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ACQUISITION COSTING IN THE FEDERAL GOVERNMENT,(U)
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(6) ACQUISITION COSTING IN THE FEDERAL GOVERNMENT,

(10) Richard T./Cheslow
James R./Dever

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Logistics Management Institute
4701 Sangamore Road
Washington, D.C. 20016

EXECUTIVE SUMMARY

The quality of acquisition costing in the Federal Government is generally good. While major revision or overhaul is not needed, some problems do exist. These can be solved by specific actions covering a small number of people or by expanding current programs, structures, or techniques. These conclusions are based on an analysis of the efficacy of costing techniques and on interviews of personnel in 19 Federal departments, agencies and offices. They are further supported by a GAO report on the reasons for cost overruns on 200 Federal acquisitions and by interviews of costing personnel in the private sector.

Our major findings are:

1. The iterative costing process is generally consistent throughout the Federal Government. (Chapter 2)
2. A full spectrum of estimating techniques is used throughout the Government, as appropriate. (Chapter 3)
3. Overall estimating errors are within generally accepted limits although some additional study of high estimating error situations may be appropriate. (Chapter 4, Section H)
4. Costing organization, training and communication present opportunities for improvement. (Chapter 4, Sections A, B, C, F, and G)

We therefore recommend that:

OFPP work with each Department and Agency to determine the most effective organizational location and career pattern for unified costing offices.

Implementing this recommendation will result in minimizing the problems discussed in Chapter 4.

Secondary recommendations include:

1. OFPP help to achieve the intended mission of the Federal Software Exchange Center, and
2. FAI provide training on specific subjects perceived as current needs by costing managers (see Chapter 5, for specific examples).

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1. INTRODUCTION

On 19 September 1977, the Logistics Management Institute (LMI) received Task Order 77-15, defining eight work packages or sub-tasks to be done for the Federal Procurement Institute (FPI). (The name was changed to Federal Acquisition Institute (FAI) on 1 March 1978.) Sub-task 5 was titled, "Contract Cost Estimating Techniques and Procedures Study." The task order called for a survey and analysis of cost estimating and cost and price analysis techniques used by Government and industry, with recommendations on how best to transfer those techniques.

On 28 February 1978, representatives of the Office of Federal Procurement Policy (OFPP), FAI, Army Procurement Research Office (APRO), and LMI met to discuss the direction of the task. All parties present agreed that:

1. Due to the interrelation of cost estimating and analysis throughout the acquisition process, the study should be expanded to cover all phases of that process.
2. There would be two separate products of this study: a guide listing available cost estimating and cost and price analysis techniques and models and a report on findings, conclusions, and recommendations concerning the improvement of cost estimating, cost analysis and price analysis in the Federal Government.

The work was to be done under the overall management of the APRO. Subsequent discussion with the FAI and APRO resulted in a division of the work effort. APRO was to concentrate on the Army, Air Force, and Defense Logistics

Agency and LMI on the remainder of the Federal Government and the private sector. LMI's specific efforts were to include:

1. a review and compilation of currently available models and techniques which may be of use within the Federal Government, and
2. a report on its findings, conclusions and recommendations concerning the improvement of cost estimating, cost analysis and price analysis in the Federal Government.

The first of the above tasks was completed by LMI with the delivery on 1 May, 22 May, 7 June and 30 June 1978, of listings, abstracts and background information on models found during the research. The models covered estimating for all segments of the acquisition process, and many could be applicable to a variety of agency situations. In all, 118 models with explanatory material were delivered. We have attached Appendix A to this report to list the models delivered on the above dates. This Appendix is only a list of the models and does not contain the abstracts and descriptive information submitted with each model. Consistent with the agreements already noted, this information was delivered to the APRO at Fort Lee, Virginia.

The second task noted above is completed with the submission of this final report. In accordance with the above agreements, it is being submitted simultaneously to the Army Procurement Research Office and the Federal Acquisition Institute. It includes our findings, conclusions and recommendations. Inasmuch as the task order describes the OFPP interest in this study, certain of the recommendations are addressed to the FAI and others to the OFPP. This research was accomplished using available literature and included an extended series of interviews with a large number of Federal agencies and a representative sample of private organizations. Appendix B is a listing of the interviews and contacts.

2. COST AND PRICE IN THE FEDERAL ACQUISITION PROCESS

A. OVERVIEW

Acquisition means the acquiring by the Federal Government of goods and services. The acquisition process includes "such related functions as determinations of the particular public need; solicitation; selection of sources; award of contracts; contract financing; contract performance; and contract administration."[1]

An attempt to precisely describe costing in the acquisition process in the Federal Government would be lengthy and confusing. Acquisition costing and its process varies among the agencies. It depends on the types of goods or services generally acquired, average contract size, organizational placement of the program management, budgeting and contracting functions, agency mission, and traditional roles of technical and administrative personnel.

We have, however, developed a general description of costing in the Federal acquisition process (Figure 1). Our objective was to present the steps that are common to most agencies. The description is not based on published directives or instructions but on information obtained during interviews in 19 departments and agencies. It represents a description of reality rather than theory. It should not be considered as descriptive of any one agency or department, but the elements are present in all agencies.

Figure 1 emphasizes the costing aspects of acquisition. Thus, the procedures and reviews inherent in needs determination, budget preparation and approval, and contracting and contract administration are not shown.

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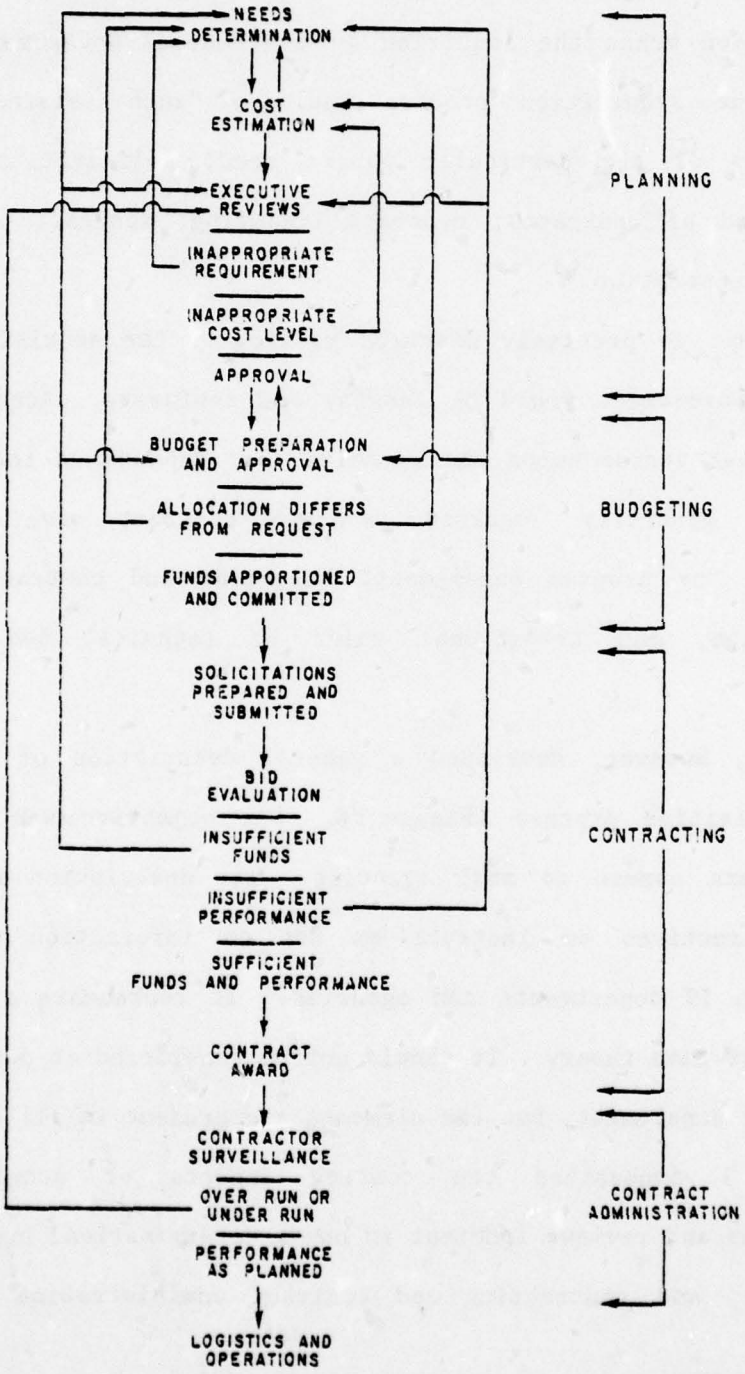
[1] S.1264, 95th Congress, 1st Session, Section 3.

FIGURE 1
COSTING AND PRICING IN
THE FEDERAL ACQUISITION PROCESS



It is apparent that the acquisition process is a series of iterative steps. Ideally, if everything "works right", there is a steady progression from need determination to receipt and use of the purchased equipment or service. In fact, however, there is usually a series of reviews, redeterminations, and adjustments to accommodate changes in need or resource availability.

The acquisition of a major, complex system is a series of iterations of the process shown in Figure 1. The phases of concept formulation, engineering development, prototyping, and production are each acquisitions in their own right. The same actions are taken during each phase, and a costing and review function is added between phases.

The acquisition process spans a number of traditional functions - planning, budgeting, contracting, and contract administration. Each of these functions has developed into a distinct area of specialization.

The traditional functional span in the acquisition process has produced a problem in definition. The costing effort and techniques in the planning process differ from those used in the contracting process. Therefore, we have defined the following terms for this report.

Acquisition Costing - The total process of developing, preparing, and monitoring a cost for goods or services. It encompasses the activities of cost estimating, cost analysis and price analysis.

Cost Estimating - The development of an expected value of the total cost without the knowledge of a definite bid for the specific goods or services.

Cost Analysis - The review and evaluation of a contractor's cost and pricing data to determine the probable cost to the contractor to supply the goods or service.

Price Analysis - The review, in varying detail, of a prospective price, without evaluation of the separate cost elements of that price.

B. PLANNING AND BUDGETING

Planning and budgeting are combined for this discussion since both involve cost estimating, as defined in this report. Thus, the techniques and problems in costing are the same for both.

The process starts with the determination of a need. This determination may be made by an agency or directly by Congress. The first estimate is usually prepared by technical specialists in the subject area. In some agencies, such as Defense and NASA, this estimate is reviewed or modified by a cost estimating group attached to a central program, budgeting, or technical office. After a number of iterations to consider varying requirements and resource availabilities, an estimate is finally submitted to the Agency Head for approval and inclusion in the agency budget. Upon completion of Congressional action, a value is included in the final, approved budget.

The number of iterations can be very high and the "Executive Review" function shown in Figure 1 may be performed by a number of individuals. To illustrate this process, the typical development path for an agency might be:

1. An initial estimate is made by technical personnel.
2. The manager of that office reviews the requirement and estimate. Modificatons, based on executive determination of agency needs and goals, may be made prior to forwarding to higher authority.
3. An estimate is prepared by a group at the regional level.

4. The regional director (executive) reviews the estimate. If modifications are desired in the light of an overall goal for the region, the plan and estimate are returned to the manager. If no modification is needed, the plan is forwarded to the next higher authority.

5. An estimate is prepared by a group at the sub-agency level.

6. The sub-agency executive reviews and modifies or approves and sends forward.

7. An estimate is prepared by a group at the agency level.

8. Upon executive review, modification, and approval at the agency and Presidential levels, the estimate is submitted to Congress as part of the agency's budget.

9. After Congressional approval, with or without modification, executive reviews within the agency, at various levels, result in an allocation.

C. CONTRACTING AND CONTRACT ADMINISTRATION

Costing in contracting and contract administration is very similar. Both use primarily cost and price analysis. Costing in contract administration involves the application of the same techniques as are employed by contracting personnel. For this reason, these two acquisition phases are combined for this discussion. While it is true that contracting and contract administration procedures will vary from agency to agency, some parts of the process are similar. An illustrative sequence for a typical agency follows.

When a program office receives an authorization and commitment to proceed for a particular item, it will issue a purchase request or equivalent. That request contains either specifications or work statements and identifies the funds available. Depending on the size of the acquisition and the procedures

of the agency, a solicitation evaluation authority will be appointed. This authority may be either an individual or a committee. The authority evaluates the realism of the purchase request and issues a Request for Proposals if its estimate roughly agrees with the budget allocation. If the selector's estimate is substantially different, the purchase will be submitted for executive review and subsequent changes in the scope of work or the allocation.

Proposals from contractors who respond to the Request for Proposals are usually divided into technical and cost packages and are analyzed independently. Following separate ratings, the cost and technical packages are usually combined for further analysis. Cost analysis and auditing procedures are utilized. Cost negotiations normally end with a best and final offer. If this final offer is not within either the technical or cost parameters of the purchase request, it is presented for executive review and subsequent modifications.[2] If the offer is within the parameters of the purchase request, either initially or after the review process, the contracting officer will either sign the contract or forward it to the appropriate reviewing office for approval. After approval by the reviewing authority, the contract will be signed.

For certain contract forms, costs are monitored throughout the performance period of the contract and recurring estimates of the expected total cost are generated. These estimates are used to track the actual expenditures against the contract amount. If the project is not expected to be completed for the contract amount, it is again subjected to executive review to make appropriate adjustments.

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[2]The result of the modification is another round of negotiation and request for "best and final" offers. This repetition raises problems which are beyond the scope of this study.

Proposed contract changes, whether contractor or Government-initiated, are subjected to cost estimating techniques in order to determine whether the change should be made. If approved, a contractor's change proposal will be analyzed by cost analysis methods.

3. THE ELEMENTS AND TECHNIQUES OF COSTING

Acquisition costing encompasses cost estimating, cost analysis, and price analysis. Despite the differences in the functions encompassed, the goal of acquisition costing remains the same: to provide an estimate of the total cost to the Government for goods or services. At each stage of the acquisition process there is a decision to be made based on the probable cost of the acquisition (e.g., between alternative systems, whether to start production, etc.). This decision must be based on the amount of data available to the analyst at that moment. A cost estimating or analysis technique provides the analyst with a method to arrange and interpret data in a way that assists the analyst in making that decision. Because of the variety of goods and services acquired by the government and quantity and quality of information available numerous techniques have evolved. These techniques range from simple arraying procedures to complex computer models.[3] These techniques can operate as links or bridges between available data and the decision. A cost estimator or analyst who understands the basic techniques can choose the one that best forms the link for the specific circumstances. This may be accomplished by using a technique already in use, adapting or modifying one to fit a specific situation, or by developing an entirely new technique. To some extent, each acquisition presents a unique problem, but a costing professional will be better able to choose or fashion the appropriate technique if he is equipped

[3] An earlier phase of this study was spent in searching for models which may have applicability beyond the specific use for which they were generated. A number were found and reported (Appendix A). More importantly, it was found that the Government has the regulatory capability and capacity to provide this knowledge through the Federal Software Exchange Center. Greater use of the center should improve the knowledge and use of models and modeling techniques throughout Federal costing offices.

with a basic understanding of the various approaches to estimating and analysis.

A. COST ESTIMATING

Cost estimating is the development of an expected cost without benefit or knowledge of a definite proposal or bid. In the planning and budgeting stages of an acquisition, no bid or proposal usually is available for analysis, hence cost estimating must normally be used. After proposals are received, cost estimates may be used as one input into a cost analysis.

Different techniques are used at various stages of the acquisition process, largely due to differences in kind and amount of data available. The appropriate technique for developing the probable cost of an item which has never been made differs from that used in estimating the probable cost of an already produced item. The techniques of cost estimating may be grouped into four generic categories:

1. Judgmental Estimating
2. Parametric Representation
3. Analogy
4. Engineering Detail

1. Judgmental Estimating

One technique of estimating is the application of expert judgment. In its simplest form, this consists of an individual providing a "guess" of probable cost based on personal knowledge of similar items or the amount of work needed to perform a task. In its more advanced form, this technique may consist of a panel of experts, each providing their rationale for an expected cost and arguing their respective viewpoints until a general consensus is achieved.

It is obvious that this technique is, in reality, a form or combination of the other three techniques. The difference lies in the ability to quantify the data. Judgment relies on personal estimates using such concepts as "more than" and "less than" rather than quantitative information of detailed work inputs and costs. This type of estimating is relied upon primarily in the early stages of the acquisition process when very little data is available.

2. Parametric Representation

This method of estimating analyzes the relationship between a characteristic and the cost of an item. The characteristic can be either a performance variable (e.g., speed, range, power output) or a physical variable (e.g., weight, volume). The relationship that a variable has to cost is called a cost estimating relationship (CER). The CER is often expressed as a mathematical equation that allows the estimator to project the cost of an item with a variable value that differs from those currently available. The accuracy of a CER diminishes as the desired value of the variable moves further away from the values that were used to form the CER.

Each CER will furnish only one cost estimate for an item, but greater reliability can be achieved by a relationship that considers more applicable variables.

Data requirements for parametric estimating are extensive. The estimator must be capable of recognizing which variables have a valid relationship to cost. Once established, CERs must be continually updated as new information is obtained.[4] Another difficulty with CERs is that they often reflect acquisition cost under relatively limited circumstances. Thus,

[4]Old data does not lose its value in parametric costing. It continues to be an integral part of the data base. New data adds to that data base allowing the CER to become more useful.

although we found parametric analysis to be used extensively during the planning and budgeting phases, there are obvious dangers in assuming that the same relationship could be used in all similar acquisitions.

Although the use of mathematical equations may imply a reasonable level of reliability, parametric costing is more reliable than judgmental estimating, but no more, and probably less, reliable than analogous costing. The reason is probably more a function of definition and use than fact. Parametric costing is usually used when variable values are being projected beyond current ranges. Analogy usually refers to the costing of items within the range of current values.

Parametric techniques can be used throughout the acquisition process although it has been traditionally associated with cost estimating.

3. Analogy

This method is based on the premise that almost all acquisitions are identical or very similar to previous acquisitions. Even though a total system may seem dissimilar to any other acquisition, there may be many similarities if it is analyzed at either the component or part level.

To establish an estimate based on an analogous previous acquisition, the price of the prior item must be verified and justified. This may be accomplished by researching the price justification of the original item if it is available. If it is either not available or insufficient, the analyst should seek to justify the reasonableness of the previous price through an established catalog, the commercial market price, or by showing that adequate competition existed. Any previous price or cost should be adjusted to current dollars by use of a price index.

Once the price of the previous acquisition has been established, justified and indexed, the analyst should briefly review the level of technology employed and reflect these in his estimate. The final step is to determine the price differential caused by the change between old and new items. These changes can be in specifications, quantities, or delivery schedules. These changes may be priced by resorting to any method of price estimating that the analyst deems appropriate.

Analogous estimating requires large amounts of data which must be carefully indexed by type of article to be acquired. This indexing must be sufficiently detailed to allow careful comparison of both total systems and various sub-systems. Since these sub-system components could be in totally unrelated systems (e.g., a power source for an airborne radar system could be identical to one required for a ground radio jammer), it is necessary, or at least desirable, to index by each separate logical sub-system level. Data sources should include a history of all recent acquisitions, catalogs, and Federal supply schedules and should not be limited to acquisitions of the department or agency seeking the information.

4. Engineering Detail

The total cost of an item is the sum of the costs of all of its elements which include material, labor, other direct costs, overhead and profit. To use engineering estimating, it is necessary to be able to estimate the amount of work and material required for each sub task. This information is often arrayed in the form of a work breakdown structure. Once all the material, labor and other requirements have been identified, each sub task is priced and summed to arrive at the total cost.

Data requirements differ from other costing techniques in that detailed projections of costs for specific labor and material elements are

required. Detailed design and scheduling information is also needed. Hence, the engineering method is most appropriate for the Government's initial estimates when the Government has responsibility for design and preparation of detailed specifications.

Among the elements, the amounts of material and labor are the most susceptible to precise estimation since they are based upon detailed knowledge of the work. The costing for these items is less exact since it involves estimates of future values. The final estimated value must include an allowance for a contractor's anticipated profit.

Historical data may aid in understanding the dynamics of the work breakdown structure, but data sources are normally utilized only for the pricing of the separate elements.

B. COST ANALYSIS

Cost analysis is the element-by-element examination of the estimated or actual cost of contract performance[5] to determine the probable cost to the vendor of supplying the goods and services. The examination and evaluation of elements looks to such factors as reasonableness, necessity and basis of allocation. Because it requires a proposal as a starting point, cost analysis is confined to the contracting and contract administration stages of the acquisition process. Cost analysis is similar to engineering estimating in the sense that both involve pricing of separate elements. Therefore, they both employ similar techniques. Cost estimates, formulated without access to contractor submitted data, may be used as an aid or guide to an analyst. An independent estimate is useful in measuring the cost realism of the contractor's proposal. A large discrepancy between an independent

[5]Armed Services Procurement Manual for Contract Pricing (ASPM No. 1), Chicago, Illinois: Commerce Clearing House, Inc., 1975, pp. 3B1.

estimate and a contractor's proposal may signal the cost analyst that a deeper probe is necessary to resolve that difference. Armed Services Procurement Manual No. 1 provides an excellent discussion of the techniques of cost analysis.

C. PRICE ANALYSIS

Price analysis evaluates a price in a bid or proposal without evaluating the separate elements of that price. Whereas cost analysis establishes what it will cost the contractor to produce an item, price analysis establishes that a price is fair and reasonable. For formally advertised acquisitions, price analysis is the only type of analysis possible. In negotiated acquisitions over $100,000 price analysis is usually used in conjunction with cost analysis. Some form of price analysis must be applied to every acquisition. Price analysis is essentially an analogous method of analysis, hence many of the techniques employed are similar to those of analogous estimating. One method of determining fairness and reasonableness is by testing for effective competition. Other methods include comparison with either catalog prices or independent government estimates. Once a past price is established as reasonable, allowances must be made for differences in delivery schedules, quantities, and specifications. The final step is to take into account the effect of inflation.

4. FINDINGS AND CONCLUSIONS

It is apparent that costing in the acquisition process covers a broad span of activities and a number of functional specialties. When the missions of specific agencies are considered, most areas of concern become associated with specific technologies and agencies. We have, however, identified issues common to all Government agencies involved with costing: organization, communication, traceability of estimates, cost estimating methods, cost and price analysis methods, data availability, training, and estimating error.

A. ORGANIZATION

Historically, legislation creating a department or agency does not address the specifics of its internal structure. With differing mission requirements, agency acquisition functions differ in organizational placement and in the role assigned the costing function.

The most common organizational situation has separate estimating and analysis units for each stage in the acquisition process. Each of the traditional functional specialties (programming, budgeting, contracting and contract administration) has developed a separate approach to the costing process. Typically, an estimate wil be generated in the program office for each project. This estimate may be made by a program person with no formal background in cost estimating. The estimate is then forwarded through a series of program and technical management offices through the organizational hierarchy to the budget office where it may again be analyzed by an internal cost estimating branch. After approval and inclusion in the budget, the program office will request the contracting office to acquire the item.

As in the program and technical management structure, the request may be reviewed and analyzed by contracting offices at any or all hierarchical

levels: department, bureau, region, district or field office. Each level has a limit to its contracting authority above which it needs approval.

Within the contracting function at the department and agency level there is normally a policy and review office. This office may operate either as a full-fledged reviewing office, or it may only review submissions for procedural completeness. In some organizations, this office devotes almost all of its time to policy, with at best a cursory review of large acquisitions for procedural completeness. In other organizations, policy and review offices devote a much higher percentage of their time to reviewing acquisitions. In these cases, the threshold for review is lower and acquisitions forwarded to them may be subjected to fairly sophisticated financial review.

A few agencies and bureaus employ centralized cost estimating and cost and price analysis offices. The central estimating unit is unique in that, rather than furnishing estimates and analyzing costs for only one phase of the acquisition process, it serves all acquisition phases. Depending on the size of the acquisition, either one person or a team will be assigned to the project at its earliest planning stages. This person or team will then follow the acquisition through the entire process, providing appropriate recurring estimates or analyses. The estimator/analyst retains familiarity with the project and updates and refines outputs as more information becomes available.

In summary, we have found that costing is performed by a number of individuals located in separate offices concerned with discrete parts of the acquisition process. In a few cases, a centralized costing office exists. Unless extraordinarily good intra-agency communication is maintained among the various offices, there is redundancy in costing effort and an intra-agency communication problem.

B. COMMUNICATION

This section is focused on communication among similar types of offices in different agencies. The questions we asked were: What systems now exist for exchange of information? Is the exchange of information of benefit in cost estimating and cost and price analysis? What is the best way to facilitate an effective exchange of information?

When asked if an effective formal communication system exists to exchange information, the answer was universally negative. Most interviewees were reasonably sure that such a system was not in existence, and the ones who were not sure were quite specific as to its lack of effectiveness. On the other hand, most of the analysts confided that they had an informal system of information exchange between and among their counterparts in similar offices.

The benefit to be derived from a formalized exchange of information is a function of the universality or transferability of that information. The expressed belief was that the only level where this exchange would be practicable would be within small functional groups that have a close identity of interests. An example of this level would be office building construction rather than general construction estimation.

Of the effective methods suggested for exchanging information and techniques, there was a marked preference among those interviewed for meetings or seminars of adequate duration to allow meaningful discussion and analysis of the subject matter.

Our finding is that no effective formal inter-agency system of information exchange exists, although informal communication links exist at all levels. Based on our interviews, we conclude that:

1. Information is transferable and valuable if exchanged at a level where the exchanging agencies have strong identity of subject matter.

2. The Government should facilitate exchange of information at a level where there is identity of interest.

3. This exchange would be most effective if conducted on a person-to-person basis through meetings and seminars.

C. TRACEABILITY

Managers and practitioners throughout the acquisition process expressed concern about the lack of traceability of estimates. Estimates undergo numerous modifications at various stages of the acquisition process. Consequently, errors in estimating are difficult to isolate. A related problem is that actual contract expenditures are rarely tracked against the original estimates. Intra-agency communication is so sparse that normal procedures do not produce a feedback of information through all process steps. This is especially true of the step from budgeting to contracting. The General Accounting Office's report on the Financial Status of Major Federal Acquisitions did succeed in gathering data on this subject. However, this was accomplished only by the extraordinary effort of an outside agency rather than by a normal internal process.

We therefore, perceive a need for improved feedback of acquisition information in order to improve subsequent estimating and to improve understanding of the technical requirements during contracting.

D. COST ESTIMATING METHODS

Cost estimating is the development of an expected cost without benefit or knowledge of a definite bid or proposal. The planning and budgeting offices must rely on cost estimating because contractor's proposals are rarely available at these phases. Contracting and contract administration offices may also use cost estimating methods to generate a Government estimate without the aid of a contractor's proposal. This independent estimate is

then compared to those submitted by contractors. This provides some objectivity that might otherwise be lacking if the only figures available were those of the contractors.

Cost estimating methods and techniques employed by government agencies and industry are almost identical; it is the correct application of a technique to a particular set of data that enables the estimator to achieve acceptable results. The techniques are widely known, and no one technique was found to be inherently superior.

Computer models apply these techniques and are a time saving aid to the estimator. The models in use in both Government and industry have been tailored for specific purposes and would rarely be useful for other acquisitions in their present form. These models may be transferable and valuable to other estimators if they possess the skills necessary to modify the model to fit their particular purpose. While one agency may be achieving good results utilizing a given model or technique, this does not mean that other agencies would achieve the same results.

E. COST ANALYSIS METHODS

Cost analysis is the element-by-element examination of the estimated or actual cost of contract performance[6] to determine the probable cost to the vendor of supplying goods and services. It is practiced in the contracting and contract administration stages because these are the only stages where a contractor's proposal is available. The techniques employed by cost analysts are common knowledge to most people in this field. They include statistical techniques, auditing, trend analysis, indexing and learning curves.

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[6] ASPM No. 1, Ibid., pp. 3B1

For both cost estimating and cost and price analysis, the key to the effective application of these tools is familiarity with the goods and services being acquired. If a contractor submits pricing data for the labor cost proposal of producing a certain item, the two factors involved will be labor hours required and cost per hour. The analyst can easily determine if the labor rate is within acceptable limits, but will be unable to evaluate production hours unless he is familiar with the production process involved. Accordingly, management stated that familiarity with the production processes for the item to be acquired was the most valuable background for a cost analyst. A skilled analyst may still operate effectively, however, if he has sufficient data at his disposal.

Very few cost analysts, with or without production expertise, are currently employed by the agencies surveyed. Lack of qualified personnel was a commonly heard complaint from management.

F. DATA AVAILABILITY

Adequate data is the key to both cost estimating and cost and price analysis. Due to the large amount of data that could be advantageous to the estimator/analyst, automatic data retrieval systems offer the advantages of both saving space and enabling the data to be indexed in different ways. One of the more common complaints we received concerned the inadequacy of data information systems. In Figure 2 below, many of the non-computerized historical data sources identified were simply files in desk drawers. Some of these systems were well kept and others were in such an apparent state of disarray as probably to be useless. Nonetheless, all such systems "qualified" for inclusion as a "data source" for this report.

Figure 2 Data Retrieval System Information

	Planning & Budgeting	Policy & Review	Contracting
Offices supplying data	8	12	7
Offices having a data system	8	5	5
Offices having a computerized data system	7	2	2

G. TRAINING

Except for contractor proposal cost analysis, training in acquisition costing is lacking. The preponderance of such training is obtained from the Department of Defense. However, it was alleged by contracting personnel in civilian agencies that this training is not relevant to the missions and operating procedures of their agencies.

Specifically, our interviews yielded the following data.

Figure 3 Costing Training Data

	Functional Area		
	Planning and Budgeting	Policy and Review	Contracting and Contract Admin.
Offices providing data	5	10	9
No training given	5	5	2
Internal training given	-	3	2
Outside training used	-	3	3
DoD courses	-	4	6
Other Federal	-	0	1
Private sector	-	0	1

In planning and budgeting, training is generally obtained by individual initiative through journals, professional associations or local college courses. In contracting, however, training is more extensive; only two offices indicated that no training was provided.

H. ESTIMATING ERROR

There is a general perception that Federal projects suffer consistent cost overruns. Because of this perception, there is pressure to make "better estimates". The GAO recently conducted a study of major Federal acquisitions in which it attempted to determine the sources of the overruns.[7] Seven sources of cost change were defined--quantity changes, engineering changes, support changes, schedule changes, economic changes (inflation), inadequate estimating (error), and "sundry". The report considered 808 Federal projects with a baseline value (budget allocation) of over $250 billion. Figure 4 summarizes the information on cost changes due to estimating error for 200 selected projects with a baseline value of over $177 billion.

The average change attributed to estimating error was 7.1% of the baseline estimate--a value well within the bounds of acceptable estimating error.[8] LMI's examination of the GAO data indicates that this figure would be even lower if it were not for the fact that several projects had such large overruns that their inclusion biases the results. It became apparent that there

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[7]Comptroller General of the United States, PSAD-78-60, Financial Status of Major Federal Acquisitions, September 30, 1977, January 20, 1978, published annually since February 27, 1976.

[8]Professional guidelines for acceptable estimating error are provided in Section Aa-4.000 of the Cost Engineer's Notebook published by the American Association of Cost Engineers, Morgantown, West Virginia.

FIGURE 4 COST CHANGE DUE TO ESTIMATING ERROR

(Dollars in millions)

For selected large acquisitions

Agency	No. of Projects	Original/ Baseline Estimate	Change Due to Estimating Error	%
Appalachian Regional Commission	1	$ 1,150.0	0	0
Department of Energy	8	978.3	$ 381.1	39.0
U.S. Army Corps of Engineers	90	6,305.0	597.3	9.5
Bureau of Reclamation	15	2,360.8	497.2	21.1
National Park Service	3	170.8	57.7	33.8
Federal Highway Administration	1	37,570.0	1,235.0	3.3
U.S. Coast Guard	1	83.3	147.8	177.4
Urban Mass Transp. Admin.	3	366.3	13.0	3.5
Environmental Prot. Agency	8	191.3	29.0	15.2
Tennessee Valley Authority	9	3,724.5	638.1	17.1
Veterans Administration	7	242.5	17.1	7.1
Washington Metro	1	2,494.6	428.4	17.2
Department of the Air Force	13	38,811.5	1,765.8	4.5
Department of the Army	15	22,628.6	1,778.4	7.9
Department of the Navy	25	60,532.6	5,022.8	8.3
	200	$177,610.1	$12,608.7	7.1

SOURCE: Comptroller General of the United States, PSAD-78-60, Financial Status of Major Federal Acquisitions, September 30, 1977. January 20, 1978

are special situations that deserved to be viewed independently. These include the following:

1. One project in the Bureau of Reclamation accounted for most of the agency's estimating error. The remaining 14 projects showed an average estimating error of 5.1%
2. All of the estimating error in the National Park Service occurred on one project. The same is true of the Urban Mass Transportation Administration.
3. Almost one-half of the estimating error in the EPA listing occurred on one project. The remaining seven projects averaged an estimating error of 8.5%.
4. In the Air Force, removing the effect of the B-1 bomber (+14.3% error) and the Minuteman III (-23.1% error), the remaining 11 projects averaged 5.4% estimating error.
5. In the Army, removing the effect of the SAM-D and Roland missiles results in the remaining 13 projects averaging 2.4% estimating error.
6. In the Navy, removing the effect of the FFG-7 ships results in the remaining 24 projects averaging a 5.5% estimating error.
7. New technology or complicated items generally show a higher estimating error (e.g., Department of Energy development programs, dams, new technology surface transportation systems, etc.). This does not hold true, however, in the Department of Defense or NASA.[9]

[9]Causal relationships were not published for any NASA projects. However, the total change in 16 NASA projects equalled 22.8%. Dropping the changes in the space shuttle, the remaining 15 projects had a total change of 3.5%. Allowing any amount for changes due to inflation, engineering changes, etc., indicates an extraordinarily small amount of change due to "estimating error".

The GAO Report does not include all acquisitions and all agencies. The GAO noted that the information had not been "verified". The civil agency acquisitions included only those having a greater than 100% cost overrun.

Conversely, the data cover a large acquisition value ($177 billion) and number of acquisitions (200). The data also cover the "worst case" situations with substantial overruns.

From this limited information, we cannot conclude that major changes in acquisition costing in the Federal Government are needed. There are indications of a need for refining the process. This data review shows a potential need for specific training of some individuals and offices. There is also an indication that the practices of the Department of Defense and NASA should be considered by other departments and agencies engaged in new technology or complex acquisitions.

As an indication of the refinement needed, some additional study of specific estimating situations, as noted above, may be appropriate.

5. RESULTS AND RECOMMENDATIONS

As noted in Chapter 1, the work performed under this subtask involved two parallel efforts:

1. identify cost estimating models and techniques to be included in a proposed directory of models for use by all Federal agencies, and
2. survey and analyze cost estimating and analysis techniques used by both Government and industry; identify the most effective techniques and recommend methods for disseminating information about such techniques among appropriate professional disciplines.

LMI's efforts under (1) above involved the compilation of computer models for inclusion in the proposed directory. This was in direct support of AFRO. Our work under (2) above was to parallel but be severable from and independent of the work described in (1).

By letters of 1 May, 22 May, 7 June and 30 June 1978, LMI delivered to APRO information, abstracts and annotations pertaining to 118 computer models we had identified during a review of several thousand potential models. The 118 models are listed in Appendix A.

Regarding the existence and availability of cost estimating computer models, it is of interest to note that there exists within the Federal Government an office with the responsiblity to identify and inventory software models of use to Government activities. The Federal Software Exchange Center, located in the General Services Administration, is a repository for, among other things, cost estimating models. Since it is a relatively new activity its cost estimating information files are not yet extensive. However, as the Center matures, it should be a valuable source of data.

Inasmuch as the existence of the Federal Software Exchange Center does not seem to be well known, it is suggested that the OFPP advise all Federal agencies of its potential value as a source of cost estimating information and of the importance of providing the Center with information about new computer models as they are developed or identified.

The major portion of this report covers our study of the current status of cost estimating and cost and price analysis within Government agencies, the second effort described above.

In view of our principal conclusion that the quality of cost estimating and analysis within the Federal Government is generally acceptable, particularly in light of the data reported by the General Accounting Office, LMI does not believe that drastic remedial changes are either necessary or desirable. This does not mean that we think no improvements can be made. Indeed, there are several actions which can be taken to upgrade capabilities where marginal performance has been observed. These actions however are in the nature of refinements and should not be construed as corrections of major deficiencies.

LMI was requested to recommend methods for transferring information about costing techniques among various professional disciplines. We construed this to mean professional disciplines involved in the acquisition process. Professional disciplines can be interpreted as either professions such as engineers, planners, programmers, budget analysts, contract negotiators or as functions such as budgeting, planning, contracting and contract administration.

We have interpreted "professional discipline", for purposes of this report, to mean "function" since the separation of costing by functional

boundaries is the primary impediment to the transfer of costing information. This separation has had the effect of making costing a functional sub-set, performed by estimators identified with discrete functions who are remote from their counterparts attached to other functions. This condition produces discontinuity and wasteful repetition where continuity and constructive iteration flowing directly from earlier analyses are desired.

If cost estimating and cost and price analysis, taken together, are recognized as a continuum which serves each part of the acquisition process, its role as an on-going function, integral to the whole process becomes clear. Accordingly, it is recommended that:

> OFPP make cost estimating and cost and price analysis a unified function within each Government agency and, organizationally, each agency be allowed to situate the function as may be most appropriate to achieve unification.

Acceptance of this recommendation should serve several ends. Unification of the costing function should mitigate problems, identified earlier, relating to transfer of techniques, traceability, data availability and training.

Regardless of the organizational alignment which might be adopted by agencies, unification should produce improved communication opportunities, both intra and inter agency; exchange and use of appropriate techniques; continuity in data use and feedback and traceability of information pertaining to program and contract changes with their concomitant cost changes. These are all desirable objectives.

As to training and career development for those engaged in costing, it became evident during our study that improved training programs are perceived

as necessary by acquisition and costing managers. LMI concurs in those perceptions. Accordingly it is recommended that:

The Federal Acquisition Institute review possibilities for improving training programs in cost estimating and cost and price analysis. Among such possibilities, the following have been suggested by acquisition managers:

a. A short (one week) course in price analysis.

b. "Civilianized" versions of Department of Defense contracting courses.

c. A guide on the principles of commodity purchasing.

d. Courses on implementation of each of the Cost Accounting Standards Board standards.

e. A "civilianized" version of Armed Services Procurement Manual #1.

f. A program to provide Government personnel an opportunity to spend several weeks with suppliers of the commodities or services for which they have costing responsibilities.

APPENDIX A

COST/PRICE ESTIMATING/ANALYSIS MODELS AND MATERIALS

This appendix lists the names of the models that have been forwarded to APRO in support of their effort to compile a directory of models. Abstracts, evaluations and other descriptive materials were furnished to APRO, but only the titles of these models are listed. Part I of this Appendix includes models available from the Government, and Part II lists commercially available models.

PART I

Accuracy of Air Force Weapons System Cost Estimates as a Function of Time, The

Acquisition Management - Cost Performance Reporting and Baseline Management (Department of Defense)

Acquisition Management - Cost/Schedule Status Report (C/SSR) (Department of Defense)

ADRA II - Army Dollar Resource Allocation (Army Concepts Analysis Agency)

AGMC Life Cycle Cost Model, An Accounting Model for Inertial Navigation Systems

Aircraft Airframe Cost Estimation Utilizing a Components of Variance Model

Air Force Cost Estimating Process: The Agencies Involved and Estimating Techniques Used, The

Ammunition Cost Research Study

Analysis of Available Life Cycle Cost Models and Actions Required to Increase Future Model Applications

Analyst's Manual for the Multiple-Bid Evaluation Model for Procurement Planning and Placement

Army Force Planning Cost Handbook

Army Life Cycle Cost Model; Programmer's Guide

Army Life Cycle Cost Model; User's Guide

A-7 Aloft Cost Model: A Study of High Technology Cost Estimating, The (Naval Postgraduate School)

Automated Cost Control and Estimating System (General Services Administration)

Computer Model to Assess Financing Provisions of Naval FPIF Shipbuilding Contracts, A (Naval Postgraduate School)

Conceptual Cost Model for Uncertainty Parameters Affecting Negotiated, Sole-Source Development Contracts

Construction Cost Trends (Department of Interior)

COSTAN (Social Security Administration)

Cost Estimating Methodology and Techniques for Preparing Industrial-Engineering Type Manhour and Material - Based Cost Estimates (NASA)

Cost Estimating Relationships: A Manual for the Army Material Command (Army Material Command)

Cost Estimating Relationships for Naval Surface Ship Electronic Warfare Equipment (Naval Postgraduate School)

Cost of Ownership Handbook

Cost Performance Forecasting Concept and Model, A

Cost Performance Forecasting - A Cost Performance Forecasting Concept and Model

Cost/Schedule Control Systems Criteria, The (Department of Defense)

Design for An Urban Services Resource/Cost Model (National Science Foundation)

Development of a Dynamic Model of Analysis and Planning of Life Cycle Costs for Navy Missile Programs

DRAMA - Diagnostic Reliability and Modularity Analysis (Manpower, Reserve Affairs and Logistics, Department of Defense)

Economic Analysis Handbook (Naval Facilities Engineering Command)

Extension of LMI Developed Model to Generate Air Force Budgets and Fund Allocation Procedures Which Take Into Account Weapon System Essentiality

Five-Year Lease vs. Cost Analysis - A User's Guide

General Technique for R&D Cost Forecasting, A

Generalized Approach for Evaluating Logistics Strategies During Advance Procurement Planning, A (Naval Postgraduate School)

Guidelines for Cost Estimating by Analogy

JCAP Make or Buy Model

Life Cycle Cost Analysis in Building Design (Naval Postgraduate School)

Life Cycle Cost Guide for Equipment Analysis (Naval Material Command)

Life Cycle Cost Guide for Major Weapons Systems (Naval Material Command)

Life Cycle Costing in the Public Building Service - Vol. I & II (General Services Administration)

Martin Cost Model - Model to Predict Final Cost Growth in A Weapon System Development Program

Methodology for Analysis of Alternatives in the Acquisition and Support of Automatic Test Equipment Software

Methodology for Estimating Jet Engine Costs Early in Weapon System Acquisition, A

Military Construction Engineering and Design Cost Forecasts

Multiple Bid Evaluation Model

Optimal Allocation of Budget Dollars Among Materiel Procurement Programs: A Mathematical Programming Model for Optimum Planning Over Time (Deputy Chief of Staff for Operation and Plans - Army)

Overhead at Newport News Shipbuilding and Drydock Company (Naval Postgraduate School)

PACE - Program for Automated Cost Estimating

PACE II - Pricing and Cost Estimating Handbook (NASA)

Parametric Cost Estimating (Defense Systems Management College)

Parametric Cost Estimating With Application to Sonar Technology (Navy Postgraduate School)

PIECOST - Probability of Incurring Estimated Cost

Pricing and the Allocation of Data Processing Resources

Procurement Module for a Management Information System: A User's Manual (Department of Energy)

Product Improved Method for Developing a Program Management Office Estimated Cost at Completion, A (Defense System Management School)

RAM - Resource Allocation Model (Naval Missile Center)

Review of Software Cost Estimation Methods, A (Department of the Air Force)

Series 150 Reclamation Estimating Instructions and Appendix (Department of Interior)

Single Channel Ground and Airborne Radio Systems Evaluation Model (Advanced Research Project Agency - Department of Defense)

Small Purchase (Under $2500) Processing Model for Naval Supply Center (Naval Postgraduate School)

SOS - Simplified Optional Sparing

TRACE - Total Risk Assessing Cost Estimate - U.S. Army Total Risk Assessing Cost Estimating Guidelines

Useful Life Cycle Cost Estimates for Defense Systems - An Evaluation (Defense Systems Management School)

Weapon System Cost Model Objectives (Department of the Army)

PART II

American Valuation Consultants, Inc., Des Plaines, Illinois
Programmed Appropriation Commitments - Fixed Asset Control System

Atlantic Software, Inc., Philadelphia, Pennsylvania
Systems Development Methodology - SMD-70
Project/Resource Management - PC-70

COSMIC, University of Georgia, Athens, Georgia
Budgetary Planning System for Assurance Management
CPM - Critical Path Method
LRC/NASA PERT TIME III
NASA Energy - Cost Analysis Program
NASA PERT TIME II
NIPS - NASA Interactive Planning System
SESOP - Program for Solar Energy Heating System Analysis
Weekly Manpower Analysis

Decision Sciences Corporation, Jenkintown, Pennsylvania
SCOPE - System for Community Planning and Evaluation
FIAS - Fiscal Impact Analysis System
NUCOMS - New Communities Simulation System
MAPS - Management Analysis Planning System

Dow Chemical U.S.A., Engineering and Construction Services,
Houston, Texas
One hundred and twenty-three (123) abstracts of engineering construction models.

International Systems, Inc., King of Prussia, Pennsylvania
PAC II System
PAC II Report Writer

McDonnell Douglas Automation Company, St. Louis, Missouri
MSCS - Management Scheduling and Control System
COPES - Cost Planning and Evaluation System
MAPS - MCAUTO Activity Planning System

MDC Systems Corp., Cherry Hill, New Jersey
Capital Project Management System

Professional Services Social Systems, Inc., Chapel Hill,
North Carolina
Simplan

Project Software & Development, Inc., New York, N.Y.
PROJECT/2

RCA, Cherry Hill, New Jersey
PRICE - Programmed Review of Information for Costing and Evaluation

PRICE L - Programmed Review of Information for Costing and Evaluation Life Cycle Cost Model

PRICE S - Programmed Review of Information for Costing and Evaluation Software Model

Scientific Time Sharing Corporation, White Plains, New York

Comprehensive Management Control System

APPENDIX B

INTERVIEWS AND CONTACTS

GOVERNMENT

Agriculture, Department of
Food Safety and Quality Service
Office of Commodity Services

Congressional Budget Office
Budget Analysis Division

Defense, Department of
Office of the Assistant Secretary (Comptroller)
Directorate of Acquisition Management Systems

Office of the Undersecretary for Research and Engineering
Directorate of Contracts and System Acquisition
Office of Cost, Pricing and Finance

Office of the Assitant Secretary (Program Analysis and Evaluation)
Directorate for Cost and Economic Analysis

Washington Headquarters Services
Directorate for Information Operations and Reports

Energy, Department of
Contracts Management Division
Cost Review and Policy Branch

General Services Administration
Federal Supply Service
Office of Procurement
Policy and Procedures Division

Public Building Service
Office of Construction Management
Estimating Branch

Automated Data and Telecommunications Service
Office of Automated Data Management Services
ADP Procurement Division

Office of Agency Assistance Planning and Policy
Federal Software Exchange Center

Health, Education and Welfare, Department of
Office of Grant and Procurement Management
Cost Policy Branch
Contract Policy Branch

Social Security Administration
Division of Procurement

Housing and Urban Development, Department of
Office of Procurement and Contracts
Policy Evaluation and Administration Division

Interior, Department of
Office of Administration and Management Policy
Division of Procurement and Grants

U.S. Geological Survey
Contracts Division
Policy and Procedures Branch

Bureau of Land Management
Procurement Branch

Bureau of Mines
Procurement Branch

Bureau of Reclamation
Procurement Office

Division of Construction
Estimates and Analyses Branch

Labor, Department of
Office of Grants, Procurement and ADP
Management Policy
National Procurement Office

National Academy of Sciences
Building Research Advisory Board

National Aeronautics and Space Administration
Deputy Comptroller and Office of Resources Analysis
Directorate of Cost and Economic Analysis

Assistant Administrator for Procurement
Pricing Division

Jet Propulsion Laboratory
Flight Projects Directorate
Resource Planning Office

John F. Kennedy Space Center
Directorate of Procurement, Supply and
Transportation
Procurement Office

NASA (cont'd.)

George C. Marshall Space Flight Center
Directorate of Program Development
Engineering Cost Group

Directorate for Administration
Procurement Support Division
Cost Analysis Branch

Goddard Space Flight Center
Programs Directorate
Resource Analysis group

National Science Foundation
Policy and Cost Analysis Branch

Navy, Department of the
Naval Material Command
OADCNM for Contracts and Business Management

Naval Air Systems Command
Cost Estimating Branch

Naval Electronic Systems Command
Cost Estimating Branch

Naval Facilities Engineering Command
Cost Estimating Branch

Naval Sea Systems Command
Cost Estimating Branch

State, Department of
Agency for International Development
Office of Contract Management

Tennessee Valley Authority
National Fertilizer Development Center
Division of Chemical Development
Design Branch

Office of Engineering Design and Construction
Cost Planning and Control Branch

Transportation, Department of
Procurement Management Division

Grants Management Division

Federal Aviation Administration
Policy and Operations Pricing

Urban Mass Transportation Administration
Office of Procurement

Treasury, Department of the
Procurement and Personal Property Management

Internal Revenue Service
National Procurement Office

Veterans Administration
Office of Construction
Estimating Service

NON-GOVERNMENT

Aerospace Industries Association, Washington, D.C.
American Association of Cost Engineers, Morgantown, W.Va.
Bechtel Corporation, San Francisco, California
Fluor Corporation, Irvine, California
Mitre Corporation, Bedford, Massachusetts
RCA, PRICE Systems Division, Cherry Hill, New Jersey

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The quality of acquisition costing in the Federal Government is generally good. Some problems exist but they can be solved by specific actions covering a small number of people or by expanding current programs, structures or techniques. The primary recommendation is that cost estimating, cost analysis and price analysis become a unified function and that each Department and Agency determine the most effective organizational location and career pattern for unified costing offices.

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