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Abstract. Cost analysis is often viewed as applying basic principles and cost methodologies to determine total system cost. These finished estimates then flow into a decision making process and the cost estimator leaves the stage. Reality shows that the cost estimator is actually one of the main contributors to the decision making process. Our introduction to this special issue explores the areas where cost estimating plays a major role in program management in areas beyond the normal program estimate. We have included articles that show the key role cost estimators can play in source selection strategies and evaluation; cost of delay analysis for management decisions, earned value management methods to predict program costs; decision criteria to rank competing projects that complement traditional cost-based methods; and a new methodology for determining research and development budget profiles.

The Relationship Between Cost Analysis and Program Management

"I believe that without concerted attention to the problems in acquisition, logistics, and industrial practices and procedures, the technological edge that is our war-fighter's greatest advantage could be eroded."

Darleen Druyun,
Principal Deputy Assistant Secretary of the Air Force, Acquisition
(Druyun, 2001)

INTRODUCTION

The United States is an undisputed super power with access to the best technologies and information systems. In this environment coupled with increased defense spending, one would expect Department of Defense (DoD) decision makers would be confronting fewer challenges. The reality of course is quite different. While we do have the best military in the world, maintaining it in a future of ill-defined and sometimes conflicting requirements presents a major challenge. We suffer from aging weapon systems, rising operations and support costs and declining manpower with increasing operations.

Addressing these challenges requires that our decision makers receive the best analysis and analysts that the nation can provide. The integration of cost analysis into these decisions is needed so that the senior leadership and program managers can make the best use of DoD's scarce resources. As stated in the above quote, we have many problems that must be solved to maintain our leading position, and cost analysis can help us to arrive at the better decisions. Traditionally when one addresses the analyses provided by cost analysts, the subject is focused on:

1. Developing cost improvement curves;
2. Collecting an appropriate data set to develop those curves;
3. Using the data to derive cost estimating relationships (CER's) with the best statistical characteristics;
4. Utilizing available tools creatively to simplify the estimating process; and/or
5. Employing the best methodologies available to produce a credible cost estimate (Kammerer 2001).

The preceding list comprises the traditional role of the cost analyst in a program office. While these aspects of cost analysis remain important and deserve proper attention by cost analysts, there are other areas of cost analysis that are critically important to DoD's decision makers. This special issue introduces several major types of analysis that have either recently impacted key decisions or serve as early research on new avenues for cost analysis. The remainder of the paper summarizes four current topics in cost analysis and the latest relevant research, before concluding with a brief summary.

COST SAVING INITIATIVES PROPOSED BY THE CONTRACTOR

Defense contractors often propose cost saving initiatives to reduce the cost of weapon systems (Kammerer 2001). In some cases these initiatives are associated with an investment. The return on the investment yields savings in the production phase of the acquisition program. The F-22 Raptor aircraft program is one such program that has embraced cost saving initiatives. These initiatives are called Production Cost Reduction Plans (PCRP's). Other U.S. Air Force programs that have proposed similar initiatives are the Joint Strike Fighter (JSF) program and the Osprey (V-22) program.

For the cost analyst, this is a new twist. While significant cost reduction is expected in the form of cost improvement curves as production quantities increase, PCRP's may go beyond the normal cost reduction associated with cost improvement curves. An example of such an initiative might be "lean manufacturing." The contractor determines that by adopting a manufacturing process that is more efficient significant cost savings could be realized. Such a change in process may require investment in new tools or supply concepts, and a rearrangement of the workspace in the factory. In the case of the F-22, the contractor has a council that evaluates proposed PCRP's, the investment required, and the expected return-on-investment.

The evaluation of a PCRP presents a cost analyst with a threefold dilemma. First, is the cost saving initiative real or not? That is, does the cost saving initiative have merit or is it unlikely to produce savings? Second, does the initiative represent a saving that would normally be expected to occur as part of the normal cost improvement one expects in production and which is captured by the historical cost improvement curve? Finally, once the cost analyst decides whether to accept or reject the cost saving initiative, how do you develop the estimate of the savings that is subsequently subtracted from your baseline estimate? It is important to track to a consistent baseline as the program changes that can be used to measure and track any savings.

In the case of the F-22, Air Force cost analysts have provided detailed reviews for approximately 80 such cost saving initiatives proposed by the contractor. These required developing separate return-on-investment relationships that were tended to be lower than the contractor's forecasts. However, the Air Force has gone on to fund several contractor proposed investments that were judged to have merit.

PROGRAM BUDGETS

Is the budget based on the cost estimate or the cost estimate based on the budget (Kammerer 2001)? The cost analyst often finds himself in the quandary of trying to fit an estimate to a budget, and this presents a dilemma, which may question the integrity of the cost analyst. Heroic measures may even be proposed to keep the cost estimate within the prescribed budget. For example, program proponents have been known to propose applying all the principles of acquisition reform to achieve a 20 percent reduction in the first units of

production. When asked exactly what they would do to achieve such reductions, they are usually less specific. But they know they will achieve their goal because everyone on the team knows the goal and will be working toward it. The cost analyst must stand firm in such cases and not support such specious goals.

Other techniques proposed to keep the cost estimate within the budget include the application of the Cost as an Independent Variable (CAIV) technique, in which tradeoffs are made early in the development stages to reduce or stabilize costs. In the case of the F-22 aircraft program and the introduction of cost savings through the PCRPs, not a single PCRp was accepted by the Air Force without specific plans that had worked their way up from an idea to a plan for implementation. This type of cost analysis allows the program manager to make a fact-based decision on whether to accept or decline contractor proposals.

New research and development (R&D) programs by definition are high risk due to the insertion of new technologies and capabilities. Determining the right budget profile is often no better than the proposed program estimate phased according to past programs. The new research in this special issue by Brown, Gallagher and White demonstrate a new technique to determine funding profiles. The authors present a method to derive budgets by using a Weibull-based forecasting method to project an expenditure profile. Starting with a recent database of 102 completed R&D defense programs, they developed a methodology to determine the required statistical inputs for the Weibull distribution. From this data, they developed a model that predicts R&D funding profile projections. These models represent a significant improvement over past attempts in this area.

Determining the final cost of a program at completion is a major challenge. While cost analysts may have access to detailed program cost models and program data bases, cost overruns continue to plague DoD. New research in this special issue by Christensen and Rees address this problem with research on bounding the estimate at completion. Previous work by Christensen demonstrated that the Estimate at Completion (EAC) computed using the cumulative Cost Performance Index (CPI) is a reasonable bound to the final cost of a defense contract (Christensen 1996). This new research confirms that a CPI-based EAC is a reasonable lower-bound to the final cost of a defense acquisition program when derived early in the program. However, in the later stages (70% complete), CPI-based EAC is no longer acts as a reliable lower bound.

PROGRAM CHANGES AND UNCERTAINTY

Program managers and cost analysts have a difficult time estimating resources when they have a well-defined program. The challenge becomes exceedingly difficult for a program with constant changes (Kammerer 2001). A recent Air Force satellite program demonstrates a dilemma. Shortly after the analysts had completed their cost estimates, they were told that the program exceeded the budget and that they would have to reduce the program from five to four satellites. In the review of the acquisition program through the Department of Defense (DOD), they were told that the program could not be a four-satellite program because it would not satisfy the requirement. In a further effort to reduce the

apparent costs of the program, the program proponents decided not to include the total number of ground terminals that would eventually be purchased for the system. DOD regulations are clear that the total program must be estimated and reported.

All of these problems associated with program definition cause a dilemma for the cost analyst. The cost analyst is sometimes asked to modify his estimate to respond to changing requirements and a smaller budget. Often he cannot do this, because as fewer units are bought, the total cost of the program increases. Add to this problem the fact that the new program may defy Congressional directions or even common sense, one sees the challenge that resource analysts face.

What constitutes the program? It is a very relevant question for the cost analyst to pursue diligently to avoid such a dilemma. The cost analyst must research the issue, not only with the program proponents but also with other authorities in the DOD. An excellent example of the type of analysis required is explained by McNutt, Hutchinson, Reinertsen and Greiner in this special issue. Their paper details a methodology and its application, in creating tactical decision rules to assist weapon system program managers in making necessary day-to-day trade-offs and decisions regarding their programs. The resulting tool assists in identifying and measuring the value of time and provides support to the decision maker in conducting the trade-off decisions associated with cost, schedule, performance and funding for weapon systems programs.

OUTSOURCING AND PROCUREMENT DECISIONS

Under the Reagan buildup, the DoD grew dramatically in an effort to win the Cold War. With the Cold War over in the 1990s, the size of the DoD dropped by 39 percent from FY85 levels with the Air Force budget dropping by almost 50 percent (Chelf 2002). These drastic reductions have forced the DoD to find new ways to save budget dollars for modernization. One solution is to reduce government operating costs by introducing competition or by outsourcing work to private companies. The vast majority of these decisions rest on cost analysis that is critical to the manager's decisions.

Whether the manager is guiding an A-76 competition or an outsourcing competition, cost analysis is critical and very different from that which the cost community normally sees. The analysis focuses on the costs of running a business or major industrial operation, not a typical weapon system. Thus, there are not normally any validated cost models lying around. Data is always a problem, since most private firms don't wish to share their cost data due to its competition sensitive nature. One of the biggest problems is the cost analyst himself—he usually isn't an experienced cost analyst (Smith 2001). Rather, he is often a contracting officer with some pricing experience. This problem is common for both the evaluation team and the government team that is bidding on the work. There is no easy solution to this problem. With continued downsizing of the cost field in DoD, one may not simply transfer more experienced cost estimators to these activities. Many of these source selections occur at base level, so the depth of knowledge is often one-deep. Local commanders are often faced with placing their best people on the teams and leaving the day-to-day activities to falter.

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A popular analysis method for large source selections is the best value decision. This method bases the decision on a total system evaluation that considers cost, technical, business performance over all aspects of the procurement (Borchers 2001). The cost analyst is challenged to consider more than just the cost of the immediate contract, but rather to consider total costs, benefits and risks to the government, or purchasing firm. This often requires the cost analyst to determine a price for the value or cost of the benefit, cost or risk. This can be as simple as determining the cost of extending an existing contract to evaluating the value of keeping and aircraft in the inventory an extra five years.

A related method, Value Focused Thinking, offers an objective method to evaluate alternatives over a variety of customers when faced with a limited budget. Lowe and Gale detail this approach in their paper "Laboratory Purchases: A Multidimensional Approach." This method takes organization values and goals and translates them into objectives. Using decision makers within the organization, alternatives are ranked based on how well they meet the objectives. Alternatives are then chosen based on this ranking until the allotted budget is gone.

SUMMARY

As this brief introduction to the special issue on the relationship between cost analysis and program management shows, cost analysts play key roles in providing needed information to managers and decision makers. Indeed, we conclude that cost analysis and program management are inextricably linked. Together cost analysis and program management will play a decisive role in shaping future military and commercial competitiveness of the United States. The following four papers provide new techniques that decision makers can use to control schedule and program risk, while balancing scarce resources.

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