AFIT/GSS/LAS/97D-3

A PRELIMINARY STUDY OF USING THE SEI'S CAPABILITY MATURITY MODEL TO SET STATISTICAL CONTROL BOUNDS ON DOD CONTRACTOR COST AND SCHEDULE PERFORMANCE

THESIS

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THESIS

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Jeffrey A. Schaefer

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List of Acronyms

ACWP	Actual Cost of Work Performed
AFMC	Air Force Materiel Command
ALC	Air Logistics Center
ASC	Aeronautical Systems Center
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
CMM	Capability Maturity Model
CPI	Cost Performance Index
CPR	Cost Performance Report
C/SCSC	Cost/Schedule Control Systems Criteria
CV	Cost Variance
CWBS	Contract Work Breakdown Structure
DOD	Department of Defense
ESC	Electronic Systems Center
ROI	Return on Investment
SA-CMM	Software Acquisition - CMM
SCE	Software Capability Evaluation
SDCE	Software Development Capability Evaluation
SED	Software Engineering Division
SEI	Software Engineering Institute
SMC	Space and Missile Systems Center
SPA	Software Process Assessment
SPI	Schedule Performance Assessment
SSEB	Source Selection Evaluation Board
SV	Schedule Variance
WBS	Work Breakdown Structure

Abstract

Current methods for monitoring the performance of Department of Defense (DOD) software development contractors have not been successful in reversing the current trend of over budget and behind schedule software development. The DOD has adopted the Software Engineering Institute's (SEI's) Capability Maturity Model (CMM) as a method of determining the process maturity of a software developer with the idea that a more mature process will lead to improved cost and schedule performance. The goal of this research was to determine if a model based on the CMM rating level of a contractor could be developed and used in conjunction with statistical process control to determine if contractor performance was progressing in a satisfactory manner.

To investigate this possibility descriptive statistics were applied to historical contractor performance data and a model was established. A different set of historical data was then used to evaluate the performance of the new model. This performance was then compared to the performance of current methods of statistical control.

The results obtained in this research suggest that using the CMM rating level of a contractor to set statistical control bounds is as good, and perhaps better than, the current method being employed.

A PRELIMINARY STUDY OF USING THE SEI'S CAPABILITY MATURITY MODEL TO SET STATISTICAL CONTROL BOUNDS ON DOD CONTRACTOR COST AND SCHEDULE PERFORMANCE

1. Introduction

1.1 General Issue

Weapon systems acquired by the Department of Defense (DOD) in the late 1950's and 1960's were comprised mostly of hardware. Software played a small role, if any, in the acquisition of weapon systems. Things have changed; Brown notes that the DOD has a "deep dependence on software for virtually all its systems" (Brown, 1996:7). "Software has become a major cost, schedule, and performance driver for virtually all DOD weapons, command and control, and information systems" (Porter, 1994). This deep reliance on software poses a dilemma for the DOD. Late and over budget software procurements are well-known as large-scale software problems (Brown, 1996:7). Unfortunately, many previous studies have identified numerous possible solutions yet most remain unimplemented (Defense Report, 1987).

In an effort to address the problem of over-budget and late software, the DOD established the Software Engineering Institute (SEI) in 1984. SEI decided to attack the problem by focusing on the quality of the software development process. This decision was based on the process management principle which states that "the quality of a product is largely governed by the quality of the process used to build it" (Paulk, 1997:

5). SEI designed a model to measure an organization's software development process maturity. This model, the Capability Maturity Model (CMM), measures an organization's maturity by evaluating process areas key to software development. These key areas include, but are not limited to, project planning, quality assurance, product engineering, configuration management and process management (Paulk et. al., 1993). The CMM is a framework, or road map, that an organization can follow to assess its own software capability maturity. It can also be used by an outside agency to evaluate a potential software developer's maturity. The organization maturity level is expressed by an ordinal scale from 1 (lowest) to 5 (highest) described in Table 1.1. The higher an organization's maturity level, the more likely it is to produce higher quality software.

Table 1.1 CMM Level Description (Paulk et. al., 1993)

CMM Level	Description
1 - Initial	The software process is characterized as ad hoc, and occasionally even chaotic. Few processes are defined, and success depends on individual effort.
2 - Repeatable	Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.
3 - Defined	The software process for both management and engineering activities is documented, standardized, and integrated into a standard software process for the organization. All projects use an approved, tailored version of the organization's standard software process for developing and maintaining software.
4 - Managed	Detailed measures of the software process and product quality are collected. Both the software process and products are quantitatively understood and controlled.
5 - Optimizing	Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

Lloyd K. Mosemann II, former deputy assistant secretary of the Air Force for communications, computers, and logistics (SAF/AQK), believes SEI's CMM to be a step toward solving the problems plaguing the development of DOD software (Mosemann, 1992:4). By following the CMM road map, DOD procurement agents can assess a potential software developer's process maturity, and thus the likelihood of obtaining a quality software product on time and within budget. In 1996, the Airlie Council, comprised of software industry experts, identified nine commercial best practices that lead to quality software development. One of these practices is formal risk management (Basili et. al., 1997). Part of risk management is attempting to reduce the risk involved with a project. "Risk involves choice, and the uncertainty that choice itself entails (Charette, 1989: 49); so it follows that increasing predictability, and thereby reducing uncertainty, would be a step towards reducing risk and increasing the quality of a software product. Another practice recognized by the Airlie council is the use of quantitative targets, or statistical control bounds, to monitor performance. This research asserts that prediction intervals, based on the CMM rating level of a contractor, can be developed and used as control bounds for cost and schedule performance of a contractor. The key assumption is that minimum and maximum cost and schedule performance ranges can be predicted from the CMM rating level with some level of confidence, and that these intervals are reasonable control bounds for performance of a developer at a particular CMM level.

1.2 Specific Problem

Recent research has established a positive correlation between CMM rating and the success of software product development in terms of cost and schedule performance (Flowe & Thordahl, 1994). It was stated in that study that a predictive model for contract performance based on CMM rating level may well be of interest to the software development community as a whole. However, little empirical research has been done to establish prediction and confidence intervals for cost and schedule performance based on CMM rating level, not because of a lack of interest, but because of a lack of available data. Case studies, involving return-on-investment, have been performed by Raytheon, Hughes, and Oklahoma City ALC, all level 2 or 3 organizations; however, these studies do not address how this return-on-investment can be used by DOD agents to predict performance. Bollinger (1991) claims that "... it appears, unlikely that such [CMM] ratings have any meaningful correlation to the actual abilities of organizations to produce ... software on time and within budget" (Bollinger & McGowan, 1991:26). Clearly, an investigation into the predictive capability of the CMM model is warranted.

1.3 Research Objective

This follow-on study to Flowe & Thordahl's 1994 research is proposed to extend our ability to predict intervals for software developer cost and schedule performance based on the developer's software process maturity as determined by SEI's CMM rating level (Flowe & Thordahl, 1994:6-6). This research also proposes that an extended ability to predict performance based on CMM level can be used to statistically control the development process. Without this extension of research, the very basic notion that

unique CMM levels lead to unique levels of performance, a fundamental underpinning of theory, will remain unverified. For the purpose of this study, performance will be expressed in terms of two measures: 1) Cost Performance Index (CPI), a ratio of Budgeted Cost of Work Performed (BCWP) to Actual Cost of Work Performed (ACWP) and 2) Schedule Performance Index (SPI), a ratio of BCWP to Budgeted Cost of Work Scheduled (BCWS).

1.4 Scope/Limitations

The research methodology used was chosen to yield the best opportunity of achieving the objectives of this research, within the time and resource constraints placed on it. Also, the methodology chosen was consistent with that used by Flowe & Thordahl (1994) to maintain a consistent research approach. Based on these constraints, an already existing database from the previously mentioned study was used for this effort. The database consisted of organizations that met the following criteria:

a. Developed software for the DOD
b. Rated in accordance with the SEI's CMM framework
c. Tracked cost and schedule in a structured format
d. Reported cost and schedule data to the DOD

The above constraints led to focusing on DOD contractor organizations that provided software to Air Force Program Offices at the Aeronautical Systems Center (ASC) and the Electronics Systems Center (ESC), where the necessary data was reported as part of the Cost/Schedule Control Systems Criteria (C/SCSC) contract requirements.

1.5 Overview

This research is planned to establish a predictive model for cost and schedule performance derived from the SEI's CMM rating level of the developers, and then to validate this predictive model as a method to set statistical control bounds on developer performance. This is achieved by applying descriptive statistics methods to information obtained from the database comprised of contractor reported statistics to establish prediction intervals; and then comparing the performance of a contractor to these bounds, to see if the intervals accurately predict typical performance. The dependent variables used in this study are cost and schedule performance indices. Taking into account the limitations and constraints under which this research is accomplished, this study should provide a useful tool that the acquisition manager can use to monitor the cost and schedule performance of a contractor. The tool will provide early detection of unsatisfactory performance, thus reducing the cost and schedule performance risk associated with a software product procurement.

2. Literature Review

2.1 Introduction

Recognizing the negative trends that had emerged in the quality of software products being developed in the DOD, Lloyd K. Mosemann made the CMM the focus of a software process improvement initiative. He issued three challenges to all Air Force software development organizations: 1). Complete SEI CMM assessments by October 1, 1994, 2). Perform follow-up assessments every two years, and 3). Achieve CMM level 3 by 1998 (Coffman &Thompson, 1997). This was SAF/AQK's attempt to reverse the trends.

The first two sections of this literature review look at the software development process and current strategies to implement the process. The third section takes an in-depth look at the SEI CMM, including its applications and limitations. The fourth section reviews some current alternatives to the CMM. The fifth section introduces common performance measures. The sixth and seventh sections look at evidence suggesting the usefulness of the CMM rating level as a predictor of performance. Finally, the eighth and last section discusses the concept of statistical process control.

2.2 The Software Development Process

According to Watts Humphrey, a software development process is "the set of tools, methods, and practices we use to produce a software product" (Humphrey, 1989). In short, anything that goes into converting inputs into a software product is part of the

software development process. Having a process is not sufficient to develop software; however, one needs to know how to put the resources together. That is where the software process model, or strategy, comes into play.

2.3 Program Strategies/Process Models

As a follow-up to the software development process, several development paradigms have been popular at different times. Whereas the software development process provides the necessary building blocks to build the software, the program strategy provides a framework into which these blocks fit. Its main purpose is to determine the order of the steps involved in developing software (Boehm, 1988). It helps guide an organization, in an orderly manner, through the development process. Program strategies often address the questions of "What to do next?" and "How long shall we continue to do it?". Several models have evolved since the earliest days, and have been popular at different times. In the next few segments, the more prominent ones will be discussed; they include Code-And-Fix, Waterfall, Prototyping, Evolutionary/Incremental, and Spiral.

2.3.1 Code and Fix.

This first methodology is best described as a haphazard approach to development. Developers using this strategy jump into coding early, without fully thinking through the problem. Later, when the requirements are better understood, they go back and fix the code to reflect this understanding. The problem with this strategy is that much time is

wasted on rework. It may seem like progress is being made, but in reality the programmers are only spinning their wheels (Humphrey, 1989: 7).

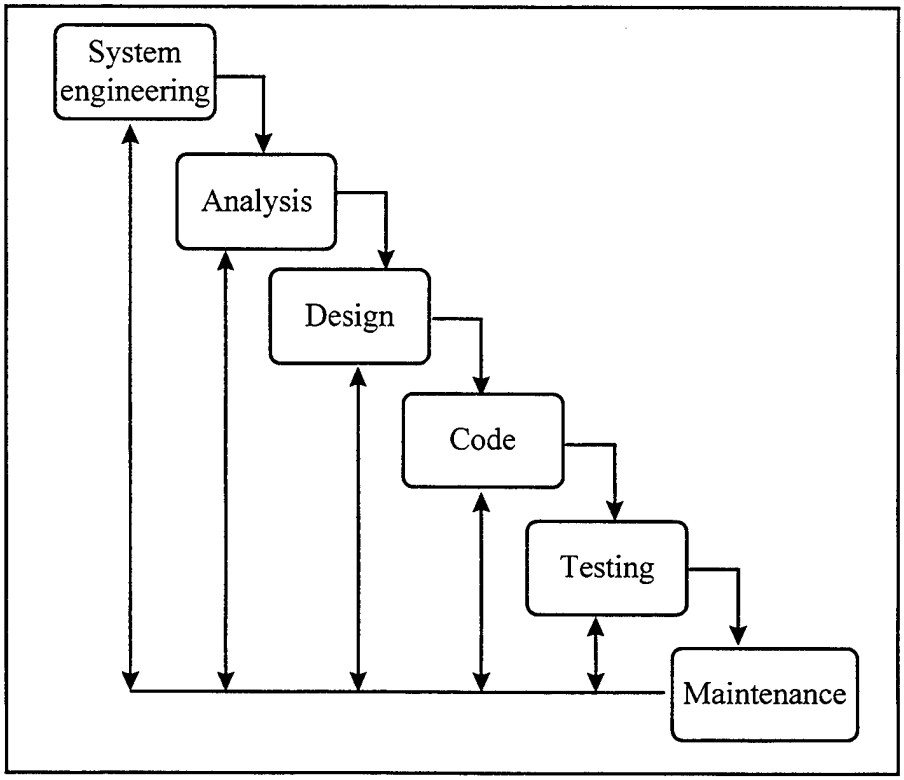

Figure 2-1 The Waterfall Model (Pressman, 1992)

2.3.2 The Waterfall Model.

Probably the most widely used and well known process model, the waterfall method, was developed in the early 1970's by Royce. This model is characterized by "a systematic, sequential approach to software development that begins at the system level and progresses through analysis, design, coding, testing and maintenance" (Pressman, 1992:24-26). Feedback is available at each of the levels of the waterfall, tying back to each of the previous levels (refer to Figure 2-1). This allows the developer to correct problems in the earlier stages, that were found later in the development process. Several

criticisms during the past ten years have raised doubt as to the applicability of this model to all situations. Some of the problems encountered are as follows: 1) Projects seldom follow a smooth sequential flow; most have some type of iteration, 2) This model requires explicit requirements statements, which are rarely available at the onset of a new development, and 3) The customer does not see a working product until very late in the project, requiring great patience and confidence on the part of the customer. Despite these very real problems, this model still has an important place in software engineering (Pressman, 1992:26).

2.3.3 Prototyping.

Prototyping has become popular recently because it addresses some of the concerns dealing with the waterfall model. Prototyping is the process of developing a working model of the software project to be built (Pressman, 1992:27). Often users are not exactly sure what they want, but *they'll know it when they see it*. Prototyping allows the user to get a preview of the final product, giving them a chance to confirm their desires and solidify their requirements. Prototypes are divided into two categories, "throwaway" and "evolutionary."

Throwaway: This category of prototypes is consistent with Fred Brooks' maxim, "plan to throw one away; you will, anyhow" (Brooks, 1996). The idea is that the prototype is only a means to an end. When the requirements are solidified and the technical feasibility established, the prototype is discarded and the deliverable product is started.

Evolutionary: The idea behind evolutionary is to use all, or part of the prototype in the final version of the product (Gordon & Bieman, 1994). By doing this, the actual coding and other work that goes into developing the prototype is not wasted and the time and resources to develop the deliverable is less.

Some caution should be used when using the prototyping model, especially the throwaway. When a developer comes under pressure, both schedule and budget, they may be tempted to include part or all of the throwaway prototype in the final product. The problem in doing this is that the prototype was designed to be thrown away, thus the structure and the integrity of the prototype is suspect (Gordon & Bieman, 1994:93).

2.3.4 Evolutionary/Incremental.

The evolutionary model is the strategy of developing a product in successive increments. The idea behind this approach is that by developing in increments, the customer sees continual progress, while receiving a usable product earlier. Each increment of the development goes through the complete development cycle, including test. By using this approach, system integration test is effectively accomplished as the product is being developed. When the very last increment is completed, the product is finished. This approach is often combined with other models. It can incorporate the use of prototyping in developing each increment, or can be part of a spiral development.

2.3.5 The Spiral Model.

The spiral model was developed over several years in an attempt to solve some of the shortcomings of earlier models. It can accommodate most previous models as special

cases, thus retaining their benefits, and provides guidance as to which combinations of previous models best fits a given software development situation (Boehm, 1988). The spiral model takes a cyclical approach to software development. The development process starts at the innermost area of the spiral (refer to Figure 2-2) and proceeds outward along the spiral. Each time the commitment partition is crossed, a review is conducted and risks are assessed. At this point actions are to be taken to counteract any risks (Williams, 1995). According to Boehm, the primary advantage of the spiral model is that its flexibility accommodates the good features of previous models, while its risk driven approach avoids their difficulties. There are difficulties in using the spiral model, mostly due to its immaturity. These difficulties include matching the model to contract software, reliance on risk assessment expertise and a need for further elaboration of the steps of the model (Boehm, 1988).

2.4 The Capability Maturity Model

The original version of the CMM was called the process maturity framework. Developed in 1987 by Watts Humphrey, the maturity framework, along with the maturity questionnaire, was intended to help the DOD identify areas where an organization's software process needed improvement (Paulk et. al., 1993: vii).

This framework later evolved into the CMM, Version 1.0 and eventually, as a result of feedback from the software community, was revised and released as Version 1.1 in 1993. This version of the CMM was intended as a foundation to improve the software process.

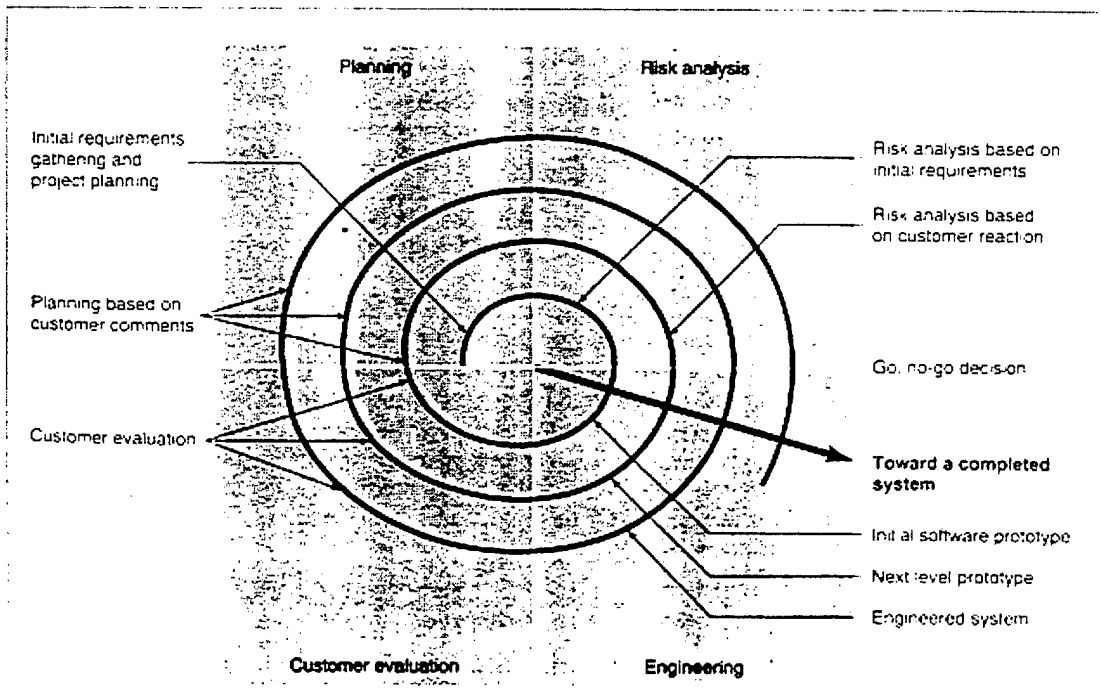

Figure 2-2 The Spiral Model (Boehm, 1988)

In order to improve one's process, one must know the current status of the process (Humphrey, 1989:3). The CMM was designed to measure the maturity of an organization's development process with the idea that increasing an organization's process maturity in stages would lead to a higher quality product (Paulk et. al., 1993:5).

As described by Paulk in his paper on the CMM, an organization with a mature process can be described as possessing an organization wide ability for managing software develepment. On the other hand, an organization with an immature process usually improvises during the course of development and often spends much time "fire fighting" (Paulk et. al., 1993:2).

The CMM consists of five different levels ranging from 1(the lowest maturity) to 5(the highest maturity). The following is a summary of the five levels from Watts Humphrey's book, Managing the Software Process:

Level 1: Labeled *initial*, a software process at this level of maturity is sometimes considered *ad hoc* or even chaotic. Usually none of the procedures are formalized, and if they are, they are not well known and often abandoned in time of crisis.

Level 2: Labeled *repeatable*, a process at this level has achieved a measure of statistical control not present at the *initial* level. This process is stable and repeatable and has rigorous project management of commitments, costs, schedules, and changes.

Level 3: Labeled *defined*, a process in this level is well established; it is likely to be used in times of crisis instead of discarded. The organization now has the foundation to examine the process and decide how to improve it. Advanced technology can now be introduced.

Level 4: Labeled the *managed* level, an organization at this level will have instituted a comprehensive system for obtaining and analyzing measurements. Because this measurement gathering and analyzing provides deep insight into the process, it is here that the most significant quality improvements can be made.

Level 5: Labeled *optimizing*, this is the ultimate goal of an organization. The organization at this level has such a good foundation in place that they can be proactive in fine-tuning their software development process, and in turn, improve the quality of the products.

Humphrey states that the reasons behind choosing these levels are: they reasonably represent historical evolution of improvement in real companies, they

represent an achievable measure of improvement from one level to the next, they suggest interim improvement goals and progress measures, and they make the priorities for improvement obvious once an organization's current status is known (Humphrey, 1989:5).

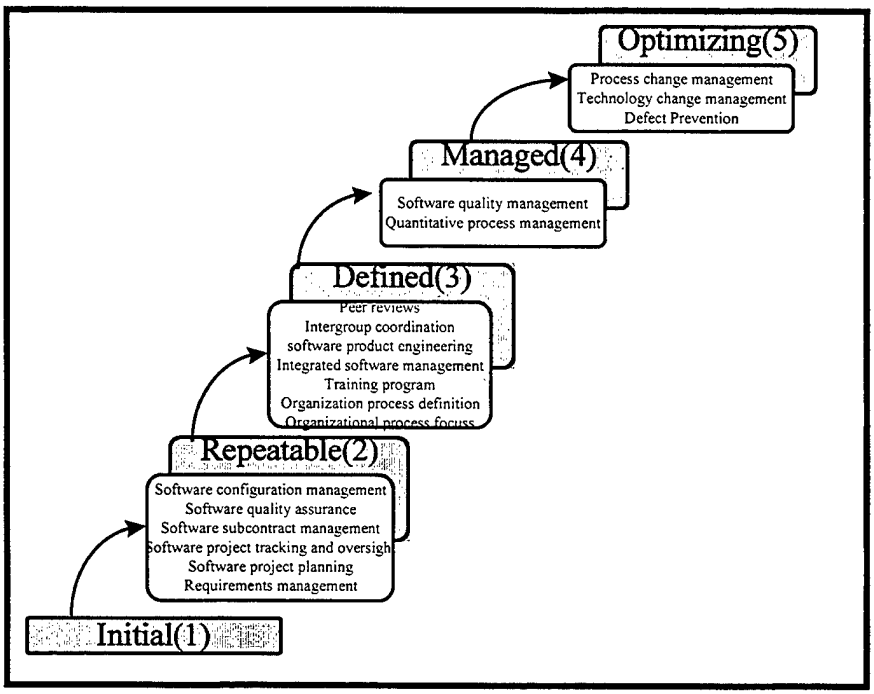

Figure 2-3 The Key Process Areas by Maturity Level (Paulk et. al., 1993).

2.4.1 Internal Structure of the CMM.

Each CMM rating level is broken down into several key process areas, with the exception of level 1. These process areas "identify clusters of related activities that achieve a set of goals important to enhancing process capability" (Paulk et. al., 1993:30). The key process areas associated with each maturity level are shown in Figure 2-3. There are other processes besides the key processes that are involved in developing and

maintaining software; however, they have no bearing on achieving a given CMM maturity level.

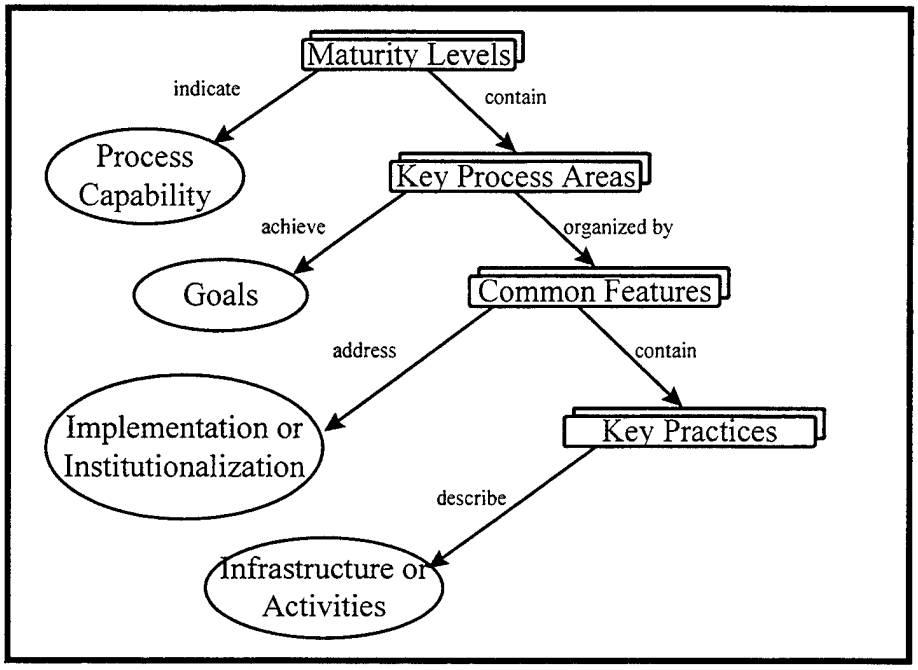

Figure 2-4 Overall CMM Structure (Paulk et. al., 1993)

Each key process area is broken down into five common features. These common features indicate whether the implementation or institutionalization of the key process areas is "effective, repeatable, and lasting" (Paulk et. al., 1993:37). They also contain the key practices that, when addressed, accomplish the goals of the key process areas. The overall structure of the CMM can be seen in Figure 2-4.

2.4.2 Applications of the CMM.

There are two main ways in which the CMM can be applied by an organization. The first is called a software process assessment (SPA) and the second is called a software capability evaluation (SCE).

The SPA focuses on the current status of an organization's software process, and identifies priorities for improvement. These assessments can be performed by a team that is either internal or external to the organization. Although these assessments can be performed by themselves, they are often done in preparation for an SCE (Bollinger & McGowan, 1991).

Whereas the SPA focuses on the current status in order to establish priorities for improvement, the SCE focuses strictly on the current capability for a given project. SCE's are performed by specially trained teams which are external to the organization being evaluated. These evaluations are often performed on bidders to a project or on existing contracts to monitor performance (Paulk et. al., 1993:44).

Both the SPA and the SCE have several commonalties. Some of these include team selection, the maturity questionnaire, analysis of the responses, site visits, and a list of team findings (Paulk et. al., 1993:45,46). As described above, however, the overall purpose of the two applications discussed is quite different.

2.4.3 Limitations of the CMM.

Despite the growing popularity and acceptance of the CMM as a measure of process maturity, several concerns and limitations to the model have been expressed by industry experts.

Probably the biggest concern raised is the inability of the CMM to adequately discriminate between levels of process maturity. An organization must satisfy all key process areas of a maturity level to achieve that level (Paulk et. al., 1993). This requirement may cause a disconnect in the comparative rating of two organizations. An

organization that satisfies none of the key process areas would be considered a level 1 organization. An organization that satisfied many key process areas should clearly score higher than level 1; however, this may not be true with the CMM. For example, if a company satisfies most of the areas for level 2 and all of the areas for level 3 they would be rated a level 1 because of the areas they did not satisfy (Bollinger & McGowan, 1991:31). In this example, the company that satisfied most of the level 2 and 3 key process areas would have the same rating as that of the company that satisfied none, yet the first plainly has a more mature process in the spirit of the model.

Another concern, or limitation, is the flexibility of a company using the model. Companies that follow the CMM framework may fall victim to what is called process fossilization. Fossilization refers to a process that cannot be easily changed in any significant way (Bollinger & McGowan, 1991:39). In striving for and achieving level 5, and organization will have committed many resources and will have implemented many tools and procedures for collecting data. When a problem occurs, this data is used as a resource to determine where in the existing structure the problem exists; and fails to recognize a problem with the overall structure of the process itself (Bollinger & McGowan, 1991:39). This type of data usage results in only minor intra-process change and an inflexible overall process.

2.5 Alternative Means of Measuring Capability

Because of the limitations of the CMM mentioned in the previous section, some alternative approaches to measuring an organization's software capability have been

developed. They were designed to be used to evaluate the software process instead of the CMM in situations for which the CMM is not fully appropriate or suited.

One alternative to the CMM is the Software Development Capability Evaluation (SDCE). The SDCE method was developed by ASC in 1992 and is fully described in Air Force Materiel Command (AFMC) Pamphlet 63-103. The SDCE is meant to be an integral part of the source selection process. In fact, the members of the SDCE team are also members of the Source Selection Evaluation Board (SSEB) (Babel, 1997). The overall purpose of this method is to evaluate a potential contractors capability to develop the proposed project, as opposed to the CMM which rates overall capability. The SDCE is used to identify strengths and weaknesses in specific source selection areas as well as the contractor's commitment to follow their proposed process (Babel, 1997).

A second alternative to the CMM is the Software Acquisition-CMM (SA-CMM). The CMM focuses on companies that develop software, but does not address organizations that acquire software from other companies. Recognizing a need for a model that focuses on the process of acquiring new software, the SEI developed the SA-CMM and published it in 1996. The purpose of the SA-CMM is to "describe the acquirer's or the buyer's role in software-intensive system acquisition" (Kind & Ferguson, 1997). Similar to the CMM, the SA-CMM defines five stages, or levels, of maturity for the software acquisition process. These five levels are summarized in Table 2.1. SA-CMM is intended to be used to improve the acquisition process similar to the way in which the CMM is used to improve software development processes (Kind & Ferguson, 1997). Because the SA-CMM is based on the CMM and is very similar in structure, it maintains the same limitations as the CMM.

Although this is not a conclusive list, it points out that the CMM is, by no means, the only available method of improving or evaluating the capability of a potential contractor. To this point, however, the CMM appears to be the most popular and widely known model.

Table 2.1 The SA-CMM Maturity Level Description (Kind & Ferguson, 1997)

CMM Level	Description
1 - Initial	The organization does not have documented processes.
2 - Repeatable	Basic acquisition management instills discipline at the project level.
3 - Defined	Acquisition organization-wide processes are defined, then tailored for each project.
4 - Quantitative	Decisions on processes and products are based on formal quantitative measures.
5 - Optimizing	Continual process and acquisition methodology improvements occur based on quantitative feedback and form piloting innovative ideas and technologies.

2.6 Cost and Schedule Performance Measures

The Airlie Council, in their study of industry best practices in 1996, recognized the project control panel as both a useful tool and a concept for tracking the progress of a project, and predicting its future progress (Basili et. al., 1997). The control panel consists of several measures of performance in primary areas of a project; such as productivity, completion, change, staff, risk, and quality.

One measure of particular interest to this research effort is the Cost Performance Index (CPI). This measure shows how well a project team is meeting its budget goals. The CPI is a ratio of Budgeted Cost of Work Performed (BCWP) to Actual Cost of Work performed (ACWP), two parameters present in most Earned Value Management Systems

(EVMS's). The CPI provides a historical measure of average productivity. A CPI of 1.0 indicates a project that is exactly on target for budget. A value less than 1.0 indicates a budget overrun where a value greater than 1.0 indicates a budget underrun.

Another performance measure of interest to this study is the Schedule Performance Index (SPI). Although not present on the project control panel mentioned above, the SPI is a relative to the CPI. Where the CPI is a historical measure of cost performance, the SPI is a measure of schedule performance. The SPI is a ratio of BCWP to Budgeted Cost of Work Scheduled (BCWS), two parameters also present in most EVMS's. Like the CPI, a value of 1.0 indicates an on schedule project. A value less than 1.0 indicates a schedule overrun and a value greater than 1.0 indicates a schedule underrun.

$$CPI = BCWP/ACWP \qquad \textbf{(2.1)}$$

$$SPI = BCWP/BCWS \qquad \textbf{(2.2)}$$

The above two measures are not the only measures of cost and schedule performance. However, these two measures have become standard for both industry and government (Nicholas, 1990:376-389).

2.7 Return-On-Investment Studies

Several companies and organizations have done return-on-investment (ROI) studies showing the economic benefits of moving up the CMM maturity scale. The studies identified the costs associated with trying to improve one's CMM rating level. They then identified and assigned dollar values to the perceived benefits, both economic and non-economic, to determine the overall ROI. Three studies of prominent

organizations at different levels are described in the further detail in the following sections.

2.7.1 Hughes Aircraft.

In 1987, Hughes Aircraft employed a team from the Software Engineering Institute (SEI), at a cost of $45,000, to perform an assessment of the Software Engineering Division (SED) of the company. The SED was rated at a level 2 (Humphrey, Snyder, and Willis; 1991:13). After receiving the recommendations from the assessment team, an action plan was devised and implemented to improve the software process. Over the course of 18 months, Hughes expended 78 man-months of effort and a total cost of $400,000 to implement the action plan.

When the SEI performed another assessment in 1990, it found that the SED had improved to a strong level 3. In the course of improving from level 2 to 3, several benefits were realized. Hughes found that working conditions, employee morale, and project schedule and cost performance had improved. The economic value of the improvements was estimated to be about $2 million annually (Humphrey, Snyder and Willis; 1991).

2.7.2 Oklahoma City ALC

In 1990, the Oklahoma City Air Logistic Center (OC-ALC), Software Division (LAS) was rated by the SEI at a CMM level of 1. In 1993, they were again rated and had achieved a level 2. Also, in 1993, and independent study was conducted to determine the cost of process improvement and the benefits obtained. The study found that over an 8-

year period, an investment of $1.5 million by LAS resulted in a cost savings of $11.3 million. Other findings included a 90% reduction in defect rate, a 26% reduction in test program set (TPS) maintenance costs, and a ten fold increase in productivity (Department, 1996:7-35).

2.7.3 Raytheon.

In 1988, an internal assessment of the Software Systems Lab at Raytheon, based on the CMM questionnaire, rated the lab at slightly less than level 2. Four areas were identified as needing improvement: documented practices and procedures, training, tools and methods, and metrics (Department, 1996:7-40).

In 1992, a follow-up analysis revealed that Raytheon achieved a 7.7:1 ROI(a $4.48 million return on a $.58 million investment). Other noted savings included a 75% reduction in rework since 1988 and a 230% increase in productivity (Department, 1996:7-41).

2.8 Correlation Study of the CMM and Software Development Performance

In 1994, Robert Flowe and James Thordahl conducted a study examining the correlation between CMM rating level, and cost and schedule performance of an organization. Although based on a relatively small database, the results provide some interesting insights.

The research used CPI and SPI as measures for performance. The study also considered nine possible moderating variables when establishing correlation. The results

suggest that a positive correlation exists between CMM rating level and both the CPI and SPI. The research found that a strong correlation is present when the moderating variable of "project relevance" is high. Also, the results reveal that the correlation with SPI becomes more evident when the moderation variable of "percent complete" is taken into consideration (Flowe & Thordahl, 1994:6-2,3).

2.9 Summary

The ROI studies described earlier provide insights into the economic value of moving up the CMM scale; however, they provide no useful information about how the CMM can be used by the software acquisition manager. The Flowe and Thordahl study provides evidence supporting the idea that higher CMM levels indicate better cost and schedule performance; however, the study stops short of explaining how this correlation can be beneficial to the software acquisition manager.

This research attempts to build upon the relationship between CMM and performance, described in the previously mentioned studies. It proposes a method of combining the CMM rating level with the concept of statistical process control, which was developed in the 1930's and later promoted by Edward Deming and Joseph Juran, to produce a method for the software acquisition manager to monitor and control the performance of a software development contractor (Paulk et. al., 1993).

3. Methodology

3.1 Overview

Once the subject of this research, the CMM, was chosen; the research continued in four phases. The first phase was the problem definition/scope phase. During this phase, a specific problem dealing with the subject was selected. Also, the scope of the problem was defined. The second phase was the data identification/gathering phase. During this phase, the appropriate data was identified, located, and gathered. Phase three was the model development phase. During this phase, the data was analyzed and a proposed model was developed. Finally, phase four was the model validation phase. During this phase, the proposed model was validated using historical data gathered about members of the target population. The following sections describe each of the four phases in full detail.

3.2 Problem Definition/Scope

The purpose of this phase was to define a specific research problem associated with the CMM. A review of the existing research pertaining to the CMM revealed that research exploring the predictive nature of the CMM might be useful to the software acquisition community (Flowe & Thordahl, 1994). It was then necessary to define the scope of the research because of the broad nature of the problem, and the limited time and resources available to conduct the research. After further review of the existing literature,

the decision was made to focus this research on applying a predictive model, based on the CMM, to the statistical process control of DOD contractors.

3.3 Data Identification and Gathering

Once the problem had been defined and the scope clearly delineated, the research moved into the data identification and gathering phase. The first step of this phase was to identify the data required to conduct this research. CMM rating level was chosen to be the independent variable. ACWP, BCWP, and BCWS were selected based on the the dependent variables of interest, CPI and SPI.

The next step was to locate reliable sources for the required data. After a search of the literature, a database containing secondary historic data from DOD software development contracts that had been established by Robert Flowe and James Thordahl for their research was located (Flowe & Thordahl, 1994). Robert Flowe was contacted and a copy of the database was obtained. The database consisted of pre-established contractor process maturity ratings (as defined by the SEI's CMM), and cost and schedule data reported to ASC and ESC in Cost Performance Reports (CPR's) as part of their contract fulfillment. The following is a summary of the steps used by Flowe and Thordahl to obtain their information (Flowe & Thordahl, 1994):

1) Identify appropriate contract elements: During this step, contracts that reported software development costs as a discrete contract work breakdown structure (CWBS) element were identified in the ASC and ESC libraries.
2) Determine rating of contractor: After identifying the appropriate contracts, it was necessary to establish whether the contractor, associated with each

contract, had been rated using the CM methodology. If not, that contract was discarded as a possible source of data; if they had, the rating information, including method used and date rating was given, was recorded.

3) Collection of relevant cost/schedule information: During this step, cost and schedule performance information, covering a period of six months prior to and six months following the rating date, was collected.

4) Collection of moderating data: Finally, other moderating data which may be used to characterize the software development project was collected to be used to gain further insight into the performance data obtained.

These steps are depicted in Figure 3-1.

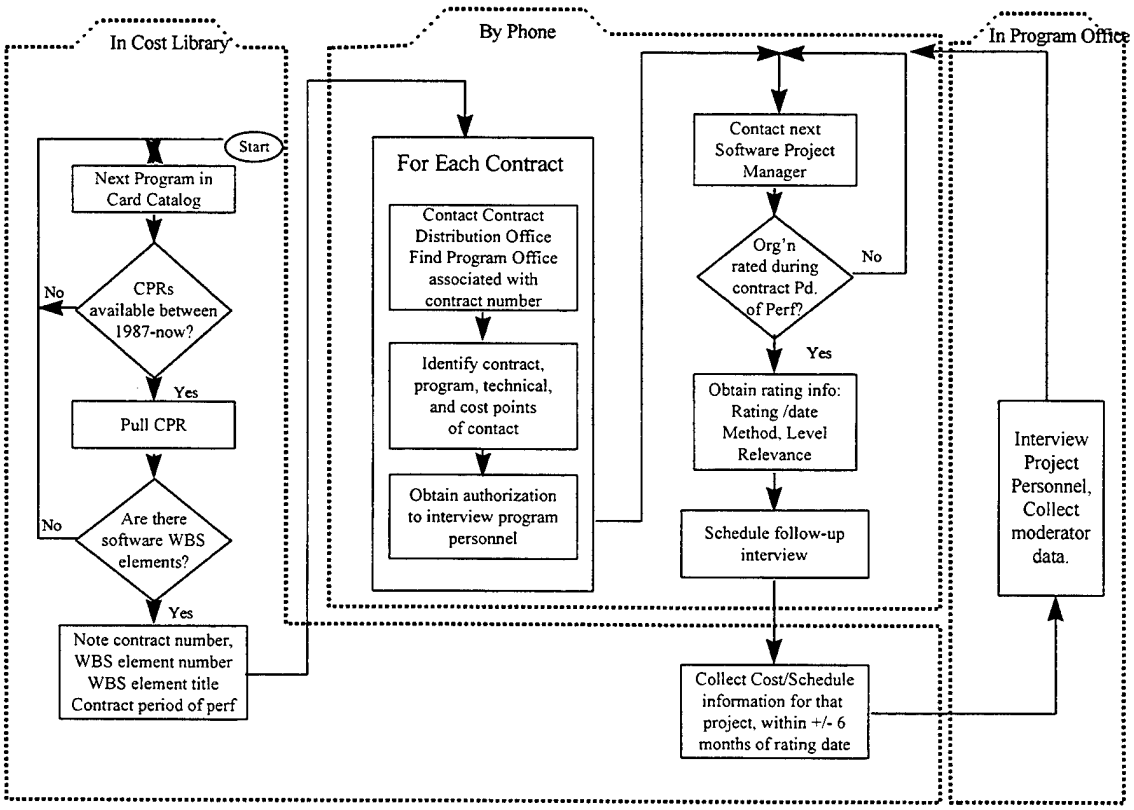

Figure 3-1 Data Gathering Flow Chart (Flowe & Thordahl, 1994)

The reliability of the information in the Flowe and Thordahl database was considered sufficient for the purposes of this research because the collection, content, and reporting of the information are governed by the C/SCSC guidelines. Also, the same criteria for cost and schedule measurement and reporting are mandated for all contracts, making the data obtained reliable for comparison between different contracts.

An attempt was made to add to the validity of the database by adding contractor information from Space and Missile Systems Center (SMC) contracts. The person in charge of the SMC cost library was contacted, and the contents of the library was discussed. It was learned that necessary data (contractor identification) was not kept in the library. Because of this fact, contractor CMM rating level could not be ascertained and linked to the performance information, making use of the SMC cost library information for this research impractical. Because there are few, if any, reliable sources of data it was decided that the existing database would be sufficient, based on the target population of this research (DOD contractors).

Some of the data points in of the Flowe and Thordahl database had to be excluded for this research effort. Low levels of contract effort cause the variances of the indices that are more due to lack of activity than to actual variances in contractor performance. Flowe and Thordahl calculated a ratio of contract activity during the twelve month period relative to total activity to date. If this ratio showed a level of activity of less than 1% for any of the three parameters, BCWS, BCWP, and ACWP, the data point was excluded (Flowe & Thordahl, 1994). These points are identified by comments in the investigator comment box of the data forms in Appendix A.

One of the moderating variables collected by Flowe and Thordahl was rating relevance. This moderating variable rates the relevance of the project listed in the WBS to the actual CMM rating of the organization. If this variable is listed as high or very high, the project in the WBS was the project used to obtain the organization rating. In an attempt to develop a model that is as accurate as possible in relationship to the CMM rating level of the contractor, only contracts with a rating relevance of high or very high were used to develop the model.

3.4 Model Development

The first step of the data analysis phase, following the removal of data to be used in the validation phase (validation data selection is described in detail in the next section), was to separate the data based on CMM rating level. After separation, equations 3.1 and 3.2 were applied to the data to obtain the sample mean and standard deviation for each rating level (Devore, 1995).

$$X_{bar} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \textbf{(3.1)}$$

where: X_{bar} is the sample mean.
n is the sample size.
x_i is a point in the sample.

$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - X_{bar})^2}{n-1}} \qquad \textbf{(3.2)}$$

where: s is the sample standard deviation.
n is the sample size.
x_i is a point in the sample.
X_{bar} is the sample mean.

The next step was to calculate prediction intervals, to be used as the predictive model upper and lower statistical control bounds for performance, using equations 3.3 and 3.4. An assumption of normality must be made about the data distributions for these equations to apply to this research (Devore, 1995). The intervals calculated using these equations will be known as the model from here on out.

$$UB = X_{bar} + t_{\frac{\alpha}{2},n-1} \cdot s \cdot \sqrt{1 + \frac{1}{n}} \qquad \textbf{(3.3)}$$

$$LB = X_{bar} - t_{\frac{\alpha}{2},n-1} \cdot s \cdot \sqrt{1 + \frac{1}{n}} \qquad \textbf{(3.4)}$$

where: UB and LB are the prediction interval upper and lower bounds.
Xbar is the sample mean.
t is the value of the t statistic.(α = 1 - prediction level/100)
s is the sample standard deviation.
n is the sample size.

One graphical method of validating an assumption of normality is the box and whisker plot (refer to Figure 3-2). A box and whisker plot gives a quick graphical picture of the median of a sample distribution and the extent and nature of any departure from symmetry (Devore, 1995). It can also be used to identify any points that lie unusually far from the main body of data. This method can be used to identify sample distributions that deviate severally from normal; however, for small sample sizes the box and whisker plot may be misleading and a more precise method is required.

A more precise method of validating the normality assumption is the Wilk-Shapiro/Rankit Plot Procedure (refer to Figure 3-3). It can be used to examine whether data conform to a normal distribution or not (Analytical, 1996). This method yields a statistic equal to the square of the linear correlation between the rankits and the order statistics (Analytical, 1996). The closer to 1.00 the value is, the more normal the distribution is. For a small sample, typically less than twenty data points, a value

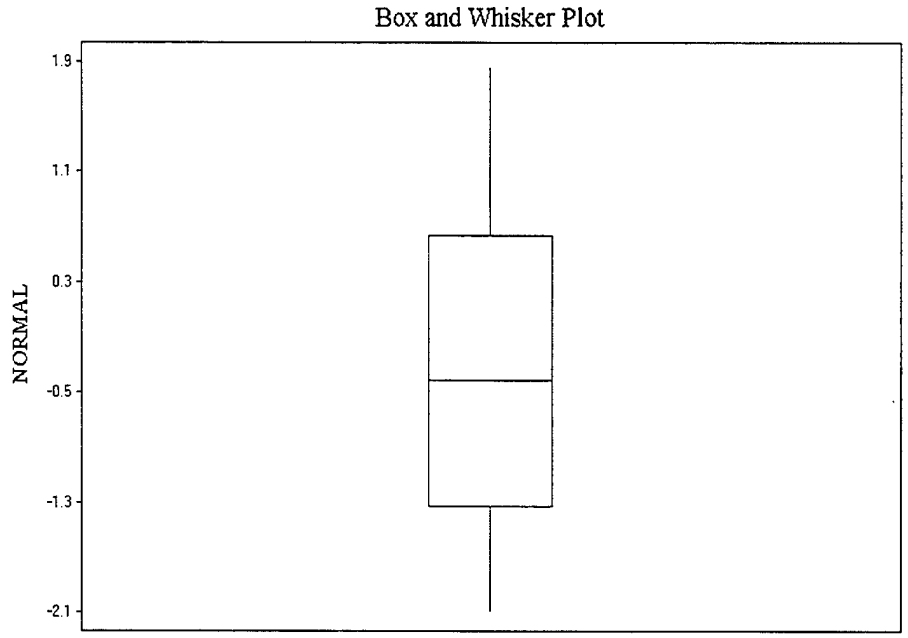

Figure 3-2 Sample Box and Whisker Plot for a normal distribution

of .8 or higher is sufficient for the distribution to be approximated with the normal (Reynolds, 1997).

3.5 Model Validation

The research entered the model validation phase following completion of data analysis and the development of the model. The first step of this phase was to select the

data to be used for validating the model. Since the target population of this research is DOD software development contractors, it was decided to select data from contractors within this population. An available source of information was the existing database. Appropriate contractors were selected from the database based on CMM rating level and the number of data points provided by each contractor. In an attempt to obtain enough points to do the validation without reducing the database size significantly, contractors that had provided three data points were chosen. These contractors are identified by a comment in the investigator comment box of the data forms in Appendix A.

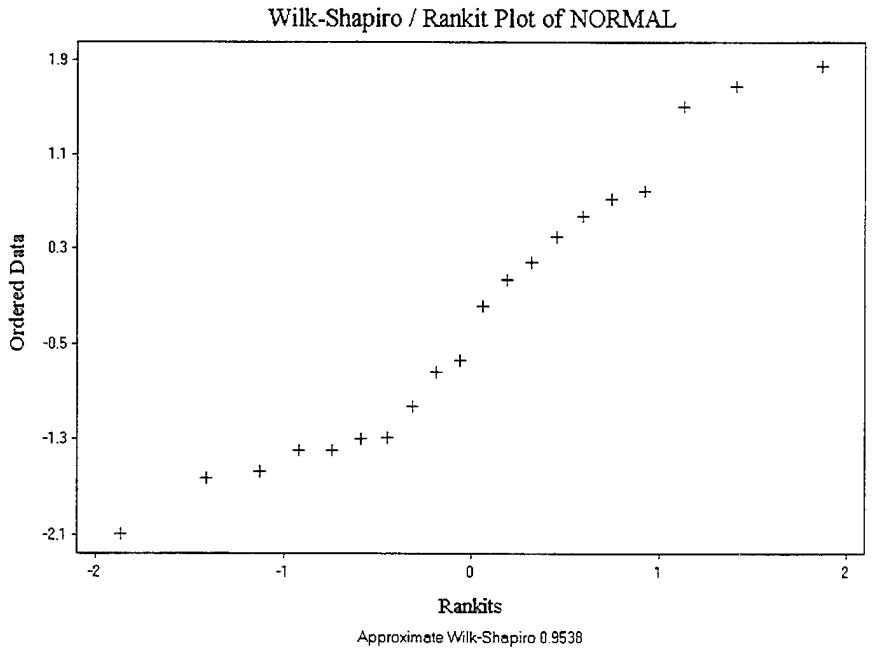

Figure 3-3 Sample Wilks-Shapiro Plot of a Normal Distribution

CPI and SPI were calculated for each of the points using equations 2.1 and 2.2 respectively. These values were then compared to the model value for the upper and lower control bounds to determine which points fall within the bounds and which points fall outside.

One current method of determining whether a contractor's performance is acceptable or not is to calculate the cost and schedule variance percentage of the contractor's performance and compare them against set limits. A common limit currently used by managers is ±10% variance for both cost and schedule (Ferens, 1997).

In order for our proposed model to be at least as good as the current method, it was expected that any point with a variance percentage of greater than ±10% would fall outside the proposed model's control bounds, and any point with a variance percentage within the ±10% range would fall inside the proposed model's control bounds. The cost and schedule variance percentages were calculated for each point using equation 3.5 and 3.6 respectively.

$$\text{Cost Variance \%(CV\%)} = 100*(\text{BCWP} - \text{ACWP})/\text{BCWP} \quad \textbf{(3.5)}$$

$$\text{Schedule Variance \%(SV\%)} = 100*(\text{BCWP} - \text{BCWS})/\text{BCWS} \quad \textbf{(3.6)}$$

These variance percentages were then compared to the ±10% limit and used to determine the expected position of the point with regards to the model's control bounds. Finally, any deviation from the expected position was noted.

4. Data Analysis/Results

4.1 Model Development

Having separated the data into two parts, the complete data set consisting of all data to be used in the development of the model, and the validation data set consisting of the data to be used in validating the model, the next step in developing the model is to validate the assumption of normality for the complete data set. The box plots of the CPI and SPI are inconclusive (see Figures B-1 and B-2 in Appendix B). There are no highly extreme values to suggest that the distributions are not normal, however, the plots are not exactly symmetrical so further analysis is needed.

Wilk-Shapiro Rankit Plots were constructed for each level of data (see Figures B-3 through B-8 in Appendix B). The Wilk-Shapiro statistics obtained from these plots are summarized in Table 4.1. The values obtained are not inconsistent with normal distributions and support the assumption of normality.

Table 4.1 Wilk-Shapiro Statistics for SPI and CPI

Rating Level	SPI	CPI
1	0.87	0.84
2	0.93	0.91
3	0.93	0.90

Having validated the assumption of normality, the next step is to apply descriptive statistics to the complete data set to obtain the mean and the standard deviation. These values can then be used to construct the prediction intervals necessary to develop the

model. Once again using *Statistix for windows*, the values were obtained and are summarized in Tables 4.2 and 4.3. Some of the values are contrary to the CMM theory which states that as rating level goes up, the performance of the contractor moves closer to the ideal and the variance improves. These discrepancies are addressed in the limitations section of chapter five.

Table 4.2 Descriptive Statistics for CPI

CMM Rating	Number in Sample	Mean	Standard Deviation
1	11	0.7326	0.2883
2	12	1.2489	0.4169
3	11	0.988	0.1104

Table 4.3 Descriptive Statistics for SPI

CMM Rating	Number in Sample	Mean	Standard Deviation
1	11	1.0668	0.3454
2	12	0.9741	0.0531
3	11	1.0457	0.0891

These values can now be used to construct the prediction intervals for all three rating levels and both performance indices. The prediction level used in this study is 90%. Usually a higher prediction level is preferred, but for the size of our sample a higher prediction level would yield intervals too wide to be meaningful. The α corresponding to a 90% prediction level is 1 - prediction level/100 or .10. Dividing α by two yields the required value for equations 3.3 and 3.4 which is .05. The t-statistic for this value, $t_{.05,n-1}$ can be obtained from a standard table such as the one in Devore (Devore, 1995: 707). Substituting into equations 3.3 and 3.4 yields the intervals displayed in Table

4.4 and 4.5. Once again, one of the results is not consistent with CMM theory and is addressed in chapter five.

Table 4.4 CPI Portion of Proposed Model

CMM Rating	n	$t_{.05,n-1}$	Lower Bound	Upper bound
1	11	1.812	0.186971	1.278229
2	12	1.796	0.469574	2.028226
3	11	1.812	0.77906	1.19694

Table 4.5 SPI Portion of Proposed Model

CMM Rating	n	$t_{.05,n-1}$	Lower Bound	Upper bound
1	11	1.812	0.413106	1.720494
2	12	1.796	0.874838	1.073362
3	11	1.812	0.877072	1.214328

The intervals in Table 4.4 and 4.5 constitute the proposed model. This model is proposed to be used by acquisition managers to predict performance or monitor performance of a contractor, based on the contractors CMM level. A performance value inside the interval for a given rating level denotes acceptable, or typical, performance for that level. A value outside the interval depicts unacceptable, or atypical, performance.

4.2 Model Validation

The first step in the model validation process is to compare the performance values for the selected data validation points to the model interval bounds developed

during the model development phase and note whether the value is inside the interval or not. A summary of the results of this comparison is located in Table 4.6.

The second step in the model validation process is to calculate the CV% and the SV% using equation 3.5 and 3.6 respectively, and compare these percentages to the standard limits of ±10%. The location of the percentages (inside or outside the limits) is then noted. A summary of the results of this comparison are located in Table 4.7.

Table 4.6 Comparison of CPI and SPI to Model Bounds

Contractor Code(Append A)	WBS Element	CMM Rating	SPI Value	CPI Value	Inside model SPI range?	Inside model CPI range?
IC	1	1	1.00	0.87	yes	yes
	2	1	1.04	0.56	yes	yes
	3	1	1.01	0.84	yes	yes
FA	1	2	0.97	0.39	yes	no
GB	1	2	1.08	0.35	no	no
HA	1	2	1.05	0.84	yes	yes
JB	1	3	0.90	1.07	yes	yes
	2	3	1.29	1.98	no	no
	3	3	1.31	2.16	no	no

Table 4.7 Comparison of CPI and SPI variance % to ±10% limits

Contractor Code(Append A)	WBS Element	CMM Rating	SPI var %	CPI var %	Inside 10% SPI limit?	Inside 10% CPI limit?
IC	1	1	0.00	-12.90	yes	no
	2	1	4.09	-58.86	yes	no
	3	1	1.30	-20.98	yes	no
FA	1	2	3.25	-53.86	yes	no
GB	1	2	7.72	-175.51	yes	no
HA	1	2	5.66	-12.88	yes	no
JB	1	3	-10.04	8.69	no	yes
	2	3	29.16	40.09	no	no
	3	3	30.69	54.69	no	no

The final step in the validation process is to compare the results in Table 4.7 to the results in Table 4.6. Table 4.8 summarizes the comparison between the 10% limit method and the proposed model method. A "yes" value indicates values lying inside the limits for the respective methods and a "no" value indicates values lying outside the limits for the respective methods. A disagreement is defined as a difference between the value in the 10% column and the value in the Model column. For the SPI performance measure, one CMM rating level 2 point disagreed and one CMM rating level 3 point disagreed. For the CPI measure, all three CMM level 1 points were in disagreement and one CMM level 2 point. The shaded areas in the table represent these disagreements between the 10% method and the model method.

Table 4.8 Comparison of 10% Method to Model Method

Contractor	WBS	Rating	SPI for 10%	SPI for Model	CPI for 10%	CPI for Model
IC	1	1	yes	yes	no	yes
	2	1	yes	yes	no	yes
	3	1	yes	yes	no	yes
FA	1	2	yes	yes	no	no
GB	1	2	yes	no	no	no
HA	1	2	yes	yes	no	yes
JB	1	3	no	yes	yes	yes
	2	3	no	no	no	no
	3	3	no	no	no	no

4.3 Analysis of Differences

There are several possible explanations for the differences noticed between the predicted values obtained using the current practice of using ±10% variance as bounds

and the values obtained using the proposed model. The following paragraphs will give some of the more probable explanations.

For the SPI performance measure, two of the nine points disagreed. Both of these points disagreed at the second decimal point level. The number of decimal places reported in the model intervals and also the variance calculations are more a result of the programs used to calculate them, (Microsoft Excel© and Statistix©), than an indication of significance. For this reason it is possible that in reality there is agreement between the model and the current method being used.

For the CPI performance measure, all three of the CMM level 1 points disagreed and one CMM level 2 point. The current method assumes that all contractors should be capable of performing within the 10% limits, it does not take into account the differing maturity levels of the organization. According to the CMM, level 1 organizations are ad hoc and have a high variance (Paulk et. al., 1993). Because of this, the model intervals for CMM level 1 contractors are extremely wide, causing points that are outside the 10% limits to still be within the acceptable performance levels for a typical CMM level 1 organization. Another possible explanation is due to the sample size for the model development. The sample is relatively small in this preliminary study causing the t-statistic to be rather large. This will cause the intervals to be wide and might explain why the model says that the contractors performance is acceptable, where as the current method says it is not. Finally, a possible explanation for the CMM level 2 point is that the model has a prediction level of 90%, meaning that it is possible for contractors whose

performance is unacceptable, to fall in the acceptable range of the model 1 out of every 10 measurements.

5. Conclusions/Recommendations

5.1 Overview

The first goal of this research was to establish a model, based on the CMM rating level of DOD contractors, to be used for the monitoring of contractor performance in developing software. The second goal of this research was to determine the usefulness of the above model to the acquisition manager in monitoring performance of contractors on software development contracts.

Often acquisition managers use performance measures for contractors in different ways. One way in which they are used is to indicate when performance is below a set standard, such as the arbitrary ±10% limit used in this study. This limit may change depending on the importance or suspected risk of a project. A project that is very important or vital to an organization may impose a limit of ±5%. A project that is less important might relax the limit to ±15%. The results of this study suggest that such a model might be useful in predicting or monitoring performance of a software development contractor when the acquisition manager wants to know if the contractor is performing up to its capability. This model can be used in conjunction with the practice of setting variance limits on the contractor, to fulfill multiple monitoring and controlling functions. In the following paragraphs, the implications of this research will be explored.

5.2 Implications for the Acquisition Manager

The theory behind the CMM suggests that the rating level of a contractor can be used as some indication of the performance capability of that contractor. The results suggest that the proposed model in this study might prove to be a useful tool to the acquisition manager. Based on the model results, performance can be predicted, given a contractors CMM rating level. Also, the model can be used to determine if the performance of a contractor is typical of an organization with the same rating level. However, the model does not perform equally well at all levels. For organizations at CMM level 1, the performance of the model is not good. It appears that because CMM level 1 organization performance has such a high variance, the interval in the model does not do a good job discriminating between acceptable and unacceptable performance. Almost any performance is considered acceptable. This is important to the acquisition manager because almost 70% of organizations are still at CMM level 1. As the rating level reaches the higher CMM levels, 2 and 3, the model discriminates as well as the arbitrary ±10% limit method. Although this study did not contain any data for the higher levels of the CMM, the results suggest that the model might discriminate at a level even higher than ±10%. As more and more companies move up the CMM rating scale, the usefulness of the proposed model should increase. The results are interesting and suggest that further research is warranted to determine the full usefulness of a model such as the one developed in this study.

5.3 Implications for the Researcher

CMM theory is grounded in the premise that as CMM rating level increases, performance also increases and becomes more predictable. Correlation studies have supported the performance aspect of this premise. A natural extension to this premise is that, given data for organizations at the different levels, a model can be developed which could be used to predict performance at each level. The results of this study support this extension for the higher levels, 2 and 3, of the CMM. However, it is interesting that the intervals with a meaningful level of prediction, for CMM level 1 organizations, are so wide that no accurate prediction could be made with them. This may be due to the limitations of this research, but these intervals suggest that perhaps the variance of organizations at CMM level 1 is so large that meaningful prediction of these organizations is not possible. Further research into this area is needed to determine the predictive ability of such a model for CMM level 1 organizations.

5.4 Limitations of the Research

There are two major areas of limitations to the applicability of this research. The first of these areas is bias in the database, the second is the content of the database itself. The following paragraphs will describe in more detail these limitations.

The database used in this research consists of second hand historical data collected by a third party. Because of this, it inherently contains bias. The method of reporting used by the contractors was controlled by guidelines (C/SCSC), which helped to reduce the level of bias introduced. The person who collected the data and constructed the database was contacted and questioned as to the thought processes and procedures

used in constructing the database. This was done in attempt to identify and reduce any bias that may be present. Unfortunately, it is impossible to eliminate the bias completely or to fully understand the nature of the remaining bias. For the above reason, the amount of bias present and the effects caused by its presence are unknown.

There are several limitations of the content of the database itself. The first of these is breadth. Data for the database was collected from DOD contractors who had reported data to ASC and ESC as part of their contracts. ASC and ESC contractors do not represent the full range of contractors providing software to the DOD. Information from contractors performing work for SMC would greatly add to the breadth of the database, but unfortunately SMC does not maintain the information in a format compatible for use in the database. Another limitation of the database is size. Even if the content of the database sufficiently covered the full range of contractors, it would still contain only a small sample. The small number of data points available for model development and model validation affected the sensitivity of the samples when data was removed for use in model validation. This sensitivity might have caused of some values obtained to deviate from theoretical expectations. The value for means and the width of the prediction intervals in the model may have been affected. A much larger database would allow the development of a more accurate model and possibly more useful model.

5.5 Recommendations

There are several areas of opportunities for further research based on some of the limitations and the results of this research. Recommendations for further research are described in the following paragraphs.

One recommendation is to broaden the database and revise the model. There are several ways in which the database can be broadened that would lend to a more accurate and useful model. The first of these is to add data for contractors with level 4 and level 5 maturity ratings. At the time the database was constructed there were very few contractors at these higher levels. Although there are still not many, there may be enough to develop a preliminary model at these levels. A second area in which the database can be broadened is the addition of space systems. At this time the SMC database is not in a format that could be used for this research. Collection of relevant information on SMC contractors would extend the range of the database and add to its validity. Finally, more data points could be added at the lower levels. This preliminary study had a small sample set from which to develop the model. Additional data at the lower levels would help in developing a more accurate and possibly more useful model.

Another recommendation for further research is to revalidate the new model with a different set of data. There are two ways in which this could be accomplished. The first way is to validate the model with more points from a single contract. In this study the model was validated using a single point from different contracts. Although this was sufficient for this preliminary study, validation of the model using multiple points from a single project might be of value in determining the usefulness of the model over time. The second way to accomplish revalidation is to attempt to revalidate using a much larger sample size at each of the rating levels. For this preliminary study only three data points were used at each of the first three CMM rating levels. Increasing the number of points used would allow the researcher to validate the prediction level proposed for the model while validating its usefulness to the acquisition manager.

5.6 Conclusion

The goal of this preliminary study was to evaluate the possibility of creating a model based on the CMM rating level of contractors and to determine the usefulness of such a model to the acquisition manager. The results of this study suggest that such a model might be possible and useful as a tool to monitor and control contractor performance, and that further research in this area is warranted.

Appendix A: Unreduced Data Set

This appendix provides the unreduced data set contained in a Microsoft Access version 2.0 database. Each database record representing an individual data point is presented in a "form" format, with each record represented by a separate page.

Data Identification

OrgTag: A RatingTag: A WBS #: 1

WBSDescription: Operational mission software planning, requirememts analysis, change review/assessment, review/approval requirements specifications

Rating Information

Rating Date: 10/15/93 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: CPI

Program Comments:

S/W Lifecycle: Requirements Language: Ada Language %: 100.00% Application: Avionics

Project Budget: 16608000 Budget Volatility: Low Size: 156800 % New/Modified Code: 100.00%

Requirements Volatility: Unk Rebaselining : No Quality Stds On Contract: ☑ Quality Params Tracked : ☑

Cost Accounting Anomalies: Variances may be influenced by letter contract prior to periods of interest

Program Manager Comments: Size was converted from bytes to DSI

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/93	Date:	8/30/93	Date:	1/30/94	Date:	4/30/94
BCWS:	3110	BCWS:	3612	BCWS:	4427	BCWS:	4635
BCWP:	2715	BCWP:	3139	BCWP:	4040	BCWP:	4797
ACWP:	4096	ACWP:	5313	ACWP:	5827	ACWP:	7681
Budget:	16782	Budget:	16782	Budget:	16633	Budget :	16608
LRE:	16031	LRE:	16168	LRE:	15541	LRE:	16698

Derived Moderators

Budget Volatility Index: -0.0104 LRE Volatility Index: 0.0416 Percent Complete: 0.2888

BCWS Activity: 0.32902 BCWP Activity: 0.43402 ACWP Activity: 0.46674

Dependent Variables

Schedule Performance Index: 1.365246 Cost Performance Index: 0.58075

Investigator Comments:

Data Identification

OrgTag: A RatingTag: A WBS #: 2

WBSDescription: Planning and integration of operational mission software

Rating Information

Rating Date: 10/15/93 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: CPI

Program Comments:

S/W Lifecycle: Integration Language: Ada Language %: 100.00% Application: Avionics

Project Budget: 5186000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Unk Rebaselining : Yes Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Variances may be influenced by letter contract prior to periods of interest--check for rebaselining

Program Manager Comments: BCWS decreased

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/93	Date:	8/30/93	Date:	1/30/94	Date:	4/30/94
BCWS:	191	BCWS:	365	BCWS:	318	BCWS:	365
BCWP:	155	BCWP:	239	BCWP:	320	BCWP:	367
ACWP:	101	ACWP:	160	ACWP:	186	ACWP:	225
Budget:	5902	Budget:	5902	Budget:	5865	Budget :	5186
LRE:	6231	LRE:	6281	LRE:	5644	LRE:	5564

Derived Moderators

Budget Volatility Index: -0.1213 LRE Volatility Index: -0.107 Percent Complete: 0.070874

BCWS Activity: 0.47671 BCWP Activity: 0.57766 ACWP Activity: 0.55111

Dependent Variables

Schedule Performance Index: 1.218391 Cost Performance Index: 1.70968

Investigator Comments:

Data Identification

OrgTag: A RatingTag: A WBS #: 3

WBSDescription: Planning, design, implementation and test of operating system

Rating Information

Rating Date: 10/15/93 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: CPI

Program Comments:

S/W Lifecycle: Multiple Language: Ada Language %: 87.00% Application: Avionics

Project Budget: 4201000 Budget Volatility: Low Size: 16300 % New/Modified Code: 100.00%

Requirements Volatility: Unk Rebaselining : No Quality Stds On Contract: ✔ Quality Params Tracked : ✔

Cost Accounting Anomalies: Variances may be influenced by letter contract prior to periods of interest

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/93	Date:	8/30/93	Date:	1/30/94	Date:	4/30/94
BCWS:	1500	BCWS:	1881	BCWS:	2428	BCWS:	2778
BCWP:	1224	BCWP:	1764	BCWP:	2269	BCWP:	2776
ACWP:	1427	ACWP:	1763	ACWP:	2244	ACWP:	2674
Budget:	5355	Budget:	5355	Budget:	5320	Budget :	4201
LRE:	5140	LRE:	5143	LRE:	4820	LRE:	4066

Derived Moderators

Budget Volatility Index: -0.2155 LRE Volatility Index: -0.209 Percent Complete: 0.6608

BCWS Activity: 0.46004 BCWP Activity: 0.55908 ACWP Activity: 0.46634

Dependent Variables

Schedule Performance Index: 1.214397 Cost Performance Index: 1.24459

Investigator Comments:

Data Identification

OrgTag: B RatingTag: B WBS #: 1

WBSDescription: Analyze, design, and code software for software simulation system component

Rating Information

Rating Date: 1/15/94 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments: May have incentive fee on contract--did not show up in CPR

S/W Lifecycle: Code/Test Language: Ada Language %: 100.00% Application: Simulation

Project Budget: 4300000 Budget Volatility: Med Size: 46746 % New/Modified Code: 100.00%

Requirements Volatility: High Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Rebaselining occurrred immediately prior to timeframe of interest. May see repercussions.

Program Manager Comments: The government may be responsible for 50% of the problems ie cost/schedule variances. Contractor has done a "competent job".

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	8/30/93	11/30/93	3/30/94	7/30/94
BCWS:	2807	3016	3524	3823
BCWP:	2794	2985	3349	3763
ACWP:	2829	2959	3353	3765
Budget:	2807	4019	4007	4300
LRE:	2829	4049	4044	4305

Derived Moderators

Budget Volatility Index: 0.53188 LRE Volatility Index: 0.5217 Percent Complete: 0.8751

BCWS Activity: 0.26576 BCWP Activity: 0.25751 ACWP Activity: 0.24861

Dependent Variables

Schedule Performance Index: 0.95374 Cost Performance Index: 1.03526

Investigator Comments:

Data Identification

OrgTag: B RatingTag: B WBS #: 2

WBSDescription: Analyze, design, and code software for software simulation system component

Rating Information

Rating Date: 1/15/94 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments: May have incentive fee on contract--did not show up in CPR

S/W Lifecycle: Code/Test Language: Ada Language %: 100.00% Application: Simulation

Project Budget: 3341000 Budget Volatility: Med Size: 22712 % New/Modified Code: 100.00%

Requirements Volatility: High Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Rebaselining occurred immediately prior to timeframe of interest. May see repercussions.

Program Manager Comments: The government may be responsible for 50% of the problems ie cost/schedule variances. Contractor has done a "competent job".

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	8/30/93	Date:	11/30/93	Date:	3/30/94	Date:	7/30/94
BCWS:	2517	BCWS:	2688	BCWS:	3048	BCWS:	3302
BCWP:	2496	BCWP:	2739	BCWP:	3028	BCWP:	3300
ACWP:	2568	ACWP:	2855	ACWP:	3119	ACWP:	3292
Budget:	2534	Budget:	3077	Budget:	3078	Budget :	3341
LRE:	2597	LRE:	3146	LRE:	3214	LRE:	3365

Derived Moderators

Budget Volatility Index: 0.31847 LRE Volatility Index: 0.2957 Percent Complete: 0.9877

BCWS Activity: 0.23773 BCWP Activity: 0.24364 ACWP Activity: 0.21993

Dependent Variables

Schedule Performance Index: 1.024204 Cost Performance Index: 1.1105

Investigator Comments:

Data Identification

OrgTag: B RatingTag: B WBS #: 3

WBSDescription: Analyze, design, and code software for software simulation system component

Rating Information

Rating Date: 1/15/94 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments: May have incentive fee on contract--did not show up in CPR

S/W Lifecycle: Code/Test Language: Ada Language %: 100.00% Application: Simulation

Project Budget: 2365000 Budget Volatility: Med Size: 138837 % New/Modified Code: 100.00%

Requirements Volatility: High Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Rebaselining occurrred immediately prior to timeframe of interest. May see repercussions.

Program Manager Comments: The government may be responsible for 50% of the problems ie cost/schedule variances. Contractor has done a "competent job".

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	8/30/93	11/30/93	3/30/94	7/30/94
BCWS:	2039	2151	2194	2315
BCWP:	2036	2129	2183	2314
ACWP:	2075	2176	2276	2337
Budget:	2043	2203	2203	2365
LRE:	2082	2250	2295	2391

Derived Moderators

Budget Volatility Index: 0.15761 LRE Volatility Index: 0.1484 Percent Complete: 0.9784

BCWS Activity: 0.11922 BCWP Activity: 0.12014 ACWP Activity: 0.11211

Dependent Variables

Schedule Performance Index: 1.007246 Cost Performance Index: 1.06107

Investigator Comments:

Data Identification

OrgTag: B RatingTag: B WBS #: 4

WBSDescription: Analyze, design, and code software for software simulation system component

Rating Information

Rating Date: 1/15/94 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments: May have incentive fee on contract--did not show up in CPR

S/W Lifecycle: Code/Test Language: Ada Language %: 100.00% Application: Simulation

Project Budget: 8685000 Budget Volatility: High Size: 10150 % New/Modified Code: 100.00%

Requirements Volatility: High Rebaselining : Yes Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: In Sep 94, a reallocation of budget was detected. Prior to this, they were on budget and on schedule

Program Manager Comments: The government may be responsible for 50% of the problems ie cost/schedule variances. Contractor has done a "competent job".

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	8/30/93	Date:	11/30/93	Date:	3/30/94	Date:	7/30/94
BCWS:	1656	BCWS:	1317	BCWS:	1442	BCWS:	1972
BCWP:	1660	BCWP:	1317	BCWP:	1431	BCWP:	1955
ACWP:	1670	ACWP:	1321	ACWP:	1418	ACWP:	1951
Budget:	1378	Budget:	-60	Budget:	2554	Budget :	8685
LRE:	1393	LRE:	-46	LRE:	2573	LRE:	10085

Derived Moderators

Budget Volatility Index: 5.30261 LRE Volatility Index: 6.2398 Percent Complete: 0.2251

BCWS Activity: 0.16024 BCWP Activity: 0.1509 ACWP Activity: 0.14403

Dependent Variables

Schedule Performance Index: 0.933544 Cost Performance Index: 1.04982

Investigator Comments:

Data Identification

OrgTag: C | RatingTag: A | WBS #: 1

WBSDescription: Design, code, and test flight control software

Rating Information

Rating Date: 5/15/92 | Rating: 2 | Rating Type: SPA (EXT) | Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Production | Contract Type: FPIF

Program Comments: 70/30 Share ratio

S/W Lifecycle: Release | Language: Jovial | Language %: 100.00% | Application: Avionics

Project Budget: 3622000 | Budget Volatility: None | Size: 31000 | % New/Modified Code: 100.00%

Requirements Volatility: Low | Rebaselining : No | Quality Stds On Contract: ☐ | Quality Params Tracked : ☑

Cost Accounting Anomalies: Minimal effort--Largely complete. May not be enough effort to be a valid data point

Program Manager Comments: Additional requirements & clarifications determined to be in or out of scope. Out-of-scope requirements added as ECPs

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	11/30/91	Date:	2/28/92	Date:	7/30/92	Date:	11/30/92
BCWS:	3532	BCWS:	3532	BCWS:	3538	BCWS:	3538
BCWP:	3539	BCWP:	3539	BCWP:	3545	BCWP:	3545
ACWP:	3705	ACWP:	3716	ACWP:	3716	ACWP:	3716
Budget:	3615	Budget:	3601	Budget:	3617	Budget :	3622
LRE:	3705	LRE:	3716	LRE:	3716	LRE:	3716

Derived Moderators

Budget Volatility Index: 0.00194 | LRE Volatility Index: 0.003 | Percent Complete: 0.9787

BCWS Activity: 0.0017 | BCWP Activity: 0.00169 | ACWP Activity: 0.00296

Dependent Variables

Schedule Performance Index: 1 | Cost Performance Index: 0.54545

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level.

Data Identification

OrgTag: D RatingTag: A WBS #: 2

WBSDescription: Define requirements for each CSCI, perform updates to legacy system

Rating Information

Rating Date: 5/15/91 Rating: 1 Rating Type: SPA (EXT) Rating Relevance: High

RateComment: Information provided by Contractor (no program office intermediary)

Moderating Variables

Acquisition Phase: EMD Contract Type: CPFF

Program Comments: Program was cancelled.

S/W Lifecycle: Test/Integration Language: Jovial Language %: 100.00% Application: Other

Project Budget: 6282000 Budget Volatility: Low Size: 150000 % New/Modified Code: 60.00%

Requirements Volatility: High Rebaselining : No Quality Stds On Contract: ☑ Quality Params Tracked : ☐

Cost Accounting Anomalies:

Program Manager Comments: Program was "overcome by events" and was thus cancelled.

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	12/30/90	Date:	3/30/91	Date:	8/30/91	Date:	11/30/91
BCWS:	3823	BCWS:	4197	BCWS:	4868	BCWS:	5109
BCWP:	3639	BCWP:	4114	BCWP:	4750	BCWP:	4997
ACWP:	4581	ACWP:	5269	ACWP:	5958	ACWP:	6179
Budget:	4445	Budget:	4850	Budget:	5000	Budget :	6282
LRE:	5359	LRE:	6135	LRE:	6275	LRE:	7562

Derived Moderators

Budget Volatility Index: 0.41327 LRE Volatility Index: 0.4111 Percent Complete: 0.7954

BCWS Activity: 0.25171 BCWP Activity: 0.27176 ACWP Activity: 0.25862

Dependent Variables

Schedule Performance Index: 1.055988 Cost Performance Index: 0.84981

Investigator Comments:

Data Identification

OrgTag: E RatingTag: A WBS #: 1

WBSDescription: Design, code, test, and integration of software for flight control system

Rating Information

Rating Date: 5/15/92 Rating: 2 Rating Type: SPA (EXT) Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments: "Cost plus some base fee plus any incentive (sic) fees awarded"

S/W Lifecycle: Multiple-Early Language: Ada Language %: 100.00% Application: Avionics

Project Budget: 316251000 Budget Volatility: Low Size: 70000 % New/Modified Code: 100.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies:

Program Manager Comments: Personnel highly experienced in digital flight control systems

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	12/30/91	Date:	3/30/92	Date:	8/30/92	Date:	11/30/92
BCWS:	0	BCWS:	8175	BCWS:	21673	BCWS:	29342
BCWP:	0	BCWP:	7418	BCWP:	18553	BCWP:	26298
ACWP:	0	ACWP:	7425	ACWP:	19140	ACWP:	28359
Budget:	316251	Budget:	0	Budget:	0	Budget :	316251
LRE:	316251	LRE:	0	LRE:	0	LRE:	316251

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: 0 Percent Complete: 0.0832

BCWS Activity: 1 BCWP Activity: 1 ACWP Activity: 1

Dependent Variables

Schedule Performance Index: 0.896258 Cost Performance Index: 0.92732

Investigator Comments:

Data Identification

OrgTag: E RatingTag: A WBS #: 2

WBSDescription: Design, code, test, and integration of low-level hardware/software routines for client

Rating Information

Rating Date: 5/15/92 Rating: 2 Rating Type: SPA (EXT) Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments:

S/W Lifecycle: Multiple-Early Language: Ada Language %: 75.00% Application: Avionics

Project Budget: 45545000 Budget Volatility: Low Size: 15000 % New/Modified Code: 100.00%

Requirements Volatility: Med Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies:

Program Manager Comments: Personnel highly experienced in digital flight control systems

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	12/30/91	3/30/92	8/30/92	11/30/92
BCWS:	0	7238	13302	13756
BCWP:	0	7516	12763	11531
ACWP:	0	6796	11835	12193
Budget:	48634	0	0	45545
LRE:	48634	0	0	45545

Derived Moderators

Budget Volatility Index: -0.0635 LRE Volatility Index: -0.064 Percent Complete: 0.2532

BCWS Activity: 1 BCWP Activity: 1 ACWP Activity: 1

Dependent Variables

Schedule Performance Index: 0.838252 Cost Performance Index: 0.94571

Investigator Comments:

Data Identification

OrgTag: E RatingTag: B WBS #: 1

WBSDescription: Design, code, test, and integration of software for flight control system

Rating Information

Rating Date: 10/15/93 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments:

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Avionics

Project Budget: 262222000 Budget Volatility: High Size: 70000 % New/Modified Code: 100.00%

Requirements Volatility: Low Rebaselining : Yes Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Rephased during this period--some aberrations may be attributable to the contractor anticipating the coming rephases and delaying expenditures

Program Manager Comments: Personnel highly experienced in digital flight control systems

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/93	Date:	8/30/93	Date:	1/30/94	Date:	4/30/94
BCWS:	46194	BCWS:	54897	BCWS:	69751	BCWS:	79080
BCWP:	43675	BCWP:	52012	BCWP:	68831	BCWP:	77422
ACWP:	43806	ACWP:	51350	ACWP:	64021	ACWP:	73745
Budget:	300751	Budget:	0	Budget:	0	Budget :	262222
LRE:	300751	LRE:	0	LRE:	0	LRE:	250617

Derived Moderators

Budget Volatility Index: -0.1281 LRE Volatility Index: -0.167 Percent Complete: 0.2953

BCWS Activity: 0.41586 BCWP Activity: 0.43588 ACWP Activity: 0.40598

Dependent Variables

Schedule Performance Index: 1.026181 Cost Performance Index: 1.12719

Investigator Comments:

Note decrease in Budget and LRE during this 12 month period.

Data Identification

OrgTag: E RatingTag: B WBS #: 2

WBSDescription: Design, code, test, and integration of low-level hardware/software routines for client

Rating Information

Rating Date: 10/15/93 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments:

S/W Lifecycle: Multiple Language: Ada Language %: 75.00% Application: Avionics

Project Budget: 87704000 Budget Volatility: High Size: 15000 % New/Modified Code: 100.00%

Requirements Volatility: Med Rebaselining : Yes Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Rephased during this period--some aberrations may be attributable to the contractor anticipating the coming rephases and delaying expenditures

Program Manager Comments: Personnel highly experienced in digital flight control systems

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/93	Date:	8/30/93	Date:	1/30/94	Date:	4/30/94
BCWS:	20629	BCWS:	25284	BCWS:	33814	BCWS:	38988
BCWP:	20043	BCWP:	25515	BCWP:	32271	BCWP:	38160
ACWP:	21518	ACWP:	26902	ACWP:	34756	ACWP:	39963
Budget:	61045	Budget:	0	Budget:	0	Budget :	87704
LRE:	61045	LRE:	0	LRE:	0	LRE:	88890

Derived Moderators

Budget Volatility Index: 0.43671 LRE Volatility Index: 0.4561 Percent Complete: 0.4351

BCWS Activity: 0.47089 BCWP Activity: 0.47476 ACWP Activity: 0.46155

Dependent Variables

Schedule Performance Index: 0.986818 Cost Performance Index: 0.98222

Investigator Comments:

Note decrease in Budget and LRE during this 12 month period.

Data Identification

OrgTag: F RatingTag: A WBS #: 1

WBSDescription: Design, develop, code, test, and install 2 Flight Programs, 2 Ground Programs

Rating Information

Rating Date: 11/15/92 Rating: 2 Rating Type: SPA (EXT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments:

S/W Lifecycle: Code/Test Language: Ada Language %: 55.60% Application: Avionics

Project Budget: 12457000 Budget Volatility: Low Size: 180000 % New/Modified Code: 100.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☐

Cost Accounting Anomalies: No revised over-target baseline since 1989

Program Manager Comments: Software is in the "top 10" budget drivers, and is a key issue on the program. Subsystems well defined, but there have been integration challenges.

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	5/30/92	8/30/92	1/30/93	4/30/93
BCWS:	11122	11179	11381	11739
BCWP:	10387	10449	10598	10983
ACWP:	16937	17431	17975	18480
Budget:	11231	11231	11381	12457
LRE:	17715	18275	18260	19542

Derived Moderators

Budget Volatility Index: 0.10916 LRE Volatility Index: 0.1031 Percent Complete: 0.8817

BCWS Activity: 0.05256 BCWP Activity: 0.05427 ACWP Activity: 0.0835

Dependent Variables

Schedule Performance Index: 0.965964 Cost Performance Index: 0.38626

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: G RatingTag: A WBS #: 1

WBSDescription: Software engineering efforts to define, develop, and test system software

Rating Information

Rating Date: 12/15/90 Rating: 1 Rating Type: SPA (INT) Rating Relevance: Very High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 61.00% Application: Command & Co

Project Budget: 22788000 Budget Volatility: Low Size: 430000 % New/Modified Code: 81.00%

Requirements Volatility: High Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Stop work orders, change in direction, etc may affect performance indices

Program Manager Comments: Thinks contractor is a level 2. "Contractor is not as good as some, but better than most"

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	6/30/90	Date:	9/30/90	Date:	2/28/91	Date:	5/30/91
BCWS:	21589	BCWS:	22208	BCWS:	22775	BCWS:	22775
BCWP:	20433	BCWP:	21754	BCWP:	22665	BCWP:	22648
ACWP:	61144	ACWP:	64402	ACWP:	69137	ACWP:	72116
Budget:	22775	Budget:	22775	Budget:	22788	Budget :	22788
LRE:	66623	LRE:	68767	LRE:	78000	LRE:	77549

Derived Moderators

Budget Volatility Index: 0.00057 LRE Volatility Index: 0.164 Percent Complete: 0.9939

BCWS Activity: 0.05207 BCWP Activity: 0.0978 ACWP Activity: 0.15214

Dependent Variables

Schedule Performance Index: 1.867622 Cost Performance Index: 0.20188

Investigator Comments:

CPI moderate low outlier; SPI extreme high outlier. Investigation reveals valid data point. Negligible influence on cumulative SPI (.946 to .994). and CPI (.334 to .314).

Data Identification

OrgTag: G RatingTag: B WBS #: 1

WBSDescription: Software engineering efforts to define, develop, and test system software

Rating Information

Rating Date: 11/15/92 Rating: 2 Rating Type: SPA (EXT) Rating Relevance: Very High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 61.00% Application: Command & Co

Project Budget: 82378000 Budget Volatility: Low Size: 430000 % New/Modified Code: 81.00%

Requirements Volatility: High Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Stop work orders, change in direction, etc may affect performance indices

Program Manager Comments: Thinks contractor is a level 2 "Contractor is not as good as some, better than most"

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/92	Date:	9/30/92	Date:	2/28/93	Date:	4/30/93
BCWS:	81331	BCWS:	82091	BCWS:	82377	BCWS:	82377
BCWP:	81248	BCWP:	82095	BCWP:	82375	BCWP:	82375
ACWP:	82324	ACWP:	83712	ACWP:	85117	ACWP:	85548
Budget:	81895	Budget:	82330	Budget:	82378	Budget :	82378
LRE:	82692	LRE:	86042	LRE:	85431	LRE:	86463

Derived Moderators

Budget Volatility Index: 0.0059 LRE Volatility Index: 0.0456 Percent Complete: 1

BCWS Activity: 0.0127 BCWP Activity: 0.01368 ACWP Activity: 0.03769

Dependent Variables

Schedule Performance Index: 1.077438 Cost Performance Index: 0.34957

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: H RatingTag: A WBS #: 1

WBSDescription: Design, code, test, and integration of software CPCIs

Rating Information

Rating Date: 11/15/92 Rating: 2 Rating Type: SPA (EXT) Rating Relevance: Very High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPI

Program Comments:

S/W Lifecycle: Multiple Language: HOL Language %: 93.00% Application: Command & Co

Project Budget: 12860000 Budget Volatility: Low Size: 357714 % New/Modified Code: 69.00%

Requirements Volatility: Med Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Internal reallocated effort--"baseline rolling to the right"

Program Manager Comments: Highly concurrent effort. ECPs effectively doubled scope of the effort without stretching schedule--thus increased program schedule risk. Program Manager thinks contractor is level 2. "Not as good as some, but better than most".

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/92	Date:	8/30/92	Date:	1/30/93	Date:	4/30/93
BCWS:	2863	BCWS:	4294	BCWS:	4879	BCWS:	6178
BCWP:	2652	BCWP:	3736	BCWP:	4879	BCWP:	6124
ACWP:	2334	ACWP:	3681	ACWP:	5251	ACWP:	6483
Budget:	16112	Budget:	16421	Budget:	11609	Budget :	12860
LRE:	16112	LRE:	16421	LRE:	11609	LRE:	12860

Derived Moderators

Budget Volatility Index: -0.2018 LRE Volatility Index: -0.2018 Percent Complete: 0.4762

BCWS Activity: 0.53658 BCWP Activity: 0.56695 ACWP Activity: 0.63998

Dependent Variables

Schedule Performance Index: 1.04736 Cost Performance Index: 0.83683

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: I RatingTag: A WBS #: 1

WBSDescription: Software-Related management activities: Baselining, Software development planning, etc

Rating Information

Rating Date: 4/15/90 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment: SEI conducted the rating

Moderating Variables

Acquisition Phase: Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple-Early Language: Other Language %: 0.00% Application: Database

Project Budget: 3267000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : Yes Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: BCWS decreased in last 6 months of period

Program Manager Comments: ***NOTE*** Quality standard in this case is 2167 (tailored)--need to determine if DOD-STD-2168 or DI-QCIC-80572 is on contract.

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	10/30/89	Date:	1/30/90	Date:	6/30/90	Date:	9/30/90
BCWS:	2410	BCWS:	2602	BCWS:	2943	BCWS:	2825
BCWP:	2410	BCWP:	2602	BCWP:	2943	BCWP:	2825
ACWP:	2401	ACWP:	2538	ACWP:	2745	ACWP:	2830
Budget:	3083	Budget:	3083	Budget:	3083	Budget :	3267
LRE:	3153	LRE:	3151	LRE:	2953	LRE:	3267

Derived Moderators

Budget Volatility Index: 0.05968 LRE Volatility Index: 0.0362 Percent Complete: 0.8647

BCWS Activity: 0.1469 BCWP Activity: 0.1469 ACWP Activity: 0.15159

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index: 0.96737

Investigator Comments:

Data Identification

OrgTag: I | RatingTag: A | WBS #: 2

WBSDescription: Specification design and integration oversight tasks. Code and unit test of database architecture.

Rating Information

Rating Date: 4/15/90 | Rating: 3 | Rating Type: SPA (EXT) | Rating Relevance: High

RateComment: SEI conducted the rating

Moderating Variables

Acquisition Phase: Upgrade | Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple | Language: Ada | Language %: 100.00% | Application: Database

Project Budget: 4602000 | Budget Volatility: Low | Size: 40000 | % New/Modified Code: 15.00%

Requirements Volatility: Low | Rebaselining : No | Quality Stds On Contract: ✓ | Quality Params Tracked : ✓

Cost Accounting Anomalies: Rebaselining prior to this period does not affect this measurement

Program Manager Comments: ***NOTE*** Quality standard in this case is 2167 (tailored)--need to determine if DOD-STD-2168 or DI-QCIC-80572 is on contract

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	10/30/89	Date:	1/30/90	Date:	6/30/90	Date:	9/30/90
BCWS:	2244	BCWS:	2306	BCWS:	2568	BCWS:	2621
BCWP:	2178	BCWP:	2226	BCWP:	2452	BCWP:	2620
ACWP:	2169	ACWP:	2340	ACWP:	2582	ACWP:	2724
Budget:	3084	Budget:	3087	Budget:	3132	Budget :	4602
LRE:	3137	LRE:	3171	LRE:	3330	LRE:	4755

Derived Moderators

Budget Volatility Index: 0.4922 | LRE Volatility Index: 0.5158 | Percent Complete: 0.5693

BCWS Activity: 0.14384 | BCWP Activity: 0.1687 | ACWP Activity: 0.20374

Dependent Variables

Schedule Performance Index: 1.172414 | Cost Performance Index: 0.7964

Investigator Comments:

Data Identification

OrgTag: 1 RatingTag: A WBS #: 3

WBSDescription: Subsystem test, test planning and integration

Rating Information

Rating Date: 4/15/90 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment: SEI conducted the rating

Moderating Variables

Acquisition Phase: Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Test Language: Other Language %: 0.00% Application: Database

Project Budget: 14880000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies: Rebaselining prior to this period does not affect this measurement--increase in budget in later qtr.

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	10/30/89	1/30/90	6/30/90	9/30/90
BCWS:	5189	5892	6881	6948
BCWP:	5038	5652	6739	6949
ACWP:	5029	5698	6635	6968
Budget:	10226	10234	10374	14880
LRE:	11023	10900	11006	15773

Derived Moderators

Budget Volatility Index: 0.45511 LRE Volatility Index: 0.4309 Percent Complete: 0.467

BCWS Activity: 0.25317 BCWP Activity: 0.275 ACWP Activity: 0.27827

Dependent Variables

Schedule Performance Index: 1.086413 Cost Performance Index: 0.98556

Investigator Comments:

Data Identification

OrgTag: I RatingTag: A WBS #: 4

WBSDescription: Design, code and unit test of CSCIs

Rating Information

Rating Date: 4/15/90 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment: SEI conducted the rating

Moderating Variables

Acquisition Phase: Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 16453000 Budget Volatility: Low Size: 755600 % New/Modified Code: 78.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✔ Quality Params Tracked : ✔

Cost Accounting Anomalies: Budget increases in Sept

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	10/30/89	Date:	1/30/90	Date:	6/30/90	Date:	9/30/90
BCWS:	6253	BCWS:	6671	BCWS:	7638	BCWS:	8821
BCWP:	6013	BCWP:	6496	BCWP:	7210	BCWP:	8817
ACWP:	6379	ACWP:	7245	ACWP:	8675	ACWP:	9300
Budget:	10443	Budget:	10512	Budget:	10512	Budget :	16453
LRE:	11216	LRE:	11445	LRE:	12147	LRE:	17109

Derived Moderators

Budget Volatility Index: 0.57551 LRE Volatility Index: 0.5254 Percent Complete: 0.5359

BCWS Activity: 0.29112 BCWP Activity: 0.31802 ACWP Activity: 0.31409

Dependent Variables

Schedule Performance Index: 1.0919 Cost Performance Index: 0.95995

Investigator Comments:

Data Identification

OrgTag: I RatingTag: A WBS #: 5

WBSDescription: Design, code and unit test of CSCIs

Rating Information

Rating Date: 4/15/90 Rating: 3 Rating Type: SPA (EXT) Rating Relevance: High

RateComment: SEI conducted the rating

Moderating Variables

Acquisition Phase: Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 3822000 Budget Volatility: Low Size: 68000 % New/Modified Code: 68.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	10/30/89	Date:	1/30/90	Date:	6/30/90	Date:	9/30/90
BCWS:	2140	BCWS:	2254	BCWS:	2364	BCWS:	2362
BCWP:	2085	BCWP:	2225	BCWP:	2344	BCWP:	2356
ACWP:	2010	ACWP:	2167	ACWP:	2298	ACWP:	2352
Budget:	3056	Budget:	3077	Budget:	3077	Budget :	3822
LRE:	2983	LRE:	3032	LRE:	3095	LRE:	3822

Derived Moderators

Budget Volatility Index: 0.25065 LRE Volatility Index: 0.2813 Percent Complete: 0.6164

BCWS Activity: 0.09399 BCWP Activity: 0.11503 ACWP Activity: 0.14541

Dependent Variables

Schedule Performance Index: 1.220721 Cost Performance Index: 0.7924

Investigator Comments:

Data Identification

OrgTag: I RatingTag: B WBS #: 1

WBSDescription: Software-Related management activities: Baselining, Software development planning, etc

Rating Information

Rating Date: 10/15/91 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract converted from FPI to FPI/CPFF during this period

S/W Lifecycle: Multiple-Early Language: Other Language %: 0.00% Application: Database

Project Budget: 2521000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Med Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☐

Cost Accounting Anomalies: **INVALID DATA POINT**May have moved work during this period (Aug 91)--indicated decrease in budget and actuals

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	3054	BCWS:	2237	BCWS:	2327	BCWS:	2368
BCWP:	3054	BCWP:	2237	BCWP:	2327	BCWP:	2368
ACWP:	3080	ACWP:	2275	ACWP:	2357	ACWP:	2492
Budget:	3273	Budget:	2387	Budget:	2387	Budget :	2521
LRE:	3334	LRE:	2438	LRE:	2429	LRE:	2693

Derived Moderators

Budget Volatility Index: -0.2298 LRE Volatility Index: -0.192 Percent Complete: 0.9393

BCWS Activity: -0.2897 BCWP Activity: -0.2897 ACWP Activity: -0.236

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index: 1.16667

Investigator Comments:

INVALID DATA POINT Accumulated costs (ACWP, BCWP) moved from this project during the period of interest. Invalidates calculation of performance indices.

Data Identification

OrgTag: I RatingTag: B WBS #: 2

WBSDescription: Specification design and integration oversight tasks. Code and unit test of database architecture

Rating Information

Rating Date: 10/15/91 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract converted from FPI to FPI/CPFF during this period

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 5015000 Budget Volatility: Low Size: 45300 % New/Modified Code: 15.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☑ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	3390	BCWS:	3724	BCWS:	4157	BCWS:	4466
BCWP:	3296	BCWP:	3646	BCWP:	4099	BCWP:	4322
ACWP:	3471	ACWP:	3840	ACWP:	4405	ACWP:	4679
Budget:	4632	Budget:	4674	Budget:	4674	Budget :	5015
LRE:	4890	LRE:	5314	LRE:	5343	LRE:	5560

Derived Moderators

Budget Volatility Index: 0.08269 LRE Volatility Index: 0.137 Percent Complete: 0.8618

BCWS Activity: 0.24093 BCWP Activity: 0.23739 ACWP Activity: 0.25817

Dependent Variables

Schedule Performance Index: 0.953532 Cost Performance Index: 0.84934

Investigator Comments:

Data Identification

OrgTag: I RatingTag: B WBS #: 3

WBSDescription: Subsystem test, test planning and integration

Rating Information

Rating Date: 10/15/91 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract converted from FPI to FPI/CPFF during this period

S/W Lifecycle: Test Language: Other Language %: 0.00% Application: Database

Project Budget: 15734000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	8723	BCWS:	9700	BCWS:	11369	BCWS:	12508
BCWP:	8678	BCWP:	9584	BCWP:	11205	BCWP:	12359
ACWP:	8544	ACWP:	9510	ACWP:	11360	ACWP:	12293
Budget:	15008	Budget:	15122	Budget:	15219	Budget :	15734
LRE:	15740	LRE:	16050	LRE:	15520	LRE:	15724

Derived Moderators

Budget Volatility Index: 0.04837 LRE Volatility Index: -0.001 Percent Complete: 0.7855

BCWS Activity: 0.30261 BCWP Activity: 0.29784 ACWP Activity: 0.30497

Dependent Variables

Schedule Performance Index: 0.972523 Cost Performance Index: 0.98186

Investigator Comments:

Data Identification

OrgTag: I RatingTag: B WBS #: 4

WBSDescription: Design, code and unit test of CSCIs

Rating Information

Rating Date: 10/15/91 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract converted from FPI to FPI/CPFF during this period

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 17584000 Budget Volatility: Low Size: 874300 % New/Modified Code: 78.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✔ Quality Params Tracked : ✔

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	11876	BCWS:	13065	BCWS:	14702	BCWS:	16106
BCWP:	11470	BCWP:	12646	BCWP:	14419	BCWP:	15757
ACWP:	12621	ACWP:	14055	ACWP:	16415	ACWP:	17765
Budget:	16444	Budget:	16604	Budget:	16663	Budget :	17584
LRE:	17657	LRE:	18632	LRE:	19066	LRE:	19889

Derived Moderators

Budget Volatility Index: 0.06933 LRE Volatility Index: 0.1264 Percent Complete: 0.8961

BCWS Activity: 0.26264 BCWP Activity: 0.27207 ACWP Activity: 0.28956

Dependent Variables

Schedule Performance Index: 1.013475 Cost Performance Index: 0.8334

Investigator Comments:

Data Identification

OrgTag: I RatingTag: B WBS #: 5

WBSDescription: Design, code and unit test of CSCIs

Rating Information

Rating Date: 10/15/91 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract converted from FPI to FPI/CPFF during this period

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 3953000 Budget Volatility: Low Size: 78700 % New/Modified Code: 68.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✔ Quality Params Tracked : ✔

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	3041	BCWS:	3354	BCWS:	3722	BCWS:	3848
BCWP:	3017	BCWP:	3261	BCWP:	3595	BCWP:	3810
ACWP:	2973	ACWP:	3223	ACWP:	3664	ACWP:	3946
Budget:	3964	Budget:	4014	Budget:	4023	Budget :	3953
LRE:	3981	LRE:	4055	LRE:	4097	LRE:	4118

Derived Moderators

Budget Volatility Index: -0.0028 LRE Volatility Index: 0.034 Percent Complete: 0.9638

BCWS Activity: 0.20972 BCWP Activity: 0.20814 ACWP Activity: 0.24658

Dependent Variables

Schedule Performance Index: 0.982652 Cost Performance Index: 0.81501

Investigator Comments:

Data Identification

OrgTag: I RatingTag: B WBS #: 6

WBSDescription: Software maintenance. Design, code and unit test.

Rating Information

Rating Date: 10/15/91 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract converted from FPI to FPI/CPFF during this period

S/W Lifecycle: Multiple-Late Language: Ada Language %: 100.00% Application: Database

Project Budget: 1871000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☑ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	5/30/91	8/30/91	1/30/92	4/30/92
BCWS:	0	0	41	203
BCWP:	0	0	23	143
ACWP:	0	0	8	139
Budget:	1074	1074	1074	1871
LRE:	1289	1289	1283	2095

Derived Moderators

Budget Volatility Index: 0.74209 LRE Volatility Index: 0.6253 Percent Complete: 0.0764

BCWS Activity: 1 BCWP Activity: 1 ACWP Activity: 1

Dependent Variables

Schedule Performance Index: 0.704433 Cost Performance Index: 1.02878

Investigator Comments:

Values for minus 6 month and minus 3 month Budget and LRE are from Oct 91 CPR, which reflects first indication of activity. This was done to avoid DIV 0 errors for derived moderators.

Data Identification

OrgTag: 1 RatingTag: C WBS #: 1

WBSDescription: Software-Related management activities: Baselining, Software development planning, etc

Rating Information

Rating Date: 3/15/93 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract FPI/CPFF

S/W Lifecycle: Multiple-Early Language: Language %: 0.00% Application:

Project Budget: 2553000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Med Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☐

Cost Accounting Anomalies: Effort is winding down

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	9/30/92	Date:	12/30/92	Date:	5/30/93	Date:	8/30/93
BCWS:	2442	BCWS:	2481	BCWS:	2553	BCWS:	2553
BCWP:	2442	BCWP:	2481	BCWP:	2553	BCWP:	2553
ACWP:	2460	ACWP:	2509	ACWP:	2563	ACWP:	2587
Budget:	2558	Budget:	2558	Budget:	2553	Budget :	2553
LRE:	2625	LRE:	2595	LRE:	2601	LRE:	2687

Derived Moderators

Budget Volatility Index: -0.002 LRE Volatility Index: 0.0236 Percent Complete: 1

BCWS Activity: 0.04348 BCWP Activity: 0.04348 ACWP Activity: 0.04909

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index: 0.87402

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: 1 RatingTag: C WBS #: 2

WBSDescription: Specification design and integration oversight tasks. Code and unit test of database architecture

Rating Information

Rating Date: 3/15/93 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract FPI/CPFF

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 5142000 Budget Volatility: Low Size: 54900 % New/Modified Code: 15.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	9/30/92	Date:	12/30/92	Date:	5/30/93	Date:	8/30/93
BCWS:	4753	BCWS:	4977	BCWS:	5106	BCWS:	5118
BCWP:	4726	BCWP:	4975	BCWP:	5100	BCWP:	5105
ACWP:	5041	ACWP:	5327	ACWP:	5597	ACWP:	5715
Budget:	5156	Budget:	5156	Budget:	5142	Budget :	5142
LRE:	5652	LRE:	5715	LRE:	5659	LRE:	5759

Derived Moderators

Budget Volatility Index: -0.0027 LRE Volatility Index: 0.0189 Percent Complete: 0.9928

BCWS Activity: 0.07132 BCWP Activity: 0.07424 ACWP Activity: 0.11794

Dependent Variables

Schedule Performance Index: 1.038356 Cost Performance Index: 0.56231

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: I RatingTag: C WBS #: 3

WBSDescription: Subsystem test, test planning and integration

Rating Information

Rating Date: 3/15/93 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract FPI/CPFF

S/W Lifecycle: Test Language: Other Language %: 0.00% Application: Database

Project Budget: 15867000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☑ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	9/30/92	Date:	12/30/92	Date:	5/30/93	Date:	8/30/93
BCWS:	14279	BCWS:	14761	BCWS:	15363	BCWS:	15730
BCWP:	14204	BCWP:	14654	BCWP:	15274	BCWP:	15668
ACWP:	13708	ACWP:	14388	ACWP:	15126	ACWP:	15455
Budget:	15958	Budget:	15958	Budget:	15867	Budget :	15867
LRE:	15709	LRE:	15647	LRE:	15507	LRE:	15627

Derived Moderators

Budget Volatility Index: -0.0057 LRE Volatility Index: -0.005 Percent Complete: 0.9875

BCWS Activity: 0.09224 BCWP Activity: 0.09344 ACWP Activity: 0.11304

Dependent Variables

Schedule Performance Index: 1.008959 Cost Performance Index: 0.83801

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: I RatingTag: C WBS #: 4

WBSDescription: Design, code and unit test of CSCIs

Rating Information

Rating Date: 3/15/93 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract FPI/CPFF

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 18238000 Budget Volatility: Low Size: 1086000 % New/Modified Code: 78.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☑ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	9/30/92	Date:	12/30/92	Date:	5/30/93	Date:	8/30/93
BCWS:	17495	BCWS:	17943	BCWS:	18220	BCWS:	18233
BCWP:	17225	BCWP:	17893	BCWP:	18181	BCWP:	18216
ACWP:	19613	ACWP:	20393	ACWP:	21156	ACWP:	21540
Budget:	18286	Budget:	18263	Budget:	18238	Budget :	18238
LRE:	20531	LRE:	20859	LRE:	21366	LRE:	21639

Derived Moderators

Budget Volatility Index: -0.0026 LRE Volatility Index: 0.054 Percent Complete: 0.9988

BCWS Activity: 0.04048 BCWP Activity: 0.0544 ACWP Activity: 0.08946

Dependent Variables

Schedule Performance Index: 1.342818 Cost Performance Index: 0.51427

Investigator Comments:

Data Identification

OrgTag: I RatingTag: C WBS #: 5

WBSDescription: Design, code and unit test of CSCIs

Rating Information

Rating Date: 3/15/93 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract FPI/CPFF

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Database

Project Budget: 3951000 Budget Volatility: Low Size: 98000 % New/Modified Code: 68.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✔ Quality Params Tracked : ✔

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	9/30/92	Date:	12/30/92	Date:	5/30/93	Date:	8/30/93
BCWS:	3940	BCWS:	3952	BCWS:	3951	BCWS:	3951
BCWP:	3937	BCWP:	3952	BCWP:	3951	BCWP:	3951
ACWP:	4167	ACWP:	4238	ACWP:	4385	ACWP:	4436
Budget:	3951	Budget:	3952	Budget:	3951	Budget :	3951
LRE:	4217	LRE:	4273	LRE:	4386	LRE:	4436

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: 0.0519 Percent Complete: 1

BCWS Activity: 0.00278 BCWP Activity: 0.00354 ACWP Activity: 0.06064

Dependent Variables

Schedule Performance Index: 1.272727 Cost Performance Index: 0.05204

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level.

Data Identification

OrgTag: I RatingTag: C WBS #: 6

WBSDescription: Software maintenance. Design, code and unit test.

Rating Information

Rating Date: 3/15/93 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Upgrade Contract Type: Other

Program Comments: contract FPI/CPFF

S/W Lifecycle: Multiple-Late Language: Ada Language %: 100.00% Application: Database

Project Budget: 2521000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ✓ Quality Params Tracked : ✓

Cost Accounting Anomalies:

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	9/30/92	Date:	12/30/92	Date:	5/30/93	Date:	8/30/93
BCWS:	1193	BCWS:	1747	BCWS:	2138	BCWS:	2321
BCWP:	1079	BCWP:	1627	BCWP:	2033	BCWP:	2224
ACWP:	904	ACWP:	1334	ACWP:	1870	ACWP:	2076
Budget:	2319	Budget:	2342	Budget:	2521	Budget :	2521
LRE:	2657	LRE:	2552	LRE:	2604	LRE:	2603

Derived Moderators

Budget Volatility Index: 0.0871 LRE Volatility Index: -0.02 Percent Complete: 0.8822

BCWS Activity: 0.486 BCWP Activity: 0.51484 ACWP Activity: 0.56455

Dependent Variables

Schedule Performance Index: 1.015071 Cost Performance Index: 0.97696

Investigator Comments:

Data Identification

OrgTag: J | RatingTag: A | WBS #: 1

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 3/15/88 | Rating: 1 | Rating Type: SPA (INT) | Rating Relevance: Med

RateComment: Government-sponsored contractor did an assessment to suggest possible process improvements

Moderating Variables

Acquisition Phase: EMD | Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Requirements | Language: Jovial | Language %: 100.00% | Application: Command & Co

Project Budget: 7488000 | Budget Volatility: Low | Size: 148000 | % New/Modified Code: 100.00%

Requirements Volatility: Low | Rebaselining : No | Quality Stds On Contract: ☐ | Quality Params Tracked : ☑

Cost Accounting Anomalies: None

Program Manager Comments: Beat target sched. Had experience with previous similar project, but subcontracted the software development. Fell behind early in project, but instituted process improvement initiatives and got well. Size in DSI

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	4/30/88	7/30/88	12/30/88	3/30/89
BCWS:	0	0	100	675
BCWP:	0	0	86	493
ACWP:	0	0	80	486
Budget:	7488	7488	7488	7488
LRE:	7488	7488	7488	7492

Derived Moderators

Budget Volatility Index: 0 | LRE Volatility Index: 0.0005 | Percent Complete: 0.0658

BCWS Activity: 1 | BCWP Activity: 1 | ACWP Activity: 1

Dependent Variables

Schedule Performance Index: 0.73037 | Cost Performance Index: 1.0144

Investigator Comments:

Values for minus 6 month and minus 3 month Budget and LRE are from Dec 88 CPR. This was done to avoid DIV 0 errors for derived moderators. Program initiated when organization was rated. Data representative of 12 months after rating only

Data Identification

OrgTag: J RatingTag: A WBS #: 2

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 3/15/88 Rating: 1 Rating Type: SPA (INT) Rating Relevance: Med

RateComment: Government-sponsored contractor did an assessment to suggest possible process improvements

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Test/Integration Language: Jovial Language %: 100.00% Application: Simulation

Project Budget: 2557000 Budget Volatility: Low Size: 42000 % New/Modified Code: 52.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments: Beat target sched. Had experience with previous similar project, but subcontracted the software development. Fell behind early in project, but instituted process improvement initiatives and got well. Size in DSI

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	4/30/88	Date:	7/30/88	Date:	12/30/88	Date:	3/30/89
BCWS:	0	BCWS:	0	BCWS:	89	BCWS:	360
BCWP:	0	BCWP:	0	BCWP:	19	BCWP:	109
ACWP:	0	ACWP:	0	ACWP:	20	ACWP:	107
Budget:	2557	Budget:	2557	Budget:	2557	Budget :	2557
LRE:	2557	LRE:	2557	LRE:	2557	LRE:	2557

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: 0 Percent Complete: 0.0426

BCWS Activity: 1 BCWP Activity: 1 ACWP Activity: 1

Dependent Variables

Schedule Performance Index: 0.302778 Cost Performance Index: 1.01869

Investigator Comments:

Values for minus 6 month and minus 3 month Budget and LRE are from Dec 88 CPR. This was done to avoid DIV 0 errors for derived moderators. Program initiated when organization was rated. Data representative of 12 months after rating only

Data Identification

OrgTag: J RatingTag: A WBS #: 3

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 3/15/88 Rating: 1 Rating Type: SPA (INT) Rating Relevance: Med

RateComment: Government-sponsored contractor did an assessment to suggest possible process improvements

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Requirements Language: Fortran Language %: 100.00% Application: Command & Co

Project Budget: 3283000 Budget Volatility: Low Size: 141000 % New/Modified Code: 91.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: Subcontracting plan did not materialize--thus more effort expended than budgeted

Program Manager Comments: Beat target sched. Had experience with previous similar project, but subcontracted the software development. Fell behind early in project, but instituted process improvement initiatives and got well. Size in DSI

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	4/30/88	7/30/88	12/30/88	3/30/89
BCWS:	0	0	189	518
BCWP:	0	0	161	452
ACWP:	0	0	164	419
Budget:	3284	3284	3284	3284
LRE:	3284	3284	3284	3283

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: -0.0003 Percent Complete: 0.1376

BCWS Activity: 1 BCWP Activity: 1 ACWP Activity: 1

Dependent Variables

Schedule Performance Index: 0.872587 Cost Performance Index: 1.07876

Investigator Comments:

Values for minus 6 month and minus 3 month Budget and LRE are from Dec 88 CPR. This was done to avoid DIV 0 errors for derived moderators. Program initiated when organization was rated. Data representative of 12 months after rating only

Data Identification

OrgTag: J RatingTag: B WBS #: 1

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 4/15/91 Rating: 3 Rating Type: SCE Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Test/Integration Language: Jovial Language %: 100.00% Application: Command & Co

Project Budget: 7998000 Budget Volatility: Low Size: 148000 % New/Modified Code: 100.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments: Beat target sched. Size in DSI

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	10/30/90	Date:	1/30/91	Date:	6/30/91	Date:	9/30/91
BCWS:	6521	BCWS:	7255	BCWS:	7928	BCWS:	7998
BCWP:	6671	BCWP:	7260	BCWP:	7853	BCWP:	8000
ACWP:	6962	ACWP:	7697	ACWP:	8198	ACWP:	8207
Budget:	7930	Budget:	7985	Budget:	7998	Budget :	7998
LRE:	7820	LRE:	7985	LRE:	8201	LRE:	8201

Derived Moderators

Budget Volatility Index: 0.00858 LRE Volatility Index: 0.0487 Percent Complete: 1.0003

BCWS Activity: 0.18467 BCWP Activity: 0.16613 ACWP Activity: 0.1517

Dependent Variables

Schedule Performance Index: 0.899797 Cost Performance Index: 1.06747

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: J RatingTag: B WBS #: 2

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 4/15/91 Rating: 3 Rating Type: SCE Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Test/Integration Language: Jovial Language %: 100.00% Application: Simulation

Project Budget: 2654000 Budget Volatility: Low Size: 42000 % New/Modified Code: 52.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments: Beat target sched. Size in DSI

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	10/30/90	Date:	1/30/91	Date:	6/30/91	Date:	9/30/91
BCWS:	2315	BCWS:	2450	BCWS:	2628	BCWS:	2654
BCWP:	2217	BCWP:	2382	BCWP:	2628	BCWP:	2655
ACWP:	2015	ACWP:	2152	ACWP:	2235	ACWP:	2236
Budget:	2654	Budget:	2654	Budget:	2654	Budget :	2654
LRE:	2563	LRE:	2320	LRE:	2235	LRE:	2235

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: -0.128 Percent Complete: 1.0004

BCWS Activity: 0.12773 BCWP Activity: 0.16497 ACWP Activity: 0.0988

Dependent Variables

Schedule Performance Index: 1.292035 Cost Performance Index: 1.9819

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: J RatingTag: B WBS #: 3

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 4/30/91 Rating: 3 Rating Type: SCE Rating Relevance: Med

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Test/Integration Language: Fortran Language %: 100.00% Application: Command & Co

Project Budget: 3432000 Budget Volatility: Low Size: 141000 % New/Modified Code: 91.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies:

Program Manager Comments: Beat target sched. Size in DSI

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	10/30/90	1/30/91	6/30/91	9/30/91
BCWS:	3009	3171	3400	3432
BCWP:	2880	3086	3406	3433
ACWP:	3252	3395	3506	3508
Budget:	3432	3432	3432	3432
LRE:	3497	3497	3513	3507

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: 0.0029 Percent Complete: 1.0003

BCWS Activity: 0.12325 BCWP Activity: 0.16108 ACWP Activity: 0.07298

Dependent Variables

Schedule Performance Index: 1.307329 Cost Performance Index: 2.16016

Investigator Comments:

Selected for model validation.

Data Identification

OrgTag: J | RatingTag: C | WBS #: 1

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 11/15/91 | Rating: 3 | Rating Type: SCE | Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD | Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Integration | Language: Jovial | Language %: 100.00% | Application: Command & Co

Project Budget: 7998000 | Budget Volatility: Low | Size: 148000 | % New/Modified Code: 100.00%

Requirements Volatility: Low | Rebaselining : No | Quality Stds On Contract: ☐ | Quality Params Tracked : ☑

Cost Accounting Anomalies: Very little effort over the period of interest--Actuals over period only .3% of actuals to date--will affect CPI

Program Manager Comments: Beat target sched. Size in DSI

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	7852	BCWS:	7998	BCWS:	7998	BCWS:	7998
BCWP:	7769	BCWP:	7998	BCWP:	7997	BCWP:	7998
ACWP:	8171	ACWP:	8201	ACWP:	8195	ACWP:	8195
Budget:	7998	Budget:	7998	Budget:	7998	Budget :	7998
LRE:	8186	LRE:	8201	LRE:	8204	LRE:	8195

Derived Moderators

Budget Volatility Index: 0 | LRE Volatility Index: 0.0011 | Percent Complete: 1

BCWS Activity: 0.01825 | BCWP Activity: 0.02863 | ACWP Activity: 0.00293

Dependent Variables

Schedule Performance Index: 1.568493 | Cost Performance Index: 9.54167

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level.

Data Identification

OrgTag: J RatingTag: C WBS #: 2

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 11/15/91 Rating: 3 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Integration Language: Jovial Language %: 100.00% Application: Simulation

Project Budget: 2654000 Budget Volatility: Size: 0 % New/Modified Code: 52.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No effort for this WBS over the time period of interest--may affect performance indices

Program Manager Comments: Beat target sched. Size in DSI

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	2605	BCWS:	2654	BCWS:	2654	BCWS:	2654
BCWP:	2605	BCWP:	2654	BCWP:	2654	BCWP:	2654
ACWP:	2233	ACWP:	2235	ACWP:	2233	ACWP:	2233
Budget:	2654	Budget:	2654	Budget:	2654	Budget :	2654
LRE:	2235	LRE:	2235	LRE:	2235	LRE:	2233

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: -0.0009 Percent Complete: 1

BCWS Activity: 0.01846 BCWP Activity: 0.01846 ACWP Activity: 0

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index:

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level.

Data Identification

OrgTag: J RatingTag: C WBS #: 3

WBSDescription: Develop requirements, design, code, and test system software

Rating Information

Rating Date: 11/15/91 Rating: 3 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments: Follow-on to previous similar efforts

S/W Lifecycle: Integration Language: Fortran Language %: 100.00% Application: Command & Co

Project Budget: 3432000 Budget Volatility: Low Size: 141000 % New/Modified Code: 91.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: Little effort for this WBS over the time period of interest--may affect performance indices

Program Manager Comments: Beat target sched. Size in DSI

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/91	Date:	8/30/91	Date:	1/30/92	Date:	4/30/92
BCWS:	3366	BCWS:	3432	BCWS:	3432	BCWS:	3432
BCWP:	3363	BCWP:	3432	BCWP:	3431	BCWP:	3432
ACWP:	3493	ACWP:	3507	ACWP:	3506	ACWP:	3506
Budget:	3432	Budget:	3432	Budget:	3432	Budget :	3432
LRE:	3513	LRE:	3507	LRE:	3507	LRE:	3506

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: -0.002 Percent Complete: 1

BCWS Activity: 0.01923 BCWP Activity: 0.0201 ACWP Activity: 0.00371

Dependent Variables

Schedule Performance Index: 1.045455 Cost Performance Index: 5.30769

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level.

Data Identification

OrgTag: K RatingTag: A WBS #: 2

WBSDescription: Subsystem architecture, database administration, and software configuration management.

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: N/A Language %: 0.00% Application: Database

Project Budget: 8451000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	6/30/89	Date:		Date:		Date:	5/30/90
BCWS:	6767	BCWS:	0	BCWS:		BCWS:	7863
BCWP:	6755	BCWP:	0	BCWP:		BCWP:	7821
ACWP:	7060	ACWP:	0	ACWP:		ACWP:	8288
Budget:	7475	Budget:	0	Budget:		Budget :	8451
LRE:	7684	LRE:	0	LRE:		LRE:	8714

Derived Moderators

Budget Volatility Index: 0.13057 LRE Volatility Index: 0.134 Percent Complete: 0.9255

BCWS Activity: 0.13939 BCWP Activity: 0.1363 ACWP Activity: 0.14817

Dependent Variables

Schedule Performance Index: 0.972628 Cost Performance Index: 0.86808

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: A WBS #: 3

WBSDescription: Overall mangement of software development effort

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: N/A Language %: 0.00% Application: Database

Project Budget: 3205000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	6/30/89	Date:		Date:		Date:	5/30/90
BCWS:	2025	BCWS:	0	BCWS:	0	BCWS:	2824
BCWP:	2025	BCWP:	0	BCWP:	0	BCWP:	2824
ACWP:	2071	ACWP:	0	ACWP:	0	ACWP:	2727
Budget:	2237	Budget:	0	Budget:	0	Budget :	3205
LRE:	2334	LRE:	0	LRE:	0	LRE:	3351

Derived Moderators

Budget Volatility Index: 0.43272 LRE Volatility Index: 0.4357 Percent Complete: 0.8811

BCWS Activity: 0.28293 BCWP Activity: 0.28293 ACWP Activity: 0.24056

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index: 1.21799

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: A WBS #: 4

WBSDescription: Requirements, design, code, and test of system control CSCI

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 2440000 Budget Volatility: Low Size: 22400 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	6/30/89			5/30/89
BCWS:	2158	0	0	2440
BCWP:	2160	0	0	2416
ACWP:	2158	0	0	2334
Budget:	2415	0	0	2440
LRE:	2412	0	0	2437

Derived Moderators

Budget Volatility Index: 0.01035 LRE Volatility Index: 0.0104 Percent Complete: 0.9902

BCWS Activity: 0.11557 BCWP Activity: 0.10596 ACWP Activity: 0.07541

Dependent Variables

Schedule Performance Index: 0.907801 Cost Performance Index: 1.45455

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: A WBS #: 5

WBSDescription: Requirements, design, code, and test of systems interface CSCI

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 4238000 Budget Volatility: Low Size: 43200 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	6/30/89			5/30/90
BCWS:	2286	0	0	3268
BCWP:	2279	0	0	3167
ACWP:	2190	0	0	2989
Budget:	2581	0	0	4238
LRE:	2515	0	0	4169

Derived Moderators

Budget Volatility Index: 0.642 LRE Volatility Index: 0.6577 Percent Complete: 0.7473

BCWS Activity: 0.30049 BCWP Activity: 0.28039 ACWP Activity: 0.26731

Dependent Variables

Schedule Performance Index: 0.904277 Cost Performance Index: 1.11139

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: A WBS #: 6

WBSDescription: Requirements, design, code, and test of applications CSCI

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 2683000 Budget Volatility: Low Size: 73200 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	6/30/89			5/30/90
BCWS:	2424	0	0	2683
BCWP:	2418	0	0	2655
ACWP:	2510	0	0	2645
Budget:	2516	0	0	2683
LRE:	2609	0	0	2755

Derived Moderators

Budget Volatility Index: 0.06638 LRE Volatility Index: 0.056 Percent Complete: 0.9896

BCWS Activity: 0.09653 BCWP Activity: 0.08927 ACWP Activity: 0.05104

Dependent Variables

Schedule Performance Index: 0.915058 Cost Performance Index: 1.75556

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: A WBS #: 7

WBSDescription: Requirements, design, code, and test of database maintenance CSCI

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 2667000 Budget Volatility: Low Size: 25700 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	6/30/89			5/30/90
BCWS:	2486	0	0	2650
BCWP:	2488	0	0	2650
ACWP:	2787	0	0	2866
Budget:	2616	0	0	2667
LRE:	2991	0	0	2874

Derived Moderators

Budget Volatility Index: 0.0195 LRE Volatility Index: -0.039 Percent Complete: 0.9936

BCWS Activity: 0.06189 BCWP Activity: 0.06113 ACWP Activity: 0.02756

Dependent Variables

Schedule Performance Index: 0.987805 Cost Performance Index: 2.05063

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: A WBS #: 8

WBSDescription: Requirements, design, code, and test of database support CSCI

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 1181000 Budget Volatility: Low Size: 14200 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	6/30/89			5/30/90
BCWS:	1162	0	0	1175
BCWP:	1160	0	0	1175
ACWP:	1258	0	0	1266
Budget:	1162	0	0	1181
LRE:	1262	0	0	1277

Derived Moderators

Budget Volatility Index: 0.01635 LRE Volatility Index: 0.0119 Percent Complete: 0.9949

BCWS Activity: 0.01106 BCWP Activity: 0.01277 ACWP Activity: 0.00632

Dependent Variables

Schedule Performance Index: 1.153846 Cost Performance Index: 1.875

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level. No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: A WBS #: 9

WBSDescription: Software integration activities.

Rating Information

Rating Date: 12/15/89 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Support/Upgrade Contract Type: FPIF

Program Comments:

S/W Lifecycle: Test/Integration Language: Fortran Language %: 100.00% Application: Database

Project Budget: 5821000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	6/30/89			5/30/90
BCWS:	3009	0	0	4949
BCWP:	3002	0	0	4784
ACWP:	5287	0	0	7574
Budget:	5928	0	0	5821
LRE:	7906	0	0	8375

Derived Moderators

Budget Volatility Index: -0.018 LRE Volatility Index: 0.0593 Percent Complete: 0.8219

BCWS Activity: 0.392 BCWP Activity: 0.37249 ACWP Activity: 0.30195

Dependent Variables

Schedule Performance Index: 0.918557 Cost Performance Index: 0.77919

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: B WBS #: 2

WBSDescription: Subsystem architecture, database administration, and software configuration management.

Rating Information

Rating Date: 9/15/90 Rating: 2 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Contract Type:

Program Comments:

S/W Lifecycle: Multiple Language: N/A Language %: 0.00% Application: Database

Project Budget: 8586000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	3/30/90	Date:	6/30/90	Date:	11/30/90	Date:	2/28/91
BCWS:	7675	BCWS:	0	BCWS:		BCWS:	8503
BCWP:	7647	BCWP:	0	BCWP:		BCWP:	8490
ACWP:	8078	ACWP:	0	ACWP:		ACWP:	9002
Budget:	8451	Budget:	0	Budget:		Budget :	8586
LRE:	8695	LRE:	0	LRE:		LRE:	9122

Derived Moderators

Budget Volatility Index: 0.01597 LRE Volatility Index: 0.0491 Percent Complete: 0.9888

BCWS Activity: 0.09738 BCWP Activity: 0.09929 ACWP Activity: 0.10264

Dependent Variables

Schedule Performance Index: 1.018116 Cost Performance Index: 0.91234

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: B WBS #: 3

WBSDescription: Overall mangement of software development effort

Rating Information

Rating Date: 9/15/90 Rating: 2 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Contract Type:

Program Comments:

S/W Lifecycle: Multiple Language: N/A Language %: 0.00% Application: Database

Project Budget: 3239000 Budget Volatility: Low Size: 0 % New/Modified Code: 0.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ✓

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	3/30/90	Date:	6/30/90	Date:	11/30/90	Date:	2/28/91
BCWS:	2679	BCWS:	0	BCWS:	0	BCWS:	3211
BCWP:	2679	BCWP:	0	BCWP:	0	BCWP:	3211
ACWP:	2609	ACWP:	0	ACWP:	0	ACWP:	3116
Budget:	3205	Budget:	0	Budget:	0	Budget :	3239
LRE:	3351	LRE:	0	LRE:	0	LRE:	3197

Derived Moderators

Budget Volatility Index: 0.01061 LRE Volatility Index: -0.046 Percent Complete: 0.9914

BCWS Activity: 0.16568 BCWP Activity: 0.16568 ACWP Activity: 0.16271

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index: 1.04931

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: B WBS #: 4

WBSDescription: Requirements, design, code, and test of system control CSCI

Rating Information

Rating Date: 9/15/90 Rating: 2 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: FPIF

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 2440000 Budget Volatility: Low Size: 22400 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No effort. No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	3/30/90	6/30/90	11/30/90	2/28/91
BCWS:	2440	0	0	2440
BCWP:	2416	0	0	2440
ACWP:	2334	0	0	2334
Budget:	2440	0	0	2440
LRE:	2437	0	0	2333

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: -0.043 Percent Complete: 1

BCWS Activity: 0 BCWP Activity: 0.00984 ACWP Activity: 0

Dependent Variables

Schedule Performance Index: Cost Performance Index:

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level. No data for plus/minus three month.

Data Identification

OrgTag: K | RatingTag: B | WBS #: 5

WBSDescription: Requirements, design, code, and test of systems interface CSCI

Rating Information

Rating Date: 9/15/90 | Rating: 2 | Rating Type: SCE | Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: | Contract Type:

Program Comments:

S/W Lifecycle: Multiple | Language: Fortran | Language %: 100.00% | Application: Database

Project Budget: 4236000 | Budget Volatility: Low | Size: 43200 | % New/Modified Code: 85.00%

Requirements Volatility: Low | Rebaselining : No | Quality Stds On Contract: ☐ | Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	3/30/90	Date:	6/30/90	Date:	11/30/90	Date:	2/28/91
BCWS:	3083	BCWS:	0	BCWS:	0	BCWS:	4236
BCWP:	3019	BCWP:	0	BCWP:	0	BCWP:	4195
ACWP:	2875	ACWP:	0	ACWP:	0	ACWP:	3538
Budget:	4238	Budget:	0	Budget:	0	Budget :	4236
LRE:	4172	LRE:	0	LRE:	0	LRE:	3839

Derived Moderators

Budget Volatility Index: -0.0005 | LRE Volatility Index: -0.08 | Percent Complete: 0.9903

BCWS Activity: 0.27219 | BCWP Activity: 0.28033 | ACWP Activity: 0.18739

Dependent Variables

Schedule Performance Index: 1.019948 | Cost Performance Index: 1.77376

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: K | RatingTag: B | WBS #: 6

WBSDescription: Requirements, design, code, and test of applications CSCI

Rating Information

Rating Date: 9/15/90 | Rating: 2 | Rating Type: SCE | Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: | Contract Type:

Program Comments:

S/W Lifecycle: Multiple | Language: Fortran | Language %: 100.00% | Application: Database

Project Budget: 2683000 | Budget Volatility: Low | Size: 73200 | % New/Modified Code: 85.00%

Requirements Volatility: Low | Rebaselining : No | Quality Stds On Contract: ☐ | Quality Params Tracked : ☑

Cost Accounting Anomalies: Negligible effort during this period. No +/- three month data

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	3/30/90	6/30/90	11/30/90	2/28/91
BCWS:	2666	0	0	2683
BCWP:	2653	0	0	2667
ACWP:	2645	0	0	2649
Budget:	2683	0	0	2683
LRE:	2755	0	0	2667

Derived Moderators

Budget Volatility Index: 0 | LRE Volatility Index: -0.032 | Percent Complete: 0.994

BCWS Activity: 0.00634 | BCWP Activity: 0.00525 | ACWP Activity: 0.00151

Dependent Variables

Schedule Performance Index: 0.823529 | Cost Performance Index: 3.5

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level. No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: B WBS #: 7

WBSDescription: Requirements, design, code, and test of database maintenance CSCI

Rating Information

Rating Date: 9/15/90 Rating: 2 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Contract Type:

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 2666000 Budget Volatility: Low Size: 25700 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: Negligible effort during this period. No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	3/30/90	Date:	6/30/90	Date:	11/30/90	Date:	2/28/91
BCWS:	2650	BCWS:	0	BCWS:	0	BCWS:	2666
BCWP:	2650	BCWP:	0	BCWP:	0	BCWP:	2666
ACWP:	2866	ACWP:	0	ACWP:	0	ACWP:	2870
Budget:	2667	Budget:	0	Budget:	0	Budget :	2666
LRE:	2874	LRE:	0	LRE:	0	LRE:	2870

Derived Moderators

Budget Volatility Index: -0.0004 LRE Volatility Index: -0.001 Percent Complete: 1

BCWS Activity: 0.006 BCWP Activity: 0.006 ACWP Activity: 0.00139

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index: 4

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level. No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: B WBS #: 8

WBSDescription: Requirements, design, code, and test of database support CSC

Rating Information

Rating Date: 9/15/90 Rating: 2 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Contract Type:

Program Comments:

S/W Lifecycle: Multiple Language: Fortran Language %: 100.00% Application: Database

Project Budget: 1181000 Budget Volatility: Low Size: 14200 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: Negligible effort during this period. No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	3/30/90	Date:	6/30/90	Date:	11/30/90	Date:	2/28/91
BCWS:	1175	BCWS:	0	BCWS:	0	BCWS:	1181
BCWP:	1175	BCWP:	0	BCWP:	0	BCWP:	1181
ACWP:	1266	ACWP:	0	ACWP:	0	ACWP:	1269
Budget:	1181	Budget:	0	Budget:	0	Budget :	1181
LRE:	1277	LRE:	0	LRE:	0	LRE:	1269

Derived Moderators

Budget Volatility Index: 0 LRE Volatility Index: -0.006 Percent Complete: 1

BCWS Activity: 0.00508 BCWP Activity: 0.00508 ACWP Activity: 0.00236

Dependent Variables

Schedule Performance Index: 1 Cost Performance Index: 2

Investigator Comments:

Data point excluded from Complete Data Set due to low activity level. No data for plus/minus three month.

Data Identification

OrgTag: K RatingTag: B WBS #: 9

WBSDescription: Software integration activities.

Rating Information

Rating Date: 9/15/90 Rating: 2 Rating Type: SCE Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: Contract Type:

Program Comments:

S/W Lifecycle: Test/Integration Language: Fortran Language %: 100.00% Application: Database

Project Budget: 6874000 Budget Volatility: Low Size: 0 % New/Modified Code: 85.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: No +/- three month data

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	3/30/90	Date:	6/30/90	Date:	11/30/90	Date:	2/28/91
BCWS:	4564	BCWS:	0	BCWS:	0	BCWS:	6486
BCWP:	4426	BCWP:	0	BCWP:	0	BCWP:	6486
ACWP:	7084	ACWP:	0	ACWP:	0	ACWP:	9461
Budget:	5821	Budget:	0	Budget:	0	Budget :	6874
LRE:	7384	LRE:	0	LRE:	0	LRE:	10014

Derived Moderators

Budget Volatility Index: 0.1809 LRE Volatility Index: 0.3562 Percent Complete: 0.9436

BCWS Activity: 0.29633 BCWP Activity: 0.31761 ACWP Activity: 0.25124

Dependent Variables

Schedule Performance Index: 1.0718 Cost Performance Index: 0.86664

Investigator Comments:

No data for plus/minus three month.

Data Identification

OrgTag: L RatingTag: A WBS #: 1

WBSDescription: Generates all sytem design requirements (logic & algorithms) and software to support technology item being developed

Rating Information

Rating Date: 5/15/92 Rating: 2 Rating Type: SPA (EXT) Rating Relevance: Low

RateComment: Conducted in accordance with an SEI-licensed vendor agreement between "vendor" and SEI

Moderating Variables

Acquisition Phase: Concept Exploration Contract Type: CPI

Program Comments: 85% software, 15% hardware. Program partially terminated after technology demonstrated.

S/W Lifecycle: Multiple Language: Ada Language %: 100.00% Application: Avionics

Project Budget: 2726000 Budget Volatility: Low Size: 76636 % New/Modified Code: 100.00%

Requirements Volatility: Med Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☐

Cost Accounting Anomalies: No agreement on Estimate to Complete. Contractor may have tried to "get well" on options. Contractor took earned value early

Program Manager Comments: Requirements changes due to interfaces with associate contractor. Overruns covered by termination agreement. Language was early Ada (non-validated compiler). Contractor cited too much documentation as reason for overrun.

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	12/30/91	Date:	3/30/92	Date:	8/30/92	Date:	11/30/92
BCWS:	2246	BCWS:	2335	BCWS:	2716	BCWS:	2739
BCWP:	2025	BCWP:	2203	BCWP:	2309	BCWP:	2369
ACWP:	2937	ACWP:	3112	ACWP:	3296	ACWP:	3367
Budget:	2716	Budget:	2726	Budget:	2726	Budget :	2726
LRE:	3222	LRE:	3226	LRE:	3226	LRE:	3226

Derived Moderators

Budget Volatility Index: 0.00368 LRE Volatility Index: 0.0012 Percent Complete: 0.869

BCWS Activity: 0.17999 BCWP Activity: 0.14521 ACWP Activity: 0.12771

Dependent Variables

Schedule Performance Index: 0.697769 Cost Performance Index: 0.8

Investigator Comments:

Data Identification

OrgTag: N RatingTag: A WBS #: 1

WBSDescription: Modify existing software for new configuration

Rating Information

Rating Date: 10/15/92 Rating: 2 Rating Type: SPA (INT) Rating Relevance: High

RateComment: Performed by a former SEI employee: "borderline"

Moderating Variables

Acquisition Phase: EMD Contract Type: CPI

Program Comments:

S/W Lifecycle: Multiple-Early Language: Fortran Language %: 90.00% Application: Command & Co

Project Budget: 2230000 Budget Volatility: Low Size: 550000 % New/Modified Code: 80.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: Increasing baseline reflected through ECPs

Program Manager Comments:

Cost Data

Six Months Prior to Rating		Three Months Prior to Rating		Three Months After Rating		Six Months After Rating	
Date:	5/30/92	Date:	8/30/92	Date:	1/30/93	Date:	4/30/93
BCWS:	0	BCWS:	530	BCWS:	1688	BCWS:	2138
BCWP:	0	BCWP:	375	BCWP:	1483	BCWP:	2080
ACWP:	0	ACWP:	300	ACWP:	1138	ACWP:	1812
Budget:	2227	Budget:	2227	Budget:	2226	Budget :	2230
LRE:	2227	LRE:	2227	LRE:	2172	LRE:	2012

Derived Moderators

Budget Volatility Index: 0.00135 LRE Volatility Index: -0.097 Percent Complete: 0.9327

BCWS Activity: 1 BCWP Activity: 1 ACWP Activity: 1

Dependent Variables

Schedule Performance Index: 0.972872 Cost Performance Index: 1.1479

Investigator Comments:

Data Identification

OrgTag: N RatingTag: B WBS #: 1

WBSDescription: Modify existing software for new configuration

Rating Information

Rating Date: 9/15/93 Rating: 1 Rating Type: SCE Rating Relevance: High

RateComment: Level 1 due to QA on another program

Moderating Variables

Acquisition Phase: EMD Contract Type: CPI

Program Comments:

S/W Lifecycle: Test/Integration Language: Fortran Language %: 90.00% Application: Command & Co

Project Budget: 2268000 Budget Volatility: Low Size: 550000 % New/Modified Code: 80.00%

Requirements Volatility: Low Rebaselining : No Quality Stds On Contract: ☐ Quality Params Tracked : ☑

Cost Accounting Anomalies: Increasing baseline reflected througth ECPs

Program Manager Comments:

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	3/30/93	6/30/93	11/30/93	2/28/94
BCWS:	2025	2199	2268	2268
BCWP:	1947	2190	2257	2257
ACWP:	1694	1862	1974	2096
Budget:	2230	2268	2268	2268
LRE:	2176	2076	1995	2222

Derived Moderators

Budget Volatility Index: 0.017 LRE Volatility Index: 0.0211 Percent Complete: 0.9951

BCWS Activity: 0.10714 BCWP Activity: 0.13735 ACWP Activity: 0.19179

Dependent Variables

Schedule Performance Index: 1.27572 Cost Performance Index: 0.77114

Investigator Comments:

Data Identification

OrgTag: O RatingTag: A WBS #: 1

WBSDescription: Design, code, test, integration of all software for entire system consisting of 3 major components

Rating Information

Rating Date: 2/15/94 Rating: 1 Rating Type: SPA (INT) Rating Relevance: High

RateComment:

Moderating Variables

Acquisition Phase: EMD Contract Type: CPAF

Program Comments:

S/W Lifecycle: Design/Code Language: Ada Language %: 100.00% Application: Simulation

Project Budget: 3153000 Budget Volatility: Low Size: 130000 % New/Modified Code: 100.00%

Requirements Volatility: Med Rebaselining : No Quality Stds On Contract: ✔ Quality Params Tracked : ✔

Cost Accounting Anomalies:

Program Manager Comments: Company does not have domain expertise. ECPs drivers of cost growth.

Cost Data

	Six Months Prior to Rating	Three Months Prior to Rating	Three Months After Rating	Six Months After Rating
Date:	8/30/93	11/30/93	4/30/94	7/30/94
BCWS:	1561	1874	2767	2943
BCWP:	1431	1609	2077	2192
ACWP:	2448	3327	4725	5669
Budget:	2889	2900	2950	3153
LRE:	4392	5378	6703	6980

Derived Moderators

Budget Volatility Index: 0.09138 LRE Volatility Index: 0.5893 Percent Complete: 0.6952

BCWS Activity: 0.46959 BCWP Activity: 0.34717 ACWP Activity: 0.56818

Dependent Variables

Schedule Performance Index: 0.550651 Cost Performance Index: 0.23626

Investigator Comments:

Appendix B: Data Supporting Analysis of Complete Data Set

This appendix contains the complete set of plots used to support the assumptions of normality. The plots were constructed by the statistical software package, *Statistix for Windows.*

1. Box Plots of CPI and SPI

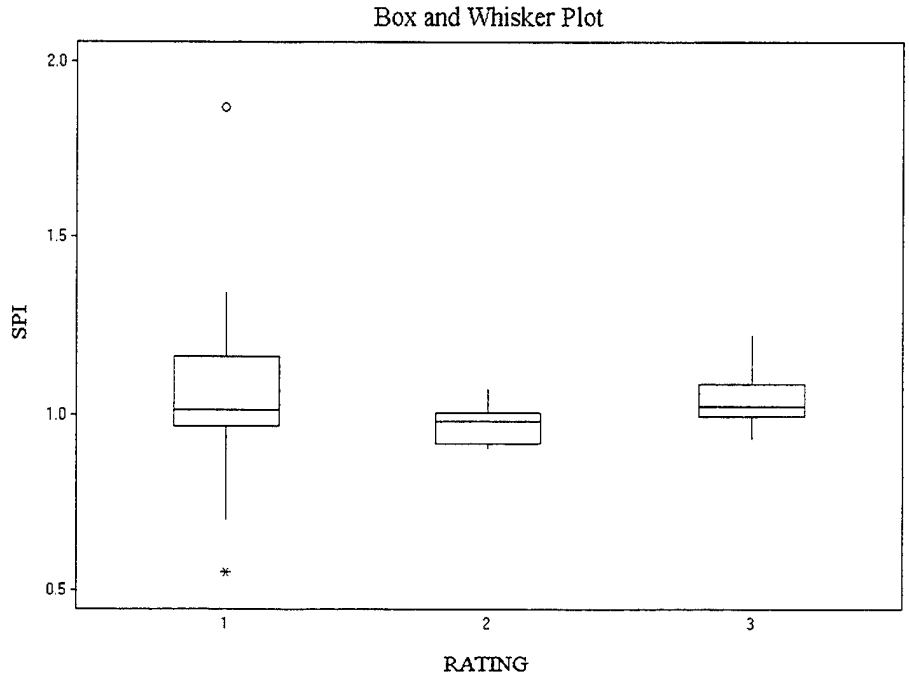

Figure B-1 Box Plot of SPI for Complete Data Set

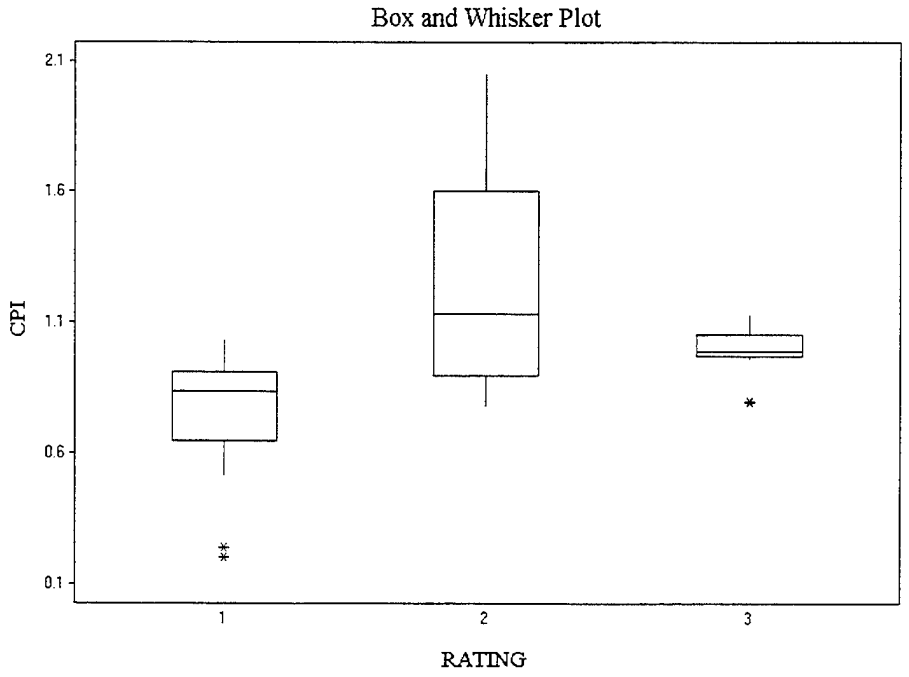

Figure B-2 Box Plot of CPI for Complete Data Set

2. Wilk-Shapiro evaluation of normality at each level

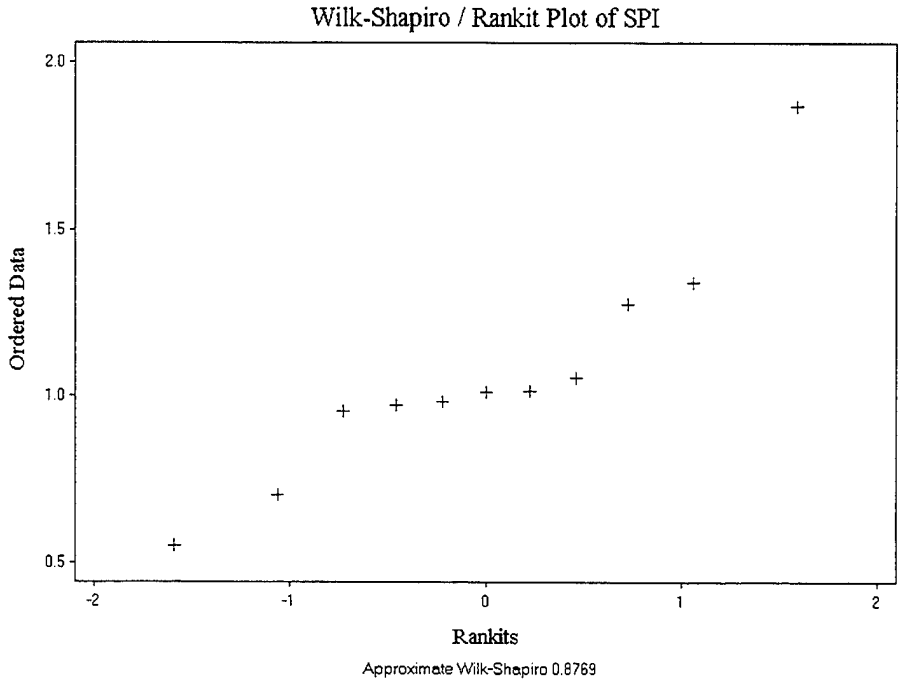

Figure B-3 Wilk-Shapiro Plot for SPI at Rating Level One for Complete Data Set

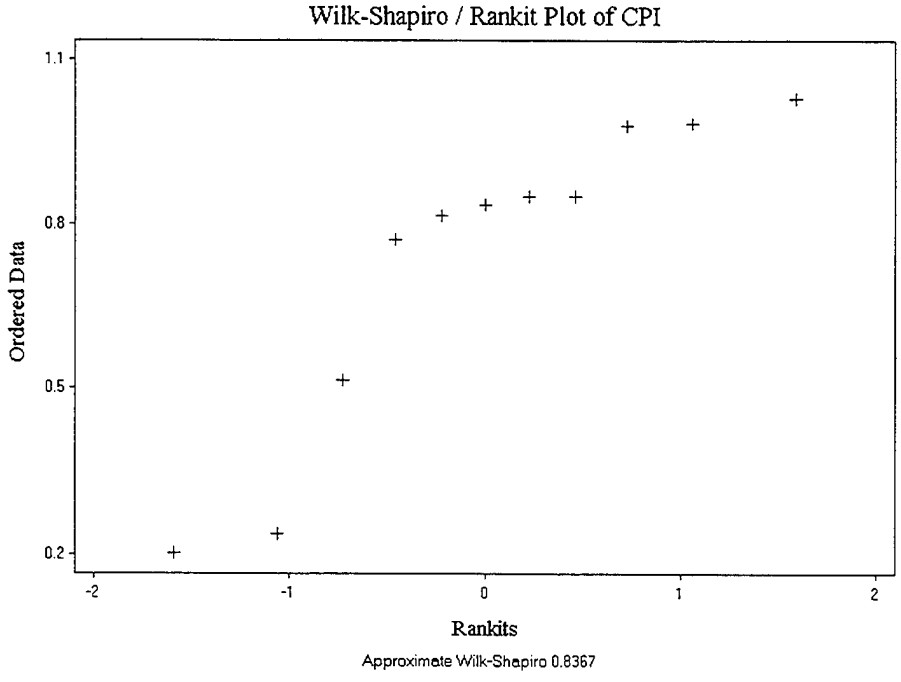

Figure B-4 Wilk-Shapiro Plot for CPI at Rating Level One for Complete Data Set

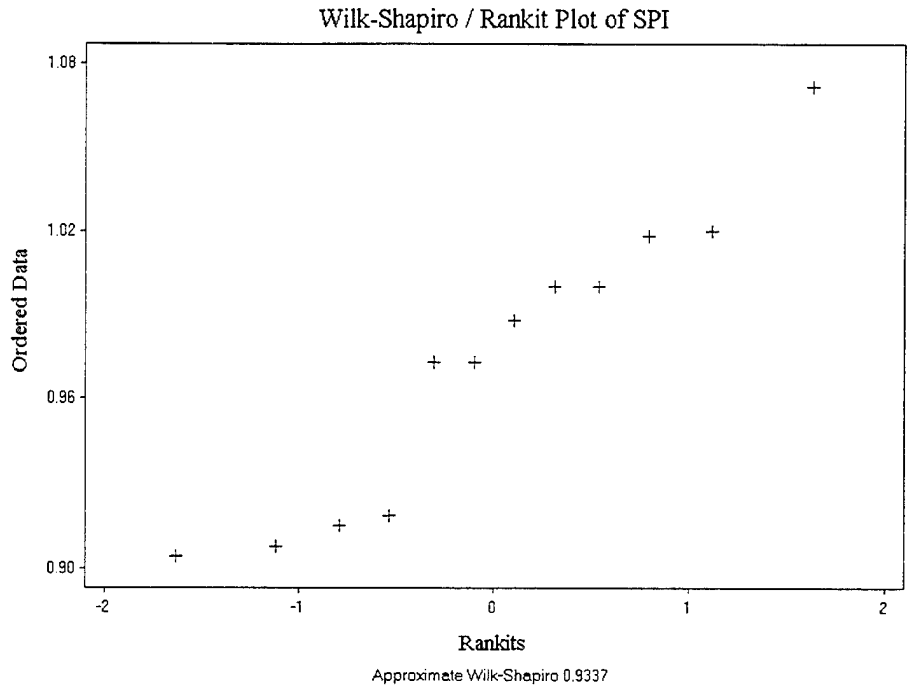

Figure B-5 Wilk-Shapiro Plot of SPI at Rating Level 2 for Complete Data Set

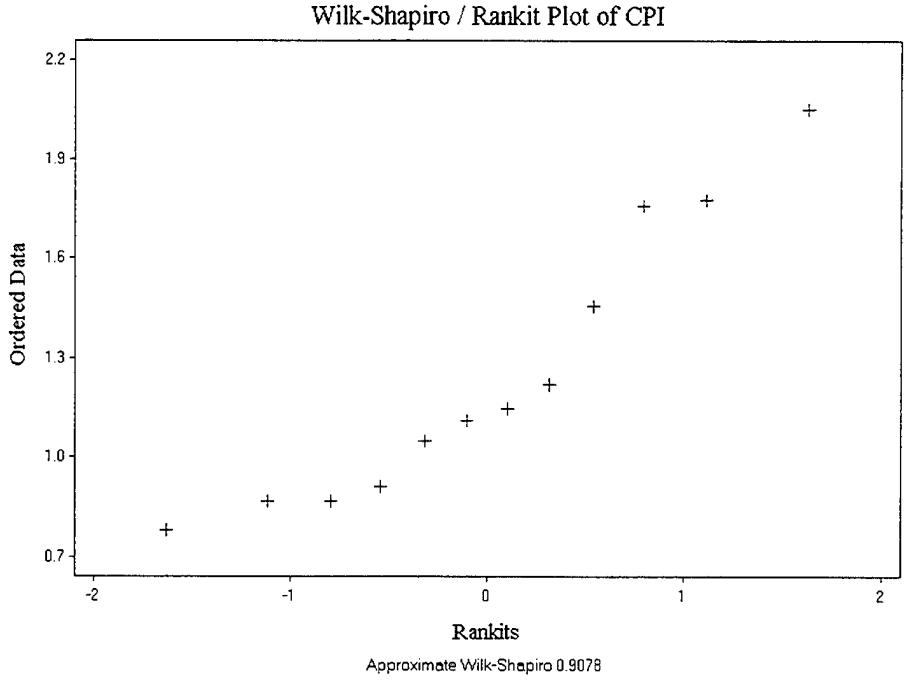

Figure B-6 Wilk-Shapiro Plot of CPI at Rating Level 2 for Complete Data Set

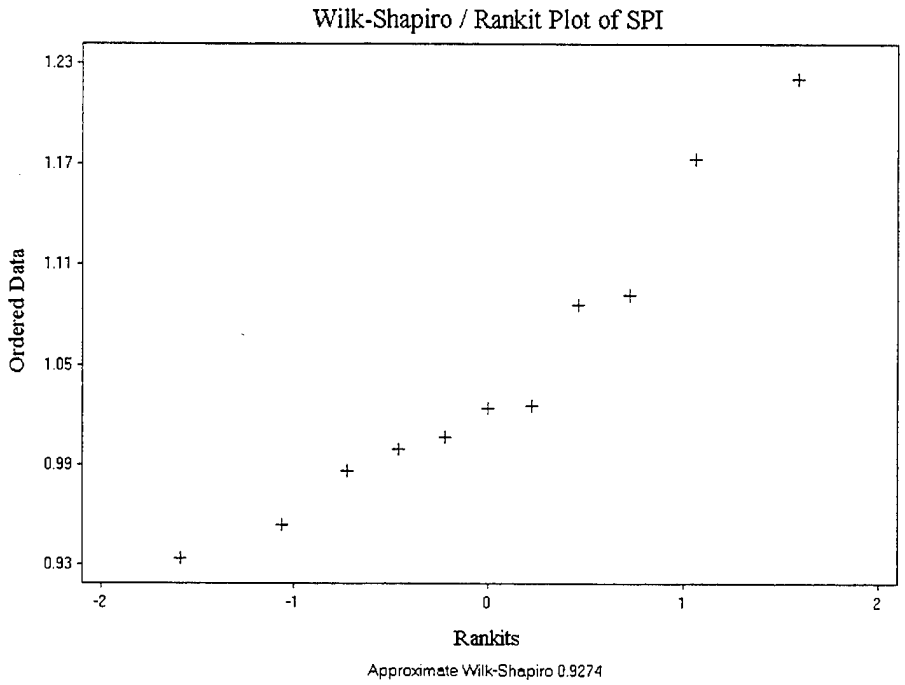

Figure B-7 Wilk-Shapiro Plot of SPI at Rating Level 3 for Complete Data Set

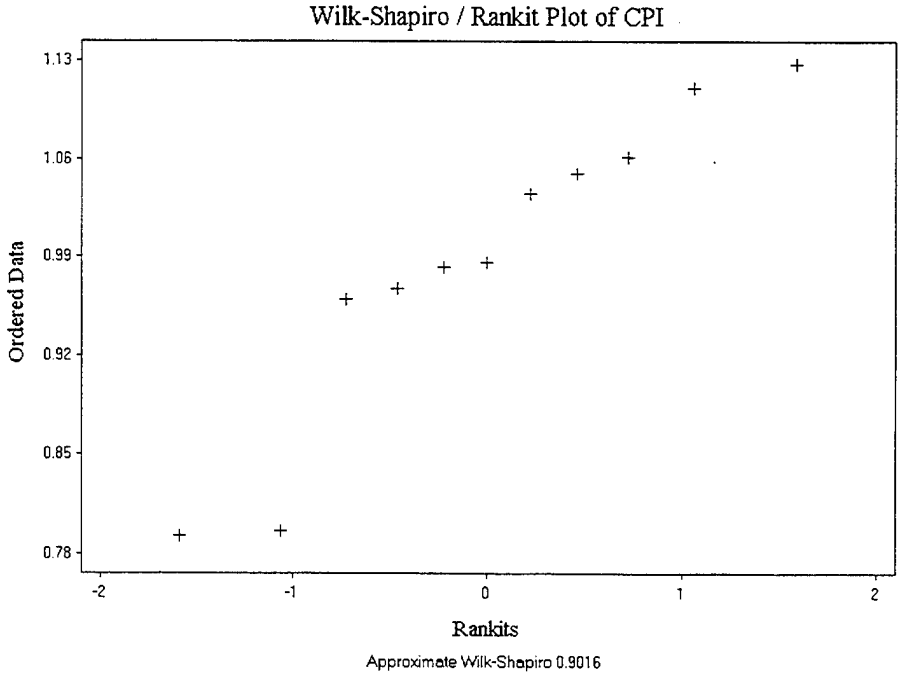

Figure B-8 Wilk-Shapiro Plot of CPI at Rating Level 3 for Complete Data Set

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Vita

Lieutenant Schaefer was born in Richmond Heights, Ohio, on 25 July 1967. He attended Eastlake North High School in Eastlake, Ohio, graduating in 1985. After high school, Lieutenant Schaefer attended Cleveland State University in Cleveland, Ohio. While pursuing an undergraduate degree in computer engineering, Lieutenant Schaefer worked for Reliance Electric in the software research and development department as part of the cooperative education program.

While still an undergraduate, Lieutenant Schaefer enlisted in the Air Force on 25 May 1989. After finishing basic training at Lackland Air Force Base, Texas, and technical school at Keesler Air Force Base, Mississippi, he was assigned to the 38th tactical reconnaissance wing, 26th aircraft generation squadron Zweibruecken, Germany as a Guidance and Control Systems Specialist for the RF-4C aircraft. After closure of the base, Lieutenant Schaefer was assigned to Charleston Air Force Base, Charleston, South Carolina to work on the C-141 aircraft.

While there, Lieutenant Schaefer separated from the Air Force to join the Air Force Reserve Officer Training Corp. at Charleston Southern University. Upon graduation from Charleston Southern with a Bachelors of Technology in Computer Science/Mathematics, Lieutenant Schaefer received his commission on 21 May 1994. Upon commissioning, Lieutenant Schaefer was assigned to the Developmental Programming Office at Los Angeles Air Force Base, Los Angeles, California. While

there, Lieutenant Schaefer was selected to attend the Air Force Institute of Technology in May 1996.

Lieutenant Schaefer is married to his wife of six years, Alexandra and they are currently expecting their first child.

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13. ABSTRACT (*Maximum 200 Words*)

Current methods for monitoring the performance of Department of Defense (DOD) software development contractors have not been successful in reversing the current trend of over budget and behind schedule software development. The DOD has adopted the Software Engineering Institute's (SEI's) Capability Maturity Model (CMM) as a method of determining the process maturity of a software developer with the idea that a more mature process will lead to improved cost and schedule performance. The goal of this research was to determine if a model based on the CMM rating level of a contractor could be developed and used in conjunction with statistical process control to determine if contractor performance was progressing in a satisfactory manner.

To investigate this possibility descriptive statistics were applied to historical contractor performance data and a model was established. A different set of historical data was then used to evaluate the performance of the new model. This performance was then compared to the performance of current methods of statistical control. The results obtained in this research suggest that using the CMM rating level of a contractor to set statistical control bounds is as good, and perhaps better than, the current method being employed.

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