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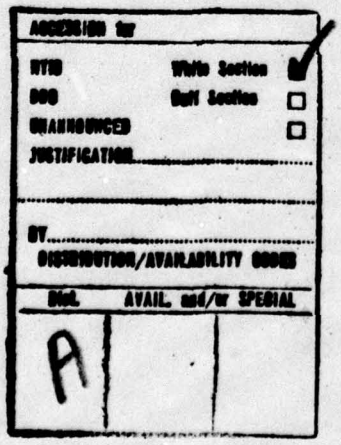
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Barry R. Lenk

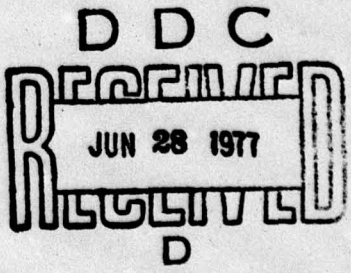
Serial T-354
12 May 1977

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Program in Logistics

Contract N00014-75-C-0729
Project NR 347 020
Office of Naval Research



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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (14) Serial - T-354 ✓	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) (6) GOVERNMENT PROCUREMENT POLICY: A SURVEY OF STRATEGIES AND TECHNIQUES.	5. TYPE OF REPORT & PERIOD COVERED (9) SCIENTIFIC reptec.
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) (10) BARRY R. LENK	8. CONTRACT OR GRANT NUMBER(s) (15) N00014-75-C-0729 ✓
9. PERFORMING ORGANIZATION NAME AND ADDRESS THE GEORGE WASHINGTON UNIVERSITY PROGRAM IN LOGISTICS ✓ WASHINGTON, D. C. 20037	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS OFFICE OF NAVAL RESEARCH CODE 430D ARLINGTON, VA 22217	12. REPORT DATE (11) 12 May 77
	13. NUMBER OF PAGES 30 (12) 32p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) NONE
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

DISTRIBUTION OF THIS REPORT IS UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

405 337

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

PROCUREMENT POLICY
RISK ALLOCATION
WEAPONS ACQUISITION
COMPETITIVE PROCUREMENT
ASPR CONTRACT TYPES

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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S/N 0102-014-6601 |

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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School of Engineering and Applied Science
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Barry R. Lenk

This paper presents a discussion of United States military procurement policies from 1947 to the present. Alternative contract types are discussed, with emphasis upon the allocation of risk between the contractor and the government. Strategies for the acquisition of major weapon systems are examined, and the impact of these strategies upon competition in the procurement process is considered.

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1. Introduction

The memorandum examines the major trends in government procurement policy from the inception of the Armed Services Procurement Regulations in 1947 to the present time. Of particular interest are those trends which affect the allocation of risk between the contractor and the government or which affect the degree of competition between contractors. In this context, "risk" refers to the occurrence of a difficulty or event during the performance of a contract which was not foreseen at the time of contracting. There may be many consequences of risk for a contractor, such as loss of reputation, loss of business opportunity, or demoralization of employees. Similarly, the consequences of risk for the government are wide-ranging and can include elements such as the late provision of necessary goods or services, allowing the contractor to make excessive profits, or the discrediting of an agency. For the purpose of this paper, the principal consequence of risk which will be examined is financial, and risk allocation will refer to the extent that each of the contracting parties bear a portion of the cost consequences which result from unforeseen circumstances.

In theory, a greater degree of risk allocated to the contractor will result in a more cost-conscious, productive performance of the

contract. This view, while true under some circumstances, will be shown to greatly oversimplify the problems of major systems acquisition and unnecessarily restrict the solution of those problems.

Another result of procurement policy that will be emphasized in this memorandum is competition. There are many examples of competition at different stages of the procurement process, such as between branches of the military for budget allocations to acquire new systems, or between competing substitute systems within the same military branch. In this paper, the principal level of competition under consideration is that which takes place between contractors for research, development, production, and follow-on contracts.

Just as in risk allocation, competition, in theory, will bring about a more conscious climate as contractors increase productivity in order to successfully compete in advertised procurement. While this theory is partially valid, it does not take into consideration many problems of major systems acquisition, such as low bids placed by unqualified contractors or "buy-ins," whereby a company will place a low bid on an early contract in order to be in a more favorable position for a later one. These and other problems will be discussed later.

2. Armed Services Procurement Regulations

Military procurement is governed by the Armed Services Procurement Regulations (ASPR) first published in 1947. Originally designed as a policy document, it has since become a detailed guide to military procurement.

The ASPR is divided into the categories of fixed-price and cost reimbursement contracts, and it also lists several less frequently used types of contracts. The ASPR originally expressed a preference for fixed-price contracts, in which a price is determined before the contract is awarded on the basis of formal competitive bidding. Under a fixed-price contract, the contractor assumes the risk for most changes in cost, and his profits increase or decrease accordingly. This preference was

in part a reaction to criticism of the cost-plus-a-percentage-of-cost contract used during World War I, under which the government reimbursed all of the contractor's allowable costs and paid a percentage of these costs, which was negotiated at the outset, for profit. Under this contract, if actual costs exceeded the original estimate, profit was greater than if actual costs were equal to or less than the estimate. This disincentive for cost control encouraged widespread waste and profiteering, with the result that this contract type was outlawed by the First War Powers Act of 1941 and later by the Armed Services Procurement Act. [2].

The types of fixed price contracts under the ASPR include the Firm Fixed-Price Contract, the Fixed-Price Contract with Escalation, the Fixed-Price Contract with Redetermination of Price, the Fixed-Price Incentive Contract, and the Firm Fixed-Price Level of Effort Term Contract.

Firm Fixed-Price Contract

The firm fixed-price contract most nearly approximates the normal marketplace relationship between buyer and seller. Under this contract, the government and the contractor determine the price before a definitive contract is awarded, and this price remains firm for the life of the contract subject to changes in the specifications. Therefore, the contractor assumes full cost responsibility under this contract, and his profit is directly related to effective cost control and management of the program.

Because the relationship between cost and profit goes into effect upon negotiation of the fixed price, the firm fixed-price contract should be used when stable and reasonably definite specifications are available at the time of contracting and when appropriate pricing can be achieved. Examples of appropriate situations for the use of this contract include where adequate competition has made initial quotations fair and reasonable, where prior purchases of similar items provide a reasonable price comparison, or where experienced cost information or sound estimates of probable costs are available. This type of contract is particularly

suitable for use in the purchase of standard commercial items, modified commercial items, or military items for which adequate information on production and cost is available.

Fixed-Price Contract with Escalation

Under a fixed-price contract with escalation, the initially determined contract price is subject to upward or downward revision upon the occurrence of certain contingencies.

The ASPR [2] places these contingencies into two categories: (1) price escalation, in which adjustment of the contract price corresponds with changes in the prices of specific items or contract end items from an agreed level, and (2) labor and material escalation, in which the contract price adjustment corresponds with changes in wage rates or specific material costs from agreed standards or indices.

The fixed-price contract with escalation is designed to reduce the business risk of the contractor by providing for an upward adjustment of the contract price, within an established ceiling, when prices or rates rise. The government can also limit its risk, in the form of increased contractor profit due solely to falling prices or rates, by a downward adjustment of the contract price. Under this type of contract, the government also requires the contractor to eliminate any contingency allowances in the base price which are covered by the escalation clause.

The fixed-price contract with escalation is designed for situations where serious doubt exists over market stability and labor conditions during an extended period of production, and where the contingency allowance for this instability can be identified and covered separately by an escalation clause. Price escalation should be used when the price of items can be accurately established, as with standard items, items normally sold at established or published prices in a competitive market, or modifications of items which can be related to the price of standard articles. Labor and material escalation should be used where these inputs will be employed over an extended period of time, where the

contractor is not prepared to accept the full risk of possible cost increases, and where government is unwilling to allow the absorption of these increases into the initial contract price as contingency allowances.

This type of contract is not designed to offer protection from the consequences of inaccurate estimates of the quantities of labor, material, or capital required for performance. This contract type may also entail major administrative difficulties, as in making certain that contingency allowances are actually eliminated before being replaced by escalation clauses, and in finding an adequate measure of market prices by which to assess the escalation of cost changes.

Fixed-Price with the Redetermination of Price

This type of contract provides for the upward or downward adjustment of the contract base price at an agreed target date in order to shift certain risks from the contractor to the government which would otherwise be included in contingency allowances of the base price. Price-redetermination contracts are appropriate where important pricing information is not initially available, such as adequate estimates of the required quantities of materials and labor, specifications adequate for a firm fixed-price, or sound initial estimates of the total cost of performance.

Prospective fixed-price redeterminable contracts provide for the negotiation of fixed prices at stated target dates for the ensuing period. These target dates, determined by percentage of contract completion or specific calendar dates, should be established as early as accurate cost data for pricing the remaining portions of the contract can be obtained; typically, a target date will be scheduled after 30% to 40% of expected costs have been incurred [51]. The redetermined price may apply only to the remainder of the contract, or it may be both prospective and retroactive. This approach has been extensively utilized in aircraft engine procurement, where the methods of manufacture and accounting for costs have lent themselves to periodic, plant-wide

pricing on a prospective basis.

Under retroactive fixed-price redeterminable contracts, price is adjusted after the contractor has completed his work. A subjective evaluation of his performance is made, supposedly taking efficiency and economy into account when considering cost and profit. Except for the price ceiling, however, the contractor lacks a calculable positive incentive for cost control under a retroactive arrangement, because the linkage between higher costs and lower profits is unclear. For this reason, retroactive fixed-price redeterminable contracts are largely limited to small dollar, short term R & D contracts.

A related factor which undermines a cost conscious climate under redeterminable contracts is the possibility that the government may increase the amount of the contractor's profit in the event of overruns and decrease profits where there are underruns. A study of 201 Army and Navy redeterminable fixed-price contracts revealed that in nearly 84% of all cases in which the redetermined price was less than the base price, the contractor's profit amount was decreased, while in 21% of the cases where the redetermined price was greater than or equal to the base price, the amount of profit was increased. [51].

There are five major varieties of prospective and retroactive redeterminable fixed-price contracts recognized by the ASPR:

1. Prospective periodic price redetermination at stated intervals, in which available data permit only the negotiation of a firm fixed price for an initial period, and prices are prospectively adjusted at subsequent intervals commonly ranging from six to twelve months.

2. Prospective price redeterminations on request, which provides a fixed price for the entire contract subject to limited demands by either party for prospective price redetermination due to unforeseen contingencies. This approach is designed for contracts with unusually long periods of contract performance where unforeseen risks of cost changes are greater than average.

3. Retroactive and prospective price redetermination at a stated time prior to completion, under which the designated time for price redetermination, which may be expressed in terms of deliveries, shop completion, or a percentage of total contract performance on a cost-incurred basis, is usually the earliest feasible opportunity and generally within 20% of deliveries, 20% of shop completion, or 40% of cost of performance on a cost-incurred basis, in comparison with initial estimates. This clause is used where the initial negotiated price is a reasonable estimate sufficient to establish a billing price and where there is sufficient time of contract performance to accomplish the price redetermination prior to completion of 60% of the contract on a cost-incurred basis.

4. Retroactive and prospective price redetermination including further prospective redetermination on request, which is identical to (3) except that additional prospective redetermination may take place, at minimum intervals of six months after the initial price redetermination, upon written demand by either party. The effect of this clause is to provide added flexibility to meeting unforeseen circumstances.

5. Retroactive price redetermination after completion, described earlier, provides for a ceiling price and retroactive price determination after performance is completed. It is generally used where the amount involved is relatively small or the time for performance relatively short, and only after negotiation of a reasonable initial target price.

Redeterminable contracts may be "flexible price" in which price can be adjusted upward or downward, or "maximum price" in which only a downward adjustment is possible. The former protects both the government and the contractor against unforeseen price changes, while the latter enables the government to examine the contractor's cost data and to make appropriate adjustments where necessary. The maximum price

contract is used where the price is otherwise suspiciously high, or where the contractor has included excessive contingencies in his quoted price (particularly when those contingencies are difficult to locate, as where they are buried in his overhead costs).

Fixed-Price Incentive Contracts

(This type of contract is described below under the discussion of incentive contracts.)

Firm Fixed-Price Level of Effort Term Contract

This type of contract describes the scope of performance in general terms, and obligates the contractor to devote a specified level of effort over a stated period of time for a fixed dollar amount. Payment is based on effort expended rather than on results achieved, making this contract particularly useful in R and D or other exploratory purposes when the work to be performed cannot be clearly defined and the level of effort desired can be identified and agreed upon in advance of performance.

3. Military Procurement During the 1950's

With the end of the Korean conflict, the procurement needs of the armed services shifted from conventional ordnance equipment to increasingly complex, sophisticated systems such as guided missiles, electronic equipment, and aircraft, requiring extensive research and development and characterized by significant cost uncertainties. For these reasons, cost reimbursement contracts were the most frequently used method of procurement during this period. The variations of cost reimbursement contracts include the Basic Cost Reimbursement Contract, the Cost-Sharing Contract, the Cost-Plus-Fixed-Fee Contract, the Cost-Plus-Incentive Fee Contract, and the Cost-Plus-Award-Fee Contract.

The Basic Cost Reimbursement Contract

This type of contract provides for government reimbursement to the contractor for all allowable costs under ASPR Section XV, and for costs allocated under specific provisions of the contract; no fee or profit is included, and a standard of "best efforts" governs contractor performance. These contracts are generally used with nonprofit educational institutions, other nonprofit organizations engaged in research and development efforts, or in contracts providing free facilities to contractors.

The Cost-Sharing Contract

Under this contract, usually involving jointly sponsored R & D procurement between the government and the contractor, the government reimburses an agreed portion of the allowable and allocable costs of contract performance to the contractor, who receives no fee but who presumably expects to benefit sufficiently from the contract to merit a sharing of the cost.

The Cost-Plus-Fixed-Fee Contract

This type of contract provides that the government reimburse the contractor for all allowable costs incurred within a cost ceiling and that the government pay to the contractor an additional fixed fee. The fixed fee cannot be varied in relation to actual cost incurred, although it may be adjusted to reflect modifications in the work or service required by the contract. Because an increase in cost does not affect the contractor's profit (i.e., the difference between total price and costs, or the fixed fee), there is less financial risk to the contractor and less incentive for cost control than in any other type of contract. At the same time, this contract minimizes a different kind of risk for the government. If costs are lower than the original estimates, the contractor receives no "windfall" profit at the government's expense because the fee is fixed. While this motive may be incompatible with cost control,

it is nonetheless of major importance to the government.

This contract is designed for situations in which fixed-price or incentive contracts cannot be used because of major uncertainties in performance or vagueness of specifications. Typical of these situations are those where the scope and nature of an R & D project cannot be definitely specified, where definite specifications exist for a product but cost cannot be estimated before or during performance because materials or services are being provided for the first time, where specifications for construction or production contracts are incomplete or major changes are anticipated, or where work is to be performed using government-owned facilities.

Cost-Plus-Incentive-Fee and Cost-Plus-Award-Fee Contracts

(These types of contracts are discussed below under incentive contracts.)

Other Types of Contracts

By the late 1950's, several types of contracts which were neither fixed-price nor cost-reimbursement had been utilized. These include the Time and Material Contract, the Letter Contract, and the Indefinite Delivery Type Contract.

Time and Material Contracts

This contract provides for the procurement of supplies or services on the basis of direct labor hours at specified fixed hourly rates and for the procurement of material at cost. Any material needed to perform the contract is acquired by the contractor (as distinguished from the labor-hour contract where the contractor does not supply the materials) and the contractor is reimbursed for costs of material acquisition.

The time and material contract is used where accurate initial estimates of the extent, duration, or cost of performance are impossible.

This contract is most frequently used to procure engineering and design services for the production of supplies; for the engineering, design, and manufacture of dies, jigs, fixtures, gauges, and special machine tools; for repair, maintenance, or overhaul work; and for work to be performed in emergency situations.

The time and material contract is used sparingly and with great care by the government because of the opportunity for the contractor to increase his overhead absorption and profits by the expenditure of additional hours of direct labor or by the use of lower graded labor than was anticipated and priced in the hourly rate.

Letter Contract

A letter contract is a written preliminary instrument authorizing commencement of performance, and it is superseded by a definitive contract at the earliest practical date. This method is used only when it is necessary that the contractor receive a binding commitment to commence work immediately and it is impossible to promptly negotiate a definitive contract because, for example, of difficulties in the preparation of requirements, specifications, and cost data.

After their use was discouraged in DOD Directive 5000.1, letter contracts have been rarely utilized [6].

Indefinite Delivery Type Contracts

The indefinite delivery type contract is divided into three categories of contracts, all of which are designed for use when the exact delivery date is unknown at the time of contracting. The definite quantity contract provides for a definite quantity of specified supplies or services for a fixed period; the requirements contract provides for the fulfilling of all actual purchase requirements of specific supplies or services during a limited contract period; and the indefinite quantity contract provides for the furnishing of an indefinite quantity of specific supplies or services during the contract period within the limits

of a stated minimum, maximum, or both.

Indefinite delivery type contracts generally apply to commercial goods or services where little research or development is necessary prior to production.

4. Procurement Strategies During the 1960's

As a result of severe criticism of cost overruns of major systems under cost reimbursement contracts, the 1960's saw an effort to reduce costs and stimulate competition in several ways. Increased emphasis was placed on management control, including improved information systems, cost accounting procedures, and purchasing methods. At the same time, procurement policy sought to shift greater risk to the contractor, while simultaneously providing a profit commensurate with the risk. Incentive and fixed-price contracts were employed whenever possible in order to facilitate competition and assumption of financial risk by contractors, and this approach finally culminated in the multi-year and total package procurement concepts.

Incentive Contracts

There are three major categories of incentive contracts: Fixed-Price Incentive, Cost-Plus-Incentive-Fee, and Cost-Plus-Award-Fee Contracts.

Fixed-Price Incentive Contracts. Fixed-price incentive contracts involve the initial negotiation of a target cost, target profit, and profit-sharing formula. This formula is based upon the relation which the actual total allowable cost bears to the total target cost, and it is applied to determine a final contract price.

This type of contract is used most frequently where there is initially a firm target, reasonably free of contingencies and providing a reasonable incentive for the contractor. Initial negotiations yield a firm target cost, target profit, final profit and price adjustment

formula. During final cost negotiations, a comparison of the target cost with the actual cost incurred by the contractor is useful to clarify the problems which the contractor encountered and to suggest the degree to which engineering, production, and management control costs were appropriate.

Application of the sharing formula to the target profit results in the final profit figure. The target profit represents those profit considerations found in most contracts, such as the degree of risk for the contractor, his contributions to the contract (e.g., facilities, manpower, and management), and the difficulty of the job. The final profit is increased in the event of a cost underrun and decreased by a cost overrun.

This contract is designed so that target cost, target profit, ceiling price, and the sharing formula can be manipulated to bring home to the contractor the results of effective cost control and sound management practices. Therefore, the greater the effort required to produce at a cost under the estimated cost, the greater the incentive that is required for the contractor. In this situation, for example, a tight target cost, relatively high target profit, a wide proportion of the financial responsibility for the contractor (at least on the underrun side), and a tight ceiling price would be appropriate.

Sometimes, the fixed-price incentive contract is used where the government's knowledge of probable cost of performance is not sufficient to establish reasonable targets until early in the performance of the contract, whereupon a firm fixed-price or fixed-price incentive contract with a firm target is negotiated.

Cost-Plus-Incentive-Fee Contracts. Cost-plus-incentive-fee contracts are designed for situations where the risk is unacceptably high for a fixed-price type of contract, but not high enough to justify a cost-plus-fixed-fee contract. Initial negotiations yield a target cost, a target fee, a minimum and maximum fee, and a fee adjustment formula which decreases or increases the fee in response to cost overruns or

underruns. The sharing formula and the maximum and minimum fees are intended to provide an incentive over a wide range of possible cost outcomes while also guaranteeing the contractor a minimum fee in the event of cost overruns and limiting him to a maximum fee in the event of cost underruns.

Cost-plus-incentive-fee contracts have been used in the procurement of advanced, engineering, or operational systems development and first production. Beginning with the B-58 supersonic strategic bomber program, incentive formulas have also been adapted to multidimensional outcomes including quality and time as well as cost. Multidimensional outcomes have also been used as the basis of incentive contracts for development programs, as in the Navy A-2F attack aircraft program where the profit variation was based upon various technical performance and cost control achievements.

Researchers thus far have been unable to establish a correlation between incentive formulas and efficiency [7]. However, there appear to be at least two major weaknesses in incentive contracts. First, by overstating the target cost and cost of supplemental changes, under incentive contracts, contractors may appear to control their costs, thereby increasing the profit or fee, while they have not actually done so at all. Second, incentive contracts operate on the premise that short-term profit maximization is the primary motivation for contractors, while this goal is, in fact, probably secondary to motives such as risk aversion and long-term market survival. These objectives may impel the contractor to accept a lower profit in order to achieve such goals as maintaining the employment of personnel or enhancing his image for technical expertise by developing more sophisticated systems than may actually be necessary [10]. To the extent that these motivations outweigh that of short-term profit maximization, incentive contracts will have a difficult time affecting the behavior of contractors.

Cost-Plus-Award-Fee Contract. Under the cost-plus-award-fee contract, the contractor is reimbursed for allowable and allocable costs,

he receives a fixed fee for his work (generally about 3% of costs), and he may earn an additional award fee (with the total fee usually ranging from 2% to 13% of costs) determined subjectively by government personnel on the basis of periodic, after-the-fact evaluations of the contractor's performance on the basis of criteria established in the contract. Typical major criteria are the performance of operations, technical management, and utilization of resources. Subfactors within these criteria often include quality, timeliness, and economy of performance. The cost-plus-award fee contract was designed for situations in which some incentive is desirable, but contract performance cannot be sufficiently measured to use an incentive contract. Originally used for level-of-effort contracts, this contract type has been expanded to include nonpersonnel and support services including the procurement of operation, maintenance, logistic, and engineering services. Extremely large award fees have also been built into the incentive structure of major hardware systems.

Multi-year and Total Package Procurement.

The concepts of multi-year procurement were also created in response to criticism of cost overruns during the 1950's. Multi-year procurement involved the award of full production programs for several years at one time, while total package procurement also included a contract award for R & D over that time period. The purpose of these strategies was to increase the initial level of competition for the contract by making it as extensive in scope as possible, and to prevent buy-ins, where a contractor may deliberately underbid on an initial contract in order to gain a more favorable position for follow-on procurement.

Multi-year procurement is designed for systems in which production requirements are firm and design specifications are clear. Advocates of these strategies claimed that they yielded impressive savings by prorating start-up costs (e.g., the expense of training, labor, or initial capital outlay for special equipment) over the entire contract period, by enabling the purchase of items and services for more than one year at a time, and by increasing efficiency through providing a stable labor force. As a result, proponents cited annual savings by DoD of $52 million from this

strategy during fiscal years 1968-1973 [49]. Advocates of this strategy also claimed that it enhanced competition for long term contracts involving a substantial capital outlay, in contrast to an annual funding arrangement under which the contractor for the first year will probably hold a decisive advantage in future competition.

Critics of multi-year procurement assert that rarely are systems requirements and design sufficiently clear to enable contracting to take place over so long a time period. Most of the services are currently exploring alternatives to multi-year procurement. For example, the Navy has decreased its use of multi-year ship contracts, having concluded that any savings are offset by the lack of continuing competition. In its place, the Navy has been drafting contracts to include production during the initial fiscal year with prepriced options for follow-on years, which could avoid costly breaks in production unless the savings which accrued from changing contractors more than offset the cost of the delay [59].

Total package procurement involves the award of a single fixed-price contract for the design, manufacture, testing, and post-production support of a major system. This procurement strategy was designed for systems which were not subject to rapidly changing technology or military requirements. A careful definition of contractual performance was to have been provided by the government, from which contractors competed for the entire program. To prevent buy-ins, contract clauses severely limiting changes in contract specifications were added to the contract.

Advocates of total package procurement claimed that it would maximize weapons systems expenditures covered by competition, extend competitive pressures to the development stage and force contractors to design with a greater concern for efficient production, and avoid administrative inconveniences and expenses involved in obtaining a new source of supply.

Several major weapon systems, including the C-5A, the Short Range Attack Missile (SRAM), the Cheyenne helicopter, and the F-14 were

contracted under this method. Serious problems were encountered in these programs, leading to the recognition of stringent limitations for the effective use of total package procurement. These limitations include the requirement that the government provide a sufficiently detailed program in order to limit change orders and supplemental agreements. However, during the contract definition stage major new systems will contain many subsystems which may require unanticipated advancement in the state of the art, even though the overall system is considered easily attainable within the state of the art. The subsystems, which defy accurate costing at the early state of development, have been one of the major sources of cost escalation experienced under total package procurement [56].

The absence of a firm technological base line results in a second problem in total package procurement: resorting to a contractual device rather than to effective management as the means to inhibit changes in the contract not only discourages unnecessary modifications but desirable technological innovations as well [19].

A third limitation of total package procurement is that the government's estimate of future service demands, technology, and military threats must be sufficiently accurate to enable an adequate evaluation of option prices by the government. Given the length of time necessary for the acquisition of a major system and the rapidly changing nature of military technology and requirements, this limitation is perhaps the most significant of the three.

In response to these problems, DoD Memorandum 5000.1 in 1970 prohibited the use of total package procurement for new complex systems, preferring cost-type contracts where substantial development is involved and fixed-price contracts where the level of contractor risk can be reduced.

5. Procurement Strategies Since 1970

As a result of substantial disillusionment from the recognition

that major technical and cost uncertainty accompanies complex and usually insufficiently defined systems, the 1970's have seen a reversion back to more government risk assumption through cost reimbursement contracts for development until prototypes and other proofs show the feasibility of production. Emphasis on competition has thereby been removed from documentation and prediction, and shifted to hardware development, testing, and actual production. This shift in emphasis has been achieved through the following strategies.

Prototyping

Prototyping involves the construction by one or more contractors of a full-scale working system or integral subsystem, not necessarily complete but in a state sufficient to demonstrate practicability of the concept, its cost effectiveness, and to test anticipated uncertainties and locate latent ones. In addition to demonstrating conceptual feasibility, as in B-1 prototypes, this approach has been used to enable the government to evaluate the capabilities of two or more weapon systems in a competitive demonstration, as was done in the AX aircraft program. In addition, a prototype can be used in an advanced development stage in order to demonstrate whether it can satisfy a future need, if and when it is fully developed as a system, as in the lightweight fighter program.

One of the most promising forms of prototyping is "parallel undocumented development," in which competing companies develop prototypes with the minimum amount of documentation needed by the contractor. The government evaluates and tests the competing prototypes in order to select a winner who undertakes the documentation necessary to manufacture the system. As a result, the design for configuration management purposes is frozen at a much later date in the development cycle, and the contractor gains substantially more responsibility and flexibility during the development phase. In addition, the decrease in required documentation should result in decreased cost of development, as high as 50% according to some estimates [60].

Critics of prototyping argue that it will add substantially to development time and hence to cost; advocates argue that the appropriate period in which to examine costs is the entire life cycle of the system, which will clearly benefit by an early discovery of major defects or problems.

Therefore, prototyping has merit as an acquisition strategy for weapon systems and subsystems which seek substantial innovation, which are to be produced in quantity, and which have a low or moderate ratio of development to total acquisition costs [18].

Breakouts, Second Sourcing, Leader-Follower Procurement, and Separation of Acquisition Stages With Technology Licensing

Just as prototyping is designed to increase competition during the development phase of system acquisition, several methods have been developed for increasing competition during or after the initial production run has occurred. Breakouts involve the competitive reprocurement of spare parts and components for weapon systems, while second sourcing, leader-follower procurement, and directed technology licensing involve competitive reprocurement for complete systems.

Second sourcing has been successfully used by the Navy for small missiles (including the Sidewinder and Bullpup), target drones, aircraft engines, and torpedos. Under second sourcing, one firm performs the underlying R & D and then provides the government with drawings, specifications, and other technical information. The government validates this information and transfers at least part of it to additional suppliers who set up production lines during the initial production run or during follow-on production. Production by the original and second source may overlap in time, several production lines may be maintained through much of the program, or the original source may drop out of the program with the award of the contract to the new suppliers.

By extending the scope of competition during production, the

government can substitute yearly procurement for long-term procurement commitments by generating competition through the dissemination of technical information. The disadvantages of this method are that it requires the government to maintain an expensive engineering and technical staff, and the duplication of tooling and other set-up costs may be prohibitive unless production runs are sufficiently large to absorb them.

Leader-follower procurement involves the government contracting with a developer - initial producer to render technical assistance and provide the necessary data to enable other firms to also set up production. To date, this strategy, which was used extensively in naval shipbuilding programs, has been used more for the purpose of increasing production capacity than for increasing competition [16]. The reason for this situation is partly because of the difficulty of motivating contractors to effectively transfer their technical expertise with the result that they might lose future contracts.

Separation of acquisition stages with technology licensing involves competition among contractors between the development and initial production stage, the initial production stage and follow-on production, during follow-on production, or during any combination of these stages. A technology clause is inserted in early contracts by the government which requires the contractor to transfer his data and technical information to the successful firm if the contractor loses the competition. The new firm is to pay royalties and compensation for technical assistance to the licensor.

While the incentive for technology transfer under this strategy, where firms are undertaking sequential phases of the contract, is probably greater than under second sourcing with its simultaneous contracting, there are still considerable problems. Firms may be reluctant to part with proprietary information, there may be critical delays in production during the technology transfer process, and this strategy would be particularly vulnerable to "buy-ins" wanting to learn trade secrets.

When one of these multiple production line arrangements is used in conjunction with prototyping, the effect may be illustrated as an hourglass, where a number of competing designs narrow into the one which is chosen, and widens again with competition for first or subsequent production runs and for reprocurement [31].

Small Business Set-Asides

In order to broaden and strengthen the industrial base for military procurement, the small business set-aside program was initiated to partially or totally restrict competition for certain procurement items to small businesses. DoD has sponsored a program with a portion of the procurement further restricted for small business in labor surplus areas.

A dilemma to the government posed by set-asides is that in the short run, prices may be higher and competition restricted as small businesses incur high start-up costs and are unable to take advantage of economies of scale to lessen costs. In the long run, however, the set-aside program enlarges the total number of contractors available to compete, and it should thereby contribute to lower contract bids.

Another problem of the set-aside program is the tendency of the procuring agency or office to enhance its statistical record of set-asides by listing, under amounts set aside, substantial amounts of procurement which, under ordinary circumstances, would be won in open competition by small business. As a result, the achievement of success on paper may not reflect reality or lead to the long-range goal of a viable and competitive small business industrial base [3].

In addition to strategies designed to increase competition, several related management strategies have been used during the 1970's to achieve cost control. They include:

Life-Cycle Costing

Prior to 1970, weapon systems competitions frequently took only

acquisition costs into consideration, with the result that subsequent support and operating costs may have made the systems which were selected more expensive than those which were rejected. In 1970, DoD Directive 5000.1 established the relevant cost for procurement considerations to include not only the cost of acquisition but of ownership as well, which includes a consideration of discrete cost elements such as unit production cost and operating and support cost.

This approach has been applied on such systems or subsystems as the patrol frigate, the NATO patrol hydrofoil ship, the sea control ship, and submarine sonar. Life-cycle costing should be particularly effective when combined with a design to cost approach.

Design to Cost

DoD Directive 5000.1 also directed that cost parameters for major systems be translated into design requirements. DoD Directive 5000.28 further defined the design to cost concept, where rigorous cost goals are established during development of the system which are equal in importance to requirements of operational capability, performance, and schedule. While these other factors had previously received greater emphasis in design than did cost, design to cost sought to achieve control of system cost by mandating that trade-offs should be made between these factors, with cost given an equal priority with the others.

DoD Directive 5000.28 also established that life-cycle costing was to be the source of cost data for design to cost. In practice, however, program managers and industry have encountered major problems with substituting life cycle for acquisition costs, in part because of the difficulty of assigning the same urgency to future as to immediate costs [38]. Furthermore, where life-cycle cost information is employed under a design to cost approach, the information is usually a gross estimate rather than detailed information covering each stage of the life of the system. Detailed cost information is necessary for intelligent trade-offs and to assure that "design-to-life-cycle-cost" will be an integral

part of the program management rather than a nonrecurring consideration [39].

Value Engineering

Developed during the 1960's but employed extensively during the 1970's, value engineering is a cost reduction effort, utilizing various analytical methods, to eliminate or modify anything contributing to the cost of an item which is not necessary to maintain required performance, quality, maintainability, reliability, standardization, or interchangeability. In addition to a vigorous in-house program, the Navy includes in most of its contracts an incentive clause by which any cost savings accrued by a contractor as a result of his value engineering program will be shared between the contractor and the government [44].

6. Conclusion

The techniques and strategies discussed in this paper represent major trends in procurement during the past 30 years, although by no means do they constitute an exhaustive listing of developments in this field. These techniques are best viewed as instruments to be utilized in appropriate situations, based upon a comprehensive understanding of the strengths and weaknesses in each technique and a careful selection of the procurement strategy that is best for the particular project at hand.

An understanding of procurement policy also necessarily includes an appreciation of its limitations. Without intelligent management and other essential extra-contractual factors, the successful implementation of any procurement policy is impossible. Our knowledge of the relationship between these extra-contractual influences and procurement policy is extremely limited. While outside of the scope of this paper, an important topic for future research is the nature of this relationship and its impact upon competition, risk, and cost control.

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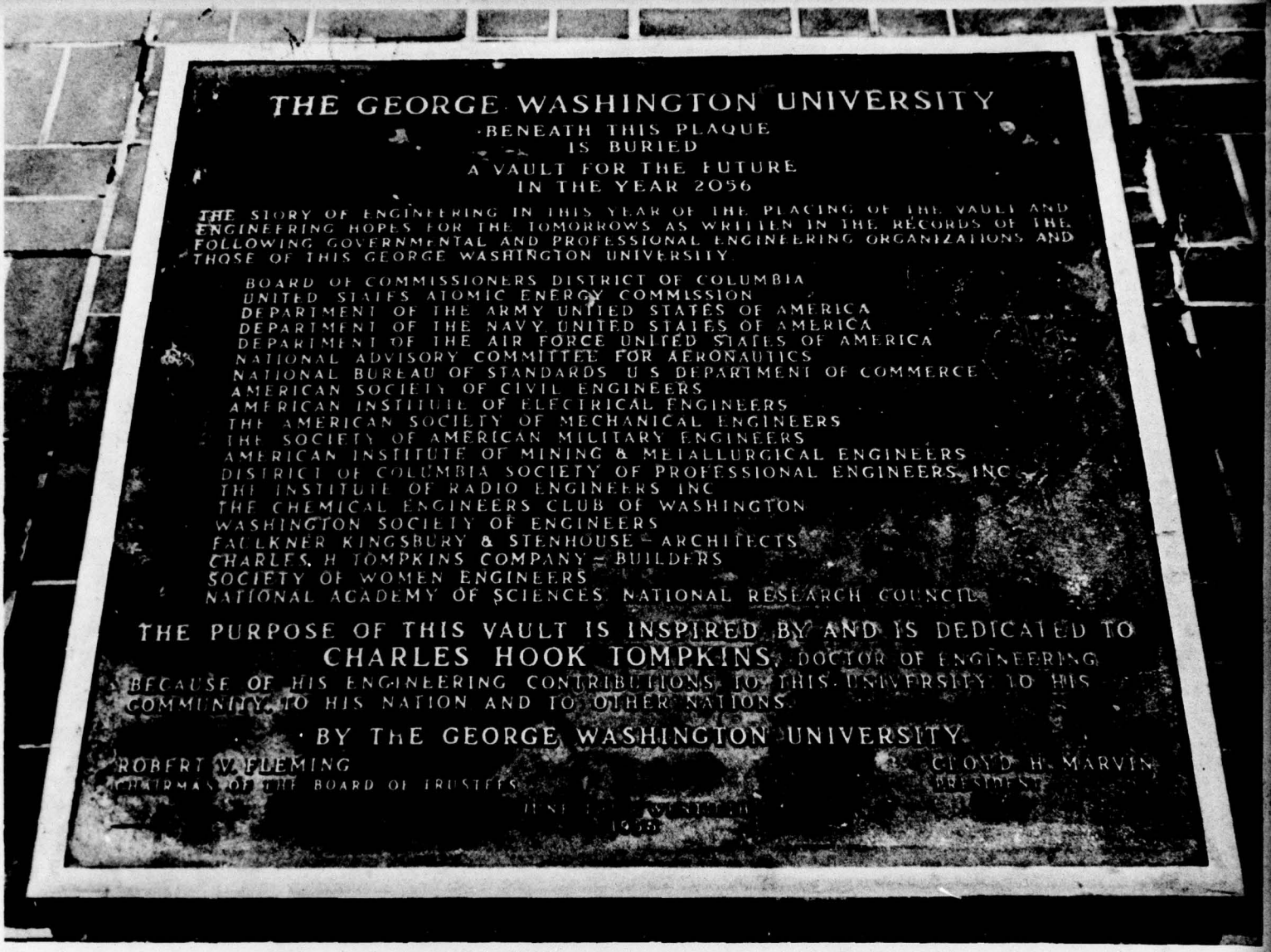
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