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INFORMATION SYSTEMS IN PROJECT MANAGEMENT 1/

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INFORMATION SYSTEMS IN PROJECT MANAGEMENT

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INFORMATION SYSTEMS IN PROJECT MANAGEMENT

I. INTRODUCTION

A project has been defined as a set of complex interrelated tasks directed toward the accomplishment of an objective. Therefore, Project Management can be defined as a system of procedures which provides for Planning, Scheduling and Control of a Project.

This paper assumes previous knowledge of project planning and scheduling techniques and reviews some of the more widely used project control techniques developed during the last decade and implemented throughout government and industry.

Information is the medium of control; it is the flow of measurement information and later the flow of corrective information which allows an item to be controlled. The techniques presented in this paper are effective means of placing information in the hands of management.

II. PROJECT CONTROL ELEMENTS

As mentioned above, information is the medium of control. This information should be in a language common to the plan, accurately measured and transmitted to the control unit

for comparison, and processed rapidly. Instrumentation using electronic devices is central to the concept of automatic control. But project control is an open-loop system; it must have guidance and decision from an intelligent human being.

Fundamentally, control is any process that guides activity toward a predetermined goal. The essence of this concept is in determining whether the activity is achieving the desired results. Note that the desired results are assumed to be known; in other words, project control cannot exist without planning, nor can control in its broadest context. The essentials of a control system involve four elements:

--A predetermined goal, plan, policy, standard, norm, decision rule, criterion, or yardstick.

--A means of measuring activity.

--A means of comparing activity with the criterion.

--Some mechanism that will correct the current activity so as to achieve the desired results.

The purpose of a control system is to provide technical performance/time/cost visibility for:

--Indication of status.

--Prediction of future performance.

--Evaluation of realism of plans.

--Indication of need for replanning.

The input/output concept is central to effective control systems and is discussed in depth below.

1. A Predetermined Criterion

The most important idea in control is to determine to some degree what the results should be, at least what is exptected from a given action. Planning and policy are prerequisites for control. Planning can yield some benefits without control, but control can never exist without some element of planning for the future.

This predetermined criterion may be qualitative but the difficulty with such qualitative statement is the lack of precision. For this reason, the evolution of management techniques on the twentieth century has involved greater use of quantitative expressions which contributes to precision. Standards provide a way of stating what should be accomplished. These standards can be in terms of time, cost, performance in physical units, or some composite index.

2. Measurement of Performance

Performance cannot be checked unless performance in a past period can be determined. This may appear to be a simple matter, but confusion can develop unless the basis of management is defined. The effectiveness of a control system depends upon promptly reporting past results to the persons who have power to produce changes. The unit of measurement should be consistent with the predetermined criterion and should be reported in a form that facilitates easy comparison.

3. Comparison of Performance with Predetermined Criteria

Much management thinking involves a study of variations. Since all activity yields some variation, it is important to determine the limits within which this variation can still be considered "in control." A manager must be able to distinguish between unimportant variations and variations indicating need for corrective action. Simple methods of comparing actual results with the predetermined goal will often provide new insights into the problems confronting him.

The purpose of comparing past performance with planned performance is not only to determine when a mistake has been made, but also to enable the manager to predict future results. An effective control system will provide quick comparisons so that the manager can attend to possible trouble while the operation is "in control." Comparison of actual performance through time will often show a significant trend that might indicate a danger signal. The manager cannot change the past, but he can use his understanding of it to help him operate in the present to make future operations better.

4. Schematic Analysis

As the managerial process has increased in complexity, a need has grown for devices to clarify the significant relationships and emphasize the most important elements. To meet this need management has developed pictorial and simple numerical methods to aid decision-making.

Effective schematic techniques help us focus on the pertinent, relevant facts and help us suggest some of their implications. The simplest and most widely applied graphs in business and project management are those plotting changes over time.

Some of these graphs will be illustrated in the course of discussion of the current control systems.

III. MANAGEMENT CONTROL SYSTEMS

The major current control systems will be briefly discussed and the strengths and limitations associated with some of the computerized information systems will be noted.

A. PERT AND EXTENSIONS

PERT is probably the most common of management control systems. This section assumes prior knowledge of the mechanics of PERT and the goal of the discussion here is to examine PERT as a management control process. Extensions of PERT provide for control over cost, manpower and other required resources.

1. PERT Computations

Figure 1 illustrates a simple network that is going to be used in developing PERT basic computation. For the sake of clarity, verbal descriptions of activities and events have been removed and events have been designated numerically. The three times estimates for each activity have been entered.

At this point, no computation of any kind has been carried out, however, much useful information about the project can be obtained from this network. The simple act of defining a project in network teams serves to pinpoint areas of critical interdependency and to provide manageable units over which control can be exercised. Using only the network shown here, the project manager is able to see which activities can be carried on in parallel and which must follow sequentially. He has a good idea of the time required by a given task and a gross indication of the degree of uncertainty surrounding the estimates given. This makes a contribution to the management control process.

Various measures useful to mangement in control of the project can be developed using the data shown in the network. First, an expected time for each activity is calculated, based upon the three estimates given. The expected time is defined by the formula:

$$\text{(T) Expected Time} = \frac{\text{(Optimistic)} + 4\text{(Most Likely)} + \text{(Pessimistic)}}{6}$$

$$t_e = \frac{t_o + 4\,t_m + t_p}{6}$$

This is the time which stands a fifty-fifty chance of being achieved. Also of interest is a measure of the uncertainty or variance associated with the three time estimates. Variance is computed by means of the formula:

$$\text{(V) Variance} = \frac{\text{(Pessimistic)} - \text{(Optimistic)}}{6}$$

$$\sigma^2 = \left[\frac{(t_p - t_o)}{6}\right]^2$$

Figure 2 shows the results of the calculation of expected time and variance for our network. Given the expected time for an activity and a measure of the variance, certain statistical inferences can be drawn. For example, the activity bounded by events 1 and 2 has a 50 percent probability of being completed in 20 weeks, a 25 percent probability of completion in 18.9 weeks, and a 75 percent probability of being finished in 21.1 weeks. The computations involved here will be explained later.

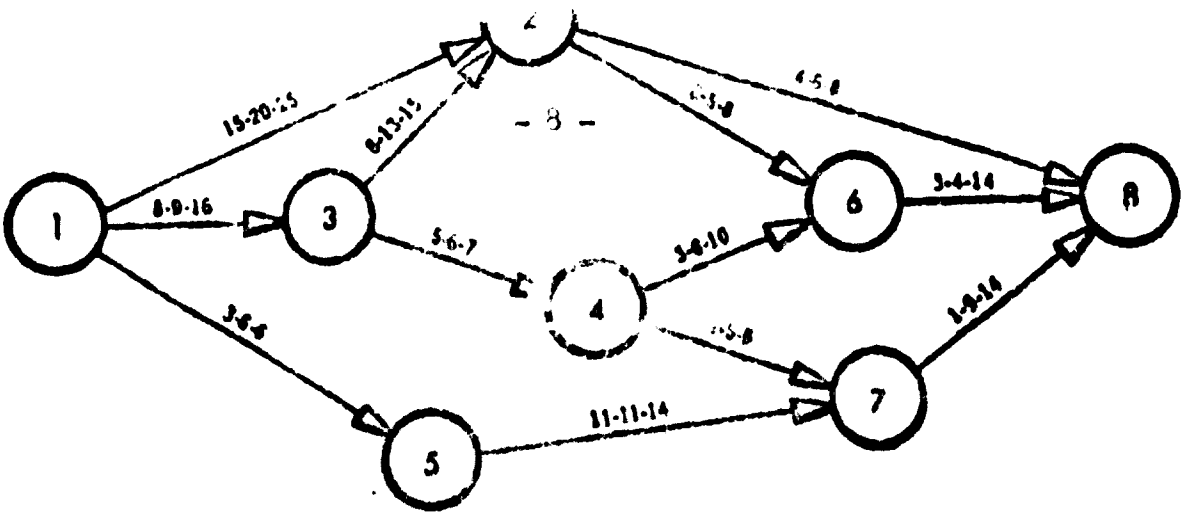


FIGURE 1 PERT NETWORK, SHOWING TIME ESTIMATES

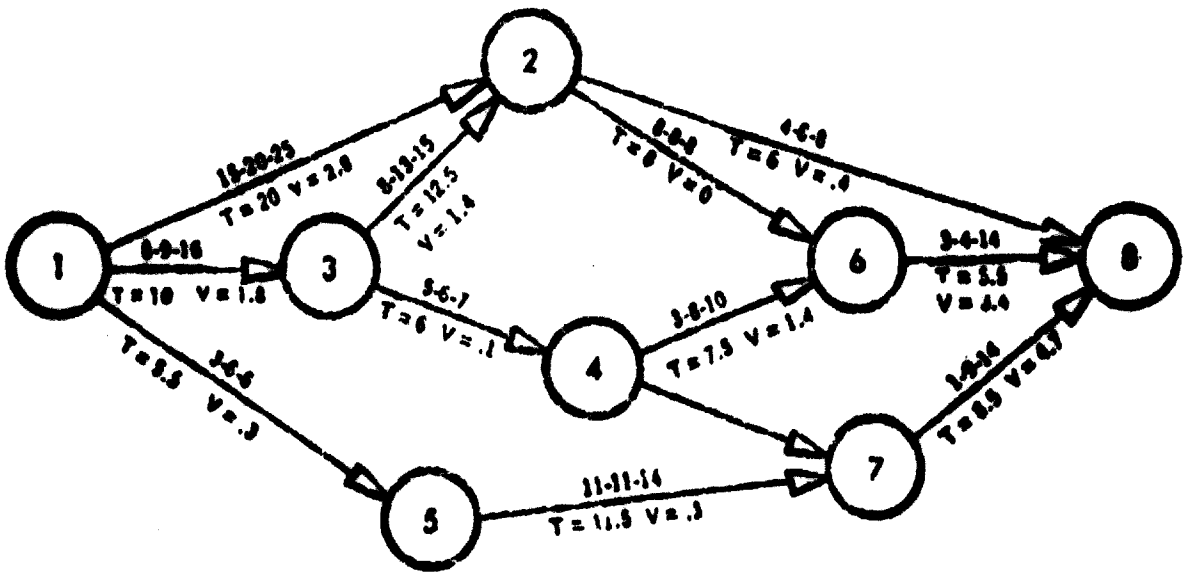


FIGURE 2 PERT NETWORK, SHOWING EXPECTED TIMES AND VARIANCES

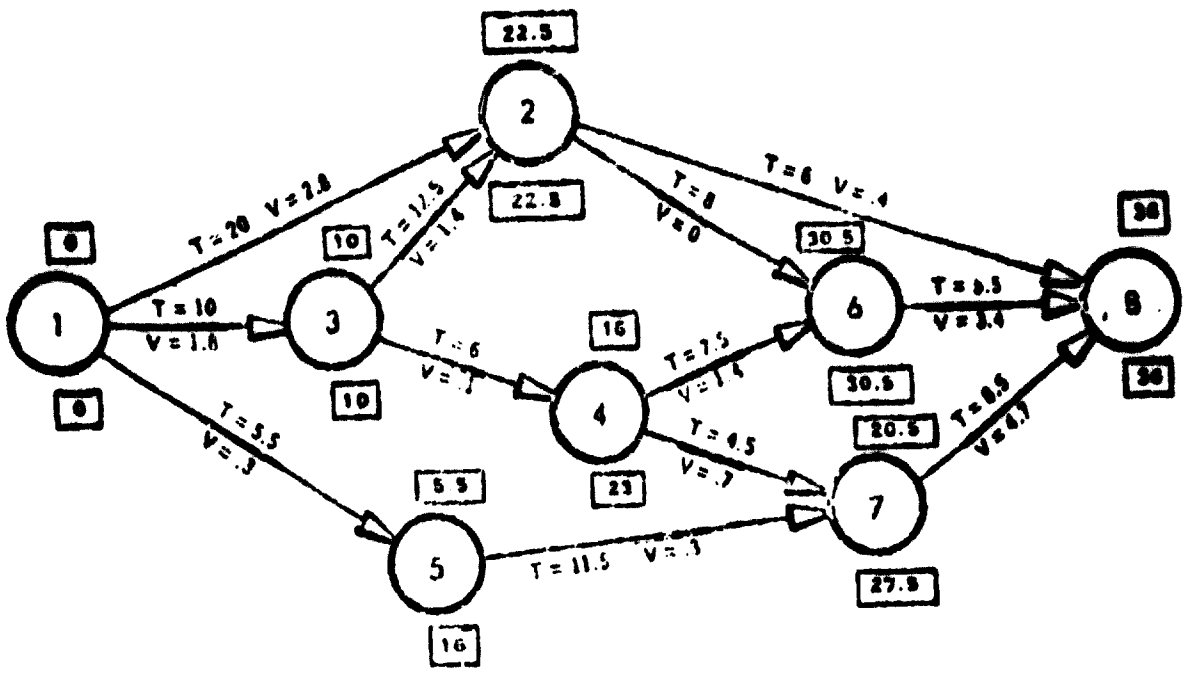


FIGURE 3 PERT NETWORK, SHOWING EARLIEST EXPECTED AND LATEST TIMES

The next measure to be derived is the earliest time each event in the network can be expected to occur. This earliest expected time is the sum of the expected times of the activities on the longest time path from the beginning of the project to the event in question. In Figure 3, the earliest expected time for each event is shown above the circle. Three paths lead form event 1, the beginning of the project. to event 6--the paths being 1-2-6, 1-3.2-6, and 1-3-4-6. The longest of these is path 1-3-2-6, which requires 30.5 weeks, the earliest expected time for event 6. The earliest expected time for event 8, 36 weeks, indicates that completion of the project cannot be expected before that time.

In addition to the earliest expected time, a latest allowable time is computed for each event. The latest allowable time is the latest possible time as event can occur without extending the total project time. It is calculated by taking the sum of the expected times along the longest time path from the event being considered to the end event, and subtracting this sum from the time the project must be completed. In our network in Figure3, the latest allowable time are shown below the events. Taking event 3, four paths lead to end event 8. The shortest of these is path 3-4-6-8, which has total expected time of 19 weeks. Nineteen is subtracted from 36 to give a latest allowable time of 17 weeks.

The difference between the latest allowable and the earliest expected time for an event is the amount of slack associated with that event. Slack is the amount of slippage permitted an event before it extends the duration of the project. Event 4 has seven weeks of slack, since it can occur anytime between the sixteenth and the twenty-third weeks without affecting the schedule. When slack for an event equals zero, the event lies on the longest time path through the network. This patch is known as the critical path, since any slippage in it will increase the duration of the project. In our network, events 1,3.2,6 and 8 lie on the critical path.

In our example, it was assumed that no delivery requirement existed. However, if the project has to be completed by the thirty-fourth week, 34 would be used as the latest allowable time for end event 8. This would automatically reduce the latest allowable times for all other events by 2, resulting in negative slack for certain ones. When such delivery requirements exist, the critical path becomes the one having the least positive or most negative slack.

PERT also provides a measure of the uncertainty associated with the attainment of designated events. It will be recalled that the earliest expected time for any event had a 50-50 chance of attainment. The variances computed along the longest time path to an event may be added together and used to calculate

the probability of reaching an event by any specified schedule date. They can also be used to compute a date which can be attained with any given level of certainty.

The calculations involved are as follows:

Standard deviations and variance of critical path activities:

Event Number on Critical path	Standard Deviation of activity	Variance of activity (V)
3	$\frac{16 - 8}{6} = 1.33$	1.8
2	$\frac{15 - 8}{6} = 1.16$	1.4
6	$\frac{8 - 8}{6} = 0$	0
8	$\frac{14 - 3}{6} = 1.83$	3.4

Total variance along the critrical path - 6.6

Standard deviations for the final event = $\sqrt{6.6} = 2.55$

Critrical path = 36 weeks

Assuming we want to reach our final event in 34 weeks

$$Z = \frac{T_c - T_e}{\sigma_{T_e}} = \frac{34 - 36}{2.55} = -0.78$$

Referring to tables of the area under the normal curve, the z statistic corresponding to the number -0.78 is approximately 0.22. This means that the probability of meeting the contract time is 22 percent. In other words only 22 times out of 100 could management expect to complete the project on schedule.

2. PERT Output

The basic report typically includes the event number, its description, the expected and latest allowable times and slack. Where scheduled dates are supplied, the probability of meeting these is printed. The more sophisticated programs provide for the inclusion of actual dates upon which are computed. Several sort options are provided, so that events may be listed in slack sequence, in sequence according to their earliest expected time, or in sequence by latest allowable time.

In processing the sample network, the event-oriented approach was utilized. CPM and some of the newer PERT systems use an activity-oriented approach in analyzing the same network. Input requirements under either system are similar, with the minor exception that activities are given a verbal description when activity-oriented output is desired.

The relative merits of event or activity orientation can be debated. As a rule, however, activity output will be of primary interest to personnel at the operating level, since

their responsibilities are defined in terms of activities, while event output will be most useful to top management, which is concerned with attainment of major milestones in the project.

One of the most challenging aspects of developing a useful PERT system is the necessity for sifting through the vast amount of data that can be generated and extracting that which is meaningful to management. The typical PERT program, with only the slightest encouragement, will spill out pages of output by the thousands. It is obvious that discrimination and selectivity is needed in order to adhere to the principle of management by exception.

The problem has been attacked from several directions. Probably the simplest approach has been to pre-define certain events in the network as being of interest to a particular level of managment and to code the master records accordingly for report purposes. Another way has been to portray the output graphically, to produce a quick visual impression of project status. Flagging of particular exception items, such as unreported or overdue occurrences, has provided a useful checklist for the project manager. Finally, some elaborate index systems have been developed, which computer a criticality index for each activity by means of a weighted combination of such measures as negative slack, low probability of attainment, and high variance in time estimation.

To be specific, the types of PERT networks used in

weapons system requisition are listed below. Various levels of management and numerous interrelationships among firms, agencies, and military offices are usually involved in project system control.

In such an environment, with its variety of demands, a single network often will not suffice. Accordingly, variations have been evolved to handle various aspects of the planning and control process.

a. Detailed and Operating Level Networks

Generally, each prime or associate contractor constructs and uses a network that covers his individual sphere of program responsibility. If a portion of the project is subcontracted to another firm that subcontractor in turn may be required to construct and use a network for his portion of the project. These networks are constructed in considerable detail and frequently comprehend even relatively minor activities and events. Such networks are utilized by operating networks, or detailed networks. In addition, since they often cover only a fragment of a project, NASA has referred to them as fragnets (fragmentary networks).

b. Integrated Project Networks

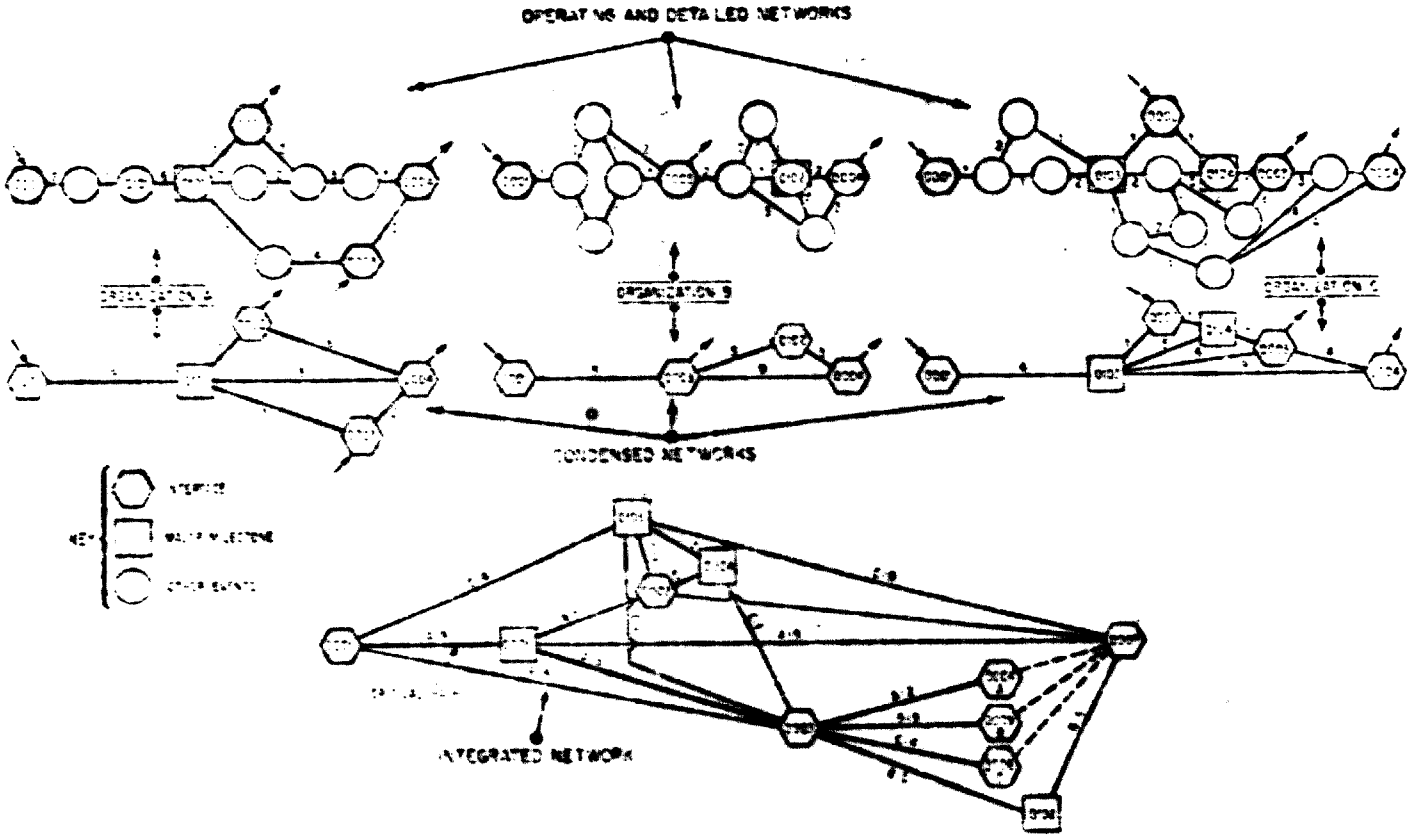
The detailed operating networks prepared by the separate firms and agencies may be combined or integrated into one comprehensive network encompassing all events in the entire project. Although perhaps not directly involved in detailed

operations, the office involved can exercise managment surveillance over the progress of the entire project through use of this integrated network.

c. Condensed or Summary Networks

Generally, detailed networks contain too much operating data for top project managment or other interested parties monitoring the progress of the program on a more aggregative basis. To accomplish this, a summary, or condensed network is constructed which eliminates much of the detail, yet retains the events of major significance. Such networks frequently are displayed in project control offices.

Accurate translations of activity time estimates must be made when the operating networks are either integrated or condensed. The integration and condensation processes involve identifying, recording, coordinating and storing interface events. Various computer routines are being developed to accomplish this complex and vital task. The relationship Among these various forms of networks is indicated in Figure 4. This diagram depicts condensation of networks prior to network integration. Either condensation or integration can occur first depending on the requirements of the levels of program management.



PERT: Relationships among networks.*

* *Adapted from* Planning and Control Techniques and Procedures (PCT), *Headquarters, U.S. Army Material Command, AMC Regulation 11-16, vol. 2, August 1963, Fig. 11-3-5.*

Figure -4-

3. Management Action

The success of a functioning PERT system should be gauged, not simply by the quality of the reports it outputs, but rather by the management response it stimulates. A good PERT reporting system will call to management attention areas in which scheduled project objectives are being threatened. Management, then must take the necessary remedial action.

When it becomes apparent that a schedule requirements cannot be met under the existing plan, it becomes necessary to devise a new plan. Activities along the critical path must be analyzed from two points of view. First, there is the possibility that certain sequential activities can be performed in parallel. Originally, activities might have been scheduled sequentially to provide assurance that a previous task was performed successfully before procceeding to a subsequent task. It might be possible to schedule these simultaneously if the project manager is willing to assume the added risk.

The second and more usual alternative is to divert manpower or other resources from activities with large positive slack to those with zero or negative slack. The report showing activities sorted in slack sequence is very useful to the manager in determining the most feasible exchanges. In making these exchanges, however, he must ascertain the effect that they will have on the total network. As the critical path is shortened, an other path may

become critical and in turn require attention. The usefulness of haveing a network model of the p oject is appar nt at this point. The network can be processed by the computer as if the contemplated changes had actually been made and their full consequences can be projected. When used in this manner, the network becomes a simulation model.

By focusing management attention on activities that lie on the critical path or on near-critical paths, PERT relieves the manager of the burden of closely auditing the 80 to 90 percent of activities which do not directly influence the duration of a project. It truly allows management by exception.

4. PERT Extensions

The term PERT alone is generally associated with planning and control of the time variable only. This forms the basis for a complete project control system, however, it can also provide the framework for extensions which allow control over other elements much as cost, manpower and other sources.

PERT/Cost

In general it is necessary to weigh the costs attached to a project. Even when time is the overriding factor, costs considerations must be included.

The PERT/Cost procedure requires as input cost data in addition to the time date required by basic PERT. This cost data is generally collected for small groups of related activities rather than for single activities, so as not to impose an undue accounting

burden.

Cost estimates are obtained only after a satisfactory schedule has been developed, since any schedule change will normally affect cost. Labor is estimated by entering the manhours required for each manpower skill category. The computer converts this input to dollars by applying the appropriate labor rates. Material costs are estimated and overhead factors added. As the project progresses, actual accrued costs are gathered for each cost collection point and revised estimates are submitted as required. A number of useful and informative reports can be generated from this data. The basic output is a status report, which combines time and cost data for each cost collection point. This enables the manager to identify activity groups which are contributing to actual or potential schedule slippages or cost overruns and also to compare the time and the cost status of any given activity group. In addition to the output obtained from a time-oriented network, this report shows the original cost estimate; the actual costs incurred; a revised estimate, if any; and the anticipated overrun or underrun. Provision is made for summarization of the time and cost data at various levels, so that each level of management is presented only with that amount of detail with which it is directly concerned.

A projection of manpower needs for each skill category is developed by the computer. The time analysis of the network is

used to determine the calendar period on which each activity will fall. The estimated manhours for each activity are then distributed by calendar period within skill category. The summarized results can be displayed in graphical form (figure 5.).

This projection is useful to the manager in predicting peaks in requirements for particular manpower skills. When future demand for a skill exceeds the available supply, some action must be taken. The situation might be relieved by rescheduling activities, by adding over-time or by hiring additional personnel. The extent to which any of these alternatives serves to alleviate the problem can be predicted by utilizing the simulation facilty of the computer program.

In most projects, manpower constitutes the most important resource. Frequently, however, other resources play a critical role in the achievement of project objectives.

These might be machines, testing facilities or computer time. Where there is a possibility of an overload on any of these facilities, a projection similar to that shown for manpower can be made.

Cost requirements for a project can also be projected in this same way. When costs are distributed by calendar period and accumulated, estimated and actual payout curves can be plotted (figure 6). At the beginning of the project, this projection is useful in determining the funding requirements of a selected

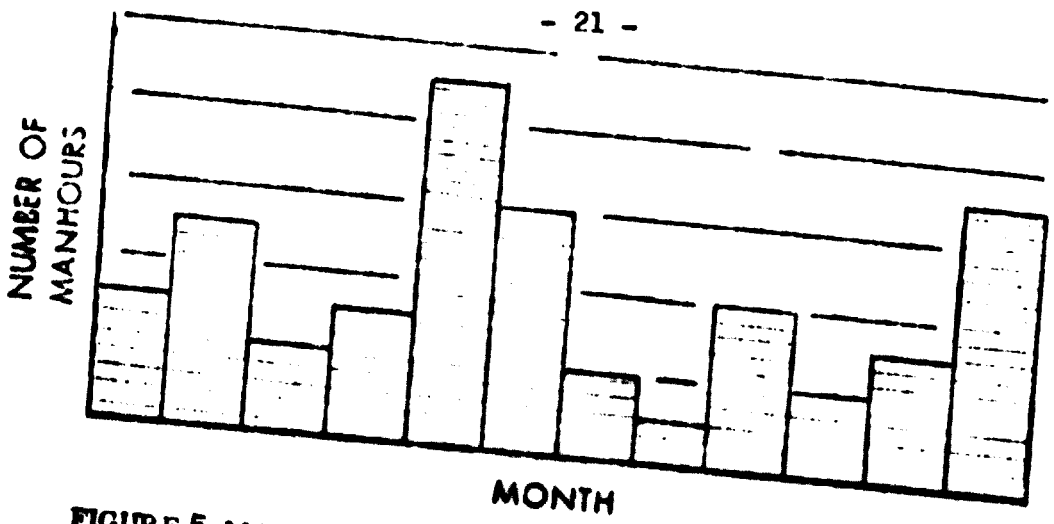


FIGURE 5 MANPOWER REQUIREMENTS, SKILL CATEGORY XX

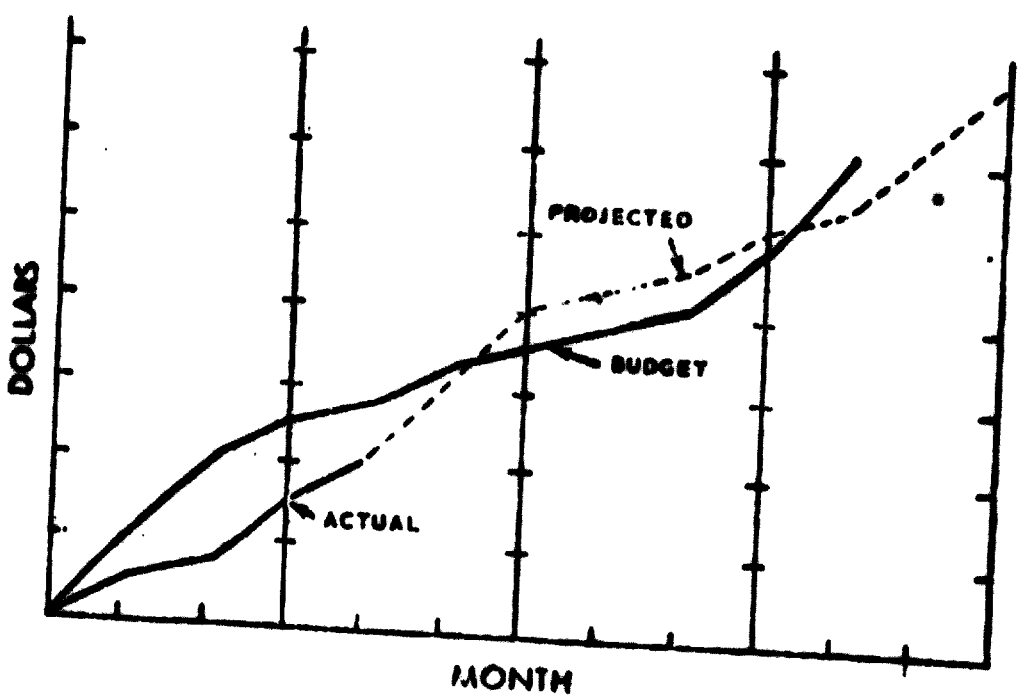


FIGURE 6 RATE OF EXPENDITURE

schedule, so that the necessary money can be provided at the proper time. As work proceeds, the actual payout can be compared with the budget and the projected needs can be used as a basis for revising the funding schedule.

Cost-Time Balancing

Selection of a suitable for a project generally involves consideration of numerous alternatives, each with a different cost picture. Choosing the schedule which provides the best balance between cost and time is an arduous task when attempted by trial and error, and it is not surprising that computer techniques have been developed for this purpose.

Most activities involving manpower reveal a direct relationship between cost and the time required for completion. Assigning additional personnel or scheduling overtime normally reduces the time requirements for an activity while incurring increased costs. Cost-Time balancing programs require two estimates of time for each activity and two of cost. Normal cost is defined as the minimum cost for a job, with normal time being the associated minimum time. Crash time is defined as the minimum possible time, with crash cost being the associated minimum cost. For example, a job might normally be completed in six weeks, at a cost of $3,000. Expediting this job, so that it can be finished in two weeks, might involve a total cost of $7,000. The latter is the crash time and the crash cost. Figure 7 shows this relationship. The

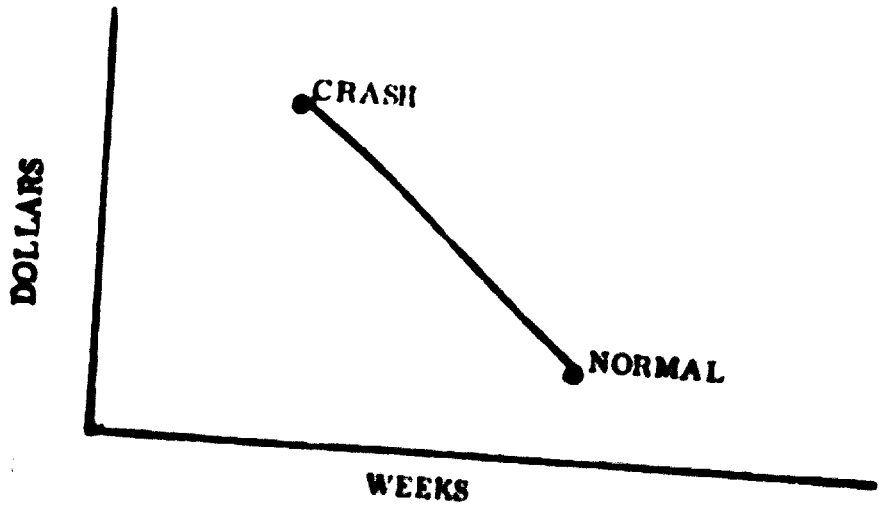


FIGURE 7 COST-TIME RELATIONSHIP FOR A GIVEN ACTIVITY

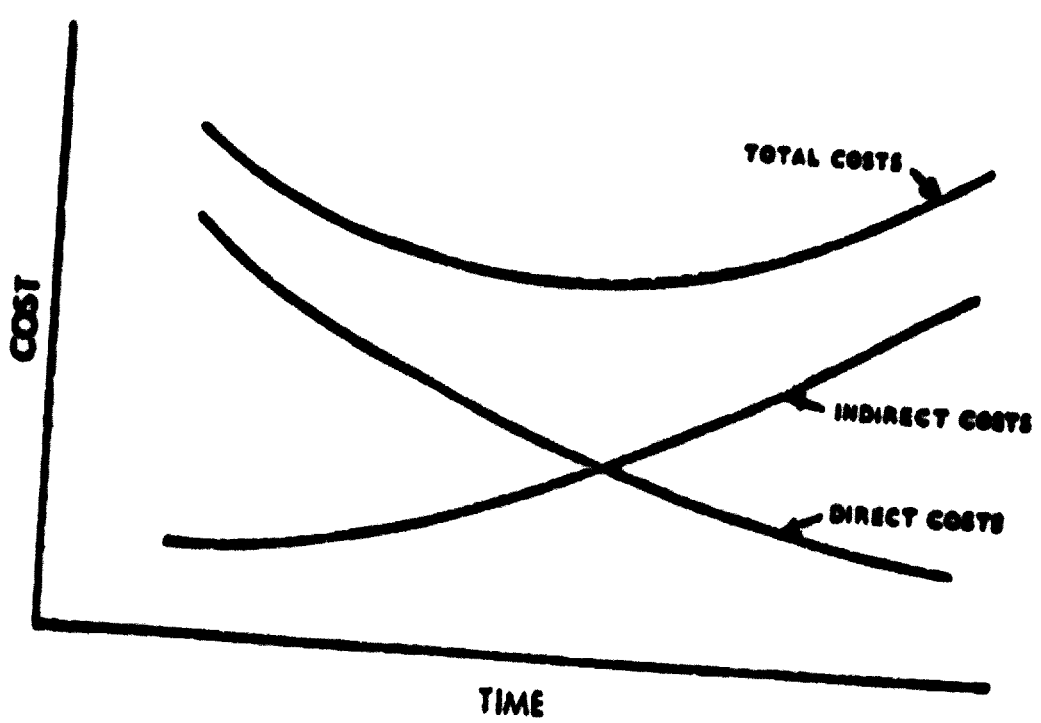


FIGURE 8 TOTAL PROJECT COSTS

line connecting normal and crash illustrates the assumption that there is a cost corresponding to any time between normal and crash.

A normal time and cost for the entire project can be obtained simply by summing the normal time and cost estimates for the network. To calculate the total project cost for shorter times, the critical path is examined and activities with lowest time per dollar ratios are expedited. As the time required along the critical path is reduced other paths in turn become critical and they too are examined. Sufficient points are obtained in this way to plot a direct cost curve for the entire project (figure 8). The addition of a manually evolved indirect cost curve gives the manager all the information he requires to select the project schedule which most closely balances his cost and time objectives.

B. STATUS INDEX

A second management technique is known as the Status Index. The Status Index permits (i) measurement of the adequacy of technical performance for the money spent, (iii) details to identify trouble spots, and (iv) forecasting of trouble spots. The index is derived as follows:

$$\frac{\text{Progress}}{\text{Scheduled Progress}} = \frac{\text{Budget}}{\text{Actual Expenditures}} = \text{Status Index Number}$$

The basic relationship is between the budget (input) and progress (output). Consider the following:

$$\frac{\text{Output}}{\text{Input}} = \frac{\frac{7T_a}{10\ T_p}}{\frac{6 \text{ million } E_a}{5 \text{ million } E_p}} = \frac{7}{10} \times \frac{5}{6} = .6$$

where a = actual, p = planned, T = time in months, and E = expenditure in dollars.

This index in itself is only usefulto indicate (i) status and (ii) status related to some prior period (better or worse). To determine where management attention is needed, progress can be measured in terms of the limiting path or the stream of related activities whose progress is slowest in relation to the other related efforts in the program.

For Example:

Project/Task	Slack
Overall Project Summary	-8
Effort A	-3
Effort B	-2
Effort C	-8
Effort D	-5
Effort E	+1
Effort N	-3

Effort C is the "slowest" and therefore is the project limiting effort; that is, the area where management attention is most necessary at the time the reading is taken.

The progress/schedule variable in the equation can be written:

$$\frac{F_w}{T_w - S_w} \qquad (1)$$

where F_w = effort (in weeks), T_w = planned project time (in weeks), and S_w = slack (in weeks), or

when using milestones instead of slack:

$$\frac{F_w - B_w}{T_w} \qquad (2)$$

where the variable B_w (weeks behind schedule) is used instead of S_w, or when using time to date; that is, considering the total program instead of planned total project time:

$$\frac{E_w}{E_w - S_w} \qquad (3)$$

Consider now the original equation:

$$\frac{\text{Input}}{\text{Output}} = (N) \times \frac{\text{Budget}}{\text{Actual Expenditures}}$$

where (N) - equation 1 or 2 or 3.

The Status Index can be applied at any level of detail in the work breakdown structure where values for the variables cited above can be identified and substituted in the equation. Indicated below is the relative criticality with reference to progress versus cost by level of effort.

Status Index	End Item	End Item S/D	Remarks
1.2	2	2.1	Possibility of excess resources
0.9	3	3.1 3.3 3.4	Normal variance range
0.8	4	1.2 1.4 2.2	May require more resources
0.7	1	2.5 2.6	
0.6	5		Immediate management action required

Forecasting cost to completion can be accomplished using status indices as shown in figure 9.

After initial fluctuations have dampened out, the least squares method or a similar technique can be used in the projection. In the example above, .95 is the projected index, which means 100/95 of the original estimated cost or a 5.3 percent overrun will be required to complete the project.

Predicating trouble areas can be accomplished through the

examples shown in figure 10.

Based on the information in figure 10-a alone, the project manager would be likely to concern himself more with Task 3 than with Task 2.

Conversely, the example in figure 10-b shows how progress, when tracked over time, would indicate that Task 2 is getting worse while Task 3 is getting better.

An extension of the above historical comparison with the plan is shown in figure 10-c. This can be used to reveal the degree of planning effectiveness--for more realism.

Variations in patterns, of course, will reveal symptoms of performance deficiencies other than consistently good or bad planning; that is (i) pessimistic at the outset but steadily improving; (ii) excellent at the outset but increasingly going out of control; and (iii) erratic, with no discernible pattern.

Technical performance, one of the most elusive measurements, can at least be approximated through another application of the Status Index. A Performance-Cost Index can be derived from the formula:

$$\frac{Z_A}{Z_p} \times \frac{B}{E}$$

where:

Z = technical performance

A = actual

P = planned

B = budget

E = expenditures

If, for example, tests are 2/3 successful versus the plan and the budget expenditure ratio is 3/2, the Performance Index is 2/3 x 3/2 = 1.0.

Task	P-C Index	PR-C Index
Memory	.7	.9
Processor	.9	.8
Input/Output	1.2	1.3
Power	1.3	.9

The above relationships would suggest that, in the Memory and I/O, true progress is behind milestone progress with a related unfavorable impact on cost. Consistently higher performance over progress, as indicated in the power supply, might be symptomatic of overdesign.

The collective impact of budget, expenditures, schedule, and technical performance and their interaction must be evaluated by a program manager, so he can be effective. This, then, is one other technique that can help to pre-digest information and expedite its conversion into program management action.

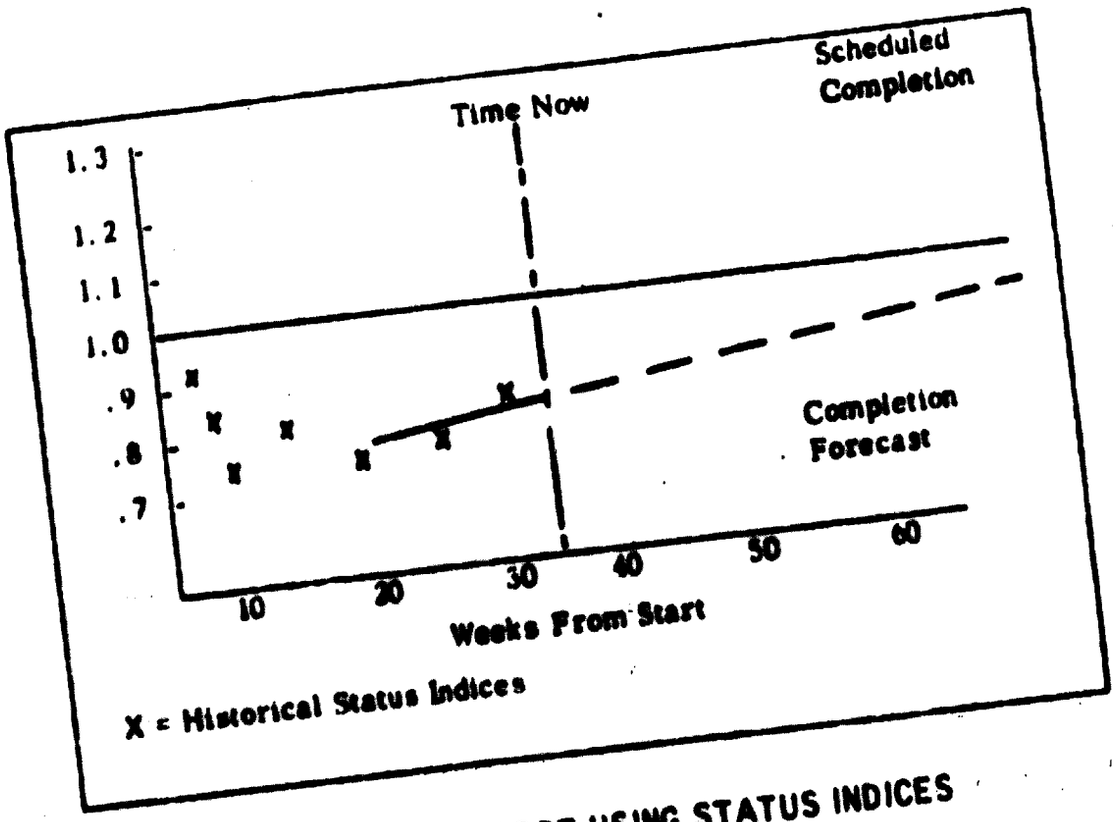


FIGURE 9 FORECAST COST USING STATUS INDICES

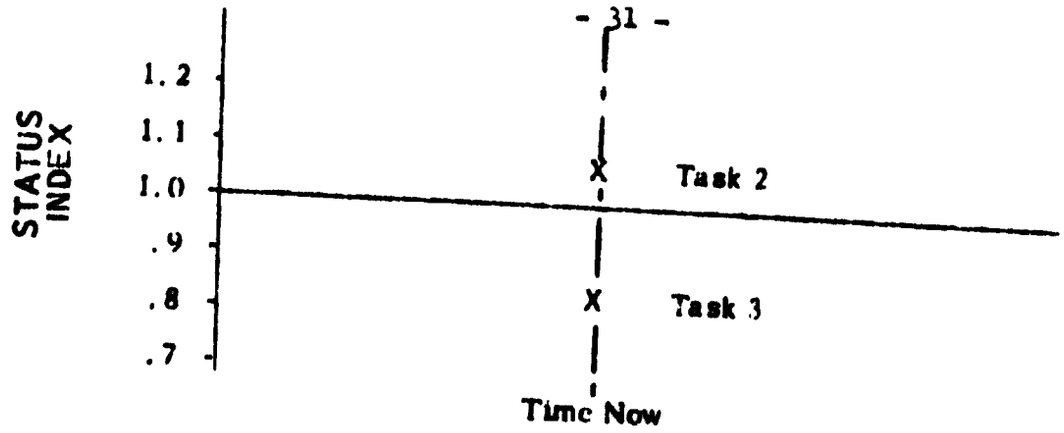


FIGURE 10-a

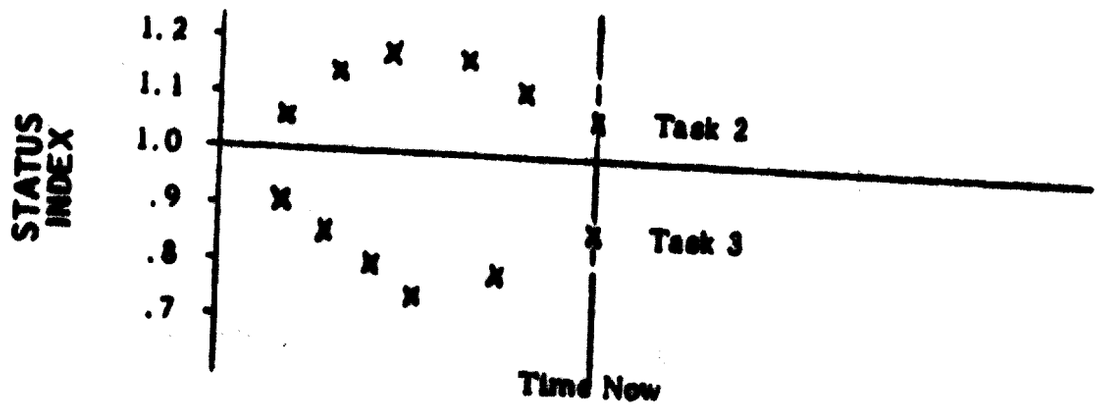


FIGURE 10-b

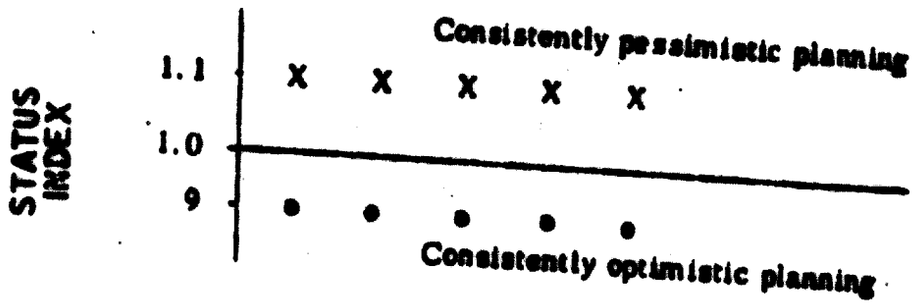


FIGURE 10-c

Basically, the Status Index is a means of relating actual progress and cost to the project plan. An index of 1.0 is par, and an index above that indicates better than expected progress for the money spent. Anything below 1.0 indicates less than expected progress for the money spent.

C. EARNED VALUE

Another management system, or more accurately, a series of related optional graphic applications of the "value" concept, is known as earned value. Essentially, it is the PERT/Cost "Value of Work Performed" expressed as a percentage or index. This can be derived, purportedly, without all the computer inputs and gyrations commonly required in PERT/Cost.

Earned value holds that an estimated value ca be placed on all work to be performed and, once the work is accomplished, that same estimated value can be considered "earned." Figures 11 through 13 show some of the many applications--for this concept.

D. COST INFORMATION

General Electric Company has developed a Companion Cost Information System for application on some of its projects. The system is tied very closely to the traditional PERT Value of Work Performed, wherein the difference between the value of work performed to date and the actual cost is added to or subtracted from the total customer base line to arrive at a cost of completion; or, in the case of a trend, the percentage over/under to date is

FIGURE 11

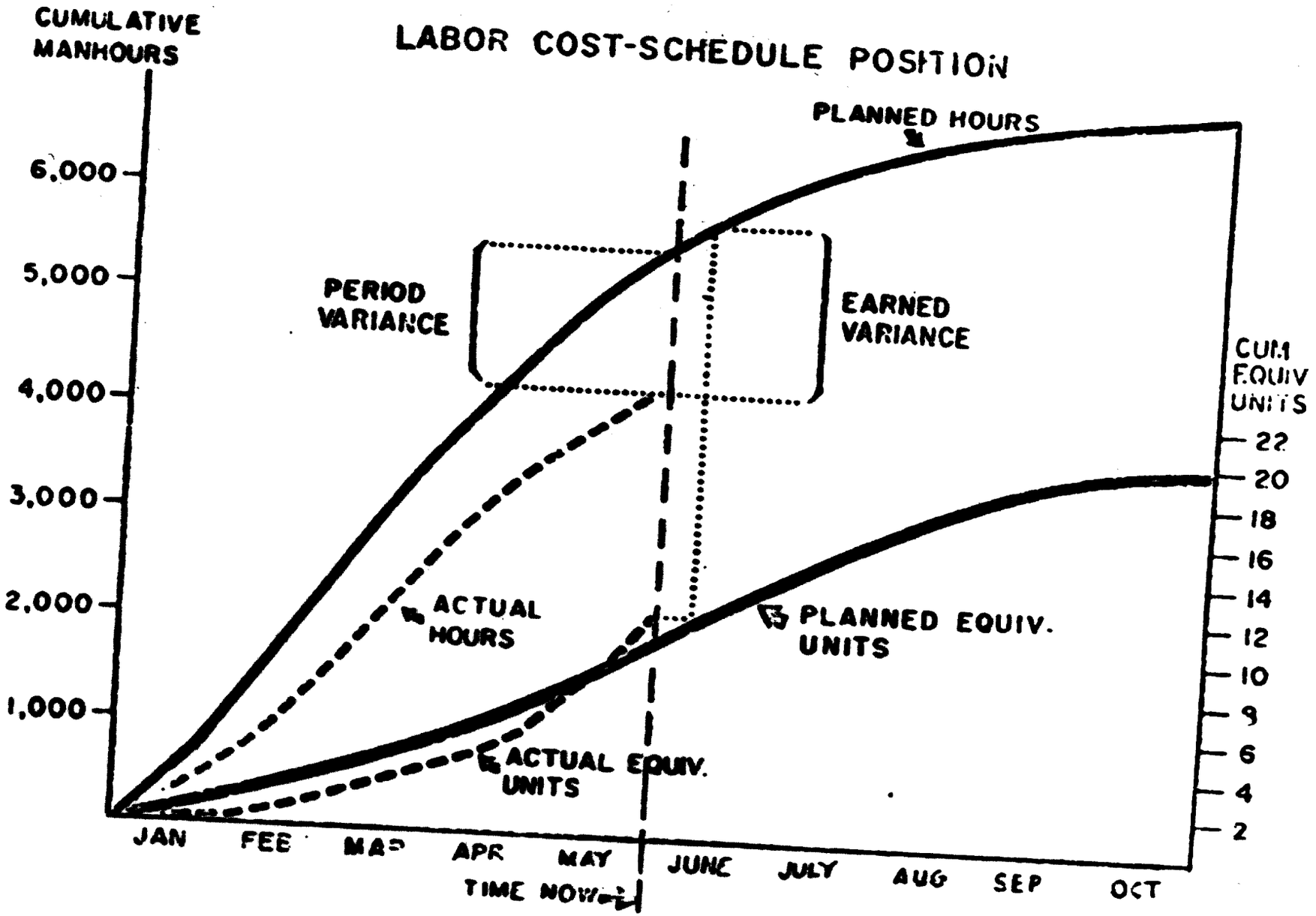

LABOR COST-SCHEDULE POSITION
CUMULATIVE MANHOURS
6,000
5,000
4,000
3,000
2,000
1,000
PLANNED HOURS
PERIOD VARIANCE
EARNED VARIANCE
ACTUAL HOURS
PLANNED EQUIV. UNITS
ACTUAL EQUIV. UNITS
CUM EQUIV UNITS
22
20
18
16
14
12
10
8
6
4
2
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEP
OCT
TIME NOW

FIGURE 12

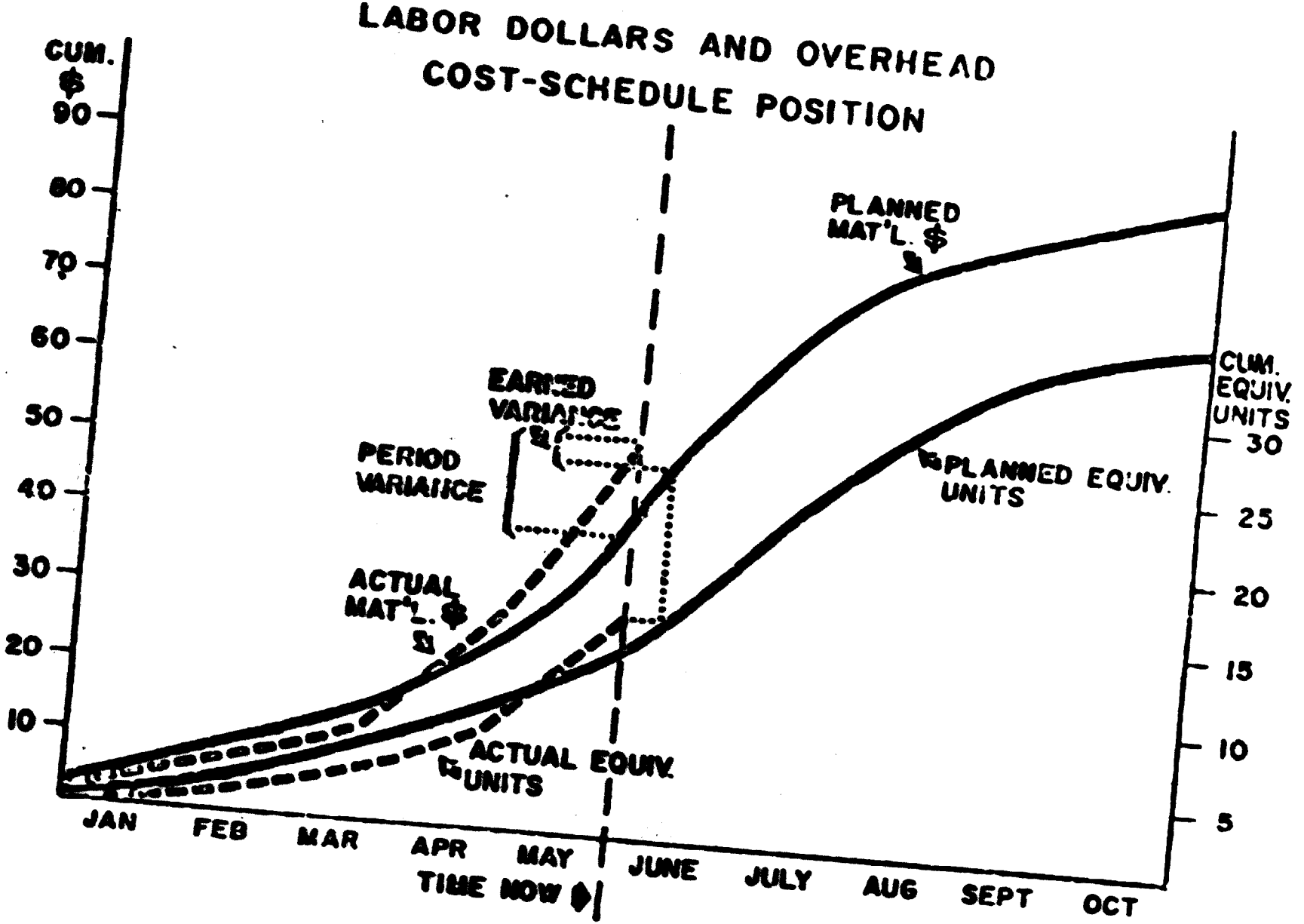
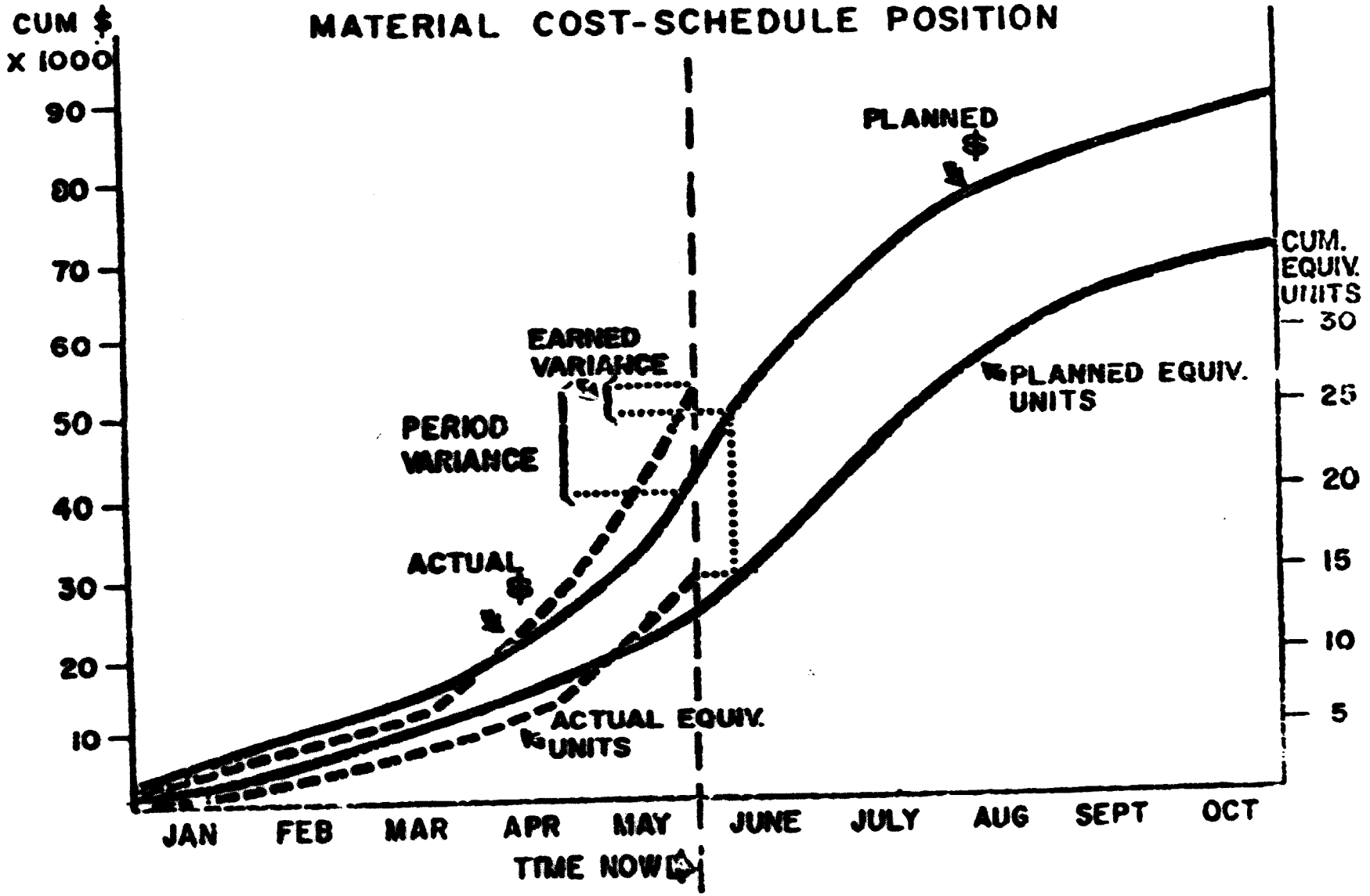

LABOR DOLLARS AND OVERHEAD
COST-SCHEDULE POSITION
CUM. $
90
80
70
60
50
40
30
20
10
PLANNED MAT'L. $
EARNED VARIANCE $
PERIOD VARIANCE
ACTUAL MAT'L. $
PLANNED EQUIV. UNITS
ACTUAL EQUIV. UNITS
CUM. EQUIV. UNITS
30
25
20
15
10
5
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
TIME NOW

FIGURE 13


MATERIAL COST-SCHEDULE POSITION
CUM $ X 1000
90
80
70
60
50
40
30
20
10
PLANNED $
EARNED VARIANCE
PERIOD VARIANCE
ACTUAL $
ACTUAL EQUIV. UNITS
PLANNED EQUIV. UNITS
CUM. EQUIV. UNITS
30
25
20
15
10
5
JAN
FEB
MAR
APR
MAY
JUNE
JULY
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SEPT
OCT
TIME NOW

extrapolated over the entire subtask, as shown in figure 14.

E. PLANNED OUTPUT

This system has been utilized by Collins Radio. Like the Status Index, it compares input (planned and incurred expenditures and commitments) with output (planned and actual performance indexes). Its expressed purpose is to establish visibility necessary to implement timely corrective actions.

Schedule performance is measured against a series of pre-selected milestones. These form the basis for the "planned output" curve.

The input curve is spread at the projected commitment rate, at both the project summary and task levels.

A target line represents total estimated cost, through general and administrative costs, but exclusive of fixed fee. This line is adjusted as a step function when and as purchase change orders are received.

Further applications of this system include:

(i) Forecast curves--New estimates of complete prior to formal contractual revision of a purchase order showing:

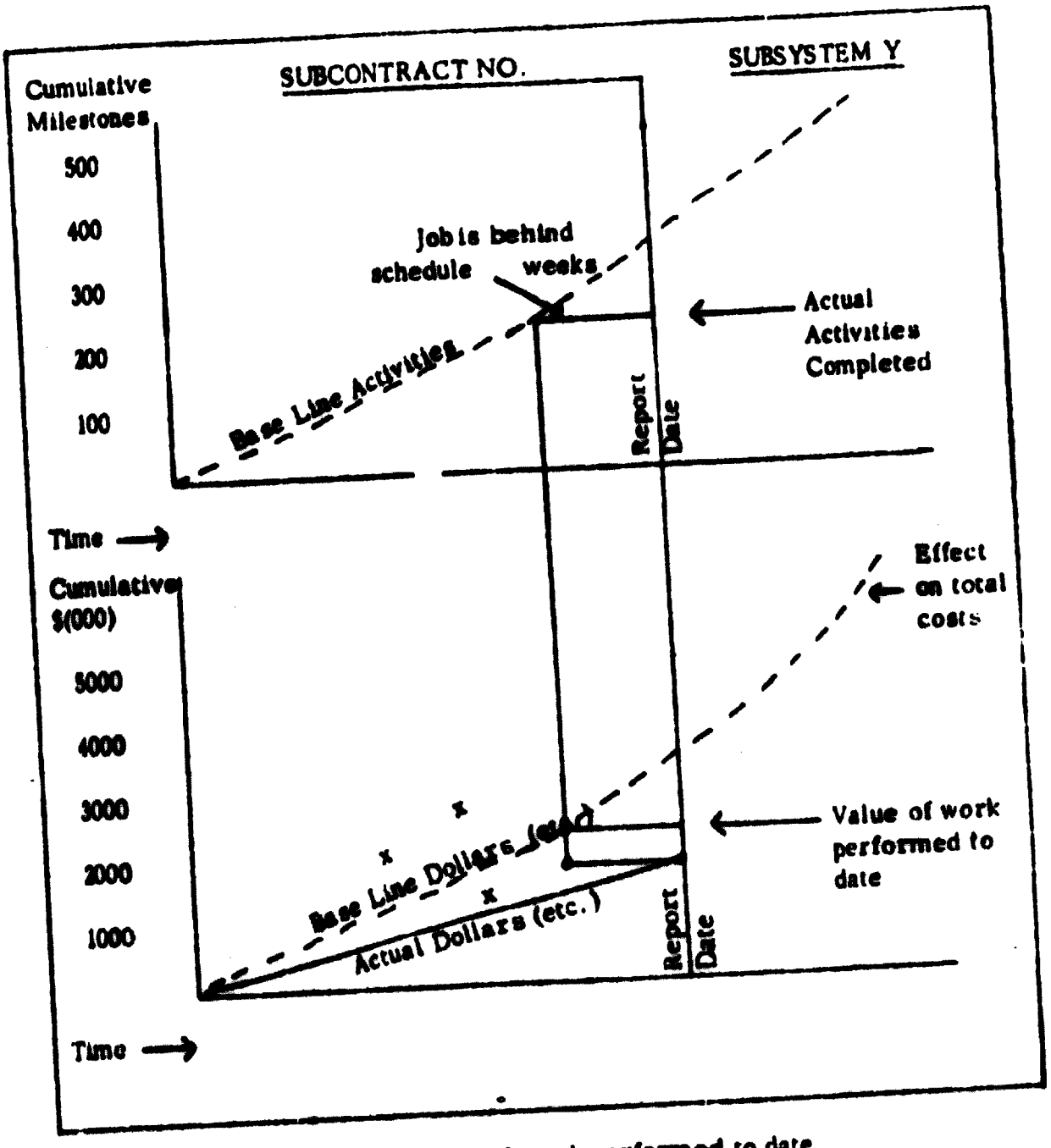
--Target cost in contract.

--Pending contractual costs to be negotiated.

--Planned variance (O/R or U/R).

(ii) Current status summary--shows total planned input and is updated monthly.

VALUE CALCULATION



x Prior month's estimates of value of work performed to date

FIGURE 14

(iii) Percentage of completion--represents and highlights planned versus actual output. It is derived by dividing cumulative attained output by total anticipated output.

(iv) Effectiveness factor.

$$\frac{\text{Planned Input x Actual Output}}{\text{Actual Input x Planned Output}} \times 100\% = \text{Factor}$$

F. LINE OF BALANCE

The line of balance technique is used to monitor production and proved demonstrably successful in breaking bottlenecks which restricted the flow of material. Studies and applications clearly demonstrated the utility of the technique as a controlling device in any operation involving the consideration and integration of a number of elements.

Example: The following description represents a hypothetical situation on production of an antiaircraft gun by X Company. To show the basic theory of graphic coordination, this is set forth in four separate phases, each illustrated by a chart.

1. Production Plan. Figure 15 presents a sample flow chart of the respective lead times for all homogeneous groupings of materials, components, and major assembly operations required to manufacture an antiaircraft gun by X Company. Each of the homogeneous groups is known as a "control point." These control points are numbered in sequence from left to right and top to bottom.

Beginning at the right with the acceptance of the gun, the lead times for these groupings are shown graphically against a time scale at the bottom of the chart. All time relationships are expressed as planned lead time prior to final acceptance of the gun, and machined parts made from these are required 2 1/2 months prior to the final acceptance. Remote control units are required 2 months prior to final acceptance. Final assembly starts 2 weeks previous to acceptance and is completed in one week, leaving one week for test and acceptance.

Management can include in this type of chart as much detailed information as is desired.

2. Cumulative Acceptance Versus Schedule. The next step is to prepare a line chart (see figure 16) showing on a time scale the cumulative production schedule. Cumulative gun acceptances are plotted against this schedule. This line chart shows there was a scheduled production, as of 1 March, of 15 guns. This has been exceeded by 8 guns, and thus the manufacturer has gained approximately a week's time in his scheduled production.

3. Determination of Balance. Before proceeding to figure 17, a basic premise must be noted. Throughout this technique all figures are expressed in terms of end-item sets. For example, if ten bearings of a specific type are required to produce one end item, 1,000 units represent 100 end-item sets of these bearings.

The third and final part of the graphic technique is a bar chart on the same vertical scale as is used for the cumulative schedule. This bar chart has provision for as many bars as there are control points in the flow chart below. These bars are keyed consecutively by number and color to the control points.

The first step in determining how the company stands with reference to its planned production schedule is to establish a "line of balance" (see figure 18). This line of balance shows the desired status for each of the control points as of the date of observation. For example, as figure 17 reveals, gun sets of forgings, castings, and extrusions (Control Point No. 1) are required 5 months ahead of final acceptance. Therefore, starting on the cumulative acceptances versus schedule chart at the point of observation, which is 1 March, we count to the right 5 months, or in other words, to the first of August. An imaginary line is drawn from this point vertically to the cumulative schedule; next, thi point of intersection is projected horizontally to Bar No. 1 on the bar chart. Thus, as of 1 March, 315 guns sets of forgings, castings, and extrusions should have been produced. Applying the same technique to raw materials (no.2) we find from the flow chart that they are required 3 1/2 months before acceptance of the gun. Therefore, we should have received by today sufficient raw material for the cumulative number of guns which are planned for acceptance by the middle of June. In the same manner this is projected across to Bar No. 2.

This is continued until we have achieved a somewhat irregular set of "stair steps" leading downward to the right across the face of the bar chart. This line is the line of balance for the various components under observation as of 1 March. This same technique also can be applied to ascertain what the line of balance should be as of 1 April, 1 May, and so forth. These lines are also shown on figure 17. Note that during the build-up period, the procurement function accelerates at a much greater rate than does final acceptance.

4. Status Versus Line of Balance. After the line of balance has been established, it follows logically that the actual status of each control point should be plotted. Figure 18 presents these data.

As mentioned above, all materials, components, and major assembly operations are grouped in homogeneous categories. Therefore, the procurement status of every individual part in the end item is not considered. Rather the height of the bar for each control point is determined by the cumulative receipts (less rejections) of the least available item within each homogeneous group as of the date of observation. This sumulative quantity is always expressed in cumulative end-item sets. The basis for this control by least available items is the fact that production of end items is conditioned by the least available part received. For example. no more complete guns can be built than recoil mechanisms received. Thus, by this method the coordinatin levels of management are given only the information on those

things which will limit production. This permits management to measure the deviations from plan and avoids unnecessary detail.

Analysis. In analyzing the situation in X Company, it is apparent that, although guns have been produced ahead of schedule, forgings, castings and extrusions have been produced in insufficient quantity to provide for scheduled production. It is evident that if this situation is not corrected, the scheduled production for July has been lost. Management, therefore, has four months in which to take corrective action such as bringing in extra capacity, operating additional shifts, or seeking outside assistance.

Raw materials and pruchased standard parts, Bar Nos. 2 and 3, respectively, show an excess of receipts in terms of lead-time requirements.

Bar No. 4, gun sets of hydraulic fittings, is behind schedule and badly out of balance.

Bar No. 5, machined parts, is also below the required balance figure. This is probably a result of the already observed insufficient production of forgings, castings, and extrusions from which they are made.

Outside purchased parts and minor assemblies, Bar No. 6, are 10 guns short of required balance and should receive attention.

Bar No. 7 shows that the recoil assembly is in balance.

Bar No. 8, representing government-furnished equipment (excluding remote control units), is in trouble. Some items of government-furnished equipment are being installed as fast as they are

received. This calls for a detailed study of the individual items to determine which of them constitutes the bottleneck and what is causing this short supply.

Bar No. 9, remote control units, and Bar No. 10, electrical system, are both in balance.

Bar No. 11, the automatic loader subcontracted to I Company, has not been received in accordance with the planned program. Steps should be taken to find out the difficulty of this company before the greater demands of scheduled build-up in production cause the situation to become an acute problem.

Bar No. 12, representing the sets of chassis subcontracted to Z Company, shows a very poor performance on the part of that company.

All other factors are in balance with the possible exception of the beginning of final assembly, which shows that although X Company is ahead of schedule on complete guns, it is failing to start gun units in final assembly on scheduled time. This will result in a failure to maintain its present rate of production.

To summarize the findings--although X Company has been exceeding its schedule to date, it is not going to be able to continue this status for long. Several indications are shown of failure to build up to schdedule monthly production within the desired time limits. Action should be taken to accelerate the procurement program.

FIGURE 15

GUN, ANTIAIRCRAFT, PRODUCTION AND MATERIAL STATUS

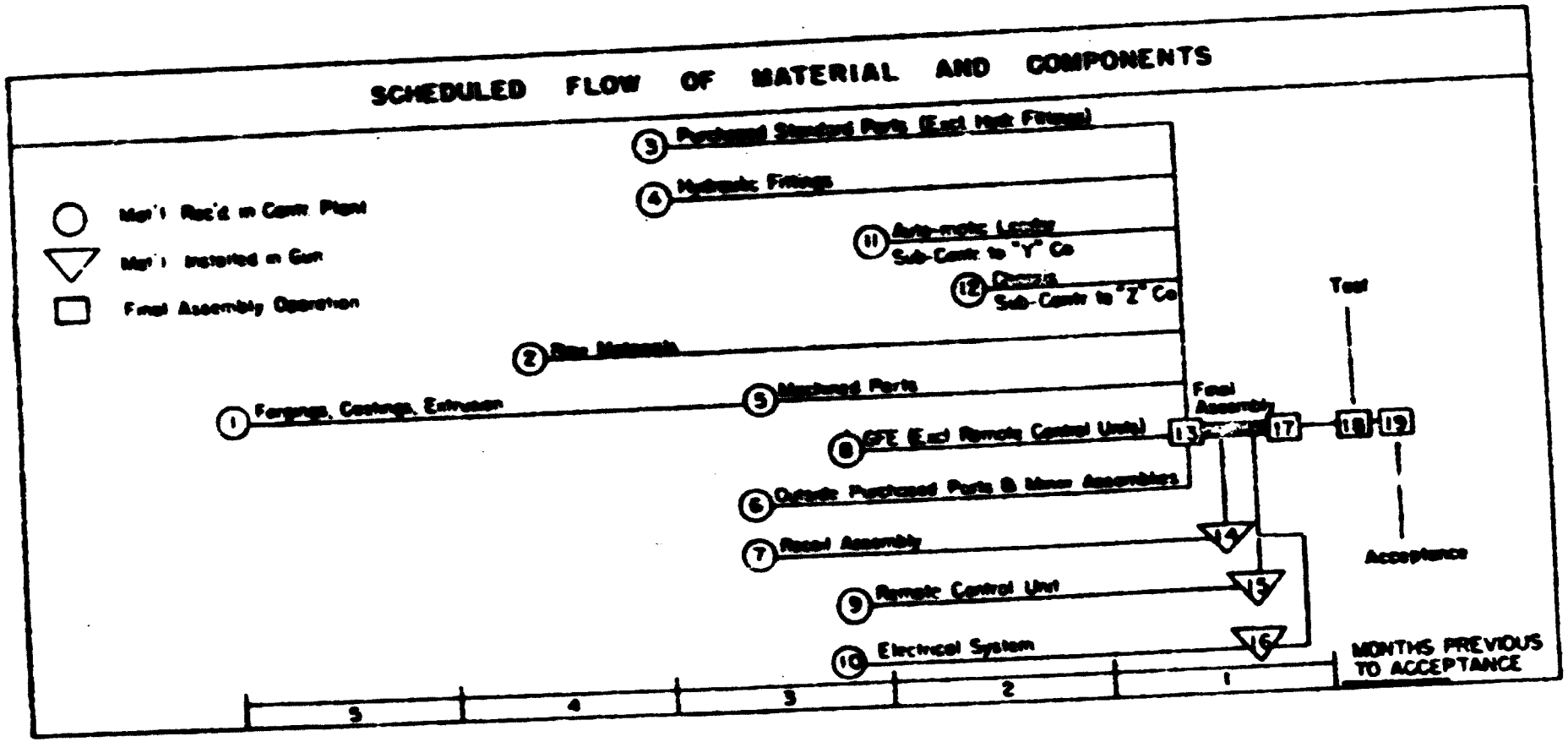
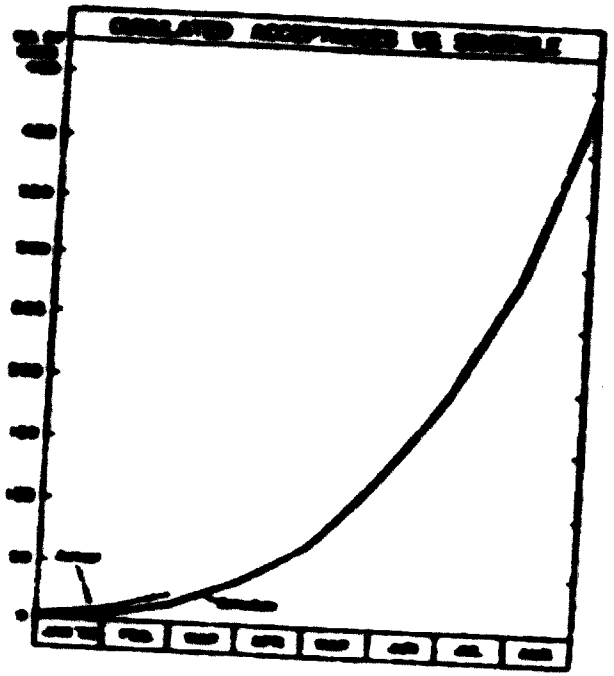


FIGURE 16

GUN, ANTIAIRCRAFT, PRODUCTION AND MATERIAL STATUS



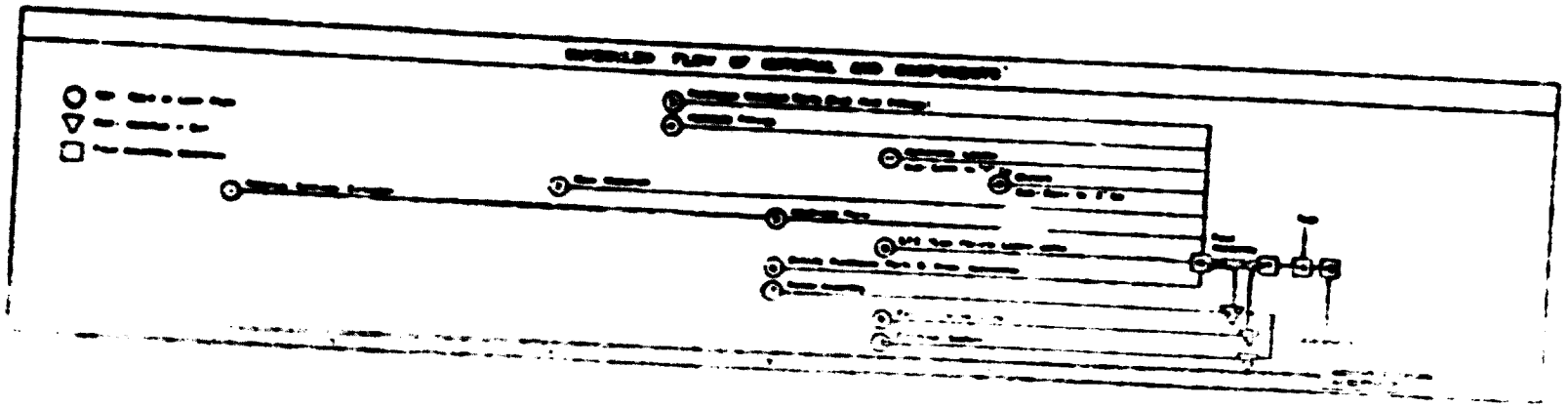
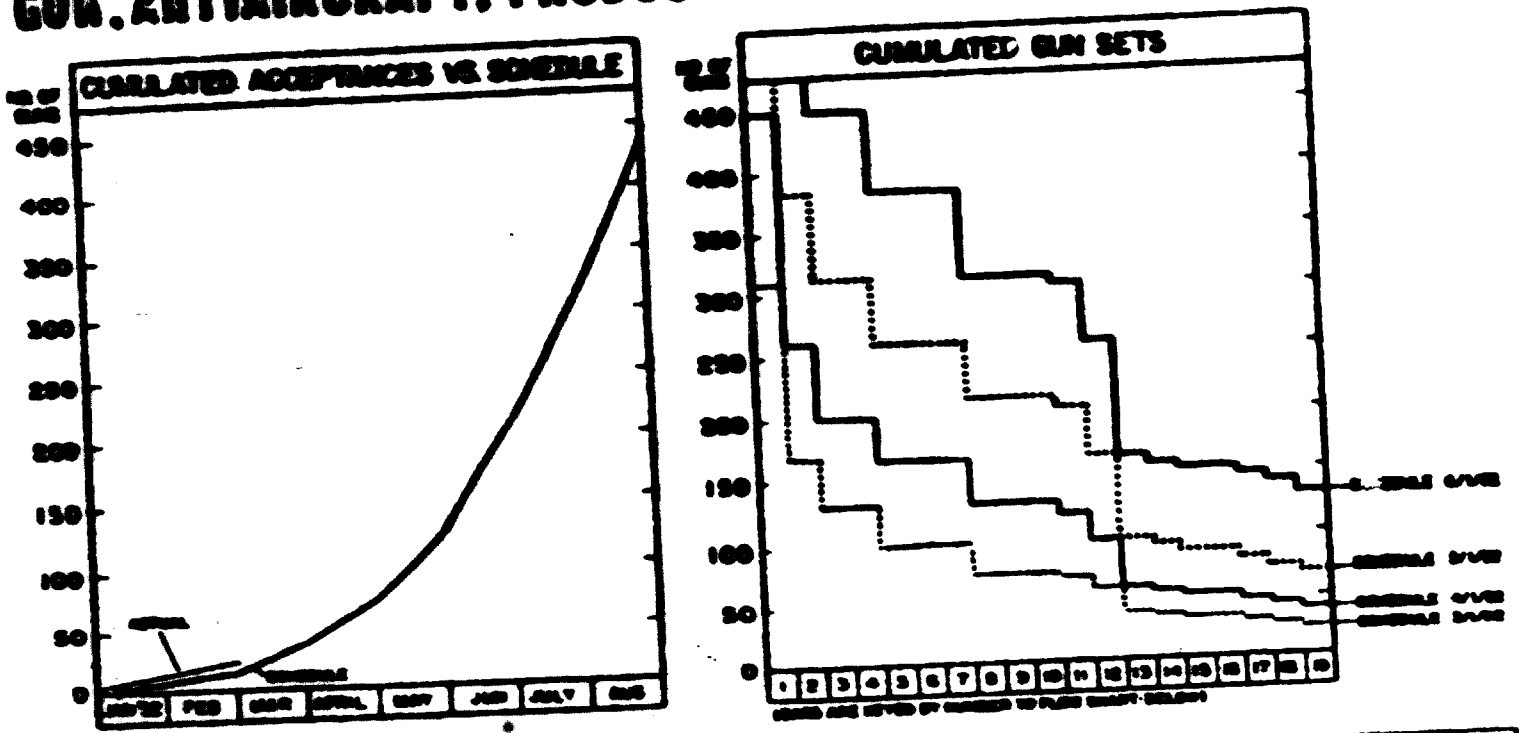


FIGURE 17

GUN, ANTIAIRCRAFT, PRODUCTION AND MATERIAL STATUS



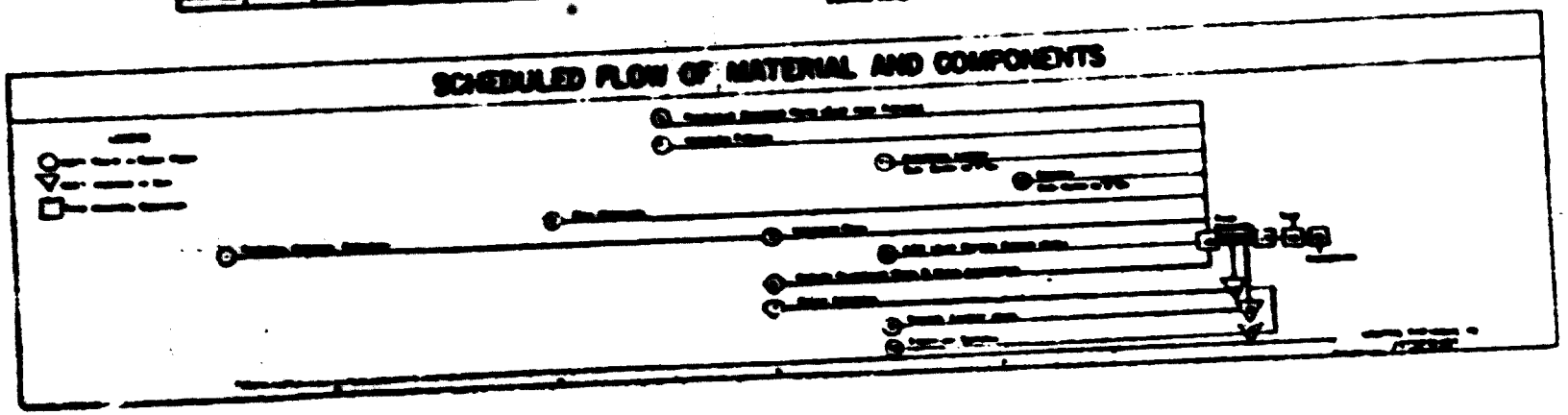
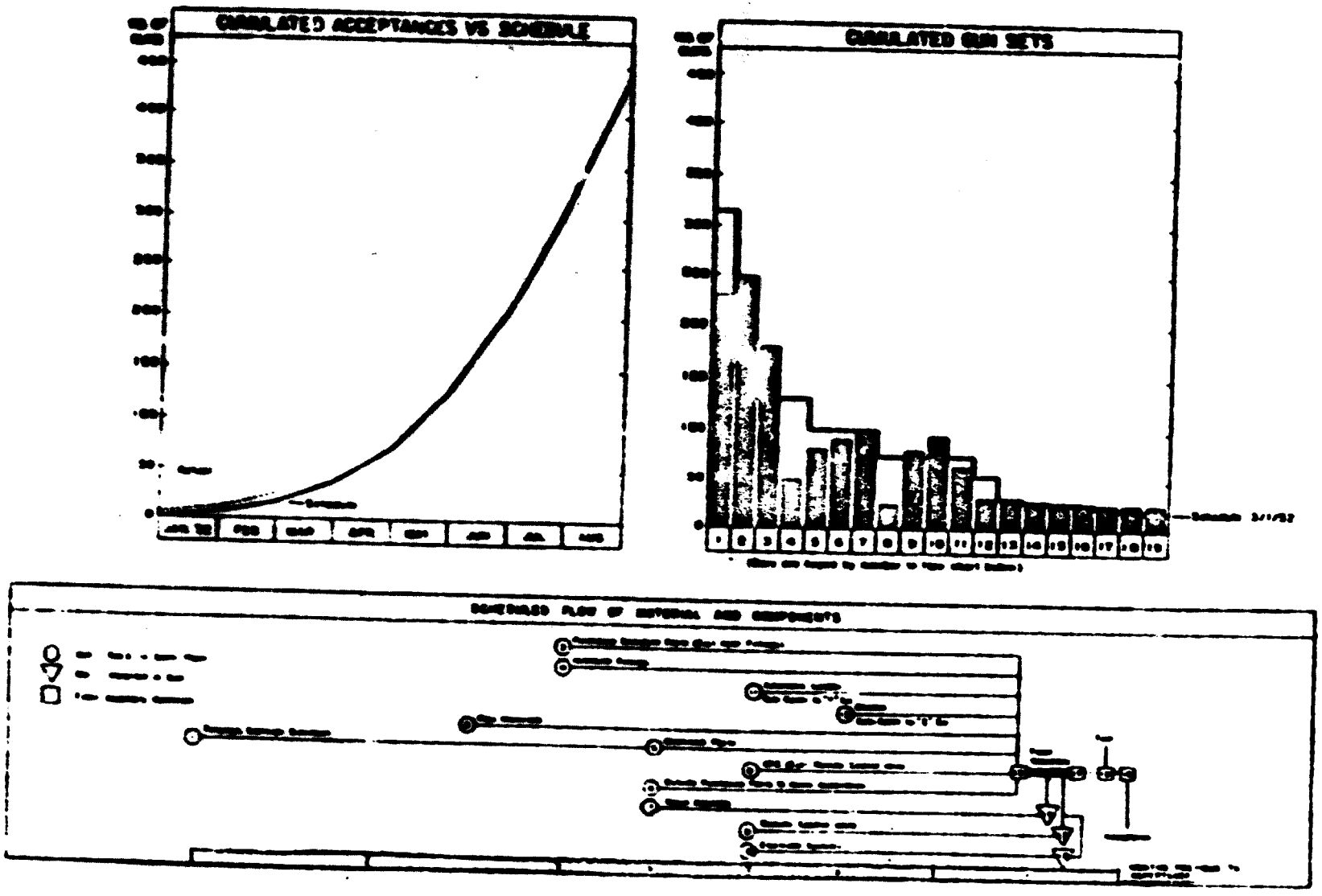


FIGURE 18

GUN, ANTIAIRCRAFT, PRODUCTION AND MATERIAL STATUS



Submission of Narrative Summary and Analysis. When data are submitted to keep a chart current, particularly to military echelons, a brief narrative summary and analysis should accompany the information. The purpose of this summmary is to:

--Identify the low item in a homogeneous group.

--State briefly what difficulty is being encountered on the low item.

--State what corrective action is being taken and when results may be forthcoming. If the problem is outside the control of the contractor, specifiy briefly what assistance is needed from higher echelons.

--Submit any other pertinent information or problems which the manufacturer or a military echelon desires to bring to the attention of the next level of management.

The analysis should not be restricted to problems shown on the charts. It should include anything that may have an adverse effect on end-item output. In addition, the latest production forecast for at least the succeeding two months should be submitted. Finally, the analysis should contain only information of value to the receiver. If no information in addition to the data is necessary, none should be submitted.

G. NASA PERT and COMPANION COST SYSTEM

The NASA PERT and Companion Cost System, first implemented in 1962, was designed as a total management system utilizing the existing NASA management and administrative tools and processes. It is a relatively straight-forward, disciplined Planning, control, and reporting instrument for the NASA project manager. Its basic

theme is that the total project management can be achieved only if the three interdependent variables--time, resources, and performance--are managed on a common framework which classifies all work elements of the project beginning from the top and breaking down to successive tiers representing systems, subsystems, and so forth, which make up the total project. This pyramidal management framework is the project work breakdown structure. The system requires the establishment of project master plans for resources and schedules directly related to the work breakdown structure.

The nature of most NASA projects is such that the total project effort is represented by a combination of the efforts is represented by a combination of the efforts of several major contractors, as well as a significant amount of NASA in-house effort. A primary responsibility of the NASA project manager is to integrate these efforts into a coordinated total project plan, monitor and guide the execution of this plan, and provide redirection as required. Consequently, the NASA PERT networking philosophy is that there will be "one overall network" which includes all efforts, in-house and contractor. In large projects, it becomes physically impractical to show the total NASA project on one piece of paper, and it is broken down into smaller portions called "fragnets" which are derived from the work breakdown structure. These fragnets are interconnected in such a way that data can be processed separately for each fragnet, for groups of fragnets representing a particular contractor's efforts, or as a total

project network. The structuring of the fragnets is accordance with the work breakdown structure will result in systems or end-item-oriented networks.

Cost and financial planning and reporting against "sub-divisions of work" and "elements of cost" for the total project effort include both contractors and NASA in-house work on the project. Both types of cost data are related to the common project work breakdown structure. It is noted that the companion cost system is not limited to use with PERT but can be used by itself or in conjunction with any other NASA time-oriented system, such as milestone reporting, line of balance, and so forth.

The minimum acceptable level of time/cost correlation for any project is to establish fragnets and subdivision of work cost accounts at the subsystem level (that is, structure subsystem, telemetry subsystem, and so forth). Using the work breakdwon structure, a separate frganet and a corresponding subdivision of work cost account is established for each subsystem. In this way, all the effort associated with a particular subsystem, as reflected by activities on the subsystem fragnet, is charged to its corresponding subdivision of work cost account. Interface activites between fragnets must be identified as being charged to one of the two corresponding subdivisions of work cost accounts.

Examples of the master schedule, master financial plan, and management summary reports of the NASA PERT and Companion Cost System are presented in figures 19, 20, and 21 respectivoly.

FIGURE 19
NASA PERT AND COMPANION COST SYSTEM

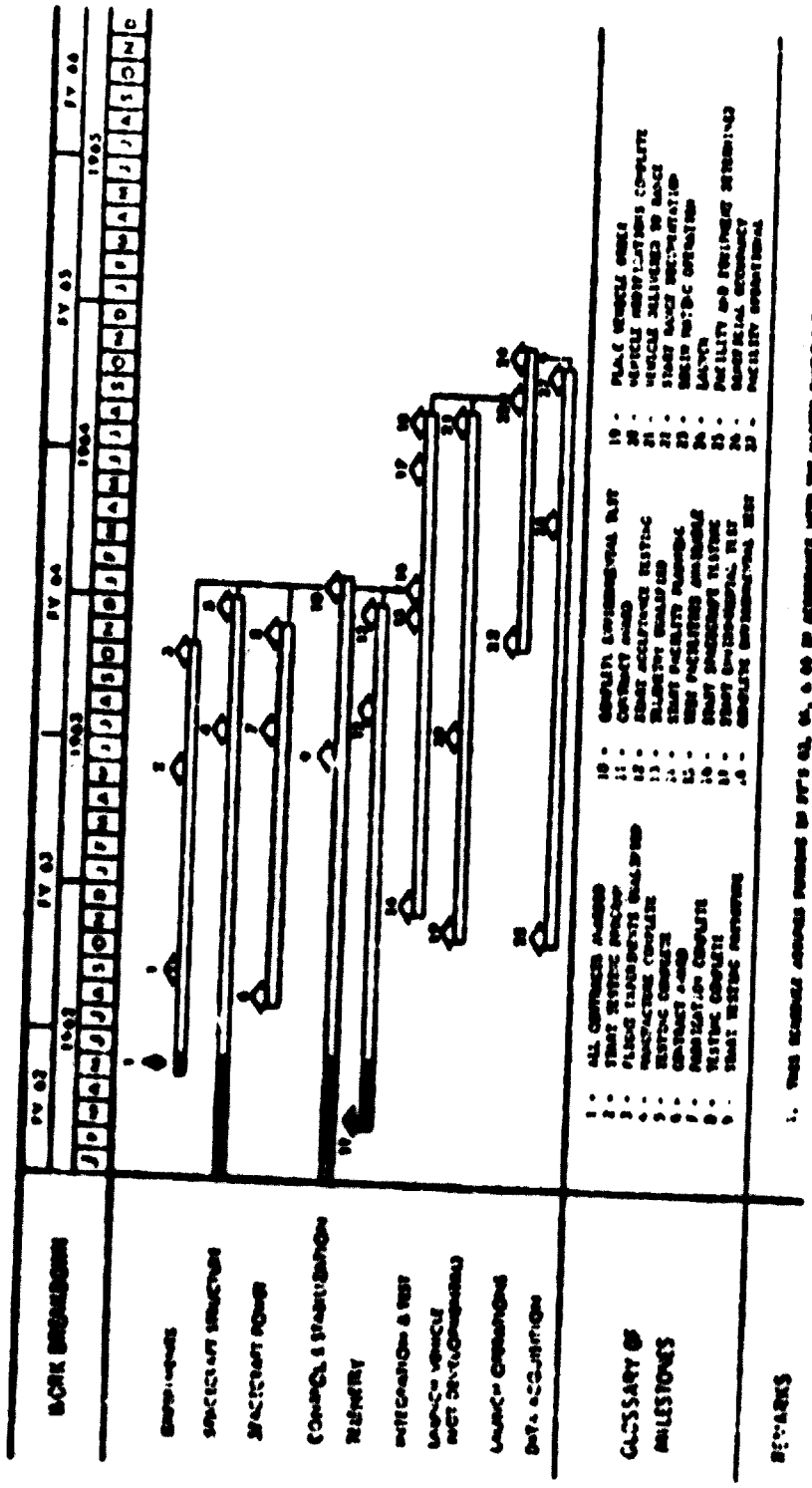


FIGURE 20
NASA PERT AND COMPANION COST SYSTEM

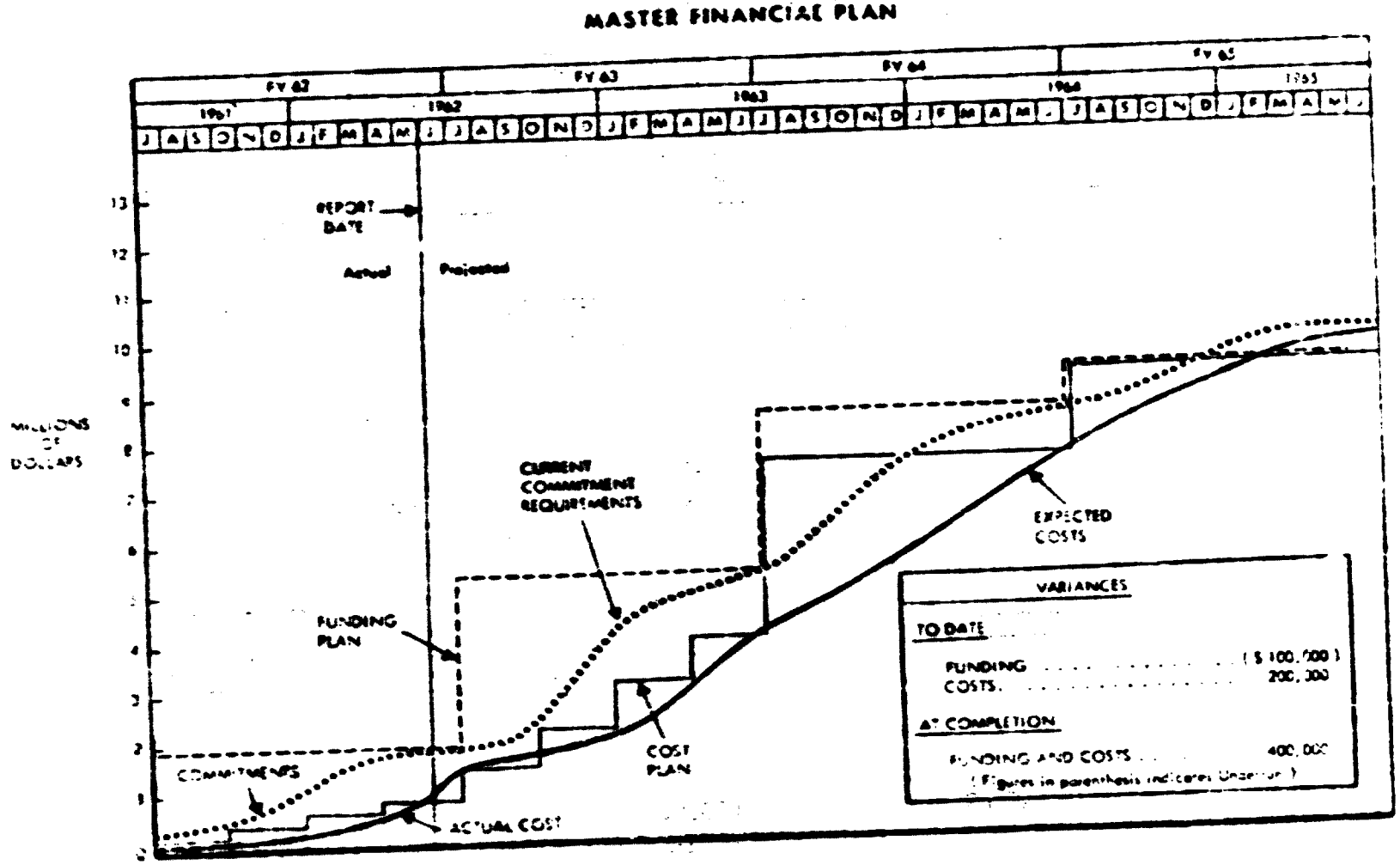


FIGURE 21
NASA PERT AND COMPANION COST SYSTEM
MANAGEMENT SUMMARY REPORT

NASA PERT & COMPANION COST MANAGEMENT SUMMARY REPORT

PROJECT: DAEDALUS

REPORT COVERS THE PERIOD: From JULY 1961 To MAY 1962

NAME AND ADDRESS OF CONTRACTOR/PERFORMING ORGANIZATION: VARIOUS

CONTRACT NUMBER/SYSTEM CODE: VARIOUS

SUMMARY LEVEL: TOTAL PROJECT

CURRENCY: THOUSANDS

WORK BREAKDOWN STRUCTURE	COSTS TO DATE: PLAN	COSTS TO DATE: ACTUAL	COSTS TO DATE: OVER (UNDER)	AT COMPLETION: PLAN	AT COMPLETION: LATEST REVISED ESTIMATE	AT COMPLETION: PROJECTED OVERRUN (UNDERRUN)	SLACK (DAYS)
Total Project	800	983	183	9240	9665	425	- 6.3
Experiments	30	38	(12)	700	700	---	+ 17.6
Spacecraft Structures	110	160	50	900	950	50	+ 8.6
Spacecraft Power	---	---	---	390	390	---	+ 19.4
Control & Stabilization	550	695	145	2000	2375	375	- 6.7
Telemetry	90	90	---	600	600	---	+ 4.7
Integration & Test	---	---	---	1500	1500	---	- 6.3
Launch Vehicle	---	---	---	2000	2000	---	+ 4.9
Launch Operations	---	---	---	390	390	---	- 6.3
Data Acquisition	---	---	---	760	760	---	+ 4.7

E = Contract completion date
L = Revised completion date
S = Latest completion date

1963 | 1964 | 1965

2. 9. 74

2 OF 2

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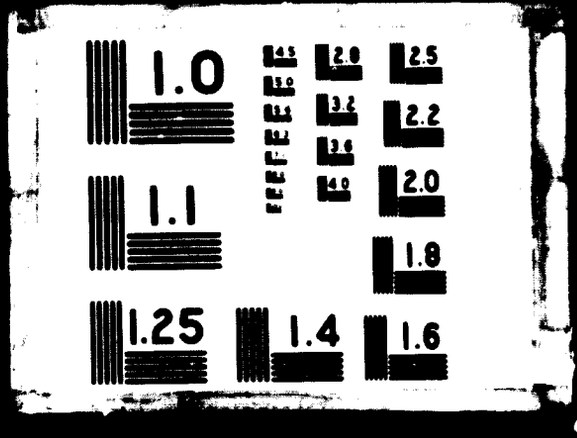

The NASA PERT and Companion Cost System does not attempt to unduly influence a contractor's internal management system. Rather, both NASA and the contractor use the bilarterally established work breakdown structure as the framework for structuring the PERT fragnets and corresponding cost reporting categories. The work breakdown structure level of indenture for reporting is established (for example, subsystem) and this becomes the interface level between NASA and the contractor for routine reporting and progress evaluation. However, the contractor's lower level time and cost details which he uses for his own management purpose must validate the information reported to NASA. On large programs in which the contractor has one or more major subcontractors, NASA often requires the contractor to exert his best efforts to ensure meaningful particpation of his subcontractors in the implementation and operation of the NASA PERT and Companion Cost System.

H. NASA PERT and COST CORRELATION TECHNIQUE (PACCT)

The MSFC PERT and Cost Correlation Technique (PACCT) is a system designed to assist project management in using existing time and cost information more effectively to evaluate contractor performance. The technique offers a systematic, practical method for correlating and analyzing the enormous amount of time and cost data that is presently available to the project manager. Correlation is attained at a high level where the data are available without requireing additional contractor reporting. Correlation at this

gross level, although broad in scope, allows the calculation of trends of contractor effectiveness in fulfilling the cost and schedule requirements of a contract. In addition, it provides the basis for predicting shifts in project funding requirements from the original plan; for funding for a set time interval, such as a fiscal year; and for predicting the total run-cost of the project according to the PERT expected date for project completion and the contractor performance to date.

The unique feature of PACCT is the computerized method used for assigning the planned cost of a project to the individual activities of the project summary PERT network. Once this initial assignment is made and each activity is costed, the PERT/time network is updated to reflect changes to the baseline plan. A new cost allocation and phasing is calculated for each update based on the network changes. Adjustments to the original planned costs are made according to two considerations: (i) for a given change in the elapsed time required for completing an activity, a proportional change is made in the dollars required for the activity; (ii) future cost projections based on the latest PERT plan are adjusted by an index of contractor performance to date.

IV. STRENGTHS AND LIMITATIONS OF CONTROL SYSTEMS

Manys strengths and limitations are associated with computerized management information systems and derivative systems--far too numerous to attempt to catalog here. Relevant experience, however, has been summarized recently by using, and this experience can be epitomized in a few brief comments on PERT/Cost. The following have

been cited specifically as significant advantages in the PERT discipline:

--It permits work breakdown structure.

--It permits effective integration of cost and time.

--It permits management by major significant exception rather than by exception only.

--It permits effective quantification of uncertainties.

--It is eminently visible.

--It lends itself to the management cycling process.

--The work breakdown structure is predicated upon true and discrete total management at each tier in the work breakdown structure. Each manager is accountable for cost, schedule, and performance.

Significant limitations have also been cited in the PERT discipline as it is known today. Some of the limitations cited are:

--PERT is diagnostic; it deals only with effects, not causes. therefore, it is not consistent with entrepreneurial objectives of buying cheap and selling dear.

--PERT is not consistent with entrepreneurial objectives of buying cheap and selling dear.

--PERT supports the fiction of resource flexibility.

--It segregates planning from scheduling; effective measurement against a plan postulates schedule-costing, not objective-costing. Scheduling is not a program management function; it is a general management function because although the project manager can plan his project through the elapsed-time phase, he does not own the resources he will need to complete the project successfully. He is dependent upon a pooled work unit.

--Project managers are frequently distracted by the slack-time fiction, so they are managing residual time, not the work.

--PERT never converted information to knowledge. Parenthetically, we might ask if it ever could be expected to do so.

--Critical path is a misnomer. It actually is the elapsed time-determinant path, and it is only critical if it turns out that way.

These, then are some of the strength and limitations of the PERT system, as seen through the eyes of those who have witnessed the evolution of the PERT discipline and the evolution of many more PERT extensions. It has been suggested in the past that one of the major limitations in project control is the failure to get enough information to the right people in time for them to take corrective action.

Operating reports should be developed according to areas of responsibility. The PERT/Cost output reports sare so structured, but satellite and derivative systems frequently lose the inherent organizational relationships that the PERT/Cost system utilizes. Reports on the operating performance of a particular manager should cover only those items for which he is responsible or should clearly distinguish between such items and thos beyond his control.

The level of responsibility to which the report is directed should dictate, to a considerable extent, the form and content of the report. To illustrate this idea, consider only the operating costs inherent in a single department during a month. The cost reports submitted to the department supervisor should detail the individual cost items, classified as controllable and noncontrollable.

These reports should indicate both actual and budgeted costs for the month, and possibly the year to date, and the resultant variances. If preferred, noncontrollable costs may be omitted from the report. The report submitted to the plant manager or the general manager will include cost data for all of the departments in his plant. These data may be summarized simply by broad functional classifications, such as materials, labor, and overhead, variability or fixedness with respect to volume, and controllability. The report submitted to the vice president, for example, may include summaries of cost data for several departments. The data for individual departments within a plant may not be identified separately at all at this lvel of responsibility. The vice president is not the one to take action to correct excessive material usage in a department--there is no point in cluttering his report with such detailed information.

Although reports of operations directed to lower levels of management should clearly distinguish between controllable and noncontrollable data, they need not omit the latter. As a matter of fact, inclusion of information that is beyond a manager's present scope of responsibility may expand his perspective of the firm's operations and, thus, help him prepare for broader managerial responsibility in the future. Also, reports to a manager with operating results of other divisions as well as his own may help to stimulate healthy competition among divisional managers. This may

be particularly beneficial in connection with sales divisions. Care must be exercised, however, to insure that such competition does not improve divisional performances at the expense of optimal company profit. This same rationale is applicable to program management within a single division. The program manager is responsible for planning his operation and planning the work load, but he does not own the resources he will need to successfully implement the program over its life cycle. This latter function belongs to general management.

Management by exception is an approach to management that focuses attention on situations and operations that deviate from plans or form normal conditions. It is predicated upon a belief that management's limited and costly time is best spent in matters requiring corrective action or other improvement, not in reviewing satisfactory performance. Regular reports of operations, therefore, should be so constructed as to draw management's attention to variances beyond the established range of tolerance, for these are the variances that call for managerial action. This may be accomplished by placing such variances in a special column in the report or by putting some identifying mark next to them. The importance of reporting exceptions does not mean that satisfactory results are unimportant. Management, naturally, wants to know the results of operations, whether good or bad, but the bad results should be clearly identified.

V. CONCLUSION

Because the U.S. Government has provided important leadership in the development and use of network-basic management systems, the report formats of the government system (Department of Defense and NASA) are used for illustrations in this paper.

Study of there reports will convey a good understanding of the government approach, but a potential user, specially in developing countries, will also need to study the problems of implementation and to tailor the system to suit his specific situation.

One particular technique; PERT/Cost is considered most complete and comprehensive management information system for project management.

Even though PERT/Cost is a highly complex management system, yet it summarizes information on a timely basis and presents it in a decision-making form. It allows for the analysis of information presented at the level of detail required and related specifically to the responsibility of the individual who will be using the information for decision-making purposes. Consequently PERT/Cost reports present information for top-level management, middle management, and first-line management.

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Technical Note: Defining the Work Breakdown Structure (740-text-165)

Technical Note: Organizing for Project Management (740-text-166)
Technical Note: Performance Measurement and Control Systems (740-text-172)
Technical Note: Project Control (740-text-171)

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IBM Project Management System for IBM System/360 (H20-0210), IBM Corp., 112 E. Post Poad, White Plains, NY.

IBM Network Processor System Manual (Y20-0083), IBM Corp., E. Post Road, White Plains, NY.

IBM Cost Processor System Manual (Y20-0084), IBM Corp., 112 E. Post road, White Plains, NY.

IBM Report Processor System Manual (Y20-0085), IBM Corp., 112 E. Post Road, White Plains, NY.

APPENDIX

PERT/COST

Technical Note: Organizing for Project Management (740-text-166)
Technical Note: Performance Measurement and Control Systems (740-text-172)
Technical Note: Project Control (740-text-171)

IBM Documentation

PERT - A Dynamic Project Planning and Control Method, (E20-8067-1), IBM Corp., 112 East Post Road, White Plains, NY.

IBM 7090 PERT COST II Reference Manual (B20-6701), IBM Corp., 112 E. Post Road, White Plains, NY.

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IBM Project Management System/360 Version 3 Application Description Manual, (H20-0690-0), IBM Corp., 112 E. Post Road, White Plains, NY.

IBM Project Management System/360 Version 2 Program Description and Operations Manual (H20-0344-2), IBM Corp., 112 E. Post Road, White Plains, NY.

IBM Project Management System for IBM System/360 (H20-0210), IBM Corp., 112 E. Post Road, White Plains, NY.

IBM Network Processor System Manual (Y20-0083), IBM Corp., E. Post Road, White Plains, NY.

IBM Cost Processor System Manual (Y20-0084), IBM Corp., 112 E. Post road, White Plains, NY.

IBM Report Processor System Manual (Y20-0085), IBM Corp., 112 E. Post Road, White Plains, NY.

APPENDIX

PERT/COST

U.S. Government PERT/COST report formats and explanations

Because the U.S. Government has provided important leadership in the development and use of network-based management systems, the report formats of the government system are presented in this appendix, with the official definitions and explanations. Study of these reports will convey a good understanding of the government approach, but a potential user will also need to study the detailed implementing procedures provided by the various branches of the government in order to be able to comply fully with specific contractual requirements.

This Appendix is a condensation of *Supplement No. 1 to DOD and NASA Guide, PERT/COST Output Reports*, Pert Coordinating Group, Washington, D. C., March, 1963.

FOREWORD

These uniform PERT Cost Output Reports have been developed by the Technical Subcommittee of the Inter-Agency PERT Coordinating Group and are based on those contained in the DOD and NASA Guide, PERT Cost Systems Design, June 1962. The document represents experience from the Mauler, TFX, and Navy Implementation Teams as well as the Air Force Systems Command, Army Management Engineering Training Agency, Bureau of Ships, National Aeronautics and Space Administration, Atomic Energy Commission, Federal Aviation Agency, and similar organizations and agencies.

The forms have been approved by the PERT Coordinating Group and have been authorized for use on current contracts of the Department of Defense including:

TFX, Mauler, Subroc, Titan III, MMRBM, Lance, Polaris, certain contracts of the Bureau of Ships covered by a military specification and previously authorized by the PERT Coordinating Group.

Bureau of the Budget Number 22R 226 is authorized for this purpose.

It is the intent of the PERT Coordinating Group that this document can serve for all agency members as an exhibit in a contract, a reference or the basis of a specification. The Navy Specification No. Mil P-23189A(Navy) 25 Oct 62 is being revised to incorporate these forms. . . .

PERT COST MANAGEMENT SUMMARY REPORT

The PERT COST Management Summary Report shows current and projected schedule and cost status of the total program and of each of the major component items or elements within the program. The report is prepared at several levels of the work breakdown structure and for all contracts or a specified combination of contracts, depending upon the needs of management. The report may be machine produced, but when it is manually prepared, the necessary information is derived from the Program/Project Status Report.

The first line of each report shows total costs and significant schedule information for the summary item shown in title block ②. Subsequent lines show each subdivision of that summary item at the next lower level of the work breakdown structure; thus, each page of the report shows the time and cost status and all the next level backup information for a single summary item. Since each page of the report is a concise summary of one element of the program or project, the report is usually divided for distribution to appropriate government and contractor managers.

DEFINITIONS PERT COST MANAGEMENT SUMMARY REPORT

① The designation of the total (or a part of the total) system program or project that is identified with the reporting organization. For example, if reporting organization XYZ has the Missile and GHE part of weapon system ABC, the program or project definition would read:

ABC—Missile and GHE

② *LEVEL/SUMMARY ITEM:* The level number, noun description, and summary number of the summary item for which the report is being prepared.

③ *REPORTING ORGANIZATION:* The name or identification of the organization responsible for the work identified in the Contract Number ④ and Program/Project ① blocks.

④ *CONTRACT NUMBER:* The numeric designation of the contract(s) or agreement(s) included in each report (e.g., 33(000)28369A). When a report is prepared for a large program or project, several contracts may be included. Therefore, each contract number (or its representative code) would be indicated in this space. It may be noted that by sorting on contract number, a report can be prepared for each individual contract.

⑤ *REPORT DATES:*

Term (span): The beginning and ending date for the total increment being covered in the report. For example:

1 Jan 62 to 31 Dec 62
Total Program (Project)
Contract

Cut off date: The accounting cut off date for the period of actual costs being reported.

Release date: The date that the report is to be released to management. In the event of subsequent rerun and redistribution of reports, it is permissible to suffix the report release date with a revision number.

⑥ *ITEM:* The level number, noun description, and summary number of each summary item on the work breakdown structure for which time information and cost information are presented in the report. The first item shown is the highest item for which the particular report is prepared and should be identical with the item named in the Level/Summary Item block ②. Three lines are available for each item description, and, if necessary, the top line may be extended into the Cost of Work columns.

⑦ *VALUE* (Work Performed to D...): The total planned cost for work completed within the summary item. The value is determined by summing the Planned Cost ⑩ for each completed work package. If a work package is in process, the part of its total planned cost which applies to work completed is approximated by applying the ratio of Actual Cost ⑤ to Latest Revised Estimate ⑪ for that work package.

⑧ *ACTUAL COST* (Work Performed to Date). The actual expenditures incurred plus any prespecified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned to the work packages within the summary item.

⑨ *(OVERRUN) UNDERRUN* (Work Performed to Date). The Value ⑦ for the work performed to date minus the Actual Cost ⑤ for that same work. When value exceeds actual cost, an underrun condition exists. When actual cost exceeds value, an overrun condition exists. The (overrun) underrun is also expressed as a percentage of the value of work performed to date immediately above the dollar amount. Parentheses are used as a notational device to indicate overruns. (Over)underruns in excess of one billion dollars print as 999,999.

⑩ *PLANNED COST* (Totals at Completion): The approved planned cost for the total summary item. This is the total of the planned costs for all work packages within the summary item.

⑪ *LATEST REVISED ESTIMATE* (Totals at Completion): The latest estimate of cost for the total summary item. This estimate is the sum of the actual costs plus estimates-to-complete for all the work packages in the summary item. This estimate is also known as anticipated final cost. For a completed item, the latest revised estimate equals the Actual Cost ⑧.

⑫ *PROJECTED (OVERRUN) UNDERRUN* (Totals at Completion): The Planned Cost ⑩ minus the Latest Revised Estimate ⑪ for the total summary item. When planned cost exceeds latest revised estimate, a projected underrun condition exists. When latest revised estimate exceeds planned cost, a projected overrun condition exists. The projected (overrun) underrun is also expressed as a percentage of the planned cost immediately above the dollar amount. Parentheses are used as a notational device to indicate (over)underruns. (Over)underruns in excess of one billion dollars print as 999,999.

⑬ *MOST CRITICAL SLACK (WEEKS)*: The slack, in weeks, associated with the "*E*" and "*L*" notations shown in the Schedule Completions section ⑯. This represents the worst slack (least algebraic) with respect to designated program or project end points for any of the activities within the summary item.

⑭ *COMPLETION DATE*: The day, month, and year of the "S," "A," "*E*," and "*L*" positions shown in the Schedule Completions section ⑯.

⑮ *SCHEDULE CALENDAR*: A calendar time reference for display of schedule completions. The calendar contains one division for all prior years, two years divided by months, four years by years, and one division for all later years. When the calendar is printed by a computer, one space is left between the months before and after the Cut Off Date ⑤. A "Time Now" line is printed in this space. If the cut off date falls between the 10th and the 30th of a month, that month is considered to be the "past month" and it appears to the left of the Time Now line. If the cut off date falls between the 1st and 10th of a month, that month is considered to be the "next future month" and it appears to the right of the Time Now line. Each year the calendar is adjusted so that two years, by months, appear ahead of the Time Now line.

⑯ *SCHEDULE COMPLETIONS*: Two types of schedule completions are displayed in this section:

a. The scheduled (S) or actual (A) completion of all work contained within the summary item shown in the item column.

b. The earliest (*E*) and latest (*L*) completion for the most critical schedule element or effort with respect to designated program or project end points within that summary item.

The symbol "S" is used to show the scheduled completion date of all work within the item. The "S" is located under the calendar position of the directed date (T_D) or the scheduled completion date (T_S) if no T_D is established for the last activity within the summary item. If T_S has not been established for the end of the total item, "S" is placed at the calendar position which represents the earliest completion date (S_E) for the last activity in the item. When the total item has been completed, the symbol "A" is placed under the calendar position of the actual completion date for the item.

The "*E*" and "*L*" symbols represent the earliest completion date (S_E) and latest completion date (S_L) for the most critical schedule element or effort within the item with respect to designated program or project end points. The most critical element within an item may or may not be the same as the last scheduled item. This will depend on whether there are critical interfaces within the item which pose more serious constraints from a program or project point of view than the completion of a total item itself. The most critical element is the one with the worst slack (least algebraic) within the item. The "*E*" and "*L*" positions, therefore, portray the earliest completion date and the latest completion date for that activity within the summary item with the worst slack status. When several activities have the same worst slack condition (for instance, when they are all on the same path), the "*E*" and "*L*" positions reflect the last activity on that path.

⑰ *REMARKS:* Notations made by an analyst to indicate critical cost and schedule conditions within summary items. Reference may be made, by paragraph number, to the Problem Analysis Report for a detailed analysis of the critical conditions. The heading for this area of the report is not computer printed.

PERT COST PROBLEM ANALYSIS REPORT

The Problem Analysis Report is a narrative report prepared to supplement the Management Summary Report as well as other reports which identify significant problems.

The report contains three basic sections:

a summary analysis of the total contractor's portion of the program covered by the Management Summary Report;

an analysis of tasks where current or potential problems exist. Problems may be schedules, costs, technical performance, or combinations of these;

a narrative description of:

- the nature of the problem;
- the reasons for cost and/or schedule variance;
- the impact on the immediate task,
- the impact on the total program; and
- the corrective action: what action, by whom, when, and expected effect.

Additional instructions for preparation of this report will be established by the Government and the contractors for each program or project.

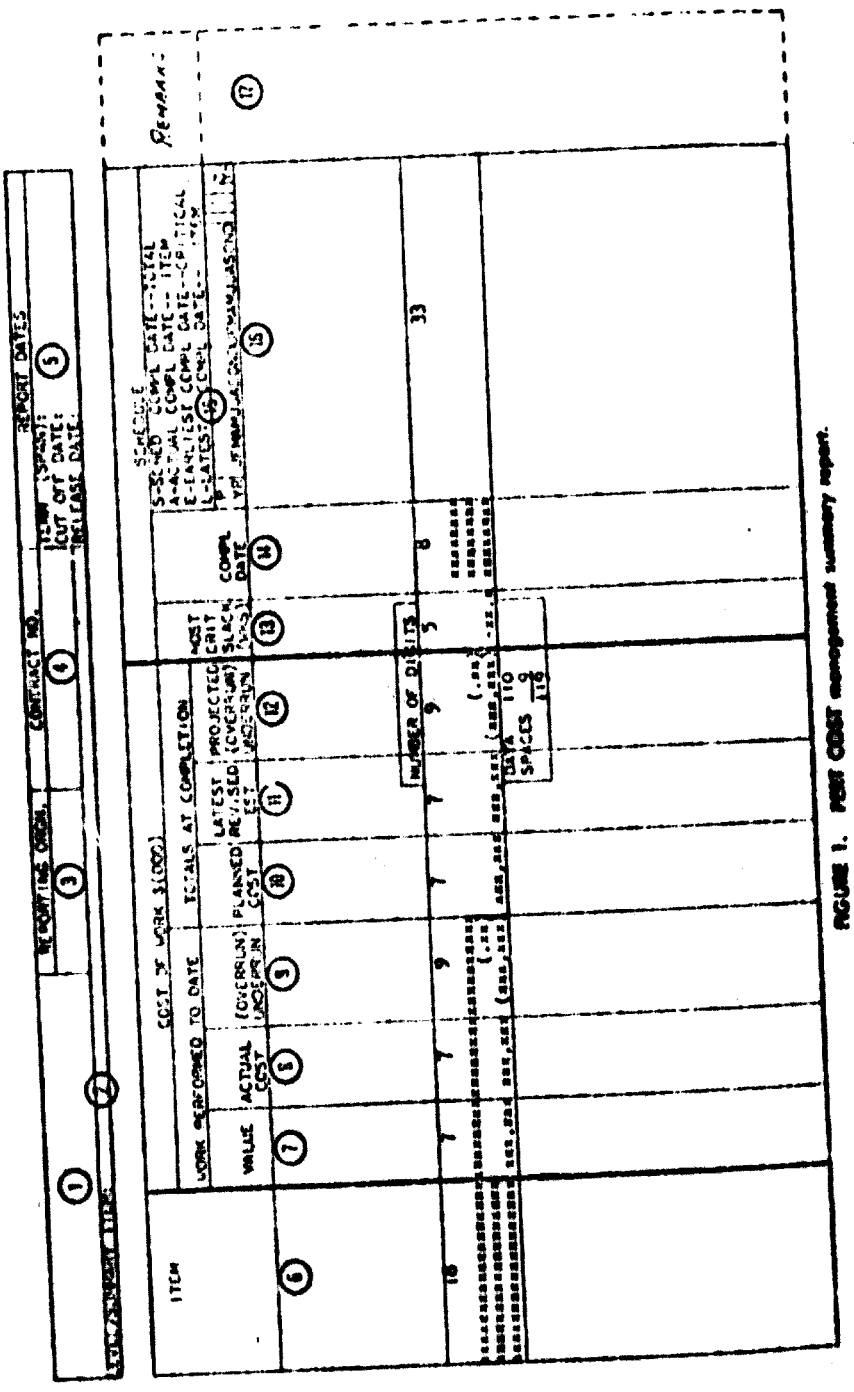


FIGURE 1. PERT COST management summary report.

ABC - MISSILE AND GSE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
LEVEL/SUMMARY ITEM: 3/BALLISTIC SHELL 22300	XYZ - A&S DIVN	33(600)28756a	PERT (SPAN): TOTAL PROGRAM CUT OFF DATE: 3CMAR63 RELEASE DATE: 10APR63

ITEM	COST OF WORK $(000): WORK PERFORMED TO DATE: VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	TOTALS AT COMPLETION: PLANNED COST	LATEST REVISED EST	PROJECTED (OVERRUN) UNDERRUN	SCHEDULE: MOST CRIT SLACK (WKS)	COMPL DATE	S-SCHED COMPL DATE--TOTAL; A-ACTUAL COMPL DATE--ITEM; E-EARLIEST COMPL DATE--CRITICAL; L-LATEST COMPL DATE--ITEM (1963 : 1964)	Remarks
BALLISTIC SHELL LEV 3 22300	19,600	20,500	(.05) (900)	35,200	39,650	(.13) (4,450)	0.0	10DEC64 31DEC63 31DEC63	S E L	See Program Summary Rpt. Items 1-3
NOSE FAIRING LEV 4 22310	27	25	.07 2	175	175		8.6	10DEC64 10JUN63 10AUG63	S E L	Item 6
FIRST STAGE LEV 4 22320	6,700	6,400	.04 300	9,200	9,700	(.05) (500)	0.0	30APR64 31DEC63 31DEC63	S E L	Items 9-12
SECOND STAGE LEV 4 22330	1,645	1,650	(5)	3,500	3,570	(.02) (70)	0.0	15JUN64 31DEC63 31DEC63	S E L	Item 15

TIME NOW

FIGURE 2. PERT COST management summary report.

PERT COST PROGRAM/PROJECT STATUS REPORT

The Program/Project Status Report is a comprehensive computer produced output report. It is organized to reflect the end item work breakdown structure and provides time and cost information from the work package level up to the top of the program or project.

For each work package and summary item shown on the report there is a line of item description followed by a line of significant time and cost information. The first line presents data for the summary item shown in the title block ②. Subsequent lines show all subdivisions of that item down to the work package levels. (Work packages may appear at different levels of the work breakdown structure.)

The primary purpose of the Program/Project Status Report is to back up the Management Summary Report. The two reports contain similar information, but whereas the Management Summary Report highlights information for a manager, this report retains detail for an analyst. The Management Summary Report is divided for distribution and the Program/Project Status Report remains intact as reference material for the entire portion of the program or project for which reports are prepared.

The standard sorting procedure for this report arranges summary items and work packages in the order determined by the work breakdown structure. However, other sorting sequences may be used; e.g., a sequential listing of work packages by charge number; a listing of only completed work, in-process work, or future work, etc.

DEFINITIONS PERT COST PROGRAM/PROJECT STATUS REPORT

[① through ⑤ previously defined.—Authors.] . . .

⑥ *CHARGE OR SUMMARY NUMBER:* The noun description and charge or summary number of each work package or summary item for which time information and cost information are presented in the report. For a work package, the charge number is the contractor or government charge number (shop order number, work order number) used to identify the work package for purposes of estimating and accumulating costs. The title or short description of the charge number is printed immediately above the number itself. For the summary item, the summary number is the identification of an end item on the work breakdown structure above the work package level. The title or description of the summary item is also printed directly above the summary number.

⑦ *LEVEL:* The number of the level on the work breakdown structure at which the charge or summary number appears.

⑧ *FIRST EVENT NUMBER:* The number of the first event in time (based on S_E) for the work package or summary item. This event number defines the beginning of the work package or summary item in relation to the network.

⑨ *LAST EVENT NUMBER:* The number of the last event in time (based on S_E) for the work package or summary item. This event number defines the end of the work package or summary item in relation to the network.

⑩ *SCHEDULED OR ACTUAL COMPLETION DATE:* The calendar date on which all the work contained in the work package or summary item is scheduled for completion or was actually completed. The scheduled completion date (T_S) is established by management as an internal control on the completion of the work. If no scheduled completion date has been established for the work package or summary item, the column is blank. The actual completion date (T_A) is the date on which all work in the work package or summary item has been completed. When the date in this column is an actual completion date, an "A" is printed in front of the date.

⑪ *EARLIEST COMPLETION DATE (S_E) AND LATEST COMPLETION DATE (S_L)*: The earliest calendar date on which the work package or summary item can be completed and the latest completion date on which the work package or summary item can be scheduled for completion without delaying the completion of the program or project. When the work package or summary item has been completed, this column is blank.

The earliest completion date (S_E), printed on the upper line, is calculated by:

summing the scheduled elapsed time (t_s) values for activities on the longest path from the beginning of the program or project to the end of the work effort; and then adding this sum to the calendar start date of the program or project.

The latest completion date (S_L), printed on the lower line, is calculated by:

summing the scheduled elapsed time (t_s) values for activities on the longest path from the end of the work effort to the end of the program or project; and then subtracting this sum from the calendar end date of the program or project.

If the longest path contains activities which are not scheduled, expected elapsed time (t_e) values for the unscheduled activities will be processed as scheduled elapsed time (t_s) values in the calculation of S_E and S_L.

⑫ *MOST CRITICAL SLACK (WEEKS)*: The worst (least algebraic) slack with respect to the designated program or project end points, in weeks, for any of the activities within the work package or summary item. This slack is based on a comparison of S_L minus S_E for each activity. The slack indicated will not necessarily be the difference between the S_L and S_E for the *end* of a work package or summary item since the worst slack situation may be associated with an activity *within* the work package or summary item. The number of the network event at the end of the worst slack path within the work package is printed below the slack value. If the work package or summary item has been completed, this column is blank. . . .

⑭ *ACTUAL COST* (Work Performed to Date): The actual expenditures incurred plus any prespecified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned to a work package. For summary items, the appropriate work package data is summed. [⑬ and ⑮ through ⑱ previously defined.—Authors.] . . .

(1)	REPORTING ORGN. (3)	CONTRACT NO. (4)	REPORT DATES (5)
LEVEL NUMBER BY TYPE (2)			TERM (SPAN): CUT OFF DATE: RELEASE DATE:

IDENTIFICATION				TIME STATUS			COST OF WORK $(000)					
							WORK PERFORMED TO DATE			TOTALS AT COMPLETION		
CHARGE OR SUMMARY NUMBER	LEVEL	FIRST EVENT NO.	LAST EVENT NO.	SCHED OR ACT (A) COMPL DATE	EARLIEST & LATEST COMPL DATE	MOST CRIT SLACK (WKS)	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
					NUMBER OF DIGITS							
18	2	9	9	8	8	9	7	7	7	7	7	9
xxxxxxxxxxxxxxxxxx	xx	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx	-xx.x	xxx,xxx	xxx,xxx	(.xx xxx,xxx)	xxx,xxx	xxx,xxx	(.xx xxx,xxx)
					DATA SPACES 109 10 119							

FIGURE 3. PERT COST program/project status report.

ABC - MISSILE AND GMC	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
LEVEL ASSEMBLY ITEM: WARHEAD STAGE 22320	XYZ - MS DIVN	33(600)28369a	ITEM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63

IDENTIFICATION				TIME STATUS			COST OF WORK ALLOC				
							WORK PERFORMED TO DATE			TOTALS AT COMPLETION	
CHARGE OR SUMMARY NUMBER	LEVEL	FIRST EVENT NO.	LAST EVENT NO.	SCHED OR ACT (A) COMPL DATE	EARLIEST & LATEST COMPL DATE	MOST CRIT SLACK (WKS)	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST PROJECTED REVISED ESTIMATE (OVERRUN) UNDERRUN
FIRST STAGE 22320	4	12000099	12000199	30APR64	31DEC63 31DEC63	0.0 12000512	6,700	6,400	.04 300	9,200	9,700 (.05) (500)
INSTRUMENTATION 22322	5	12000700	12000400	10JAN64	31DEC63 31DEC63	0.0 12000612	165	172	(.04) (7)	415	435 (.04) (15)
POWER CABLE ASSY. 22323	5	12000699	12000300	15FEB64	15JUN63 15JUN63	0.0 12000761	270	290	.26 (20)	1,250	1,180 .06 70
ELECTRICAL DESIGN 32164	6	12000700	12000420	25JUL63	10JUN63 25JUN63	2.1 12000562	110	112	(.02) (2)	205	209 (.02) (4)
ELECTRICAL DESIGN 32165	6	12000869	12000860	12JAN64	15JUN63 15JUN63	0.0 12000783	22	20	.10 2	175	175
MANUFACTURING 50973	6	12000690	12000410	22AUG63	10JUN63 25JUN63	2.1 12000682	55	60	(.11) (5)	125	137 (.10) (12)
TESTING 75340	6	12000622	12000400	10JAN64	31DEC63 31DEC63	0.0 12000612				85	85 .01

FIGURE 4. PERT COST program/project status report.

PERT COST ORGANIZATION STATUS REPORT

The Organization Status Reports provide operating level contractor managers with detailed information to follow from the available store of data in the PERT COST computer program.

Several types of reports may be produced within this format by changing the sorting sequence of Charge Number ⑤, Responsible Organization ⑦, Performing Organization ⑧, and Resource Code ⑨.

Following are several examples of possible reports:

Responsible Organization 1, Charge Number 2, Performing Organization 3, Resource Code 4. This report shows, for each responsible organization, all work packages which are within its responsibility and a breakout of organizations and skills which will actually perform the work (Figure 6).

Performing Organization 1, Charge Number 2, Responsible Organization 3, Resource Code 4. This report shows, for each performing organization, that portion of each work package assigned to it for accomplishment, with a further identification of the organization responsible for each work package and the resources required.

Performing Organization 1, Charge Number 2. This report is another version of the above. It shows less detail and is more suitable for higher levels of management (Figure 7).

Charge Number 1, Performing Organization 2. This report is a work package listing (shop order ledger) commonly used as an accounting aid.

Totals are shown on the reports for the first and second sort categories only.

DEFINITIONS PERT COST ORGANIZATION STATUS REPORT

[① through ⑨ previously defined.—Authors.] . . .

⑥-⑨ The sorting sequence for these identification columns is indicated in the report title. Information will appear only in those columns listed in the title.

⑤ *CHARGE NUMBER.* [Previously defined.—Authors.] . . .

⑦ *RESPONSIBLE ORGANIZATION.* The contractor's organization responsible for management of the work package ⑥.

⑧ *PERFORMING ORGANIZATION.* The contractor's department or organization which will perform work on the work package.

⑨ *RESOURCE CODE.* The contractor's code for a particular manpower skill or material type.

⑩-⑬ *MANHOURS.* Cost information shown in this area of the report may be used for services and facilities, such as computer usage, as well as for direct labor. No totals are shown in these columns.

⑫ *ACTUAL* (Work to Date). The actual manhour expenditures assigned to a work package or work package subdivision.

⑪ *PLANNED* (Totals at Completion). The approved planned manhours for the work package or work package subdivision. [⑫ & ⑬ Previously defined.—Authors.] . . .

⑭-⑰ *DIRECT COST $ Only.* Cost information in this area of the report represents materials and other direct costs as well as the direct labor dollar value of costs shown in ⑩ ⑬. Total dollar costs (including overhead) may be used when they are more appropriate to a contractor's normal operation than direct costs. [⑪ through ⑲ previously defined.—Authors.] . . .

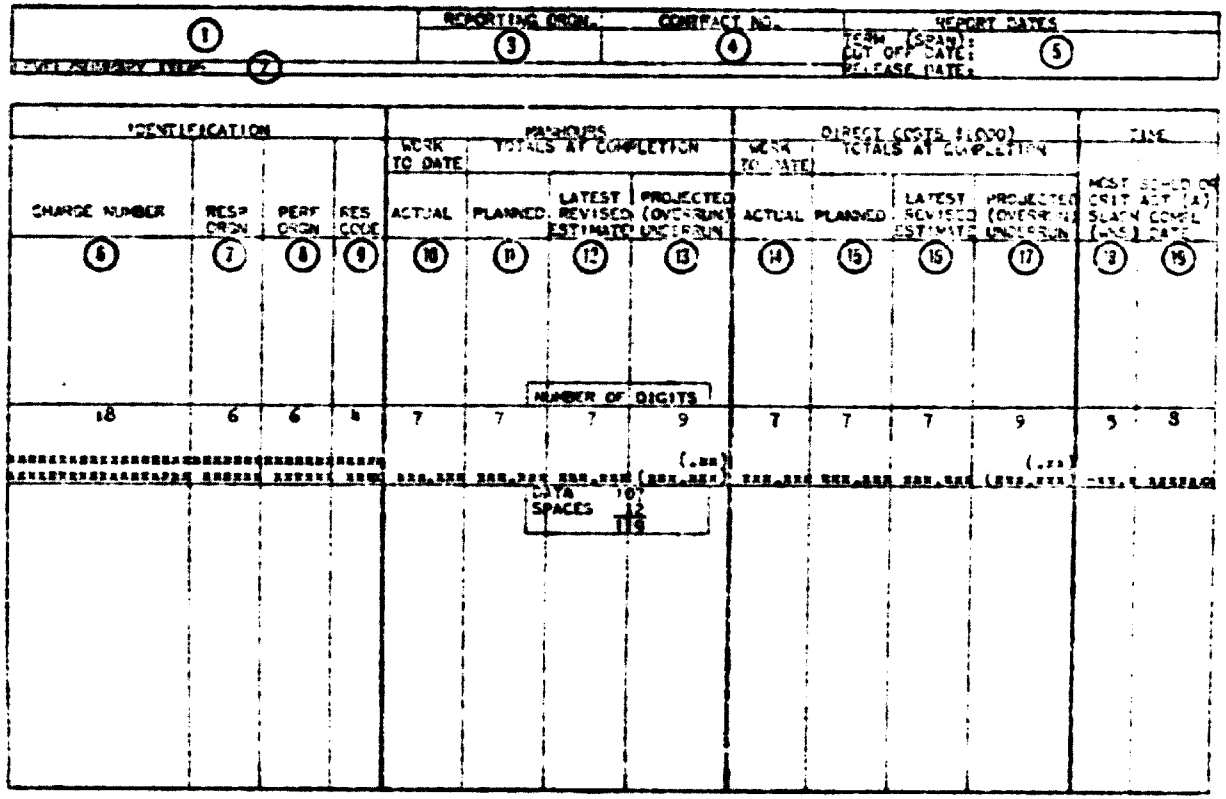


FIGURE 5. PERT COST organization status report.

ABC - MISSILE AND GMC	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
[illegible] XYZ/BALLISTIC SHELL 22300	XYZ - A&S DIVN.	33(600)-52694	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: [illegible]

IDENTIFICATION				MANHOURS				DIRECT COSTS $(000)				TIME	
				WORK TO DATE	TOTALS AT COMPLETION			WORK TO DATE	TOTALS AT COMPLETION				
CHARGE NUMBER	RESP ORGN	PERF ORGN	RES CODE	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	MOST BEHIND OR CRIT. SLACK (WKS)	SCHED OR ACT(A) COMPL. DATE
ELECTRICAL DESIGN, INSTRUMENTATION 32164	2210	2217	E1	15,800	30,000	31,100	(1,100)	41	90	[illegible]	(4)	[illegible]	25JUL63
			E2	10,500	20,000	20,100	(100)	40	60	60			
		4-22	A10	3,500	7,000	7,000		12	25	25			
			M60					5	5	4			
		5514	D1	1,200	5,000	5,000		5	15	15			
			[illegible]	2,800	3,300	3,300		[illegible]	16	15			
TOTAL								112	205	207	(.02) (4)		
ELECTRICAL DESIGN, PWR CABLE ASSY 32165		5514	D1	2,200	4,200	4,200		6	12	12		4.2	15JUL63
	TOTAL							1,300	2,600	2,500	.04 100		

FIGURE 6. PERT COST organization status report by responsible organization, charge number, performing organization, responsibility code.

PRC - MISSILE AND ONE SUMMARY ITEM: 3/BALLISTIC SHELL 22300	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ - AES DIVN	33(600)28360A	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63

IDENTIFICATION				MANHOURS				DIRECT COSTS $(000)				TIME
				WORK TO DATE	TOTALS AT COMPLETION			WORK TO DATE	TOTALS AT COMPLETION			
CHARGE NUMBER	RESP ORGN	PERF ORGN	RES CODE	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK (WKS) / SCHED OR ACT (A) COMPL DATE
32163		2217		9,200	25,000	25,300		32	75	75		3.6 [illegible]
32164				33,700	50,000	51,200	(1,200)	81	150	154	(4)	3.1 [illegible]
		TOTAL						382	825	831	(.01) (6)	
32163		4422		500	1,200	1,200		2	-	-		3.6 15JUL63
32164				3,500	7,000	7,000		12	25	25		2.1 25JUL63
		TOTAL						297	622	622		

FIGURE 7. PERT COST organization status report by performing organization, charge number

PERT COST FINANCIAL PLAN AND STATUS REPORT

The Financial Plan and Status Report provides data for a monthly comparison (at any given level) of actual costs and/or late revised estimates against planned costs, and thus serves as a tool for monitoring the financial plans.

Historical (prior month) cumulative costs are shown for each charge number. Both incremental and cumulative costs by charge number are shown for each future month within the time period identified in the Report Dates block ②.

The report is prepared for higher levels of management by printing only totals for each month (Figure 10).

The Cost vs Work Report Display may be prepared from data available in the Financial Plan and Status Report.

DEFINITIONS PERT COST FINANCIAL PLAN AND STATUS REPORT

[① through ⑤ reason by defined – Authors] . . .

⑥ *MONTH*: The accounting time period for which (or through which) estimates and actuals are shown.

⑦ *CHARGE NUMBER*: [Previously defined – Authors] . . .

⑧ *ACTUAL* (Incremental Cost): The actual expenditures incurred plus any pre-specified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned during the indicated month ⑨. This value is shown for individual Charge Numbers ⑦ when they are included in the report. This column is used only for the month preceding "cut off date."

⑨ *PLANNED*: (Incremental Cost): The approved planned cost for the indicated time period ⑩. This value is shown for individual Charge Numbers ⑦ when they are included in the report. No information appears in this column for prior months.

⑩ *LATEST REVISED ESTIMATE* (Incremental Cost): The latest estimate of cost for the indicated time period ⑥. This value is shown for individual Charge Numbers ⑦ when they are included in the report.

⑪ *(OVER) UNDER PLAN* (Incremental Cost): The Planned Cost ⑨ minus the Latest Revised Estimate ⑩. When planned cost exceeds latest revised estimate, a projected underplan condition exists. When latest revised estimate exceeds planned cost, a projected overplan condition exists. Parentheses are used as a notational device to indicate an overplan condition. No information appears in this column for prior months.

⑫ *ACTUAL* (Cumulative Cost): The actual expenditures incurred plus any pre-specified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned during the period from the beginning of the program or project to the end of the indicated Month ⑥. This value is shown for individual Charge Numbers ⑦ when they are included in the report.

⑬ *PLANNED* (Cumulative Cost): The approved planned cost during the period from the beginning of the program or project to the end of the indicated Month ⑥. This value is shown for individual Charge Numbers ⑦ when they are included in the report.

⑭ *LATEST REVISED ESTIMATE* (Cumulative Cost): The latest estimate of cost during the period from the beginning of a program or project to the end of the indicated Month ⑥. This value is shown for individual Charge Numbers ⑦ when they are included in the report. This estimate is the sum of actual costs plus estimates through the end of the indicated month. For the period prior to the cut off date, the latest revised estimate equals the Actual ⑫.

⑮ *(OVER) UNDER PLAN* (Cumulative Cost): The Planned Cost ⑬ minus the Latest Revised Estimate ⑭. When planned cost exceeds latest revised estimate, a projected underplan condition exists. When latest revised estimate exceeds planned cost, a projected overplan condition exists. Parentheses are used as a notational device to indicate overplans.

⑯ *REMARKS*: This column contains the remaining data needed to make the Financial Plan and Status Report the sole source of information for plotting the Cost of Work Display. This data, (which may be transferred from the Program/Project Status Report), is:

Value of Work Performed to Date: 1) Cumulative – (from column ⑲ Program/Project Status Report); 2) Latest Month – (from column ⑲ Program/Project Status Report this month minus column ⑲ Program Project Status Report last month).

(Over) Underrun to Date (from column ㉑ of the Program/Project Status Report).

(1)	REPORTING ORGN. (3)	CONTRACT NO. (4)	REPORT DATES (5)
(2)			TERM (SPAN): CUT OFF DATE: RELEASE DATE:

MONTH (6)	CHARGE NUMBER (7)	INCREMENTAL COST $(000) ACTUAL (8)	PLANNED (9)	LATEST REVISED ESTIMATE (10)	(OVER) UNDER PLAN (11)	CUMULATIVE COST $(000) ACTUAL (12)	PLANNED (13)	LATEST REVISED ESTIMATE (14)	(OVER) UNDER PLAN (15)	REMARKS (16)
		NUMBER OF DIGITS								
12	16	7	7	7	9	7	7	7	9	
		DATA SPACES								

FIGURE 8. PERT COST financial plan and status report.

ABC - MISSILE AND GME LEVEL SUMMARY ITEM: [illegible]	REPORTING ORGN. XYZ - ABS DIVN	CONTRACT NO. 33(600)25364A	REPORT DATES WBS (START): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 15APR63

MONTH	CHARGE NUMBER	INCREMENTAL COST $(000) ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	CUMULATIVE COST $(000) ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	Remarks
PRIOR	32163 32164 52072 52073 52330					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	TOTAL					6,150	6,200	6,150	50	[illegible]
MAR63	32163 32164 52072 52073 52330	20 [illegible]	19 [illegible]	20 [illegible]	(1) (1)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	TOTAL	250	300	250	50	6,400	6,500	6,400	100	
APR63	32163 32164	[illegible]	2	6	(4)		26 16	25 21	(5)	
	TOTAL		96	140	(42)		6,593	6,540	53	
TOTAL PERIOD						6,400	9,200	9,700	(500)	

FIGURE 9. PERT COST financial plan and status report by month, charge number.

MSC - MISSILE AND GHE COST/SUMMARY ITEM: [illegible] STAGE, BALLISTIC SHELL 22500	REPORTING ORGN. XYZ - ABS DIVN	CONTRACT NO. 33(600)28969a	REPORT DATES TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: [illegible]

MONTH	CHARGE NUMBER	INCREMENTAL COST $(000) ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	CUMULATIVE COST $(000) ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	Remarks
PRIOR						6,150	6,200	6,150	50	[illegible]
MAR63		250	300	250	50	6,400	6,500	6,400	100	[illegible]
APR63			98	140	(42)		448	378	70	[illegible]
TOTAL PERIOD						6,400	9,200	9,700	(500)	

FIGURE 10. PERT COST financial plan and status report by month

PERT COST MANPOWER LOADING REPORT AND DISPLAY

The Manpower Loading Report and the Manpower Loading Display are intended for use by contractors to report manpower loading for various levels of summary within the program. The Manpower Loading Report lists actual, planned, and latest estimated monthly manhours for the desired level of summary by the type of manpower.

The Manpower Loading Display is a graphical presentation of the data contained in the Manpower Loading Report and is manually prepared.

The "type of manpower" is one of (or a combination of) the contractor's resource codes. These codes often identify types of materials, services, and facilities for which cost estimates have been made in hours, but which may not be significant in an analysis of manpower application. Therefore, the Manpower Loading Report is frequently prepared only for certain specified resource codes (skill categories).

The report is prepared for higher levels of management by printing only totals for each month (Figure 13). When the Government requires reporting in categories other than those identified by contractors' resource codes, the report is prepared by grouping resource codes within the specified categories by use of a translation table.

The sequence of sort and the categories included in the report are indicated in the report title. In addition to the examples shown, the report may be prepared by Performing Organization ④, Month ⑥, and Resource Code ⑦, to show organizational loading.

DEFINITIONS PERT COST MANPOWER LOADING REPORT AND DISPLAY

[① through ⑨ previously defined.—Authors.] . . .

①-⑨ The sorting sequence for these identification columns is indicated in the report title. Information will appear in only those columns listed in the title.

⑤ *MONTH:* The accounting time period for which estimates and actuals are shown.

⑦ *RESOURCE (SKILL) CODE:* The contractor or government organization code for a particular manpower skill.

④ *PERFORMING ORGANIZATION:* The contractor or government organization which will perform work on the work package.

⑨ *CHARGE NUMBER:* [Previously defined.—Authors.] . . .

⑩ *ACTUAL* (Manhours): The actual manhour expenditures incurred or assigned to a work package or work package subdivision. This information may appear only as a total figure when charge numbers are not shown in the report.

⑪ *PLANNED* (Manhours): The manhours planned for a work package or work package subdivision during the indicated month. This information may appear only as a total figure when charge numbers are not shown in the report.

⑫ *LATEST REVISED ESTIMATE* (Manhours): The latest estimate of manhours for a work package or work package subdivision during the indicated month. This information may appear only as a total figure when charge numbers are not shown in the report.

⑬ *(OVER) UNDERPLAN* (Manhours): The Planned Manhours ⑪ minus the Latest Revised Estimate ⑫. When planned manhours exceed latest revised estimate, a projected underplan condition exists. When latest revised estimate exceeds planned manhours, a projected overplan condition exists. Parentheses are used as a notational device to indicate an overplan condition.

⑭ *MOST CRITICAL SLACK (WEEKS):* [Previously defined.—Authors.] . . .

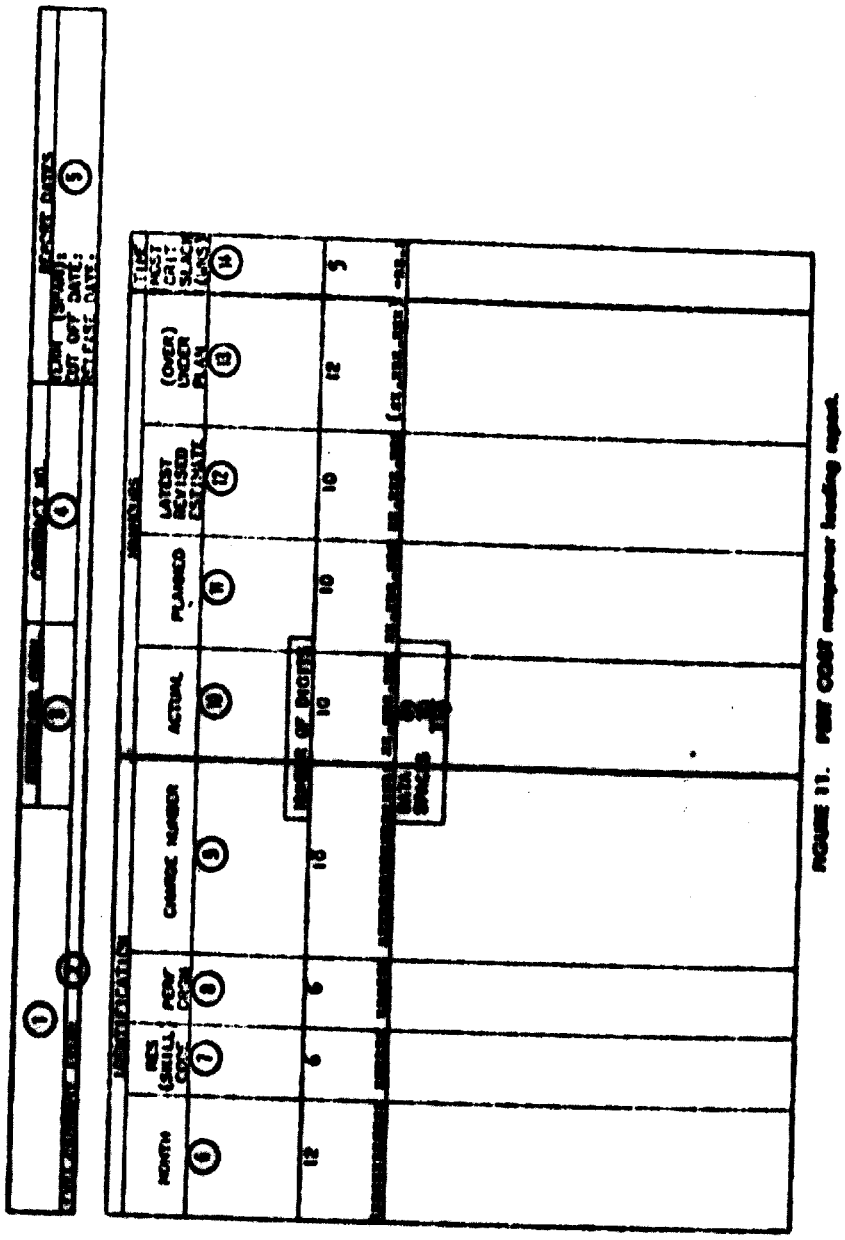


FIGURE 11. PERT COST response loading report.

[illegible] - MISSILE AND GHE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
[illegible]	XYZ - ABS DIVN	33(600)28369A	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63

IDENTIFICATION				MANHOURS				TIME
MONTH	RES (SKILL CODE)	PERF ORGN	CHARGE NUMBER	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	MOST CRIT SLACK (WKS)
PRIOR	L[illegible]	2217	32163	300	2,100	800	1,300	0.0
			321[illegible]	13,000	14,000	13,000	1,000	2.1
			[illegible]	2,200	2,200	2,200		16.2
		4422	32163	400	400	400		0.0
			32166	600	600	600		16.2
TOTAL				175,000	179,000	175,000	4,000	
[illegible]		2217	32163	400	400	400		0.0
			32166	3,900	4,100	3,900	200	2.1
TOTAL				95,000	97,000	95,000	2,000	
[illegible]		2217	32163		400	400		0.0
			32164		4,500	4,500		2.8
TOTAL					86,000	98,000	(12,000)	
	TOTAL			270,000	850,000	856,000	(6,000)	

FIGURE 12. PERT COST manpower loading report by resource, month, performing organization, charge number

ASC - MOBILE AND EMC	PERFORMING DIV. XYZ - ABB DIVN	CONTRACT NO. 33(600)00000A	REPORT DATES ITEM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 15APR63

IDENTIFICATION				MANHOURS				TIME
MONTH	RES (SKILL/ COST	PERF ORGN	CHARGE NUMBER	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	MILST CRIT SLACK (-DAYS)
PRIOR	EI			175,000	179,000	175,000	4,000	
MAR63				95,000	97,000	95,000	2,000	
APR63					86,000	98,000	(12,000)	
	TOTAL			270,000	890,000	896,000	(6,000)	

FIGURE 13. PERT COST manpower loading report by resource, month.

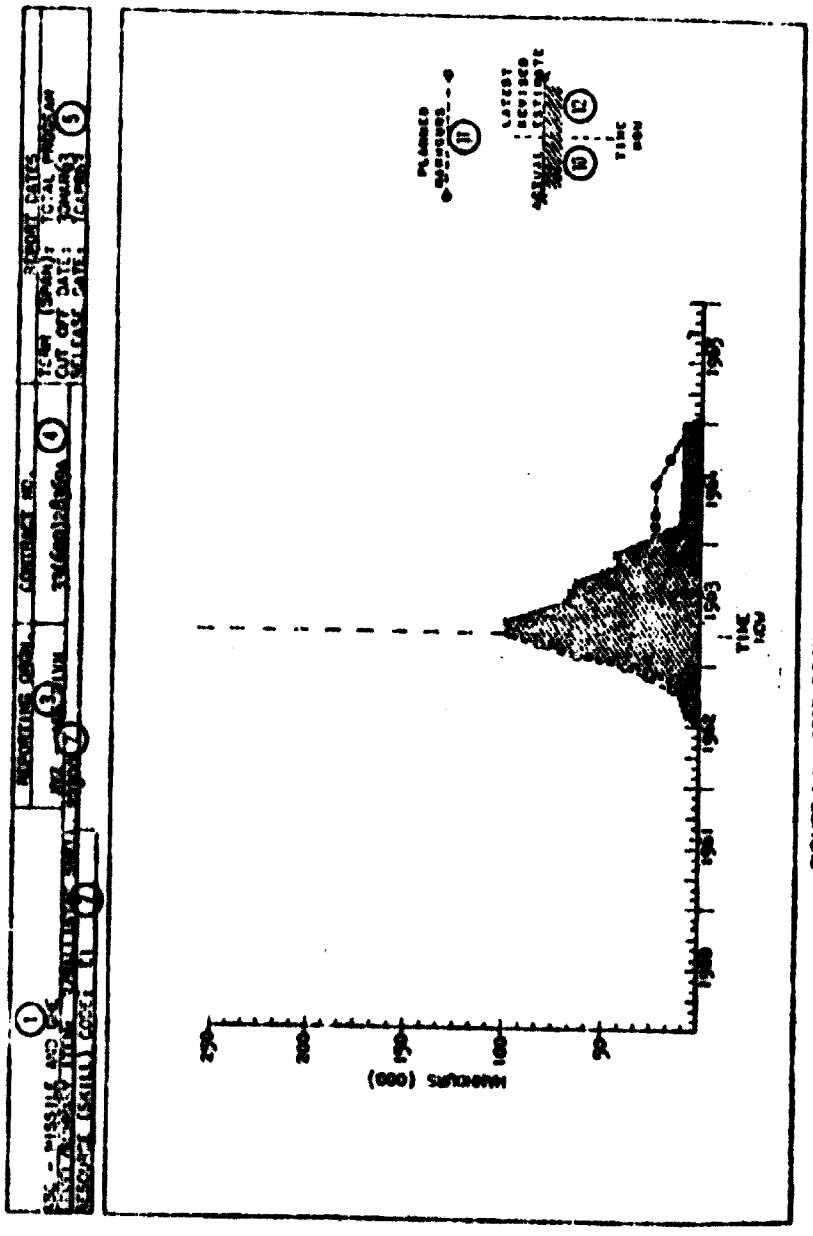


FIGURE 14. PERT COST manpower loading display.

PERT COST COST OF WORK REPORT

The Cost of Work Report is a graphical equivalent of the Financial Plan and Status Report with the additional feature of showing the distribution of actual cost and the value for work performed to "time now."

The Cost of Work Report is manually prepared each month from data contained in the Financial Plan and Status Report. The Cost of Work Report provides a comparison of:

Projected cost vs. planned cost at completion.
Value for work performed vs. actual cost to date.
Planned rate of expenditure vs. actual rate of expenditure to date.
Planned rate of expenditure vs. latest estimated rate of expenditure to completion.

DEFINITIONS PERT COST COST OF WORK REPORT

{① through ⑨ previously defined.---Authors.} . . .

⑩ *PLANNED COST:* The planned cost for the Summary Item ③ plotted cumulatively by month. Values are plotted each month from the Financial Plan and Status Report, column ⑬.

⑪ *ACTUAL COST:* The actual cost for the Summary Item ① plotted cumulatively by month. This line is developed by plotting, each month, the new cumulative actual cost from the Financial Plan and Status Report, column ⑫.

⑫ *LATEST REVISED ESTIMATE:* The latest estimate of cost for the Summary Item ② plotted cumulatively by month from "time now" to program or project completion. This value is available from the Financial Plan and Status Report, column ⑭.

⑬ *VALUE FOR WORK PERFORMED TO DATE:* The planned cost for work completed within the Summary Item ④ plotted cumulatively by month. This line is developed by plotting, each month, the new value of work performed to date from the Financial Plan and Status Report Remarks ⑯ (or from the Program/Project Status Report ⑪).

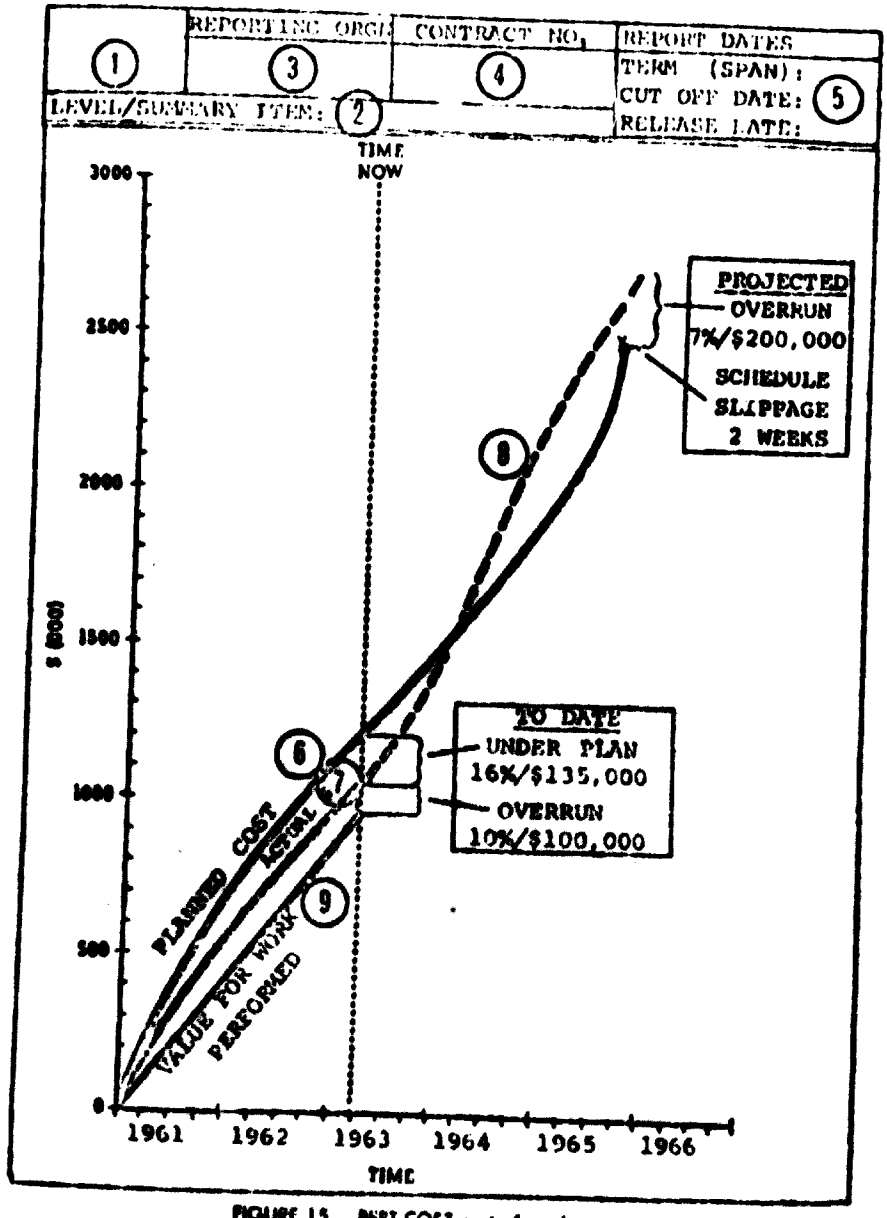


FIGURE 15. PERT COST cost of work report.

PERT COST COST OUTLOOK REPORT

The Cost Outlook Report shows (for any given level and summary item) the projected cost status at work completion. It also shows what the projected cost was at every cycle previous to the current one, thus providing for the recognition of trends.

Each month, new projections which provide new entries for the Cost Outlook Report are obtained from the Management Summary Report. The Cost Outlook Report is manually prepared by periodically plotting the projections obtained. These projections may be plotted by month for two years, after which the report is redrawn to show previous projections condensed by year.

Limit lines, established by the manager for each program or project, identify the values of (over) underrun which require a narrative analysis to be included in the Problem Analysis Report.

DEFINITIONS PERT COST COST OUTLOOK REPORT

[① through ⑤ previously defined.—Authors.] . . .

⑥ *TARGET:* The planned cost for the Summary Item ③ identified in the title block. An arrow indicates on the Calendar ⑦ the date when the target value was established.

⑦ *CALENDAR:* The calendar shows two years of projected values by month and six years of condensed historical information. Managers may elect to use other time scales.

⑧ *LIMIT LINES:* Limit lines, established for each program or project, identify the values of overrun) underrun which require that a narrative analysis be included in the Problem Analysis Report.

⑨ *PROJECTED (OVERRUN) UNDERRUN:* This value, from the Management Summary Report Projected (Overrun) Underrun ⑫, is plotted each month.

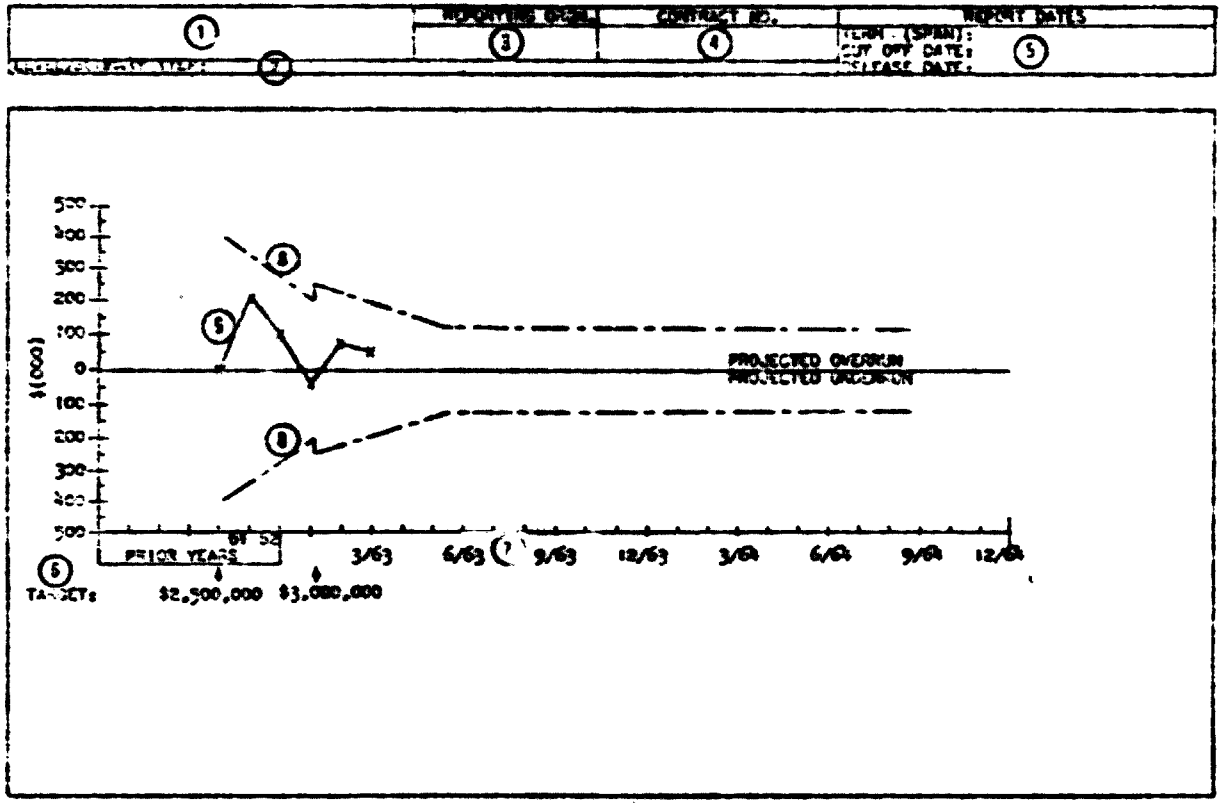


FIGURE 14. PERT COST cost outlook report.

PERT COST SCHEDULE OUTLOOK REPORT

The Schedule Outlook Report shows (for any given level and summary item) the projected schedule status at work completion. It also shows what the projected schedule status was at every cycle previous to the current one, thus providing for the recognition of trends.

Each month, new projections are obtained from the Management Summary Report which provide new entries for the Schedule Outlook Report. This report is manually prepared by periodically plotting the projections obtained. These projections may be plotted by month for two years, after which the Schedule Outlook Report is redrawn to show previous projections condensed by year.

Limit lines, established by the manager for each program or project, identify the values of schedule status which require a narrative analysis to be included in the Problem Analysis Report.

DEFINITIONS PERT COST SCHEDULE OUTLOOK REPORT

[① through ⑤ previously defined.—Authors.] . . .

⑥ *TARGET DATE:* The planned scheduled completion date for the Summary Item ① identified in the title block. An arrow indicates on the Calendar ⑦ the date when the target value was established.

⑦ *CALENDAR:* The calendar shows two years of projected values to be plotted by month and six years of condensed historical information. Managers may elect to use other time scales.

⑧ *LIMIT LINES:* Limit lines, established for each program or project, identify the values of schedule slippage which require that a narrative analysis be included in the Problem Analysis Report.

⑨ *PROJECTED SCHEDULE STATUS:* This value, from the Most Critical Slack ⑪ of the Management Summary Report, is plotted each month.

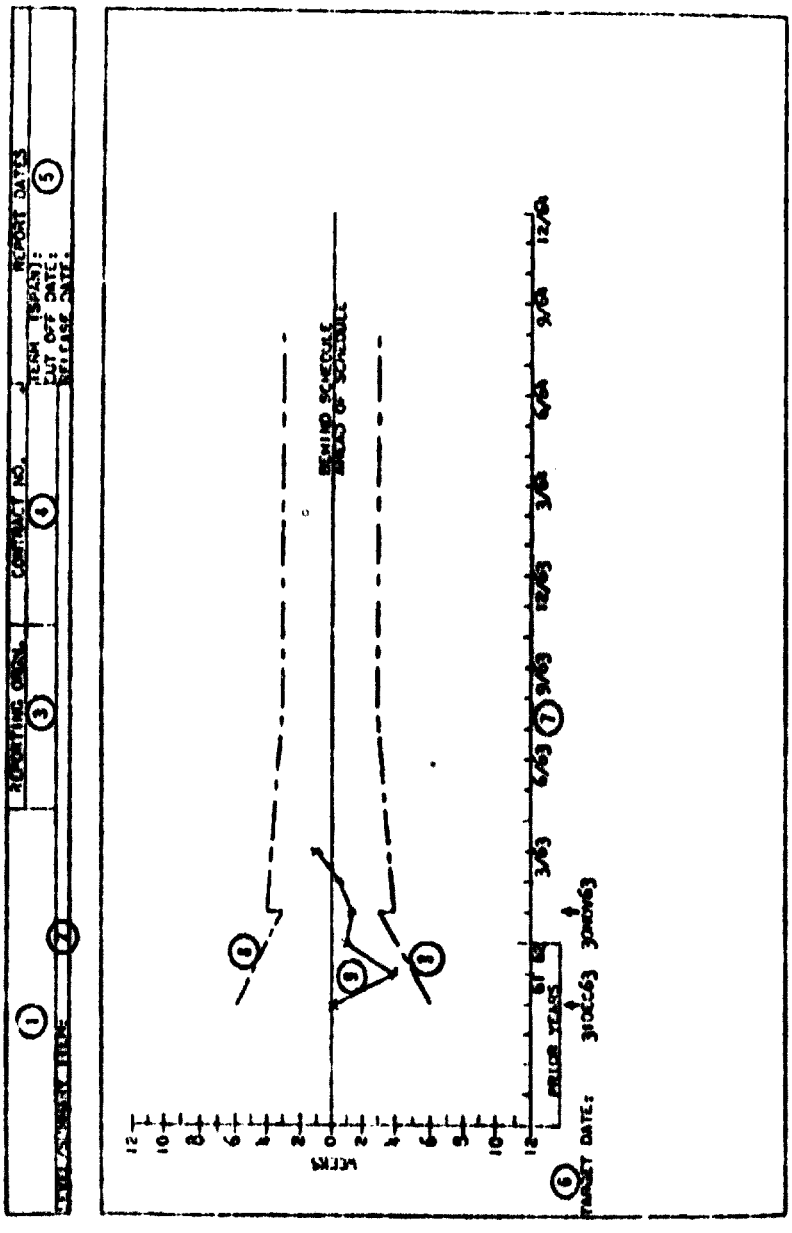


FIGURE 17. PERT COST schedule outlook report.

PERT COST COST CATEGORY STATUS REPORT

The Cost Category Status Report presents a grouping of functional, hardware, or other significant cost elements in specified categories for reporting purposes.

These cost categories are established by relating work packages or elements of cost within work packages to the specified categories. Thus, no distortion of the work breakdown structure is required to segregate these data.

Any cost categories which satisfy this relationship to the work breakdown structure may be established for a program or project, but once established, they must remain as originally defined for the life of the program or project.

The Cost Category Status Report provides for each cost category a manpower and total dollar comparison of:

planned vs. actual expenditure to date.
planned vs. latest revised estimate at completion.

DEFINITIONS PERT COST COST CATEGORY STATUS REPORT

[① through ⑯ previously defined.--Authors.] . . .

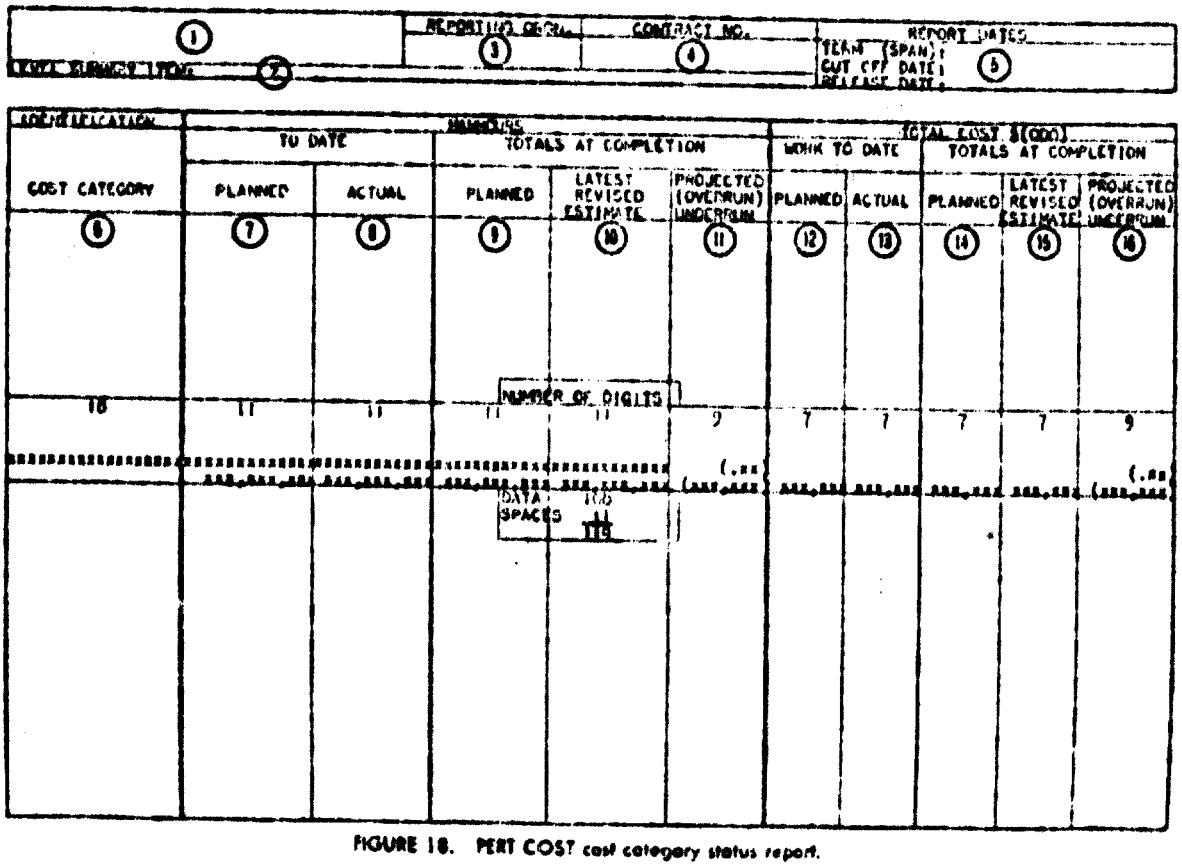


FIGURE 18. PERT COST cost category status report.

ABC - MISSILE AND GHE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
[illegible]	MVE - ABS	33(600)[illegible]	YEAR (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63

IDENTIFICATION	MANHOURS					TOTAL COST $(000)				
	TO DATE		TOTALS AT COMPLETION			WORK TO DATE		TOTALS AT COMPLETION		
COST CATEGORY	PLANNED	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	PLANNED	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN
1010 ENG ABS	117,000	120,000	220,000	225,000	(.02) (5,000)	2,500	2,700	3,500	3,900	(.01) (400)
1012 DEV O&T	172,000	172,000	380,000	380,000		2,100	2,100	4,300	4,300	
2010 EQUIP FABC	211,000	[illegible] 300	420,000	421,000	(1,000)	3,100	3,800	5,200	5,900	(.01) (700)
3010 ENG FLD SPT	63,000	61 300	170,000	169,000	1,000	980	900	2,800	2,700	.0[illegible] 100
TOTAL						18,620	20,900	35,200	39,650	(.13) (4,45[illegible])

FIGURE 19. PERT COST cost category status report.

PERT MILESTONE REPORT

The PERT Milestone Reports present schedule information for selected network events which represent major milestones of accomplishment toward completion of the program or project.

The reports are tiered, like the Management Summary Report, for several levels of management. However, the Milestone Report represents key network events that are of major significance in achieving the program or project objectives, whereas the Management Summary Report flags critical areas and work completions.

Together, the Milestone Report and the Management Summary Report provide the most comprehensive status information available in the PERT COST System.

DEFINITIONS PERT MILESTONE REPORT

[① through ⑤ previously defined.—Authors.] . . .

⑥ *MILESTONE DESCRIPTION:* The network event number and nomenclature which are selected as milestones. Two lines are available for description.

⑦ *SLACK:* The slack, in weeks, associated with the network event (Milestone) ⑥. This is the time difference between the "*E*" and "*L*" dates shown in the Schedule ⑨.

⑧ *DATE:* The day, month, and year of the "*S*," "*A*," "*E*," "*L*," or "*M*" positions shown in the Schedule ⑨.

⑨ *SCHEDULE CALENDAR:* A calendar time reference for display of schedule completions. The calendar contains one division for all prior years, two years divided by months, four years by years, and one division for all later years. A "Time Now" line appears between the next future month and the month of the cut off date.

⑩ *SCHEDULE COMPLETIONS:* The scheduled "*S*," Actual "*A*," Earliest "*E*," and Latest "*L*" completion dates for the network event (Milestone) in column ⑥ with respect to designated program or project end points. "*M*" may be entered by an analyst to indicate a revised completion date anticipated as a result of management action.

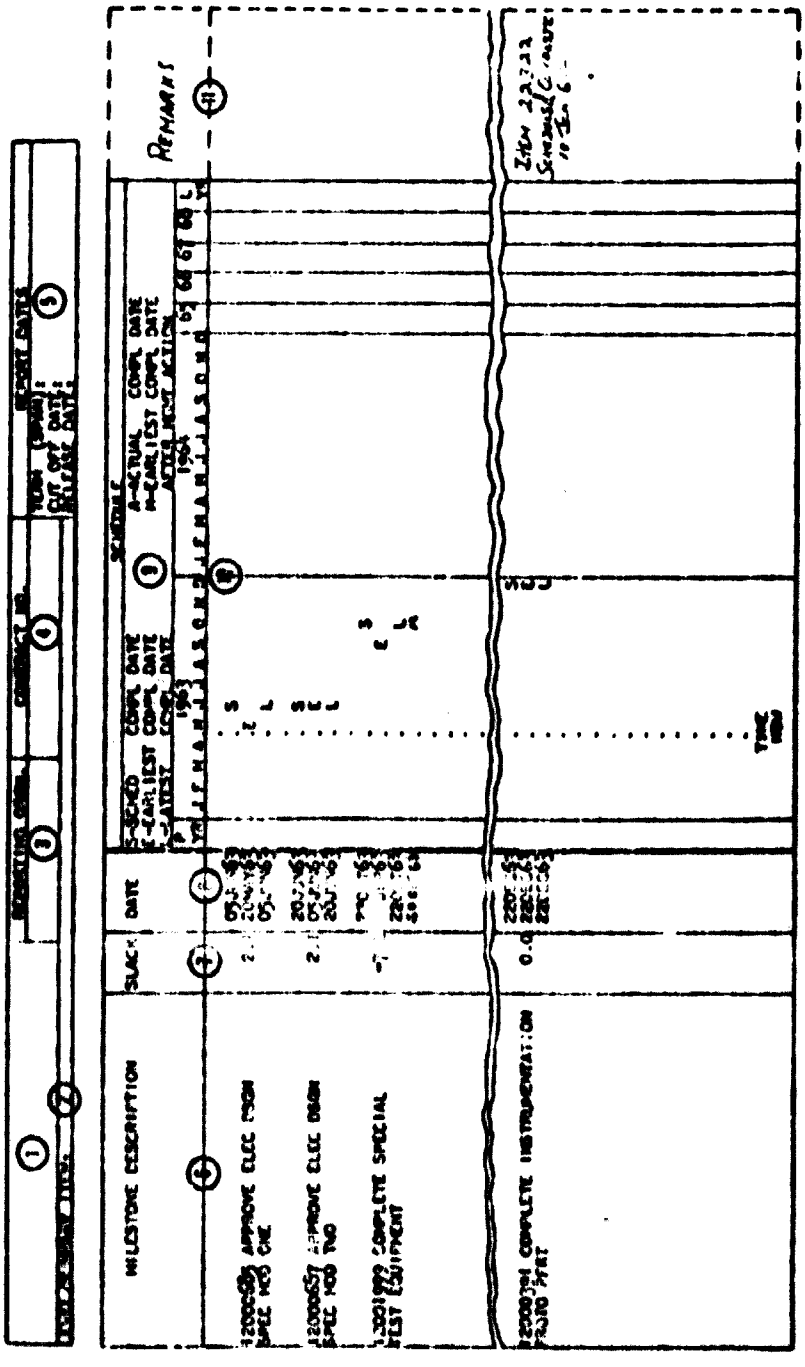
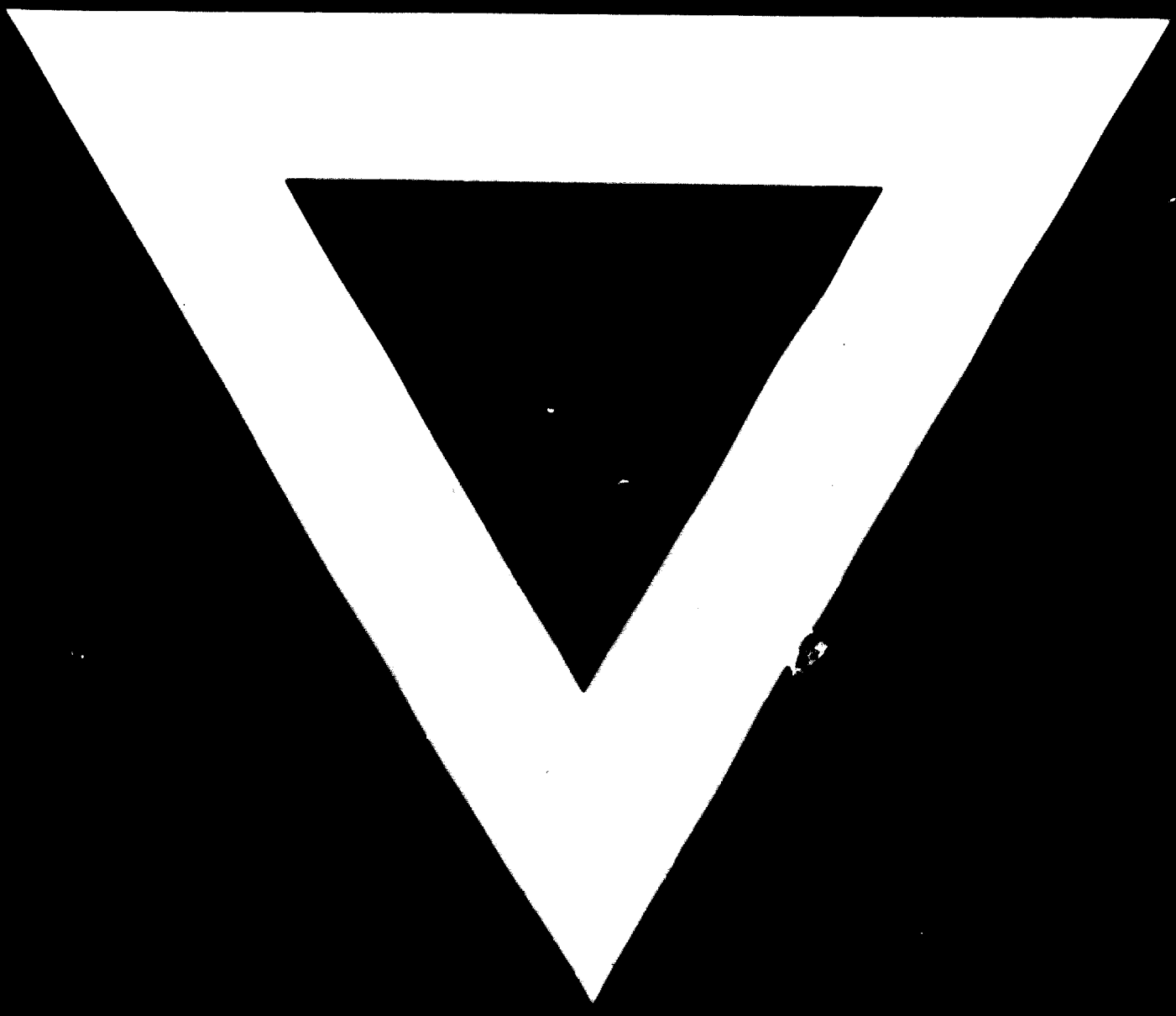


FIGURE 28. PERT milestone report.



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