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AN EXAMINATION OF THE FOUNDATIONS OF INCENTIVE CONTRACTING

Task 66-7

May 1968

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AN EXAMINATION
OF THE FOUNDATIONS
OF INCENTIVE CONTRACTING

Task 66-7

May 1968

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NOTE

This report was submitted to and has been reviewed by the Office of the Secretary of Defense. The Assistant Secretary of Defense (Installations & Logistics) has requested that the following statement be included in the report for general distribution:

> "This report should prove useful in stimulating dialogue within the Department of Defense and Industry as a part of our continuing evaluation of incentive contracting. Recommendation No. 2 herein has been considered within the Department of Defense, and there are no basic changes in policy contemplated as a result of this report. However, the contents of the report indicate the need for very careful evaluation on a case by case basis in arriving at the proper selection of contract type and in negotiating meaningful incentive arrangements."

FOREWORD

LMI has been conducting incentive contracting studies for about six years. Those studies primarily have been directed at improving techniques for structuring incentive arrangements--particularly multiple incentive arrangements.

During the same period of time LMI also has investigated contractor motivation in a broader context, with studies on the function of profit, the use of various procurement methods and types of contract, and the role of competition. Those studies, together with field review of contractor effort on incentive contracts, prompted a more comprehensive examination of contractual incentive arrangements--their purpose, their logic, and their effect on management of defense programs.

This report focuses on the effect that contractual incentive arrangements, in the context of other motivating forces, may reasonably be expected to have in reducing the cost, increasing the timeliness, and improving the performance of Department of Defense programs. It draws upon theory and empirical evidence. It utilizes the ideas and findings of numerous government and industry studies as well as those of LMI.

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AN EXAMINATION OF THE FOUNDATIONS OF INCENTIVE CONTRACTING

INTRODUCTION

Several years have passed since Department of Defense management substantially increased its emphasis on contractual incentives as a means for inducing greater contractor efficiency. It has become common practice to make the contractor's profit or fee dependent on actual contract cost. In addition, there has been a gradual increase in relating profit or fee to contractor success in meeting schedule and satisfying performance goals. A large number of studies have been devoted to developing effective incentive structures for cost, schedule, and the various performance characteristics.

It is time to review the role of contractual incentives in the light of past experience, the findings of special studies, and the current contracting environment. This report consists of reflections on the effectiveness of contractual incentives in promoting accomplishment of the government's contracting objectives. It presents recommendations for future incentive contracting policy and practice.

The word "incentive" is used exclusively to refer to contractual provisions which relate contractor profit or fee to actual contract cost, time of completion, or level of performance attained. "Performance" refers to the capability of the product designed, developed, or delivered rather than to the management proficiency of the contractor. "Product" means the design or hardware, including models and prototypes, resulting from the contract.[1] Elementary knowledge of DoD incentive contracting principles is assumed.

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[1]This report does not address the use of incentives in contracts for services.

Both cost-plus-incentive-fee (CPIF) and fixed-price-incentive (FPI) contracts are addressed. Since cost-plus-fixed-fee (CPFF) contracts generally are appropriate for basic research and for exploratory and advanced development, and since firm-fixed-price (FFP) contracts usually are suitable for production effort, the frame of reference primarily is engineering and operational systems development.

THE PURPOSE OF INCENTIVES

Cost reduction was the original justification for increased DoD use of contractual incentives. Some other possible benefits were quickly recognized, however, and the list of reasons for negotiating incentive arrangements has continued to grow.

LMI conducted a brief survey of government contracting personnel to discover their motives for using incentives. Twenty-three justifications were identified. They are reported in the Appendix.

It is readily apparent that some of the justifications are invalid. Those justifications are not discussed, except in the Appendix. The others are summarized here in four general statements:

(1) Incentives motivate efficient contract management and achievement of a high performance product.

(2) Incentives enable the Government to reward contractors on the basis of demonstrated management ability and product performance.

(3) Incentives assign to the contractor a larger portion of contract risk than he would bear with a CPFF contract.

(4) Incentives provide explicit communication of the Government's contracting objectives.

The first three statements are logically related. Number (1) is primary. Statements (2) and (3) speak of consequences which are intermediate, their value lying in that they result in the motivation of statement number (1).

Rewarding a good contractor or penalizing a poor one monetarily should not be an end in itself. Paying a higher profit or fee for more efficient management or a superior product is justified only when the prospect of higher return provides

some of the motivation for the contractor's achievement or for the interest of outstanding companies in DoD business. The amount of a financial penalty almost always is small compensation to the Government for the injury it suffers as a result of contractor inefficiency or a marginally acceptable product. Penalties are of minor consequence unless they stimulate improvement or discourage a company from seeking DoD business for which its competence is questionable. Therefore, rewards and penalties must be regarded as instruments of motivation; and statement number (2) above is subsidiary to statement number (1).

Similarly, the sharing of contract risk is of value primarily as an instrument of motivation. Giving a contractor a portion of the benefits of a highly successful effort can be justified only if better management or increased technical effort can be expected to result, or if such compensation helps attract highly competent companies to the defense market. Contractor assumption of partial responsibility for failure to meet target levels does not give the Government reason to be satisfied with the contract outcome. Sharing the costs of low achievement is of little advantage unless the contractor is stimulated to reduce his risk of failing to meet expectations or unless companies of dubious capability are discouraged from seeking DoD business. Statement number (3) above is hence also subsidiary to statement number (1).

Statement number (4) is based on the planning discipline which incentive structuring necessitates and the effectiveness of an incentive arrangement as a vehicle for communicating the government's objectives to the contractor. It is not related to the distinguishing feature of an incentive contract: i.e., the dependency of profit or fee on cost, schedule, or performance outcomes. Strictly speaking, explicit communication of government objectives is a fortuitous benefit of, rather than a justification for, an incentive arrangement.

Through requirements analysis and clear communication of objectives are critically important for the success of a contract. When techniques normally associated with the structuring of incentive arrangements can help in establishing requirements and clarifying objectives, the techniques should be used for those purposes. Their usage does not in itself, however, require that an incentive profit or fee be inserted in the contract.

The usefulness of multiple incentive contracting techniques in efforts for which multiple incentives are not appropriate will be discussed later in the report.

The four general justifications reduce, then, to one. The purpose of incentive arrangements in contracts is to motivate efficient contractor management and the achievement of a high performance product.

MEASURING INCENTIVE EFFECTIVENESS

The effectiveness of incentives as instruments of motivation cannot be assessed simply by examining contract results. Too many other forces influence the ultimate outcome of a contract relative to its stated objectives. Unforeseen problems, sudden technical breakthroughs, and sundry chance phenomena often have significant impact. Actions of the Government and other contractors affect the outcome. General economic trends also can be a factor.

To evaluate the effectiveness of an incentive arrangement, it is not adequate to ask: What was the result? It is necessary to ask a much more difficult question: How did the contractor's effort differ from that which would have occurred without the incentive arrangement?

Incentive contracting studies to date, for the most part, have (1) concentrated heavily on contract results, (2) failed to give serious consideration to other forces affecting contractor decisions, (3) neglected the influence that pre-award conditions have on the difference between stated objectives and final outcome, and (4) focused on poorly structured contracts Some studies and study segments are exceptions, and their findings are used later in this report.

The most common deficiency in completed studies is their failure to view incentives in perspective; i.e., to inquire about the influence of incentives relative to that of all the other forces acting upon the contractor. They do not ask: To what extent is contract profit or fee a motivating factor? They either assume that the contractor attempts to maximize his profit or fee on a contract-by-contract basis, or they recognize the existence of other influences and dismiss

them immediately with a statement of the following type: To the extent that contractors are motivated by contract profit or fee, incentives promote the government's interests.

It is important to accede to the undeniable logic of cost incentives; namely, that a contractor will be more cost-conscious if more of his own money is at stake. It is equally important to acknowledge, however, the extent to which other objectives of the contractor may conflict with and perhaps take precedence over his emphasis on low cost.

It is important that the contractor make technical decisions in the interest of the Government. But before it is concluded that performance incentives are advisable, there should be recognition of the motivational forces already existing and of the contractor's opportunities significantly to alter the performance outcome after the contract is let.

Enough is known about contractor behavior to place incentives in their proper perspective. The next section examines the impact of contract profit or fee relative to that of other motivating forces. The findings presented are based on interviews with contractors and confirmed by many published analyses of contractor behavior.[1]

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[1]See, in particular, the works of Cherian, Hill, Jones, Kratz, McGuire, and Scherer cited in the Bibliography.

CONTRACTOR OBJECTIVES

There is much controversy about the importance of profit as a contractor objective. Many managers and analysts argue that other considerations (e.g., company growth, market share, and public image) are paramount. Some insist that profit is the ultimate objective and other factors are only intermediate goals; i.e., they are sought only because they lead to greater future profit.

In assessing the effectiveness of contractual incentives, ultimate or long-range profit is relevant only as it influences short-range goals. Incentives, being associated with individual contracts are instruments of short-range motivation.

There is virtually unanimous agreement among managers and analysts who have studied overall contractor motivation that, in the short run, contractor management does sacrifice short-run profit on defense business in favor of achieving

(1) company growth,

(2) increased share of the industry market,

(3) better public image,

(4) organizational prestige,

(5) carry-over benefits to commercial business (commercial spinoffs),

(6) greater opportunity for follow-on business, or

(7) greater shareholder expectations for future growth and profit.

Profit sacrifices are made in the process of acquiring a contract as well as in the process of executing it. While there is a practical limit on the extent to which current profit can be sacrificed, that limit rarely causes short-range profit to dominate management decision making.

The profit or fee objective of a contract is not established in isolation from other current contracts or anticipated future work. Contractor management relates each contract to overall business objectives and reports to shareholders on an overall basis. It is not unusual for a company deliberately to take a loss on a contract of any type. It is in the interest of the company to accept, if necessary, a loss (or low profit or fee) if doing so provides an opportunity to

(1) gain competitive advantage by engaging in developmental effort in areas of potential future business,

(2) acquire or retain competent personnel in scarce disciplines,

(3) spread fixed costs over a substantially broader base, or

(4) prevent a potential competitor from gaining entry to the market.

Any of those accomplishments can be of far greater consequence than a few percentage points of profit or fee on a single contract.

Objectives of a contractor organization as an impersonal entity are not the only ones which are pertinent to incentive effectiveness. The personal goals of individual managers also have an effect.

The remuneration of managers, as well as their prestige and professional stature, is more dependent on company sales than on profit rate. It has been demonstrated that executive salaries correlate well with sales and bear very little relation to profit.[1] In addition, managers usually have power and prestige ambitions which are served best by company growth and increased market share.[2] Primary emphasis on enlarging the business is therefore consistent with a manager's self-interest.

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[1] McGuire, Joseph W., Chiu, J. S. Y. and Elbing, A. E. "Executive Incomes, Sales and Profits," American Economic Review, Vol. LII, No. 4, September 1962.

[2] Kratz, Lawrence A , "The Motivation of the Business Manager, Behavioral Science, Vol. 5, No. 3, 1960.

Even a defensive manager is motivated to concentrate on sales. Survival is a more basic goal than is profit. Low profit usually can be explained satisfactorily if business volume is increasing. Higher sales are a good omen for the future. Reduced business volume, on the other hand, is not so easily excused. It virtually always reflects poorly on management.

In summary, whether management is operating in the company's interest or for its own personal gain, it does not attempt to maximize profit or fee on individual contracts. It attempts to optimize among many objectives, placing particular stress on those which contribute most to maintaining or improving market position and assuring the future strength of the firm. The drive for profit is not absent, but is constrained by aims which ultimately are more consequential.

FINDINGS OF OTHER INCENTIVE CONTRACTING STUDIES

Doubt about the motivational effect of incentive arrangements arises not only from analysis of the role of short-range profit in relation to that of other forces acting upon the contractor; it also is based on empirical evidence gathered in reviewing contractor efforts on incentive contracts.

As previously has been pointed out, most completed incentive contracting studies have serious defects. Not the least of those defects is the basing of analysis on poorly structured contracts. Most contracts reviewed were structured early in the learning period which followed the decision of DoD management to make substantially greater use of incentives. Contractor shares of cost risk were, in general, extremely low; ranges of incentive effectiveness often greatly exceeded ranges of possible outcome; and the decisions encouraged sometimes conflicted with other guidance provided to the contractor. If incentives were effective instruments of motivation, such poorly structured contracts would not show them to be. Findings of the studies therefore should be used with caution.

While it would be unwise to accept the findings of past studies without reservation, it would be equally unwise to ignore them. A few of the studies address the question of incentive effectiveness in a comprehensive manner. Furthermore, those few are in agreement on numerous findings.

Findings reported in this section come from six studies, carefully selected as being among the most objective and thorough inquiries into the effectiveness of incentives. They are the efforts of Booz, Allen and Hamilton (for NASA), Dr. Cherian, the Defense Science Board, Professor Hill, Colonel Jones, and Professor Scherer.[1] The points cited are restricted to those on

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[1]See the Bibliography for complete references.

which most of the six studies concur, and on which none takes exception. Each study omits a few of the points.

Eleven findings are used. Seven of them reflect unfavorably on incentive contracting:

(1) Extra-contractual considerations dominate over profit or fee. A contractor rarely seeks to maximize profit during the short run of a single contract. He is more interested in taking actions that will expand company operations, lead to increased future business, enhance company image and reputation, benefit his non-defense business, or relieve such immediate problems as loss of skilled personnel and a narrow base for fixed costs. (The previous section deals more fully with this point.)

(2) No significant correlation can be found to exist between cost sharing ratios and overruns or underruns.

(3) Incentives have not been significantly effective as protection against cost growth on programs.

(4) Contractors establish upper limits on profit on government contracts. Those limits pertain to individual contracts and to overall business with the Government. A large profit or fee on a contract arouses suspicions of cost padding and profiteering, making future negotiations more difficult and possibly damaging company reputation. Sometimes an investigation results and exaggerates the consequences. A high profit on overall government business results in renegotiation, and some of the profit increments gained may be taken away. Contractors go to great lengths to avoid investigation and to avoid refunds resulting from renegotiation.

(5) Incentives are costly to negotiate and administer. The process of making a contract change is much more complex when an incentive arrangement is involved.

(6) Contractors will not sacrifice performance attainment for profit. Performance is of such importance to company image and future business acquisition that all performance incentives provide little, if any, additional motivation to the contractor.

(7) It is often difficult to pass incentive motivation to the people who carry out the contract effort on a day-to-day basis, because it is difficult to relate individual activity with specific contracts. Many workers' time cannot be associated with individual contracts in such a way that they usually know what contract they are working on and what the incentive arrangement is.

Since some able researchers, after lengthy study, agree on the above points, those points should be given serious consideration when DoD procurement policy is reviewed and evaluated.[1]

Some qualification is in order for two of the points. Findings (2) and (3) cannot be considered conclusive because they are based on contracts negotiated early in the DoD effort to increase the use of incentives. A learning period usually is essential for both government and contractor personnel before any substantial change in policy is successfully implemented.

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[1]Some of the studies also concluded that the use of incentive contracting in research, exploratory development, and advanced development is not in the interest of the Government or the contractor. In such efforts cost and schedule are highly uncertain and there is insufficient knowledge for deciding what performance goals are reasonable, so incentives are little more than a gamble.

That conclusion is now widely recognized by both procurement specialists and scientists and engineers. Since it does not address engineering or operational systems development, it is outside the boundaries of this report.

Four additional key findings relate to the favorable aspects of incentives:

(8) Incentives do not work to the disadvantage of the Government except in administrative cost. When a contractor discovers that his incentive arrangement does not correspond to the government's interest, he ignores the incentives.

(9) Incentives serve as a planning discipline for DoD personnel. When an incentive arrangement is to be negotiated, requirements analysis is more thorough and the work statement is more precise.

(10) Incentive structures clearly communicate the government's objectives to the contractor. They attract special management attention to the objectives and explicitly show their relative importance.

(11) When it is possible to associate activities of individuals with specific contracts, incentives provide a useful tool for motivating workers.

As with the first seven findings, some reservations must be drawn. Finding (8) is not a justification for incentive contracting, but simply a statement that its use will not lead to catastrophe. Findings (9) and (10) represent important advantages which have resulted from the use of incentives, but those advantages are not dependent upon the presence of a variable profit or fee in the contract. Finding (11), as some of the studies pointed out, is unrelated to the amount of profit or fee swing in the contract.

In summary: There is no compelling evidence that cost incentives are working. Contractors have such strong motivation to emphasize performance attainment that performance incentives may be unnecessary. The use of incentives has, however, produced more thorough government acquisition planning and more complete and precise communication of procurement objectives to contractors.

CONTRACTOR TRADE-OFF POSSIBILITIES

In reports, courses, and instructions on multiple incentive contracting, much attention is devoted to trade-offs which the contractor may make among cost, schedule, and performance, and among the various performance characteristics on which incentives are placed. It usually is assumed or concluded that the contractor can and should be concerned with those trade-offs throughout his work on the contract, and that incentives can be used to guide him in revising his plans as expectations of achievement on the various incentive elements change.

Investigation of program management in defense contractors' plants has led LMI to the conclusion that the potential for improving contract management by using incentives to provide guidance in making trade-offs is greatly overestimated. In general, a contractor becomes committed to a single technical approach relatively early in the life of a program. Opportunities to adopt new technical approaches or to revise the balance of emphasis among various objectives rapidly diminish. Pursuing parallel courses of action or maintaining the capability to change emphasis significantly is extremely costly. In fact, it is a luxury the Government can rarely afford, either in cost or time, except in research or exploratory development effort.

Key contractor trade-offs are made in such activities as selection of plant, selection of personnel, establishment of the program budget, establishment of management plans and controls, adoption of a technical approach, and selection of a preliminary design. Those activities occur very early in the contractor effort. All but the last one largely may be completed during proposal preparation and contract negotiation. During most of the effort, therefore, the contractor is restricted to relatively minor cost versus schedule trade-offs.

After a program is organized and the management team has started to carry out the contract, it is unrealistic to expect that opportunities will exist for the exercise of trade-offs significantly affecting performance. Hence the utility of performance incentives is severely inhibited.

THE EFFECT OF CONTRACT DEFINITION

Those cost or schedule versus performance trade-off opportunities which traditionally have been available to the contractor early in execution of engineering and operational systems development contracts are, for the most part, eliminated when such a contract is preceded by Contract Definition (CD).[1] The Government requires that CD contractors carry out extensive trade-off studies, and it reviews and analyzes those studies before awarding the follow-on development contract. By the end of CD, the Government expects to have achieved, in conjunction with the winning contractor, a near optimum balance among life cycle cost, delivery schedule, and performance characteristics, given budgetary constraints and the state of current technology. The winning CD contractor is committed to a technical approach and a preliminary design. At the end of Phase B,[2] the amount by which contractors can alter performance characteristics is a small fraction of what it was at the beginning of Phase B.[3]

Having just completed optimization of cost, schedule, and performance during CD, it is unlikely and inappropriate for the winning contractor to restudy and revise his plan during the early part of the follow-on contract. Later he finds any significant change involving performance to be prohibitively costly or time-consuming, performance incentives notwithstanding, unless he is faced with the prospect of program failure.

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[1]Office of the Secretary of Defense. "Initiation of Engineering and Operational Systems Development," DoD Directive 3200.9, 1 July 1965

[2]Phase B begins with the award of Contract Definition contracts and ends with the contractors' submittals of Contract Definition reports and development proposals.

[3]Some Military Department personnel who have participated in CD estimate the amount to be between ten and twenty percent of what it was at the beginning of Phase B. If, as is increasingly the case, the follow-on contract is a Total Package contract rather than simply a development contract, each CD contractor is induced to extend his CD effort beyond evolution of preliminary design.

Two of the key benefits of CD are:

(1) CD assures that the available trade-offs among cost, schedule, and the various performance elements are thoroughly studied before a preliminary design and a management plan are accepted.

(2) CD causes that part of the development effort in which significant trade off opportunities are available to be separated from that part in which the contractor is committed to a relatively fixed approach and a firm set of performance specifications. A more definite contract for the latter part is hence possible.

The above two points make CD desirable on development programs of all sizes, and whether or not competition is feasible.

RECOMMENDATION NO. 1

Use the Contract Definition process in all development programs to assure thorough trade-off analysis and achieve firm specifications for engineering and operational systems development contracts.

Field investigations, examination of incentive contracting studies, and consideration of current DoD procurement practice have resulted in two basic arguments on performance incentives. Those arguments have been presented on preceding pages and can be summarized as follows:

(1) The contractor considers a reputation for technical competence to be critical to future business success and hence is strongly motivated for technical accomplishment. Performance attainment overbalances immediate financial gain in contractor trade-off decisions. Consequently performance incentives are unnecessary either to assure stress on performance or to create a balanced emphasis among cost, schedule, and performance.

(2) Contractor trade-off decisions significantly affecting performance are made during preparation of proposals, conduct of CD, and planning of the development effort. Trade-off opportunities do not exist for the contractor to be guided by performance incentives in carrying out the development.

Another recommendation therefore is in order:

RECOMMENDATION NO. 2

Discontinue the use of performance incentives in development contracts.

THE NEED FOR COST INCENTIVES

There is a vast difference in financial risk between CPFF and FFP contracts. A contractor has virtually no cost risk on a CPFF contract; the Government has virtually none on a FFP contract.

Dominance of performance in contractor trade-off decisions notwithstanding, it is to the financial advantage of the Government to have the contractor bear as much of the cost risk as he will accept without inclusion of substantial contingencies in target cost. Whatever the trade-off decisions and resulting program plan, that plan can be carried out at different levels of efficiency and thus at different costs. If the contractor financially has more at stake on the cost outcome of the contract, it is only reasonable to assume that he will have some additional degree of cost-consciousness in his management.

It is not contradictory to the usefulness of cost incentives that no significant correlation has been found between sharing ratios and overruns or underruns. Since goals other than short-term profit take precedence, and profit is sought within the constraints imposed by the other goals, no correlation can be expected except at very low levels of statistical confidence.

Cost incentives should not be abandoned because they are effective only within the constraints of contractor objectives other than profit. The advantage of cost-conscious operation within those boundaries should be pursued. Whenever the contractor has sufficient confidence in his cost estimate to accept some degree of responsibility for overruns, yet has insufficient confidence to agree to a firm fixed price without inclusion of large contingencies, a cost incentive arrangement should be negotiated.

Cost-sharing of underruns and overruns should serve, at least in a small way, to strengthen efficient contractors and weaken inefficient ones (or help drive them away from the defense market). Hopefully, it should help discourage unrealistically low estimates on cost reimbursable contracts. Based on incentive contracting experience to date, however, it cannot be expected to arrest the cost growth which frequently occurs in DoD programs. The performance outcome and extra-contractual considerations discussed earlier in this report will continue to dominate contractor decision-making.

If cost incentives are to bridge the entire gap between CPFF and FFP contracts, government/contractor sharing ratios must be extended beyond the customary 98/2 to 70/30 range. The rationale for cost incentives makes it essential that contractor shares, in general, be larger than they have been to date.

RECOMMENDATION NO. 3

Employ cost incentives in engineering and operational systems development contracts whenever contractors will accept some cost risk, yet will not agree to firm fixed price contracts.

THE LIMITED ROLE OF SCHEDULE INCENTIVES

Unlike trade-offs involving performance, trade-offs between cost and schedule are possible throughout the entire period of a contract. The contractor can, for example, accelerate his effort by using more overtime or employing redundant approaches to problems.

The relationship between cost and schedule is not necessarily, however, an inverse one. For instance, late accomplishment of a milestone may impose additional working capital requirements on a contractor and necessitate overtime on another contract by delaying the availability of facilities, equipment, or personnel. In general, delays are costly, and the contractor has a natural motivation to meet his schedule.

Schedule nevertheless is rarely as important to the contractor as performance. Performance has such great impact on company reputation and ability to obtain future business that it governs the contractor's trade-off decision making in the event of a conflict with schedule.

The importance to the Government of meeting schedule varies widely among contracts. In some instances, delays are of minor consequence. In others, they may jeopardize the success of vast programs. In the extreme case, a delay may impair the national security.

In contracts on which delays are not of serious concern, no incentive should be placed on schedule. If the contractor can benefit from extending his effort, such as by increasing the quality of his product or by continuing absorption of fixed costs on a cost reimbursable contract, schedule incentive of modest amount will not be sufficient to motivate him to sacrifice that advantage.

Even without incentive on schedule, some inducement for the contractor to fulfill his responsibilities on time is always present. The desire to avoid a record of lateness prompts contractors to meet deadlines. In addition, since delays usually result in extra cost, they reduce any incentive earned on the element of cost. A small incentive for timeliness of contract execution would provide negligible, if any, additional encouragement.

If achievement of contract goals would be seriously endangered by schedule slippage, then lateness should, if practical, be made a matter of contractor nonconformance. The Government then would be in a position to terminate for default and possibly collect damages if the schedule were not met, and the contractor, in addition to financial injury, would suffer degradation of reputation. Except for the possibility of letting redundant contracts to increase the probability of meeting deadlines, making on-time completion a firm requirement and including liquidated damage clauses is the only appropriate course of action for the Government if lateness is likely to result in failure of the program.

Termination and collection of damages are, however, difficult and costly. Government and contractor efforts often are so interrelated that joint responsibility must be assumed for lateness. Furthermore, most programs can survive delays.

When schedule slippage can be tolerated but would be of substantial consequence to the Government, incentive should be placed on schedule. The Government should estimate the value of delays and attempt to negotiate incentives in the amounts of those values multiplied by the same contractor share percentage as is employed in the cost incentive. Such a procedure would help motivate the contractor to make those cost versus schedule trade-offs that would best serve the government interest.

If more than one sharing ratio were used as the cost incentive, then the appropriate share on schedule would be the average cost share over the range between actual cost and target cost.

A problem with the above approach is that the value to the Government of delays can be extremely large--so large that corresponding schedule incentives might be impossible for a contractor to accept. If such is the case, and yet it is recognized that delays will, if necessary, be tolerated, the Government should give serious consideration to letting redundant contracts. If that course of action is not acceptable, there is no alternative for the Government but to negotiate the largest incentive possible for delays.

This section has not addressed the subject of rewards for early completion of work. It has dealt only with schedule delays. Usually, early completion is not of value to the Government. Sometimes it can result in additional cost. Prototypes might, for example, be delivered at an inconvenient time and might require storage and care over an extended period. Rewards for schedule advances are, therefore, not generally advisable. In the event that early completion is of value, however, incentives can be established in a manner analogous to that recommended for delays.

RECOMMENDATION NO. 4

Employ schedule incentives in engineering and operational systems development contracts only when delay in work completion is of substantial consequence, yet is tolerable. Base the amounts of such incentives on the estimated values of avoiding delay and the sharing ratios of accompanying cost incentives.

ISOVALUE ANALYSIS

This report would now be complete, were it not that Recommendation Number 2 generates a question which has not been answered: If performance incentives are discontinued, will not the DoD lose an effective instrument for assuring thorough requirements planning and clear communication of objectives? Careful planning and explicit statements of purpose have nothing to do with the need for a variable profit or fee in a contract, but they have emerged as fortuitous benefits of the establishment of multiple incentive arrangements.

It is generally acknowledged that the reason multiple incentive contracting has resulted in better planned and executed procurements is that it has caused government personnel to devote more attention to identification and analysis of trade-off opportunities among the various performance characteristics, as well as among cost, schedule, and performance. Incentive research of the DoD, NASA, and their contractors has provided techniques which facilitate trade-off analysis. Most of the techniques and procedures are based on the same approach; generation and examination of curves (or surfaces) representing sets of potential contract results which are considered to be of equal value to the Government. The concept of "equal value" is basic, and such curves have meaning for contracts without, as well as with, multiple incentives.

The primary advantage of the curves, which are called isovalue curves in this report, and of associated techniques is that they make it easy for people to visualize the net effect of the outcomes of cost, schedule, and performance and of several performance characteristics. The oversights that frequently result from analysis of elements or characteristics on an individual basis only are therefore reduced.

Those oversights occur whether or not incentives are being used. Cost, schedule, and performance objectives and proposed requirements should be examined jointly, and performance characteristic objectives should be studied on a collective basis, for any contract. Isovalue analysis therefore has utility beyond incentive contracting.

Air Force[1] and LMI tested the presumed advantage of using isovalue analysis by selecting more than twenty existing contracts and plotting isovalue curves in conjunction with government personnel who had participated in the structuring of the contracts. In every instance those personnel concluded from the isovalue analysis that there was information in the contract which did not accurately represent the government's objectives. There was unanimous agreement that isovalue analysis would have resulted in contracts containing more complete and accurate guidance on the relative importance of cost, schedule, and performance goals.[2]

Figure 1 portrays a set of isovalue curves. The horizontal axis represents contract cost, measured in millions of dollars; and the vertical axis represents performance, measured in points ranging from 0 to 100, with 0 corresponding to minimum acceptable performance. Each point on the graph represents a particular combination of cost and performance; i.e. a hypothetical contract outcome.

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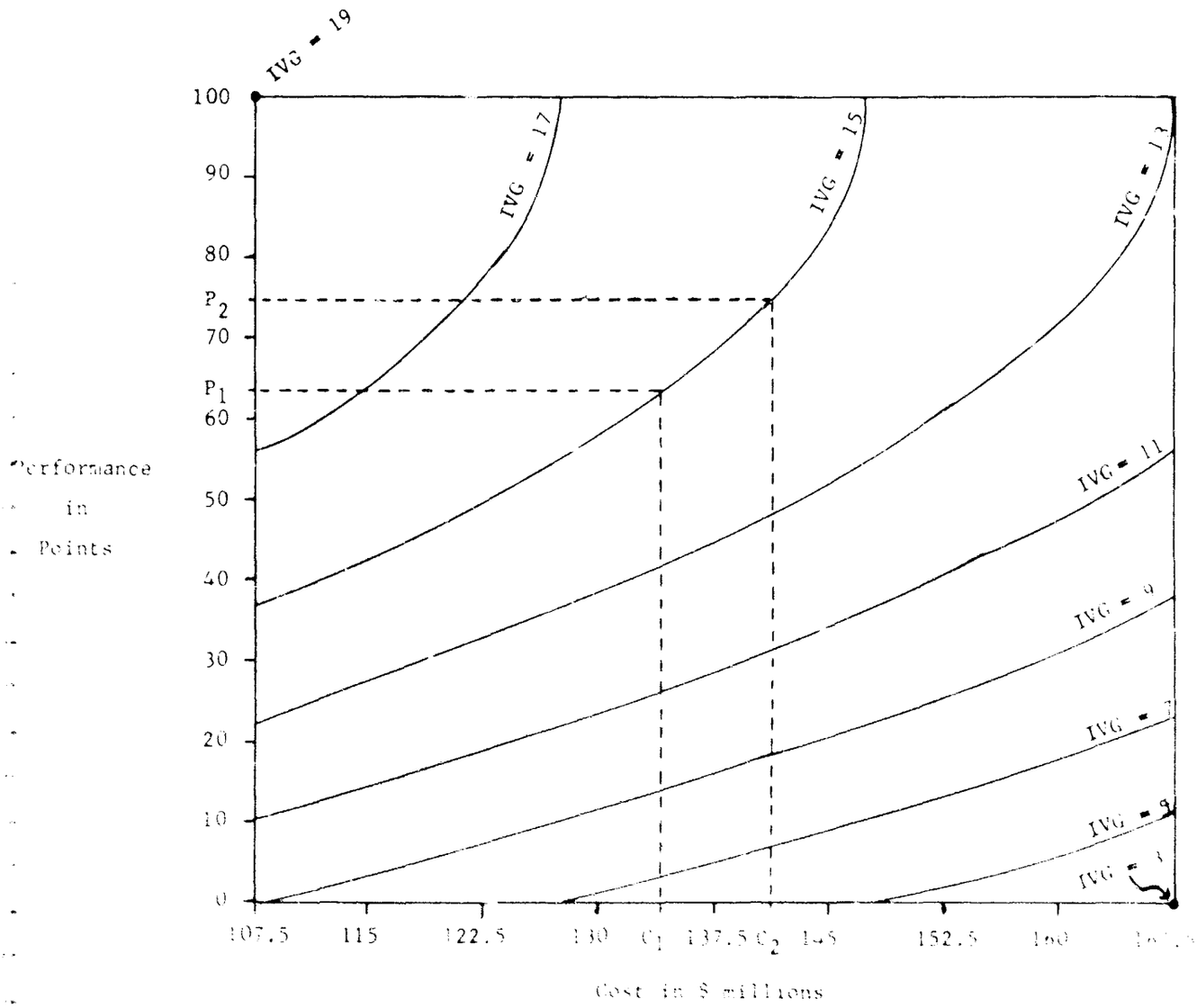
[1]Members of the USAF Academy Consulting Team, under the sponsorship of the Pricing Division (SMKP), Space and Missile Systems Organization, Air Force Systems Command.

[2]The contracts studied did not have the advantage of comprehensive systems analysis. When such analysis has been conducted, the need for isovalue analysis is reduced or eliminated. Isovalue curves may still be useful, however, in facilitating explanation of value relationships.



IVG = Index of Value to the Government

FIGURE 1

ISOVALUE CURVES

All points on the same isovalue curve represent outcomes which are considered to be of equal value to the Government. Two points on different isovalue curves correspond to outcomes which are of unequal value. The outcome of higher value is the one lying on the curve with the higher Index of Value to the Government (IVG) number. Points to the left of a curve will serve the government's interest to a higher degree than points on the curve, and points to the right will serve the government's interest less. If Figure 1 accurately expresses the government's evaluation of possible contract results, then the following statements are true:

(1) Contract outcomes (C_1, p_1) and (c_2, p_2) are of equal value to the Government.

(2) Increase in performance from p_1 to p_2 is worth (c_2-c_1) million dollars to the Government.

(3) Contract outcomes (c_1-1, p_1) and (c_1, p_1+1) are of greater value to the Government than (c_1, p_1).

(4) Contract outcomes (c_1+1, p_1) and (c_1, p_1-1) are of less value to the Government than (c_1, p_1).

It is necessary only to include a few curves in an isovalue graph to indicate the value pattern over the entire graph. The differing impact of performance or cost increments in different parts of the graph easily can be seen. A more precise depiction of that impact can be provided by inclusion of more isovalue curves; but a large number usually are not required to establish whether the relationship portrayed corresponds to the government's interest.

To simplify this discussion, schedule considerations have thus far been ignored. Schedule can be added as a third axis on the isovalue graphs. The result is a three-dimensional display with isovalue surfaces. Such a figure is, however, difficult to draw and difficult to interpret, especially when schedule is not a continuous variable.

It usually is adequate to indicate the effect of schedule differences by showing cost versus performance isovalue curves for selected points on the schedule axis. That approach may be described as slicing the three-dimensional isovalue surfaces with planes perpendicular to the schedule axis.

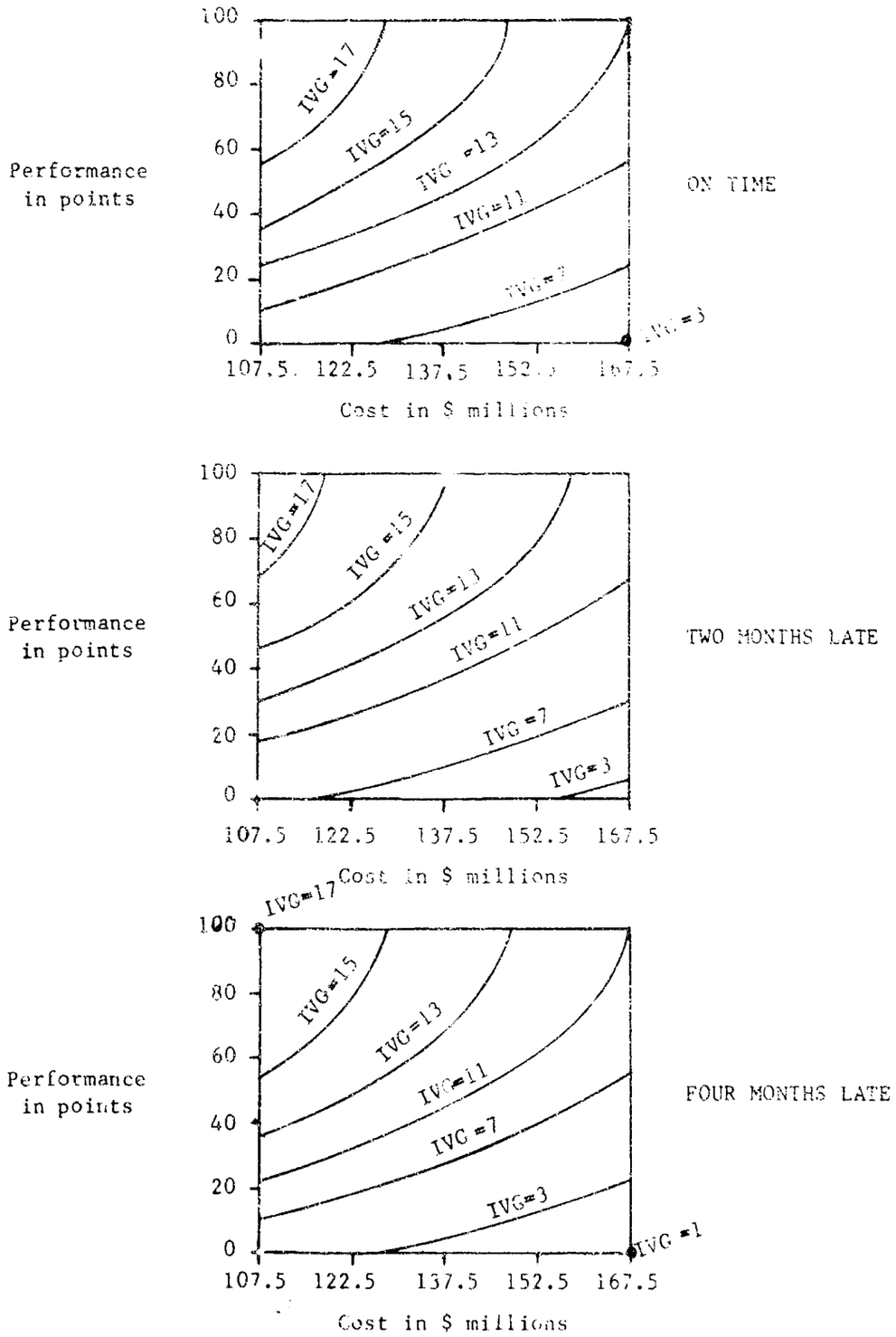
Suppose that schedule is added to the example of Figure 1. A hypothetical resulting isovalue pattern is shown in Figure 2. While graphs are shown only for completion of work on-time, two months late, and four months late, the reader can picture the approximate effect of work completion at intermediate points by visual interpolation.

Performance has thus far been treated as a single element. Sometimes a single index for performance achievement is readily attainable or is provided by prior systems analysis. More frequently it is not, and individual performance characteristics must be considered.

It would be possible (theoretically, at least) to produce curves of constant value for different combinations of achievement on various performance characteristics. Such an approach is analagous to the generation of isovalue curves for combinations of cost, schedule, and overall performance.

Curves of constant value for combinations of performance characteristics are, however, impractical. The technique previously described for handling schedule differences generally will not suffice for performance characteristics, and there usually are three or more characteristics which must be considered. When the characteristics amount to four or more, constant value curves are extremely difficult to work with.

Misconceptions from studying performance characteristics independent of one another can be as great, however, as those from examining cost, schedule and overall performance on a separate basis.



IVG = Index of Value to the Government

FIGURE 2

ISOVALUE CURVES FOR SELECTED COMPLETION DATES

Performance achievement must be evaluated in terms of the net effect of the levels of attainment on individual characteristics. The following steps therefore have been introduced as a practical means of analyzing performance achievement on a composite basis and establishing a rating scheme which reflects the results of that analysis:

(1) Assign tentative percentage weightings to the individual performance characteristics in accordance with their relative importance to mission success.

(2) For each characteristic, relate (tentatively) all acceptable levels of achievement to numbers of performance points. Let the points range from zero to the percentage weighting for the characteristic.

(3) Select twenty to forty hypothetical performance results; i.e., combinations of achievement on the individual characteristics. Selection may be random or calculated to cover the range of possible results.

(4) Make a table showing the combinations selected and their associated point totals.

(5) Study the table to ascertain whether the point totals accurately reflect the relative values of the various combinations. Obtain additional tables if the issue is in doubt or if it is not clear what adjustments might be desirable.

(6) Unless satisfied, revise the percentage weightings and/or point relationships and obtain new tables. Repeat the process until the point totals are acceptable as an index of relative value to the Government of overall performance results.

The above steps are illustrated in Figures 3, 4, and 5. Figure 3 gives percentage weightings for the characteristics (Step 1). Figure 4 relates numbers of performance points to the various levels of achievement on the individual characteristics (Step 2). Figure 5 is a table of performance combinations and their associated point totals (Step 4).

Air Force personnel have written computer programs which can be used to generate and plot isovalue curves and to select performance combinations, calculate point totals, and print performance combination ranking tables.[1] Those programs were produced for the purpose of structuring multiple incentive contracts, but may be used for isovalue analysis on any contract if the word "fee" is translated to mean "index of value to the Government." The Air Force approach to multiple incentive structuring uses incentive fee as a value index as well as a fee, so the translation does not constitute a change in logic.

If analysis of isovalue curves indicates that they do not coincide with the interest of the Government, the curves should be redrawn. When they are properly structured, the Government will be indifferent to the choice among points on a single curve. Points to the left of a curve will serve the government's interest to a higher degree than points on the curve, and points to the right will serve the government's interest less.[2]

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[1]See Cook, Maj. Jack W., Baggiano, Capt. Anthony L., Johnston, Capt. John D., Everett, ClC Warren D., Linsmayer, ClC Robert M., Schwengels, ClC Forest V., Hildebrandt, 1st Lt. Gregory G., Zangri, 2nd Lt. Alfred G. The Evaluation and Structuring Techniques of Multiple Incentive Contracts. Pricing Division--SMKP, Space and Missile Systems Organization, Air Force Systems Organization, Air Force Systems Command, Los Angeles Air Force Station, California, August 1967.

[2]Assuming, as in the examples, that the vertical axis represents performance and the horizontal axis represents cost.

Performance Characteristic	Range	% Weight
Availability*	0.90 - 0.98	40
Camera Capacity	1000 - 1400 feet of film	20
Resolution	50 - 100 lines/mm	40

$$* = \frac{MTBF}{MTBF + MTTR}$$

FIGURE 3

PERFORMANCE CHARACTERISTIC WEIGHTING

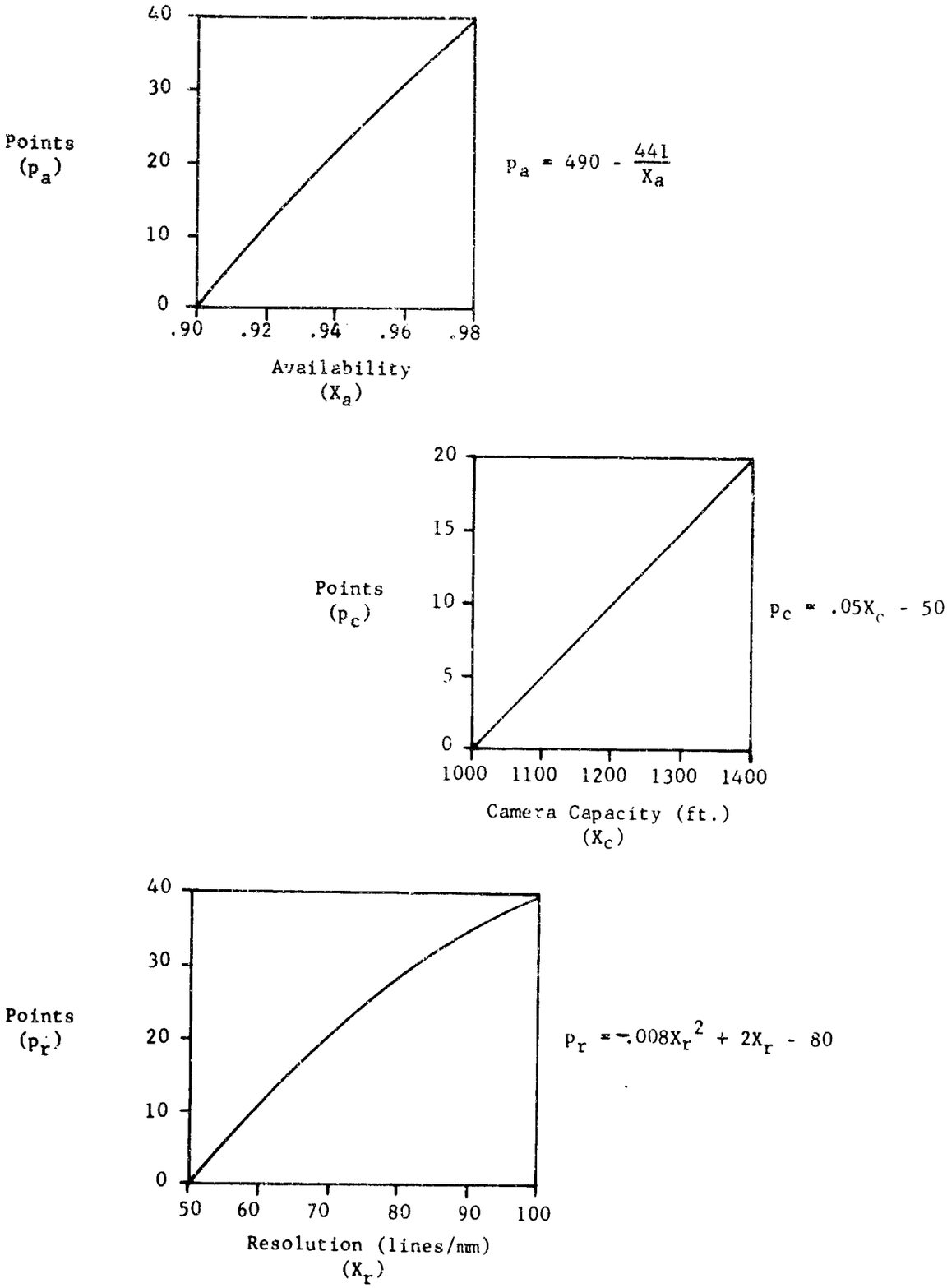

FIGURE 4

POINT ASSIGNMENTS FOR PERFORMANCE CHARACTERISTICS

Availability	Camera Capacity (feet)	Resolution (lines/mm)	Total Performance Points
.91	1100	60	21.585
.91	1200	60	26.585
.91	1300	60	31.585
.91	1100	75	35.385
.94	1100	60	37.051
.91	1200	75	40.385
.94	1200	60	42.051
.91	1300	75	45.385
.91	1100	90	45.585
.94	1300	60	47.051
.91	1200	90	50.585
.94	1100	75	50.851
.97	1100	60	51.561
.91	1300	90	55.585
.94	1200	75	55.851
.97	1200	60	56.561
.94	1300	75	60.851
.94	1100	90	61.051
.97	1300	60	61.561
.97	1100	75	65.361
.94	1200	90	66.051
.97	1200	75	70.361
.94	1300	90	71.051
.97	1300	75	75.361
.97	1100	90	75.561
.97	1200	90	80.561
.97	1300	90	85.561

FIGURE 5

PERFORMANCE COMBINATION RANKING

Similarly, the process of revising performance characteristic weightings and point relationships should not be considered accomplished until the point totals of performance combinations are acceptable as a composite performance index.

Thus isovalue analysis and performance combination ranking are useful instruments for developing objectives and studying proposed requirements. They can be used to improve communication of objectives within the Government and to contractors, because they present a complete picture of the relative desirability to the Government of all feasible contract outcomes.

Since the isovalue method of analysis and the performance combination ranking procedure result in a depiction of the relative value of all feasible contract outcomes, they also portray the relative desirability of proposals with different cost estimates, schedules, and promises of performance achievement. They therefore provide a useful framework for deciding which proposal is in the best interest of the Government, and for telling contractors in advance how that decision will be made.

RECOMMENDATION NO. 5

Make isovalue analysis and performance combination ranking a routine feature of acquisition planning and proposal evaluation for engineering and operational systems development.

SUMMARY OF RECOMMENDATIONS

Recommendation No. 1:

Use the Contract Definition process in all development programs to assure thorough trade-off analysis and achieve firm specifications for engineering and operational systems development contracts.

Recommendation No. 2:

Discontinue the use of performance incentives in development contracts.

Recommendation No. 3:

Employ cost incentives in engineering and operational systems development contracts whenever contractors will accept some cost risk, yet will not agree to firm fixed price contracts.

Recommendation No. 4:

Employ schedule incentives in engineering and operational systems development contracts only when delay in work completion is of substantial consequence, yet is tolerable. Base the amounts of such incentives on the estimated values of avoiding delay and the sharing ratios of accompanying cost incentives.

Recommendation No. 5:

Make isovalue analysis and performance combination ranking a routine feature of acquisition planning and proposal evaluation for engineering and operational systems development.

APPENDIX

Survey of Incentive Justifications

The DoD Incentive Contracting Guide states: "Incentive contracting is used to increase technological progress and produce cost savings."[1] Early LMI fieldwork revealed that Military Department contracting personnel considered that general statement to cover a large variety of more specific reasons for incentives.

Between July 1965 and April 1967 LMI conducted an informal survey to learn the range of purposes for including incentive arrangements in contracts. Only Military Department contracting personnel were queried. They were asked what their reasons had been for using contractual incentives. The reasons given are

(1) to encourage cost control

(2) to encourage control of schedules and deliveries

(3) to encourage improvement in product performance

(4) to promote more efficient allocation of resources

(5) to provide contractor management with tools to motivate workers

(6) to obtain optimum trade-offs among cost, schedule, and performance

(7) to obtain optimum trade-offs among performance goals

(8) to effect future pricing based on actual accomplishment

(9) to avoid CPFF contracts when FFP agreements are not feasible but the contractor will accept some responsibility for cost overruns

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[1]Office of Assistant Secretary of Defense (Installations and Logistics). Incentive Contracting Guide. Washington, D.C.: U.S. Government Printing Office, 1965. Page 1.

(10) to achieve contractor assumption of a large share of the risk associated with undertakings

(11) to force government personnel to state contract objectives more explicitly

(12) to assure clear communication of government objectives

(13) to attract contractor management attention to key objectives

(14) to avoid stating firm requirements when there is insufficient knowledge for such statement

(15) to prevent "frozen" design

(16) to assure that acceptance tests will be included in contracts and subsequently will not be waived

(17) to assure attainment of minimum specifications

(18) to discourage "buy-in"

(19) to serve as a compromise with contractors who demand escalation clauses

(20) to justify higher profits or fees

(21) to obtain desired pricing data

(22) to give contractors protection against the Renegotiation Board

(23) to conform to DoD policy

The first thirteen reasons can be summarized as follows: Numbers 1 through 7 relate to motivation of efficient contract management and achievement of a high performance product. Number 8 has to do with rewarding contractors on the basis of demonstrated management ability and product performance. Numbers 9 and 10 reflect intent to assign contractors a larger portion of contract risk than they would bear with CPFF contracts. Numbers 11 through 13 deal with providing more effective communication of the government's contracting objectives.

The remaining eleven reasons represent improper use of incentives. Establishment of variable profit or fee in contracts is not necessary for the accomplishment of numbers 14, 15, and 16. Those reasons imply that incentives are an acceptable substitute for properly structured work statements, complete contracts, and strong program management.

Number 17 is not a valid justification because incentives do not add to the government's ability to enforce minimum requirements. They provide reward for achievement in excess of those requirements--a distinctly different matter.

Incentives are not effective in satisfying number 18. When companies conclude that "buying in" is advantageous, the additional costs they are willing to incur far exceed the losses of profit or fee which can result from including incentives in contracts. (The discussion of extracontractual motivation in this report relates to that point.)

Numbers 19 and 20 represent attempts to evade problems which should be solved directly. Numbers 21 and 22 amount to subterfuge--against the contractors in the case of reason number 21; against the Government in number 22.

Compliance with policy is never conditional upon agreement or understanding. Reason number 23 therefore is not invalid. When given without other reasons or supplementary explanation, however, it suggests unreasoning application and in that sense reflects improper use of incentives.

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13. ABSTRACT The report focuses on the effect that contractual incentive arrangements may reasonably be expected to have in reducing the cost increasing the timeliness, and improving the performance of engineering and operational systems development efforts in DoD programs. It develops arguments, based on field observations and analytic study, which lead to the following recommendations for DoD management: 1) use the Contract Definition process in all development programs to assure thorough trade-off analysis and achieve firm specifications; 2) discontinue the use of performance incentives in development contracts; 3) employ cost incentives whenever contractors will accept some cost risk, yet will not agree to firm fixed-price contracts; 4) employ schedule incentives only when delay in work completion is of substantial consequence, yet is tolerable. Base the amounts of such incentives on the estimated values of avoiding delay and the sharing ratios of accompanying cost incentives. 5) Make iso-value analysis and performance combination ranking routine features of development acquisition planning and proposal evaluation

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