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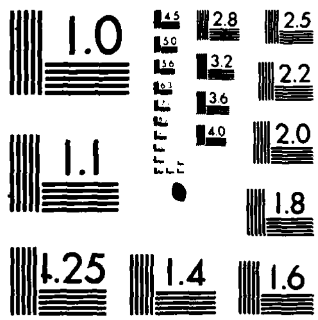

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FINAL

STRATEGY SELECTION FOR THE PRODUCTION PHASE OF WEAPON SYSTEM ACQUISITION

MAY 1982

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

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STRATEGY SELECTION FOR THE PRODUCTION PHASE OF WEAPON SYSTEM ACQUISITION

MAY 1982

by

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

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EXECUTIVE SUMMARY

A. BACKGROUND. Selecting a strategy for the production phase of a weapon system acquisition is one of the most important decisions in successfully achieving a system's fielding objectives. However, the decision and its outcomes are nonobvious, and existing analytical models used to assist in the decision-making process do not provide for the systematic analysis of each available option. Neither do the models consider all three parts of the decision environment: potential strategies, objectives, and system specific conditions. What the decision analysis demands is an approach that realistically deals with both the complexities and uncertainties present.

B. STUDY OBJECTIVES. The objectives of this study were to: (1) define the production acquisition strategy problem; (2) develop a structured approach to the decision process; (3) develop a mathematical representation of the cost outcomes; (4) report findings on strategy impacts on non-cost issues; (5) develop a screening methodology to focus the decision process on key alternatives; and (6) discuss the applicability of Venture Evaluation and Review Technique (VERT) in the analysis effort.

C. REPORT METHODOLOGY. Research began with a literature review of previous studies on strategy decisions, competition cost savings, and uncertainty analysis. Limitations in the existing studies were identified to determine what aspects of the decision process required more complete treatment. A requirement for empirical data to analyze non-cost factors was established from this effort. A cost model incorporating cost improvement curves and uncertainty analysis was created for use in analyzing the alternative strategies. A VERT analysis was included to demonstrate the advantages of using a coherent framework in a complex analysis effort.

D. CONCLUSIONS AND RECOMMENDATIONS. The empirical research on non-cost issues, specifically reliability and schedule, was limited by the few qualifying systems with auditable records. Tentative conclusions were that (1) given government monitoring the reliability objective should typically be given little weight in the strategy decision and (2) second sources do experience initial schedule delays of greater magnitudes than the developer. The study presents an approach to analyzing the strategy selection problem. A screening technique is used to focus the detailed analysis on the viable strategies. The cost model integrates inputs from the areas of methodology, historical data, and judgment. It is shown that a stochastic network can be used to represent the dynamics of the acquisition process. The study recommends the cost-saving behavior of multi-year contracts be investigated.

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CHAPTER I

INTRODUCTION

A. PROBLEM DESCRIPTION.

Selecting an acquisition strategy for a weapon system is one of the most important decisions in making the fielding of that system a reality. The acquisition strategy decision has far ranging impacts on the possibilities of generating competitive cost savings [10] and the degree of success in meeting performance and schedule parameters. Since the decision and its outcomes are nonobvious, the decision should be made only after a systematic analysis of each available option.

Existing analytical models used to assist in the decision making process do not fulfill this requirement. They generally accomplish only part of the necessary analysis (e.g., production cost) or in some cases fail to correctly interpret the data. None consider all three parts of the decision environment: (1) the potential strategies, (2) the various objectives they would affect or achieve, and (3) the special conditions describing a specific system. The purpose of this report is to present an approach to this decision problem that realistically deals with both the complexities and the uncertainties present at the time a decision must be made.

B. BACKGROUND/SCOPE.

To better understand the complexities involved in the decision environment, the three parts are discussed below.

1. Acquisition Strategy.

In Cox and Hullander [4], an acquisition strategy was a vector quantity (T_0, T_1, T_2, T_3) representing the selection of a particular strategy for each of the four major phases of a system acquisition:

concept development, demonstration and validation, full-scale development, and production and deployment. The strategies suggested by Cox and Hullander are displayed in Figure 1. Interdependencies between the T_i's may exist in the sense that a decision for an early phase may preclude the use of a particular strategy in a later phase.

The scope of this study is limited to the selection of a strategy for the production phase (T_3) of system acquisition. Major portions of the total cost are encountered in the production phase. Earlier studies (e.g., 10) collect and analyze data pertaining to this phase. This study attempts to provide a more complete perspective on the production strategy problem.

The set of production strategies in Figure 1 has been expanded as shown in Figure 2. Further, the concept of a production strategy is expanded. Production may be accomplished through a series of buys. Thus, a production strategy itself can be regarded as a vector quantity. Additionally, at the level of the contracting officer, tactics must be chosen to support the strategic choice [23].

2. Acquisition Objectives.

The objectives of the acquisition comprise the second major part of the environment. A hierarchy of general objectives relevant to the production strategy decision is shown schematically in Figure 3. Each strategy will have different effects according to the objective it is measured against as the following examples show. Existing data has shown that recurring production costs tend to be reduced by competitive strategies [5, 7, 10]. The time at which the system is fielded can also be affected. In some cases this timing impact may best be measured as the

T_0/Phase 0: CONCEPT EXPLORATION

- Directed Concept
- By Non-Industrial Firms
- By Industrial Firms

T_1/PHASE 1: DEMONSTRATION AND VALIDATION (D&V)

- Waive D&V
- Contract Definition

  By Non-Industrial Firm
  Industrial Firm (Single Source)
  Industrial Firms (Multiple Sources)

- Subsystem and/or Component Development

  By Non-Industrial Firm
  Industrial Firm (Single Source)
  Industrial Firms (Multiple Sources)

- System Prototypes

  By Non-Industrial Firm
  By Industrial Firm (Single Source)
  By Industrial Firms (Multiple Sources)

T_2/PHASE 2: FULL-SCALE DEVELOPMENT (FSD)

- Incremental Development

  Single Source
  Multiple Sources

- Concurrent Development

  Single Source
  Multiple Sources

T_3/PHASE 3: PRODUCTION & DEPLOYMENT

- Single Source, No Options
- Single Source with Options
- Single Source, Multi-Year Contract
- Leader-Follower
- Licensing
- Second Sourcing

Figure 1. Acquisition Strategy Alternatives.

SOURCE: Cox and Hullander

Sole Source	Multiple Sources
Single Source, No Options	Leader-Follower
Single Source with options	Licensing
Single Source, multi-year contract	Technical Data Package (TDP)
	Form, fit, function (F^3)
	Teaming

Figure 2. General Production Strategies.

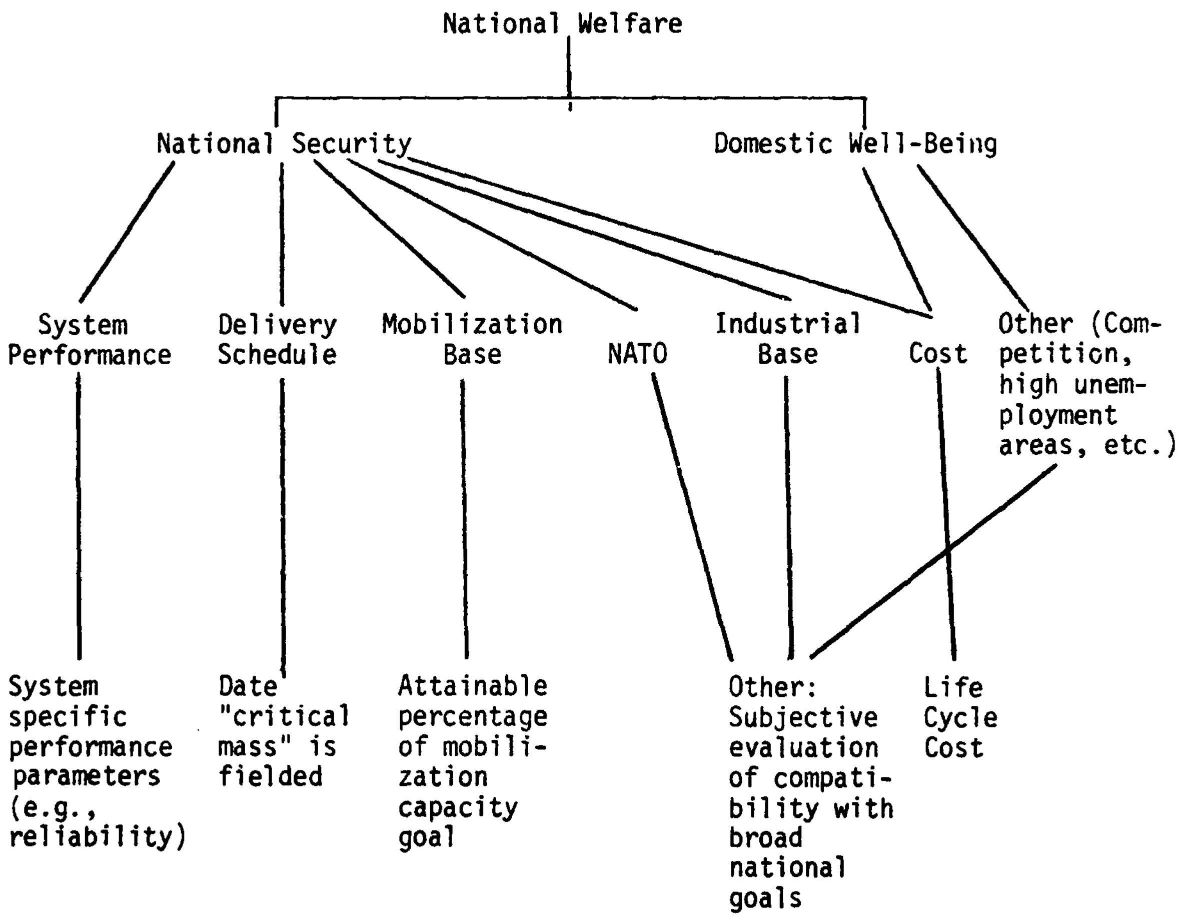


Figure 3. Hierarchy of Acquisition Objectives.

date by which a "critical mass" of the system is fielded. Likewise, the strategy decision can affect the ultimate operational reliability of the system. For example, a second source may produce a less reliable product due to a deficiency in its manufacturing process below the level of detail specified by the technical data package. Equally, in any given setting specific objectives may be paramount. For example, it may be critical that a multi-source mobilization capability exist. The objectives vary in importance from case to case. Cost, however, is almost always considered important, and it is the objective that most fully needs and is suited to a comprehensive modeling effort.

3. System Conditions.

In addition to strategies and objectives, the third major defining topic is the conditions present for the system. A suggested list of conditions that affect the various outcome objectives is provided in Figure 4. Other authors [4, 16, 17, 23] have also suggested critical conditions in a system acquisition.

4. Key Factors of Strategy Selection Studies.

Earlier studies have looked at the strategy selection problem and especially at the relative costs of competitive and non-competitive production strategies. The proposed decision models, however, have been too simplistic in their analysis of the problem. A model for the strategy selection decision should recognize several key factors associated with the problem.

One of the factors of major significance in system cost estimating is the phenomenon of learning, or cost improvement, over time. Cost improvement resulting from production experience must play a central role

1. Affecting Life Cycle Cost:

Complexity	Funding
Quantity	Commodity class
Duration	Technical maturity at beg. of production
Non-recurring costs to establish a source	Capacity
Extent of subcontracting	Learning curve slopes
Nature of Production Process	Quality of TDP
Extent of FMS	No. of qualified Krs
Technical data rights	Attitude of Prime

2. Affecting Performance:

Complexity	No. of qualified Krs.
Extent of subcontracting	Attitude of prime
Nature of production process	Cost to develop 2nd source
Commodity Class	Time to develop 2nd source
Technical maturity at beg. of production	Kr's past performance
Quality of TDP	Commonality

3. Affecting IOC:

Complexity	Quality of TDP
Commodity class	No. of qualified Krs.
Technical maturity at beg. of production	Attitude of prime

4. Affecting mobilization goal:

Capacity

5. Broad goals:

NATO agreements
State of industrial base
State of general economy

Figure 4. Significant System Conditions.

in any cost-oriented decision model. Usually analysts have assumed a power function cost improvement curve ($y = ax^b$). Such a curve results from the assumption that every doubling of cumulative production quantity results in a fixed percentage reduction in unit cost. In recent years all serious cost efforts in defense systems acquisition have incorporated the cost improvement curve notion.

A second factor--production rate effects on system cost--has not achieved the same recognition as the cost improvement curve. Yet it is important to include this factor in comparing alternatives involving significantly different production rates. For example, dual sourcing strategies result in lower rates for individual producers. Several different approaches have been suggested for linking the rate effect with the learning effect [1, 2, 18]. While the proposed treatments have differed, actual cases have demonstrated that in the current defense environment production stretchouts with their lower annual quantities lead to higher costs.

A third key factor in the problem is the form taken by the competitive buy. It is clear that greater competitive pressures exist in some contracting situations than in others. Further, the extent to which competitive prices are reduced below sole source levels ought to reflect the necessarily subjective degree of competitive pressure.

The three factors discussed above--learning, production rate, and competitive environment--are key factors affecting the outcomes of strategy selection decisions. It is important to dissect the problem and understand how these factors manifest themselves even if objective data do not provide satisfactory estimates of their values in a given situation.

Several difficulties impinge upon the ability to formulate a decision model providing insight into the effect of alternate production strategies. For example, not nearly enough programs have been executed and documented under different production strategies to provide statistical data on individual strategies under particular sets of conditions. For obvious economic reasons, it is infeasible to obtain data via experiments. Therefore, an approach must be devised that enables one to extract the very maximum information available. The model proposed in this report can help in analyzing the relative effects of the primary components of the problem. It is an integrated model in the sense that model inputs depend on a blend of judgment and existing quantitative data.

5. Assessment of Historical Work.

Several areas of research effort have provided a stimulus for the present work. Key documents are described in the following paragraphs.

a. Competition Data and Cost Models.

A fundamental study concerned with estimating the savings resulting from production competition in defense system acquisition was Lovett and Norton [10]. Prior to this effort, assessments of competitive savings had typically been done in crude ways that did not reflect factors such as sole-source learning. Recently other studies have analyzed the empirical findings from competitive system procurements [5, 7]. The different studies agree in their findings of observed savings and the high degree of variability in these savings. These studies form the primary empirical base for estimates of recurring cost savings behavior. Previous attempts to go beyond the empirical savings to predictive models, however, have shortcomings. This topic will be discussed in Chapter III when a modeling approach is proposed.

The most complete case analysis of the second sourcing decision for production seems to be the MLRS Second Sourcing Rocket Acquisition Study [12].

The model proposed in this report attempts to extend [12] by providing a more comprehensive framework for the uncertainty present in costing. The analysis of non-cost issues in [12] can also serve as useful background for analysts doing a strategy selection study.

b. Acquisition Conditions.

The contingency theory of management is explored by Hofer [8] and Luthans [11] among others. This approach attempts to relate the appropriate management strategy to the existing conditions. Williams and Knittle [23] suggest this approach for defense systems, but their results remain too general for operational use. Parry and Sellers [16, 17] focus more specifically on the conditions favorable or unfavorable to second sourcing, but they do not deal with the relative importance and magnitude of the various conditions. Sparks [21] proposed a condition-oriented model for licensing, but the model leaves some of the fundamental issues to be answered with simple yes-no responses. A few other such models have been proposed[14, 22].

c. Subsidiary Problems.

The relationship of production rate to the strategy selection problem was discussed earlier. Other areas which may bear on a given strategy decision are described below. One of these is the problem of allocating production quantities among sources when attempting to sustain both a competitive environment and dual sources. Solinsky discussed this problem and recommended an allocation rule in [20]. A second subproblem deals with price improvement curve slopes under competitive strategies relative to sole source strategies. In [19] Smith and Lowe concluded that sole source and competitive slopes should ordinarily be treated as equal or with slight improvement for competition.

d. Decision Modeling.

Some studies from decision-making literature are also relevant to the current research. Park et al. [15] suggested a decision plan net that served as a guide to the decision screen part of the approach discussed in Chapter III. The screen, as applied in this report, reduces the strategies to a smaller set capable of more detailed evaluation. The primary emphasis in this report is on structuring an appropriate model regardless of the relative weight given differing objectives in a particular case. DeWispelare and Sage [6] suggest a multi-attribute utility approach to a different defense acquisition problem. Much of their work could be applied to preference evaluation when preferences cannot be easily assessed directly from predicted outcomes. Thus, their approach could be used in conjunction with the effort described in this report. The Venture Evaluation and Review Technique (VERT) is used to analyze the probabilistic network describing an acquisition strategy in Chapter III. This technique was developed by Moeller [13].

e. Assessment Summary.

In summary, previously proposed models for system strategy selection have lacked sufficient content to be a useful operational guide to project management. The work has been heavily process-oriented and non-quantitative. This effort tries to bring the problem closer to an operational solution through explicit analysis coupling systematically judgment and empirical observations. A real dearth of work exists treating multi-year procurement which is likely to see increased use in the future [3].

C. STUDY OBJECTIVES.

The objectives of this study were to:

1. Define the production acquisition strategy problem to include identifying the interrelationships between strategies, system conditions and objectives.

2. Discuss previous approaches to the strategy decision and their limitations.

3. Report findings on strategy impact on non-cost issues.

4. Develop a structured approach to the decision process which recognizes the dynamics of the factors and the uncertainty involved.

5. Develop a mathematical representation of the cost outcomes.

6. Develop a production acquisition strategy screening methodology to focus the decision process on key alternatives.

7. Discuss the applicability of various analytical tools with emphasis on the Venture Evaluation and Review Technique (VERT).

CHAPTER II

RELIABILITY AND SCHEDULE FINDINGS ABOUT SECOND PRODUCTION SOURCES

A. GENERAL.

Earlier empirical research related to acquisition strategy decision-making has focused on the cost dimension. Nothing systematic was found that focused on the attainment of non-cost objectives. In this chapter data bearing on the other major dimensions of the decision--schedule and reliability--are examined. Cases providing schedule and reliability information about second source production proved to be extremely limited. The cases for which data proved obtainable were projects with the Naval Material Command and the US Army Materiel Development and Readiness Command. The findings are insufficient for rigorous analysis, but the charts and graphs recording the actual observations are presented in Appendices A and B. The identity of the contractors involved is not revealed. Attention should be focused on the phenomena observed and not on which party may have been involved. All the cases were second sourcing of the TDP (technical data package) type in which an exact copy was made by the second source.

B. RELIABILITY.

The second sources sometimes encountered reliability problems early in production. These were generally corrected with little or no degradation of operational reliability. It must be noted that these cases reflect situations where competition was actually undertaken. Therefore, some basic conditions must have been previously met. For example, a determination would have been made that the source was technically qualified. Note too that the aspect of reliability bearing on the strategy decision is the operational reliability of the second source's product relative to the first source. Under some options it may be that the second source is producing a different product than the original developer. However, as mentioned above, all of the data presented here deals with identical TDP copies.

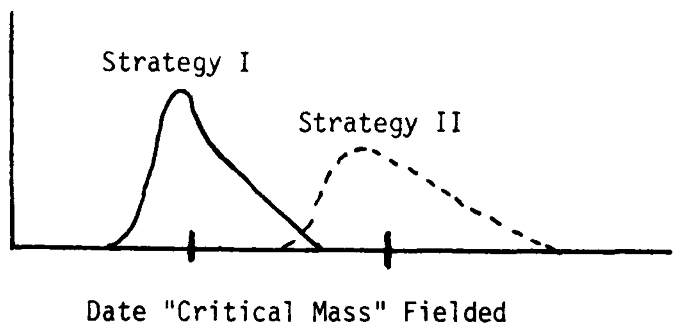
An important point is that deficiencies in the technical data packages were commonly acknowledged by Government personnel. Contracting-oriented persons seemed frequently, however, to have a narrow and mistaken view that a quality technical data package and a well-prepared contract would resolve all the problems. It is apparent, though, that even a quality technical data package is not sufficient to insure the absence of production problems. At least two reasons have been offered to explain this. In the first place, continual corrections are made to the TDP in the early stages of production. Some of these corrections may fail to be fed to the second source. Secondly, the level of detail of a TDP is not sufficient to explain all production processes.

Appendix A documents the situations the data-gathering effort uncovered. The tentative conclusion is that the weight of reliability considerations in the strategy selection decision should typically be very small provided the government monitors reliability. Most problems are uncovered in system acceptance testing and do not reach the field to affect capability.

C. SCHEDULE.

The date at which a "critical mass" of a system is fielded may be used to measure strategy differences in the schedule area. The definition of a critical mass may vary with the system, but it typically might involve the fielding of many more product units than the initial operating capability (IOC) entails. IOC is a commonly used date for reporting progress on major systems.

There are two ways in which delivery time of the system can be affected by a second source strategy. First, an alternative production strategy may require a new fielding schedule. For example, additional time may be required for adequately establishing a second source. The other effect is on the risk of meeting planned delivery schedules. These two effects are illustrated in Figure 5.



A. PRODUCTION SCHEDULE CHANGE (SHIFT OF MEAN)
B. RISK CHANGE (INCREASED VARIANCE)

Figure 5. Example Schedule Effect.

Commonly, the second sources encountered an initial period of difficulty in meeting their production delivery schedule. The graphs in Appendix B suggest the extent and duration of this problem. For the six systems graphed in Appendix B the second production sources were consistently more delinquent than the original source at comparable points in their production experience. The results varied widely, but the difference between the sources in deliveries versus schedule was typically three to five months. Informal comments are also provided in Appendix B applicable to some of the systems.

The suggested conclusion from the data is that the technical data package does not solve all production-related issues. It is common for the second source to encounter production delays. Since the second source is usually initially assigned only small quantities, the total effect on system effectiveness may be slight. Review of Lovett and Norton [10] leads to the thought that another, albeit small, risk also exists that this study's limited data base also found. This risk is the risk of never getting deliveries from the second production source.

D. DECISION PROBLEM IMPACT.

It seems conceivable that the developer's reliability is enhanced by the mere presence of an alternate source. The second source's reliability, if deficient early in production, does seem to improve over time. In any case, the relatively small observed differences in reliability are most likely overwhelmed by the conditions of actual use, e.g., gunner accuracy.

The available data are too sparse and the effect typically too small to make a complex approach to dealing with schedule and reliability worthwhile. It is recommended that the analyst combine judicious use of the data reported with system-specific considerations to directly create an outcome probability density function. The ultimate goal is the same as for the cost objective--to project a measure of the difference in outcome to be expected if one follows a competitive or sole source stragegy. The decision-maker will typically be able to evaluate directly the relative importance of schedule and reliability differences among strategies. If this is too difficult, then the more elaborate techniques of multi-attribute utility theory can be used [6].

CHAPTER III

DECISION APPROACH

A. INTRODUCTION.

This chapter offers a structure that provides a realistic approach to the complex strategy selection problem with its dynamic, probabilistic, multi-objective nature. A first step in problem analysis is to dissect the problem in order to clearly identify the key pieces that materially affect the outcome. It is important to consider these key structural pieces whether or not their values can be accurately determined in a given setting. The problem is then structured to allow exploring the effects of the key factors on alternative strategies. An example of a key factor is the competitive environment present for the buy. The state of knowledge of the values of these factors is limited. Not enough cases of any given type exist to provide firm guidance concerning outcomes. The infeasibility of conducting experiments precludes gathering information by that means. Thus, the best that can be attained is to use an approach employing all available information in the best way possible. The mathematical approach explained below provides an integrating structure in which one can explore the relative effects of the components.

Consider the structure of the problem. A given competitive strategy and its basic means of expression can be illustrated by the example in Figure 6. The uncertainty present in tracing the series of outcomes over the production phase suggests the suitability of a stochastic model. The heart of the cost model is a stochastic structure capable of evaluating specific strategies relative to a baseline alternative. The other key part of the model is the set of input probability density functions that can be modified to meet the specific circumstances of a given case.

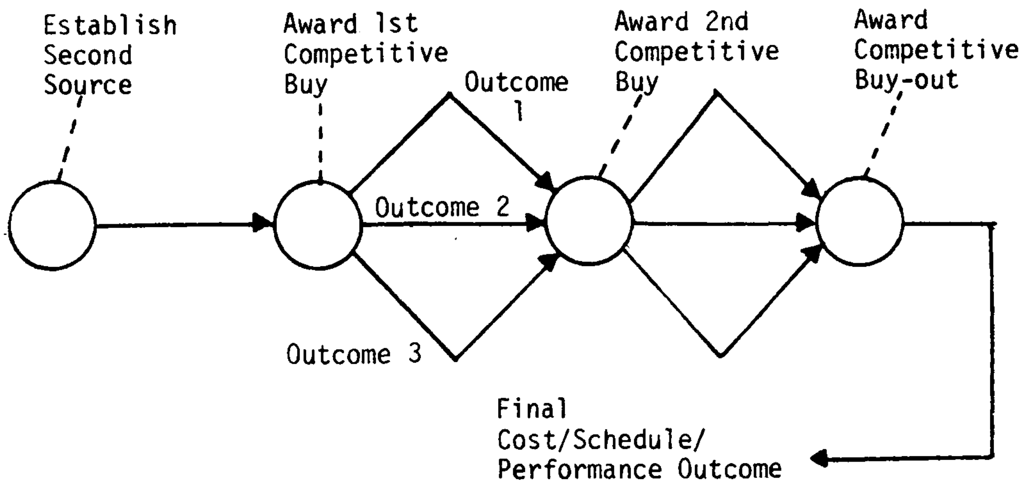


Figure 6. Example Illustrating Competitive Strategy.

An overview of the entire decision approach is given in Figure 7. In applying the approach the first step is to apply a decision net which will reduce the number of candidate strategies through the systematic application of a series of questions. Then viable production schedules must be prepared for the surviving strategies. Each suitably defined production schedule is a required input to the cost model. Several probabilistic parameters must also be provided, and the entire acquisition network developed for each candidate strategy. One tool for analyzing such networks is VERT [13]. The novel use of VERT proposed here is illustrated in Section D for a sample problem. Finally, the analyst must consider the other objectives of the decision in providing the full array of projected outcomes to the decision-maker.

B. DECISION SCREEN.

A decision screen is a series of questions used as a device to eliminate unsuitable strategies from the analysis effort. The screens designated for the approach are illustrated in Figures 8 and 9. The first screen is concerned with program conditions while the second screen focuses

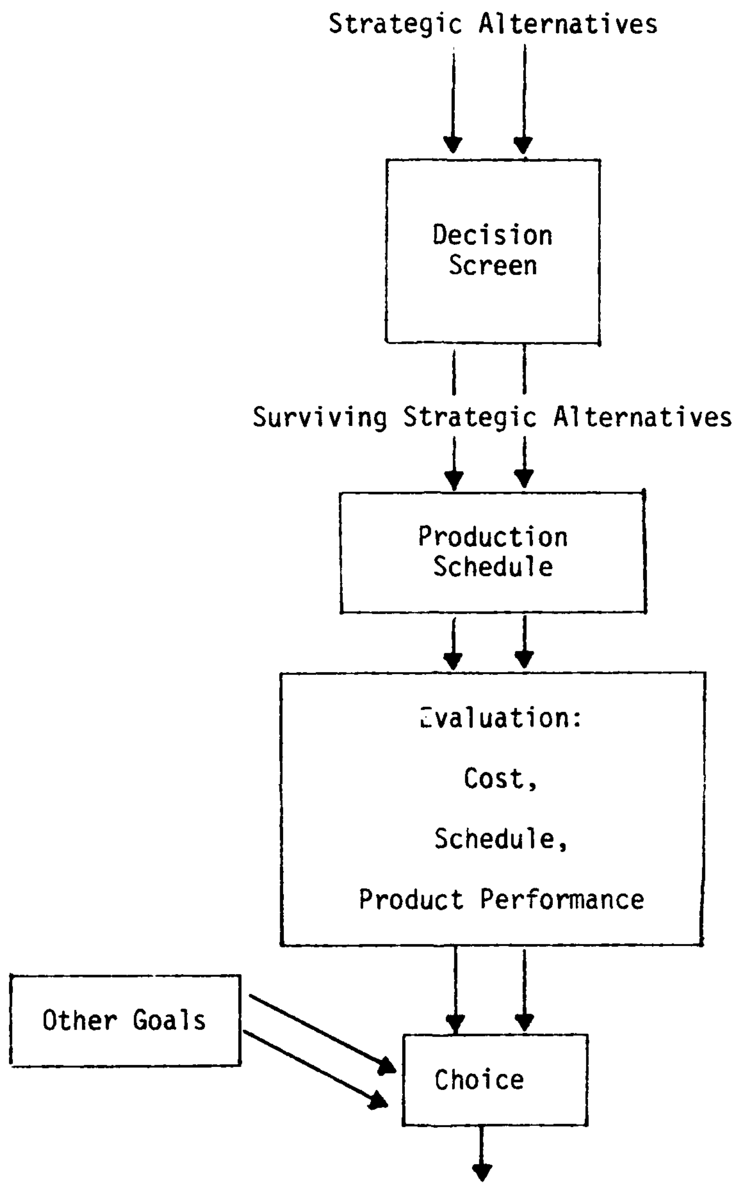


Figure 7. Approach Schematic.

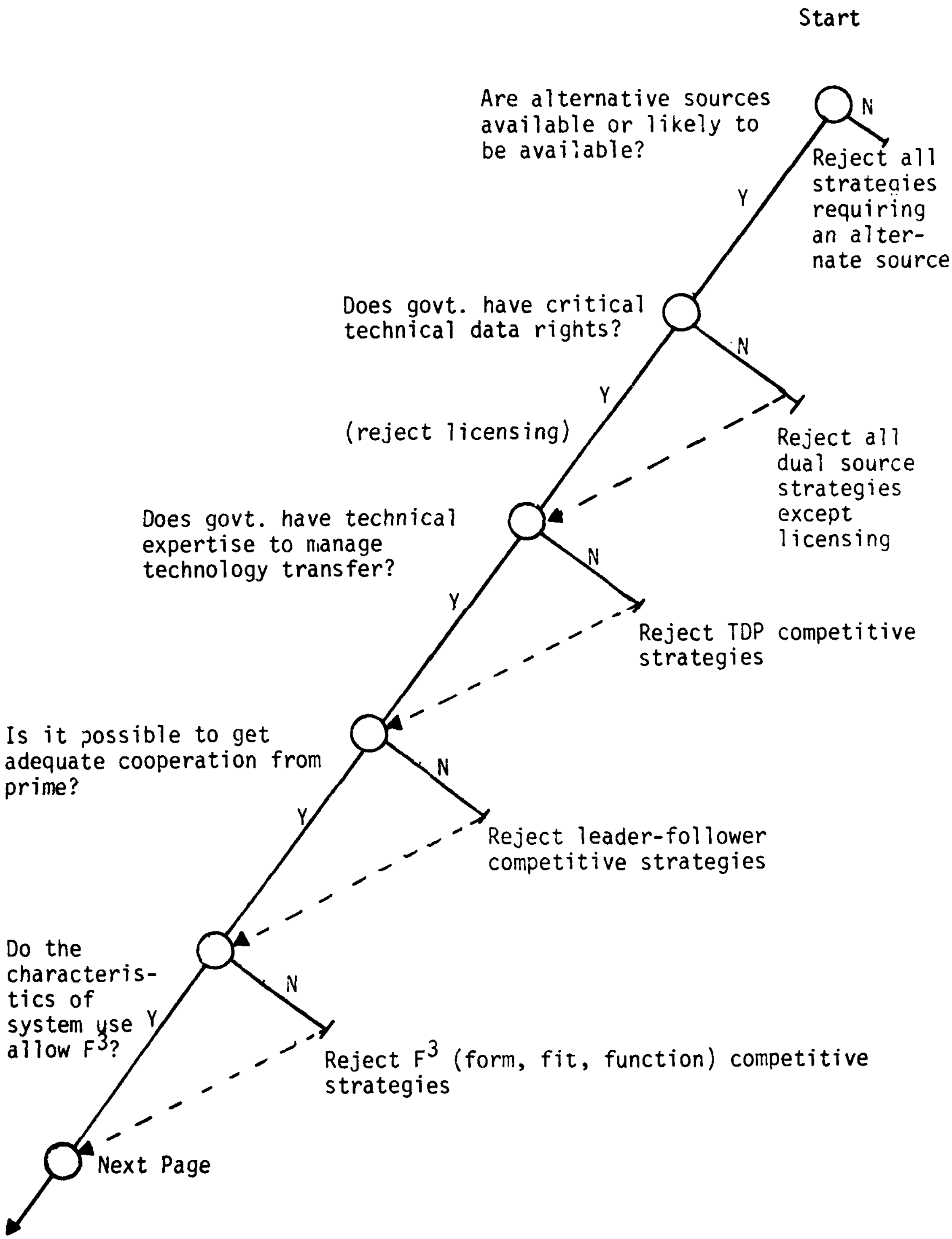


Figure 8. Screen 1 - Program Conditions.

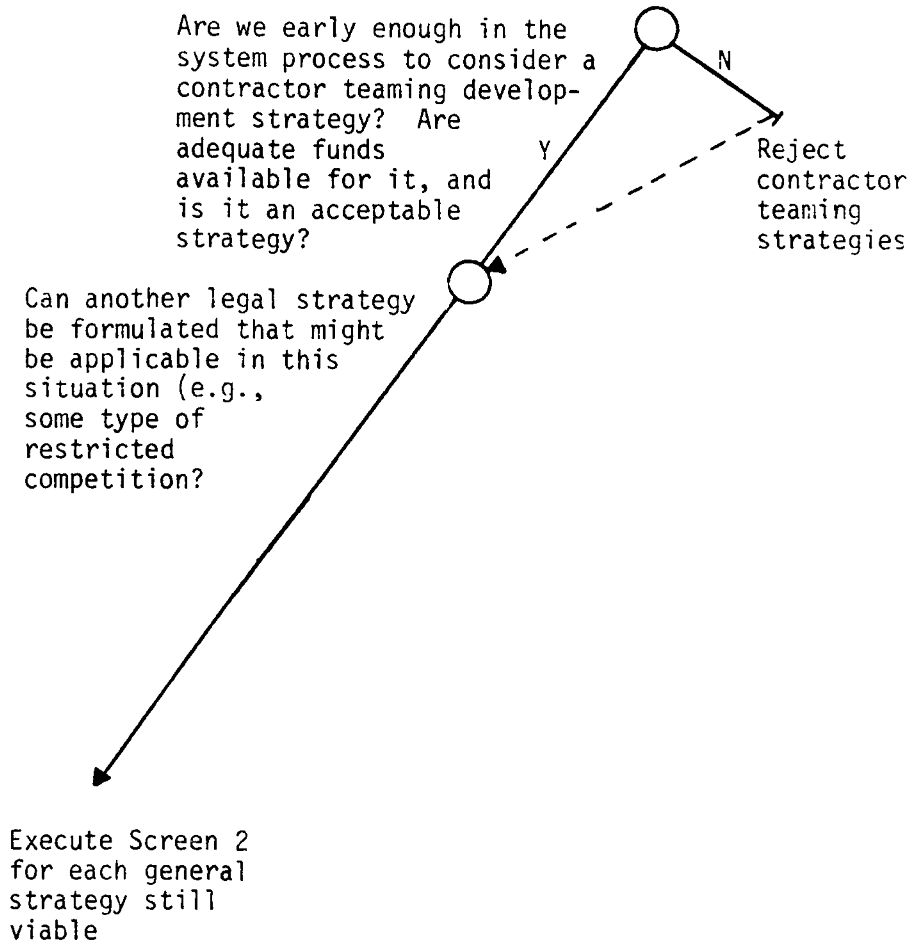


Figure 8 (Cont'd)

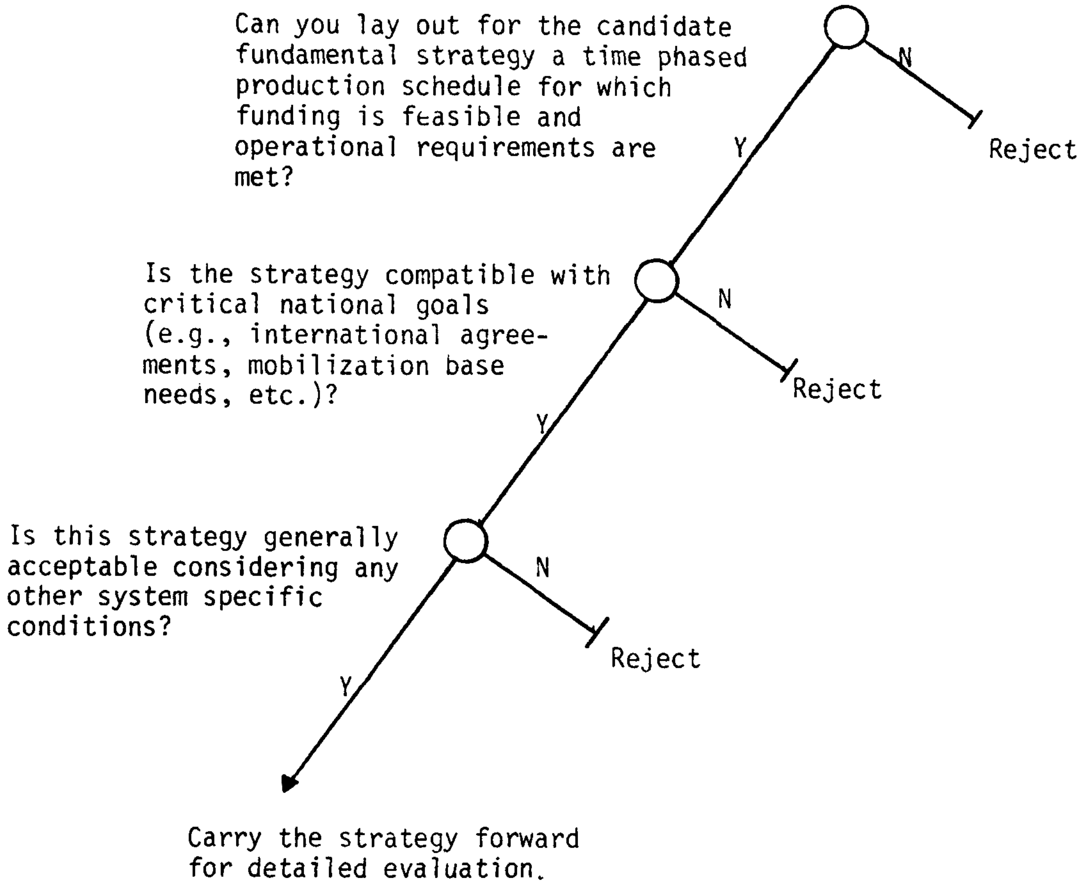


Figure 9. Screen 2 - Strategic Issues.

on issues related to the strategy being evaluated. The screen can be applied to each potential strategy in turn, following the layout of the figures. After the viable general strategies are determined, the detailed construction of schedules and strategy choices for each time period can be performed. These steps are preliminary to actually developing the VERT network and costing each strategy in a probabilistic manner.

C. COST MODEL.

1. Overview.

Earlier cost models of the competitive versus sole source strategy problem have been too simplistic. In [5] and [10] regression models were proposed for use in predicting the cost of acquiring systems under competition. These models are unsatisfactory because they do not permit a reasonably accurate estimate of recurring cost savings and do not recognize the wide variation in possible outcomes. The dependent variable in these regressions is inappropriate; typically it is the projected competitive price. The studies then show a regression curve using this dependent variable which has a deceptively good fit (R^2). Seemingly accurate prediction of the competitive price is not nearly the same as predicting the savings, however. The underlying data are simply too erratic to permit accurate projections of savings.

In [7] another approach is presented, but the model in [7] applies only to the case of sustained split awards among the two sources. Like the models above, it does not recognize the wide variations in competitive environments. It indiscriminately uses the historical data base to predict savings in the split award environment. Thus this approach extends without modification the data base findings too far outside their legitimate domain.

In fact, most of the historical cases reflected buy-out situations or a mixture of split award and buy-out results. The cost model presented in this chapter improves on the approach in [7] by reflecting the dynamic nature of the competitive environment.

2. Model Definition.

The starting point for the cost model is the basic cost expression of unit learning curve theory. According to this theory, total recurring cost C to the government can be represented as the sum of a declining set of unit costs represented usually by a power function

$$C = \sum_{q=q_1}^{q_2} aq^b \tag{1}$$

where a is the theoretical first unit cost, b reflects the rate of cost improvement, and production extends from unit q_1 to q_2.

Several modifications to the basic expression in (1) are required in order to analyze the strategy problem. Consider a single delivery year which is embedded in an overall production effort. Since the particular delivery year deals with only a portion of the total buy, an appropriate discount rate α_i should be applied to the recurring cost expression. This leads to year i cost C_i given by

$$C_i = \alpha_i \sum_{q=q_{i-1}+1}^{q_i} aq^b \tag{2}$$

where q_i represents the production experience of a producer at the end of year i.

In addition to several years of production, several different production contracts may also be involved. Alterations to the competitive environment may lead to expected cost effects reflected by the random variables $\tilde{I}_i$ and $\tilde{b}_i$ where typically the expected value $E(\tilde{I}_i) < 1$ for more competitive environments. Then the contract cost is given by

$$K_i = \tilde{I}_i \sum_{q=q_{i-1}+1}^{q_i} aq^{(b-\tilde{b}_i)} \tag{3}$$

where $\tilde{I}_i$ measures a competitive shift in the improvement curve and $\tilde{b}_i$ measures a change in the rate of improvement. In this particular expression, the previously mentioned discounting has been suppressed for purposes of simplicity. The values of $\tilde{I}_i$ and $\tilde{b}_i$ and the degree of production experience q_{i-1} are affected by the previous production awards for the system. The value of $\tilde{I}_i$ can also incorporate production rate shifts.

These complexities suggest that a strategy's cost can best be modeled as a stochastic network like the example in Figure 10. The various branches represent potential outcomes of contract awards. The branches are labeled with estimates of the conditional probability of that particular outcome being generated. The competitive environment is path dependent and described by subjectively estimated probability density functions. Some examples are provided in Figure 11. The total set of probabilities to the cost model includes the non-recurring costs, the recurring savings, and the contractor win probabilities. The other major input is the detailed strategic schedule as illustrated by the example in Figure 12. For the more complex strategies the VERT technique can be used as illustrated in section 4. To acquire in-depth familiarity with VERT the reader should see [13] and then acquire a VERT guide from the US Army Logistics Management Center, Fort Lee, VA.

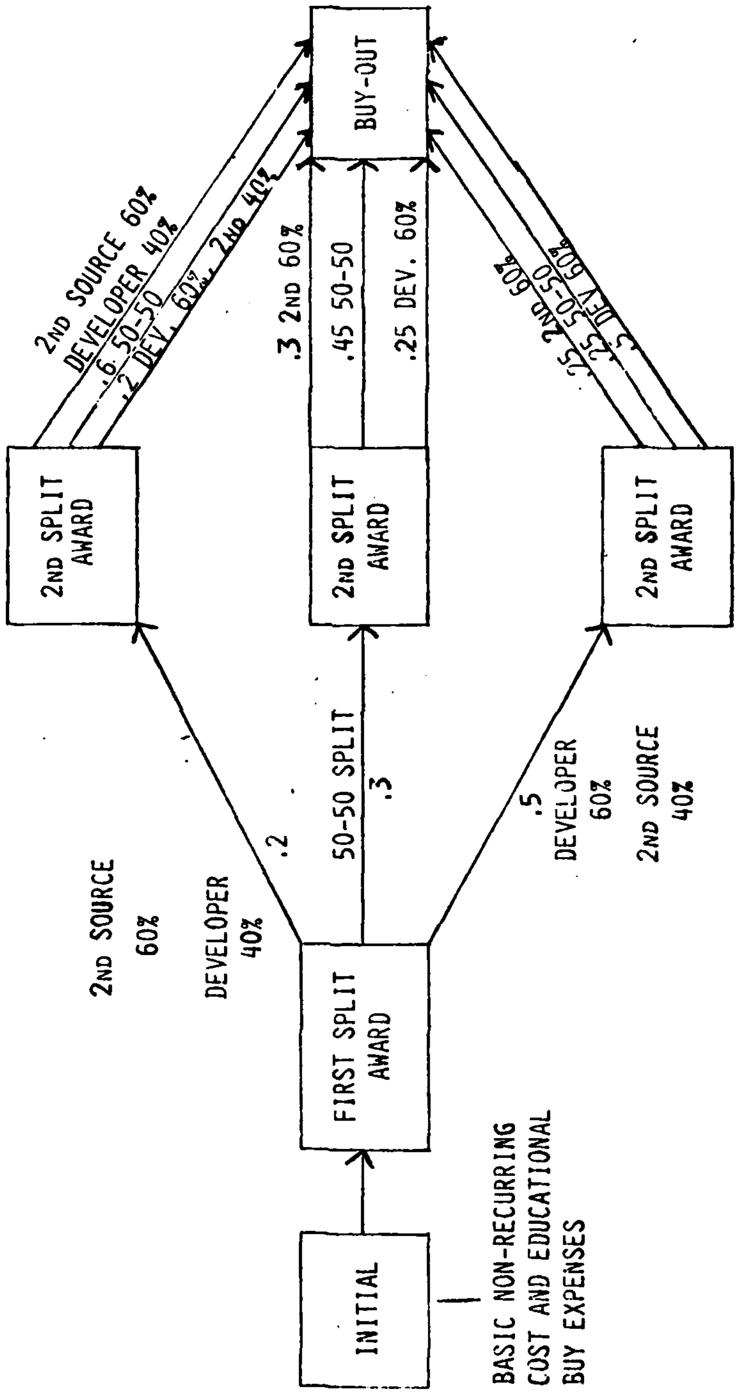


Figure 10. Network for Example Competitive Strategy.

Competitive Environment	Type of Distribution	Minimum	Maximum	Mode
First Split Award	Triangular	4%	10%	7%
Second Split Award where second source won 60% of first split award	Triangular	9	16	12
Second Split Award where developer won 60% of first split award	Triangular	7	14	10
Buy-out where both split awards divided evenly between the two sources	Triangular	12	30	20
Buy-out where developer won 60% of both split awards	Triangular	9	16	12

Figure 11. Some Example Probability Density Functions for Percentage Recurring Cost Savings Relative to Sole Source.

QUANTITY BY YEAR

	1	2	3	4	5	6	7
Developer	50	60					
Second Source		40					
Split Award (Competitive)			250 (60%-40% MAX. SPLIT)	500 (60%-40% MAX. SPLIT)			
Competitive Buy-Out					500	500	500
					MULTI-YEAR		

Figure 12. Example Production Schedule for a Strategy Alternative.

3. Remarks.

The approach advocated here tries to deal realistically with the important parameters of the problem. It is important to have a certain structural integrity to the model even though it means admitting that some of the input data in an application is heavily judgmental. If factors do importantly affect the outcome, it is preferable to make conscious efforts to evaluate their effects than to use a more simplistic model in which the influence of these important factors is suppressed.

Comments need to be made about certain specific characteristics of the cost model. For example, the allocation of production quantity in split-buy situations affects future cost projections because it affects the production experience of the firms. Particular assessments of outcomes and their probabilities can be made judgmentally for each case. The allocation history should not be ignored, however, for a contractor who gets little production experience will not likely remain a viable competitor.

Each individual case will require the direct estimation of uncertain outcomes in a setting that differs from all prior data base cases. There are no mathematical results such as Bayes Theorem that can reveal what the probability distributions ought to be. It is necessarily a subjective process. Yet the magnitude of the cost makes a formal, explicit judgment preferable. For example, the estimated recurring cost savings is affected by variations in the competitive environment, by special contracting factors, and by system-specific production characteristics. The latter factor is very important; it includes features such as degree of production automation, percentage of total cost represented by materials, and many others.

In some situations it will be necessary to model various dependencies. For example, one of the potential second sources may already be a system subcontractor and have available some of the necessary production equipment. This particular case may not be common, but it has occurred and every real case is likely to have some peculiarity. Yet the modeling approach recommended here is general and ought to be able to accommodate most of these unusual features.

Another reason to avoid over generalization blindly from the data base is that the cases studied have had a conglomeration of strategies, but the results have all been lumped together. That is, savings from buy-outs have not been carefully distinguished from savings from split awards. It should be noted that different researchers tend to get quite different savings projections on the same systems [7, 10]. Also each successive study tends to be further removed from the primary data. Finally, it can be deduced from [7] that behavior may be different for different classes of systems. For example, the missile system findings in [7] are quite different than the data base average. What then does one do about systems for which no past data base exists (e.g., armor)?

4. Example VERT Application.

Suppose that the Little Boy missile system is nearing the stage of development where a serious analysis of its planned production strategy needs to be conducted. Assume that the decision screen described above has been applied and that two strategies--one sole source and one competitive--need detailed outcome projections.

The competitive strategy consists of the following stages:

a. Selection of a second source and award of a small initial buy

b. Award of a split buy to the two sources with the award percentages determined by the relative bid prices

c. Award of a second split buy with the same allocation technique as used previously, but with larger production quantities

d. A multi-year buy-out with the total award quantity going to the lowest offeror.

The schedule and contracting plan for this strategy was given in Figure 12. A schematic view of the strategy dynamics was given in Figure 10. The arcs emanating from the split buy points show the different allocation decisions possible for this case. The outcomes in the last block can be measured with reference to a baseline sole source strategy. Note that the result expected at the buy-out point depends on the outcome of the previous split-award competitions. For example, if the second source has not shown itself as a viable cost competitor during the split awards, very little competitive pressure may be present during the buy-out situation.

Key "most likely" estimates for the baseline sole source strategy are as follows:

Theoretical first unit cost: a = $10,000.

Cost improvement curve slope of 90%. This translates into $b = -.152$ in the learning curve formula: Unit cost = $a\ x^b$.

In order to compare the cost results of the competitive strategy with those likely under the sole source alternative, the estimation of several input parameters is required. The values of these inputs are not accurately established by available data. Yet nothing is gained by neglecting them, for they do impact the results. The best approach is to extract the maximum information regarding these parameters using both the limited data base and informed judgment. By this means the required probability density functions can be selected. Some examples were described in Figure 11. Note that some of these functions depend on the outcomes of preceding buys. Contractor win probabilities have also been estimated, and the entire structure was summarized pictorially in Figure 10.

VERT simulation of the complete example case described above was performed for 500 iterations with the results shown in Figure 13. The required VERT input necessary to describe the network is listed in Appendix C. This application of VERT is unusual because key data reflecting experience and also the competitive density functions were transmitted through parts of the VERT program designed to carry time and performance information. In the example presented here the baseline sole source strategy has a cost of $8,037,000 which can be easily computed from the learning curve assumptions. In this example the two strategies have the same annual production schedules, and production rate adjustments (such as may occur for split-buys) do not affect the unit costs. The model can be altered to handle variations of these conditions, however. A non-zero discount rate can also be applied. In the present case Figure 13 shows that only about 20% of the time would the competitive strategy be lower-priced than the sole source alternative. The cost outcome would be coupled with the other decision factors discussed in this report in order to arrive at a decision.

```
OVERALL COST FOR NODE      END

                 CFD  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9  1.0
7411016.1954 I----I----I----I----I----I----I----I----I----I----I MIN
             I                                                   0.000
7411016.1954 I
             I                                                   0.002
7486404.7876 I
             I*                                                  0.010
7561793.3797 I
             I*                                                  0.012
7637181.9718 I
             I*                                                  0.024
7712570.5640 I
             I**                                                 0.042
7787959.1561 I
             I***                                                0.062
7863347.7482 I
             I*****                                              0.094
7938736.3404 I
             I*******                                            0.142
8014124.9325 I          Sole Source Baseline Cost
           ______________________________________________________________
             I**********                                         0.206
8089513.5246 I
             I***************                                    0.298
8164902.1168 I
             I*******************                                0.376
8240290.7089 I
             I***********************                            0.462
8315679.3010 I
             I****************************                       0.554
8391067.8932 I
             I********************************                   0.644
8466456.4853 I
             I************************************               0.720
8541845.0774 I
             I****************************************           0.804
8617233.6696 I
             I********************************************       0.870
8692622.2617 I
             I**********************************************     0.916
8768010.8538 I
             I************************************************   0.956
8843399.4460 I
             I************************************************* 0.986
8918788.0381 I
             I**************************************************0.990
8994176.6302 I
             I**************************************************1.000
9069565.2224 I
             I**************************************************1.000
9069565.2224 I----I----I----I----I----I----I----I----I----I----I MAX

             NO OBS-----------        500  STD ERROR-       307185.5297
             COEF OF VARIATION-      0.04  MEAN------      8340966.1236
             KURTOSIS (BETA 2)-      2.65  MEDIAN----      8341299.1468
                                           MULTIMODAL DISTRIBUTION
```

Figure 13. Total Cost Distribution for a Competitive Strategy.

CHAPTER IV

DISCUSSION AND SUMMARY

The studies analyzing the cost behavior of systems acquired competitively have reported varying levels of competitive savings due to lower unit recurring costs. Despite the wide variation in the reported savings, the studies consistently agree that the potential savings are substantial. This study reported the limited state of the art in modeling problems of acquisition strategy choice. Key conditions which affect the outcomes likely for a given system were described. Progress in dealing with such related problems as the effect of production rate on system cost was also described.

This study marked the first empirical attention to non-cost issues in strategy selection. In particular, findings concerning the reliability and schedule effects of second sources were reported. A tentative conclusion was that the reliability objective should be given little weight in the strategy selection decision provided adequate government acceptance testing is planned. Initial schedule delays involving second sources are common. The importance of this consideration depends on the volume of production affected and on the significance of a schedule delay for the given system.

One of the aims of this study was to provide an approach to analyzing the acquisition strategy problem. To accomplish this purpose, a decision screen and a cost model were presented. The overall approach involved applying a screen in order to focus attention on the key strategies. Feasible production schedules are required for the remaining strategies in order to perform detailed cost evaluation. Finally, assessment of effects on other objectives is also required prior to choice of the best strategy.

A highlight of the cost model is the attempt to closely integrate and provide for contributions from each of the areas of methodology, historical data, and judgment. The paper contends that such a blending is demanded for an approach that realistically focuses on the key issues in selecting an acquisition strategy. The structure of the problem and the limited number and type of cases comprising the data base lead to the importance of a systematic application of judgment.

For relatively complex strategies, it was shown that a stochastic network could represent the dynamics of the acquisition process. The applicability of combining parametric cost estimates with the Venture Evaluation and Review Technique (VERT) to analyze cost outcomes was also illustrated.

Several future research steps are possible. Advances specific to the approach recommended here include refining of the decision screen as it is used by actual project management in a variety of circumstances. Automated computing refinements could also make the linkage between cost estimating tools and the VERT network automatic. More generally, a great need exists to investigate fully cost-saving behavior under multi-year contracts [3]. The ideas discussed in this report may also be applicable to strategy selection for phases prior to production.

APPENDIX A

SECOND SOURCE RELIABILITY FINDINGS

Findings relating to the reliability of second source production are described in this appendix. All systems for which such data were located are reported. The completeness of the available information varied from informal generalities in personal interviews to extensive test results for thousands of missile firings. The following table describes the type of information and the principal findings for the systems. Following the table, an analysis of two Navy missile system cases is included. This analysis was provided to the researchers by personnel of the Pacific Missile Test Center, Point Mugu, California.

RELIABILITY FINDINGS

SYSTEM	SYNOPSIS OF FINDINGS
1. Army missile	Second source initially had reliability problems due to production details (a specific soldering requirement and installation of a particular spring). Reliability soon improved, and any manufacturer's difference was overwhelmed by other factors (e.g., weather, target speed, gunner skill). Source: written documentation from Test and Evaluation Directorate, MICOM.
2. Army missile subsystem	Government sources informally reported no differences in reliability.
3. Army missile	Examination of results of several thousand firings showed essentially no difference in reliability from the beginning of production by the two sources.
4. Army missile subsystem	Government sources informally reported no differences in reliability.
5. Army missile	Examination of statistics covering missile firing over several years showed no reliability differences. These firings included a stockpile reliability testing which permitted comparison by age.
6. Army laser range finder	Government sources informally reported no differences in reliability.
7. Army night vision system	Government sources informally reported no differences in reliability.

RELIABILITY FINDINGS (Continued)

SYSTEM	SYNOPSIS OF FINDINGS
8. Army night vision subsystem	Government sources informally reported no significant differences in reliability.
9. Army night vision system	Government sources informally reported no differences, but for the second source only first article testing had been accepted to date.

A COMPARISON OF MISSILE QUALITY
FROM
PRIMARY AND SECOND SOURCE CONTRACTORS

SUMMARY

Data packages for two air-launched missiles were developed by the Naval Weapons Center (NAVWPNCEN), China Lake. For each data package two contractors (a primary and a second source) were selected. Extensive monitoring was performed to assure that the contractors could produce in accordance with the data packages.

The quality of the production missiles was verified by tests at the Pacific Missile Test Center (PACMISTESTCEN), Point Mugu. Corrective actions were taken when warranted.

It is concluded that second source contractors can produce missiles of equivalent quality to primary contractors. It would appear that production quality cannot be assured by the data package. Fabrication techniques, workmanship, and quality assurance techniques unique to the contractor can significantly influence production quality. The timely detection of quality problems is aided by a production verification test program.

A COMPARISON OF MISSILE QUALITY
FROM
PRIMARY AND SECOND SOURCE CONTRACTORS

INTRODUCTION

The Production Acceptance Test and Evaluation Division of the PACMISTESTCEN is conducting production verification test and Government lot acceptance test programs with the objective of verifying the performance and reliability of production missiles.

This report presents a comparison of the test data on missiles from two procurement sources and the general deductions which can be reached. In view of the nature of the test programs, which were designed to accept production missiles on the basis of tests conducted on a sample, the data is not well suited to support strong conclusions about differences which might exist between the quality of missiles from two sources.

The data packages were developed by NAVWPNCEN, China Lake. Very extensive monitoring, including tests at the PACMISTESTCEN, was performed to assure that the contractors could produce in accordance with the data packages. During the production years monitoring was continued at the level necessary to assure that performance and reliability were maintained.

RESULTS AND DISCUSSION

Missile A

Missile A is an air-to-air guided missile. A sample of 15 guidance sets was selected from each contract year production and subjected to individual tests and environmental failure rate tests.

The individual tests are functional tests conducted with the use of the approved guided missile test set. The desired yield of the test is 95 percent.

The environmental failure rate test (reliability test), is a laboratory simulation of the captive-flight parameters that contribute to random failures. The desired mean-time-to-failure (MTBF) is 450 hours.

Table 1 shows a summary of data from the conducted tests.

The second source contractor delivered pilot production guidance sets for contract year 1975. When a sample of these guidance sets was subjected to the reliability test it demonstrated an MTBF of 30 hours. The problems were related to substandard vendor components and production processes. By taking 33 corrective actions and conducting further reliability tests in the test analyze and fix mode, the MTBF was increased to 300 hours.

Guidance sets from the second source contractor for contract years 1976 and 1978(1) demonstrated early failures when subjected to the reliability test. The problems were not detected until the independent production verification tests were conducted. The problems were attributed to substandard components, workmanship, and quality assurance techniques. The guidance sets were produced in accordance with the data package.

The guidance sets for contract year 1976 were combined with those for contract year 1975 in a retrofit program. The guidance sets for contract year 1978(1) were subjected to an extensive inspection and screening program and a second sample designated as contract year 1978(2) was selected.

The data show that guidance sets produced by the primary contractor meet the individual test and reliability test desired yield of 95 percent and desired MTBF of 450 hours. The second source contractor has experienced difficulty in producing guidance sets which meet the test objectives; however, the problem appears to be fabrication techniques, workmanship, and production processes unique to the contractor.

Missile B

Missile B is also an air-to-air guided missile. A sample of 15 guidance control sections was selected from each lot within the contract year production and subjected to depot tests and flight test simulation.

The depot tests are functional tests conducted in accordance with Naval Air Systems Command specifications using automatic test equipment. The desired yield of the depot test is 95 percent.

The flight test simulation (reliability test) uses a composite mission profile derived from response measurements aboard the carrying aircraft. The simulation reproduces in level, sequence, and combination the stresses of temperature, operation, shock, and vibration that are the primary contributing factors to failure. The desired MTBF is 450 hours.

Table 2 shows a summary of data from the conducted tests.

It can be seen that both contractors produce guidance control sections which meet the depot test and reliability test objectives of 95 percent and 450 hours. In addition, both contractors not only exceed the reliability test objective, but exhibit a trend for an increasing MTBF.

CONCLUSIONS

Second source contractors can produce missiles of equivalent quality to primary contractors.

Production quality cannot be assured by the data package.

Production quality can be significantly influenced by fabrication techniques, workmanship, and quality assurance techniques.

Timely detection of quality problems is aided by a production verification test program.

Table 1. Missile A, Guidance Set Test Results

Primary Contractor

Contract Year	Individual Test Tested	Failed	Yield	Reliability Test Hours	Failed	MTBF
1975	15	0	100.0%	720	1	720
1976	15	0	100.0%	1390	4	348
1977	15	0	100.0%	459	0	---
1978	15	2	86.7%	958	2	479
1979	15	1	93.3%	950	1	950
1980	15	1	93.3%	945	2	473
Overall	90	4	95.6%	5422	10	542

Second Source Contractor

Contract Year	Individual Test Tested	Failed	Yield	Reliability Test Hours	Failed	MTBF
1976	21	1	95.2%	1379	7	197
1977	15	0	100.0%	Assets used for Flight Test Program		
1978(1)	15	3	80.0%	1319	4	330 *
Subtotal	51	4	92.2%	2698	11	245
1978(2)	15	0	100.0%	950	2	475
1979	15	2	86.7%	714	1	714
1980	15	0	100.0%	Test in process		
Subtotal	45	2	95.6%	1664	3	553

*Table separated to distinguish initial problems and to illustrate compliance in following years.

Table 2. Missile B, Guidance Control Section Test Results

Primary Contractor

Contract Year	Depot Test Tested,	Failed,	Yield	Reliability Test Hours,	Failed,	MTBF
1977	48	3	93.7%	6206	8	776
1978	120	5	95.8%	9355	5	1871
1979	60	1	98.3%	5170	2	2585
Overall	228	9	96.1%	20,731	15	1382

Second Source Contractor

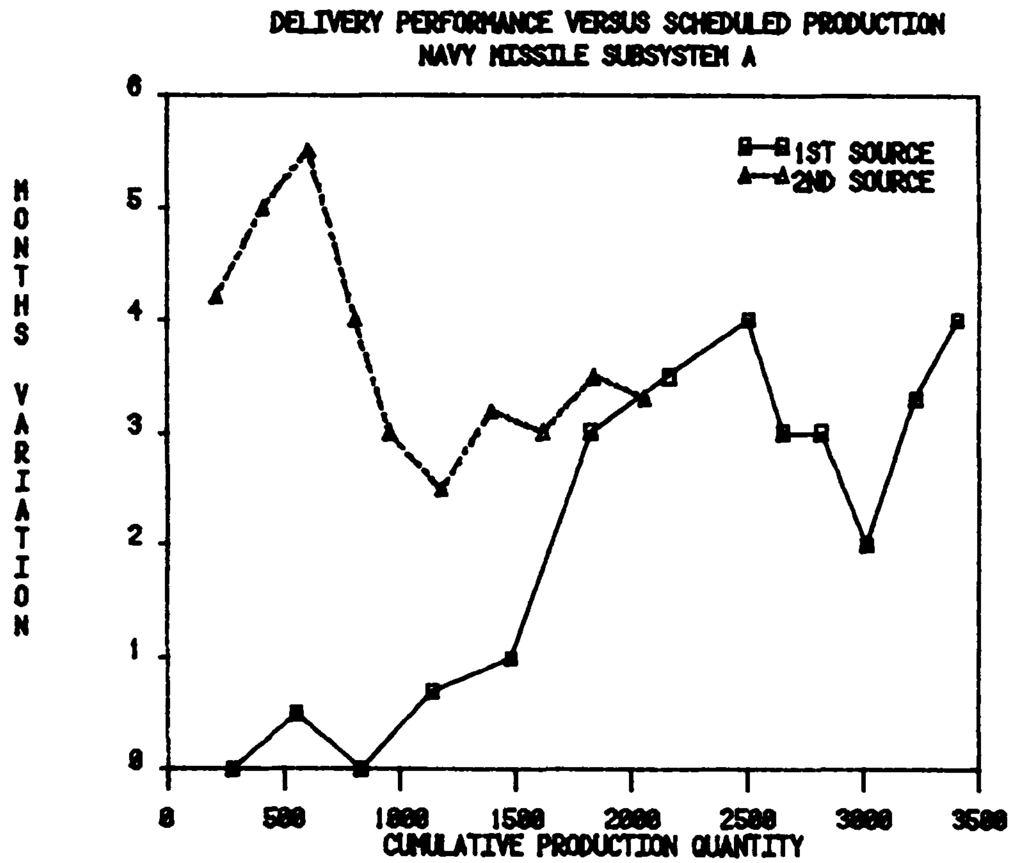
Contract Year	Depot Test Tested,	Failed,	Yield	Reliability Test Hours,	Failed,	MTBF
1977	72	3	95.8%	8733	9	970
1978	48	2	95.8%	4490	1	4490
1979	60	3	95.0%	5356	3	1785
Overall	180	8	95.6%	18,579	13	1429

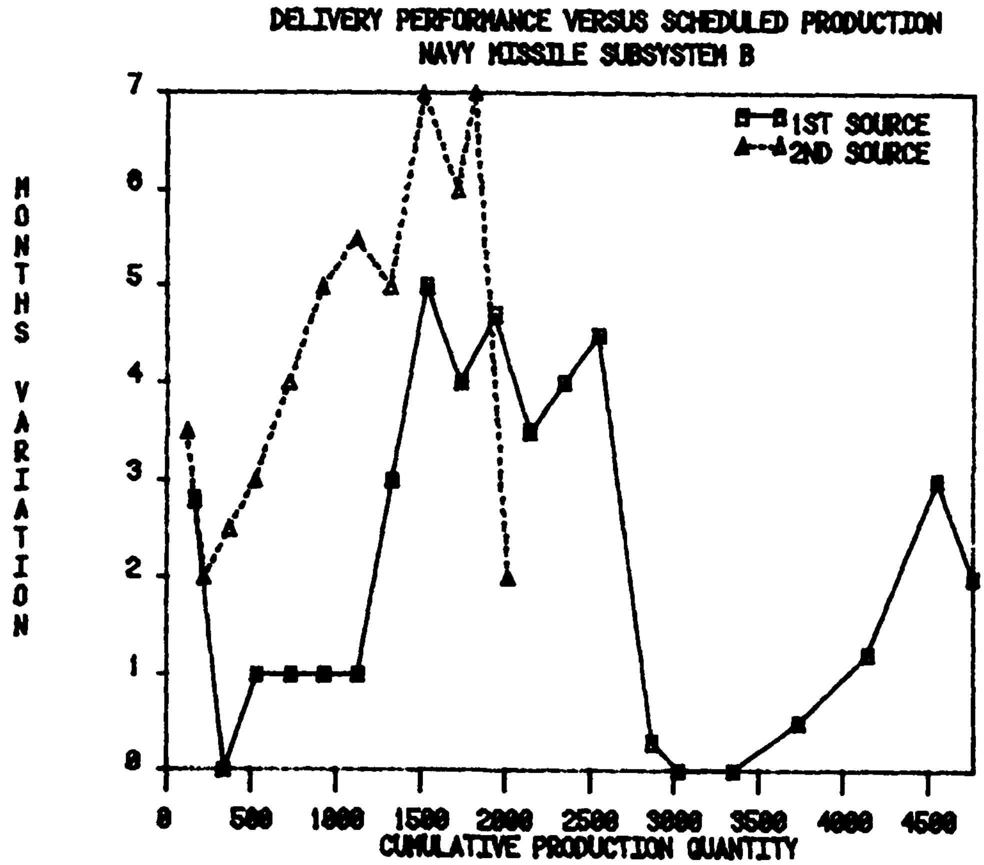
APPENDIX B

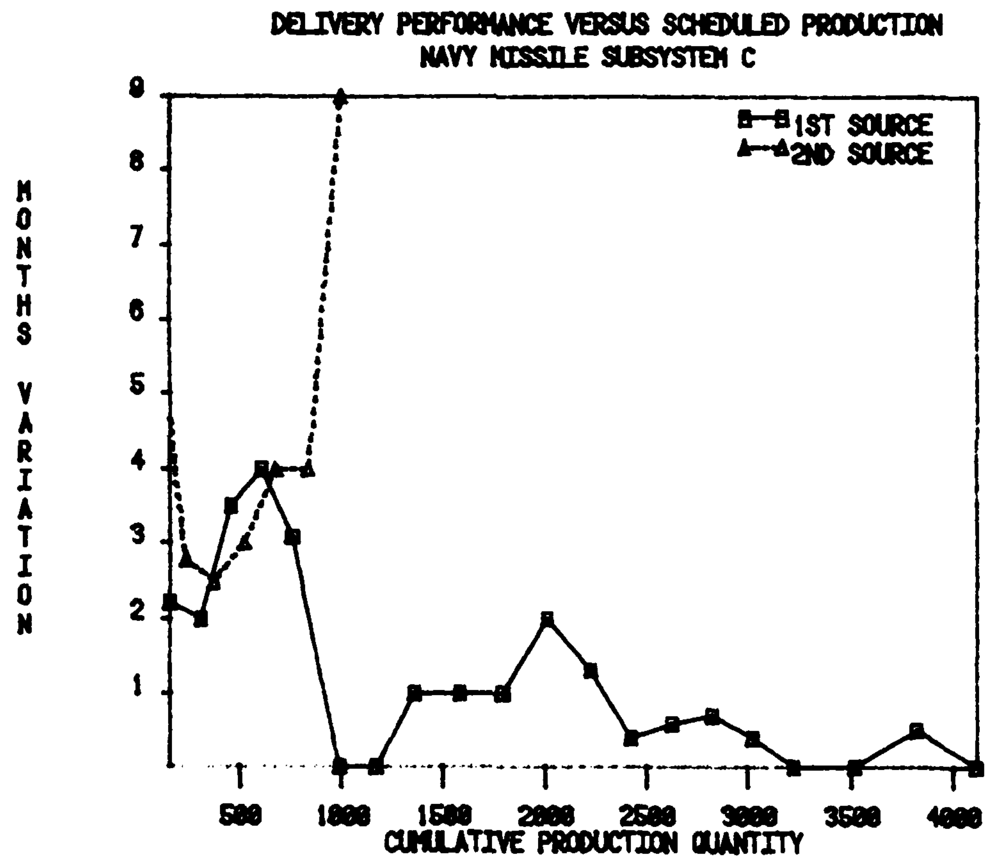
DELIVERY SCHEDULE FINDINGS

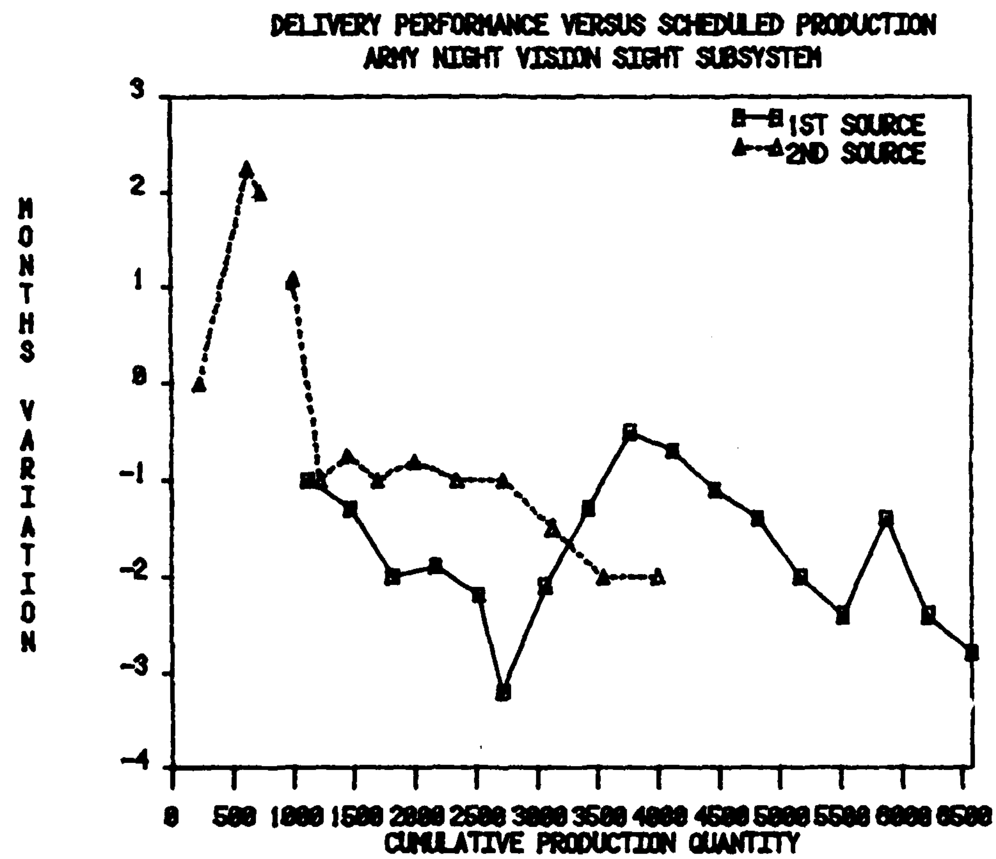
The first part of this appendix consists of twelve graphs contrasting the schedule performance of original and second source producers of six weapon systems. The first six graphs compare the two sources at equivalent production quantities. The final six graphs compare the sources at equivalent times past their original initial delivery date. In all cases the vertical axis measures the months from scheduled delivery to actual delivery of the required quantity. A positive value is measuring a late delivery, and a negative value reflects ahead of schedule performance.

Following the graphs, a table reports additional findings. For most of these cases, the available information was insufficient to create a graph. All identified cases are reported either in the graphs or in the table.


DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
NAVY MISSILE SUBSYSTEM A
MONTHS VARIATION
CUMULATIVE PRODUCTION QUANTITY
1ST SOURCE
2ND SOURCE
0
1
2
3
4
5
6
500
1000
1500
2000
2500
3000
3500


DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
NAVY MISSILE SUBSYSTEM B
1ST SOURCE
2ND SOURCE
MONTHS VARIATION
0
1
2
3
4
5
6
7
0
500
1000
1500
2000
2500
3000
3500
4000
4500
CUMULATIVE PRODUCTION QUANTITY


DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
NAVY MISSILE SUBSYSTEM C
1ST SOURCE
2ND SOURCE
MONTHS VARIATION
9
8
7
6
5
4
3
2
1
500
1000
1500
2000
2500
3000
3500
4000
CUMULATIVE PRODUCTION QUANTITY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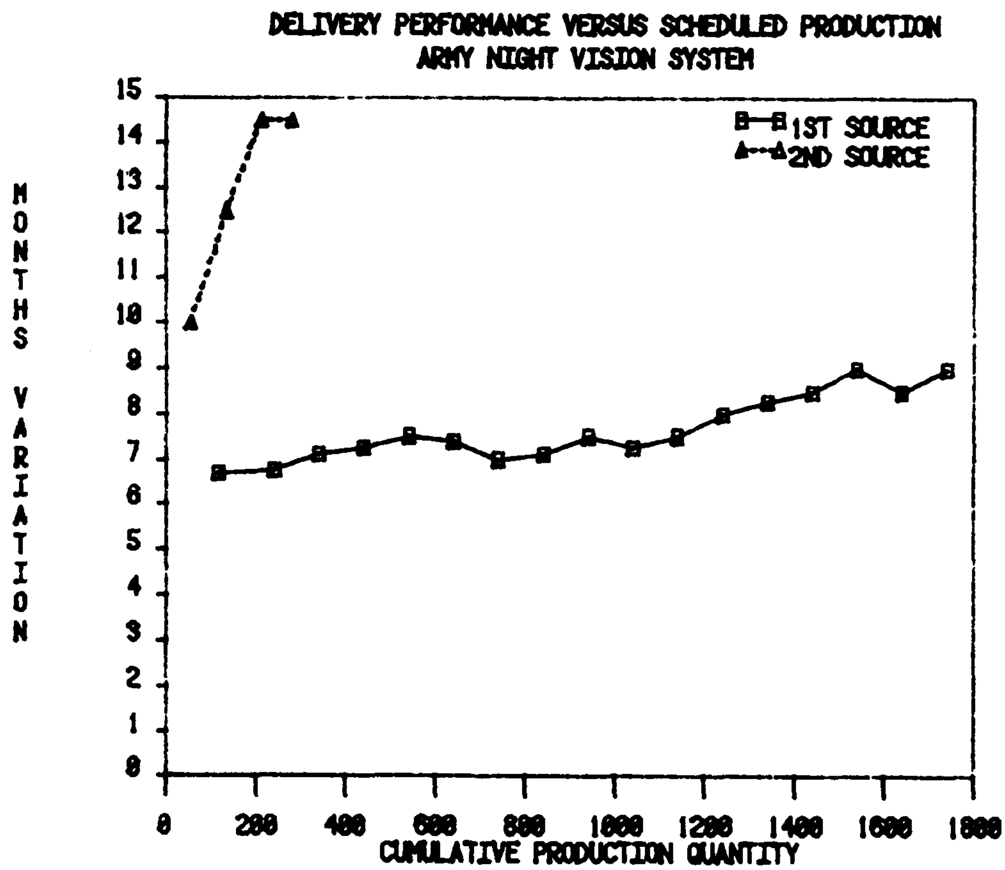
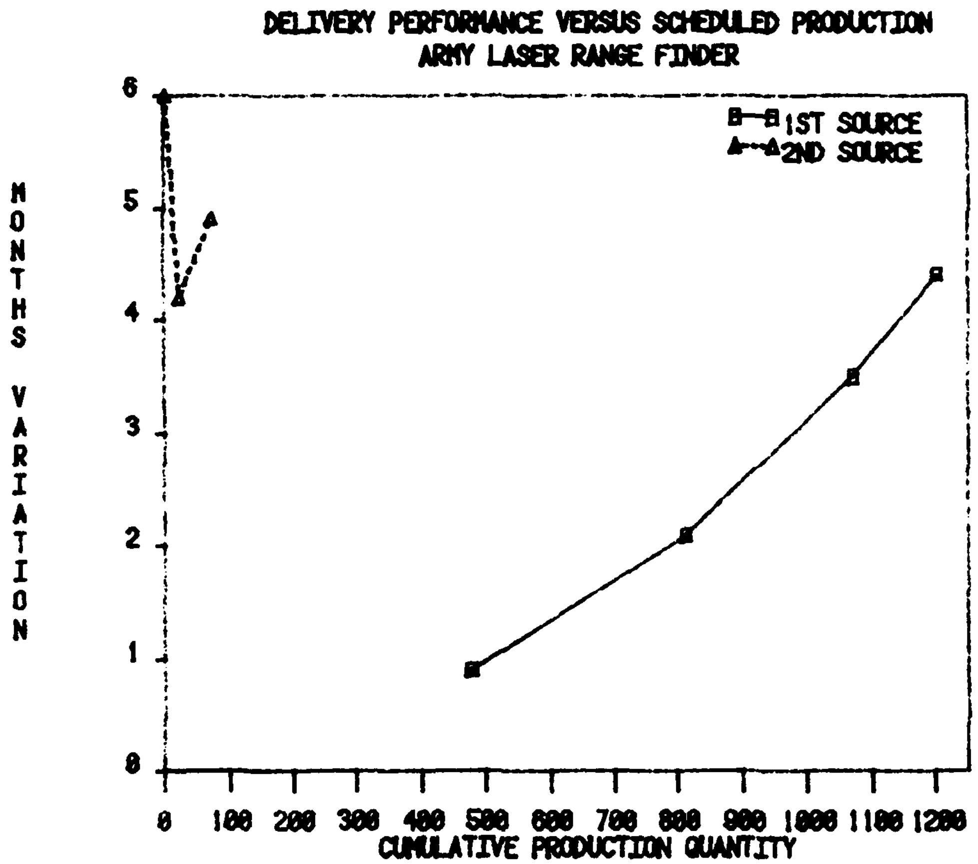
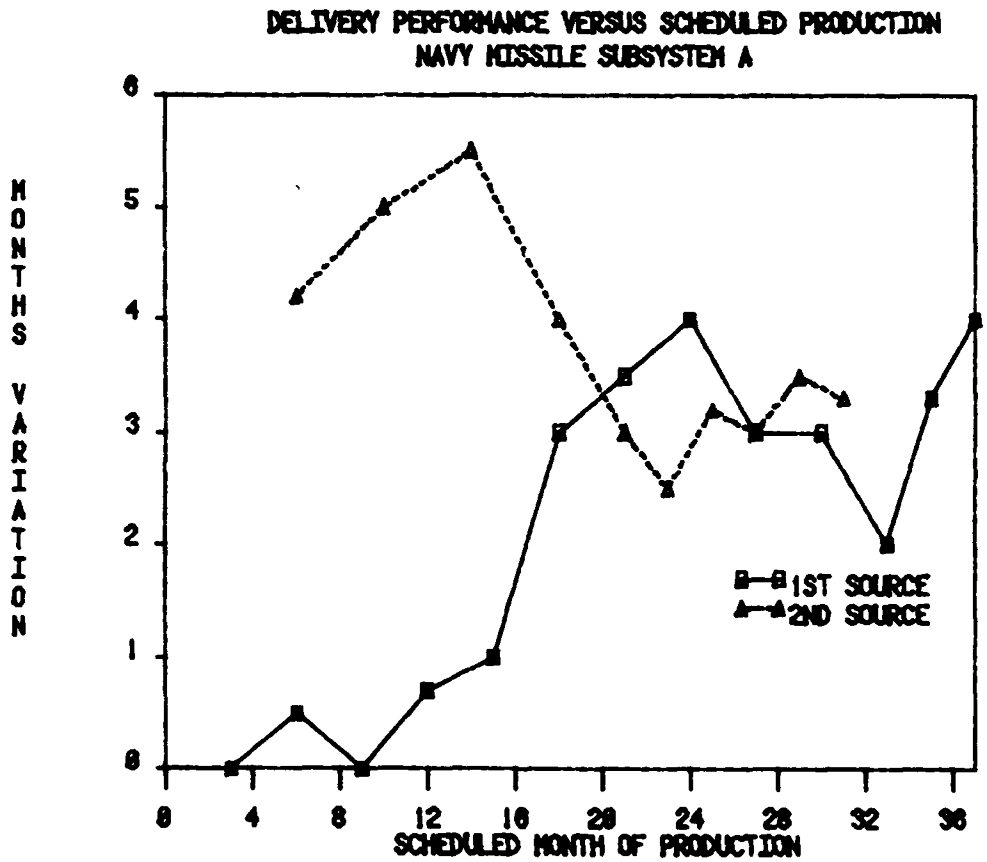
ARMY NIGHT VISION SIGHT SUBSYSTEM
1ST SOURCE
2ND SOURCE
MONTHS VARIATION
3
2
1
0
-1
-2
-3
-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
CUMULATIVE PRODUCTION QUANTITY

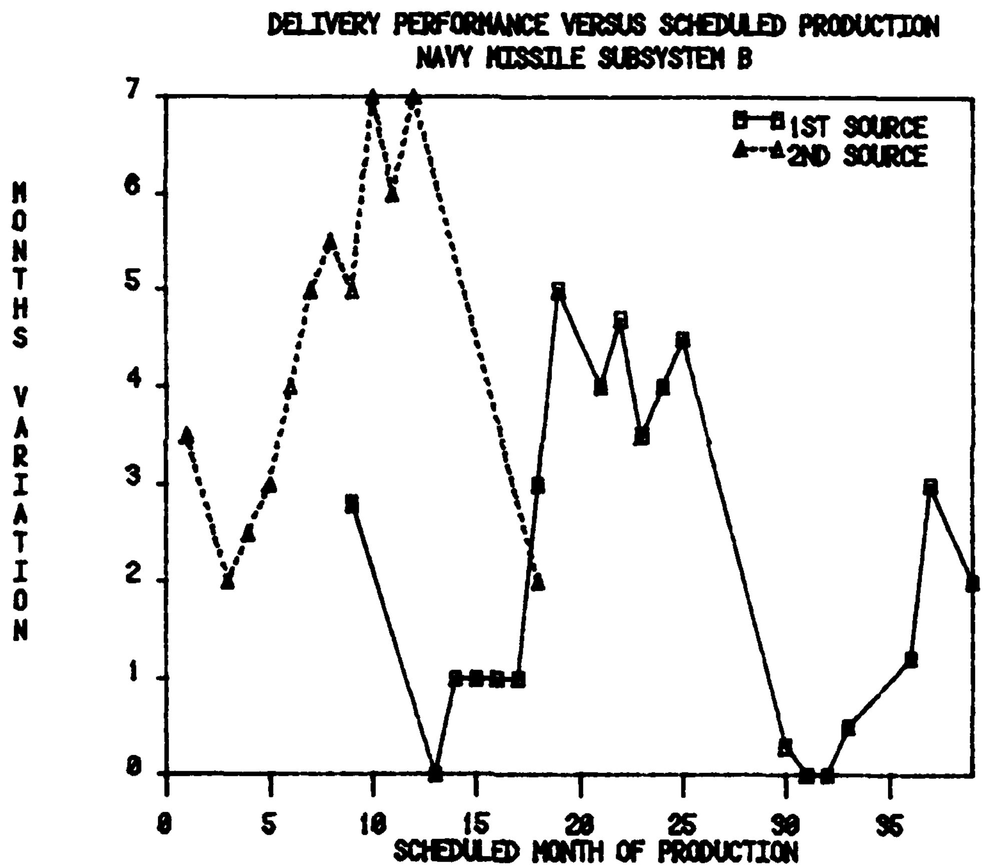

DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
ARMY NIGHT VISION SYSTEM
MONTHS VARIATION
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1ST SOURCE
2ND SOURCE
0
200
400
600
800
1000
1200
1400
1600
1800
CUMULATIVE PRODUCTION QUANTITY



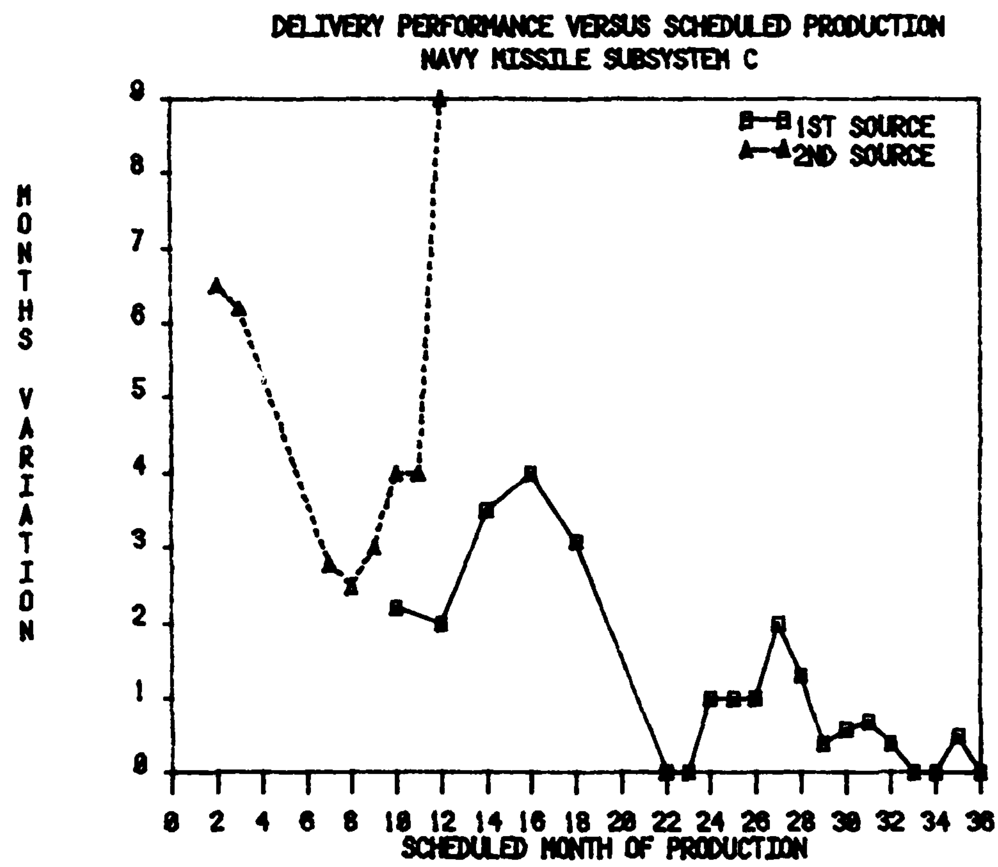
DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
ARMY LASER RANGE FINDER
1ST SOURCE
2ND SOURCE
MONTHS VARIATION
0
1
2
3
4
5
6
0 100 200 300 400 500 600 700 800 900 1000 1100 1200
CUMULATIVE PRODUCTION QUANTITY



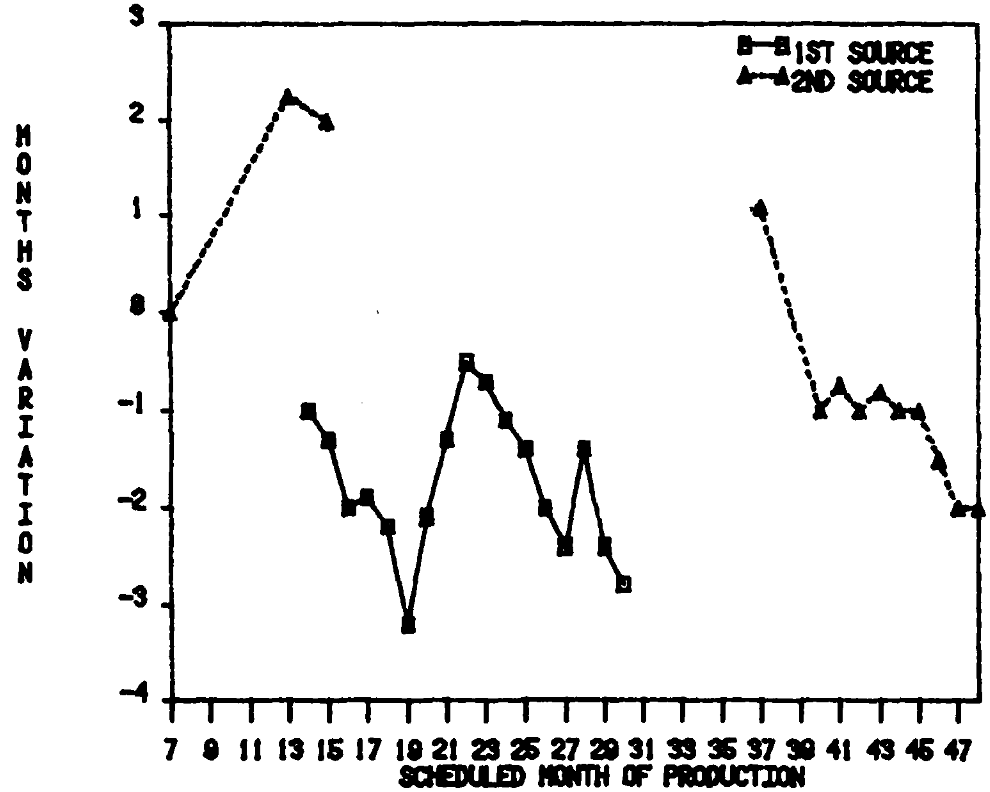
DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
NAVY MISSILE SUBSYSTEM A
MONTHS VARIATION
0
1
2
3
4
5
6
0
4
8
12
16
20
24
28
32
36
SCHEDULED MONTH OF PRODUCTION
1ST SOURCE
2ND SOURCE



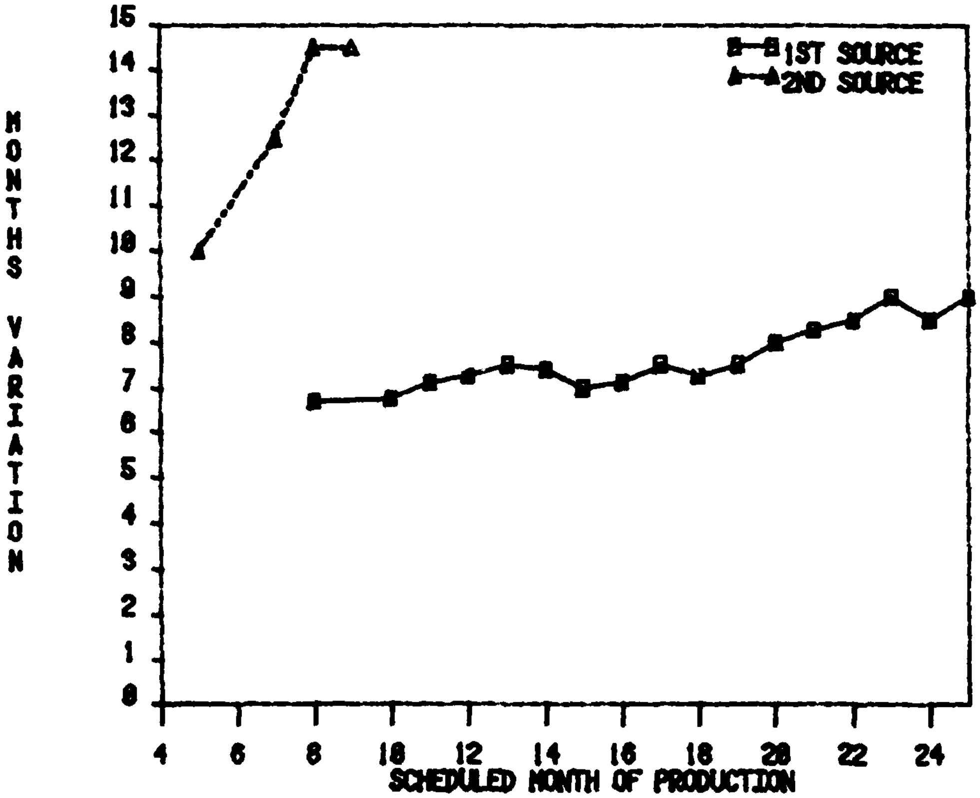
DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
NAVY MISSILE SUBSYSTEM B
1ST SOURCE
2ND SOURCE
MONTHS VARIATION
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
SCHEDULED MONTH OF PRODUCTION

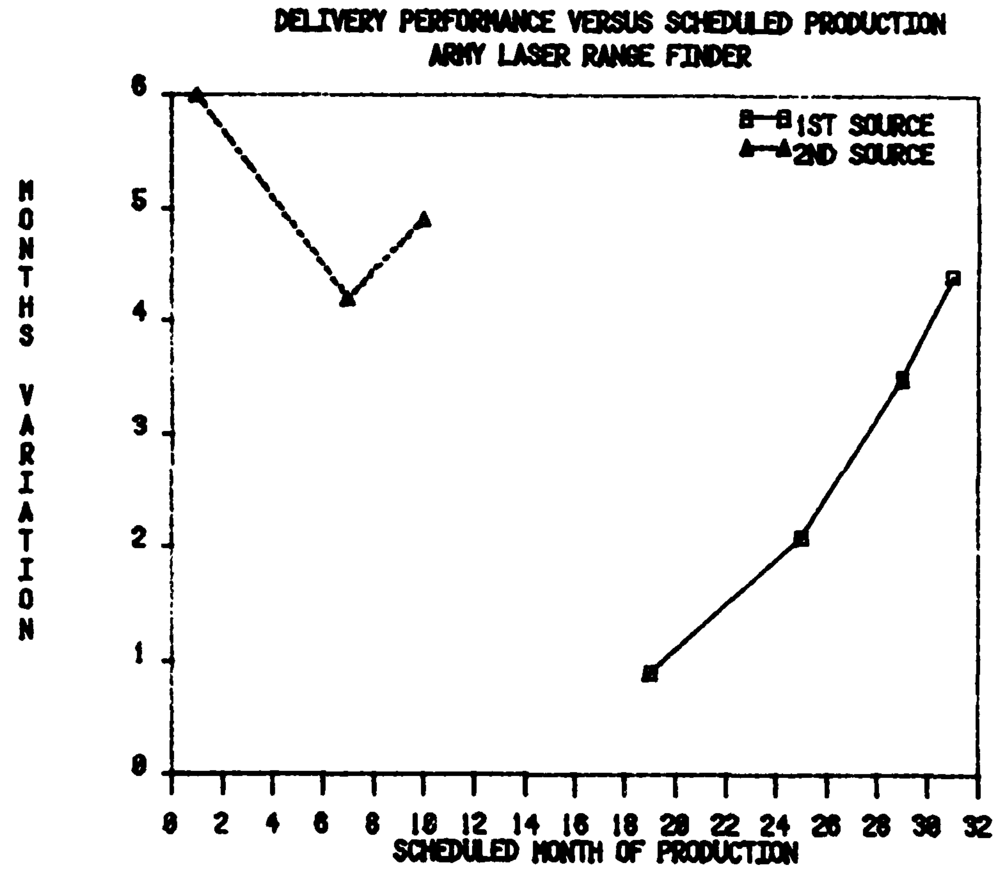

DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
NAVY MISSILE SUBSYSTEM C
1ST SOURCE
2ND SOURCE
MONTHS VARIATION
SCHEDULED MONTH OF PRODUCTION

DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
ARMY NIGHT VISION SIGHT SUBSYSTEM



DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
ARMY NIGHT VISION SYSTEM




DELIVERY PERFORMANCE VERSUS SCHEDULED PRODUCTION
ARMY LASER RANGE FINDER
1ST SOURCE
2ND SOURCE
MONTHS VARIATION
0
1
2
3
4
5
6
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
SCHEDULED MONTH OF PRODUCTION

ADDITIONAL SCHEDULE INFORMATION

SYSTEM	COMMENTS
1. Army laser range finder (This case was also graphed.)	Government sources reported that an inadequate TDP delayed the second source contractor. The second source was used before the TDP was under Government configuration control. In the second source's early phase of production 2000 changes were issued incrementally. After the initial period, the second source's performance was suitable.
2. Missile subsystem	Second source had only delivered for about three months but was on schedule.
3. Army missile	Second source had some delays due to GFE but otherwise met schedule. Prime only missed schedule a few times which was also due to GFE.
4. Army missile subsystem	Second source had difficulty first few months, then met schedule.
5. Army missile	Second source delivered original contract within a few weeks of schedule.
6. Army missile subsystem	Government sources said a poor TDP caused second source problems during the educational buy. There were many changes. This led to a decision to have a split award following the educational buy.
7. Army night vision system (This case was also graphed.)	Government sources said a TDP problem (lack of change control) was the biggest problem. The original source was obstinate and refused to talk with the second source.
8. Army ground radar system	Second source was a technically unqualified small business and never delivered a complete system.

APPENDIX C

EXAMPLE VERT INPUT

```
NON_REC    BEGIN     SAN1 1.0
NON_RECOCOST 1          3.0  1000000.  2000000.  1500000.

  SAA11    SAN1   SAN112 1.0
  SAA11OPERF 1         3.0       4.0       10.0       7.0
  SAA11RCOST 1340K       1.0P    SAA11K    100. 1S      1.0K1147329.K      1.0
  SAA11M     1         .2

  SAA12    SAN1   SAN122 1.0
  SAA12OPERF 1         3.0       4.0       10.0       7.0
  SAA12RCOST 1340K       1.0P    SAA12K    100. 1S      1.0K1147329.K      1.0
  SAA12M     1         .3

  SAA13    SAN1   SAN132 1.0
  SAA13OPERF 1         3.0       4.0       10.0       7.0
  SAA13RCOST 1340K       1.0P    SAA13K    100. 1S      1.0K1147329.K      1.0
  SAA13M     1         .5

  SAA21  SAN112    SAN21 1.0
  SAA21OPERF 1         3.0       7.0       14.0      10.0
  SAA21RCOST 1340K       1.0P    SAA21K    100. 1S      1.0K2029385.K      1.0

  SAA21M     1         .6

  SAA22  SAN112    SAN22 1.0
  SAA22OPERF 1         3.0       7.0       14.0      10.0
  SAA22RCOST 1340K       1.0P    SAA22K    100. 1S      1.0K2029385.K      1.0
  SAA22M     1         .2

  SAA23  SAN112    SAN23 1.0
  SAA23OPERF 1         3.0       7.0       14.0      10.0
  SAA23RCOST 1340K       1.0P    SAA23K    100. 1S      1.0K2029385.K      1.0
  SAA23M     1         .2

  SAA24  SAN122    SAN24 1.0
  SAA24OPERF 1         3.0       9.0       16.0      12.0
  SAA24RCOST 1340K       1.0P    SAA24K    100. 1S      1.0K2051180.K      1.0
  SAA24M     1         .3

  SAA25  SAN122    SAN25 1.0
  SAA25OPERF 1         3.0       9.0       16.0      12.0
  SAA25RCOST 1340K       1.0P    SAA25K    100. 1S      1.0K2051180.K      1.0
  SAA25M     1         .45

  SAA26  SAN122    SAN26 1.0
  SAA26OPERF 1         3.0       9.0       16.0      12.0
  SAA26RCOST 1340K       1.0P    SAA26K    100. 1S      1.0K2051180.K      1.0
  SAA26M     1         .25

  SAA27  SAN132    SAN27 1.0
  SAA27OPERF 1         3.0       9.0       16.0      12.0
  SAA27RCOST 1340K       1.0P    SAA27K    100. 1S      1.0K2029385.K      1.0
  SAA27M     1         .25
```

APPENDIX C (Cont'd)

```
SAA28   SAN132    SAN28 1.0
SAA28DPERF 1         3.0          9.0        16.0        12.0
SAA28RCOST 1340K        1.0P     SAA28K      100. 1S         1.0K2029385.K       1.0
SAA28M      1          .25

SAA29   SAN132    SAN29 1.0
SAA29DPERF 1         3.0          9.0        16.0        12.0
SAA29RCOST 1340K        1.0P     SAA29K      100. 1S         1.0K2029385.K       1.0
SAA29M      1          .5

80A1    SAN21       END 1.0
80A1DPERF 1         3.0         8.0        22.0        14.0
80A1RCOST 1340K        1.0P     80A1K      100. 1S         1.0K4778050.K       1.0

80A2    SAN22       END 1.0
80A2DPERF 1         3.0        10.0        28.0        18.0
80A2RCOST 1340K        1.0P     80A2K      100. 1S         1.0K4812218.K       1.0

80A3    SAN23       END 1.0
80A3DPERF 1         3.0        10.0        28.0        18.0
80A3RCOST 1340K        1.0P     80A3K      100. 1S         1.0K4778050.K       1.0

80A4    SAN24       END 1.0
80A4DPERF 1         3.0        10.0        28.0        18.0
80A4RCOST 1340K        1.0P     80A4K      100. 1S         1.0K4794870.K       1.0

80A5    SAN25       END 1.0
80A5DPERF 1         3.0        12.0        30.0        20.0
80A5RCOST 1340K        1.0P     80A5K      100. 1S         1.0K4830130.K       1.0

80A6    SAN26       END 1.0
80A6DPERF 1         3.0        10.0        26.0        16.0
80A6RCOST 1340K        1.0P     80A6K      100. 1S         1.0K4794870.K       1.0

80A7    SAN27       END 1.0
80A7DPERF 1         3.0        12.0        30.0        20.0
80A7RCOST 1340K        1.0P     80A7K      100. 1S         1.0K4778050.K       1.0

80A8    SAN28       END 1.0
80A8DPERF 1         3.0        12.0        30.0        20.0
80A8RCOST 1340K        1.0P     80A8K      100. 1S         1.0K4812218.K       1.0

80A9    SAN29       END 1.0
80A9DPERF 1         3.0         9.0        16.0        12.0
80A9RCOST 1340K        1.0P     80A9K      100. 1S         1.0K4778050.K       1.0
```

APPENDIX C (Cont'd)

```
ENDARC
   BEGIN1  215
    SAN12  315
  SAN1122  315
  SAN1222  315
  SAN1322  315
   SAN212  215
   SAN222  215
   SAN232  215
   SAN242  215
   SAN252  215
   SAN262  215
   SAN272  215
   SAN282  215
   SAN292  215
     END4  1
ENDNODE
```

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Selecting an acquisition strategy for the production phase of weapon system acquisition is an important decision. This report proposes a structured approach for analyzing the problem by explicitly considering all the major parts of the decision environment: potential strategies, objectives, and system specific conditions. Both new data on non-cost aspects of the decision and a general cost model are presented.

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The empirical research on non-cost issues, specifically reliability and schedule, was limited by the few qualifying systems with auditable records. Tentative conclusions were that (1) given government monitoring the reliability objective should typically be given little weight in the strategy decision and (2) second sources do experience initial schedule delays of greater magnitudes than the developer. The study presents an approach to analyzing the strategy selection problem. A screening technique is used to focus the detailed analysis on the viable strategies. The cost model integrates inputs from the areas of methodology, historical data, and judgment. It is shown that a stochastic network can be used to represent the dynamics of the acquisition process. The study recommends the cost-saving behavior of multi-year contracts be investigated.

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