, and contract documents; and technical advice to the customer during the construction phase, including periodic visits to the construction site. Optional services often included in the A-E contract are provisions for predesign services, full-time on-site resident inspector(s), design services during construction, and part or all of the contract administration services usually provided by the customer.

The task of the builder is to construct the facility in accordance with contract specifications. The services provided by the customer, designer and builder are summarized in Table 2-1. On military construction projects, all services ordinarily provided by the customer are performed by C-E and NAVFAC.

Additionally, C-E and NAVFAC will do much of the economic analyses, conceptual design work, and development of contract specifications usually performed on a private sector project by the A-E firm which also does all of the on-site inspection of construction work. NAVFAC usually includes predesign services such as surveys, soil tests, and foundation and materials investigations in the A-E contract, whereas C-E arranges for these services separately. Some C-E districts have the in-house capability to perform predesign services.

TABLE 2-1. A TYPICAL DISTRIBUTION OF CONSTRUCTION SERVICES

	CUSTOMER	DESIGNER	BUILDER
Performer	Government, corporation, individual	Architectural-Engineering firm	Construction firm
Major Services Provided	Define facility requirements Plan construction program and estimate costs Contract for predesign, design and construction services	Basic Services Economic analyses and conceptual design work	Construct facility contract specifications
	Oversee/inspect design and construction work	Production of designs, plans, specifications and contract documents	
	Administer design and construction contracts	Technical advice to customer during construction based on periodic visits to job site	
		Optional Services	
		Responsibility for predesign services	
		Design during construction	
		Full time resident inspection of construction work	
		Contract administration (part or all)	

In the private sector, a typical arrangement is depicted in Table 2-1. The customer may choose to delegate a part or all of the typical customer services to the A-E firm, a construction manager or the builder. Since customers differ in their approach to arranging for the services needed in constructing facilities, care must be taken to insure that cost comparisons are made for the same services provided by all customers.

COMPARATIVE COSTS

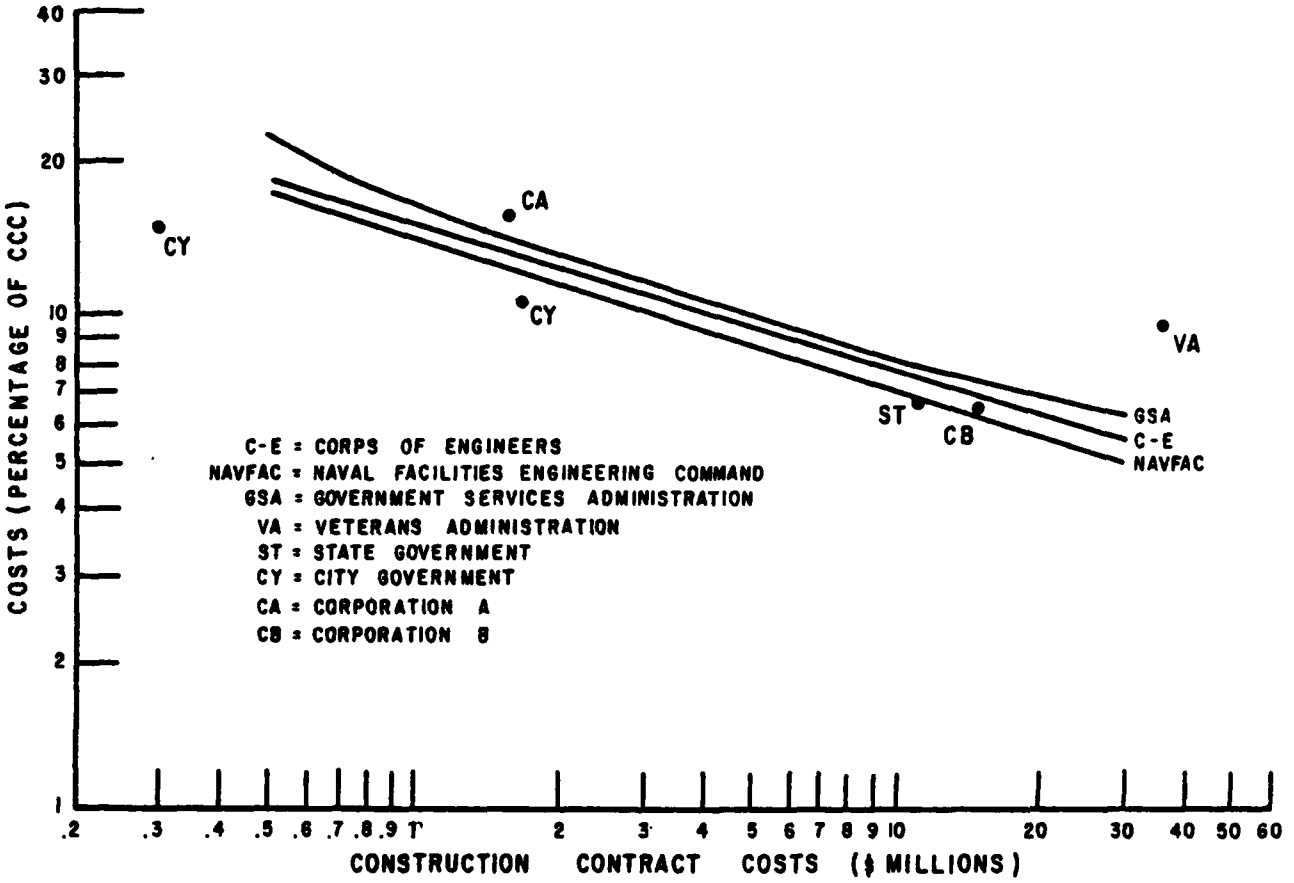
Comparisons of construction support services costs in the planning and design phase and construction phase are made between C-E, NAVFAC, other government agencies and three large corporations. Costs are expressed as a percentage of construction contract costs (CCC) and are adjusted for effects of project size and project complexity. Criteria developed by the American Society of Civil Engineers were used to classify projects into average and above average complexity. Costs for C-E and NAVFAC are estimates based on statistical analyses of existing data sources for a sample of projects.

Of the corporations surveyed for purposes of this study, cost by type of service provided was generally not available. However, the costs for the construction contract, the A-E contract and for in-house services provided during the planning and design (P&D) and construction phases of a project were generally available. Comparisons between C-E, NAVFAC, other government agencies and large corporations were made on this basis and are presented below for P&D phase, construction phase and total costs, in that order.

Planning and Design Phase Costs

Total P&D phase costs as a percentage of construction contract cost are shown in Figure 2-1 for C-E, NAVFAC, GSA, VA, a state and city government and two corporations. Total P&D phase costs include: (1) design and engineering services (DES); (2) in-house supervision and review (S&R); and

FIGURE 2-1. TOTAL PLANNING AND DESIGN PHASE COSTS vs CONSTRUCTION CONTRACT COSTS



(3) other in-house costs (OIH) for reproduction, travel, indirect, and overhead. The DES costs included in Figure 2-1 are for projects of above average complexity. Total P&D phase costs as a percentage of CCC decline as CCC increases.

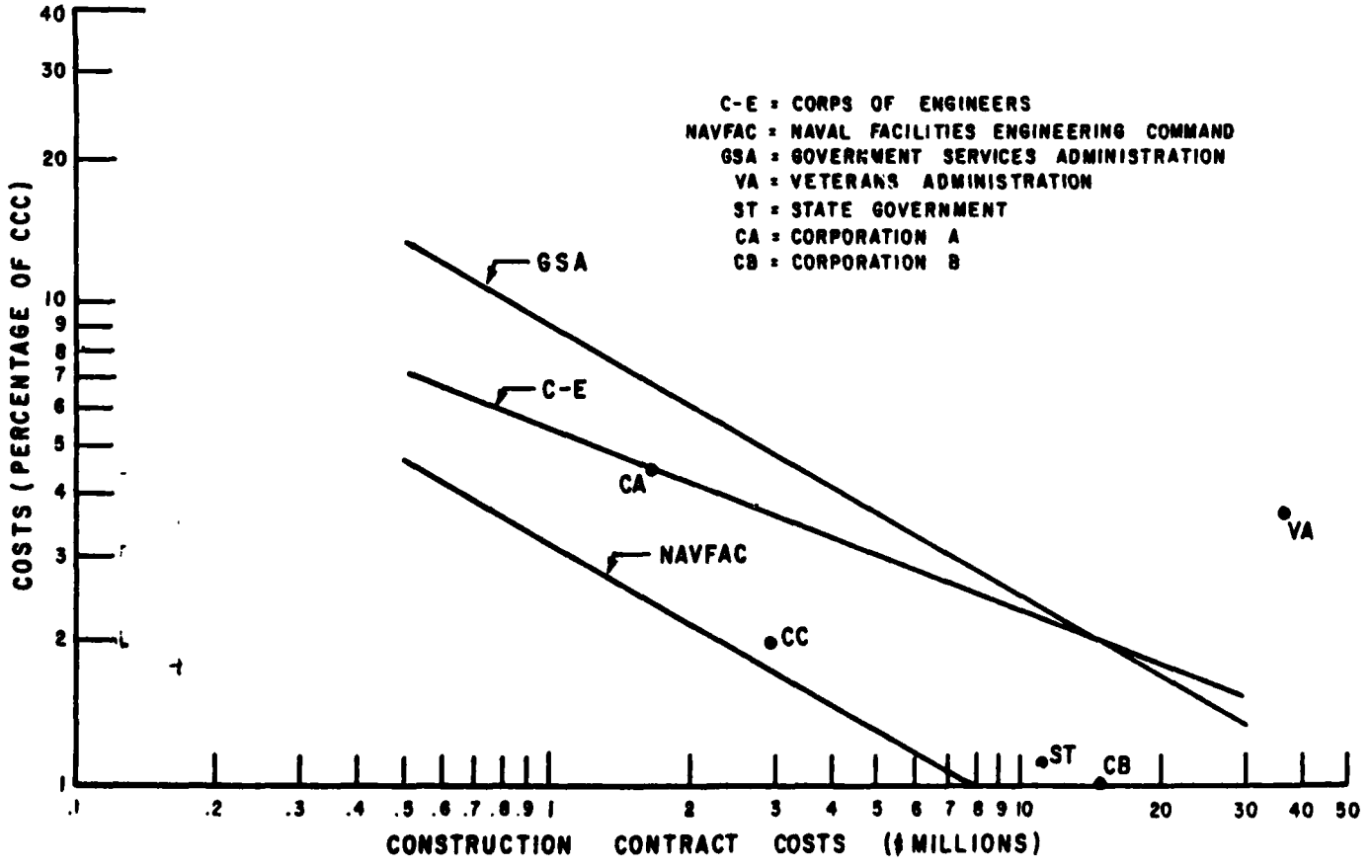
GSA provided a schedule of costs as a function of project size. Figure 2-1 shows that costs from the GSA schedule are slightly higher than those of C-E, which are slightly higher than those of NAVFAC. C-E and NAVFAC cost lines were estimated for a sample of design projects. The cost differences cited above are well within the range of potential errors resulting from the estimating procedures used (which are described in Appendices A

and B). We concluded that differences between these three schedules of P&D phase costs are not statistically significant.

The costs for P&D phase services of a city and state government, two corporations and the VA also are shown in Figure 2-1. C-E and NAVFAC costs compare favorably with all of these organizations. VA costs are somewhat higher and the city government costs are less than C-E's and NAVFAC's. However, in this latter comparison, costs for construction phase services presented in the next section have a compensating effect so differences in total support service costs are small.

Figure 2-2 shows the P&D phase costs for total in-house services covering supervision and review and other in-house costs. GSA total in-house

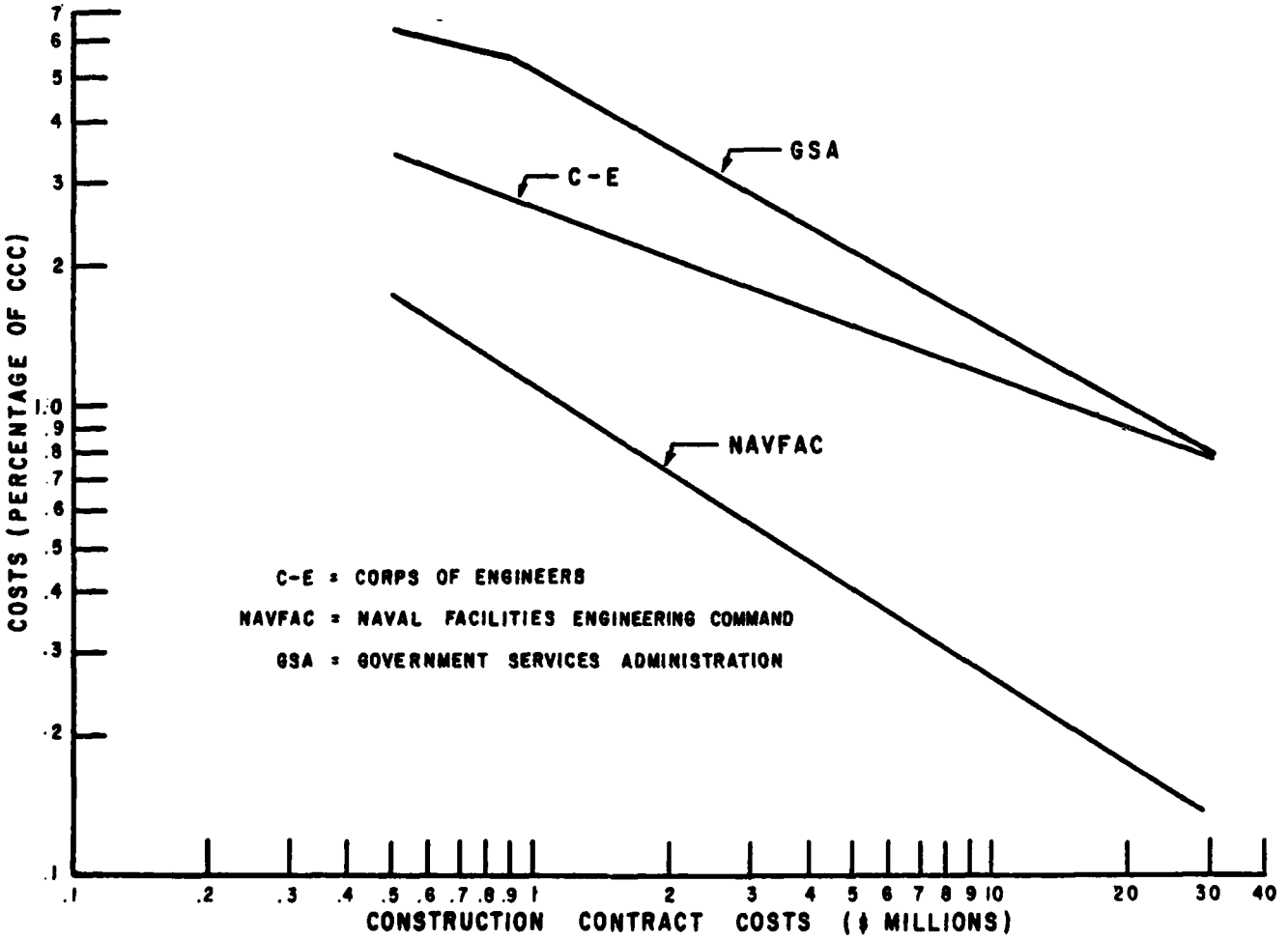
FIGURE 2-2. P&D PHASE COSTS FOR IN-HOUSE SERVICES vs CONSTRUCTION CONTRACT COSTS



costs are higher than those of C-E and NAVFAC except for very large projects. NAVFAC costs are uniformly lower than the others. The in-house costs of three corporations and the state government fall between those of C-E and NAVFAC. VA in-house costs are higher than all others.

Figure 2-3 provides a comparison of supervision and review costs. The GSA costs are higher than those of both C-E and NAVFAC. Comparable S&R data for the corporations, state government and VA were not available.

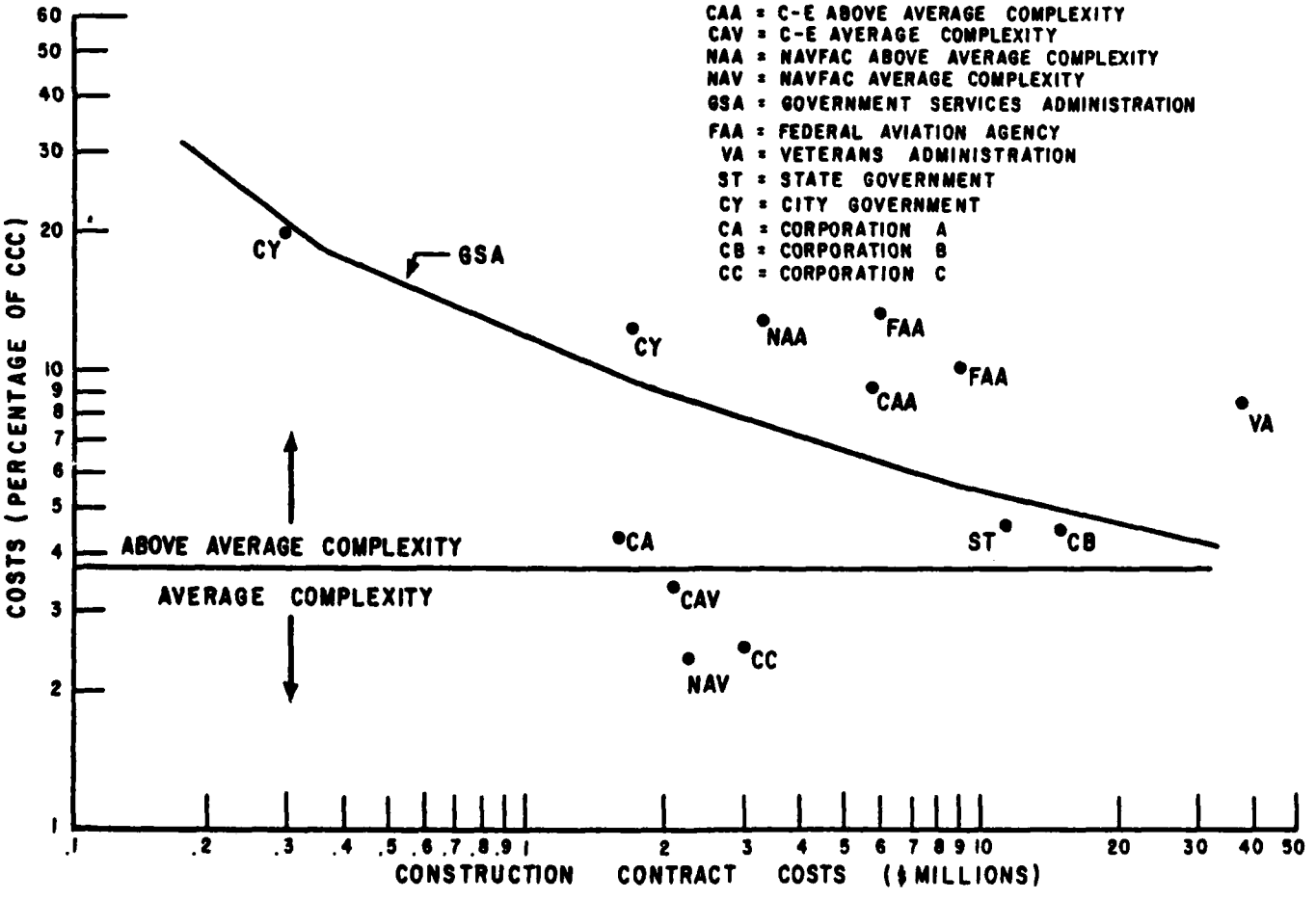
FIGURE 2-3. P&D PHASE COSTS FOR SUPERVISION AND REVIEW vs CONSTRUCTION CONTRACT COSTS



Construction Phase Costs

Costs for supervision, inspection and administration (SIA) as a percentage of construction contract costs are shown in Figure 2-4 for projects of average and above average complexity. For projects of above average complexity, C-E and NAVFAC costs compare favorably to similar costs in the FAA, VA and a city government and are somewhat higher than costs in the GSA, a state government and a large corporation. The higher cost is most probably due to the higher complexity of C-E and NAVFAC projects which include engineering and electronics laboratories, high technology test facilities, and other unique weapon support facilities. Those projects are more complex, for example, than federal office building complexes included in GSA's building

FIGURE 2-4. SUPERVISION, INSPECTION AND ADMINISTRATION COSTS vs CONSTRUCTION CONTRACT COSTS



program. The definition of average and above average complexity was taken from the American Society of Civil Engineers Manual.[1] It appears that additional categories which isolate higher technology test and weapons support facilities are needed to further differentiate projects of above average complexity.

One corporation (CC) had a construction program classified as of average complexity. Costs for supervision, inspection and administration services on projects of average complexity for C-E and NAVFAC and this corporation are shown in Figure 2-4. These costs are uniformly lower than those for all organizations with projects classified as above average complexity.

It should be noted that about 50 percent of C-E military construction projects are classified as of average complexity and the comparable figure for NAVFAC is about 80 percent. No effect of project size on C-E and NAVFAC SIA costs was found using available data.

Construction phase costs for design during construction are 1.2 percent of CCC in NAVFAC and 0.5 percent in C-E. Costs for military personnel support in NAVFAC and C-E and for headquarters and division level support in C-E add 0.2 percent to support costs in the construction phase.

TOTAL COSTS

The total costs for all construction support services as a percentage of CCC are shown in Figure 2-5. These costs include total P&D phase costs plus construction phase costs. NAVFAC costs are higher than C-E costs for above average complexity projects and lower than C-E for average complexity projects. Total GSA costs appear to decline more rapidly than either C-E or NAVFAC. This difference is due to the fact that project size had no measurable effect on C-E and NAVFAC construction phase costs.

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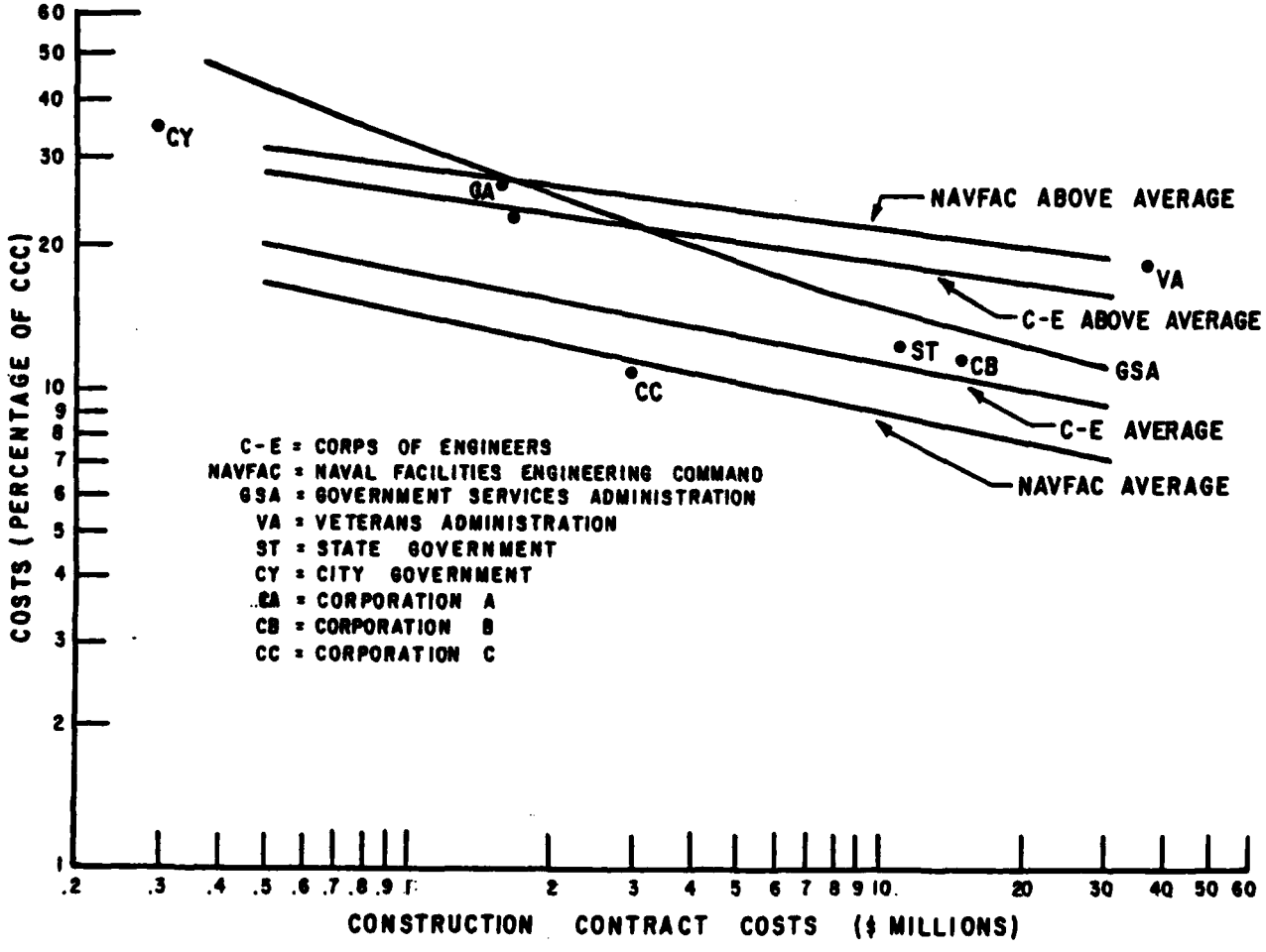
[1]Consulting Engineering: A Guide for the Engagement of Engineering Services, American Society of Civil Engineers' Manual No. 45, 1981.

FIGURE 2-5. TOTAL COST FOR CONSTRUCTION SUPPORT SERVICES vs CONSTRUCTION CONTRACT COSTS



Costs for above average complexity projects of a city government, corporation A and the VA fall closely along the C-E and NAVFAC cost lines for above average complexity projects. The state government and corporation B sponsor larger projects and are closer to the GSA cost line, which is lower than C-E and NAVFAC cost lines at higher CCC values. The cost associated with average complexity projects of corporation C is close to the NAVFAC cost line for similar projects.

In the comparison of total costs for all construction support services, it can be seen that some of the differences noted in the comparison of P&D and construction phase costs disappear. For example, the costs of P&D phase

services in the city government were slightly below C-E and NAVFAC lines in Figure 2-1 while construction phase costs are slightly higher in the city government at the project sizes noted. P&D phase costs in corporation A and the VA are notably higher than those of the GSA, C-E and NAVFAC in Figure 2-1. However, their total cost for all construction support services falls right on the NAVFAC total cost line in Figure 2-5.

This effect results either from differences in accounting classifications of reported costs or from differences in relative effort applied by these organizations between the two phases of construction. In either case, their total costs are closer to those of C-E and NAVFAC than are any subelements of total cost.

Table 2-2 compares C-E and NAVFAC costs for construction support services for average complexity projects, above average complexity projects, and a 50/50 mix of average and above average complexity projects in the $5 million range. As mentioned above, NAVFAC total costs are less than C-E costs on average complexity projects and the reverse is true on projects of above average complexity. For a 50/50 mix of average and above average complexity projects, costs are nearly equal -- 16.5 percent for C-E projects and 17.0 percent for NAVFAC projects. C-E in-house costs are 9.5 percent and NAVFAC in-house costs are 9.2 percent. Design phase in-house costs are 3.0 percent in C-E and 1.3 percent in NAVFAC. In-house costs in the construction phase are 6.5 percent in C-E and 7.9 percent in NAVFAC. NAVFAC costs in the P&D phase are 1.6 percent less than C-E costs due to lower costs for supervision, review and administration, and other in-house costs. This difference is offset by higher costs in the construction phase in NAVFAC for supervision, inspection and administration and design during construction.

TABLE 2-2. C-E AND NAVFAC COSTS FOR CONSTRUCTION SUPPORT SERVICES AS A PERCENTAGE OF CONSTRUCTION CONTRACT COST FOR A $5.0 MILLION PROJECT

PROJECT COMPLEXITY / COST ELEMENTS	AVERAGE		ABOVE AVERAGE		50/50 MIX	
	C-E	NAVFAC	C-E	NAVFAC	C-E	NAVFAC
P&D Phase	8.8	6.7	10.2	9.0	9.5	7.9
Design and Engineering Services	5.8	5.4	7.2	7.7	6.5	6.6
Supervision and Review	2.5	1.2	2.5	1.2	2.5	1.2
Other In-House Costs[1]	0.5	0.1	0.5	0.1	0.5	0.1
Construction Phase	4.1	3.8	9.9	14.4	7.0	9.1
Design During Construction	0.5	1.2	0.5	1.2	0.5	1.2
Supervision, Inspection and Administration	3.4	2.4	9.2	13.0	6.3	7.7
Other In-House Costs[1]	0.2	0.2	0.2	0.2	0.2	0.2
Sub-totals						
In-House Costs[2]	6.3	3.9	12.7	14.5	9.5	9.2
Contractor Costs[3]	6.3	6.6	7.4	8.9	7.0	7.8
TOTAL	12.9	10.5	20.1	23.4	16.5	17.0

[1]Includes headquarters and division level costs in C-E, and military personnel costs in both C-E and NAVFAC

[2]Supervision and review and other in-house P&D costs plus supervision, inspection and administration and other in-house construction phase costs

[3]Design and engineering services plus design during construction

FINDINGS

The C-E and NAVFAC costs used in the comparative analysis are estimates derived from existing data for a sample of projects. Considerable variability surrounds these estimates. Despite this limitation, we believe three major findings can be supported by the comparative analysis:

1. Total cost for all construction support services in C-E and NAVFAC compare favorably to costs in the large corporations and other government agencies included in this analysis.

2. In the planning and design phase, C-E and NAVFAC costs for supervision, review and administration of design contracts compare favorably to the same costs experienced by large corporations and other government agencies.

3. In the construction phase, C-E and NAVFAC costs for supervision, inspection and administration of average complexity projects compare favorably with costs in the private sector. For projects of above average complexity, these C-E and NAVFAC costs are comparable with FAA, VA and a city government, but are somewhat higher than in two corporations and the GSA. The higher complexity of test facilities, electronic and engineering laboratories and unique weapon support facilities in the military compared to that of GSA's federal office building complexes, for example, is believed to be responsible for this higher cost.

Seven additional findings are based on the comparative analysis and discussions with construction managers in government and private sector:

1. Comparison of subelements of costs reveals more substantial differences. For example, NAVFAC costs for supervision and review and other in-house costs in the P&D phase are less than those in C-E and GSA. These differences may be due to use of a broader definition of S&R in C-E than in NAVFAC cost accounts and to the NAVFAC policy of including engineering services in the A-E contract. For these reasons, the comparisons of total P&D phase or construction phase or the total for all construction support services are more meaningful.

2. Costs for construction support services in C-E and NAVFAC are not comparable to costs in A-E firms, which typically do not provide services ordinarily performed by the customer in a facility construction project.

3. The corporations and other government agencies interviewed retain in-house staffs that perform functions similar to those of C-E and NAVFAC including planning, estimating, project management, design review and control, contract administration and on-site inspection of construction work.

4. Several organizations interviewed use A-E firms to provide technical advice based on periodic visits to the construction site. However, they use their own staffs for project management, additional technical A-E support, contract administration, and on-site inspection of construction work as needed.

5. Government construction agencies must comply with legal and regulatory requirements that do not apply to the private sector. This compliance sometimes results in increased costs. Even so, government agency costs were not out of line with similar costs in the large corporations included in this analysis.

6. C-E and NAVFAC charge flat rates for supervision, inspection and administration in the construction phase without regard to project complexity or size. The analysis in this report shows that these two factors, especially complexity, influence the true costs for SIA services.

7. C-E and NAVFAC managers would be in a better position to evaluate the manpower needs of area offices based on their projected workload mix by complexity and size categories if these true costs were known.

CHAPTER 3. FACTORS INFLUENCING COST COMPARISONS

PLANNING AND DESIGN PHASE

Table 3-1 lists the services provided in the design phase of a typical contruction project. The services do not apply equally to Government and private sector work. Many apply primarily to federal or federally-financed

TABLE 3-1. TYPICAL PLANNING AND DESIGN PHASE SERVICES

Special Studies
- Developing criteria and alternative siting plans
- Preparing life-cycle cost estimates
- Preparing environmental impact assessments
- Performing traffic and parking analyses
- Performing alternative energy and solar energy analyses
- Investigating sites including drainage analyses, soil borings, utilities, etc.
- Preparing preliminary sketches and budget estimates
Contract Administration
- Preparing scope of work descriptions and government cost estimates for negotiations with prospective architect-engineers
- Establishing architect-engineer listings for use by the Architect Engineer Selection Board
- Evaluating and selecting architect-engineers with whom to negotiate
- Conducting negotiations and awarding design contract
- Establishing design schedule and formal design review percentages
Design Activities
- Preparing designs, plans, specifications and contract documents
- Exercising continuing surveillance and review of the A-E's product at appropriate times during development

construction, e.g., environmental impact assessments, alternative energy analyses, solar energy studies, life-cycle cost studies, architect-engineer selection procedures, and construction project bid advertisement, bid analysis and award procedures. Not all functions are performed on every project. There is also considerable difference as to whether services are accomplished in-house or are contracted out.

NAVFAC performs less than 10 percent of its design in-house, while C-E performs about 25 percent of its design in-house. No other federal agency contacted had any significant capability to perform project design in-house; all relied almost exclusively on A-E firms. This was also true of the other governmental entities examined, except for the State of California where a number of projects were designed by the staff of the State Architect's Office.

In the private sector, only one of the three firms contacted elected to do its own design work. This corporation also provided construction contractor services for its own customer needs.

One of the most important design services is supervision and review of the efforts and product at varying and specified milestones in the design development. Supervision and review of design contracts are done by all the corporations and government agencies interviewed for this analysis as well as by C-E and NAVFAC. This effort assures that the design contractor is following the design guidance furnished, is following accepted norms and standards, and is preparing a finished set of designs and specifications that will fulfill all the stated needs of the customer. Proper supervision and review should minimize design and construction changes that could cause project delays and cost growth. Supervision and review can also foster a professional rapport with the design contractor that will encourage innovative approaches and cost-saving suggestions from the design contractor.

CONSTRUCTION PHASE

Construction phase services occur in two phases -- prior to the award of a construction contract, and subsequent to the award during the actual construction of the facility. Table 3-2 lists the typical services provided in the construction phase.

Again, as in the design phase, there are differences in how government agencies (including C-E and NAVFAC) and private sector organizations carry out construction phase services. C-E and NAVFAC provide virtually all of the services listed in Table 3-2. They typically establish area offices near each project to permit daily or continuous oversight of the construction contractor efforts. Other government agencies are generally not staffed to provide the level of construction surveillance exercised by C-E and NAVFAC. Services are either substantially reduced or are provided by a separate construction management service contract.

Of the three corporations contacted during the course of this study, only one provided the same services as C-E and NAVFAC. In addition, this corporation acted as its own prime contractor. This corporation also procured materials and equipment in-house and produced piping at their own manufacturing plants.

COMPLEXITY FACTOR

Before attempting to compare the C-E and NAVFAC construction support service costs with those in the private sector and other government agencies, the FY1982 military construction programs of the Army, Navy and Air Force were analyzed in two separate areas. First, we examined the distribution of projects falling within three cost ranges, and secondly, we determined those projects which could be characterized as being of average complexity and those considered to be of above average complexity.

TABLE 3-2. TYPICAL CONSTRUCTION PHASE SERVICES

Pre-Contract Award Services

- Liaison and conferences with design personnel on analyses of site selection, utility investigations and general design criteria
- Development of preliminary budget cost estimates
- Site visits with prospective bidders to acquaint them with site problems or limitations
- Provision to bidders of soil investigation logs, location of utility lines, etc.
- Studies and analysis of plans and specifications and conferences of construction staffs to establish construction sequence, etc., with design personnel to become familiar with design requirements
- Award and administration of construction contracts
- Award and administration of contracts that provide for supervision and inspection of construction

Post-Contract Award Services

- Establishment of bench marks and base lines required for layout of construction
- Review of shop drawings, manuals, catalogue cuts, and other information submitted by the construction contractor
- Assurance that construction is performed in compliance with plans and specifications by supervision and inspection of construction work, conferences with the contractors to coordinate various features of the project and enforced compliance with schedules
- Sampling and testing during construction phase of subsurface work and construction materials to determine their suitability and compliance with plans and specifications
- Estimation of quantities, determination of periodic payments to contractors, and review and approval of construction contract payments, including measurements required by Government forces
- Negotiation with construction contractors on all contract modifications, including preparation of all contract documents required, and preparation of Government estimates on those contract modifications that do not require preparation of revised designs, plans and specifications
- Construction staff's review and approval of construction schedules and progress charts, as prepared by contractors
- Assessment of contractors' liquidated damages as a credit offset for additional supervision and inspection expenses incurred by the construction agent
- Preparation of construction progress and completion reports

Average complexity projects include most routine horizontal construction, such as roads, curbs and gutters, runways, parking areas and hard stands, as well as the more common vertical structures such as housing and support facilities for enlisted men and officers, warehouses, small shop buildings and similar uncomplicated and relatively simple common facilities.

Those characterized as above average complexity would include: tactical and operational facilities designed to support various classes of weapons or ordinance; specific weapon system, research, development and test facilities; administrative and office buildings; applied instruction facilities including elementary and secondary schools; medical and dental facilities including laboratories, clinics and acute care hospitals; highway bridges and tunnels; and systems designed to dispose of or treat water, sewage or other large quantities of solid or liquid common or industrial wastes.

To classify the complexity of the construction projects, general criteria developed by the American Society of Civil Engineers in "Consulting Engineering: A Guide for the Engagement of Engineering Services," Manual 45, 1981, were used.

MILITARY CONSTRUCTION PROGRAM CHARACTERISTICS

In segregating the projects by cost, three price ranges were used: those of $1 million or less; those costing between $1 million and $10 million and, finally; all remaining projects (those costing more than $10 million). The ratio of such projects to the total of all projects was determined in each case. Similarly, the total dollar value of projects in each cost range was determined and expressed as a percentage of the total program cost. The results are shown in Table 3-3.

TABLE 3-3. COST RANGES OF PROJECTS IN FY1982 MILCON PROGRAMS (891)

Projects Costing Less Than $1 Million			Projects Costing From $1 Million to $10 Million			Projects Costing Over $10 Million		
Number of Projects	Total Projects (%)	Total Program Cost (%)	Number of Projects	Total Projects (%)	Total Program Cost (%)	Number of Projects	Total Projects (%)	Total Program Cost (%)
371	41.6	4.9	447	50.2	37.0	73	8.2	59.0

Almost 92 percent of the projects are concentrated in projects costing $10 million or less. These projects represent slightly more than 40 percent of the total funding.

Deletion of the few very large projects (e.g., the MX missile facilities) from the total program cost does not alter the distribution of costs significantly, as shown in Table 3-4. Again, over 90 percent of the number of

TABLE 3-4. COST RANGES OF PROJECTS IN FY1982 MILCON PROGRAMS (762)

(Total Program Less Bulk Lump Sum Projects for M-X Missiles and Overseas Area)

Projects Costing Less Than $1 Million			Projects Costing From $1 Million to $10 Million			Projects Costing Over $10 Million		
Number of Projects	Total Projects (%)	Total Program Cost (%)	Number of Projects	Total Projects (%)	Total Program Cost (%)	Number of Projects	Total Projects (%)	Total Program Cost (%)
301	42.2	5.6	370	52.0	43.3	41	5.8	51.1

projects cost $10 million or less. The correlation of these projects to the total dollar amount of the program does not change appreciably either. They still would represent less than 50 percent of the total cost. Neither is there any significant change in projects over $10 million, which, although less than 6 percent of the line item projects, would still require over half of the total fund request. Therefore, it can be concluded that although the

lump sum of unspecified and overseas projects would appear on the surface to contain a disproportionate number of projects among those costing in excess of $10 million, their exclusion from the total program does not markedly change the distribution of the program which is preponderantly concentrated in projects of $10 million and less.

With respect to the complexity of projects in the military construction programs, 45 percent were of above average complexity in FY1982 and 42 percent in FY1981.

PRIVATE SECTOR CONSTRUCTION

The general characteristics of private sector construction reviewed in this analysis are based on information collected from the large corporations visited and a sample of data collected in a survey of A-E firms conducted by the American Consulting Engineers Council.

For the corporations examined, the results showed a marked difference from the data derived from the military program analysis. Where the military programs had a total of almost 92 percent of their projects in the $10 million or less category, the private sector data indicated some 67 percent in this cost range. Conversely, where the military had only 8 percent or less in projects costing more than $10 million, the private sector data reflected about 33 percent.

In the area of complexity, 29 percent of the private sector projects were of average complexity. This is markedly lower than the 42-45 percent found in the military. These data appear to demonstrate that private sector work is less complex than a large proportion of military projects and therefore could be assumed to require a lesser amount of planning and design effort than a comparable sampling of military projects.

ACCOUNTING SYSTEMS

In general, the accounting systems used by C-E, NAVFAC, other government agencies and private sector firms for construction management are similar. Only one organization -- a corporation -- maintained accounting records that would reflect the cost of individual construction support services by project. This general lack of definitive accounting by construction service and by project precluded an item-by-item cost comparison. However, the costs for the design contract, the construction contract, and for in-house services provided during the planning and design and construction phases were generally available in aggregate.

In the very nature of business practice, prices for services charged in the private sector include all direct, indirect and overhead costs of doing business plus an additional amount for fee or profit. Private sector prices include all rents or lease costs or a value for capitalization of costs of owned facilities and equipment as well as the total costs paid for personnel benefits (including all payments to retirement funds or insurance companies). In the budgets of government organizations, some of these cost elements are not fully included. The most significant of these is civilian personnel benefits, the cost of which is 20.4 percent of base pay for retirement and 5.6 for insurance and other items, for a total of 26.0 percent according to recent OMB guidance. Organizational budgets include a cost of about 8.5 percent for these elements.

Civilian labor costs are about 80 percent of total costs for P&D and construction phase services. Civilian labor costs in C-E, and NAVFAC and other federal agencies for P&D and construction phase services were increased by 16 percent to include the full cost of benefits. This results in a 13 percent increase in total costs since 20 percent of costs are not affected by this consideration.

LEGAL AND REGULATORY REQUIREMENTS

A number of other factors complicate the comparison of design and construction phase costs in government with those in the private sector. Many legal and regulatory restrictions and procedures not applicable in commercial construction are required by government agencies. These include environmental impact assessments, life cycle cost studies, alternative energy, and solar energy feasibility studies. Similarly, to select a design contractor, government agencies must go through a detailed procedure for establishing a list of qualified A-E firms, must establish a selection board to evaluate such firms, and finally must select and negotiate with at least three such firms before awarding the design contract. These negotiations must be extensively documented and minutes kept of all negotiations. None of these are required in the private sector. After determination to proceed with a project, the private sector firm can select any firm it wishes without consideration of possible criticism of its choice of one firm over any other.

Again, during the preconstruction and construction phases, government agencies must provide services and comply with regulatory procedures which are either not required in private sector work or are provided at a much lower level of intensity. Both C-E and NAVFAC operate under a basic concept of providing daily and continuous oversight of the contracting and subcontracting activities. To do this they establish resident or area offices to oversee their projects. In most private sector work, such inspection is frequently accomplished through periodic, once or twice weekly, visits by the A-E or a member of his office. The presence of a Contracting Officer representative on site permits rapid resolution of conflicts or apparent conflicts between drawings and specifications, adjustment of specified quantities of work if required, quick negotiation and acceptance of low or no cost change orders,

and most importantly, continuous monitoring of the contractor's work, staffing and compliance with contractual schedule requirements.

Another factor which favors reduction of the costs of private construction is freedom from the labor cost constraints of the Davis-Bacon Act. The Davis-Bacon Act adds to both the cost of construction and the in-house costs for monitoring compliance. Private contractors working for private sector firms are not required to adhere to such wage structures and normally can accomplish a given amount of work at lower cost in the absence of such constraints.

Finally, private firms can specify proprietary or firm-named equipment and supplies by make and model number where government agencies are unable to do so. This again permits them to negotiate contracts that are the most price advantageous rather than having to advertise on performance specifications in order to maximize the equality of opportunity for potential bidders. In essence, all of these freedoms from legal and procedural constraints, which must be complied with by federal or federally-financed projects, tend to reduce the overall costs of private sector work and increase construction management costs in the government.

APPENDIX A

CORPS OF ENGINEERS

The C-E manages its design and construction program at twelve district and division offices, nine of which cover the contiguous United States. District offices are primarily engaged in contracting for design and construction services; supervision, review and administration of design contracts; and supervision, inspection and administration of construction work.

About 25 percent of design work is accomplished in-house at the district offices and 75 percent is contracted out. Supervision, inspection and administration of construction work is almost entirely an in-house function. Each district office has several area offices that house quality assurance/ inspection and contract administration staffs to service a defined area. These offices support the construction director in each district office with on-site construction inspection and contract administration services.

Additional program control and construction support services are performed at the division and headquarters level in C-E.

Costs for construction support services in the P&D and construction phases are affected by the size and complexity of a construction project. Relationships were developed to express this in quantitative terms. These relationships are used to compare costs experienced in C-E with comparable costs in private firms and other government agencies for construction projects of the same approximate size and complexity level.

P&D PHASE COSTS

P&D phase costs in C-E are categorized below for design work done by an A-E firm.

- In-house Costs
  - Direct Costs for Supervision and Review
  - Engineering Services
    - Surveys
    - Hydrographic/topographic investigations
    - Soils and subsurface investigations
    - Foundation/materials investigations
    - Solar studies
    - Other Studies
- Reproduction and miscellaneous
- Indirect
- Overhead
- A-E Contract Costs

Costs data by project for this level of detail were not available at C-E headquarters. Therefore, a special data call to district offices was prepared to include a sample of recently completed design projects. The response to this request produced usable cost reports for 58 design projects, 33 of which were of above average complexity and 25 of average complexity.

Regression analysis was used to develop the relationship between design costs and construction contract costs (CCC) and a complexity factor (c.f.). The first relationship is:

$$DES = 1.85\ CCC^{-0.225}_{(-3.82)} \times c.f_{(1.55)} \qquad r^2 = 0.218$$

where

DES = design and engineering services expressed as a fraction of CCC.

CCC = construction contract costs

c.f.= complexity factor equals 1.235 for above average complexity projects and equals 1.0 otherwise.

( ) = t statistic of regression coefficient

DES includes the A-E contract value plus all costs for engineering services defined previously. The second and third relationships are:

$$S\&R = 2.89\ CCC^{-0.339}_{(-4.52)} \qquad r^2 = 0.267$$

$$IH = 22.8\ CCC^{-0.443}_{(-6.77)} \qquad r^2 = 0.450$$

where

S&R = direct costs for supervision and review expressed as a fraction of CCC

IH = S&R plus all other in-house costs, except engineering services, expressed as a fraction of CCC

( ) = t statistic of regression coefficient

The original sample cost values for S&R and IH were increased by 13 percent to adjust the value of civilian personnel benefits to be comparable to private sector personnel costing. Estimated average costs for P&D phase services obtained from these equations for projects of various sizes are is shown in Table A-1.

TABLE A-1. C-E PLANNING AND DESIGN PHASE COSTS

			PERCENTAGE OF CONSTRUCTION CONTRACT COST (CCC) (CCC In Million $)				
COST ELEMENT	EQUATION	COMPLEXITY LEVEL	$1.0	$2.0	$4.0	$8.0	$16.0
Design and Engineering Services	DES	Average	8.3	7.1	6.0	5.2	4.4
		Above Average	10.3	8.8	7.4	6.4	5.4
Supervision and Review	S&R	Both	2.7	2.1	1.7	1.3	1.0
Other In-House	IH-S&R	Both	2.3	1.6	1.0	0.7	0.5
Total P&D Phase	DES+S&R +OIH	Average	13.3	10.8	8.7	7.2	5.9
		Above Average	15.3	12.5	10.1	8.4	6.9

Estimated design and engineering services costs decline from 8.3 to 4.4 percent as construction contract costs increase from $1 million to $16 million for projects of average complexity and from 10.3 to 5.4 percent

for projects of above average complexity. Supervision and review and other in-house costs decline in a similar fashion but are not affected by project complexity.

When expressed as a percentage of DES costs, S&R costs range from 32.5 (26.2) to 22.7 (18.5) percent for average (above average) complexity projects. Similarly, total IH (S&R plus OIH) costs range from 60.2 (48.5) to 34.1 (27.8) percent.

The t statistic for the complexity factor indicates that this variable is only marginally significant in the DES equation. However, a similar value for a complexity factor has been identified by the American Society of Civil Engineers and it is, therefore, included in this analysis.

The equations derived using the above approach estimate the average cost for construction services for a large number of projects of a given CCC value. There is a substantial project-to-project variation in cost about that average, and the use of CCC and c.f. in the regression analysis leaves 55 to 78 percent of the original variation unexplained. This large variation in potential costs of facility projects highlights the danger of making comparisons based on one project or a small sample of projects which may not reflect typical or average experience. Also, the regression equations yield estimates of average costs. These estimates are subject to potential estimating error and should, therefore, be regarded as approximate rather than precise values.

CONSTRUCTION PHASE COSTS

In cost estimates and appropriation requests, C-E includes a 5.0 percent charge for supervision, inspection and administration (SIA) services during the construction phase of military construction projects in the United States with few exceptions. The 5.0 percent cost factor is the same for all projects regardless of size or complexity level. SIA costs include costs to operate

the area offices that house construction inspection and contract administration staffs and costs of the construction division at district offices.

Costs for SIA services are not accounted for by project, and the relationship between these costs and project size and complexity level could not be studied directly. A relationship was developed by selecting a sample of 34 area offices and relating the 1982 operating costs for each office to the dollar value of work accomplished by size and complexity category. The relationship developed is:

$$AO = 0.1 + \underset{(2.10)}{0.016W_C} + \underset{(14.86)}{0.043W_B} + \underset{(1.92)}{0.023W_O} \qquad r^2 = 0.881$$

where

AO = area office operating cost (millions of FY1982 dollars)

W_C = dollar value of work accomplished in FY1982 on projects of average complexity in $ millions.

W_B = dollar value of work accomplished in FY1982 on projects of above average complexity in $ millions.

W_O = dollar value of work accomplished in FY1982 in $ millions

( ) = t statistic of regression coefficient

A typical area office cost is

$0.63M with W_B = $7.2M, W_C = 8.7, W_O = 3.6.

An attempt was made to develop a relationship between AO and work accomplished by project size category. Results obtained were not encouraging. Since this could be due to the sample size limitations, no conclusion about size effects is possible at this time.

Using the above equations, typical costs for SIA on average and above average complexity military construction projects (and non-MILCON projects)

are derived by applying the following multiplier to each regression coefficient:

1.20	to prorate the $0.1 million fixed cost from the regression over $0.5 million variable costs in an assumed office with total costs of $.6 million
1.58	to include a typical value for SIA costs at the district office
1.13	to include total costs for civilian benefits for comparison with similar values in private firms

The product of these multipliers is 2.14. When applied to the coefficients of work accomplished, the following estimates of costs for SIA services are obtained:

Military construction projects	
Above average complexity	9.2 percent
Average complexity	3.4 percent
Non-military construction projects	4.9 percent

This compares to a rate of 5.7 percent, the rate charged all projects, including the adjustment factor for civilian pay comparability.

APPENDIX B

NAVAL FACILITIES ENGINEERING COMMAND

NAVFAC manages its construction program at headquarters level and at six Engineering Field Divisions, four of which provide construction support services in the contiguous United States. The Atlantic EFD services both the U.S. and Europe, and the Pacific EFD services the Pacific theatre. EFDs are primarily engaged in contracting for design and construction services; review and administration of design contracts; and supervision, inspection and administration of construction work.

About 95 percent of design work is contracted out to A-E firms. The A-E contract usually provides for both basic design and engineering services such as surveys, foundation and materials investigations, solar studies, and others as needed. Supervision, inspection and administration of construction work is almost entirely an in-house function. Each EFD has several area offices for the officer or resident officer in-charge of construction (OICC/ROICC). These house the quality assurance/inspection and contract administration staffs in a defined area. The offices also support the construction directorate in each EFD with on-site construction inspection and contract administration services.

Relationships were developed that estimate the cost experienced by NAVFAC for construction support services in the P&D and construction phases as a function of project size and complexity level. These relationships allow for comparison of NAVFAC to private firms and other government agencies for facility projects of comparable size and complexity levels.

P&D PHASE COSTS

P&D phase cost data by project was obtained from NAVFAC headquarters on 133 projects included in the FY1982 and FY1983 program and for which design

effort was at or near completion. Seventeen of the 113 projects were above average in complexity. The remaining 116 were judged to be of average complexity.

Only A-E contract costs and direct in-house charges to a "plans and specs-AE" account are identified with projects in the NAVFAC cost accounting system. Indirect and overhead costs are allocated to projects to obtain an estimate of total in-house costs comparable to the C-E, private firms, and other government agencies included in the comparison.

The development of the overhead factor is shown below.

$1.00	Direct costs for supervision and review
1.13	EFD overhead costs
0.25	EFD administration costs
0.36	NAVFAC headquarters costs
$2.74	Overhead factor

EFD overhead costs include all charges to P&D funds (known as Z planning) except in-house design costs and direct costs for supervision and review. EFD administration costs reflect about one-third of total administration costs charged to the construction fund (SIOH). NAVFAC headquarters costs include all charges to P&D funds (Z planning) made at headquarters level. The three sources of overhead funds are assumed to apply 95 percent to A-E contracted design and 5 percent to in-house design to obtain the separate components of the overhead factor.

Both direct S&R and total in-house costs are increased by 13 percent to include the costs of civilian personnel retirement and other benefits not included in the source budget and accounting reports. This adjustment facilitates the comparison of military to private sector costs with all costs included.

Regression analysis was used to develop the relationship between design costs, construction contract costs and a complexity factor.

The first relationship is:

$$DES = 3.21\ CCC^{-0.266}_{(-5.27)} \times \underset{(2.62)}{c.f.} \qquad r^2 = 0.197$$

where

DES = design and engineering services costs expressed as a fraction of CCC

CCC = construction contract costs

c.f.= complexity factor equal to 1.428 for above average complexity projects and equal to 1.0 otherwise

( ) = t statistic of regression coefficient

DES equals A-E contract costs. The t statistics are shown in parentheses below regression coefficients. The second and third relationships are:

$$S\&R = 28.5\ CCC^{-0.568}_{(-7.20)} \qquad r^2 = 0.284$$

$$IH = 78.1\ CCC^{-0.568}_{(-7.20)} \qquad r^2 = 0.284$$

where

S&R = direct costs for supervision and review expressed as a fraction of CCC

IH = S&R plus all other in-house costs computed equal to 2.74 times S&R costs

( ) = t statistic of regression coefficient

Estimated average costs for P&D phase services obtained from these equations for projects of various sizes are shown in Table B-1.

Estimated design and engineering service costs decline from 8.1 to 3.9 percent as construction contract costs increase from $1 million to $16 million for projects of average complexity and from 11.6 to 5.6 percent for projects of above average complexity. Supervision and review and in-house costs decline in a similar fashion but are not affected by project complexity.

When expressed as a percentage of DES, S&R costs range from 13.6 (9.5) to 5.1 (3.6) percent for average (above average) complexity projects. Similarly total IH costs range from 38.3 (26.7) to 15.4 (10.7) percent.

TABLE B-1. ESTIMATED COST FOR P&D PHASE SERVICES PROVIDED BY NAVFAC

			PERCENTAGE OF CONSTRUCTION CONTRACT COST (CCC) (CCC In Million $)				
COST ELEMENT	EQUATION	COMPLEXITY LEVEL	$1.0	$2.0	$4.0	$8.0	$16.0
Design and Engineering Services	DES	Average	8.1	6.8	5.6	4.7	3.9
		Above Average	11.6	9.7	8.0	6.7	5.6
Supervision and Review	S&R	Both	1.1	0.8	0.5	0.3	0.2
Other In-House	IH-S&R	Both	2.0	1.3	0.9	0.6	0.4
Total P&D Phase	DES+S&R +OIH	Average	11.2	8.9	7.0	5.6	4.5
		Above Average	14.7	11.8	9.4	7.6	6.2

The equations derived provide estimates of the average cost of construction services for a large number of projects of a given CCC value. There is a substantial variation in project-to-project cost that is not explained by construction contract cost or the complexity factor. The regression equations yield approximate estimates of average costs that are useful for comparisons only to the average or typical costs experienced by private firms and other government agencies.

CONSTRUCTION PHASE COSTS

NAVFAC includes a 5.5 percent charge for supervision, inspection and administration (SIA) services in cost estimates and appropriation requests for all projects except family housing, for which the charge is 3.5 percent, and facilities service contracts, for which the charge is 3.0 percent. Some

service projects are performed without charge. The 5.5 percent cost factor applies to all projects regardless of size or complexity level.

As in the C-E, SIA costs are not accounted for by project and the relationship between these costs and project size and complexity could not be studied directly. A relationship was developed by selecting a sample of 38 area offices and relating the 1982 operating costs for each office to the dollar value of work accomplished by size and complexity category. The relationship developed is:

$$AO = \underset{}{0.1} + \underset{(2.08)}{0.008W_C} + \underset{(4.53)}{0.043W_B} + \underset{(5.72)}{0.015W_O} \qquad r^2 = 0.810$$

where

AO = area office operating cost in FY1982 (millions)

W_C = dollar value of work accomplished in FY1982 on projects of average complexity (millions)

W_B = dollar value of work accomplished in FY1982 on projects of above average complexity (millions)

W_O = dollar value of work accomplished in FY1982 on facility service contracts and other work not covered in the military construction appropriation (millions)

( ) = t statistic of regression coefficient

Based on the sample selected, an average area office cost is \$0.5M with W_B = \$2.5M, $\$W_C$ = \$9.3M and W_O = \$13.9M. This is not representative of all NAVFAC area offices since only those offices with the highest percentage of military construction work were selected for analysis. W_O constitutes 54 percent of area office workload in the sample. W_O would probably be 75 percent or more for area offices outside of this sample.

As in the similar analysis of C-E area office costs, the attempt to relate AO costs to project size did not yield significant results, perhaps because of sample size limitations.

Using the above equations, typical costs for SIA services are derived by applying the following multipliers to each regression coefficient:

1.20	to prorate the $0.1 million fixed cost from the regression equation over $0.5 million variable cost in an assumed office with total costs of $0.6 million
1.77	to include a typical value for EFD office costs
1.26	to include NAVFAC headquarters and professional development costs
1.13	to include costs for civilian benefits for comparison to similar values in private firms

The product of these multipliers is 3.02. When applied to the coefficients of work accomplished, the following estimates of costs for SIA services are derived:

Military construction projects	
Above average complexity	13.0
Average complexity	2.4
Non-military construction projects	4.5

This compares to the rates charged of 6.2 percent for military construction projects and 3.4 percent for family housing projects and facilities service contracts including the adjustment factor for civilian pay comparability.

APPENDIX C

OTHER GOVERNMENT AGENCIES

GENERAL SERVICES ADMINISTRATION

The General Services Administration (GSA) administers the design and construction of public office buildings, courthouses, warehouses, and border stations. Sometimes these elements are combined into federal office building complexes. The building program is administered at GSA headquarters in Washington, D.C. and at 11 regional offices.

GSA provides essentially the same list of construction support services as is provided by military construction agencies. These include contract administration, supervision and review of the design effort and supervision, administration and inspection of construction work. The technical complexity of GSA's new facilities is comparable to that of the administrative category of military facilities. A new GSA facility is somewhat larger than most military projects. GSA projects are typically in the $5-50 million category. Both GSA and the military must comply with federal procurement regulations and the requirements imposed by congressional legislation.

GSA has developed cost adjustment guidelines for use in reviewing and evaluating project cost estimates in the budget review cycle. These guidelines are based on an analysis of historical costs of 13 projects ranging in size from a three-level federal office and post office complex of 53,000 square feet in Carson City, Nevada, to a 17-level federal office building of 580,000 square feet in Los Angeles, California.

Tables C-1 and C-2 contain the cost adjustment guidelines for design and construction services expressed as a percentage of the estimated construction

TABLE C-1. COST OF PLANNING AND DESIGN PHASE SERVICES PROVIDED BY THE GOVERNMENT SERVICES ADMINISTRATION

CONTRACT CONSTRUCTION COST[a] (THOUSANDS)	CONTRACT ADMINISTRATION	TECHNICAL DESIGN REVIEW	BASIC DESIGN FEE	CONSULTING DESIGN SERVICES	REPRODUCTION AND MISCELLANEOUS	TRAVEL[b,d]	TOTAL COST OF DESIGN SERVICES (PERCENT OF ECC)
100 - 250	3.0	6.0	6.0	3.0	4.8	8.1	30.9
250 - 500	1.5	5.5	6.0	2.0	3.1	3.8	21.9
500 - 1000	1.0	5.1	6.0	1.7	1.9	1.9	17.6
1000 - 2500	0.6	3.6	5.7	1.3	1.0	0.8	13.0
2500 - 5000	0.4	2.5	5.3	1.1	0.7	0.4	10.4
5000 - 10000	0.3	1.5	5.0	0.9	0.5	0.2	8.4
10000 - 20000	0.2	1.0	4.8	0.6	0.4	0.1	7.1
20000 - 40000	0.1	0.7	4.4	0.5	0.3	0.1	6.1
40000 - 60000	0.1	0.6	4.2	0.4	0.3	0.04	5.6
OVER 60000	0.05	0.5	4.0	0.35	0.3[c]	0.03[c]	5.2

[a]Includes allowance for reserve and contingency funds.

[b]Calculated at the mid-point value of ECC for each class.

[c]Average ECC in this class is assumed to be $80 million.

[d]To obtain values for central and regional office travel, the cost of projects under and over $10 million were averaged across the 11 regions. This cost was divided by the mid-point value of ECC in each class to obtain the percentage figures indicated.

TABLE C-2. COST OF CONSTRUCTION PHASE SERVICES PROVIDED BY THE GOVERNMENT SERVICES ADMINISTRATION

CONTRACT CONSTRUCTION COST[a] (THOUSANDS)	CONTRACT ADMINISTRATION	CONTRACT INSPECTION	DESIGN SUPPORT	TESTING AND MISCELLANEOUS[b]	TRAVEL[d]	TOTAL COST OF CONSTRUCTION SERVICES (PERCENT OF ECC)
100 - 250	3.0	8.0	4.0	2.6	14.2	31.8
250 - 500	2.6	7.5	3.0	1.4	6.6	21.1
500 - 1000	1.8	7.0	2.5	0.8	3.3	15.4
1000 - 2500	1.3	5.2	2.0	0.4	1.4	10.3
2500 - 5000	1.1	4.3	1.5	0.3	0.7	7.9
5000 - 10000	0.8	3.9	1.3	0.2	0.3	6.5
10000 - 20000	0.5	3.5	1.0	0.2	0.3	5.5
20000 - 40000	0.4	2.8	0.8	0.4	0.2	4.6
40000 - 60000	0.3	2.0	0.6	0.4	0.1	3.4
OVER 60000	0.2	1.5	0.5	0.3[c]	0.06[c]	2.6

[a]Includes allowances for reserve and contingency funds.

[b]Calculated at the mid-point value of ECC for steel structures in each class.

[c]Average ECC is assumed to be $80 million.

[d]To obtain values for central and regional office travel costs, the estimated travel cost for projects under and over $10 million in ECC were averaged across the 11 regions. This cost was divided by the mid-point value of ECC in each class to obtain the percentage figures indicated.

cost (ECC). Costs are shown by type of design and construction service provided.

FEDERAL AVIATION AGENCY

The FAA sponsors a construction maintenance program of about $60 million per year for new facility acquisitions and modification, maintenance and repair of existing facilities. A typical new building project sponsored by the FAA is the addition or relocation of an air traffic control tower/terminal radar approach control facility (ATCT/TRACON) costing from $5 to $10 million.

The FAA relies heavily on the use of standard designs in the building of ATCT/TRACON facilities. After an architectural-engineering firm develops the standard design, it receives intensive review at FAA headquarters. As many as eight or more facilities are constructed from one standard design. Although the cost of in-house supervision and review of the design effort is not accounted for in the FAA, total design costs are about 2 percent of construction costs. About 1.5 percent is for architectural-engineering firms and the remaining 0.5 percent is for in-house supervision, review and support of design effort.

The new facilities construction program is monitored at nine regional offices, including one in Alaska, and by the resident engineer at the airport. The FAA has developed standard budget and cost factors for developing construction cost estimates to be included in the FY1984 budget. These are displayed in Table C-3 for ACTCs, with or without a TRACON facility included, located at airports with major, intermediate or low levels of flight activity.

Standard inspection and acceptance costs shown in Table C-3 provide for the services of a resident inspector employed full time on site during the construction phase. These costs range from 2.8 percent to 6.3 percent of construction costs depending on the size and complexity of the ATCT/TRACON

TABLE C-3. COST OF CONSTRUCTION PHASE SERVICES PROVIDED BY THE FAA

	TOWER HEIGHT (FEET)	BASE BUILDING SIZE (SQ.FT.)	STANDARD INSPECTION & ACCEPTANCE COST	STANDARD CONSTRUCTION CONTRACT COST	INSPECTION & ACCEPTANCE % OF CCC	SUPERVISION, INSPECTION & ADMINISTRATION % OF CCC
Major Activity Level	150	14,500[a]	$142,250	$5,140,000	2.8	8.8
Major Activity Level (Tower Only)	150	5,400[b]	101,250	3,422,000	3.0	9.0
Intermediate Activity Level	75	5,000[a]	126,250	2,028,000	6.2	12.2
Intermediate Activity Level (Tower Only)	75	3,600[b]	91,750[c]	1,586,000	5.8	11.8
Low Activity Level (Tower Only)	40	1,000[b]	49,000	781,000	6.3	12.3

[a]Base building is a TRACON facility.

[b]Base building is an administrative facility.

[c]Adjusted value.

facility. Costs for contract administration and administrative support from the budget, logistics and accounting organizations within the FAA are not included in these costs. A 6 percent fee for administrative services is usually added to standard costs where the FAA provides an ACTC/TRACON facility on a reimbursable basis to a military or foreign government organization. Total costs for supervision, inspection and administration, shown in Table C-3, range from 8.8 percent to 12.3 percent of construction costs when this 6 percent charge is added to the cost for resident inspector services.

The FAA provides essentially the same construction support services as are provided by military construction agencies. The FAA also must comply with the federal procurement regulations and requirements imposed by congressional legislation.

In the design phase, the FAA reaps the economic benefits of heavy reliance on standard designs. Multiple facilities are constructed from one

design, thereby reducing design costs as a percentage of the construction budget. Flight safety considerations require that air traffic control staffs are able to function in standardized ATCTs at many locations.

In the construction phase, supervision and inspection of the construction contractor is thought to be more intense than is typical in the military environment because of airport security and flight safety requirements.

VETERANS ADMINISTRATION

The Veterans Administration manages the construction of hospitals, nursing home care units, and domiciliaries at VA Headquarters in Washington, D.C. The VA contracts for A-E design services on most projects. The costs for in-house construction support services are not accounted for by project in the VA.

Data were obtained on 17 projects completed over the past 15 years. In-house costs were allocated to these projects. In-house costs were increased by 25 percent to include overhead costs for rents and utilities and personnel, legal, comptroller, and ADP support services not included in the accounting reports of the VA construction organization. These costs were further increased by the 13 percent factor to adjust civilian personnel benefit costs for comparability to the private sector.

The average construction contract costs for 17 projects is $37.0 million in FY1982 dollars. Adjusted costs for construction support services are shown below.

	Planning and Design Phase (Percent of CCC)	Construction Phase (Percent of CCC)	Total (Percent of CCC)
In-house	3.6	8.6	12.2
A-E Contract	6.0	.6	6.6
Total	9.6	9.2	18.8

STATE OF CALIFORNIA

The construction program in the State of California is managed by the Office of the State Architect located in Sacramento. This office is responsible for construction work amounting to about $120 million per year. This constitutes all state construction except roads and highways, state universities and colleges, and correctional facilities.

The Office of the State Architect accomplishes about one-third of the annual design workload with in-house design capability. Remaining design work is done on contract by A-E firms. Technical design and the financial administration of A-E contracts are reviewed by the State architect's office. Supervision and inspection of construction work is accomplished at four area offices staffed by state employees who are organizationally also within the Office of the State Architect.

In-house and contract costs for construction services during the planning and design and construction phases are shown below for an $11.2 million state office building located in Van Nuys, California.

	Planning and Design Phase (Percent of CCC)	Construction Phase (Percent of CCC)	Total (Percent of CCC)
In-House	1.2	3.2	4.4
A-E Contract	5.5	1.2	6.7
Total	6.7	4.4	11.1

Information from interviews indicates that the Office of the State Architect hires competent A-E firms licensed by the State of California and does not conduct detailed technical design reviews. Initial, mid-term and final design review sessions are usually conducted on all projects.

CITY GOVERNMENT

The General Services Department of this city government routinely manages construction on a number of small projects for improvements of streets, sewers and storm drains and occasionally manages construction of libraries, fire stations, parking facilities and other government facilities. Costs were provided for the former group of projects as shown below.

Project Size (CCC)	Average CCC	Planning and Design Phase (Percent of CCC)	Construction Phase (Percent of CCC)	Total (Percent of CCC)
Less than $1 million	$0.3M	14.8	20.0	34.8
Greater than $1 million	$1.7M	10.5	12.5	23.0

A-E costs are not shown above because these projects were designed in-house. The city does account for man-hours and costs by project, however. Direct man-hour cost data provided include hourly salary plus 50 percent for personnel benefits. An additional 40 percent factor has been added to include city indirect and overhead costs for management, personnel, legal and accounting support provided by other departments, and rents, utilities and other general expenses.

APPENDIX D

PRIVATE SECTOR ORGANIZATIONS

CORPORATION A

Corporation A is a large aerospace firm. The average costs for construction support services based on information obtained on five small construction projects of above average complexity shown below. The average construction cost of these projects is $1.6 million. The five projects include a machine shop, tool manufacturing facility, paint hangar, office building and an addition to ADP facility.

In-house costs of 4.5 percent during the planning and design phase amount to 40 percent of contract costs for basic design and other engineering services. Contract costs for design during the construction phase amount to 1.9 percent of construction contract costs. The remaining 4.3 percent for construction phase costs are for inspection and contract administration.

	Planning and Design Phase (Percent of CCC)	Construction Phase (Percent of CCC)	Total (Percent of CCC)
In-house	4.5[a]	1.7	6.2
Contract Service	11.3[b]	4.5[c]	15.8
Total	15.8	6.2	22.0

[a]Includes costs for contract administration technical design review, reproduction, travel and miscellaneous costs.

[b]Includes costs for basic design from A-E firm and other engineering services (surveys, soil tests, etc.).

[c]Includes design support (1.9 percent) and contract administration (1.1 percent) by the A-E firm plus inspection services (1.5 percent) provided by an independent contractor (e.g., a certified testing laboratory).

CORPORATION B

Corporation B's construction program is managed by a centralized Construction Division located in New York. This division contracts for and oversees a construction program of about $500 million annually. Most of these funds are used for large construction projects of above average complexity such as high-rise office buildings and manufacturing plants. The largest of these projects can exceed $100 million in total cost.

The construction division does not account for in-house cost by construction project. Total in-house costs for the management of the construction program are about 2.5 percent of construction contract costs. The distribution of costs by function for the planning and design and construction phases is shown below:

	Planning and Design Phase (Percent of total cost)	Construction Phase (Percent of total cost)	Total (Percent of total cost)
Construction	-	35	35
Estimating	5	7	12
Consulting Services	13	2	15
Planning	20	-	20
Finance, Contracts and Accounting	4	14	18
Total	42	58	100

In addition Corporation B contracts for design and construction services with an an A-E firm. A-E contract costs on a typical project are about 6 percent for design effort and 2 to 4 percent for construction phase services. The A-E contract typically provides for the services of full time resident engineers/inspectors located on the construction site.

A summary of the cost of construction support services is shown below:

	Planning and Design Phase (Percent of CCC)	Construction Phase (Percent of CCC)	Total (Percent of CCC)
In-house	1.0	1.5	2.5
A-E Design Services	5.5	0.5	6.0
A-E Construction Services	-	3.0	3.0
Total	6.5	5.0	11.5

A typical value of construction contract cost is $15.0 million.

CORPORATION C

Corporation C contracts for and manages a construction program of about $100 million per year through its construction group located near corporate headquarters. The group consists of 16 senior level architects or engineers. The group provides estimating, design control, engineering, purchasing, scheduling and construction project management services to 60 operating divisions. The costs of operating this group are included in corporate overhead and are not accounted for by project.

Using a nominal cost factor of $125 thousand per senior level architect/engineering manyears plus $700 thousand for travel including administrative costs yields an annual cost of $2.7 million which includes industry typical values for overhead costs, general and administrative expenses and profit. This amounts to three percent of estimated direct construction contract costs of $90 million annually.

Corporation C contracts for A-E services for design and technical advice during construction. Additional consultants are hired to accomplish surveys, foundation and material testing and other predesign services as needed. The typical A-E fee is 6.5 percent of direct construction contract costs.

Total in-house and A-E (including 0.5% for predesign services) costs for planning and design and construction phase services are shown below:

	Planning and Design Phase (Percent of CCC)	Construction Phase (Percent of CCC)	Total (Percent of CCC)
In-house	2.0	1.0	3.0
A-E Contract	5.5	1.5	7.0
Total	7.5	2.5	10.0

Corporation C manages a wide variety of construction projects. The typical project cost is medium in size ranging from $2.5 million to $3.5 million. The group is responsible for the delivery of basic brick, mortar and steel structures. Equipment needed to operate the facility is the responsibility of the operating division. The basic structure of facilities is judged to be of average complexity.

Corporation C interviews a few preselected local A-E firms and quickly awards a design contract that requires the A-E to design to within 5 percent of a construction cost target. If needed, the A-E must redesign at no cost to the corporation until construction cost is in the acceptable range. The corporation usually invites six each of general, electrical and mechanical contractors to bid on a project and awards the job to the lowest bidders.

SURVEY OF ARCHITECT-ENGINEER FIRMS

In order to expand the sampling base for design and construction services cost data within the private sector, the cooperation of the American Consulting Engineers Council (ACEC) was solicited. The Council, which represents some 3800 engineering firms nationally, distributed a standard questionnaire to a selected number of their architect and engineer members.

In preparing the sample questionnaire, care was taken to ensure that the information requested was tailored along lines to reflect the same predesign, design and construction services normally provided by the U.S. Army Corps of Engineers and the U.S. Navy Facilities Engineering Command. The addressees were also encouraged to list other special or unique services they may have provided, together with pertinent costs where available.

Some 24 firms were asked to participate in the survey, and of these, a total of seven responded with services and cost data on a total of 34 projects. The projects for which data were furnished represented a variety of functional construction in characteristics and costs. They included almost every basic type of construction involved in the governmental programs, from relatively simple shop structures of modest cost to more complex and expensive facilities such as acute care hospitals. The lowest cost project represented was a small analytical laboratory priced at over $900,000; the largest was a containerized port facility with associated berths and storage structures at over $45 million.

In analyzing the data submitted by the firms in response to the survey, we noted that in all instances the respondents were unable to provide cost data for the design and construction services furnished by the customer. This inability is to some degree understandable in that such costs, whether provided by separate contract or from within the customer's own staff, would not normally be available to the architect-engineer. We also noted that in general, the ratio of design cost to project construction cost tended to decrease as the cost of the project escalated.

The total construction cost of the 34 projects for which data were submitted aggregated $367,569,756. The design costs for these same projects totaled $17,554,822 or, on the average, design costs were about 4.8 percent of

construction costs. This compares with design and engineering services cost estimates in the C-E and NAVFAC for designs of average complexity when CCC is $10.8 million. The survey respondents were unable to put a dollar value on design review costs incurred by the customer during the evolution and development of the final design. Therefore, a comparison of supervision and review and other in-house costs on the customer side is not possible.

An additional factor in the difference between private sector and military construction design work is the degree of complexity that characterizes military construction and, conversely, represents a smaller percentage of private sector work. Admittedly the project sampling submitted by the ACEC respondents is relatively small and may not be representative of all commercial work. Even so, it is believed that the fraction of above average complexity projects is higher in the military than in the private sector.

Using the criteria developed by the American Society of Civil Engineers (ASCE) for assessing the complexity of projects in fee negotiations, the projects submitted by the respondents to the ACEC survey averaged about 27 percent in above average complexity. A similar sampling of military construction projects based on the same criteria indicated a ratio of some 46 percent of the projects meeting the criteria for above average complexity. This was some 70 percent higher than the private sector average. One of the major reasons for this predominance of higher complexity projects within the military construction programs stems from the almost quantum increases in the advanced and high technology weapon and defense systems introduced in recent years. These systems demand increasingly higher technology and more complex facilities for fielding and testing such weaponry.

In evaluating the added design costs attributable to above average complexity projects, the design fee percentage curves developed by the ASCE were

used. These curves established that, in the median range of project costs ($1-5 million), those of above average complexity could be expected to require design fees exceeding those of average complexity by 1.3 percent. Thus the significantly higher proportion of above average complexity projects in the military construction programs would produce increased military construction A-E fee averages over those in the private sector.

APPENDIX E

CONSTRUCTION SUPPORT SERVICES COSTS

This appendix contains the cost data used in the comparative analysis in Chapter 2 and found in several places throughout the report. Tables E-1 through E-3 show total P&D phase and construction phase costs in the C-E and NAVFAC. Costs for construction support activities of military personnel and C-E headquarters and division levels not funded in the military construction appropriation have been added to data previously reported. Tables E-4 through E-6 contain total P&D phase and construction phase costs for the other government agencies and corporations included in the comparison.

TABLE E-1. TOTAL COST OF CONSTRUCTION SUPPORT SERVICES
(% Of Construction Contract Costs)

	CONSTRUCTION CONTRACT COST ($ MILLIONS)	PLANNING AND DESIGN PHASE (%)	CONSTRUCTION PHASE (%)	TOTAL (%)
C-E				
Average Complexity Projects	1.0	13.8	4.1	17.9
	2.0	11.3	4.1	15.4
	4.0	9.2	4.1	13.3
	8.0	7.7	4.1	11.8
	16.0	6.4	4.1	10.5
C-E				
Above Average Complexity Projects	1.0	15.8	9.9	25.7
	2.0	13.0	9.9	22.9
	4.0	10.6	9.9	20.5
	8.0	8.9	9.9	18.8
	16.0	7.4	9.9	17.3
NAVFAC				
Average Complexity Projects	1.0	11.3	3.6	14.9
	2.0	9.0	3.6	12.6
	4.0	7.1	3.6	10.7
	8.0	5.7	3.6	9.3
	16.0	4.6	3.6	8.2
NAVFAC				
Above Average Complexity Projects	1.0	14.8	14.2	29.0
	2.0	11.9	14.2	26.1
	4.0	9.5	14.2	23.7
	8.0	7.7	14.2	21.9
	16.0	6.3	14.2	20.5

TABLE E-2. COST OF CONSTRUCTION SUPPORT SERVICES IN THE PLANNING AND DESIGN PHASE
(% Of Construction Contract Costs)

	CONSTRUCTION CONTRACT COST CCC ($ MILLIONS)	DESIGN AND ENGINEERING SERVICES DES (%)	SUPERVISION AND REVIEW S&R (%)	OTHER IN-HOUSE OIH (%)	NON-MILCON[a] (%)	TOTAL P&D PHASE (%)
C-E Average	1.0	8.3	2.7	2.3	0.5	13.8
	2.0	7.1	2.1	1.6	0.5	11.3
	4.0	6.0	1.7	1.0	0.5	9.2
	8.0	5.2	1.3	0.7	0.5	7.7
	16.0	4.4	1.0	0.5	0.5	6.4
C-E Above Average	1.0	10.3	Same Values as for Average			15.8
	2.0	8.8				13.0
	4.0	7.4				10.6
	8.0	6.4				8.9
	16.0	5.4				7.4
NAVFAC Average	1.0	8.1	1.1	2.0	0.1	11.3
	2.0	6.8	0.8	1.3	0.1	9.0
	4.0	5.6	0.5	0.9	0.1	7.1
	8.0	4.7	0.3	0.6	0.1	5.7
	16.0	3.9	0.2	0.4	0.1	4.6
NAVFAC Above Average	1.0	11.6	Same Values as for Average			14.8
	2.0	9.7				11.9
	4.0	8.0				9.5
	8.0	6.7				7.7
	16.0	5.6				6.3

[a]Cost of construction support activities not paid from military construction appropriations

TABLE E-3. COST OF CONSTRUCTION SUPPORT SERVICES IN THE CONSTRUCTION PHASE
(% of Construction Contract Costs)

	CONSTRUCTION CONTRACT COST CCC ($ MILLIONS)	SUPERVISION, INSPECTION, AND ADMINISTRATION SIA (%)	DESIGN DURING CONSTRUCTION DDC (%)	NON-MILCON[a] (%)	TOTAL CONSTRUCTION PHASE (%)
C-E					
Average	2.1	3.4	0.5	0.2	4.1
Above Average	5.8	9.2	0.5	0.2	9.9
Flat Rate	Any	5.7	0.5	0.2	6.4
NAVFAC					
Average	2.3	2.4	1.2	0.2	3.8
Above Average	3.3	13.0	1.2	0.2	14.4
Flat Rate	Any	6.2	1.2	0.2	7.6

[a]Cost of construction support activities not paid from military construction appropriations

TABLE E-4. TOTAL COST OF CONSTRUCTION SUPPORT SERVICES
(% of Construction Contract Costs)

	CONSTRUCTION CONTRACT COST ($ MILLIONS)	PLANNING AND DESIGN PHASE (%)	CONSTRUCTION PHASE (%)	TOTAL (%)
GSA	0.4	23.7	23.5	47.2
	0.8	18.9	17.1	36.0
	1.8	13.8	11.4	25.2
	3.8	10.9	8.7	19.6
	7.5	8.7	7.2	15.9
	15.0	7.3	6.1	13.4
	30.0	6.3	4.9	11.2
FAA	6.0	NA	13.6	NA
	9.0	NA	10.2	NA
VA	37.0	9.6	9.2	18.8
State Government	11.1	6.7	5.4	12.1
City Government	0.3	14.8	20.0	34.8
	1.7	10.5	12.5	23.0
Corporation A	1.6	15.8	6.2	22.0
Corporation B	15.0	6.5	5.0	11.5
Corporation C	3.0	7.5	3.5	11.0

TABLE E-5. COST OF CONSTRUCTION SUPPORT SERVICES IN THE PLANNING AND DESIGN PHASE
(% Of Construction Contract Costs)

	CONSTRUCTION CONTRACT COST CCC ($ MILLIONS)	DESIGN AND ENGINEERING SERVICES DES (%)	SUPERVISION AND REVIEW S&R (%)	OTHER IN-HOUSE OIH (%)	TOTAL P&D PHASE (%)
GSA	0.4	8.0	6.2	9.5	23.7
	0.8	7.7	5.8	5.4	18.9
	1.8	7.0	4.1	2.7	13.8
	3.8	6.4	2.8	1.7	10.9
	7.5	5.9	1.7	1.1	8.7
	15.0	5.4	1.1	0.8	7.3
	30.0	4.9	0.8	0.6	6.3
VA	37.0	6.0		3.6	9.6
State Government	11.1	5.5		1.2	6.7
City Government	0.3	14.8		a	14.8
	1.7	10.5		a	10.5
Corporation A	1.6	11.3	Not Separately Identified	4.5	15.8
Corporation B	15.0	5.5		1.0	6.5
Corporation C	3.0	5.5		2.0	7.5

[a]In-House Design

TABLE E-6. COST OF CONSTRUCTION SUPPORT SERVICES IN THE CONSTRUCTION PHASE
(% Of Construction Contract Costs)

	CONSTRUCTION CONTRACT COST ($ MILLIONS)	SUPERVISION, INSPECTION AND ADMINISTRATION SIA (%)	DESIGN DURING CONSTRUCTION DDC (%)	TOTAL CONSTRUCTION PHASE (%)
GSA	0.4	20.5	3.0	23.5
	0.8	14.6	2.5	17.1
	1.8	9.4	2.0	11.4
	3.8	7.2	1.5	8.7
	7.5	5.9	1.3	7.2
	15.0	5.1	1.0	6.1
	30.0	4.1	0.8	4.9
FAA	6.0	13.6	1.0[a]	14.6
	9.0	10.2	1.0[a]	11.2
VA	37.0	8.6	0.6	9.2
State Government	11.1	4.4	1.0[a]	5.4
City Government	0.3	20.0	b	20.0
	1.7	12.5	b	12.5
Corporation A	1.6	4.3	1.9	6.2
Corporation B	15.0	4.5	0.5	5.0
Corporation C	3.0	2.5	1.0[a]	3.5

[a]No value reported. Nominal value of 1.0 is assumed.

[b]Included in SIA cost

APPENDIX F

GLOSSARY

NAVFAC	Naval Facilities Engineering Command
C-E	Corps of Engineers
VA	Veterans Administration
FAA	Federal Aviation Administration
GSA	Government Services Administration
ST	State Government Construction Authority
CY	City Government Construction Authority
CA	Corporation A
CB	Corporation B
CC	Corporation C
P&D	Planning and Design Phase
DES	Design and Engineering Services Costs
S&R	Supervision and Review Costs
OIH	Other In-House Costs
SIA	Supervision, Inspection, and Administration Costs
DDC	Design During Construction Costs

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Study compares management costs of Corps of Engineers and Naval Facilities Engineering Command for design and construction of military construction projects with those of other government agencies and the private sector. Conclusion is that costs are comparable when differences in type of services provided, size of construction project, and complexity of project are accounted for.

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