AFIT/GSM/LAS/93S-8

A STUDY OF THE ESTABLISHMENT OF COST AND SCHEDULE VARIANCE THRESHOLDS ON DEPARTMENT OF DEFENSE MAJOR PROGRAM CONTRACTS

THESIS

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AFIT/GSM/LAS/93S-8

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THESIS

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Preface

The purpose of this thesis was to discover to what extent theoretical models are used to establish cost and schedule variance thresholds on the Department of Defense major program contracts. Further, it identifies how cost and schedule variance thresholds are actually established for these contracts. The authors recognized that the number of our interviews would be limited due to funding and time constraints. However, this research provided a general understanding of the variance threshold concept and its possible application to program management. It could also serve as a starting point for an in-depth study of the subject.

In performing the research and writing this thesis, we have received a great deal of assistance from others. We are deeply indebted to our faculty advisors, Major David S. Christensen and Professor Richard C. Antolini, for their continuing patience and guidance and providing many points of contacts for our interviews throughout the program. We also wish to thank the entire professional staff of the AFIT Library for the excellent services in providing modern information retrieval systems and locating necessary materials for this thesis. We would like to recognize the tremendous professional support and enthusiasm from all interview participants. Finally, the authors would like to thank Lily T. Nguyen whose patience, understanding, and words of encouragement contributed much to the success of this learning process.

Tuan A. Hoang

Steven M. Quick

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Abstra

This thesis examined to what extent theoretical threshold models are used to establish cost and schedule variance thresholds on Department of Defense (DoD) major program contracts and identified how these thresholds are actually established. First, numerous theoretical methods for establishing variance thresholds including the accounting approach, the statistical process control approach, and the Dyckman and Kaplan models were investigated and assessed. Interviews were then conducted with a sample of DoD and civilian defense contractor personnel who had first-hand knowledge of the establishment of cost and schedule variance thresholds. Findings indicated that none of these methods was being used. Repeatedly, interviewees related that threshold levels for new contracts were established by either management experience and judgment or by copying threshold levels from previous contracts. One possible explanation for this occurrence is the apparent lack of awareness of the many theoretical models available. This lack of knowledge could have been the result of inadequate supplemental training which could expose personnel to these additional methods. In addition, neither government nor defense contractor documents provided any specific methods or techniques to derive thresholds. This lack of specific guidance further contributes to the necessary reliance on personal experience and judgment to set the threshold levels. Upper management should provide functional personnel with additional supplemental training to expose them to the various theoretical methods.

A STUDY OF THE ESTABLISHMENT OF COST AND SCHEDULE VARIANCE THRESHOLDS ON DEPARTMENT OF DEFENSE MAJOR PROGRAM CONTRACTS

I. Introduction

General Issues

Since the mid-1980s there has been an increasing perception of mismanagement, waste, and even fraud and abuse in defense acquisition programs. Critics have pointed to the Department of Defense (DoD) paying $5000 for an ordinary hammer and $2000 for a plastic cap for a stool leg (Gansler, 1991:4). This is illustrated by the headlines in a major American newspaper:

> *"Arms Systems Running Far Over Budget"*
>
> The pentagon is seeking large funding increases for 20 major weapons programs, many of which have had technical problems and huge cost overruns, according to the draft of a General Account Office report.
>
> . . .it depicts significant problems in some of the nation's most important weapons programs just as they are to enter full-scale development or production, milestones that will require sharp funding increases.
>
> The report that was leaked to the news media, indicates that overall the 20 weapons systems have experienced cost increases of $20.3 billion.

Thirteen of the 20 programs are behind schedule, nine have posted cost increases. . . (Vartabedian, 1987:I-1)

In another program, Congressional scrutiny of the United States Air Force's C-17 program widened as internal DoD documents being circulated in Congress showed that McDonnell Douglas is likely to exceed the development program cost ceiling by $1.4-2.6 billion. An Office of the Secretary of Defense analysis concluded it will cost $8-9.2 billion to complete the full-scale development contract and the first six production aircraft. This range is far higher than the USAF's recently revised figure of $7.3 billion, which would result in an overrun of $700 million. McDonnell Douglas estimates it will cost $7 billion or $390 million above the $6.6-billion ceiling. Representative John Dingell (D.-Mich.), chairman of the House Energy and Commerce Oversight and Investigations Subcommittee, told Defense Secretary Richard B. Cheney in an August 26 letter that the C-17 contract should be canceled for default (Gilmartin, 1991:25).

Another scenario is the ill-fated A-12 program, shot down by the Secretary of Defense, Richard Cheney. Originally, the Department of the Navy expected to produce 620 high-tech stealth aircraft at a cost of $57 billion. The program was running $2.7 billion over its fixed price contract cost of $4.8 billion for development. It was also 18 months behind schedule. The bottom line was that no one in the Department of the Navy was able to tell the Secretary Cheney how much money it would take to finish the development program (Magnuson, 1991:46).

These examples paint a very bleak picture of DoD management. However, in comparison to many other organizations, the DoD does a "relatively" good job of controlling cost overruns (Figure 1). But "relatively" may not be good enough. Traditionally, acquisition cycle cost overruns on DoD procurement programs have been between 40 and 100 percent (Gansler, 1991:171). Table 1 depicts procurement plans versus actual results for selected weapons systems between 1981 and 1985 (Gansler, 1991:132). If the trend continues, by the year 2054 the U.S. will be able to purchase a single fighter plane per year (Augustine, 1983:55).

However, these perceived problems should be put in perspective. The DoD's seemingly uncontrollable cost overrun problems may be due to the enormous size of the organization and the large volume of contract transactions. As Gansler points out:

> It is not an exaggeration to state that defense acquisition is the largest business enterprise in the free world. Annual purchases by the Department of Defense total around 170 billion dollars (more than the combined purchases of General Motors, Exxon, and IBM). The DoD's research and development expenditures alone are 7.5 times the combined R&D expenditures of France, Germany, the United Kingdom, and Japan. Defense acquisition involves almost 15 million separate contract actions each year, implemented through over a thousand buying offices around the world. More than 300,000 industrial suppliers are involved, and about 4.5 million different kinds of items are purchased each year. (Gansler, 1991:142)

Considering the magnitude of the workload it is almost certain that occasional errors will occur. Even a level of 99.99% perfect transactions would result in 1,500 errors each year (Gansler, 1991:5). However, in order to minimize the number of these occurrences, DoD implemented a system to monitor the acquisition process.

In 1967 the Department of Defense implemented the Cost/Schedule Control Systems Criteria (C/SCSC) to standardize cost and schedule reporting requirements and to provide visibility of acquisition program accomplishments. C/SCSC is required

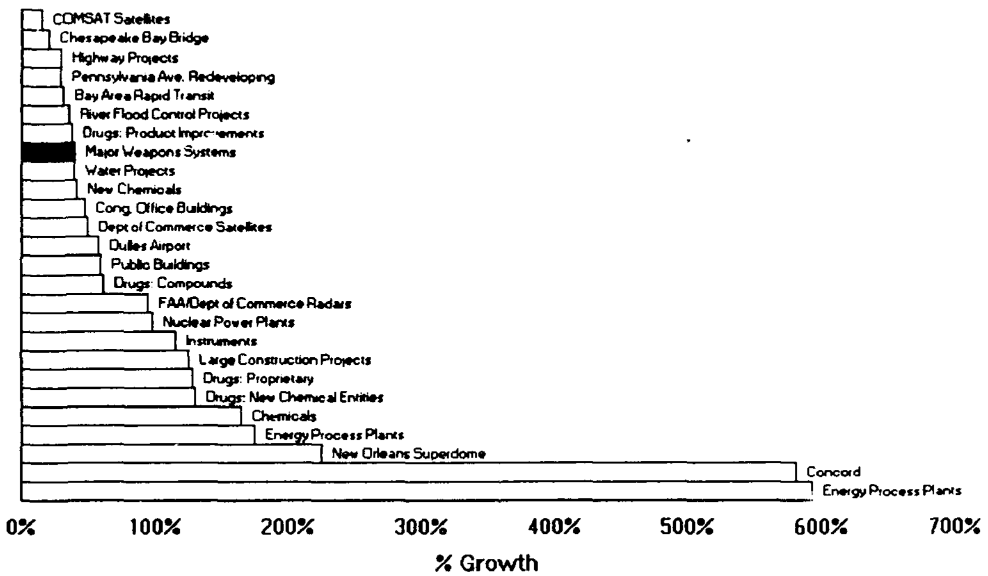

Figure 1. Cost Growth of Major Programs
(Adapted from Gansler, 1991:5)

TABLE 1

PROCUREMENT PLAN VERSUS ACTUAL RESULTS
FOR SELECTED WEAPONS SYSTEMS, 1981-1985

WEAPONS SYSTEM	PLANNED[a]			ACTUAL			PERCENTAGE CHANGE		
	QTY	TOT $[b]	UNIT COST	QTY	TOT $[b]	UNIT COST	QTY	TOT $[b]	UNIT COST
M1 Tank	3891	6332	1.63	3804	8966	2.36	-2	42	45
M2/3	3720	3591	0.97	2855	4522	1.58	-23	26	64
AH-64	248	2615	9.20	315	3955	12.56	11	51	36
F/A-18	656	13692	20.90	375	12387	33.00	-43	-10	58
F-15	90	2764	30.70	195	7379	37.80	117	167	23
F-16	660	8717	13.20	714	11713	16.40	8	34	24

a. As contained in FY81 budget and five-year plan.

b. In constant 1985 dollars.

(Adapted from Gansler, 1991:132)

for major acquisition programs exceeding $250 million for procurement contracts and $60 million for research and development efforts.

The C/SCSC consists of 35 criteria which specify the minimum requirements a contractor's management control system must meet. These criteria are still in effect some 25 years later and have been adopted by other United States government agencies, such as the Department of Energy (DoE) and the National Aeronautics and Space Administration (NASA) as well as the North American Treaty Organization (NATO) and the Swedish military. Despite this widespread international recognition, DoE officially abandoned the C/SCSC in August of 1992 after having used them to help manage their programs for 20 years (Fleming, 1993:6).

The major objectives of the C/SCSC are:

> For contractors to use effective internal cost and schedule management control systems, and
>
> For the government to be able to rely on timely and auditable data produced by those systems for determining product-oriented contract status. (Fleming, 1992:25)

More specifically, the C/SCSC was developed to:

> Provide the contractor and the government program office managers with accurate data to monitor execution of their program;
>
> Provide an adequate basis for responsible decision making by both contractor management and DoD Component personnel, by requiring that contractors' internal management control systems produce data that: (a) indicate work progress; (b) properly relate cost, schedule and technical accomplishment; (c) are valid, timely and able to be audited; and (d) supply DoD Component managers with information at a practical level of summarization; and
>
> Bring to the attention of DoD contractors, and encourage them to accept and install, management control systems and procedures that are most

effective in meeting requirements and controlling contract performance. (DoDI 5000.2, Part 11, Section B, paragraph 1)

An important aspect of the 35 criteria is performance measurement to analyze departures from the planned, budgeted, or expected performance. A departure from the planned, budgeted or expected performance is known as a "variance." Actual performance and planned performance rarely coincide. As a result, variances are expected. However, when does a variance become significant enough to require management attention?

One way to address this problem is by using control limits called "variance thresholds" (Figure 2). When a variance exceeds these thresholds, it is considered a significant variance, and an analysis of the variance is required. The key is to set variance thresholds at appropriate levels so that only significant variances are detected and actions be taken to correct the problem. Variances that do not exceed a threshold do not require investigation. Investigation of insignificant variances which have little potential for adverse impact on a program is both costly and time consuming.

> Careful selection of these thresholds is necessary to prevent unnecessary work associated with preparing an excessive number of written analyses. The analysis of every cost and schedule variance is usually unnecessary and unproductive. (DoD, 1987:3-17)

Problem Statement

Despite the emphasis for appropriate levels of variance thresholds cited in the Joint Implementation Guide (JIG), these levels mean different things to different people. For instance, a significant variance threshold in a relatively low dollar value

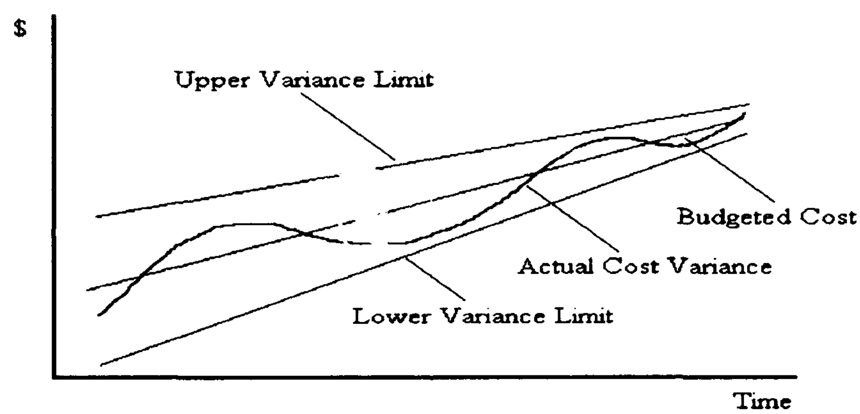

Figure 2. Graphic Presentation of Variance Thresholds
(Adapted from Nicholas, 1990:396)

program may not be viewed as significant in a relatively high dollar value program. In 1984, a study by Arthur D. Little Company attempted to determine the utility of C/SCSC. This study surveyed 12 defense contractors and 12 DoD program offices, four each from the Air Force, Army, and Navy. One important finding with regard to Cost/Schedule Performance Reporting (CPR) emphasizes the contrasting perception between government personnel and defense contractors concerning CPR reporting requirements.

Government personnel were more concerned with the timeliness and the quality of the analysis reports than the level of variance thresholds. Government personnel felt that the CPR variances thresholds were not as critical as the quality of variance reporting in CPRs. In general, government personnel felt the quality of variance reporting was poor, particularly the analysis of schedule variances (Little, 1984:III-25).

On the other hand, contractors were critical of excessive reporting requirements due to overly stringent variance thresholds required by the government. Contractors felt variance analyses were required too frequently, leaving little time to perform the contract work. Contractors consistently wanted less variance reporting (Little, 1984:III-24).

The problem was also addressed in an October 1979 study. The National Security Industrial Association Management Systems Subcommittee prepared the Cost/Schedule Systems Compendium. This compendium surveyed companies which had been identified as having experience with performance measurement requirements. The purpose of this survey was to examine the responses and provide recommendations for improving the requirements and implementation of C/SCSC.

From the 74 responses received, the results pertaining to the use of variance thresholds indicate:

> Most contracts contain a percentage figure for current month cumulative-to-date and at completion periods. Many also contain a minimum and/or maximum dollar threshold intended to truncate extremes caused by percentages applied to high and low value Work Breakdown Structure (WBS) item. (NSIA, 1980:I-7)
>
> For example, 39 percent of the responses required the same threshold to be applied to current period and cum-to-date variances. Forty-seven percent of the responses required the same threshold applied to cum-to-date and at completion variances. (NSIA, 1980:I-14)

Specific Problem

Different interpretations of variance thresholds between government and defense contractor personnel indicate the need for setting appropriate variance thresholds. Recognizing the importance of appropriate threshold levels, researchers have developed many theoretical models to help establish such threshold levels (e.g., Dyckman (1969) and Kaplan (1975)). Although variance thresholds are found in many defense acquisition contracts, little is known about the methods the government and contractors use to establish these threshold values.

The research objectives of this thesis are:

1) to discover to what extent these theoretical models are used to establish cost and schedule variance thresholds on DoD major program contracts, and

2) to identify how cost and schedule variance thresholds are established on DoD major program contracts.

Investigative Questions

In order to achieve these objectives, the following investigative questions must be addressed:

1) What models are available for establishing variance thresholds?

2) Are any of these models applicable to DoD major program contracts?

3) Who is responsible for setting cost and schedule variance thresholds on DoD major program contracts?

4) Are DoD personnel aware of these models?

5) Are any of these models being used by the DoD?

6) How are cost and schedule variance thresholds established on DoD major program contracts?

7) What models for establishing cost and schedule variance thresholds are used?

8) Do the chosen methods vary depending on program type, preparation time, risk, contract phase, and contract cost?

The first two investigative questions will require a thorough literature review on the topic of variance thresholds. The advantages, disadvantages, differences, and the applicability of these models to DoD major program contracts will be described. The remainder of the investigative questions will require personal interviews with government system program office and contractor personnel.

Scope and Limitations

This thesis is a formalized study consisting of eight structured investigative questions. It is descriptive in nature. It examines things as they exist and does not attempt to manipulate any variables.

The population of interest includes all government financial managers and civilian contractor counterparts who establish cost and schedule variance thresholds for DoD major program contracts. The interviews will be conducted with a sample of Aeronautical System Center (ASC) staff and System Program Office (SPO) personnel at Wright-Patterson Air Force Base, Ohio who have first hand knowledge of the establishment of variance thresholds. Additionally, several contractor personnel will be interviewed.

As this thesis is descriptive in nature, rigorous statistical methods to manipulate data will not be used. This limits the inferences which can be drawn concerning the population. However, basic descriptive statistics of data will be calculated and presented.

Summary and Overview

Cost and schedule overruns are a source of inspiration for critics of the DoD. Due to increasingly limited resources all measures for controlling cost must be exercised.

In 1967 the DoD implemented C/SCSC to standardize cost and schedule reporting requirements and to provide visibility of acquisition program accomplishments. The C/SCSC Analysis Group addresses this problem through the use of variance thresholds.

The JIG specifically discusses the importance of establishing appropriate levels of cost and schedule variance thresholds. However, despite the emphasis on appropriate levels of variance thresholds cited in the JIG, these levels mean different things to government and contractor personnel.

The purpose of this thesis is to examine to what extent theoretical threshold models are used to establish cost and schedule variance thresholds on DoD major program contracts, to identify how these thresholds are established, and to report those findings.

The first two investigative questions will require a thorough literature review on the topic of variance thresholds. The remainder of the investigative questions will require personal interviews.

After 25 years, C/SCSC has been proven as a good management tool for controlling cost and schedule on major DoD programs. However, problems still exist. Numerous articles concerning cost overruns and schedule delays seem to indicate serious lack of attention by program management. Different interpretations of variance thresholds between government and contractor personnel indicate the need for setting appropriate variance thresholds. If C/SCSC is to be an effective management tool, then proper attention should be given to the establishment of appropriate cost and schedule variance thresholds.

The next chapter examines a number of theoretical models which can be used to establish cost and schedule variance thresholds. It describes the advantages, disadvantages, and the applicability of these models to DoD major program contracts. In addition, contractor and government documents for establishing variance thresholds are reviewed.

The chapter on methodology describes the process used to acquire data to answer the six investigative questions. In the subsequent chapter, data are analyzed and presented. Finally, conclusions and recommendations are presented.

II. Literature Review

Introduction

The previous chapter indicated the need for setting appropriate variance thresholds. There are many methods suggested in literature which are used to establish variance thresholds and may be applicable to government contract management.

This literature review answers the first two investigative questions addressed in the introduction chapter. These questions are:

1) What models are available for establishing cost and schedule variance *thresholds?*

2) Are any of these models applicable to DoD major program contracts?

This chapter examines a number of theoretical models which may be used to establish cost and schedule variance thresholds. These methods range from relatively simple accounting approaches to more complex statistical process control methods.

First, this chapter examines the basic control aspects of three quantitative models for accounting control: 1) the traditional accounting model using standard costing, 2) an accounting model based on classical statistical theory, and 3) a control model based on modern decision theory. Second, a variety of statistical process control models such as Shewhart Bar Chart, Cumulative Sum Chart, Economic X-Bar Chart, and Economic Cusum Chart are examined. Finally, threshold models developed by T.R. Dyckman and Robert Kaplan will be described. Table 2 outlines the models examined in this chapter.

For each of these models the discussion includes the advantages, disadvantages, and the applicability of the model to DoD major program contracts.

Accounting Approach

Accounting control is a management function concerned with discovering deviations from planned activities and prompt correction of these deviations (Onsi, 1967:321). Onsi examined three quantitative models for accounting control which may be used to identify deviations and determine whether corrective actions are necessary. The models examined are: 1) the traditional accounting model using standard costing, 2) an accounting control model based on classical statistical theory, and 3) an accounting control model based on modern decision theory.

Traditional Accounting Model. The traditional accounting model uses a relatively informal method to establish cost and schedule variance thresholds (Onsi, 1967:321). In this model, management judgment and experience are the criteria for determining whether to investigate deviation from planned activities. Threshold limits are based on the absolute or relative size of the deviation. For example, a deviation of less than five percent may be considered acceptable and hence does not require investigation. Such a percentage is set based on prior knowledge of experienced managers.

TABLE 2

SUMMARY OF MODELS EXAMINED

- Accounting Approach
  - Traditional Accounting Model
  - Accounting Model Based on Classical Statistical Theory
  - Accounting Control Model Based on Modern Decision Theory
- Statistical Process Control Approach
  - X-Bar Chart, R Chart, and S Chart
  - Cumulative Sum Chart
  - Economic X-Bar Chart
  - Economic Cusum Chart
- Dyckman Model
- Kaplan Model

The major advantage of this model is it simplicity. It is simple to use because no extensive or time-consuming computations are necessary. Only managerial judgment and experience are required. However, one limitation is that it does not provide a clear indication when these informal limits are no longer valid. For instance, how do decision makers decide that a five percent deviation from planned activity is still acceptable?

This model can be used to establish cost and schedule variance thresholds on DoD major program contracts. However, there are potential drawbacks. Though management judgment and experience are beneficial for program control, often in the DoD environment, managers do not remain with the same program throughout its life. In addition, experience and judgment vary among managers. This may cause the level of program control to be less effective. The accounting models based on classical statistical theory and modern decision theory evolved to address these limitations.

Accounting Model Based on Classical Statistical Theory. In contrast to the traditional accounting model, this accounting model relies on classical statistical theory rather than management judgment and experience to set cost and schedule variance thresholds. In this model, two types of deviations or variations are possible: 1) a "chance variation" which occurs randomly and 2) an "assignable variation" attributable to systematic causes (Onsi, 1967:322). Chance variations are always present as a natural part of the process whereas assignable variations arise from external sources which are not inherent to the process (Evans, 1993:206). Since chance variations are random in nature, they should not be investigated. In contrast, assignable variations should be investigated (Onsi, 1967:322). This model makes four major assumptions.

First, expected cost is equal to the mean of a normal probability distribution (Figure 3). By assuming that deviations around the mean are normally distributed, management hypothesizes that favorable and unfavorable deviations due to random causes will fall equally on either side of the standard.

The second assumption is that standards are developed as ranges, not as point-estimates (such as, an absolute value established in the traditional accounting model). Statistical analysis allows establishing the range of variations within which deviations are attributed to chance. Variance thresholds are then set so that chance and assignable variations are identified. This analysis requires that both the mean of the distribution and its standard deviation be known. These parameters are estimated from historical data to represent the current situation.

Third, variations are investigated when one or more consecutive observations lie outside the variance thresholds as illustrated in Figure 4.

Fourth, the allowable deviation is represented by the size of the variance thresholds. Determination of the upper and lower control limits for variance analysis depends upon the relative weight assigned to two types of possible error. The first error, Type I, is the error of investigating when it is unnecessary; that is, investigating a deviation which is due to random influences. The second, Type II, is the error of failing to investigate when there is in fact an assignable variation from the expected standard.

If the cost of variance analysis is high relative to the risk of cost and schedule overruns, variance thresholds should be relatively large. On the other hand, if the risk of cost and schedule overruns is high relative to the cost of variance analysis, variance

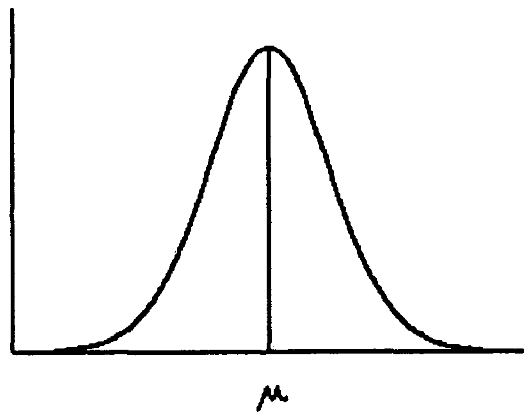

Figure 3. Normal Probability Distribution

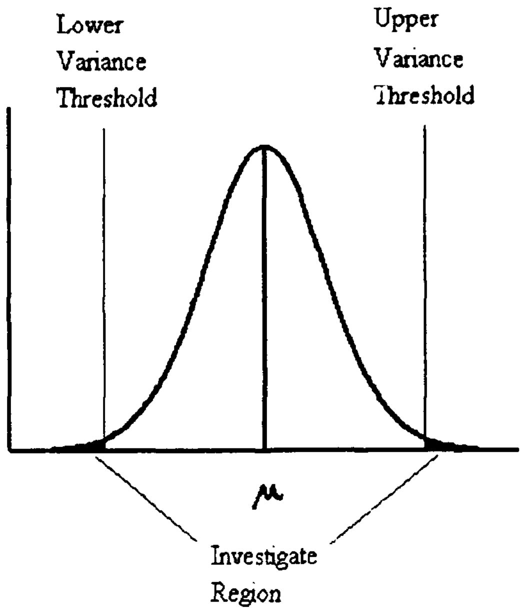

Figure 4. Normal Distribution with Variance Thresholds

thresholds should be tight. In setting variance thresholds, one tries to minimize the penalties from an erroneous decision (i.e., Type I or Type II error). Ideally, it is desirable to balance the two types of errors with the degree of risk prevailing in certain situations (Onsi, 1967:323).

However, this model has some drawbacks. The decision making process requires objective evidence, given a certain accepted pre-specified risk or error. However, objective evidence may be difficult or expensive to obtain prior to making a decision. Onsi also observed:

> It does not make an explicit structural use of prior information and the *a priori* probability of the unknown parameter. A decision should be made using both prior information and current objective evidence. It does not make formal use of the risks of error of each decision rule as a function of the possible values of the parameter or standard. (Onsi, 1967:324)

This means a reasonable manager will insist on a higher level of significance before rejecting, on the basis of given sample evidence, a strongly held belief as compared with a weak conjecture. An analyst is more likely to make an erroneous decision by failing to formalize this information (Hirshleifer, 1961:477). A model based on modern decision theory will provide a solution to some of these problems.

Accounting Control Model Based on Modern Decision Theory. Unlike the traditional accounting model and the accounting model based on classical statistics, a control model based on Bayesian modern decision theory will (Onsi, 1967:324):

1) Be based on sample evidence and considers both economic loss and prior belief. Economic loss results from either investigating a deviation when it is unnecessary (i.e., Type I error) or not investigating a deviation when necessary (i.e., Type II error).

2) Consider the prior state or a priori probability distribution of the process.

3) Not require the determination of Type I and Type II errors as in the model based on classical statistical theory. However, the economic impact of these errors is incorporated.

4) Provide a systematic approach for selecting an optimum sample size. The trade-off between the sampling cost and the reduction of risk determines optimum sample size.

5) Make explicit use of the opportunity cost concept to evaluate the worth of each action relative to the best possible action for the given situation. The opportunity loss of any alternative is equal to the difference between the cost of that alternative and the cost of the alternative that would be the best possible considering the value of the deviation. This model provides a procedure to select the best alternative to minimize expected economic loss of the unchosen alternatives.

The model makes two basic assumptions. First, the manager decides whether to investigate variations based on incomplete information which is obtained by periodic random sampling of output. Any decision based on incomplete information carries a degree of risk. To minimize this type of risk, an analytic tool is required.

Second, the manager is not only interested in the cause of variation, but also wishes to determine if the process is stable. If the process is considered stable, the central tendency and variations are expected to be within a pre-determined range.

The manager may decide to investigate a deviation based on the available prior information (i.e., using the a priori probability distribution). However, the degree of the risk may be reduced by delaying such a decision until additional information is obtained. To obtain additional information, a sample from the deviations is taken. The value of additional information obtained through sampling is equal to the difference between the expected economic loss of a decision based only on prior information and the expected economic loss of the same decision based on the additional information (i.e., a posteriori probability distribution) plus the cost of sampling. In short, if the cost of the sampling is greater, the value of obtaining additional information does not justify the cost.

For instance, if, under a given a priori probability distribution, the cost of uncertainty is very small, sampling is likely to cost more than it is worth. In this case, a decision can be made without a large degree of risk. Conversely, if the cost of uncertainty is large, the expected value of additional information is likely to be equal to or greater than the cost of sampling.

Accounting control based on modern decision theory takes advantage of the expected value of additional information obtained from investigation. The value of this information is derived by comparing the reduction of expected cost of the proposed initial decision with the cost of sampling and not by the reduction of the magnitude of the standard deviation, as in classical statistics (Onsi, 1967:326).

The major advantage of this model is that it incorporates an analytical tool to reduce the degree of risk. However, several weaknesses do exist. First, it is difficult to determine the a priori probability distribution. Second, because managers' attitude toward risk vary, it may be difficult to place a monetary value on the usefulness of the decision. This is a problem when potentially large gains or losses are expected.

To the extent that the probability of an event under uncertain conditions can be determined, modern decision theory is a practical tool for managing DoD acquisition programs. Through management experience, subjective (i.e., personal judgment based on experience) probability distributions approximating reality can be developed. This then provides a good method for choosing the best management alternative under uncertainty (Onsi, 1967:325).

This chapter has examined three different accounting control models and accessed their applicability to DoD acquisition programs. The goal of these three models is to decide whether or not to investigate variations. The traditional accounting model relies strictly on management judgment and experience to determine an absolute value for variation control limits. The second model based on classical statistics uses a mathematically derived frequency distribution as a basis for the establishment of control limits. Finally, a model based on modern decision theory uses subjective or personal probability for making informed decisions to investigate variances.

Statistical Process Control Approach

Statistical Process Control (SPC) uses control charts to monitor the outcome of a process. These control charts assists managers to identify and eliminate special causes of variations. Control charts are derived through statistical process control which is a proven technique for reducing variations, thus, increasing management control over the process (Evans, 1993:530).

Control charts were first proposed by W.A. Shewhart in the 1920s, who belonged to the Bell Telephone Laboratories. The purpose of these charts is to eliminate abnormal variation by distinguishing variations due to assignable causes from those due to chance causes (Kume, 1985:91).

A control chart consists of a central line, a pair of control limits allocated one above and one below the central line. Characteristic values (e.g. cost variations) are plotted on the chart to represent the state of a process. If all these values are plotted within the control limits without any particular tendency, the process is regarded as being in the controlled state. However, if they fall outside the control limits or exhibit a peculiar form, the process is considered to be out of control (Figure 5).

Similar to accounting control approaches, the purpose of using control charts is to determine when to take action to adjust a process which has fallen out of control. Just as important, it also indicates when to leave a process alone. This section examines several commonly used control charts:

1) X-Bar Chart, R Chart, and S Chart

2) Cumulative Sum (Cusum) Chart

3) The Economic X-Bar Chart and Economic Cusum Chart

X-Bar Chart, R Chart, and S Chart. The X-Bar and the R charts (range chart) are the most commonly used control charts. These charts are used together for the analysis data measured along a continuous scale. The X-Bar Chart is used to monitor the central tendency of a process whereas the R chart is used to monitor the variation of the process.

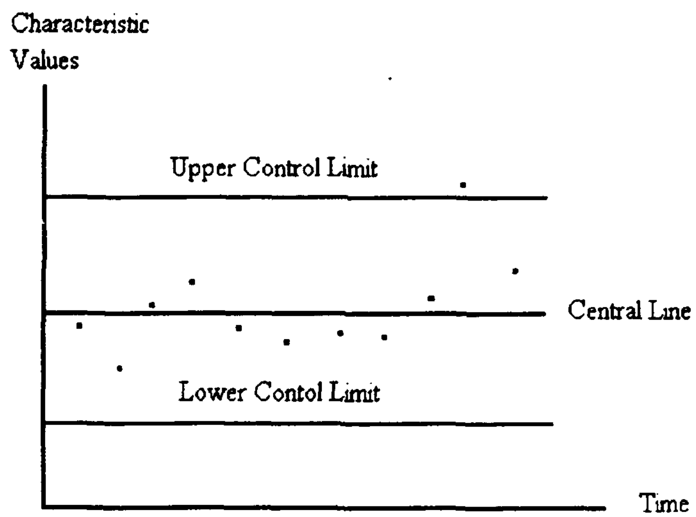

Figure 5. A Typical Control Chart

In order to construct these charts, samples of some given sample size are taken from the process of interest. For each sample, the average and the range are computed. Next, the average of the averages (i.e. overall process mean) and the average of the ranges (R-Bar) are computed. These averages form the basis for the central lines of the respective charts. From these central values control limits are computed.

The control limits are usually set at three standard deviations from the average measure. The underlining assumption for the computation of the control limits is that the distribution of the sample averages is normally distributed (Evans, 1993:541). Therefore, it is expected that approximately 99.7 percent of the sample data will fall within these control limits (Figure 6). If any point fall outside the control limits or if any unusual patterns are observed, it is likely that some assignable cause is affecting the process, and an analysis should be performed to determine that cause (Moore and Hendrick, 1992:A.3.1; Wheeler, 1986:204; Devore, 1991:415; Horngren and Foster, 1992:845).

If the assumption of a normal distribution for the sample data holds, the following rules can be applied for examining a process to determine if it is in control:

1) No points are outside the control limits.

2) The number of points above and below the center line is approximately the same.

3) The points seem to fall randomly above and below the center line.

4) Most points, but not all, are near the center line, and only a few are close to the control limits (Evans, 1993:539).

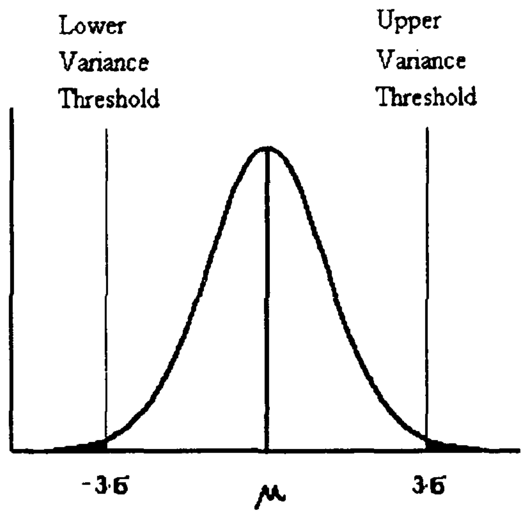

Figure 6. Normal Distribution with 3σ Control Limits

An alternative to using the R Chart along with the X-Bar Chart is to compute and plot the standard deviation, *s*, of each sample. Although the range has traditionally been used, since it involves less computational effort and is easier to understand, there is an advantage to using *s* instead of R. The sample standard deviation is a more sensitive and better indicator of process variability (Evans, 1993:585). Therefore, when tight control of variability is required, *s* should be used. The procedure for constructing S Chart is similar to the procedure for constructing the R Chart.

A defect of the traditional X-Bar Chart is its inability to detect a relatively small change in a overall process mean (Devore, 1991:653). This is largely a consequence whether a process is judged out of control at a particular time depends only on the sample at that time, and not on the past history of the process. To overcome this shortcoming, the Cumulative Sum control chart was designed to give early indication of process changes.

Cumulative Sum Chart (Cusum). The Cusum Chart incorporates all past data by plotting cumulative sums of the deviation of sample values from a target value. The Cusum Chart looks very different from the previous control charts. In place of a center line and horizontal control limits, a "V mask" is constructed. Any particular V-mask is determined by specifying design parameters such as, the "lead distance," d, and "half-angle," θ, as illustrated in Figure 7. One method for deciding which mask to use involves specifying the size of a shift in the process mean that is of particular concern to an investigator. Then the parameters of the mask are chosen to give

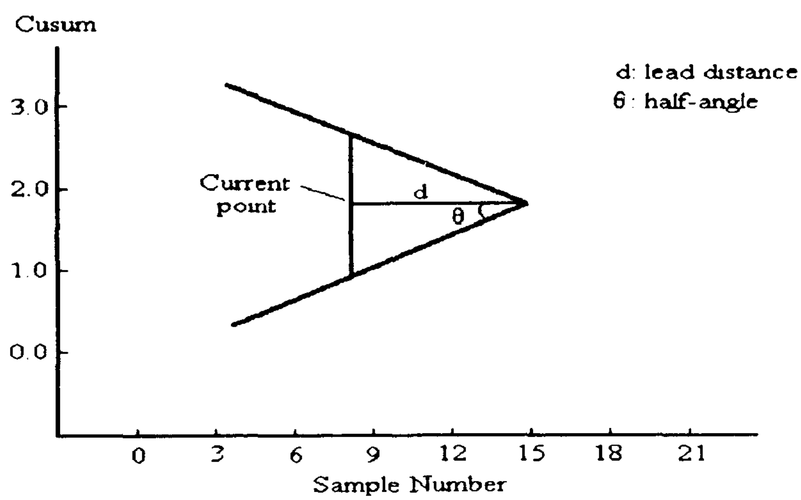

Figure 7. Cusum Vmask (Adapted from Devore, 1991:652)

desired values of Type I and Type II error, the false alarm probability and probability of not detecting the specified shift, respectively.

The mask is located on the chart so that the point p lies on the last point plotted. If no previous points lie outside the control limits, the process is assumed to be in control (Figure 8-a). If there is a shift in the process mean above the reference value, each new value if added to the cumulative sum will cause the cumulative sum to increase and result in an upward trend in the chart. Eventually a point will fall outside the upper control limit, indicating that the process has fallen out of control (Figure 8-b).

A major advantage of the cusum control chart is the ease of detecting the shift in process mean through visual inspection of the chart. However, the disadvantage is that is very difficult to define appropriate design parameters.

X-Bar and Cusum charts are useful in determining if a process is in or out of control and any shift of process mean. However, these charts ignore the cost and risk associated with the process. Therefore, the Economic X-Bar and Economic Cusum charts were developed to account for these costs and risks.

Economic X-Bar Chart and Economic Cusum Chart. Duncan established a criterion that measures approximately the average net income of a process under surveillance of an X-Bar Chart when the process is subject to random shifts in the process mean. In his analysis, it is assumed an assignable cause is investigated whenever a point falls outside the control limits. The criterion is for the case in which it is assumed that the process is not shut down while the search for the assignable cause is in progress, nor is the cost of adjustment or repair and the cost of bringing

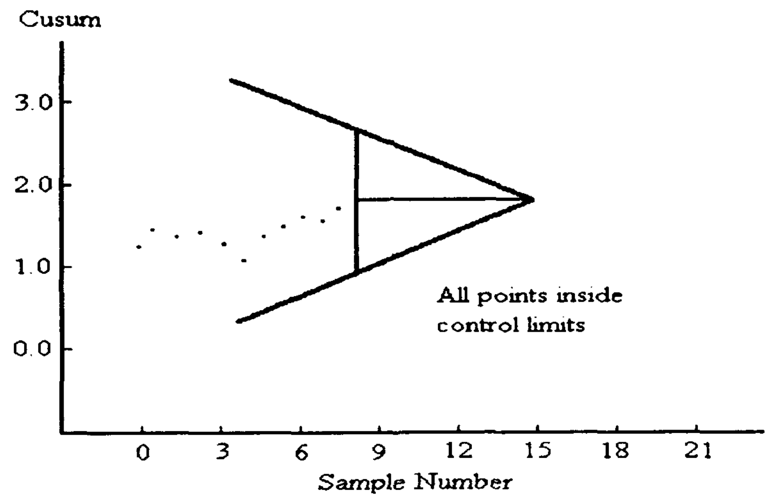

Figure 8-a. Vmask with All Points within Control Limits

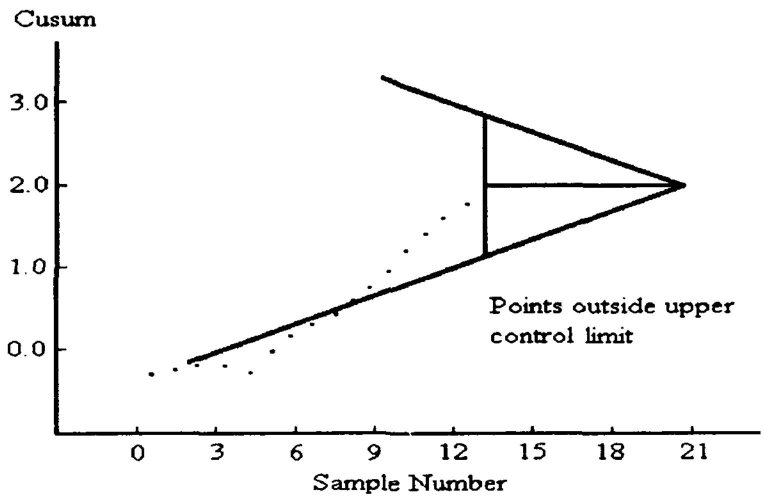

Figure 8-b. Vmask with Points Outside Control Limits
(Adapted from Evans, 1993:602)

the process back into a state of control after the assignable cause is discovered charged to the control chart program.

This design maximizes the long run average net income for the process. It assumes that the management has knowledge of the risk of occurrence of an assignable cause, knowledge of various costs and income parameters. The maximum income criterion is the b is for deciding whether of not to investigate variances.

An assumption is made, the control chart is maintained to detect a single assignable cause that occurs at random and results in a change in the process of known proportions.

Even though control charts as proposed by Shewhart have been in use for over sixty years, the increasing complexity and cost of industrial processes have necessitated a search for more efficient and economical means of improving quality (Goel and Wu, 1973:1272). An important development in this direction was the introduction of the Cusum procedures in 1954, which are based on sums of observations rather than individual observations.

Goel and Wu provided a methodology for the economic design of cusum charts to control the mean of a process with a normally distributed quality characteristic (Goel and Wu, 1973:1281) . Unlike the previous cusum model, this model is based on minimum cost criterion for investigating variances. A model is derived which gives the long-run average cost as a function of both the design parameters of the chart and the cost and risk factors associated with the process.

These statistical process control techniques are widely used in private industry to detect shifts in process mean and changes in variation (Evans, 1993:565). In a similar way, control charts can be used by DoD program managers to monitor the outcome of program cost and schedule management. Control charts help managers assess the program stability in order to determine whether or not to conduct cost and schedule variance analysis.

Dyckman Model. The Dyckman model is a two-state (in control, out of control), two-action (investigate, do not investigate) model using a critical value (probability) approach to determine the action required (Jacobs, 1978:191). The model employs a stochastic process and a Bayesian based decision making process to describe transitions between an in-control state and an out-of-control state and to update the probability of being in either state after each observation from the process (Kaplan, 1975:328).

Dyckman assumes a constant savings from investigating an out-of-control process. He calls it the "present value of the savings obtainable from an investigation when the activity is out-of-control." This method also considers the cost of correcting an out-of-control process and the present value of the losses from not investigating an out-of-control process. The variance thresholds are determined by a ratio of these factors.

However, the difficulty arises because Dyckman "suppresses the sequential decision-making nature of the problem" (Kaplan, 1975:328). As a result, the benefit from delaying the investigation for another period when more sample evidence maybe obtained is not evaluated.

The application of this model to DoD major program management is feasible. DoD program managers are responsible for the control of the level of several process variables, such as cost, schedule, and performance. These process variables may move only from a desirable state to a less desirable state, e.g., schedule slippage, cost overruns. Dyckman's model can be used as a control tool to indicate when intervention should take place.

Kaplan Model. One method developed by Kaplan is an extension of Dyckman's model. This model is a multi-period model which uses the actual costs when operating in or out-of-control to establish optimal thresholds. Therefore, a decision to delay investigating for one period incurs the risk of operating an additional period out-of-control. That is, obtaining a cost realization from an out-of-control distribution rather than from an in-control distribution (Kaplan, 1975:324).

Kaplan assumes the relevant information from the prior observations, since the last investigation was made, can be summarized by a single state variable--the probability that the system is currently operating in-control. This variable is updated after each observation via Bayes' theorem to incorporate information from the most recent observation.

Another assumption of the model is the simplification of the process to a two-state system, in-control and out-of-control, with sudden transitions between the states. Additionally, Kaplan assumes that an out-of-state process can always be returned to the in-control state.

It is these assumptions which may limit the applicability of this model. First, a forced dichotomy between in-control and out-of-control may not be an accurate description of a reality. Also, fundamental shifts in the process may occur that are not reversible even after discovery. For example, prices may have risen which may be impossible to reverse. This feature represents one of the fundamental differences between the traditional quality control settings for which most of the models and the cost variance setting have been developed (Kaplan, 1975:327). Physical processes monitored in the quality control environment can almost be returned from the out-of-control state to the desired setting once such a state is discovered. Therefore, the benefits from investigating these processes can be measured. Finally, the situation where the investigation fails to detect and out-of-control situation when one exists is not considered.

In general, this multi-period economic model is consistently more effective than previous models reviewed although each may have specific applications (Jacobs, 1978:202). This model might be similarly applied in DoD program acquisition management. However, its assumptions might limit applicability to DoD scenarios. For instance, in the cost and schedule variance setting, the benefits from investigation may be difficult to determine.

This literature review answered the first two investigative questions addressed in the introduction chapter.

Investigative Question #1: What models are available for establishing variance thresholds?

Based on the conduct of a thorough literature review, there are at least nine models which may be used to establish cost and schedule variance thresholds. The following list of models summarizes those examined in the literature review:

Traditional Accounting Model

Accounting Model Based on Classical Statistical Theory

Accounting Control Model Based on Modern Decision Theory

X-Bar Chart, R Chart, and S Chart

Cumulative Sum Chart

Economic X-Bar Chart

Economic Cusum Chart

Dyckman Model

Kaplan Model

The Traditional Accounting Model relies on simple and informal ways, such as management judgment and experience for determining an absolute value variation. The second model is based on classical statistical theory rather than management judgment and experience to set cost and schedule variance thresholds. This model uses a mathematically derived frequency distribution as a basis for setting the control limits. In addition, it makes a distinction between chance variation and assignable variation, and that only assignable should be investigated. The third model based on modern decision theory uses subjective probability for making an informed decision whether or not to investigate a variance.

The statistical process control approach uses control charts to monitor the outcome of a process. Its purpose is to determine when to take action to adjust a process which has fallen out of control. This approach employs several commonly used control charts, such as X-bar Chart, R Chart, S Chart, Cusum Chart, Economic S-Bar Chart, and Economic Cusum Chart.

The Dyckman and Kaplan models are extensions of the control chart models. The Dyckman model provides a means for making the cost deviation investigation decision that incorporates both the cost of investigation and the expected savings from returning the process to an in-control state. It uses a Bayesian decision theory approach to make that decision. The Kaplan model illustrates how the probability distribution of operating out of control and the various costs, the cost of operating out of control and cost of investigation, can be integrated to yield the best economic decision.

As evident from this research, there are a number of models which can be used to help managers to establish appropriate cost and schedule variance thresholds. From these thresholds, decisions can be made to determine whether an investigation is necessary to find a cause for an out-of-control process.

Investigative Question #2: Are any of these models applicable to DoD major program contracts?

To some extent these models can be applied to the establishment of cost and schedule variance thresholds on DoD major program contracts. In the authors' judgment, applicability of the models can be characterized in three broad categories: easy, moderate, and difficult. Table 3 presents the characteristics of the models examined in Chapter II and the assessment of the applicability of these models to DoD major program contracts. This assessment of the applicability was the result of considering the four characteristics listed in the table. These characteristics are Complexity, Factors Considered, Period, and Decision Approach.

Complexity refers to the degree of difficulty in modeling the process and executing the model (e.g., mathematical tools used, assumptions made, etc.). The authors assumed the more complex the model the more difficult in applying it to DoD

TABLE 3

SUMMARY CHARACTERISTICS

Model	1	2	3	4	App
Traditional Accounting Model	Simple	None	Single	M.J.	Easy
Accounting Model Based on Classical Statistical Theory	Mod	PK, Risk	Multi	CS	Mod
Accounting Control Model Based on Modern Decision Theory	Complex	PK, Cost Risk	Multi	BDT	Diff
X-Bar Chart, R-Chart, and S-Chart	Simple	None	Single	SPC	Easy
Cumulative Sum Chart	Mod	PK	Multi	SPC	Mod
Economic X-Bar Chart	Mod	Cost	Single	SPC	Mod
Economic Cusum Chart	Mod	PK, Cost	Multi	SPC	Mod
Dyckman Model	Complex	Cost	Multi	BDT	Diff
Kaplan Model	Complex	PK, Cost, Risk	Multi	BDT	Diff

1-Complexity - Simple, Moderate (Mod), Complex
2-Factors Considered - Prior Knowledge (PK), Cost, Risk
3-Period - Single, Multiple (Multi)
4-Decision Approach - Management Judgment (MJ), Classical Statistics (CS), Bayesian Decision Theory (BDT), Statistical Process Control (SPC)

major programs. The Factors considered included the prior knowledge required to initiate the model, the cost, and the risk of investigating a variance or not investigating a variance. Period means that the models used data from either a single period or more than one period. The Decision Approach signifies the method by which a decision to investigate a variance was derived. These methods consist of management judgment, classical statistical approach, statistical process control approach, and Bayesian decision theory.

The Traditional Accounting Model used to establish cost and schedule variance thresholds can be easily applied to DoD major program contracts. The major advantage of this model was its simplicity because no extensive or time-consuming computations were necessary. Only managerial judgment and experience were required. However, this model might not prove as effective because it did not explicitly consider other factors, such as prior knowledge, cost, or risk. Also, since the model considered only a single period, the variance thresholds were not updated to reflect the latest condition of the process. Though management judgment and experience are beneficial for program control, often in the DoD environment, managers do not remain with the same program throughout its life. Further, experience and judgment vary among managers. This may cause the level of program control to be less effective.

The Statistical Process Control models examined in Chapter II consisted of the X-Bar Chart, R Chart, S Chart, Cumulative Sum Chart, Economic X-Bar Chart, and Economic Cusum Chart. The degree of difficulty in modeling the process for these models ranged from simple to moderate in complexity. In the less complex X-Bar, R

Bar, and S Bar charts, decisions were made based on a single observation. The Economic X-Bar Chart also used a single observation but did consider various investigation costs and income data. In the more complex Cusum and Economic Cusum charts, decisions were based on multiple observations. Again, the Cusum Chart did not consider the investigation costs while the Economic Cusum Chart did consider these costs.

These models are widely used in private industry to detect shifts in process mean and changes in variation (Evans, 1993:530). With some basic knowledge in statistics, the decision maker can easily apply the X-Bar Chart, R Chart, and S Chart to DoD major programs. However, while this model may be simple to use, it is similar to the Traditional Accounting Model in that it ignored prior knowledge, cost, and risk.

The other three SPC models, Economic X-Bar Chart, Cusum Chart, and Economic Cusum Chart, are relatively more difficult to apply to DoD major programs. This is due mainly to a higher level of complexity required to develop the models. For example, the models required additional information such as, prior knowledge, cost data, and an estimation of the risk of investigating a variance.

In general, the authors believe control charts can be used by DoD program managers to monitor the outcome of program cost and schedule management. Control charts help managers assess the program stability in order to determine whether or not to conduct cost and schedule variance analysis.

The Accounting Model based on Classical Statistical Theory is also moderately applicable to DoD major programs. Similar to Cusum models, this model utilized multiple observation data and considered all risks associated with the decision to investigate a variance. Again, a basic knowledge of statistics was required to develop and execute the model. Moreover, since this model considered multiple periods, it is often difficult and time-consuming to collect the necessary data.

The other three models which used a Bayesian decision approach are potentially difficult to apply to DoD programs due to their complexity. First, these models required an extensive knowledge in statistics to develop and execute. Second, the development and implementation costs were potentially higher because of the additional expertise required and the time required to gather data and develop these models.

In short, the degree of applicability of threshold models to DoD programs is mainly dependent upon the complexity of each model and the time and costs associated with the development and implementation of these models. It seems that, there is no single best model for all programs.

Summary

In the accounting approach, the traditional accounting model relies on simple and informal ways, such as management judgment and experience for determining a absolute value variation. Another model based on statistical theory rather than management judgment and experience to set cost and schedule variance thresholds. This model uses a mathematically derived frequency distribution as a basis for setting the control limits. In addition, it makes a distinction between chance variation and assignable variation, and that only assignable should be investigated.

The statistical process control approach uses control charts to monitor the outcome of a process and to determine when to take action to adjust a process which has fallen out of control. This approach employs several commonly used control charts, such as X-Bar Chart, R Chart, S Chart, Cusum Chart, Economic X-Bar Chart, and Economic Cusum Chart, for its purpose.

The Dyckman and Kaplan models are extensions of the control chart models. Dyckman model provides a means for making the cost deviation investigation decision that incorporate both the cost of investigation and the expected savings. It uses a statistical decision theory approach to make that decision. Kaplan model illustrates how the probability distribution of operating out of control and the various costs: the cost of operating out of control and cost of investigation can be integrated to yield the best economic decision.

These models can be used to established cost and schedule variance thresholds in DoD major programs. In authors' judgment, the level of applicability of these models depends largely on the complexity of each model and the time and cost associated with the development and implementation of these models.

The next chapter will describe the specific procedures for conducting the research. The chapter will cover the following subtopics:

1) Research Findings

2) Population

3) Sample

4) Instrument Development

5) Data Collection.

III. Methodology

Introduction

This chapter explains the process used to collect the information necessary to answer the investigative and research questions discussed in Chapter I.

Research Design

Different interpretations of variance thresholds between government and contractor personnel may present problems controlling contract cost and schedule. These different interpretations indicate the need for setting appropriate variance thresholds. Recognizing this fact, researchers have developed many theoretical models as described in the previous chapter to help establish such thresholds. Although cost and schedule variance thresholds are required on DoD major program contracts, little is known about the methods the government and contractors use to establish these threshold values.

The purpose of this thesis is:

1) to examine to what extent theoretical models are used to establish cost and schedule variance thresholds on DoD major program contracts,

2) to identify how cost and schedule variance thresholds are established on DoD major program contracts, and

3) to report those findings.

This thesis is descriptive in nature. It examines things as they exist and does not attempt to manipulate any variables.

This thesis is a formalized study consisting of eight structured investigative questions. These investigative questions are:

1) What models are available for establishing variance thresholds?

2) Are any of these models applicable to DoD major program contracts?

3) Who is responsible for setting cost and schedule variance thresholds on DoD major program contracts?

4) Are DoD personnel aware of these models?

5) Are any of these models being used by the DoD?

6) How are cost and schedule variance thresholds established on DoD major program contracts?

7) What models for establishing cost and schedule variance thresholds are used?

8) Do the chosen methods vary depending on program type, preparation time, risk, contract phase, and contract cost?

A thorough literature review on the topic of variance thresholds in the last chapter answered the first two investigative questions. The chapter also discussed the advantages, disadvantages, differences, and the applicability of these models to DoD major program contracts. The remainder of the investigative questions required personal interviews with government and contractor personnel.

Population

Based on the research objective, the relevant population of interest was determined. This population included all government financial managers and civilian contractor counterparts who had first-hand knowledge of the establishment of cost and schedule variance thresholds for DoD major program contracts.

According to a memorandum from the Office of the Under Secretary of Defense for Acquisition addressed to the service secretaries dated 9 February 1990, there were 123 U.S. Army, USAF, U.S. Navy, and DoD major programs (Appendix A). Based on the authors' observations, an average of two financial managers and two contractor counterparts for each DoD major program was a reasonable estimate. Therefore, the total number of personnel involved in the establishment of cost and schedule variance thresholds for these programs was estimated to be approximately 492.

Since the release of the above memorandum, a number of major programs have been canceled (e.g., A-12, Rail Garrison, Small Missile) due various reasons, such as poor management and the reduced threat from the communist block. These cancellations coupled with DoD and defense industry personnel reductions rendered this population estimate highly debatable.

Sample

For the scope of the thesis, elements of this sample were DoD system program office personnel. Additionally, several defense contractor personnel were interviewed.

This sample consisted of USAF Aeronautical Systems Center (ASC) Financial Management Staff personnel, USAF System Program Office (SPO) personnel at Wright-Patterson AFB, U.S. Army and U.S. Navy program office personnel, and defense contractor personnel. Even though the population size estimate was subjective, it was the goal of the authors to include as many samples as possible given the authors' time and funding constraints. As this thesis was descriptive in nature, rigorous statistical methods to manipulate data were not used. This limited the inferences which could be drawn concerning the population.

A judgmental decision on the sample was made due to several factors:

1) Almost all USAF major aeronautical program contracting is done at Wright-Patterson AFB.

2) Data are readily available for collection.

3) There is a large government and contractor personnel pool for interview.

Instrument Development

The research question was to discover to what extent the theoretical models were used to establish cost and schedule variance thresholds on DoD major program contracts, and eight specific investigative questions were used to answer this research question. In addition, four measurement questions were derived from the investigative questions and were posed to each interviewee. The first of these questions was dichotomous to determined if the interviewee possessed first-hand knowledge of the establishment of variance thresholds. A negative response to this question would terminate the interview as the interviewee would not be representative of the population of interest. The remainder of the measurement questions were open-ended to facilitate discussion. For example, the fourth measurement question was designed to include all potential factors, such as contract costs and program type, which might affect the establishment of cost and schedule variance thresholds.

These measurement questions were:

1) Do you establish cost and/or schedule variance thresholds on any DoD major program contracts?

2) What method or methods do you use?

3) What other theoretical models for establishing variance thresholds are you aware of?

4) What factors (i.e., program type, preparation time, risk, contract phase, contract cost) do you consider when setting cost or schedule variance thresholds?

All the questions were structured with the following factors considered to minimize measurement errors and respondent confusion (Emory, 1991:362).

1) Shared vocabulary - Technical terms such as variance thresholds, C/SCSC, and variance analysis were understood by all respondents. This is verified at the time of each interview.

2) Clarity - The questions posed contained very little ambiguous wording. They were short, direct, and focused toward a single element.

3) Hidden assumptions - No hidden assumptions. Measurement questions established the competence level of interviewees and minimized measurement error.

4) Biased wording - Bias was minimized by asking all respondents the same questions. No superlatives, slang expressions or fad words were used.

5) Personalization - Personalization was chosen to put interviewees at ease and to promote the flow of information. Questions were worded with second personal pronouns.

6) Adequate alternatives - All but the first measurement questions were open-ended, again to promote the flow of information.

Additionally, the questions were arranged in such a manner as to encourage the respondents' interest in the topic. For instance, the first question was designed to stimulate the respondents' attention to and interest in C/SCSC, specifically in variance analysis and variance thresholds. Moreover, the first question ensured the interviewee's subject knowledge. They were sequenced in a logical order and range from simple to complex, general to specific (Emory, 1991:371).

Another consideration in instrument development is whether the purpose of the study should be disguised. The accepted wisdom is that knowledge of the purpose of the research may bias the results (Emory, 1991:352). However, if respondents are aware of the study's purpose and perceive that the topic is relevant to their own interest, they are more willing to provide information (Emory, 1991:359). Thus, in this study, there was no reason to disguise the objectives, and interviewees were made aware of its purpose.

Data Collection

Questioning was the basic methodology used in this study. Tl technique selected for questioning the study participants was the personal interv v. The personal interview offered several advantages to this study. First, dat .re readily available as almost all USAF major program contracting is done at W ght-Patterson AFB. For this reason, there was a large government and contractor p onnel pool for interviews. In addition, to gather information from other DoD agenci telephone interviews was used.

For personal interviews, each sample element was contacted b elephone to arrange a convenient time for an interview. After this initial contact, ch interview was conducted by the authors. At the beginning of each interview, tl participants were given a copy of the interview agenda. This agenda included the urpose of the study and the designed measurement questions. Responses were reco d by both interviewers and later compared for consistency and accuracy.

Telephone interviews were conducted in much the same mann as personal interviews. Each sample element was contacted by telephone to arran a convenient time for an interview After this initial contact. each interview was co lucted by one of the authors. At the beginning of each interview, the participants w informed of the interview agenda which included the purpose of the study and the signed measurement questions. Responses were recorded by the interviewer.

To ensure consisten nd accurate results for data collection, the same set of measurement questions wa pplied to all elements of the sample. Moreover, these questions were posed by th ame investigators.

Information gathere rom interviewees was studied and analyzed to provide answers to the eight investi tive questions. Tables presenting the research information have also been cluded when they add to the reader's understanding of the presented material. Th indings and analysis are presented in the next chapter.

All participants in t study were given anonymity and no associations were made to the various contra rs and organization that are involved in the study. The interviewees were told that y questions they felt uncomfortable with answering would be excluded. No in viewee express such a discomfort; as a result, no questions were excluded in y interview.

Summary and Overview

Four measurement stions were derived to address the research objective. These questions were pose a sample of DoD government and civilian contractor personnel who had first-ha knowledge of the establishment of cost and schedule variance thresholds. Questi s were structured to minimize measurement errors and respondents' confusion. In viewee responses based on the four measurement questions were collected. T findings and analysis are presented in the next chapter.

IV. Research Findings and Analysis

Introduction

This chapter documents the information obtained from following the research methodology as outlined in the previous chapter. Information was gathered from:

1) A comprehensive literature review of theoretical models.

2) Six personal interviews conducted with individuals from USAF AFMC/ASC, U.S. Army, U.S. Navy, and defense contractors who had first-hand knowledge of the establishment of cost and schedule variance thresholds (Appendix B).

3) A review of nine defense contractor system description documents.

4) A review of The U.S. Army study, Establishment of Consistent Variance Thresholds For Problem Analysis on the Cost Performance Report for the LoAD PPD Program Phase IB.

5) A review of DoD Manual 5000.2-M, Defense Acquisition Management Documentation and Reports.

6) A review of the Cost/Schedule Control Systems Criteria Joint Implementation Guide.

In general, this chapter will answer the following investigative questions:

1) What models are available for establishing variance thresholds?

2) Are any of these models applicable to DoD major program contracts?

3) Who is responsible for setting cost and schedule variance thresholds on DoD major program contracts?

4) Are DoD personnel aware of these models?

5) Are any of these models being used by the DoD?

6) How are cost and schedule variance thresholds established on DoD major program contracts?

7) What models for establishing cost and schedule variance thresholds are used?

8) Do the chosen methods vary depending on program type, preparation time, risk, contract phase, and contract cost?

Research Findings

The first two investigative questions were answered in Chapter II, Literature Review. This section will address the six remaining investigative questions.

Investigative Question #3: Who is responsible for setting cost and schedule variance thresholds on DoD major program contracts?

According to interviews conducted with financial management personnel at USAF AFMC/ASC staff level, USAF, U.S. Army, and U.S. Navy SPOs, cost and schedule variance thresholds on DoD major program contracts were established by the financial managers of each SPO.

While ASC staff personnel did not directly supervise SPO financial personnel, they did exert some degree of functional authority over financial matters. For instance, an ASC policy letter regarding the establishment of cost and schedule variance thresholds was issued to the various SPOs (Appendix C).

Based on inputs from various product divisions, the experience from ASC staff cost analysts, and collected sample financial Contract Data Requirements Lists (CDRLs), this policy letter provided lessons learned concerning preparation of financial CDRLs and suggested approaches for establishing reporting levels, variance thresholds, etc., with explanations as to why the approach was recommended.

Investigative Question #4: Are DoD personnel aware of these models?

Interview results indicated that none of the interviewees had knowledge of the existence of various models examined in Chapter II. In addition, interviewees indicated that they were not aware of any other type of models which were not examined in this thesis and which might be used to establish cost and schedule variance thresholds on DoD major program contracts.

***Investigative Question #5:* Are any of these models being used by the DoD?**

Basically, none of these models was being used by the DoD. Even though interviewees stated that they were not aware of or using any of the specific models examined, interview results suggested otherwise. Interview results suggested that the method used by some of these personnel was similar to the Traditional Accounting Model. For some interviewees, managerial experience and judgment were the tools used to set cost and schedule variance thresholds.

Investigative Question #6: How are cost and schedule variance thresholds established on DoD major program contracts?

Research into the fiscal year 1983 DoD Authorization Act showed a serious commitment to the reporting requirements of the DoD to the United States Congress.

By law the DoD must report to the Congress any time a program exceeds its baseline values by pre-established thresholds.

This public law known as the "Nunn-McCurdy Amendment" requires a baseline which reflects the estimated worth of the program in the President's budget (U.S. Congress, 1982:1557). This baseline is expressed in two types of "unit cost" estimates. The two types of unit costs are defined as:

> (1) Program Acquisition Unit Cost (PAUC)- Representing the sum of all RDT&E, production, and weapon system specific military construction costs for the total acquisition program, divided by the total program acquisition quantity; and/or
>
> (2) Current Procurement Unit Cost (CPUC)-Representing the total of all procurement funds appropriated for the program for a given year, divided by the number of end items to be procured in that same year. (Fleming, 1992:216)

Thus, a given program will have on record with the DoD and the Congress a baseline of "total program unit cost" (PAUC), and a "yearly unit cost" value (CPUC), both of which will be monitored for the life of the program. Two threshold limits are prescribed: a 15% and a 25% level. Both these levels require specific reporting actions by the DoD when they are exceeded. When a program manager reports that a breach exceeding 15% has occurred, the service secretary must submit a report to Congress. If the breach exceeds 25%, then the Secretary of Defense must take action to assure Congress that the program is essential to national defense and is the least cost alternative, and that the management team is still capable of managing and controlling the program costs (Fleming, 1992:218).

The Nunn-McCurdy Amendment invariably affected DoD's internal management regarding the establishment of variance thresholds. DoD 5000.2-M, part

20, Cost Management Reports, paragraph 7.b.5 stated: "All reporting provisions will be negotiated and specified in the contract, including reporting frequency, specific variance analysis thresholds, and the contract WBS elements to be reported." This was the only reference to variance thresholds found in this manual. No specific guidance regarding the actual formulation of variance thresholds was addressed.

The C/SCSC JIG paragraph ae, page 2-3 stated: "appropriate thresholds should be established as to the magnitude of variances which will require variance analysis." Paragraph e, page 3-17 went on to state: "it is essential that these internal variance thresholds be so established that all significant variances will be analyzed while at the same time avoiding an excessive number of variance analyses." This is to minimize the generation of analyses and explanations of variances which do not have potential for negative impact on the program.

Furthermore, the JIG mentioned that: "no particular approach or set of thresholds is 'best' for all circumstances" (JIG, 1987:3-17). Different thresholds should be considered for different levels of management, for different organizational elements, and for reporting to the DoD. Concerning the establishment of variance thresholds, the guide stated: "generally, thresholds are established requiring a variance analysis for any cost or schedule variance that exceeds a certain percentage of the budget of work scheduled or work performed and/or exceeds an established dollar minimum" or "to set the thresholds as a percentage of the budget for the entire project." It is clear the guide emphasized the importance of setting appropriate variance thresholds. However, the guide provided no specific means or technique to establish cost and schedule variance thresholds.

A review of nine major defense contractor system descriptions was conducted. Contractor system descriptions are documents which detail to the government all the managerial and accounting procedures the contractor uses to manage internally during the contract. Pertinent excerpts of these documents are included in Appendix D.

Although the importance of setting appropriate variance thresholds has been illustrated in Chapter I, of the nine system descriptions reviewed by the authors, none addressed this topic in any specific detail. For instance, one of the documents contained over 300 pages. Four separate pages described the requirement of variance analysis. However, not a single sentence was devoted to the establishment of variance thresholds. In another case, four pages out of 153 pages described several topics related to variance thresholds. The issues described included variance analysis, variance analysis reporting, and variance computation (e.g., Cost Variance = Budgeted Cost of Work Performed - Actual Cost of Work Performed). Again, no specific techniques for establishing thresholds were described.

When the establishment of variance thresholds was addressed, the instructions were very general. For instance, one contractor suggested using a percentage and an absolute dollar value as variance thresholds stating "the cost account threshold are usually defined by both a percentage figure and a resource value figure in hours or dollars (e.g., +/- 10 percent and 1000 hours)." However, there was no indication as to how these values should be derived.

Another way in which contractors addressed the establishment of variance thresholds is through contract direction. One system description stated: "variance thresholds may be established at the reporting level by the customer via contract direction." Another stated: "at the report level, tolerances are contractually established for each program." This implies that cost and schedule variance thresholds are established by government direction. Also, variance thresholds were established by contract negotiation. One interviewee related that variance thresholds were agreed upon and documented on the back of his business card. As a matter of fact, in the documents reviewed, no specific calculation methods for the establishment of cost and schedule variance thresholds were described.

In contrast to the documents described above, a U.S. Army study titled The Establishment of Consistent Variance Thresholds For Problem Analysis on the Cost Performance Report for the LoAD PPD Program Phase IB suggested a mathematical model to set variance thresholds (Appendix E). According to this model, variance thresholds should be a function of the amount of work performed in relation to the estimated cost at completion (i.e. the thresholds should change over time). In practice, contracts frequently call for the same thresholds to be used throughout the life of the contract. A survey conducted by the National Security Industrial Association (NSIA) Cost/Schedule System Compendium in 1979 supported the Army study. The NSIA survey asserted using the same threshold throughout the life of the contract "tends to place emphasis on minor variances in low value items while ignoring major variance in high value items" (NSIA Management Systems Subcommittee, 1980:I-14).

Additionally, the Army model compensated for cost variations between different WBS levels in a contract. The study stated that "these thresholds shall be applied routinely at level three and above the WBS." The application to lower-level

WBS elements shall be based on specific government management needs for limited time periods.

As addressed in Investigative Question #3, ASC staff personnel issued a policy letter to the various SPOs regarding lessons learned for preparing financial CDRLs. With regard to the establishment of cost and schedule variance thresholds, this policy letter suggested approaches for establishing reporting levels, variance thresholds, etc., with explanations as to why the approach was recommended.

Specifically, the policy recommended establishing thresholds using both an absolute dollar amount and a percentage. For example, personnel were to use a percentage threshold, such as +/- 10 percent, or combined it with a minimum dollar value. When an element breaches both thresholds, written analysis is required. Furthermore, the letter stated, "when creating thresholds, remember that -15 percent is unsatisfactory when reporting to higher headquarters." Again, the letter failed to instruct personnel how these threshold levels should be derived.

Interview results indicate that no models were explicitly used to establish cost and schedule thresholds on DoD major program contracts. For some interviewees, managerial experience and judgment were the only tools used to set these thresholds.

One interviewee indicated that as far as he could remember, variance thresholds for new contracts were established by using variance thresholds from previous contracts. Two other interviewees supported this view. Additionally, this was a very subjective process. If the SPO personnel perceived no problem with the previous threshold levels, he would continued to use the same thresholds for other contracts.

A seasoned financial manager with over 30 years of experience, used his experience rather than any formal model to establish cost and schedule variance thresholds. In a similar manner, another financial manager conceded that the establishment of variance thresholds was not viewed as a structured set of values. In his opinion, it was viewed as "a philosophical approach with a touch of personal angle" and "requires no brain." Again, past experience was the dominant factor when setting threshold levels.

The research results revealed that cost and schedule variance thresholds were essentially established on DoD major program contracts by using management experience. No specific guidance to formally establish variance thresholds was found.

Investigative Question #7: What models for establishing cost and schedule variance thresholds are used?

Basically, none of these models are being used by the DoD. Interviewees stated that they were not aware of or using any of the specific models examined. Interview results suggested that the method used by some of these personnel was similar to the Traditional Accounting Model.

Investigative Question #8: Do the chosen methods vary depending on program type, preparation time, risk, contract phase, and contract cost?

As evident through the review of numerous government and defense contractor documents and interviews with knowledgeable government and defense contractor personnel, no specific methods examined in this thesis were chosen to establish cost and schedule variance thresholds. Therefore, these variables, program type, preparation time, risk, contract phase, and contract cost, did not affect the choice of a method to establish cost and schedule variance thresholds. Three interviewees related that none of these variables affected their choice of method.

Even though interviewees did not use any of the models examined to establish cost and schedule variance thresholds, some did consider these variables when selecting threshold levels for a new contract. For instance, according to one interviewee, contract phase was a factor in setting variance thresholds. Cost and schedule variance thresholds remain the same throughout the contract life for the current month values. However, these thresholds may vary throughout the life of the contract for cumulative amounts. This policy is consistent with the guidance set forth in the C/SCSC JIG, para 3-5e(2) which states: "When initially establishing the thresholds, it may be advisable to provide for tightening these thresholds as the contract progresses. . ."

Summary

This chapter used the information gathered to answer the following investigative questions:

1) What models are available for establishing variance thresholds?

2) Are any of these models applicable to DoD major program contracts?

3) Who is responsible for setting cost and schedule variance thresholds on DoD major program contracts?

4) Are DoD personnel aware of these models?

5) Are any of these models being used by the DoD?

6) How are cost and schedule variance thresholds established on DoD major program contracts?

7) What models for establishing cost and schedule variance thresholds are used?

8) Do the chosen methods vary depending on program type, preparation time, risk, contract phase, and contract cost?

The findings indicated that while there were many methods for establishing cost and schedule variance thresholds which could be applicable to DoD major program contracts, none of these methods was being used. Repeatedly, interviewees related that threshold levels for new contracts were established by either management experience and judgment or by copying threshold levels from previous contracts.

The next chapter will provide conclusion and recommendations.

V. Conclusions and Recommendations

Introduction

This chapter uses the findings based on the research presented in Chapters II and IV in order to draw conclusions regarding to what extent the theoretical threshold models were used to establish cost and schedule variance thresholds on DoD major program contracts. Following the conclusions, recommendations will be presented.

Conclusions

As discussed in Chapter I, the specific problem regarding the establishment of cost and schedule variance thresholds centers around the fact that there is no universal agreement on what constitutes appropriate threshold levels. Different interpretations of variance thresholds between government and defense contractor personnel indicated the need for setting appropriate variance thresholds. Research presented in Chapter II demonstrated that there were many well developed theoretical models to help establish such threshold levels. Although variance thresholds are found in many defense acquisition contracts, little was known about the methods the government and contractors use to establish these threshold values.

As the results in Chapter IV indicated, DoD and defense contractor personnel rely on personal management experience and judgment in establishing the variance threshold levels for a contract. One possible explanation for this occurrence is the apparent lack of awareness of the many theoretical models available which can be applied to the establishment of variance thresholds for defense contracts. This lack of knowledge could have been the result of inadequate supplemental training of personnel which could expose them to these additional methods.

In addition, government documents and regulations as well as defense contractor documents did not provide any specific methods or techniques to derive cost and schedule variance thresholds. This lack of specific guidance further contributes to the necessary reliance on personal experience and judgment to set the threshold levels.

Recommendations

Upper management should provide functional personnel with additional supplemental training to expose them to the various methods to establish variance thresholds which can be applied to DoD major program contracts.

This thesis has shown how DoD establishes cost and schedule variance thresholds. But this research has only laid the foundation for further investigation into this subject. A study to determine the relative effectiveness of variance threshold levels for all DoD major program contracts should be conducted. Such a study would aid the decision maker as to whether any changes should be made to improve the effectiveness of the current practices used to establish variance thresholds.

Further study should be performed to determine specific guidelines for establishing variance thresholds. This study should be based on available empirical data from past and on-going programs. Informal techniques which are intuitive in nature should not be the only tool used to establish variance thresholds.

Summary

This chapter provided some insights into the current practice by government and defense contractor personnel with regard to the establishment of variance thresholds. It also identified the lack of awareness of the various methods of establishing variance thresholds which could be effectively applied to DoD major program contracts. Finally, recommendations were made which address increased training requirements and potential follow-on studies to determine the relative effectiveness of variance threshold levels and finally achieve success in controlling cost overruns problems.

Appendix A: Listing of Major Defense Acquisition Programs

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301

ACQUISITION

9 FEB 1990

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS

SUBJECT: Designation of Major Defense Acquisition Programs

Attached are updated listings of Defense Acquisition Board (DAB) and Component programs. These listings officially update the February 23, 1989, versions.

The DAB and Component categories are used to determine whether the programs are subject to management oversight either by the DAB or by the Component decision process. These listings do not reflect or obviate separate guidance on SAR, baseline, and DAES oversight.

John Betti

Attachments

cc:
DAB Principals & Advisors

MAJOR DEFENSE ACQUISITION BOARD (DAB) PROGRAMS

ARMY	NAVY	AIR FORCE	DoD
AAWS-H	A-12	ACM	ADI
AAWS-M	AAAM	AL TACIT RAINBOW	SDS
ADDS	AAA	AMRAAM	SBWAS
ASAT	ATS	ATF	WAM
ATACMS	AIWS	B-1B	
FAADS C^2I	AN/BSY-2	B-2	
FAADS LOS-F-H	AN/SQQ-89I	C-17A	
FAADS LOS-R	ASPJ	CMU	
FOTL	FDS	JOINT STARS	
GL TACIT RAINBOW	LRCSW	JTIDS	
HFM	MK-50 TORPEDO	MARK XV CIS	
JTF	NAAWS	MILSTAR	
LHX	NATF	NAS	
LONGBOW	P-7A (LRAACA)	NASP	
MLRS-TGW	SSN-21	NAVSTAR USER EQUIPMENT	
PLS	T-45TS	RAIL GARRISON	
SADARM	TRIDENT II MISSILE	SMALL MISSILE	
SINCGARS	UHF FOLLOW-ON	SFW	
		SRAM II	
		SRAM-T	

Attachment 1

As of January 29, 1990

MAJOR DEFENSE ACQUISITION COMPONENT LIST

ARMY	NAVY	AIR FORCE
AH-64	A-6E	ATARS
BRADLEY FVS	AN/BSY-1	DMSP
CH-47D	AN/SQQ-89 (BASIC)	DSCS III
FAADS NLOS	AOE-6 FAST SUPPORT SHIP	DSP
FMTV	AV-8B	E-3A (Radar Improvement)
HELLFIRE	CG-47 AEGIS	F-15
M1A1 TANK	C/MH-53E	F-16
MLRS	CVN 68 Class	F-100 Eng Upgrade
MSE	DDG-51	IIR MAVERICK (AGM-65)
OH-58D AHIP	E-2C	IUS (SPACE SHUTTLE)
PATRIOT	E-6A (TACAMO)	KC-135R
STINGER	EA-6B ADCAP	LANTIRN
STINGRAY	F-14D	NAVSTAR GPS
TOW 2	F/A-18	OTH-B
UH-60A	HARM	PEACEKEEPER
	HARPOON	TITAN IV
	LAMPS MK III (SH-60B)	
	LCAC	
	LHD-1	
	LSD-41	
	LSD-41 CARGO VARIANT	
	MCM-1	
	MK-48 ADCAP	
	PHALANX CIWS (MK-15)	
	PHOENIX (AIM-7M) sic	
	ROTH-R	
	SH-60F	
	SLAT	
	SM-2	
	SSN-688	
	TAO OILER	
	TOMAHAWK	
	[illegible]	[illegible]

Appendix B: Interview Summaries

Government A, USAF, MAJCOM Staff

Date: 18 Jan 93

Position: Staff

Summary:

- This office does not set variance thresholds for SPOs

- Gov't sets external variance thresholds

- Contractor's set internal variance thresholds

- Internal tighter than external

- Staff tries to educate folks through training and memos/policy letter(s)

- Disagrees with analysis is excessive as often claimed by contractors

- Cost is not an issue/factor

- Variance threshold levels depend on PM interest in variance analysis

- Experience that variance thresholds set using whatever is in last contract

- Sometimes top 10 cost drivers are chosen (WBS $wise or WBSs which may be troublesome areas)

Government B, USAF, Systems Program Office

Date: 9 Feb 93

Position: Program Financial Manager

Summary:

- A subjective process

  -- If no problem perceived then reuse old variance thresholds from previous contract(s)

- Same variance thresholds for all (i.e. cumulative and current month)

- Troubled that establisher and users are not the same (i.e. cost estimator versus budget executioner)

- User of variance thresholds analysis develop attitudes toward

- Variance thresholds are +/- 10% or $50,000 of BCWS and BCWP whichever is greater and 10% for BAC in any reported WBS element

Government C, USAF, Systems Program Office

Date: 2 Apr 93

Position: Financial Manager for engine contract

Summary:

- Contract phase is EMD

    -- Contract let in Aug 19xx
    -- Duration is 19xx-2xxx

- Plan to produce 9 a/c and 27 engines for EMD, plan procure 648 a/c.

- $1.5B contract

- Cost plus award fee contract

    -- Cost +4% base fee (guaranteed) and 9% incentive fees)

- Contract recently rephased stretching development 1.5 yrs

- First flight expected summer 19xx

- FM has 6 financial analysts

- Yes, individual established variance thresholds for this contract

    -- Past experience used to establish variance thresholds.

- Not aware of other theoretical models

- Factors

    -- Prep time does not play here
    -- Risk is not a factor
    -- Phase is factor in setting variance thresholds

        --- For current month value

            ---- Variance thresholds stay the same throughout the contract

        --- For cumulative amounts

---- May vary throughout the life of the contract
---- Vt usually gets tighter toward the end.

-- Quit reporting at 90-95% spent
-- Yes cost is a consideration
-- No other factors considered

- Variance thresholds for the contract are 10% and $250K (cumulative)

- Variance thresholds are negotiated with contractor

-- Contractor internal variance thresholds is 5% and $50K

- Contractor generates and gives individual flash report Format 1 (raw data) 5 to 10 days after the close of each acct period

-- Individual does a quick analysis for internal use

- SPO conducts a monthly review on program status with the contractors paying special attention 9 major WBS and those that busted variance thresholds

- Formal CPRs are prepared but. . .

-- Traditionally takes 30-45 days to receive CPRs after the end of acct period which is the fifth work day of the month

Government D, USA, Systems Program Office

Date: 12 Apr 93

Position: Program Cost Management Supervisor

Summary:

- Method has recently been changed

  -- Previously used a +/- $ thresholds for 1st, 2nd, and 3rd level format
  -- Determined this was not working well, no way to access if 'adequate' thresholds were being applied
  -- Next tried $ thresholds PLUS gov't contractually reserved the right to change thresholds once it was determined 'too much/too little' reporting
  -- No contract modification necessary as this was written into the contract

- On the program

  -- Absolute value of TOP TEN variances by value (current cost and schedule, cumulative cost and schedule, and at completion variances)
  -- Which ones exceed 10%

    --- If > 10% then report
    --- If < 10% do not report

  -- This method was derived from the Joint DoD Industry TQM Team Report for Program Management on the Cost and Schedule Management Process, May 17, 1991
  -- Noted that OSD is familiar with this topic

- It is written into the contract to change thresholds as required

- There were NO specific factors (cost, risk, program phase) considered when setting these thresholds

Governme̲nt E, USN, Systems Program Office:

Date: 21 Apr 93

Position: Staff

Summary:

- Variance thresholds not viewed a structured set of values

  -- Viewed as a philosophical basis or a personal angle

- Depends on who uses the info generated by 5 C/SCSC data elements (USDA, SAE, PEO, PM, or analyst)

  -- Each has different view about variance thresholds

-Historical overview

  -- 19xx SAR annual requirements

    --- EAC from program office and contractors

  -- Nunn-McCurty requirements

    --- 15% threshold overrun in program or a major contract in program

      ---- 10 days for PM to report to OSD
      ---- 25 days to Congress

    --- 25%

      ---- Stop work
      ---- Report to Congress

  -- Services want an internal mechanism to respond to above requirements

    --- That is they set a tighter vt

  -- In late 1970, USAF implemented PAR/CAR/SPR approach

    --- Program Acquisition Approach (PAR) with vt of 5%
    --- Component Acquisition Report (CAR) with vt of 10%
    --- Secretarial Acquisition Report (SPR) with vt of 15%

---- Red = 10% and over
---- Yellow = 5 to 9.99%
---- Green = 0 to 4.99%

-- SAR phased out in 1985

--- Supplemental Contractor Cost Report (SCCR)

-- 5000.2M, Part 16, Section H changes SCCR to Supplemental Contractor Cost Info (SCCI) in 1989 (see p 16-H-1-1)

- Naval Air Command comfortable with 5% and 10%

-- Varies from location to location

- Bottom line

-- Purpose of variance thresholds

--- To sort out info
--- To prioritize activities in managing program
--- To draw manager attention to problem areas

- That is variance thresholds need no brain

Defense Contractor X, Program Office:

Date: 12 Apr 93

Position: Subcontracts Manager, C/SCSC monitor

Summary:

- Variance thresholds are established on a 'contract by contract' basis
    - -- Vary by type (e.g. development vs production)
- Variance thresholds may be changed over time (contract phase) via re-negotiation
- 70% of contract C/SCSC monitoring is done by subcontractors

Appendix C: HQ AFSC/FMC Policy Letter

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6503

17 MAR 1992

REPLY TO ATTN OF: FMC

SUBJECT: Sample Financial Contract Data Requirements Lists (CDRLs) and Lessons Learned for Preparing Financial CDRLs

TO:

ASD/AEP	ASD/VCP	ASD/XRP	ASD/YSP	VL/FM
NAP	VFP	YCP	YTP	OL-FM
RWP	VJP	YFP	YWP	4950TW/AMP
SDP	VLP	YPP	YZP	

1. Several months ago we asked you for sample financial CDRLs and lessons learned concerning preparation of financial CDRLs. We consolidated your responses, inputs from other product divisions, and the experiences from our staff cost analysts.

2. Attachment 1 is a summary of the lessons learned. This narrative serves as a reminder that certain aspects of the CDRLs must be negotiated and specified in each RFP/contract. In addition, we suggest approaches for establishing reporting levels, variance thresholds, etc., with explanations as to why the approach is recommened.

3. Attachment 2 is set of sample CDRLs for the following reports:

   a. Contract Funds Status Report (CFSR)
   b. Contract Work Breakdown Structure (CWBS)
   c. Cost Performance Report (CPR) - top "driver" variance approach
   d. CPR - dollar/percentage variance approach
   e. Cost/Schedule Status Report (C/SSR) - top "driver" variance approach
   f. C/SSR - dollar/percentage variance approach

Note that the sample CDRLs do not contain every condition discussed in the lessons learned. Together, however, the two documents should assist you in preparing comprehensive CDRLs early in the procurement cycle which mitigate the need for changes and contractual disputes later in the program.

4. We are constantly looking for ways to improve our cost reporting. Please encourage your personnel to share their knowledge and concerns with us, so we can pass fresh ideas on to others and help resolve recurring problems.

5. Please contact Capt Lisa Hendel, ASD/FMCA, 55904 with comments or questions.

Donna J. Vogel

DONNA J. VOGEL
Director of Cost
DCS Financial Management
and Comptroller

2 Atch
1. Lessons Learned
2. Sample CDRLs

LESSONS LEARNED FOR PREPARING FINANCIAL CDRLS

1. General Comments

a. ALWAYS know why you are buying each financial CDRL. Be able to justify the reporting level, frequency of submission, distribution list, tailoring, etc. Know up front who is supposed to use the data and make sure each user has input into the CDRL.

b. Before preparing a DD Form 1423, carefully read the applicable Data Item Description (DID). Many of the financial DIDs require you to specify values in individual CDRLS (these may require negotiation). These values include variance thresholds, forecast periods, etc. Not all sample CDRLs will include these areas, so use the DID as your primary source.

c. Cross-check your DD Form 1423s with the content of the Contractor Cost Data Reporting (CCDR) Plan. The CCDR Plan included in the solicitation and contract contains the summary/reporting level Contract Work Breakdown Structure (CWBS) and the types, frequency, and reporting levels of the major financial CDRLs.

d. Incorporate revisions to the summary CWBS and financial CDRLs due to proposed contract changes before the changes are sent to the contractor.

e. In the past, some CDRLs have included information pertaining to timing of Cost/Schedule Control Systems Criteria (C/SCSC) implementation, estimate at completion (EAC) frequency, delivery of system descriptions, flowdown of C/SCSC and Cost/Schedule Status Report (C/SSR) to subcontractors, restrictions on handling of material costs, etc. These areas should be handled as special contract provisions as they pertain to the cost/schedule management clauses (C/SCSC or C/SSR) contained in the solicitation and contract.

f. Accept contractor format whenever possible to reduce data costs.

g. Use electronic transfer and split delivery dates to cut transmission time. Use of the ANSI ASC X12 Electronic Data Interchange standards is now mandatory for transmission of cost management information.

h. Be extremely clear on the delivery requirements. For example, you may assume that delivery of the first Contract Funds Status Report NLT 15 calendar days after the end of the first Government fiscal quarter following contract award includes partial fiscal quarters, but the contractor may interpret "first" to mean the first full Government fiscal quarter.

i. Strategize how you want the contractor to handle special aspects of the contract, such as award fee, long lead items, mixed contract types, etc. Separate CPRs are required for R&D and production. Separate CFSR pages are required for each contract appropriation but are bought on the same CDRL.

j. Request a copy of the contractor's accounting calendar so you know when each monthly accounting period closes and can track CDRL due dates.

k. Include a copy for ASD/FMCA on the distribution list of all financial CDRLs. We will forward this copy to the Cost Library for permanent storage.

2. Contract Funds Status Report (CFSR)

a. Structure reporting levels for Block 11 by total contract whenever possible. Block 11 provides obligation and expenditure information to support contract funding actions, including overrun and underrun adjustments. If the contracting officer is funding at total contract and would make all billing price adjustments at total contract, then Block 11 reporting should be specified as total contract. If funding/billing price adjustments may be done by separately priced Contract Line Item Number (CLIN)/sub-CLIN, then Block 11 reporting elements should be specified as separately priced CLINs/subCLINs. If you have efforts on the same contract funded only by specific fund cites (AF versus SDIO, "M" account versus current year, etc.), you may have to require separate CFSR pages for each effort to have time-phased obligation and expenditure forecast data for each effort from Blocks 12-14.

b. You must reconcile the actual and at completion CFSR data with the CPR or C/SSR. Standard adjustments include fee/profit, differences in handling of material and subcontractor costs, etc. To assist you, request the contractor attach a reconciliation to the CFSR. Contact the DPRO or DCAA for assistance in performing the reconciliation.

c. The forecast periods of open commitments, accrued expenditures, billings, and termination liability in Blocks 12-14 must be specified in the CDRL. Detailed data is needed for incremental funding decisions in the current fiscal year, with some data needed to support the next fiscal year's forecast. Consider using the following forecast parameters: monthly for the current fiscal year, quarterly for at least four quarters, and then quarterly, semi-annually, or annually to completion. The contractor can continue the forecast on an attachment if it exceeds the number of forecast blocks printed on the DD Form 1586 or continue on a second DD Form 1586.

d. Blocks 12-14 are projections of <u>authorized</u> work only, matching the subtotal in Block 11g. It does <u>not</u> include work which has not been authorized (options, change orders, supplemental agreements, etc.) from Blocks 11h-11j. If you plan to authorize new work in the current fiscal year, make sure you get an updated funding profile from the contractor which includes both the old and new efforts prior to authorization of the new work.

e. The CFSR data (especially the forecast of accrued expenditures and termination liability) should support contractor's requests for incremental funding under the Limitation of Funds (LOF) clause. You can require the contractor to include a projected date for submission of his next LOF notification in the Remarks section (Block 15) so you can reconcile that date against the numbers in the CFSR. The contracting officer can provide the exact LOF parameters (i.e., notification due 60 days prior to 75% expended, 60 days prior to 100% expended, etc.) for each contract.

3. Contract Work Breakdown Structure (CWBS)

a. Include MIL-STD-881 (latest version) in your solicitation and contract as a compliance document.

b. Reporting levels for the CWBS shall reference the CCDR Plan attached in the solicitation and contract (separate attachment or attached to this CDRL).

c. You need to specify the level to which the contractor extends the summary CWBS provided in the CCDR Plan to form the complete CWBS. For contracts with C/SCSC, request extension to the cost account level. For C/SSR or CPR (without application of C/SCSC) contracts, request extension to the level where the work will be done/costs accumulated. Require identification of subcontracted effort by subcontractor name at the lowest level of the CWBS.

d. Part I of the CWBS is the Index, which outlines the elements of the extended CWBS and includes a cross-reference to the CLINs, Statement of Work (SOW), and specifications. If the CWBS was properly used to structure the SOW, CLINs, and specifications, the cross-reference should be simple. If the CWBS wasn't used to structure the other areas, you should attached a cross-reference at the summary CWBS level to the CCDR Plan to assist the contractor in performing the cross-reference.

e. Part II of the CWBS is a narrative explanation of the extended CWBS elements. Since reporting is done at the summary level, the dictionary is helpful in identifying the detailed content of each summary reporting level.

4. Cost Performance Report (CPR)

a. Format 1 reporting elements should reference the CCDR Plan attached in the solicitation and contract.

b. To improve monthly analysis and EAC generation, require Format 1 CWBS elements to contain only direct costs, as these costs are under the program manager's control. Overhead, General and Administrative, and Cost of Money should be reported and analyzed separately since they are impacted by facility changes as well as program actions. If cost estimating personnel require fully-burdened CWBS data for their purposes, they should include a CDRL for the Cost Data Summary Report (annual submission to support the annual program estimate or a single delivery at contract completion). The CPR is structured to support performance measurement, not cost estimating.

c. Specify Format 2 reporting elements, normally the second level of the contractor's organization structure (Engineering, Manufacturing, etc.).

d. If you have critical subcontractors, you can have each subcontractor reported separately on Format 2, rather than combined with all material costs.

e. For the largest contracts, consider having the Level 2 organizational elements include direct labor costs only. Material, subcontracts, other direct costs, and indirect costs would be reported separately. Segregation of direct labor cost by organization allows you to compare actual and forecasted labor dollars on Format 2 with actual and forecasted manpower on Format 4.

f. If there is C/SCSC and/or C/SSR flowdown to subcontractors, request the contractor include a summary of subcontractor performance measurement data with his CPR. Attaching the subcontractor CPR or C/SSR is acceptable.

g. Specify that the reporting elements for labor will be the same for Format 2 and Format 4.

h. You must specify the forecast periods for Format 3 and Format 4 and that the contractor must use the same forecast periods for both formats.

i. There are two approaches for Format 1 and Format 2 variance analysis thresholds:

(1) The preferred method is to concentrate on those CWBS elements which have the largest impact on cost and schedule performance. Under the "top driver" method, the contractor prioritizes the CWBS elements in terms of cost driver status and schedule driver status. The Government approves the lists. The list is updated to reflect changes during the contract.

(2) The contractor submits current month and cumulative cost and schedule variance analysis for the top 50% of the CWBS elements from the approved driver lists. You can specify a minimum dollar threshold below which the contractor does not submit written analysis.

(3) Include variance thresholds for the indirect cost elements.

(4) All variances at completion exceeding +/- 5% and a minimum dollar value are explained.

(5) The standard variance analysis approach is to combine dollar and percentage thresholds. When an element breaches both thresholds, written analysis is provided. The difficulty is that each CWBS and indirect cost element has varying dollar values. Choosing one dollar threshold which provides the optimum amount of analysis is difficult. You can specify different thresholds for various elements but this increases the contractor's cost.

(6) If you choose the standard method, you should change thresholds during the life of the contract for the cumulative variances. Recommend these thresholds change when the total contract reaches a certain percent complete rather than after a certain number of months (in case the program is slipping behind schedule). The cumulative dollar thresholds can be raised over time while tightening the percentage thresholds.

(7) Current month variances can use one threshold for the life of the contract.

(8) Variances at completion can also use a single threshold, since you want analysis on those variances which the contractor cannot resolve before contract completion.

j. You must define the "significant changes" in Format 3 which require explanation in Format 5. Thresholds should included changes in each forecast period and the total performance measurement baseline. Use a percentage threshold, such as +/- 10%, or combine it with a minimum dollar value.

k. You must define the "significant changes" in Format 4 which require explanation in Format 5. Thresholds apply to current month actual manpower, forecasted manpower by period, and total manpower at completion. Consider using a percentage threshold, such as +/- 10%, since the amount of manpower varies greatly between functional categories. You must also specify whether the variances are calculated for each reporting element or total contract.

l. Tailor Format 4 to provide the labor budget baseline (extracted from Format 3) in the same units as the rest of Format 4. Without this labor budget baseline, you cannot tell whether changes in manpower are related to increasing the baseline effort, increasing the manpower estimate, or both.

m. When creating thresholds, remember that -15% is unsatisfactory when reporting to higher headquarters. You should receive data from the contractor which is at least as stringent as this definition.

n. Include a provision for periodic review of variance thresholds to ensure the initial thresholds are proving the right amount of data. Changes should be negotiated and a new CDRL included via contract modification.

5. Cost/Schedule Status Report (C/SSR)

a. CWBS reporting elements should reference the CCDR Plan attached in the solicitation and contract.

b. To improve monthly analysis and EAC generation, require the CWBS elements to contain only direct costs, as these costs are under the program manager's control. Overhead, General and Administrative, and Cost of Money should be reported and analyzed separately since they are impacted by facility changes as well as program actions. If cost estimating personnel require fully-burdened CWBS data for their purposes, they should include a CDRL for the Cost Data Summary Report (annual submission to support the annual program estimate or a single delivery at contract completion). The C/SSR is structured to support performance measurement, not cost estimating.

c. If there is C/SSR flowdown to subcontractors, request the contractor include a summary of subcontractor performance measurement data with his C/SSR. Attaching the subcontractor C/SSR is acceptable.

d. There are two approaches regarding variance analysis thresholds:

(1) The preferred method is to concentrate on those CWBS elements which have the largest impact on cost and schedule performance. Under the "top driver" method, the contractor prioritizes the CWBS elements in terms of cost driver status and schedule driver status. The Government approves the lists. The list is updated to reflect changes during the contract.

(2) The contractor submits current month and cumulative cost and schedule variance analysis for the top 50% of the CWBS elements from the approved driver lists. You can specify a minimum dollar threshold below which the contractor does not submit written analysis.

(3) Include variance thresholds for the indirect cost elements.

(4) All variances at completion exceeding +/- 5% and a minimum dollar value are explained.

(5) The standard variance analysis approach is to combine dollar and percentage thresholds. When an element breaches both thresholds, written analysis is provided. The difficulty is that each CWBS and indirect cost element has varying dollar values. Choosing one dollar threshold which provides the optimum amount of analysis is difficult.

(6) If you choose the standard method, you should change thresholds during the life of the contract. Recommend thresholds change when the total contract reaches a certain percent complete rather than after a certain number of months (in case the program is slipping behind schedule). The dollar thresholds can be raised over time while tightening the percentage thresholds.

(8) Variances at completion can use a single threshold, as you need analysis on variances the contractor cannot resolve before completion.

e. When creating thresholds, remember that -15% is unsatisfactory when reporting to higher headquarters. You should receive data from the contractor which is at least as stringent as this definition.

f. Include a provision for periodic review of variance thresholds to ensure the initial thresholds are proving the right amount of data. Changes should be negotiated and a new CDRL included via contract modification.

SAMPLE CONTRACT FUNDS STATUS REPORT (CFSR) CDRL

1. SEQUENCE NUMBER: A00X

2. TITLE: CONTRACT FUNDS STATUS REPORT (CFSR)

3. SUBTITLE:

4. AUTHORITY: DI-F-6004B/T

Report at price (including fee/profit) by separately priced Contract Line Item Number (CLIN) or subCLIN and Total in Blocks 11a-11m. Projections in Blocks 12-14 shall be monthly for the duration of the current fiscal year, quarterly for at least four quarters, and then quarterly, semi-annually, or annually to completion. As part of Block 15 (Remarks), contractor shall include a projected date for the next written notification required by the "Limitation of Funds" clause. Contractor shall include a reconciliation of the actual to date and at completion data reported in the CFSR with the Cost Performance Report or Cost/Schedule Status Report for the same accounting period. Contractor format acceptable if it includes all required data and is approved by the Government.

5. CONTRACT REFERENCE: SOW TASK X.X.X

6. TECHNICAL OFFICE: ASD/XXPF

7. DD 250 REQ: LT

8. APP CODE:

9. INPUT TO IAC:

10. FREQUENCY: QTRLY

11. AS OF DATE: Last day of the contractor's monthly accounting period nearest the end of the Mar, Jun, Sep, and Dec Government fiscal quarters.

12. DATE OF 1ST SUBMISSION: Due NLT 20 calendar days after the end of the Government fiscal quarter (including partial quarter) subsequent to the contracting officer's authority to proceed (including undefinitized contracting actions).

13. DATE OF SUBSEQUENT SUBMISSION/EVENT ID: Due NLT 20 calendar days after the end of each Government fiscal quarter. CFSR data shall be reconciled to the 30 Sep Government fiscal year end if the contractor's accounting period does not end on 30 Sep.

14. DISTRIBUTION:

ASD/XXXX	PCO
ASD/XXPF	ACO
ASD/FMCA	

15. TOTAL:

16. REMARKS:

SAMPLE CONTRACT WORK BREAKDOWN STRUCTURE (CWBS) CDRL

1. SEQUENCE NUMBER: A00X

2. TITLE: CONTRACT WORK BREAKDOWN STRUCTURE (CWBS)

3. SUBTITLE:

4. AUTHORITY: DI-A-3023/T

The CWBS Index (Part I) and Dictionary (Part II) shall be prepared in accordance with the Contractor Cost Data Reporting Plan (CCDRP) attached to the Request for Proposal (RFP) and contract. Contractor shall also use MIL-STD-881A (or latest approved version) for guidance in preparation of the CWBS.

The CWBS Index and Dictionary shall be extended from the summary reporting level provided by the Government in the CCDRP to the lowest level at which work will be done (the cost account level for contracts with a Cost/Schedule Control System Criteria requirement), including identification of each individual management/cost account. Contractor shall identify subcontracted effort, including subcontractor name, at the lowest level of the extended CWBS.

Contractor format shall suffice if it contains all required data and is approved by the Government.

5. CONTRACT REFERENCE: SOW TASK X.X.X

6. TECHNICAL OFFICE: ASD/XXPF

7. DD 250 REQ: LT

8. APP CODE:

9. INPUT TO IAC:

10. FREQUENCY: ONE/R

11. AS OF DATE:

12. DATE OF 1ST SUBMISSION: Draft CWBS Index (Part I) shall be submitted with the proposal in response to the Government RFP.

13. DATE OF SUBSEQUENT SUBMISSION/EVENT ID: The complete CWBS Index and Dictionary (including any changes agreed to during negotiations) shall be submitted NLT 60 calendar days after the contracting officer's authority to proceed (including undefinitized contracting actions). A revised Index and revisions to Dictionary pages (due to Government-directed changes and internal changes) shall be submitted NLT 30 calendar days after the CWBS changes.

14. DISTRIBUTION: ASD/XXXX PCO
ASD/XXPF ACO
ASD/FMCA

15. TOTAL:

16. REMARKS:

SAMPLE COST PERFORMANCE REPORT CDRL
(TOP VARIANCE DRIVER APPROACH)

1. SEQUENCE NUMBER: A00X

2. TITLE: COST PERFORMANCE REPORT (CPR)

3. SUBTITLE:

4. AUTHORITY: DI-F-6000C/T

Formats 1-5 apply. Contractor format acceptable if it contains all required data and is approved by the Government.

Format 1 Contract Work Breakdown Structure (CWBS) reporting elements shall be in accordance with the Contractor Cost Data Reporting Plan attached in the contract and shall include direct cost only. Overhead/fringe benefits, General and Administrative (G&A), and Cost of Money (COM) shall be reported as three individual elements added to the direct cost subtotal. Major/critical subcontractor summary level performance measurement data shall be reported as an attachment to Format 1 (subcontractor CPR or C/SSR is acceptable).

All Budget at Completion (BAC) changes on Formats 1 and 2 shall be explained in Format 5. The explanation of Management Reserve forecasted consumption required in Format 5 shall include estimated dollar value, potential work scope, and estimated budget distribution date.

Reporting elements for Formats 2 and 4 shall be the second level of the contractor's organizational structure (i.e., Engineering, Manufacturing, etc.).

Formats 3 and 4 shall include identical forecast periods. These periods shall be monthly for at least six months, quarterly for at least two quarters, and then quarterly, semi-annually, or annually to completion. Any change in the Format 3 total Performance Measurement Baseline (PMB) and/or any change in a forecast period which exceeds 10% shall be explained in Format 5. Any change in current, forecast period, or total manpower for each Format 4 reporting element which exceeds 10% shall be explained in Format 5. Include on Format 4 (as a non-add item marked "BCWS") the total labor budget baseline spread (in the same units as the rest of Format 4) extracted from the total budget baseline dollars on Format 3.

On Format 5 of the first CPR, the contractor's program manager shall rank, in descending order of criticality (i.e., the most critical element at the top), all Format 1 CWBS reporting elements anticipated to be schedule variance "drivers." The contractor shall also rank, in descending order of criticality, all Format 1 CWBS elements anticipated to be cost variance drivers. The Government reserves the right to modify these rankings based on its perception of criticality. Contractor shall submit updated schedule variance and cost variance rankings every six months, as a minimum, based on performance to date and anticipated problems. If the contractor uses critical path/networking scheduling techniques, identification of the critical path and near critical path CWBS elements shall meet the schedule variance driver requirement.

Variance analysis shall be reported for each Format 1 reporting element as follows (subcontractor variance analysis shall be included as a part of the prime contractor's variance analysis):

SAMPLE COST PERFORMANCE REPORT CDRL (CONTINUED)
(TOP VARIANCE DRIVER APPROACH)

a. Current month and cumulative schedule variances (SV) - SV narratives shall be submitted for those CWBS elements which represent the top 50% of the SV drivers discussed above, with a minimum SV of $50,000. If there are fewer than 10 schedule variance drivers, all variances over $50,000 shall be explained.

b. Current month and cumulative cost variances (CV) - CV narratives shall be submitted for those CWBS elements which represent the top 50% of the CV drivers discussed above, with a minimum CV of $50,000. If there are fewer than 10 cost variance drivers, all variances over $50,000 shall be explained.

c. All current and cumulative cost and schedule variances for the indirect cost elements which exceed +/- 10% and $50,000 shall be explained.

d. All variances at completion exceeding +/- 5% and $50,000 shall be addressed.

e. Specific corrective actions, forecasted closure date, and impact to the Estimate at Completion (EAC) shall be included in each variance narrative. Contractor shall go to the lowest CWBS level (including the cost account level) needed to completely explain the variances.

f. Contractor shall provide a summary variance analysis of Format 2 reporting elements with cumulative schedule or cost variances exceeding +/- $100,000.

g. Contractor shall format and submit the CPR in accordance with the attached specification for electronic data transmission.

5. CONTRACT REFERENCE: SOW TASK X.X.X

6. TECHNICAL OFFICE: ASD/XXPF

7. DD 250 REQ: LT

8. APP CODE:

9. INPUT TO IAC:

10. FREQUENCY: MTHLY

11. AS OF DATE: Last day of the contractor's monthly accounting period.

12. DATE OF 1ST SUBMISSION: Due NLT 25 calendar days after the end of the first complete accounting period subsequent to the contracting officer's authority to proceed (including undefinitized contracting actions).

13. DATE OF SUBSEQUENT SUBMISSION/EVENT ID: Formats 1-4 due NLT 15 calendar days after the end of each monthly accounting period. Format 5 due NLT 25 calendar days after the end of each monthly accounting period. Contractor shall format the data for electronic data transmission in accordance with the attached standard.

14. DISTRIBUTION: ASD/XXXX ASD/FMCA ACO
ASD/XXPF PCO

15. TOTAL:

16. REMARKS:

SAMPLE COST PERFORMANCE REPORT CDRL
(DOLLAR/PERCENT THRESHOLDS)

1. SEQUENCE NUMBER: A00X

2. TITLE: COST PERFORMANCE REPORT (CPR)

3. SUBTITLE:

4. AUTHORITY: DI-F-6000C/T

Formats 1-5 apply. Contractor format acceptable if it contains all required data and is approved by the Government.

Format 1 Contract Work Breakdown Structure (CWBS) reporting elements shall be in accordance with the Contractor Cost Data Reporting Plan attached in the contract and shall include direct cost only. Overhead/fringe benefits, General and Administrative (G&A), and Cost of Money (COM) shall be reported as three individual elements added to the direct cost subtotal. Major/critical subcontractor summary level performance measurement data shall be reported as an attachment to Format 1 (subcontractor CPR or C/SSR is acceptable).

All Budget at Completion (BAC) changes on Formats 1 and 2 shall be explained in Format 5. The explanation of Management Reserve forecasted consumption required in Format 5 shall include estimated dollar value, potential work scope, and estimated budget distribution date.

Reporting elements for Formats 2 and 4 shall be the second level of the contractor's organizational structure (i.e., Engineering, Manufacturing, etc.).

Formats 3 and 4 shall include identical forecast periods. These periods shall be monthly for at least six months, quarterly for at least two quarters, and then quarterly, semi-annually, or annually to completion. Any change in the Format 3 total Performance Measurement Baseline (PMB) and/or any change in a forecast period which exceeds 10% shall be explained in Format 5. Any change in current, forecast period, or total manpower for each Format 4 element which exceeds 10% shall be explained in Format 5. Include on Format 4 (as a non-add item marked "BCWS") the total labor budget baseline spread (in the same units as the rest of Format 4) extracted from the total PMB dollars on Format 3.

The Government reserves the right to review and modify, through negotiations, the variance analysis requirements for Formats 1-4 during the performance of the contract, but no sooner than six months after contract award.

Variance analysis shall be reported for each Format 1 and 2 reporting element (including indirect cost elements) as follows (subcontractor variance analysis shall be included as a part of the prime contractor's variance analysis):

a. Current month cost and schedule variances - plus or minus 15% and $25,000.

b. Cumulative cost and schedule variances:

0-20% complete - plus or minus 15% and $25,000

20-50% complete - plus or minus 10% and $50,000

50-100% complete - plus or minus 5% and $100,000

(Percent complete equals cumulative BCWP divided by the PMB)

SAMPLE COST PERFORMANCE REPORT CDRL (CONTINUED)
(DOLLAR/PERCENT THRESHOLDS)

c. All variances at completion of plus or minus 5% and $50,000 shall be addressed.

d. Specific corrective actions, forecasted closure date, and impact to the Estimate at Completion (EAC) shall be included in each variance narrative. Contractor shall go to the lowest CWBS level (including the cost account level) needed to completely explain the variances.

e. Contractor shall format and submit the CPR in accordance with the attached specification for electronic data transfer.

5. CONTRACT REFERENCE: SOW TASK X.X.X

6. TECHNICAL OFFICE: ASD/XXPF

7. DD 250 REQ: LT

8. APP CODE:

9. INPUT TO IAC:

10. FREQUENCY: MTHLY

11. AS OF DATE: Last day of the contractor's monthly accounting period.

12. DATE OF 1ST SUBMISSION: Due NLT 25 calendar days after the end of the first complete accounting period subsequent to the contracting officer's authority to proceed (including undefinitized contracting actions).

13. DATE OF SUBSEQUENT SUBMISSION/EVENT ID: Formats 1-4 due NLT 15 calendar days after the end of each monthly accounting period. Format 5 due NLT 25 calendar days after the end of each monthly accounting period. Contractor shall format the data for electronic data transmission in accordance with the attached standard.

14. DISTRIBUTION: ASD/XXXX PCO
ASD/XXPF ACO ASD/PMCA

15. TOTAL:

16. REMARKS:

SAMPLE COST/SCHEDULE STATUS REPORT (C/SSR) CDRL
(TOP VARIANCE DRIVER APPROACH)

1. SEQUENCE NUMBER: A00X

2. TITLE: COST/SCHEDULE STATUS REPORT (C/SSR)

3. SUBTITLE:

4. AUTHORITY: DI-F-6010A/T

Contract Work Breakdown Structure (CWBS) reporting elements shall be in accordance with the Contractor Cost Data Reporting Plan attached in the contract and shall include direct cost only. Overhead/fringe benefits, General and Administrative (G&A), and Cost of Money (COM) shall be reported as three individual elements added to the direct cost subtotal. Major/critical subcontractor summary level performance measurement data shall be reported as an attachment (subcontractor C/SSR is acceptable). Contractor format acceptable if it contains all required data and is approved by the Government.

All Budget at Completion (BAC) changes shall be explained in the narrative analysis. The explanation of Management Reserve forecasted consumption required in the narrative analysis shall include estimated dollar value, potential work scope, and estimated budget distribution date.

In the narrative analysis of the first C/SSR, the contractor's program manager shall rank, in descending order of criticality (i.e., the most critical element at the top), all CWBS reporting elements anticipated to be schedule variance "drivers." The contractor shall also rank, in descending order of criticality, all CWBS elements anticipated to be cost variance drivers. The Government reserves the right to modify these rankings based on its perception of criticality. Contractor shall submit updated schedule variance and cost variance rankings every six months, as a minimum, based on performance to date and anticipated problems. If the contractor uses critical path/networking schedule techniques, identification of the critical path and near critical path CWBS elements shall meet the schedule driver requirement.

Variance analysis shall be reported for each reporting element as follows (subcontractor variance analysis shall be included as a part of the prime contractor's variance analysis):

a. Cumulative schedule variances (SV) - SV narratives shall be submitted for those CWBS elements which represent the top 50% of the SV drivers discussed above, with a minimum SV of $25,000. If there are fewer than 10 schedule variance drivers, all variances over $25,000 shall be explained.

b. Cumulative cost variances (CV) - CV narratives shall be submitted for those CWBS elements which represent the top 50% of the CV drivers discussed above, with a minimum CV of $25,000. If there are fewer than 10 cost variance drivers, all variances over $25,000 shall be explained.

c. All cumulative cost and schedule variances for the indirect cost elements which exceed +/- 10% and $25,000 shall be explained.

d. All variances at completion of plus or minus 5% and $25,000 shall be addressed.

SAMPLE COST/SCHEDULE STATUS REPORT (C/SSR) CDRL (CONTINUED)
(TOP VARIANCE DRIVER APPROACH)

e. Specific corrective actions, forecasted closure date, and impact to the Estimate at Completion (EAC) shall be included in each variance narrative. Contractor shall go to the lowest CWBS level needed to completely explain the variances.

5. CONTRACT REFERENCE: SOW TASK X.X.X

6. TECHNICAL OFFICE: ASD/XXPF

7. DD 250 REQ: LT

8. APP CODE:

9. INPUT TO IAC:

10. FREQUENCY: MTHLY

11. AS OF DATE: Last day of the contractor's monthly accounting period.

12. DATE OF 1ST SUBMISSION: Due NLT 25 calendar days after the end of the first complete accounting period subsequent to the contracting officer's authority to proceed (including undefinitized contracting actions).

13. DATE OF SUBSEQUENT SUBMISSION/EVENT ID: CWBS format due NLT 15 calendar days after the end of each monthly accounting period. Narrative analysis due NLT 25 calendar days after the end of each monthly accounting period. Contractor shall format the data for electronic data transmission in accordance with the attached standard.

14. DISTRIBUTION: ASD/XXXX PCO
ASD/XXPF ACO
ASD/FMCA

15. TOTAL:

16. REMARKS:

SAMPLE COST/SCHEDULE STATUS REPORT (C/SSR) CDRL
(DOLLAR/PERCENT THRESHOLDS)

1. SEQUENCE NUMBER: A00X

2. TITLE: COST/SCHEDULE STATUS REPORT (C/SSR)

3. SUBTITLE:

4. AUTHORITY: DI-F-6010A/T

Contract Work Breakdown Structure (CWBS) reporting elements shall be in accordance with the Contractor Cost Data Reporting Plan attached in the contract and shall include direct cost only. Overhead/fringe benefits, General and Administrative (G&A), and Cost of Money (COM) shall be reported as three individual elements added to the direct cost subtotal. Major/critical subcontractor summary level performance measurement data shall be reported as an attachment (subcontractor C/SSR is acceptable). Contractor format acceptable if it contains all required data and is approved by the Government.

All Budget at Completion (BAC) changes shall be explained in the narrative analysis. The explanation of Management Reserve forecasted consumption required in the narrative analysis shall include estimated dollar value, potential work scope, and estimated budget distribution date.

The Government reserves the right to review and modify, through negotiations, the variance analysis requirements during the performance of the contract, but no sooner than six months after contract award.

Variance analysis shall be reported for each reporting element (including indirect cost elements) as follows (subcontractor variance analysis shall be included as a part of the prime contractor's variance analysis):

a. Cumulative cost and schedule variances:

0-20% complete	- plus or minus 15% and $10,000	(Percent complete equals cumulative BCWP divided by the Performance Measurement Baseline)
20-50% complete	- plus or minus 10% and $25,000	
50-100% complete	- plus or minus 5% and $50,000	

b. All variances at completion of plus or minus 5% and $25,000 shall be addressed.

c. Specific corrective actions, forecasted closure date, and impact to the Estimate at Completion (EAC) shall be included in each variance narrative. Contractor shall go to the lowest CWBS level needed to completely explain the variances.

5. CONTRACT REFERENCE: SOW TASK X.X.X

6. TECHNICAL OFFICE: ASD/XXPF

SAMPLE COST/SCHEDULE STATUS REPORT (C/SSR) CDRL (CONTINUED)
(DOLLAR/PERCENT THRESHOLDS)

7. DD 250 REQ: LT

8. APP CODE:

9. INPUT TO IAC:

10. FREQUENCY: MTHLY

11. AS OF DATE: Last day of the contractor's monthly accounting period.

12. DATE OF 1ST SUBMISSION: Due NLT 25 calendar days after the end of the first complete accounting period subsequent to the contracting officer's authority to proceed (including undefinitized contracting actions).

13. DATE OF SUBSEQUENT SUBMISSION/EVENT ID: CWBS format due NLT 15 calendar days after the end of each monthly accounting period. Narrative analysis due NLT 25 calendar days after the end of each monthly accounting period. Contractor shall format the data for electronic data transmission in accordance with the attached standard.

14. DISTRIBUTION: ASD/XXXX PCO
ASD/XXPF ACO
ASD/FMCA

15. TOTAL:

16. REMARKS:

Appendix D: Contractors' System Description Excerpts

Defense Contractor A

Performance Measurement System Review

- Gave information on when variance analysis reports must be generated and who is responsible for setting cost account variance analysis thresholds/parameters (p 4 of 7).

- No specifics on how the variance thresholds were established.

Defense Contractor B

- 'Tolerances are expressed as being plus or minus a percentage and a minimum value; e.g. +/- 10 percent and $10,000 for nonlabor, and +/- 10 percent and 300 hours for labor.'

- 'They are applied to cumulative-to-date variance at two levels: the cost account level and the report level. They can be different at each level and can vary from program to program. Cost account tolerances are established by the program.'

Defense Contractor C

- 'If the tolerances are exceeded either plus or minus, the variances are flagged for special analysis as a problem area.'

- 'Responsibilities'

  -- Cost Control - Establish all tolerance bands for variance analysis.'

Defense Contractor D

- Responsibilities for Cost Management

  -- Establish all tolerance bands for variance analysis.

- Tolerances

  -- Exactly the same as March 19xx version

Defense Contractor E

- 'Thresholds are established which set parameters for variance analysis reporting.'

- 'Normally the contract sets forth the thresholds for external reporting'

- 'If no reporting thresholds are established in the contract, the Program Manager will still establish variance analysis thresholds.'

Defense Contractor F

- 'Variance threshold levels above which analysis is required as specified in' another document.

- This document 'identifies instructions applicable to C/SCS programs. Variance thresholds, high-cost material definition, CPR reporting levels, and other requirements are discussed.'

Defense Contractor G

- 'Normally contractually established for each program'

- 'They may be reviewed and changed during the program if necessary.'

Defense Contractor H

- 'Tolerances always will be established for cum-to-date and at-completion variance and may be established for current period variances. Also the tolerances could contain a minimum value; for example, 20% or $50,000, which is less, favorable or unfavorable, but at least $15,000.'

- 'Other combinations of tolerances are possible and depend on what the customer believes will best serve his needs.'

Defense Contractor I

- In the appendix of document, it described variance thresholds as a percentage and/or an established hour or dollar minimum. No specific method for establishing variance thresholds was mentioned.

Appendix E: U.S. Army Study

ESTABLISHMENT OF

CONSISTENT VARIANCE THRESHOLDS

FOR PROBLEM ANALYSIS

ON THE

COST PERFORMANCE REPORT

FOR THE

LoAD PPD PROGRAM PHASE IB

30 JUNE 1981

PREPARED BY

TELEDYNE BROWN ENGINEERING
RESEARCH PARK
HUNTSVILLE, ALABAMA 35807

PREPARED FOR

BALLISTIC MISSILE DEFENSE SYSTEMS COMMAND
SYSTEMS TECHNOLOGY PROGRAM
LOW ALTITUDE DEFENSE PREPROTOTYPE PROGRAM
HUNTSVILLE, ALABAMA 35806

30 JUNE 1981

The attached paper presents a method of calculating cost and schedule thresholds for variances on the cost performance report. The equation shown in the attached paper is being considered for incorporation in TS 705-622A in place of the table shown on page 9 (Table 1). Paragraph 3.3.3.1 of TS 705-622A would be changed to delete the next-to-last sentence in the paragraph, which refers to Table 1. A set of words similar to the following would become part of paragraph 3.3.3.1.

<u>Words for TS 705-622</u>

Page 7, paragraph 2, seventh sentence - delete. Replace with:

"For completion type contracts, the thresholds for explaining variances shall be computed monthly by the equation shown below unless otherwise specified in the contract.

$$\text{Variance} = (\pm .005 \cdot \text{BAC}) \left(\frac{\text{BCWP}}{\text{BAC}}\right)^{1/2}$$

where

BAC = Contract budget at completion

BCWP = The cumulative budgeted cost of work performed for the cost element involved through the end of the reporting period.

These thresholds shall be applied routinely at level three and above of the WBS. The application of the equation to lower-level WBS elements shall be based on specific Government management needs for limited time periods. The Government reserves the right to require CPR reporting at lower level of the WBS when significant budget/management needs are identified, or when specified in the contract in accordance with the contract DD Form 1423. The expanded reporting prerogative will be utilized to the minimum extent consistent with sound management control."

CONSISTENT VARIANCE THRESHOLDS

As presently formulated the LoAD variance thresholds are discontinuous from year to year. This leads to a situation where a given variance on a cost reporting element may be within threshold at the end of one year and beyond threshold at the beginning of the next. In addition, there were both percentage and absolute thresholds at level three of the WBS. For sufficiently large elements, the absolute values are exceeded before the percentage thresholds; for small elements, the obverse is true. Lastly, the thresholds vary with time in such a manner that the magnitude of the element existing at the crossover from percentage to absolute varies tremendously with time.

This memo presents a means of setting thresholds which does not suffer from the above inconsistancies and irrationalities. In the following derivation, it is assumed that variable thresholds are the result of an attempt to take account of the statistics of estimating error. Let us consider this in terms of the standard deviation of the estimate, σ. In accordance with the requirements of C/SCSC, an estimate or budgeted cost of work to be performed at any level of the WBS is the summation of a number of such estimates at the lowest level. For the moment, we will assume that the lowest level estimates are roughly equal in magnitude and have the same standard deviation. Given this, the standard deviation as a percentage of the estimate will become smaller as one moves up the WBS. It further follows from the assumption of equal magnitude and σ's of the elemental costs that the standard deviation in percentage terms of any work element at any level in the WBS is related to that for any other element as the square root of the inverse ratio of the two costs per the following.

The square of the standard deviation at one level, σ_t^2, is equl to the sum of σs at the lower level

$$\sigma_t^2 = \sigma_1^2 + \sigma_2^2 + \cdots \sigma_n^2$$

If, as noted above, all low level σs are equal,

$$\sigma_t^2 = n\,\sigma_B^2$$

or

$$\sigma_1^2 = n_1\,\sigma_B^2$$

$$\sigma_2^2 = n_2\,\sigma_B^2$$

Also the total cost for any element, C_x, is equal to the sum of the costs of the work packages comprising it. Since these are equal;

$$C_x = N_x C_B \quad ,$$

From the above

$$\left(\frac{\sigma_1}{C_1}\right)^2 = n_1\left(\frac{\sigma_B}{n_1 C_B}\right)^2 = \frac{\sigma_B{}^2}{n_1 C_B{}^2}$$

$$\left(\frac{\sigma_2}{C_2}\right)^2 = n_2\left(\frac{\sigma_B}{n_2 C_B}\right)^2 = \frac{\sigma_B{}^2}{n_2 C_B{}^2}$$

Simplifying,

$$\frac{\left(\frac{\sigma_2}{C_1}\right)^2}{\left(\frac{\sigma_2}{C_2}\right)^2} = \frac{(n_2 C_B)}{(n_1 C_B)}\frac{(C_B)}{(C_B)} = \frac{C_2}{C_1}$$

$$\frac{\left(\frac{\sigma_1}{C_1}\right)}{\left(\frac{\sigma_2}{C_2}\right)} = \left(\frac{C_2}{C_1}\right)^{1/2}$$

where

σ_n = standard deviation of estimate for element n

C_n = cumulative cost estimate for element n

C_B = cost of lowest level element

σ_B = standard deviation of error in estimate at lowest level

In the above the cost estimate (C_x) may be for the total for the work element, or the total for any given period of time. Thus, the larger the cost of an element, the lower the percentage error in the estimate of that cost; and, the longer work has progressed (and the more spent on it) the smaller the percentage error of the estimate.

Now

$$\frac{\left(\frac{\sigma_1}{C_1}\right)}{\left(\frac{\sigma_2}{C_2}\right)} = \left(\frac{C_2}{C_1}\right)^{1/2}$$

and so

$$\left(\frac{\sigma_1}{C_1}\right) = \left(\frac{C_2}{C_1}\right)^{1/2} \left(\frac{\sigma_2}{C_2}\right)$$

If we assume a σ_2/C_2 is the percentage variance allowable at completion and set it at X, the allowable variation at any level for any work element would be

$$\frac{\sigma_1}{C_1} = \left(\frac{C_2}{C_1}\right)^{1/2} X$$

Since $\frac{\sigma_1}{C_1}$ is a percentage, the absolute would be $\left(\frac{\sigma_1}{C_1}\right) C_1$ or $\left(\frac{C_2}{C_1}\right)^{1/2} C_1 X$. Now if C_1 is the cumulative cost of work performed (BCWP), for any element at any time and C_2 is the contract budgeted cost at completion, the variance for any element at any time becomes $(BCWP)^{1/2} (BAC)^{1/2} \cdot X$. If the program office sets a value for X, all variances follow. The above equation may be restated as

$$\cdot\, X \left(\frac{BAC}{BCWP}\right)^{1/2} (BCWP)$$

Since $X \left(\frac{BAC}{BCWP}\right)^{1/2}$ is a percentage, this in effect says that the percentage variance allowable for any cost element is larger than that allowable for the contract budget at completion by the factor $\left(\frac{BAC}{BCWP}\right)^{1/2}$

One can also express the relationship as

$$(X \cdot BAC) \left(\frac{BCWP}{BAC}\right)^{1/2}$$

This may be interpreted to mean that the absolute variance allowable for any cost element is smaller than that allowable for budget at completion ($X \cdot BAC$) by the factor $\left(\frac{BCWP}{BAC}\right)^{1/2}$.

It was initially assumed for the purposes of the analysis that the costs of lowest level work package were of equal magnitude and had equal uncertainties associated with their cost estimates. It may be objected that these assumptions are so restrictive as to never be met and therefore that the methodology cannot be used. In fact the assumptions need not be so restrictive. It can be proven that the conclusions are valid if the relationship

$$\frac{\dfrac{\sigma_1}{C_1}}{\dfrac{\sigma_2}{C_2}} = a\left(\frac{C_2}{C_1}\right)^{1/2}$$

holds; that is, if the ratio of the work package variance is proportional to the inverse square root of the ratio of the costs of the work packages. They are also valid if the standard deviations (σs) are equal for work packages of equal magnitude and each work element at the high levels of the WBS comprises equally proportioned mixes of different sized work packages.

These may yet seem rather restrictive. However the averaging process as one moves up the WBS is such that only approximate adherance to these conditions will result in the conclusions being quite accurate.

A comparison of the application of this approach to the prior one may be seen in Figure 1. This shows the level three breakout of a level two work element, the L.I.S. The CUM $ figures in each block represent the cumulative year by year cost estimates. They may be considered the cumulative BCWP, at the end of each year. The old figures are the variance reporting thresholds per the current issue of TS 705-622. The new figures are the thresholds as computed from the equation derived above. It may be seen that for small cumulative BCWP figures, the new thresholds are usually lower; for large values of BCWP, the old are lower.

BMD

THRESHOLD APPLICATION SAMPLE

UNCLASSIFIED

SYSTEMS TECHNOLOGY PROGRAM

$176.7M ELEMENT OF $1B PROGRAM — % AT COMPLETION = 0.5%

ELEMENT		PROGRAM YR. 1	2	3	4	5	WBS LEVEL
AIR VEH	CUM $	3.5	40.7	73.4	96	111.2	3
	OLD	.200	.300	.400	.700	1.000	
	NEW	.295	1.009	1.354	1.549	1.667	
LAUNCHED GSE	CUM $	0.9	9.4	212	31.3	36.1	3
	OLD	.180	.300	.400	.700	.360	
	NEW	150	485	720	.885	.950	
IA & T	CUM $	1.1	2.8	5.1	7.7	9.7	3
	OLD	.200	.300	.400	.385	.097	
	NEW	.165	.265	.357	.439	.472	
SUBS ENG.	CUM $	1.5	5.1	10.8	16.4	19.7	3
	OLD	.200	.300	.400	.700	.197	
	NEW	.194	.357	.520	.640	.702	
TOTAL	CUM $	6.9	57.9	110.4	150.8	176.7	2
	OLD	N/A	N/A	N/A	N/A	N/A	
	NEW	.415	1.203	1.661	1.942	2.102	

FIGURE 1. THE .D APPLICATION SAMPLE

There are various advantages to the previous way of setting variance thresholds, chiefly:

1) There are no discontinuities in threshold year end to year beginning.

2) The threshold for any element of work for any period of time is related to all others via the statistics of the estimating errors.

3) No tabular threshold dada need be entered into a computer. One simple equation is all that is needed for all threshold computations.

There is one change in costing practice which is required for the method to work. The costs used must be the mean costs, not the most likely ones. The tow are different since the estimating error has a skewed distribution. (An estimated cost can be overrun more than it can be under run). This may be an advantage in terms of forcing more realistic program cost estimation, The expected value or mean cost for the program is the sum of the means of elemental cost estimates and with a distribution skewed as mentioned above the sum of most likely costs is less than the sum of the means. Thus, insofar as a program cost estimate is the sum of the most likely costs of its elements, it will be an underestimate.

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13. ABSTRACT *(Maximum 200 words)* This thesis examined to what extent theoretical threshold models are used to set cost and schedule variance thresholds on Department of Defense major program contracts and identified how these thresholds are actually established. First, numerous theoretical methods for establishing variance thresholds were investigated. Interviews were then conducted with government and civilian defense contractor personnel who had first-hand knowledge of the establishment of cost and schedule variance thresholds. Repeatedly, interviewees related that threshold levels for new contracts were established by either management experience and judgment or by copying threshold levels from previous contracts. One possible explanation for this is the apparent lack of awareness of the available models. This lack of knowledge could have been the result of inadequate supplemental training which could expose personnel to these additional methods. In addition, both government and defense contractor documents provided no specific techniques to derive thresholds. The lack of specific guidance further contributes to the necessary reliance on personal experience and judgment. Upper management should provide functional personnel with additional supplemental training to expose them to the various methods.

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