ESD-TDR-64-208

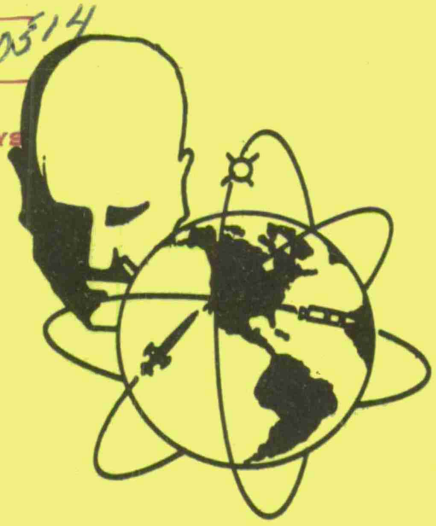
An Introduction To

PERT COST

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-64-208

MARCH 1964

Frank T. Mooty



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FOREWORD

The Program Evaluation and Review Technique (PERT), in its broad sense, represents the concept of an integrated management system which can be used by program managers in controlling the variables of time, cost, and technical performance. A major step in the development of this concept was completed in 1958 when the PERT TIME System was implemented for planning and control of time in research and development programs.

As PERT TIME became established in both industry and government, the Department of Defense undertook the design of a PERT COST technique. Concepts were clarified, a technique developed, and pilot tests conducted. The resulting PERT COST System was adopted by the Department of Defense and the National Aeronautics and Space Administration. In June of 1962, the system was described in the DOD/NASA PERT COST System Design Guide, and concurrent with the publication, the Secretary of Defense directed the three military services to implement PERT COST on a test basis.

The Air Force and Air Force Systems Command undertook a system study of the DOD/NASA PERT COST Guide with the objective of implementing PERT COST as rapidly as possible. As a result, "USAF PERT COST System Description Manual (Preliminary Draft) - December 1962" was established which definitized the basic PERT COST System Design described in the DOD/NASA Guide. The manual was later revised to incorporate the new uniform PERT COST output forms package approved by OSD PERT Coordinating Group on 8 February 1963 and was reissued under a March 1963 date still as a preliminary draft. The technique described in the manual is used to test PERT COST in connection with the development of a major weapon system. It may be assumed that the knowledge obtained during the test period will permit preparation of a more comprehensive and advanced manual at a future date.

The content and criteria contained in this pamphlet is based on the following USAF PERT manuals:

Volume I - USAF PERT TIME SYSTEM DESCRIPTION MANUAL

Volume III - USAF PERT COST SYSTEM DESCRIPTION MANUAL

The purpose of this pamphlet is to present a condensed description of the PERT COST System. Consequently, the content is very basic in some cases and details are purposely excluded.

This pamphlet was prepared by the Techniques Branch (ESCPT), Programs Division, Comptroller, Electronic Systems Division (AFSC), L G Hanscom Field, Bedford, Mass. Additional copies may be obtained by addressing request to the above office.

ABSTRACT

A general introduction to PERT COST, an innovation in the field of management. This technique employs a networking, statistical and scheduling methodology using advanced data processing procedures. The PERT COST technique is based on the principle that planning must be developed in a manner that facilitates its use as a management control tool and a management control system must use as its base the planning that governs the program. Accordingly, PERT COST can be used in both the planning and control functions of management.

This Technical Documentary Report has been reviewed and approved.

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KEYWORD LISTING

Management Engineering
Costs, PERT
Networking
Statistics
Scheduling
Data Processing

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Introduction To PERT Cost

Complex research and development programs can be managed effectively if program managers have the means to plan and control the schedules and costs of the work required to achieve their technical performance objectives. Schedule slippages and cost overruns indicate that managers at all levels need improved management techniques. For example, managers at each level must be able to determine:

* whether the current estimated time and cost for completing the entire program are realistic;

* whether the program is meeting the schedule and cost estimate and, if not, the extent of any difference;

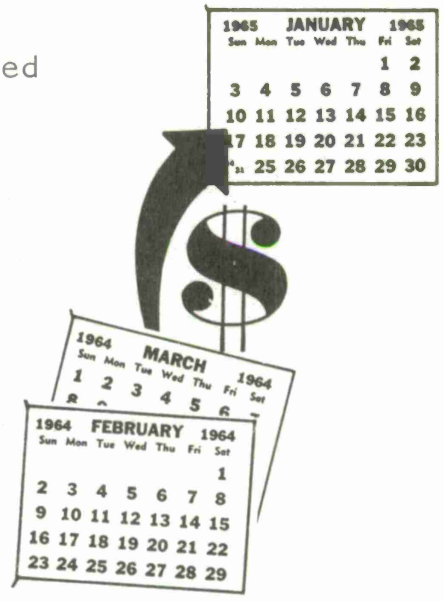
* whether requirements for manpower and other resources have been planned realistically to minimize premium costs and idle time;

* how manpower and other resources (available within the program) can be shifted to expedite critical activities;

* how manpower and other resources made available by changes in the program tasks can best be utilized.

The PERT COST System, a complement to the basic PERT TIME System, has been developed to meet these planning and control needs for the various levels of management. In order to obtain an understanding of the contents of this pamphlet, it is necessary that you be familiar with the PERT TIME System. If you are not, another ESD Techniques Branch (ESCPT) pamphlet titled "An Introduction to PERT - June 1963," which is similar to this in explaining PERT TIME, is available upon request to ESCPT.

In PERT COST, both cost and schedule are planned and controlled on a common basis. This interrelation not only permits more accurate measurement of progress but also enables managers to appraise more realistically the consequences of alternative courses of action.



Under the PERT COST System, the program is specifically defined and then broken down in order to establish the work breakdown structure including work packages. Work packages are identified with activities on a conventional PERT network.

If the time required to complete the program exceeds the time available, the appropriate activities in the network are analyzed to determine whether their times can be reduced or whether some of the activities can be performed concurrently. Such analysis is continued until a plan is developed which indicates that the program should be completed by the directed or desired date. At this point, scheduled times for the program actions are established.

After the schedule has been prepared, a cost estimate is established for each work package. The cost estimates are based on projections of manpower and other resources that will be assigned for the performance of each work package. Since responsible contractor personnel should participate in estimating the manpower and other resources required, the cost estimates also serve contractors as yardsticks for internal measurement and control of performance.

The PERT COST System requires periodic comparisons of the actual costs incurred versus estimated costs for each work package and the actual time versus scheduled time for the activities concerned. This comparison significantly improves cost and schedule control by establishing the cost and time status of the program and identifying any potential cost overruns, underruns and schedule slippages. Concurrent estimates of the cost and time needed to complete work not yet performed are also made available.

The method of describing PERT COST in this pamphlet involves the following approach:

1 → **TERMINOLOGY**

Symbols and terms used in PERT COST are briefly defined. In addition to initially identifying such symbols and terms, the list of definitions can serve as a ready reference later on as you progress through the pamphlet.

2 → **ELEMENTS**

Pertinent elements of PERT COST are presented and described. The sequence in presenting these elements

is somewhat comparable to the sequence of things you would have to do in establishing and maintaining a PERT COST System.

3 CASE PROBLEM

In an effort to better illustrate the manner in which the above elements are identified and used in a PERT COST operation, a very simple case problem of building a house is also included. The case problem is progressively applied as the PERT COST System description evolves.

4 INFORMAL LANGUAGE

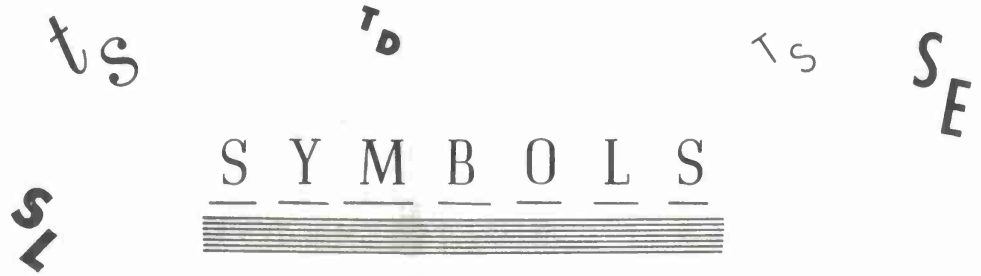
As you will notice, portions of this pamphlet are written in an informal person-to-person language. This approach was taken because we feel that an informal language would be helpful in putting across points in cases, particularly when the case problem becomes involved.

Symbols & Terms

II

You should readily recognize some of the symbols and terms as those used in a PERT TIME operation. However, to refresh your memory, the symbols and terms peculiar to PERT TIME are identified with an asterisk (*).

Common terms, such as commitment, expenditures, etc., which are used in any kind of cost operation, are not included below. Included below are only those terms considered necessary to explain PERT COST to the depth contained in this pamphlet.



*a = Optimistic time estimate for an activity.

*b = Pessimistic time estimate for an activity.

*m = Most likely time estimate for an activity.

*t_e = Expected elapsed time for an activity.

t_s = Scheduled elapsed time for an activity.

S_E = Earliest completion date for an activity (based on t_s).

S_L = Latest completion date for an activity (based on t_s).

T_A = Actual completion date.

*T_E = Earliest expected date for an event (based on t_e).

T_D = Directed date (directed by USAF, DOD, or other top level authority) for a specific accomplishment.

*T_L = Latest allowable date for an event (based on t_e).

T_S = Scheduled completion date for an activity.

ACCOUNT CODE STRUCTURE - The numbering system used to assign summary numbers to elements of the work breakdown structure and charge numbers to individual work packages.

*ACTIVITY - An element of a program which is represented on a network by an arrow. An activity cannot be started until the event preceding it has occurred. An activity may represent:

- a process
- a job to be performed
- a procurement cycle
- waiting time
- an interdependency or constraint between two events.

ACTIVITY SLACK - The difference in time, comparing the earliest completion date (S_E) with the latest completion date (S_L) for a given activity. The activity slack indicates the range of time within which an activity can be scheduled for completion. When the S_E for an activity is later than the S_L, then the activity is said to have negative slack and either the current activities or subsequent activities must be replanned or the program schedule

will slip. When the S_L for an activity is later than the S_E, the activity is said to have positive slack, and additional time is available for performing the activity without causing the program schedule to slip.

ACTUAL COSTS - The expenditures incurred plus any pre-specified types of unliquidated commitments charged or assigned to a work effort.

CHARGE NUMBER - A number used for identifying the costs charged to a work package.

*CONSTRAINT - The relationship of an event to a succeeding activity wherein an activity may not start until the event preceding it has occurred. The term "constraint" is also used to indicate the relationship of an activity to a succeeding event wherein an event cannot occur until all activities preceding it have been completed.

COST ACTIVITY - An activity which employs resources, the cost of which is a direct charge to the program.

COST CATEGORY - The name and/or number of a functional, hardware, or other significant cost category for which costs are to be summarized.

*CRITICAL PATH - That particular sequence of activities that has the greatest negative (or least positive) activity slack.

DIRECT COST - Costs charged directly to the contract.

DIRECTED DATE FOR AN EVENT (T_D) - Date for a specific accomplishment directed by top level authority.

EARLIEST COMPLETION DATE (S_E) - The S_E value for a given activity is equal to the sum of the scheduled elapsed time (t_s) for the activities on the longest path from the beginning of the program up to and including the given activity. Thus, S_E represents the earliest date on which an activity can be completed.

*EARLIEST EXPECTED DATE (T_E) - The earliest date on which an event can be expected to occur. The T_E value for a given event is equal to the sum of the statistically calculated expected elapsed times (t_e) for the activities on the longest path from the beginning of the program to the given event.

ESTIMATE-TO-COMPLETE - The estimated man-hours, costs, and time required to complete a work package or summary item (includes applicable overhead except where direct costs are specified).

*EVENT - A specific definable accomplishment in a program plan, recognizable at a particular instant in time. Events do not consume time or resources and are normally represented in the network by circles or rectangles.

*EXPECTED ELAPSED TIME (t_e) - The expected (or statistically computed) time in weeks for accomplishing an activity. The expected elapsed time is identical to a single time estimate for the work to be accomplished or is calculated using the formula $\frac{a + 4m + b}{6} = t_e$.

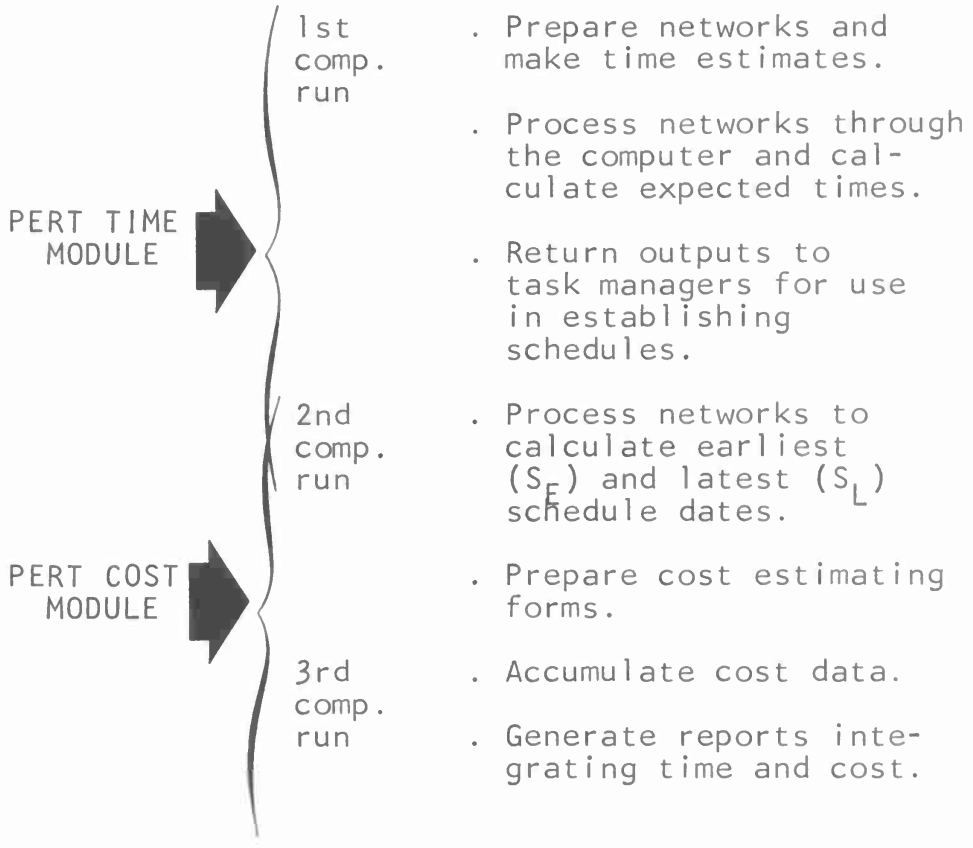
FIRST EVENT NUMBER - The number of the first event in time (based on S_E) for a work package or summary item. This event number defines the beginning of the work package or summary item in relation to the network.

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

*LATEST ALLOWABLE DATE (T_L) - The latest date on which an event can occur without creating an expected delay in the completion of the program. The T_L value for a given event is calculated by subtracting the sum of the expected elapsed times (t_e) for the activities on the longest path from the given event to the end event of the program from the latest date allowable for completing the program. T_L for the end event in a program is equal to the directed date (T_D) of the program. If a directed date is not specified, the T_E for the end event is used as the T_L and recognized as such.

LATEST COMPLETION DATE (S_L) - The S_L value for a given activity is calculated by subtracting the sum of the scheduled elapsed times (t_s) for the activities on the longest path from the given activity to the end event of the program from the directed date or latest allowable date (T_L) for completing the program. Therefore, S_L represents the latest date on which an activity can be scheduled for completion without delaying the completion of the program.

MODULAR CONCEPT - The development and use of separate but compatible data processing programs for PERT TIME and PERT COST applicable to a common network. The mechanics of data processing in the modular concept involve the sequential processing of the time date and the cost data. The following steps illustrate the method of operating the modular technique:



MOST CRITICAL SLACK (WEEKS) - The worst (least algebraic) slack with respect to 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 $S_L - S_E$ 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 rather than at the end of the work package.

PERFORMING ORGANIZATION - The contractor or government organization which will perform work on a work package.

PLANNED COST - The approved planned cost for a work package or summary item. This cost, when totaled with the planned costs for all other work packages, results in the total cost estimate, committed under contract, for the program or project. Planned and budgeted are used synonymously.

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

RESPONSIBLE ORGANIZATION - The contractor or government organization responsible for management of a work package.

SCHEDULED COMPLETION DATE (T_S) - A date assigned for completion of an activity (accomplishment of an event) for purposes of planning and control within an organization. (Where no specific date is assigned, S_E equals T_S.

SCHEDULED ELAPSED TIME (t_s) - The period of time scheduled for performing an activity.

SLACK - The difference in time, comparing the earliest completion date (S_E) with the latest completion date (S_L) for a given activity. The activity slack indicates the range of time within which an activity can be scheduled for completion. When the S_E for an activity is later than the S_L, then the activity is said to have negative slack and either the current activities or subsequent activities must

be replanned or the program schedule will slip. When the S_L for an activity is later than the S_E, the activity is said to have positive slack, and additional time is available for performing the activity without causing the program schedule to slip.

SUMMARY ITEM - An item identified in the work breakdown structure.

SUMMARY LEVEL - Any level in the work breakdown structure.

SUMMARY NUMBER - A number which identifies an item in the work breakdown structure.

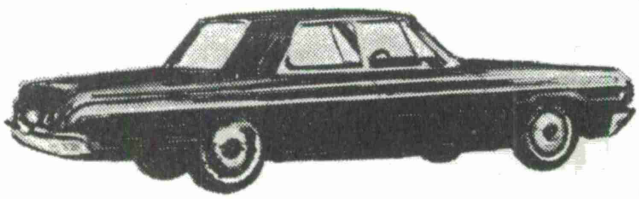
WORK (PROGRAM) BREAKDOWN STRUCTURE - A family tree subdivision of a program, beginning with the end objectives and then subdividing these objectives into successively smaller end item subdivisions. The program breakdown structure establishes the framework for:

- defining the work to be accomplished;
- constructing a network plan;
- summarizing the cost and schedule status of a program for progressively higher levels of management.

WORK PACKAGE - The unit of work required to complete a specific job or process, such as a report, a design, a documentation requirement, a piece of hardware or a service. A work package may consist of one or more cost significant activities. The content of a work package may be limited to the work which can be performed by a single operating unit in an organization or may require the contributing services of several operating units. The overall responsibility for the work content of a work package should be assigned to a single organization or responsible individual.

Work Breakdown

III



A work breakdown is simply nothing more than taking a good hard look at an end objective and determining what type of services and/or hardware are necessary to accomplish the end objective. To over simplify it, say you want to break down the manufacture and assembly of a new model automobile. You first determine the major components you want to control. Let's say these are initially determined to be the -

1 Body

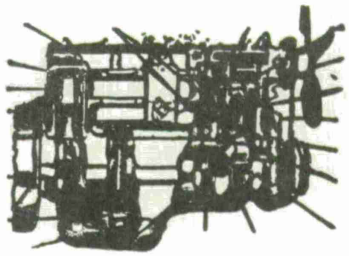
2 Engine

3 Chassis

4 Handbook

Is that all? What about documentation? You might say, "Well, what about it!" When you buy a new car, you look in the glove compartment and expect to find an "Owner's Handbook." If you don't, you would most likely tell the dealer to give you one. So you see, as matter-of-fact it may seem, documentation to the automobile manufacturer is a major item because the "Owner's Handbook" is only one publication compared to all other documentation that must be developed and printed, such as service manuals, parts catalogs, etc. Don't you think you'd better add "Documentation" to the above list of major components?

Your next step is to take each of these major components and break them down to the next level of major items. Take the engine for example. You could break that down to items such as -



* **block**
* **carburation**
* **ignition**

You would break the engine down as far as it was necessary to satisfy your requirement for schedule and cost control. Now let's see how a work breakdown can serve both a program manager and contractors concerned.

During the initial planning phase the work breakdown serves the program manager as a basis for preparing and publishing the Request for Proposal. It provides the contractor with a basis for developing:

- a statement of work;
- document specifications;
- pricing documents and
- PERT COST proposals.

During the acquisition phase the work breakdown provides the contractor with a basis for continuing the breakdown to successively lower levels until the end item subdivisions become manageable units for planning and control purposes. This detailed program breakdown provides:

a basis for defining and relating program objectives;

a framework for integrated cost and schedule planning and control;

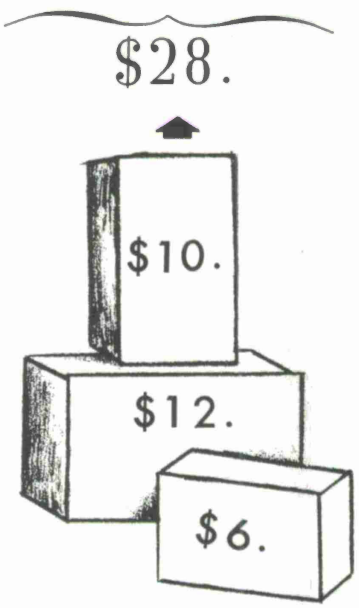
a framework and technique for summarizing cost and schedule status of work packages.

During the contractor's proposal preparation phase and continuing through the program execution phase, the planning and control become more detailed. Subdivision of the work breakdown structure continues to successively lower levels. The end item subdivisions appearing at the last level in the work breakdown structure are then divided into work packages (which is the next element to be discussed).

In the operating phase, the program breakdown serves as the framework for summarizing data "from the bottom up." Therefore, the decision-making requirements of any level of management can be satisfied. When summary reports indicate problems in specific areas of the program, PERT COST permits more detailed information to be obtained by merely moving to successively lower levels of the program breakdown structure.

Work Packages

IV



Work package determination is nothing more than identifying the types of work required to accomplish a program.

The size of work packages will vary. Assume that you have established a standard for the lowest level work package to have a value not to exceed $100,000 and requiring no more than three months to complete. This work package standard may, however, be modified by one or more of the following example considerations:

✸ NATURE OF THE WORK PACKAGE

In some cases the nature of a work package does not permit reduction to the standard value and does not require such reduction for good cost control. Program management, for example, might have a cost value of $500,000 and represent a fixed level of effort for the life of a program.

✸ ABILITY TO DEFINE WORK PACKAGE AS AN ACCOMPLISHMENT

A work package must contain a clearly defined "recognizable accomplishment." If a work package is clearly defined but extends beyond three months, it should be recognized as a larger work package provided it affords better cost control.

✸ CAPABILITY OF UPDATING

The usefulness of PERT COST is subject to the timely processing of good updating information. Therefore, work packages should be established at a level of detail that will provide efficient updating.

Read the case problem contained in Appendix A. We will start using it to try to illustrate what is being discussed. What are the major items (first breakdown) you might identify in Project HOME? They could be the

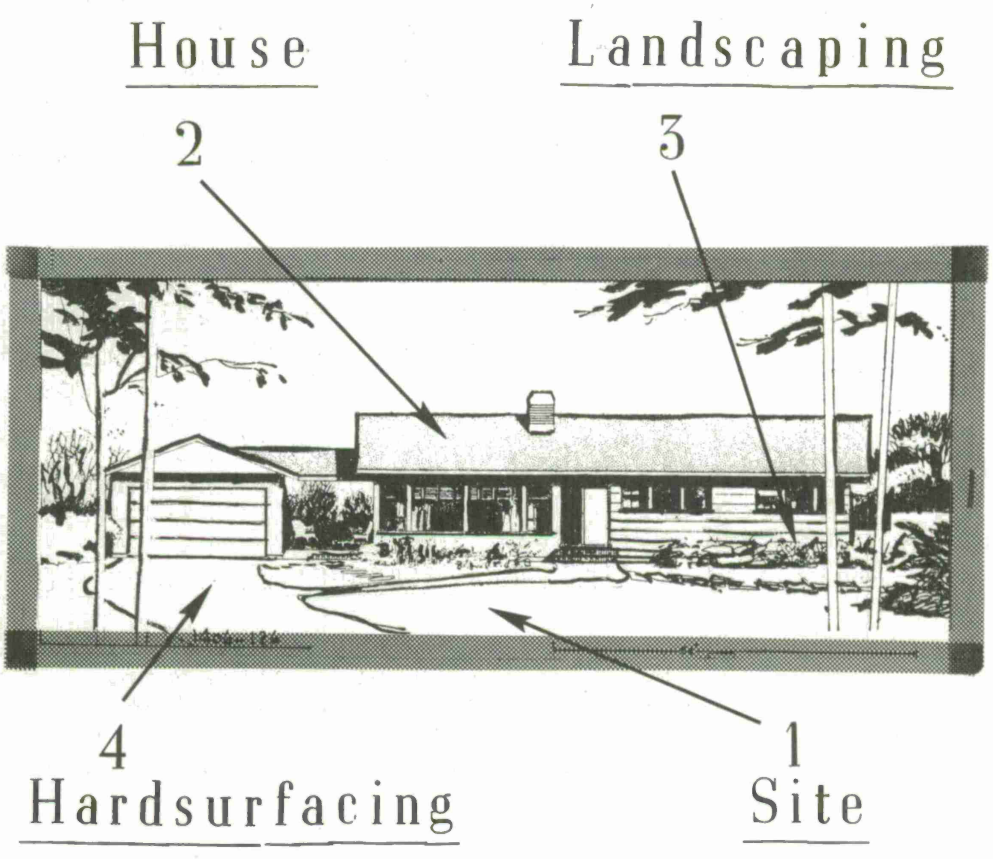
CASE PROBLEM

WORK BREAKDOWN

AND

WORK PACKAGE

IDENTIFICATION



You will probably have your own idea of how the work breakdown should look. The work breakdown shown in Figure IV-1 is not the only possible one that could be established for Project HOME.

Notice that the work breakdown is not complete. The purpose of Figure IV-1 is not to show a complete breakdown but to show you how the breakdown is developed. A breakdown to the sixth level is shown starting from Project HOME and progressing downward to HOUSE - to INTERIOR (of house) - to KITCHEN - to ELECTRICAL and then to WALL OUTLETS and FIXTURES. The other major items shown in the 3rd level could likewise be broken down to lower levels.

In Figure IV-1 notice also that some work packages have been established. Under actual conditions other work packages such as design, masonry, etc. would be included, if you wanted to maintain cost control on them. Also, under actual conditions, you might want to have separate work packages to identify rough carpentry and finish carpentry rather than lump all carpentry costs in one package.

PROJECT HOME WORK BREAKDOWN STRUCTURE

1st Level	2nd Level	3rd Level	4th Level	5th Level	6th Level
1 Project HOME	1 Site	1 Purchase			
		2 Survey			
		3 Grading			
	2 House	1 Foundation			
		2 Exterior			
		3 Interior	1 Living Room		
			2 Dining Room		
			3 Kitchen	1 Electrical	1 Outlets
					2 Fixtures
				2 Plumbing	
				3 Paint	
			4 Bathrooms		
			5 Bedrooms		
	3 Landscape	1 Shrubs			
		2 Lawn			
	4 Hard Surfacing	1 Driveway			
		2 Walks			

WORK PACKAGES

26104 Site work (other than landscaping)
18753 Landscaping
15940 Carpentry
30621 Plumbing
28430 Painting
19256 Hard surfacing
13808 Electrical
20010 House construction - other

FIGURE IV-1

Account Code Structure

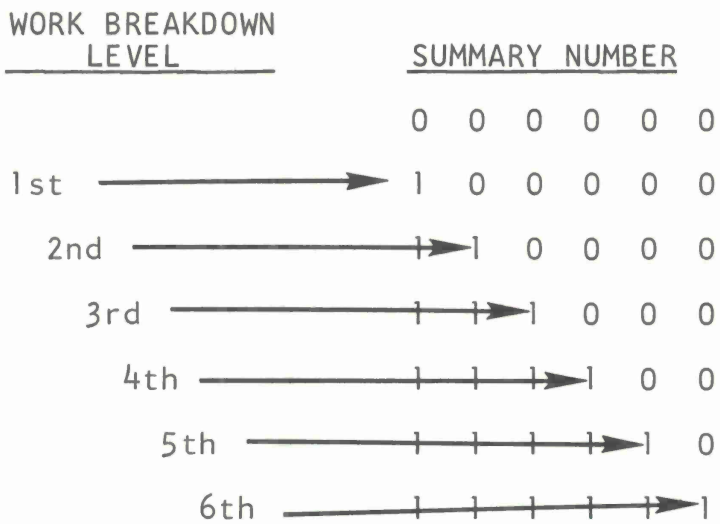
V

The account code structure consists of two types of numbers. One is called "CHARGE NUMBERS" and the other "SUMMARY NUMBERS."

A charge number is assigned by a contractor to each work package with which he is concerned. He will normally use the same numbers he is using in his own cost system.

Summary numbers are assigned to each end item subdivision of the work breakdown structure. The numbers are used to accumulate or summarize costs for each subdivision in the program breakdown.

The size of summary numbers depends on the depth of the work breakdown. In Figure IV-1, note that the breakdown is to the sixth level. This means that the summary numbers for this work breakdown structure must contain 6 digits. The 1st level is assigned the basic summary number "100000" for Project HOME. As summary numbers are assigned to each following level, the digit in the basic number corresponding to the level is used.



Applying the above criteria to the Project HOME work breakdown shown in Figure IV-1, you should be able to see how the following example summary numbers were determined:

SUBDIVISION IDENTIFICATION	SUMMARY NO.
Kitchen electrical outlets	123311
Driveway	141000
Bedrooms	123500
Site	110000

Therefore, if you wanted to summarize the cost for the kitchen in Project HOME, you would have to total the cost associated with all summary numbers having "1233" as the first four digits of the number. The last two digits would not be considered in this case. As you summarize at higher levels, you would control on less digits. For example, controlling on the first two digits "12" of the summary number would summarize cost for the house.

The PERT COST System provides the flexibility for a contractor to assign charge numbers to work packages and summary numbers to end items. Contractors can assign charge numbers which have significance to their existing accounting systems without regard to the PERT COST summary requirements. For contractors having a functional account code structure, the costs of the work packages can be summarized for progressively higher levels of functional management, such as engineering, manufacturing, and testing. Although summary numbers never appear in the contractor accounting system, the PERT COST System will regroup the contractor assigned charge numbers so that summarizing up through the work breakdown structure is accomplished to satisfy the Program Manager's requirements.

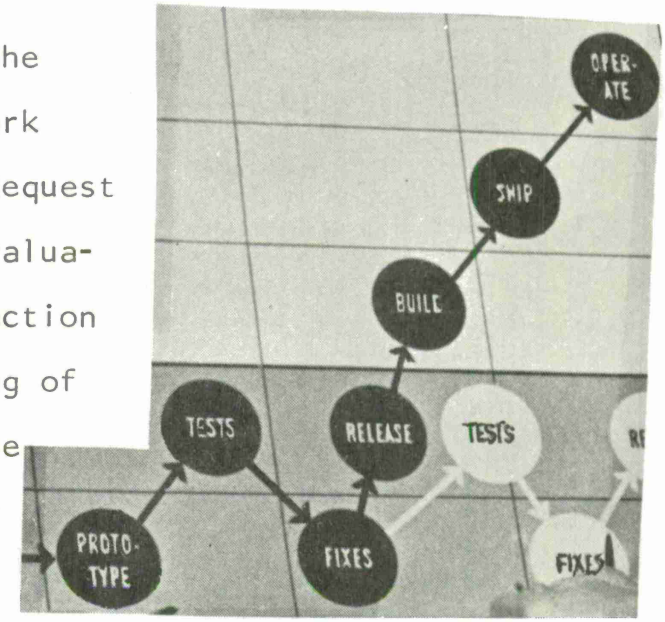
Networking VI

As previously stated, this pamphlet was prepared under the assumption that the reader has an understanding of the PERT TIME technique. The details and logic for constructing a time oriented network will, therefore, not be repeated. In general, the criteria for constructing a PERT TIME-COST network is the same as for a pure PERT TIME network except that, in the case of TIME plus COST, the network must be constructed so that cost data can be associated and recognized within the network structure.

Two types of networks are maintained during operation of the PERT COST System:

* the Program Management Network which is used by the Program Manager to reflect the total program in summary form and
* the Detail Networks which are developed and used by contractors and other agencies as operating level plans for their portions of the program.

There are two versions of the Program Management Network. The first, known as the PRELIMINARY PROGRAM MANAGEMENT NETWORK, is constructed by the Program Manager at the beginning of the program as a planning network to use for:



the preparation of the program plan, the work statement, and the Request for Proposal; the evaluation and source selection period; the conveying of summary events to the contractor and other agencies for their guidance in continuing the program breakdown and preparing detailed networks.

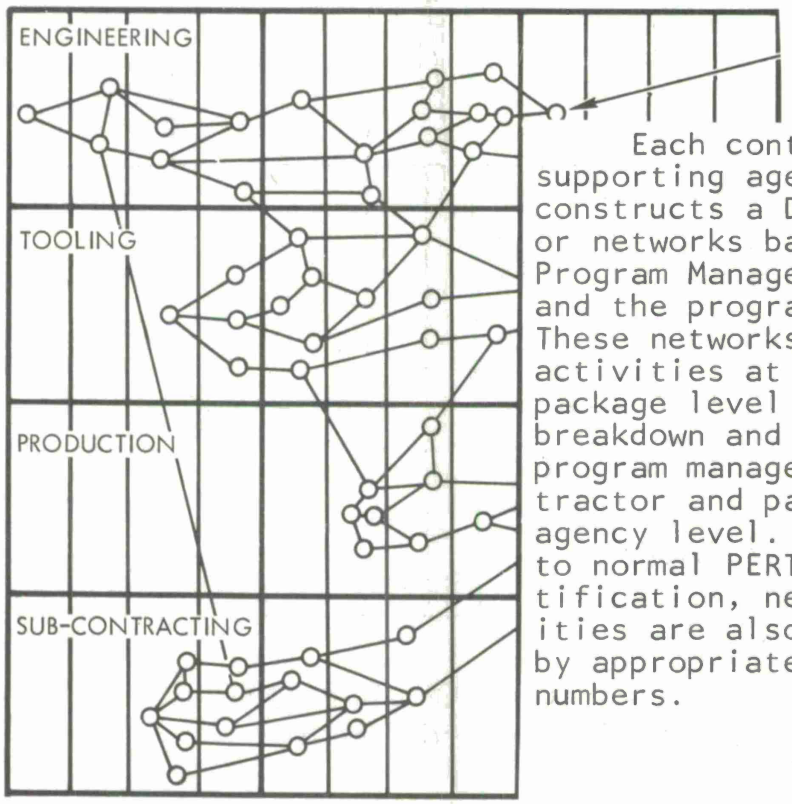
The second, known as the OPERATING PROGRAM MANAGEMENT NETWORK, is developed by the Program Manager in collaboration with all participating organizations after award of contracts. The method of creating the operating version is described later under "Network Integration."

The Program Management Network is a generalized network, yet it must contain the level of detail required by the Program Manager for overall planning and control of the entire program. This network should enable the Program Manager's staff to survey the entire program and quickly ascertain the critical areas insofar

as milestones and schedules are concerned. Program Management Networks must also include the interface events that identify the inputs of the various contributors to the program.

Figure VI-1 illustrates the general concept of developing an Operating Program Management Network. Each contractor and other agency prepares a detail network representing his area of responsibility. The summarization and integration of these detail networks produces the Operating Program Management Network. Summarized networks are established by each contractor and agency for the portion of the program concerned and submitted to the Program Manager for acceptance. Upon acceptance, the summarized networks of the several contributors are fitted together, through the interfaces, to form the Program Management Network.

The prime or integrating contractor maintains and updates this network giving the results to the Program Manager in accordance with the requirements of the contractual work statement.



Each contractor and supporting agency involved constructs a Detail Network or networks based on the Program Management Network and the program breakdown. These networks reflect the activities at the work package level of the program breakdown and should provide program management at contractor and participating agency level. In addition to normal PERT TIME identification, network activities are also identified by appropriate charge numbers.

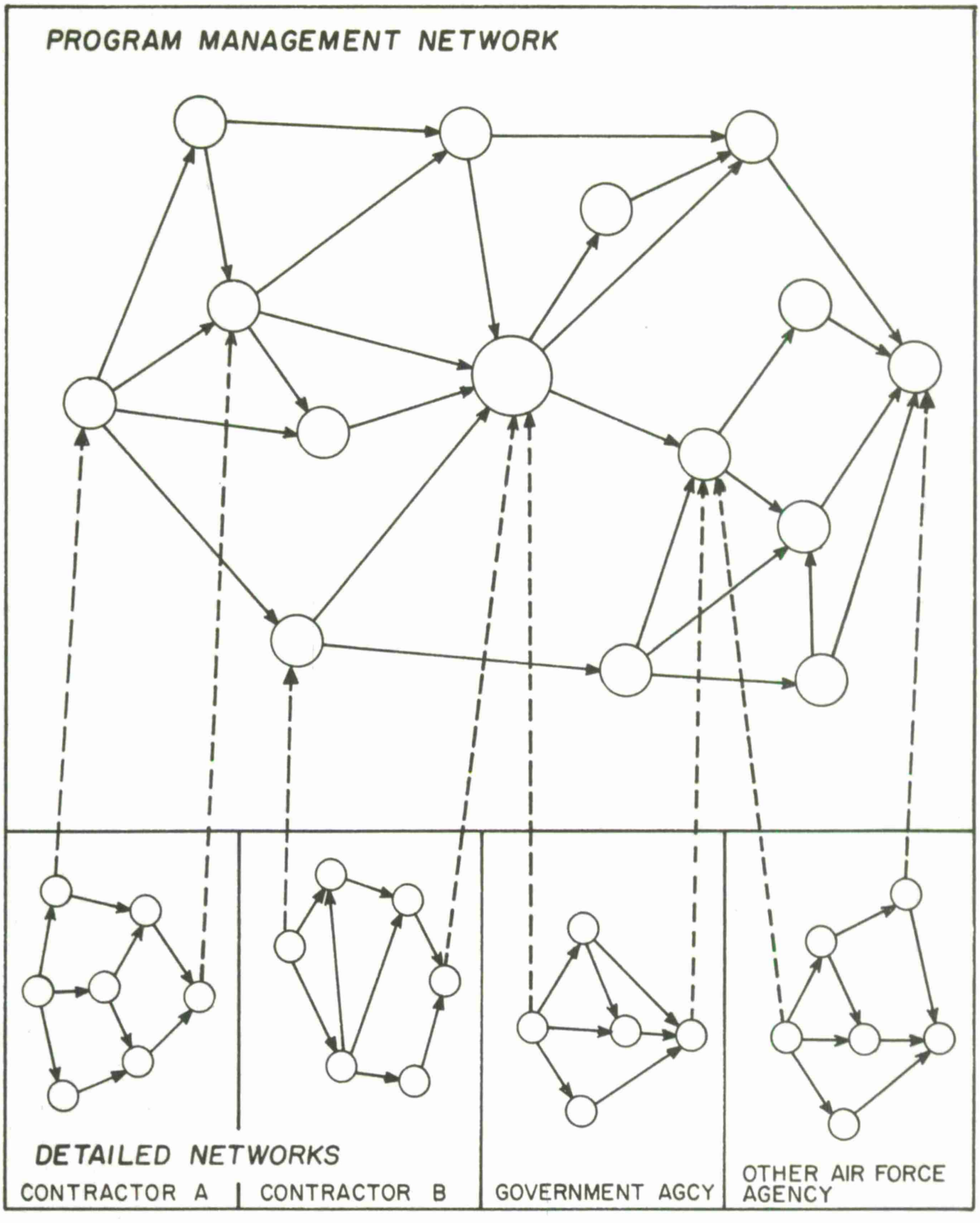


FIGURE VI-1 – DEVELOPMENT OF THE OPERATING PROGRAM MANAGEMENT NETWORK

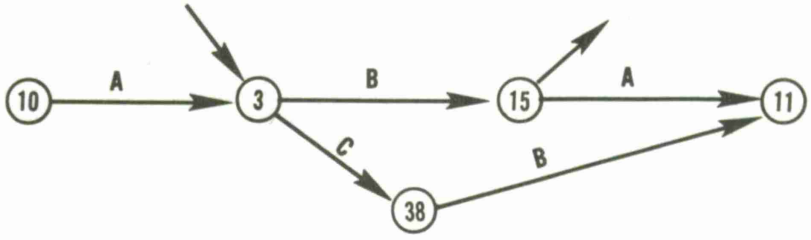
Detail in the initial network should be kept to a level that will readily enable the network data to be computed and analyzed. Too much detail at this time can delay the first analysis of the network. More detail can be added later by:

- breaking up numerous activities in the entire network and inserting more activities and events;
- adding detail to only the most critical areas to provide more detailed information concerning critical paths;
- progressively adding detail to the portion of the plan in the immediate future (say the next three to six months), while maintaining less detail in the more distant future. In most cases, this method is considered the best and is particularly useful in the PERT COST System due to the requirement to estimate the cost of the total program.

Networks may include additional activities not normally required for PERT TIME networks to take care of allowable direct charges to the contract. The system described in this pamphlet involves the use of a common network for both time and cost management. Therefore, there will be some activities on the network for which there are no cost factors involved.

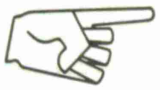
Work packages are generally represented by activities in the Detail Networks. A total work package may sometimes be represented by only a single activity, for example:

or a work package may be represented on a network by a number of activities separated by events which serve as beginning or ending points for other activities in the program, for example:

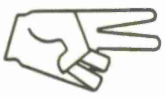


In some cases, work packages may not be represented on the PERT network. For example, work packages for such items as "purchasing" or "travel" (assuming they generate direct charges to the program) may be subdivided to the desired level of the work breakdown structure. In those cases, the costs are accumulated and summarized up the work breakdown structure by including such data in the data input forms for computer processing.

Network integration will be discussed very briefly for two reasons:



network summarization and integration results from proper network coding and by the processing of a computer program for that purpose;



and to fully explain the integration technique would require a detailed explanation of the computer program logic which was not intended for this pamphlet. Therefore, only the principle of network summarization and integration is included.

Network integration consists of three basic steps:

1. summarization of the individual detail networks (see Figure VI-2);
2. integration of the individual summarized networks (see Figure VI-3).

Updating of the interface events in the individual detail networks is then accomplished by updating of the integrated network which can affect the detail network as a whole.

As an example of summarization, note that the computer (by use of a computer program) has identified the path between events "B" and "G" in Figure VI-2 and added all of the activity times along that path to identify a single activity between these two events for a total activity time of 25 weeks. Look at the activities between events "A" and "D". You can see that there are two paths between these events and that the most time consuming path (19 weeks) is included in the summary network.

The summary technique is applied for the purpose of reducing a network to a "minimum." This "minimum" is defined by the user by specifying the events he wishes included in the summary network. The computer then determines the relationships between the specified events to form the summary network.

All interface events must be included in the summary networks. Other events of special significance (major milestones) can also be included. Note in Figure VI-3 that event "C" is an interface with the summary network below whereas event "D" would be a major milestone within its summary network.

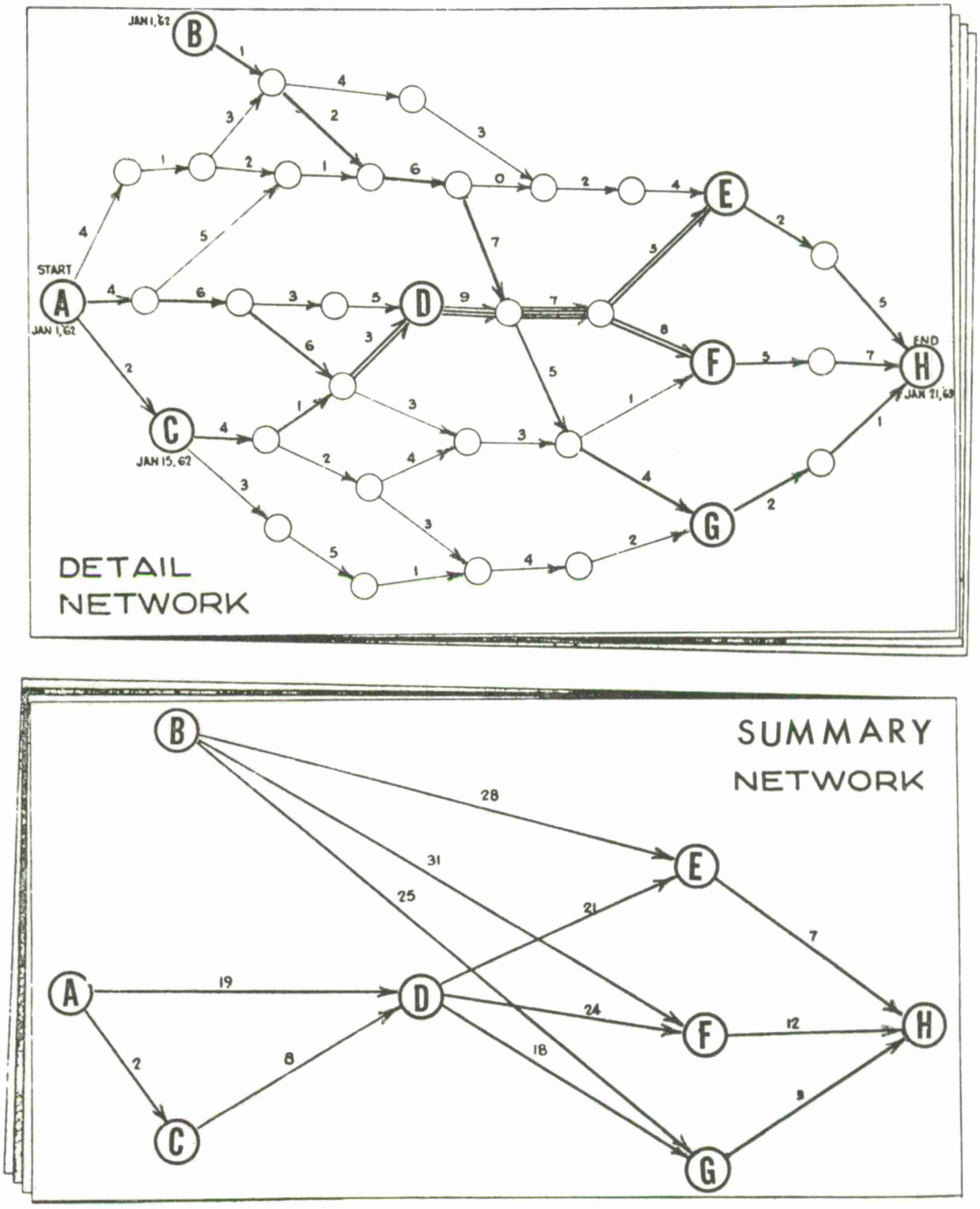


FIGURE VI-2 Network Summarization

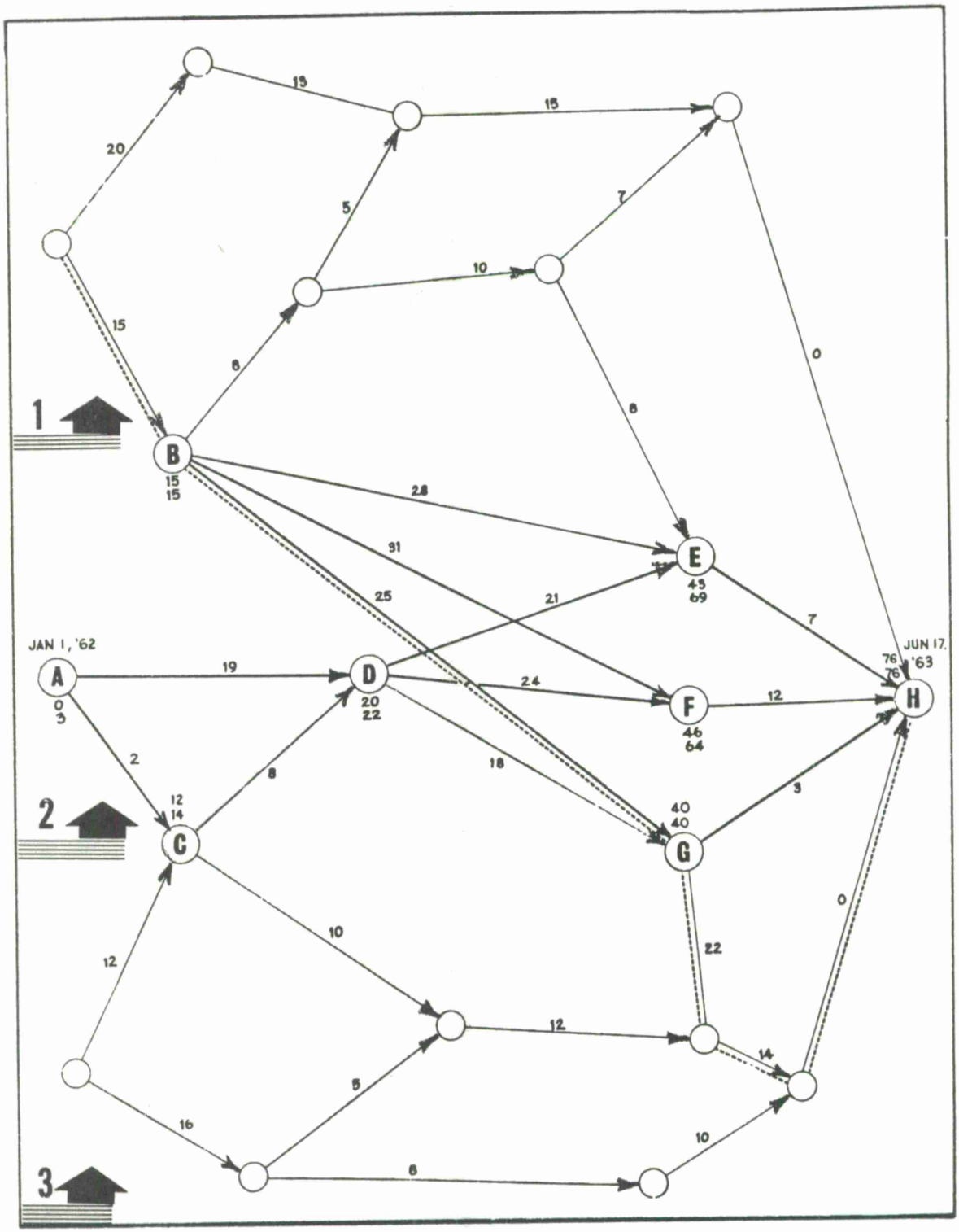


FIGURE VI-3 **Integration of 3 Summary Networks**

NETWORKING THE CASE PROBLEM

Let's take the case problem now and apply what has been discussed up to this point and establish the required networks. For the purpose of this pamphlet, the networks, including the detail networks, must be kept small. Under actual conditions you can imagine how much more detailed the networks could be depending on the degree of management control you would want to establish from the start to the end of Project HOME.

In addition to the assumptions and requirements included in Appendix A for the case problem, we will also establish the following to facilitate working of the problem:

You are the Program Manager for Project HOME and will need a Program Management Network (Event numbers in 100 series).

You have separate contractors for the following work and each of these contractors will establish detail networks which you will have summarized for integration into your Program Management Network.

- Contractor A. SITE PREPARATION (Event numbers in 200 series).

- Contractor B. HOUSE CONSTRUCTION In this case, the contractor has included electrical, plumbing and painting work in his contract (Event numbers in 300 series).

- Contractor C. LANDSCAPING (Event numbers in 400 series).

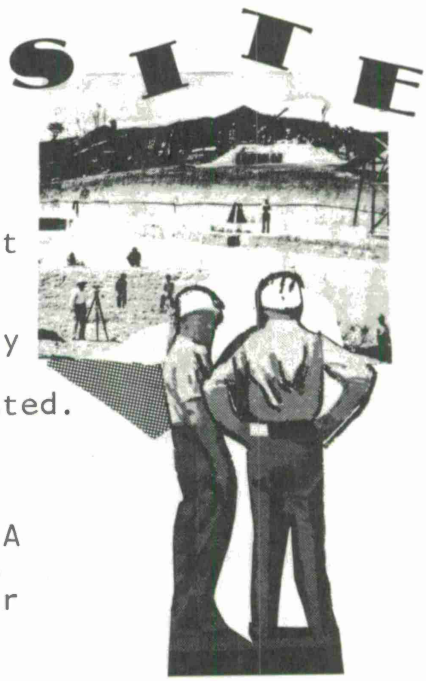
- Contractor D. HARD SURFACING (Event numbers in 500 series).

NOTE: The USAF PERT operation on which this pamphlet is based requires an 8-digit event number but we will use a 3-digit number with this problem, as it will be easier to read and will serve the purpose.

Before you take a look at the networks you may want to review the case problem and the work breakdown structure for Project HOME to refresh your memory. A brief explanation is associated with each network but a clear understanding on your part of the problem and work breakdown should help in more readily understanding the networks.

If you are ready, let's take a look at the networks. The detail network is the one submitted by the contractor receiving the award and shows only PERT TIME calculations. To provide simplicity we can either assume that 3-time estimates were used and the t_e's shown on the network resulted from the 3-time estimates or the t_e's represent 1-time estimates if you prefer a 1-time estimate operation. The version of the detail summarized networks indicates how you (the Program Manager) specified the events for data reporting. Keep in mind that at this point we are only talking about PERT TIME. Application of PERT COST to the networks will be explained later.

* CONTRACTOR A's NETWORK
(See Figure VI-4.)



Due to the nature of the work, the contractor's network is very simple. It indicates that he intends to start work 1 week after contract award and will parallel surveying and grading work with the grading continuing approximately 1-1/2 workdays (3/10ths of a week) after surveying is completed.

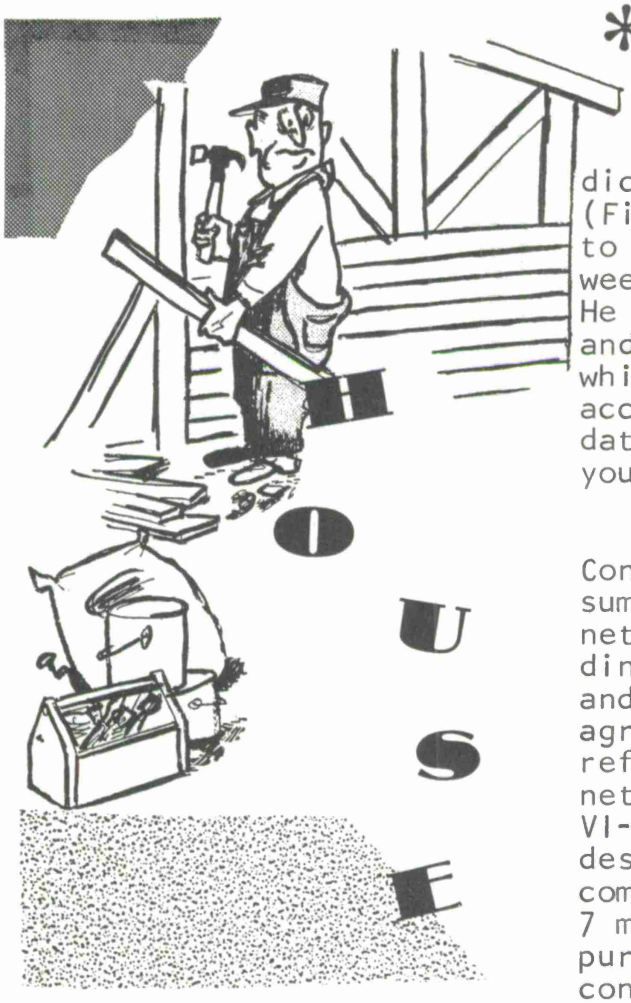
You (the Project HOME Manager) through the summary technique have told Contractor A that you have included only the "Start" and "End" events in your Program Management Network.

FIGURE VI-4 Contractor A Network - Site Preparation

(NETWORK CODE A)

DETAIL NETWORK

SUMMARY NETWORK



* CONTRACTOR B's NETWORK (See Figures VI-5 & VI-6.)

Contractor B has indicated by his network (Figure VI-5) that he expects to complete the house 27.5 weeks after contract award. He has included activities and events in his network which will permit you to accumulate time and cost data, as you indicated in your request for bid.

Now let's see how Contractor B's network was summarized. (The summary network represents a coordinated position between you and Contractor B who has agreed to the changes reflected in the summary network.) Look at Figure VI-6. Remember that you desire to have the project completed in approximately 7 months after you have purchased the land. In this connection, you have told the contractor that:

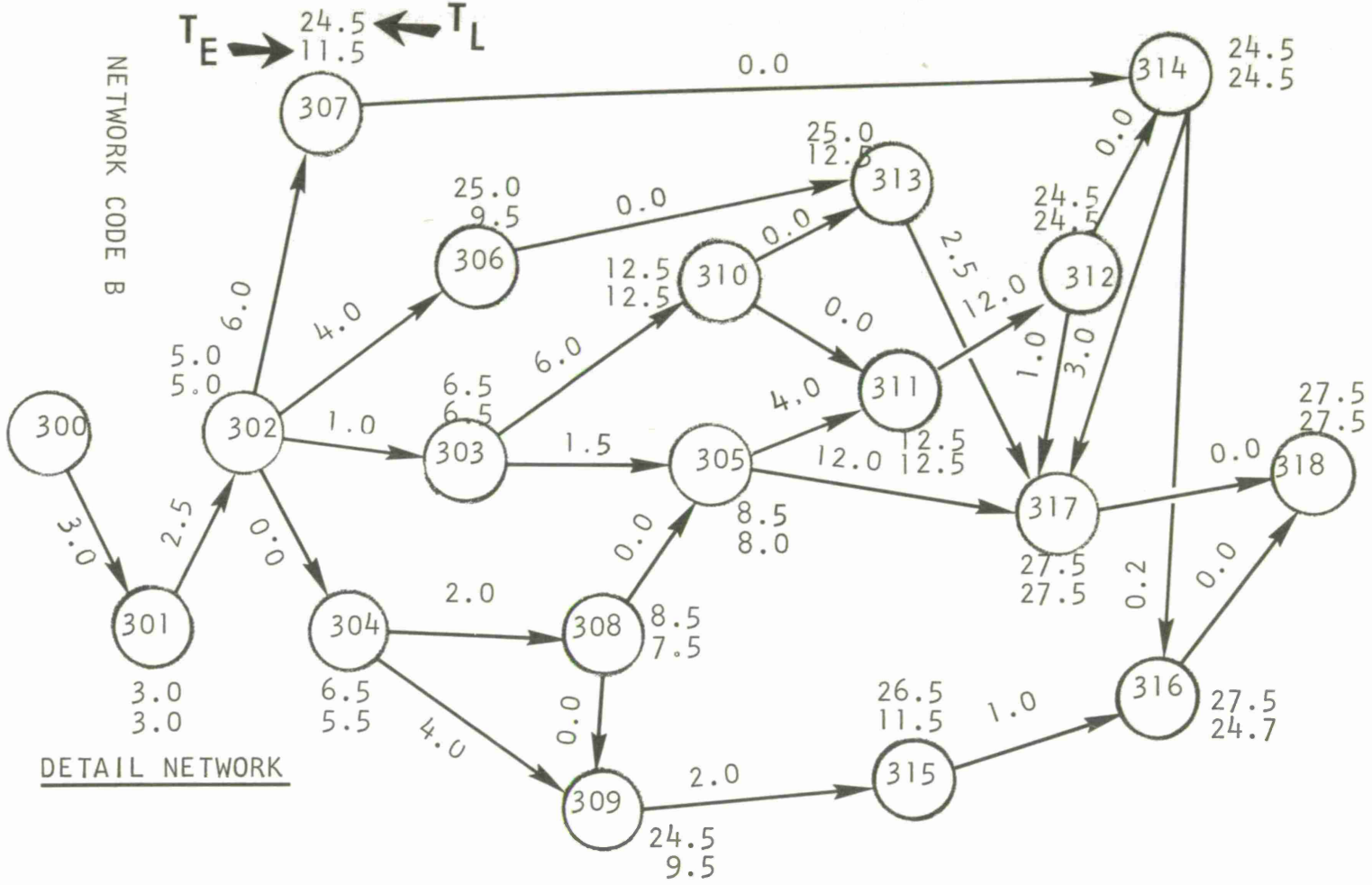
He will have a signed contract on or before 3 June 1964.

His original estimate of 27.5 weeks to complete the house is too long if you intend to stay within the 7-month span for the project. (Five weeks of this 7-month period will already have been used by the time the contract is awarded, as you will be able to see later when you look at the Program Management Network.)

Therefore, the total time has been reduced to 24.5 weeks which results in 3 weeks negative slack along the critical paths in the network. You and the contractor have agreed to try to take care of this excess time by:

FIGURE VI-5—Contractor B Network
House Construction

NETWORK CODE B



300-Cont. Award
301-Found. Comp.
302-Frame Comp.
303-Rough Int. Carp. St.
304-Ext. Carp. St.
305-Fin. Int. Carp. St.
306-Rough Plumb. Comp.
307-Rough Elec. Comp.
308-Roof Comp.
309-Ext. Carp. Comp.
310-Rough Int. Carp. Comp.
311-Int. Paint St.
312-Int. Paint Comp.
313-Plumb. Fix. Ins. St.
314-Elec. Fix. Inst. St.
315-Ext. Paint Comp.
316-Ext. Comp.
317-Int. Comp.
318-House Comp.

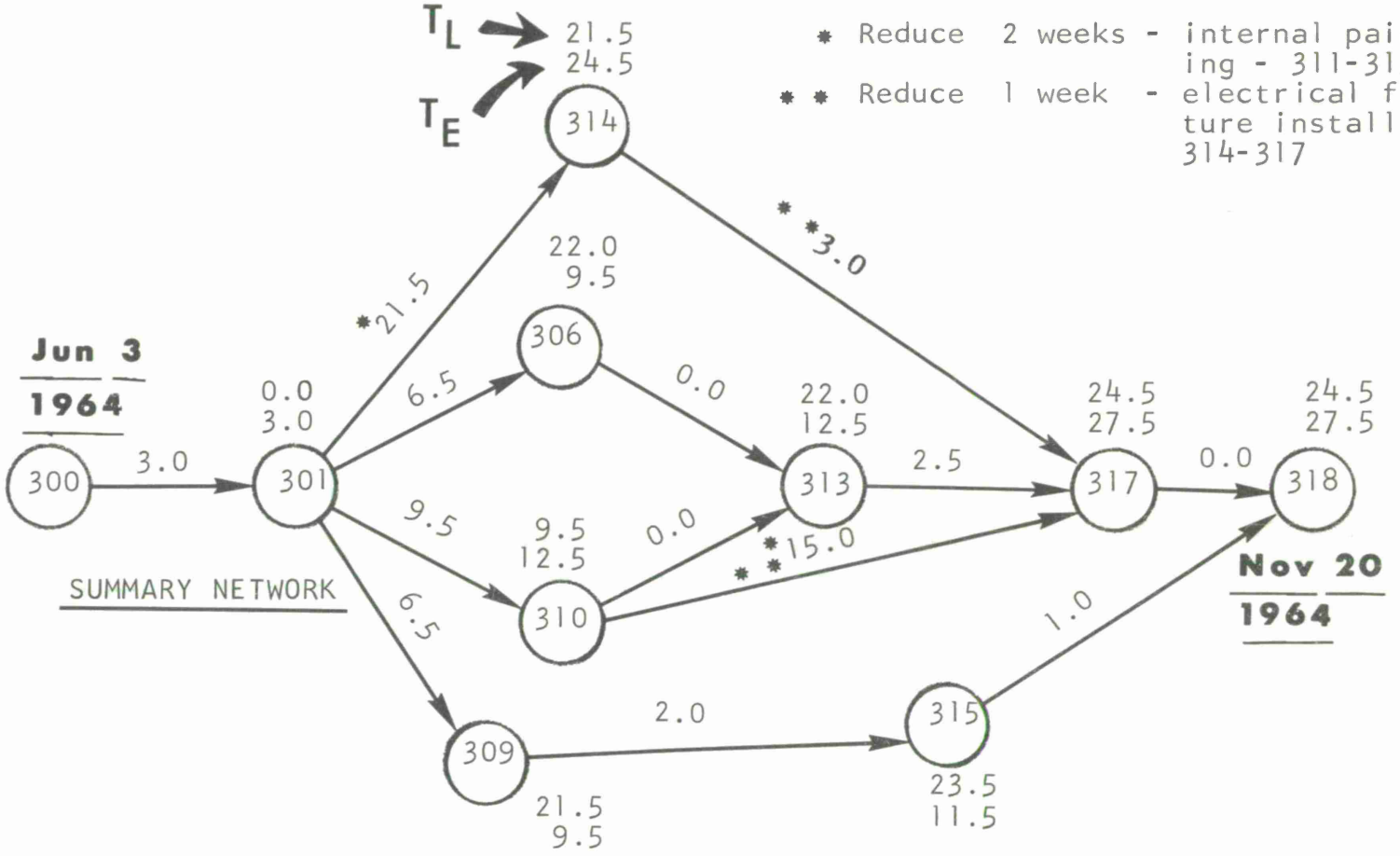


FIGURE VI-6 — Contr. B Summary Network

300 - Cont. Award
301 - Found. Comp.
306 - Rough Plumb. Comp.
309 - Ext. Carp. Comp.
310 - Rough Int. Carp. Comp.
313 - Plumb. Fix. Instl. St.
314 - Elec. Fix. Inst. St.
315 - Ext. Paint. Comp.
317 - Int. Comp.
318 - House Comp.

1. Using quick drying latex interior paint which could reduce the interior painting time from 12.0 weeks to 10.0 weeks (activity 311-312 in detail network).

2. Using an additional electrician in the installation of electrical fixtures which should reduce such time from 3.0 weeks to 2.0 weeks (activity 314-317 in detail network). Also, by completing the interior painting 2 weeks sooner than originally estimated, the electricians could start fixture installation 2 weeks earlier than originally planned.

By taking the above actions, the summary network would be changed as follows:

* Activity time between events 301 and 314 would be reduced from 21.5 to 19.5 weeks, as it includes interior painting time.

* Activity time between events 314 and 317 would be reduced from 3.0 to 2.0 weeks, as it includes electrical fixture installation time.

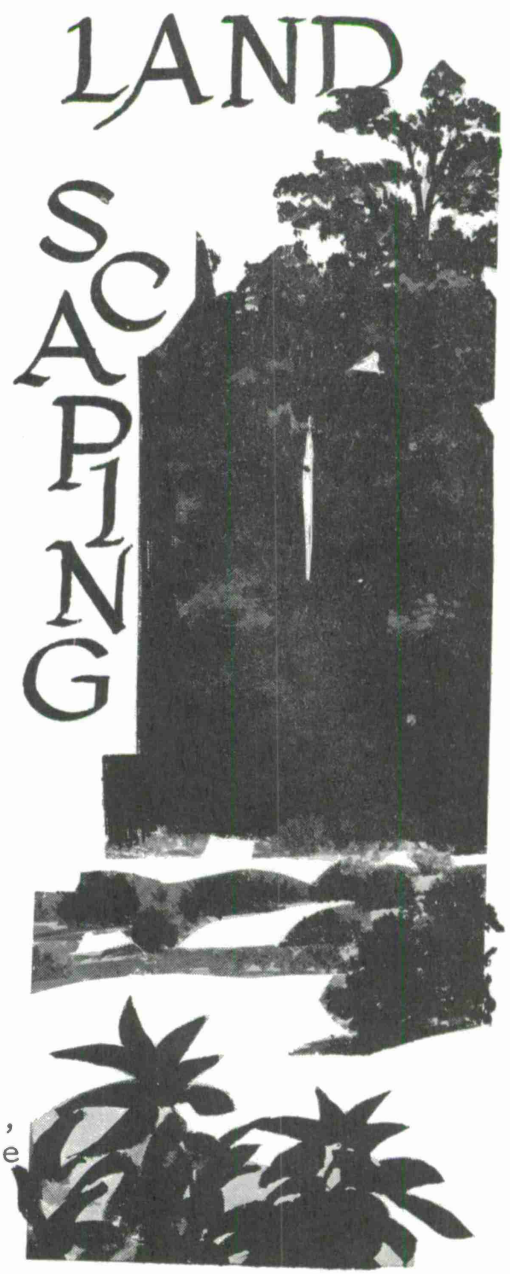
* Activity time between events 310 and 317 would be reduced from 15.0 to 12.0 weeks, as it includes both interior painting and electrical fixture installation time.

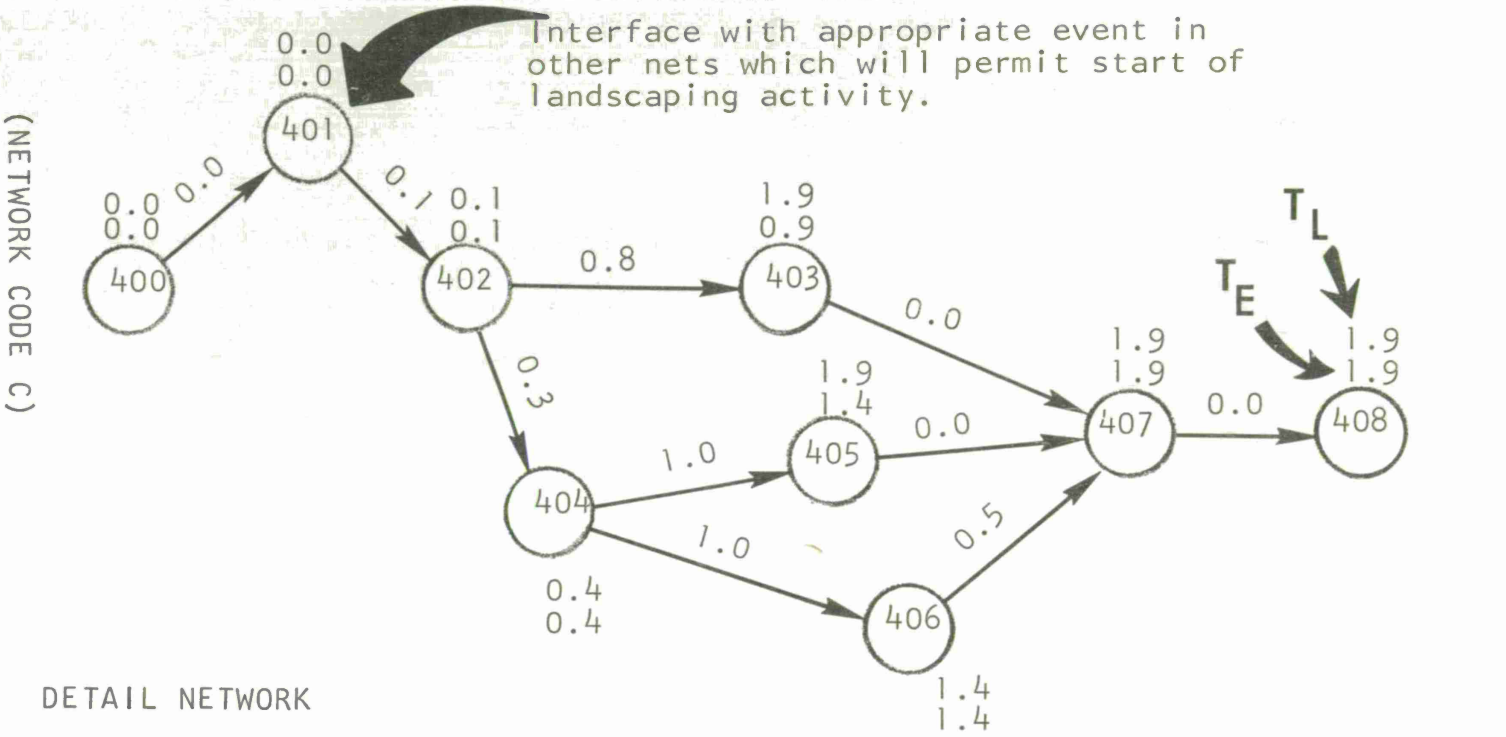
* Both the T_E and T_L for the final event (318) would be 24.5 weeks which would result in zero slack time along the critical path. This would likewise establish a completion date of 20 November 1964.

NOTE: Under normal conditions, the summary network would already reflect the above changes. The summary network is shown in Figure VI-6 as it is so that the negative time condition and actions taken could be illustrated. You will notice later that the changed activity times appear in the Program Management Network.

CONTRACTOR C's NETWORK
(See Figure VI-7.)

Contractor C by his detail network has indicated that he expects to complete the landscaping work 1.9 weeks after he starts work. He considers his immediate job completed after the grass seed is planted (event 407). He could always come back after the house was occupied to see how the lawn and plants were progressing and do any additional work required to comply with the contract. His main problem is knowing when he can start work which must be a point in time when there will be no obstructions to his work such as workmen and trucks needing to use the general land area. For that reason, he has included an interface (event 401) which you and he will have to agree to connect to the Program Management Network which will permit him to start his work at a time of minimum interference. After the Program Management Network is established and the estimated times are converted to calendar dates, he will have an approximate date established for event 401 for starting his landscaping work.





400 - Cont. Award
401 - Interface
402 - Topsoil Delvd.
403 - Topsoil Spread
404 - Plants Delvd.
405 - Shrubs Planted
406 - Trees Planted
407 - Lawn Seeded
408 - Landscap. Comp.

FIGURE VI-7 — Contractor C Network
Landscaping
(NETWORK CODE C)

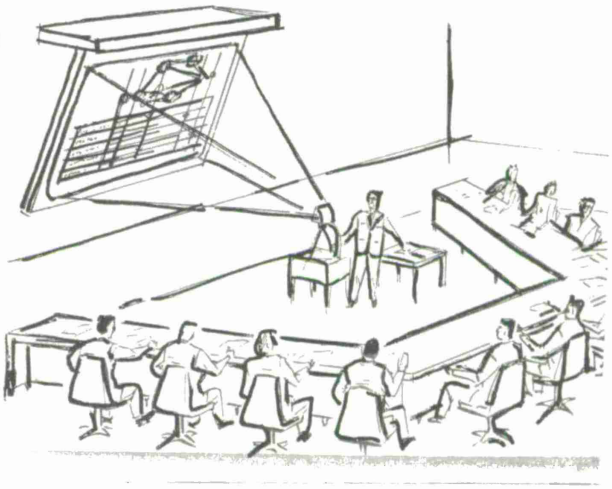
In the summary network notice that you picked up the interface for your Program Management Network and you also included event 406 which is along the critical path. The duration of this work is so short (1.9 weeks) that only the start and end events would be included under actual conditions.

Hard Surfacing

CONTRACTOR D's NETWORK (See Figure VI-8.)

The logic for Contractor D's network and summarization is the same as for Contractor C; so there isn't much point in discussing the networks shown in Figure VI-8.

PROGRAM MANAGEMENT NETWORK (See Figure VI-9.)

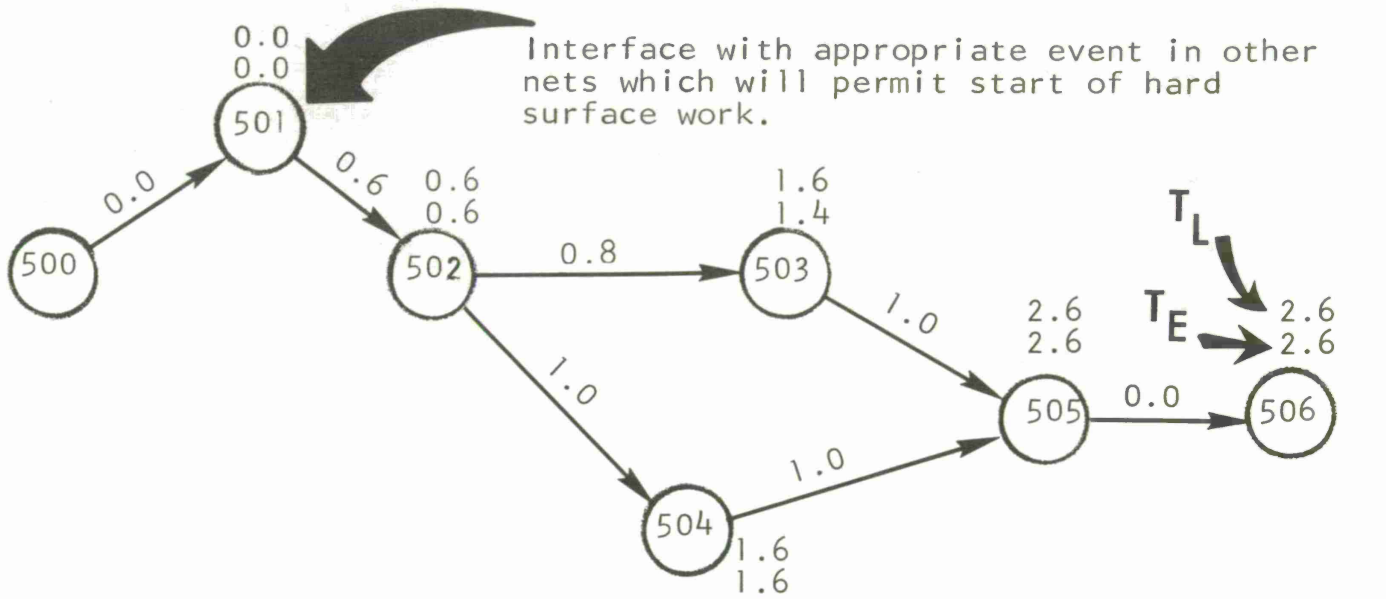


You, as the Program Manager, must now develop your Program Management Network using and interfacing the contractors' summary networks and adding events and activities which are important to your administration. So take a look at Figure VI-9 and let's see how you could have accomplished this based on the following assumptions and guidelines.

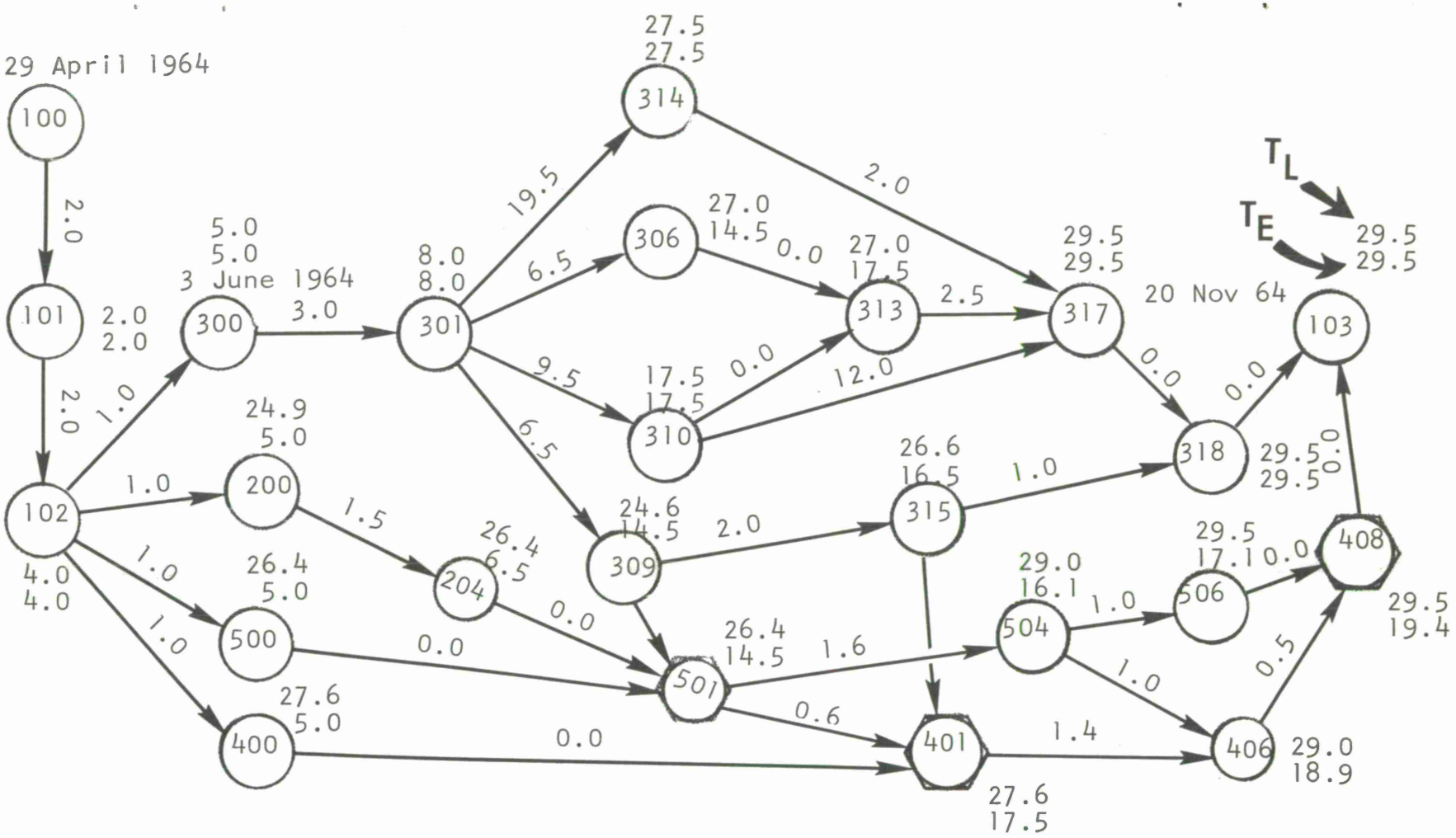
On 29 April 1964 purchase of the land was completed (event 100) and during the following 4 weeks the project plans were completed (event 101) and bids solicited and received (event 102).

FIGURE VI-8 — Contractor D Network
Hard Surfacing

NETWORK CODE D



500 - Cont. Award
501 - Interface
502 - Excavations Comp.
503 - Driveway Comp.
504 - Walks Comp.
505 - Curing Comp.
506 - Hard Surface Comp.



100 - Land Acquired
101 - Plans Comp.
102 - Bids Rec'd
103 - Project Comp.
200 - Site Prep. Cont. Award
204 - Site Prep. Comp.
300 - House Const. Award
301 - Found. Comp.
306 - Rough Plumb. Comp.
309 - Ext. Carp. Comp.
310 - Rough Int. Carp. Comp.
313 - Plumb. Fix. Inst. St.
314 - Elec. Fix. Inst. St.
315 - Ext. Paint. Comp.
317 - Int. Comp.
318 - House Comp.
400 - Landscape Cont. Award
401 - Landscape Work St.
406 - Planting Comp.
408 - Landscaping Comp.
500 - Hard Surface Cont. Award
501 - Hard Surface Work St.
504 - Walks Comp.
506 - Hard Surfacing Comp.

FIGURE VI-9 — Program Management Network

➧ One week is determined necessary to evaluate the bids, negotiate and make awards (events 200, 300, 400 and 500). Here you can see why you worked with the house contractor to reduce his total time estimate by 3 weeks to try to complete the project in approximately 7 months. Look at the path through events 100-101-102-300 and you can see that 5 weeks of the 7 months will already have been used by the time the house contractor receives the award.

➧ The house contractor's summary network (300 series events) and site preparation network (200 series events) can be easily identified.

➧ The hard surfacing work (500 series events) cannot start until certain progress has been made on the total project at which point the "hard surface work start" event must interface. So, on the network you will notice that event 501 interfaces with events 204 and 309. Site preparation has to be completed and the exterior of the house should be basically completed before any hard surfacing is started. When the hard surfacing work actually starts is another question. Note that event 501 has 11.9 weeks of positive slack. Based on the actual completion dates for events 204 and 309 plus the overall progress being made on the project you will later on have to notify the hard surfacing contractor of a specific date on which he can start work so that his work can be completed within the deadline for the project. Even though all activity is on time, you cannot allow him the full 11.9 weeks slack. Do you see why? Because there is a slack path of 10.1 weeks which is constrained by the hard surfacing activity. We will get into scheduling later at which time we will continue with these networks.

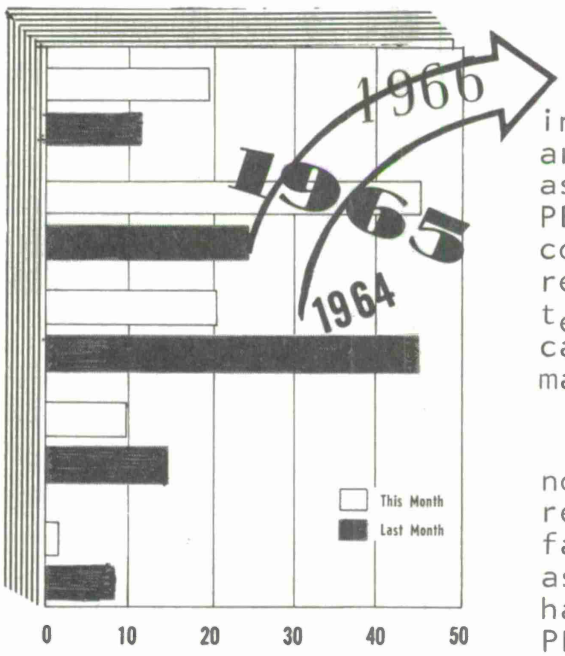
➧ Finally, let's look at the landscaping portion (400 series events) of the network. The "start" interface in this case is tied in with events 501 and 315. Landscaping should not start until a certain period of time after hard surfacing work has started to allow for construction of forms for the driveway and walks, truck traffic, etc. Such things as delivery of topsoil could be started

at this time. Likewise, landscape completion (event 408) is tied in with event 506 because you would not want shrubs or grass seed planted along walks and driveway while they were still being worked on. Maybe you didn't recognize it at the time but, if you will look at events 503, 504 and 505 in the detail network in Figure VI-8, you will notice that 1 week is allowed for driveway and walk curing before the landscape work is considered complete which is event 506 and which constrains the landscaping completion event (408) in the program management network. When you are in a position to notify the hard surfacing contractor of a specific start date for event 501, you will also be able to notify the landscape contractor of a start date for event 401.

So much for networking the case problem, let's take up network scheduling which is necessary for a PERT COST operation.

Timing & Scheduling

VII



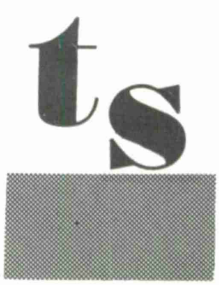
Activities and events in a network for PERT COST are assigned scheduled times as compared to a strictly PERT TIME network which contains expected times represented by the symbols t_e, T_E and T_L. In both cases, directed dates (T_D) may be included, however.

Time estimating will not be discussed for the reason that you should be familiar with the subject assuming that you already have an understanding of PERT TIME.

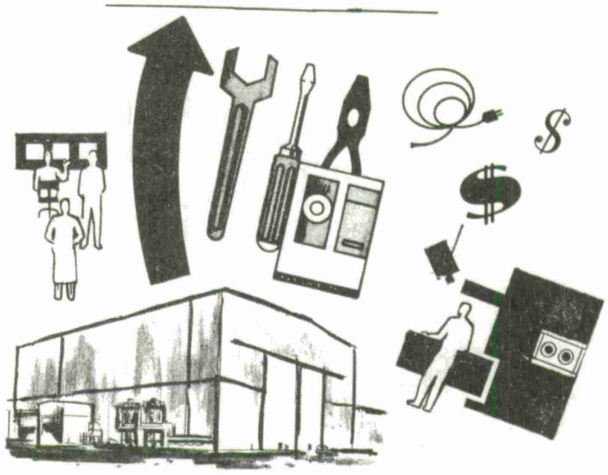
Regardless of time scheduling for PERT COST, a planning network not influenced by schedules but based on the program work breakdown should be constructed prior to use of the network for scheduling. That is what we have done up to this point with the Project HOME networks.

In PERT COST, you must become acquainted with the symbols t_s, T_S, S_E and S_L.

Schedules must be established in the network down to work package level identification. Practical problems in some cases will prevent establishing schedules. When this condition exists, either the one-time estimate or t_e resulting from a three-time estimate should be processed as though it were scheduled time (t_s).



SCHEDULE



A program plan is translated into a schedule by assigning specific resources and facilities to accomplish the planned tasks within certain calendar time periods. Consequently, the process of scheduling involves not only the precedences and dependencies inherent in the work to be performed, but also the availability of particular resources and facilities within specific time periods.

The scheduled elapsed time (t_s) may be shorter, the same as, or in some cases even longer than the expected elapsed time (t_e) previously determined for the same activity.

Scheduling may be by work package rather than activities. Large packages of work may first be blocked into so-called master schedules, which are then used as a control in further scheduling each activity, or each activity may first be scheduled as a single unit. In either case, the desired goal is the establishment for control purposes of an integrated calendar time-phased plan, using the specified time, cost, and resources that will achieve the program objectives.

Even though the t_e's for the activities on the longest path in a network sum to a T_E for the total program that is equal to a directed completion date, the individual t_e values do not necessarily represent a useful schedule except as a <u>starting point</u>. Factors that must be considered for a PERT COST operation are:

- the availability of the required manpower, equipment, and facilities during specific calendar periods;
- the minimizing of premium costs and idle time for manpower, equipment, and facilities;

- funding limitations;
- the manager's judgment as to what is a reasonable time to allow for performing the work.

After considering the above scheduling factors, a manager establishes scheduled elapsed times (t_S) which are then converted to scheduled completion dates (T_S). This schedule then constitutes the time plan for the program until such time as a change is required as a result of such conditions as slippages in the work, changes in the program objectives, changes in resource availability, etc.

The above is a broad brush on scheduling. Let's learn more about specific scheduling and what the scheduling symbols represent.

SCHEDULED ELAPSED TIME FOR AN ACTIVITY - t_s

The symbol t_s represents the period of time assigned for performing an activity. It is used in determining the scheduled earliest (S_E) and latest (S_L) completion dates for activities. The t_s is comparable to the t_e in a strictly PERT TIME network.

EARLIEST COMPLETION DATE FOR AN ACTIVITY - S_E

This is the earliest calendar date on which an activity can be completed. The date is determined by adding the scheduled elapsed times (t_s) for the activities on the longest path from the beginning event in the network to the event concerned. The total t_s is then converted to a date by adding it to the calendar date for the beginning event used in the calculation. For activities which have not been assigned a t_s, the t_e for such activities will be recognized as the t_s and will be used in determing the S_E.

LATEST COMPLETION DATE FOR AN ACTIVITY - S_L

This is the latest calendar date on which an activity can be scheduled for completion without delaying the completion of the total program. The date is determined by adding the t_s for activities along the longest path from the end of the work effort concerned (completion event) to the end (final event) of the program. The total t_s is then converted to a date by subtracting it from the calendar date established for completion of the program. If a t_s has not been assigned to an activity, the t_e for the activity is recognized as the t_s and is used in calculating S_L.

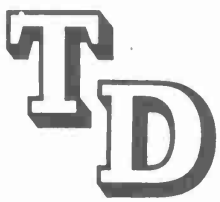
SCHEDULED COMPLETION DATE FOR AN ACTIVITY OR EVENT - T_S

This is a specific date assigned for completion of an activity or an event for purposes of planning and control <u>within</u> an organization. When a specific T_S is not assigned, the S_E for the activity (event) is also considered as the T_S.

Now that you know all about the scheduling symbols and what they represent, let's take a quick look at activity and event scheduling and directed dates.

Network activity scheduling identifies the content and timing of the work to be accomplished. This could cover a large segment of the network, such as all the carpentry work included in the case

problem network shown in Figure VI-5 or just a portion of the carpentry work represented by activity 303-310. In either case, the network must show scheduled activity (t_s) rather than expected elapsed time (t_e) and calculated completion dates (S_E) rather than expected occurrence (T_E).



A program manager is concerned with specific dates for significant decision points or events in a program. He determines such dates and assigns them to the events. This is event scheduling. Event scheduling, rather than activity scheduling, is therefore used on the Program Management Network. A scheduled date (T_S) may be evaluated at any time by comparing it with the most recently calculated expected date (T_E) for its event. These scheduled dates may be "Directed Dates" or "Desired Dates" or a combination thereof.

A directed date is identified by the symbol T_D and is usually a date established by an office or agency to which a program manager is subordinate. A desired date is one that is normally determined and assigned by the program manager.

SCHEDULING THE "PROJECT HOME" NETWORKS

First, we will take the Program Management Network and determine and assign scheduled dates to the events. Look at Figure VII-1. Note that the events are arranged in T_E time sequence as shown in Figure VI-9 as we want to compare the PERT TIME estimated elapsed time (T_E) with the PERT COST scheduled completion date (T_S). At the time the schedule is initially established, the resulting S_E, by definition, should equal T_S for all network activities. After a program is underway and changes occur, the calculated S_E will move ahead or behind the T_S for an activity. As the program progresses, replanning will result in closer alignment of the S_E and T_S dates. In scheduling the program management network we have made certain decisions which you would be required to do had you

EVENT NO.	EVENT TITLE	(WEEKS) T_E	T_E DATE (1964)	SCHEDULED (T_S) DATE (1964)
100	Land Acquired	-	-	Apr 29
101	Plans Complete	2.0	May 13	May 13
102	Bids Received	4.0	May 27	May 27
200	Site Preparation Contract Awarded	5.0	Jun 3	Jun 3
300	House Const. Contract Awarded	5.0	Jun 3	Jun 3
400	Landscaping Contract Awarded	5.0	Jun 3	Jun 3
500	Hard Surfacing Contract Awarded	5.0	Jun 3	Jun 3
204	Site Preparation Complete	6.5	Jun 12	Jun 10
301	Foundation Complete	8.0	Jun 24	Jun 24
306	Rough Plumbing Complete	14.5	Aug 7	Aug 7
309	Exterior Carpentry Complete	14.5	Aug 7	Aug 19
501	Hard Surfacing Work Start	14.5	Aug 7	Nov 7
504	Walks Complete	16.1	Aug 19	Nov 15
315	Exterior Painting Complete	16.5	Aug 21	Aug 21
506	Hard Surfacing Work Complete	17.1	Aug 26	Nov 20
310	Rough Interior Carpentry Complete	17.5	Aug 28	Aug 19
313	Plumbing Fixtures Install. Start	17.5	Aug 28	Aug 19
401	Landscape Work Start	17.5	Aug 28	Nov 13
406	Planting Complete	18.9	Sep 9	Nov 25
408	Landscaping Complete	19.4	Sep 11	Nov 27
314	Electrical Fixtures Install. Start	27.5	Nov 6	Nov 6
317	House Interior Complete	29.5	Nov 20	Nov 20
318	House Complete	29.5	Nov 20	Nov 20
103	Project HOME Complete	29.5	Nov 20	Nov 27

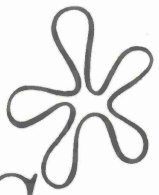
FIGURE VII-1

Estimated and Scheduled Times for Case Problem

scheduled the events, and we have also accepted some decisions made by your contractors in coordinating the scheduling with them.

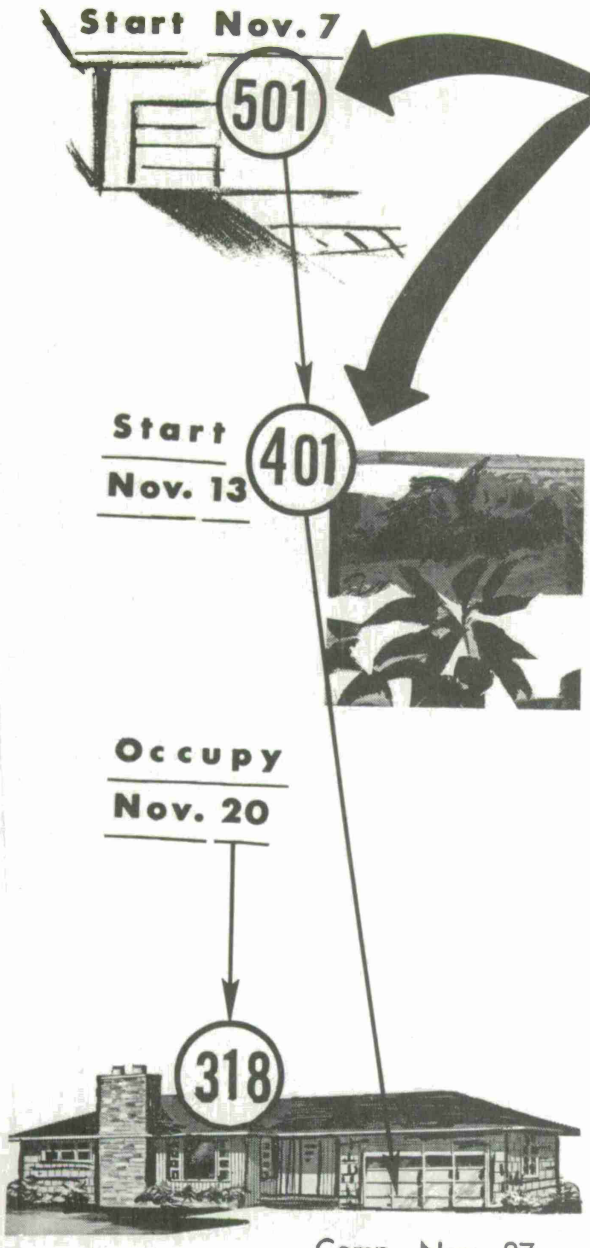
Site Time Reduction

The site preparation contractor intends to complete his work by June 10th instead of June 12th as originally planned so that he can move his equipment to meet a start date on another job. We agreed with his intent. This action established a t_s time of 1.0 weeks for activity 200-204 as compared to the estimated t_e time of 1.5 weeks.



Carpentry–Plumbing Time Adjustment

The house contractor has agreed to shift some carpentry effort so that the interior rough carpentry (event 310) will be completed on Aug 19th instead of Aug 28th. He will do this by extending completion of the exterior carpentry work (event 309) to Aug 19th. This will permit installation of plumbing fixtures (event 313) to start 1.5 weeks sooner than originally planned.

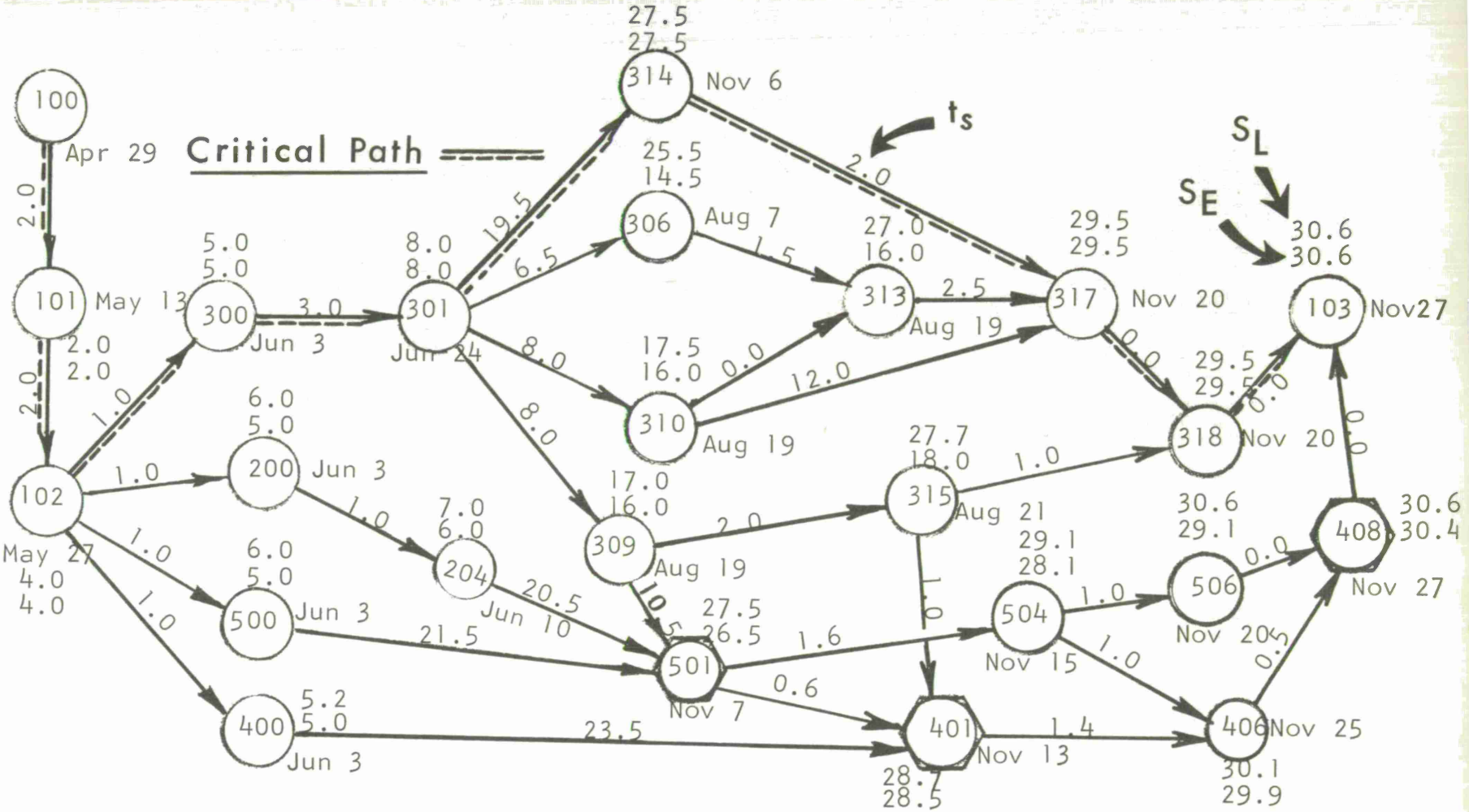


These two events identify the starts for the hard surfacing and landscape work. Remember, we stated earlier that definite start dates would have to be established for these two events based on the planned progress of the project as a whole. In addition, let's assume that you decided you would like to be in your new home about a week before the landscaping is completed so that you can sort of oversee the work. You have not changed the house completion (event 318) date which is Nov 20th. Therefore, if you moved into your home on Nov 20th, you would schedule the landscaping completion (event 408) for Nov 27th. So going backward from that date through event 406 to 401, you would schedule the start for landscaping work for Nov 13th. You still want the hard surfacing work to start 0.6 weeks before the landscaping work starts so that would establish a start date of Nov 7th (3 workdays) for event 501.

For the balance of the events on your program management network not affected by the above decisions and to keep the case problem from becoming too involved, we decided that the T_E dates will be recognized as the scheduled dates at the present time. You could establish distinct scheduled dates later on for any of these events as the project would progress under actual conditions.

How does all of this affect the original PERT-TIME network? Look at Figure VII-2. Here you have the project network reflecting PERT COST times and dates. Compare it to the pure PERT TIME network shown in Figure VI-9. The layouts are the same but you will notice the differences, in some cases, between the estimated elapsed times (PERT TIME) and scheduled elapsed times (PERT COST). Did you notice also that by adjusting the carpentry effort to accomplish events 309 and 310 you eliminated the "most" critical path running through event 310 in Figure VI-9. You now have 1.5 weeks positive slack time for event 310.

Otherwise, the most critical path is the same on both networks. Another thing - look at the activity times between events 309-501, 204-501, 500-501 and 400-401 on both networks. The zero activity times for these activities shown in Figure VI-9 indicate that there is actually no time being consumed but that events 309, 204 and 500 have to be completed before event 501 can start and event 400 has to be completed before event 401 can start. The T_E of 14.5 weeks for event 501 indicates that this event is expected to start about Aug 7th which is not true because a scheduled date had to be established for the start of this event. The scheduled activity times of 10.5, 20.5, 21.5 and 23.5 shown for these activities in Figure VII-2 would indicate that time is to be consumed. This is true but these times are not being consumed by work efforts but are included simply for the fact that they are "waiting" periods of time <u>from</u> the completion times for events 309, 204, 500 and 400 <u>to the scheduled start dates</u> for events 501 and 401, as the case may be. For this reason, the positive slack time of 1.0 and 0.2 weeks shown along the site, hard surfacing and landscape work paths is not exactly true. There could be considerable slippage in activities 500-501 and 400-401 without jeopardizing the project completion date because of the "waiting time" cushion. However, regardless of the "waiting time," you would have to watch the completion of event 204 because any delay in its completion would most likely cause a delay in the completion of event 301. Likewise, any delay in the completion of event 309 beyond 10.5 weeks (which would be most unlikely in this type project) would require you to reschedule a later start date for event 501.



100 - Land Acquired
101 - Plans Comp.
102 - Bids Rec'd
103 - Project Comp.
200 - Site Prep. Cont. Award
204 - Site Prep. Comp.
300 - House Const. Award
301 - Found. Comp.
306 - Rough Plumb. Comp.
309 - Ext. Carp. Comp.
310 - Rough Int. Carp. Comp.
313 - Plumb. Fix. Inst. St.
314 - Elec. Fix. Inst. St.
315 - Ext. Paint. Comp.
317 - Int. Comp.
318 - House Comp.
400 - Landscape Cont. Award
401 - Landscape Work St.
406 - Planting Comp.
408 - Landscaping Comp.
500 - Hard Surface Cont. Award
501 - Hard Surface Work St.
504 - Walks Comp.
506 - Hard Surfacing Comp.

FIGURE VII-2 — PROGRAM MANAGEMENT NETWORK (PERT-COST)

Zero times for these "waiting" activities could also have been assigned to the Figure VII-2 network and the computer instructed to consider the scheduled date of Nov 7th for event 501 on its own merit.

As a result of establishing the scheduled network shown in Figure VII-2, the contractors' detail and summary networks would also have to be scheduled for PERT COST. We didn't include them because we hope that we have put the estimate time versus schedule time point across by now. Maybe you would like to take the PERT TIME detail networks and schedule them based on the Figure VII-2 network. It isn't too difficult. You will have to make some decisions of your own. For example, which activities in the detail network would you change to take care of the carpentry effort?

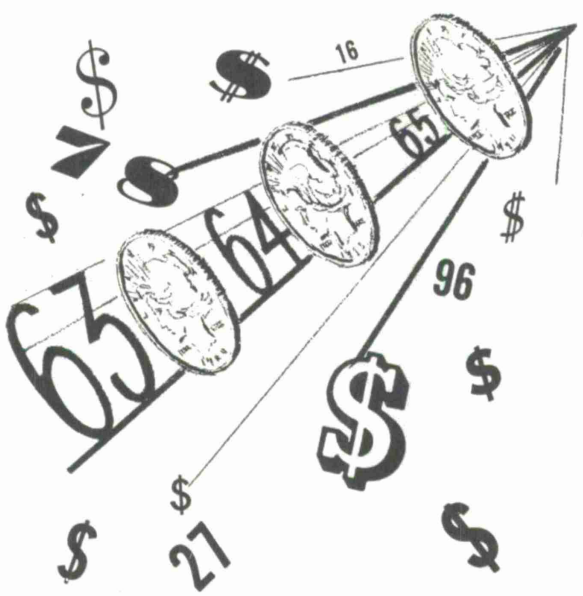
Up to now we have laid the groundwork for applying cost. We will take up next the means of determining and applying cost.

Costing

VIII

In general, there are two types of cost data involving dollars in a PERT COST operation. Namely, those concerned with "budgeting and estimating" and those with "actual costs." There are other types of cost data involved but these are concerned with tying the entire PERT COST operation together and relating it to its PERT TIME counterpart.

At this time we will discuss costing very broadly so that you may understand the philosophy of compiling cost data for a PERT COST operation. Later on, when the subject of Data Input is presented, we will go into more detail on cost data.



Cost estimates required by the PERT COST System provide a basis for cost planning and control. These estimates are made by first determining the manpower, material, and other resources required to perform each work package. The "resource" estimates are then converted to dollars. Indirect costs are added to each work package or are applied at some summary level in the work breakdown structure depending on the accounting practices of the contractor.

Budget authorizations and resource estimates are recorded on estimating forms on which they are also identified with specific work packages or summary items. Cost estimates are normally based on the description of the total work package rather than on individual associated activities.

As the PERT COST operation progresses, various computer output becomes available which displays time-phased cost estimates covering the life of the program. This output data is summarized in various ways, such as for charge numbers, program breakdown summary items, etc. It is used as a basis for control, to assure good cost estimates, and to insure valid budget request for funds.

The PERT COST System includes both expenditures and unliquidated commitments in the term "actual costs." Costs are accumulated against work packages by the applicable charge number. The data is entered on a form to show the actual hours and dollars expended for a particular charge number-organization-resource code combination.

Estimated

vs

Actual

Costs !

A Program Manager must designate the levels of cost report summarization required for effective management. The level of breakdown will vary in each area depending upon such factors as complexity of technical problems, dollar value, pacing items, etc. A Program Manager should require a minimum amount of data needed to meet the goal of effective program management but retain the right to request additional detailed information, whenever required, to meet existing or anticipated problems.

It is most important that whenever possible cost reporting periods should correspond to the contractor's accounting periods. Reports involving only time scheduling may be required more often. All cost reports provided by the PERT COST System may not be desired every accounting period. This is something that you as a Program Manager would have to work out with your contractors.

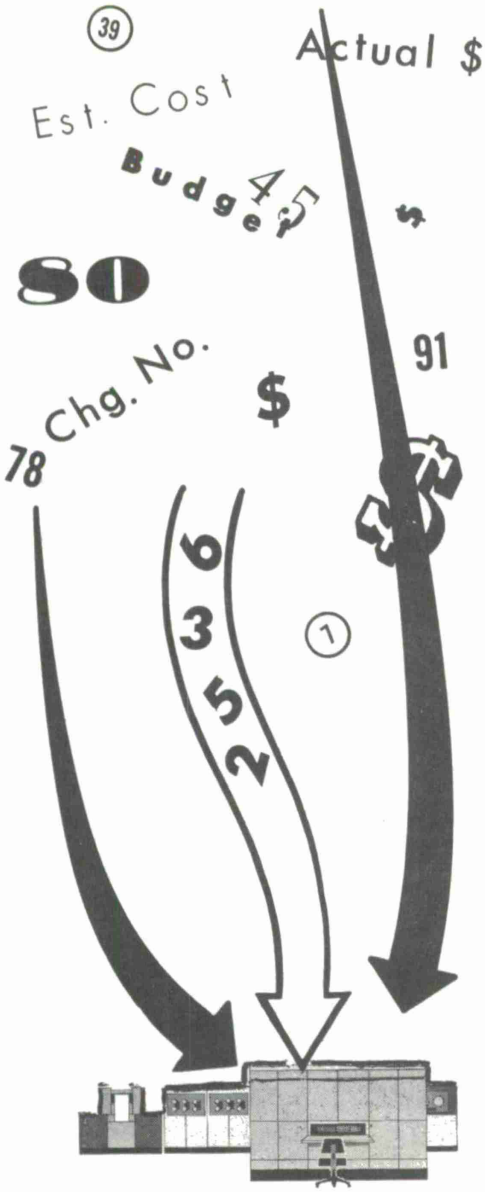
As the program progresses, it may become necessary to update cost estimate data because of the addition and deletion of activities, deviations in scheduled completion dates, and correction of

previous errors in judgment and other reasons. This updating action is accomplished by providing revision data which is processed by the computer to revise existing records.

We will now go into Data Input and will present a few illustrations using Project HOME data so that you may more fully understand some of the very broad language above.

Data Input

IX



We will discuss the flow of information from contractors to a program manager in a very general manner. In actual practice the procedure would vary depending on the program and existing conditions. If you were a program manager, you would see to it that details concerning the flow of data were included in any Request for Bids and a definite requirement confirmed later in the contract award.

Basically, the procedure is that, at the beginning of your program, each major subcontractor would furnish the prime contractor with a summary network and related data including the identification of interface events. The prime contractor would then process this data in addition to his own summary network data and furnish you with information to support your program management network. Separate agencies supporting your program would follow the same procedure except that their summary network and data would be sent directly to you.

Periodic updating data would likewise flow in this manner. After analyzing the input you would have to feed back any changes such as a revised scheduled date, a change in a directed date received from higher authority, etc. The prime and subcontractors and other agencies then take a look at the revised data you sent them to see how it affects their detail networks and contract fulfillment.

A program such as Project HOME would never justify such a data flow and computer processing procedure required for a PERT COST operation. On the other hand, including a case problem in this pamphlet involving a program to be representative of one of today's electronic or space programs for example would be impractical. We had to include something that we could show from start to finish and include sufficient actions and events in between to recognize continuity and relationship of work. Of equal importance, however, was to include a problem concerning a subject with which we thought you would be familiar.

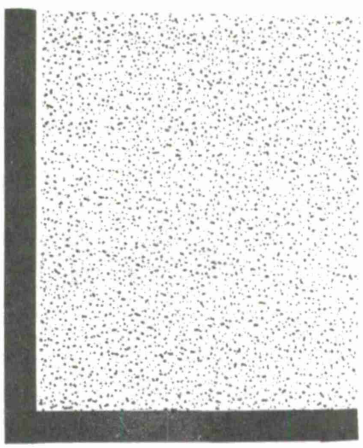
So - insofar as Project HOME is concerned - THINK BIG - think of it as "Project HOME ON THE MOON" and let's assume the following for trying to illustrate data input and, later on, data output.

You are the Program Manager.

The house construction contractor is the prime contractor (Contractor B) and he will process the data at his computer facility.

The site, landscape, and hard surface contractors (Contractors A, C & D respectively) are subcontractors and will submit their summary networks and data to Contractor B.

INPUT FORMS

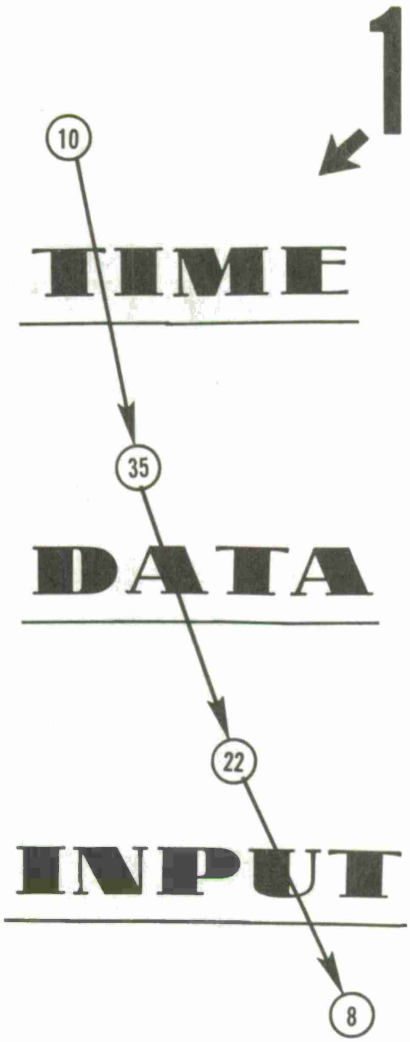


The following forms are used for inputing data under the USAF PERT COST operation:

- PERT Time Input (AFSC Forms 30 & 30A)
- Work Breakdown Structure Form
- Activity to Charge Number Form
- Charge or Summary Number Identification Form
- Cost Estimating Form
- Actual Cost Form
- Budget Authorization Input Form
- Rate Table Input Form
- Manpower Skill/Rainbow Category Form
- Resource Code/Cost Category Input Form

AFSC Forms 30 and 30A are the only established and numbered AFSC forms used at the time of publication of this pamphlet.

The other input forms are shown only to identify the required elements of data to be included on the forms. Since the PERT COST data is normally computer processed by the contractors, the data is actually entered on forms designed to facilitate key-punching of the data. In addition to the input data presented here, these forms also provide space to identify card codes, etc. required for any kind of automated operation.



AFSC Forms 30 and 30A (Continuation Sheet) are the only forms required for data input operation of the USAF PERT TIME System. They are used for initial entries and for the periodic updating cycles. Separate Forms 30 must be prepared for each network to be processed.

The data on the PERT network is transcribed onto the AFSC Form 30 in the form of activities. Each activity is described by its beginning event number, ending event number, time estimate, scheduled dates and event/activity titles. In addition to the activity input information, certain other data, such as transaction codes, interface codes, and level codes must be entered. The data on the Form 30 is punched in cards and used to establish a network master file or to update an existing master file.

That is as far as we are going with the PERT TIME input form because, as was stated at the beginning of this pamphlet, we assume that you at least understand the fundamentals of the PERT TIME operation.

2 WORK BREAKDOWN

The Work Breakdown Structure Input Form is used to:

* initially identify the relationship among items in the work breakdown structure;

* initially provide descriptions for charge and summary numbers;

* initially establish a charge and summary number record in the master file and

* to delete or change any of the elements of data established in the master file by previous use of this form.

After establishment in the master file, the computer recognizes and uses this data in summarizing cost information for reporting to different levels of management. This form is first prepared when the work breakdown is defined and the data initially established on the master file. Under actual conditions it is necessary to keypunch two cards to establish one record item in the file. Thereafter, the form is used only to change or delete elements of data in the master file.

Figure IX-1 shows the work breakdown structure data input format. We have taken sample data from the work breakdown appearing in Figure IV-1 to show how the data is entered on the form. A code has to be entered in the "Responsible Organization" column to identify the organization responsible for accomplishing the work. In this case, we used the letter A, B, C, or D assigned to the contractors, as the case may be. Code "A" is shown in the "Change Code" column inasmuch as this represents an initial entry of data. When changes are input later, codes used in this column are "A" for adding, "D" for deleting and "C" for changing an element in the line entry. Other than the above explanation, you should be able to understand the other entries in Figure IX-1 by associating the data with the work breakdown in Figure IV-1.

USAF PERT COST SYSTEM

WORK BREAKDOWN STRUCTURE INPUT FORM

Prepared by _____ Page _____ of _____

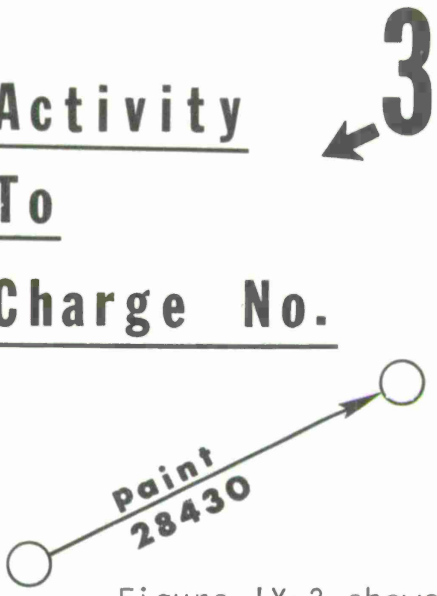
Date _____

Change code

CARD CODE	CHARGE OR SUMMARY NUMBER	CARD 0 WORK PACKAGE OR SUMMARY ITEM DESCRIPTION	RESP ORGN	COST CAT CODE	CARD 1 PARENT SUMMARY NUMBER	LEVEL CODE	SUM/DET IND CODE
1 2	19	20 55	56 61	78 80	20 37	38 39	40 78
	110000	SITE PREPARATION	A	A	100000	2	
	112000	SITE SURVEY	A	A	110000	3	
	113000	SITE GRADING	A	A	110000	3	
	26104	SITE WORK (OTHER THAN LANDSCAPING)	A	A	113000	4	
	120000	HOUSE CONSTRUCTION	B	A	100000	2	
	121000	FOUNDATION CONSTRUCTION	B	A	120000	3	
	122000	HOUSE EXTERIOR CONSTRUCTION	B	A	120000	3	
	123000	HOUSE INTERIOR CONSTRUCTION	B	A	120000	3	
	123100	LIVING ROOM CONSTRUCTION	B	A	123000	4	
	123200	DINING ROOM CONSTRUCTION	B	A	123000	4	
	123300	KITCHEN CONSTRUCTION	B	A	123000	4	
	123310	ELECT. INST. IN KITCHEN (TOTAL)	B	A	123300	5	
	123311	ELECTRICAL OUTLETS IN KITCHEN	B	A	123310	6	
	13808	ELECTRICAL WORK	B	A	123311	7	
	15940	CARPENTRY WORK	B	A	123100	5	
	30621	PLUMBING WORK	B	A	123100	5	
	28430	PAINTING	B	A	123100	5	
	18753	LANDSCAPING	C	A	131000	4	
	19256	HARD SURFACING WORK	D	A	141000	4	

FIGURE IX-1

Activity To Charge No.



The Activity to Charge Number Form is used to associate network activities with charge and summary numbers. The data on this form provides the basis for tying together the PERT TIME system and the PERT COST system. The form is initially prepared after a time network and work breakdown structure have been developed. Thereafter, the form is used only when changes are made to the network and/or charge or summary numbers.

Figure IX-2 shows the activity to charge number input format. The activity identification and network codes were obtained from the detail networks shown in Figures VI-4, 5, 7 and 8. The charge numbers were picked up from Figure IV-1. The change codes are the same and serve the same purpose as for the work breakdown form which we just discussed. All of the activities were not extracted from the detail networks. We just selected a few to show how the form is prepared.

Do you understand how the sample entries were made on the form? If not, let's take activity identification 302 to 307 shown on the form. Find events 302 and 307 in Figure VI-5. Note that the title for event 302 indicates that the house framework is complete and event 307 is titled to indicate that the rough electrical work is complete; therefore, the only activity that would take place between these two events is electrical work which has a charge number 13808.

If your networks and work breakdown structure are well defined, the preparation of this input will be simple.

USAF PERT COST SYSTEM

Prepared by _____ ACTIVITY TO CHARGE NUMBER INPUT FORM Page ____ of ____

Date _____

CARD CODE	NETWORK CODE	ACTIVITY IDENTIFICATION		CHARGE NUMBER	CHG CODE
		PREDECESSOR EVENT NUMBER ►	SUCCESSOR EVENT NUMBER ►	►	
1	7 12	13 21	22 30	31 48	80
2	A	201	202	26104	A
2	A	203	204	26104	A
2	B	300	301	20010	A
2	B	301	302	15940	A
2	B	302	307	13808	A
2	B	302	306	30621	A
2	B	311	312	28430	A
2	C	402	403	18753	A
2	D	502	503	19256	A
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2		NOTE: You will notice that this			
2		form and others which appear later			
2		are printed so that the data entered			
2		on them can be readily keypunched.			
2		There are some columns on the forms that			
2		are necessary for an actual PERT COST			
2		operation but are not necessary to be			
2		explained for the purpose of this pamphlet.			
2		An example is the card code column on this			
2		form in which the code "2" appears.			

Figure IX-2 Activity to Charge Number Input Form

4 Charge or Summary Number Identity

The Charge or Summary Number Identification Form is used for entering the following types of data in the PERT COST master file:

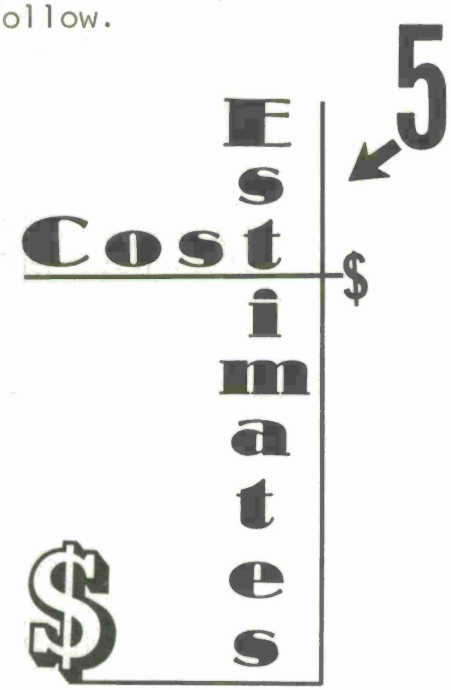
- Network code for each charge or summary number which is not network activity oriented. This optional code permits the inclusion of charge or summary numbers in the output reports which are sequenced by network code.

- Contract number and reporting organization for all charge and summary numbers. This is the only input form on which the contract number and reporting organization appear.

- Start and end dates for any of the charge and summary numbers in the system. These dates establish the time references for the budgeted and estimated values of the performing organization-resource codes associated with the corresponding charge or summary numbers. These dates are used in the system to select the corresponding labor and overhead rates. There are two options in identifying dates. If you used the dates contained in the network, you leave the date field on the form blank and the computer program will pick up these dates. Otherwise, you can place other specific start and end dates on this form. In the case of non-network activity oriented charge or summary numbers, the computer will pick up the current master file date as the start date and no end date will be assigned.

All data, with the exception of charge or summary numbers, entered into the system by use of this form can subsequently be changed by use of this form. Modifications to charge or summary numbers must be processed by use of the "Activity to Charge Number" form which we just finished discussing.

Figure IX-3 shows the format for this form. We have included a few entries using some of the data associated with the Project HOME detail networks. In cases where dates are not included, you can assume that we intended for the computer to use network dates. You will also notice that we included summary number 120000 with a start date. This summary number identifies "House" in the work breakdown structure and the sample entry on the form would represent an example of how the contractor could start accumulating overhead expenses on that start date. Of course, there is more to it than this, as you will discover as you read about the other forms to follow.



The Cost Estimating Form is used for establishing the estimated hours and costs for the various summary items and work packages (charge numbers) with their corresponding performing organization-resource code combination. Monthly estimates may be in the form of man-hours, man-months, direct costs, total costs or other units for each of these combinations. Direct and total costs may be generated by the computer through use of a "Rate Table" which will be discussed later.

USAF PERT COST SYSTEM

Page _____ of _____

Prepared by _____ CHARGE OR SUMMARY NUMBER IDENTIFICATION INPUT FORM Date _____

CHARGE OR SUMMARY NUMBER	START DATE DAY	START DATE MONTH	START DATE YEAR	END DATE DAY	END DATE MONTH	END DATE YEAR	CONTRACT NUMBER	REPORTING ORGN CODE	NETWORK CODE
120000	03	JUN	64	20	NOV	64	XYZ123	HO	B
123310	07	OCT	64	20	NOV	64	XYZ123	HO	B
13808	07	OCT	64	20	NOV	64	XYZ123	HO	B
18753							ABC456	LD	C

NOTE: In an actual PERT COST operation, it is necessary to enter data in specific punch card columns identified under the columnar titles appearing at the top of the form. For example, the contract numbers appearing above should actually be entered in the extreme left of the Contract Number column immediately following "64" in the End Date columns. However, for the purpose of this pamphlet, data will be shown in the columns so that it will stand out.

Figure IX-3 Charge or Summary Number Identification Input Form

After the estimate values and other data have been initially established in the master file, the computer can produce on request a form known as the Cost Estimating and Updating Form which can be used as an input form to modify certain estimating data currently existing in the master file.

The revisions can be accomplished by manually entering the revised data on the computer produced input form and keypunching accomplished by use of this form. However, some of the data such as charge number and summary numbers cannot be changed by such annotating. Previously discussed input forms are used to effect such changes. The purpose of using this computer produced input form is to reduce the manual effort in revising such data. However, consideration should be given to using this method instead of using the regular printed form due to the keypunching requirements. If you have "quality" keypunching at your installation, use of the computer produced form can be considered. Otherwise, use of the computer produced form in lieu of accomplishing a regular printed form can easily result in keypunch errors being entered into the master file.

If you become involved in an actual PERT COST operation, you will have complete instructions to follow concerning this form; so we will not go into any further discussion as it would become too detailed for this pamphlet.

Now, let's apply what we discussed to Project HOME using the same assumptions and information in illustrating entries on previously discussed input forms. First, take a look at the estimating form shown in Figure IX-4. The "Charge Number" column should be readily understood. The other columns are explained briefly:

* PERFORMING ORGANIZATION: A code to identify the organization that will do the work is entered. We used fictitious codes just for illustration.

USAF PERT COST SYSTEM

COST ESTIMATING INPUT FORM

Prepared By ______________________

Page ____ of ______

Date ______________

CARD CODE	IDENTIFICATION				RESOURCE ESTIMATES IN MONTHLY INCREMENTS						TYPE CODE	CARC CODE	CHG CODE
	CHARGE NUMBER	PERFORMING ORGN.	RESOURCE CODE	UOC CODE									
1	2 19	20 25	26 29	30	31 JULY 36	37 AUG 42	43 SEPT 48	49 54	55 60	61 66	78	79	80
7	30621	14	6	H	100	100					4		A
7	30621	14	8	H	50	50	100				4		A
7	30621	10	2	D	280	1000	550				4		A
7											4		
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Figure IX-4 Cost Estimating Input Form

* RESOURCE CODE: A code to identify the type of material or particular manpower skill used by the performing organization, as determined by the resource coding scheme which will be discussed later. We used fictitious codes.

* UDC COLUMN (UDC means "Units or Dollars Code"):

The codes used are:

H - Labor (man) hours

M - Man-months

D - Direct dollars

T - Total dollars

U - Other units

In the case of codes H, M and U, the estimates for these codes can be converted to direct dollars by the computer program.

Now look at the entries in Figure IX-4. The resource estimates are fictitious. Actual estimates would be based on the contractor's scheduled performance as represented on the network. To briefly explain how data is entered on this form, we will discuss the 3 entries for charge number 30621 (plumbing work). Assume that performance organization codes 14 and 10 identify plumbers work and the contractor's purchasing office respectively. Also, assume that resource code 6 identifies rough plumbing; 8 identifies finish plumbing and 2 identifies plumbing fixtures and hardware. The network also indicates that the plumbing work is scheduled to start July 24th and be finished Sept 4th. So, based on the above, the 3 line entries for charge number 30621 can be interpreted as follows:

1st LINE ➡ The estimate is that 100 man-hours (code H) will be used during July (1st month column) and also August (2nd month column) by the plumbers (code 14) for rough plumbing work (code 6). Based on the rate for

resource code 6 which is contained in the rate table, the computer will convert the 100 man-hours into a cost (dollar) estimate.

2nd LINE — The same applies here except that the estimated man-hours are spread over 3 months (July-August-September) for the finish plumbing work.

3rd LINE — This line indicates an estimate of direct dollars (Code D) in the amounts of $280.00, $1000.00 and $550.00 for the months of July, August and September respectively to be spent for plumbing fixtures and hardware by the contractor's purchasing office. The computer just picks up these dollars and includes them in the program.

We could go into considerable more detail with this form but that is only necessary if you become involved in an actual PERT COST operation.

After data from the cost estimate input form is processed by the computer, a print-out known as the "Cost Estimating and Updating Form" is produced. This is the form on which manual entries or changes can be made to modify current cost estimating records. Figure IX-5 is included only to show you how the cost estimating and updating form would appear. The sample used in this figure has no relationship to Project HOME. You will notice that there is a lot more information contained in this form as compared to the cost estimating form. This is caused by the computer picking up data from several of the various inputs and records establishment.

So much for the estimating form.

PERT COST
COST ESTIMATING AND UPDATING FORM

	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
TEST PROGRAM	1234	ABCC	TERM (SPAN) - TOTAL PROGRAM
TEST - TEST PERT TIME NETWORK			CUT OFF DATE - 01DEC62
LEVEL / SUMMARY ITEM - 3 /	816293 SUB-SYSTEM F		RELEASE DATE - 01JAN63
LEVEL / CHARGE NUMBER- 4 /	101014 WORK PACKAGE 17		RESP ORGN - 104

EVENT NUMBER	EARLIEST DATE	SCHEDULED DATE
FIRST - 3	START DATE - 09SEP63	START DATE - 19AUG63
LAST - 34	END DATE - 16DEC63	END DATE - 16DEC63

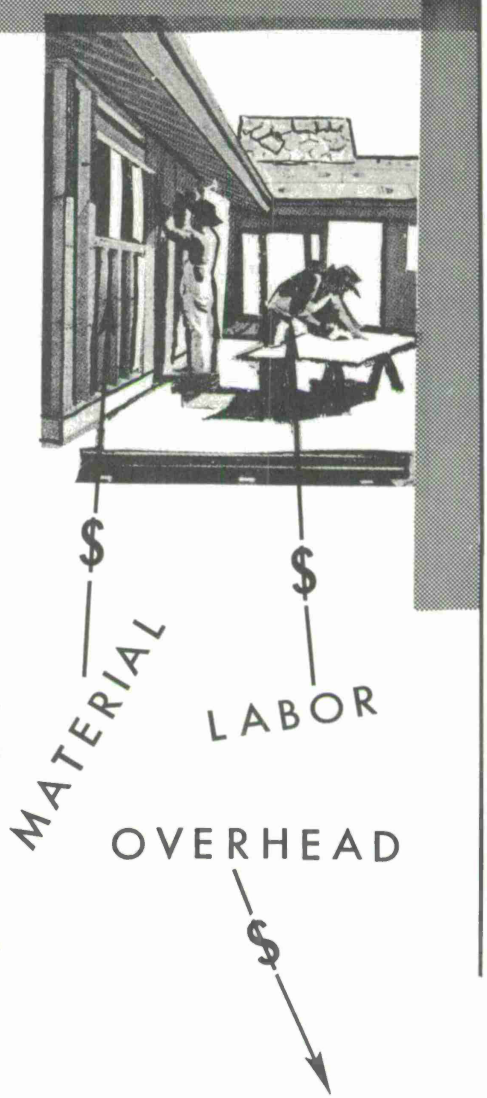
IDENTIFICATION				RESOURCE ESTIMATES MONTHS BEGINNING WITH SCHEDULED START DATE													
CD PERF ORGN	RES CODE	UCD CO		AUG	SEP	OCT	NOV	DEC	JAN	CO NO.	FEB	MAR	APR	MAY	JUN	JUL	CO NO.	TOTAL
7 DEPT 1	LAB1	H		2000	2000	2500	2000	1000		40							41	9500
7 DEPT 1	LAB1	O		9000	9000	11250	9000	4500		40							41	42750
7 DEPT 1	LAB1	T		13500	13500	16875	13500	6750		40							41	64125
7 DEPT 1	MAT1	O		6000	9000	13000	20000	7000		40							41	55000
7 DEPT 1	MAT1	T		9000	13500	19500	30000	10500		40							41	82500
7 DEPT 3	LAB3	H		200	500	500	300	150		40							41	1650
7 DEPT 3	LAB3	O		1200	3000	3000	1800	900		40							41	9900
7 DEPT 3	LAB3	T		1800	4500	4500	2700	1350		40							41	14850

SECURITY NO.

PAGE NO. 2

Figure IX-5 Cost Estimating and Updating Form

6. Actual Costs



Entries of data on the Actual Cost Form identify elements of actual cost obtained from the contractor's accounting system. This data is the source for information appearing in the PERT COST output reports as "Actuals."

The contractor inputs the actual costs into the PERT COST system on a monthly basis. The form provides for manual preparation of actual cost input data. Some contractors may input the actual cost data directly by tape if their cost accounting system is compatible and automated. Actual costs are collected for each charge number-performing organization-resource code combination.

The type of information entered on the Actual Cost Form is the same as for previously discussed forms except for the following (see Figure IX-6):

* CHANGE CODE: The codes are a little different. When a new monthly actual is being reported for the first time, the code "T" is entered in this column. When codes "D" or "R" are used, actual cost data already in the master file will be deleted or modified.

* MONTH - YEAR: The month and year for which the actual cost is being reported.

* VALUE: All values entered in this column are considered to be actual dollar values. Therefore, the computer program does not provide for conversion of these values unless the UDC code "M" (man-months) is associated with a particular value. In this case, the computer will convert the reported man-months to man-hours based on the conversion factor included in the computer program.

The four "date and value" fields are provided so that more than one monthly actual cost figure can be reported for a particular charge number-performing organization-resource code combination on one line of the form. For example, in addition to entering the actual figures for the report month, information to cause changes to actual figures reported on previous reports can also be included on the same line entry.

Included are sample entries in Figure IX-6 to show how charge number 30621 could have been reported for Project HOME, as compared to the entries in Figure IX-4. Rates of $7.00 and $9.00 per man-hour for resource codes 6 and 8 respectively were used in arriving at the actual figures on Figure IX-6. If you care to do a little figuring, you will note that the actual cost figures represent <u>used</u> man-hours different in quantity from those included on the cost estimate form. This would be normal under actual conditions.

7

Budget Authorization

The Budget Authorization Input Form is used to:

* establish the hours and costs which have been budgeted for the summary items and work packages with their corresponding performing organization-resource code combinations.

USAF PERT COST SYSTEM

ACTUAL COST INPUT FORM

Prepared by

Page __ of __

Date ____

CARD CODE	CHARGE NUMBER	PERFORMING ORGN.	RESOURCE CODE	1ST FIELD					2ND FIELD					3RD FIELD					4TH FIELD					
				DC CODE	PG CODE	DATE		VALUE	DC CODE	PG CODE	DATE		VALUE	DC CODE	PG CODE	DATE		VALUE			DATE		VALUE	
						MO	YR				MO	YR				MO	YR				MO	YR		
1	2 19	20 25	26 29	30	31	32	35	36 41	42	43	44	47	48 53	54	55	56	59	60 65				71	72	
7	30621	14	6	H	T	7	64	720																3
7	30621	14	8	H	T	7	64	435																3
7	30621	10	2	D	T	7	64	285																3
7																								3
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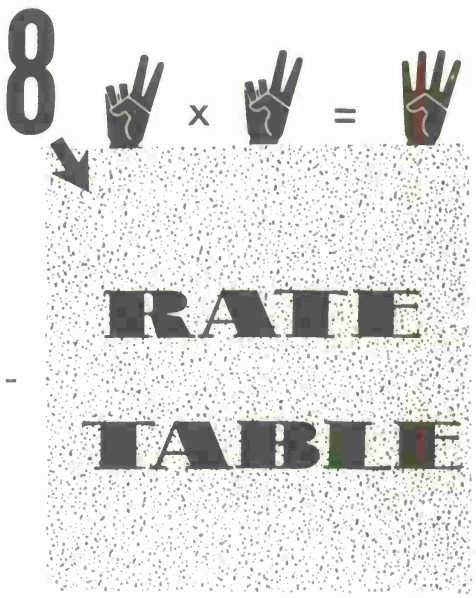
Figure IX-6 Actual Cost Input Form

The budget data is identified in terms of man-hours, man-months, direct costs and total costs in the same manner as for the cost estimating input form which we just discussed. The computer converts the hours into dollar values by use of the rate table which we will discuss shortly.

This form is used initially to establish the budget data in the master file. After that the computer can produce a Budget Authorization and Updating Form which is also considered as an output form. A separate Budget Authorization and Updating Form will be printed for each work package and summary number. Changes to existing budget data are made on the form by hand printing the new or changed data above the machine printed data.

Look at Figure IX-7. You will notice that this form looks almost like the Cost Estimating Input Form which we already discussed. The preparation and use of both forms are basically the same. Therefore, Figure IX-7 is only included to show you the format. We did not include sample entries because of this similarity.

The Rate Table Input Form is initially prepared to enter hourly and overhead rates into the system for each performing organization-resource code combination. Thereafter, it is used only to input rate changes. These unit rates are used by the computer for converting the resource estimates appearing on the budget authorization and cost estimating forms. The unit rate converts hours and other units into direct dollars and the overhead rate converts direct dollars to total dollars.



USAF **PERT COST SYSTEM**

Page _____ of _____

BUDGET AUTHORIZATION INPUT FORM

Prepared by _____ Date _____

CARD CODE	IDENTIFICATION				BUDGET ESTIMATES IN MONTHLY INCREMENTS						TYPE CODE	CARD NO	CHG CODE
	CHARGE OR SUMMARY NUMBER	PERFORMING ORGN.	RESOURCE CODE	SUB CODE									
1	2 19	20 25	26 29	30	31 36	37 42	43 48	49 54	55 60	61 66	78	79	80
7											5		
7											5		
7											5		
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Figure IX-7 Budget Authorization Input Form

Look at Figure IX-8. Here again, you will notice that some of the information entered on this form is the same type as has already been discussed. However, we will briefly explain the type of information that would be entered in the other fields.

✸ QUARTER (QTR): A code (1, 2, 3 or 4) in this column identifies the quarter of the specified year during which the rates appearing in the unit and overhead rate column are effective.

✸ YEAR: The year during which the unit and overhead rates are applicable.

✸ UNIT RATE: An hourly labor or unit used to extend unit resource figures (man-hours, man-months, or other units) to direct cost for the performing organization/resource code combination appearing in the line entry.

✸ OVERHEAD RATE: A rate used to extend direct cost to total cost for the performing organization/ resource code combination appearing in the line entry.

✸ CHANGE CODE: Code "A" indicates that the rate is being added to the master file for the first time; a "D" that it is being deleted; and a "C" that an existing rate is being changed.

The four (4) rate fields are provided to permit the recording of different rates for the same performing organization-resource code combination over different quarters if necessary. A few sample entries for Project HOME are shown in Figure IX-8.

9 Manpower Skill & Rainbow Category

The Manpower Skill/ Rainbow Category Input Form is used to group resource codes into Rainbow categories. This will enable the computer to prepare an output which shows the manpower distribution in terms of the Rainbow report categories.

USAF PERT COST SYSTEM

RATE TABLE INPUT FORM

Prepared by ____________________ Page ______ of ______

Date ____________

Card Code	Performing Orgn.	Resource Code	1st Field ETO	1st Field Year	1st Field Unit Rate	1st Field Overhead Rate	2nd Field ETO	2nd Field Year	2nd Field Unit Rate	2nd Field Overhead Rate	3rd Field ETO	3rd Field Year	3rd Field Unit Rate	3rd Field Overhead Rate	4th Field ETO	4th Field Year	4th Field Unit Rate	4th Field Overhead Rate	Card Code
1	7–12	13–16	18	19–20	21–27	28–32	33	34–35	36–42	43–47	48	49–50	51–57	58–62	63	64–65	66–72	73–77	80
4	14	6	3	64	7.00	1.00													A
4																			
4	14	8	3	64	9.00	1.00													A
4																			
4	18	3	1	64	2.00	0.75	2	64	2.25	0.75									A
4																			
4	5	11	2	64	3.30	0.80	3	64	3.50	0.85									A
4																			
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Figure IX-8 Rate Table Input Form

We will not discuss this form. If you know what is meant by "Rainbow Reporting" in the Air Force, you should readily understand the purpose of this form. If not, it would require an explanation of "Rainbow Reporting" which is not practical for this type pamphlet. If you actually become involved in a PERT COST operation and are subject to "Rainbow Reporting," you will receive full information on this form.

10

The Resource Code/Cost Category Input Form is used to identify resource codes with the various categories of cost elements with which a contractor is concerned.

The data input by this form is used by the computer in compiling the information appearing in the Cost Category Status Report.

Figure IX-9 shows this form with some fictitious data to give you an idea of how the form is prepared.

So much for input of data. Let's see what this input will do to give us some output products.

USAF **PERT COST SYSTEM**

RESOURCE CODE/COST CATEGORY INPUT FORM

CARD CODE	COST CATEGORY DESCRIPTION	RESOURCE CODES 1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH	11TH	12TH	13TH	CHG CODE
	1 2 19	27 30	31 34	35 38	39 42	43 46	47 50	51 54	55 58	59 62	63 66	67 70	71 74	75 78	80
6	ENG. LABOR HOURS	1234	5678	9101	1234	1516	1718	1920	2122	2324	2526	2728	2930	3132	A
6	ENG. LABOR HOURS	3334	3536												A
6															
6	TOOLING LABOR HRS	3738	3839	4042	4337	4647	4850								A
6															
6	TOOLING LABOR DLRS	6162	6371	7273	7475	7677	8090	9192	9394						A
6															
6															
6															
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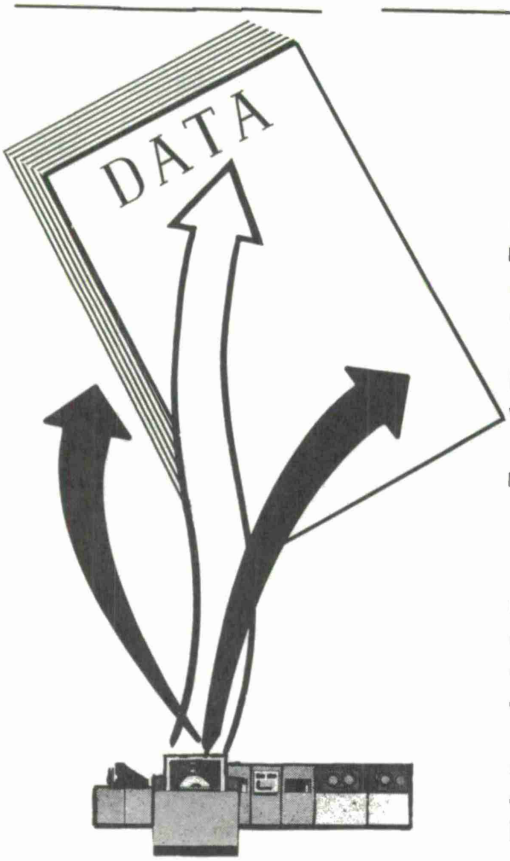
6															

Figure IX-9 Input Example for Resource Code/Cost Category Input Form

Data Output



The machine products made available by a PERT COST operation must be understood by you or your analysts so that the information can be fully analyzed in order that management decisions can be made. Otherwise, you are wasting your time and money. If you care to look into the matter, you will probably find that in most cases today when you hear a person say that PERT is no help that the person is not capable of analyzing the output data or having it analyzed or does not otherwise make use of it. Provided your input data is clean and up-to-date, the output will identify existing or potential trouble spots. PERT won't resolve these conditions - you have to try to do that.

We will now discuss PERT COST output formats. The periodic reports required by you as the Program Manager for Project HOME would be selected from those presented in this pamphlet. Report requirement will vary from program to program. Specific requirements should be defined by each Program Manager at the start of his program.

The reports contain schedule and cost data which can be used by management to identify present and projected trouble spots requiring management action. Identification of potential trouble spots in the program makes it possible for managers to anticipate schedule slippages and cost overruns or underruns. The reports provide the following type of information in varying degrees of detail:

- the current program plan, schedule and budget;
- time and cost performance to date, in relation to the plan;
- time and cost projections to completion of the program objectives.

In discussing outputs, keep in mind the concept of reporting "level" whereby the inclusion of each lower division of the work breakdown structure causes an additional "level" or depth of report data to be produced.

This feature permits the information to be summarized from the bottom of the structure upward without distortion to each level of the program. This relieves a manager of reviewing detailed data from subordinate levels in order to evaluate program status. However, this lower level information can be made available to a manager without additional processing if he cares to look at it.

KIND of OUTPUT

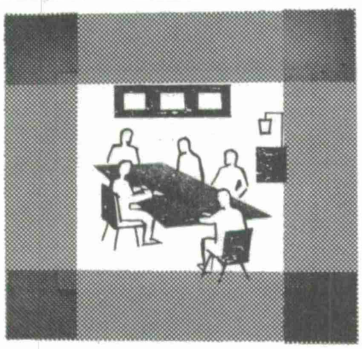
The basic information generated in a USAF PERT COST operation can be summarized in several ways for program management reporting. The detail in which this information is presented can vary depending upon the planning and control requirements of different levels of management.

Following is a list of the reports provided by the USAF PERT COST System. Discussion of the formats will follow.

* MANAGEMENT SUMMARY REPORT
* PROBLEM ANALYSIS REPORT
* PROGRAM/PROJECT STATUS REPORT
* ORGANIZATION STATUS REPORT
* FINANCIAL PLAN AND STATUS REPORT
* MANPOWER LOADING REPORT
* COST CATEGORY STATUS REPORT
* WORK PACKAGE/ACTIVITY REPORT
* RAINBOW CATEGORY REPORT
* COST OF WORK REPORT
* COST OUTLOOK REPORT
* SCHEDULE OUTLOOK REPORT
* SUMMARY FINANCIAL FORECAST

1

MANAGEMENT



SUMMARY

The Management Summary Report contains current and projected schedule (time) and cost status for the total program and for each of the major elements within the program based on specific levels of the work breakdown structure and the contracts concerned. The report can be output by the computer or it may be manually prepared.

The information for this report is obtained from the more-detailed Program/Project Status Report which we will discuss next. The Management Summary Report is designed for program managers and contractor management to provide them with a big picture of the program status.

Some of the type of information included on the form is obvious. However, the columnar fields will be briefly explained. Look at Figure X-1 which shows the format for this report.

(1) ➧ ITEM: The work breakdown level number, noun description, and summary number of each summary item on the work breakdown structure. The first line item is always the highest level item for which the particular report is prepared and should be identical with the entry in the "Level/Summary Item" block.

(2) ➧ VALUE (Work Performed to Date): The total planned cost for work completed within the summary item. This value is determined by summing the Planned Cost for each completed work package. If a work package is in process, the work completed portion is approximated by applying the ratio of Actual Cost to Latest Revised Estimate for that work package.

(3) ➧ 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.

(4) ➧ (OVERRUN) UNDERRUN (Work Performed to Date): The Value of the work performed to date minus the Actual Cost for the same work. When actual cost exceeds value, an overrun condition exists. When

PERT COST
MANAGEMENT SUMMARY REPORT
REPORTING ORGN. HO CONTRACT NO. XYZ123

PROJECT HOME

LEVEL/SUMMARY ITEM - 3/

HOUSE INTERIOR
COST OF WORK $(000)

REPORT DATES
TERM (SPAN) - TOTAL PROGRAM
CUT OFF DATE - 31 JULY 64
RELEASE DATE - 1 AUGUST 64

① LEVEL/SUMMARY ITEM		WORK PERFORMED TO DATE ② VALUE	③ ACTUAL COST	④ (OVERRUN) UNDERRUN	TOTALS AT COMPLETION ⑤ PLANNED COST	⑥ LATEST REVISED EST	⑦ PROJECTED (OVERRUN) UNDERRUN	⑧ MOST CRIT SLACK (WKS)	⑨ COMPL DATE	⑩ SCHEDULE S - SCHED COMPL DATE - TOTAL A - ACTUAL COMPL DATE - ITEM E - EARLIEST COMPL DATE - CRITICAL L - LATEST COMPL DATE - ITEM P - 1964 1965 L YRJFMAMJJ ASONDJFMAMJJASOND YR
HOUSE INT.				(.08)			(.05)		20NOV	. S
LEV 3	123000	2500	2700	(200)	10,000	10,500	(500)		20NOV	. E
								0.0	20NOV	. L
LIVING ROOM				.08					20NOV	. S
LEV 4	123100	600	550	50	2,000	2,000	0		30SEP	. E
								2.0	15OCT	. L
DINING ROOM				(.11)			.03		20NOV	. S
LEV 4	123200	450	500	(50)	1,500	1,450	50		20OCT	. E
								0.0	20OCT	. L
KITCHEN				(.20)			(.11)		20NOV	. S
LEV 4	123300	500	600	(100)	1,800	2,000	(200)		30OCT	. E
								0.0	30OCT	. L

FIGURE X-1 MANAGEMENT SUMMARY REPORT

value exceeds actual cost, you have an underrun. The percentage of overrun or underrun appears immediately above the dollar amount. Parentheses are used as a visual aid to indicate overrun dollars and percentages.

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

(6) ➧ LATEST REVISED ESTIMATE (Totals at Completion): This estimate is the sum of the actual costs plus estimates-to-complete for all the work packages in the summary item and is also known as the anticipated final cost. For a completed item, the Latest Revised Estimate equals the Actual Cost.

(7) ➧ PROJECTED (OVERRUN) UNDERRUN (Totals at Completion): The Planned Cost minus the Latest Revised Estimate 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 percentage of projected overrun or underrun appears immediately above the dollar amount. This overrun data is enclosed with parentheses.

(8) ➧ MOST CRITICAL SLACK (WEEKS): The slack, in weeks, associated with the "E" and "L" symbols shown in the Schedule portion of the form. This represents the worst (most negative or least positive) slack for program end points of any of the activities within the summary item.

(9) ➧ COMPLETION DATE: The actual dates for the positions of the symbols "S", "A", "E" and "L" shown in the calendar time spread in the Schedule portion of the form.

(10) ➧ SCHEDULE CALENDAR: A calendar time spread for display of completion symbols. The calendar spread contains one division for all prior years, another division covering two years divided by months, another division covering four years by years, and one division for all later years beyond the four-year spread. The computer provides one space within the two-year spread in which a vertical line of periods are printed to represent "Time Now." "Time Now" represents the date appearing in the Cut-Off Date block on the form. This line will appear before or after the month in which the cut-off date is contained depending on whether the day is in the early or later part of the month concerned.

Two types of schedule completions are displayed in the schedule calendar:

1. The symbol "S" is used to show the scheduled completion of all work within the summary item. The "S" represents 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 or the earliest completion date (S_E) for the last activity in the item if T_S has not been established. When the total item has been completed, the symbol "A" is placed under the calendar position of the actual completion date for the item.

2. 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 is not necessarily the last scheduled 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.

REPORTING PROJECT HOME

To give you a better idea of how information appears on this report, look at the sample data on Figure X-1.

We entered a portion of Project HOME work breakdown in the "Item" column. You will not be able to identify any of the dollar figures in the "Cost of Work" columns and very little of the time figures in the "Schedule" columns because we did not go into that detail in previous illustrations. So just assume that this information is correct and was obtained from an actual PERT COST operation. Also, you will note that the dollar figures in the "Cost of Work" columns under actual conditions would be shown in "thousands" of dollars, as indicated by the three zeros after the title "Cost of Work."

Due to the small amount of dollars involved in Project HOME, as compared to the thousands or millions for an actual program, we have shown total dollars for better display. In other words, the dollar figure 2500 in the "Value" column should be interpreted as $2,500.00 and not $2,500,000.

Now let's perform a little analysis of the information appearing in Figure X-1.

Sample Analysis

Overrun needs attention

HOUSE INTERIOR ENTRY: At the present time the cost of the interior of the house is experiencing an .08% overrun; but, according to the best estimate that can be made now, the overrun is expected to be reduced to .05% at time of completion.

OK now but watch

LIVING ROOM ENTRY: Here you have just the reverse where you have an underrun of .08% at the present time. However, the completion estimate indicates that the living room is expected to be completed as originally costed.

OK!

DINING ROOM ENTRY: Something is causing you to experience an .11% overrun at the present time, but it must be something of an immediate temporary condition because the completion estimate indicates that you should be in an .03% underrun position at that time.

Serious Overrun

KITCHEN ENTRY: This indicates that you are in a serious overrun condition at the present time, and it is not expected to improve much by completion time.

Watch zero slack

SCHEDULE (TIME) ENTRIES: From the time information shown, you are not in trouble except that you have a zero time critical slack condition which must always be watched.

The above shows how a broad analysis can be made. Under actual conditions, the program manager should have analysts who would analyze the information in detail using other more detailed output reports (which we will get into). The analysts would identify the conditions in more detail in a Problem Analysis Report.

2 Problem Analysis

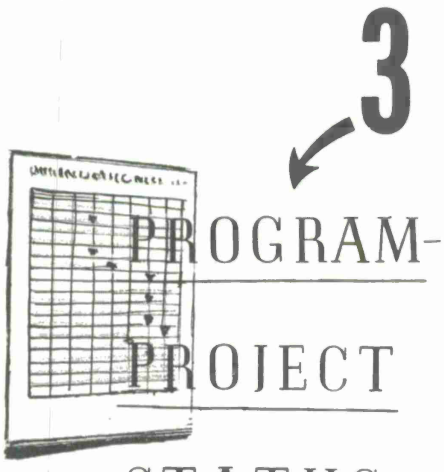
The Problem Analysis Report is a narrative type report which supplements the Management Summary Report and other reports which identify significant problems.

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 in program areas such as schedules, costs, technical performance, or combinations of these;
- a 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;
  - * the corrective action: what action, by whom, when, and expected effect.

Detailed instructions for preparation and submission of this report is a matter of coordination between the Government and the contractors concerned as part of the PERT COST implementation procedures.

You should readily see how this report would provide detailed information for the problems we found in the analysis exercise for the sample entries on Figure X-1.



The Program/Project Status Report contains detailed time and cost information for work packages and lower summary levels which are associated with a higher summary item within the work breakdown structure.

The primary purpose of this report is to provide detailed back-up data for the summarized data contained in the Management Summary Report. The Program/Project Status Report is used by analysts in analyzing the detail status.

The line entries on the Status Report are so arranged that the end summary item to which all of the data is related appears as the first line entry followed by lower summary items and work packages in the order determined by the work breakdown structure.

Figure X-2 shows the format for the Program/Project Status Report. The header information is the same as for the Management Summary Report; so we will not discuss that portion of the form. The following brief explanation is given for the columns under "Identification":

✸ CHARGE OR SUMMARY NUMBER: The noun description, work package charge number and summary number for which time and cost information are presented appears in this column. For a work package, the charge number is the contractor or government charge number used to identify the work package for purposes of estimating and accumulating costs. The noun description of the charge number is printed above the number. For the summary item, the summary number is the identification of an end item on the work breakdown structure above the

PERT COST
PROGRAM/PROJECT STATUS REPORT

PROJECT HOME — REPORTING ORGN. HO — CONTRACT NO. XYZ123

REPORT DATES
TERM (SPAN) - TOTAL PROGRAM
CUT OFF DATE - 31 JULY 64
RELEASE DATE - 1 AUGUST 64

LEVEL/SUMMARY ITEM - 4/ — IDENTIFICATION — 123300 KITCHEN

CHARGE OR SUMMARY NUMBER	LEV	FIRST EVENT NO.	LAST EVENT NO.	TIME STATUS SCHD OR ACT(A) COMPL DATE	EARLIEST - LATEST COMPL DATE	MOST CRIT SLACK (WKS)	WORK PERFORMED TO DATE VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	COST OF WORK $(000) TOTALS AT COMPLETION PLANNED COST	LATEST REV. EST.	PROJECTED (OVERRUN) UNDERRUN
KITCHEN					30OCT64	0.0			(.20)			(.11)
123300	4	301	317	20NOV64	30OCT64	317	500	600	(100)	1800	2000	(200)
ELECTRICAL					30OCT64	0.0			.10			(.12)
123310	5	302	317	20NOV64	30OCT64	317	100	90	10	250	280	(30)
ELECT. FIXTURE					30OCT64	0.0						
123312	6	314	317	20NOV64	30OCT64	317				50	50	
CARPENTRY					19AUG64	1.5			(.17)			
15940	6	303	310	19AUG64	28AUG64	310	300	350	(50)	1000	1000	

FIGURE X-2 PROGRAM/PROJECT STATUS REPORT

work package level. The noun description of the summary item is also printed above the summary number.

✸ LEVEL: The work breakdown structure level of the charge or summary number concerned.

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

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

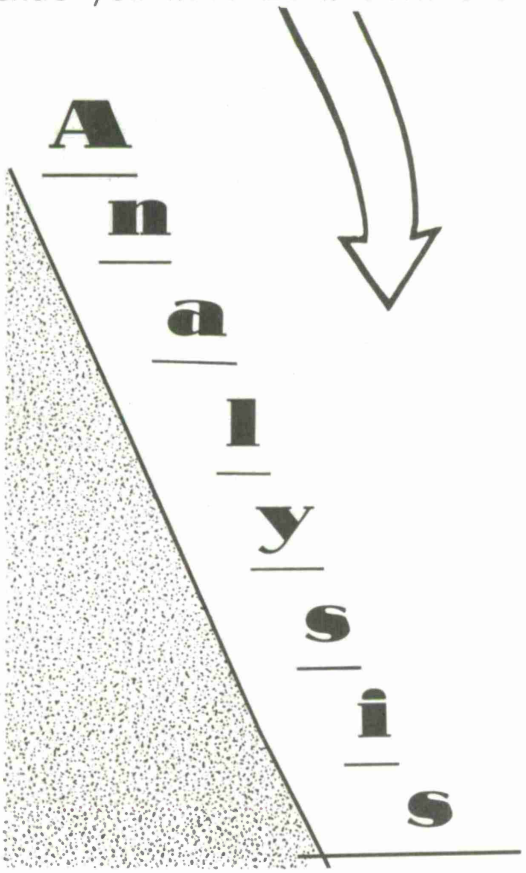
The information entered in the "Time Status" and "Cost of Work" columns is of the same type as appears in the Management Summary Report except that the network event number at the end of the slack path concerned is also identified in the "Most Critical Slack" column.

Now look at the sample Project HOME entries on Figure X-2. Note that the first line entry is the same as the "Kitchen" line entry in Figure X-1. Below that appears line entries which represent only three work performances necessary in constructing the kitchen. Under actual conditions, all charge or summary numbers related to the kitchen construction would be included in which case the dollar figures would balance. To give you an idea of how this report can be used, let's briefly analyze the sample entries:

The "electrical" line indicates that you are experiencing an overrun at the present time for the total electrical work and that at time of completion you expect to have a slight increase in the overrun. The next line "electrical fixtures" tells you that this work has not started yet but you are not in trouble because you are on schedule. Insofar as dollars are concerned, it

indicates that you should have no trouble either because your planned and estimated dollars are the same. This means that your overrun is caused by some other electrical work which is going on such as wiring, conduit, outlets, etc. Here again, additional line entries could appear on the report under actual conditions and you could pinpoint the cause for the overrun.

The "carpentry" line shows that you have no time trouble because you have 1.5 weeks positive slack, but you are in a 17% overrun condition. However, this is evidently a temporary condition because the completion dollar figures indicate that you will be within the planned cost.



The present overrun could be caused by various reasons - for example, maybe the weather conditions lately have been such that a carpenter who would normally be working on the exterior of the house is temporarily working on the kitchen. This would cause more dollars to be spent on the kitchen for labor and material than was planned at this point in time but this would not cause an actual increase for the kitchen. Also, you would not want to change your time/schedule figures for this temporary condition.

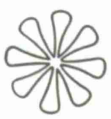
This should be sufficient to show you how this status report can be used; so let's go to the next one.

Organization Status

The Organization Status Report provides operating level contractor managers with detailed information obtained from available computer-stored data. In other words, this report provides contractors with detailed data pertinent to his operation in the same manner as the previously discussed reports provide the total program manager with the type of detailed information he needs.

Look at the report format in Figure X-3 and you can see that the type of information on this form is oriented towards a contractor's participation in a program.

This publication was written primarily for use by persons concerned with total program management rather than industry. For that reason and also the fact that the Organization Status Report format is so similar to those we have already discussed, we will only include a few comments on the format for this report.



The information can be sequenced by various combinations of data contained in the 4 columns under the "Identification" heading. The sequence is always identified in the heading of the report by the printing out of the sequence concerned. Look at the top of the figure and you will note that the data is sequenced in Performing Orgn., Charge Number, Responsible Orgn. and Resource Code order. Each of the different sequences is designated by a distinctive report number. The report number(s) concerned are identified when requesting the reports.

PERT COST
ORGANIZATION STATUS REPORT
BY PERF ORGN, CHARGE NUMBER, RESP ORGN, RES CODE

REPORTING ORGN. FMC | CONTRACT NO. AF33(600)28369 | REPORT DATES

STX/RDT & E | TERM (SPAN) - TOTAL PROGRAM | CUT OFF DATE - 31JAN64 | RELEASE DATE - 01FEB64

LEVEL / SUMMARY ITEM - 3/ 11000 AIRFRAME

IDENTIFICATION				MANHOURS					DIRECT COSTS $(000)			TIME	
					TOTALS AT COMPLETION				TOTALS AT COMPLETION			MDST	SCHD OR
CHARGE NUMBER	RESP ORGN	PERF ORGN	RES CODE	ACTUAL WORK TO DATE	PLANNED	LATEST REV. EST.	PROJECTED (OVERRUN) UNDERRUN	ACTUAL WORK TO DATE	PLANNED	LATEST REV. EST.	PROJECTED (OVERRUN UNDERRUN	CRIT SLACK (WKS)	ACT(A) COMPL DATE
ELEV AERODYNAMICS											(.31)		
56780	3302	3302	E05	2,000	1,500	2,000	(500)	17	13	17	(4)	0.0	
											(.40)		
			T12	2,000	1,500	2,000	(500)	7	5	7	(2)		
											(.33)		
TOTAL									18	24	(6)		
ELEV MECH DESIGN											(.25)		
56781	3302		E03	3,000	2,400	3,000	(600)	25	20	25	(5)	0.0	
											(.26)		
			E04	3,000	2,400	3,000	(600)	24	19	24	(5)		
TOTAL									39	49			
ELEV DWGS REV											(.42)		
56789	3302		E03		1,500	2,000	(500)		12	17	(5)	0.0	
											(.33)		
			E04		1,500	2,000	(500)		12	16	(4)		
TOTAL									24	33			
WING AERODYNAMICS (1)											(.25)		
77780	4417		E02	10,000	20,000	25,000	(5,000)	85	170	212	(42)	-8.0	
											(.10)		
			E03	10,000	20,000	22,000	(2,000)	83	165	182	(17)		
TOTAL									335	394			
WING MECH DESIGN (1)											(.25)		
77781	4417		E03	8,000	12,000	15,000	(3,000)	66	99	124	(25)	-5.6	
											.50		
			E04	9,000	30,000	20,000	10,000	72	160	80	80		
TOTAL									259	204			

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FIGURE X-3 — ORGANIZATION STATUS REPORT—BY PERFORMING ORGANIZATION

The type of information contained on the balance of the form is basically the same as appears on the previously discussed forms. The sample information shown in Figure X-3 has no relation to Project HOME.

NOTE: For the remainder of the reports identified at the beginning of this section, we feel that the purpose of this pamphlet can be satisfied by including a brief description and an illustration for each remaining report. You should get a fairly good idea of the purpose of the reports and how they can serve you.

FINANCIAL PLAN AND STATUS REPORT 5

The Financial Plan and Status Report provides data at any specified work breakdown level for a monthly comparison of actual costs and/or latest 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. (See Figure X-4 as an example.)

The report is also prepared for higher levels of management showing only incremental and cumulative cost totals for each month. Charge numbers are not shown. In other words, the costs for all charge numbers for a month are totaled and the totals are shown in a one-line entry for that month under the columnar headings of the form.

MANPOWER LOADING REPORT 6

The Manpower Loading Report is intended for use by contractors to report manpower loading for various levels of summary within the program. The report includes actual, planned, and latest estimated man-hours, by month, for specified summary levels by the types of man-hours. (See Figure X-5 as an example.)

PERT COST
FINANCIAL PLAN AND STATUS REPORT
BY MONTH, CHARGE NUMBER

	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
STX/ROT & E	FMC	AF33(600)28369	TERM (SPAN) - TOTAL PROGRAM
			CUT OFF DATE - 31JAN64
LEVEL / SUMMARY ITEM - 5/	11440 ELEVATOR		RELEASE DATE - 01FEB64

		INCREMENTAL COST $(000)				CUMULATIVE COST $(000)			
MONTH	CHARGE NUMBER	ACTUAL	PLANNED	LATEST REV. EST.	(OVER) UNDER PLAN	ACTUAL	PLANNED	LATEST REV. EST.	(OVER) UNDER PLAN
PRIOR	56780					66	49	66	(17)
	56781					137	109	137	(28)
	56782					86	72	86	(14)
	56783	13	11	13	(2)	69	61	69	(8)
	56785	3	3	3		84	81	84	(3)
	56788	10	10	10		19	21	19	2
	56790	5	4	5	(1)	41	36	41	(5)
	TOTAL	31	28	31	(3)	502	429	502	(73)
JAN64	56786	18	18	22	(4)	18	18	22	(4)
	56788	12	13	12	1	31	34	31	3
	56790	6	5	6	(1)	47	41	47	(6)
	TOTAL	36	36	40	(4)	96	93	100	(7)
FEB64	56786		15	17	(2)		33	39	(6)
	56788		10	8	2		44	39	5
	56790		4	5	(1)		45	51	(6)
	TOTAL		29	30	(1)		122	129	(7)

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FIGURE X-4 — FINANCIAL PLAN AND STATUS REPORT BY MONTH, CHARGE NO.

PERT COST
MANPOWER LOADING REPORT
BY RESOURCE, MONTH, PERF ORGN, CHARGE NO.

	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
STX/RDT & E	FMC	AF33(600)28369	TERM (SPAN) - TOTAL PROGRAM
			CUT OFF DATE - 31JAN64
LEVEL / SUMMARY ITEM - 3/	11000 AIRFRAME		RELEASE DATE - 01FEB64

IDENTIFICATION				MANHOURS				TIME
MONTH	RES (SKILL) CODE	PERF ORGN	CHARGE NUMBER	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	MOST CRIT SLACK (WKS)
PRIOR	E02	3302	56790	1,000	800	1,000	(200)	5.0
			56797	2,200	2,500	2,200	300	0.0
		4417	49721	500		500	(500)	0.0
			49722	1,900	2,700	1,900	800	10.2
			49723	2,000	2,000	2,000		2.6
	TOTAL			7,600	8,000	7,600	400	0.0
JAN64		3302	56790	80	80	80		5.0
			56797	120	100	120	20	0.0
		4417	49721	40		40	(40)	0.0
	TOTAL			240	180	240	(20)	0.0
FEB64		3302	56790		86	96	(10)	5.0
	TOTAL				86	96	(10)	5.0
MAR64		3302	56790		86	96	(10)	5.0
	TOTAL				86	96	(10)	5.0
APR64		3302	56790		107	119	(12)	5.0
	TOTAL				107	119	(12)	5.0
MAY64		3302	56790		86	96	(10)	5.0
	TOTAL				86	96	(10)	5.0
JUN64		3302	56790		86	96	(10)	5.0
	TOTAL				86	96	(10)	5.0
JUL64		3302	56790		107	119	(12)	5.0
	TOTAL				107	119	(12)	5.0

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FIGURE X-5 — MANPOWER LOADING REPORT BY RESOURCE, MONTH

The report can also be prepared for higher levels of management by including only totals by resource code for each number. In this case, the Performing Organizations and Charge Numbers are not shown.

The contractor's resource codes sometimes identify materials, services, and facilities for which cost estimates have been made in hours which may not be significant in analyzing manpower. For that reason, the report is often compiled for certain specific resource codes.

When reporting is required in categories other than those identified by contractor's resource codes, a translation table is developed and used to group resource codes to identify the categories.

COST CATEGORY STATUS REPORT ◀ 7

The Cost Category Status Report (see Figure X-6) shows functional, hardware, or other significant cost elements in distinctive cost categories which are established by relating work packages or elements of cost within work packages to the specified categories.

This report identifies the manpower and total dollar comparison by cost category for:

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

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

WORK PACKAGE/ACTIVITY REPORT ◀ 8

This report (see Figure X-7) identifies all PERT activities associated with a specific charge number and shows the current time data for those activities. By looking at the form illustration, you will note that the responsible organization for the activities is also identified.

PERT COST
COST CATEGORY STATUS REPORT

REPORTING ORGN.	CONTRACT NO.	REPORT DATES
STX/ROT & E	AF33(600)28369	TERM (SPAN) - TOTAL PROGRAM PR
		CUT OFF DATE - 31JAN64
LEVEL / SUMMARY ITEM - 4/ 14500 FLIGHT CONTROL		RELEASE DATE - 01FEB64

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 REV EST.	PROJECTED (OVERRUN UNDERRUN
DEVELOPMENT					(.02)					(.02)
			15,050	15,350	(300)			451	459	(8)
MAJOR SUBCONTRACT					.00					(.13)
							30	252	289	(37)
MANUFACTURING					(.33)					(.26)
	4,000	38,888	73,730	110,268	(36,538)	24	197	498	673	(175)
MATERIAL					.00					(.31)
							48	109	158	(49)
PLANNING					(.33)					(.39)
		6,912	14,600	21,812	(7,212)		43	70	114	(44)
PURCHASED PARTS					.00					(.03)
								28	29	(1)
TESTING					(.31)					(.32)
		10,200	24,205	35,225	(11,020)		95	217	319	(102)
TOOLING					(.27)					(.24)
		4,724	14,200	19,424	(5,224)		31	109	144	(35)
TOTAL										(.21)
						24	442	1,734	2,184	(450)

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FIGURE X-6 — COST CATEGORY STATUS REPORT

PERT COST
WORK PACKAGE/ACTIVITY REPORT
BY CHARGE NO., PREO, SUCC

RESP ORGN 3302

REPORTING ORGN. FMC

CONTRACT NO. AF33(600)28369

REPORT DATES
TERM (SPAN) - TOTAL PROGRAM
CUT OFF DATE - 31JAN64
RELEASE DATE - 01FEB64

STX/ROT & E

LEVEL / CHARGE NUMBER- 6/ 56787 TESTING

ACTIVITIES PRED EVENTS	ACTIVITIES SUCC EVENTS	ACTIVITY DESCRIPTION	SCHD ELAPSED TIME	COMPLETION DATE EXPECTED (SE)	COMPLETION DATE LATEST (SL)	COMPLETION DATE SCHD OR ACTUAL	ACTIVITY SLACK (SL-SE)
14400430	14400425	FLIGHT TEST REPORT	2.0	12NOV64	26NOV64		2.0
14400440	14400430	FLIGHT TEST MONITORING	12.0	29OCT64	12NOV64		2.0
14400450	14400445	ENVR TEST REPORT	2.0	29OCT64	26NOV64		4.0
14400460	14400450	ELEVATOR ENVR TESTING	10.0	15OCT64	12NOV64		4.0
14400490	14400480	DEV TEST REPORT	4.0	01OCT64	01OCT64		0.0
14400540	14400490	ELEVATOR DEVELOPMENT TESTING	12.0	03SEP64	03SEP64		0.0
14400600	14400575	TEST PLANNING				21NOV63A	

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FIGURE X-7 — PERT COST WORK PACKAGE/ACTIVITY REPORT

RAINBOW CATEGORY REPORT ◀ 9

This is a report by which contractors identify manpower loading for various levels of summary within the program. Air Force organizations required to prepare what are commonly called "Rainbow Reports" would make use of this output. If you become involved in a PERT COST operation and are required to submit "Rainbow Reports" to higher headquarters, you will receive full information on this output as part of your PERT COST System training course.

NOTE: Up to now, we have discussed reports that are printed by the computer as output products. Based on the data contained in these reports, you can establish many kinds of manually prepared graphic-type charts or displays. Following are three types of such graphic reports.

COST OF WORK REPORT ◀ 10

The Cost of Work Report (see Figure X-8) is a display of data from the Financial Plan and Status Report with the additional feature of showing the distribution of actual costs and the value for work performed to "time now."

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.

COST OUTLOOK REPORT ◀ 11

The Cost Outlook Report (see Figure X-9) shows the projected cost status at work completion for any given level or summary item. It also shows the previous projected costs at the previous cycles, thus providing for the recognition of trends.

REPORTING ORGN		CONTRACT NO.	REPORT DATES
			TERM (SPAN):
			CUT OFF DATE:
LEVEL / SUMMARY ITEM:			RELEASE DATE:

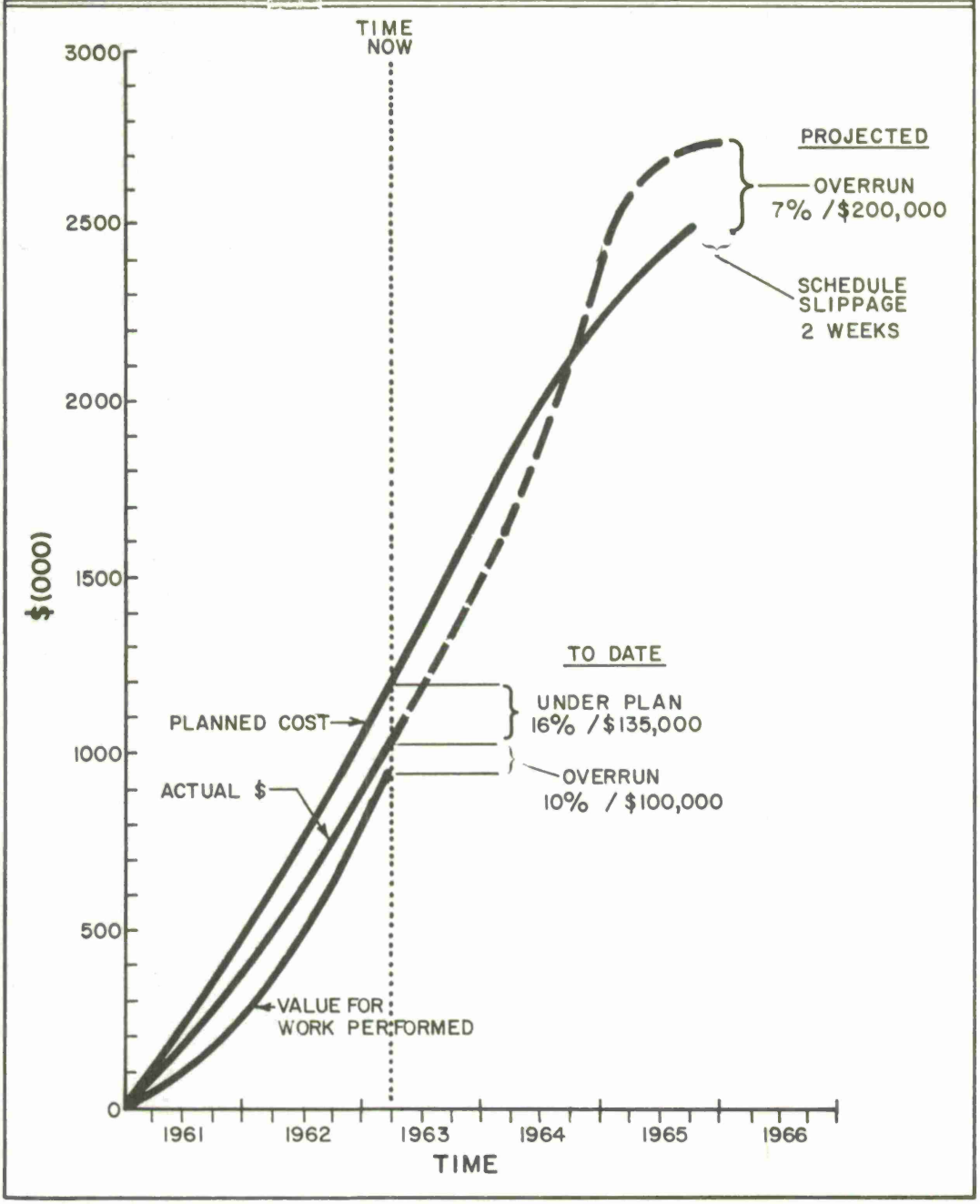
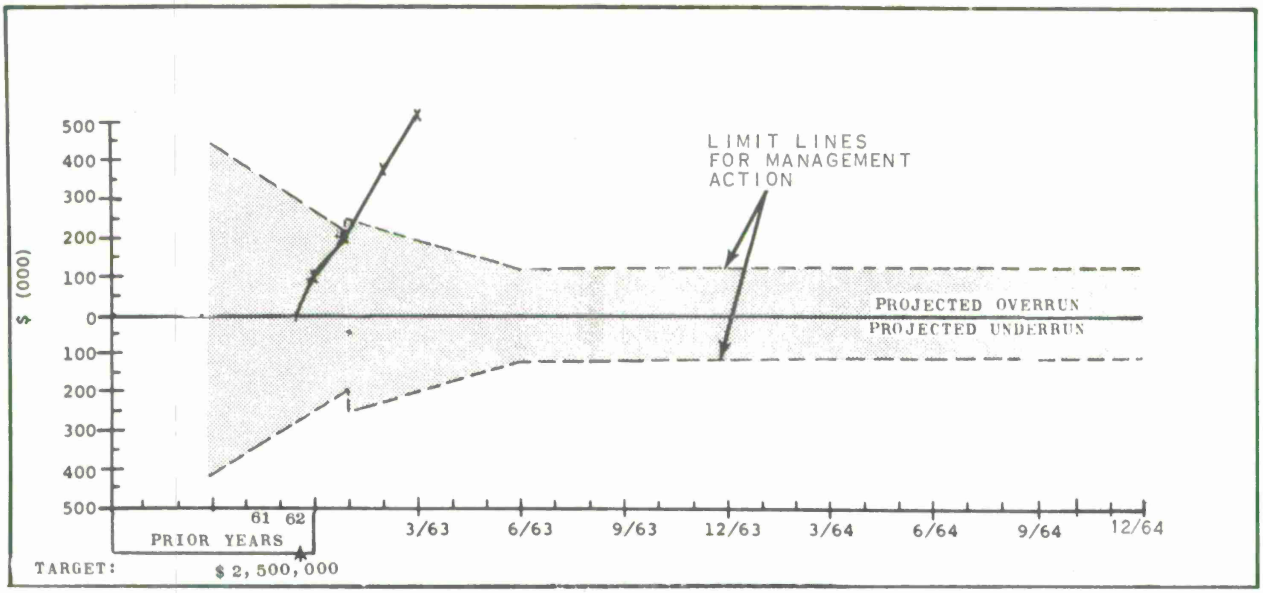


FIGURE X-8

PERT COST — COST OF WORK REPORT

PERT COST
COST OUTLOOK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
ABC DEVELOPMENT PROGRAM	MQZ CORP.	98-7865	TERM (SPAN): TOTAL PROG. CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 2/OPERATIONAL PILOT PLANT			



PERT
SCHEDULE OUTLOOK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
ABC DEVELOPMENT PROGRAM	MQZ CORP.	98-7865	TERM (SPAN): TOTAL PROG. CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 2/OPERATIONAL PILOT PLANT			

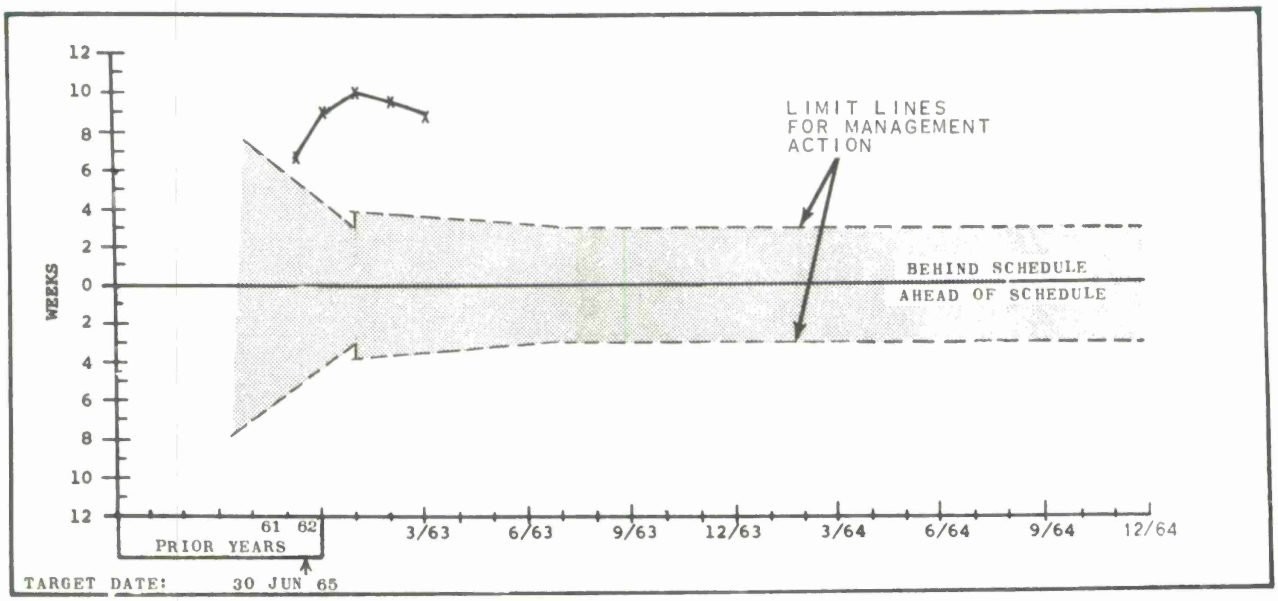


FIGURE X-9

Each month, new projections are obtained from the Management Summary Report and are plotted on the Cost Outlook Report. These projections may be plotted by months for a two-year span after which the report can be redrawn to show prior year projections by year followed by monthly increments.

Limit lines, established by the manager for each program or project, identify the value limitations for overruns and underruns beyond which the manager requires a narrative analysis to be included in the Problem Analysis Report.

SCHEDULE OUTLOOK REPORT ◀ 12

The Schedule Outlook Report (see Figure X-9) shows the projected schedule status at work completion for any given level or summary item. It also shows the previous projected schedule status at the previous cycles, thus providing for the recognition of trends.

Each month, new projections are obtained from the Management Summary Report, and they are plotted on this chart which is maintained in the same manner as the Cost Outlook Report except that schedule data is portrayed instead of cost.

SUMMARY FINANCIAL FORECAST ◀ 13

The Summary Financial Forecast presents actual and planned or budgeted costs, grouped by summary item or cost category, for any level of the work breakdown structure. The summary items are derived from the work breakdown structure; cost categories are derived from entries made on the Resource Code/Cost Category Input Form. This output can be obtained in four different formats.

* By Summary Item by Year (see Figure X-10);
* By Summary Item by Month;
* By Cost Category by Year;
* By Cost Category by Month.

PERT COST
SUMMARY FINANCIAL FORECAST
BY SUMMARY ITEM BY YEAR

STX/RDT & E | REPORTING ORGN. FMC | CONTRACT NO. AF33(600)28369 | REPORT DATES TERM (SPAN) - TOTAL PROGRAM; CUT OFF DATE - 31JAN64; RELEASE DATE - 01FEB64

LEVEL / SUMMARY ITEM - 3/ 11000 AIRFRAME

SUMMARY ITEM/ COST CATEGORY	LEV	PRIOR FYS	CURRENT FY	CURRENT FY+1	CURRENT FY+2	CURRENT FY+3	CURRENT FY+4	CURRENT FY+5	CURRENT FY+6	TO COMPLETE	TOTAL
AIRFRAME 11000	3	24,050	18,600	32,350	30,000						105,000
ENVIRONMENTAL CONTROL 11100	4	2,100	1,800	3,100	3,000						10,000
MAJOR MATING 11200	4	1,900	1,800	7,500	7,800						18,000
EMPENNAGE 11400	4	2,280	3,500	3,200	3,020						12,000
ALIGHTING GEAR 11500	4	2,100	2,270	3,600	3,030						11,000
WING 11600	4	4,200	5,600	6,200	6,000						22,000
FUSELAGE 11700	4	7,500	8,600	7,500	8,400						32,000

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FIGURE X-10— SUMMARY FINANCIAL FORECAST BY SUMMARY ITEM BY YEAR

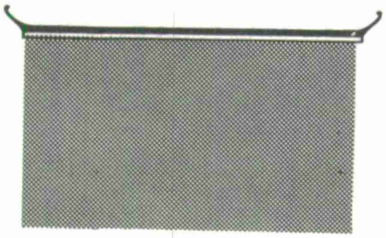
Analysis XI

The efficient and timely analysis of data provided by any management system is extremely important. The data concerned, however, must be current and of good quality. Needless to say, if the data you intend to analyze is not reliable and is old, you just might as well not analyze it unless you have a special purpose for doing so.

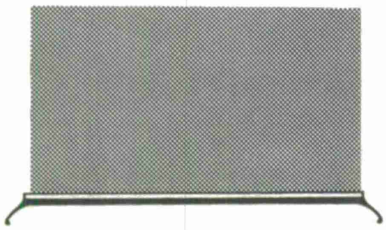
The output products provided by the PERT COST System can be used to very good advantage in program management. We repeat though - the data must be current and reliable. In performing the analysis, there are three elements to consider:

* PROBLEM IDENTIFICATION;
* PROBLEM EVALUATION;
* MANAGEMENT DECISION.

When considering the problems exposed by the PERT COST output products, they must be identified as to type so that appropriate management decisions and actions can be accomplished. The basic types are:



IDENTIFY and EVALUATE the PROBLEMS



CRITICAL PROBLEMS which are related to the program elements along the critical paths (time) in the network or that indicate serious cost deviations.

CHANGE PROBLEMS which are related to the program elements that have significantly deteriorated since the previous analysis with respect to time progression and dollar outlay. These problems could be identified as critical at the time of analysis and moved to the critical category but in many cases the problem can be resolved by the input of data to change the program plan at the next data processing cycle when such changes will not cause schedule slippage or increased dollar expenditure to the final objectives of the program.

DISTRIBUTION PROBLEMS which are related to the need for shifting resources within the program to meet the final objectives as currently planned. This problem is associated in many cases with the two types of problems just discussed if the use of resources is a part of the program element concerned. If such is the case and you have the ability to shift resources without creating other problems, you can resolve those current problems.

The following shows problem areas (schedule, cost and manpower) and PERT COST reports that could most likely be used in recognizing the problem which is the first thing you have to do:

Use For ↓

* CRITICAL PROBLEMS
  * Cost of Work Report
  * Management Summary Report
  * Program/Project Status Report
  * Schedule Outlook Report

Schedules

* CHANGE PROBLEMS
  * Schedule Outlook Report

Use For Costs

* CRITICAL PROBLEMS
  * Cost of Work Report
  * Cost Outlook Report
  * Financial Plan and Status Report
  * Management Summary Report
  * Organization Status Report
  * Program/Project Status Report
* CHANGE PROBLEMS
  * Cost Outlook Report
* DISTRIBUTION PROBLEMS
  * Cost of Work Report
  * Financial Plan and Status Report

Use For Manpower

* CRITICAL PROBLEMS
  * Organization Status Report
* DISTRIBUTION PROBLEMS
  * Manpower Loading Report

MANAGEMENT DECISIONS

After an analysis has been completed, the Program Manager may be required to make decisions to minimize or adjust the cost of the program. To do this, the Manager may decide to:

1. Adjust schedules along network paths to reduce the need for overtime or additional hiring.
2. Reallocate funds from underrun areas to those of a critical or overrun nature.
3. Revise the planned resources for work packages by trading off interchangeable resources between critical and non-critical path activities or otherwise increasing or reducing the planned resources for activities.

Revise network activity sequence and/or content by:

- employing a greater or lesser amount of parallel accomplishment of activities and/or
- modifying the work specifications or performance requirements which will change or delete activities without jeopardizing the total program requirement.

You may recall that in the previous section in which we discussed the various PERT COST reports, a few examples of analysis were included. Based on what you have just read, you may want to refer to some of the output report illustrations in the previous section and see what you can do in analyzing the sample data shown.

Although there are definite fundamentals and logic that must be followed in performing an analysis, if you actually became involved in a PERT COST operation, it would be imperative that your organization and the contractors and other agencies supporting your program get together and establish an analysis criteria to fit your program so that a sound analysis can be performed.

Computer Operation XII

The USAF PERT COST System is considered to be an integrated time and cost system. However, the computer programs involved permit separate processing of PERT TIME and PERT COST information.

Although a person may be very knowledgeable and efficient with a PERT TIME operation, he will not be able to participate to the same degree in a PERT COST operation until he has received adequate training. If he happens to be a computer type, he will have to become familiar with and thoroughly understand the PERT COST computer program. In this sense, the PERT TIME and PERT COST operations can be considered as two separate and distinct systems. As PERT is extended to other areas, these likewise will be separate systems although they will be compatible with PERT TIME and COST.

The type and make of computers to support the PERT COST System is governed only by the requirement that the computer installation concerned has the technical capability and machine time availability to accept the input data and to adequately perform the necessary processing routines so that the resulting data output products will conform to the standards established for the USAF PERT System.

If you should become involved in the application of PERT COST to a program, it would be necessary for you to include the PERT COST standards in your request for proposal. We do this by including a statement in the request for proposal establishing the fact that PERT is to be applied to the program concerned and including other requirements such as the type of output reports and number of copies, the reporting cycles, source and availability of input data, etc. As an exhibit to the request for proposal, we also attach a copy of the current policy and procedures or system description type manual or other documents which completely identify the PERT standards concerned.

There is nothing more that can be added to this pamphlet concerning the computer operation because it is not intended as a computer technique orientation type publication. A completely different type of pamphlet would have to be written for readers such as computer programmers and technicians who are interested or concerned with the PERT COST computer program technique.

Summary of PERT COST XIII

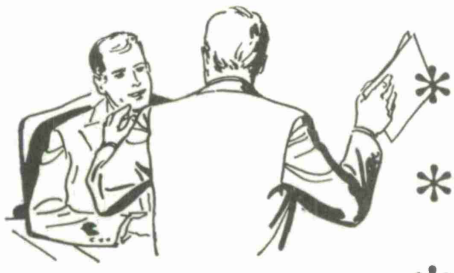
We hope that by reading this pamphlet you have acquired a fairly good understanding of the PERT COST System. However, to finish, let's summarize.

The following summary sets forth some of the more important steps involved in program integration of PERT COST information. Figure XIII-1 illustrates these steps. In actual practice, circumstances involving your program, including local or higher headquarters policy, could cause a variance in these steps.

PROGRAM MANAGER PLANNING

Establish and publish program requirements:

* establish a program work breakdown;
* establish contractor level of reporting and specific PERT COST reports required;
* establish criteria for network event coding;
* prepare preliminary program management network;
* prepare request for proposal.



CONTRACTOR PROPOSAL PERIOD

* Complete the work breakdown and account code structures to the work package level;
* Construct detailed networks of activities and events showing the technical dependencies and constraints inherent in the program:

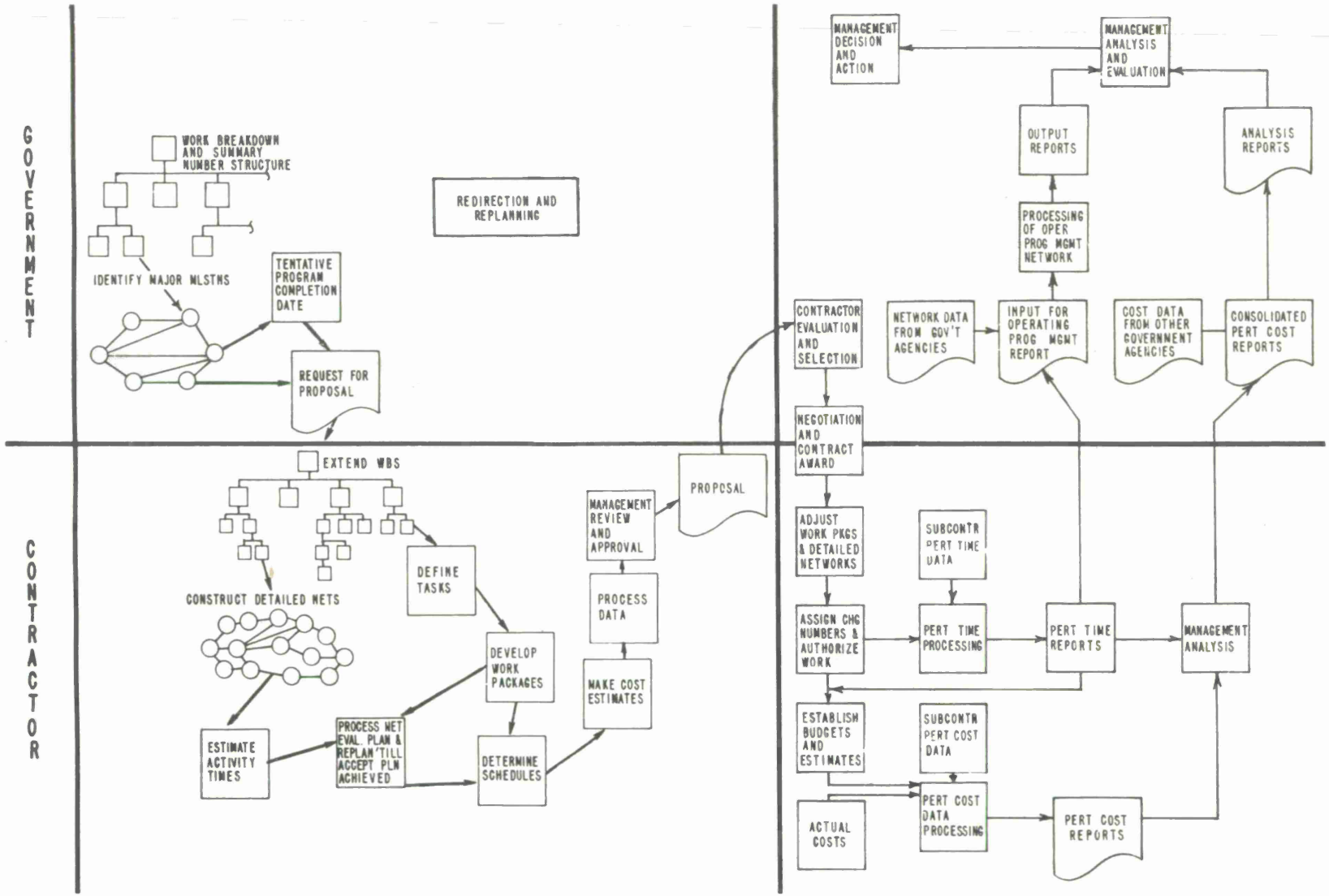
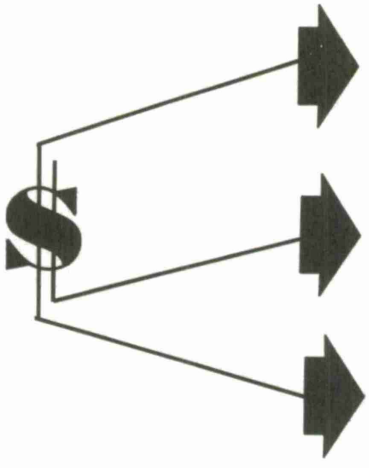


FIGURE XIII-1 – DATA FLOW

- prepare elapsed time estimates for each activity;
- calculate and identify the critical path, earliest expected date (T_E), and latest allowable dates (T_L);
- compare calculated completion dates with directed dates; if required, the network may be revised to meet directed completion dates by one or more of the following methods:
  - revising concurrency of activities;
  - revising effort levels;
  - modifying technical approach;
- establish activity schedules (t_s, T_S);
- calculate earliest schedule completion dates (S_E) and latest schedule completion dates (S_L).

* Prepare cost estimates for each work package:



prepare a summary Financial Forecast for each summary item of the program to permit later comparison of actuals with estimated costs;

conduct management review and revise networks, estimates, and plans as required to meet program objectives;

incorporate schedules, budgets, and related networks in the program plan.

NEGOTIATION

Negotiate terms and award contract:

- reaffirm or revise technical specifications, time, and cost reporting requirements;
- reach complete agreement on program breakdown and level of reporting;
- assure that the contractors' work breakdown, below the reporting level, is generating reliable data and being processed in a manner to produce understandable, meaningful and dependable information for presentation to top-level management;
- award contract and stipulate that the PERT COST System be implemented and operated in accordance with the contractual work statement.

PROGRAM OPERATION

Contractor requirements in program operation:

- assign charge numbers;
- accumulate costs according to normal company procedures;
- summarize actual costs as described by contract;
- record work progress in terms of completed activities;
- revise time and cost estimates-to-complete as required;
- process data such as actual cost, schedules, and estimates-to-complete and produce required PERT COST reports.

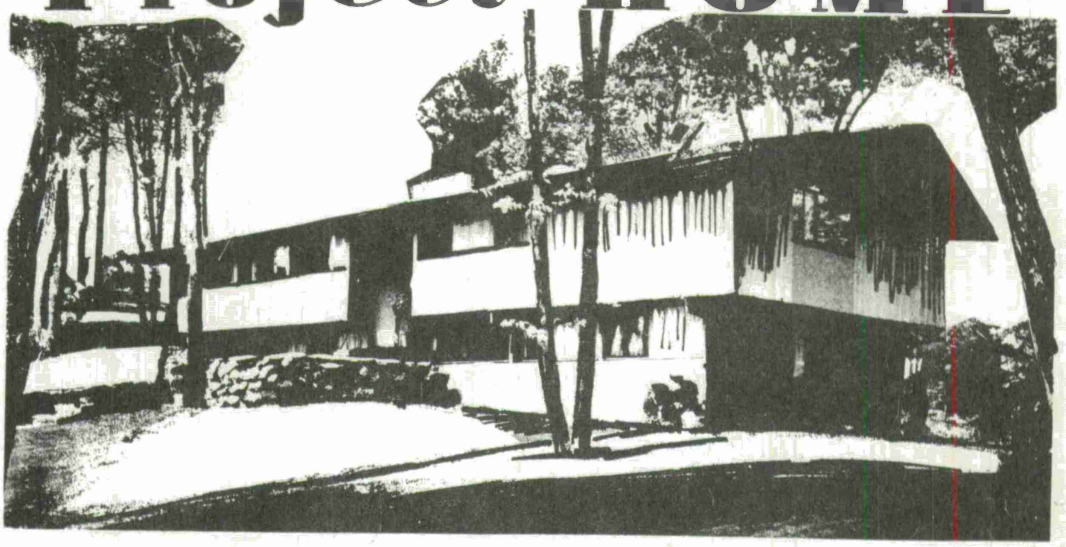
- Contractor technique of program evaluation:
  - produce PERT COST management reports for analysis;
  - identify problem areas, obtain required reports, and formulate solution to eliminate or minimize the problem by:
    - changing "program element" resource allocation;
    - trading off resources from less critical areas;
    - revising network sequencing;
    - changing total program budget or scheduled completion.
- Program Manager's technique of program evaluation:
  - continual analysis of the complete system program;
  - feedback of information and data to the contractors' management system.

We would like to summarize for ourselves by stating that we sincerely hope that this document has been of benefit to you. If even of small benefit, we will feel that our effort was not wasted. If you have any comments concerning the improvement of this publication or of any nature, feel free to forward them to: Electronic Systems Division, L G. Hanscom Field, Bedford, Mass., Attn: Techniques Branch (ESCPT).

APPENDIX A

CASE PROBLEM

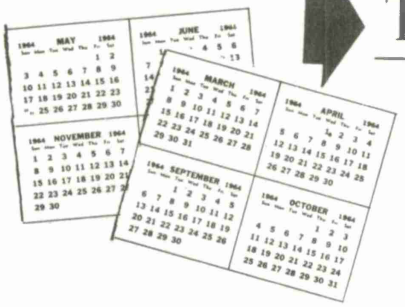
Project HOME



The case problem outlined below will be used to provide simple illustrations of the PERT COST technique as it is progressively presented in this pamphlet.

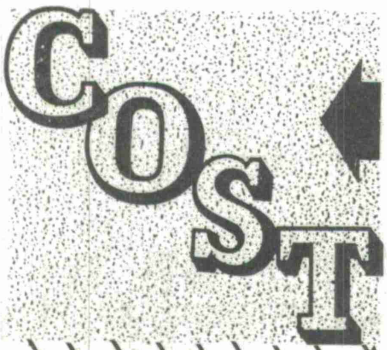
The problem involves the building of a home including landscaping and drive and walks construction. For want of a name, let's call this Project HOME.

Here are the things we want to consider in applying PERT COST to this project:



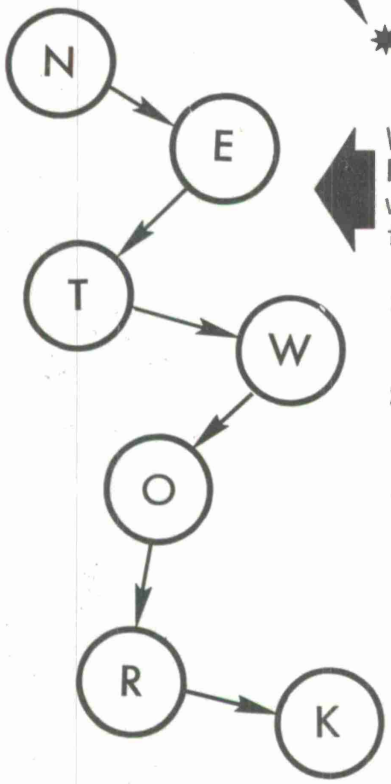
TIME

Total time for the project is desired to be approximately seven months starting with "Land Acquisition" and ending with "Project Complete" as events.



A total planned cost for Project HOME is not established due to the fact that we will be working only pieces of the project. However, to be able to work these pieces, the work breakdown structure and network will have to be constructed so that we will be able to identify cost for the following elements of Project HOME:

- Land acquisition
- Site surveying
- Site grading
- Carpentry work
- Plumbing work
- Painting
- Shrubs and plants
- Driveway
- Walks



We want the PERT network for Project HOME constructed so that we can obtain management data for the following:

* Completion of exterior of house (closed-in)
* Completion of interior of house
* Start of plumbing installation
* Completion of exterior painting
* Start of electrical fixture installation
* Completion of foundation
* Completion of rough carpentry (interior)

Some additional details concerning Project HOME are included in this pamphlet as you reach the portions where we use Project HOME.

Under actual conditions, every detail necessary for the attainment of the end objective of a program must be considered. The same is true for this case problem but for the purpose of this pamphlet we have to assume that certain things have already been or will be accomplished and all other details other than the above have been considered. Examples of other such details are house specifications and drawings, contractor selection, selection of plumbing and electrical fixtures, approval of landscape design, etc. These are just a few. So based on that you can readily see how this case problem could be developed into a large scale PERT COST operation.

APPENDIX B

SYSTEM MODIFICATIONS

The PERT COST system described in this pamphlet has been implemented on a limited number of major weapon systems. During the course of this implementation, the PERT COST operation is being continually evaluated by both Government and industrial personnel.

During this initial implementation, Government and contractor personnel concerned determined that certain modifications could or should be made to the PERT COST system the results of which would be beneficial to both Government and industry. Although all of these modifications may or may not be included in the present initial implementation efforts, they will result in a more comprehensive and refined PERT COST system for future applications.

Therefore, it is possible that some of the modifications may have been developed, tested and included in the PERT COST system by the time you read this pamphlet.

The modifications which are being worked on at this time are identified below. You will recognize that the establishment of them will require not only changes to the present computer program but also to such things as form formats, procedures, etc.

1. Provide for separate rate tables for both estimated and budgeted values.

2. Provide capability for computer processing of data for variable length accounting months.

3. Provide for the inclusion of various overhead rates at various levels of the work breakdown structure.

4. Provide for the assignment of resource codes and work packages to multiple manpower skill and cost categories.

5. Provide an option for printing the rate and skill code tables from the master file.

6. Modify the Cost Estimating and Updating Form to display actual costs as they are accrued by charge or summary number.

7. Modify the Cost Estimating and Updating and Budget Authorization and Updating Forms to provide an indication as to which values are raw data and which are computer produced.

8. Provide an option which will permit the applicable output reports to contain full dollar value identification or values indicated to the nearest thousand.

9. Expand the capacity of the rate table to accommodate 300 "performing organization-resource code" combinations.

10. Modify the Cost Estimating Input and Budget Authorization Input forms to enable man-months to be input in tenths of man-months.

11. Provide an option whereby reports can be generated in either man-hours or man-months.

12. Provide an optional calendar routine whereby the computer will or will not consider holidays.

AIR FORCE BEDFORD, MASS.