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C/SCSC OVERVIEW:
APPROACH, IMPLEMENTATION, USE

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INTRODUCTION

With the increasing emphasis on Project Management over the last ten years, many disciplines have formally become part of management control systems. These disciplines span areas of accounting, material inventory, organization structures, and performance measurement.

This paper is intended for management, administrative and technical personnel who are either finding themselves entering the world of the latest Government performance measurement requirements for cost and schedule reporting or those who might require some form of a management control system. The paper will acquaint the "newcomer" to C/SCSC with the events leading to the C/SCS requirement, how to approach the requirement, and a discussion on implementing and use of the system.

There are many Government publications, directives and instructions on the subject and most are listed in the following paragraphs. This paper is intended to answer a question I have received many times. Where can I read what C/SCSC is all about?

In the mid-sixties, several Department of Defense (DOD) service agencies embarked on a new performance measurement concept to track cost and schedule performance on major DOD programs.

Over the past ten years, constant surveillance, re-evaluation and modifications have produced the present version of the Cost/Schedule Control System Criteria, known as C/SCS or C/S "Squared".

The performance measurement concept of C/SCS has expanded from DOD use, to the Department of Energy (PMS), NASA (533 Reports), and private industry such as shipbuilding, utilities and construction.

The use of a common type of reporting system has enabled DOD Program Offices to integrate performance data from various contractors within a major program, and produce a summary report for higher DOD

reporting purposes. Although the individual contractors have their own unique management control systems, the form of data presented has to meet certain criteria which would insure commonality in terminology and method of calculations.

The above mentioned criteria is formerly found in the Cost/Schedule Control Systems Criteria Joint Implementation Guide, and is listed under the following service identification numbers.

- Air Force Systems Command - AFSCP/AFLCP 173-5
- Air Force Logistics Command - AFSCP/AFLCP 173-5
- Army Material Development and Readiness Command - DARCOM-P 715-5
- Navy Material Command - NAVMAT P5240
- Defense Supply Agency - DSAH 8315.2

The document used by service agencies to follow a uniform method of surveillance is called the C/SCSC Joint Surveillance Guide and is used to insure adequate adherence to the requirements under contractual obligations.

Each agency has established dollar value thresholds for major programs, both for R&D and Production as guidelines for performance measurement contractual requirements. The requirements are formally documented as ASPR or FPR contract clauses.

COST SCHEDULE CONTROL SYSTEM CRITERIA (C/SCSC)

The C/SCSC Joint Implementation Guide is the basic document that sets forth the guidelines for use during planning, implementation and surveillance of the listed criteria.

The criteria discussion is divided into five major subsystems:

- Criteria Subsystems

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- (1) Organization, (2) Planning and Budgeting, (3) Accounting, (4) Analysis, (5) Revisions

Detailed discussions covering each subsystem provide instructions, terminology, definitions, and guidelines for Government personnel, as well as contractors.

There are 35 major criteria listings and these are broken down into 157 sub-items. This checklist is used as the "test" document by Government Team personnel to determine a contractor's compliance to contractual requirements. The successful completion of the "Demonstration" results in a "Validated" system.

The following sections of this paper will be devoted to the method of approaching a C/SCS requirement; organization, implementation, program use.

AN APPROACH TO C/SCS

The following paragraphs will take the reader through chronological steps in either meeting a contractual requirement for performance measurement, or in developing or modifying an internal system as part of management control improvements.

ORGANIZATION

Typical organization for C/SCS Development:

- RFQ - Prime or Subcontract
- Visit Organization with Validated System
- Establish C/SCS Committee

A Request for Quotation (RFQ) will address the type of management control system required and the detail of response by a contractor. Specific Statement-of-Work (SOW) paragraphs call out for the type of management detail needed in engineering disciplines, as well as program management disciplines. This transverse schedules, major milestones, technical parameter monitoring, and cost planning techniques. Further detail will usually be found in the Contracts Data Requirement List (CDRL).

The RFQ will direct all bidders to meet the C/SCS requirements, if that was the decision made by the Government agency and Program Office. Subcontractors or team

members of any major bid must also be considered by the prime contractor as to the desirability and capability to comply with C/SCS.

The prime contractor responds to the RFQ by discussing his present management control system and those of his major subcontractors or team members. The discussion usually takes the following format:

• RFQ Response Format

- Do we presently have a "validated" C/SCS System?
- If so, do we agree to use it on this program?
- If not, describe the present system and any modification necessary to meet the Criteria.
- Outline the proposed system after planned modifications.
- Show Implementation Schedule for planning and completion of Management Control System after contract award.

During the RFQ and award phase, it is desirable to start all studies and investigations (prior to contract award).

A committee, representing major functions within the organization, should be formed with a definitive charter authorized by management. Functional groups, as a minimum, should contain representatives from Engineering, Manufacturing or Production, Accounting and Financial Management. Computer Services should be represented and might be found in either Accounting or Financial Management.

• Committee Charter

- Examine C/SCS requirements versus existing accounting, functional, planning and control systems.
- Separate all major and minor differences so costs can be properly analyzed.
- Develop plan for design of system to meet C/SCS requirements with minimum changes to existing system and documentation.
- Develop implementation schedule.

Depending on the findings of the above committee, a typical output report would be summarized in the following manner.

- Committee Output Highlights

- 1-2 year study and design effort with minimum changes in existing accounting system.
- Produce training manual and procedures for personnel.
- Modularize system for C/SCSC, CSSR, or general use. (Cost Schedule Status Report, CSSR, is a modified version of C/SCSC with less emphasis on criteria and formal documentation.)

IMPLEMENTATION

The implementation task is divided into two phases - prior to contract award and after contract award.

Prior to contract award, management must make a decision as to the C/SCSC Committee recommendations. They may choose to embark on a total system, independent of the contract award; start implementation of certain changes prior to contract award; or develop a detailed plan on how to proceed immediately upon contract award.

Some of the items which must be considered in this plan are listed below:

- Documentation

How many different systems or procedures are being used, how many must be revised, how many can be consolidated into one useful system?

- System Design

Who are the best people to represent various functional groups to produce a manual operating system which can easily be automated?

- Automation of Data

Allow the computer personnel to understand the "building" of the manual system so automation will be done at the best time and at least cost.

- Training

Plan on the type of training that personnel with immediate needs will require,

upon contract award. Develop the training program for future overall use in the organization.

Figure 1 shows a flow diagram of the criteria items investigated, analyzed, commented upon during reviews, and itemized for contractor corrective action.

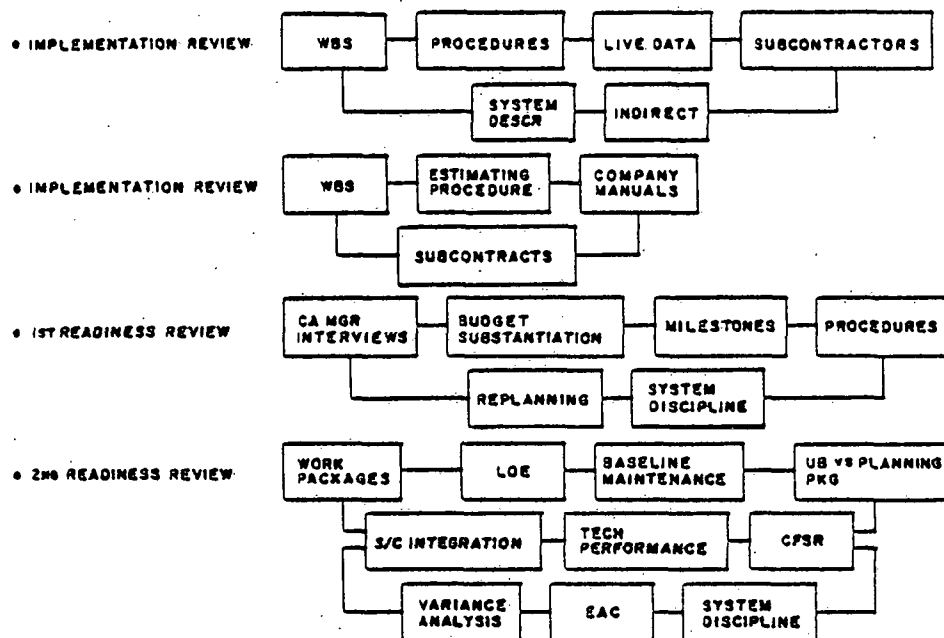
After contract award, the Government agency forms a team made up of various types of personnel. The team is usually comprised of military and civilian personnel with experience in the accounting, audit and program management areas. The team is assembled under a Team Chief assigned by headquarters and permanently assigned to a specific contractor during the implementation and through the validation process. A typical team would be made up of 10 to 15 members, with the Demonstration lasting approximately two to four weeks.

A series of team visits are scheduled, and are designated as Implementation Reviews and Readiness Reviews. The Implementation Reviews are made as formal visits, with the Team Chief selecting certain people to be part of each review until the final Demonstration when all are usually present.

During the Implementation Reviews, the contractor's progress is analyzed, preferably using live data. The Readiness Reviews are scheduled as the Contractor is approaching the Demonstration.

As Figure 1 shows, early emphasis is placed on the Work Breakdown Structure, procedures, the handling of major subcontractors, the writing of procedures and the total system description. The system description is a well written document describing exactly how the management control system operates, and shows forms used by functional groups for planning of direct labor dollars, indirect labor dollars, and levels of schedule planning.

These areas are repeated during each review with others added, as shown. Future visits include detailed investigations into estimating procedures which vary between functional groups. Engineering might estimate by experience, past jobs which are similar but not exactly alike; while manufacturing might estimate by standard units per operation, complexity factors compared to previous jobs; and service groups such as Drafting, Quality Assurance, Reliability, Maintainability, etc., might use support group factors based on Engineering estimates.



C/SCSC GOVERNMENT REVIEWS-DISCUSSION ITEMS

FIGURE 1

During the Readiness Review, it should be noted that Cost Account Managers (the persons responsible for the cost and schedule of a specific Work Breakdown Structure element) will be interviewed and are expected to be very knowledgeable on the management system being used. Failures in Cost Account Manager interviews will definitely delay the start of Demonstration.

Cost Account Managers are questioned as to their method of budgeting, choosing a milestone, and understanding of procedures. The questions are not addressed to how the manager has operated in the past, but how he intends to meet the criteria of C/SCS.

System Discipline is one area where many Cost Account Managers do not come across well. They must fully understand the procedure for making changes to budgets, schedules, milestones, performance measurement techniques, etc. System Discipline also covers senior management (above Cost Account) knowledge of C/SCS requirements and the system description and procedures.

Financial baseline maintenance problems occur when the sum of the parts do not equal the whole. Formal documentation must be maintained showing up-to-date changes via contract or internal action. This goes

along organization requirements, as well as WBS elements.

Subcontract integration is an essential part of the validation process. Data must be received for timely incorporation into the management report cycle. Some of the data may come from a C/SCS required subcontractor and other data will be non-C/SCS formatted. It is the prime contractors responsibility to produce a fully integrated report meeting the contractual C/SCS requirements.

The following list shows proposed suggestions to help towards a successful demonstration.

• Demonstration Suggestions

- Have cost account managers well trained formally
- Give certificates for training program
- Have company team members available at all times during working day
- Have cost account managers workbook
- Respond to all Government questions within 24 hours, if possible

- Provide publications department support
- Use live exhibits showing flow of system
- C/SCSC chairman review with Team Chief at conclusion of work day
- Produce histograms for work packages and cost accounts

PROGRAM USE

After contract award, the contractor must finalize the Contractor Work Breakdown Structure (WBS) by extending the three levels of the WBS developed by the Government. This WBS is extended down to the Cost Account level where cost accounts are defined by name, WBS number, and are considered manageable work tasks where both cost and schedule can be monitored, analyses performed, corrective action taken, and last but not least, a Cost Account Manager is assigned responsibility.

The WBS follows the guidelines found in MIL-STD-881 and finalization of the CWBS is approved by the Government agency. Cost account levels can vary for various WBS extensions within the CWBS. The level of extension depends on the decision as to what is a manageable work task for cost and schedule, technical achievement, and the collection of cost and schedule data.

The CWBS usually will contain hardware, software, support services, construction field service, major subcontractors, and

will be logically extended in a vertical direction.

Figures 2 and 3 describe two Contract Work Breakdown Structures, a DOD Electronic System and a DOE Construction and R&D Project.

Each CWBS basically follows the guidelines of MIL-STD-881 showing how the final project will go together, the logical breakdown or extension of prime WBS elements down to the cost account level.

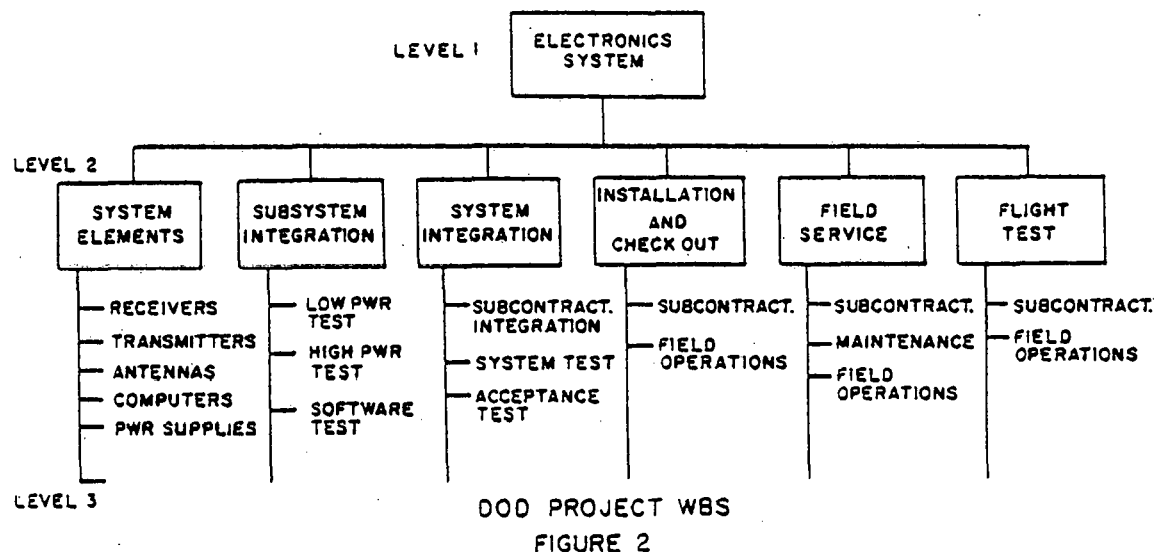
Planning is developed below the cost account level where tasks are broken into "work packages" which will be discussed in more detail.

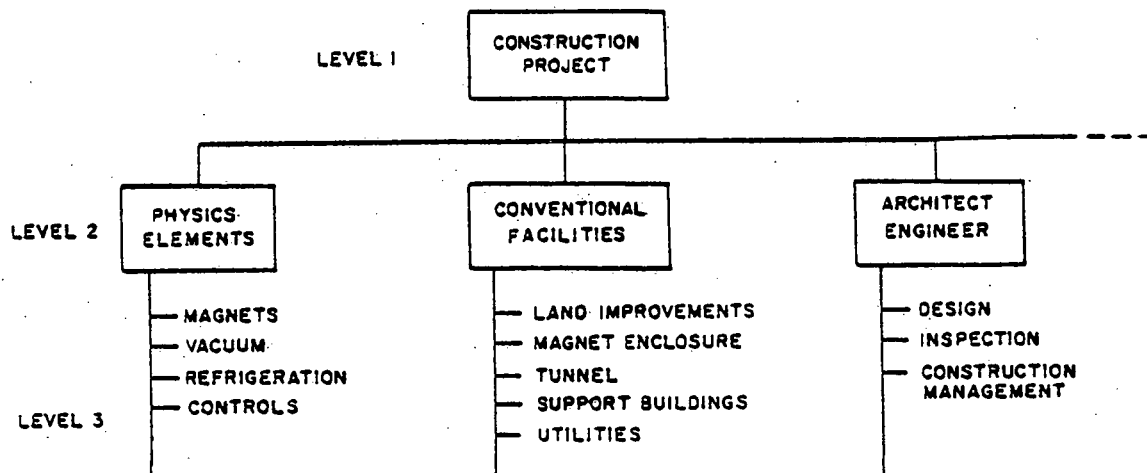
The project must adhere to the Criteria by using formal documentation throughout the five major sections of the C/SCSC Implementation Guide: Organization, Planning and Budgeting, Accounting, Analysis, and Revisions.

A sample list of formal system documentation is shown below. This list represents a minimum amount of documentation required to assure system discipline, thereby assisting the cost account manager in meeting the Criteria.

• System Documentation

- Work Statements
- Work Package Planning (BCWS)
- Work Package Status (BCWP)





DOE PROJECT WBS
FIGURE 3

- Variance Analysis
- Baseline Transaction Log (ECP's, MR, UB)
- Undistribute Budget (UB) Log
- Management Reserve Log

• Performance Reports

- Cost Account
- WBS (All Levels)

A few short sentences will give the reader insight into the necessity of the documents.

Work Statement

A "contract" between Program Management and the functional group (Cost Account Manager) describing the task, budget and schedule. (See sample, Figure 4.)

Work Package Planning

Planning of work packages showing hours, dollars and milestones which will be used for performance measurement.

Work Package Status

A formalized method of reporting status on work package milestones by the Cost Account Manager.

Planning Package Summary

Planning of future tasks which will eventually become work packages using a "rolling wave" concept. These planning packages are defined, budgeted and scheduled.

Variance Analysis

A formalized method of reporting on Cost Account cost and schedule variances. This analysis covers monthly and cumulative variances, and estimates at completion. (See sample, Figure 5.) Variance thresholds determine the necessity of reporting with mutual agreements being negotiated on items as follows.

• Variance Thresholds

- Contractor/Customer Agreement
- Significant Values
- Sliding Scale
 - Reduce Threshold % as Program Progresses
 - Fixed % Cost and Schedule
 - % + Minimum Dollar Value

Baseline Transaction Log

For program management use in monitoring all financial transactions such as; ECP's, change orders, authorized and negotiated

- ☐ FUNCTIONAL
☐ COST ACCOUNT
☐ OTHER

PROGRAM		WBS NO.		
CONTRACT NO.		CA NO.		
PROJECT/J.O. NO.		SCHEDULE REFERENCE		
DIV/DEPT RESR				
NARRATIVE DESCRIPTION	BUDGET	SCHED. START DATE	SCHED. COMP DATE	
BUDGET				
DL HRS	DL \$	ODC	MATERIAL	
			TOTAL BUDGET	
APPROVALS			DISTRIBUTION	
FUNCTIONAL		COST ACCOUNT		
PROG. DIR.	DATE	PROG. CONT. MGR.		DATE
PROG. CONT. MGR.	DATE	F/MGR.		DATE
ACCEPTANCE				
F/MGR.	DATE	CA MGR.	DATE	
		SERIAL NO.	REV	
		DATE		

WORK STATEMENT

FIGURE 4

work, authorized and non-negotiated work, internal budget transactions within cost accounts, Undistributed Budget, and Management Reserve.

Undistributed Budget Log

A chronological log of the depletion of Undistributed Budget. Undistributed Budget is a sum of allocated dollars to a particular task which has not been assigned to an organization or WBS, or final decisions have not been made as to the budget authorizations between subcontractors or internal groups. Undistributed Budget is depleted as dollars are assigned to Cost

Accounts and Organizations.

Management Reserve Log

A chronological log of the distribution of all Management Reserve dollars to organizations and WBS elements. Management Reserve is a sum of dollars set aside (contingency) for use on "unknowns".

Cost Account Performance Measurement Report

A report which shows work package cost and schedule variances. These reports vary in degree as to whether costs and hours are collected at the work package or Cost

☐ FUNCTIONAL
☐ COST ACCOUNT

PROGRAM CONTRACT NO. PROJECT/J.O. NO. CA NO. WBS NO. CA MGR.	VARIANCES		
	TYPE COST SCHEDULE	CURRENT	CUMULATIVE
	VAC	LAST PERIOD	PRESENT MONTH
TASK DESCRIPTION			
VARIANCE CAUSE DESCRIPTION			
CORRECTIVE ACTION			
EXPECTED RESULTS / PROGRAM IMPACT			
APPROVALS TASK MGR. DATE F/MGR. DATE PROG. CONT. MGR. DATE		DISTRIBUTION SERIAL REV. DATE	

VARIANCE ANALYSIS

FIGURE 5

Account level.

WBS Reports

The WBS reports are a summary of work package and cost account variances summarized vertically through the Work Breakdown Structure. The upper level reports (Level 3, 2, 1) are used for monthly reporting purposes in completing the C/SCSC reporting requirements.

Accounting

The accounting system must accumulate ACWP

data for the work accomplished (BCWP). Such traceability must exist for both WBS and Organization. The accounting numbering system should allow easy traceability from a work package or cost account level to the highest project level.

A completely computerized system for performance measurement can calculate all cost and schedule variances using actual data from the accounting system. Variances are made in hours, dollars, or both, and are usually for current, as well as cumulative, reporting. A summarization of the important ingredients of the C/SCS Criteria for

accounting is listed below.

- C/SCS Accounting

- ACWP Data Accumulation
- Dual Traceability
 - WBS - Organization
- Project Numbers
 - WBS Elements - Cost Accounts
- Job Orders
 - Work Packages
- Apply All Indirect Charges
- Account for Material

WORK PACKAGE PLANNING

Work package planning is the heart of the C/SCS performance measurement system. If the planning is "weak", the heart will not survive, and time and dollars are wasted.

Listed below are the important items from the Criteria to understand prior to start of planning.

- Work Package Planning

- Work Package Characteristics:
 - Type of Work Package
 - Cost Element
 - Performance Measurement Formula
 - Single Performing Org Responsibility
- Planning and Budgeting:
 - Time Phased BCWS (Plan)
 - BCWP (Status)
- Organization
 - WBS Identity
 - Cost Account

The type of work package will be described as Discrete, Apportionment, or Level-of-Effort. A Discrete package is one that has a defined task; budget, scheduled milestones, and has organizational responsibility.

An Apportionment work package is one that was planned showing an inter-dependency on another task. For example, an inspection package might have been planned as a percentage of the planned completion of assembly packages; a drafting checking package might have been planned as a percentage of the drawings planned for completion at that time.

A Level-of-Effort package is one where milestones cannot truly be identified; however, manpower coverage is definitely required in specific areas. Some examples

will be found in Quality Assurance, Program Management, Expediting, etc.

Work Package milestones should be selected with great care. Is it tangible? Can it be seen, touched or heard? Will you rely on someone telling you something is finished without evidence?

Typical examples of good milestones are as follows:

- Good Milestones

- Vibration Test Completed
- Flow Diagram Completed
- Preliminary Report Completed
- Subcontract Specification Completed
- Piping Design Start
- Power and Water Available
- Final Acceptance Test Start

A work package cost element will be identified as to whether it is direct labor, material or ODC (Other Direct Charges), such as travel and subsistence, consulting or other services not covered under labor or material.

COST ACCOUNTS

Cost accounts reflect the summarization of all work package and planning package schedule and cost data for that particular task. Work packages are summarized to cost accounts and cost accounts are summarized to higher level WBS elements. The following list shows the direct relationship between work packages, cost accounts, documentation and responsibility.

- Cost Account Planning and Budgeting

- Planning
 - Schedule Relationship (Top-to-Bottom/Bottom-to-Top)
 - Σ Work Package Schedules = Cost Account Schedule
 - Σ Cost Account Schedule = WBS Element Schedule
- Budgeting
 - Σ Work Packages \$ + Planning Pkg \$ = Cost Account \$
 - Functional Organization Budgets = WBS Budgets

Typical cost accounts for hardware and construction projects are listed below.

• Typical Cost Accounts in Hardware

- Electrical Design
- Mechanical Design
- Drafting
- Material
- Fabrication
- Electrical Assembly
- Test

• Typical Cost Accounts in Construction and Engineering

- Tunnel Construction
- Experimental Buildings
- Storage Buildings
- Land Improvement
- Utilities
- Vacuum System
- RF System
- Refrigeration System

PERFORMANCE MEASUREMENT DATA

The performance measurement formula is the second most important part of C/SCS. Having meaningful work packages with good milestones (1st most important), one must choose a method of assigning values to milestones in order to take "credit" for achievement, or get no "credit", or get "partial credit".

Budgeted Cost of Work Scheduled (BCWS)

The assignment of values, in hours or dollars, to milestones, will establish the BCWS (Budgeted Cost of Work Schedule). BCWS is a time phased plan of achievement in accordance with predetermined values for milestones. The milestones should be one or two months duration in order to get timely variance reporting. No interim monthly reporting would be available on a six (6) month work package with only a start and complete milestone.

Work Package Performance Reporting (BCWP)

The Budgeted Cost of Work Performed (BCWP) represents the value of achievement taken for completion of a milestone and work in process. If the BCWS was in hours, BCWP is taken in hours; if in dollars BCWP will be taken in dollars.

Actual Cost of Work Performed (ACWP)

The actual costs from accounting data, of labor, material, and ODC, for work packages, cost accounts, and summary WBS elements. Summary reporting will include indirect as well as direct costs, as applied to the project. Material costs may be taken as point of usage or on receipt, depending on customer agreements.

Variance Analysis

Having the BCWS, one must collect BCWP and actual costs to calculate cost and schedule performance measurement results. The basic formulas are shown below:

$$\pm \text{Schedule Variance \%} = \frac{\text{BCWP} - \text{BCWS}}{\text{BCWS}} \times 100$$

$$\pm \text{Cost Variance \%} = \frac{\text{BCWP} - \text{BCWS}}{\text{BCWP}} \times 100$$

(+ indicates favorable variance)

Trending Analysis

The above formulas are useful for trending analysis, with additional trending projections available by additional formulas, as shown below.

- Cost Performance $\frac{\text{BCWP}}{\text{ACWP}}$
 $\text{BCWP} > \text{ACWP}$ = Favorable Cost Index
 $\text{BCWP} < \text{ACWP}$ = Unfavorable Cost Index
 $\text{BCWP} = \text{ACWP}$ = Par Cost Index

- Schedule Performance $\frac{\text{BCWP}}{\text{BCWS}}$
 $\text{BCWP} > \text{BCWS}$ = Favorable Schedule Index
 $\text{BCWP} < \text{BCWS}$ = Unfavorable Schedule Index
 $\text{BCWP} = \text{BCWS}$ = Par Schedule Index

- Percent Complete $\frac{\text{BCWP}}{\text{BAC}}$
 (Budget at Completion)
 $\text{BCWP} = 0.5 \text{BAC}$ = Project 50% Complete
 $\text{BCWP} = \text{BAC}$ = Project Completed

- Percent Spent $\frac{\text{ACWP}}{\text{EAC}}$
 (Estimate at Completion)
 $\text{ACWP} = 0.5 \text{EAC}$ = 50% Project Cost Expended
 $\text{ACWP} = \text{EAC}$ = All funds expended -
 Project should be completed

- Estimate at Completion $\text{EAC} = \text{BAC} \times \frac{\text{ACWP}}{\text{BCWP}}$
 $\text{BCWP} > \text{ACWP}$ = Projected Underrun
 $\text{BCWP} < \text{ACWP}$ = Projected Overrun

Performance Measurement Examples

A few simple examples, as shown in Figure 6, will show the reader how the performance measurement data is used after choosing a method of establishing BCWS (Work-in-Process Plan - WIP) and taking status on milestones (BCWP).

Four work packages have been planned and status is to be taken after two months. Using Work Package No. 1, as an example, the total value is \$10K and approximately 1.5 months duration. Using a 50/50 rule, which normally is only used on short work

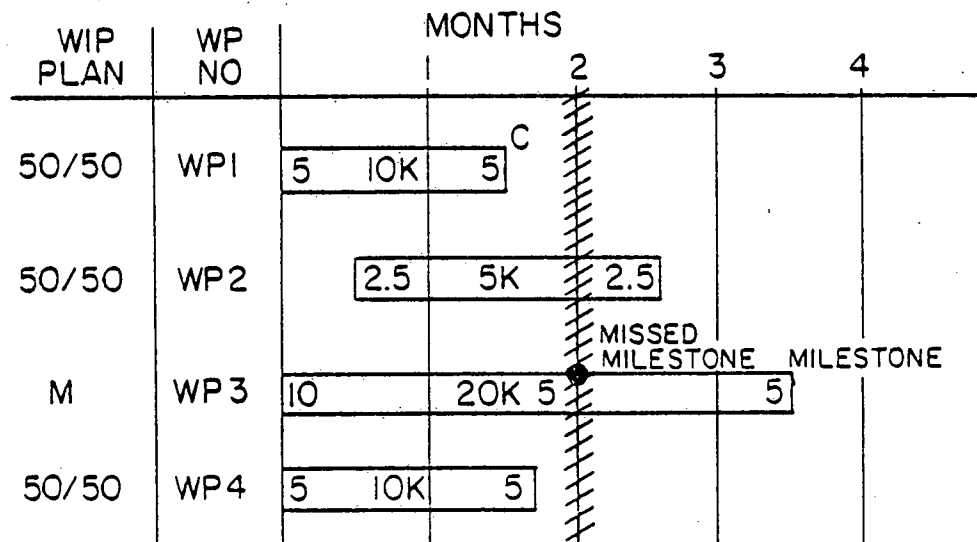
packages (less than two months), the BCWS is established as 50% for start, and 50% for completion. At the end of two months, the cumulative BCWS is equal to \$10K; the "C" represents completion status taken in this example, therefore, BCWP is equal to \$10K (\$5K when started - \$5K when completed).

$$\text{Schedule Variance} = \frac{\text{BCWP} - \text{BCWS}}{\text{BCWS}} = \frac{10K - 10K}{10K} \times 100 = 0\%$$

Assuming an Actual Cost of \$8K

2 MONTH REPORT

	BCWS	BCWP	ACWP	SCHEDULE	COST
WP 1	10.0K	10.0K	8K	0	+2
WP 2	2.5K	2.5K	2K	0	+0.5
WP 3	15.0K	10.0K	11K	-5	-1
WP 4	10.0K	5.0K	7K	-5	-2
COST ACCOUNT	37.5K	27.5K	28K	-10	-0.5



TYPICAL WP/CA PERF MEASUREMENT

FIGURE 6

$$\text{Cost Variance} = \frac{\text{BCWP} - \text{ACWP}}{\text{BCWP}} = \frac{10\text{K} - 8\text{K}}{10\text{K}} \times 100 = +20\%$$

The performance measurement analysis for WP No. 1 indicates completion within budget.

Looking at WP No. 3 as another example, milestones are used with assigned values for BCWS. The start milestone has been given a \$10K value, the two month milestone \$5K and the completion \$5K. The cumulative BCWS at two months equals \$15K; the cumulative BCWP at two months equals \$10K, since the milestone completion was missed.

$$\text{Schedule Variance} = \frac{\text{BCWP} - \text{BCWS}}{\text{BCWS}} = \frac{10\text{K} - 15\text{K}}{15\text{K}} \times 100 = -33\%$$

Assuming an Actual Cost of \$11K

$$\text{Cost Variance} = \frac{\text{BCWP} - \text{ACWP}}{\text{BCWP}} = \frac{10\text{K} - 11\text{K}}{10\text{K}} \times 100 = -10\%$$

The performance measurement analysis for WP No. 3 indicates a -33% schedule slip and a 10% overrun for the present work accomplished. Detailed explanations should be provided by the Cost Account Manager on the Variance Analysis form.

The Cost account analysis is made after summarizing all work packages as shown.

$$\text{Schedule Variance} = \frac{27.5\text{K} - 37.5\text{K}}{37.5\text{K}} \times 100 = -26\%$$

$$\text{Cost Variance} = \frac{27.5\text{K} - 28\text{K}}{27.5\text{K}} \times 100 = -1\%$$

The Cost Account Manager in his analysis would discuss the overall slippage of -26% while staying approximately within cost for work accomplished. Had the schedule been made, the cost variance might have been higher. On the other hand, if most of the work has been done with only minor items remaining before BCWP is taken, the cost account could be in excellent condition. With "work-in-process" and completions, the variances could be deceiving and must be analyzed and discussed on the Variance Analysis form.

For C/SCS, the completion of the Cost Performance Report (CPR) requires current and cumulative status. The formulas are used in the identical manner for current variances using monthly BCWS, BCWP and ACWP.

Cost Schedule Status Report (CSSR)

The CSSR reporting requirement is similar to C/SCS but is used on non-major programs with less dollar values. The Criteria is not imposed but recommended for use as a guideline.

Performance measurement data must be reported in the BCWS-BCWP-ACWP format on a cumulative basis only. Detailed work packages and total formality of C/SCS are not required, however, a system of planning and gathering data must be approved by the Government agency or customer.

A "No-Work Package" method of using schedule data from a formal schedule system to arrive at BCWP is described in the Project Management Quarterly, March 1979¹. This method uses the slack status of the schedule system with BCWS to calculate BCWP, whereas in C/SCS BCWS and BCWP are used to calculate schedule variance.

INITIAL IMPLEMENTATION PROBLEMS

Going through a "full-blown" C/SCS demonstration is a learning process for everyone involved. The Government team is made up of personnel from various agencies (Program Office, Headquarters Audit, Engineering, etc.). This team will work together with their contractor counterparts for approximately two to four weeks.

Each sub-group has its own area of the Criteria to examine for compliance. Live data must be assembled, verified, analyzed and used in the system. The Government team must decide as to the compliance to Criteria, and if found to be not in compliance, a detailed report prepared on each item. Reports are usually broken down into major and minor items recommended for corrective action.

The following list shows some Initial Implementation Problems encountered by most contractors.

• Initial Implementation Problems

- RDT&E Environment
- Major Subcontractors without C/SCS Experience - FFP and CPIF
- New Planning Technique for Engineers

- Personnel Discipline on System
- Continuous Management Surveillance at Work Package Level

- Continuous Problems

- Train New Personnel
- Replanning Required in RDT&E Environment for Existing Work, ECP's

- Material Planning in RDT&E Environment

- Breadboard Effort Not Fully Defined
- Changes in Design

- Development of Performance Measurement Technique for Software

R&D ENVIRONMENT

The R&D program lends itself to uncertainty in planning during the early phases. Changes to baseline planning must occur. This alternative is better than explaining variances which are due to poor planning, early in the program.

MAJOR SUBCONTRACTOR WITHOUT C/SCSC

This problem must be clearly solved prior to Implementation and Readiness Reviews. Awarding a firm fixed price or cost plus contract is a determining factor as to the C/SCS requirement. The original DOD guidelines recommended C/SCS for CPIF or FPIF (on production, with additional guidelines on dollar amounts). These guidelines were for the prime contractor only. The Program Office and Contractor must reach an agreement for major subcontractors. Will they meet all of the criteria, part of the criteria, or none of the criteria? If none, how will the monthly data be incorporated into the formal C/SCS system?

NEW PLANNING TECHNIQUE FOR ENGINEERS

This is a problem that must not be underestimated. Within organizations, departments, sections, or any other company structures, there usually will be many planning techniques with no formality or commonality. A common system must be used to allow meaningful planning and tracking of labor, material and other direct costs.

Formal procedures must detail exactly how one must plan, establish milestones, and calculate the value of a milestone for performance measurement purposes. Each manager must retain a "bottoms-up" planning and

budgeting system for work packages and summarization of cost account.

PERSONNEL DISCIPLINE ON SYSTEM

Once the Cost Account Manager has established the planning and budgeting in accordance with authorized procedures, discipline must be maintained to assure use of the system and required updating. All updating must be in accordance with authorized procedures and detailed as to the cause of change. Is it an internal change to schedule without budget change? Is it a budget change with existing schedule? Is it a contract authorized change to budget and schedule?

MANAGEMENT SURVEILLANCE AT WORK PACKAGE LEVEL

Someone must have the responsibility of maintaining the integrity of the system. Can managers be allowed to input data to a computer by themselves? Can managers change method of calculating BCWP or change the value of a milestone? Can managers operate to an unofficial increase to their Estimate-at-Completion (EAC)? Can work packages be opened and closed at any time by a manager?

One central office or manager must be established to maintain the integrity of the system. One cannot, and should not, assume that Cost Account Managers will complete forms correctly, or make changes in accordance to authorized procedure.

CONTINUOUS PROBLEMS

A training program should be maintained to insure the availability of personnel trained to work with the C/SCS system.

Many organizations have set up a formal training program with training manuals for various levels of management. These levels include Senior Management, Cost Account Managers and Work Package Supervisors.

A typical training program is outlined below.

- Training Details

- Five 2-Hour Sessions - 2 Days/Week
- 20 Workshop Questions/Session
- Individual Training Manuals
- On-the-Job Training

MATERIAL PLANNING

Material planning baselines are preferred to be established to a cost payment plan. Previous C/SCS firm requirements of planning on a consumption basis has led to much Industry/Government discussion. A production environment lends itself to a better prepared material cost plan than one finds in R&D. In R&D, breadboards, prototypes, models, and combinations, thereof, lead to many unexpected planning changes and usually leads to high cost and schedule variances.

SOFTWARE

The WBS usually contains software as a WBS element and/or software within many elements. To gather WBS and organization data for the software tasks, a method of planning must be established which will enable the accumulation of BCWS, BCWP and ACWP performance measurement data.

A reasonable approach to take is the development of a Software Work Breakdown Structure, broken out into routines and subroutines. Each subroutine may then be estimated in man-days with milestones allocated for performance measurement.

POST VALIDATION SYSTEM IMPROVEMENTS

Some of the major areas of concern after Validation are listed below. After Validation and system utilization, many improvements become obvious to the user. Work package planning to more realistic milestones, method of estimating BCWS for milestones, improved output reports for analysis, integration of subcontractor data, improved training methods, more meaningful variance analysis, improved forward planning, and last but not least, automated system improvements for use in production as well as R&D.

- Post-Validation System Improvements
 - Automate System Improvements Toward Production Validation
 - Changes in Training Programs Using On-the-Job Experiences
 - More Meaningful Variance Analyses by Cost Account Managers
 - Better Forward Planning
 - Surveillance of Major Subcontractors

In a production environment, many parts of the management control system will be handled differently than in R&D. Some of the critical areas which usually demand special attention for production are listed below:

- Material Inventory and Usage
- Estimating Methods
- Work Package Planning for Production Lots
- Responsibility

The above items are self explanatory, with the exception of responsibility. In an R&D environment, engineering personnel might plan and be responsible for the entire job. The engineering group would plan, design, possibly fabricate, and test the major portion of the project.

In a production environment, the responsibilities might shift back and forth throughout the project cycle. Engineering would have the design responsibility until a package is released. Production or manufacturing shop would have the responsibility of fabricating and assembling units, or it is possible that engineering would have to share in the assembly process. Continuing the production environment, the testing phase might be completely under a production test group using automated equipment.

The difference between R&D and Production, as discussed above, leads to many changes in the methods of compliance to the criteria of C/SCS. In fact, the Validation process explained throughout this paper must be repeated for required production after receiving an R&D Validation.

SYSTEM USE AND BENEFITS

Possible uses and benefits for a C/SCS system or any modified version thereof are shown below.

- System Use and Benefits
 - Use
 - Management Reviews
 - EAC
 - Subcontract Control
 - Schedule System
 - Manpower Forecast
 - Benefit
 - Cost Allocations Established Early

Cost Allocations Documented
 Discipline Prevents Budget Moving
 without Work Assignments
 Early Look at Cost and Schedule
 Projections
 Development of Engineer Concern on
 Cost and Schedule with Formal
 Documented System
 Shows Changing Manpower Forecasts
 as a Result of Program Impacts

The system reporting techniques can give excellent material for management reviews. Exhibits can be prepared in the form of schedule and cost variance projection curves, EAC projection curves, and percentage complete projection curves. Curves showing cumulative projections for BCWS, BCWP and ACWP are used at the Cost Account, WBS Summary, or organization levels.

Dynamic manpower forecasting curves can be shown with the use of the Cost Performance Report requirement of man-month projections for each of the next six months and designated periods thereafter until completion of the project.

Benefits derived from C/SCS are found in financial management, as well as in engineering areas. Having cost allocations established in the early phase of the program has never been an easy task to accomplish. If no requirement were made to allocate long term, as well as short term, dollars, immediate concern was always on immediate tasks. C/SCS requires dollar allocations to the established CWBS and organization element. Having this requirement as part of the reporting data assures timely allocations.

Certain criteria prevents movement of dollars from one WBS element to another without following proper procedure and documentation.

One of the major benefits derived from C/SCS is the development of managers in the areas of Program Management disciplines. "Scratch sheet" planning and budgeting will disappear, consciousness of schedule and cost variances will increase, manpower forecasting will be given more thought, and maintaining documentation will become a "way-of-life" instead of complaining about the creation of a "paper-mill".

CONCLUSION

C/SCS has proved to be both helpful and

painful to most users. In the sense of instituting new organizational procedures, training, and familiarization with terminology and what one is allowed to do and not allowed to do; it is painful in proportion to the starting status of the organization. Starting from ground zero, with a minimum of formalized company procedures in cost and schedule planning and data accumulation proves to be most painful. Having a good existing management control system leads to a minimum amount of pain in modifying to meet the Criteria.

Having a good internal management system, with minimum changes to meet C/SCS still requires the training of personnel and surveillance to insure usage of the system.

It proves to be most helpful in the areas of financial allocations and reporting. The discipline of allocating dollars to WBS and organization elements, both near term and future, allows management and the customer to see where the dollars are going now, how many dollars are being held for tasks undefined, and in the future, and maintenance of all transactions which change the original baseline.

Schedule data, however, is a little more subjective when one projects variances based on dollar values to milestones ($BCWP - BCWS = \pm \text{Schedule Variance}$). The subjectivity arises when one must project this variance in terms of real time; weeks, months, etc. All organizations must retain a good schedule system (PERT, CPM, BARCHART, Line-of-Balance); C/SCS requirement or not.

Major problems usually occur in the areas of material variances and "over-target" planning. For an "overtarget" account or project, customer authorization must be received to continue planning in accordance with the Criteria.

It is my opinion, that the most important and critical part of C/SCS is the realistic approach to work package planning and BCWS values for milestones. Having the most sophisticated computerized or manual system will produce data, performance measurement calculations, variance analysis and customer reports which are useless, unless training and system discipline are enforced by management.

Details and formats of most customer reports are found in DODI 7000.10 and are listed below.

- Customer Reports

- Cost Performance Reports
 - WBS
 - Functional
 - Performance Measurement Baseline -
 - Forecast
 - Manpower Loading
 - Problem Analysis
- Contract Fund Status Report (CFSR)
 - Funding Data for Customer
 - Includes Authorized and Non-
 - Authorized ECP's
 - Includes Definitized and Undefined-
 - tized but Authorized Work

- To Minimize Problems - Make Sure Answers Are Yes

- Do you know exactly what to build?
(R&D Versus Production)

- Does Your Subcontractor Know Exactly What to Build?
- Do you have People Trained?
- Do you have Top Management Support?

REFERENCES

- 1 Turf, L., "Cost/Schedule Performance Measurement Without Work Packages", Project Management Quarterly, Volume X, No. 1, March 1979, Project Management Institute, Drexel Hill, PA, pp. 30-32.