THE ROLE OF ANALYSIS IN C/SCSC[1]

INTRODUCTION

The United States President has the Office of Management and Budget as an analytical arm to deal with budget decisions. The United States Congress has the Congressional Budget Office. The Department of Defense has thousands of cost, budget and price analysts. How can this analytical expertise be utilized effectively? This paper answers this question by addressing how an analyst can help the decision-maker. For focus, it addresses the role of the analyst involved with the Department of Defense (DOD) Cost/Schedule Control Systems Criteria (C/SCSC) and related performance reports.[2]

As indicated in Table 1, an analyst should be involved in each step of responsible decision-making. First, the analyst should understand the decision context. Who are the decision-makers? What are their decisions? Second, the analyst should understand the database. What are the basic data elements? How are the data generated? How is the database controlled? Third, the analyst should understand basic techniques in transforming data into information. What analytical techniques are available? What tabular and graphical presentation methods best communicate the information? What are the underlying assumptions and limitations of these methods? In short, it is not enough merely to manipulate some database. A responsible analyst is more than a "number cruncher." A responsible analyst is an information engineer or broker who is actively involved in facilitating the decision process.

TABLE 1

THE ANALYST'S CUSTOMER IS THE DECISION-MAKER

Responsible Analysis	*Responsible Decision-Making*
Know the decision context	Determine the information requirements
Know the database and the system that generates it	Evaluate the quality of the information
Know the tools of analysis and their limitations	Use the information

DISCOVERING DECISION CONTEXT

The stated purpose of the C/SCSC is to foster responsible decision-making. A responsible decision is based on information[3]. Information can be defined as data that are useful for decisions.[4] To be useful for decisions, data reliability depends on the contractor's management control system. If the contractor complies with the generic criteria for management control systems detailed in the DOD *Joint Implementation Guide,* the DOD assumes that the data provided on standardized contractor performance reports are reliable. Data relevance depends on the decision context, which involves factors relating to the decision problem and the decision-maker.

The analyst's customer is the decision-maker. One of the tenants of total quality management (TQM) is to know the customer. The responsible analyst should work with the decision-maker to discover the kinds of decisions likely to be required. Learning about the decision problems should help specify the information requirement.

In context of C/SCSC, decisions involve either implementation and surveillance issues, or the use of performance measurement data in assessing the cost, schedule, or technical performance of the contract. Examples of decision-makers dealing with implementation/surveillance issues include the team chief, surveillance monitor,

[1] Christensen, David S. 1990. "The Role of Analysis in C/SCSC." *Program Manager*, pp. 26-33 (July-August).
[2] Cost/Schedule Control Systems Criteria (C/SCSC) was renamed "Earned Value Management Control Systems" (EVMS) Criteria in the early 1990s.
[3] Department of Defense Instruction 7000.2, "Performance Measurement for Selected Acquisitions," June 10, 1977.
[4] David S. Christensen, "Management Control Systems Theory Is Useful Tool," *Program Manager,* November-December 1989, pp. 20-23.

review director, and the Performance Measurement Joint Executive Group. These decision-makers generally are responsible for interpreting the intent of the criteria and deciding if the contractor's management control system complies with the criteria. Specific responsibilities are described in the *Joint Implementation Guide* and the *Joint Surveillance Guide.*

Examples of decision-makers who must rely on performance measurement data include government program managers and resource providers. These decision-makers monitor the cost, schedule, and technical progress on the contract. Again, the responsible analyst should meet with these decision-makers regularly to establish rapport and a feeling of mutual respect.

For both groups of decision-makers, the decision problems demand considerable judgment and cover complex issues in multiple functional areas. When confronted with complexity, many decision-makers will either request more data or focus their attention on some area consistent with their background (e.g., engineering, accounting or production). In either case the result can be dysfunctional: more data do not necessarily lead to better decisions; and a penchant for functionally-specific data can leave the decision-maker unaware of problems outside of that functional area.

The responsible analyst can be of great help here by filtering the database and by knowing the decision-maker well enough to recognize the latter's penchant for some functional area. For example, a team chief on a demonstration review may have considerable experience with the budgeting area. Under the stress of completing the review in a timely manner, the team chief unwittingly may focus too much attention on budgeting at the expense of other important areas like planning or accounting. The responsible analyst should tactfully bring this to the decision-maker's attention. This is only possible if the decision-maker and analyst have established a favorable working relationship.

The analyst may help by becoming familiar with the typical kinds of deficiencies or problems encountered. In the implementation and surveillance area, several studies have documented a "corporate memory" of C/SCSC experiences and lessons learned. A recent paper, "C/SCSC Lessons Learned Theoretical Framework" (1988), for example, details problems and issues commonly encountered in C/SCSC.[5] It behooves the responsible analyst to become familiar with these problems by reading C/SCSC literature, attending conferences, and participating in professional organizations. The appendix to this paper lists selected publications and professional organizations relevant to the C/SCSC area.

UNDERSTANDING DATABASE

In addition to understanding the decision context, the analyst must understand the database and how it is controlled. Assuming that traditional data sources are useful (relevant and reliable) for future decisions is dangerous. Hopefully, by understanding the decision context, the analyst will be able to eliminate data that are not relevant. By understanding the related control system, the analyst can properly assess reliability of the database. The database should be considered unreliable if existing controls are either inadequate or not functioning. If controls are found deficient, the analyst should warn the decision-maker that the database is suspect and take steps to strengthen the controls. If controls are adequate but not followed, the analyst should again caution the decision-maker that the database is not reliable and suggest that existing controls be followed.

There are five basic data elements in performance reporting under C/SCSC: budgeted cost of work scheduled (BCWS); budgeted cost of work performed (BCWP); actual cost of work performed (ACWP); budget at completion (BAC); and estimate at Completion (EAC). Definitions and related controls of these data elements are detailed in the *Joint Implementation Guide.* Each of these elements is reported as specific columns on the standardized performance reports prepared by DOD contractors.

The prudent analyst must understand these elements, and the relationships between them. For example, at any given time and for any given element of work, the contractor's estimate at completion should never be less than

[5] Anthony Webster, "C/SCSC Lessons Learned Theoretical Framework," *Program Manger,* July-August 1988, pp. 13-22.

the cumulative actual cost of work performed for that same element of work. This follows from the definition of EAC, which is defined as sum of actual costs to date and the estimated cost of the remaining work on the contract. Similarly, the budgeted cost o f work performed should never be greater than the budget at completion for the same element of work. By understanding these basic data elements and relationships the analyst can assess more effectively potential reliability of performance reports.

In addition, the analyst should thoroughly understand the system and controls that generate the database. Understanding how to use an information system is not enough. Although the following citation addressed the need for managers to understand their management information system (MIS), it is an equally applicable challenge to the analyst:

> *Most MIS designers seek to make their systems as innocuous and unobtrusive as possible to managers lest they become frightened. The designers try to provide managers with very easy access to the system and assure them that they need to know nothing about it. The designers usually succeed in keeping managers ignorant in this regard. This leaves the managers unable to evaluate the MIS as a whole…. In failing to evaluate their MIS, managers delegate much of the control of the organization to the system designers and operators who may have many virtues, but managerial competence is seldom among them.*[6]

The Cost/Schedule Control System Criteria (C/SCSC) outline commonsense standards for management control systems. The analyst must not only understand these criteria, but how they apply in the specific decision context. Ideally, analysts should thus be part of implementation or surveillance teams involved with their contractors. This will provide insight that is not likely available from behind a desk.

UNDERSTANDING TECHNIQUES OF ANALYSIS

The responsible analyst should be thoroughly familiar with basic analysis techniques and apply them appropriately. Understanding the decision context, the database, and the system that generates the data can help determine appropriate techniques and are thus necessary precursors to this third step in responsible analysis: transforming data into information. There are many potentially useful algebraic and graphical techniques. In addition, most techniques have implicit assumptions about the data and the decision-maker.

The responsible analyst should learn the techniques and test implicit assumptions before relying on results. For example, a common technique is linear regression analysis. In addition to being able to apply regression analysis, the analyst should evaluate critical assumptions such as linearity and the independence of the errors across observations.

In the context of C/SCSC, the basic data elements are transformed into information by computing cost and schedule variances and indices. For example, cost variances are computed as the difference between BCWP and ACWP; schedule variances are computed as the difference between BCWP and BCWS; the cost performance index (CPI) is computed as the ratio of BCWP divided by ACWP, and the schedule performance index is BCWP/BCWS.

Cost Variance (CV) = BCWP – ACWP	(1)
Schedule Variance (SV) = BCWP – BCWS	(2)
Cost Performance Index (CPI) = BCWP / ACWP	(3)
Schedule Performance Index (SPI) = BCWP/BCWS	(4)

These variances and ratios can be computed and graphed using current, cumulative, or average data values for any element of work on the contract. As such, they represent an effective and versatile way to summarize an enormous amount of data. An excellent guide to generating and interpreting this kind of information is the Air Force System Command Pamphlet 173-4, "Guide to Analysis of Contractor Cost Data," (Sept. 1, '89)

[6] Russell L. Ackoff, "Management Misinformation Systems," *Management Science,* 1967, p. 508.

Another common analytical technique used in C/SCSC is to compute an independent estimate at completion for comparison purposes. The generic formula for estimate at completion (EAC):

$$EAC = ACWPcum + (BAC - BCWPcum) / Performance\ Factor \qquad (5)$$

The responsible analyst should understand fully the assumptions implicit in this formula. For example, while a performance index (e.g., CPI) is routinely used to adjust the remaining work on the contract (BAC-BCWPcum) to a more reasonable value, its arbitrary use is dangerous. The index usually is based on past performance of the contractor and calculated as the ratio of BCWP to either BCWS or ACWP. When the analyst uses cumulative data, the analyst is implicitly assuming that what has happened since start of the contract is recurrent and reflective of the future. If the early months on the contract are not indicative of the efficiencies presently being demonstrated by the contractor, then the use of cumulative data for the performance index is not appropriate.

In another example, the use of budget at completion (BAC) in the generic EAC formula ignores possible application of management reserve budget to future work. If the contractor is likely to use the entire management reserve budget by end of the contract, then it should probably be added or otherwise included in the EAC computation. In short, the responsible analyst should understand the assumptions implicit in the formulas and other computations and communicate them to the decision-maker.

In addition to being aware and careful with algebraic analytical techniques, the analyst should understand the strengths and limitations of graphical techniques. While graphs can be excellent tools for communicating information to the decision-maker, there are pitfalls that the responsible analyst should avoid. A number of writers have identified criteria for high integrity graphics.[7] [8] [9] If the criteria are followed, the chart will faithfully represent data and communicate the information intended. If not followed, the chart can be extremely misleading.

In general, graphics criteria are caveats about arbitrary scale manipulation, inadequate or otherwise misleading labeling, excessive use of "chart junk" (enhancements) to decorate a chart, and other rules intended to prevent the viewer form being misled. With the wide availability of powerful graphics software, the temptation to play with various graphical types and parameters is irresistible. In the process, the analyst may unwittingly create a misleading graphic. The strata charts in Figure 1, for example, illustrate how the incorrect placement of strata can be misleading. The analyst or decision-maker may conclude incorrectly that annual indirect costs are decreasing when, in fact, they are constant. In strata charts, the stratum with the least variability should be on the bottom.

Unfortunately, misleading graphics may sometimes be intentional. For example, research has demonstrated that misleading graphics appear to be highly associated with adverse financial trends in published financial statements.[10] It appears the temptation to create a false impression of prosperity with misleading graphics is too great for some companies. On occasion, the analyst is an advocate. An ethical analyst should resist the temptation to make the picture appear better than the underlying data. Knowingly misleading the decision-maker is unethical; unknowingly misleading the decision-maker is irresponsible.

Another potential pitfall relevant to analytical technique concerns what Kaplan calls, "the law of the instruments." Kaplan explains as follows: "Give a small boy a hammer, and he will find that everything he encounters needs pounding." [11] Analysis necessarily requires algebraic and graphical techniques. The problem is that some analysts love specific techniques (instruments) so much that their analysis does not go beyond the

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[7] Edward R. Tufte, *The Visual Display of Quantitative Information,* Cheshire, Conn., Graphics Press, 1983.
[8] Barbara G. Taylor and Lane K. Anderson, "Misleading Graphics: Guidelines for the Accountant," *Journal of Accountancy,* October 1986, pp. 126-135
[9] Paul Steinbart, "The Auditor's Responsibility for the Accuracy of Graphics in Annual Reports: Some Evidence of the Need for Additional Guidance," *Accounting Horizons 3,* September 1989, pp. 61-70
[10] Ibid.
[11] Abraham Kaplan, *Conduct of Inquiry,* San Francisco, Chandler Publishing Company, 1964, p. 28.

application of their favorite technique. While regression analysis is a wonderfully powerful technique, it is not always the most appropriate technique. The responsible analyst should recognize personal biases and be willing to go beyond the information generated by his favorite technique. To paraphrase Kaplan, give an analyst some graphics software, and he or she will happily generate charts of every row and column on a cost-performance report. In short, good analysis is not defined by the type, variety, or relative sophistication of the analytical techniques applied, but by the information the techniques generate.

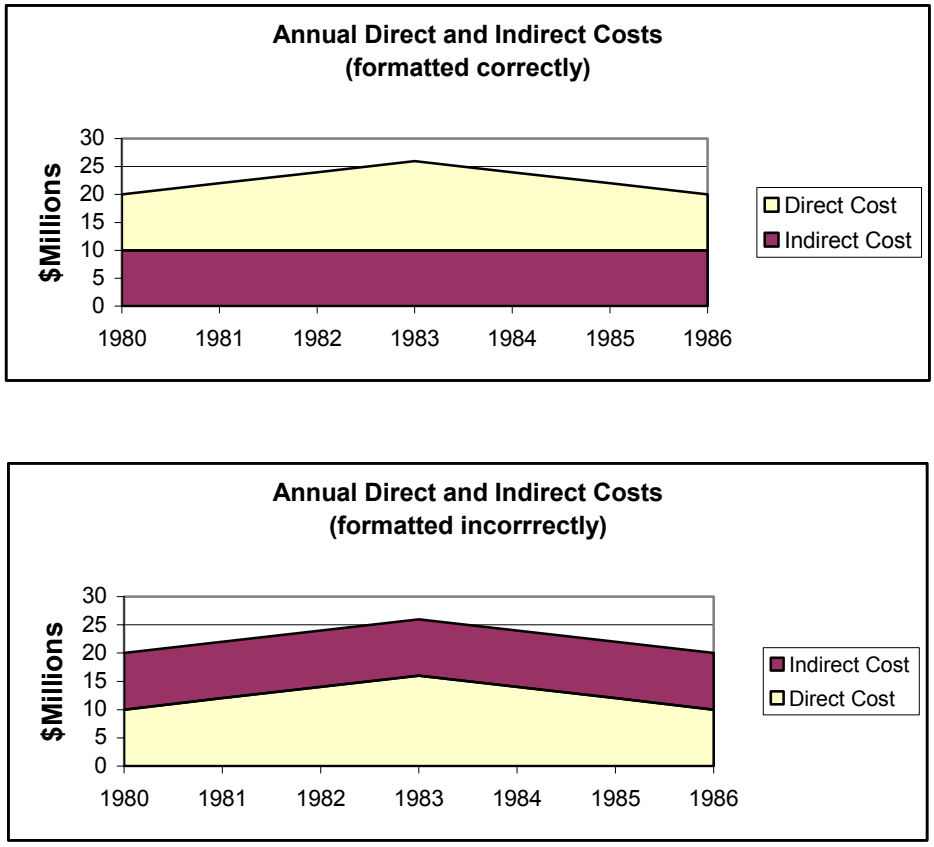

Figure 1. Misleading Graphics.

CONCLUSION

The responsible analyst should be involved in the entire decision process. The analyst's customer is the decision-maker. To help the decision-maker determine the information requirements, the analyst should know the decision context. As a minimum, this requires learning who decision-makers are and the kinds of decisions they face. To help the decision-maker evaluate the quality of the information, the analyst should be skilled at applying an assortment of analysis techniques that effectively transform data into information and be wary of the many associated assumptions and pitfalls of those techniques. While specific examples have focused on the role of the C/SCSC analyst as a system or performance evaluator, the general concepts apply to all analysts.

SELECTED REFERENCES TO C/SCSC LITERATURE

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