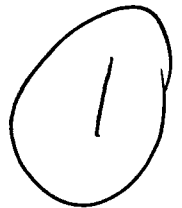


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**COST/SCHEDULE CONTROL SYSTEMS CRITERIA
A REFERENCE GUIDE TO C/SCSC INFORMATION**

THESIS

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Captain, USAF

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AFIT/GCA/LSY/92S-2

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**COST/SCHEDULE CONTROL SYSTEMS CRITERIA
A REFERENCE GUIDE TO C/SCSC INFORMATION**

THESIS

**Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Cost Analysis**

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September 1992

Approved for public release; distribution unlimited

Preface

The primary purpose of this research was to provide those in the contract performance measurement community with a guide to C/S related material and sources. At the beginning of our research effort, we both knew very little about C/SCSC and its related topics. We therefore approached our research first through an intensive literature search in order to determine what the C/S community required. As is usually the case with neophytes, we began with a vision of producing an authoritative and complete guide. It was not too far along in the process when we realized our naïveté. There is an ocean of information on this subject out there. On the positive side, however, we feel we have made a good start. We believe the relatively little amount of information we have succeeded to acquire and compile in this thesis and guide will enable those seeking information to find some of what they need, but more importantly, guide them in the right direction.

We both gratefully acknowledge the aid and support of our thesis advisors, Maj David Christensen and Dick Antolini. It is through their efforts and guidance that this work has progressed as far as it has. Finally, we would like to thank our wives, Kathy Schneider and Sophie Cummings, for all the support and patience we have received from them throughout this thesis process.

Erik G. Cummings

Kirk A. Schneider

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Abstract

This thesis effort provides a valuable tool for contract performance measurement (CPM) analysts to use both while attending formalized Cost/Schedule Control Systems Criteria (C/SCSC) training, and while on the job. Research indicated a large amount of written material existed on contract performance measurement and the more specific topic of C/SCSC, yet this information was hidden in a wide array of unindexed professional journals, master's thesis, and texts. Further, while many professions have a reference guide of annotated bibliographies, CPM had none. Through an extensive literature review using several search and retrieval methods, the authors were able to amass a bibliography of nearly 100 professional journal articles, thesis, and texts which address contract performance measurement issues within 11 more specific topic areas. While these sources do not begin to represent a census of the available information, it does represent a wide cross-section of some of the more important contributions to the performance measurement knowledge base.

The end product of this work is a stand alone C/SCSC reference guide (appendixed at the end of the main thesis body for ease in reproduction). It contains a bibliographic entry and abstract for each source, a comprehensive indexing system, and information to aid those in need of additional CPM literature. An analysis of the literature search revealed that while many journals publish articles relating to CPM, only a handful cover it in any depth, and *In Control*, published by the Performance Measurement Association, gives the subject the most attention.

COST/SCHEDULE CONTROL SYSTEMS CRITERIA A REFERENCE GUIDE TO C/SCSC INFORMATION

I. Introduction

The United States Department of Defense procurement system is probably the most complex asset acquisition system in use in the country. *Aviation Week & Space Technology* reports of the 1200 total Pentagon directives and policy memoranda on the books, 512 "directly relate to the acquisition process" (19:73). The DOD's weapon system needs are contracted out to private industry. Because the technology behind these weapons is often state of the art and these buys regularly cost billions of dollars, when the DOD asks for bids on a weapon system, interested contractors will submit a response to the government specifying the contractor's proposed design, cost, and schedule for delivery. Once the government decides on a contractor, the proposed budget and time schedule become a "base-line" or standard for the contractor to follow (15:28), but from this point and throughout the life of the contract, these terms become "open for negotiation " (2:30). Grskovich explains "during the life of a program, changes to the base line will take place almost continuously" (15:29) as the contractor pushes into new, uncharted territory and begins to research, develop, and build tomorrow's technologically advanced weapon system.

The requirement for private industry to bid on tomorrow's technology today imposes the need for a flexible base-line concept, and it is this flexibility in cost and schedule which demands an effective cost and schedule control system or *Contract Performance Measurement* device as it's more commonly called today. It is this

flexibility and accompanying control system which makes the DOD procurement system the most complicated material acquisition system any United States firm deals with.

The Need for Control. As previously mentioned, the defense atmosphere of today consists of high-technology, mega-dollar weapon systems. "During World War I, the cost of the airplanes, parts, and flying equipment assigned to the [United States Army] Air Corps was \$498,090,781" (20:1). The price of a single B-2 bomber today approaches half a billion dollars. On such a project as the B-2, the government cannot expect private firms to foot the bill for all the required R&D, nor could it burden the firms with financing a multi-billion dollar weapon system through delivery. Further, it could not expect the contractor to be able to push an unknown production timetable into an inflexible schedule. Conversely, the taxpayers are not about to write the defense contractors a blank check, nor is the Department of Defense prepared to wait forever on a weapon system they need yesterday.

To meet all these conflicting desires, the government uses the cost-type contract with an accompanying cost/schedule control system for measuring the performance of this type of contract. Cost/Schedule Control Systems Criteria (C/SCSC) (the DOD mandated control systems guidelines) has improved our performance measurement tremendously. However, it is not a panacea: it still has its problems in tracking and controlling contract costs and schedules.

Both the Government and the contractors have reservations about the system. One study by Dr. Anthony Webster from the Defense Systems Management College found that both contractors and government analysts were deficient in analyzing the performance data. It was found also that variance thresholds defined in the contracts were too restrictive or asked for the wrong information. Finally, C/SCSC training as well as implementation concepts were non-standard and not supported by top management in either the Government or in the contracted firms (27:20). Another study done by

Owen Gadeken and Thomas Tison found that contractors complained that the government did not train review teams well in C/SCSC (14). Lack of training was not due to a lack of training availability in C/SCSC. Training is offered through several DOD courses (14:17), and for those who do not have the time to attend the classes, the Government has published easily attainable regulations and guides. There is also an extensive amount of other material on C/SCSC implementation and monitoring available to aid the analyst, however, this information is difficult for the analyst to obtain.

As a result of the down-sizing of our defense budget, more and more emphasis is being placed on efficiently acquiring weapon systems. The Department of Defense mandated the use of Cost/Schedule Control Systems Criteria to aid in this endeavor. A ready source of practical information on the subject such as a reference guide can be of immense benefit and importance to the analysts who are monitoring and assisting in the C/S implementation process.

Specific Objective

Our goal is to provide those seeking information on C/SCSC with an easy to use, cross-referenced document of summarized information to augment C/SCSC training and to serve as a tool for on the job analysts.

Research Questions

In order to meet the above stated goal, several questions needed to be researched and answered. First, we had to define what subject areas will and will not be covered in the reference guide. We had to determine what C/SCSC issues and concerns are important and should be addressed in our document. Next, there was the issue of what types or classes of reporting media to reference in the guide. C/SCSC information is disclosed in everything from books dedicated solely to the topic, to

student papers which briefly mention contract performance measurement, to everything in between.

The next consideration was how to locate these sources of information. There are several data retrieval methods available to us, so we had to decide which were most appropriate and would yield the data we required. We also had to decide where to look for the information sources in terms of what information repositories to utilize.

Next, we had to decide how to summarize the data. Should we devote a paragraph or a page to each entry? Should we interpret our findings or just report them? Should we comment on the source's validity and/or importance?

Then, we needed to decide if we should include any other information in the guide in addition to the summaries, i.e. should we include a glossary, compilation of acronyms, formula section, and/or any other potentially useful information.

Finally, there was the question of how best to present our summaries in a format which would best benefit the users. What do the analysts want our referencing guide to do for them, and how do we as researchers provide this for them? Are there books available to guide us in our indexing and cross-referencing endeavor, and what do they say?

All these questions needed to be answered before we started a single summary.

Scope and Limitations

Based upon our research, we have elected to bound the scope of our project to providing a document which serves as a reference guide containing information on C/SCSC related issues. The document will be published for possible dissemination to students at the Air Force Institute of Technology, as well as for use by analysts, program management, business offices, surveillance personnel, and others have a

need for concise C/SCSC information. Informal one-on-one personal interviews have shown that there is a wealth of C/SCSC information, hidden in various libraries and available from many sources, in just about every report format available. We therefore have based our data collection on three parameters: subject, class of recording media, and location of resource. These are more thoroughly discussed in the Methodology chapter under the heading *Data Collection*.

Definition of Terms

1. Cost/Schedule Control Systems Criteria -- The Department of Defense established set of 35 "criteria that contractor information systems must meet in order to obtain the desired visibility of cost and schedule deviations which occur during the weapons system acquisition process" (20:1-2).
2. Abstract -- A concise, unbiased summary of a longer literary piece. Also called summaries (18:69-71). Usually used to determine if the original article is "worthwhile to run down" (18:421).
3. Annotated Bibliography -- An index, as in periodical index, which also gives an abstract of the literary work, in addition to author, title, source document, and other bibliographical information.
4. Taxonomy -- A classification by subject. A breakout by similarly grouped subject characteristics.
5. Cross-referencing System -- A statement usually found at the end of an abstract which directs the reader to related materials, or lists key words which may yield further information on the subject.
6. Indexing System -- A "pointer" to facilitate the researcher quickly finding the information he desires (25). Indexes can be arranged by any number of parameter to include author, title, or subject.

7. **Classes of Reporting Media** -- The mode of presenting information from the originator to the inquisitor. Examples of the more common media reporting classes are books; papers; video tapes; computer aided instruction diskettes; Department of Defense pamphlets, guides, regulations, and directives; scholarly journal articles; periodical articles; master's theses, doctoral dissertations; newspaper articles; conference minutes; and government reports.

8. **Repositories** -- Any location where information is made available to enlighten the minds of others. In this context, repositories are those libraries which potentially hold C/SCSC material.

Background

To understand the concept of performance measurement, it helps to take a step back and look at the evolution of the program we presently use. After the second world war, technology advanced at a tremendous rate. Industries produced very complex and highly technical weapon systems for our country's defense. As technology and system complexity increased, the Government's need to monitor and track the defense contractor's performance increased as well.

In 1958, we began using the first formal contract performance measurement (monitoring) tool, the Program Evaluation and Review Technique (PERT). Next, we added cost information to this system to arrive at PERT COST. For a brief period, the Air Force used the Cost/Schedule Planning Control Specifications (C/SPCS or C-Specs) until the Department of Defense instituted our present system, Cost/Schedule Control Systems Criteria (C/SCSC).

Before C/SPCS and C/SCSC, each branch of the Department of Defense often imposed individual reporting systems on contractors. These systems were separate from the contractor's in-house planning and accounting systems. Each branch of the

DOD required multiple contract defense contractors to use separate reporting systems (15:26). A big defense contractor doing business with different branches of the Department of Defense would have the problem of trying to translate performance information from their in-house system into separate formats for the separate branches of the DOD, a grievous task. On the other hand, the Government often requested contractors to submit performance data in formats which differed between program offices. Personnel who went from one program to another often had to learn a new reporting system. They had to analyze data from different contractors who used different planning and accounting systems. This was an equally grievous task. A common system for both the Department of Defense and the defense contractors became the goal.

Program Evaluation and Review Technique (PERT). In the late 1950s, the Navy used a new project planning technique, PERT, on their Polaris Missile program (23:6). PERT broke the project down into small work packages. The engineers decided the probabilistic amounts of time it would take to complete each work package and decided which work packages had to be completed before others could be started. This provided a chronology of events that had to take place to complete the project. The greatest benefit of this technique was its ability to provide a critical path to completion (14:13) and probabilistic program completion times. Whereas some tasks can be performed in parallel, the critical path exposes the chronological events that must be completed in sequence to complete the project. A slip in the schedule of a non-critical path event might not affect the completion date of the entire program. However, a slip of an event on the critical path will, by definition, extend the completion date of the entire program. PERT enabled managers to see which tasks were critical, and, if problems arose, they could concentrate their efforts on those critical path items to avoid a delay in system delivery.

Although PERT helped considerably in cutting down schedule slips, it did not provide information concerning cost over-runs or under-runs; it was strictly a schedule management tool. Also, the system remained separate from the contractor's in-house accounting and planning systems. Contractors had to develop separate staffs to analyze program data and prepare very detailed reports for the Government (14:14). This duplication of effort was not only inefficient but drove up the overhead costs on the contract (14:14).

PERT COST. The next step in the evolution process of performance management was PERT COST. PERT COST allowed budget information to be added to the schedule work packages in the PERT system (14:13). Now managers could analyze not only schedule problems but also budgeting over-runs or under-runs. PERT COST told us how much time a task should take, how much money it should cost, and how much money it actually did cost. This ability to provide budgeted and actual cost information was a great improvement over the schedule analysis exclusivity of the PERT system. Unfortunately, it retained PERT's reporting problems. We still received very detailed reports that were often too late to allow sufficient time to solve the problem, and the system still remained separate from the contractor's in-house accounting and planning systems. This duplicating effort, as in PERT, required the contractor to employ separate analysis staffs and drove up the overhead costs on the contract. What we required was a system in which the Government could get timely summary reports provided by the contractor's own in-house system in a common format.

Cost/Schedule Planning and Control Specifications (C/SPCS or C-Specs). In 1964, the Deputy for Management Systems, Assistant Secretary of the Air Force, Mr. J. Ronald Fox and Brigadier General W. E. Carter worked with McKinsey & Company to develop practical techniques and rules to measure contractor planned work value and

actual incurred costs (13:9-11). They also sought better information for estimating program completion costs. In 1966, the Air Force initiated a new performance measurement system known as Cost/Schedule Planning and Control Specifications or C-Specs (23:9). This revolutionary system aimed toward government disengagement from the contractor's day to day management and toward reliance on the contractors use of their own accounting systems (23:32). This system instituted project accounting specifications that the contractor's in-house accounting and planning systems were required to meet, and it avoided the excessive and detailed reporting of PERT and PERT COST (14:14). These specifications assured the Government much more accurate information. Before C/Specs, contractors had been making retroactive adjustments to estimates and schedules to equal their actual costs. They could avoid short-term over-runs by transferring funds from undefinitized portions of the project to definitized portions. This system also gave the Government managers better insight into the organization of contractor work groups, project teams, and organization subdivisions (16:114). In 1967, the current performance measurement system was born, Cost/Schedule Control Systems Criteria (C/SCSC) (23:9).

Cost/Schedule Control Systems Criteria (C/SCSC). C/SCSC has evolved from the Air Force's C-Specs to become the DOD wide contract performance measurement standard. Contractors use their own accounting systems; however, their systems must meet with the specified criteria. These criteria are " . . . a set of standards that a contractor's management system, whatever it may be, must meet in undertaking development of a major defense program" (3:32).

There are thirty-five criteria distributed into five groups -- organization, planning and budgeting, accounting, analysis, and revisions and access to data (11:11-B-1-2). During the source selection process, a contractor whose system has not been validated by the Government is required to propose how he will comply with the criteria.

An approved management system provides measurements of the amount of work budgeted to be completed (Budgeted Cost of Work Scheduled (BCWS)), the amount of budgeted work actually completed (Budgeted Cost of Work Performed (BCWP)), and actual costs incurred (Actual Cost of Work Performed (ACWP)). Most importantly, C/SCSC incorporates the idea of earned value (BCWP). "The C/SCSC approach to management is a significant improvement over the old conventional 'budget versus actuals' method. The concept of Earned Value requires the quantification of work progress, using objective indicators of work performed" (12:xii). One compares BCWS to BCWP to find the schedule variance between the budgeted schedule and the actual amount of work completed. Then BCWP is compared with ACWP to find the cost variance between the amount of budgeted work completed and the actual cost to complete that work. C/SCSC provides analysts with a tool to help determine cost and schedule variances between our budgets and our actuals.

When cost or schedule variances are discovered, the contractor must explain why they have occurred. To avoid massive amounts of variance analyses, the Government establishes variance thresholds in the contract. When the contractor exceeds these thresholds, the contract requires him to explain the variance and provide solutions to the problem identified.

Thesis Organization

The next chapter of this thesis contains an in-depth literature review of works pertaining to C/SCSC issues and our data presentation concerns. This chapter reflects the current concerns of C/SCSC analysts, and determines what issues and subject areas should be covered in the reference guide. An analysis of the unfulfilled information needs of C/SCSC students and analysts was conducted so that they might

be included in the document. The chapter will also reveal the preferred methods of data presentation in relation to formatting and organizing our guide.

The Methodology chapter will explain how we defined and bounded the scope of our research, and how we went about the data collection, summarization, and presentation.

The final chapter, Analysis/Conclusion, provides an analysis of the published C/SCSC material which was found. This analysis is designed to provide researchers with insight into the direction C/SCSC research is taking, as well as which publications tend to offer which subject matter. The second portion of this chapter will include a summary of the research, instructions for distribution of the guide, and recommendations for follow-on research.

The reference guide itself follows the Analysis/Conclusion chapter as a stand-alone document.

II. Literature Review

A review of contract performance measurement material reveals that although the use of Cost/Schedule Control Systems Criteria has many benefits, it also has many areas for improvement. This chapter further defines C/SCSC, lists the advantages of using the system, discusses some problems and weaknesses, proposes some alternatives to C/SCSC, and then postulates ways to make the system work. The second half of the chapter is devoted to reviewing the options for presenting and organizing C/SCSC material within the annotated bibliography format. It explores the specifics on how to properly present material, and analyzes how other scholarly reference guides and indexes are arranged.

C/SCSC Defined

Cost/Schedule Control System Criteria is a set of 35 criteria posted in Department of Defense Instruction 5000.2 for application on "significant" Department of Defense contracts. Unless waived by the Milestone Decision Authority or his representative, "significant" refers to "contracts and subcontracts within all acquisition programs, including highly sensitive classified programs and major construction programs" with a value of \$60 million or more for research, development, test, and evaluation efforts, or \$250 million for procurement contracts. The above figures are in constant fiscal year 1990 dollars (10:11-B-2). The objectives of these directives are to provide timely, accurate cost and schedule reporting for use by both the contracting agency and the contractor management (15:26). In simpler terms, Ostdiek and Estes describe it as a device "designed to insure that the contractor's internal information system would document the planning, scheduling, and accounting aspects of the

weapons acquisition process in a standardized and controlled form" (20:2). The DODI 5000.2 says the ultimate purpose of the criteria "is to foster responsible decision making" on the part of the contractor and government acquisition team (6:26). The DOD instruction was specifically written to be used as standards or guidelines for contractors to follow in modifying, if need be, their own internal information management system. This arrangement would allow the government program office to extract the performance measurements they needed without imposing another management system on top of the contractor's existing internal system (14:15).

Benefits of C/SCSC

Although some literature focuses on the negative aspects of this contract performance measurement device (20, 14, 19) it has proved for the last 24 years to be a viable alternative to 1) taking the contractor at his word that he was progressing on the contract, and 2) relying on the contractor's honesty that his stated end costs only contained "normal" profits. C/SCSC has provided DOD cost analysts a system from which they receive, normally on a monthly basis, the indicators listed in Figure 1 (presented graphically in Figure 2). Once the cost analysts analyze this data, they can then integrate their findings with technical performance outputs and report to the decision makers information on contractor progress, delays, cost overruns and important milestones.

Management Indicators

1. Costs by Work Breakdown Structure (WBS) element. The WBS breaks down a weapon system into lower and lower levels of work elements. The most simple subsystems at the lowest WBS level are called work packages. From this, the contractor assigns work to his own work force, subcontracts projects sets a schedule of subsystem completion, and apportions the total budget to the individual work packages. The contractor reports rolled up costs to the Government generally at the level three or four WBS element. This allows the cost analysts to get an overall picture of the contractor's plan and see major project completion milestones.
2. Cumulative and Present Month Budgeted Cost of Work Scheduled (BCWS) -- this tells the managers, by WBS element by month, the budgeted cost of all work scheduled up to that date.
3. Cumulative and Present Month Budgeted Cost of Work Performed (BCWP) -- this identifies the work actually complete in terms of what this amount of work is worth in budgeted dollars. When compared to BCWS, the analyst can see areas of schedule departure.
4. Cumulative and Present Month Actual Cost of Work Performed (ACWP) -- this set of figures tells the managers the amount of money the contractor or his subcontractors have spent. The analysts can compare this figure to BCWP and determine whether the contract is over, under, or right-on budget.
5. Estimate at Completion -- the contractor's "best guess" at the final cost of the contract.
6. Manhours -- the above information represented in manhours as opposed to dollars amounts.
7. Variance Analysis -- the contractor's explanation, by WBS element, of significant cost/schedule variances, and remedies.

Figure 1. C/SCSC Management Indicators

F-25 ATF FSD

Cost/Schedule Performance

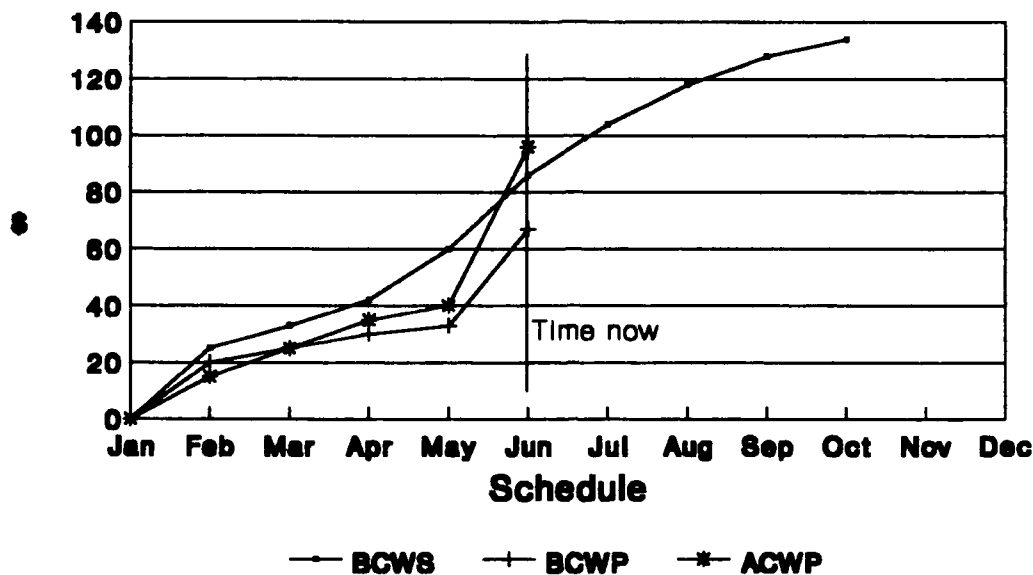


Figure 2. Cost Relationships (21:23)

Problems, Weaknesses, and Costs of C/SCSC

Despite the many benefits of this set of criteria, the experts have pointed out many areas of consternation over the system. Maj. David Christensen, Associate Professor of Accounting, Air Force Institute of Technology, suggests the problems are not in the system but instead in the people who use the system. While DODI 5000.2's stated goal was to "foster responsible decision-making" (6:26), it is up to the analysts to provide the decision makers with the proper information to make those decisions.

Along these same lines, many feel that additional training is needed both on the part of contractor managers (16) as well as the government's on-site C/SCSC review teams (14:17). Perhaps one of the most difficult obstacles in implementing a useful performance measurement system is that many of the analysts, both contractor and

government, must be re-trained to comply with the C/SCS criteria (12:285). People used to doing business a certain way, day in and day out, need to be periodically re-exposed to both new and existing C/SCSC methods. People tend to be stubborn and it is difficult to reverse their mind sets. As Fleming says, ". . . no one has yet devised a method to accomplish an 'organizational lobotomy'" (12:285). Webster and Fleming declare both contractor and government management fail to support the C/SCSC process (27:20, 12:285). Re-training top managers is another problem which must be overcome in order for a C/SCSC system to work. Frequently we find that in the high-tech defense contractor industry, top executives are engineers who have risen to the top. Out of habit, they tend to focus on technical issues versus cost and schedule problems (12:24). For C/SCSC to work, top management must support the process and executives must learn to re-prioritize their goals.

Other complaints strike at the heart of C/SCSC itself. Since its inception, managers have argued of it being too imposing upon their organization; the government was trying to run their business. Dr. Anthony Webster states the system requires too detailed, but not timely enough management data; is worded too generally to be consistently interpreted; lacks top level support; has too stringent of threshold requirements of cost and schedule variances; and requires excessive reporting procedures (27:20). Finally, one study suggests this measurement device totally ignores one of the major causes of cost overruns -- *work in progress* inventory (5:15).

Need for Contract Performance Measurement

C/SCSC helps keep cost overruns down, schedule departures to a minimum, and defense contractor profit at a fair level. Nonetheless, there are many who are calling for drastic changes to the current system. The Navy A-12 program is an example of failure in communicating cost and schedule problems to decision makers

(7). The public perceives, as does G.R. Simonson, professor of economics at California State University, the defense contractors are making far too much profit (over twice the rate they make on private sector contracts) and taking none of the risk (22:50). There are some indications, however, that more pressure is being put on contractors to perform. "The moans you hear from industry in the past few years are the moans of people facing up to the free enterprise system" boasted Secretary Lehman (4:179), but the taxpayers want more.

How to make C/SCSC Work

Major Christensen suggests analysts acquire the skills necessary to analyze (6:28). Nearly all critics call for more training for all managers involved with C/SCSC (26:11; 14:17; 27:20; 19:74). Varady proposes further economic incentives for contractors who live up to their end of the contract by complying to C/SCSC throughout the life of the contract (26:11). Finally, an annotated bibliography of works related to contract performance measurement would aid the field immensely.

Need for Reference Guide

Most academic and professional areas of interest have a set of reference materials to aid in the furtherance of their proficiency and broadening of their knowledge base. Many professional trades have their own journals dedicated to the educating and cross flow of information among the trade's members. The physicists have the *Molecular Physics* journal, hydraulic engineers can reference the *Journal of Fluid Control*, and the *Journal of Accountancy* keeps accountants informed on the latest standards. See Appendix A, this chapter for a list of those journals which frequently include articles pertaining to contract performance measurement.

Many professions also have dedicated bibliographies which at least help the tradesmen find the information they desire in other publicized materials. Defense

logisticians can locate material in the *Annual Department of Defense Bibliography of Logistical Studies*, and *Computer Abstracts* direct hackers to a wealth of computer information. Although information on performance measurement may be gleaned from databases such as the *Defense Technical Information Center (DTIC)*, *Abstracted Business Incorporated Information (ABI/INFORM)*, *Air University Index*, etc., the effort is time consuming and difficult. C/SCSC information is mixed in with multitudinous amounts of other managerial, programmatic, and accounting subjects. The contract performance measurement discipline needs its "own" bibliographic index in which to find C/SCSC references.

Ways to Present Material

The reference guide will be compiled as an annotated bibliography, or what is sometimes referred to as an "index" with abstracts. There are hundreds of examples of annotated bibliographies in subjects from chemical engineering to general accounting, and most are arranged in similar formats. After a review of the most popular annotated bibliographies, and after talking to associates, we have decided to include the following attributes within our reference guide: bibliographic entries, abstracts, cross-references, several indexes. The specific make-up of each attribute is covered in more detail below.

Bibliographic Entry. The *Air Force Institute of Technology Style Guide for Theses and Dissertations* devotes extensive discussion on what to include in bibliographic entries. Overall, depending on what information is available, the entry should include, from first to last, the author(s) names, title of work, publisher, and date of publication (9:20-25). The *Defense Logistics Bibliography*, however, lists in order: title, authors, report format, number of pages, classification, and date published (8).

Abstract. A compilation, by Maj. John Stibravy, of student papers presents many characteristics of effective abstracts, and helpful guidelines on how to write them. He states an abstract is a short condensation of the original work; "A thumbnail sketch of the whole." According to the American National Standards Institute, it is "An abbreviated, accurate representation of the contents of a document." Stibravy stresses the abstract must cover the entire document, hit all the major points, and relate the important facts on which the report's conclusions are based, for he says "There is no way of knowing how much excellent research may, in effect, be lost because of poor abstraction." It should be a self contained bird's eye view, capable of being published separately as a stand alone article. "It is meant to keep professionals informed by giving them a handle with which to grip a bulky object." He says the abstract should not use highly specialized jargon, nor contain graphics, examples, derivations, non-standard abbreviations or symbols, tables, charts, references, or pictures (24, 25).

Cross-referencing. Cross references usually appear at the ends of each abstract within the index, and provide the reader with either a specific author or article to reference, or a list of subject key words with which to start a literature research on the same or related subject. The *Defense Logistics Bibliography*, for example, lists "subject descriptors" and "key words" at the end of its abstracts (8).

Indexing. The majority of annotated bibliographies are only indexed by subject, while a few others, like the *Defense Logistics Bibliography* is indexed by the publisher's branch of service, by releasing office, author, and subject (8). The *Annotated List of Student Research Reports – Air University Library* indexes by school of origination, subject, and author (1). As indexing is a helpful, efficient tool to helping the researcher acquire needed information, indexing systems can be as elaborate as the creator wants to be accommodating.

Conclusion

Hopefully this reference guide will lead to a valuable resource for performance measurement professionals and to a more educated team of cost analysts. The end result will be a more stringent system of controlling contract costs and schedules while maintaining a strong industrial base and keeping our fighting force on the leading edge of technology.

III. Methodology

This chapter serves as a blueprint to the research conducted. Specifically, this chapter discusses the parameters which make up our research design and sampling population. Then it goes through the initial fact finding portion of the research effort, presents the data collection steps, discusses the data manipulation phase, and concludes with specifics on how the data is presented within the reference guide.

Research Design

Our research started as an exploratory review of contract performance measurement history, issues, and concerns. This review revealed the problem that cost analysts lack in-depth exposure to contract performance measurement information, and that there is no ready source of practical contract performance measurement information available to the analysts. We derived the objective of our study from this, and our research progressed into the problem of fulfilling our goal: to provide those seeking information on Cost/Schedule Control System Criteria with an easy to use, cross-referenced document of summarized information to augment C/SCSC training and to serve as a tool for analysts to use on the job. Our research has been descriptive, as we did not look for any cause and effect relationships. We have reported the information that is already available and viewed the entire collection of information as it stands now. Finally, our data analysis is qualitative as we used no statistical manipulations to make any inferences about the data we have collected.

Population. Theoretically, the population for this research could include every phrase that has ever been recorded on a subject related to contract performance measurement. When viewed in light of our research limitations, we are only taking a *convenience* sample of the population. None-the-less, we have realistically defined the

population in light of our limiting factors (see *Data Collection*, this chapter), and from this we took a *census* of the more narrowly defined population.

The above constitutes the specifics of our research design. Following are the actual steps we have taken in keeping with this design and accomplishing our object -- publishing the document, *Cost/Schedule Control System Criteria: A Reference Guide to C/SCSC Information*.

Fact Finding

Our first step in the research process was to conduct a narrative literature review of C/SCSC issues and concerns to see where the problems in C/SCSC implementation and monitoring lie. We found the major problems to be inadequate training, exposure to C/SCSC fundamentals, and lack of research tools for the analyst to use. We concluded a reference document would aid in alleviating the impact of the problems. From this, we were able to develop the research objective as stated in the Introduction.

We have conducted an in-depth narrative literature review in light of two objectives: 1. To get a general feel for the quantity, type, and location of C/SCSC information currently available in the various recorded media. 2. Solve taxonomy issues associated with the organization and presentation of the individual sources.

Data Collection

A literature review and informal one-on-one personal interviews have shown that there is a wealth of C/SCSC information hidden in various libraries and available from many sources and in just about every report format available. We therefore have had to limit our data collection by three parameters: subject, class of recording, and location of resource. We have chosen to include the following classes of reporting: books, scholarly journal articles, theses, and government publications and reports. The

thoroughness of our research has been limited to the available time. We only looked at those individual sources that are dedicated to or make a significant contribution to our specific subject area. Finally, our collection activities have been limited by physical location and/or collection technique of the individual resources. We have identified the following libraries as repositories of C/SCSC related information, and potential sources for our data collection: Air Force Institute of Technology Student Library, Aeronautical Systems Division Library, Air Force Cost Center, Air University Library, Aeronautical Systems Division Cost Data Center, Performance Measurement Association/Society of Cost Estimating and Analysis Library, and the Defense Systems Management College Library. These repositories are listed in Section 3 of the attached guide. Actual collection of hard copy data has been limited to what we have been able to acquire at AFIT.

Our data collection steps for the above stated material have been:

1. Use both manual and computer directed indexing systems to exhaust the AFIT and ASD libraries of their on-hand, indexed resources.
2. Through talking to other cost analysts, analyzing the bibliographies of C/SCSC related works, and referencing "Journals in Print" and "Books in Print" type indexes, determining which journals carry C/SCSC articles but are not indexed. Then manually searched all issues of those journals for target articles. We began with the most currently published (or available) materials, working our way back to 1967 when C/SCSC first came into being.

Data Analysis

We have reported though summaries, what each information resource provided in terms of contribution to C/SCSC implementation and monitoring. We have also classified each source by the following specific C/SCSC subject areas: C/SCSC,

Contracting Issues, C/S Software, EAC Techniques, C/S Control, Variance Analysis, C/S Reporting, C/S Utility, CPM History, Earned Value, and Foreign C/S.

Presentation

Our literature review and contacts with intended users have identified several presentation and organization preferences. In accordance with these requests the summarized materials have been presented as abstracts with an extended bibliographical citation. Within the document, the abstracts are presented in alphabetical order by last name of the author, and indexed both by author and by subject. The actual guide that contains these indices and abstracts is formatted as an appendix to the main body of the thesis. This was done to facilitate the separation of the guide from the main body of the thesis, as the guide is meant as a stand-alone document.

IV. Analysis/Conclusion/Recommendation

The primary purpose of this thesis and guide is to provide the performance measurement community with sources of information. However, in this chapter, we wish to analyze the information we have gathered during our research and perhaps bring some additional light to the C/S field.

Analysis

The abstracted materials which are found in the attached reference guide have been indexed by six subject headings which closely or directly relate to Contractor Performance Measurement, and the more specific topic of Cost/Schedule Control System Criteria. The abstracted journal articles, books, and theses fall under one or more of these subject areas, and have been indexed as such. These selected subject areas are not all inclusive, but are meant to give as broad and in-depth a coverage of Contract Performance Measurement as possible.

<i>Subject</i>	<i>Description</i>
1. C/SCSC	Those works which specifically address the DOD mandated Cost/Schedule Control Systems Criteria.
2. Contracting Issues	Those works which discuss contract types and their impact on the need for cost/schedule control.
3. C/S Software	Those works that discuss software which has been developed to aid in contract performance measurement.
4. EAC Techniques	This literature proposes or critiques various Estimate at Completion techniques.
5. C/S Control	Those works which are not necessarily directly related to C/SCSC, but cover control techniques in a broader sense.

- | | |
|----------------------|--------------------------------------------------------------------------------------------------------------|
| 6. Variance Analysis | Materials that discuss the various C/S indicators of cost and schedule performance, i.e. cost variance, etc. |
| 7. C/S Reporting | These works review the various means of reporting contract cost and schedule performance. |
| 8. C/S Utility | This literature weighs the costs and benefits of contract performance measurement. |
| 9. CPM History | Those media which cover the growth of contract performance measurement to include the evolution of C/SCSC. |
| 10. Earned Value | These materials present a means of measuring progress in terms of relevant monetary or hourly means. |
| 11. Foreign C/S | These selections review contract performance measurement as practiced abroad. |

Table 1 shows the source and quantity of articles/theses/texts which have been abstracted in the guide. Table 2 contains the source breakout by the subject area. Since a single source article can be composed of more than one subject, the total number of articles will not equal the total number under the subjects heading; for example, the article in *In Control*, "Cost Schedule Control Systems Criteria (C/SCSC) Schedule Analysis" by Capt. Catherine Ahye covers both the C/SCSC and Variance Analysis subject areas. Table 2 also provides the analyst with a quick look at which source might provide him/her with the subject type of information required.

It is apparent that the C/SCSC information and C/S Control subject areas (both general topic areas) have had the most written about them. The specific topics of Earned Value and C/S Software have also received good coverage in the literature. However, has this always been so or has a particular area become more or less important to the performance measurement community?

We believe looking at subject areas published over a period of time might help us to determine which performance measurement topics have become more or less important over the years. For our analysis, we have restricted the sources to the first six of Table 2. We have done this because we feel that a meaningful trend would not

be evident without at least five articles published per source. Table 3 displays the total number of subject areas published for the past ten years. Table 3 is somewhat misleading because not all of the six sources cover the entire ten year period. To counter this problem, we have broken out the six sources individually so as to see any trends by the individual source (Tables 4 to 9).

In Control (Table 4) is by far our largest source of data and should offer us the best chance to notice any trends. Most of the *In Control* material has been published in the C/SCSC area followed by an almost equal amount in the areas of C/S Software, EAC Techniques, C/S Control, and C/S Reporting. The C/SCSC area seems to be becoming more published beginning in 1991. Publishing of the other topics appears to have fallen since 1986/1987. *AACE Transactions* (Table 5) also offer us a large amount of data. Published subjects from this source tend to be mostly in the C/S Control and Earned Value areas and do not display any clear publishing trends. Table 6 shows the published subjects in AFIT Masters Theses are mixed with no apparent trends. Again, we see a scatter of published subjects in Table 7 with no apparent trends. We have only 1991 and 1992 data available from *The Measurable News* (Table 8)— not enough to determine a trend. Finally, subject areas are scattered in *Program Manager* (Table 9) as well, with no trends evident.

Table 1. Number of Sources Abstracted

Source	Number Abstracted
<i>In Control</i>	37
<i>AACE Transactions</i>	12
<i>AFIT Masters Theses</i>	9
<i>Managerial Texts</i>	9
<i>The Measurable News</i>	5
<i>Program Manager</i>	5
<i>Project Management Journal</i>	3
<i>Cost Engineering</i>	2
<i>National Contract Management Journal</i>	2
<i>Business Communications Review</i>	1
<i>CPA Journal</i>	1
<i>InfoWorld</i>	1
<i>Management Accounting</i>	1
<i>Manufacturing Systems</i>	1
<i>SCEA Proceedings (1992)</i>	1
<i>Software Magazine</i>	1
Total	91

Table 2. Source by Subject

Source	Subject Area	C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
<i>In Control</i>		18	1	6	6	8	3	5	2		2		51
<i>AACE Transactions</i>		2		1		12	3	1			8		27
<i>AFIT Masters Theses</i>		4	1	3	3	1		3	2	1			18
<i>Managerial Texts</i>		4	1			4					2		11
<i>The Measurable News</i>		2	2		1	1					1		7
<i>Program Manager</i>		3		1		2	1		1		1		9
<i>Project Management Jml</i>		1		1		1					1	1	5
<i>Cost Engineering</i>		1	1	1		2							5
<i>Natl Contract Mgt Journal</i>		1	1							1		1	4
<i>Business Comm. Review</i>		1											1
<i>CPA Journal</i>			1										1
<i>InfoWorld</i>				1									1
<i>Management Accounting</i>						1					1	1	3
<i>Manufacturing Systems</i>						1							1
<i>SCEA Proceedings (1992)</i>					1								1
<i>Software Magazine</i>				1		1					1		3
Totals		37	8	15	11	34	7	9	5	2	17	3	148

Table 3. Publishing Trends - Total of Six Sources

Total

	Subject Area											
	C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
1982	1				1							2
1983												
1984					1					1		2
1985	3	1	1	1						1		7
1986			1									1
1987			2	5	4	2	1			1		15
1988	3		2		6	3	3			2		19
1989	7	1			5	1	1	1		3		19
1990	2	1	1	1	2	1	2			1		11
1991	8	2	2	3	7		2			3		27
1992	7		1					2		1		11
Totals	31	5	10	10	26	7	9	3		13		114

Table 4. Publishing Trends - In Control

In Control

	Subject Area											
	C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
1982												
1983												
1984												
1985												
1986			1									1
1987			2	5	4	2	1			1		15
1988	2		1		3		3			1		10
1989	4	1										5
1990	1					1						2
1991	6		1	1	1		1					10
1992	5		1					2				8
Totals	18	1	6	6	8	3	5	2		2		51

Table 5. Publishing Trends - AACE Transactions

AACE Transactions

Year	Subject Area C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
1982												
1983												
1984												
1985												
1986												
1987												
1988	1				3	2				1		7
1989	1				4	1				3		9
1990					1					1		2
1991			1		4		1			3		9
1992												
Totals	2		1		12	3	1			8		27

Table 6. Publishing Trends - AFIT Masters Theses

AFIT Masters Theses

Year	Subject Area C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
1982												
1983												
1984												
1985	2	1	1	1								5
1986												
1987												
1988												
1989	1						1	1				3
1990			1	1			2					4
1991				1								1
1992												
Totals	3	1	2	3			3	1				13

Table 7. Publishing Trends - Managerial Texts

Managerial Texts

Year	Subject Area C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
1982					1							1
1983												
1984					1					1		2
1985	1									1		2
1986												
1987												
1988												
1989												
1990	1	1										2
1991					1							1
1992	1											1
Totals	3	1			3					2		9

Table 8. Publishing Trends - *The Measurable News*

The Measurable News

Year	Subject Area C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991	1	2		1	1							5
1992	1									1		2
Totals	2	2		1	1					1		7

Table 9. Publishing Trends - *Program Manager*

Program Manager

Year	Subject Area C/SCSC	Contracting Issues	C/S Software	EAC Techniques	C/S Control	Variance Analysis	C/S Reporting	C/S Utility	CPM History	Earned Value	Foreign C/S	Totals
1982	1											1
1983												
1984												
1985												
1986												
1987												
1988			1			1						2
1989	1				1							2
1990					1							1
1991	1											1
1992												
Totals	3		1		2	1						7

Problems With the Analysis

There are two major problems possible with the above analysis. 1) The subject areas in which the data have been classified. 2) The limited amount of data obtained. During our research we discovered what seemed to be eleven categories in which the information we found logically fell. Perhaps if the data were to be re-classified, publishing trends might be more evident. Only in the *In Control* and *AACE Transactions* sources did we acquire a decent number of data. With more data from the other sources available, perhaps trends would be found.

Conclusions

In conclusion, we have provided the performance measurement community with the beginnings of a reference guide to C/S related material and source locations. Analysis of publishing trends/interests has been inconclusive most probably because of

the above reasons. The C/S subject area is growing larger and more information is being produced daily. It is hoped that this guide will aid those seeking data in this field but more so that our preliminary work will continue.

Recommendations

We have but two recommendations:

1. Most importantly, we recommend our work continue. We believe this guide will help the C/S community, but there is much much more data to gather and there will be much much more forthcoming. We suggest others continue to compile and abstract additional sources of C/S material and incorporate this information into the existing guide. There are a number of sources which have important information which have not yet been covered by us. Also, computerization of this information would help immensely through the incorporation of this document into an electronic database for quick retrieval and searches. Such an electronic database would provide the user with a means to sort, analyze, and printout the specific information required without having to page through a hardcopy document.
2. With additional data, analyses such as we have done here could very well provide conclusive and meaningful results. Statistical analysis should be applied to the published information as well as different categorizations of the subject material.

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Vita

Captain Erik G. Cummings was born on 31 March 1961 in Denver, Colorado. In 1979, he graduated from Heritage High School in Littleton, Colorado and immediately entered the United States Marine Corps as an enlisted member. After serving four years stateside and overseas as an Aviation Ground Support Electrician, he separated from the Marines to attend the University of California at Irvine. In 1986, he graduated from UCI with a Bachelor of Arts degree in Economics. In July of 1987, he entered the Air Force Officer Training School and was commissioned a Second Lieutenant in the Air Force on 23 October, 1987. He served as a cost analyst for the SACDIN, ACCE, and C³ Integration programs in the Strategic Command Control and Communications System Program Office at Electronics System Division, Hanscom Air Force Base, Massachusetts. His final assignment before entering the Cost Analysis masters program at the Air Force Institute of Technology in May of 1991 was as Chief of Program Control for the SAC Mission Planning program. Upon graduation from AFIT, Captain Cummings will be assigned to the Air Force Cost Analysis Center in Washington DC.

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Vita

Captain Kirk A. Schneider was born in Chicago Illinois 23 August 1965, and later adopted by Charles and Mary Schneider. He graduated salutatorian from Pierce High School, Pierce Nebraska in 1987, and was offered entry to the Academies of West Point Military, United States Air Force, Annapolis Naval, and Merchant Marine. Captain Schneider choose to enter the U.S. Air Force Academy where he majored in Middle East Area Studies (with an emphasis on history) and minored in the Arabic Language. In May 1987, he graduated at the top of his class both militarily and academically, and was awarded the Bachelor of Science degree. His first assignment was to Goodfellow AFB Texas where he underwent intensive training as an Imagery Intelligence Officer. Captain Schneider excelled, and was awarded a prestigious assignment to the Naval Photographic Interpretation Center, Washington DC. Following this, he served as Deputy Chief of Public Affairs once again at Goodfellow AFB. During this assignment, he met the beautiful Kathleen McCrea, and would later take her for his wife on 20 August 1990.

Captain Schneider's first logistics assignment was to Francis E. Warren AFB Wyoming where he assumed the joint duties as Chief, Materiel Management Branch for the supply squadron, and Alternate Installation Mobility Officer for the 90th Strategic Missile Wing. He was next chosen to attend the Air Force Institute of Technology, School of Systems and Logistics, and graduated with a Masters of Science degree in Cost Analysis, 22 September 1992.

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Appendix

Attached is the major product of this thesis effort --the reference guide. This guide was purposefully published as an appendix to the main body of the thesis to facilitate its easy removal, reproduction, and use as a stand alone document. Like the thesis effort, it is also entitled *Cost/Schedule Control Systems Criteria: A Reference Guide to C/SCSC Information*. Included in this guide is a separate cover, preface, table of contents, introduction, and instructions on the use of the guide. Since this is the fruit of the research, it was appropriate to interrupt the numbering of the thesis pages at this point, and start at "1" for the first page of the guide.

COST/SCHEDULE CONTROL SYSTEMS CRITERIA
A REFERENCE GUIDE TO C/SCSC INFORMATION

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September 1992

Approved for public release; distribution unlimited

Preface

The primary purpose of this guide is to provide those in the contract performance measurement community with a clue to C/S related material and sources. At the beginning of our research effort, we both new very little about C/SCSC and its related topics. We therefore approached our research first through an intensive literature search in order to determine what the C/S community required. As is usually the case with neophytes, we began with a vision of producing an authoritative and complete guide. It was not too far along in the process when we realized our naïveté. There is an ocean of information on this subject out there. On the positive side, however, we feel we have made a good start. We believe the relatively little amount of information we have succeeded to acquire and compile in this thesis and guide will enable those seeking information to find some of what they need, but more importantly, guide them in the right direction. We can only encourage others to take up where we have left off. If they do, one day our community may have a really superb reference document.

Erik G. Cummings

Kirk A. Schneider

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Introduction

The United States Department of Defense procurement system is probably the most complex asset acquisition system in use in the country. The DOD's weapon system needs are contracted out to private industry while the technology behind these weapons is often state of the art and these buys regularly cost billions of dollars.

The requirement for private industry to bid on tomorrow's technology today imposes the need for a flexible base-line concept, and it is this flexibility in cost and schedule which demands an effective cost and schedule control system or *Contract Performance Measurement* device as it's more commonly called today. It is this flexibility and accompanying control system which makes the DOD procurement system the most complicated material acquisition system any United States firm deals with.

Our goal is to provide those seeking information on C/SCSC with an easy to use reference guide with cross-referenced documentation of summarized information to augment C/SCSC training and to serve as a tool for on the job analysts and future researchers.

Our literature review and contacts with intended users have identified several presentation and organization preferences. In accordance with these requests, the guide contains material source locations along with summarized materials which have been presented as abstracts with an extended bibliographical citation. Within the document, the abstracts are presented in alphabetical order as well as by subject area.

How to Use the Guide

The guide is broken into sections as follows:

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|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Section 1: Trade Journals | This section lists trade journals which contain C/SCSC articles and information |
| Section 2: Library Locations | Section 2 lists several libraries which hold journals, books, and reports on C/SCSC |
| Section 3: DOD Guides, Regulations, Instructions | The Department of Defense has published numerous sources of information and guidance on contractor performance measurement related topics, many of which can be found in this section |
| Section 4: Keywords used in searches | Whether searching through subject indices or gathering source material through many of the computer database services, keywords on which to search are invaluable. In this section we have provided many of the keywords which have helped us to find source material |
| Section 5: Subject Headings for Abstracts | Throughout our research, we have found that the material we located falls into several logical categories or subject areas. Section 5 lists the abstracted material first alphabetically and then by these subject areas. We have divided the material in this way to provide the user of the guide with an easy way to locate information which he/she may be seeking in a particular area. |
| Section 6: Abstracts | This section contains the abstracts, in alphabetical order of the material presented in Section 5. |

Section 1: Abstracted Trade Journals

The following are a list of those professional and trade journals and periodical publications from which reference data pertaining to contract performance measurement have been obtained and abstracted. Included with the title of each journal is the number of articles from each journal which has been abstracted in this thesis, the society/organization responsible for the journal's publication, and the place of publication.

***In Control* (37)**

Performance Management Association
101 South Whiting, Suite 201
Alexandria VA 22304
(509) 375-6652

***AACE Transactions* (11)**

American Association of Cost Engineers
P.O. Box 1557
Morgantown WV 26507
(304) 296-8444

***The Measurable News* (5)**

Performance Management Association
101 South Whiting, Suite 201
Alexandria VA 22304
(509) 375-6652

***Program Manager* (5)**

Defense Systems Management College
Fort Belvoir, VA 22060
(703) 684-5082
Printed at GPO
Washington DC 20402
(202) 783-3238

***Project Management Journal* (3)**

Project Management Institute
P.O. Box 43
Drexel Hill PA 19026
(215) 622-1796

***Cost Engineering* (2)**

American Association of Cost Engineers
P.O. Box 1557
Morgantown WV 26507
(304) 296-8444

***National Contract Management Journal* (2)**

National Contract Management Assoc.
1912 Woodford Road
Vienna VA 22180
(703) 442-0137

***Business Communications Review* (1)**

BCR Enterprises, Inc.
950 York Road
Hilldale IL 60521
(312) 986-1432

***CPA Journal* (1)**

New York State Society of CPAs
200 Park Avenue
New York NY 10166
(212) 973-8300

***InfoWorld* (1)**

IDG Communications
1060 Marsh Road
Menlo Park CA 94025

Management Accounting (1)

United Kingdom
Institute of Cost and Management Accountants
63 Portland Place
London England

Manufacturing Systems (1)

Hitchcock Publishing Co.
Hitchcock Building
Wheaton IL 60188
(312) 665-1000

Software Magazine (1)

Sentry Publishing
1900 Office Park Drive
Westborough MA 01581
(617) 366-2031

Section 2: Other Trade Journals

The following are a list of those professional and trade journals and periodical publications which routinely publish articles pertaining to contract performance measurement, but because of time limitations, were not abstracted from. Most notable as excellent sources of CPM and C/SCSC articles are those published by the Society of Cost Estimating & Analysis. Included with the title of each journal is the society/organization responsible for the journal's publication and place of publication. This is only a partial list, as many other periodicals have carried relative material.

Defense Management Journal

Office of the Assistant Secretary of Defense
716-R Church St.
Alexandria VA 22314
(202) 274-4582

Air Force Journal of Logistics

GPO
Washington DC 20402
(202) 783-3238

The Armed Forces Comptroller

American Society of Military Comptrollers
Box 132
Mount Vernon VA 22121
(703) 780-8144

National Defense

American Defense Preparedness Society
2101 Wilson Blvd
Arlington VA 22201
(703) 522-1820

Logistics Spectrum

Society of Logistics Engineers
125 W. Parkloop #201
Huntsville AL 35806
(205)837-1092

National Estimator
Society of Cost Estimating & Analysis
Alexandria VA 22304

Journal of Cost Analysis
Society of Cost Estimating & Analysis
Alexandria VA 22304

SCEA Newsletter
Society of Cost Estimating & Analysis
Alexandria VA 22304

Section 3: Library Locations

AFIT Student Library
Air Force Institute of Technology
Area B
Wright Patterson AFB OH 45433

Air Force Cost Analysis Agency
Crystal City, VI

ASC Master Reference Library
Aeronautical Systems Center
Area B, Bldg 16, Room 46 & 123
Wright Patterson AFB OH

ASC Cost Data Center
Aeronautical Systems Center
Area B, Bldg 16, Room 16
Wright Patterson AFB OH

Air University Library
Air University
Maxwell AFB, AL 36112
(205) 293-2505

Defense Systems Management College
Bldg 226
Fort Belvoir, VI 20402
(703) 664-2900

Defense Technical Information Center
Cameron Street, Bldg 5
Alexandria VA 22304
(509) 227-6833

Performance Measurement Association/
Society of Cost Estimating and Analysis Library
101 South Whiting Street, Suite 201
Alexandria VA 22304
(509) 375-6652

Section 4: Department of Defense Guides, Regulations, Instructions

This appendix lists Department of Defense sources which will provide the researcher with direction and guidance on how to implement and track contractor performance measurement through C/SCSC.

1. Air Force Systems Command. *Acquisition Management Program Control -- Financial*, AFSC Supplement 1 to AFR 800-6. Andrews AFB MD: HQ AFSC, 13 October 1981.
2. Air Force Systems Command. *C/SCSC Team Member Handbook*. Andrews AFB MD: HQ AFSC, not dated.
3. Department of Defense. *Contract Work Breakdown Structure*. DOD Data Item Description DI-A-3023/M-126-1. Washington: Government Printing Office, 21 May 1971.
4. Department of Defense. *Cost Performance Report*, DOD Data Item Description DI-F-6000C. Washington: Government Printing Office, 1 December 1979.
5. Department of Defense. *Cost/Schedule Status Report*. DOD Data Item Description DI-F-6010A. Washington: Government Printing Office, 1 November 1979.
6. Department of Defense. *Defense Acquisition Management Policies and Procedures*. DODI 5000.2. Washington: Government Printing Office, 23 February 1991.
7. Department of Defense. *Defense Acquisition Management Documentation and Reports*. DODI 5000.2-M. Washington: Government Printing Office, 23 February 1991.
8. Department of Defense. *Work Breakdown Structures for Defense Materiel Items*. Military Standard 881A. Washington: Government Printing Office, 25 April 1975.
9. Department of Defense. *Work Measurement*. Military Standard 1567A. Washington: Government Printing Office, 11 March 1983.
10. Departments of the Air Force, the Army, the Navy, the Defense Logistics Agency, and the Defense Contract Audit Agency. *Cost/Schedule Control Systems Criteria: Joint Implementation Guide*. AFSCP 173-5. Washington: Government Printing Office, 10 October 1987.

Section 5: Keywords Used in Searches

Most often, Contract Performance Measurement and Cost/Schedule Control Systems Criteria articles are printed in highly specialized journals such as *In Control* or *National Estimator*. These journals are not indexed in any of the major reference guides such as the *Air University Guide to Military Periodicals* or *Abstracted Business Incorporated - Information*; therefore, coming up with a key word to unlock a useful listing is no problem -- there is none. However, some of the more common sources of pertinent articles are referenced, but by a gambit of non-standardized words and phrases. Following is a list of some of those key words which have proved fruitful when looked up in a hard-copy index, or plugged into one of the many computerized referencing systems. Usually, capitalization does not matter, however, exact letter/number arrangement does when using the computerized data bases such as *ABI-Inform*.

C/SCSC	Cost/Schedule Control Systems
C/SCS	Cost/Schedule Control Systems Criteria
CS2	Defense Contracts
Contract Performance Measurement	Earned Value
Contracts (Defense)	Government Contracts
Control Systems	Performance Measurement
Cost Analysis	Program/Project Budgeting
Cost Containment	Project Management
Cost Engineering	Public Contracts (United States)
Cost plus	Variance Analysis
Cost plus fixed fee	United States Department of Defense
Costs (Variances)	(Procurement) (Cost Control)
Cost-plus contracts	Work Measurement
Cost/Schedule Control	

Section 6: Subject Headings for Abstracts

The following are those subject areas which closely or directly relate to Contractor Performance Measurement, and the more specific topic of Cost/Schedule Control System Criteria. The abstracted journal articles, books, theses, and computerized media fall under one or more of these subject areas, and are indexed as such. These selected subject areas are not all inclusive, but are meant to give as broad and in-depth a coverage of Contract Performance Measurement as possible.

<u>Subject</u>	<u>Description</u>
1. C/SCSC	Those works which specifically address the DOD mandated Cost/Schedule Control Systems Criteria.
2. Contracting Issues	Those works which discuss contract types and their impact on the need for cost/schedule control.
3. C/S Software	Those works that discuss software which has been developed to aid in contract performance measurement.
4. EAC Techniques	This literature proposes or critiques various Estimate at Completion techniques.
5. C/S Control	Those works which are not necessarily directly related to C/SCSC, but cover control techniques in a broader sense.
6. Variance Analysis	Materials that discuss the various C/S indicators of cost and schedule performance, i.e. cost variance, etc.
7. C/S Reporting	These works review the various means of reporting contract cost and schedule performance.
8. C/S Utility	This literature weighs the costs and benefits of contract performance measurement.
9. CPM History	Those media which cover the growth of contract performance measurement to include the evolution of C/SCSC.
10. Earned Value	These materials present a means of measuring progress in terms of relevant monetary or hourly means.

11. Foreign C/S

These selections review contract performance measurement as practiced abroad.

Section 7: Cross-Referencing Indices

Author

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19. Christensen, Capt David S. "Responsible Analysis in C/SCSC," *In Control*, 3:4-10 (March 1991).
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21. Christensen, Maj David S. and Capt Terry V. Smith. "An Evaluation of Cost/Schedule Performance Analysis Software," *In Control*, 5:288-292 (April 1992).
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AFIT/GSM/LSY/85S-28. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1985 (AD-A162282).

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Section 8: Abstracts

Following, in alphabetical order by the authors' last name, are the abstracts of the material presented in Section 7.

Each page provides the following information on each item abstracted:

Title:	The title of the material
Author:	The author(s) of the material
Format:	The format in which the information was published; journal article, book, thesis, etc. under which the is the bibliographic information necessary to find the material.
Subjects:	The subject(s) under which the material applies. This field provides a simple cross-referencing system to aid the user in locating similar subject sources.
Orientation:	The orientation of the material; business, government/defense, etc.
Abstract Source:	The source of the written abstract. For example, if the abstract was obtained from a thesis, the source would be "subject thesis abstract" etc. Abstracts written by the authors of this guide are referenced simply by the word "authors".
Abstract:	The abstract of the material itself.

Title: "Over-Target Schedules"

Author: Abba, Wayne

Format: Journal Article

Journal: *In Control*

Volume: 2 (November 1989)

Pages: 135-139

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The Department of Defense Cost/Schedule Control Systems Criteria addresses scheduling in this way: "Schedule the authorized work in a manner which describes the sequence of work and identifies the significant task interdependencies required to meet the development, production, and delivery requirements of the contract." However, due to actions within or outside of the contractor's control, changes to the schedule are often necessary. To deal with these, the criteria allowed for contractual changes and internal replanning. The former is fairly straight forward and deals with program cost and schedule changes due to such contract scope changes such as engineering change proposals. The changes are mutually agreed upon by the contractor and government, and the baseline is updated to reflect the new schedule. Internal replanning, however, is different, and is required when a contractor determines he can no longer meet the contractual schedule requirements. Replanning is necessary, as Norm Augustine states "Most projects start off slowly -- and then sort of taper off." Previously, the criteria stated that schedule changes within the scope of the contract only required notification of the procuring agency after the fact through prescribed procedures. This, however, has resulted in scheduling problems for both parties involved. To clear any ambiguity and return programs back to their schedules, the Performance Measurement Joint Executive Group has issued supplemental guidance now requiring prior governmental approval for any internal replanning which would result in changes to the performance measurement baseline which are inconsistent with the contractually required schedule.

Title: "EV – Not Only for Large Projects

Author: Adamczyk, Walter F.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1989

Pages: J.2.1-J.2.5

Subjects: Earned Value, C/S Control

Orientation: Business

Abstract source: ABI-INFORM

Abstract: Earned value techniques were successfully applied to manage an Ohio Edison Co. utility project that was originally budgeted at \$16 million. The project is now being completed on schedule and has a budget of \$12.5 million. The utility decided to relocate six of seven area dispatching offices into one system control center (SCC). While formal project management techniques were chosen for use in the SCC project, the approach also included the use of earned value. A detailed contract performance measurement network was developed, with a total of approximately 1,500 activities. Each month a chart of activities that could or should have been worked on was sent to the project participants for subsequent updating and analysis. A work breakdown structure was developed at the beginning of the job to ensure each participant knew the scope of the work. An organizational reporting structure was also developed to ensure that each functional department understood its responsibilities.

Title: "Cost Schedule Control Systems Criteria (C/SCSC) Schedule Analysis"

Author: Ahye, Capt Catherine

Format: Journal Article

Journal: *In Control*

Volume: 3 (December 1990)

Pages: 11 plus attachments

Subjects: Variance Analysis, C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: A survey of 20 System Program Offices (SPOs) revealed 80 percent of those interviewed did not perform schedule analysis as it relates to project completion time and man-loading requirements. Typically, when Cost Performance Report (CPR) data is used in analysis, the schedule variance (Budgeted Cost of Performed minus Budgeted Cost of Work Scheduled [BCWP-BCWS]) is given as a dollar figure. However, schedule deviations are normally thought of in terms of a period of time behind or ahead of where they actually should be. Furthermore, the traditional CPR can be misleading as it does not indicate whether the Work Breakdown Structure (WBS) element is on a critical path or if the element's path has "slack" time in it.

One way of converting the schedule variance from a dollar to a more useful time measurement is to divide the variance by either an average (of the past or future one, three, or six month) monthly BCWS or monthly BCWP. This will yield an indicator, in months, of how far behind or ahead of schedule the project is. This determination can then be compared to the contractor's networked schedule or "get well plan" to judge whether or not the variance has an effect on project completion time, whether or not it will impact other WBS elements, and whether or not the contractor has adequately considered the variance in his analysis.

Title: *Effect of Feedback on Cost Performance Report Utility*

Author: Amaral, Capt Juan H.

Format: Master's Thesis

Published: Wright Patterson AFB, OH – School of Systems and Logistics, Air Force
Institute of Technology, 1971

Total Pages: 130

Relevant Pages: all

Subjects: C/SCSC, C/S Utility, C/S Reporting

Orientation: Defense/Government

Abstract source: Subject thesis' abstract

Abstract: The purpose of this thesis was to assess the effect of feedback on the utility of the Cost Performance Report (CPR). The effort consisted of administering a controlled experiment to two groups: a gathering of contractor personnel and a group of Government employees. Both groups had some degree of knowledge in the area of variance analysis reporting.

Each experiment consisted of two randomly assigned instruments, the feedback instrument (given to the experimental group) and the non-feedback instrument (given to the control group).

The experiment required the subjects to perform a task similar to that performed during the preparation of a CPR and to provide a response in the form of a variance analysis. The responses were rated by three experts and the mean value of the feedback responses and non-feedback responses were tested to determine if a statistically significant difference existed between the two means.

No statistically significant difference was found to exist between the two means suggesting that providing feedback to subjects, as given in this experiment, has no effect on the quality of the variance analysis they prepare.

Title: *Management Control Systems: Text and Cases*

Author: Anthony, Robert N. and John Dearden

Format: Book

Published: Homewood IL: Richard D. Irwin Inc, 1976.

Total Pages: 771

Relevant Pages: Few

Subjects: C/S Control

Orientation: Business

Abstract source: Authors

Abstract: The purpose of a management control system is to "maintain a desired state or condition" and includes four processes: 1. detection of the current state of operations, 2. analysis of data received from the system, 3. correction or alteration of deviant happenings, and 4. the reporting of the detection, analysis, and correction activities. A control system is set in motion to compare what is actually occurring within an organization or project to what is planned to happen, with the goal of identifying deviations, correcting them, and preventing further variances from occurring. Several dozen Harvard School of Business case studies of actual companies help illustrate the coordinated effort required to effectively control major financial undertakings. Of special relevance to contract performance measurement students are the sections on the nature of management control, analyzing and reporting financial performance, and the appraisal of performance.

Title: "For Contractors: Cost/Schedule Control Systems Training"

Author: Antolini, R.C.

Format: Journal Article

Journal: *In Control*

Volume: 3 (March 1991)

Pages: 14-34

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The Air Force Institute of Technology (AFIT), Wright-Patterson Air Force Base, OH offers both Department of Defense and civilian contractor personnel formalized training in contract performance measurement disciplines. In the past four years, approximately 1,000 students (and about 5 percent of them civilian contractors) have gone through the three course offerings. The first "SYS 361 --Surveillance of Cost Schedule Control Systems" is a two week course designed to provide those working on a Cost/Schedule Control Systems Criteria (C/SCSC) Surveillance Team with the skills necessary to properly monitor the in-plant control functions. "SYS 362 -- Cost/Schedule Control Systems Criteria" lasts three weeks and is the primary performance measurement course offered at AFIT. Designed for those who will be Review Team members or actual C/SCSC analysts, the course is structured around the Joint Implementation Guide's criteria checklist. It also includes instruction on data analysis, information presentation, and the earned value concept. The one week course, "SYS 363 --Basic Analysis of Performance Measurement," provides analysts with the tools and methods available to interpret and manipulate the data provided in the performance measurement reports. Procedures for enrolling in the course (only one of the three is recommended for any one person) are straightforward, and questions should be addressed to AFIT/LSY, WPAFB, OH 45433.

Title: "The Estimate at Completion Paradigm"

Author: Antolini, R.C.

Format: Journal Article

Journal: *In Control*

Volume: 5 (April 1992)

Pages: 179-194

Subjects: C/SCSC, EAC Techniques

Orientation: Defense/Government

Abstract source: Authors

Abstract: The Estimate to Complete (ETC) is one of the most important, yet least understood, measures pertaining to contract performance measurement. "Estimating costs on major systems acquisition contracts is comparable to weather forecasting. Nothing is certain, and yet decisions must be made." With a multitude of Estimate at Completion (EAC) formulas available to analysts (with no two analysts using the same one, or no two formulas providing the same estimate), more attention needs to be placed on refocusing the entire acquisition/performance measurement process. The EAC is essentially a combination of two measures: the Actual Cost of Work Performed (ACWP), and an ETC measure. Two theories are proposed which can help give meaning to EAC measures: 1. "The theory of ACWP relevance" which states that attention should be paid to ensuring the management control system provides budgets and actuals that are relatable, and 2. "The theory of detached analysis" which means that EACs should not be performed mindless of the contractor's management system characteristics. In an experiment where 24 trained government analysts (in groups of four) were asked to provide EACs on a set of Contract Performance Report data, the results ranged from \$811,555 to \$558,292. Furthermore, no group could explain the contractor's own estimate of \$516,000 estimate, despite being given the data to do so. If the current acquisition process and corresponding Cost/Schedule Control System approach is to survive into the next century, "nothing short of a complete reorientation of applied management systems and applied management concepts can save the ship."

Title: "DOE-ID C/SCSC Validation Program"

Author: Arenaz, Mark R.

Format: Journal Article

Journal: *In Control*

Volume: 5 (April 1992)

Pages: 125-131

Subjects: C/SCSC

Orientation: Government

Abstract source: Authors

Abstract: The Department of Energy has determined its order governing Cost/Schedule Control Systems Criteria (C/SCSC) (DOE 2250.1C is in need of revision. Until such time as a new set of guidance is published, the field offices have been instructed to develop and implement their own set of regulations governing the validation of a contractor's management control system (MCS). One such field office conducting this exercise was the Department of Energy Field Office, Idaho (DOE-ID). A meeting with the management of its major contractors yielded the following proposals for the interim validation procedures: 1. Formal acceptance of the contractor's MCS is important. 2. Validation Team quality needs to improve. 3. The current 35 criteria represent sound management concepts. 4. The validation process should be streamlined, but not at the expense of information quality. 5. Accounting system reviews should be eliminated if the system has already been validated.

The resulting guide (which is available upon request) states that the performance measurement data should come from the same MCS that the contractor uses for his internal purposes, that it is impractical for the DOE to mandate a certain control system, and that the criteria approach is the best method for validation. With this basis, the validation involves five steps: "Procedure/System Description Review," "Implementation Assessment," "Demonstration Review," "Review Report," and "Systems Validation." The key to a successful validation is for the validation team and the contractor to thoroughly understand the requirements of the criteria and what constitutes compliance.

Title: "Does Automation Remove the Need for Cost and Schedule Engineers?"

Author: Baumgartner, John H.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 3 (April 1987)

Pages: 75-79

Subject: C/S Control

Orientation: Business

Abstract source: Authors

Abstract: Baumgartner feels that we tend to turn to the computers too soon in the cost/schedule arena. Great strides have been made in analytical software recently, providing the analyst with amazingly quick results and information. However, the author contends that these tools are not meant to replace the analysts who use them. The extremely important aspects of a program (planning, defining the logical dependencies of tasks, and fine tuning activities) cannot be handled by computers. Throughout the program the computer is invaluable in providing the engineers and managers with the data necessary to keep the project on track. In conclusion, the author reminds us that computers are wonderful tools for us to use, but we should not mistake them for artificial humans.

Title: *Systems Management*

Author: Baumgartner, J. Stanley

Format: Book

Published: Washington D.C.: The Bureau of National Affairs, Inc., 1979.

Total Pages: 507

Relevant Pages: many

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: This compendium of 70 papers looks at the various requirements of project management through the eyes of several topic experts. Following are just a few of those papers, authors, and main points which are most applicable to contract performance measurement: 1. "The Program Manager and the Subcontractor: Hands On or Hands Off?" by J. S. Baumgartner. A prime contractor will benefit if he teams with a subcontractor who has also been validated in and works under the standards set for in the Cost/Schedule Control Systems Criteria. 2. "Project Planning and Control" by John Stanley Baumgartner. Most cost and schedule problems can be traced to improper planning, and more specifically, a poorly formed work breakdown structure. The control function can pinpoint problems, and alert the decision makers to take corrective action, through the comparisons of actuals verses budgeted costs, manpower, and progress. 3. "Work Breakdown Structures for Defense Materiel Items" by E. J. Nucci and A. L. Jackson, Jr. Work breakdown structures are an excellent planning and control tool which gives top management visibility and data reporting that is consistent with the way in which the work is actually being accomplished. 4. "Line of Balance" by Commander Gerald J. Chasko. The line of balance technique provides management a means of collecting, analyzing, and presenting information on project status. 5. "C/SCSC: Alive and Well" by J. Stanley Baumgartner. Although met by strong resistance, the Cost/Schedule Control Systems Criteria have been successfully implemented by several hundred contractors for us on both defense and proprietary projects. 6. "Cost Performance Analysis" by General John R. Guthrie. Cost/Schedule Control Systems Criteria facilitates the data analysis which is necessary for effective cost control and informed decision making.

Title: "A Relatively Easy Leap to Effective Program Control"

Author: Baumgartner, Stan

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 3 (April 1987)

Pages: 171-181

Subject: C/S Control, EAC Techniques

Orientation: Business

Abstract source: Authors

Abstract: Baumgartner describes a method of cost/schedule integration initially presented in his 1963 book, *Project Management*. When CPM analysis is not contractually required on a project, the use of a Status Index provides a way of integrating cost and schedule. The Status Index combines basic cost and budget information "to produce an index of progress for money spent." The author presents the derivation of this index in some detail and describes its use in providing a picture of project status. With 1.0 being "par," the manager can see whether resources below par need to be added or if excess resources exist on items above par.

The author states that the Status Index can provide equivalent status assessments as CPM and forecast trouble spots, EAC, track trouble spots, provide problem criticality ranking, and more. On the other hand, it does not conform to a CPR or C/SSR format nor is it as thorough as CPM analysis. The big benefit of the Status Index, for those who do not have or are not required to use CPM, is that it is relatively cheap and provides the manager with a quick and accurate look at the program's status.

Title: *Applied Cost and Schedule Control*

Author: Bent, James A.

Format: Book

Published: New York: Marcel Dekker, Inc, 1982.

Total Pages: 416

Relevant Pages: most

Subjects: C/S Control

Orientation: Business/Construction

Abstract source: Authors

Abstract: To be effective, the control function of an organization must be an integral part of project management. From the early planning stages of a project, the project manager should be in constant consultation with the cost/schedule controllers, as their role is to support the decision maker. The controlling function starts with that of the cost and schedule estimate for the project, and it is not recommended that the contractor's estimates follow the purchasing office's work breakdown structure and cost accounts, but instead be allowed to work from his own. The next step, once the normative or budgeted costs and schedules are documented (often in graphs, tables, or networks), the project control team's function is to detect deviations, anticipate problems, and forecast revised estimates through project completion. Trend performance is analyzed so that remedial action can be prescribed and taken, and planned versus actual "S" curves aid in showing variations in performance. Monthly cost/schedule status reports should reflect the current project status, trends, a discussion of any significant deviations, and estimated impacts on planned cost/schedule. Included in this book are over 200 illustrations depicting example trend analysis graphics, status reports, and other control related tools.

Title: "Cost and Schedule Integration - Useful Concept or Fantasy?"

Author: Bronn, John W.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 7 (April 1988)

Pages: 8-14

Subject: C/S Control

Orientation: Business

Abstract source: Authors

Abstract: Integrated cost/schedule planning is one of the key objectives of C/SCSC. The author explains what integration really means and some approaches to integrating C/S information. Bronn defines integration within the C/SCSC context to mean the "bringing together of the cost information with the schedule information in a meaningful way." The intent of integration, states the author, is the integration of three areas; planning, status, forecasting. The planning of resources with tasks provides a basis for discerning the status of the project and the impact of the plan on the schedule. Integrated plans aid in avoiding inconsistencies between the cost and schedule plans. Integrated plans providing an accurate status of the project allow better forecasting of future expenditures and resource needs.

In the next section of the article, the author critiques some approaches to integration. In what he calls end-to-end integration, Bronn explains the approach of controlling the ends of the tasks. This approach provides consistency between the schedule and resource expenditures from the beginning to end of the project. Usually this approach utilizes a standard "S" curve to time phase plans and is generally more useful for high level integration. In order to gain more insight into detailed tasks, many analysts resort to a critical path network. The author says this method is usually accepted more for its ease of use, however, it often leads to unrecognizable results as the priorities change month to month. This process can be carried further by a leveling and smoothing approach which only adds more confusion to the plan. The author concludes that these approaches fail due to the extensive amount of effort required to obtain results, concentration on the wrong milestones, and answers which are too complex.

Instead of these problematic approaches, Bronn offers another – Integrated Milestones. Integrated Milestones are events which describe the interfaces between tasks. The resources which need to be integrated are those that fall into the Integration Milestones. These milestones can be used at higher or lower levels in the program. Implementation of the milestones should be with systems requirements which are usually non-specific enough to be covered by Integrated Milestones. Next, implementation training needs to be accomplished, and finally, begin with simple milestones and add more complex ones as the program progresses. The author believes that such an implementation of Integrated Milestones will aid in obtaining a more practical and meaningful control system.

Title: "Using Line of Balance (LOB) to Effectively Measure Earned Value for Repetitive Manufacturing"

Author: Bronn, John W.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 3 (April 1987)

Pages: 65-74

Subject: Earned Value

Orientation: Business

Abstract source: Authors

Abstract: In this article, the author shows how traditional Line of Balance (LOB) analysis can be used to measure earned value. He begins with a short description of the steps taken in LOB analysis; the process plan, striking the Line of Balance, and comparing actual progress to the Line of Balance. Bronn believes that LOB analysis is a useful tool for controlling the schedule of repetitive manufacturing tasks. The key to the author's earned value approach lies in the Control Points which are chosen for sensitivity to cost and schedule. Each Control Point is assigned a budget to derive BCWS. BCWP (earned value) is determined by the quantities completed multiplied by the planned Control Point values. Learning curve analysis can be applied to the planned values to increase accuracy. An additional approach is to assign a percentage value to each Control Point representing a portion of the total value of a single unit. As each portion is completed, BCWP can be earned as a percentage of the singular item.

For successful use of the LOB earned value method, Bronn lists several prerequisites. Firstly, a large amount of planning is necessary to correctly select the Control Points. Accuracy of BCWP is dependent on the accuracy of the Control Point selection. Differences between the actual schedule status and the schedule variances caused by this earned value technique may result from attrition allowances and "safety bank time." However, this tends to show a problem where there really is none rather than the other way around. In conclusion, the author believes that using the LOB technique can provide managers with useful earned value measurement.

Title: "A Most Important Subject"

Author: Caseria, Tony

Format: Journal Article

Journal: *The Measurable News*

Volume: Summer 1991

Pages: 4-5

Subject: Contracting Issues

Orientation: Defense/Government

Abstract source: Authors

Abstract: The purpose of this article is not to offer a solution but to bring to light a problem. The author has noted that there exist many good articles on bringing Total Quality Management (TQM) into the earned value arena. However, few of these articles emphasize the use of TQM during the pre-award phase of a project. The steps that take place before a contract is awarded, according to the author, are vital in setting the stage for future contract performance. He believes that the preparation of the Work Breakdown Structure (WBS), Program Organization, Responsibility Assignment Matrix (RAM), and the Statement of Work (SOW) are often rushed and end up incomplete. Caseria feels the heart of a good program is the WBS and offers several suggestions to improve the quality of the WBS construction process from which the rest of the program flows.

Title: "Earned Value Graphics -- New, Exciting, Innovative"

Author: Cass, Donald J.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1991

Pages: L.4.1-L.4.6

Subjects: Earned Value, C/S Control

Orientation: Business/Construction

Abstract source: ABI-INFORM

Abstract: Adopting selected graphing/charting techniques from the financial/stock market community and applying them to earned value principles, or labor productivity, for construction projects monitored at summary levels has shown surprising success. Estimate at completion work hours, plotted throughout the lifetime of a project, generate a trend line pattern. These definitive trend lines can be further analyzed by graphing earned value data from ongoing construction projects to provide management with a visual recovery path to meet work hour budgets. Projection of data points above or below the initial recovery trend line indicates potential overruns or underruns of budgetary constraints via revised recovery trend lines. Projecting the data points of these revised trend lines delineates order-of-magnitude overruns or underruns from the budgetary base.

Traditional "S" curve earned value graphing still gives a visual signal of cost/schedule problems, however, it does not indicate a path of recovery as the trend analysis graphics do. Early budgetary problem identification through trend analysis is the first step towards salvaging an ailing project. Several examples show these graphic aids at work in several actual projects.

Title: "Applying Earned Value Procedure to Engineering Management"

Author: Chen, Mark T.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1991

Pages: O.4.1-O.4.5

Subjects: Earned Value, C/S Control

Orientation: Business

Abstract source: ABI-INFORM

Abstract: An earned value procedure that was used to manage a 30,000 engineering work-hour effort for a \$25 million paper factory upgrade project at the Weyerhaeuser Paper Company illustrates the usefulness of this contract performance measurement technique. The company management learned several lessons from the project: 1. earned value measurement techniques are valuable performance indicators and should be used whenever possible, 2. performance indices, both cumulative and current, should be incorporated with the earned value procedure, 3. key department performance should be tracked, and finally, 4. a critical path network schedule should be used to track more complex projects. The earned value procedure is an effective tool for engineering management, and the trend of the performance indexes serves as an early warning. Of these indices, the cumulative cost performance index must be monitored at all engineering milestones.

Title: "Management Control Systems Theory is a Useful Tool"

Author: Christensen, Capt David S.

Format: Journal Article

Journal: *Program Manager*

Volume: 18 (November-December 1989)

Pages: 20-23

Subject: C/SCSC, C/S Control

Orientation: Business

Abstract source: Authors

Abstract: The author analyzes management control systems within the context of the C/SCSC. These criteria promote quality decision making and analysis of a project. As such, the control system used should provide quality information from which quality decisions can be made. According to the author, decision makers should 1) have input into the content, format, and frequency of the information and 2) evaluate the quality of the information. Reliable information must be bias free, have feedback value, be timely, provide predictive merit, be consist, and have comparability.

While the C/SCS Criteria do not dictate a company's structure or cultural values, a good management control system must incorporate the above qualities in order to provide reliable, quality information and the system must be accepted into the company's business philosophy. If the system is compliant with the criteria, it is assumed the information from it is of good quality. However, unless the company's attitude toward the system engenders the intent of the criteria, the results are of little value.

Title: "Responsible Analysis in C/SCSC"

Author: Christensen, Capt David S.

Format: Journal Article

Journal: *In Control*

Volume: 3 (March 1991)

Pages: 4-10

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The primary objective of an analyst is to foster responsible decision making by providing the decision makers with reliable, relevant information from which to make his choices. It is not enough to blindly manipulate a data base and provide it to the management as "information." The analyst must be able to accurately determine whether or not the data coming from the contractor's management control system (MCS) is reliable. The 35 Cost/Schedule Control Systems Criteria were written to help ensure the MCS can provide the needed information in a reliable format -- it's up to the analyst to ensure the resulting data makes sense. The prudent analyst must understand the relationships between the different data elements, and be able to determine if the existing controls are adequate or not functioning properly.

Several activities can add to the relevancy of the information provided the decision makers: 1. The analyst must know the decision context. This involves discovering the types of decisions management will have to make, and tailoring the information to it. 2. The analyst must be able to filter out the filler and fill in the forgotten data for an overworked, narrowly focused team chief. 3. The analyst should be thoroughly familiar with the various analytical techniques, and be able to properly apply them in congruence with the current decision context. "... good analysis is not defined by the type, variety, or relative sophistication of the analytical techniques applied, but by the information the techniques generate." Further, he should understand the assumptions and limitations of the statistical techniques available to him. 4. Finally, the analyst should be careful when presenting the information using graphical techniques, as they can be extremely misleading. "An ethical analyst should resist the temptation to make the picture appear better than the underlying data."

Title: "The Role of Analysis in C/SCSC: A Responsible Analyst is an Information Engineer Involved in the Decision Process"

Author: Christensen, Capt David S.

Format: Journal Article

Journal: *Program Manager*

Volume: 19 (July-August 1990)

Pages: 26-33

Subject: C/S Control

Orientation: Business

Abstract source: Authors

Abstract: The author believes that responsible analysis will lead to responsible decision making. The analyst needs to first determine the decision context, then know the database system which generates the data, and finally, know the analysis tools he has available and their limitations. By following this process the decision maker can then determine what information is required, evaluate the information quality, and finally utilize the information.

The analyst needs to work closely with the decision maker in order to discern what kind of decisions need to be made. In order to provide the decision maker with quality information, the analyst must thoroughly understand the system(s) which produce the data. Just having the data is not enough, one must be able to apply analysis tools to transform the data into meaningful information. If the analyst does not know the tools or their limitations, he cannot derive quality information.

The author feels that the responsible analyst must be involved in the decision process from beginning to end in order to effectively support the decision maker.

Title: "An Evaluation of Cost/Schedule Performance Analysis Software"

Authors: Christensen, Maj David S. and Capt Terry V. Smith

Format: Journal Article

Journal: *In Control*

Volume: 5 (April 1992)

Pages: 288-292

Subjects: C/S Software, C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The use of personal computer driven cost/schedule performance analysis software has been growing in popularity and quality, no evaluations of the software packages have been undertaken. An organization in need of an analysis package is not likely to have the data or personnel resources to effectively evaluate the many choices prior to its acquisition, installation, and training. Further, a preferred package may help to avoid possible confusion between analysts using different software.

Four non-commercial performance analysis software programs are currently available from different sources: *Performance Analyzer* (Space System Division), *CPR-EZ* (Air Force Cost Center), *Contract Appraisal System* (Defense Systems Management College), and *Contractor Cost Analysis System* (Air Force Cost Center). To evaluate the characteristics of each, two questionnaires were sent out to Air Force Systems Command product division. The first response identified 21 criteria which users prefer in an analysis program. The second questionnaire then asked the analysts to rank order the criteria. The top five responses were "user friendly" (menu-driven screens), "variance analysis," "regression analysis," "installation," and "easy to learn." A decision support system, *Expert Choice*, was then used to evaluate the four alternative packages in regards to the 14 highest rated attributes. *Performance Analyzer* was identified as a clear winner over the next highest scoring package – *Contract Appraisal System*. The choice of software however, despite the results of this research, must be made in the applicable decision context and mindful that the end result must best support the decision makers involved.

Title: "Cost Performance Index Stability -- Fact or Fiction?"

Author: Christensen, Maj David S. and Maj Kirk I. Payne

Format: Journal Article

Journal: *In Control*

Volume: 5 (April 1992)

Pages: 273-287

Subjects: C/SCSC, C/S Indicators

Orientation: Defense/Government

Abstract source: Authors

Abstract: The cost performance index (CPI) is one of many contract performance indicators that can be produced from a contractors Cost Performance Report (CPR) or Cost/Schedule Status Report (C/SSR). This index takes the form $CPI = BCWP/ACWP$ where BCWP is the budgeted cost of work performed, and ACWP is the actual cost of work performed. The CPI indicates the cost efficiency at which the contractor is working (either up to that point in the contract, for the last several reporting periods, or in the current month, depending upon whether cumulative, moving average, or current BCWP and ACWP measures are used). A CPI of greater than one (1) is favorable and means the contractor is under cost. A CPI of less than one means the contractor is overrunning the budget, and actions must be taken to get the project back on track.

The CPI is often used in Estimate at Completion predictions, but it is also often used as a comparison to the To Complete Performance Index (TCPI). This index tells the analyst the cost efficiency that is needed for the remainder of the contract if the contractor is to finish on budget. $TCPI = (BAC - BCWP_{cum}) / (BAC - ACWP_{cum})$ where BAC is budget at completion.

Research was conducted based on the performance data of 26 CPRs from seven different aircraft acquisition programs in several stages of procurement. The study confirmed the commonly believed postulate that the CPI of a contractor was stable to a range of 20 percent, and varied less than 10 percent when measured at the 50 percent complete point in the contract. In fact, the CPI range proved stable as early in the contract as only 20 percent complete. Therefore, if the contractor is running over budget at the 50 percent complete point, it is unlikely (if his TCPI is greater than 10 percent higher than his CPI) that he will recover by contract end.

Title: "A Review of Estimate at Completion Research"

Authors: Christensen, David S., Richard C. Antolini, and John W. McKinney

Format: Journal Article

Journal: *Cost Estimating and Analysis: Balancing Technology and Declining Budgets (1992 Proceedings of SCEA)*

Volume: July 1992

Pages: 207-224

Subjects: EAC Techniques

Orientation: Defense/Government

Abstract source: Authors

Abstract: This paper was written as a result of Master's thesis work at the Air Force Institute of Technology. The authors present the findings from 25 previously conducted Estimate at Completion studies in three sections: existing EAC formulas, new EAC methodologies, and a comparison of actual contract costs versus various EAC formula results.

The recent cancellation of the United States Navy's A-12 program has brought to light the years old problem of accurately estimating the cost to complete an ongoing development or procurement program under cost-plus contracts. Currently, no one method of estimating this cost is dictated in Department of Defense guidance nor universally accepted by contractors, program office personnel, or upper level decision makers.

All EAC formulas are based on the following data contained in either the Cost/Schedule Status Report or the Cost Performance Report: Budgeted Cost of Work Scheduled, Budgeted Cost of Work Performed, and Actual Cost of Work Performed. EAC formulas come in three forms: index, regression, and other. The index adjusts the remaining budget cost of work on the contract. "The assumption implicit in this adjustment is that the contract's past cost and schedule performance is recurrent and reflective of future performance." Regression formulas are derived from linear or nonlinear regressions with ACWP as the dependent variable. All remaining EAC formulas are grouped as "other".

Although regression-based models show promise, their current accuracy is not better than that of the more popular index-based models. More research is needed in developing the regression model. Further, no one index based model is best in all situations -- various models tend to perform better depending upon the weapon system being procured, the stage of acquisition, and the phase of the contract.

Title: "The Performance Measurement System: An Overview of Aerospace Program Control"

Author: Cressman, Kenneth R.

Format: Journal Article

Journal: *In Control*

Volume: 2 Number 2 (November 1988)

Pages: 7-12

Subject: C/SCSC

Orientation: Defense/Business

Abstract source: Authors

Abstract: In this article, the author has developed a brief primer in contractor program control. In particular, he explains the system used by the McDonnell-Douglas Astronautics Company (MDAC). The article begins with a short explanation of C/SCSC compliance and validation procedures. It continues with an description of the use of the WBS by the cost account managers (CAMs) to develop the work plan and the tasks to be accomplished. Cressman continues to illustrate the importance of the CAM's development of the BCWS as well as the basic procedures used in the development of cost and schedule variances by the CAM for monthly reporting purposes. MDAC has incorporated the central performance management office, Contract Performance Systems Group, to provide formal training to the engineering, material, and fabrication personnel on the use of C/SCSC. The author concludes the article with an emphasis on the upper management's concern, support, and continuing improvement of their compliant system.

Title: "Power and Potential of the Management Control System Description"

Author: Diffenderfer, Hope A.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 7 (April 1988)

Pages: 4-7

Subject: C/S Control, C/S Reporting

Orientation: Defense/Government

Abstract source: Authors

Abstract: Mr. Diffenderfer, Assistant Secretary of the Navy (S&L), presents in this article several key particulars of superior management control systems descriptions. A management control system description a description of the contractor's policy in implementing the C/SCS criteria for government contracts. The article begins with a brief explanation of the requirements for a control system description per DODI 7000.2 and the Joint Implementation Guide. The author feels a good description starts with a statement of purpose which describes the company's management philosophy. Also incorporated into a superb description is a section devoted to the contractor's pre-award planning to include policies of negotiation, terms, administration, and good business practices. Scheduling systems and techniques available to the program manager for budgeting and scheduling should be discussed as well as the subjects of milestone and PERT charts, Line of Balance, Material Planning Systems, and shop scheduling. Finally, an excellent management control system description should explain the company's accounting system and provide well referenced procedures either at the end of the document or throughout the description. A good description allows the Government to easily assess the contractor's system and conduct their reviews more efficaciously.

Title: "ACES -- A Wild Card in Beating Cost/Schedule Disintegration"

Author: Draper, David L.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1989

Pages: C.9.1-C.9.2

Subjects: Earned Value, Variance Analysis, C/S Control

Orientation: Defense/Government

Abstract source: ABI-INFORM

Abstract: The Applied Control and Evaluation Strategy (ACES) offers a creative solution to some of the more important management data problems frequently found in earned value applications. ACES is a simplification of the method of developing planning data and determining the progress or earned value. It applies to all project work where neither a purely objective nor level of effort approach is appropriate. It uses only the realistic product milestones and events that represent completion of all or a portion of a given activity and attributes the value of the planned and actual resources to that milestone. ACES improves the quality of input data by simplifying the method and frequency of input. One main advantage with ACES is that the difference between planned value to date and earned value to date is traceable to the value of specific milestones. Another feature of the ACES approach is the detail that may be presented within the segment cost variance. ACES augments traditional cost and schedule variances so that the resulting management data are more useful.

Title: "Aces – A Wild Card in Beating Cost/Schedule Disintegration"

Author: Draper, David

Format: Journal Article

Journal: *In Control*

Volume: 2 (June 1989)

Pages: 91-93

Subjects: C/S Control, Variance Analysis, Earned Value

Orientation: Business/Government

Abstract source: Authors

Abstract: The practice of using and earned value measure as part of the management control system (MCS) is gaining popularity, however, there still exists many problems with the traditional ways of obtaining and using this measure. The Applied Control and Evaluation Strategy (ACES) MCS offers a simplified approach to measure progress, track schedule variances, and segment cost variances. The problem with measuring earned value exists when the output is neither an objective, quantifiable unit, as in number of bolts produced, nor when level of effort (such as project management) is being evaluated. For these remaining cases, ACES uses interim product milestones completion to record the planned resources for that milestone. In this way, a more objective measure of earned value is simplistically obtained. The only periodic input required from the control account is a report of the milestones achieved, or no report for no measurable progress.

ACES produces a traceable schedule variance (TSV), which like a traditional schedule variance, compares planned work to scheduled work, but reports is by milestones which are behind or ahead of schedule. Traditional earned value analysis experiences the problem of reporting negative cost variances when resources are expended, yet come reporting time, no quantifiable work has been done. ACES does not overcome this, however, the cost variances are not reported as negative unless the actual cost expended exceeds the budgeted resources for that upcoming milestone. This feature is called "smart threshold," and along with the segmented cost variance feature, allows the analyst to make more accurate estimate to complete predictions.

Title: "Estimate Variance: Charting the Rate of Change in 'Estimate At Completion'"

Author: Duncan, William R.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 3 (April 1987)

Pages: 55-64

Subject: EAC Techniques, Variance Analysis

Orientation: Defense/Government

Abstract source: Subject article's abstract

Abstract: One key objective of performance measurement is to identify significant variances from plan with sufficient lead time to allow appropriate corrective action. In the extreme case, excessive variances must be identified early enough to allow shutting down the project with minimal loss.

Periodic re-estimating represents one attempt to address this issue. However, in the early stages of a project, the current "estimate at completion" is seldom a true re-estimate; it is usually the sum of the actual costs incurred to date plus the balance of the remaining estimates:

$$\text{EAC} = \text{ACWP} + (\text{Original Estimate} - \text{BCWP})$$

This calculation produces a modest change in EAC which has the effect of masking major problems until it is too late. Comprehensive re-estimating at this point is seldom effective since it usually produces a similarly modest adjustment to the EAC.

This paper offers an alternative method based on the author's experience with information systems projects. The "estimate variance" is defined as the rate of change in the estimate at completion. Estimate variance provides a reliable, cost effective indicator of the true cost to complete.

Title: "Managing Production with Flying Colors"

Author: Dutton, Barbara

Format: Journal Article

Journal: Manufacturing Systems

Volume: 6 (December 1988)

Pages: 20-22

Subjects: C/S Control

Orientation: Business/Defense/Government

Abstract source: ABI-INFORM

Abstract: Martin Marietta Electronics and Missiles Group developed the Aerospace Planning, Execution and Control System (APECS) to control costs by boosting product quality, as well as maintaining accurate scheduling and ensuring the timely movement of material used in government defense contract projects. The system contains controls to ensure that operational processes are properly sequenced and controlled while maintaining exact status of all work on the shop floor. Interest in the APECS project was sparked when Martin Marietta won the Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN) project, and saw the necessity for automation, control, and guards against cost overruns. APECS is made up of four major subsystems: 1. planning and control, 2. distributed shop floor control, 3. manufacturing integrated production planning, and 4. work measurement. The benefits of APECS include lower support costs, improved yield, reduced material costs, and lowered material obsolescence.

Title: "The Five W's of Subcontractor Surveillances"

Author: Earley, Deborah S.

Format: Journal Article

Journal: *In Control*

Volume: 3 (March 1991).

Pages: 294-299

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The requirements for surveillance of a prime contractor's management control system are fairly well known, or at least definitively spelled out in the Department of Defense Cost/Schedule Control Systems Criteria (C/SCSC) literature. The "which," "whom," "why," "where," and "when" questions surrounding a subcontractor's surveillance requirements, however, are less understood.

How the C/SCSC are applied to a contractor is mutually determined by the government and prime contractor. The decision centers around the criticality and cost of the subcontractor's effort. Normally, a Phase II-Type set of surveillances are performed by and/or on the subcontractor, and is essentially a scaled down version of what the prime must undergo. There exists two main categories of reviews for the subcontractor: external, which is performed either by the prime contractor or by the government (if requested), and internal, which is a function of the company's own C/SCSC organization. A never before validated subcontractor will undergo a System Surveillance which is intended to ready the sub for work on the contract. A Subsequent Application Review is performed on a sub who had been previously surveyed, but for a different contract. A Mock Subsequent Application review readies the sub for the real thing, and tests out the system for problem identification. The Readiness Review is another preparatory review which is intended to familiarize the prime and sub with each other's management style. Finally, the Internal Audit is a data verification of the entire management control system.

Effective control requires trained professionals. The Air Force Institute of Technology teaches several formal courses on the concepts, requirements, and interpretations of the C/SCSC, as well as techniques available to the analyst in data manipulation.

Title: "C/SCSC and the Program Manager -- or -- Why Program Managers Ought to Take a Closer Look at C/SCSC and Ask: What Is It and What Can It Do for Me"

Author: Faibisch, Irwin J.

Format: Journal Article

Journal: *In Control*

Volume: 5 (April 1992)

Pages: 195-203

Subjects: C/SCSC, C/S Utility

Orientation: Defense/Government

Abstract source: Authors

Abstract: Program managers, both government (customer) and contractor (supplier) has a powerful tool available to them, yet often it is under utilized. The tool is the Cost/Schedule Control System required of contractors on major Department of Defense Contracts. True, most program managers have been using the system to produce the monthly Cost Performance Reports (CPRs) and Cost/Schedule Status Reports (C/SSRs), yet its true strength lies in the "scheme and discipline" that the implementation of the system provides, not in the reports. The C/SCS provides for the internal control and management of the program from the cost account and work packages level through the overall program manager's level.

The Cost/Schedule Control Systems Criteria, as stated in the Joint Implementation Guide has two objective, only one of which is to provide visibility into the program through the regular reports. The other is for the contractor to implement and use an effective internal control system. The properly functioning and fully utilized C/SCS can provide the framework for planning, controlling, instantaneous problem identification, progressing, and proactive (instead of reactive) problem correction.

Title: "Cost/Schedule Control Systems Criteria: It May Be More Than We Think"

Author: Faibisch, Irwin J.

Format: Journal Article

Journal: Program Manager

Volume: 20 (September-October 1991)

Pages: 30-33

Subject: C/SCSC, C/S Utility

Orientation: Defense/Government

Abstract source: Authors

Abstract: The author's thesis is that in the past technical performance has been lost in the hubbub of C/SCSC, and that technical performance should be at the hub of C/SCSC as an effective metric for performance measurement. The author contends that the majority of C/SCSC users find the system useful for reporting, but do not use the system in the day to day business of contract management. The correct use of C/SCSC, states the author, is its ability to provide the program and cost account managers a tool to take immediate action to solve project problems.

Faibisch feels that the engineers and technicians who actually do the planning, designing, and manufacturing should be educated in C/SCSC so as to take advantage of its management power in technical areas. Technical performance should be assessed at the cost account and work package level, and thereby, those whose day to day duties lay in these areas can take advantage of the power of C/SCSC -- budgeting, scheduling, earned value, etc. The author feels that C/SCSC is viewed too narrowly as just another tool for management. He states that C/SCSC should be the primary tool of a manager as well as the sub-managers.

Title: "What Ever Happened to 'Technical Performance' in C/SCSC?"

Author: Faibisch, Irwin J.

Format: Journal Article

Journal: *The Measurable News*

Volume: Summer 1991

Pages: 8-10

Subject: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The author believes that C/SCSC has recently become treated as only a cost/schedule reporting tool for managers. He believes that C/SCSC's real usefulness lies in its ability to manage the program's baseline. Faibisch suggests "that both government and contractor program managers should use the mechanisms established by C/SCSC as the principal vehicles for the management of the program . . . specifically not to exclude the management of technical performance." C/SCSC can provide a time-phased management baseline, a Work Breakdown Structure to parcel out tasks, and visibility into the lower WBS levels which provides the manager with insight into the work packages where technical performance can be assessed.

The author believes C/SCSC's primary value is in providing program and planning control and should not be relegated to the position of just an internal/external reporting device, although it works extremely well in this function also.

Title: "Cost/Schedule Control Systems Criteria Under Inflation"

Author: Farid, Foad and Saeed Karshenas

Format: Journal Article

Journal: Project Management Journal

Volume: 19 (November 1988)

Pages: 23-29

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: ABI-INFORM

Abstract: The Cost/Schedule Control Systems Criteria (C/SCSC) outlines procedures for monitoring cost performance of Department of Defense contractors. These criteria are more versatile than Project Evaluation and Review Technique/Cost (PERT/Cost) and have practically replaced the cost planning and control function of PERT/Cost. C/SCSC maintains the Work Breakdown Structure that breaks down the project into manageable work packages, with clearly identifiable milestones or outputs. These are used to monitor the progress of packages against planned cost and schedule. Cost variances can then be scrutinized by project managers to locate any problem area. Additional insight into the status of the project is provided by three performance ratios: 1. cost performance, 2. schedule performance, and 3. completed work. The revised C/SCSC proposes a "deflated cost of work performed" curve that breaks down the cost variance into expenditure variance and inflation variance.

Title: *Cost/Schedule Control Systems Criteria: The Management Guide to C/SCSC*

Author: Fleming, Quentin W.

Format: Book

Published: Chicago: Probus Publishing Company, 1992.

Total Pages: 526

Relevant Pages: all

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The Cost/Schedule Control Systems Criteria are a set of requirements imposed upon contractors who provided major services or materials for the Department of Defense and several other government agencies. The criteria are written for broad interpretation in order to give contractors the flexibility to tailor their existing control system in a way which will meet a standardized set of guidelines. The main purpose of this resulting standardized management control system is to provide both the contractor and the government procurement office with a tool for planning and tracking progress, and visibility into cost and schedule performance through auditable data output. C/SCSC embodies careful planning, baseline establishment, reporting discipline, variance analysis, corrective action, and measurement of accomplishments at multiple levels. The book covers all areas of cost/schedule control and contract performance measurement from the budgeting and planning functions to the concept of earned value and variance reporting. Appendixes are copies of the applicable DOD regulations pertaining to C/SCSC (which, although outdated, are still insightful) as well as a copy of the Arthur D. Little Study on C/SCSC which found that the criteria were useful, but that there is room for improvement, mainly in the area of better training and improving the qualifications of the practitioners.

Note: this is a recently revised edition of Fleming's two previous releases. This release has been updated to more closely follow the direction given in the new Department of Defense 5000 series regulations which were distributed since the previous edition.

Title: "The Gleam and Glitter of Cost Reimbursable Government Contracts"

Author: Fordham, Gregory L.

Format: Journal Article

Journal: *CPA Journal*

Volume: 58 (September 1988)

Pages: 80-83

Subjects: Contracting Issues

Orientation: Government

Abstract source: ABI-INFORM

Abstract: Before entering into cost reimbursable contracts, contractors should consider the additional administrative responsibility, restricted earning potential, and unwelcome oversight by the government. Also, a professionals' opinion should be sought. Three of the more common cost reimbursable contracts are cost-plus fixed fee, cost-plus award fee, and cost-plus incentive fee. When working under one of these contracts, contractors must provide current, accurate, and complete cost and pricing data to the government. Differences between actual costs and estimated data will be analyzed for evidence of defective pricing. The elaborate cost accounting systems that contractors are required to maintain are complicated by many factors: 1. the existence of allowable and unallowable costs, 2. the limitation on costs imposed by contract provisions, and 3. the allocation of indirect costs to the contract. An additional burden is the statutory limitation on fees for cost reimbursable contracts.

Title: "Improved Cost Control Through the Application of the Personal Computer"

Author: Gage, P.R. and G. A. Sponder

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 2 (January 1987)

Pages: 3-10

Subject: C/S Software

Orientation: Business

Abstract source: Authors

Abstract: The authors feel that the use of the PC can help cost account managers (CAMs) handle the deluge of information they receive and process. The article explains the use of the PC in cost control in the Martin Marietta Orlando Aerospace Microelectronics Center. Three steps are necessary for maintaining control over costs; establishment of goals or standards, measurement of performance, corrective action. The PC helps the CAM with the this process. The authors present several report formats which they have developed on the PC for project status analysis; Work Package Summary, Work Package Summary By Department, Earned Value Monthly Report, and Labor Estimate To Complete Report.

The others conclude that the PC has served them as a valuable tool in getting their hands around the data and synthesizing the data into meaningful and useful reports.

Title: "C/SCSC Schedule Variance: Focus on Dollars"

Author: Graham, David R.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 3 (April 1987)

Pages: 4-6

Subject: Variance Analysis

Orientation: Business

Abstract source: Authors

Abstract: The word "schedule" connotes time. However, BCWS and schedule variances are expressed in dollars. The author believes we need to think more of schedule variances in terms of dollars rather than time. Although the actual monetary impact of the schedule variance may not necessarily equal the dollar amount of the variance, we should start by accepting that dollar amount as the monetary impact and then utilize other scheduling data to determine whether its representation is correct or not. The cost account manager (CAM) budgets time phased work packages converting them into dollar values, BCWS. When schedule variances occur, explanations of the reasons should also be in dollars in order to preserve the monetary form. By accurately translating scheduling data into dollar form, managers get better cost information.

The author concludes that the combination of schedule information integrated with the dollar value of schedule variances will improve performance measurement.

Title: "Reward for Earned Value"

Author: Graham, David R.

Format: Journal Article

Journal: *In Control*

Volume: 2 Number 1 (August 1988)

Pages: 11-14

Subject: C/SCSC, Earned Value

Orientation: Defense/Government

Abstract source: Authors

Abstract: In this article the author wishes to generalize the use of the term "earned value" to include the entire C/SCSC system beyond the specific concerns of the cost account manager (CAM). Earned value should be incentivized and rewarded in other company departments; contracts, program control, financial management, and schedule control. The Government can reward contractors for earned value through their validation and review teams by awarding compliance. However, the surveillance teams located at the contractor's plant are not empowered to do so at this time. The author contends that the surveillance teams are in the perfect place (at the plant) to assess the value of the contractor's efforts, and therefore, should have the ability to reward a good system. Such a policy, according to Graham, would incentivize the contractor to become more customer oriented towards the Government instead of resenting the surveillance teams presence. The author suggests offering an award to contractors whose systems go beyond the basic requirements of C/SCSC compliance and explains how such an award might be incorporated into the present surveillance system. Graham submits that both DOD components and contractors would benefit from such an incentive system. The contractor would gain recognition as an innovative and cooperative source, and the Government would obtain higher quality systems.

Title: "What is C/SCSC? -- In English, Please!"

Author: Grskovich, Donald L.

Format: Journal Article

Journal: National Contract Management Journal

Volume: 23 (Winter 1990)

Pages: 25-32

Subjects: C/SCSC, CPM History

Orientation: Defense/Government

Abstract source: ABI-INFORM

Abstract: Cost/Schedule Control Systems Criteria (C/SCSC) was developed because the United States Government needed a way to reliably quantify the costs of planned procurements before they were begun. The main objectives of C/SCSC are to require contractors to employ management control systems for cost/schedule planning and tracking, and to provide timely and auditable data for use by the contractor and custom project contract management. A 1967 Department of Defense (DOD) document defined 35 criteria that the DOD would impose on management control systems of contractors with which it did business. These criteria involve five requirements: 1. organization, 2. planning and budgeting, 3. accounting, 4. analysis, and 5. revisions and access to data. The five steps involved in complying with the C/SCSC are establishment of a baseline, management of the base one, measurement of performance as the work is done, assessment of what is left to be accomplished, and projection of the estimate to complete.

Title: "Use of C/SCSC Data in the Factory"

Author: Hays, Ram J.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 3 (April 1987)

Pages: 80-101

Subject: C/S Control

Orientation: Business

Abstract source: Authors

Abstract: The author, Cost Control Supervisor for Westinghouse Electric Corporation, Marine Division, Sunnyvale, describes his company's performance measurement system. Using several examples of daily, weekly, monthly, and quarterly reports, Hays explains the way Westinghouse Sunnyvale complies with the C/SCS criteria.

The author has arrived at several recommendations for effective factory labor cost control which have worked at his company: use C/SCSC as a tool instead of just a reporting system; integrate information through mainframe computers; regularly generate reports for critical hardware items; insure timely information for corrective actions; monitor corrections until completed; utilize dedicated analysts for factory cost control; strive for consistency in control for all programs; hold routine meetings with involved personnel; use CPI for trend analysis; and sparingly use floor charts for trend analysis.

In summary, Hays believes using C/SCSC as a management tool has lead Westinghouse Sunnyvale to strong performance.

Title: "Product Comparison -- Mission: Made Possible"

Author: Heck, Michael

Format: Journal Article

Journal: *InfoWorld*

Volume: 11 (25 September 1989)

Pages: 57-76

Subjects: C/S Software

Orientation: Business/Defense/Government

Abstract source: ABI-INFORM

Abstract: According to recent surveys, project management is expected to outpace other software for user interest. *Project Scheduler 4, Version 1.5*, from Scitor Corporation combines a graphical interface with mouse input, making it much easier for casual users to create and update a schedule. *Microsoft Project, Version 4.0*, from Microsoft Corporation features a Gantt screen that works like a spreadsheet, in which a task is inserted by filling in a pop-up form. Instaplan Corporation's *Instaplan, Version 2.0*, features cost/schedule status report formats, earned value analysis, and subcontractor capabilities. It also comes with several print options covering budgeted, actual, and estimated work outputs given in both monetary and man-hours per period format. *Harvard Project Manager, Version 3.01*, from Software Publishing Corporation features the "Fast Track" mode, which allows task arrangement on a time line very quickly. All the project managers are affordably priced at under \$700.

Title: "Performance Measurement of FFP Major Subcontracts"

Author: Hildreth, Don

Format: Journal Article

Journal: *In Control*

Volume: 2 (June 1989)

Pages: 96-98 + overheads

Subjects: C/SCSC, Contracting Issues

Orientation: Defense/Government

Abstract source: Authors

Abstract: A cost/schedule control system and reporting is not only required on high value cost-plus defense contracts, but also on major, critical contracts and subcontracts. A standardized reporting format will help the prime contractor when analyzing the performance reports coming in from the subcontractor. This Program Status Review (PSR) report should be mutually established during subcontractor negotiations, and subsequent requirements should be specified in the resulting subcontract. In addition, the subcontractor must furnish a time phased spending plan complete with milestones sufficiently definitized so that objective progress measurement can be performed. Program Status Review meetings should be held regularly for the subcontractor to present his PSR report to the prime contractor. As with the prime, the subcontractor's performance measurement is usually the responsibility of a program control representative, and he is tasked with monitoring the technical, cost, and schedule progress of the effort.

Several sample report formats are included to help a prime contractor establish an effective reporting system with his its subcontractors.

Title: "Toward More Effective Management and Control of Contractor Payments"

Author: Hill, William J.

Format: Journal Article

Journal: *The Measurable News*

Volume: Summer 1991

Pages: 6-8

Subject: Contracting Issues, C/S Control

Orientation: Defense/Government

Abstract source: Authors

Abstract: The author offers several ideas for improving the government payment and review process. The process begins when the Administrative Contracting Officer (ACO) receives, for review and approval, a request for payment from the contractor. Before approval, some questions must be answered; 1) is the contractor making satisfactory progress, 2) do delivered items meet contract requirements, and 3) will the contract overrun/underrun? Adjustments to the payment requested will then be adjusted according to the answers to these questions. There are two review methods usually used in the payment approval process -- Incurred Cost (ACWP) method and Percent of Work Completed (BCWP) method. The Incurred Cost method is used on non-validated C/S systems. Its advantage is that it is relatively easy to gather actual costs from the contractor's accounting system. For the larger programs requiring C/S data, the Percent of Work Completed method is used. Using CPR or C/SSR data provide several advantages to the payments process. The information is usually more objective, Earned Value and Cost at Completion data are available, time is saved by government personnel because the information is in a single report, the information is traceable to the contractor's internal records, direct and indirect costs are readily available, and contractually, the Government has access to all this information.

In conclusion, the author suggests the Government require CPR or C/SSR requirements on all large dollar contracts so as to take advantage of the benefits these requirements provide to the payments and monitoring processes.

Title: "Project Management for Large-Scale Systems"

Author: Horan, Ron and Don McNichols

Format: Journal Article

Journal: Business Communications Review

Volume: 20 (September 1990)

Pages: 19-24

Subject: C/SCSC

Orientation: Defense/Government

Abstract source: ABI-INFORM

Abstract: The project management approaches traditionally used in the telecommunications industry, particularly in large-scale projects, have not provided a balance among cost, schedule, and technical issues. The federal government has used a cost and schedule control system (C/SCS) for selected industry and government procurements since 1967. There are three basic components of the C/SCS: 1. the concept of earned value, 2. the work breakdown structure, and 3. the criteria concept. The primary objective of the earned value concept is to prevent a vendor or a system owner from waiting until it is too late to find out that a task will be delayed or will experience an overrun. The work breakdown structure resolves the conflict between the customer's desire for everything to be done in relation to the requirements of the statement of work and the vendor's desire to assign tasks and responsibilities based on its own internal organization. The criteria concept defines the standards that a vendor's management control system must meet.

Title: *Cost Accounting: A Managerial Emphasis*

Author: Horngren, Charles T. and George Foster

Format: Book

Published: Englewood Cliffs NJ: Prentice Hall, Inc., 1991.

Total Pages: 964

Relevant Pages: some

Subjects: C/S Control

Orientation: Business

Abstract source: Authors

Abstract: There are a number of techniques available to monitor/control costs and identify variances using accounting principles. Standard costs have long been used to "track variances for control purposes department-by-department, or activity-by-activity, or operation-by-operation. Cost variances can be broken down first into manpower, material, and overhead variances, and then each by price and efficiency variances, thus pinpointing the causes of cost overruns/underruns. Once identified and reported in this manner, this information can be used to direct management attention to correcting deficiencies and improving performance. Effective project management involves the control of project scope, quality, cost, and schedule. The Department of Defense requires cost performance reporting and variance analysis on many of its high dollar projects [an example analysis is included].

A major concern in compliance with the Cost/Schedule Control Systems Criteria is in the proper allocation of direct and indirect costs to the contract. This text provides a thorough discussion on identifying costs with their cost objects.

Title: "C/SCSC -- Is There a Missing Criterion?"

Author: Kagan, Stanly S.

Format: Journal Article

Journal: *In Control*

Volume: 2 (April 1989)

Pages: 45-52

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: The 35 Cost/Schedule Control Systems Criteria establish guidelines for the contractor's management control system (MCS). They cover the implementation, use of, and government visibility into the MCS, yet they leave out one important consideration -- that of self-maintenance through internal surveillance actions.

Although covered in the Federal Acquisition Regulation Supplement on C/SCSC, self-maintenance of the contractor's control system has been "assumed" within the intentions of the 35 criteria. After all, the control system is "of their own design." None the less, surveillance reviews and subsequent application reviews show the contractor's MCS tend to deteriorate after their initial acceptance, and it's only because of government intervention that the systems return to an acceptable state. In the meantime, however, questionable data is generated and used from these systems.

Proposed is a 36th criteria which established the requirement for regular, formal self-audit, which should lessen the need for government review, and turn the contractor's MCS back to the contractor, as originally intended. The responsibility for self-audit should be given to an internal organization independent of programs, and the team chief should be given direct access to top management. Formal audit plans should be published, with government validation/review coincidental with the regularly scheduled cost/schedule control system validation/reviews. The result of this effort will be better information for both the contractor and government to use in their decision making, and less government interference in the internal workings of the defense contractors.

Title: "Material Applied Costs Under C/SCSC -- Maybe There's a Better Way for Cost Visibility"

Author: Kagan, Stanly S.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 4 (1987)

Pages: 39-43

Subject: EAC Techniques

Orientation: Business

Abstract source: Authors

Abstract: In this article the author asks some basic questions concerning the C/SCSC requirements for handling material resources and suggests adding a new EAC criterion for materials. Kagan questions the emphasis of placed on the "cost time-frame" after which material costs have already been determined. Such an emphasis neglects early consideration of the material planning process. The author feels that costs should be tracked at the beginning of material definition and continue through the purchasing process. A new EAC criterion for material would provide cost visibility earlier in the program. He also questions the utility of earned value on the receipt date of ordered materials. Measuring earned value here, according to the author, does not add to schedule control visibility. Emphasis on the internal schedule tracking systems rather than the "applied cost" provide greater utility.

The author concludes that the present EAC requirements do not fully address the material management process. The author suggests that the applied cost and earned value approaches to material management do not provide any better information than a material Estimate At Completion criterion would.

Title: "Coordination Mechanisms During the Construction Project Life Cycle"

Author: Karaa, Fadi A. and Badi Abdallah

Format: Journal Article

Journal: Project Management Journal

Volume: 22 (September 1991)

Pages: 45-53

Subjects: Foreign C/S, C/S Control

Orientation: Business/Construction

Abstract source: ABI-INFORM

Abstract: A reorganization proposal of a large construction firm performing large volumes of rehabilitation work in Lebanon is presented. It is shown that the company strategy, considering its environmental constraints, was controlled and sought cautious growth through a multi-project resource management approach. This helped identify the selected organizational structure as a weak matrix at the project level. A resource manager, or coordinator position was created, with formal and informal lines of authority. The coordinator acts as a profit center manager/strong matrix manager for a portfolio of projects located in the same geographical area. Appropriate coordination mechanisms are defined in the different stages of the project life, underlining the pivotal role of the coordinator. The importance of multi-project resource programming, along with formal cost-schedule control is stressed in this highly changing environment.

Title: "The C/SSR Conundrum"

Author: Kemps, Robert R.

Format: Journal Article

Journal: *The Measurable News*

Volume: Spring 1992

Pages: 1+

Subject: C/SCSC, Earned Value

Orientation: Defense/Government

Abstract source: Authors

Abstract: In this article, the author provides a brief history of the C/SSR, some of its problems, and recommendations for improving the C/SSR. In the past, C/SCSC was being required on the large dollar contracts, the lower level programs were left without standard reporting requirements. Although not as expensive as the big guys, the lower cost programs still needed some form of performance measurement. The C/SSR was the result. The C/SSR placed less stringent requirements on the contractor but still provided reporting of earned value. Because the C/SSR requirements were not as tough as the CPR, many of the reports received were almost worthless. Kemps relates several ideas which were proposed for correcting the C/SSR problem. He believes that the root problem with the C/SSR has been in the validity of determining the BCWP. The author believes we do not need to require C/SCSC compliance for a good C/SSR; we need to emphasize the BCWP's importance. He believes procedures need to be designed to improve the earned value formulation. The contractor's original work plan must be logical. The work measurement methods should be objectively based upon physical accomplishment, and control must be placed on changes to the work plan with no uncontrolled transfers.

Title: Project Management: A Systems Approach to Planning, Scheduling and Controlling

Author: Kerzner, Harold

Format: Book

Published: New York: Van Nostrand Reinhold Company, 1984.

Total Pages: 937

Relevant Pages: some

Subjects: C/S Control, Earned Value

Orientation: Business

Abstract source: Authors

Abstract: Cost control involves not only monitoring costs, but also to analyze variance, raise the danger flag, and take action before the problem becomes insurmountable. The cost control system is part of the larger management cost and control system (MCCS). This larger system must be able to accurately portray progress to date, relate cost to schedule performance, analyze variances and identify potential problem areas, and provide relevant information to the decision makers. The measures of budgeted cost for work scheduled, budgeted cost for work performed, and actual cost of work performed are used to measure cost and schedule deviation from planned to actual performance. This analysis is useless, however, if it's not communicated to executive management in a timely, concise, usable format. Earned value, a key in variance analysis, may not be useful at the lowest level of a work breakdown structure, however, the effort is worthwhile at the task level and above. A case study is presented to emphasize the usefulness of this cost control system.

Title: "Project Controls: Management's Decision-Making Tool"

Author: Kunz, Gerald R.

Format: Journal Article

Journal: *Cost Engineering*

Volume: 30 (January 1988)

Pages: 16-22

Subjects: C/S Control, Contracting Issues

Orientation: Business/Construction

Abstract source: ABI-INFORM

Abstract: Project controls are management's decision-making tools, and when properly designed, maintained, and used, these tools can allow management to forecast the future. In any project, four objectives exist: low cost, high quality, optimal safety, and timely completion. Project controls depend on the type of contract, of which there are three: the reimbursable cost contract under which the contractor is paid for all costs plus a reasonable profit; the unit-price contract, under which the contractor is paid a fixed amount for each unit of work; and the lump-sum contract, under which the contractor is paid a fixed amount for all work. Project controls are most difficult to implement under the lump-sum contract. To help the contractor in the preparation of a bid proposal relative to scheduling and project controls, a summary-level schedule should be included in the bid package. The contractor should hold weekly progress meeting with the project team to review near-term schedules, progress, and problems.

Title: "Cost/Schedule Control System Criteria: A Lighthearted Introduction for the Non-Believer"

Author: Lambert, Lee R.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1988

Pages: D.11.1-D.11.5

Subjects: C/S Control

Orientation: Defense/Government/Business

Abstract source: ABI-INFORM

Abstract: The key to meaningful utilization of the Cost/Schedule Control Systems Criteria (C/SCSC) approach to technical project management is whether a clear return on investment can be demonstrated. C/SCSC's purpose is to develop information as input to the total decision-making and communication process. It will provide information that will enable managers to take a more active role in defining and justifying a project. It can also call attention to potential problems before they become catastrophic. C/SCSC, however, will not solve technical problems, solve funding problems, make decisions, or manage the program. Thorough preparation for conducting research and development based on C/SCSC workshops will achieve the best possible learning experience. With informed and supportive users, C/SCSC can become one of the most effective tools that a project manager has available.

Title: "Understanding the Value of Earned Value or Where Have All Your Dollars Gone?"

Author: Lambert, Lee R.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1989

Pages: H.2.1-H.2.4

Subjects: Earned Value, C/S Control

Orientation: Business

Abstract source: ABI-INFORM

Abstract: Earned value is the designation generally given to management approaches, systems, or criteria that carefully attempt to integrate the elements of cost and time. This is done by developing a common denominator for those two elements that can be used over time to ensure that the planning, monitoring, and reporting of progress or problems constantly considers this common denominator and uses it to acquire consistency and enable clear and focused communication, both within the project and to the sponsor or client. The data elements that are critical to the earned value process are 1. budgeted cost of work scheduled, 2. actual cost of work performed, and 3. budgeted cost of work performed, which allows the removal of subjectivity that is associated with determining how much real work was accomplished. The effectiveness of earned value in an application is determined by such elements as the logical planning and integration of the work and realistic assignment of resources to support the work.

Title: A Comparative Analysis of Two Cost Performance Forecasting Models: The automated Financial Analysis Program, Electronics System Division, November 1976 Versus A Cost Performance Forecasting Concept and Model, Aeronautical Systems Division, November 1974

Authors: Land, Capt Thomas J. and Capt Edward L. Preston

Format: Master's Thesis

Published: Wright Patterson AFB, OH – School of Systems and Logistics, Air Force Institute of Technology, 1980.

Total Pages: 62

Relevant Pages: all

Subjects: C/S Software

Orientation: Defense/Government

Abstract source: Subject thesis' abstract

Abstract: The authors investigated the comparative accuracy of linear and non-linear cost forecasting models in estimating a contractor's cost at completion. Using cost performance reports for 20 completed aircraft programs, the authors generated estimates covering the span of the programs. the mean absolute percentage errors for each method and program were analyzed using ANOVA. Where indicated by ANOVA, Fisher's least significant difference test statistic was used to test the differences and established set groupings. The authors conclude, based on the sample that the linear cost forecasting model is as accurate as the non-linear cost forecasting model.

Title: "Project Management: Working Toward Cost, Resource Management"

Author: L. W. L. Harvey A.

Format: Journal Article

Journal: *Software Magazine*

Volume: 8 (October 1988)

Pages: 74-87

Subjects: C/S Software, C/S Control, Earned Value

Orientation: Business

Abstract source: ABI-INFORM

Abstract: The integrated, schedule driven approach to project management consists of critical path schedules, which are the foundation of traditional project management software, and the resources and components that are driven by the schedule component. While this approach will serve most project management situations well, the schedule component does not drive all applications. A stronger emphasis on the resource or cost control aspects of the project is required by many applications. Project management software that addresses these needs is becoming increasingly available. Earned value based facilities are available in three formats in project management programs that use the methods popular in traditional schedule based circles. The effective integration of work measurement and cost measurement systems continues to be an elusive goal, and the question remains as to who is responsible for basic project management training. Because of the need for wide access to the project management databases, a trend toward microcomputer based project management software on local area network systems is developing.

Title: "Performance Measurement is Not Program Management"

Author: Marchionna, Frederick H.

Format: Journal Article

Journal: *In Control*

Volume: 5 (April 1992)

Pages: 214-222

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: Performance measurement is neither performance management nor program management. Performance measurement is a tool, that if used correctly, can aid the manager in making decisions concerning his program. Program management involves a "myriad of technical decisions," all of which have an impact on cost and schedule, but being able to use performance measurement indications is just one of many skills required by the program manager (PM).

Contract Performance Measurement techniques, as required under the Cost/Schedule Control Systems Criteria, can provide the information necessary for the PM to make the cost, schedule, and performance tradeoffs involved in successful project management. C/SCSC can highlight where problems lie, show trends, and facilitate predictions, but it cannot be the only communication between program management, the project team, and the customer. Further, if performance measurement is to be of any use to the PM, it must be timely -- "almost real time." Perfect information is less important than current information which is accurate enough to show trend and facilitate immediate problem correction.

Title: "Pulling It All Together"

Author: Mast, Patricia A.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 2 (January 1987)

Pages: 19, 23-25

Subject: C/S Software

Orientation: Business

Abstract source: Authors

Abstract: Many companies deal with several different scheduling systems, internal, subcontractor, vendor, customer, etc. The problem, according to the author, is how to integrate all the different schedules into a single overview for management. Mast suggests a seven step process for schedule integration. 1) Identify those schedules which need to be integrated. 2) Identify the computer system on which each schedule is located. 3) Determine the way each system structures data. 4) Execute a translation program. 5) Integrate the translated schedules with the host computer's. 6) Establish an update schedule. 7) Document the procedures of the process.

The author encourages analysts to acquire the assistance of in-house programmers in the process. The above steps, according to Mast, will be well worth effort in providing an integrated program schedule.

Title: "The State of Artificial Intelligence in CPR Analysis"

Author: Maust, Gregory E.

Format: Journal Article

Journal: *In Control*

Volume: 3 (March 1991)

Pages: 35-46

Subjects: C/S Software, C/S Reporting

Orientation: Defense/Government

Abstract source: Authors

Abstract: Artificial intelligence (AI) applications to contract performance measurement (CPM) can aid the analyst in highlighting data anomalies, making forecasts, and identifying problem areas within the work breakdown structure. Traditional analysis has focused on the manipulation of basic Cost Performance Report (CPR) and Cost/Schedule Status Report (C/SSR) elements -- budgeted cost of work performed (BCWP), budgeted cost of work scheduled (BCWS), and actual cost of work performed (ACWP) -- into various performance indices and variances. These numbers are then provided to whomever to interpret the findings.

If, however, AI were used to interpret the numbers, early problem identification in narrative form would be what management would be looking at, instead of a mystic set of numbers. The AI program would "include a set of algorithms which can spot unusual performance, recognize critical variances, identify significant trends, "highlight potential problems, identify obvious data inconsistencies and anomalies, and unusual situations. One AI program *Contract Appraisal System (CAPPS)* used colored highlighting to better reflect the urgency of its narrative comments. Future AI programs should include an expanded set of possible comments, graphic support, and incorporate more detailed analysis. Artificial Intelligence can help eliminate the apprehension associated with contract performance measurement reports, and help increase their usefulness as internal management control aids.

Title: *Estimate-at-Completion Research -- A Review and Evaluation*

Author: McKinney, John W.

Format: Master's Thesis

Published: Wright-Patterson AFB, OH -- School of Systems and Logistics, Air Force Institute of Technology, September 1991.

Total Pages: 101

Relevant Pages: All

Subjects: EAC Techniques

Orientation: Defense/Government

Abstract source: Subject thesis' forward

Abstract: This research derives from the Performance Measurement discipline and consists of a comprehensive analysis of Estimate at Completion (EAC) studies published since 1973. The EAC studies consisted of models, comparison studies, and computer analysis programs. The studies were located through the Defense Technical Information Center (DTIC), the Cost Library at Wright-Patterson Air Force Base OH, and professional periodicals or contracted research.

Each study was categorized by formula type and described in terms of methodology and conclusions. Each study was evaluated based on clarity, documentation, methodology, and source. The description and evaluation of the studies are summarized in two tables.

After reviewing the studies some areas were found to be weak. The Air Force System Command formula that uses weighted percentages of .2 Schedule Performance Index (SPI) and .8 Cost Performance Index (CPI) is not supported by a critical review of the literature. In the area of comparison studies, different past performance factor formulas have been compared with respect to different percent completion points, type of contract, and type of product. A summary of the results are provided in Chapter II. Little work has been done comparing regression formulas to past performance factor formulas. An important outcome of this research identified the scarcity of formal EAC theory or relevant research concerning the underlying causes of why certain EAC formulas are better predictors of performance.

Title: "The Marriage of Manufacturing Resource Planning (MRPII) and Performance Measurement Systems"

Authors: Miller, George J. and Leah C. Loyd

Format: Journal Article

Journal: *In Control*

Volume: 3 (March 1991)

Pages: 153-162

Subjects: C/SCSC

Orientation: Government/Defense/Business

Abstract source: Authors

Abstract: The Department of Defense *Cost/Schedule Control Systems Criteria* requires the data used in performance measurement be the same data used in the contractor's own internal management control system (MCS). An existing Manufacturing Resource Planning (MRP) system can provide this integration. In many operations, the concurrent running MRP, performance measurement, and cost accounting systems are resulting in labor redundancy, data redundancy, data contradiction, auditing problems, and slowed communications and reporting. An integrated MCS could solve these problems and provide help with contract planning, actual cost and earned value measurement, forecasting, rebaselining, performance analysis, and formal reporting.

Currently, a few companies employ a somewhat integrated MCS with some success. However, further integration of the three systems is seen due to the benefits of data sharing, more reliable inputs, and better information for the contractor and customer.

Title: "Cases Impairing C/SCSC Application in Program Management"

Author: Nguyen, Nghi M.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1989

Pages: E.2.1-E.2.11

Subjects: C/SCSC, C/S Control

Orientation: Defense/Government/Business

Abstract source: ABI-INFORM

Abstract: Cost/Schedule Control Systems Criteria (C/SCSC) involve examining and evaluating defense contractors' internal management control systems for validation purposes in the execution of government programs. The application of C/SCSC is large-scale projects is expected to rise in many other industries as well. There are five major criteria requirements of C/SCSC: 1. organization, 2. planning and budgeting, 3. accounting, 4. analysis, and 5. revision and access to data. Typical cases impairing C/SCSC application occur when the contractor's management control points (cost accounts) are not available at the appropriate levels selected for control and analysis or when the work packages do not consist of discrete tasks used in performance measurement. The contractor must be provided with flexibility and not forced to subdivide work down to very low forms of reporting. The proper cost account levels should mainly be determined by the scope of work.

Title: "CS² in High-Tech Program Management"

Author: Nguyen, Nghi M.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1988

Pages: U.1.1-U.1.10

Subjects: C/S Control, C/SCSC, Earned Value, Variance Analysis

Orientation: Defense/Government

Abstract source: ABI-INFORM

Abstract: A reliable management control system is essential to effectively manage high-technology programs in the electronics, aerospace, and defense industries. The United States Department of Defense has introduced Cost/Schedule Control Systems Criteria (C/SCSC) standards for evaluating contractors' control systems. Generally, C/SCSC groups 35 criteria into five major categories: 1. organization, 2. planning and budgeting, 3. accounting, 4. analysis, and 5. revision and access to data. Cost and schedule performance measurement is provided by the earned value technique, which requires five elements: 1. budgeted cost for work scheduled, 2. budgeted cost for work performed, 3. actual cost for work performed, 4. budget at completion, and 5. estimate at completion. Performance data are provided in tabular form on the cost performance report at agreed upon levels and frequency.

Title: "Effective Subcontractor Management in High-Tech Projects"

Author: Nguyen, Nghi M.

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1991

Pages: D.1.1-D.1.7

Subjects: Earned Value, C/S Reporting, C/S Control

Orientation: Business

Abstract source: ABI-INFORM

Abstract: An effective approach used in the planning, monitoring, and control of a subcontractor's contract performance in high-technology projects is presented. The planning associated with subcontractor performance involves the acquisition planning for products, goods, and services to be procured to support the needs of the main contractor's contracted work for the customer. The subcontractor's status monitoring and control involves regular project reviews and is based on the concept of earned value to provide the technical, cost, and schedule performance measurement. The following four measurement techniques can be used to monitor subcontractor activities: 1. equipment delivery progress, 2. completion of deliverable end items, 3. design reviews, and 4. demonstration by the subcontractor of the achievement of milestones. A cost performance report can ensure that performance analysis and the resulting corrective actions are performed.

Title: "If the Pharaoh Had Only Used An Earned Value System in Building the Pyramids"

Author: Niemann, Lt Col William J.

Format: Journal Article

Journal: Program Manager

Volume: 11

Pages: 3-7

Subject: Earned Value, C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: This article provides a light-hearted view into the concept of earned value through which a pharaoh of ancient Egypt uses C/SCSC techniques to build a pyramid. The author hypothesizes competing programs, Sphinx, Icarus, Pegasus, to illustrate the need for effective cost and schedule effectiveness. Humorously, the article explains how the pharaoh builds the Performance Measurement Baseline (PMB) from the cumulative Budgeted Cost of Work Scheduled (BCWS). How the pharaoh compares it to the Actual Cost of Work Performed (ACWP), and realizes the need for a measurement of earned value, Budgeted Cost of Work Performed (BCWP), so that he can determine cost and schedule variances for the pyramid program.

The author provides a simple example of the concepts of earned value and C/SCSC whose humorous hypothesis effectively covers the basics of performance measurement.

Title: *Project Management: Risks and Productivity*

Author: Obradovitch, M. M. and S. E. Stephanou

Format: Book

Published: Bend OR: Daniel Spencer Publishers, 1990.

Total Pages: 438

Relevant Pages: some

Subjects: C/SCSC, Contracting Issues

Orientation: Business/Government

Abstract source: Authors

Abstract: The control function of a project management organization involves the monitoring of project progress in relation to a predetermined cost and schedule plan. This measurement information is made available to the project management decision makers through the "Project Management Information System (PMIS)" so that deviations can be acted upon. This system should report relevant information as it relates to the work breakdown structure, and could include financial reports, continually updated network schedules, "performance/cost/time" graphs depicting variances, variance reports, progress reports, subcontractor and vendor progress reports, special problem reports, and meeting minutes. Although the Cost/Schedule Control Systems Criteria (C/SCSC) offers an excellent means of integrating budget and time progress analysis, the "accomplished cost procedure (ACP)" provides an even stronger, more simple technique for "relating and monitoring the elusive relationship between the resources budgeted and the work accomplished."

Of special relevance to Department of Defense cost controllers are the chapters entitled "Project Planning and Scheduling" which presents work breakdown structures and networking, "Project Monitoring and Control" that discusses C/SCSC, ACP, and other reporting and analysis methods, and "Legal Aspects of Project Management" which covers the various contract types requiring contract performance measurement.

Title: *Cost/Schedule Control Systems Criteria: An Analysis of Managerial Utility*

Authors: Ostdiek, Lt Cgi Marion A. and Maj Richard T. Estes, Jr.

Format: Master's Thesis

Published: Wright Patterson AFB, OH -- School of Systems and Logistics, Air Force
Institute of Technology, 1975

Total Pages: 118

Relevant Pages: all

Subjects: C/S Control, CPM History, C/S Utility, C/SCSC

Orientation: Defense/Government

Abstract source: Subject thesis' abstract

Abstract: The Cost/Schedule Control Systems Criteria (C/SCSC) is imposed on a contractor's management information system during the performance of a contract for a major weapon system. Previous studies on C/SCSC had identified managerial resistance to the criteria. Data, gathered through structured interviews with military and contractor managers, was analyzed to find if a predetermined set of attitudes affected the perceived utility of C/SCSC. The selected variables of acceptance of quantitative techniques, cost consciousness, knowledge of quantitative techniques, and hierarchical position were studied as major factors influencing the perceived utility of the criteria. Relationships between the selected variables are not supportive of all five stated hypotheses; however, the study provided detailed data on the selected variables and on C/SCSC as a management tool. After a review of the managers' opinions and the available data, a conclusion was reached showing that the criteria in its present form is not sufficiently productive for the project goals. The study also indicates that a significant difference exists between military and civilian managers. The contractor manager exhibited a high correlation between perceived utility and each of four variables while the military manager shows this relationship between perceived utility and only one of the four variables.

Title: "NASA Space Station -- The Ultimate PMS Challenge"

Author: Pakiz, John J.

Format: Journal Article

Journal: *In Control*

Volume: 3 (March 1991)

Pages: 97-110

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: A continually changing program requires a flexible, continually changing performance measurement system (PMS). The National Aeronautic and Space Administration (NASA) Space Station is such a program. With the current environment of budget cutbacks on many major programs, "funding uncertainties and adjustments are compounding the efforts to control, maintain and evolve a comprehensive program baseline." This constant instability of the baseline has made performance measurement of the research, development, test, and engineering contract a challenge. The traditional, static techniques cannot properly portray work progress in this ever changing cost, schedule, and performance environment. Further complicating the picture are the numerous subcontractors that are also affected by the changing requirements.

In response, NASA, the prime contractor (McDonnell Douglas Space Systems Company) and the subs have been continually working together to evolve a PMS which is responsive to the changes, and provides the program managers the information they need to make proper program decisions. The key to the success of the effort is in the proper balance of work and planning package replanning with resource control. This balance is needed in order to give meaningful performance indicators while ensuring work is being performed according to the most up to date baseline. Effort to further improve the PMS continues in three main areas: 1. strengthening the basic variance and to complete analysis, 2. making more efficient the rebaselining effort, and 3. tailoring the PMS analysis and reporting to better meet the needs of program management.

Title: *An Investigation of the Stability of the Cost Performance Index*

Author: Payne, Maj Kirk I.

Format: Master's Thesis

Published: Wright-Patterson AFB, OH – School of Systems and Logistics, Air Force
Institute of Technology, September 1990.

Total Pages: 73

Relevant Pages: All

Subjects: EAC Techniques

Orientation: Defense/Government

Abstract source: Subject thesis' forward

Abstract: This study examines the stability of the Cost Performance Index (CPI). The CPI is an indicator of the cost performance efficiency achieved on a contract and is used to analyze cost performance on defense contracts. It has long been asserted that the index does not change by more than 10 percent after a contract is 50 percent complete, but an exhaustive literature search did not locate any empirical work that supports this assertion. Knowing that the CPI is stable is important because it indicates that a contractor has a healthy management system, it increases the reliability we place in the contractor's planning process, it gives us confidence in our Estimate at Completion computations, and if a contractor is overrunning his budget, it gives us confidence when we declare the contractor in trouble.

After defining CPI stability, two methods to test for stability were developed. The two methods chosen were: first, to measure the range of CPIs that occurred at greater than 50 percent complete and second, to calculate a percentage interval and verify that the CPI falls within the bounds of this interval. The results of both methods show that the CPI is stable after a contract is 50 percent complete.

Title: "Performance Indices -- Their Use and Misuse"

Author: Peck, Ron K.

Format: Journal Article

Journal: *The Measurable News*

Volume: Summer 1991

Pages: 1+

Subject: EAC Techniques

Orientation: Business

Abstract source: Authors

Abstract: In this article, the author states that with the existence of computers, analysts do not have to resort to just reporting information, they can easily make use of C/S performance indices, to-complete indices (TCPIs), and independent estimates at completion (IEACs) in which to aid managers gain better control over a program. By comparing TCPIs to CPIs, combined with the program's percentage complete, the analyst can validate the IEACs where raw data may under/overestimate C/S results. Peck also urges analysts endeavor to provide timely and meaningful data. Analysts must understand the technical facets of the program as well in order to judge the project's status.

In conclusion, the author reminds analysts that performance indices are only tools which must be used in conjunction with technical knowledge if they are to provide reliable estimates.

Title: "The Use of Alternate Contract Types in Europe as Protection Against Overruns"

Author: Peeters, W. A. and J. Veld

Format: Journal Article

Journal: National Contract Management Journal

Volume: 23 (Summer 1989)

Pages: 23-35

Subjects: Foreign C/S, Contracting Issues

Orientation: Business/Government

Abstract source: ABI-INFORM

Abstract: Recent technological development contracts have proven that the traditional types of contracts, such as the firm-fixed price (FFP) and Cost-plus percentage fee (CPPF), were inadequate for controlling expenditures. To remedy this, a number of intermediate types of contracts, most of which contain incentive provisions, were developed. A systems approach is used to analyze the applications of intermediate type contracts in Europe. A general contract model is presented that emphasized three contractual parameters: cost, delivery time, and performance. The final model is presented in the form of a decision tree, which makes it possible to select objectively the most appropriate type of contract for each specific case. It is found that there has been a steady transfer from the high-technology environment, such as the National Aeronautic Space Administration, over large procurement contracts to the traditional sectors. Europe is still limited to the first step – the European Space Agency. The aerospace industry is the most experienced user of intermediate type contracts.

Title: "Standards for Analysis for CPR/CSSR from the Customer Perspective"

Author: Powell, Sandra S.

Format: Journal Article

Journal: *In Control*

Volume: 5 (April 1992)

Pages: 165-178

Subjects: C/SCSC, C/S Utility

Orientation: Defense/Government

Abstract source: Authors

Abstract: The Program Control function of Aeronautical Systems Division (ASD) program offices (POs) and laboratories is required to provide an analysis of the periodic Cost Performance Reports (CPRs) and Cost/Schedule Status Reports (CSSRs) they receive from contractors. The quality and depth of analysis varies widely from program to program and from time to time due to military rotations and a lack of finite guidance of analysis requirements. This leaves many customers of this analysis (program management) wanting more.

The author performed a survey of program managers from four different program types: major weapon system, non-major weapon system, non-major system supporting a major weapon system, and science-technology programs. As a whole, the respondents reported, and this paper suggests, that although an analyst's CPR/CSSR analysis be friendly and concise, it should include as a minimum the following:

1. A validation of the arithmetic, format, and variance explanation accuracy of the contractor's report.
2. Both current and cumulative cost and schedule variance. Variance drivers should be insightfully explained with help from functional team members. This narrative should include problem cause, alternative solutions, program impact, and get well date.
3. Trend analysis to include two graphs: 1. a cost/schedule variance trend graph, and 2. a graph depicting Budgeted Cost of Work Scheduled, Budgeted Cost of Work Performed, Actual Cost of Work Performed, Budget at Completion, and Latest Revised Estimate.

Many other suggestions are proposed to improve the cost/schedule control process from the perspective of the customer -- program management.

Title: An Evaluation of CPRA Estimate at Completion Techniques Bases Upon AFWAL Cost/Schedule Control System Criteria Data

Author: Price, Capt James B.

Format: Master's Thesis

Published: Wright-Patterson AFB, OH -- School of Systems and Logistics, Air Force Institute of Technology, 1985.

Total Pages: 57

Relevant Pages: All

Subjects: C/S software, C/SCSC, EAC techniques

Orientation: Defense/Government

Abstract source: Subject thesis' forward

Abstract: This thesis examined techniques used to derive estimates of the cost at completion for various research and development programs. The six methods examined were the methods used in the Cost Performance Report Analysis (CPRA) computer program to calculate estimates at completion.

The analysis is based on a linear regression between the cost at completion and the estimate at completion for each technique available. The techniques were ranked by coefficient of determination and a general linear test was performed to test for equality among the regression lines.

The results of this investigation indicate that an estimate at completion based upon weighted cost and schedule indices [the thesis does not clearly state whether these are cumulative or current month indices] minimizes the unexplained error (as a percentage of total error) and is thought to be the superior forecaster of costs at completion. The general linear test for equality among the regression lines generated by the different techniques did not indicate the existence of commonality between regression lines. This means that each technique tested provided a unique estimate at completion.

Title: "Project Control – 2: Measuring, Analyzing and Reporting"

Author: Pryor, Stephen

Format: Journal Article

Journal: *Management Accounting (UK)*

Volume: 66 (June 1988)

Pages: 18-19

Subjects: Foreign C/S, C/S Control, Earned Value

Orientation: Business

Abstract source: ABI-INFORM

Abstract: Effective project control requires the comparison of actual costs and physical progress with an integrated financial and physical plan. Earned value is the unit of measure used to determine the percentage completion of dissimilar physical activities in the work breakdown structure. In addition, variance analysis focuses management attention at regular intervals on factors that may obstruct timely project completion. Earned value also reveals the effects of variances on project objectives. All projects require a formal reporting system, designed to provide information on actual progress and on what is expected during the remainder of the project. While controllable variances stem from problems within the project, uncontrollable variances typically relate to external events. Corrective action, requiring compromises between objectives, schedule, and costs, is determined by the size and significance of the variance. To achieve a successful completion, management commitment to the project control system is essential.

Title: Evaluation of Procedures Employed During Source Selection for Contracts Including Clauses Requiring Cost/Schedule Control Systems Criteria (C/SCSC)

Author: Pugh, Capt James E.

Format: Master's Thesis

Published: Wright Patterson AFB, OH -- School of Systems and Logistics, Air Force Institute of Technology, 1985.

Total Pages: 94

Relevant Pages: all

Subjects: C/SCSC, Contracting Issues

Orientation: Defense/Government

Abstract source: Subject thesis' abstract

Abstract: To effectively manage Research and Development, and full-scale production programs, the DOD requires contractors to submit performance measurement information. Performance measurement information is produced by management systems for control purposes and is verified as valid and timely by its adherence to the Cost/Schedule Control Systems Criteria (C/SCSC). This research effort examines how performance measurement systems are evaluated during source selection. This thesis explains: the C/SCSC-related items of a DOD solicitation and the resulting requirements placed on a contractor's proposal; how the source selection process works; the importance of C/SCSC in regard to the overall source selection; and how the contractor's C/SCSC plan is evaluated during source selection.

The research is based primarily on interviews with Aeronautical Systems Division personnel. Those interviewed were chosen based upon their position, experience, and training. The general agreement among those interviewed provides a basis for developing a list of important items to consider during source selection when evaluating contracts which include C/SCSC clauses.

Title: "Production Management: Integrating Cost Performance With Line of Balance"

Author: Reeves, Jerry and Joseph Maddock

Format: Journal Article

Journal: Program Manager

Volume: 17

Pages: 29-33

Subject: C/S Software, Variance Analysis

Orientation: Defense/Government

Abstract source: Authors

Abstract: The authors review an IBM-PC based software package which incorporates C/SCSC with a traditional line of balance concept thereby providing an integrated program management tool. The article explains how the software incorporates the C/SCSC concepts to form the integrated system. The software will prompt the user to enter Budgeted Cost of Work Scheduled (BCWS) information which will be automatically adjusted according to a user defined learning curve rate to provide the performance baseline. When a milestone is completed according to the original line of balance, Budgeted Cost of Work Performed (BCWP) is then displayed allowing schedule variance determination. Actual Cost of Work Performed (ACWP) information can be downloaded from the accounting system and compared with the BCWP for cost variance analysis. The system also produces various charts and summary reports.

The authors feel that the system provides the manager with a cost effective, MIL-STD-1567A compliant tool which enables him/her to plan, budget, measure, and report the status of a program.

Title: "Contractor Self Governance: A Concept Who's Time has Now Arrived"

Authors: Reuter, Maj Robert and Anthony Webster

Format: Journal Article

Journal: *In Control*

Volume: 2 (November 1989)

Pages: 221-224

Subjects: C/SCSC

Orientation: Defense/Government

Abstract source: Authors

Abstract: There exists the possibility of reducing the number of Department of Defense, Cost/Schedule Control Systems Criteria reviews to a contractor during the course of a contract. The answer is through self governance of the contractor's management control system (MCS), and the key to making this work is to incorporate the MCS as an integral part of the company. The contractor has to claim his ownership of the control system, and not treat it as an externally applied burden.

Currently, many contractors have "crisis action teams" which ensure the MCS is working properly prior to each DOD visit. This results in less than efficient control, and hence more DOD visits. What is needed instead is a full time, professionally staffed, internal Program Control office to continuously monitor the MCS operation, ensure its compliance with the criteria, identify and fix any deficiencies, and conduct training programs to better facilitate its proper operation.

Experience shows that without continuous supervision, the contractor's internal control system quickly goes astray. To gain the "self governance" status, the contractor will have to convince the DOD customer that his MCS will reliably provide the information required to make proper program decisions.

Title: *Managing Projects: A Systems Approach*

Author: Roman, Daniel D.

Format: Book

Published: New York: Elsevier Science Publishing Co., Inc., 1986.

Total Pages: 454

Relevant Pages: many

Subjects: C/S Control, C/SCSC

Orientation: Business/Government

Abstract source: Authors

Abstract: Planning and control are two fundamental elements of project management. Planning involves the scheduling of work and budgeting of resources, while control entails the process of measuring progress and ensuring the project goes as planned. A key tool in planning is the work breakdown structure (WBS) which embodies a networked list of tasks that need to be accomplished, as well as the time and resources needed for its accomplishment. The controller's job lies in variance analysis and the communication of his findings to the decision makers on the project. This textbook presents project management from a conceptual as opposed to mechanical approach. It is written for general application, but mostly in Department of Defense (DOD) adopted terminology, so much of the model is directly applicable to Cost/Schedule Control Systems Criteria (C/SCSC). Of special relevance to DOD cost analysts are the chapters on "Planning and Control Techniques" (which includes sections discussing C/SCSC and the work breakdown structure), "Financial Management" (that covers cost allocation, budgeting, and estimates to complete), "Project Controls" (which describes the control process), and "Some Legal Aspects of Project Management" (that goes into contractual issues).

Title: "Communication of Performance Results: Pictures and Numbers"

Author: Scholz, William H.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 7 (April 1988)

Pages: 15-21

Subject: C/S Software, C/S Reporting

Orientation: Business

Abstract source: Authors

Abstract: With the growth in knowledge of performance measurement and analytical tools available to the analyst, there also is a growth in demand for higher levels of performance. This article discusses two areas relative to communication of performance results which the author feels need to be improved; graphics and the technology in presenting results.

Scholz believes that managers are inundated by complicated and illegible charts and tables. The solution is to first focus on the important facts which need to be communicated. Next, use whatever tool most clearly expresses the information which needs to be imparted. Third, often a creative spin can be added to better get the idea across to the decision maker. Fourth, keep the graphic as simple as possible. The graphic should be such that it needs no explanation. And finally, use a lot of slides. Often people will become bored staring at a single slide for a long period of time.

The author feels that the choice of graphic tools is an important factor in communication. Obtain tools which can be used in a variety of environments to avoid obsolescence. Interface project management software with other data systems in order to provide a "standard output." Output should be available on several different peripherals. Select one tool which will provide all the necessary output. The ability to customize reports is a must. The tool should be able to produce small and large drawings as well as multi-page drawings, etc.

The author concludes that with available technology, presentations of complex information can and should be clearly communicated to those who need it.

Title: "Knowledge Bases for C/SCSC

Author: Singh, Amarjit

Format: Journal Article

Journal: Cost Engineering

Volume: 33 (June 1991)

Pages: 39-49

Subjects: C/SCSC, C/S Software, C/S Control

Orientation: Defense/Government

Abstract source: ABI-INFORM

Abstract: Cost/Schedule Control Systems Criteria (C/SCSC) is a sound and powerful tool for project progress measurement and control. It was initiated in 1967 by the United States Department of Defense to reduce cost and schedule overruns. Although C/SCSC is not a panacea for chronic project ailments, it does provide a more accurate statement of project status. It works on the principle of measuring actual quantities and costs within specific duration, plotting their histograms, fitting a smooth distribution curve, deriving the cumulative profile, and then comparing the actual observations against budgeted observations. Ten knowledge bases that categorize C/SCSC are presented. Programs written using conventional operations and those using expert system shells revealed that the conventional programs are more practical, simple, and user-friendly when applied to C/SCSC problems than are expert programs.

Title: "Cost/Schedule Control Vs Computer Programs"

Author: Singh, Rohit

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1991

Pages: C.3.1-C.3.3

Subjects: C/S Control, C/S Software

Orientation: Business

Abstract source: ABI-INFORM

Abstract: Several types of project management software are available. One type of this software, built upon a relational database foundation, can produce printed reports and graphics, time-phased logic diagrams, pure logic diagrams, histograms, and progress curves. A second type of software provides a comprehensive estimating database. Estimating software can produce an estimate very quickly, change information, and provide thorough backup information. Planning-schedule software can produce various reports, including current versus target scheduling reports and various listings by activity. The basis of cost management software is cost control that is based on a work breakdown structure. It provides a comprehensive cost performance reporting capability. In addition to the various cost-benefit analyses, other factors to consider in choosing software should be the company's project management goals.

Title: *The Principles and Practice of Cost/Schedule Control Systems*

Author: Slemaker, Chuck M.

Format: Book

Published: Princeton: Petrocelli Books, 1985.

Total Pages: 427

Relevant Pages: Most

Subjects: C/SCSC, Earned Value

Orientation: Defense/Government/Business/Construction

Abstract source: Authors

Abstract: Traditionally, cost control and schedule control have been treated as separate disciplines. The proposed management control system integrates the two, and can be tailored to meet the control needs of a variety of firms where a project management philosophy is followed, or could/should be followed. Earned value -- a way of measuring progress from detailed, worker developed plans -- is the key to being able to control costs, make forecasts, and communicate performance. The book is written as a general text to be applied to any commercial venture, however, each chapter is annexed to provide further detail on how this control philosophy can be tailored to meet the specifics of the United States Department of Defense imposed Cost/Schedule Control System Criteria, with a minimum level of added work. The Cost/Schedule Control System is a compilation of several disciplines integrated into a single information/decision support system. The system combines the output of work definition, schedule control, work planning, an operating organization, a project office, cost control, work authorization, and cost accounting. While these subsystems are found in all organizations, the key is integration.

Title: "Mainframe ARTEMIS: More than a Project Management Tool; Project Earned Value Analysis (PEVA)"

Author: Smith, Larry A.

Format: Journal Article

Journal: Project Management Journal

Volume: 19 (April 1988)

Pages: 23-28

Subjects: Earned Value, C/S Software

Orientation: Business

Abstract source: ABI-INFORM

Abstract: The *ARTEMIS* project management software system by Metier Management Systems Incorporated has five major components: a relational database, library, control identification, command language, and files/programs. Metier expects it will modify the application to fit particular company needs. For network and scheduling, *ARTEMIS* offers both a simplified approach for small projects, and a massive detailed approach for large, complex projects. Although graphics capabilities are another plus, *ARTEMIS* carries a large price tag, and program documentation is lacking. *Project Earned Value Analysis* by Engineering Management Consultants was designed to track one or multiple projects with capability to review each project. The concept is to calculate an earned value for each task representing how effectively man hours were expended. It includes 22 task descriptors per project. Input screens, menus, and user options are easy to use, but continuous disk access seems to require more time than it should during program execution.

Title: *CPR Software Analysis: Determining "The Ideal" Software*

Author: Smith, Capt Terry V.

Format: Master's Thesis

Published: Wright-Patterson AFB, OH -- School of Systems and Logistics, Air Force Institute of Technology, September 1990.

Total Pages: 119

Relevant Pages: All

Subjects: C/S software, C/S Reporting

Orientation: Defense/Government

Abstract source: Subject thesis' forward

Abstract: The purpose of this study was to determine "the ideal" personal computer (PC)-based Cost Performance Report (CPR) analysis software package currently available. In conducting this study, evaluation criteria needed to be selected for analyzing the software. In order to establish what criteria were to be used in evaluating the CPR analysis software, two questionnaires were sent to Air Force Systems Command (AFSC) product divisions. The first questionnaire asked the users what features would be useful and/or ideal in a CPR analysis software package. The second questionnaire then asked the users to rank order the criteria established from the first questionnaire. The final evaluation criteria were then selected based on an analysis of the responses to the second questionnaire. Upon selection of the criteria, four PC-based CPR analysis software packages were evaluated against those criteria.

Further analysis of the CPR software packages was conducted on a decision support software package, Expert Choice. Expert Choice ranked the CPR software packages with respect to the evaluation criteria established. A sensitivity analysis was also performed with regard to the importance of the evaluation criteria in ranking the software packages. In comparing the results from the verbal and numerical analysis of the CPR software packages using Expert Choice as well as the sensitivity analysis that was performed, Performance Analyzer was selected as "the most ideal" CPR analysis software package from the four packages that were evaluated.

Title: "How to Structure a Proposal Around Your Cost/Schedule Control System"

Author: Snell, Lyn and Bob Wacker

Format: Journal Article

Journal: *In Control*

Volume: 2 Number 1 (August 1988)

Pages: 15-22

Subject: C/S Control, C/S Reporting

Orientation: Government/Business

Abstract source: Authors

Abstract: Most winners of contracts, according to the authors, win because of well planned proposals centered around good cost/schedule control systems. Many bidders believe that "a proposal is a proposal, and a program is a program," whereas the program should be viewed as a continuation of the proposal, not just a separate effort. Generally, the cost/schedule system is considered only part of the program due to its measurement and tracking of the work being done on the project. The authors suggest constructing the WBS in the proposal with a view towards applying it during the life of the program as well. The proposal sets the framework of the program and if the system is put in place during the proposal process, transitioning into the program can be accomplished in a more efficacious manner.

Snell and Wacker feel that cost and schedule are surrogate measurements of technical performance and suggest a technical performance measurement (TPM) parameter be incorporated within the proposal and program to allow a more precise measurement than simply cost and schedule reporting. The authors believe that current systems are capable of providing a cost/schedule/technical control system and if used, should provide better control over the proposal/program processes.

Title: "A System for Monitoring Cost and Schedule Performance of Professional Design Services"

Author: Suarez, Luis F. and Howard A. Green

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1988

Pages: G.7.1-G.7.5

Subjects: C/S Control, Variance Analysis

Orientation: Business/Construction

Abstract source: ABI-INFORM

Abstract: A technique is presented for monitoring, reporting, and controlling the cost and schedule performance of professional design services. The essence of the technique is the identification of early signals of cost and/or schedule deviations from certain target objectives. The method is a systems application of earned value concepts. It uses a simple model of the planned performance of architect/engineering design services. After the architect/engineer submits the performance plan, the owner can prepare an S-curve that shows, in graphical fashion, the cumulative percentage of work planned for each month and the rate of planned progress. During project execution, the owner must obtain data similar to the performance plan on a monthly basis. These data include the actual number of work hours charged to the project and actual percentage of physical completion for each discipline. The owner can compare actual performance with the original plan, make forecasts, and perform what-if analyses.

Title: *An Investigation into the Use of Faces as a Means of Presenting Cost Performance Report Data*

Author: Tkach, Jeffrey B.

Format: Master's Thesis

Published: Wright-Patterson AFB, OH -- School of Systems and Logistics, Air Force Institute of Technology, September 1990.

Total Pages: 118

Relevant Pages: All

Subjects: C/S Reporting

Orientation: Defense/Government

Abstract source: Subject thesis' forward

Abstract: This research focused on the use of faces as a means of representing contractor generated Cost Performance Report (CPR) data. The study investigated the feasibility to using faces, and whether the use of faces would lead to effective decision making based on the information that the faces represent. The faces concept involved the transformation of data into cartoon-like faces by pairing specific variables of the data set with distinctive facial features, such as pupil location and nose length.

Feasibility of use was defined in terms of the availability of a personal computer based program that could be used to draw the faces and whether individuals would feel confident using the faces. Effective decision making is defined as the ability to make accurate decisions in a reasonable period of time.

A computer program was developed to draw the faces. A test scenario was designed to evaluate a user's decision making confidence and decision making effectiveness. The test utilized the tabular data presentation mode as a basis for comparison.

A statistical analysis of the data collected indicated that the use of faces resulted in lower decision making confidence and lower decision making effectiveness as compared to the use of tables. However, training and experience in the use of faces significantly increased both the confidence and effectiveness levels.

Title: "Contemporary Planning in the '90s"

Author: Trufant, Thomas M. and Robert H. Murphy

Format: Journal Article

Journal: *AACE Transactions*

Volume: 1990

Pages: H.3.1-H.3.5

Subjects: Earned Value, C/S Control

Orientation: Business/Construction

Abstract source: ABI-INFORM

Abstract: The contemporary planning process of the 1990s will closely echo the approaches of the past. However, the challenge will be to enhance the project controls organizations by balancing the traditional small project controls approach with the current, myriad fast-track microcomputer cost and scheduling applications. The planning engineer should reinforce the use of the computer as a data-handling tool. Engineers and constructors will be updating their work at personal computer workstations, and their inputs will be translated to an earned value network based reporting system. As a result, there will be a greater need and opportunity for the planning engineer of the 1990s to become more involved with the cost and schedule analysis function, with less time required to obtain progress updates. Currently, there is a lack of seasoned planning and cost engineers. As a result, most companies will have to develop and groom young engineers for the profession.

Title: "Effective Use of PMS Data"

Author: Tyler, Douglas W.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 3 (April 1987)

Pages: 102-116

Subject: C/S Control, EAC Techniques, C/S Reporting

Orientation: Business

Abstract source: Authors

Abstract: Tyler, in his article, describes some analysis techniques which aid in analyzing C/S data and improving communication of the information. The author suggests a four step analysis process: 1) analyze the data; 2) understand the data; 3) cause corrective action; and 4) monitor the results. The steps should occur each month and analyses, notes, briefings, etc. for each month should be filed separately.

Next, the author advocates the use of computer tools for quick analysis and some management concerns which the analyst needs to be on top of. Critical path analysis should be used from the start to prevent future scheduling problems, and he insists lower level analysis is necessary to locate problems early. The author also describes some methods of trend analysis presentation which aid the manager in understanding the status of the project. Such analyses are developed into a "Trend Summary" report. Tyler has also developed a color coding method of identifying overrun and underrun situations which are easily understandable to the manager located in the "Program Management Summary." Other summaries for managers are the "Critical Path Summary" and the "Executive Management Summary" reports. Finally a "Hot Sheet" is provided to management to inform them of critical problems which need immediate attention. The author believes analysts who can effectively communicate project status to managers will provide invaluable benefit to the progress of the program.

Title: "HQ Air Force Systems Command Estimate At Completion Formula Justification"

Author: Wallender, Capt Timothy J.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 4 (1987)

Pages: 9-19

Subject: EAC Techniques

Orientation: Defense/Government

Abstract source: Subject article's forward and abstract

Abstract: There is a continuing need to develop and provide cost/financial analysts, decision makers, and technicians with forecasting techniques for use on Cost Performance Reports (CPRs) and Cost/Schedule Status Reports (C/SSRs). A commonly used forecasting technique is the trend extension. This technique takes a "snapshot" of the contractor's performance to date and extends that performance to the completion of the program as an estimate of final costs at completion. The advantages of using an Estimate At Completion (EAC) trend extension are: (i) it is easy and quick to use; (ii) it uses published data; and (iii) it is based on a history of past cost and schedule performance.

This report describes the HQ Air Force Systems Command (HQ AFSC) Estimate At Completion (EAC) trend extension formula and three studies that support its use.

The introductory section of the report provides insight into why a standard trend extension was developed at HQ AFSC.

The following three sections describe studies completed by HQ AFSC, ASD, and AD. These three studies are provided to support the HQ AFSC EAC trend extension formula as one of the best trend extension formulas currently in use.

The final section describes how to properly use the HQ AFSC EAC formula.

Title: "The Development of an On-Line Management Information System for Cost/Schedule Control"

Author: Weger, R. L.

Format: Journal Article

Journal: *In Control*

Volume: 1 Number 1 (October 1986)

Pages: 14-24

Subject: C/S Software

Orientation: Defense/Government

Abstract source: Authors

Abstract: In this article, the author explains IBM's development of the on-line management information system (MIS), AB/BSY-1, for the Naval Sea Systems Command (NAVSEA). The author defines the problems of the NAVSEA system and covers the system's requirements. IBM's solution to the problem was the AN/BSY-1 Management Information System (BMIS) which runs on a 3081 mainframe at the Manassas Information Systems computer center. BMIS provides the Navy with the ability to transmit data from other systems to the BMIS, provides customized user screens, and a library of common procedures for key-driven menus. The system will output various C/S reports in tabular or graphic formats. BMIS also incorporates a help facility.

According to the author, BMIS has provided the Navy with improved data quality and improvements in report generation. BMIS is continually evolving to incorporate more useful features.

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13. ABSTRACT (Maximum 200 words) This thesis effort provides a valuable tool for contract performance measurement (CPM) analysts to use both while attending formalized Cost/Schedule Control Systems Criteria (C/SCSC) training, and while on the job. Research indicated a large amount of written material existed on contract performance measurement and the more specific topic of C/SCSC, yet this information was hidden in a wide array of unindexed professional journals, master's theses, and texts. Further, while many professions have a reference guide of annotated bibliographies, CPM had none. Through an extensive literature review using several search and retrieval methods, the authors were able to amass a bibliography of nearly 100 professional journal articles, theses, and texts which address contract performance measurement issues within 11 more specific topic areas. While these sources do not begin to represent a census of the available information, it does represent a wide cross-section of some of the more important contributions to the performance measurement knowledge base. The end product of this work is a stand alone C/SCSC reference guide (appendixed at the end of the main thesis body for ease in reproduction).					
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