PERT/Cost: The Challenge

Don T. DeCoster

PERT has proved its usefulness as a device for controlling time in project scheduling. Now it offers the promise of optimizing project costs—if the accountant can find a way to provide the needed data.

PERT/COST THE CHALLENGE

by Don T. DeCoster
University of Washington

Each day that passes sees the growth of new management planning and control tools. Many of these new tools leave the accountant with the unhappy feeling that he should be participating in their use but that he lacks the orientation for active involvement. The desire of the accountant to become involved with these tools is evident from the growth of "management planning and control" chapters in textbooks and the numerous articles dealing with the managerial aspects of accounting output.

One of the newest tools, if evidenced by current publications, is Program Evaluation and Review Technique (PERT). Recently, there have been many discussions, publications, and applications of this technique. PERT's acceptance has been widespread. The accountant must become involved with PERT if he accepts the challenge of Norman Bedford that "the accounting profession has the potential to become one of the great professions if it will accept all phases of measurement and communication of economic data as within its province."[1]

The principal motivating factor in PERT development has been the growth of the concept of systems management within the military services. With programs of unprecedented size, complexity, and breadth, an integrating device has become mandatory. In addition, time is of the essence in weapons system design and development. PERT/Time has been a powerful tool in the kit of managers for planning, co-ordinating, and integrating these weapon systems.

The culmination of PERT/Time is the network. This network is a pictorial representation of the events and activities that lead to completion of the end objectives. The events represent the beginning and/or ending of activities. An *event* is a specific accomplishment, or milestone. The *activities* represent things that must be done in going from one event to another. The activity is the time-consuming task. The activities are related to their order of precedence in accomplishing the events. The end result is a network depicting a well-thought-out plan. After the flow of activities and events is mapped, schedule timing can be superimposed. When completion times are included on the activities, the critical path (longest time path) can be determined.

At this point the manager has a tool which needs no further justification. The network presents a clear picture of all the activities and events that must be accomplished before the end objective can be attained. The individuals with responsibility for accomplishment will have discussed all of the relationships, potential drawbacks, and completeness of the plan. When times are imposed upon the plan, the problems of a timely completion are apparent. The activities affecting a timely completion and the schedule's effect on workloads are laid bare for scrutiny. When actual times become available, the updated estimates provide a dynamic control tool to anticipate adverse results. There can be little question that PERT/Time is a tool which, when applied with common sense and vigor, represents a "breakthrough" in management planning and control of the valuable resource of time.

Time-Cost Mix

PERT/Cost is, in reality, an expansion of PERT/Time. With times indicated on the network, it becomes possible to consider alternative plans of action. As the network is being developed, time-options are presented which can be considered. Techniques of system stimulation can be employed to ensure that the activities and events will lead to the best climax. The next logical step, with time-options available, is to obtain the optimum mix of time and cost. This has led to the attempt to assign costs to the activities on the network. An additional advantage when costs have been assigned to the network for time-cost options is that they can be summed for total cost planning and control.

The development of a system for cost accumulation synchronized with the PERT/Time network must be founded upon objectives consistent with the responsibility of management. In program management, the manager is faced with a twofold job. He is charged with the financial planning and control of his firm's resources, while at the same time he is committed to delivery of the end items with a minimum of cost incurrence to the customer.

This was recognized by the developers of PERT/Cost, NASA and the Department of Defense, when they visualized it as a three-part system.[2] Basic PERT/Cost is intended to assist the project managers by assigning costs to the working levels in the detail needed for planning schedules and costs, evaluating schedule and cost performance, and predicting and controlling costs during the operating phase of the program. In addition, there are two supplemental procedures. The Time-Cost Option Procedure displays alternative Time-Cost plans for accomplishing project objectives. The Resource Allocation Procedure determines the lowest cost allocation of resources among individual project tasks to meet the specified project duration. The basic system is to provide total financial planning and control by functional responsibility, while the two supplements are to achieve minimum cost incurrence.

The concept of cost predetermination for planning and control is not new to the accountant. The entire function of budgeting is predicated upon predetermination. Comprehensive budgeting relates income budgets, covering revenues and expenses, to the financial goals of the firm. The expense budgets lead to financial planning and control via projected income, while at the same time the flexible budget and the expense forecasts serve as tools for decision making by relating costs to volume.

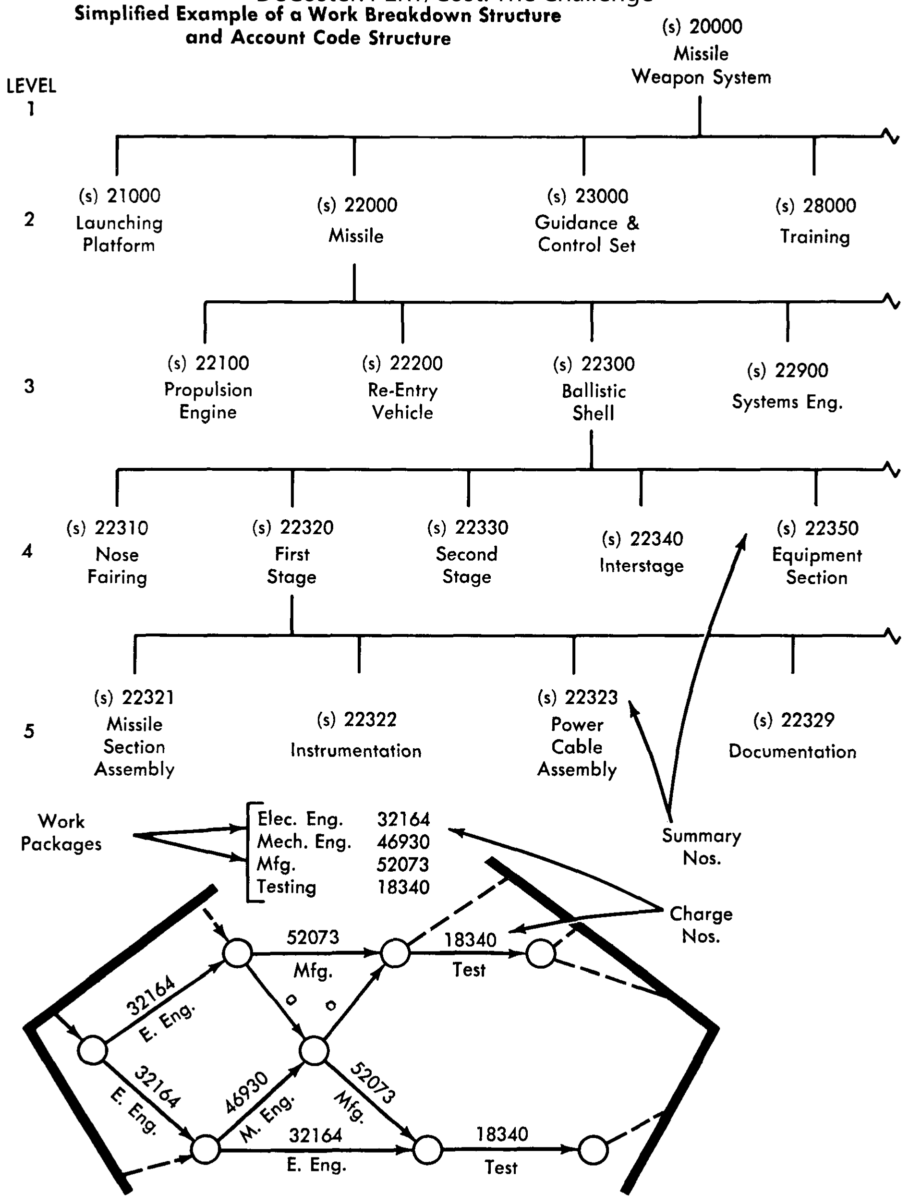
PERT/Cost estimates are a new way of looking at the expense budgets. If properly conceived, they can become an integral part of the comprehensive budget program. Yet they differ from conventional expense budgeting in certain respects. From the financial planning and control viewpoint, the PERT/Cost estimates are not concerned with accounting periods. PERT/Cost is activity oriented. There is a cutting across of organizational structures and time periods to define "things to be accomplished." The focal point of cost accumulation shifts from the department to the project work package. The annual budget is bypassed to encompass an end item accomplishment. From the detailed decision-making viewpoint, where the flexible budget normally uses volume as the factor of variability, PERT/Cost attempts to use activity time. These two differences will now be examined in more detail.

Cost Framework

The establishment of a PERT/Cost system begins by developing a framework for gathering cost data and preparing the schedule for all activity levels. The project is defined, then broken down into end item subdivisions, and then into work packages which are assignable to front-line supervision. The integration of the work packages is accomplished through the conventional PERT/Time network. When the interrelationships and time paths have been plotted, the responsible operating and managerial personnel develop cost estimates for each work package.

It is important that both cost and time be planned and controlled from a common framework. From such a framework, the managers can obtain an accurate picture of progress and at the same time appraise realistically the consequences of alternative courses of action. The PERT/Time network is this common framework. This imposes upon the network developers the responsibility of carefully defining the activities so that they can represent cost centers as well as the areas of work effort.

The identification of the project objectives in terms of end items is the starting point for network design to be used with PERT/Cost. By using a top-down approach in the development of the network, the total project is fully planned and all components of the plan are included. Standard units for the breakdown of work below the proj-



ect level are system, subsystem, task, and subtasks. The work breakdown continues to successively lower levels until the size, complexity, and dollar value of each level is a workable planning and control unit. These subdivisions are end item subdivisions representing horizontal segments of the total project. The final step would be to divide each of these end item subdivisions into the tasks that must be done to complete them; i.e., design, manufacturing, testing, and so forth. This concept is demonstrated in the illustration[3] on this page. It is this project work breakdown that serves as the input data to the network.

The theoretical optimum level of cost accumulation would be the functional level of each of the end item subdivisions. For example, a cost account would be established for mechanical engineering of the instrumentation, one for manufacturing, and one for testing. The PERT/Cost estimates would then be made for manpower, material, and overhead charges for each of these work packages. It is obvious that a cost accounting system broken down into such intricate detail would comprise numerous accounts. The pragmatic number of account subdivisions will naturally depend upon the detail needed for planning and control, the dollar value of the subdivisions, the activity time on the network, and the machine and personnel capacity available. A practical compromise is often necessary.

PERT/Cost Cost Development

Once the network has been established, based upon the project work breakdown, costs can be estimated. If the breakdown has been made satisfactorily, it will serve as both an estimating and actual cost accumulation vehicle. The proper implementation of PERT/Cost, like budgeting, must rest upon active participation by the responsible executives. This was recognized by the NASA/DOD PERT/Cost Guide when it was recommended that the operating and management personnel develop the cost estimates for each work package.[4] As with budgeting, any accounting work during the estimation period would be of co-ordinating nature.

The development of the cost estimates must rest upon a sound philosophical basis consistent with management needs. Presently there are four approaches to developing the cost estimates:

1. A single cost estimate of expected actual cost

2. Three cost estimates combined by formula into expected cost

3. Optimum time-cost curves (used in construction industries and by NASA/DOD Resource Allocation Procedure Supplement)

4. Three separate cost estimates (used in the NASA/DOD Time-Cost Option Procedure Supplement)

Each of these theories of PERT/Cost estimating has as its goal the assigning of the best cost estimates possible to the network. Yet each offers the manager separate, distinct planning capabilities.

A single cost estimate of expected actual cost is based upon the summation of the cost elements. These estimates are first made by determining the manpower, material, and other resources required to complete each work package. The estimates for the direct costs applicable to the network activities are expressed in terms of expected dollar expenditures. Indirect costs may then be allocated to the individual work package or added to the total cost of the project.

The three-cost-estimate approach has as its goal the determination of the "expected cost." The advantage of the three cost estimate over the single cost estimate is that the result is subject to probability analysis. The formula combines an optimistic, most likely, and pessimistic cost estimate. The mean cost for each activity is calculated by the formula:

$$C_e = \frac{C_P + 4C_L + C_O}{6}$$

where C_P is the pessimistic estimate, C_L is the most likely cost, and C_O the optimistic estimate. The standard deviation of the cost distribution can insert probability into the analysis. With this expected cost, the manager cannot necessarily assume that he has the optimum cost-time mix. However, if the cost estimates are realistic, the probabilities of achieving the expected cost can be used for project negotiations.

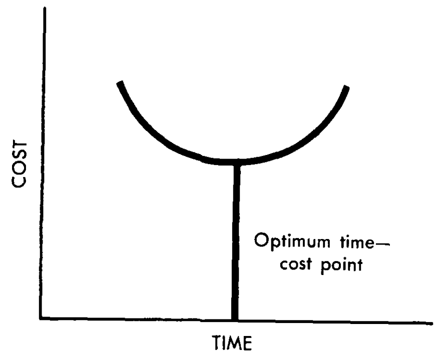


Figure A

A third approach to cost estimates is the optimum time-cost curve concept. This is differential costing with time as the factor of variability. The intention of this approach is to optimize time and costs by using optimum estimated costs. It assumes there is a direct relationship between time and costs on any activity. This relationship can be expressed by a continuous curve. If a cost curve can be developed similar to Figure A, many insights can be gained. Network schedules can be modified to obtain the lowest cost commensurate with the customer's delivery desires. Other questions can also be anticipated—questions such as: How long will completion take with a fixed budget? What will the costs be to complete the project within a given time period? In theory this concept is undoubtedly superior to either the one or three formula estimates, but without complete historical cost data the development of this curve is impractical.

Because the development of continuous time-cost curves for all activities is extremely difficult, if not practically impossible, the Resource Allocation Supplement to PERT/Cost was developed. This supplement is a variation of continuous time-cost curves which can be used in planning a small group of *significant* activities representing only a minor portion of the over-all project. This method is also based upon the concept that activities are subject to time-cost tradeoffs. The steps of this procedure are shown in the diagrams in the illustration on page 17.[4]

Another alternate to overcome the practical problem of the continuous cost curve is a linear function based upon two time-cost relationships. The cost and time expenditures are forecast for two conditions: normal and crash. The normal point is the minimum activity cost and the corresponding time. The crash point is defined as the minimum possible time to perform the activity and the related cost. A linear function is assumed to exist between these points. Figure B shows this graphically. This method is similar to the high-low point method of fixed and variable cost determination and suffers from the same type of criticism.

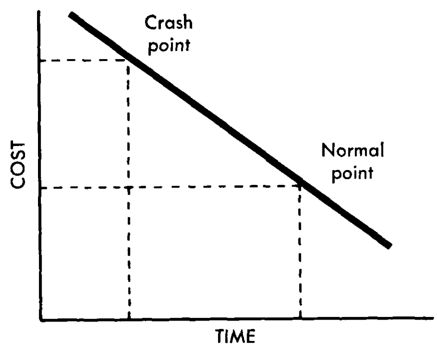


Figure B

The problems of realistic estimates, discretionary costs, stair-stepped cost functions, incorrect correlation between time and cost, and external factors are continually present. It is justifiable due to its relative simplicity when the element of nonpredictable error can be permitted. A simplified, but typical usage is shown in the illustration on page 18.

The NASA/DOD PERT/Cost Guide presents a time-cost option (called the Time-Cost Option Procedure Supplement) based upon three time estimates. The single estimate of expected cost and the three-cost-estimate formula methods do not indicate whether there may be a substantially more efficient alternative plan. The continuous cost curve concept provides these data,[6] but requires considerable sophistication in cost analysis, or else, considerable supposition. The time-cost supplement recognizes that a single estimate will normally be used for contract proposals and that additional data are needed to provide information as to the amount of time that might be saved by spending more money or the amount of money that could be saved by extending the contract time. The three time estimates used are:

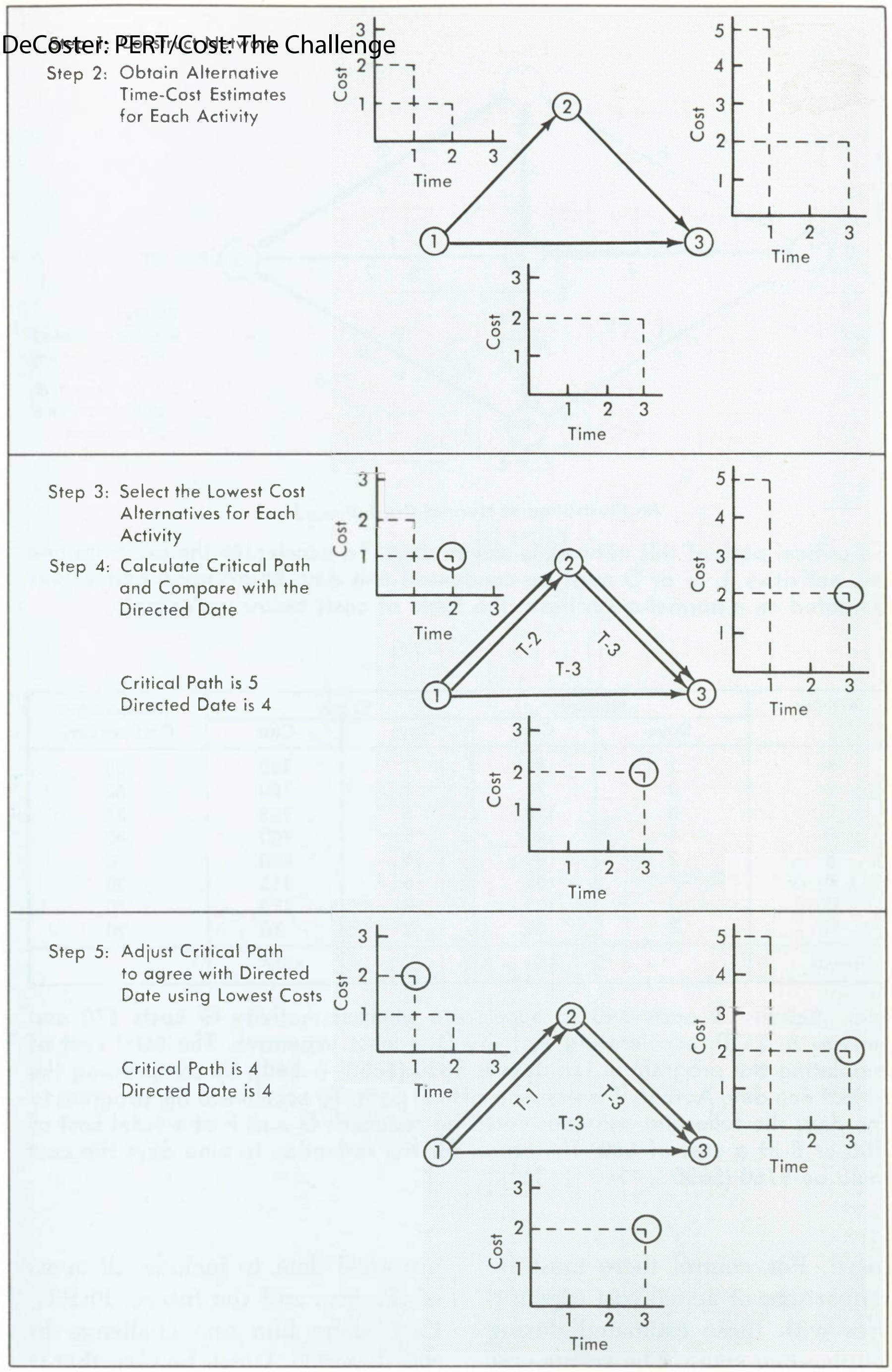
The most efficient plan. This is the network plan that will meet the technical requirements of the project utilizing the most efficient use of present resources. This is the plan that would be chosen without budget and time constraints.

The directed date plan. This is the network plan developed to meet the technical requirements of the project by the specified completion date.

The shortest time plan. This is the network plan that will meet the technical requirements of the project in the shortest possible time.

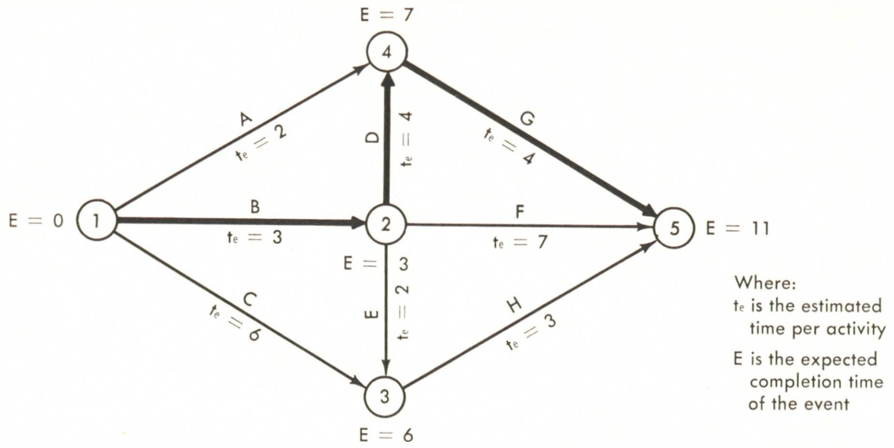
Since the desired plan is the most efficient plan, any study should begin there. This most efficient plan must then be modified to achieve the project's objectives by the specified date. The most efficient plan when altered to attain the desired delivery date becomes the directed date plan. The directed date plan is then revised to obtain the shortest time plan. The work packages that have not changed in evolving the alternate plans will utilize cost estimates for the most efficient plan. New cost estimates will be necessary only on those work packages that are expected to increase or decrease because of the modifications. With three estimates on these work packages, the customer is apprised of the impact of his decisions during negotiations. Once the customer has made his decision, the appropriate cost estimate can be assigned to the network.

These cost estimating techniques represent the current approaches to computing forecasted costs. When coupled with a sound approach to determining the project work breakdown, forward planning is definitely facilitated. To this point PERT/Cost is a planning tool, but the loop between planning and control is not



A Summary of the Resource Allocation Procedure

In the Resource Allocation Procedure, we can determine how to accomplish a project by a specified date at minimum cost. The critical path here is the path from Event 1 to Event 2, and from Event 2 to Event 3 since this will require five days at absolute minimum costs. But the Directed Data for completing the project is four days from its beginning. Thus, from the time-cost chart, we find that we can cut the time between Events 1 and 2 to one day, but we double the cost of this activity. Since shortening the time of the second step in the critical path would cost more, however, we choose to reduce time of the first step to one day.



An Illustration of Normal-Crash Procedure

The critical path of this network is eleven days. To accelerate the program one day, activities B, G or D must be condensed one day. Based upon cost curves computed on a normal-crash basis, the table of costs below is available.

Activity	Normal		Crash		Acceleration Cost per Day
	Days	Cost	Days	Cost	
A	2	80	1	130	50
B	3	70	1	190	60
C	6	110	5	135	25
D	4	60	3	100	40
E	2	90	1	100	10
F	7	85	6	115	30
G	4	105	3	175	70
H	3	50	2	70	20
Totals		650		1015	

Since Activity D costs $40 to accelerate whereas Activity G costs $70 and Activity B, $120, accelerating Activity D is least expensive. The total cost of completing the program in ten days is $690 ($650 + $40). By compressing the project one day, Activity F enters the critical path. To accelerate the program to nine days the following activities could be reduced: G and F at a total cost of $100 or B at a cost of $60. Therefore, for the reduction to nine days the cost would be $750 ($650 + $40 + $60).

closed. For control there must be comparisons of actual cost expenditures with those estimated during the planning stage. The accountant must play an active role when the loop is closed between the planning and control phases. The generation of feedback data consistent with the planning stage calls for a chart of accounts correlated to the PERT network.

The PERT/Cost Challenge

The accountant is charged by management and society with providing financial information for all levels of decision making. If the accountant is to serve the managers effectively, he will have to broaden his influence beyond the confines of historical data to include all areas of the firm and the future. PERT/Cost offers him one challenge in this direction. It can be seen that if PERT/Cost can be co-ordinated with PERT/Time, the manager has an excellent tool for project planning and control. In addition to financial reporting both on the total cost level and the individual manager's level, it offers distinct opportunities for decision making during both the planning and control phases.

The discussions here might lead one to believe that PERT/Cost offers no problems. Unfortunately, this is not the case. Despite the potential there are basic problems. An enumeration of some of these problems would include:

1. PERT/Cost for decision making in optimizing costs requires a sophistication of cost analysis that is not possessed by some firms.

2. There is a lack of historical information for assigning costs to networks since the concept is new.

3. There is difficulty in making project costs compatible with fiscal practices.

4. The problems of overhead charges, joint costs, and incompatibility of the organizational cost flow with the functional flow are numerous.

5. There is a problem of reconciling the "jobs" that are using PERT/Cost with those that aren't for fiscal reporting.

6. The personnel and machine capabilities are not always available.

7. Cost accumulation for financial stewardship reports can conflict with the cost centers for PERT/Cost and can therefore create redundant systems.

8. The conversion of project oriented costs to mesh with annual budget concepts requires additional analysis.

If the problems associated with PERT/Cost can be resolved, PERT with COST could be considered a major breakthrough as was PERT with TIME. The majority of the potential problem areas with PERT/Cost lie in the controller's department. These difficulties present a very real challenge to the controller. PERT/Cost is putting the adaptability of the accountant to the test.

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[1]John L. Carey, *The Accounting Profession: Where Is It Headed?* (New York, American Institute of CPAs, 1962), p. 94.

[2]*DOD and NASA Guide: PERT/Cost.* Published by the Office of the Secretary of Defense and the National Aeronautics and Space Administration, June 1962.

[3]*Ibid.*, p. 28.

[4]*Ibid.*, pp. 109-113.

[5]Glenn Welsch, *Budgeting: Profit Planning and Control* (Englewood Cliffs, N. J., Prentice-Hall Inc., 1957), pp. 173-174.

[6]See Figure A on page 16.