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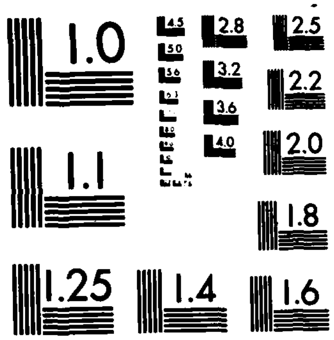

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FINAL

COMPETITION DECISION-ASSIST PACKAGE (CDAP)

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U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ARMY PROCUREMENT RESEARCH OFFICE
FORT LEE, VIRGINIA 23801

APRO 82-08
FINAL

COMPETITION DECISION-ASSIST PACKAGE (CDAP)

by

Robert F. Williams

William B. Williams

G. Paul Bradley

The pronouns "he," "his," and "him," when used in this publication represent both the masculine and feminine genders unless otherwise specifically stated.

Information and data contained in this document are based on input available at time of preparation. Because the results may be subject to change, this document should not be construed to represent the official position of the United States Army.

US ARMY PROCUREMENT RESEARCH OFFICE
US Army Materiel Systems Analysis Activity
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EXECUTIVE SUMMARY

A. <u>BACKGROUND</u>. The Army has learned that competition is desirable in general for the production of its weapons, but that it must be evaluated on a case-by-case basis before it is applied. This guidance is intended to give the analytical staff of a typical project manager a framework for the analysis of production competition.

B. <u>OBJECTIVE</u>. The objective of this study is therefore to develop this guidance to allow the rigorous comparison of competitive and non-competitive alternatives and evaluate the relative benefits and risks of these alternatives. The product is to consist of an instructional guide with a program to be used by decision-makers onsite.

C. <u>SCOPE</u>. The research plan called for analyzing competitive effects and integrating the best features of various approaches in a set of guidance instructions. The economic analysis was programmed in a computerized decision model.

D. <u>CONCLUSIONS AND RECOMMENDATIONS</u>. The result of the study effort was the preparation of a proposed pamphlet designed to guide the project manager in his analysis of competitive issues. It is recommended that DARCOM adopt this guidance and promulgate it in a DARCOM Pamphlet, 715-XX series.

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CHAPTER I

INTRODUCTION

A. BACKGROUND.

Competition is a fundamental principle of American society. It is a concept that pervades all avenues of American life. By its nature it brings on the virtue of efficiency, economy, and innovation. Consequently, competition among firms is sought on the production of every Army weapon system. Unfortunately, history has shown us that competition is not an absolute good in Army acquisition. That is, it is not always possible or appropriate. For example, the expertise required for a weapon system may be held by only one firm, or the investment required for two producing firms prohibitive.

The Army has learned that competition is indeed desirable in general for the production of its weapons, but that it must be evaluated on a case-by-case basis before it is applied. Further, there are many variations of production competition that must be considered. Because of the importance of the competitive decision and its high visibility in both government and industry, acquisition decision makers, typically project managers (PM), make studies of competition on their particular projects.

The analysis required is often complex, and PM's may be concerned about the ability of their staff to perform a study that will withstand scrutiny or the efficacy of hiring consultants to handle such a critical part of their acquisition strategy. It is toward these concerns that the enclosed guidance was developed. This guidance is intended to give the analytical staff of a typical project manager, perhaps augmented by supporting command directorates, a framework for the analysis of production competition. Using this guidance gives the PM the assurance of having an accepted analytical approach with higher likelihood of accuracy and avoids the necessity of bringing in outside help to handle sensitive project data.

This guidance is based on the research and consultation experience of the Army Procurement Research Office (APRO) and APRO's survey of Army experience on competition in general. It covers the economic and noneconomic aspects of competition in a systematic framework.

B. STUDY OBJECTIVE.

The objective of this study is therefore to develop this guidance to allow the rigorous comparison of competitive and non-competitive alternatives and evaluate the relative benefits and risks of these alternatives.

C. STUDY APPROACH.

This study evaluated the various approaches to analyzing competitive effects and brought forward the best features in an integrated set of guidance instructions. The economic analysis lent itself to the use of a cost model and programming. After the model was developed, an interactive program, Competition Decision-Assist Package (CDAP), was written to allow the processing of the individual project data. The non-economic issues were found to be judgmental in nature and suggestions toward analyzing each issue are given. Nonetheless the non-economic portion of the analysis will be incorporated in CDAP later.

The results of the study were synthesized into guidance on how to make the competitive decision.

D. ORGANIZATION OF REPORT.

The report is modest in design. Chapter II will describe the development of guidance. Chapter III discusses the use of the guidance. The Appendix is the guidance itself in the form of a draft pamphlet.

CHAPTER II

DEVELOPING THE GUIDANCE

A. GENERAL.

The analysis of competitive alternatives is complex and filled with uncertainty because it speculates on the impact of competition on a sophisticated system on a number of economic and non-economic issues over a relatively long period of time in the future. The attempt, of course, is to find the most accurate and reliable analytical approach for the Army. Experience has shown that the competitive decision must be made on a number of criteria. Recent decisions have successfully grouped these criteria into economic and non-economic. The analysis of non-economic issues is fairly straight-forward systematic judgment. The economic analysis requires more treatment. This chapter discusses the rationale for the guidance selected.

B. GUIDANCE FOR ECONOMIC ANALYSIS.

Typically the competition of weapon system production requires investment. The economic analysis of competitive alternatives involve the comparison of non-recurring cost (i.e., Government investment) and recurring cost savings. Is the amount of savings worth the investment?

The estimation of non-recurring cost comes from the judgment of costs based on data on the system and the contractors involved. The guidance will describe the processing of the data and the type of judgments needed.

The recurring cost analysis is more complex. Actually there are a number of alternatives for analyzing this cost. The first alternative is regression analysis. An initial reaction to predict savings is to predict the competitive price and compare it to the sole source price. An approach found in the literature is a regression model with the competitive price as the dependent variable and other leading indicators (e.g., sole source price, quantity remaining) as predictor variables.[1,3,5] Unfortunately, the data has not supported a general theory explaining competitive pricing as a function of these leading indicators.

A more direct and simple approach is to compare submitted and imputed cost data from the incumbent and potential new sources for the competition at hand. [2] Unfortunately, this data is not always available. Moreover, objectivity is suspect and not particularly reliable over a number of years in the future. As competition information is somehow exchanged, contractors tender new, often drastically different data. Another disadvantage is that the new source data does not include production experience gained by the incumbent.

A third alternative is to try to recover the competitive savings history from previous competitions while considering the savings potential of the immediate program by projecting cost behavior of the firms.[4,5] In this approach the cost improvement curve slope for a firm in a sole source environment is contrasted with the curve slope of a firm in a competitive environment. These slopes are derived from the data base of previous competitions and cost data of the incumbent and prospective firms.

The cost improvement methodology was selected for the competition guidance because it has fewer disadvantages than the alternatives and, in fact, has met with more operational success. This approach, however, does require experienced judgment, from outside the organization if in-house expertise is not available. The guidance will describe how to use the cost improvement methodology in detail.

C. GUIDANCE FOR NON-ECONOMIC ANALYSIS.

Although one normally thinks of competition in terms of cost savings, competition has many non-cost impacts. One of the contributions of the guidance will be a list of the main factors found to be relevant to the competitive decision.

The first is quality or reliability risk. A buying activity must ask whether a new firm can make an item of the same quality as the incumbent firm. The primary factors to be evaluated are complexity of the system to be purchased, the condition of the technical data paackage describing the system to be produced, and the technical, financial, and managerial capability of the prospective firms.

Even though a firm may be able to make an item, there is a possibility it may not be able to make it in the time required. The schedule risk is a function of the above factors, the prospective new vendor structures, the amount of proprietary data, and the project management office's ability to administer additional producers (e.g., configuration management). Mobilization may be affected by competition. The analyst will have to establish whether mobilization is an issue for the system and, if it is, the impact of the competitive strategy on the time and cost of reaching mobilizating rate and the effect on surge capability.

Other factors are often relevant in a given situation. Memoranda of Understanding agreements may be affected. Existing arrangements with the prime such as warranties may influence the decision. Acquisition management (e.g., contractor cooperation) can be greatly enhanced by competition. Assessing these non-economic factors is largely a matter of judgment. Analysts must review these factors and the data concerning them and associate a level of risk with each factor. The guidance reflects this approach and has an option for those wanting to prioritize and score the factors for total "scores."

D. GUIDANCE FOR THE DECISION.

On the basis of the assessment of the economic and non-economic factors, the analyst will derive a position for recommendation to the decision maker. The guidance will describe a display of the information for the decision.

E. USAGE OF THE GUIDANCE.

This guide is designed to help users assess in a structure way the particular conditions existing in their program. Underlying the guidance presented here is a data base composed of a variety of systems. These systems were primarily in the missile and electronics areas, and they share the common property of actually having been competed sometime during production. Consequently, it may be that peculiarties of a user's program are inadequately treated by the guide. Users are expected to supplement the guide in considering these peculiarities.

The proper extent of any effort to evaluate the probable effects of competition depends on the value of the information gained. For very large systems (with potentially very large effects arising from the competition decision, e.g., $25 million and upward) it may be justified to establish a special team to carry out a more extensive evaluation than the guidance here provides.

In any event the guidance is just that--a guide, an aid in focusing thinking on the important decision factors. The aid is used in coordination with and as a supplement to judgment to enhance the manager's decision making.

CHAPTER III

RECOMMENDATIONS FOR IMPLEMENTATION

The competition decision on weapon system production is a serious one. It involves typically a large investment which should be recovered by competitive savings. The analysis is complex and rigorous. A mistake in judgment can be costly.

Expedient promulgation of the current CD :n a DARCOM Pamphlet, 715-XX series, is recommended even though a numbe. ꞏ potential enhancements are already envisioned. These enhancements would improve on the output presentation, expand the competition analysis capability, and increase the analytical self-sufficiency in the field. These improvements have been deferred in the interest of providing some guidance in this important area in the near future, but it is recommended that APRO incorporate them into CDAP as part of its continuing contribution to competition analysis. Because of the importance of a quality analysis and the fact that the demand for these analyses has increased, the kind of guidance described in this study is critical.

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NOTE: A comprehensive bibliography is provided in the draft, proposed pamphlet at Appendix A.

STUDY TEAM COMPOSITION

Robert F. Williams, Project Officer, Chief, Test and Evaluation Group, US Army Procurement Research Office, AMSAA, B.S., Aeronautical Engineering, University of Wyoming, 1963; Master of Commerce, OR/Marketing, University of Richmond, 1972; Ph.D., University of Alabama, 1982. Prior to joining APRO, Dr. Williams was an aero/systems engineer for six years with the Air Force.

William B. Williams, Procurement Analyst, US Army Procurement Research Office, AMSAA, Ft. Lee, VA; B.A., Davidson College, 1949; M.S., University of Richmond, 1962. Mr. Williams was formerly a technical writer, instructor, and course director. His instructional and course director assignments were at the Army Logistics Management Center in research and development and acquisition.

G. Paul Bradley, Operations Research Analyst, Systems and Cost Analysis Directorate, US Army Tank-Automotive Command, Warren, MI; B.S., Aeronautical Engineering, Northrup University, 1964; M.S., Industrial Engineering, Texas A & M University, 1968. Mr. Bradley was asked to collaborate with APRO on this study after his recent work on competition modeling. He developed the CDAP program described in the Appendices.

APPENDIX

COMPETITION DECISION-ASSIST PACKAGE (CDAP)

PAMPHLET

Headquarters

U. S. ARMY MATERIEL
DEVELOPMENT AND READINESS COMMAND

DARCOM PAMPHLET

715-X

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COMPETITION

DECISION-ASSIST PACKAGE

(CDAP)

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CHAPTER I

INTRODUCTION

A. GENERAL.

The competition decision is a serious one to a program because its outcome can affect program performance drastically. Many view competition as an opportunity to save money. Others fear competition will disrupt the orderly development of a program. The fact is that both of these outcomes can occur, among others. What is necessary is an analysis of each competitive situation to allow anticipation of what might occur if various competitive strategies are employed. In other words, each decision must be made on the merits of the individual case. This document is written to give decision-makers the ability to assess these merits.

Project Managers (PM's) have approached this analytical problem in many ways, ranging from a one-day effort by an analyst on the staff of the fielding of a multidisciplinary team involved in a sophisticated and lengthy analysis of diverse issues. PM's generally are going to agree, however, that the main criteria for the design of the analysis are rigor, accuracy, defensibility, security, and parsimony. A framework that features these criteria should be of assistance to the PM who may not have the resources to fully design the appropriate approach.

B. PURPOSE AND SCOPE.

The purpose of this document is provided the guidance to allow the individual PM to design his own approach. This guidance is based on competition studies recently completed in the Army. In using this guidance the PM can minimize the hiring of consultants and, at the same time, save resources and insure the security of program information. Because the procedures described have already been employed with some success, the PM can feel more confident in the accuracy and defensibility of the results.

Ultimately, however, the usage of the guidance is up to the individual manager. This guide is designed to help users assess in a structured way the particular conditions existing in their program. Underlying the guidance presented here is a data base composed of a variety of systems. These systems were primarily in the missile and electronics areas, and they share the common property of actually having been competed sometime during production. Consequently, it may be that peculiarities of a user's program are inadequately treated by the guide. Users are expected to supplement the guide in considering these peculiarities.

The proper extent of any effort to evaluate the probable effects of competition depends on the value of the information gained. For very large systems (with potentially very large effects arising from the competition decision, e.g., $25 million and upward) it may be justified to establish a special team to carry out a more extensive evaluation than the guidance here provides.

In any event the guidance is just that--a guide, an aid in focusing thinking on the important decision factors. The aid is used in coordination with and as a supplement to judgment to enhance the manager's decision-making.

The primary readers of this guidance should be the project managers and his analysis who must agree on the interpretation of each section. The appendix contains the Competition Decision-Assist Package (CDAP) which will be employed by the analyst, but should be understood by the PM.

In addition, the guidance can be used by the nonprogram manager, primarily procurement, who have to make competition decisions on non-program-managed items and appointed advocates for competition. The concepts described should be applicable to any competition.

C. ORGANIZATION OF THE DOCUMENT.

The next chapter will describe competitive strategies used in production and how to select the ones most favorable to an individual program. These strategies will be the ones evaluated in terms of cost and noncost issues in the next two chapters. Consequently, the following chapter will describe economic (i.e., cost) issues and how to evaluate them, followed by a chapter on the evaluation of non-economic issues. The last chapter is concerned with the presentation of the data for decision making display. The appendices describe the CDAP program and its use.

CHAPTER II

COMPETITIVE PRODUCTION STRATEGIES

A. INTRODUCTION.

Competition is the rivalry among firms to obtain Army business. The Army position should be to encourage this rivalry. There are many alternative strategies for obtaining this competition. This chapter describes the most effective competitive strategies and appropriate conditions for their use. A decision maker can use this chapter to find which, if any, of the strategies are feasible and contrast these feasible strategies with the sole source alternative(s) to find if savings and other benefits are likely and risks are acceptable. Chapters III and IV are useful in assessing these risks and benefits.

B. TYPES OF COMPETITION STRATEGIES.

1. Technical Data Package (TDP).

The TDP strategy involves the competition between the incumbent and a new source with the incumbent's TDP. The TDP is defined as a technical description of an item adequate for use in procurement. This description defines the required design configuration and assures adequacy of item performance. It consists of all applicable technical data such as plans, drawings, and associated lists, specifications, standards, models, performance requirements, quality assurance provisions and pacakaging data.

a. Validated TDP.

Definition alone is not sufficient for determining when a TDP is ready for competitive procurement. Criteria must be established by which the competitive status of the TDP can be judged. The term most frequently used to describe a TDP ready for competitive procurement is a "validated TDP." Other phrases used also include "mature TDP" and "proven TDP." (See p. 34)

b. TDP Risk on Initial Production Contracts.

On the initial production contract for Army hardware, the TDP may not have been validated according to the validation criteria. Risks are inherent in using an unproven TDP for the first time in production. The TDP may not accurately describe a system which can be mass produced -- resulting in the production of inferior equipment, delays in delivery, and increased costs due to frequent engineering changes. To counter these adverse effects the Army may rely on contractual provisions to share some of the responsibility for the adequacy of the TDP.

One example might be the inclusion of a Preproduction Evaluation Clause (PPE) in the initial contract. For further information, refer to DARCOM Pamphlet 715-6, "Preproduction Evaluation (PPE) Contract," 5 May 70.

c. Implications for Usage.

The TDP method is the one most often used in the acquisition of military equipment. A validated TDP is the most complete technical description which exists for military hardware. It has the advantage of promoting competition in Defense procurement and supporting the aims of the DOD with respect to standardization and interchangeability. There is a high probability that the validated TDP is an accurate description of hardware which meets the needs of the user. But the TDP is no panacea. It is very difficult to prepare a document of such technical detail without omitting some essential feature. Additionally, the manufacture of complex equipment usually entails more than documented instructions. "Know-how" is an intangible related to the production of an item which cannot be put down on paper. The TDP may also include proprietary features which may complicate the acquisition. In instances where the TDP cannot stand alone as a competitive instrument, other methods may be called upon to supplement the description. Leader/Follower may assure the successful transfer of technology in the event of "know-how" problems. Licensing can be used to counter the legal complications of proprietary data.

2. Form, Fit, and Function (F^3).

a. Definition.

The Form, Fit and Function (F^3) method is the description of military equipment by performance characteristics. The equipment is described in terms of output, function and operation. External configuration, mounting provisions or interface requirements may be included. But details of design, fabrication and internal structure are normally left to the option of the contractor. F^3 is the classic "black box" concept where it is not necessary to define the internal workings of the products. The method is also referred to as the "freedom of design" alternative.

b. Advantages.

(1) Increased competition can be expected. Since a variety of technical approaches may result in a product giving the desired function, it is certainly probable that more potential sources are available. It is also likely that the increased competition will mean lower prices.

(2) The F^3 description encourages innovation and ingenuity. Private industry is not constrained by Government designs. Contractors are given extensive design latitude and are expected to provide new approaches and concepts.

(3) The responsibility for meeting performance is placed squarely upon the contractor. Responsibility for adequate design is vested in the contractor. The Government is able to get out from under the doctrine of implied warranty which is associated with design descriptions. The doctrine states that "if the (design) specifications are followed, a satisfactory product will result." In other words, the burden of performance is upon the Government if the contractor adheres to the design requirements.

(4) The problem of procuring or maintaining a Technical Data Package is removed from the Government. Technical data is expensive; configuration control is troublesome and costly.

c. Disadvantages.

(1) The overriding disadvantage of the F^3 description relates to logistic implications. The likelihood is that, over time, a number of different items will be purchased, all of which conform to the functional description. Yet they will not be alike internally. Standardization and interchangeability will be adversely affected. The number of repair parts for stockage will increase. Operational and maintenance training will be required for each item of equipment. The problems are magnified for maintenance and supply personnel in field units who are required to support equipment under already less than ideal conditions.

(2) It is alleged that the performance specification is more apt to encourage the marginal producer to bid lower than he would were a design package required. The low bidder may not appreciate the engineering effort required to meet stringent performance requirements. To counter this threat the Government must place greater reliance on source selection criteria. The

criteria must be carefully constructed to include the means to evaluate contractor awareness of critical elements as well as the capability to produce the item.

(3) Performance specifications place more emphasis upon testing. Qualification (first article) testing will be essential since one may be dealing with an unproven design. Initially, the added requirement for testing may not appear to be a disadvantage. However, it must be remembered that structuring tests requires creativity. In addition, it is possible that test equipment must be built. Finally, the tests may be time-consuming and costly, factors which may be overlooked in a superficial analysis of the proper method to be used.

d. Implications for Usage.

Normally, F^3 specifications are best used for the acquisition of expendable, nonreparable items where systems performance is not dependent upon internal configuration of components. Commercial off-the-shelf and modified commercial items especially meet this definition. Even in circumstances where the items are reparable, the F^3 description can be expected to be applicable for commercial items because responsibility for repair and stockage of parts can remain with the supplier. Typewriters and ADP equipment are examples of such equipment.

Although F^3 specifications are more appropriate for nonreparable items, they are also used for totally different types of military equipment; e.g., generators and military construction equipment. Generally, systems in this category are quasi-commercial with a mix of military and commercial characteristics. Because Government TDP of the design type is not imposed, more competition is achieved and industry retooling is not required. On the other hand, field maintenance support of the equipment in this category can be a special problem as described in the F^3 disadvantages. The difficulties--repair part support and maintenance training--can possibly be alleviated through the use of special contractual arrangements. These include warranty provisions, renewable maintenance contract provisions, and service contracts which require the equipment manufacturer to support the equipment throughout its operating life. Multiyear contracts would tend to standardize the items being purchased over a longer period of time.

3. <u>Leader/Follower (L/F)</u>.

a. Definition.

The leader/follower (L/F) method is an acquisition technique under which the developer or other producer of an item or system (the leader company) furnishes manufacturing assistance and know-how or otherwise enables a follower company to become a source of supply for the item or system (DAR 4-701).

b. Procedures.

Three procedures are available for implementing the L/F technique (DAR 4-703): the Government contracts with the leader who subcontracts with the follower, the Government contracts with both, and the Government contracts with the follower who subcontracts with the leader for assistance.

(1) Award of a prime contract for supplies to an established source (leader) who is obligated to subcontract a part of the quantity to a specified or competitively selected subcontractor (follower). The leader is also required to furnish technical assistance to the subcontractor in producing the subcontracted quantity.

(2) Award of a prime contract for a part of the total requirements for supplies to the leader company. In turn, the prime contract also obligates the leader company to provide technical assistance to the follower who has a direct contract with the Government for the remaining portion of the total requirements.

c. Planning for L/F.

Early planning for L/F not only facilitates later use but also provides lead time to industry for its planning. *Reaching an L/F agreement in* principle with the developer during the R&D phase is recommended. The agreement provides leverage and motivation with the evential leader. It makes it clear to all parties early in the acquisition that production competition is anticipated. The contractors cannot at a later time accuse the Government of breaching faith or changing the rules.

d. L/F and the Technical Data Package.

(1) The L/F method is closely akin to the Technical Data Package method of achieving competition. The L/F method presupposes the existence of a TDP adequate for competition. Whether or not a validated TDP is a prerequisite is subject to debate. Delaying competition until the TDP is validated may effectively prohibit obtaining realistic competition due to an insufficient quantity of items remaining to be produced. Using a TDP which is not validated may mean technical problems resulting in schedule slippages, increased engineering changes, and concomitant increases in costs. Certainly a validated TDP is desirable, but a production TDP which has evolved from R&D may be sufficient. The leader company is expected to bridge the gap between the initial production TDP and the validated TDP. The leader complements the TDP with its knowledge of system production.

(2) Generally, L/F is used in conjunction with the TDP in the following circumstances:

(a) A system of moderate complexity has evolved from research and development.

(b) The transfer of technology cannot be accomplished through the TDP alone; technical assistance is required in order to provide the manufacturing "know-how" essential to the successful production of the hardware.

(c) The system is essentially new with production only by the developer of the system.

(3) The advantages ascribed to L/F as opposed to using the TDP alone are:

(a) A higher assurace of successful technology transfer.

(b) Accomplishing production qualification at an earlier date thereby increasing the opportunity for competition.

(c) Ability to assign reliability and warranty responsibility.

(4) The major disadvantage of L/F is the large amount of money required to bring the second source up to performance.

e. Industry Surveys.

Industry willingness to participate as followers in a L/F acquisition is obviously essential to success. In many instances project management personnel or acquisition managers may be able to make this determination through its knowledge of the firms with which it does business. On the other hand it may be necessary to conduct physical surveys to gather information on selected potential bidders. The survey should lead to a detailed analysis of the following:

(1) The desire of specific firms to participate as followers.

(2) The determination of open capacity available for producing the system or component.

(3) Special tooling and equipment required to support quantity production.

(4) Acquisition lead times to obtain tooling and equipment.

(5) Costs associated with getting ready to participate as follower.

f. Implementation of L/F in the Army.

(1) Applications of L/F in the Army have resulted in significant cost savings. Real competition was generated; the follower became a viable competitor of the leader. An examination of these successful programs noted the following essential characteristics.

(a) First year production of the system by the developer-leader, during which time the TDP is validated.

(b) Concurrent with the release of the first production equipment, a competition among established producers for selection of a second source.

(c) Award of an educational buy (see next paragraph) with option provisions to the follower to enable him to become proficient in manufacturing the hardware.

(d) Follower production of a small quantity of items for qualification testing, with technical assistance furnished by the leader.

(e) Exercise of option by the Government so that follower can demonstrate his capability to achieve quantity production. (Unless the leader has the capability to produce quantities needed by the Government, leader/follower will not accomplish the purpose for which it is intended--competition in the full production phase.)

(f) Split buy award between leader and follower to build up production capability of follower.

(g) Buy-out, winner take all competition, for full production quantities.

(2) These historical acquisitions were conducted under relatively ideal conditions--stable budgets, large quantities, and short acquisition leadtime. Today's conditions are different. To use L/F successfully, steps will have to be taken to compress the schedule. Acquisition decision makers will need to be innovative, finding shortcuts without taking undue risks.

4. Educational Buy.

a. Definition.

An educational buy is a contract to provide a firm the opportunity to learn how to manufacture limited production quantities of a military item of equipment in accordance with a Government TDP. Normally, the purpose of the method is to generate a competitive second source for an item which has previously been bought noncompetitively. The second source contractor is usually selected as a result of competition, although the source can be directed by the Government.

b. Advantages of the Educational Buy.

(1) The educational buy can be an excellent method of enhancing competition.

(2) It is likely to be much less costly to implement than L/F, licensing or teaming.

c. Disadvantages of the Educational Buy.

(1) The use of the method to develop a second source is time consuming. A realistic schedule must be provided to allow the second source

time to learn how to produce the item, time for a gradual production rate build-up, and time to permit valid testing.

(2) Its use may be limited, e.g., it may not be feasible to use the method by itself for second sourcing complex items.

5. Directed Licensing.

a. Definition.

The directed licensing method is akin to leader/follower in that the leader provides data and assistance to help a follower become a qualified producer. However, with licensing, not only is assistance provided but the developer (who may be the leader or subcontractor of the leader) is selling or renting something he owns (patents, trade secrets, etc.).

The directed licensing method consists of the use of a special provision (1) as part of a contract between the Government and developer or sole producer of an item or system, or (2) as a separate agreement between the developer or sole producer and another potential producer whereby the developer or sole producer agrees to gant authoritative permission to another source for the production of the item or system. Rand, who has performed most of the research in licensing, has coined the following definition. "The directed licensing concept consists essentially of having the Government obtain from a weapon system developer, at the time of issuance of the development contract, a contractual commitment for rights to production data and an agreement to license whomever the Government designates to produce the weapon system during any or all production runs, following initial production by the developer. The developer would agree to provide a data package and such technical assistance as may be required to get the new contractor into production. The development contractor would be compensated for his efforts by fees and royalties agreed upon at the time of initial commitment," As with other second sourcing methods the objectives of licensing are twofold, expanding the production base and enhancing price competition.

b. Applicability of Directed Licensing.

Directed Licensing has limited applicability for major systems in the Army. Licensing is primarily applicable when the technical data or patents were generated by the developer or sole source at his own expense and the rights to that data clearly belong to the developer/contractor. Most major systems in the Army have evolved through a Government-financed R&D cycle. Hence, the Government owns the TDP and the need to license the systems does not exist. But it should be recognized that a system is made up of many parts. These parts, major subsystems or components, may have been developed with private funds. Subsystem or component licensing thus becomes a distinct possibility and appears to offer the greatest hope as a viable competition alternative within the Army.

6. Contractor Team Arrangements.

a. Definition.

Contractor team arrangements are described in Section 4-117 of the DAR. The DAR recognizes two distinctly different types of teaming:

(1) The prime contractor arrangement where two or more companies form a partnership or joint venture to act as a potential prime contractor.

(2) The prime-subcontractor arrangement where a potential prime contractor agrees with one or more other companies to act as his subcontractor(s) under a specific Government acquisition.

b. Applicability.

Teaming allows team members to complement the unique capabilities of each and to offer the Government the best combination of capabilities to achieve the system performance, cost and delivery desired for the system being procured. In the DOD the method has been applied in the following circumstances:

(1) Research and Development (R&D). Teaming has been primarily associated with research and development contracts where the combined expertise of two or more companies has been necessary to design and engineer products to meet complex military requirements.

(2) Production contracts. The DAR acknowledges, almost as an afterthought, that teaming might be appropriate for other situations, including production contracts.

c. Criteria for usage.

(1) Moderate to high level complexity. In the context of which teaming is discussed in the DAR system complexity underlies its application. It is assumed that the development of major defense systems might from time to time be beyond the design capabilities of a single industrial concern. In such circumstances drawing together the technical talents of two or more companies in some form of legal teaming arrangement is a feasible way of assuring the Government's requirements can be met.

(2) Parity of subsystem. Major systems are composed of subsystems. Teaming, as a competition technique, requires near equality among team members. Therefore, if one subsystem and hence one team member is dominant, it would appear unlikely that the lesser team member would ever be in a position to seriously compete during the production. One system is composed of several

black boxes, all of nearly equal complexity. In this connection, it can also be concluded that the prime-subcontractor teaming arrangement is not preferred on those teaming programs where production competition is envisioned between team members. The joint venture or partnership arrangement is recommended.

(3) Program stability and large production quantity. As with any major competition scheme, high volume and stability are essential. It is even more imperative, when two or more major firms are being asked to commit themselves for both the R&D and production phases of the program.

(4) Dollar ranges where competition can be expected to result in significant benefits. This primarily applies to unit costs of each system to be produced rather than total program costs. When unit costs are high, it can be expected that there will be greater opportunities for efficiencies and economies through competition.

(5) Expectation that each team member will have the capability of producing the entire system at the conclusion of R&D. This means that each has the facilities and technical and managerial talents to manufacture the system without the assistance of the other team member.

d. Advantages of Teaming.

(1) Price competition throughout the life of the program. Price is emphasized during each contract proposal evaluation throughout the R&D and production phases. Of particular value is the assurance of competition earlier in the production cycle.

(2) Acceleration of combat readiness. The availability of two sources from the outset of production insures higher production rates and faster deliveries.

(3) Full design data disclosure. Team members are required to share technology; hence no information concerning proprietary processes or techniques can be withheld from team members of the Government. There is, in effect, a cost-free sharing of technology and no need to procure a full unlimited technical data package.

(4) Enlargement of the industrial base. The erosion of the defense industrial base is frequently cited as a major problem of the U.S. economy. Teaming results in the creation of at least two sources fully capable of independently manufacturing the total system.

(5) Enhancement of design competition. Smaller contractors who do not have the in-house capabilities to compete independently on major acquisitions may compete through teaming arrangements.

7. Other Strategies.

In addition to the basic competitive and non-competitive strategies, there are others that may be contemplated. Examples are associate contractors, component breakout, and multiyear contractor. The analyst is encouraged to consider these alternatives (or variations of those covered) on the basis of available literature.

C. SELECTION OF FEASIBLE COMPETITIVE STRATEGIES.

Based on the criteria of this chapter the decision maker and/or analyst will have to decide what strategies are feasible. These strategies will then be analyzed in more depth in the economic and non-economic chapters to follow. In the CDAP example, variations of the TDP strategy will be analyzed for simplicity in the economic portion.

CHAPTER III

ECONOMIC ANALYSIS

A. GENERAL.

In the most general sense the economic analysis deals with an examination of the overall cost associated with each strategy under consideration relative to expected cost of a sole source procurement. Considered in this analysis are the non-recurring costs of introducing a second source and the year by year recurring costs associated with production operations. The end objective is to determine what changes in the program cost could be expected to occur by adopting any one of the identified alternatives.

Estimating the individual elements of cost of competition involves two different approaches. Non-recurring costs tend to be more directly identifiable and consequently lend themselves to a "bottoms-up" estimation. Recurring cost estimating represents an entirely different problem. Generally they are spread over a long period of time and are subject to many influences. As a result, considerably more uncertainty is inherent in estimates of recurring cost. Second sourcing compounds the uncertainty in these estimates. In order to deal with this uncertainty and to also allow for possible influences of a competitive procurement environment, a quantitative model is needed for use in estimating the recurring cost portion of the analysis.

B. NON-RECURRING COSTS.

Non-recurring costs are those that occur one time or do not vary with quantity and time. Non-recurring costs may be limited to start-up costs for a second source and capacity adjustments to meet future production needs. These costs include special tooling and test equipment, training, initial manufacturing engineering, technical data package evaluation costs, plant rearrangement and others. Facilities and capital equipment may be excluded because, one, the second source RFP may not allow direct charge of these items, and two, normal accounting practice is to depreciate these items over time and charge depreciation to overhead, a recurring cost. The analyst will have to decide on the inclusion on the individual case.

Start-up costs consist of start-up capacity costs (non-recurring) and initial production penalty costs (recurring). Start-up capacity costs can be assessed directly by examining second source budgetary estimates. Initial production penalties are calculated by subtracting the expected sole source price to produce some expected quantity (e.g., an educational buy) and start-up capacity costs from estimated second source prices for this quantity. Uncertainty intervals for prices should be calculated to reflect uncertainty about such matters as the quality of the TDP and about negotiations to be conducted during second source selection.

In order to understand both recurring and non-recurring costs, one must understand the firms' approaches to production. Each of the firms has a slightly different approach to programming the production of the system which reflects its existing conditions and circumstance. The cost of capacity adjustments for various production quantities can be calculated by evaluating the incumbent and prospective firms' production program. The analyst must anticipate the change in vendor tooling, plant rearrangement, training, engineering, special test and inspection equipment, gauges, fixtures and special tools needed by the firm and its subcontractors to meet any rate contemplated for the system. Further, the additional plant and capital equipment additions for future production rates may also be required.

C. RECURRING COSTS.

1. General Approach.

While specific details of studies on competition vary, one factor is common. This factor is the general relationship of individual unit cost to quantify produced. For items in quantity production, the cost of individual units tends to decrease as the quantity produced increases. Although the specific relationship can take a number of different forms, the generally accepted relationship is as follows:

Unit Cost = (First Unit Cost) X (Unit Number)^{B}

Where B is a function of the rate of improvement.

The given relationship says that as the quantity produced doubles, the unit price will be a fixed percentage less than the unit price that occurred prior to the doubling. For example, if a 90% improvement rate is being observed, the cost of the 200th item will be 90% of the cost of the 100th item. This relationship formed the core of the cost model used in this guide.

The given unit price performance relationship lends itself very nicely to developing estimates of recurring cost. Basically, there are only two parameters that must be estimated in order to project the cost of any item in a given production run. These parameters are the first unit cost and the rate at which unit price improvement can be expected to occur. By calculating the unit price of each item in the total production run and summing the results, one obtains an estimate of the total recurring cost associated with production operations.

While a quantity-price relationship is common to studies of competition on program costs, the use of this technique must consider the specific program being evaluated. For example, treatment of the expected unit price improvement rate can influence greatly the developed results and is highly dependent on the specific items being evaluated. Adding to the problem of complexity is the projected behavior of the individual unit price improvement relationship parameters to the introduction of competition. It has been claimed that increased improvement slopes occur after competition begins or that downward shifts in the unit price can be expected. It is even possible that combinations of the preceeding effects will be observed.

A recurring cost model must be flexible enough to accommodate various changes to price improvement parameters. The model must also allow the total production effort to be broken down into segments corresponding to specific contract awards. Due to the uncertainty inherent in a study of this nature, specific parameters are treated appropriately. the final model can then combine these features into a process that allows generation of recurring cost estimates having a probability distribution.

As was noted previously, the foundation of the model used to develop recurring cost estimates for this analysis is a unit price vs. production quantity relationship. This relationship is often referred to as unit learning curve theory. According to this theory, total recurring cost can be represented as the sum of a declining set of unit costs represented usually by the following function:

$$c = \sum_{q=q_1}^{q_2} aq^b$$

In this relationship a represents the first unit cost, b is the rate of cost improvements, and the production quantity of interest extends from unit q_1 to q_2.

When using the given expression as a basis for evaluating possible effects of introducing competition into an on-going program, several modifications to the relationship are required. First, since it is common to have several delivery years embedded within the total production effort, it becomes important to deal with the time value of money. Consequently, an appropriate discount rate needs to be introduced into the expression. Further, the impact of competition itself on the fundamental expression parameters must be accommodated. A shift in unit price from the expected sole source values can be represented by an equivalent shift in the first unit cost. Similarly, changes in the rate of price improvement can be modeled by adjusting the expression exponent an appropriate amount. As a result the basic relationship becomes the following for year i:

$$c_i = \alpha_i p_i \sum_{q=q_{i-1}+1}^{q_i} a q^{(b-\sigma_i)}$$

In this revised expression, α_i represents the discount factor for year i, q_i represents the production experience of a producer at the end of year i, p_i is the percent reduction in unit cost at year i due to competition, and σ_i is the relative change in price performance improvement rate at year i due to competition. For any given production year any one of the adjustments could be applied, or it may be assumed that no adjustments are necessary and the expression reverts back to its original form.

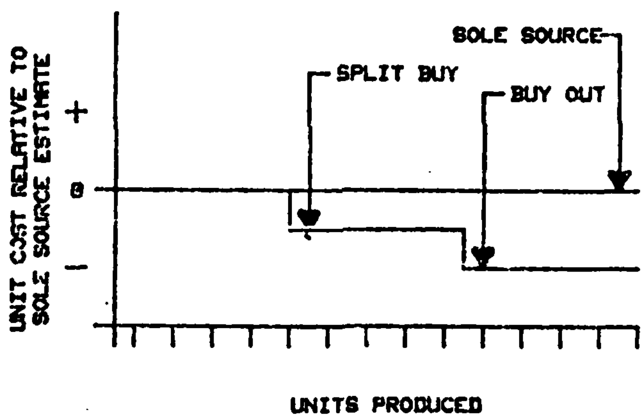
The actual adjustments made to the baseline expression in order to describe possible influences of competition have been the source of considerable discussion. For this reason adoption of the modified expression is adopted here since it can accommodate a price shift behavior and changes in price improvement rate in any combination for a given production year. By evaluating the given expression for each program production year and making assumptions about the parameter changes upon the introduction of a second source, it is possible to calculate a total alternative recurring cost estimate in constant dollars and discounted constant dollars. This can be done for a number of parameter combinations. The costs computed for a given alternative are highly sensitive to the adjustments made to reflect competition. This observation combined with the already known uncertainty inherent in the analysis require additional steps to be taken in developing recurring cost estimates.

Various studies have suggested that one approach to handling the uncertainty question is through a computer simulation of the program being studied. This is especially valuable where several types of production awards are being evaluated within the one program. For example, a sole source period may be followed by a period of split awards with a concluding buy out. Each of these phases in the production effort could be expected to create entirely different influences on the basic cost relationship parameters. In consideration of the variations of the alternatives being evaluated in this analysis and the inherent level of uncertainty, the final recurring cost estimating model will be calculated in the form of simulation.

In this model the individual factors of the basic cost relationship are treated as a distribution of values having minimum, maximum, and most likely magnitudes. For example, the first unit cost along with a baseline cost improvement rate are given minimum, maximum, and most likely estimates. The actual range reflect the general level of uncertainty. In addition to baseline parameters being given distribution estimates, expected competition adjustments are also treated in the same manner. For the years that competition is present, anticipated unit price shifts and any price performance rate adjustments are also treated in the same manner. For the years that competition is present, anticipated unit price shifts and any price performance rate adjustments are given minimum, maximum and most likely estimates. By treating each of these parameters in this manner it is possible to develop a corresponding comulative probability distribution for each factor. The model can then select on a random basis individual values for each factor. The model can then select on a random basis individual values for each parameters of the cost relationship for each production year and compute the associated recurring cost. By repeating the process many times a range of possible alternative costs is developed having a corresponding probability distribution. As a result, it is possible to discuss a given alternative recurring cost estimate in terms of its most likely value and associated range of values.

Since one aspect of several alternatives is split awards between two sources, an influencing factor on the estimated program recurring cost is the quantity awarded to each producer. Costs associated with each supplier are related to the number of units produced which could vary depending on how split buys were awarded. Although it is possible to treat split award quantities in the simulation model, any decision rule would be too speculative to be valid. Consequently, for period within a given alternative that are based on split awards between the sources, each producer can be treated as having equal performance with equal quantities. This has the net effect of reducing the sole source quantity to half its original magnitude for two suppliers with the associated unit price not reaching as low a value on the price performance curve. In order to overcome the lost price performance that would have been achieved by the sole source supplier, some influence of the competition, such as a unit price shift, is considered for introduction based on the competitive circumstances.

In dealing with unit price shifts within the model, the point of reference for the given shifts is the expected sole source unit price. This should be done for all shifts that might be projected at various points within the production cycle. An example of this procedure is the alternative containing both split buy and buy out periods. Unit price shifts are introduced at the beginning of each period and are referenced to the original projected sole source unit price curve. This is illustrated in Figure 3-1.



TREATMENT OF UNIT PRICE SHIFTS RESULTING FROM COMPETITION

FIGURE 3-1

One final note regarding the model concerns treatment of monthly production rate efficiency relative to achieved unit cost. In addition to the previously discussed influences on unit price, monthly production rate also can have an effect on actual unit price values. If the number of units being produced falls below the quantity required to sustain the production resources at their rate of best efficiency, a loss in price improvement will occur. In evaluating the various second source alternatives, those cases involving split award periods represent possible loss of production rate benefits from the sole source supplier due to a reduced quantity being awarded to the individual producers. The recurring cost model allows for this situation by incorporating upward shifts in the expected unit price. In Appendix B sample outputs from the model provide displays of projected costs. A cumulative probability vs. strategy cost is given along with the associated probability density. Individual production year data is also given.

2. <u>Types of Recurring Cost Inputs</u>.

It is assumed that most sole source and second source strategies contemplate paying for all possible items, except Systems Technical Support, under a single contract unit price. Therefore, costs can be segregated into contract prices for hardware, Government administrative costs, other program costs, and spillover effects.

Contract Prices for hardware often include unit hardware cost, all capital equipment including facilities (assumed to be capitalized and depreciated), tooling amortized directly to contracts, sustaining tooling, manufacturing engineering, plant rearrangment, quality control, testing, ECP's, contractor program management, first destination transportation costs, vendor tooling, correction of deficiencies where appropriate, Pre-production Evaluation of TDP's, handling of GFE, and other miscellaneous costs. Contractor General and Administrative expenses, profit and facilities capital cost of money can also be included.

Government administrative costs can be estimated from data supplied by the system project management office. They include: incremental PM administration, additional testing, contract administration, logistics, maintenance, and engineering government costs.

Spillover effects to other Government programs must also be consistent. There may be cost increases to other systems made by the incumbent due to lower volume lost to a competitor and cost reductions in programs already being made by a new producer.

Other program costs potentially affected by a second source program are contractor systems technical support (e.g., ECP processing), contract data requirements, government-furnished equipment, product improvement programs, and spares. These again will have to be assessed on a given system.

3. Data Sources.

A variety of sources must be used to estimate the economic effects of competition. Typically they will include historical data for the commodity class, historical competitive data from other systems, prior studies concerning competition on the system, the incumbent's contract performance to date, second source proposal cost data (if any), the incumbent's budgetary cost estimates, and the PM's Baseline Cost Estimates.

4. Major Contracting Factors Affecting Recurring Costs.

Several contracting factors may affect competitive pressures for the acquisition. The primary factors are considered to be the timing of competition, split buy guarantees, and multi-year contracting.

Stable design and program quantity remaining determine the optimal timing of competition. The TDP may not be available for competition until a certain date. At least a certain percent of the program quantity must be available for a viable competitive strategy. Split buy guarantees tend to reduce competitive pressure. Multi-year contracts should enhance competitive pressures. The effects of contract features, contract type, data requirements, solicitation type, capital equipment depreciation methods, and the incumbent sunk start-up costs may be important.

5. Selected Input Distributions.

The basic model inputs derived are the sole source baseline (first unit and curve slope), curve rotations and shifts under competition, and production rate penalties. Ranges of uncertainty must be judgmentally assigned, based on the program, the system, and system empirical data.

The sole source strategy values can be found from the review of the PM's Baseline Cost Estimate updates, the incumbent's historical data and contract negotiations to date. It is possible the incumbent firm's claim for its learning curve slope will be steeper than indicated by current data and historical evidence. If the issue cannot be resolved, the analyst may want to use two or three sole source slopes to discern sensitivity in the results.

It is possible the new firm may introduce some innovation or otherwise be able to reduce cost at a faster rate than the incumbent. In other words, the firm may be able to rotate its learning curve slope down to give a greater benefit of competition. In order for a new firm to have a steeper learning curve, certain conditions will have to be present. Labor cost will normally have to be a large part of cost to have an opportunity to improve learning. A small "value-added" by a firm leaves little chance for a steeper stop. There will have to be an opportunity for the new firm to operate more efficiently; if the incumbent is at the state-of-the-art in terms of production technology, it is unlikely the new firm will reduce cost. Opportunities for and improvements are less if there has already been competition and other cost reduction activity in the program.

The most important estimate to be made is the one-time cost reduction one can anticipate from competition. Rather than a change in slope, this is the learning curve shift often resulting from competition. This saving comes from the new firm's "sharper pencil," a willingness by management to accept lower margin, absorb more cost, or to take some other discretionary action. Careful judgment comes to play here. One must consider the current cost structure and level of cost in the current program and a new firm's opportunity to offer a lower price. To help in this judgment, it is important to consider what others have done under competition. The most appropriate data base is the competition savings from similar commodities or from the firms of interest. Next in use would be the savings data from other commodity competition.

Normally one can assume a U-shaped production rate curve (cost vs. production rate) for a given plant structure, but it is possible a curve may have to be derived for peculiar set-ups. In any event the analyst should attempt to derive rate penalities from the incumbent and interested firms for the quantity schedule anticipated.

After making judgments on learning curve rotations and shifts, production rate effects, and the uncertainty in these judgments for each strategy (e.g., multi-year TDP "buy-out" or single year TDP split-buy), the analyst can start to initiate the cost calculations. At this point he or she will have to decide on the discount rates to be employed. Two recommended values are 0% and 10% (from Army economic analysis doctrine).

The analyst should also educate decision makers on the kind of dollars to be used in the analysis. It should be stressed that discounted constant (i.e., based on a given year inflation rate) dollars are the fairest most objective basis for comparison of complex competitive strategies. The analyst may have to additionally do the comparison on other bases (e.g., escalated dollars) for other usage (e.g., budgeting implications).

CHAPTER IV

NON-ECONOMIC ANALYSIS

A. GENERAL.

The non-economic issues that may represent risks or benefits in the introduction of competition have to be considered along with the cost effects. Because there are so many non-cost impacts, the analyst must develop a conceptual framework to assist in isolating only those issues significant to the immediate competition for examination.

A primary concept for determining the scope of the analysis is to examine only those issues that are truly determinant to the competition decision. Thus a certain issue, such as downstream configuration changes, may be important to the system development, but it may be irrelevant for competition alternatives. Note also that competitive alternative evaluations are only meaningful when compared to alternatives such as a non-competitive baseline evaluation.

Another basic rule is to group issues by objectives of the acquisition. Minimization of cost is a main objective and is, of course, the concern of much of a typical analysis. The primary non-cost objectives of an acquisition are to maintain the develiery schedule and meet the technical requirements for the system. In addition, on a given program the PMO may be interested in other objectives such as meeting mobilization plans, meeting RSI and other foreign commitments, maintaining good acquisition management, and satisfying higher headquarter objectives. This chapter will discuss these objectives in terms of both the risk that they may not be satisfactorily accomplished and their potential enhancement because of competition.

It is always a good idea to use as much quantitative information as possible, but not to shrink from statements of expert judgment on the issues. It goes without saying that the analyst must gather every piece of information possible, particularly when more qualitative analysis is performed.

To roll up the overall assessment of an issue, an analyst might assign some sort of relative rating such as low, medium, or high risk.

Because there are powerful constituencies on both sides of the competition decision, the analysis will undergo a considerable amount of scrutiny. This scrutiny will fall heavily on the non-economic side of the analysis because of the large degree of judgment. This behooves the analyst to insure the analysis is all-inclusive, that all information is obtained, and that judgments are corroborated. The difficulty in accomplishing these tasks depends on whether the analyst has any concrete indications that the prospective firms can make the system. Such information can vary from an actual proposal, which would lend great credibility to judgments, to no information on the firms, which would lead to weaker judgments.

The remainder of the chapter deals with treatement of individual issues.

B. SCHEDULE RISK.

Since this guidance involves production competition probably over a number of contracts with a number of important dates, the analyst will have to find from the decision maker what schedules to pursue.

The most important is, of course, hardware delivery. Research has shown that a new source will typically suffer an unanticipated slippage in delivery. This will, therefore, be a determinant factor in most analyses. The risk of hardware slippage is a function of the complexity of the system, the producibility of the system, the condition of the specifications of the system, the capabilities of the prospective firms, the capabilities of the government office, the resources of that office, and a number of external factors.

A primary source of risk is the inherent complexity of the system and its state of development. That is, a new firm may have difficulty in replicating state-of-the-art designs and, if the production of the system is still experiencing change, difficulty in tracking the configuration of the design. Beyond the design, there may be a problem if the producibility of the system is particularly troublesome or much of the production process is not included in the technical data package (TDP).

It is imperative that the technical data package be validated; that is, the new firm should have assurance that following the TDP will produce an exact operational replica of the system being produced by the incumbent firm. At least five criteria should be considered in deciding the level of production readiness, i.e., of validation, of the TDP:

1. Successful completion of initial production test (IPT)
2. Completion of physical configuration audit (PCA)
3. Determination that hardware design is stable
4. Production of system on "hard" tooling
5. TDP conformance to level 3 (form 1) requirements of DOD-D-1000B.

One should not underestimate the rippling effect of difficulty resulting from a TDP with even a few flaws. One phenomenon that is quite possible in contemplating competition is that the incumbent contractor may become slow in delivering the TDP. The Project Management Office (PMO) must be alert to this occurrence and monitor the progress of TDP development and logistics. Moreover, a considerable amount of proprietary data can require new design and thus lead to schedule disruption.

The technical, financial, and managerial capability of the prospective firms must be considered in assessing schedule risk. This kind of assessment is beyond the responsibility determination of a pre-award survey. The analyst must decide whether the prospective firms have the ability to handle the specific requirements of the given system at a given production rate over its entire life cycle. In the absence of relevant experience on the system, probably the most difficult assessment is the ability to manufacture the hardware. Particularly important is the availability of facilities and machine tools, experience of production personnel, and vendor structure. It may take an unacceptable amount of time to prepare for production.

The government has to also face its own abilities to be able to support a competitive strategy. The PMO staff must have the necessary inhouse skills and resources to design the strategy and then execute it, or be able to obtain them.

Many other factors can, of course, introduce risk to the delivery schedule. For example, the new firm can experience a strike or its plant can burn down; or government requirements can be expanded. Guidance for these isolated events is too broad, however, to be useful.

C. PERFORMANCE OR RELIABILITY RISK.

Virtually the same list of factors that affect schedule risk affect performance risk. Limited research results suggest that product quality can be maintained from new sources if testing is adequate. The biggest cause for concern is the production capability of the prospective firms. The best technical expertise of the government must be brought in to consult on this critical question.

D. OTHER RISKS.

As mentioned earlier each system has its own list of other objectives that are at risk under a competitive strategy.

Mobilization readiness is a major objective for many PMO's. Competition can enhance or degrade mobilization capability. One part of the basic competitive analysis is finding whether the prospective firms' can meet the basic production rates of the contract. Beyond this analysis, the PMO must ascertain that these firms can achieve the extreme mobilization rates and find if they can produce any cheaper or faster than can the incumbent. Another important criterion is whether having a new source will assure greater surge capability by virtue of introducing a labor supply (and reducing risk of a strike with the incumbent holding up production), introducing a corporate entity (and reducing risk from incumbent technical or business failure), and geographical dispersion (and reducing risk from catastrophe).

It is entirely possible the PMO will have an agreement with some other organization that might be jeopardized by competition. One example is a Memorandum of Understanding (MOU) with another country for the future production of the system by a foreign producer. In this case a form, fit, and function competition might violate the conditions of the MOU. Similarly, all agreements with other PMO's on some integrated acquisition or logistical effort must be scrutinized.

Improved acquisition management may be an explicit goal for competition in some programs. This is another issue that competition could affect positively or negatively. If the incumbent contractor has not been cooperative with the PMO and the new firms are truly viable sources, it is likely competition will make acquisition management with the incumbent more successful. On the other hand, the evidence shows the PMO will have more administrative workload when two concurrent sources have to be supported. If the strategy leads back to one source, the manpower problem is resolved.

There are opportunities for other benefits. Genuine competition can greatly increase the leverage the PMO has over the incumbent and improve contractual cooperation. A new firm may introduce new vendors who may deliver better performance and provide an enhanced industrial base. As discussed earlier a new source may help meet mobilization objectives. Additional non-economic benefits will have to be assessed on a case-by-case basis.

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APPENDIX A

CDAP
COMPUTER PROGRAM
DESCRIPTION

CDAP COMPUTER PROGRAM DESCRIPTION

A. INTRODUCTION.

The CDAP computer program has been designed to calculate estimates of recurring costs associated with two producers involved in a competitive unit production effort. The concepts employed in this program are those described in Chapter III of this pamphlet. Unit price improvement curves combined with Monte Carlo simulation form the model foundation. The computer program also incorporates functions to make its operation interactive and useable for any number of evaluation data sets. The basic program output provides an estimate of the total program recurring cost that can be displayed in discounted dollars as well as constant base year dollaars. For multiple production periods, the cost of each period is given for each producer along with an aggregate lot cost. The program will also determine which of the two producers is most likely to win a split buy award and will display the relative win percentage if this feature is selected. Finally, options also allow a cumulative probability versus total program recurring cost and probability density plots to be displayed.

The program has been divided into three basic operational modes; data file create, data file modification, and program execution. Each of these modes are described in the sections which follow, and example data files are given. An example session for each mode is also provided.

B. DATA FILE CREATE MODE.

This program mode allows data files to be created interactively by following prompts given at the user's terminal. The following information is requested.

1. Desired file name

2. File identification (for example specific conditions being evaluated)

3. Number of production lots to be evaluated

4. First unit cost for prime producer (minimum, expected, maximum)

5. First unit cost for the second source (minimum, expected, maximum)

6. Prime producer performance curve slope (optimistic, expected, maximum)

7. Second source performance curve slope (optimistic, expected, maximum)

8. Individual lot data

   a. Major split quantity

   b. Minor split quantity

c. Prime producer competition shift percentage (pessimistic, expected, optimistic)

d. Second source competition shift percentage (pessimistic, expected, optimistic)

e. Prime producer curve competition rotation (pessimistic, expected, optimistic)

f. Second source curve competition rotation (pessimistic, expected, optimistic)

Several notes are important while using the file create mode. When a proposed file name is entered, its existence is checked to determine if another file with the entered name already exists. If the name does not already exist it is accepted for use with the file being created. Should the name be found to already exist in the user's directory, the program will ask for another name. This is done to prevent over writing an existing file. A number of input parameters require three values to be entered. If conditions do not warrant a range of values to be utilized, the same value for each of the three entries is entered. Input values for competition shifts are entered as decimal percentages, i.e., a 5 percent shift is entered in its complement form of .95. These values may be positive to indicate a downward shift or negative to suggest an upward shift in the price improvement curve. Values entered for improvement surve shifts should take into consideration the effect of production rate. If for a given period production rate will cause a unit price change, that relationship can be incorporated in the estimated shift parameter. For example, introduction of competition using a split buy might be assumed to cause the prime producer to lower his unit price by 12 percent. However, due to the split buy his quantity is reduced causing production rate to fall off. The composite shift might then be assumed to be only 8 percent due to production rate efficiency loss. Actual entry of the resulting 8 percent downward shift would be in the form of .92. Entry of performance curve rotation values is based on slope percentage points. If, for example, the basic curve slope had been entered as .93 and is expected to reach a value of .91 after competition, the rotation entry would be .02 to indicate a downward rotation. Upward rotations may be indicated by using negative input values.

In addition to the preceding notes, special mention needs to be made regarding the individual production lot split quantities. If it is desired to establish a sole source producer baseline, all lot quantity is entered in the major split value. The output will then only reflect results for the prime producer under sole source conditions. One feature of the program is computation of lot costs for split buy awards based on a major/minor quantity award to each producer. For a given cycle of the simulation the program awards the major split quantity to the producer having the lowest unit price prior to the given lot (adjusted for any shifts). This approach to dealing with split awards may not be appropriate in all cases. Consequently, an alternate method is available within the program to handle split buys. This second source will behave in excactly the same manner and the total lot is evenly split between them. This latter method will then produce equal lot costs for each producer. Implementation of these alternative treatements of split buy awards is determined by the values entered for major and minor split quantities. If different values are entered the split award approach is used. Entry of equal values will invoke the composite performance approach.

One final note regarding the data file create mode is the stored data format. To maximize ease of data review, appropriate headings are stored along with the data entries. Even though a file modification mode is available, if numerous data sets are being evaluated by having appropriate headings in the file it is possible to quickly review individual file contents for accuracy.

C. FILE MODIFY MODE.

Changes to existing data files can be easily made using the modify mode. When this mode is entered the name of the data file to be modified is requested. All information in the file is then displayed along with a reference number. Entry of the appropriate reference number cause the data entry prompt for the affected element to be displayed.

While in this mode it is possible to extend the number of lots to be evaluated by simply changing the entry for number of lots. When that value is increased the program will automatically display the lot data prompts for the new lot or lots. It should also be noted that if one entry for a given lot is to be modified, all data entry prompts for that lot will be given. The data elements that remain unchanged are simply reentered.

D. PROGRAM EXECUTION MODE.

When the program execution mode is entered a series of preliminary prompts are displayed. The name of the appropriate data file is requested and checked for its existence. If the file is found to exist the program will continue, otherwise the input file name prompt will be redisplayed. Once the proper data file has been estblished the user is asked if a cumulative probability density plot will be desired. Basic program output consists of a presentation of the total average cost along with individual lot average costs. Basic output also displays the individual input parameters derived from the specified file. Presentation of the probability plots was made optional to minimize printing time if that information is not actually needed for a given analysis. The next run mode input parameter is the desired number of simulation cycles. Selection of a value for this parameter should consider several factors. A large number (5000 is the maximum allowed) will give better assurance that the simulation results will predict the true range of possible outcomes. A large run cycle value will also give smoother probability curve plots when those options are selected. Program execution time, though, will increase substantially as the number of simulation cycles becomes large. Therefore, if many different runs are to be made it is desirable to reduce the cycle count. A good starting figure is 500 cycles. Using non-parametric statistical methods, it is possible to show that at least 500 cycles will generate 99 percent of the total range of possible outcomes at the 95 percent confidence level. The last input parameter that is needed prior to actual program execution is selection of discounting. If a negative response is given to the prompt, output results will be in constant base year dollars. A positive response will cause the program to request the lot number that discounting should begin. When discounting is selected the output will be annotated accordingly. Discounting in this program is based on yearly midpoints.

E. <u>EXAMPLE INPUT DATA FILES</u>.

1. Example 1.

This example sets up data for a sole source baseline. The production period covers four years. Note that all lot quantities are placed in the major split category, and that no performance curve shifts or rotations are entered.

```
ID : EXAMPLE 1: DATA FILE FOR SOLE SOURCE BASELINE                       4
PRIME FIRST UNIT COST---MIN>  80000.  MOST LIKELY> 100000.  MAX> 127000.
SECOND SOURCE-----------MIN>0.  MOST LIKELY>      0.  MAX>     0.
PRIME PCURVE SLOPE------MIN>0.910    MOST LIKELY>0.930    MAX>0.950
SECOND SOURCE-----------MIN>0.000    MOST LIKELY>0.000    MAX>0.000
```

LOT #	LOT QUAN MAX	MIN	SHIFT FACTOR PRIME MIN	M.L.	MAX	SHIFT FACTOR SECOND SOURCE MIN	M.L.	MAX	ROTATION FACT PRIME MIN	M.L.	MAX	ROTATION FACT SECOND SOURCE MIN	M.L.	MAX
1	500.	0.	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1000.	0.	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1500.	0.	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1500.	0.	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE A-1. EXAMPLE 1 INPUT DATA FILE

2. <u>Example 2.</u>

This example sets up a file for a four year production program where a split buy competition is introduced in the third year. Note that both shift and rotation are introduced for the prime supplier in the third year only, thus indicating no further change due to competition is expected. Also note that lot quantities for each source are equal in years three and four indicating a composite price performance curve is desired.

ID : EXAMPLE 2: DATA FILE FOR SPLIT AWARD COMPETITION 4

PRIME FIRST UNIT COST---MIN> 80000. MOST LIKELY> 100000. MAX> 127000.

SECOND SOURCE-----------MIN> 60000. MOST LIKELY> 85000. MAX> 110000.

PRIME PCURVE SLOPE------MIN>0.910 MOST LIKELY>0.930 MAX>0.950

SECOND SOURCE-----------MIN>0.900 MOST LIKELY>0.030 MAX>0.960

LOT #	LOT QUAN		SHIFT FACTOR PRIME			SHIFT FACTOR SECOND SOURCE			ROTATION FACT PRIME			ROTATION FACT SECOND SOURCE		
	MAX	MIN	MIN	M.L.	MAX	MIN	M.L.	MAX	MIN	M.L.	MAX	MIN	M.L.	MAX
1	500.	0.	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1000.	0.	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	750.	750.	0.93	0.90	0.88	1.00	1.00	1.00	0.01	0.02	0.03	0.00	0.00	0.00
4	750.	750.	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE A-2. EXAMPLE 2 INPUT DATA FILE

Example CDAP program output is shown in Section H, CDAP RUN SESSION EXAMPLE.

F. FILE CREATE MODE EXAMPLE SESSION.

```
OK, SEG #SIM2
ARE YOU USING A THERMAL PRINTER TYPE TERMINAL (Y,N)
N


 THE FOLLOWING PROGRAM MODES ARE AVAILABLE :

      1. CREATE A NEW DATA FILE (C)

      2. MODIFY AN EXISTING DATA FILE (M)

      3. RUN USING AN EXISTING DATA FILE (R)

 PLEASE ENTER THE LETTER SHOWN IN ( ) THAT CORRESPONDS TO THE DESIRED MODE
C
 WHAT IS THE DATA FILE NAME
TESTFILE


 PLEASE ENTER THE FILE I.D. (75 CHARACTERS MAX)
EXAMPLE FILE CREATE SESSION
 HOW MANY LOTS ARE THERE IN THIS DATA SET ?
2
 FIRST UNIT COST FOR PRIME
 MININUM :
100000
 MOST LIKELY :
120000
 MAXIMUM :
170000
 SECOND SOURCE FIRST UNIT COST
 MINIMUM :
90000
 MOST LIKELY :
115000
 MAXIMUM :
170000
 PRIME PERFORMANCE CURVE SLOPE (.XXX)
 MINIMUM :
.95
 MOST LIKELY :
.90
 MAXIMUM :
.88
 SECOND SOURCE PERFORMANCE CURVE SLOPE (.XXX)
 MINIMUM :
.95
 MOST LIKELY :
.89
 MAXIMUM :
.86
```

F. FILE CREATE MODE EXAMPLE SESSION (CONT'D)

```
 DATA FOR LOT #  1
 MAJOR SPLIT QUANITY
600
 MINOR SPLIT QUANITY
300
 PRIME SHIFT FACTOR (.XXX)
 MINIMUM :
.99
 MOST LIKELY :
.95
 MAXIMUM :
.90
 SECOND SOURCE SHIFT FACTOR (.XXX)
 MINIMUM :
.98
 MOST LIKELY :
.93
 MAXIMUM :
.88
 PRIME ROTATION FACTOR (.XXX)
 MINIMUM :
.01
 MOST LIKELY :
.02
 MAXIMUM :
.03
 SECOND SOURCE ROTATION FACTOR (.XXX)
 MINIMUM :
.01
 MOST LIKELY :
.02
 MAXIMUM :
.03
 DATA FOR LOT #  2
 MAJOR SPLIT QUANITY
900
 MINOR SPLIT QUANITY
450
 PRIME SHIFT FACTOR (.XXX)
 MINIMUM :
1.00
 MOST LIKELY :
1.00
 MAXIMUM :
1.00
 SECOND SOURCE SHIFT FACTOR (.XXX)
 MINIMUM :
1.00
 MOST LIKELY :
1.00
 MAXIMUM :
1.00
```

F. FILE CREATE MODE EXAMPLE SESSION (CONT'D)

```
 PRIME ROTATION FACTOR (.XXX)
 MINIMUM :
0
 MOST LIKELY :
0
 MAXIMUM :
0
 SECOND SOURCE ROTATION FACTOR (.XXX)
 MINIMUM :
0
 MOST LIKELY :
0
 MAXIMUM :
0


 ANOTHER FILE (Y,N) ?
N
 WOULD YOU LIKE TO ENTER ANOTHER MODE (Y,N)
Y
```

G. FILE MODIFY EXAMPLE SESSION.

```
 THE FOLLOWING PROGRAM MODES ARE AVAILABLE :

      1. CREATE A NEW DATA FILE (C)

      2. MODIFY AN EXISTING DATA FILE (M)

      3. RUN USING AN EXISTING DATA FILE (R)

 PLEASE ENTER THE LETTER SHOWN IN ( ) THAT CORRESPONDS TO THE DESIRED MODE
M
 WHAT IS THE NAME OF THE FILE YOU WISH TO MODIFY
TESTFILE


 (1) ID : EXAMPLE FILE CREATE SESSION
 (2) NUMBER OF LOTS :  2
 (3) PRIME FIRST UNIT COST-MIN> 100000.  MOST LIKELY> 120000.  MAX> 170000.
 (4) SECOND SOURCE---------MIN>  90000.  MOST LIKELY> 115000.  MAX> 170000.
 (5) PRIME PCURVE SLOPE----MIN>0.950     MOST LIKELY>0.900     MAX>0.880
 (6) SECOND SOURCE---------MIN>0.950     MOST LIKELY>0.890     MAX>0.860
 (7)
LOT  LOT QUAN  SHIFT FACTOR   SHIFT FACTOR   ROTATION FACT  ROTATION FACT
 #                PRIME       SECOND SOURCE     PRIME       SECOND SOURCE
     MAX  MIN  MIN  M.L. MAX  MIN  M.L. MAX  MIN  M.L. MAX  MIN  M.L. MAX
 1  600.  300. 0.01 0.02 0.03 0.01 0.02 0.03 0.01 0.02 0.03 0.01 0.02 0.03
 2  900.  450. 1.00 1.00 1.00 1.00 1.00 1.00 0.00 0.00 0.00 0.00 0.00 0.00


 ENTER THE NUMBER IN THE ( ) THAT CORRESPONDS TO THE LINE YOU WANT TO MODIFY
7
 WHAT LOT NUMBER DO YOU WANT TO MODIFY
1
 DATA FOR LOT #  1
 MAJOR SPLIT QUANITY
600
 MINOR SPLIT QUANITY
300
 PRIME SHIFT FACTOR (.XXX)
 MINIMUM :
.98
 MOST LIKELY :
.96
 MAXIMUM :
.93
 SECOND SOURCE SHIFT FACTOR (.XXX)
 MINIMUM :
.98
 MOST LIKELY :
.96
```

G. FILE MODIFY EXAMPLE SESSION (CONT'D)

```
 MAXIMUM :
.93
 PRIME ROTATION FACTOR (.XXX)
 MINIMUM :
0
 MOST LIKELY :
0
 MAXIMUM :
0

 SECOND SOURCE ROTATION FACTOR (.XXX)
 MINIMUM :
0
 MOST LIKELY :
0
 MAXIMUM :
0.00



 ANY MORE CHANGES (Y,N) ?
N
 WOULD YOU LIKE TO ENTER ANOTHER MODE (Y,N)
N
OK,
0
```

H. CDAP RUN SESSION EXAMPLE.

```
OK, SEG #S1M2
ARE YOU USING A THERMAL PRINTER TYPE TERMINAL (Y,N)
N


THE FOLLOWING PROGRAM MODES ARE AVAILABLE :

     1. CREATE A NEW DATA FILE (C)

     2. MODIFY AN EXISTING DATA FILE (M)

     3. RUN USING AN EXISTING DATA FILE (R)

 PLEASE ENTER THE LETTER SHOWN IN ( ) THAT CORRESPONDS TO THE DESIRED MODE
R
 WHAT IS THE DATA FILE NAME ?
BREAKEVEN3
 DO YOU WANT A CUMULATIVE PROBABILITY DISPLAY (Y,N) ?
Y
 DO YOU WANT A PROBABILITY DENSITY DISPLAY (Y,N) ?
Y
 HOW MANY SIMULATION CYCLES WOULD YOU LIKE (5000 IS MAX) ?
1001
 DO YOU WANT THE RESULTS IN DISCOUNTED DOLLARS (Y,N)
N
```

H. CDAP RUN SESSION EXAMPLE (CONT'D)

RUN --> WED, JUL 06 1983 16:26:20

ID : STRATEGY 3 --- **** BREAK EVEN **** .93 SOLE SOURCE CURVE SLOPE

***** AVERAGE COST = 205783735 *****

***** MEDIAN COST = 205340640 *****

PRIME SPLIT WIN PERCENTAGE LOT #	%	LOT QUANITY	AVERAGE LOT COST	AVERAGE UNIT COSTS PRIME	SECOND SOURCE	COMPOSITE
1	100.00	100	0	0	0	0
2	100.00	400	0	0	0	0
3	100.00	600	0	0	0	0
4	100.00	600	2824998	0	564999	4708
5	100.00	829	129384753	0	564998	156073
6	100.00	1080	24037652	22257	22257	22257
7	100.00	1080	0	0	0	0
8	100.00	1080	49535857	45866	0	45866
9	100.00	1113	61	0	0	0
10	100.00	1080	61	0	0	0
11	100.00	1080	61	0	0	0
12	100.00	1080	61	0	0	0
13	100.00	1080	61	0	0	0
14	100.00	1080	61	0	0	0
15	100.00	1080	61	0	0	0
16	100.00	1080	61	0	0	0

TOTAL NUMBER OF UNITS = 14442

DATA USED IN RUN---> WED, JUL 06 1983 16:26:20 FROM FILE BREAKEVEN3
****
PRIME FIRST UNIT COST--MIN> 1400000 MOST LIKELY> 1400000 MAX> 1400000
SECOND SOURCE----------MIN> 565000 MOST LIKELY> 565000 MAX> 565000
PRIME PCURVE SLOPE-----MIN> 0.870 MOST LIKELY> 0.870 MAX> 0.870
SECOND SOURCE----------MIN> 1.000 MOST LIKELY> 1.000 MAX> 1.000
NUMBER OF CYCLES---> 1001

LOT #	LOT MAX	QUAN MIN	SHIFT FACTOR PRIME MIN	M.L.	MAX	SHIFT FACTOR SECOND SOURCE MIN	M.L.	MAX	ROTATION FACT PRIME MIN	M.L.	MAX	ROTATION FACT SECOND SOURCE MIN	M.L.	MAX
1	100	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
2	400	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	600	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	595	5	1.00	1.00	1.00	1.00	1.00	1.00	-.08	-.06	-.04	0.00	0.00	0.00
5	600	229	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
6	540	540	0.86	0.93	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
7	540	540	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1080	0	0.75	0.85	0.95	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1113	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1080	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

H. CDAP RUN SESSION EXAMPLE (CONT'D).

RUN ---> WED, JUL 06 1983   16:26:20

LOT #	LOT MAX	QUAN MIN	SHIFT FACTOR PRIME MIN	M.L.	MAX	SHIFT FACTOR SECOND SOURCE MIN	M.L.	MAX	ROTATION FACT PRIME MIN	M.L.	MAX	ROTATION FACT SECOND SOURCE MIN	M.L.	MAX
11	1080	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
12	1080	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
13	1080	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
14	1080	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
15	1080	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
16	1080	0	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

```
RUN ---> WED, JUL 06 1983   16:26:20

STRATEGY COST                              CUMULATIVE PROBABILITY
               0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
                 +----|----|----|----|----|----|----|----|----|----|
      164451136  |                                                     0.0000
      165299424  |                                                     0.0040
      166996032  |                                                     0.0060
      168692640  |*                                                    0.0110
      170389248  |*                                                    0.0170
      172085856  |*                                                    0.0240
      173782464  |*                                                    0.0300
      175479072  |**                                                   0.0340
      177175680  |**                                                   0.0460
      178872288  |***                                                  0.0599
      180568896  |****                                                 0.0759
      182265504  |*****                                                0.0959
      183962112  |*****                                                0.1069
      185658720  |******                                               0.1249
      187355328  |********                                             0.1518
      189051936  |*********                                            0.1798
      190748544  |**********                                           0.2078
      192445152  |************                                         0.2308
      194141760  |*************                                        0.2627
      195838368  |***************                                      0.2987
      197534976  |****************                                     0.3287
      199231584  |******************                                   0.3686
      200928192  |*********************                                0.4116
      202624800  |***********************                              0.4525
      204321408  |*************************                            0.4935
      206018016  |**************************                           0.5275
      207714624  |****************************                         0.5684
      209411232  |******************************                       0.6024
      211107840  |********************************                     0.6434
      212804448  |**********************************                   0.6753
      214501056  |***********************************                  0.6973
      216197664  |************************************                 0.7263
      217894272  |**************************************               0.7572
      219590880  |****************************************             0.7922
      221287488  |*****************************************            0.8202
      222984096  |******************************************           0.8472
      224680704  |********************************************         0.8711
      226377312  |*********************************************        0.9001
      228073920  |**********************************************       0.9201
      229770528  |***********************************************      0.9351
      231467136  |************************************************     0.9500
      233163744  |************************************************     0.9640
      234860352  |*************************************************    0.9730
      236556960  |*************************************************    0.9790
      238253568  |*************************************************    0.9840
      239950176  |*************************************************    0.9870
      241646784  |**************************************************   0.9920
      243343392  |**************************************************   0.9950
      245040000  |**************************************************   0.9970
      246736608  |**************************************************   0.9990
      248433216  |**************************************************   1.0000
                 +----|----|----|----|----|----|----|----|----|----|
               0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
STRATEGY COST                              CUMULATIVE PROBABILITY
```

```
RUN [illegible] WED, JUL 06 1983    16:26:20

STRATEGY COST                        PROBABILITY
            0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10
            +----|----|----|----|----|----|----|----|----|----|
 16[illegible]51136 |                                                      0.0000
 165299424 |**                                                    0.0040
 166996032 |*                                                     0.0020
 168692640 |**                                                    0.0050
 170389248 |***                                                   0.0060
 172085856 |***                                                   0.0070
 173782464 |***                                                   0.0060
 175479072 |**                                                    0.0040
 177175680 |******                                                0.0120
 178872288 |*******                                               0.0140
 180568896 |********                                              0.0160
 182265504 |**********                                            0.0200
 183962112 |*****                                                 0.0110
 185658720 |*********                                             0.0180
 187355328 |*************                                         0.0270
 189051936 |**************                                        0.0280
 190748544 |**************                                        0.0280
 192445152 |***********                                           0.0230
 194141760 |****************                                      0.0320
 195838368 |******************                                    0.0360
 197534976 |***************                                       0.0300
 199231584 |********************                                  0.0400
 200928192 |*********************                                 0.0430
 202624800 |********************                                  0.0410
 204321408 |********************                                  0.0410
 206018016 |*****************                                     0.0340
 207714624 |********************                                  0.0410
 209411232 |*****************                                     0.0340
 211107840 |********************                                  0.0410
 212804448 |****************                                      0.0320
 214501056 |***********                                           0.0220
 216197664 |**************                                        0.0290
 217894272 |***************                                       0.0310
 219590880 |*****************                                     0.0350
 221287488 |**************                                        0.0280
 222984096 |*************                                         0.0270
 224680704 |************                                          0.0240
 226377312 |**************                                        0.0290
 228073920 |**********                                            0.0200
 229770528 |*******                                               0.0150
 231467136 |*******                                               0.0150
 233163744 |*******                                               0.0140
 234860352 |****                                                  0.0090
 236556960 |***                                                   0.0060
 238253568 |**                                                    0.0050
 239950176 |*                                                     0.0030
 241646784 |**                                                    0.0050
 243343392 |*                                                     0.0030
 245040000 |*                                                     0.0020
 246736608 |*                                                     0.0020
 248433216 |                                                      0.0010
            +----|----|----|----|----|----|----|----|----|----|
            0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10
STRATEGY COST                        PROBABILITY
```

H. CDAP RUN SESSION EXAMPLE (CONT'D).

```
 ANOTHER RUN (Y,N) ?
N
 WOULD YOU LIKE TO ENTER ANOTHER MODE (Y,N)
N
```

APPENDIX B

PROGRAM LISTING

```
C***********************************************************************
C* THIS PROGRAM SETS UP A SIMULATION OF TWO PRODUCERS OPERATING IN A       *
C* COMPETITIVE ENVIRONMENT. THE PURPOSE OF THE SIMULATION IS TO CALCULATE  *
C* THE COST OF ACQUIRING THE TOTAL QUANTITY OF ITEMS BEING PRODUCED BY BOTH*
C* SOURCES. CONSIDERED IN THIS SIMULATION PROGRAM ARE THE EFFECTS OF       *
C* QUANTITY PRODUCED ON UNIT PRICE (PRICE PERFORMANCE CURVES, OR LEARNING  *
C* CURVES), INFLUENCE OF COMPETITION ON UNIT PRICE UNDER CONDITIONS OF     *
C* MULTIPLE CONTRACT AWARDS, AND THE EFFECT OF COMPETITION ON RELATIVE     *
C* PRODUCTION EFFICIENCY. DATA FOR THIS PROGRAM IS READ FROM A DATA FILE   *
C* THAT IS PREPARED AND MAINTAINED BY A UTILITY WITHIN THIS PROGRAM.       *
C*                                                                         *
C*                  US ARMY TANK AUTOMOTIVE COMMAND                        *
C*                  COMPUTER MANAGEMENT AND APPLICATIONS                   *
C*                  RESEARCH OFFICE                                        *
C*                  DRSTA-RY (MR. PAUL BRADLEY)                            *
C*                  WARREN, MICHIGAN  48090                                *
C*                                                                         *
C*                  Telephone  AV 786-6228    COM  (313)-574-6228          *
C***********************************************************************
C
C
C*******************************
C*
C* VARIABLES DEFINITION
C*
C*******************************
C ACLOT(25)    AVERAGE COST OF LOT N
C ALUC(25)     AVERAGE UNIT COST FOR LOT N (COMPOSITE)
C AMID         MEDIAN STRATEGY COST FROM SIMULATION RESULTS
C AP           PRIME SHIFTED FIRST UNIT COST AT LOT N AND A GIVEN SIM CYCLE
C APUCL(25)    AVERAGE UNIT COST FOR THE PRIME IN LOT N
C ASUCL(25)    AVERAGE UNIT COST FOR THE SECOND SOURCE IN LOT N
C AS           SS SHIFTED FIRST UNIT COST FOR LOT N AND A GIVEN SIM CYC
C AVG          AVERAGE STRATEGY COST
C BBP          ROTATED PRIME SLOPE AT LOT N AND A GIVEN SIMULATION CYCLE
C BBS          ROTATED SECOND SOURCE SLOPE AT LOT N AND A GIVEN SIM CYCLE
C BP(3)        PRIME PERFORMANCE CURVE SLOPE VALUES--MIN, ML, MAX
C BPT          PRIME SLOPE TRIANGULAR DISTRIBUTION THRESHOLD VALUE
C BSS(3)       SECOND SOURCE PERFORMANCE CURVE SLOPE VALUES--MIN, ML, MAX
C BSST         SECOND SOURCE SLOPE TRIANGULAR DIST THRESHOLD VALUE
C CIP(3)       FIRST UNIT COST FOR THE PRIME--MIN, ML, MAX
C CIPT         PRIME FIRST UNIT COST TRIANGULAR DIST THRESHOLD VALUE
C CISS(3)      FIRST UNIT COST FOR THE SECOND SOURCE--MIN, ML, MAX
C CISST        SECOND SOURCE FIRST UNIT COST TRIANG DIST THRESHOLD VALUE
C COST         VARIABLE USED TO PRINT THE COST VALUES USED IN OUTPUT PLOTS
C CUM          SELECTS PROPER MODE FOR CUM PROB DISPLAY(1=CUM, 0=PDF)
C CWP(25)      PRIME WIN PERCENTAGE FOR LOT N
C CYCLES       FLOATING POINT VERSION OF NCYC (SIMULATION CYCLES)
```

```
C DATE          VARIABLE USE TO RETURN THE DATE FROM THE OPERATING SYS
C DF            DISCOUNT FACTOR USED IN CALCULATING LOT COSTS
C DIS           SELECTION PARAMETER FOR IMPLEMENTING DISCOUNTING
C DISC(25)      INDIVIDUAL DISCOUNT FACTORS USING A 10% RATE
C DP            VALUE USED IN CALCULATING AVG UNIT COST OF PRIME AT LOT N
C DS            VALUE USED IN CALCULATING AVG UNIT COST OF SS AT LOT N
C FID(35)       FILE ID STORAGE VARIABLE--READ FROM THE DATA FILE
C FINC          CLASS INTERVAL VALUE FOR SETTING UP THE OUTPUT PLOTS
C FNAME(16)     VARIABLE USED TO READ THE DATA FILE NAME (16A2)
C HOLD          TEMPORARY VARIABLE USED IN SORTING THE SIMULATION VALUES
C ICK           TEMPORARY VARIABLE USED DURING VALUE SORTING AND TESTS
C IDF           LOT NUMBER THAT DISCOUNTING WILL BEGIN
C IFF           TOP OF FORM PRINT VARIABLE FOR IMPACT TERMINALS
C IVAL          INTEGER VARIABLE USED TO SCALE THE OUTPUT PLOT LINES
C LINE          DATA FILE MODIFICATION ENTRY POINT (*MODIFY)
C LOTN          DATA FILE MODIFICATION LOT ENTRY POINT (*MODIFY)
C M1            ARGUMENT OF SUBROUTINE *CREATE -- ENTRY POINT FROM *MODIFY
C M2            ARGUMENT OF SUBROUTINE *CREATE -- BEGINING LOT NUMBER
C M3            ARGUMENT OF SUBROUTINE *CREATE -- ENDING LOT NUMBER
C NCYC          NUMBER OF SIMULATION CYCLES ---- INPUT PRIOR TO RUN
C NLN           LENGTH OF DATA FILE NAME -- RETURNED FROM NLEN$A (SYS UTILITY)
C NLOT          NUMBER OF LOTS READ FROM THE DATA FILE
C NLOTM         MODIFIED NUMBER OF LOTS FROM *MODIFY
C NLOTP         CURRENT NUMBER OF LOTS+1 -- USED IN *MODIFY
C PAVG          PRIME RUNNING AVERAGE UNIT COST AT LOT N AND A GIVEN SIM CYC
C PB            PRIME PERFORMANCE CURVE SLOPE FOR CYCLE N OF THE SIMULATION
C PC(50)        CALCULATED CLASS INTERVAL PROBABILITY
C PCOST(50)     CALCULATED COST CLASS INTERVAL PROBABILITY
C PCF           CUMULATIVE PROBABILITY DENSITY DISPLAY OPTION (1=YES, 0=NO)
C PDF           PROBABILITY DENSITY DISPLAY OPTION (0=NO, 1=YES)
C PFUC          PRIME FIRST UNIT COST FOR CYCLE N OF THE SIMULATION
C PPCOST        PRIME RUNNING CUMULATIVE COST FOR A GIVEN SIMULATION CYCLE
C PROT          PRIME ROTATION FACTOR FOR LOT N AND A GIVEN SIMULATION CYCLE
C PSF           PRIME SHIFT FACTOR FOR LOT N AND A GIVEN SIMULATION CYCLE
C PUCOST        PRIME UNIT COST FOR LAST ITEM IN LOT N-1 FOR A SIM CYCLE
C PV(50)        HISTOGRAM PLOT VAR (DEFINES PHYSICAL NUM OF PLOT POINTS)
C Q1P           LAST UNIT NUMBER FOR PRIME AT LOT N-1 AND A GIVEN SIM CYCLE
C Q1S           LAST UNIT NUMBER FOR THE S S AT LOT N-1 AND SIMULATION CYC
C Q2P           LAST UNIT NUMBER FOR PRIME A LOT N AND A GIVEN SIM CYCLE
C Q2S           LAST UNIT NUM FOR SECOND SOURCE FOR LOT N AND GIVEN SIM CYC
C QM(25)        MAJOR SPLIT QUANITY FOR LOT N
C QP            PRIME LOT QUANITY FOR LOT N FOR A GIVEN SIMULATION CYCLE
C QPC           PRIME CUMULATIVE QUANITY FOR CYCLE N  OF THE SIMULATION
C QS(25)        MINOR SPLIT QUANITY FOR LOT N
C QSS           SECOND SOURCE QUANITY FOR LOT N FOR A GIVEN SIMULATION CYCLE
C QSSC          SECOND SOURCE CUM QUANITY FOR CYCLE N OF THE SIMULATION
C RN            RANDOM NUMBER USED IN THE SIMULATION
C ROTP(25,3)    PRIME SLOPE ROTATION FACTOR FOR LOT N --- MIN, ML, MAX
```

```
C ROTPT        PRIME SLOPE ROTATION TRIANGULAR DIST THRESHOLD VALUE
C ROTSS(25,3) SECOND SOURCE SLOPE ROTATION FACTOR FOR LOT N--MIN, ML, MAX
C ROTSST       SECOND SOURCE ROTATION TRIANGULAR DIST THRESHOLD VALUE
C SAVG         SECOND SOURCE RUNNING AVERAGE UNIT COST AT LOT N AND SIM CYC
C SCOST(5000) STRATEGY COST FOR THE NTH SIMULATION CYCLE
C SF           SCALE FACTOR USED IN SCALE SUBROUTINE
C SFP(25,3)    PRIME FIRST UNIT COST SHIFT FACTOR FOR LOT N--MIN, ML, MAX
C SFPT         PRIME SHIFT FACTOR TRIANGULAR DISTRIBUTION THRES VALUE
C SFSS(25,3)   SECOND SOURCE FIRST UNIT COST SHIFT FOR LOT N--MIN, ML, MAX
C SFSST        SECOND SOURCE SHIFT FACTOR TRIANGULAR DIST THRES VALUE
C SOLE         SOLE SOURCE FIRST UNIT COST-- USED FOR REFERENCING SHIFTS
C SSB          SECOND SOURCE PERFORMANCE CURVE SLOPE FOR CYCLE N OF THE SIM
C SSCOST       SECOND SOURCE RUNNING CUMULATIVE COST FOR A GIVEN SIM CYCLE
C SSFUC        SECOND SOURCE FIRST UNIT COST FOR CYCLE N OF THE SIMULATION
C SSROT        SECOND SOURCE ROTATION FACT FOR LOT N AND A GIVEN SIM CYCLE
C SSSF         SECOND SOURCE SHIFT FACTOR FOR LOT N AND A GIVEN SIM CYCLE
C SUCOST       SECOND SOURCE UNIT COST FOR LAST UNIT OF LOT N-1 AND SIM CYC
C TIME         VARIABLE USED TO RETURN TIME OF DAY FROM THE OPERATING SYS
C TCK          VARIABLE USED TO INDICATE TYPE OF TERMINAL BEING USED
C TFUC         TEMP FIRST UNIT COST USED BETWEEN LOTS SPECIFYING SHIFTS
C TOTAL        VALUE USED TO PRINT TOTAL LOT QUANITIES
C TTYP         VARIABLE USED TO INPUT TERMINAL TYPE (IMPACT OR THERMAL)
C VAL          VARIABLE USED TO PRINT PROBABILITY VALUES IN OUTPUT PLOTS
C YP           COST OF LOT N FOR THE PRIME FOR A GIVEN SIMULATION CYCLE
C YS           COST OF LOT N FOR THE SS FOR A GIVEN SIMULATION CYCLE
C
C**************************************************************************
C
C
C*************************
C*
C* BEGIN MAIN PROGRAM
C
C*************************
$INSERT SYSCOM>A$KEYS
      COMMON/ A / PV(51),PCOST(50),SCOST(5000)
      COMMON/ RD /FID(35),NLOT,CIP(3),CISS(3),BP(3),BSS(3),QM(25),
     +QS(25),SFP(25,3),SFSS(25,3),ROTP(25,3),ROTSS(25,3),ACLOT(25),
     +ALUC(25),APUCL(25),ASUCL(25),FNAME(16),TIME,DATE(2)
      REAL*8 PV,PCOST,SCOST,FID,CIP,CISS,ACLOT,ALUC,BP,BSS,SFP,SFSS,
     +ROTP,ROTSS,SFPT(25),SFSST(25),ROTPT(25),ROTSST(25),QM,QS,CWP(25),
     +AVG,COST,PPCOST,SSCOST,TIME,DATE,PAVG,SAVG,YP,YS,SSFUC,PFUC,
     +ASUCL,APUCL,DISC(25)
      INTEGER FNAME,TCK
      LOGICAL EXST$A
      DATA DISC/.954,.867,.788,.717,.652,.592,.538,.489,.445,.405,
     +.368,.334,.304,.276,.251,.228,.208,.189,.172,.156,.142,.129,
     +.117,.107,.0977,M1/0/,M2/0/,M3/0/
```

```
      [illegible]
C*************************
C*
C* DISPLAY MENUE OF RUN MODES. CREATE A NEW FILE, MODIFY AN EXISTING FILE,
C* AND RUN THE SIMULATION FROM AN EXISTING FILE.
C*
C*************************
      PRINT 500
500   FORMAT('ARE YOU USING A THERMAL PRINTER TYPE TERMINAL (Y,N)')
      READ(1,505) TTYP
505   FORMAT(A1)
      IF(TTYP.EQ.1HY) TCK=0
      IF(TTYP.NE.1HY) TCK=1
510   PRINT 520
520   FORMAT(//1X,'THE FOLLOWING PROGRAM MODES ARE AVAILABLE :'//5X,
     +'1. CREATE A NEW DATA FILE (C)'//5X,'2. MODIFY AN EXISTING ',
     +'DATA FILE (M)'//5X,'3. RUN USING AN EXISTING DATA FILE (R)'//)
530   PRINT 540
540   FORMAT(1X,'PLEASE ENTER THE LETTER SHOWN IN ( ) THAT CORRESPONDS',
     +' TO THE DESIRED MODE'/)
      READ(1,1250) ANS
      IF(ANS.EQ.1HC) CALL CREATE(M1,M2,M3)
      IF(ANS.EQ.1HM) CALL MODIFY
      IF(ANS.EQ.1HR) GO TO 570
550   PRINT 560
560   FORMAT(1X,'WOULD YOU LIKE TO ENTER ANOTHER MODE (Y,N)')
      READ(1,1250) ANS
      IF(ANS.NE.1HY) CALL EXIT
      GO TO 510
570   PRINT 580
580   FORMAT(1X,'WHAT IS THE DATA FILE NAME ? ')
      READ(1,590) FNAME
590   FORMAT(16A2)
      NLN=NLEN$A(FNAME,32)
      IF(EXST$A(FNAME,NLN)) GO TO 610
      PRINT 600
600   FORMAT(1X,'THE SPECIFIED DATA FILE DOES NOT EXIST----'/
     +1X,'PLEASE ENTER ANOTHER FILE NAME')
      GOTO 580
610   CONTINUE
C*************************
C*
C* SET UP RUN PARAMETERS
C*
C*************************
      PDF=0.
      PCF=0.
      PRINT 620
```

```
620   FORMAT(1X,'DO YOU WANT A CUMULATIVE PROBABILITY DISPLAY (Y,N) ? ')
      READ(1,1250) ANS
      IF(ANS.EQ.1HY) PCF=1.
      PRINT 630
630   FORMAT(1X,'DO YOU WANT A PROBABILITY DENSITY DISPLAY (Y,N) ?')
      READ(1,1250) ANS
      IF(ANS.EQ.1HY) PDF=1.
640   PRINT 650
650   FORMAT(1X,'HOW MANY SIMULATION CYCLES WOULD YOU LIKE ',
     +'(5000 IS MAX) ?')
      READ(1,*) NCYC
      IF(NCYC.GT.5000) GO TO 640
      CYCLES=NCYC
      DIS=0.
      PRINT 660
660   FORMAT(1X,'DO YOU WANT THE RESULTS IN DISCOUNTED DOLLARS (Y,N)')
      READ(1,1250) ANS
      IF(ANS.EQ.1HY) DIS=1.
      IF(DIS.EQ.0.) GO TO 680
      PRINT 670
670   FORMAT(1X,'WHAT LOT WILL DISCOUNTING BEGIN ?')
      READ(1,*) IDF
680   CALL READ(NLN)
C**************************
C*
C* COMPUTE TRANGULAR DISTRIBUTION CUMULATIVE PROBABILITY THRESHOLD VALUES
C* FOR USE IN GENERATING DESIRED VARIABLE VALUES FROM A RANDOM NUMBER.
C* IF THE MIN, ML, AND MAX VALUES ARE EQUAL SKIP THE CALCULATION. ALSO,
C* OBTAIN THE DATE AND TIME FROM THE OPERATING SYSTEM FOR USE IN IDENTIFYING
C* THE GIVEN RUN.
C*
C**************************
      IX=2735
      RN=RND(IX)
      CIPT=CIP(3)
      CISST=CISS(3)
      BPT=BP(3)
      BSST=BSS(3)
      IF(CIP(1).NE.CIP(3)) CIPT=(CIP(2)-CIP(1))/(CIP(3)-CIP(1))
      IF(CISS(1).NE.CISS(3)) CISST=(CISS(2)-CISS(1))/(CISS(3)-CISS(1))
      IF(BP(1).NE.BP(3)) BPT=(BP(2)-BP(1))/(BP(3)-BP(1))
      IF(BSS(1).NE.BSS(3)) BSST=(BSS(2)-BSS(1))/(BSS(3)-BSS(1))
      CALL TIME$A(TIME)
      CALL DATE$A(DATE)
      DO 780 I=1,NLOT
      CWP(I)=0.
      SFPT(I)=SFP(I,3)
      IF(SFP(I,1).EQ.SFP(I,3)) GO TO 750
```

```
      SFPT(I)=(SFP(I,2)-SFP(I,1))/(SFP(I,3)-SFP(I,1))
750   SFSST(I)=SFSS(I,3)
      IF(SFSS(I,1).EQ.SFSS(I,3)) GO TO 760
      SFSST(I)=(SFSS(I,2)-SFSS(I,1))/(SFSS(I,3)-SFSS(I,1))
760   ROTPT(I)=ROTP(I,3)
      IF(ROTP(I,1).EQ.ROTP(I,3)) GO TO 770
      ROTPT(I)=(ROTP(I,2)-ROTP(I,1))/(ROTP(I,3)-ROTP(I,1))
770   ROTSST(I)=ROTSS(I,3)
      IF(ROTSS(I,1).EQ.ROTSS(I,3)) GO TO 780
      ROTSST(I)=(ROTSS(I,2)-ROTSS(I,1))/(ROTSS(I,3)-ROTSS(I,1))
780   CONTINUE
C*************************
C*
C* BEGIN THE SIMULATION ----------
C*
C* GENERATE A FIRST UNIT COST AND PERFORMANCE CURVE SLOPE FOR THE PRIME
C* AND SECOND SOURCE SUPPLIERS.
C*
C*************************
      DO 910 I=1,NCYC
      PFUC=CIP(3)
      SSFUC=CISS(3)
      PB=BP(3)
      SSB=BSS(3)
      IF(CIP(1).EQ.CIP(3)) GO TO 790
      RN=RND(0)
      IF(RN.GE.CIPT) PFUC=CIP(3)-SQRT((1-RN)*(CIP(3)-CIP(1))*
     +(CIP(3)-CIP(2)))
      IF(RN.LT.CIPT) PFUC=CIP(1)+SQRT(RN*(CIP(3)-CIP(1))*
     +(CIP(2)-CIP(1)))
790   IF(CISS(1).EQ.CISS(3)) GO TO 800
      RN=RND(0)
      IF(RN.GE.CISST) SSFUC=CISS(3)-SQRT((1-RN)*(CISS(3)-CISS(1))*
     +(CISS(3)-CISS(2)))
      IF(RN.LT.CISST) SSFUC=CISS(1)+SQRT(RN*(CISS(3)-CISS(1))*
     +(CISS(2)-CISS(1)))
800   IF(BP(1).EQ.BP(3)) GO TO 810
      RN=RND(0)
      IF(RN.GE.BPT) PB=BP(3)-SQRT((1-RN)*(BP(3)-BP(1))*
     +(BP(3)-BP(2)))
      IF(RN.LT.BPT) PB=BP(1)+SQRT(RN*(BP(3)-BP(1))*
     +(BP(2)-BP(1)))
810   IF(BSS(1).EQ.BSS(3)) GO TO 820
      RN=RND(0)
      IF(RN.GE.BSST) SSB=BSS(3)-SQRT((1-RN)*(BSS(3)-BSS(1))*
     +(BSS(3)-BSS(2)))
      IF(RN.LT.BSST) SSB=BSS(1)+SQRT(RN*(BSS(3)-BSS(1))*
     +(BSS(2)-BSS(1)))
```

```
820   SCOST(I)=0.
      PPCOST=0.
      SSCOST=0.
      QPC=0.
      QSSC=0.
      PAVG=0.
      SAVG=0.
C***************************
C*
C* CALCULATE FIRST UNIT COST AND SLOPE ADJUSTMENT FOR LOT N DURING THE
C* GIVEN SIMULATION CYCLE.
C*
C***************************
      DO 910J=1,NLOT
      PSF=SFP(J,3)
      IF(SFP(J,1).EQ.SFP(J,3)) GO TO 830
      RN=RND(0)
      IF(RN.GE.SFPT(J)) PSF=SFP(J,3)-SQRT((1-RN)*(SFP(J,3)-SFP(J,1))*
     +(SFP(J,3)-SFP(J,2)))
      IF(RN.LT.SFPT(J)) PSF=SFP(J,1)+SQRT(RN*(SFP(J,3)-SFP(J,1))*
     +(SFP(J,2)-SFP(J,1)))
830   SSSF=SFSS(J,3)
      IF(SFSS(J,1).EQ.SFSS(J,3)) GO TO 840
      RN=RND(0)
      IF(RN.GE.SFSST(J)) SSSF=SFSS(J,3)-SQRT((1-RN)*
     +(SFSS(J,3)-SFSS(J,1))*(SFSS(J,3)-SFSS(J,2)))
      IF(RN.LT.SFSST(J)) SSSF=SFSS(J,1)+SQRT(RN*(SFSS(J,3)-SFSS(J,1))*
     +(SFSS(J,2)-SFSS(J,1)))
840   PROT=ROTP(J,3)
      IF(ROTP(J,1).EQ.ROTP(J,3)) GO TO 850
      RN=RND(0)
      IF(RN.GE.ROTPT(J)) PROT=ROTP(J,3)-SQRT((1-RN)*
     +(ROTP(J,3)-ROTP(J,1))*(ROTP(J,3)-ROTP(J,2)))
      IF(RN.LT.ROTPT(J)) PROT=ROTP(J,1)+SQRT(RN*
     +(ROTP(J,3)-ROTP(J,1))*(ROTP(J,2)-ROTP(J,1)))
850   SSROT=ROTSS(J,3)
      IF(ROTSS(J,1).EQ.ROTSS(J,3)) GO TO 860
      RN=RND(0)
      IF(RN.GE.ROTSST(J)) SSROT=ROTSS(J,3)-SQRT((1-RN)*
     +(ROTSS(J,3)-ROTSS(J,1))*(ROTSS(J,3)-ROTSS(J,2)))
      IF(RN.LT.ROTSST(J)) SSROT=ROTSS(J,1)+SQRT(RN*
     +(ROTSS(J,3)-ROTSS(J,1))*(ROTSS(J,2)-ROTSS(J,1)))
C***************************
C*
C* BASED ON THE RUNNING UNIT AVERAGE COST FOR EACH SOURCE, DETERMINE WHICH
C* SOURCE WILL WIN THE MAJOR SPLIT QUANITY WHEN SPLIT BUYS ARE BEING USED.
C* USING THE SELECTED QUANITIES, CALCULATE LOT COSTS FOR EACH SORCE.
C* INCREMENT RUNNING CUMULATIVE COSTS AND UPDATE UNIT AVERAGE COSTS.
```

```
C* CONTINUE UNITL ALL LOTS HAVE BEEN EVALUATED FOR THE GIVEN SIMULATION CYCLE.
C*
C***************************
860   IF(QPC.EQ.0.) GO TO 870
      BBP=ALOG(PB)/ALOG(2.)
      SOLE=PFUC*QPC**BBP
      PUCOST=TFUC*QPC**BBP
      IF(QSSC.EQ.0.) GO TO 870
      BBS=ALOG(SSB)/ALOG(2.)
      SUCOST=SSFUC*QSSC**BBS
870   QP=QM(J)
      QSS=QP
C*
C*
C* IF QM AND QS ARE EQUAL, A COMPOSITE PERFORMANCE CURVE IS BEING USED,
C* THEREFORE BYPASS THE LOT SPLIT PROCESS.
C*
C*
      IF(QS(J).EQ.QM(J)) GO TO 890
      PAVG=PAVG*(1.-PSF)
      SAVG=SAVG*(1.-SSSF)
      IF(SAVG.EQ.0.) GO TO 880
      IF(SAVG.LT.PAVG) QP=QS(J)
      IF(QS(J).EQ.0.) QP=QM(J)
C*
C*
C* DECISION RULE : FOR SPLIT BUY AWARDS THE SOURCE HAVING THE LOWEST AVERAGE
C* PRICE AS OF THIS LOT FOR A GIVEN SIMULATION CYCLE IS GIVEN THE MAJOR
C* SPLIT QUANITY.
C*
C*
880   QSS=QM(J)+QS(J)-QP
890   IF(QP.EQ.QM(J)) CWP(J)=CWP(J)+1.
      PB=PB-PROT
      BBP=ALOG(PB)/ALOG(2.)
      TFUC=PFUC
      IF(QPC.NE.0.) PFUC=SOLE/(QPC**BBP)
      IF(QPC.NE.0.) TFUC=PUCOST/(QPC**BBP)
      IF(PSF.NE.0.) TFUC=PFUC*(1.-PSF)
      BBP=BBP+1.
      SSB=SSB-SSROT
      BBS=ALOG(SSB)/ALOG(2.)
      IF(QSSC.NE.0.) SSFUC=SUCOST/(QSSC**BBS)
      BBS=BBS+1.
      Q1P=QPC
      Q2P=QPC+QP
      Q1S=QSSC
      Q2S=QSSC+QSS
```

```
      QPC=Q2P
      QSSC=Q2S
      DF=1.
      IF(DIS.EQ.0.) GO TO 900
      IF(J.LT.IDF) GO TO 900
      IJ=J-IDF+1
      DF=DISC(IJ)
900   YP=DF*TFUC*((Q2P+.5)**BBP-(Q1P+.5)**BBP)/BBP
      YS=DF*SSFUC*((Q2S+.5)**BBS-(Q1S+.5)**BBS)/BBS
C*
C*
C* IF QM AND QS ARE EQUAL, A COMPOSITE PERFORMANCE CURVE IS BEING USED,
C* THEREFORE THE LOT COST FOR EACH SOURCE IS EQUAL.
C*
C*
      IF(QS(J).EQ.QM(J)) YS=YP
      SCOST(I)=SCOST(I)+YP+YS
      PPCOST=PPCOST+YP
      SSCOST=SSCOST+YS
      PAVG=PPCOST/Q2P
      IF(Q2S.NE.0.) SAVG=SSCOST/Q2S
      ACLOT(J)=ACLOT(J)+(YP+YS)/CYCLES
      ALUC(J)=ALUC(J)+(YP+YS)/(CYCLES*(QM(J)+QS(J)))
      IF(QP.NE.0.) APUCL(J)=APUCL(J)+YP/QP
      IF(QSS.NE.0.) ASUCL(J)=ASUCL(J)+YS/QSS
910   CONTINUE
C*
C*
C* COMPUTE THE AVERAGE UNIT COST FOR EACH SOURCE AT LOT N. THIS PROCESS IS
C* REQUIRED SINCE A BUYOUT PERIOD CHANGES THE NUMBER OF CYCLES A GIVEN
C* SOURCE WILL APPEAR IN A GIVEN SIMULATION RUN DUE TO THE AWARD RULE.
C*
C*
      DO 920 I=1,NLOT
      DP=CYCLES
      DS=CYCLES
      IF(QS(I).EQ.0.) DS=CYCLES-CWP(I)
      IF(DS.EQ.0.) DS=CYCLES
      IF(QS(I).EQ.0.) DP=CWP(I)
      APUCL(I)=APUCL(I)/DP
      ASUCL(I)=ASUCL(I)/DS
920   CONTINUE
C**************************
C*
C* SORT THE SIMULATION RESULTS AND COMPUTE THE CLASS INTERVAL SIZE ----
C* (MAX - MIN)/50 ----  ALSO COMPUTE THE AVERAGE COST AND DETERMINE THE
C* MEDIAN COST.
C*
```

```
C*************************
      N=NCYC
930   ICK=0
      N=N-1
      IF(N.EQ.1) GO TO 960
      DO 950 I=1,N
      IF(SCOST(I).GE.SCOST(I+1)) GO TO 950
940   HOLD=SCOST(I)
      SCOST(I)=SCOST(I+1)
      SCOST(I+1)=HOLD
      ICK=1
950   CONTINUE
      IF(ICK.GT.0) GO TO 930
960   FINC=(SCOST(1)-SCOST(NCYC))/50.
      ICK=NCYC/2+1
      AMID=SCOST(ICK)
      DO 970 I=1,50
      PCOST(I)=0.
970   CONTINUE
      AVG=0.
      DO 980 I=1,NCYC
      AVG=AVG+SCOST(I)/CYCLES
      J=((SCOST(I)-SCOST(NCYC))/FINC)+1.
      IF(J.GT.50) J=50
      PCOST(J)=PCOST(J)+1.
980   CONTINUE
      DO 990 I=1,50
      PCOST(I)=PCOST(I)/CYCLES
990   CONTINUE
      DO 1000 I=1,50
      PV(I)=1H
1000  CONTINUE
      LC=1
      IPAGE=0
      PRINT 1010 IFF
1010  FORMAT(A2)
      CALL PAGE(IPAGE,LC,TCK)
      PRINT 1130  FID
      LC=LC+7
      IF(DIS.EQ.0.) GO TO 1050
      PRINT 1020
      LC=LC+3
1020  FORMAT(/17X,'< <  RESULTS ARE IN DISCOUNTED DOLLARS >>>>'/35X,
     +'( 10% )')
1050  PRINT 1060  AVG,AMID
      LC=LC+4
1060  FORMAT(/20X,'***** AVERAGE COST = ',I11,' *****'/
     +/20X,'*****  MEDIAN COST = ',I11,' *****')
```

```
      IF(DIS.EQ.1.) PRINT 1020
      IF(DIS.EQ.1) LC=LC+3
      CALL HEAD1
      LC=LC+5
      DO 1100 I=1,NLOT
      TICK=1H
      IF(DIS.EQ.0.) GO TO 1080
      IF(I.GE.IDF) TICK=1H*
1080  CWP(I)=CWP(I)/CYCLES*100.
      TOTAL=QM(I)+QS(I)
      PRINT 1090  I,CWP(I),TOTAL,ACLOT(I),TICK,APUCL(I),TICK,
     +ASUCL(I),TICK,ALUC(I),TICK
1090  FORMAT(2X,I2,3X,F6.2,4X,I7,4X,I11,A1,1X,I7,A1,4X,
     +I7,A1,5X,I7,A1)
      LC=LC+1
      IF(LC.LT.63) GO TO 1100
      CALL ENDP(LC)
      CALL PAGE(IPAGE,LC,TCK)
      CALL HEAD1
      LC=LC+5
1100  CONTINUE
      TOTAL=QPC+QSSC
      PRINT 1110  TOTAL
      LC=LC+2
      IF(LC.LT.56) GO TO 1150
      CALL ENDP(LC)
      CALL PAGE(IPAGE,LC,TCK)
1110  FORMAT(/1X,'TOTAL NUMBER OF UNITS = ',I7)
1120  FORMAT(///)
1130  FORMAT(//1X,'ID : ',35A2//)
1150  PRINT 1160  DATE,TIME,FNAME
      LC=LC+4
1160  FORMAT(//1X,'DATA USED IN RUN---> ',2A8,2X,A8,2X,'FROM FILE ',
     +16A2/1X,79('*'))
      PRINT 1170  CIP
      LC=LC+1
      IF(LC.LT.63) GO TO 1175
      CALL ENDP(LC,TCK,IFF)
      CALL PAGE(IPAGE,LC,TCK)
1170  FORMAT(1X,'PRIME FIRST UNIT COST--MIN>',I8,2X,'MOST LIKELY>',
     +I8,2X,'MAX>',I8)
1175  PRINT 1180  CISS
      LC=LC+1
      IF(LC.LT.63) GO TO 1185
      CALL ENDP(LC,TCK,IFF)
      CALL PAGE(IPAGE,LC,TCK)
1180  FORMAT(1X,'SECOND SOURCE---------MIN>',I8,2X,'MOST LIKELY>',
     +I8,2X,'MAX>',I8)
```

```
1185  PRINT 1190 BP
      LC=LC+1
      IF(LC.LT.63) GO TO 1195
      CALL ENDP(LC,TCK,IFF)
      CALL PAGE(IPAGE,LC,TCK)
1190  FORMAT(1X,'PRIME PCURVE SLOPE-----MIN>',1X,F5.3,4X,'MOST LIKELY>',
     +1X,F5.3,4X,'MAX>',1X,F5.3)
1195  PRINT 1200  BSS
      LC=LC+1
      IF(LC.LT.63) GO TO 1205
      CALL ENDP(LC,TCK,IFF)
      CALL PAGE(IPAGE,LC,TCK)
1200  FORMAT(1X,'SECOND SOURCE---------MIN>',1X,F5.3,4X,'MOST LIKELY>',
     +1X,F5.3,4X,'MAX>',1X,F5.3)
1205  PRINT 1210  NCYC
      LC=LC+1
      IF(LC.LT.56) GO TO 1215
      CALL ENDP(LC,TCK,IFF)
      CALL PAGE(IPAGE,LC,TCK)
1210  FORMAT(1X,'NUMBER OF CYCLES---> ',I4)
1215  CALL HEAD2
      LC=LC+5
      DO 1240 I=1,NLOT
      PRINT 1230  I,QM(I),QS(I),(SFP(I,J),J=1,3),(SFSS(I,J),J=1,3),
     +(ROTP(I,J),J=1,3),(ROTSS(I,J),J=1,3)
      LC=LC+1
      IF(LC.LT.63) GO TO 1240
      IF(I.EQ.NLOT) GO TO 1240
      CALL ENDP(LC,TCK,IFF)
      CALL PAGE(IPAGE,LC,TCK)
      CALL HEAD2
      LC=LC+5
1230  FORMAT(1X,I2,2X,I4,1X,I4,' ',12(1X,F4.2))
1240  CONTINUE
      CALL ENDP(LC,TCK,IFF)
C**************************
C*
C* IF SELECTED GENERATE A CUMULATIVE PROBABILITY PLOT.
C*
C**************************
      IF(PCF.EQ.0.) GO TO 1246
      CALL PAGE(IPAGE,LC,TCK)
      PRINT 1245
      SF=10.
      CALL SCALE(SF)
      CALL LINE
      CUM=1.
      CALL PLOT(SF,CUM,NCYC,FINC)
```

```
      CALL LINE
      CALL SCALE(SF)
      PRINT 1245
1245  FORMAT(1X,'STRATEGY COST',18X,'CUMULATIVE PROBABILITY')
      LC=LC+57
      CALL ENDP(LC,TCK,IFF)
1246  IF(PDF.EQ.0) GO TO 1248
      CALL PAGE(IPAGE,LC,TCK)
C***************************
C*
C* IF SELECTED GENERATE A PROBABILITY DENSITY PLOT.
C*
C***************************
      CUM=0.
      SF=100.
      PRINT 1247
      CALL SCALE(SF)
      CALL LINE
      CALL PLOT(SF,CUM,NCYC,FINC)
      CALL LINE
      CALL SCALE(SF)
      PRINT 1247
1247  FORMAT(1X,'STRATEGY COST',24X,'PROBABILITY')
      LC=LC+57
      CALL ENDP(LC,TCK,IFF)
1248  IPAGE=IHE
      CALL PAGE(IPAGE,LC,TCK)
      PRINT 1249
1249  FORMAT(//,1X,'ANOTHER RUN (Y,N) ? ')
      READ(1,1250) ANS
1250  FORMAT(A1)
      IF(ANS.EQ.1HY) GO TO 570
      GO TO 550
      END
C***************************
C*
C* END OF MAIN PROGRAM
C*
C***************************
```

```
C**************************
C*
C* SCALE ----- ARGUMENT IS THE SCALE FACTOR TO BE USED IN LABELING THE
C*             PLOT AND LATER CALCULATING PLOT POINTS.
C*
C**************************
      SUBROUTINE SCALE(SF)
      DIMENSION D(10)
      DO 1260 I=1,10
      D(I)=I/SF
1260  CONTINUE
      PRINT 1270 D
1270  FORMAT(15X,'0.00',10(1X,F4.2))
      RETURN
      END
```

```
C**************************
C*
C* LINE ----- THIS SUBROUTINE SIMPLY LAYS OUT THE REFERENCE MARKS FOR THE
C*            SELECTED SCALE.
C*
C**************************
      SUBROUTINE LINE
      PRINT 1280
1280  FORMAT(16X,'+',10('----|'))
      RETURN
      END
```

```
C**************************
C*
C* PLOT ----- ARGUMENTS ARE THE SCALE FACTOR, SELECTION PARAMETER FOR
C*            CUMULATIVE OR DENSITY PLOT(CUM), INTEGER VALUE OF THE
C*            NUMBER OF SIMULATION CYCLES(NCYC), AND CLASS INTERVAL
C*            VALUE(FINC).
C*
C**************************
      SUBROUTINE PLOT(SF,CUM,NCYC,FINC)
      REAL*8 PV,PCOST,SCOST
      COMMON / A / PV(51),PCOST(50),SCOST(5000)
      COST=SCOST(NCYC)
      VAL=0.
      DO 1290 I=1,50
      PV(I)=1H
1290  CONTINUE
      PRINT 1320  COST,(PV(J),J=1,50),VAL
      COST=COST-FINC/2.
      DO 1330 I=1,50
      IF(CUM.EQ.0.) VAL=PCOST(I)
      IF(CUM.EQ.1.) VAL=VAL+PCOST(I)
      IVAL=VAL*5.*SF+.5
      DO 1300 J=1,IVAL
      PV(J)=1H*
1300  CONTINUE
      IVAL=IVAL+1
      DO 1310 J=IVAL,50
      PV(J)=1H
1310  CONTINUE
      COST=COST+FINC
      PRINT 1320  COST,(PV(J),J=1,50),VAL
1320  FORMAT(4X,I11,1X,'|',50A1,2X,F6.4)
1330  CONTINUE
      RETURN
      END
```

```
C**************************
C*
C* READ ----- ARGUMENT IS THE FILE NAME LENGTH. THIS SUBROUTINE
C*            READS THE SELECTED DATA FILE FOR THOSE PROGRAM MODES THAT
C*            USE AN EXISTING FILE.
C*
C**************************
      SUBROUTINE READ(NLN)
$INSERT SYSCOM>A$KEYS
      COMMON/ RD /FID(35),NLOT,CIP(3),CISS(3),BP(3),BSS(3),QM(25),
     +QS(25),SFP(25,3),SFSS(25,3),ROTP(25,3),ROTSS(25,3),ACLOT(25),
     +ALUC(25),APUCL(25),ASUCL(25),FNAME(16),TIME,DATE(2)
      REAL*8 FID,CIP,CISS,BP,BSS,QM,QS,SFP,SFSS,ROTP,ROTSS,ACLOT,
     +ALUC,APUCL,ASUCL,TIME,DATE
      INTEGER FNAME
1340  CALL OPEN$A(A$READ+A$SAMF,FNAME,NLN,2)
      READ(6,1350) FID,NLOT
1350  FORMAT(5X,35A2,I2)
      READ(6,1360) CIP
1360  FORMAT(28X,F8.0,14X,F8.0,6X,F8.0)
      READ(6,1360) CISS
      READ(6,1370) BP
1370  FORMAT(28X,F5.3,17X,F5.3,9X,F5.3)
      READ(6,1370) BSS
      DO 1390 [illegible]=1,4
      READ(6[illegible]80) DUMMY
1380  FORMAT(A1)
1390  CONTINUE
      DO 1410 I=1,NLOT
      READ(6,1400) QM(I),QS(I),(SFP(I,J),J=1,3),(SFSS(I,J),J=1,3),
     +(ROTP(I,J),J=1,3),(ROTSS(I,J),J=1,3)
1400  FORMAT(3X,F5.0,1X,F5.0,12(1X,F4.2))
      ACLOT(I)=0.
      ALUC(I)=0.
      APUCL(I)=0.
      ASUCL(I)=0.
1410  CONTINUE
      CALL CLOS$A(2)
      RETURN
      END
```

```
C*************************
C*
C* CREATE ----- THIS SUBROUTINE IS USED TO CREATE A NEW DATA FILE. ONCE
C*              A FILE NAME HAS BEEN ENTERED ITS EXISTANCE IS CHECKED
C*              TO INSURE A FILE DOES NOT ALREADY EXIST THAT MAY BE
C*              OVERWRITTEN. REMOVAL OF FILES IS HANDLED WHILE IN THE
C*              OPERATING SYSTEM COMMAND MODE. ARGUMENTS REPRESENT ENTRY
C*              POINTS WHEN CALLED FROM *MODIFY. M1 SETS THE BASIC ENTRY,
C*              M2 IS THE STARTING LOT NUMBER, AND M3 IS THE ENDING LOT
C*              NUMBER.
C*
C*************************
      SUBROUTINE CREATE(M1,M2,M3)
$INSERT SYSCOM>A$KEYS
      COMMON/ RD /FID(35),NLOT,CIP(3),CISS(3),BP(3),BSS(3),QM(25),
     +QS(25),SFP(25,3),SFSS(25,3),ROTP(25,3),ROTSS(25,3),ACLOT(25),
     +ALUC(25),APUCL(25),ASUCL(25),FNAME(16),TIME,DATE(2)
      REAL*8 FID,CIP,CISS,BP,BSS,QM,QS,SFP,SFSS,ROTP,ROTSS,ACLOT,
     +ALUC,APUCL,ASUCL,TIME,DATE
      INTEGER FNAME
      LOGICAL EXST$A
      IF(M1.EQ.1) GO TO 1465
      IF(M1.EQ.2) GO TO 1555
      IF(M1.EQ.3) GO TO 1495
      IF(M1.EQ.4) GO TO 1525
      IF(M1.EQ.5) GO TO 1535
      IF(M1.EQ.6) GO TO 1545
      IF(M1.EQ.7) GO TO 1555
1420  PRINT 1430
1430  FORMAT(1X,'WHAT IS THE DATA FILE NAME')
      READ(1,1440) FNAME
1440  FORMAT(16A2)
      NLN=NLEN$A(FNAME,32)
      IF(.NOT.(EXST$A(FNAME,NLN))) GO TO 1460
      PRINT 1450
1450  FORMAT(1X,'THAT NAME ALREADY EXISTS---PLEASE ENTER ANOTHER')
      GO TO 1420
1460  CONTINUE
      CALL OPEN$A(A$WRIT+A$SAMF,FNAME,NLN,2)
1465  PRINT 1470
1470  FORMAT(//,1X,'PLEASE ENTER THE FILE I.D. (75 CHARACTERS MAX)')
      READ(1,1480) FID
1480  FORMAT(35A2)
      IF(M1.EQ.1) RETURN
1485  PRINT 1490
1490  FORMAT(1X,'HOW MANY LOTS ARE THERE IN THIS DATA SET ? ')
      READ(1,*) NLOT
      M2=1
```

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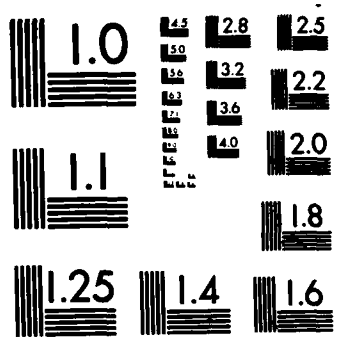

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```
      M3=NLOT
      IF(M1.EQ.2) RETURN
1495  PRINT 1500
1500  FORMAT(1X,'FIRST UNIT COST FOR PRIME'/1X,'MININUM : ')
      READ(1,*) CIP(1)
      PRINT 1510
1510  FORMAT(1X,'MOST LIKELY : ')
      READ(1,*) CIP(2)
      PRINT 1520
1520  FORMAT(1X,'MAXIMUM : ')
      READ(1,*) CIP(3)
      IF(M1.EQ.3) RETURN
1525  PRINT 1530
1530  FORMAT(1X,'SECOND SOURCE FIRST UNIT COST'/1X,'MINIMUM : ')
      READ(1,*) CISS(1)
      PRINT 1510
      READ(1,*) CISS(2)
      PRINT 1520
      READ(1,*) CISS(3)
      IF(M1.EQ.4) RETURN
1535  PRINT 1540
1540  FORMAT(1X,'PRIME PERFORMANCE CURVE SLOPE (.XXX)'/1X,
     +'MINIMUM : ')
      READ(1,*) BP(1)
      PRINT 1510
      READ(1,*) BP(2)
      PRINT 1520
      READ(1,*) BP(3)
      IF(M1.EQ.5) RETURN
1545  PRINT 1550
1550  FORMAT(1X,'SECOND SOURCE PERFORMANCE CURVE SLOPE (.XXX)'/
     +1X,'MINIMUM : ')
      READ(1,*) BSS(1)
      PRINT 1510
      READ(1,*) BSS(2)
      PRINT 1520
      READ(1,*) BSS(3)
      IF(M1.EQ.6) RETURN
1555  DO 1620 I=M2,M3
      PRINT 1560  I
1560  FORMAT(1X,'DATA FOR LOT # ',I2/1X,'MAJOR SPLIT QUANITY')
      READ(1,*) QM(I)
      PRINT 1570
1570  FORMAT(1X,'MINOR SPLIT QUANITY')
      READ(1,*) QS(I)
      PRINT 1580
1580  FORMAT(1X,'PRIME SHIFT FACTOR (.XXX)'/1X,'MINIMUM : ')
      READ(1,*) SFP(I,1)
```

```
      PRINT 1510
      READ(1,*) SFP(I,2)
      PRINT 1520
      READ(1,*) SFP(I,3)
      PRINT 1590
1590  FORMAT(1X,'SECOND SOURCE SHIFT FACTOR (.XXX)'/1X,'MINIMUM :')
      READ(1,*) SFSS(I,1)
      PRINT 1510
      READ(1,*) SFSS(I,2)
      PRINT 1520
      READ(1,*) SFSS(I,3)
      PRINT 1600
1600  FORMAT(1X,'PRIME ROTATION FACTOR (.XXX)'/1X,'MINIMUM : ')
      READ(1,*) ROTP(I,1)
      PRINT 1510
      READ(1,*) ROTP(I,2)
      PRINT 1520
      READ(1,*) ROTP(I,3)
      PRINT 1610
1610  FORMAT(1X,'SECOND SOURCE ROTATION FACTOR (.XXX)'/1X,
     +'MINIMUM : ')
      READ(1,*) ROTSS(I,1)
      PRINT 1510
      READ(1,*) ROTSS(I,2)
      PRINT 1520
      READ(1,*) ROTSS(I,3)
1620  CONTINUE
      IF(M1.EQ.2) RETURN
      IF(M1.EQ.7) RETURN
      CALL WRITE
      CALL CLOS$A(2)
      PRINT 1630
1630  FORMAT(///1X,'ANOTHER FILE (Y,N) ? ')
      READ(1,1640) ANS
1640  FORMAT(A1)
      IF(ANS.EQ.1HY) GO TO 1420
      RETURN
      END
```

```
C***************************
C*
C* WRITE ----- THIS SUBROUTINE WRITES DATA IN TO A PERMANENT FILE.
C*             IT IS USED BY *CREATE AND *MODIFY.
C*
C***************************
      SUBROUTINE WRITE
      COMMON/ RD /FID(35),NLOT,CIP(3),CISS(3),BP(3),BSS(3),QM(25),
     +QS(25),SFP(25,3),SFSS(25,3),ROTP(25,3),ROTSS(25,3),ACLOT(25),
     +ALUC(25),APUCL(25),ASUCL(25),FNAME(16),TIME,DATE(2)
      REAL*8 FID,CIP,CISS,BP,BSS,QM,QS,SFP,SFSS,ROTP,ROTSS,ACLOT,
     +ALUC,APUCL,ASUCL,TIME,DATE
      INTEGER FNAME
      WRITE(6,1650) (FID(J),J=1,35),NLOT
1650  FORMAT('ID : ',35A2,I2)
      WRITE(6,1660) (CIP(J),J=1,3)
1660  FORMAT('PRIME FIRST UNIT COST---MIN>',F8.0,2X,'MOST LIKELY>'
     +F8.0,2X,'MAX>',F8.0)
      WRITE(6,1670) (CISS(J),J=1,3)
1670  FORMAT('SECOND SOURCE-----------MIN>',F8.0,2X,'MOST LIKELY>',
     +F8.0,2X,'MAX>',F8.0)
      WRITE(6,1680) (BP(J),J=1,3)
1680  FORMAT('PRIME PCURVE SLOPE------MIN>',F5.3,5X,'MOST LIKELY>',
     +F5.3,5X,'MAX>',F5.3)
      WRITE(6,1690) (BSS(J),J=1,3)
1690  FORMAT('SECOND SOURCE-----------MIN>',F5.3,5X,'MOST LIKELY>',
     +F5.3,5X,'MAX>',F5.3)
      WRITE(6,1700)
1700  FORMAT(/'LOT  LOT QUAN  SHIFT FACTOR',3X,'SHIFT FACTOR',3X,
     +'ROTATION FACT',2X,'ROTATION FACT'/1X,'#',16X,'PRIME',7X,
     +'SECOND SOURCE',5X,'PRIME',7X,'SECOND SOURCE'/5X,'MAX  MIN',
     +2X,4('MIN  M.L. MAX  '))
      DO 1720 I=1,NLOT
      WRITE(6,1710) I,QM(I),QS(I),(SFP(I,J),J=1,3),(SFSS(I,J),J=1,3),
     +(ROTP(I,J),J=1,3),(ROTSS(I,J),J=1,3)
1710  FORMAT(I2,1X,F5.0,1X,F5.0,12(1X,F4.2))
1720  CONTINUE
      RETURN
      END
```

```
C*************************
C*
C* MODIFY ----- THIS SUBROUTINE ALLOWS MODIFICATION OF AN EXISTING DATA
C*              FILE. WHEN CALLED THE CURRENT DATA IS DISPLAYED ALONG
C*              WITH LOCATOR REFERENCES. A GIVEN DATA ELEMENT CAN BE
C*              MODIFIED BY ENTERING THE LOCATOR WHICH WILL CAUSE THE
C*              APPROPRIATE PROMPT TO BE GIVEN. THIS ROUTINE WILL ALSO
C*              ALLOW THE LOT NUMBER TO BE EXPANDED WITH CORRESPONDING
C*              INPUT PROMPTS FOR THE EXPANDED LOT DATA. IF THE LOT
C*              NUMBER IS REDUCED EXISTING DATA WILL BE RETAINED AND
C*              SIMPLY IGNORED WHEN THE SIMULATION IS RUN.
C*
C*************************
      SUBROUTINE MODIFY
$INSERT SYSCOM>A$KEYS
      COMMON/ RD /FID(35),NLOT,CIP(3),CISS(3),BP(3),BSS(3),QM(25),
     +QS(25),SFP(25,3),SFSS(25,3),ROTP(25,3),ROTSS(25,3),ACLOT(25),
     +ALUC(25),APUCL(25),ASUCL(25),FNAME(16),TIME,DATE(2)
      REAL*8 FID,CIP,CISS,BP,BSS,QM,QS,SFP,SFSS,ROTP,ROTSS,ACLOT,
     +ALUC,APUCL,ASUCL,TIME,DATE
      INTEGER FNAME
      LOGICAL EXST$A
1730  PRINT 1740
1740  FORMAT(1X,'WHAT IS THE NAME OF THE FILE YOU WISH TO MODIFY')
      READ(1,1750) FNAME
1750  FORMAT(16A2)
      NLN=NLEN$A(FNAME,32)
      IF(EXST$A(FNAME,NLN)) GO TO 1770
      PRINT 1760
1760  FORMAT(1X,'THE SPECIFIED FILE DOES NOT EXIST --- PLEASE ENTER',
     +' ANOTHER NAME')
      GO TO 1730
1770  CALL READ(NLN)
      NLOTP=NLOT+1
      PRINT 1780  (FID(J),J=1,35),NLOT
1780  FORMAT(//1X,'(1) ID : ',35A2,/1X,'(2) NUMBER OF LOTS : ',I2)
      PRINT 1790  (CIP(J),J=1,3)
1790  FORMAT(1X,'(3) PRIME FIRST UNIT COST-MIN>',F8.0,2X,'MOST LIKELY>',
     +F8.0,2X,'MAX>',F8.0)
      PRINT 1800  (CISS(J),J=1,3)
1800  FORMAT(1X,'(4) SECOND SOURCE---------MIN>',F8.0,2X,'MOST LIKELY>',
     +F8.0,2X,'MAX>',F8.0)
      PRINT 1810  (BP(J),J=1,3)
1810  FORMAT(1X,'(5) PRIME PCURVE SLOPE----MIN>',F5.3,5X,'MOST LIKELY>',
     +F5.3,5X,'MAX>',F5.3)
      PRINT 1820  (BSS(J),J=1,3)
1820  FORMAT(1X,'(6) SECOND SOURCE---------MIN>',F5.3,5X,'MOST LIKELY>',
     +F5.3,5X,'MAX>',F5.3)
```

```
      PRINT 1830
1830  FORMAT(1X,'(7)'/'LOT  LOT QUAN  SHIFT FACTOR',3X,'SHIFT FACTOR',3X,
     +'ROTATION FACT',2X,'ROTATION FACT'/1X,'#',16X,'PRIME',7X,
     +'SECOND SOURCE',5X,'PRIME',7X,'SECOND SOURCE'/5X,'MAX  MIN',
     +2X,4('MIN  M.L. MAX  '))
      DO 1850 I=1,NLOT
      PRINT 1840  I,QM(I),QS(I),(SFP(I,J),J=1,3),(SFSS(I,J),J=1,3),
     +(ROTP(I,J),J=1,3),(ROTSS(I,J),J=1,3)
1840  FORMAT(I2,1X,F5.0,1X,F5.0,12(1X,F4.2))
1850  CONTINUE
1860  PRINT 1870
1870  FORMAT(//1X,'ENTER THE NUMBER IN THE ( ) THAT CORRESPONDS TO',
     +' THE LINE YOU WANT TO MODIFY')
      READ(1,*) LINE
      IF(LINE.LT.1) GO TO 1870
      IF(LINT.GT.7) GO TO 1870
      IF(LINE.NE.2) GO TO 1890
      PRINT 1880
1880  FORMAT(1X,'PLEASE INPUT THE NEW NUMBER OF LOTS')
      READ(1,*) NLOTM
      IF(NLOTM.GT.NLOT) CALL CREATE(LINE,NLOTP,NLOTM)
      NLOT=NLOTM
      GO TO 1920
1890  IF (LINE.NE.7) GO TO 1910
      PRINT 1900
1900  FORMAT(1X,'WHAT LOT NUMBER DO YOU WANT TO MODIFY')
      READ(1,*) LOTN
      CALL CREATE(LINE,LOTN,LOTN)
      GO TO 1920
1910  CALL CREATE(LINE,NLOT,NLOT)
1920  PRINT 1930
1930  FORMAT(///1X,'ANY MORE CHANGES (Y,N) ? ')
      READ(1,1940) ANS
1940  FORMAT(A1)
      IF(ANS.EQ.1HY) GO TO 1860
      CALL OPEN$A(A$WRIT+A$SAMF,FNAME,NLN,2)
      CALL WRITE
      CALL CLOS$A(2)
      RETURN
      END
```

```
C***************************
C*
C* PAGE ---   THIS SUBROUTINE KEEPS TRACK OF INDIVIDUAL OUTPUT PAGES.
C*            THE ARGUMENT IS THE RUNNING PAGE NUMBER AND LINE COUNT.
C*
C***************************
      SUBROUTINE PAGE(IPAGE,LC,TCK)
      COMMON/ RD /FID(35),NLOT,CIP(3),CISS(3),BP(3),BSS(3),QM(25),
     +QS(25),SFP(25,3),SFSS(25,3),ROTP(25,3),ROTSS(25,3),ACLOT(25),
     +ALUC(25),APUCL(25),ASUCL(25),FNAME(16),TIME,DATE(2)
      REAL*8 FID,CIP,CISS,BP,BSS,QM,QS,SFP,SFSS,ROTP,ROTSS,ACLOT,
     +ALUC,APUCL,ASUCL,TIME,DATE
      INTEGER FNAME,TCK
      IF(TCK.EQ.1) GO TO 2005
      PRINT 2000
2000  FORMAT(79(1H-))
2005  IF(IPAGE.EQ.1HE) RETURN
      IPAGE=IPAGE+1
      LC=5
      PRINT 2010  DATE,TIME,IPAGE
2010  FORMAT(1X,'RUN ---> ',2A8,3X,A8,36X,'PAGE ',I2////)
      RETURN
      END
```

```
C***************************
C*
C* HEAD1 ----- THIS SUBROUTINE PRINTS THE HEADING ASSOCIATED WITH
C*                SIMULATION LOT DATA RESULTS. IT IS CALLED WHENEVER
C*                A PAGE BREAK OCCURES IN THE GIVEN PORTION OF THE
C*                OUTPUT.
C*
C***************************
      SUBROUTINE HEAD1
      PRINT 2020
2020  FORMAT(/1X,'PRIME SPLIT WIN',32X,'AVERAGE UNIT COSTS'/1X,
     +'PERCENTAGE',17X,'AVERAGE LOT',2X,'-----------------------',
     +'----------'/1X,'LOT #',3X,'%',5X,'LOT QUANITY',5X,'COST',7X,
     +'PRIME',3X,'SECOND SOURCE',2X,'COMPOSITE'/1X,'-----',1X,'------',
     +2X,'-----------',2X,'-----------'2X,'-------',2X,
     +'-------------',2X,'---------')
      RETURN
      END
```

```
C**************************
C*
C* HEAD2 ----- THIS SUBROUTINE PRINTS THE HEADING ASSOCIATED WITH
C*                THE DATA FILE DISPLAY. IT IS CALLED FOR EACH PAGE
C*                BREAK.
C*
C*****************
      SUBROUTINE HEAD2
      PRINT 2030
2030  FORMAT(/16X,'SHIFT FACTOR',3X,'SHIFT FACTOR',3X,'ROTATION FACT',
     +2X,'ROTATION FACT'/1X,'LOT  LOT QUAN',5X,'PRIME',7X,
     +'SECOND SOURCE',5X,'PRIME',7X,'SECOND SOURCE'/2X,'#',3X,
     +'MAX  MIN',2X,4('MIN  M.L. MAX  ')/1X,'---',1X,'---- ----',2X,
     +4('---- ---- ---- '))
      RETURN
      END
```

```
C***************************
C*
C* ENDP ----- THIS SUBROUTINE PADS THE BOTTOM OF EACH PAGE WITH BLANK
C*            LINES TO INSURE EACH PAGE IS PRINTED IN 8 1/2 X 11 INCH
C*            FORMAT WHEN USING A THERMAL TYPE TERMINAL.
C*
C***************************
      SUBROUTINE ENDP(LC,TCK,IFF)
      IF(TCK.EQ.0) GO TO 2035
      PRINT 2037 IFF
2037   FORMAT(A2)
      RETURN
2035  LC=LC+1
      DO 2050 I=LC,67
      PRINT 2040
2040  FORMAT(/)
2050  CONTINUE
      RETURN
      END
```

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Competition; Procurement; Acquisition; Cost Analysis; Economic Analysis; Computer Program; Decision Model

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

Although competition is generally desirable for the production of Army weapons, it must be evaluated on a case-by-case basis before it is applied. The objective of this study was to develop guidance for the rigorous comparison and evaluation of competitive and non-competitive alternatives with their associated benefits and risks.

Research methodology included analyzing competitive effects and integrating the best features of various approaches in a set of guidance instructions.

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An economic analysis was programmed in a computerized decision model.

CONCLUSIONS.

The analysis of competitive alternatives is complex, filled with uncertainty and dependent on both economic and non-economic criteria. While the analysis of non-economic issues and non-recurring costs involves fairly straight-forward systematic judgment, the recurring cost analysis is more complex. A cost improvement methodology was selected for the competition guidance because it has fewer disadvantages than the alternatives and has met with more operational success. The guidance describes how to use this cost improvement methodology.

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