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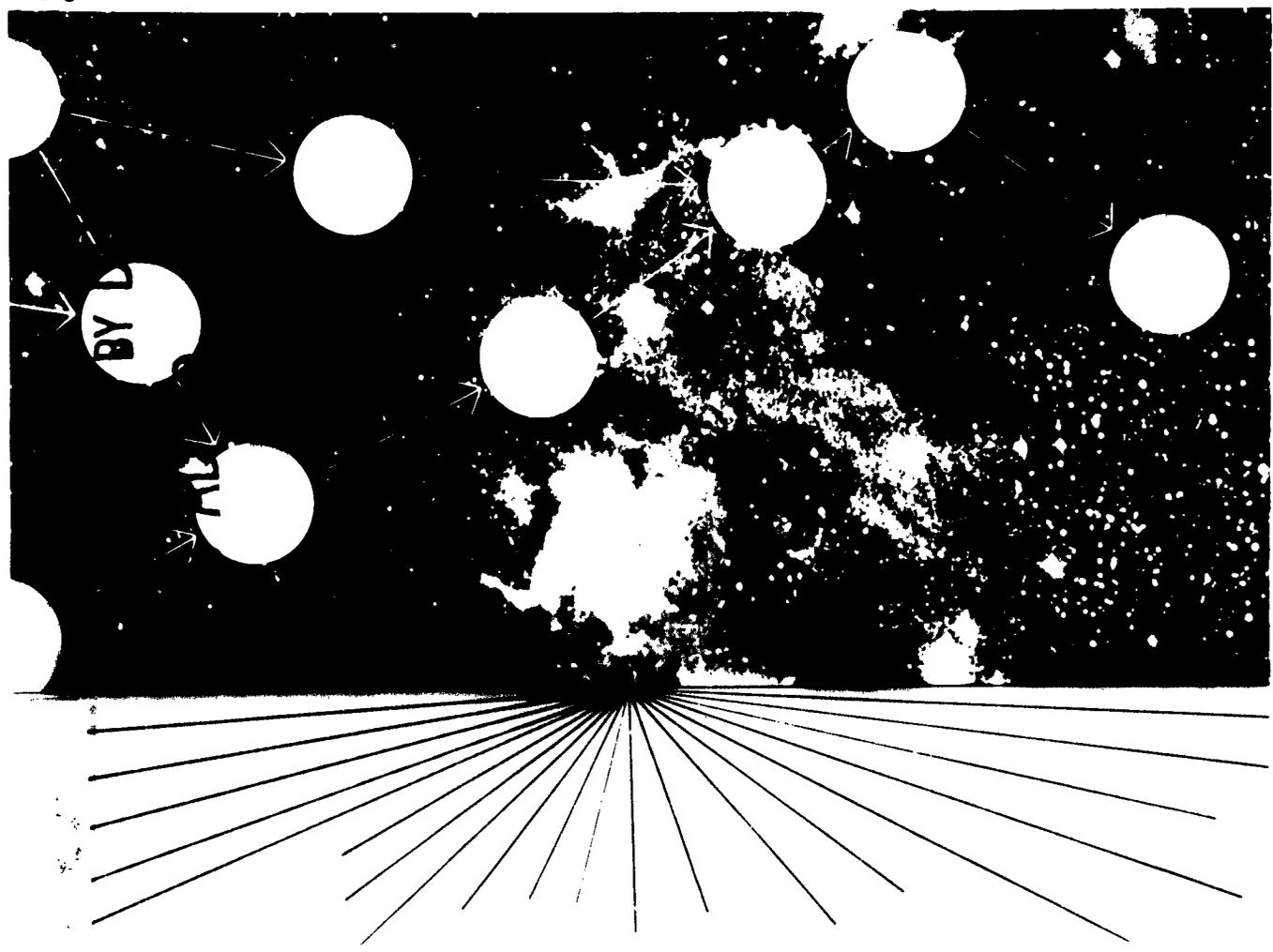


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# USAF • PERT



VOLUME I  
**PERT-TIME SYSTEM DESCRIPTION MANUAL**

ADVANCE COPY FOR AFSC IMPLEMENTATION



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SEPTEMBER 1963

## FOREWORD

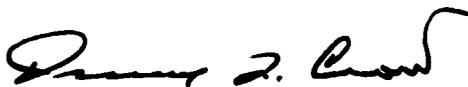
This manual contains a detailed description of the USAF PERT-Time System. It provides methodology and guidance, and serves as a reference for all levels of management in the application of PERT.

In the interests of achieving uniformity of current and future extensions of PERT, a USAF PERT series of documents is being developed. This Manual is Volume I of the series.

This series is grounded in a common philosophy. It is interrelated to the extent that each volume may be used independently or in conjunction with any other volume in the series. The extent of usage is dependent upon the specific requirements of any given program or the management desires of the Program Director concerned.

This advanced copy is effective immediately within AFSC and is currently being coordinated for use within other Commands by Headquarters USAF. It replaces AFSC PERT Policies and Procedures Handbook, ASD Exhibit ASOO 61-1, dated 5 January 1962.

Comments concerning any part of this publication are solicited from both government and industry, and should be forwarded to Headquarters AFSC (SCCS), Andrews AFB, Washington 25, D. C.



DUWARD L. CROW  
Brigadier General, USAF  
DCS/Comptroller

**USAF PERT**

**VOLUME I**

**PERT TIME SYSTEM DESCRIPTION MANUAL**

**SEPTEMBER 1963**

USAF has produced a series of PERT documents to provide understanding of the USAF PERT TIME and PERT COST Systems presently in use. This manual, Volume I, is the first in the USAF PERT series.

**USAF PERT**

<b>VOLUME I</b>	<b>USAF PERT TIME SYSTEM DESCRIPTION MANUAL</b>
<b>VOLUME II</b>	<b>USAF PERT TIME SYSTEM COMPUTER HANDBOOK</b>
<b>VOLUME III</b>	<b>USAF PERT COST SYSTEM DESCRIPTION MANUAL</b>
<b>VOLUME IV</b>	<b>USAF PERT COST SYSTEM COMPUTER PROGRAM HANDBOOK, PART I USAF PERT COST SYSTEM COMPUTER PROGRAM HANDBOOK, PART II</b>
<b>VOLUME V</b>	<b>USAF PERT IMPLEMENTATION MANUAL</b>

## **PREFACE**

The Program Evaluation and Review Technique (PERT), in a 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 PERT was implemented for planning and control of the time variable in research and development work.

This manual describes detailed methods of PERT TIME applications which are used by the Air Force and suggested for use by its contractors. This manual can stand by itself in its coverage of PERT TIME. It contains general concepts, principles, and methods, as well as specific material related to a given computer program operation. However, the manual is related to other documents which should be examined by the reader for more comprehensive understanding of the broad scope of PERT. Some of the other documents are:

### DOD Documents

PERT Guide for Management Use

DOD and NASA Guide; PERT COST Systems Design

Supplement No. 1 to DOD and NASA Guide;  
PERT COST Output Reports

### USAF Documents

USAF PERT TIME System Computer Program Handbook<sup>1</sup>  
USAF PERT COST System Description Manual  
USAF PERT COST System Computer Program Handbook-Part I<sup>2</sup>  
USAF PERT COST System Computer Program Handbook-Part II<sup>3</sup>

### USAF PERT Implementation Manual

A goal of this manual is the attainment of uniformity in Air Force applications of PERT TIME. Since PERT COST requires inputs from PERT TIME, this data should be as uniform as possible during the development of PERT COST techniques.

Although there are several PERT TIME computer programs which may be used to process the data and produce the desired outputs, only one such program is discussed in this manual. Consequently, the illustrations and detailed description of output reports in Chapter XI refer to the format in which data is printed out when using the Air Force program. Essentially the same output information can be produced by any PERT TIME computer program. The program was developed for the specific purpose of incorporating as many of the features desired by Air Force and industry users as possible without overloading the program to the extent that processing time would become prohibitive. The program will therefore produce outputs that may contain information considered extraneous to certain users. With a thorough understanding of basic PERT concepts and operation, the user can select the information pertinent to his particular requirements from the variety of outputs available.

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<sup>1</sup> Formally AFSC PERT III Computer Program Handbook.  
<sup>2</sup> Formerly AFSC PERT COST System Cost Module - Vol. I.  
<sup>3</sup> Formerly AFSC PERT COST System Cost Module - Vol. II.

The material for this manual was arranged in a sequence which permits the reader to advance from the basic concepts through the mechanics to the PERT TIME System operation. Chapter II introduces the basic PERT concepts. Chapters III, IV, and V explain the mechanics of PERT TIME. Chapters VI through XIII describe the PERT TIME System operation.

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**CHAPTER I**

**INTRODUCTION**

## CHAPTER I

### INTRODUCTION

Management like invention is no longer a matter of individual effort; Space-Age programs are too complex. Management of major space, weapons, construction, military or other programs is accomplished through large organizations of professional experts in administration, finance, science, engineering, and production, to list but a few.

In the task of acquiring modern aerospace systems today, the pacing factor is management-not science or technology. Management is the element that directs, guides, coordinates, and controls the many aspects of system development. The need to utilize all our research and development resources effectively, efficiently, and on a timely basis and the need to translate new discoveries into new weapons with the shortest possible lead time-these are our two basic management problems in maintaining technological supremacy today. <sup>1</sup>

Not only must new systems embody the latest technical developments; they must also become operational in time to meet future needs. Each program must be carefully planned, scheduled, evaluated, and managed toward attainment of specific objectives. The complexity of directing and controlling these programs has challenged conventional management techniques.

#### A. Program Evaluation and Review Technique (PERT)

PERT represents a significant step toward an integrated management system encompassing the variables of time, resources, and technical performance. The improved planning produced by PERT offers a sound basis for scheduling as a means by

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1

General Bernard A. Schriever, "The Role of Management in Technological Conflict", Air University Quarterly Review, Winter and Spring 1962 and 1963, pp. 20, Vol XIV, Nos. 1 and 2.

which status may be measured and current and potential problems detected in time to take corrective action. It provides the integrative discipline for government and corporate managers at all levels necessary for the definition, communication, and successful attainment of the prime and supporting objectives of the plan.

PERT is a set of principles, methods, and techniques for planning of objective-oriented work thereby establishing a sound basis for effective scheduling and controlling and replanning in the management of programs.

It employs:

- . a product-oriented work breakdown structure, beginning with these objectives subdivided into successively smaller end-items;
- . a flow plan (called a network) consisting of all the activities and events that must be accomplished or completed to reach the program objectives, showing their planned sequence of accomplishment, interdependencies, and interrelationships;
- . elapsed time estimates and identification of critical paths in the networks;
- . a schedule which attempts to balance the objectives, the network flow plan, and resources availability;
- . analysis of the interrelated networks, schedules and slack values as a basis for continuous evaluation of program status, forecast of overruns, and the identification of problem areas in time for management to take corrective action.

This basic PERT technique is flexible enough to encompass effectively a variety of objectives and applications including allocation of resources to serve several concurrent projects.

## B. PERT and the Management Process

PERT provides clear concise reports for top management in order to evaluate status of completed work and forecast or identify potential problems.

PERT aids managers from the inception to the completion of a program. Although PERT can be introduced in any phase of a program, its full potential is realized only when it is utilized in all phases by both government and industry. In this manner, PERT correlates the many aspects of a complete program and provides continuity through each of the three phases:

- . Pre-contract Phase;
- . Contract Negotiation Phase; and
- . Contract Management Phase.

Government use of PERT assures industrial management that:

- . the objectives of the program and interrelated aspects have been defined, evaluated, and communicated before a request for proposal is issued;
- . contract awards are made on the basis of definitive analyses and improved evaluations.

Similarly, government management is assured that:

- . industry has improved opportunity to plan, bid, and manage a program.
- . more precise planning and control over resources exists;
- . negotiations can be conducted in a more informed manner.

Both government and industrial management benefit from the common use of PERT. It makes a team of the highest and lowest level of government agencies, field establishments, and industry by serving as a means of communication in all phases of the program. It is especially useful in construction projects, system development, production engineering,

and few-of-a-kind production programs. When a high volume production program passes the production engineering or prototype production and test phase, other techniques may prove more appropriate. However, these must be compatible with an overall network management technique suitable for planning, scheduling, and controlling the entire system from conception to operation.

Contractual arrangements, whether they are fixed price, cost-plus-fixed-fee, or incentive variations of either, do not affect the applicability of PERT. The type of contract, however, may influence the emphasis placed on the use of PERT by either government or industry. For example, a contractor may elect to use PERT on a firm fixed-price contract, even though its use may not be required by the contracting authority. Conversely, on a cost-plus-fixed-fee contract, the government may be equally as concerned as the contractor with the use of PERT for program control.

**PERT:**

- . provides disciplines which insure complete program coverage, avoids omission of important tasks at the outset of a program, and provides visibility from the total program objective down to the lowest supporting task;
- . fixes responsibility and assures continuity of effort despite turnover in either executive or operating personnel;
- . assists in identifying real time requirements and provides limits for detailed scheduling;
- . spots potential problem areas in time for preventive action or for improvement;
- . uses the management-by-exception principle in reporting to higher levels of management;
- . measures accomplishment against current scheduled plans and objectives;

- . provides an opportunity for consideration of trade-offs in funds, manpower, performance, and time between critical and noncritical areas of effort as a means of improving schedule plans for one or more programs;
- . permits rescheduling and provides periodic evaluation of plans;
- . makes it possible through its simulation techniques to evaluate and forecast outcomes of alternate plans before implementation;
- . provides a historical data bank for the program which can be drawn upon for new programs.

**CHAPTER II**

**PERT CONCEPTS**

## CHAPTER II

### PERT CONCEPTS

A brief discussion of the basic PERT concepts is presented here to prepare the reader for the detailed treatment to follow.

#### A. The PERT Network

##### 1. Description

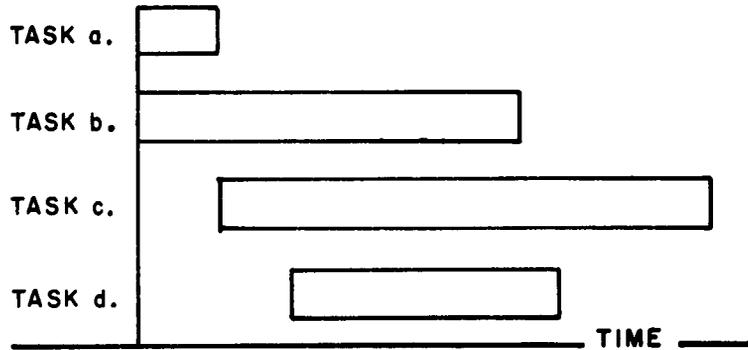
The PERT network is a graphic description of the plan showing the sequential steps needed to reach a stated objective (for example, the R&D, testing, tooling, establishment of a logistics system, etc., that are needed to make a system operational). The network must be comprehensive and include all significant interdependencies and interactions required to perform the program. However, judgment must be exercised to limit the level of detail to that which will best serve the objectives of management.

Networks define activities and interrelationships between activities. They are an improvement over the Gantt chart, which shows activities but either does not indicate their relationships or, at best, indicates only a vague relationship in time. They are also an improvement over the milestone charts, which describe points in time when various items are complete or available but not the interrelationships among these items. These charts usually fail to identify the progress which must be made in one task before subsequent tasks can begin. PERT networks, unlike milestone charts, recognize the progress which must be made in one task before subsequent tasks can begin. The identification of activities and their points of interaction is an essential of networking. Figure II-1 shows a comparison of the Gantt chart, the milestone chart, and the PERT network.

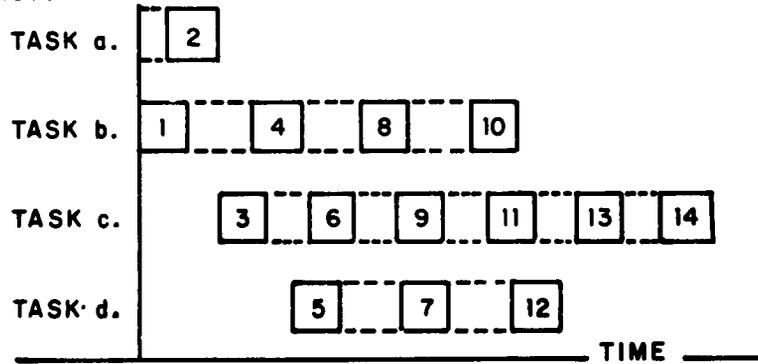
##### 2. Events

By PERT definition, an event is a specific, definable accomplishment in a program plan, recognizable at a particular instant in time. Events do not consume time or resources.

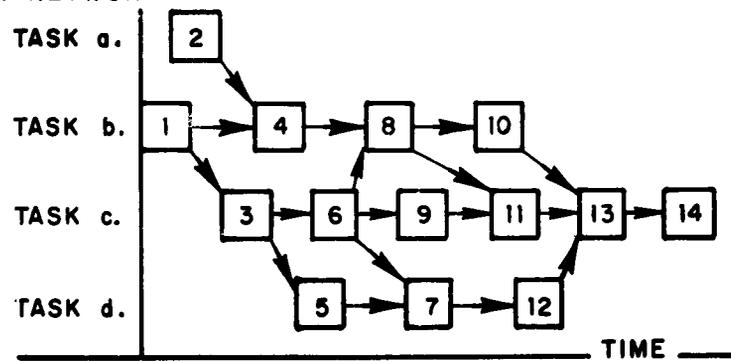
**GANTT BAR CHART**



**MILESTONE CHART**

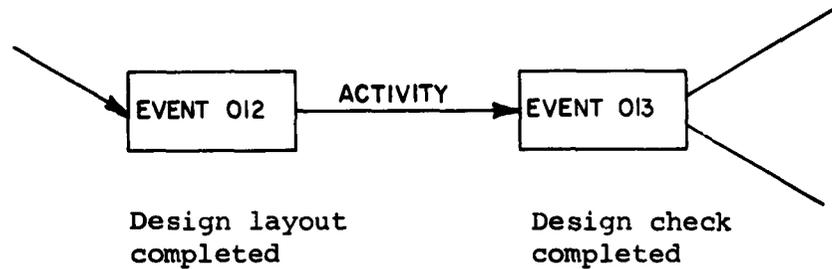


**PERT NETWORK**



**II-1 — COMPARISON OF SCHEDULE PLANNING TECHNIQUES**

An example of two events is shown below. Circles, squares, rectangles, or other geometric figures are used to represent events in the network.



Events are the basis for status monitoring and often for partially describing the activities which lie between them. Care must be exercised that events are clearly defined and therefore meaningful.

The use of network events is demonstrated in Figure II-2. This simplified network shows the key events that are required in an aircraft development task.

### 3. Activities

Activities are the work efforts of a program. They represent the action of the network, such as preparing, designing, building, testing, negotiating, etc. It is these time-consuming elements, whether they be human effort, use of facilities, or use of materials, that the managers must attempt to control.

An activity is represented on a PERT network by an arrow which links two successive events, as shown in Figure II-2. While an activity is normally time-consuming, it may simply represent a relationship of interdependency between two events on the network.

### 4. Constraints

The term "constraint" is used to indicate the relationship of an event to a succeeding activity wherein an activity may not start until the event preceding it has occurred and

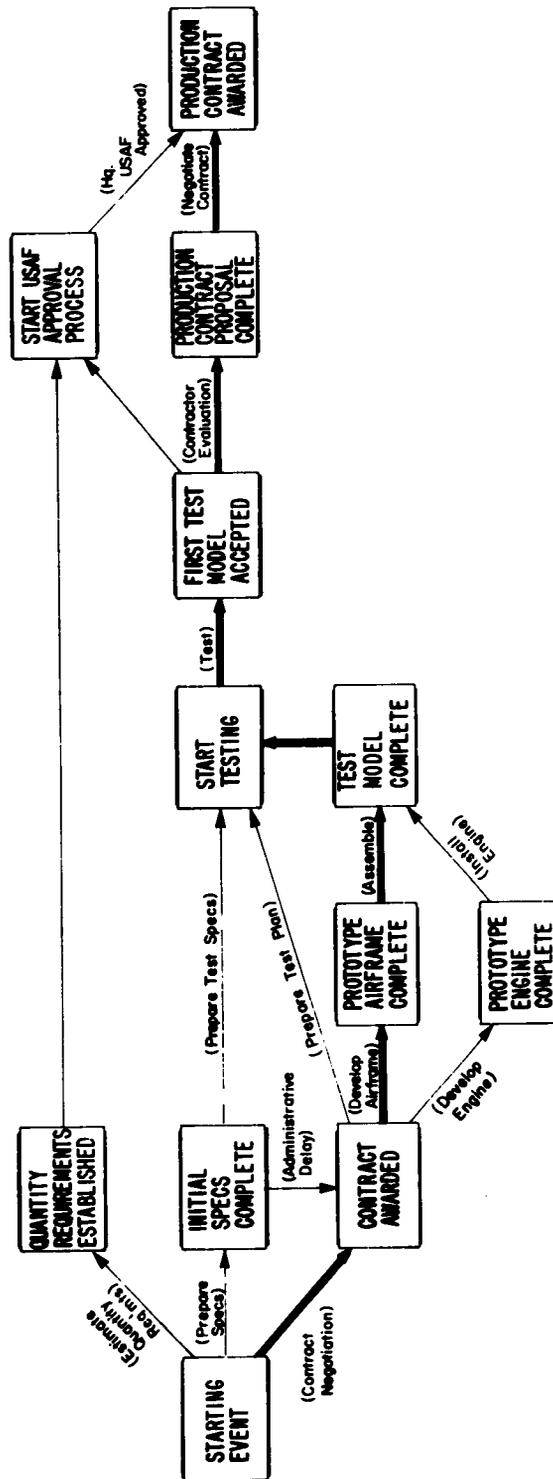
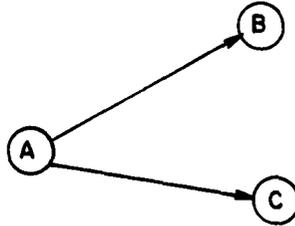


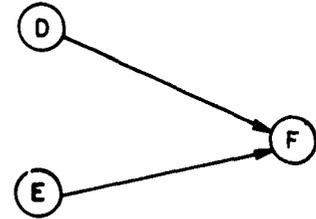
FIGURE II-2 — PERT NETWORK CONSTRUCTED OF EVENTS AND ACTIVITIES

the relationship of an activity to a succeeding event where-  
in an event cannot occur until all activities preceding it  
have been completed.

These event and activity relationships are illustrated  
below.



Event A constrains  
Activities A-B and  
A-C.



Activities D-F and  
E-F constrain Event  
F.

#### B. Time Estimating

The time required to perform each activity in the  
network must be estimated. These estimates are based  
on:

- . planned manpower or other resources;
- . average resource application rates or work  
schedules (the 40-hour week, the number of  
shifts, etc.).

Because of the uncertainty involved in the duration of  
some activities, a range of estimates is usually made. In  
this case, an optimistic, a most likely, and a pessimistic  
time estimate is made for each activity. These activity  
estimates are defined as follows:

- . Optimistic Time Estimate (a) The time in which the activity can be completed if everything goes exceptionally well. It is estimated that an activity would have no more than one chance in a hundred of being completed within this time.
- . Most Likely Time Estimate (m) The most realistic estimate of the time an activity might consume. This time would be expected to occur most often if the activity could be repeated numerous times under similar circumstances.
- . Pessimistic Time Estimate (b) An estimate of the longest time an activity would require under the most adverse conditions, barring acts of God.

A statistically derived "expected elapsed time" ( $t_e$ ) for the activity is then determined from the three time estimates. The three time estimates and the resultant expected elapsed time are illustrated on the activity lines of Figure II-3.

In some areas, e.g. commercial construction, most of the activities are well-defined, and it may not be necessary to use more than one time estimate. When a single time estimate is given for an activity, it is used in all subsequent calculations in the same manner as the expected time ( $t_e$ ) calculated from the three time estimates.

### C. Slack and the Critical Path

#### 1. Expected Date ( $T_E$ )

After calculating the expected elapsed times ( $t_e$ ), the next step is to sum these times throughout the various network paths to determine the total expected elapsed time for the program. This accumulated activity time establishes the expected date ( $T_E$ ) for the program.  $T_E$  is also calculated for each event in the network and shown in Figure II-4 expressed in terms of time rather than calendar dates.

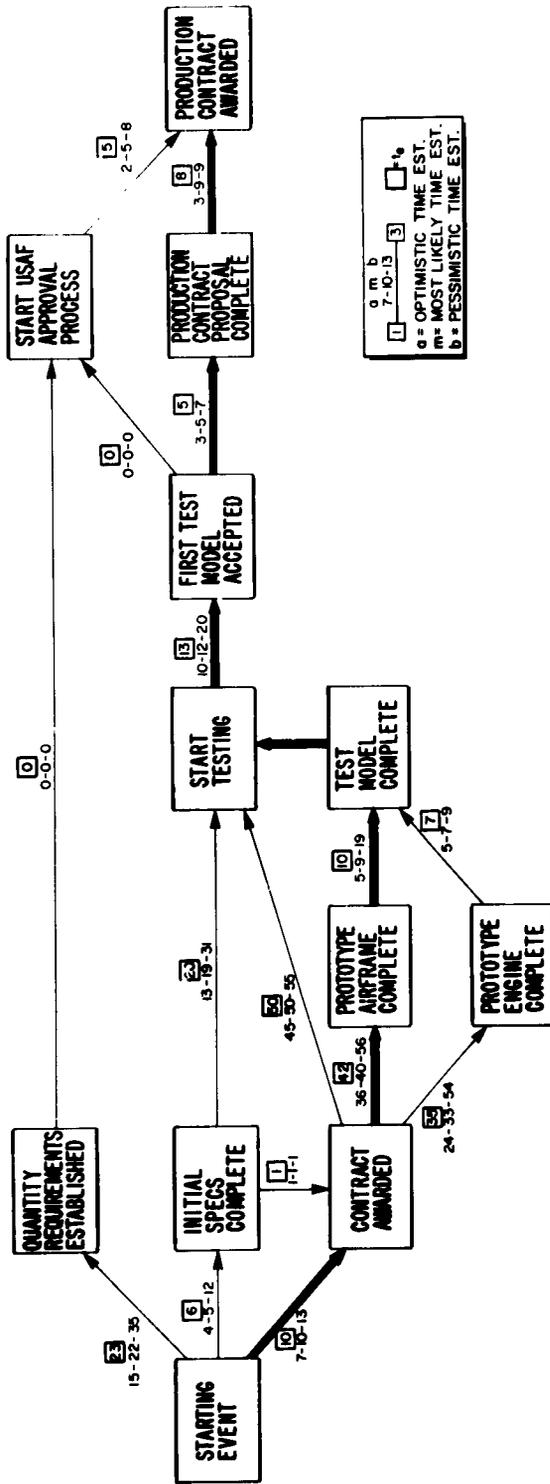


FIGURE II-3—PERT NETWORK WITH TIME ESTIMATES AND CALCULATED EXPECTED ELAPSED TIMES ( $t_e$ )

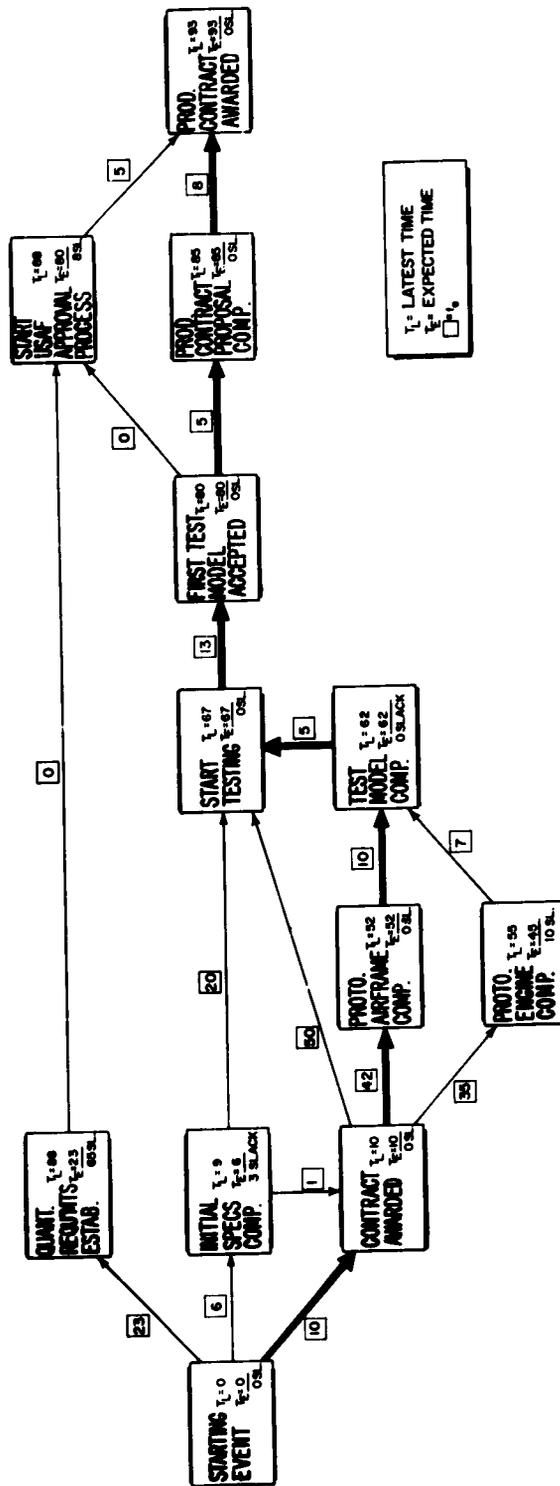


FIGURE II-4 — PERT NETWORK WITH CALCULATED TIMES

Since there are several activities leading into some events, there will be a choice of  $T_E$ 's for those events (one for each path leading into the event). Since no event can occur until all activities leading into it have been completed, the latest of these possible  $T_E$ 's is assigned to the event.

## 2. Latest Allowable Date ( $T_L$ )

$T_L$  is defined as the latest calendar 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 between the given event and the end event of the program from the latest date for completing the program. The  $T_L$ 's expressed in terms of time rather than calendar dates are shown in Figure II-4.

## 3. Determination of Slack and the Critical Path

Slack is the time difference between the latest allowable date and the expected date:  $Slack = T_L - T_E$ . It can have a positive, negative, or zero value. When the latest allowable date ( $T_L$ ) is later than the expected date ( $T_E$ ) positive slack exists. Positive slack is "time to spare".

The path in the network that has minimum slack is the longest time path and therefore is called the critical path. It is characterized by the fact that a slip in an activity time along the critical path will cause an equal slip in the expected completion date of the end event. In Figure II-4 it is the path shown as a heavy line. In the example, all events along this path have zero slack. Zero slack occurs along a path when  $T_L = T_E$  for all events on that path through the network.

If the latest allowable date ( $T_L$ ) for the end event occurs before the expected date ( $T_E$ ) for the end event, the end event must be expected to occur behind schedule unless some action is taken. (In this case, the critical path, and perhaps other paths, will have negative slack.) Thus the program manager's attention is focused on those areas most warranting management action.

**CHAPTER III**

**NETWORK DEVELOPMENT**

## CHAPTER III

### NETWORK DEVELOPMENT

This chapter describes the mechanics of constructing networks.

#### A. Guidelines for Network Construction

Construction of the networks should be initiated by a team of personnel familiar with the objectives and requirements of the program and experienced in the functional areas involved. A member of the local PERT staff office should participate in this initial effort. Later, networking may be continued by program personnel without the assistance of outside specialists.

##### 1. Program Control Events and Activities

Prior to actual network construction, the program milestones which are to be included must be available in their logical sequence as an initial guide line, and all activity and event definitions and responsibilities must be agreed on. Agreement on definitions and responsibilities is especially important when an event is common to one or more functions and is identified as an interface event.

##### 2. Construction Methodology

Experience has shown that there are advantages in constructing a PERT network by starting with the end objective of the program and proceeding backward to the beginning or start event. Since the end objective is constantly and clearly in view, the plan may be developed in direct relation to it.

If network construction were to begin instead at the start event, the question "What comes next?" is asked as each event is defined. This procedure continues through a functional area to reach its objective and then begins again in another functional area. The network is not constructed with direct relation to the end event.

However, if network construction starts at the end event, the question is asked "What activities must be completed before this event is completed?" This avoids the question of what can occur now and substitutes the more objective question of what must have occurred in relation to the end event. The "must-have-occured" question will result in an initial network with fewer personal biases and therefore a more objective and inclusive picture which may be modified as needed.

### 3. Rules of Logic

The fundamental rule of logic for network construction lies in the observance of the constraint relationship. The term constraint is used to indicate the relationship of an event to a succeeding activity wherein an activity may not start until the event preceding it has occurred and the relationship of an activity to a succeeding event wherein an event cannot occur until all activities preceding it have been completed.

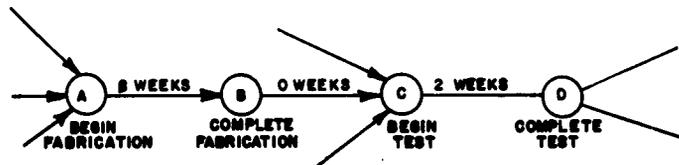
Other rules that must be observed in network construction are:

- . An event must be unique, i.e., it appears only once in the network.
- . An event can appear only once in any continuous path, i.e., the network must not contain a loop.
- . Activities must be able to take place independently of each other and must not require inputs other than those shown by the network as feeding into the initiating event.
- . The activities in a series with each other must also be independent, i.e., the time which one takes must not affect the time which any of the others take.
- . Only one activity or constraint time may connect any pair of events.

#### 4. Zero-time Activity

Another aspect of constraint is the zero-time activity. A zero-time activity is an activity which constrains the completion of the event to which it leads by requiring that the event from which it proceeds be completed first. It has no elapsed time associated with it, i.e., the time estimate is zero. It is often used to tie the completion of several activities to the beginning of a single activity, or vice versa.

The zero-time activity may also be used when it is desirable to indicate by separate events the ending of one activity and the beginning of the following one. This may be desirable in cases where the completion of one activity is of major significance and where it is necessary to assure that the following activity begins immediately as planned. Illustrated below is a zero-time activity between two events to show the completion of one activity and the beginning of another activity.



#### B. An Example of Network Development

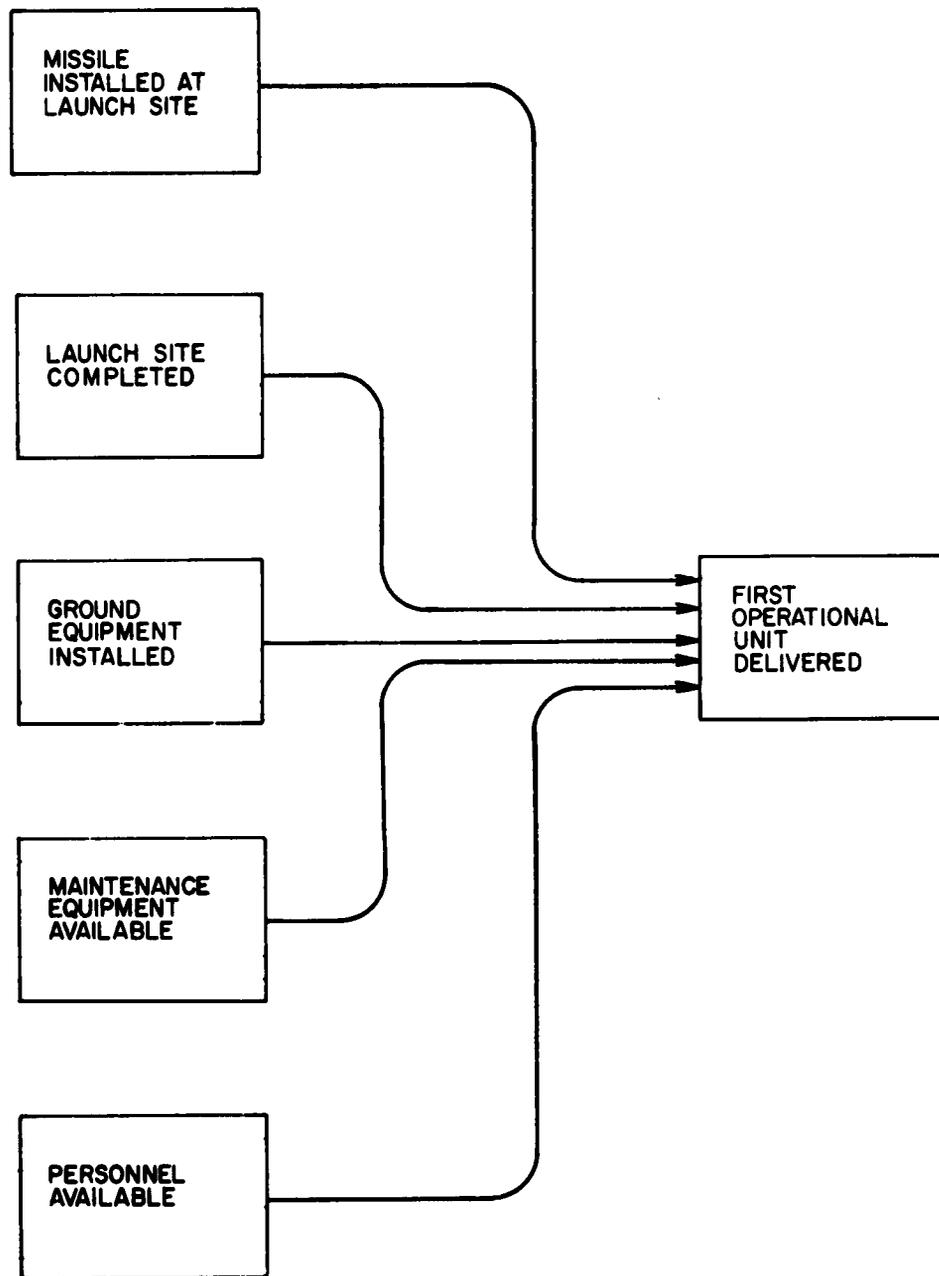
An example of network development is shown in the following pages. In the network to be developed, the delivery of the first operational unit of a program was selected as the end objective or final event. The event is placed on the network worksheet at the far right as depicted below.



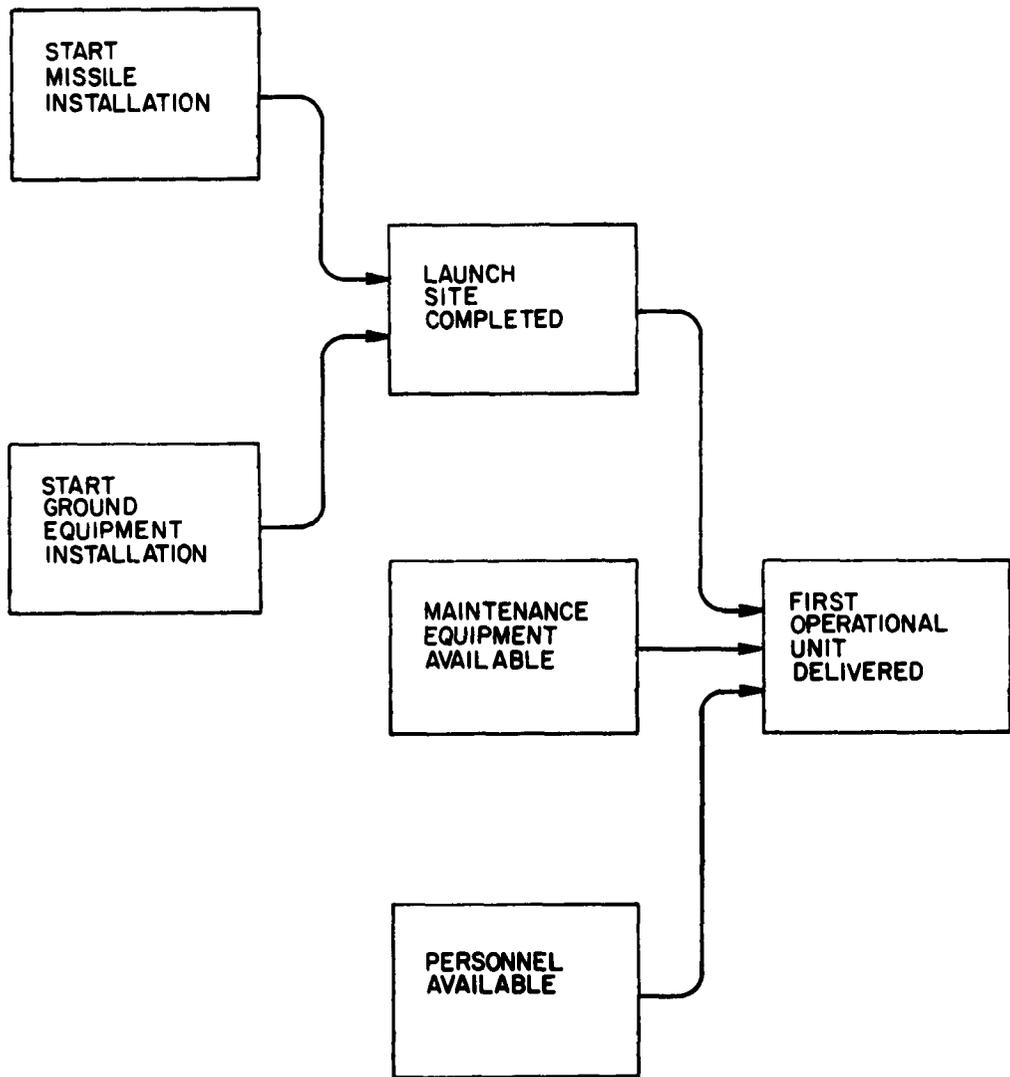
This example assumes that the operational unit consists of five major components: the missile, a missile site, equipment to fire the missile, equipment to maintain both the missile and the ground-based equipment, and personnel to operate the site, maintain the equipment, and if necessary, launch the missile. Figure III-1 shows that delivery of the first unit is dependent on all five of these components.

In analyzing this limited network, a problem of logic is apparent: Do all five components have a direct relationship to the first unit delivery or are they interrelated as shown in Figure III-2. This latter relationship required installation of the missile and ground equipment before the launch site may be considered complete. It can be assumed that the relationship shown in Figure III-2 is correct. Note that the definitions of the Missile and Ground Equipment Events have been changed. These are now starts of installation activities as well as completion of other activities to be defined.

The activity lines leading from the Missile and Ground Equipment Events represent the installation activities. The activity lines between the Launch Site Completed, Equipment Available, and Personnel Available Events, and the Delivery Event may or may not require activity time. If not, a zero time would be assigned to these activities to indicate simply that these events must occur before delivery is considered complete.



**FIGURE III-1 — NETWORK CONSTRUCTION**



**FIGURE III-2 — NETWORK CONSTRUCTION (FURTHER DETAIL)**

Figure III-3 illustrates the process of continuing the network construction toward the program start. (Note that in Figure III-3, the Construction Complete Event is connected to both the Missile and Ground Equipment Installation starts, as well as the Launch Site Completed Events, indicating that construction must be complete before any of these events can occur.)

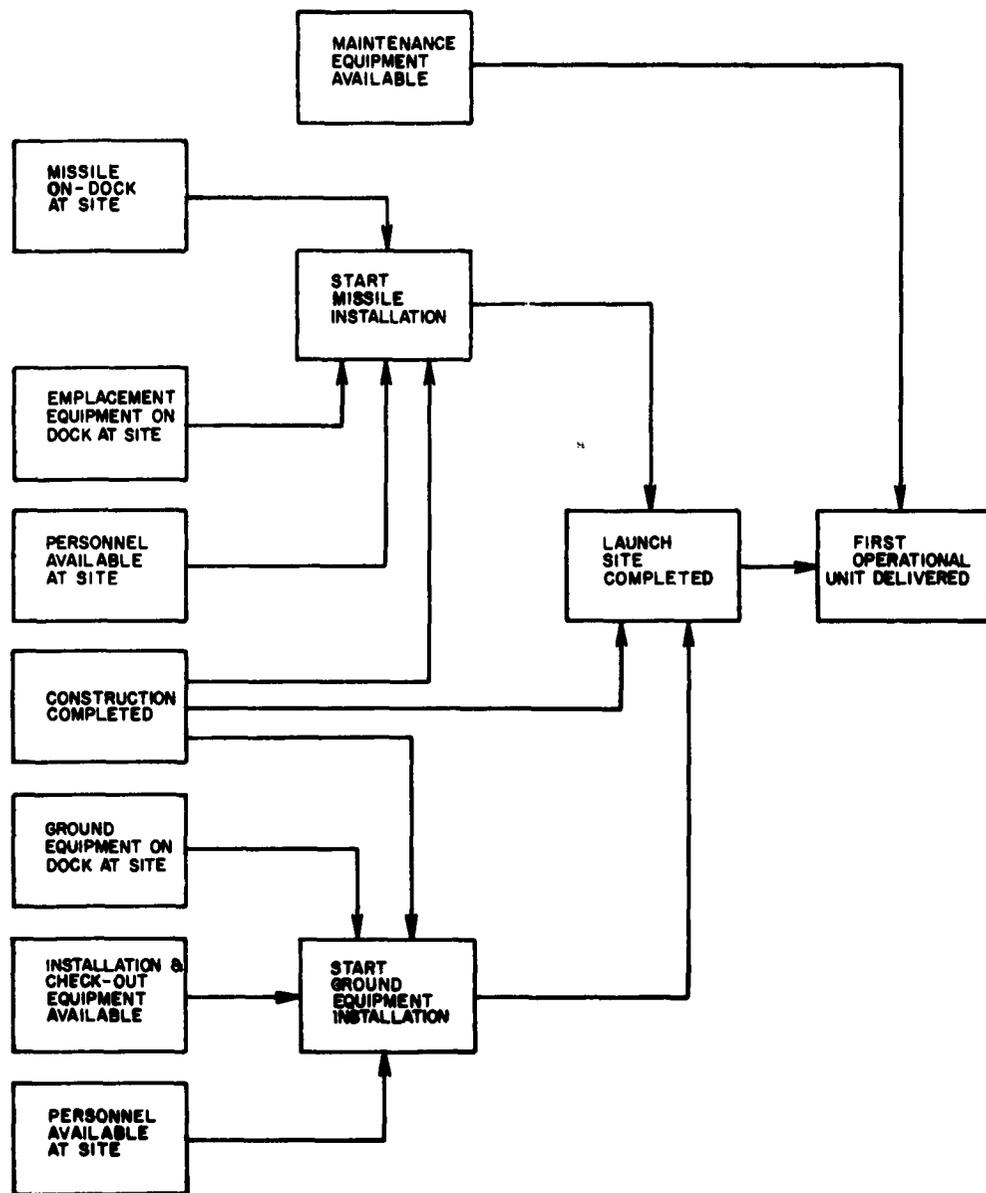
At this point, it may be easier to establish the series of activities that lead up to each of the events now existing in the network. The planner may follow a sequence of thoughts such as the following which refer to the Missile-On-Dock Event:

- . "What is necessary to start loading the missile?" - a transportation vehicle, the missile itself, and equipment to place the missile on the vehicle. All of these must be complete and ready and consequently shown as completed events.
- . "What is necessary to have the missile complete and ready to load?" - it needs to be tested. This can be a start event.
- . "What is necessary to start the testing operation?" - testing equipment, a place to conduct the test, and an assembled and physically complete missile.

This examination results in a progressively more complex network eventually leading back to the source of the network.

Figure III-4 is an example of a simple or broadly defined network which may be drawn in the early phases of a program. Detail is added progressively by inserting related events between those already established in the broad network. Figure III-5 illustrates this process.

As activity and event definition progresses, the interdependencies between elements of the program must be identified. There are many interdependencies between elements such as the missile, missile handling equipment, ground equipment, installation and checkout equipment, etc. For example, the design of the handling equipment must account



**FIGURE III-3 — NETWORK CONSTRUCTION (FURTHER DETAIL)**

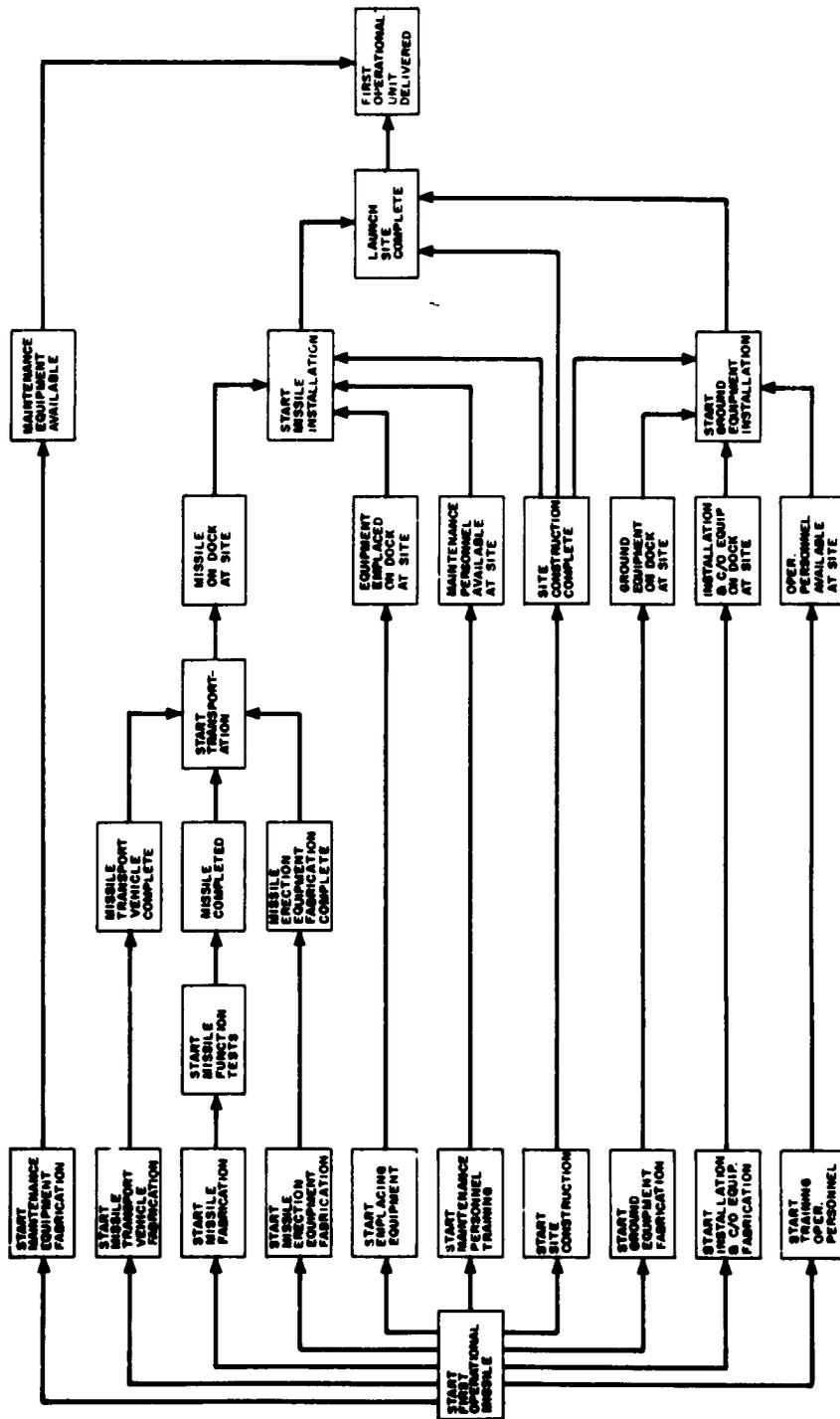
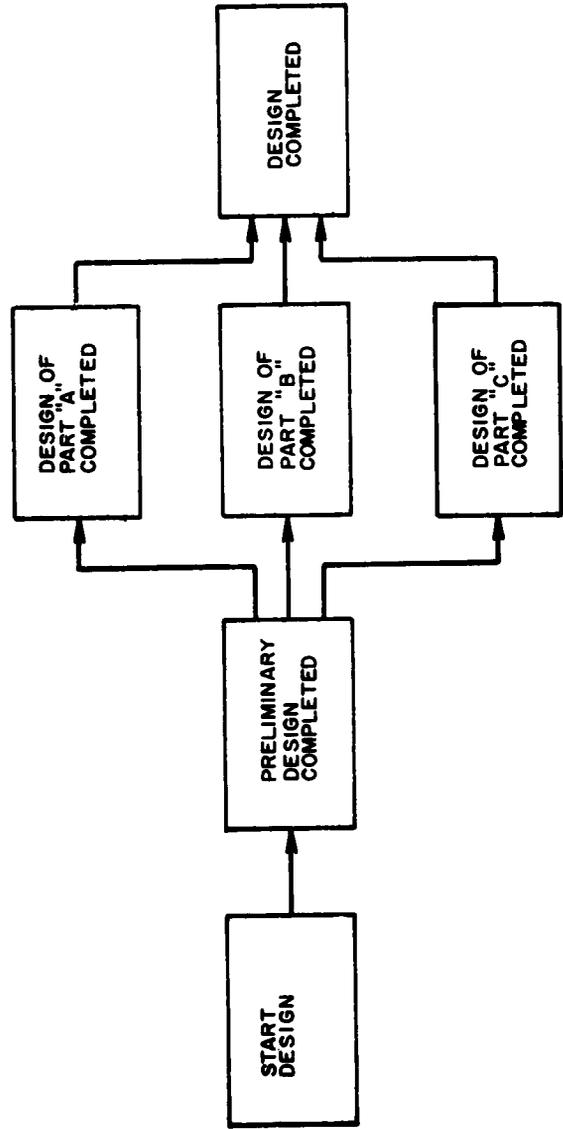


FIGURE III-4 — COMPLETED DETAILED NETWORK



**EXAMPLE OF SIMPLE ACTIVITY**



**FIGURE III-5—INSERTION OF ADDITIONAL DETAIL**

for, as one of its inputs, the dimensions, weights, etc., of the missile itself.

The network in Figure III-6 illustrates these interdependencies and indicates that certain preliminary missile data must be made available to the group designing handling equipment before they can begin detail design. Prior to that point, there could be some design work of a broad nature, and prior to starting a final handling equipment design review, the missile design should be reviewed to resolve any inconsistencies caused by changes to the preliminary missile design.

A similar relationship exists when a series of activities which are normally planned end to end are replanned in parallel. Figure III-7 shows an example of a network which has been replanned to recognize the interrelationships.

In Figure III-8, the sample network has been partially expanded to recognize interdependencies. Note that events which are internal to a function have been added for the sole purpose of expressing interrelationships with other functions.

Initial layout of the sample network is now completed.

### C. Event Identification

Code numbers are assigned to all events in order to identify them adequately for computer processing. USAF PERT uses eight (8) digit event numbers. This is subdivided so that significant coding can be applied to identify specific networks, program functions, items, and hardware and components.

Events are normally numbered by placing low order numbers on the left or beginning of the network. However, in the USAF PERT random assignment of event numbers will create no problem in computer processing, e.g., 30-100-002 need not precede 30-100-003.

The event number, title, and other data may be identified within the event rectangle as illustrated in Figure III-9.

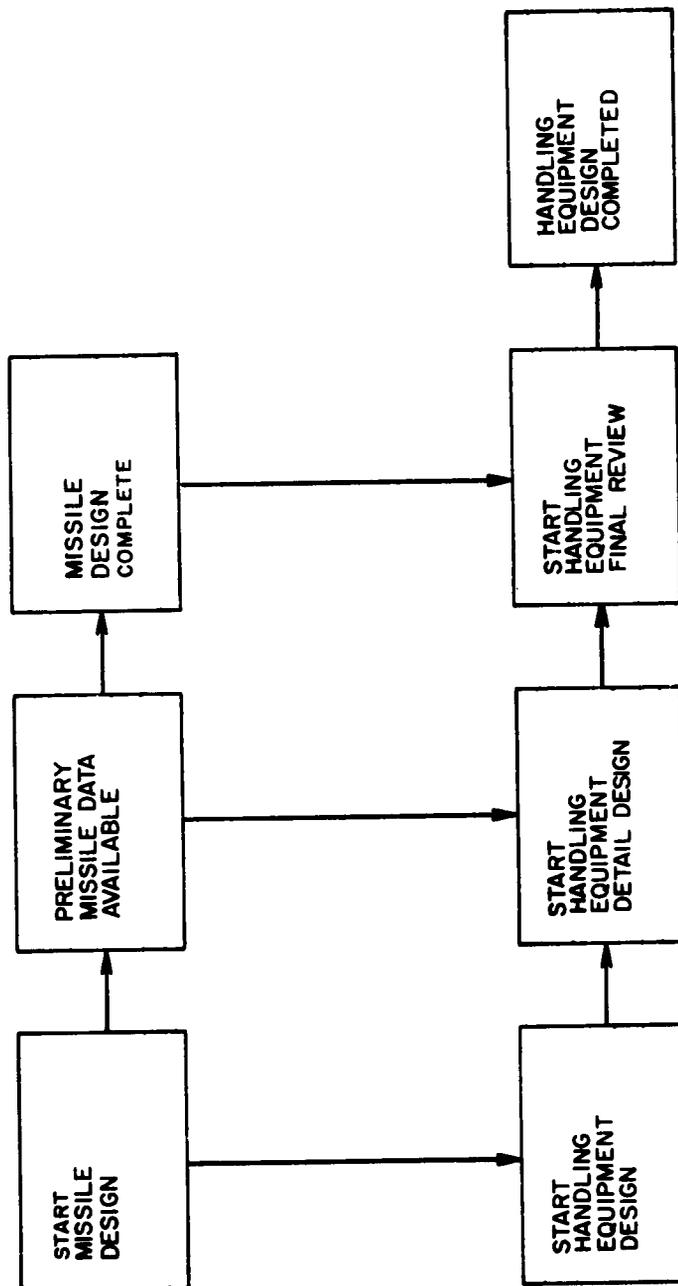


FIGURE III-6 -- INTERDEPENDENCIES BETWEEN PARALLEL EFFORTS

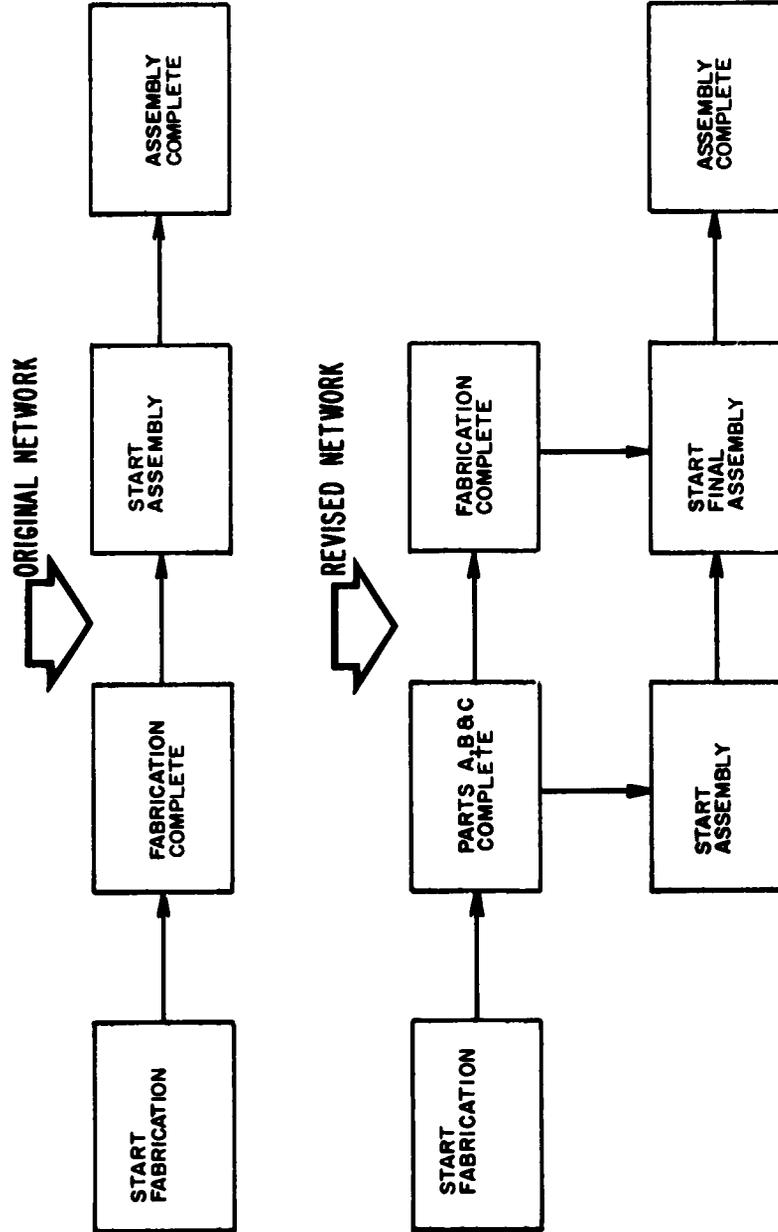


FIGURE III-7 — RECOGNITION OF PARALLEL EFFORTS

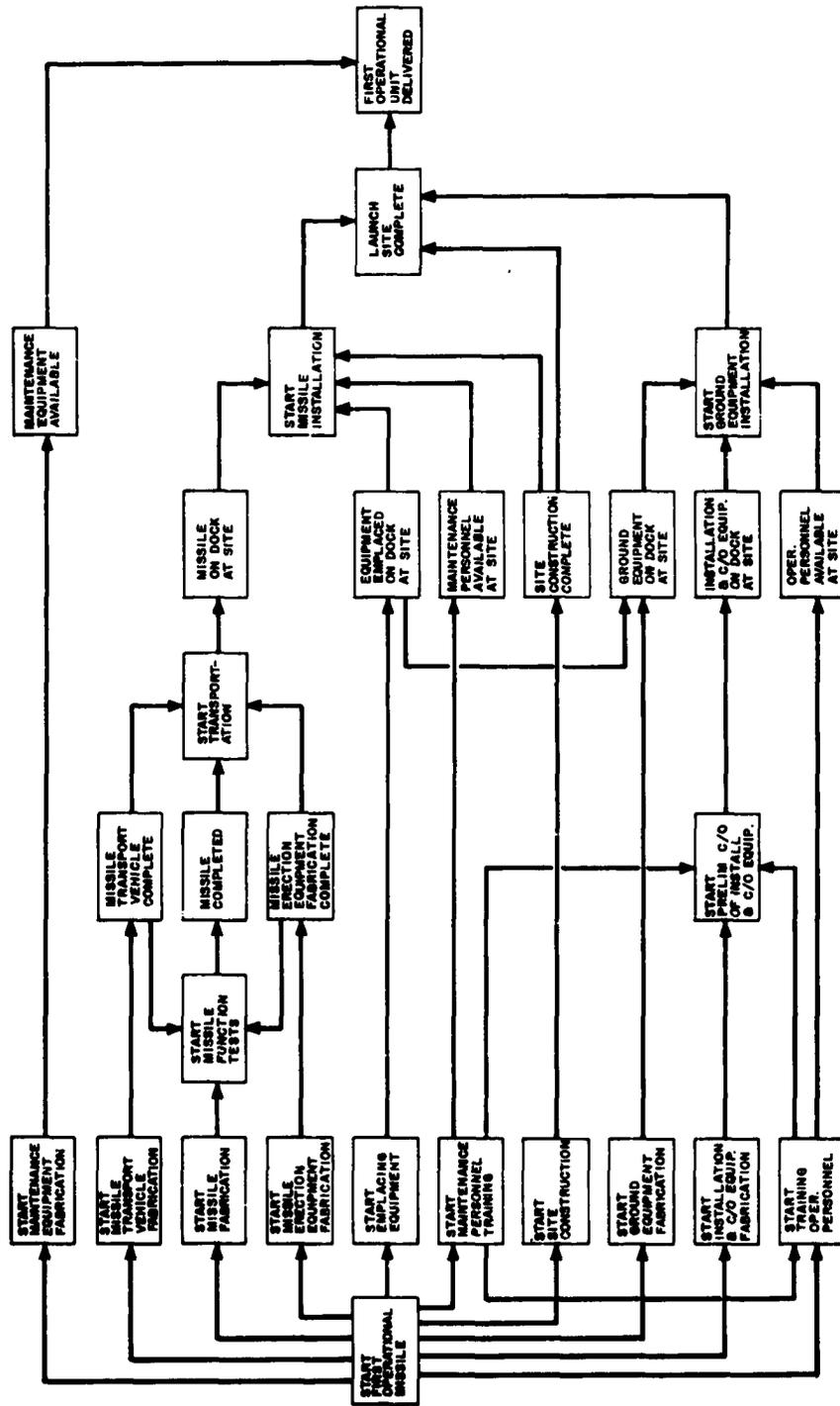


FIGURE III-8 — DETAILED NETWORK EXPANDED TO SHOW INTERDEPENDENCIES

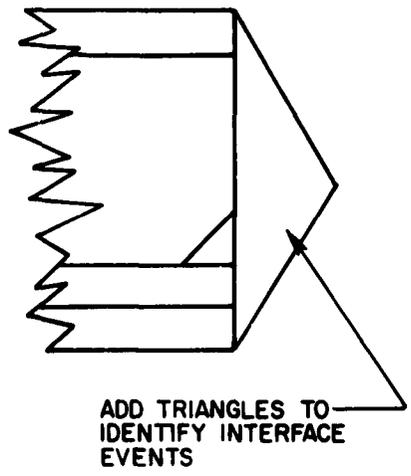
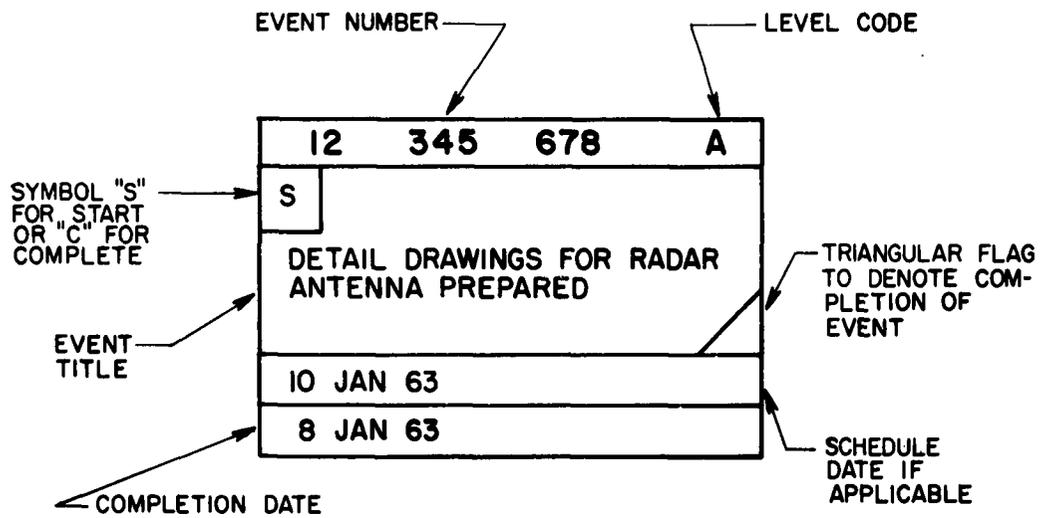


FIGURE III-9 — SAMPLE EVENT BLOCK

**CHAPTER IV**

**TIME CALCULATIONS**

## CHAPTER IV

### TIME CALCULATIONS

This chapter describes the calculations necessary for understanding and operating the PERT TIME System. A simple 9-event, 14-activity network shown in Figure IV-1, is used as a sample network. To simplify the explanations, the events in the sample network were assigned one-digit event numbers, and the standard format was not used.

#### A. Establishment of the Time Estimates

As previously stated, each activity in the network must be assigned time estimates. Since all calculations are based on these estimates, it is imperative that they be as accurate as possible.

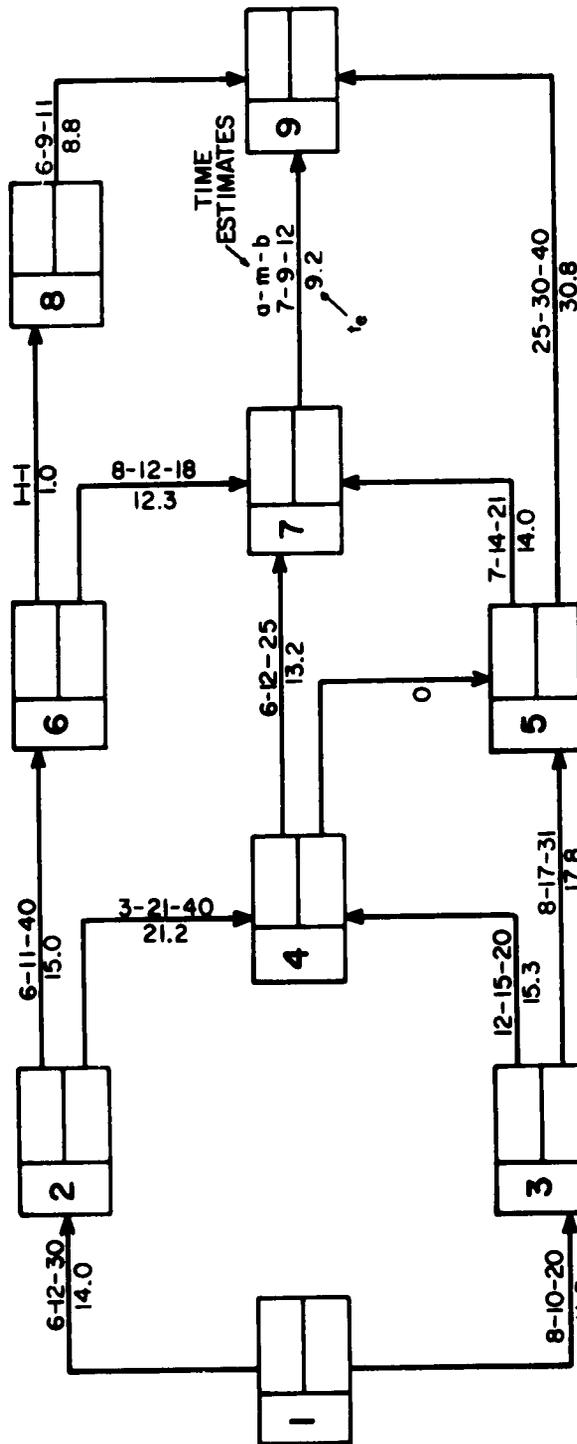
The estimates should be made without regard to calendar or schedule dates and under the assumption that all resources necessary to accomplish an activity are available during a normal work period.

The first time estimate to be established, is the "most likely" time. It is the most realistic estimate of the time an activity might consume. This time would be expected to occur most often if the activity could be repeated numerous times under similar circumstances.

The second estimate, the "optimistic time", is the time in which the activity can be completed if everything goes exceptionally well. It is estimated that an activity would have no more than one chance in a hundred of being completed within this time.

The third estimate, the "pessimistic time", is an estimate of the longest time an activity would require under the most adverse conditions, barring acts of God.

When the estimates are established, they are entered on the applicable network activity line in the order of optimistic, most likely, and pessimistic as shown in Figure IV-1.



ACTIVITY	1-2	1-3	2-4	3-4	3-5	4-5	2-6	4-7	5-7	6-7	6-8	5-9	7-9	8-9
OPTIMISTIC TIME (a)	6.0	8.0	3.0	12.0	8.0	0.0	6.0	6.0	7.0	8.0	1.0	25.0	7.0	6.0
MOST LIKELY TIME (m)	12.0	10.0	21.0	15.0	17.0	0.0	11.0	12.0	14.0	12.0	1.0	30.0	9.0	9.0
PESSIMISTIC TIME (b)	30.0	20.0	40.0	20.0	31.0	0.0	40.0	25.0	21.0	18.0	1.0	40.0	12.0	11.0
EXPECTED ELAPSED TIME ( $t_e$ )	14.0	11.3	21.2	15.3	17.8	0.0	15.0	13.2	14.0	12.3	1.0	30.8	9.2	8.8
EXPECTED TIME ( $T_E$ )														
LATEST TIME ( $T_L$ )														
SLACK ( $T_L$ MINUS $T_E$ )														

FIGURE IV-1— COMPUTATION OF  $t_e$

For computational purposes, these values have also been listed in the table appearing in Figure IV-1. The zero time value between Events 4 and 5 in this network indicates a constraint with no work content.

It is essential that the time estimate for each activity be made by the individual responsible for its execution (or if the responsibility has not been established, as in the case of developing a proposal, by the individual with the most experience in similar types of activity). As the program progresses it is the responsible manager who can best be expected to learn progressively more about his activity and to sense changes in the situation. The ability of the PERT System to provide predictions of problems far enough in advance to permit management to resolve them is based on the manager's ability to translate these changes into new time estimates.

There are some activities, such as the Curing of Concrete to Specifications, which require a predictable or known period of time, in which case the three time estimates may be equal.

B. Expected Elapsed Time ( $t_e$ )

The three time estimates are converted to a single calculated expected elapsed time by the simple approximation formula  $t_e = \frac{a + 4m + b}{6}$ . The expected elapsed time is a statistically weighted average of the three time estimates and represents a value for which there is an approximate 50 percent chance that the time span will, in fact, prove to be shorter and a 50 percent chance that the time span will, in fact, prove to be longer. With this formula, the  $t_e$  for Activity 1-2 is calculated using the time estimates shown along the activity line in Figure IV-1;

$$\frac{6 + (4 \times 12) + 30}{6} = \frac{84}{6} = 14.0 = (t_e)$$

The values are rounded off to the nearest one-tenth of a week.

### C. Expected Date ( $T_E$ )

The expected date ( $T_E$ ) for each event is the date that the event is expected to occur. It is calculated by adding to the date of each start event or completed event of the network the activity times along each possible path up to the event under consideration. The latest of these computed dates is the expected date of completion for the event.

In the sample network (Figure IV-2) there is one activity leading from Event 1 to Event 2 and one activity leading from Event 1 to Event 3. Therefore, the  $T_E$ 's for Events 2 (14.0) and 3 (11.3) are the same as the  $t_e$ 's for the activities leading to the events.<sup>1</sup>

Since there are two activities (2-4 and 3-4) leading to Event 4, there are two values, and the larger of the two is selected as the  $T_E$  for Event 4. The  $t_e$ 's for the two paths are added as follows:

- . For Path 1 to 2 to 4, add 14.0 and 21.2, which equals 35.2.
- . For Path 1 to 3 to 4, add 11.3 and 15.3, which equals 26.6.

The larger of these values, 35.2, obtained through Event 2, becomes the  $T_E$  for Event 4.

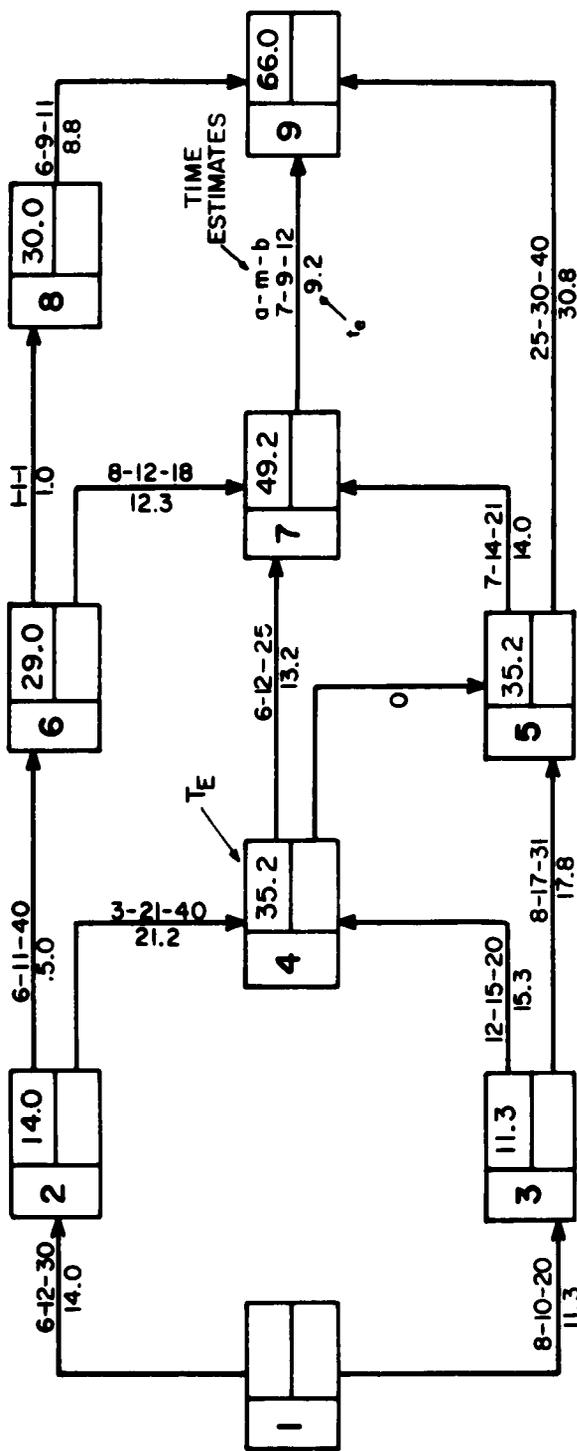
Carrying the calculations into Event 5, it must be remembered that although there are two activities leading to Event 5, there are three paths leading to that event as follows:

- . Path 1 - Activities 1 to 2 to 4 to 5;
- . Path 2 - Activities 1 to 3 to 5;
- . Path 3 - Activities 1 to 3 to 4 to 5;

---

<sup>1</sup>

The expected date ( $T_E$ ) is a calendar date. However, in making calculations it is often useful to make use of an expected time which is a numerical value for the expected date equal to the number of weeks from the start date to the expected date. In the following discussions of  $T_E$  and  $T_L$ , the time values are used.



ACTIVITY	1-2	1-3	2-4	3-4	3-5	4-5	2-6	4-7	5-7	6-7	6-8	5-9	7-9	8-9
OPTIMISTIC TIME (a)	6.0	8.0	3.0	12.0	8.0	0.0	6.0	6.0	7.0	8.0	1.0	25.0	7.0	6.0
MOST LIKELY TIME (m)	12.0	10.0	21.0	15.0	17.0	0.0	11.0	12.0	14.0	12.0	1.0	30.0	9.0	9.0
PESSIMISTIC TIME (b)	30.0	20.0	40.0	20.0	31.0	0.0	40.0	25.0	21.0	18.0	1.0	40.0	12.0	11.0
EXPECTED ELAPSED TIME ( $t_e$ )	14.0	11.3	21.2	15.3	17.8	0.0	15.0	13.2	14.0	12.3	1.0	30.8	9.2	8.8
EXPECTED TIME ( $T_E$ )	14.0	11.3	35.2	26.6	29.1	35.2	29.0	48.4	49.2	41.3	30.0	66.0	58.4	38.8
LATEST TIME ( $T_L$ )														
SLACK ( $T_L$ MINUS $T_E$ )														

FIGURE IV-2 — COMPUTATION OF  $T_E$

The  $T_E$  for Event 4 is 35.2 and is based upon the longest path, which comes via Event 2 and not Event 3. Therefore, in computing the  $T_E$  for Event 5, it is obvious that the value of the path through Events 3 and 4 is less than the value along the path through Events 2 and 4. Consequently Path 3 above need not be computed. Paths 1 and 2, however, do have to be computed as follows:

- . Path 1 - Add 35.2 and 0.0, which equals 35.2;
- . Path 2 - Add 11.3 and 17.8, which equals 29.1.

The 35.2 value is larger than 29.1 and therefore becomes the  $T_E$  for Event 5.

In the same way,  $T_E$ 's are obtained for each event in the network until a  $T_E$  of 66.0 weeks is obtained for Event 9, the end event. This value of 66.0 weeks after program start is the expected time for program completion. The  $T_E$ 's for each event are shown on the network and listed in the table in Figure IV-2. The expected time for each event is converted to a calendar date and carried as such after a start date for Event 1 has been established.

#### D. Latest Allowable Date ( $T_L$ )

The latest allowable date ( $T_L$ ) is the latest date on which an event can occur without creating an expected delay in the completion of the program.  $T_L$  is found by calculating backward from the end event of a network to the start event. To determine the  $T_L$  for an event, the expected elapsed time ( $t_e$ ) for an activity leading from that event is subtracted from the  $T_L$  already established for the event into which the activity leads. Where an event has several activities leading from it, the subtraction is made for each activity and the earliest date obtained is designated as the  $T_L$  for that event. This date is used in further backward computations.

The  $T_L$  for Events 7 and 8, which have only one activity leading from each, is computed as follows:

Previous Event $T_L$	Minus the $t_e$ for the activity leading into it	Result in the $T_L$ for the event from which the activity leads
66.0 (Event 9)	- 8.8	= 57.2 ( $T_L$ for Event 8)
66.0 (Event 9)	- 9.2	= 56.8 ( $T_L$ for Event 7)

The  $T_L$  for Event 5, which has two activities leading from it, is computed as follows:

<u>Previous True <math>T_L</math></u>	<u>Minus the <math>t_e</math></u>	<u>Equals <math>T_L</math> for Event 5</u>
66.0 (Event 9)	- 30.8	= 35.2
56.8 (Event 7)	- 14.0	= 42.8

Since there are two possible  $T_L$ 's for Event 5, the smallest value is selected; therefore the value of 35.2 is the  $T_L$  for Event 5. The complete calculation of  $T_L$  for the events is shown in Figure IV-3.

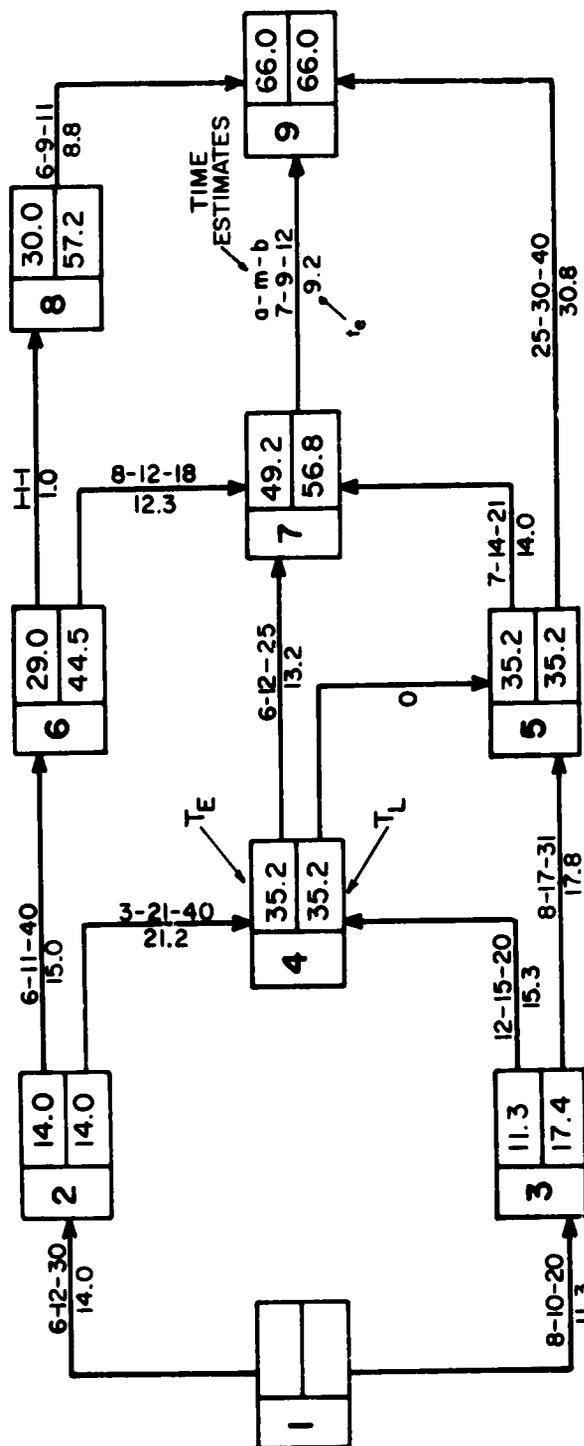
#### E. Slack ( $T_L - T_E$ )

In computing slack for the sample network,  $T_L$  was made equal to  $T_E$  for the end event. When this condition exists there is zero slack. Since the  $T_E$ 's and the  $T_L$ 's are marked on the network in Figure IV-3, they are easy to compare and it can be seen that  $T_E$  equals  $T_L$  for Events 9, 5, 4 and 2. Therefore, these events have zero slack.

Slack for the other events is determined by subtracting  $T_E$  from  $T_L$ . Slack of Event 8 is 27.2 (57.2 - 30.0), and for Event 7 it is 7.6 (56.8 - 49.2). This process is continued until the slack for each event is obtained and is listed in the table in Figure IV-3.

#### F. Critical Path

The final step is an identification of the critical path. The critical path of a network is that path which is the most time consuming. Events having the least slack lie on the critical path. In the example, the least slack



ACTIVITY	1-2	1-3	2-4	3-4	3-5	4-5	2-6	4-7	5-7	6-7	6-8	5-9	7-9	8-9
OPTIMISTIC TIME (a)	6.0	8.0	3.0	12.0	8.0	0.0	6.0	6.0	7.0	8.0	1.0	25.0	7.0	6.0
MOST LIKELY TIME (m)	12.0	10.0	21.0	15.0	17.0	0.0	11.0	12.0	14.0	12.0	1.0	30.0	9.0	9.0
PESSIMISTIC TIME (b)	30.0	20.0	40.0	20.0	31.0	0.0	40.0	25.0	21.0	18.0	1.0	40.0	12.0	11.0
EXPECTED ELAPSED TIME ( $t_e$ )	14.0	11.3	21.2	15.3	17.8	0.0	15.0	13.2	14.0	12.3	1.0	30.8	9.2	8.8
EXPECTED TIME ( $T_E$ )	14.0	17.4	35.2	35.2	35.2	35.2	44.5	56.8	56.8	49.2	41.3	66.0	66.0	66.0
LATEST TIME ( $T_L$ )	0.0	6.1	0.0	8.6	6.1	0.0	15.5	8.4	7.6	15.5	27.2	0.0	7.6	27.2
SLACK ( $T_L$ MINUS $T_E$ )														

FIGURE IV-3 — COMPUTATION OF  $T_L$  AND SLACK

is zero; therefore, the critical or longest path consists of Activities 1-2-4-5-9. The network for a large and complex system will probably have several paths having equal or approximately equal slack. In this example, the second most critical path (Activities 1-3-5-9) has a 6.1-week positive slack, and the third most critical path (Activities 1-2-4-5-7-9) has a 7.6-week positive slack. Although these paths are not critical at this time, the manager must be aware that a path may slip more than the difference in slack between it and the critical path, thereby becoming the new critical path.

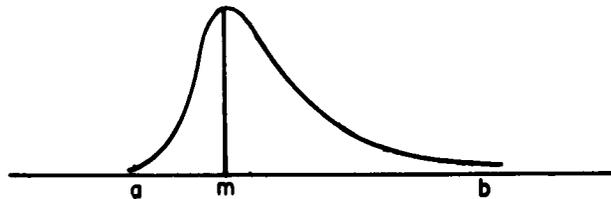
The critical path may be outlined on the network drawing in color, or where reproduction is required, a double or heavier line may be drawn. Less critical paths may be shown in various other colors or patterns for better graphical presentation.

G. Derivation of the Expected Elapsed Time ( $t_e$ ) and the Standard Deviation ( $\sigma$ ) from the Three Time Estimates

The expected elapsed time ( $t_e$ ) was introduced as a statistically weighted average of the three time estimates which could be expressed by the simple equation

$$t_e = \frac{a + 4m + b}{6}$$

This expression rests on the assumption that the expected activity time is best represented by a distribution of values. In particular, the beta distribution is used as the model of this distribution of activity time values. The node of this curve is located at the most likely time and its range is the interval between the optimistic and pessimistic times, as illustrated below.



The two important parameters to be derived from this distribution are the expected (or mean) elapsed time and the standard deviation.<sup>1</sup>

For a certain class of frequency distributions, of which the beta is one, the standard deviation can be estimated as one-sixth of the range. Therefore, the standard deviation of an activity's expected elapsed time is expressed by the equation

$$\sigma = \frac{b-a}{6}$$

To derive the expected time, the probability density function of the distribution is expressed, straightforward calculations are performed, and a linear approximation is made, resulting in the equation

$$t_e = \frac{a + 4m + b}{6}$$

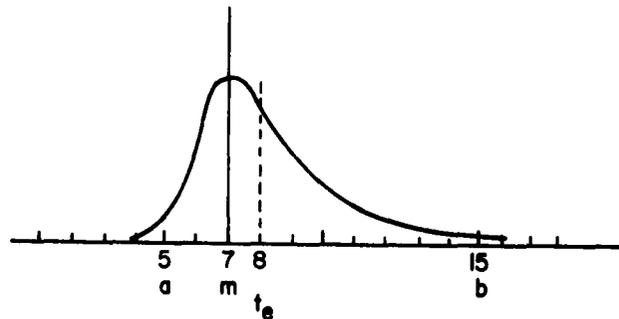
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The standard deviation, sigma ( $\sigma$ ), is a measure of variation about the mean of a distribution. Its numerical value is such that 67 percent of the values making up the distribution will be within one sigma of the mean value, 95 percent of the values will be within two sigma of the mean value, and 99 percent, within three sigma.

The figure below shows a beta distribution for three estimates of 5, 7, and 15 weeks corresponding respectively to the optimistic (a), most likely (m), and pessimistic (b), time estimates. From a, m, and b the expected elapsed time of 8 weeks is derived, i.e.

$$t_e = \frac{5 + (4)(7) + 15}{6} = 8$$



This value of eight weeks is the mean of the distribution and divides the area under the curve in half. Thus, there is an estimated 50-percent chance that the time span will, in fact, prove to be shorter than 8 weeks and a 50-percent chance that the time span will, in fact, prove to be longer.

The standard deviation is 1.7 weeks, i.e.

$$\sigma = \frac{b - a}{6} = \frac{15 - 5}{6} = 1.7$$

Thus, there is a .99 probability that the actual elapsed time will fall within  $8 \pm 5.1$  weeks or between 2.9 and 13.1 weeks.

When the values of  $t_e$  and  $\sigma$  have been derived for all the activities in the network, the probability that the end event of the program will be completed by some scheduled or desired date can be calculated. This calculation is demonstrated in Chapter XII, Program Analysis.

CHAPTER V

NETWORK SUMMARIZATION AND INTEGRATION

## CHAPTER V

### NETWORK SUMMARIZATION AND INTEGRATION

In large programs, detailed networks will be generated by several agencies. These networks will be constructed to the depth of detail necessary for control at the operating level and generally will contain more detail than required by middle and top management. A technique has been developed whereby a detailed network can be summarized to a level appropriate for the higher levels of management. Likewise, the technique facilitates the integration of a number of summarized networks for the appraisal of an overall program. The summarization technique and integration procedure require that certain rules be followed in handling the events that must be included in a summarized network and the events that are common to several networks in order that integration may be accomplished. These requirements are described in the following paragraphs.

#### A. Interface Events

One of the key elements in the summarization technique is the interface event. Interface events are those that signal the necessary transfer of responsibility, end items, or information from one part of the effort to another. As there are several agencies involved in a weapon system development and each agency's detailed network is not always independent of the others, interface events will exist. These events will appear and retain their identity in the detailed, summarized and integrated networks.

Interface events may appear as either start, end, or regular events in the body of the network. Since  $T_E$  and  $T_L$ , as computed for interface events in the processing of the integrated network, must be accepted as valid dates by the detailed networks, processing is more convenient if the interface events appear as start or end events; otherwise, the process must have the capability to fix firmly the  $T_E$  and  $T_L$  values so that they are not affected by subsequent internal processing of detailed networks.

## B. Network Summarization

The summarization technique is a process of reducing detailed networks to a skeletal or summary network for simplification in the integration cycle. Each reporting organization, as required, will prepare and submit summarized network data to the organization responsible for integrating the summarized networks into a total system network. The summarized network may be constructed manually or mechanically, depending upon the capabilities of the reporting organization.

The summarized network will contain the following events: start, end, interface, milestone, and those selected by the summary technique from the detailed networks. Each constraint in the summarized network represents the longest path from one event to the next. The corresponding  $t_e$  values represent the summation of the  $t_e$  values along the longest path as derived from the detailed network. The  $T_E$  and  $T_L$  for the events appearing in the summarized network equal the  $T_E$  and  $T_L$  computed for these events in the detailed networks. Figure V-1 illustrates the general concept of summarized networks.

Designated events are identified by level codes. The summarizing program then considers every possible pair of these events and determines whether or not a topological relationship between the two events exists (i.e., at least one path passes through both events). If such a relationship exists, then a constraint between the two events is calculated for the summarized network, and the expected elapsed times are derived from the longest path between the two events. The optimistic and pessimistic time values for each such constraint are established at three standard deviations each side of the calculated  $t_e$ .

The constraints obtained in this manner are sufficient to describe the full effect of the detailed activities.

It should be noted that the summarizing program does not initially determine expected or latest dates or any of the other standard PERT calculations. It simply produces a file of the constraints in the summarized network along with their time estimates and other information. This constraint file along with similar files from other detailed

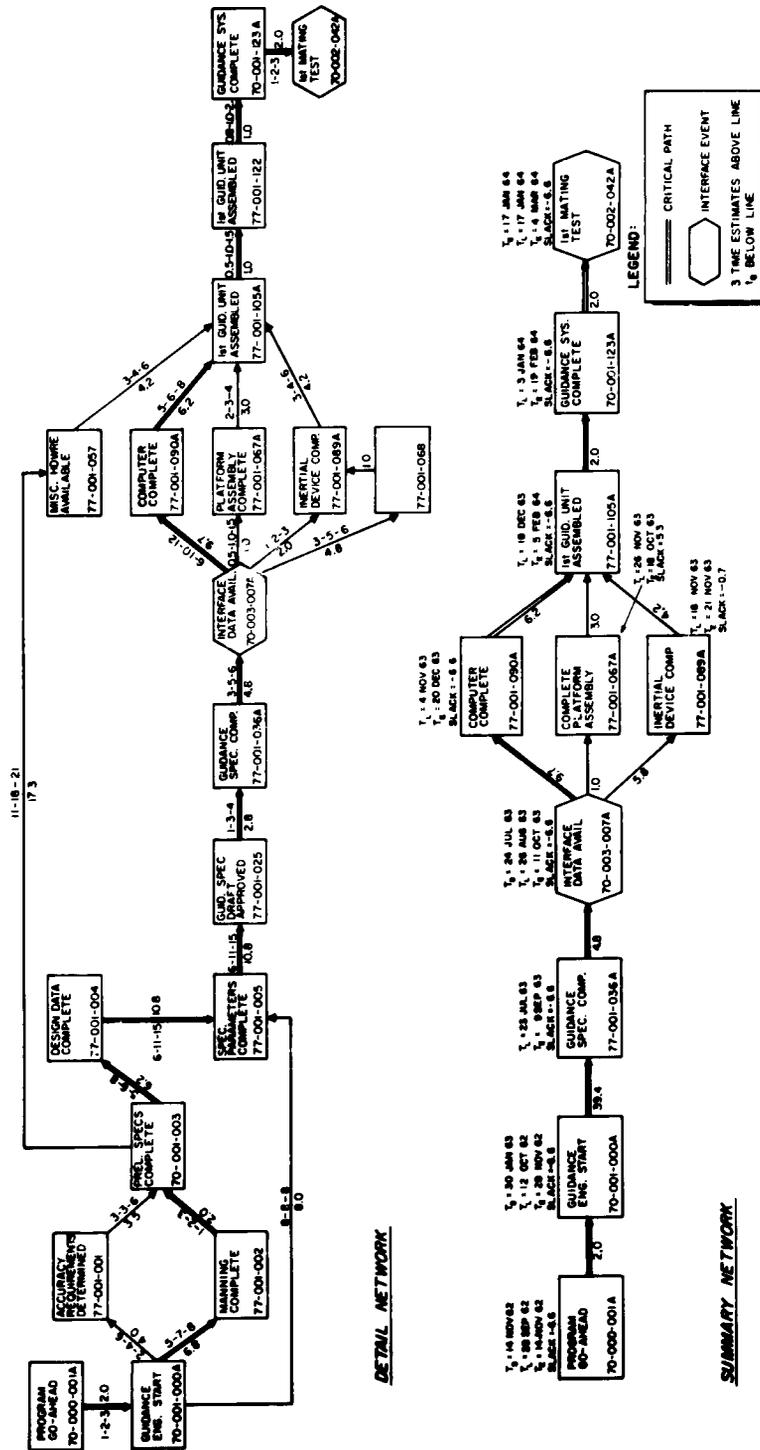


FIGURE Y-1 — GUIDANCE NETWORK

networks and/or detailed network files then form input for a network integration process.

### C. Network Integration

Network integration is a process of combining all sub-networks into a total program network. The input data for the program network, as described above, may be derived from summarized networks and/or detailed networks.

Each reporting agency will submit its required network data with expected elapsed times ( $t_e$ ) to the Designated Processing Agency (DPA) for maintaining and processing the program network. This integrated network will provide an overview of total system progress and allow observance of the interrelationships and impacts among the various agencies involved in the system development. The event  $T_E$  and  $T_L$  dates, obtained by processing the integrated network, will provide information for evaluating the planned or contractually scheduled dates for major milestones and interface events. When the integrated network expected dates show that any of the scheduled dates are unrealistic, the program manager may desire to negotiate a change of these scheduled dates.

Figures V-2 and V-3 show two more examples of network summarization. Figure V-4 is the network resulting from the initial integration of the three summarized networks. The impact of the integrated network calculations on the original networks is as follows:

- . The critical path of the integrated network has changed significantly from the critical paths of each individual network. The path now starts in the Guidance Network, drops to the Re-entry Vehicle Network, and then moves to the Airframe Network.
- . The latest allowable date ( $T_L$ ) for Interface Event 70-003-007 was computed to be 26 Aug 63 in the Guidance network, 24 July 63 in the Airframe network, and 21 May 63 in the Re-entry network. However, it is seen from the integrated network that the true  $T_L$  for this event





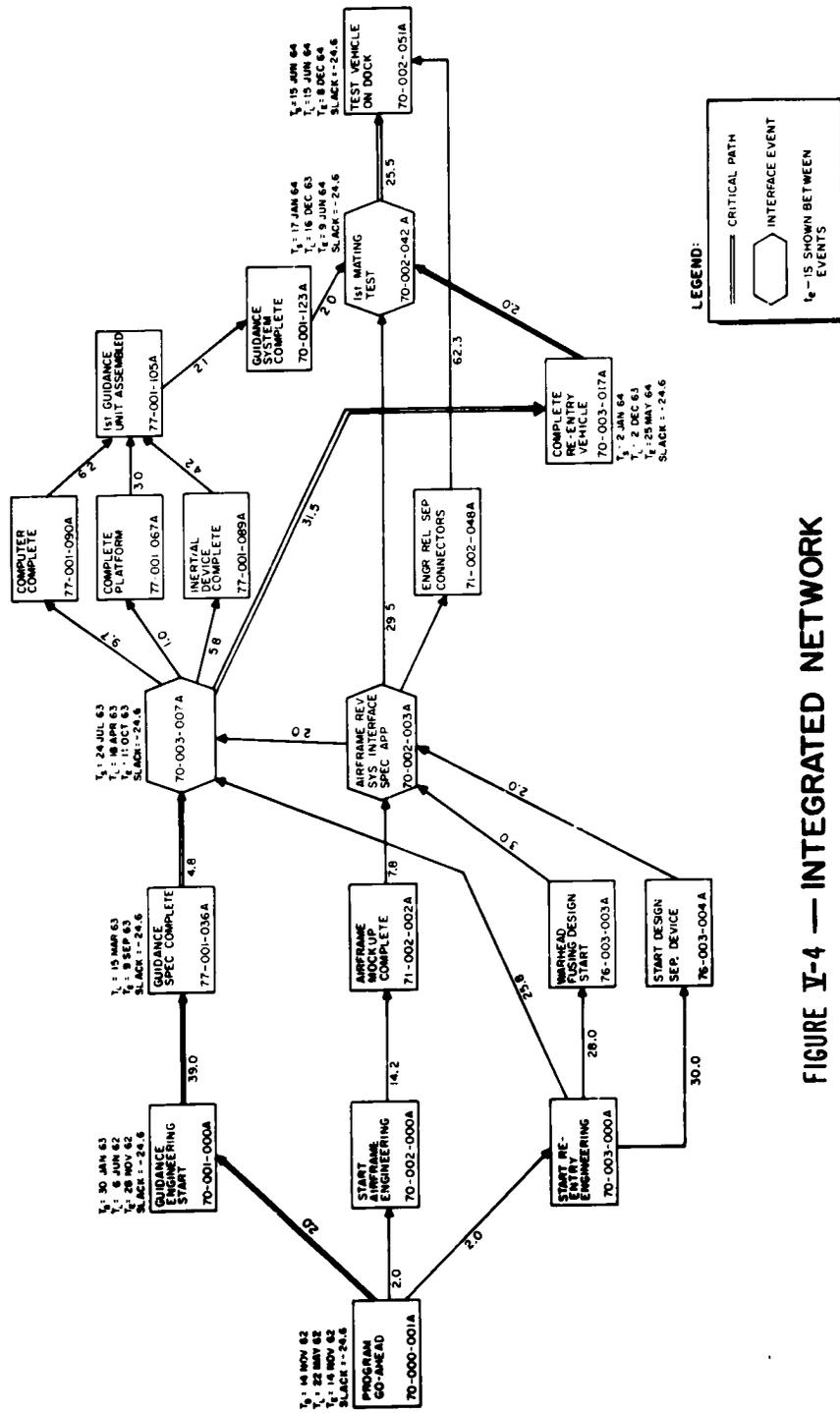


FIGURE V-4 — INTEGRATED NETWORK

is 18 April 63. Thus, new and more re-straining  $T_L$ 's have resulted for Event 70-003-007 and its predecessor events in each summarized network.

- . Slack originally computed along the critical path in the Guidance network was 6.6 weeks negative, in the Airframe network 6.7 weeks negative, and in the Re-entry Vehicle network 9.9 weeks negative. Slack computed along the critical path in the integrated network, however, is 24.6 weeks negative.
- . The three networks' start event, Program Start (70-000-001), was originally scheduled for 14 Nov 62 with the end event of the program, Test Vehicle on Dock (70-002-051) in the Airframe network, scheduled for 15 June 64. After the integration, it is seen that the program requires 24.6 weeks more time than is available between the scheduled program start and finish dates, indicating that the program should actually have started almost six months earlier than planned in order to meet the present schedule. Since this earlier date has passed, a change in either the plan or resource application must be made if the scheduled completion date is to be met.

#### D. Controlled Events

In establishing and maintaining the integrated network, a method of identifying and defining the interface events and significant milestones must be established. An event coordination process has been developed for the selection, recording, coordination, and storage of those events which define and interrelate the overall system. (A detailed description of this event coordination process is given in Appendix C. Figure C-1 illustrates the process.) Specific data for these events is collected by the integrating agency and maintained in a Controlled Event Data File. Events selected from this file, with program manager approval, make up the Controlled Event Log. This log is issued by the DPA to all participating organizations and serves to identify those events which must appear in each organization's summarized network.

The event originator or performing agency has prime responsibility for controlled event identification, description, and numbering. Each user of an interface event is responsible for notifying the originator of his intended use and of his agreement or disagreement with the interface event data. The DPA maintains a data file and produces the controlled event data reports.

**CHAPTER VI**

**PERT TIME SYSTEM OPERATION**

## CHAPTER VI

### PERT TIME SYSTEM OPERATION

Chapters II through V describe the basic concepts and the mechanics of the PERT TIME System without relating these techniques to the operation of the system. These techniques and procedures are related to the application and operation of PERT TIME in Chapters VI through XIII.

The entire system is introduced in this chapter in order to provide a framework or perspective for greater understanding of the succeeding material.

#### A. System Phases

The PERT TIME System Cycle involves two distinct phases, a Planning Phase during which a master time plan expressed in network form and a program schedule are developed, and an Operating Phase during which program progress is assessed and the impact of accomplishment on future plans is forecast. An illustration of the overall cycle is shown in Figure VI-1. A more definitive relationship of the two phases within this overall cycle is illustrated in Figure VI-2. The interaction between government and industry occurring within the cycle is illustrated in the data flow of Figure VI-3.

Ideally, the whole program is planned, the plan is approved, work is authorized, and the operating phase of measuring, processing, analyzing, and decision-making begins. In actual practice, however, a plan is developed and approved for part of the program; this particular plan then commences while some other parts of the program are still being planned. Also, the Planning Phase is repeated in part for portions of the program that have been in process where, because of some significant deviation from plan, management has adopted some alternative course of action. Consequently, planning tends to continue throughout the life of the program.

The Operating Phase on the other hand takes place regularly and frequently (typically, every two weeks).

A summary of the elements of these phases is presented below.

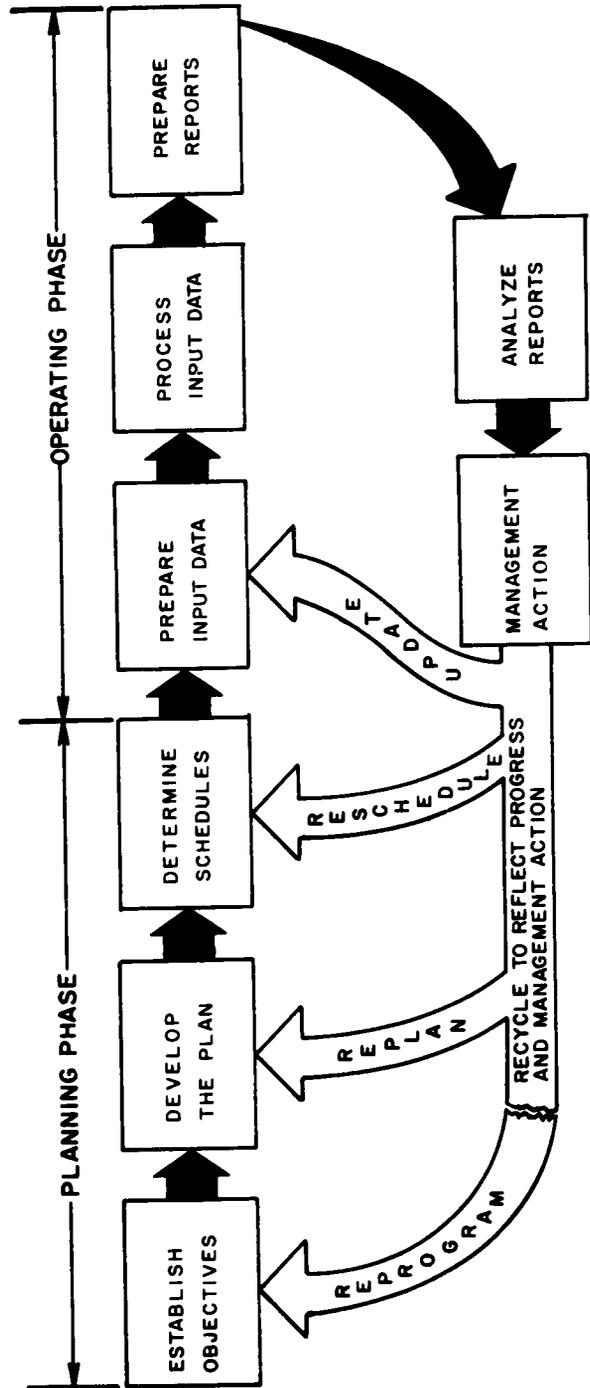


FIGURE VI-1--PERT TIME SYSTEM CYCLE

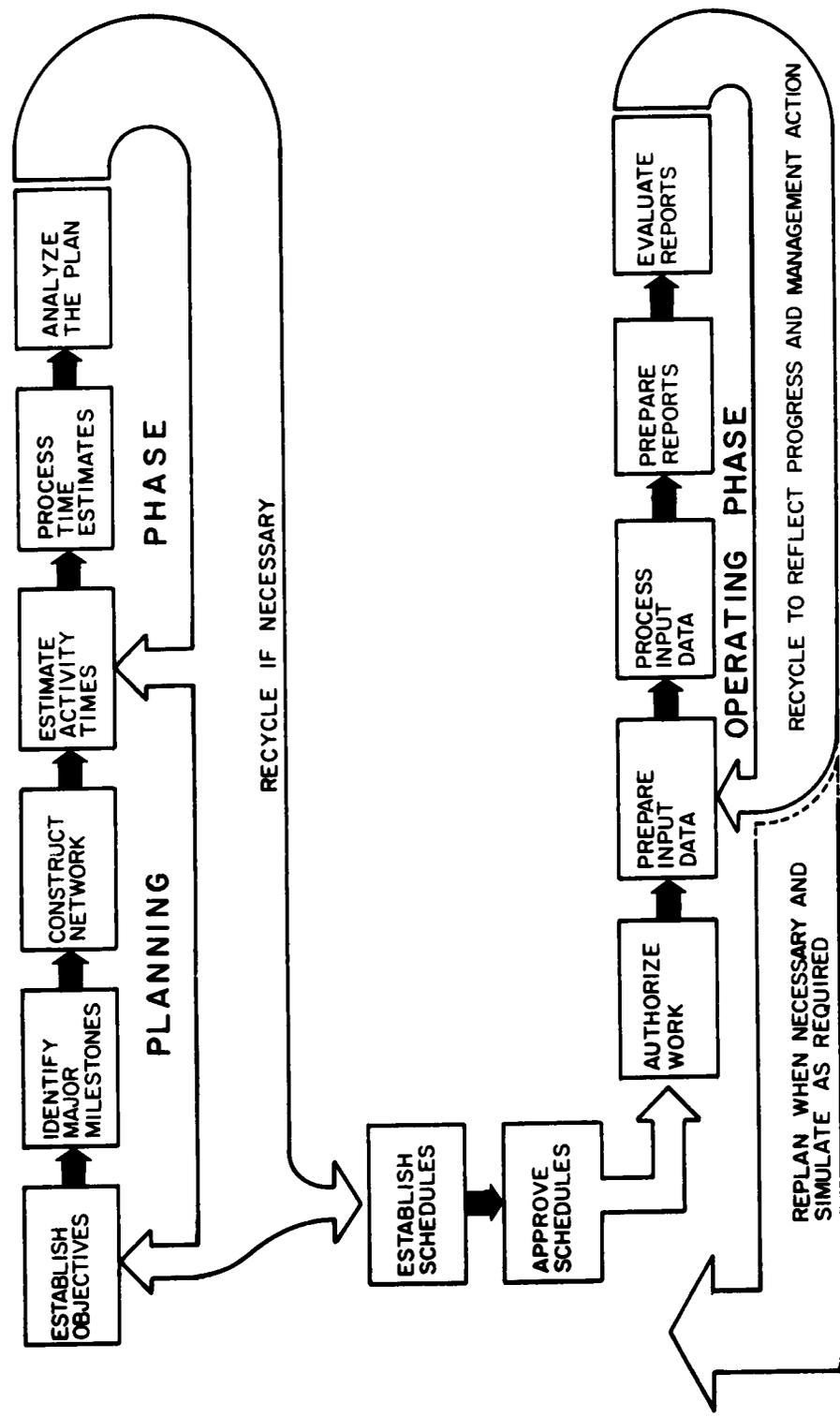


FIGURE VI-2 — PLANNING AND OPERATING PHASES

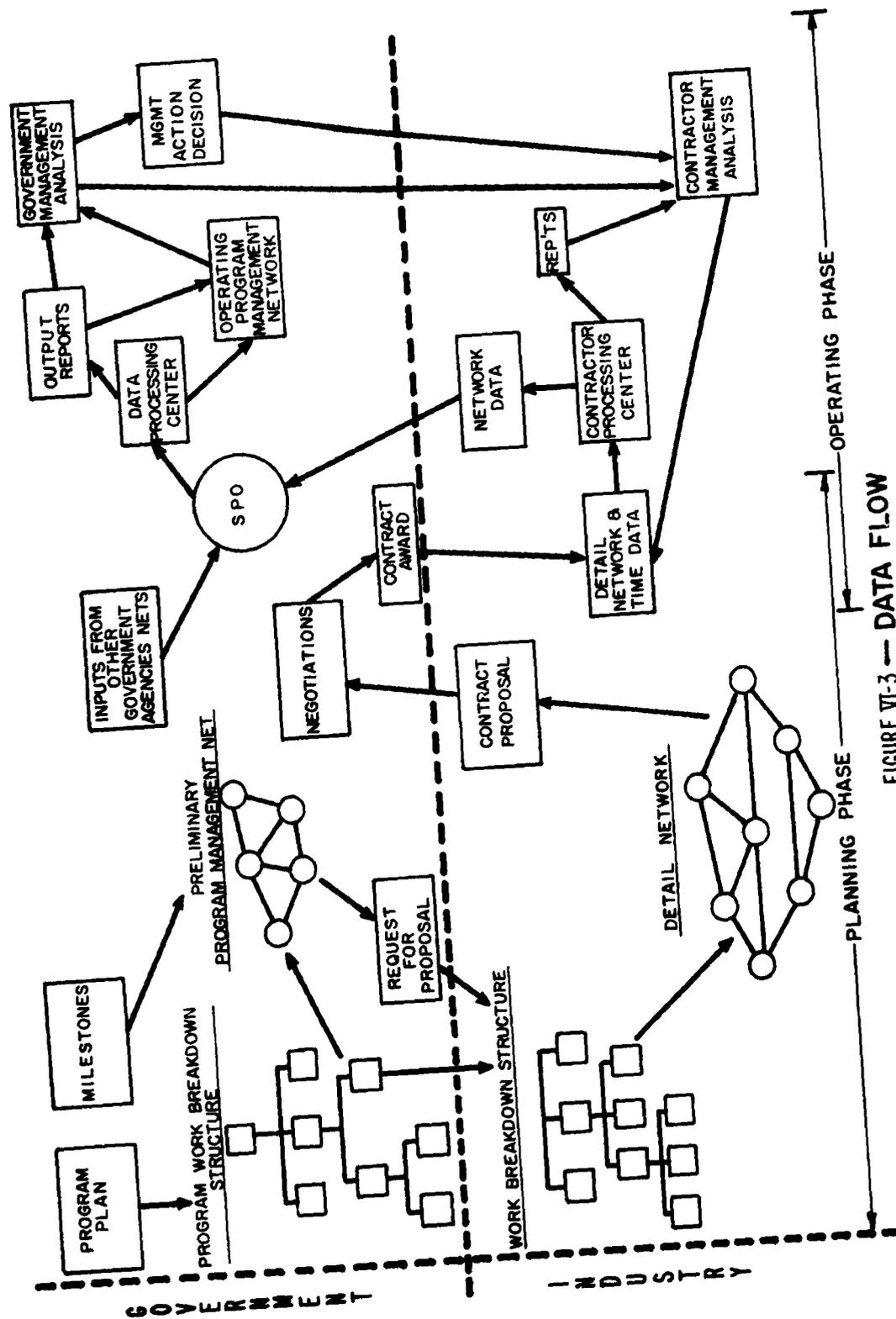


FIGURE VI-3 — DATA FLOW

## B. The Planning Phase

### 1. Establishing Program Objectives

Planning originates with the careful definition of what has to be accomplished, i.e., delineation of the end items of the program.<sup>1</sup> These end items can be identified by subdividing the total system into its component end items and successively dividing each of these end items into their component parts. Such a process will generate a program "work breakdown structure" as shown in Figure VII-1, Chapter VII. This work breakdown structure will then serve as the framework for schedule planning and monitoring (and more generally, it will serve as the framework for planning and monitoring all aspects of the program).

### 2. Developing the Plan

Once the end items of the program have been defined, the major interim achievements or milestones in the accomplishment of these end items must be identified. The sequencing of these milestones provides a time-phased framework within which the network plan and subsequently schedule are developed.

Guided by the work breakdown structure and the major milestones, a PERT network representing the plan for the accomplishment of the program is constructed. The network for the total system acquisition plan may be developed at once or the network may be developed a portion at a time as needed and feasible.

Time estimates are made for each activity in the network assuming a normal level of resource availability during a normal work period. These time estimates are fed into the

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<sup>1</sup> The term "end item" represents hardware, services, equipment, or facilities that are deliverable to the customer or that constitute a commitment on the part of the contractor.

data processing system which calculates  $t_e$ ,  $T_E$ ,  $T_L$ , and slack, identifies the critical path, and expresses the network plan in calendar dates thereby enabling comparison with the program's gross schedule requirements.

Usually the initial time plan does not conform sufficiently to the directed or desired completion dates. Under these circumstances, a replanning process is initiated, resulting in new time estimates and new completion dates. This cycle is repeated until sufficient conformity with desired dates is obtained.

### 3. Establishing Schedules

The resultant network plan will not, generally, provide a schedule for the work to be done. This is true because the time estimates, made irrespective of calendar dates and based on normal working conditions, do not take into account the availability of resources (manpower, equipment, facilities, and funding) during specific calendar time periods and because they may not have allowed for the manager's judgment of a reasonable time for performing the work. Hence the network plan must be translated into a timetable with specific calendar dates, which will govern the start and completion of work and authorize the expenditure of resources. This translation process will be controlled by the availability of resources and the manager's judgment.

When a satisfactory schedule backed up by a consistent network plan has been developed, approval is given and work may be authorized.

### C. The Operating Phase

The Operating Phase begins with the authorization of the work to be performed under that part of the program for which a schedule has been established and approved.

#### 1. Preparing Input Data

During the Operating Phase, the following information is reported:

- . completed activities and their completion date;
- . changes in activity time estimates;
- . changes in schedule;
- . event and activity additions or deletions.

This data is prepared in computer input format and sent to the Designated Processing Agency.

## 2. Processing the Input Data

This input data will be processed to produce the desired PERT output reports. In all but small PERT applications a computer will be used to accomplish this processing. Specifically in the USAF PERT TIME System, the USAF PERT TIME program will be utilized.

## 3. Preparing Reports

From the data processing system a number of output reports displaying current and forecasted status will be produced for analysis and evaluation.

## 4. Analyzing Reports

The computer output reports and perhaps special purpose reports derived from the computer outputs will be analyzed to aid in determining:

- . what the problems are;
- . where management action is needed;
- . what the alternative courses of action are; and
- . the best course of action.

## 5. Management Action

Using the results of the analysis, management makes decisions and takes action to correct the problem. Normally, this results in an updating of the input data to reflect the action taken. However, this action may involve rescheduling, replanning or in some instances, reprogramming. Where alternative courses of action are contemplated, simulation provides a means for evaluating the impact of these alternatives.

**CHAPTER VII**

**DEVELOPMENT OF THE PLAN**

## CHAPTER VII

### DEVELOPMENT OF THE PLAN

In the previous chapter, the elements of the planning phase were enumerated and briefly discussed. There are two primary end products resulting from the performance of these steps: the master time plan, expressed in network form, and the program schedule, based on the time plan. This chapter expands on the development of the plan. The succeeding chapter treats the scheduling process.

#### A. Identification of Objectives

Development of the plan begins with the identification of the objectives of the program. Before work on the program begins the following steps should be accomplished:

- . the prime objectives must be carefully determined and defined;
- . the supporting objectives leading to the attainment of each prime objective must be carefully determined and defined;
- . the objectives must be organized and inter-related to enable attainment of overall program objectives; and
- . these objectives must be communicated effectively to operating management in the next lower levels of the organization.

#### B. Program Work Breakdown Structure

As the objectives are developed in greater detail they form the program work breakdown structure which establishes a common framework for the accomplishment of all the work to be performed. It provides a basis for uniform planning and program visibility, enables assignment of responsibilities, and delineates objectives for monitoring progress. Additionally, it establishes the basis for constructing networks at any desired level of detail by identifying the end items to be accomplished at that level.

The work breakdown structure is developed downward by proceeding from the major program end items (hardware, services, equipment, or facilities) to successively lower levels, until manageable units for planning and control are derived. A top-down approach is used to guide planning rather than allowing detailed plans to be generated outside of a common framework. It is apparent that networks can readily be constructed without the use of a work breakdown structure, but quite possibly such networks will be incomplete or inconsistent with program objectives.

Briefly, the work breakdown structure establishes the basis for:

- . defining the work to be performed in successively greater detail;
- . determining how the various end items of work are related to one another;
- . constructing networks at any desired level of detail;
- . identifying the organizational element(s) responsible for accomplishing the work at each successive level of work definition;
- . summarizing actual status and forecasted progress of the program for progressively higher levels of management.

A partial work breakdown structure is shown in Figure VII-1. A complete work breakdown structure is shown in Appendix A.

### C. Identifying Major Milestones

Once the objectives have been defined the means of attaining these objectives must be laid out. Specifically, a plan, depicted by a PERT network, is evolved. The first step in this process is the identification and selection of the major milestones of the program. Many of these may already have been established by earlier and higher level planning processes. However, additional major milestones, peculiar to the particular program, will also have to be identified. Once identified, the milestones must be carefully defined. With the work breakdown structure, these

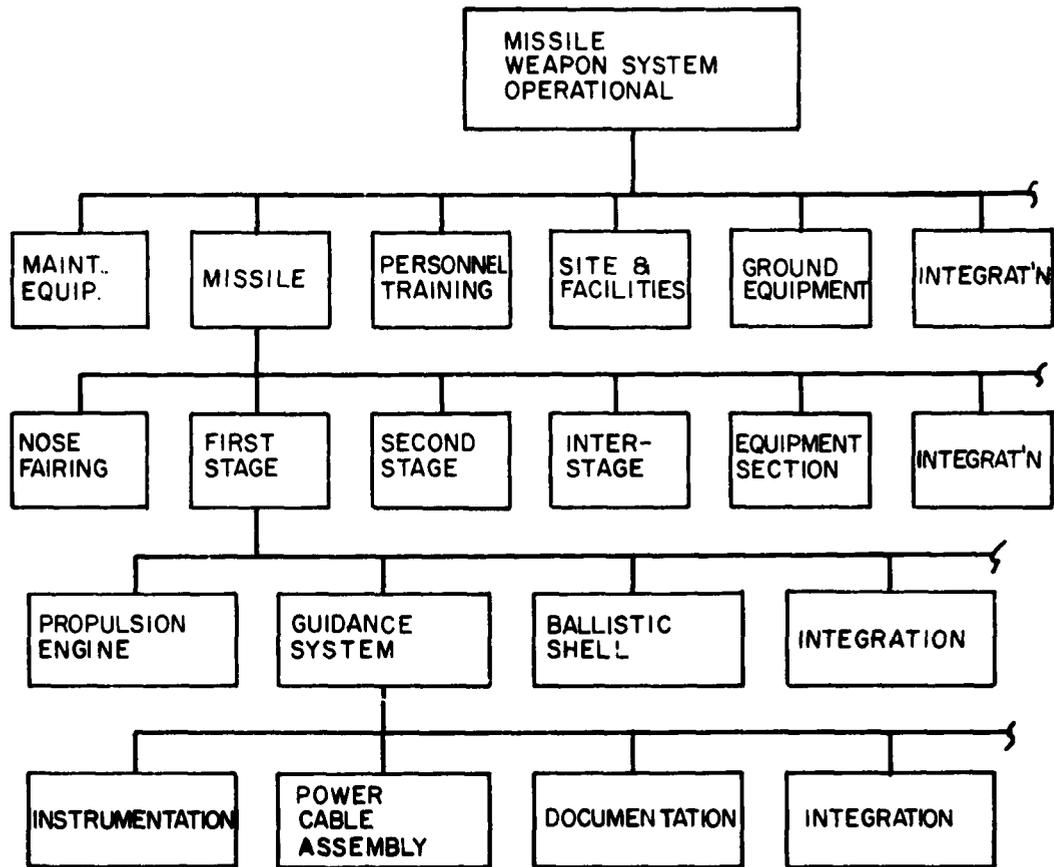


FIGURE VII-1 - PROGRAM WORK BREAKDOWN STRUCTURE

milestones will then serve as the base for the development of the networks, and additionally they will provide anchor points for the establishment of schedules. It might be considered that the work breakdown structure is a vertical framework for the networks, identifying the program objectives in the form of end items at all levels of detail, while a sequenced array of major milestones constitutes a horizontal framework for the networks, identifying the time-phased plan for the attainment of these objectives.

The milestones adopted should include not only those depicting the progress of the design and hardware but also key management decision or action events and the major logistic events involved in bringing the system to an operational status.

#### D. Development of the Plan in Network Form

The network must be developed as a valid depiction of the program plan, suitable for use in the actual management of the program. If the network does not accurately represent the program, serious errors may result. In making the network plan valid, the manager himself must undoubtedly become involved.

The development of the PERT network is inseparable from the function of planning as understood by management. Perhaps the single most significant statement to be made regarding the development of the PERT network is that it must be created by personnel in the manager's organization who are normally responsible to him for performance of the program planning function. Until these planners become skilled in the development, use, and maintenance of PERT, they may require the assistance of PERT specialists in the creation of new or revised networks. All participants must have a common understanding of the objectives to be reached.

If responsibilities are clearly assigned to these personnel, the network will be more complete and accurate than plans prepared in other forms and formats. Program planning personnel must plan in detail to effect the development of the program plan in the form of PERT networks.

The development of the network materially improves performance of the planning function. This function on a large, complex program is demanding. The logical and systematic thought processes required of planners in the construction of the PERT network inevitably deepens understanding of the objectives of a project and of the work to be performed.

#### 1. Program Management Network

A network reflecting the total system acquisition plan is called the Program Management Network. This network, in preliminary form, is initially prepared by the Program Director's Office as part of the precontractual planning effort. Later in the negotiation and early contractual phases, the network is refined through the assistance of other Air Force and government agencies and the contractors involved, and becomes the operating version of the network for both planning and control purposes.

There are two versions of the Program Management Network. The first, known as the Preliminary Program Management Network, is drawn "in-house" 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; and
- . the conveying of key events to the contractor for his guidance in preparing detailed networks.

The second, known as the Operating Program Management Network, is developed in conjunction with all participating organizations after award of contracts.

The Program Management Network is a generalized or simplified network, yet it must contain the level of detail required by the Program Director for overall planning and control of the entire program. When properly constructed, this single network should enable the Program Director's staff to survey the entire program and quickly ascertain the critical areas insofar as milestones and schedules are concerned. The Program Management Networks are essentially

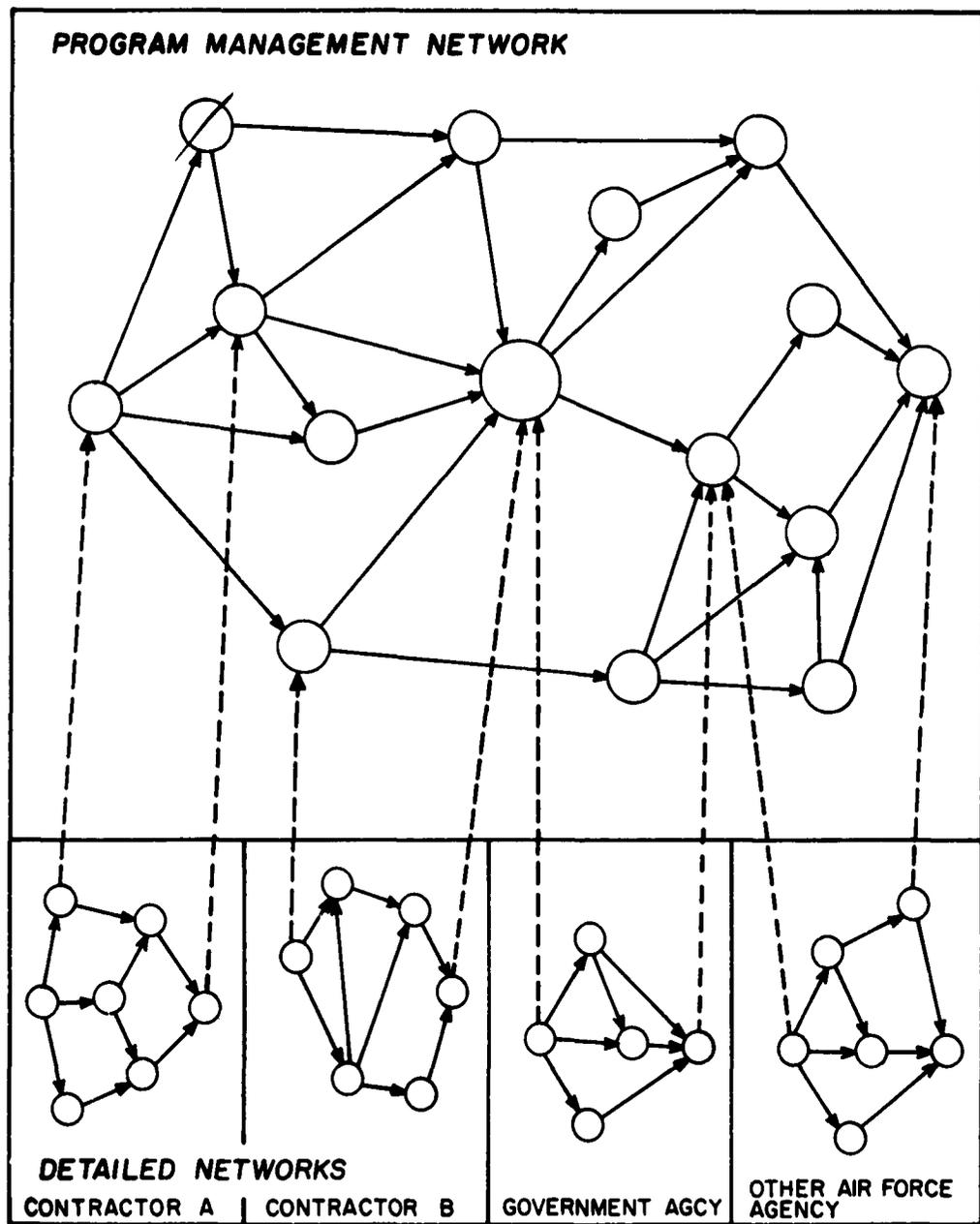
event-and-date-oriented (i.e., concerned with identifying and tying together all the major milestones of the program and the related schedules).

Both types of the Program Management Network must include the significant milestones in the program as determined and prescribed by the Program Director. These mandatory milestones must be augmented by other events representing additional, but less significant, milestones as well as by the interfaces and constraining events that reflect the inputs of the various contributors to the program. Thus, a network is evolved that ties together all the major segments of the program.

Figure VII-2 illustrates the general concept of developing an Operating Program Management Network. Each contractor and government agency prepares a detailed network representing his area of responsibility. The subsequent integration of these segments produces the Operating Program Management Network. Actual development of the operating version of the network for control purposes (as differentiated from the network initially developed primarily for planning purposes) will be accomplished by the cooperative effort of all concerned under the guidance of the Program Director.

## 2. Detailed Networks

Each contractor and supporting governmental agency involved will construct a detailed network or networks in accordance with the requirements of the Program Director and based on the work breakdown structure. The detailed networks are drawn within the framework of the Preliminary Program Management Network and the work breakdown structure. As unplanned efforts are discovered during detailed networking, the program breakdown and ultimately the Program Management Network are modified to reflect these changes. A top-down approach is used to guide detailed planning rather than allowing detailed plans to be generated outside of a common framework. Significant data from the detailed networks are carried upward to the Program Management Network. Thus, while the detailed networks are an operating tool under the immediate control of the organization responsible for doing the work, their status is displayed on the Program Management Network.



**FIGURE VII-2—DEVELOPMENT OF THE OPERATING PROGRAM MANAGEMENT NETWORK**

It is important that detail be kept to a level that will enable the network data to be computed and analyzed. Too much detail in the initial network delays the first analysis of the network. After an initial analysis is made, more detail can readily be added.

It is not necessary, however, or even recommended, that the degree of detail in the network be the same for all parts of the network. For instance, that portion of the plan in the near future should be maintained in more detail than the portions of the plan farther out. As time passes, more detail is added gradually to the near-term portions of the network. This is a natural method, since most plans are continually refined as more becomes known about the current results and their effect on the future course of action. Another recommended practice is to maintain more detail on the most critical areas of the program (where they are known). However, the pitfall of grossly slighting apparently straightforward or ancillary functions must be avoided as any part of the program can become critical.

In general, however, the network should be established to the level of detail needed to exercise management control. As the program progresses, the network will require revision to reflect unforeseen dependencies and tasks, and changes to the program as well as more or less detail.

To be realistic and comprehensive, the network should be developed by those personnel responsible for accomplishment of the tasks being networked and by personnel familiar with networking techniques.

### 3. Making the Time Estimates

Time estimates must be made for each activity in the network. These time values should not initially be considered in terms of calendar date, but rather as flow time. Any identification with preset calendar dates is to be avoided, for it nullifies one of the major advantages of the use of the network.

Time estimates should be made by personnel most familiar with individual activities. The quality of the time estimates will depend on their background and understanding of the work to be performed as well as the capability of the interviewers who are collecting the data.

#### 4. Refinement of the Plan

Once the time estimates for each activity have been obtained, the first data processing run can be made. From these estimates, the expected dates, the latest allowable dates, slack and the critical path are determined.

From this data, the feasibility of the plan can be judged. Usually the results of the first run will not be satisfactory and a revision of the plan must be generated. Activity times cannot, of course, be shortened arbitrarily. Alternatives for shortening the planned time for the program are:

- . alteration of the network by introducing greater concurrency of effort;
- . loading of resources on limiting activities;
- . change in performance requirements;
- . balance of the plan by reallocating resources among activities.

Following this analysis and replanning process, new time estimates are made and processed and the data is once more prepared for analysis. The cycle is repeated until sufficient conformity with directed or desired dates is obtained.

#### 5. Approving the Plan

When the establishment of the program work breakdown structure and the construction of the network have been completed, the Program Director will review the entire system. The purpose of the review is to insure that the data to be presented will be understandable, meaningful, and reliable. The Program Director must be convinced that the formal plans and procedures established and employed by the contractor will start at the bottom of the work breakdown structure and be realistically summarized.

## 6. PERT Planning Standards

The plan must meet certain fundamental standards which are stated below.

The work breakdown structure and the network(s) must:

- . outline the complete, current plan, which in terms of activities and events, indicates the step-by-step process of attaining the qualitative and quantitative objectives of the program;
- . detail the current and projected division of labor between responsible organizations in a manner consistent with the objectives and plans of higher level authority;
- . indicate the relationships between supporting objectives and the end of work objectives;
- . include only activities and events which have been defined by competent authority;
- . provide the structure for a meaningful reporting system for program management use;
- . be so constructed that they coordinate or interface with programs of lateral, higher, or lower level authority;
- . be used on a continuing basis as an effective communication device to integrate the objectives and activities of the various program managers, their operating managers, and other external organizations concerned.

The statistical data must:

- . be derived after definition of the work to be done within the activities to be accomplished;
- . derive from an approved source, which is either the responsible organization having cognizance over the work or the organization performing the work.

**CHAPTER VIII**

**SCHEDULING TO ACHIEVE OBJECTIVES**

## CHAPTER VIII

### SCHEDULING TO ACHIEVE OBJECTIVES

Scheduling may be defined as the translation of a plan into a timetable with specific calendar dates, which will govern the start and completion of work and authorize the expenditure of resources. The schedule, when approved by responsible management:

- . alerts lower level organizations and authorizes the use of resources including money and time;
- . permits continuous comparative analysis of schedule versus actual accomplishment, thereby enabling measurement and evaluation of status and forecast of progress.

The goal of the scheduling function is to bring into being an approved authoritative schedule. Scheduling requires a high degree of skill and knowledge of the requirements of the activities to be accomplished, and the capacities available. It is the means by which the resource demands of several programs or projects can be established and managed. The balancing of these multiple and competing requirements for resources is a responsibility of top local management. This chapter emphasizes the importance of this function as a discrete and integral part of the management process.

Emphasis is placed on the scheduled start date as well as on the scheduled completion date for planned activities. This is to:

- . alert and authorize the responsible organization to get ready to start the effort;
- . establish the earliest possible date to detect a significant deviation from plan; and
- . verify the completion of activities or relief of constraints.

#### A. Nature of the Scheduling Function

An approved plan is translated into a schedule by assigning resources and facilities to accomplish the planned tasks during specific calendar time periods. A major constraint in scheduling is the requirement to conform to the plan. In the scheduling process a manager and scheduler must consider:

- . the availability of the required manpower, equipment, and facilities during specific calendar time periods;
- . sequencing of the work;
- . consideration of conflicting demands of other programs on the same skills or resources;
- . adequacy of available local capacity and its augmentation potential;
- . funding limitations;
- . the minimization of premium costs and idle time for manpower, equipment, and facilities;
- . the manager's judgment of a reasonable time for performing the work under existing constraints;
- . technical constraints in the form of uncertainties in activities which may require the provision of extra time;
- . the local procedure for the development and communication of work authorization;
- . local management policy with respect to work practices (i.e., single versus multiple shifts, union contract provisions, vacation policy, etc.);

- . laws governing work practices;
- . difficulties involved in scheduling detail far in advance;
- . varying number of work days per month and translation to calendar dates.

All these considerations bear significantly on the problem of scheduling. Each must be weighed and balanced against other offsetting considerations.

Methods vary widely for converting time estimates for activities into specific calendar dates for starting and completing the work. For example, large packages of work may first be blocked into so-called master schedules to be used as a control in further scheduling. Each activity in such a block may then be scheduled until ultimately the entire block is scheduled. Conversely each activity may first be scheduled as a single unit.

Schedule formats will also vary. However, regardless of the method used for developing and communicating schedules, they become authorizations for performing the work only with management approval of their reasonableness for accomplishing the entire plan within the directed date. This approval requires a management appraisal of the risks involved in the various parts of the program and the advisability of reserving time and possibly resources for unanticipated problem areas.

This manual recognizes the importance of the scheduling function to achieve objectives as separate and discrete from the function of planning to achieve objectives.

The interdependence between planning and scheduling must be maintained through the life of the planned effort. Any tendency to disturb the logical relations between these two functions should be avoided. Principles involved in this relationship include:

- . the approved plan must govern the sequence and content of work to be performed;
- . the schedule must validate the plan by converting it to a feasible timetable which

can be approved by management. If the schedule cannot for any reason validate the plan, appropriate changes must be made to the plan;

- . the schedule will not change the planned sequence of work. It will, with the approval of management, set the timetable which will actually govern the start and completion of work and resource expenditures required by specific activities in the plan;
- . scheduling and planning must be so performed and continuously related that there is in effect at any one time only one scheduled plan for a given program approved by management.

#### B. Scheduled Dates versus Directed Dates

Some confusion has historically been generated by an indiscriminate use of the words "scheduled dates" or "directed dates". When a higher level passes objectives on to a lower level for planning purposes, these objectives are often accompanied by a "directed" date. This is not to be confused with "scheduled" date, although the two may coincide. If the "directed" date cannot be met, the scheduling activity must notify the planning activity so that higher level planning and validation of the plan can be adjusted. The scheduler does not alter the plan.

#### C. Relationship of PERT to Scheduling

An important function of scheduling involves validation of the plan depicted by PERT networks. Validation of the plan is the verification of the availability of the resources required for achievement of the objectives as depicted in the network. Given unlimited resources, the "expected times" and the "expected dates" derived in planning might be automatically used as the schedule. It is unlikely, however, that this situation will occur. The network calculations were made with time estimates based on the conduct of activities with normal availability of resources. However, because of peak loads, the resources needed for an activity

will not always be available to it. Hence, the scheduling process will generally require some changes in the network plan in order to insure that activities can be performed with the specific resources available.

Some users of PERT have, in error, tended to take mechanical and automatic steps to arrive at program schedules by:

- . "crashing" all activities into minimum possible times and relying completely on slack time as a measure of effectiveness or need for additional resources;
- . scheduling only completion dates for activities and ignoring start dates.

These steps fail to consider the conflicting need for resources. Scheduling considerations are so interdependent that such steps as a substitute for judgment must be avoided.

Validation of the plan depicted by the PERT network should include the following:

- . analysis of the network and associated expected time estimates;
- . study of the individual activity and path slack values;
- . study of "earliest expected" and "latest allowable" dates for events and the related periods of time in which calculations indicate activities should start and complete;
- . decisions to schedule specific activities:
  - a. according to the earliest expected dates,
  - b. between the earliest expected and latest allowable dates, or
  - c. earlier or later than either of these;
- . validation or change of the time estimates produced during planning;

- . subsequent study of any revision in the networks and accompanying data, occasioned by changes;
- . coordination with other appropriate personnel organizations.

The three time estimates provided in the planning function provide the scheduler with an additional source of information. Certain activities possess an inherent high degree of uncertainty in the amount of time which they will require. This will be indicated by the spread of the three time estimates. Schedulers must take this uncertainty into account in considering possible schedule alternatives.

#### D. Expected Time versus Scheduled Time

The process of estimating expected time must be clearly separated from the process of scheduling. The scheduled time ( $t_s$ ) may be shorter, the same as, or even longer than the expected time ( $t_e$ ) determined in the planning process.

In scheduling, an earliest completion date<sup>1</sup> ( $S_E$ ) and a latest completion date<sup>1</sup> ( $S_L$ ) for each activity in the network must be calculated in the same manner as the expected date and the latest allowable date. The only difference is that scheduled time ( $t_s$ ) values for network activities which have been scheduled are used in the calculation. Subsequent to the establishment of initial schedule, these calculations should be made available to the schedulers on a routine basis.

When a program is of long duration it may not be possible to commit resources in detail to specific time periods through an entire plan. Where this situation prevails, expected time values should be processed as scheduled time values until scheduling is actually accomplished.

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1

See Glossary of Symbols, Standard Abbreviations, and Terms, Appendix D.

#### E. Study of Slack Values Based on Expected Elapsed Time

The slack time values for individual activities and paths through the network indicate a latitude of time within which the activities or the paths should start or complete.

The "latitude" or "cushion" may be used as a vital resource. Whenever the activities being scheduled are on a slack path the scheduler can use this slack time to even peak demands on particular resources. This point is stressed even though slack values are based on expected time estimates. In refining expected date to the scheduled date for start or completion or an individual activity or path, the scheduler must know the slack values in local areas of the plan before taking action to schedule.

The action of the scheduler in distributing the slack value inherent in a given path in no way violates or changes the plan itself. Other work in process in the same organization may preclude the application of slack which requires a change in resource application. Such situations may be resolved only by higher level management.

#### F. Validation of the Schedule

Once the schedule has been drafted, scheduling must feed back the necessary input data for revision of plan. Entries into appropriate PERT input forms by the scheduling organization or other designated personnel subsequent to schedule decisions, will provide the necessary basis for changes in PERT records. However, before these decisions are placed in the PERT master data processing file, and prior to any promulgation of the newly developed schedules as the official schedule, a special "simulation" run of this input data, in conjunction with appropriate data in the master file, should be made. This impact of the newly developed schedule on the plan can be assessed by both scheduling and planning personnel prior to its official adoption. If more than one cycle of simulation is required, this can be continued until the schedule is consistent with management requirements.

### G. Study of Revised PERT Networks and Data

At the time the schedule for individual activities and events is initially established, the expected completion date may be the same as the scheduled completion date. Once the program is underway and changes occur, the calculated earliest completion date may move ahead or behind the assigned scheduled completion date for an activity. Since this calculated date is likely to change frequently as the program continues, it would be impractical to change the schedules every time there is a change in the earliest completion date for an activity. Rather, changes in this date should serve as one indicator for a scheduler in re-appraising his schedule and resource requirements. When this date deviates consistently, necessary adjustments in the schedule should be made.

Following scheduling of particular activities in the program and the introduction into PERT master files of scheduled elapsed time or scheduled completion dates to replace expected elapsed time ( $t_e$ ) for these scheduled activities, slack values for these activities and the paths containing them are automatically calculated by the computer and printed. Scheduled activity time values and expected activity time values for those parts of the plan not yet scheduled, are merged in slack path calculations. Positive slack must be reviewed with reserve after scheduling of activities on segments of paths has occurred. Accordingly, managers should use this as only one indicator in accomplishing schedule revisions to offset negative slack conditions. There should also be an awareness that critical areas of the program may be found in areas of the program having a positive slack condition. Accordingly, only experienced personnel should be used in translating slack into schedule or resource allocation changes.

### H. Rescheduling

The need for updating the schedule may occur as a program proceeds for the following general reasons:

- . change in the prime or supporting objectives;
- . change in plans to achieve objectives;

- . schedule slippage or gains affecting the timing of related activities in the plan which require rescheduling;
- . change in funding.

The method for rescheduling is similar to the original scheduling process. Formal procedures for rescheduling should be established for adjusting schedule and communicating these adjustments to others involved in the program. These formal procedures should also permit ready appraisal of the effect of the rescheduling changes by all personnel concerned.

**CHAPTER IX**

**INPUT PREPARATION**

## CHAPTER IX

### INPUT PREPARATION

When a schedule has been approved, work is authorized and the program effort commences. In parallel with, and as a part of, the PERT TIME System Cycle, the operating phase then commences. The four major elements of this phase (Figure VI-1, Chapter VI) are the:

- . preparation of input data;
- . processing of input data;
- . preparation of reports; and
- . evaluation of reports.

These elements comprise the subject of the next four chapters.

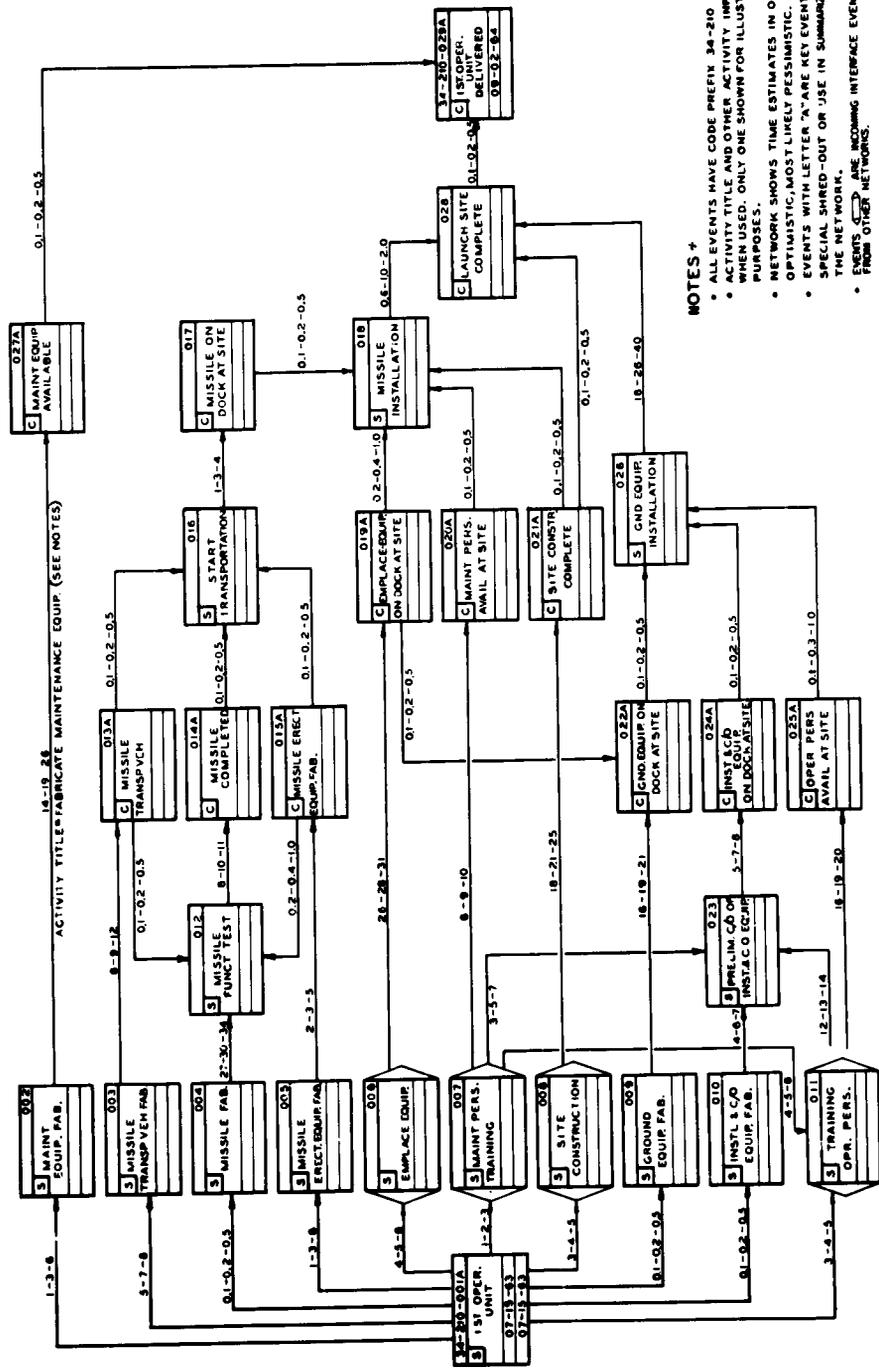
This chapter describes PERT data inputs and their preparation for computer processing. The procedures relate to processing of input data by the Designated Processing Agency using the USAF PERT TIME computer program.

#### A. Input Data Preparation

The preparation of data for processing begins when the network has been drawn, events have been coded, and activities labeled with three time estimates.

AFSC Forms 30 and 30A are the only forms required for operation with the PERT TIME System. The network shown in Figure IX-1 will be used as an example for the preparation of the data. Figures IX-2a through IX-2d show the network data transferred to AFSC Forms 30 and 30A. The data from these forms is subsequently transferred to key punch cards for input to the computer program.

The following paragraphs contain the detailed instructions for preparation of AFSC Forms 30 and 30A. A condensation of these instructions is printed on the reverse side of Form 30, as shown in Figure IX-2b. The Form 30 has two data areas:



- NOTES +**
- ALL EVENTS HAVE CODE PREFIX 34-210
  - ACTIVITY TITLE AND OTHER ACTIVITY INFORMATIVE WHEN USED. ONLY ONE SHOWN FOR ILLUSTRATIVE PURPOSES.
  - NETWORK SHOWS TIME ESTIMATES IN ORDER, OPTIMISTIC, MOST LIKELY PESSIMISTIC.
  - EVENTS WITH LETTER "A" ARE KEY EVENTS FOR SPECIAL SHRED-OUT OR USE IN SUMMARIZING THE NETWORK.
  - EVENTS WITH "C" ARE INCOMING INTERFACE EVENTS FROM OTHER NETWORKS.

FIGURE IX-1 -- CODED NETWORK WITH TIME ESTIMATES

SECURITY CLASSIFICATION

PAGE 1 OF 4 PAGES

Form Approved  
Number 80-106-01-2-1-10-000

REPORT DATE		SYSTEM START DATE		NETWORK OPERATION DATE		SYSTEM PROJECT NUMBER		OUTPUT HEADING		USER'S SYMBOL	
DAY	MO	DAY	MO	DAY	MO	DAY	MO	NO.	NO.	NO.	NO.
1	15	1	15	1	15	1	15	1	15	1	15
2	16	2	16	2	16	2	16	2	16	2	16
3	17	3	17	3	17	3	17	3	17	3	17
4	18	4	18	4	18	4	18	4	18	4	18
5	19	5	19	5	19	5	19	5	19	5	19
6	20	6	20	6	20	6	20	6	20	6	20
7	21	7	21	7	21	7	21	7	21	7	21
8	22	8	22	8	22	8	22	8	22	8	22
9	23	9	23	9	23	9	23	9	23	9	23
10	24	10	24	10	24	10	24	10	24	10	24
11	25	11	25	11	25	11	25	11	25	11	25
12	26	12	26	12	26	12	26	12	26	12	26
13	27	13	27	13	27	13	27	13	27	13	27
14	28	14	28	14	28	14	28	14	28	14	28
15	29	15	29	15	29	15	29	15	29	15	29
16	30	16	30	16	30	16	30	16	30	16	30
17	31	17	31	17	31	17	31	17	31	17	31
18	1	18	1	18	1	18	1	18	1	18	1
19	2	19	2	19	2	19	2	19	2	19	2
20	3	20	3	20	3	20	3	20	3	20	3
21	4	21	4	21	4	21	4	21	4	21	4
22	5	22	5	22	5	22	5	22	5	22	5
23	6	23	6	23	6	23	6	23	6	23	6
24	7	24	7	24	7	24	7	24	7	24	7
25	8	25	8	25	8	25	8	25	8	25	8
26	9	26	9	26	9	26	9	26	9	26	9
27	10	27	10	27	10	27	10	27	10	27	10
28	11	28	11	28	11	28	11	28	11	28	11
29	12	29	12	29	12	29	12	29	12	29	12
30	13	30	13	30	13	30	13	30	13	30	13
31	14	31	14	31	14	31	14	31	14	31	14
32	15	32	15	32	15	32	15	32	15	32	15
33	16	33	16	33	16	33	16	33	16	33	16
34	17	34	17	34	17	34	17	34	17	34	17
35	18	35	18	35	18	35	18	35	18	35	18
36	19	36	19	36	19	36	19	36	19	36	19
37	20	37	20	37	20	37	20	37	20	37	20
38	21	38	21	38	21	38	21	38	21	38	21
39	22	39	22	39	22	39	22	39	22	39	22
40	23	40	23	40	23	40	23	40	23	40	23
41	24	41	24	41	24	41	24	41	24	41	24
42	25	42	25	42	25	42	25	42	25	42	25
43	26	43	26	43	26	43	26	43	26	43	26
44	27	44	27	44	27	44	27	44	27	44	27
45	28	45	28	45	28	45	28	45	28	45	28
46	29	46	29	46	29	46	29	46	29	46	29
47	30	47	30	47	30	47	30	47	30	47	30
48	31	48	31	48	31	48	31	48	31	48	31
49	1	49	1	49	1	49	1	49	1	49	1
50	2	50	2	50	2	50	2	50	2	50	2
51	3	51	3	51	3	51	3	51	3	51	3
52	4	52	4	52	4	52	4	52	4	52	4
53	5	53	5	53	5	53	5	53	5	53	5
54	6	54	6	54	6	54	6	54	6	54	6
55	7	55	7	55	7	55	7	55	7	55	7
56	8	56	8	56	8	56	8	56	8	56	8
57	9	57	9	57	9	57	9	57	9	57	9
58	10	58	10	58	10	58	10	58	10	58	10
59	11	59	11	59	11	59	11	59	11	59	11
60	12	60	12	60	12	60	12	60	12	60	12
61	13	61	13	61	13	61	13	61	13	61	13
62	14	62	14	62	14	62	14	62	14	62	14
63	15	63	15	63	15	63	15	63	15	63	15
64	16	64	16	64	16	64	16	64	16	64	16
65	17	65	17	65	17	65	17	65	17	65	17
66	18	66	18	66	18	66	18	66	18	66	18
67	19	67	19	67	19	67	19	67	19	67	19
68	20	68	20	68	20	68	20	68	20	68	20
69	21	69	21	69	21	69	21	69	21	69	21
70	22	70	22	70	22	70	22	70	22	70	22
71	23	71	23	71	23	71	23	71	23	71	23
72	24	72	24	72	24	72	24	72	24	72	24
73	25	73	25	73	25	73	25	73	25	73	25
74	26	74	26	74	26	74	26	74	26	74	26
75	27	75	27	75	27	75	27	75	27	75	27
76	28	76	28	76	28	76	28	76	28	76	28
77	29	77	29	77	29	77	29	77	29	77	29
78	30	78	30	78	30	78	30	78	30	78	30
79	31	79	31	79	31	79	31	79	31	79	31
80	1	80	1	80	1	80	1	80	1	80	1
81	2	81	2	81	2	81	2	81	2	81	2
82	3	82	3	82	3	82	3	82	3	82	3
83	4	83	4	83	4	83	4	83	4	83	4
84	5	84	5	84	5	84	5	84	5	84	5
85	6	85	6	85	6	85	6	85	6	85	6
86	7	86	7	86	7	86	7	86	7	86	7
87	8	87	8	87	8	87	8	87	8	87	8
88	9	88	9	88	9	88	9	88	9	88	9
89	10	89	10	89	10	89	10	89	10	89	10
90	11	90	11	90	11	90	11	90	11	90	11
91	12	91	12	91	12	91	12	91	12	91	12
92	13	92	13	92	13	92	13	92	13	92	13
93	14	93	14	93	14	93	14	93	14	93	14
94	15	94	15	94	15	94	15	94	15	94	15
95	16	95	16	95	16	95	16	95	16	95	16
96	17	96	17	96	17	96	17	96	17	96	17
97	18	97	18	97	18	97	18	97	18	97	18
98	19	98	19	98	19	98	19	98	19	98	19
99	20	99	20	99	20	99	20	99	20	99	20
100	21	100	21	100	21	100	21	100	21	100	21

SECURITY CLASSIFICATION

FORM 100-10-10-000

FIGURE IX-20 — SAMPLE INPUT DATA FORM

General: This report is designed to provide (1) estimates of time intervals required to complete activities, and (2) PERT flow charts, and (3) information on program progress. A separate report will be submitted for each PERT flow chart. Time interval estimates should be made by a person in highest level of the organization who could perform the work himself.

Submission: Reports will be submitted bi-weekly. Required timing will be specified at the time of finalization of the PERT System for the component involved. Reports are required whenever no significant developments occurred during the reporting period. Activity reports will be accepted under unusual circumstances but must be confirmed with written reports.

Scope of Report: The following items will be reported on: (1) new activities, (2) deleted activities, (3) completed activities, (4) any activities for which the estimated completion date requires revision, and (5) other changes listed under transaction codes for the activity cards.

Punch Card Instructions: First Card of a deck representing a network must be punched in the Initial Card Format and all succeeding cards must be in the Input Format for Activity Cards.

Initial Card Instructions

Column 1-7: Report Date (ddmmmyy) i.e., 07 JAN 62

8-9: Run Number - 01 - Initial Run

10-11: Blank

12-14: Month - }  
15-16: Day - }  
17-18: Year - }

19: Blank - No Master File Report printed

20: Blank - No Event Output

21: Order of Event Output

22: Blank - No event output

23: Blank - No event output ordered by event number

24: Blank - No event output ordered by expected date

25: Blank - No event output ordered by slack

26: Blank - No event output ordered by slack

27: Blank - No event output ordered by slack

28: Blank - No event output ordered by slack

29: Blank - No event output ordered by slack

30: Blank - No event output ordered by slack

31: Blank - No event output ordered by slack

32: Blank - No event output ordered by slack

33: Blank - No event output ordered by slack

34: Blank - No event output ordered by slack

35: Blank - No event output ordered by slack

36: Blank - No event output ordered by slack

37: Blank - No event output ordered by slack

38: Blank - No event output ordered by slack

39: Blank - No event output ordered by slack

40: Blank - No event output ordered by slack

41: Blank - No event output ordered by slack

42: Blank - No event output ordered by slack

43: Blank - No event output ordered by slack

44: Blank - No event output ordered by slack

45: Blank - No event output ordered by slack

46: Blank - No event output ordered by slack

47: Blank - No event output ordered by slack

48: Blank - No event output ordered by slack

49: Blank - No event output ordered by slack

50: Blank - No event output ordered by slack

51: Blank - No event output ordered by slack

52: Blank - No event output ordered by slack

53: Blank - No event output ordered by slack

54: Blank - No event output ordered by slack

55: Blank - No event output ordered by slack

56: Blank - No event output ordered by slack

57: Blank - No event output ordered by slack

58: Blank - No event output ordered by slack

59: Blank - No event output ordered by slack

60: Blank - No event output ordered by slack

61: Blank - No event output ordered by slack

62: Blank - No event output ordered by slack

63: Blank - No event output ordered by slack

64: Blank - No event output ordered by slack

65: Blank - No event output ordered by slack

66: Blank - No event output ordered by slack

67: Blank - No event output ordered by slack

Input Format for Activity Cards

Column 1: Transaction Code

2: Revised Time Estimates, change or delete interface and Level Codes.

3: Add, change, or delete scheduled date and/or scheduled date option:

4: Add or change event title

5: Activity Completion

6: Add actual date and/or title to beginning events of network

7: Not used

8: Add or delete short path flag of an activity.

9: Use short path flag on and line to add activity title and 18 columns of activity information

10: Blank: No short path flag

11: Short path flag

12: Scheduled date option not used

13: Scheduled date option used

14: Blank - Beginning event is not an interface

15: Beginning event is an interface

16: Blank - Beginning event number

17: Beginning event number

18: Blank - Ending event is not an interface

19: Ending event is an interface

20: Blank - Ending event number

21: Ending event number

22: Level code for ending event number; letters A through O

23: Optimum time in tenths of weeks (003.5 = 3 1/2 weeks) (leave blank for

24: Most likely time in tenths of weeks (use for either 1- or 3- time estimates)

25: Pesimistic time in tenths of weeks (leave blank for single time estimates)

26: Month

27: Day

28: Year

29: Must always be blank

30: Event title

31: Blank

32: Blank

33: Blank

34: Blank

35: Blank

36: Blank

37: Blank

38: Blank

39: Blank

40: Blank

41: Blank

42: Blank

43: Blank

44: Blank

45: Blank

46: Blank

47: Blank

48: Blank

49: Blank

50: Blank

51: Blank

52: Blank

53: Blank

54: Blank

55: Blank

56: Blank

57: Blank

58: Blank

59: Blank

60: Blank

61: Blank

62: Blank

63: Blank

64: Blank

65: Blank

66: Blank

NOTE: If single activity times are used, place in Columns 29 -32, "Most Likely Time Estimate."

Second Lines(Optional)

Column

1: Transaction Code 9 must be used

2-4: Blank

5-24: Use same data as on first line.

25-28: Activity Field #1

29-32: Activity Field #2

33-36: Activity Field #3

37-42: Activity Field #4

43-78: Activity Title (Title may occupy columns 25-78 if activity fields are not used)

79-80: Blank

FIGURE IX - 2b — INSTRUCTION SHEET FOR INPUT DATA FORM





- . The initial card information at the top of the form represents the job order or instructions to the computer for a particular run.
- . The transaction cards portion of Form 30 which is continued by the use of Form 30A accepts the network information for activities and/or events.
- . A one-line entry is used for each activity or event. When it is desired to use activity titles and other special activity identification to supplement the information provided by a single-line entry, two lines are used to record the complete information for each activity.

#### Initial Card

Following is a description of the data columns on the AFSC Form 30 used for initial card preparation. The top portion of Figure IX-2a is filled out only once for a particular run since it contains the instructions for what should be printed out in that run.

- Column 1-7:            Report Date. This is the cutoff date for the report, e.g., 01Jan63.
- 8-9:                    Run Number. This number provides a convenient method of network control for the user and is printed in the output heading. The run number must be 01 for each initial network run and must be greater than 01 for update runs.
- 10:                    Blank - (For use by computer programmers only)
- 11:                    Blank - Not used.
- 12:                    Master File Report. This is a listing of the current network.  
Blank - Pert Master File Report not requested.  
1 - PERT Master File Report requested.

- 13-18: Start Date of the Network. The computer will start computations from this date. It must be the earliest known or established for the network e.g., 013063 for Jan. 30, 63.
- 19: E-L Chart - By Weeks.  
Blank - No E-L Chart requested.  
1 - E-L Chart with D--D spread. <sup>1</sup>.  
2 - E-L Chart with D--D spread omitted.  
A report date must always be given if an E-L Chart is desired, since it is used as the starting point for the Chart.
- 20: Summary Report. This code indicates whether a summary report is desired and designates the level of the summary. When a certain level is designated, all higher levels of summary will also be printed out. The letters "A" through "0" may be used.  
Blank - No Summary requested.  
A - Summary on level A requested.  
B - Summary on levels A and B requested.  
C - Summary on levels A, B, and C requested.  
-  
-  
- etc., through  
0 - Summary on levels, A, B, C, ...  
0 requested.  
1 - Minimum Summary. A summary network containing only those events required to maintain the logic of the detailed network.
- 21: Event Output Options - A code number (1 through 7) is entered to indicate the type of event output desired.  
Blank - No event output.

---

<sup>1</sup> See Glossary of Symbols, Standard Abbreviations, and Terms, Appendix D.

- 1 - Event output ordered by event number.
  - 2 - Event output ordered by expected date.
  - 3 - 1 and 2.
  - 4 - Event output ordered by slack.
  - 5 - 1 and 4.
  - 6 - 2 and 4.
  - 7 - 1, 2, and 4.
- 22:        Blank (not used).
- 23:        Run Date.  
Blank - Run date is included in the output.  
1 - Run date is omitted.
- 24:        Blank - (not used).
- 25-30:    Network Completion Date. e.g., 013063  
for January 30, 1963. This date is  
used for reverse computations, i.e.,  
to establish  $T_L$  for events.
- 31-36:    System Number (First line, first  
field of output heading - 6 alpha-  
numeric character field). This is  
the system number that will be printed  
in the heading of the selected output  
reports.
- 37-72:    Output title (First line, third field  
of output heading - 36 alpha-numeric  
character field). This field may be  
used as desired. The entries will  
appear in the output headings.
- 73-78:    User's Symbol of Identification (Second  
line, last field of output heading -  
6 alpha-numeric character field).
- 79:        E-L Chart - By Months.  
Blank - No E-L Chart requested.  
1 - E-L Chart requested.
- 80:        Activity Output Options. A code number  
(1 through 7) is entered to designate  
the type of activity output desired.

Blank - No activity output.  
1- Activity output ordered by ending/  
beginning event numbers (EE-BE).  
2 - Activity output ordered by activity  
expected end time.  
3 - 1 and 2.  
4 - Activity output ordered by activity  
slack.  
5 - 1 and 4.  
6 - 2 and 4.  
7 - 1, 2, and 4.

Transaction Card Input Data (for first line of activity  
information)

The following explanation pertains to the data portion of Forms 30 and 30A as used for recording the first line of information for each activity. Examination of Figure IX-2a will show how this entry is made.

Column 1: Transaction Code. Transaction codes are used to indicate the action to be taken in processing each line entry. The following codes are used:

TC-1: Code 1 indicates a new activity to be added. All activities for the first run of a network will have this code with the exceptions cited under TC-3.

All fields of the "Input Format for Activity Cards" are applicable. Scheduled dates may be included with any activity and will be automatically associated with the ending event of the activity. Actual dates cannot be entered with this code.

TC-2: This code indicates a change in any one or all of the three time estimates for an existing activity. The new time estimates replace the former ones. If the time estimates are left blank, no change in the previous estimates is

made. This code is also used to change the interface flags and/or level codes. If columns 5, 14, 15, or 24 are blank, nothing is done to the interface flags or level codes. A zero in any of these columns will delete the corresponding interface flag or level code. An "I" in columns 5 or 15 will add an interface flag for corresponding event, and a letter "A" through "O" will add a level code for the corresponding event. To change an interface flag or level code, this 2 code must contain the same activity as was used initially to establish the interface flag and/or level code. (This does not apply when adding a new interface flag or level code.) If the level code or interface flag was assigned to an event more than once, a 2 code must be used with each activity that contained the flag or code. When using this transaction code, column 3 must be blank, and the activity must be defined by its two event numbers in columns 6-13 and 16-23. Columns 5, 14, 15, 24, and 25-36 are used as mentioned above. All other columns are not used.

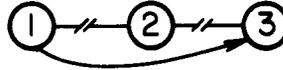
**TC-3:** A 3 code is used to add, change, or delete a scheduled date, to add or change the scheduled date over latest date option, and/or to add or change the title of a particular event. This might be considered an event information code. The program will take the event number from columns 16-23, and if a scheduled date is given, store that date and the scheduled date/latest date option with the event number. If any character of the title field is not a blank, the program takes the information from columns 44-78 of this input card as a description of the event and stores this title for output.

This card code enables one to give a description and a scheduled date to initial events and, hence, might appear in an initial run along with the transaction code 1 cards. To change only the scheduled date over latest date option associated with a scheduled date which has previously been included in the network, the scheduled date must again be inserted into the network by being punched in columns 37-42 of this card together with the desired option in column 3, blank to omit the option; one to include this option in the computation. When a scheduled date is changed with this card, the scheduled date option for the new scheduled date is taken from column 3 of this card. To delete a scheduled date, zeros must be placed in all columns of the date field. Only columns 1, 3, 16-23, 37-42, and 44-78 are used by the program.

**TC-4:** This code is used to establish an actual date of completion for an activity. The date is assigned to the ending event of the activity. A date of completion will not appear in the output for this ending event until all activities with the same ending event have reported dates of completion. Then, the latest completion date which the computer received will be included in the output as the actual date of completion for the ending event. Only columns 1, 6-13, 16-23, 37-42 are used by the program.

**TC-5:** Code 5 is used to delete an activity. The only information needed is the beginning and ending event numbers. Care must be used with code 5 to maintain the desired network. For example to delete

an event linking two activities to a network, two activities must be deleted and one added.



to delete Event 2, one must delete Activities 1-2 and 2-3 and add a new Activity 1-3.

Only columns 1, 6-13, and 16-23 are used by the program.

**TC-6:** Code 6 is used to add an actual date and if desired to add a title to a beginning event of the network. The date must be greater than or equal to the start date of the system. If only the event title is to be added, a TC-3 code should be used. The only information which a TC-6 card needs is the event number in column 16-23, the actual date in the date field (columns 37-42) and, if included, the title in columns 44-78.

**TC-7:** Code 7 is not used at this time.

**TC-8:** Code 8 is used to add or delete a short path flag of an activity. The beginning and ending event numbers must be given together with the new short path flag (blank or 1). Special care must be exercised in using the short path flag.

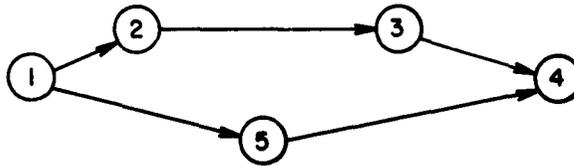
**TC-9:** Code 9 is only used when activity titles or associated data are entered on the second line of activity information. This is not used for the first line of activity information.

**Column 2: Short Path Flag**

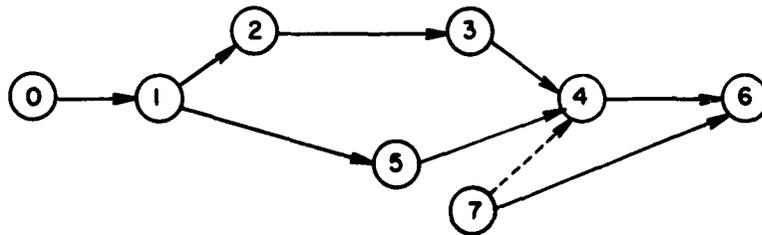
Blank - No short path flag.

1 - Short path flag is desired. If this flag is used all terminal activities of a parallel effort must be identified with a "1" (one) in this column. The short path flag is used when

several parallel developments are under way, and it is desired to know which will require the shortest time to completion. The computer program will calculate this path for all parallel efforts which commence with the same beginning event and conclude with the same ending event. The flag will appear in the output with the terminating event. Application of the flag is demonstrated by using the following network in which paths 1-2, to 2-3, to 3-4, and 1-5 to 5-4 represent two parallel efforts to complete Event 4.



Activities 3-4 and 5-4 must be flagged with a "1" to indicate the end of the parallel effort. The program does not allow any other activities to end with Event 4. That is, parallel efforts must be considered separately from other interactions. Dummy activities can always be introduced if there are other tie-ins with Event 4. For example:



If Activity 7-4 represents an additional, but not parallel effort necessary for the completion of Event 4, it can be included in introducing Activity 4-6, with zero time estimates and now representing the additional effort with Activity 7-6 instead of 7-4. The expected time for 6 will represent the longer of the two expected times along 4-6 and 7-6 where the expected time for 4 is the minimum of the two times along 3-4 and 5-4.

Column 3: Scheduled Date Option. This option is used to designate scheduled dates that are to be used in backward computations. For these selected events, the computer will replace the latest computed date with the scheduled date if it is earlier than the  $T_L$  and continue the computation using the scheduled date as the latest date.

Column 4: Blank. (For use by computer programmers only)

Column 5: Interface for Beginning Event.  
Blank - The beginning event is not an interface.  
I - The beginning event is an interface.

6-13: Beginning Event Number (BE) - must be numeric and greater than zero. All columns must be filled.

14: Level Code for the Beginning Event. A letter "A" through "Ø" (the latter should be written "Ø" to distinguish it from zero which is used in the same column for deletion purposes) is used to identify the beginning event for various management levels for summary or shredout purposes. The level code need be included only once for each event.

Blank - No summary level designated.

A - Ø - As assigned.

0 - (number zero) - delete the level code.

15: Interface for Ending Event.

Blank - The ending event is not an interface.

I - Ending event is an interface.

- 16-23: Ending Event Number (EE). Must be numeric and greater than zero. All columns must be filled.
- 24: Level Code for Ending Event (A through Ø)  
A letter "A" through "Ø" (the latter should be written "Ø" to distinguish it from zero which is used in the same column for deletion purposes) is used to identify the ending event for various management levels for summary or shredout purposes. The level code need be included only once for each event.  
Blank - No summary level designated.  
A - Ø - As assigned.  
0 (number zero) - delete the level code.
- 25-28: Optimistic Time Estimate. In weeks and tenths of weeks. (003.5 equals a time of 3½ weeks). Four digits must be used.
- 29-32: Most Likely Time Estimate. In weeks and tenths of weeks. (003.5 equals a time of 3½ weeks). Four digits must be used. When single time estimates or scheduled times are used, they are placed in these columns only.
- 33-36: Pessimistic Time Estimate. In weeks and tenths of weeks. (003.5 equals a time of 3½ weeks). Four digits must be used.
- 37-42: Date Field. These columns are used to enter a scheduled date for an event or actual completion date of an activity. The date Jan 30, 1963, would be entered as 013063.
- 43: Blank. (For use by computer programmers only.)
- 44-78: Event Title. The ending event title may be entered in this field. Alphabetic, numeric, or other special characters available can be used to describe an event. To include a title with a starting event, a transaction code 3 must be used.
- 79-80: Blank (not used).

Transaction Card Input Data (for second line of activity information).

The use of data columns on Forms 30 and 30A for the second line entry which records additional activity information (activity title and special activity identification such as responsible organization or department, charge number, priority number, etc.) is described below. Figure IX-2a illustrates how this second line entry is made when using only one of the four available fields of activity information. The data entered as a second line will be printed on the second line of the Activity Reports. (Figures XI-6 through XI-8, Chapter XI).

- Column 1: The transaction code to enter activity titles and activity associated information is always 9.
- 2-5: Blank (not used).
- 6-13: Beginning Event Number (BE). The (BE) number is common to both lines of data and need be entered only on the first line.
- 14-15: Blank (not used).
- 16-23: Ending Event Number (EE). The (EE) number is common to both lines of data and need be entered only once.
- 24: Blank. (Not used)
- 25-42: Activity Information. The activity associated information is divided into 4 fields; the first 3 fields contain 4 columns of information each and the 4th field can contain 6 columns of information. This division of the 18 columns is prompted by the AFSC Form 30, where these 4 fields correspond to the three time estimates and the date fields. These 4 fields are used at the discretion of the PERT user. Any information the user desires to associate with a given activity

may be included. The information entered in any or all of these 4 fields will be printed on a second line of the Activity Report. Columns 25-42 may also be used to increase the title length.

43-78: Activity Title. The activity title may be entered in this field. Alphabetic, numeric or other special characters available may be used to describe an activity.

79-80: Blank (not used).

## B. Updating

### 1. Updating Process

Once the initial input data has been entered into the computer, the periodic reporting of updated data commences. The network in Figure IX-3 is an updated version of the original network shown in Figure IX-1.

The update report requires a submittal of AFSC Form 30 or 30A. Examples of entries required for processing the updated network are illustrated in Figure IX-4. Updating does not require resubmittal of the information for all the activities in the network, but submittal only of new information. The information reported on an update will include:

- . all activities completed during the last report period;
- . revised time estimates for activities that were not completed during the report cycle, but were expected to be completed;
- . revised estimates for activities expected or scheduled for completion during the next cycle which will not be completed;
- . changes in the network such as:
  - . new activities to be added;





- . deletions to the network;
- . revisions of future time estimates;
- . corrections to previously reported data.

Figure IX-4 shows data for updating the initial report with proper entries and transaction codes. Referring to the updated network (Figure IX-3) and the accompanying AFSC Form 30 (Figure IX-4), note that Activity 34-210-27 to 34-210-029 was deleted by using transaction code 5 and two new Activities 34-210-027 to 34-210-030 and 34-210-030 to 34-210-029 were added in its place. Time estimates also were made for these new activities. Transaction code 1 was used to insert into the program these two new activities and their time estimates. A scheduled date for Event 34-210-017 was added using transaction code 3. Revised time estimates for Activities 34-210-016 to 34-210-017 and 34-210-026 to 34-210-028 were entered with transaction code 2. Transaction code 4 was used to enter completion dates for three activities completed between the starting date of 15 Jul 1963 and the updating report date of 22 Jul 1963.

A computer run incorporating the updated information is initiated by instructions on the initial card as shown at the top of Figure IX-4. "Run Number 02" has been entered in Columns 8-9 to indicate in the resulting print-outs that this is an update run.

## 2. Updating by Teletype, Telephone, or Data Communications Network (Transceiver System)

Minor changes to the network and updating of input data may be reported by teletype, telephone or data communication network, but only when agreed upon by the DPA and the reporting agency. For the purpose of uniformity, the following procedure will apply:

Authorized submission by teletype will be analyzed in accordance with AF Reg 205-53, and Encrypt for Transmission Only procedures will be applied to those which, though individually unclassified, may collectively reveal

significant information related to sensitive plans, programs, or operations. Teletype will be prepared in the format shown in Figure IX-5.

The first line in the body of the teletype will contain the following information.

From: Initiator  
To: Office of DPA  
Project Number  
Network Title  
Report Period  
Security Classification

Each transaction will be numbered sequentially beginning with the number "one" and will be shown as a two line entry. The data entered in the "Transaction Code" field through the "Scheduled or Completed Date" or the "Activity Title" field (Columns 43-78) will be the second line entry (on transactions other than "9", card column 43 will be blank). Each field of a teletype message will be separated by a diagonal. When no entries are required in a specific field, the field will be shown as "BLK".

AFSC Form 30 data may be transmitted by telephone, when authorized, with confirmation copies of the form to follow. The copies will be conspicuously marked "Confirmation Copy" on the face of each sheet.

AFSC Form 30 data may be submitted by transceiver when authorized. Data in 80 column punch card format may be submitted to the transmitting station in accordance with the procedure contained in Allied Communications Publication (ACP) 127, USAF Supplement 4 and US Supplement 2.

JOINT MESSAGEFORM				SECURITY CLASSIFICATION			
SPACE BELOW RESERVED FOR COMMUNICATION CENTER							
PRECEDENCE		TYPE MSG (Check)			ACCOUNTING SYMBOL	ORIG. OR REFERS TO	CLASSIFICATION OF REFERENCE
ACTION		BOOK	MULTI	SINGLE			
INFO							
FROM:						SPECIAL INSTRUCTIONS	
FAIRWEATHER MISSILE CORP. PERT COORDINATOR							
TO:							
LSE, WS325A SYSTEM PROGRAM OFFICE, NORTON AFB, CALIF.,							
FOR PERT MANAGER							
PROJECT NR 123, WS325A INTEGRATED AFSC PERT, PERIOD DEC 3-							
DEC 16, UNCLASSIFIED.							
TRANSACTION NUMBER ONE							
1/1/BLK/F/BLK/13421001/A/BLK/13421002/D/0010/0030/0060/BLK/							
BLK/START MAINT EQUIP FAB/							
						DATE	TIME
						MONTH	YEAR
SYMBOL				SIGNATURE			
TYPED NAME AND TITLE (Signature, if required)				TYPED (or stamped) NAME AND TITLE			
PHONE		PAGE NR.	NR. OF PAGES				
SECURITY CLASSIFICATION							

DD FORM 173 1 MAY 60 173 REPLACES DD FORM 173 1 OCT 49 WHICH WILL BE USED UNTIL EXHAUSTED

**FIGURE-IX-5 — TELETYPE REPORTING  
FORMAT**

### C. Pitfalls in Data Preparation

Many pitfalls commonly encountered when preparing data for PERT computation may be avoided by exercising proper care and strict adherence to procedures. Listed below are some of the pitfalls commonly encountered.

- . Duplication of event numbers in a network or on the reporting AFSC Form 30. Use of duplicate numbers will generally create a loop in the network.
- . Repetition of an activity on the reporting form will cause two input cards to be key-punched for the same activity. These cards may or may not be exact duplicates, i.e., they could have the same identifying numbers, but have different time estimates, etc. The first card is accepted by the computer and the others dropped from further processing although reported as a duplicate activity in the error report printout. When this occurs a check should be made to ascertain that the correct activity information was on the card processed by the computer.
- . Illogical time estimate; e.g., pessimistic or most likely time estimates shorter than the optimistic. This produces an error message. The "m" value will be used in the computation.
- . Reporting an activity completed before its beginning event is complete.
- . Zero time estimates not shown as four zeros on the reporting form and therefore not punched onto the cards. (The card will be rejected by the computer.)

- . Assignment of a network start date, which is later in time than any of the scheduled or completion dates assigned to events or activities.
- . Activities inserted and deleted on the same report, i.e., reporting a code "1" activity and then deleting it with code "5" or vice versa on the same run.
- . Event recording that does not fulfill the following conditions: the event number be an eight digit number greater than zero; and all column spaces be filled.
- . Failure to keep the number of transcriptions of the input data to an absolute minimum.

**CHAPTER X**

**DATA PROCESSING REQUIREMENTS AND LOGIC**

## CHAPTER X

### DATA PROCESSING REQUIREMENTS AND LOGIC

USAF PERT was designed for uniform application of PERT within the Air Force. It considers the many requirements of both Air Force and industry, and every effort was made to fulfill these requirements.

#### A. Data Processing Requirements

The features and parameters described below are requirements of the system.

- . The system must have the capability for processing networks of a size required to meet the needs of management.
- . Activity and/or event titles are accepted and printed out.
- . A master file is maintained for successive update runs.
- . When all activities leading into a common event have been given actual dates, the latest of these is taken as the actual date for that event.
- . Activities are not assumed to have been completed until so reported.
- . No activity can be reported completed until all prior events have been reported as having occurred and prior activities have been reported as completed.
- . Duplicate activities are dropped during validation.
- . All network start events may have a scheduled date entered. This scheduled date is used as the expected date for forward computation. If a scheduled date is not given to a network start event, then the network base date is used as the expected date for the start event.

- . There are three options for the assignment of latest allowable dates ( $T_L$ ) to events which have no succeeding activities:
  - . The scheduled date for each is selected as its latest allowable date or,
  - . A program completion date may be assigned as the latest allowable date for all end events or,
  - . If one of the two above is not selected, the latest expected date ( $T_E$ ) in the network is assigned as the latest allowable date ( $T_L$ ).
- . The process must have the option of selecting certain scheduled dates (as designated by the user) for backward computation. These scheduled dates may be assigned anywhere in the network.
- . The calendar routine is based on a five day work week with holidays considered. The holidays are controlled by a table of desired holidays.
- . Loops must be identified and eliminated from the network.
- . Input is always by activities.
- . Networks may have multiple start and/or end events.
- . Three time estimates for each activity are accepted.
- . The process will also accept single time estimates.
- . Events without predecessors should be given actual dates.
- . The process must compute the probability of meeting scheduled dates.
- . Input data must be validated.

- Event, activity, master file and graphical reports must be available at the user's option and can be ordered by slack, event/activity number, or expected dates as desired. Shredouts of any of these reports may be selected.
- The process identifies the shortest path in parallel efforts when the short path option is used.
- The process must produce a listing of paths in order of criticality.
- The process must compute the probability of positive slack for each event.
- An event standard deviation must be calculated.
- A level code for events is included.
- The process must possess a network summarization and integration capability; and
- The process must be capable of accepting an unlimited number of changes to the master file.

#### B. Data Processing Logic

Often the operators and users of the PERT System are unaware of how the computer processes the input data to produce the output reports. To help fill this gap in some PERT operators' knowledge of their system and to improve their ability to communicate with the data processing personnel, the process or logic used in the USAF PERT TIME System is described below.

Standard sort routines, file maintenance routines, input and output routines and monitor routines are utilized by the program. The program is broken into several independent sections. Each section can be assembled alone and then inserted into the total program, or all sections can be assembled as one unit.

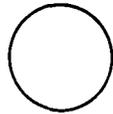
The employment of the standard control routines and sectioning of the program allow for easy maintenance. It

also simplifies the making of additions and/or changes to the program.

The logic diagrams below show an overall flow of the data from input to output. Although the logic diagram is one continuous flow process, for ease of reading it has been chronologically segmented so that the text and that portion of the diagram it pertains to, appear on the same page.

However, before continuing, the reader should acquaint himself with the following terminology so as to understand more fully the explanation of the computer logic presented.

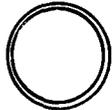
## COMPUTER LOGIC DIAGRAM TERMINOLOGY



Intermediate tapes.



Option.



This indicates the system output tape for printing the reports. The reports are stacked on this tape.



This indicates the system output tape from which card type outputs are derived.

**ACT FILE** - A file that contains the pseudo event nos. that identify the activity,  $t_e, \sigma_{t_e}, t_a$ , and certain program control data.

**BEL File** - A file that contains the  $T_L, \sigma_{T_L}$ , and certain program control flags.

**Event Nomen  
File** - A file that contains the event titles.

**FEL File** - A file that contains the  $T_E, \sigma_{T_E}$ , and certain program control flags.

**PEN File** - A file that contains the event numbers in packed form and the level codes.

**Rank Backward  
File** - The same as the rank forward file except that it is in descending rank order.

**Rank Forward  
File** - The same as the ACT FILE except that rank has been added and the file is in ascending rank order.

**SDL File** - A file that is composed of the schedule dates, predecessor, successor, and activity actual date tallies, and certain other program control flags.

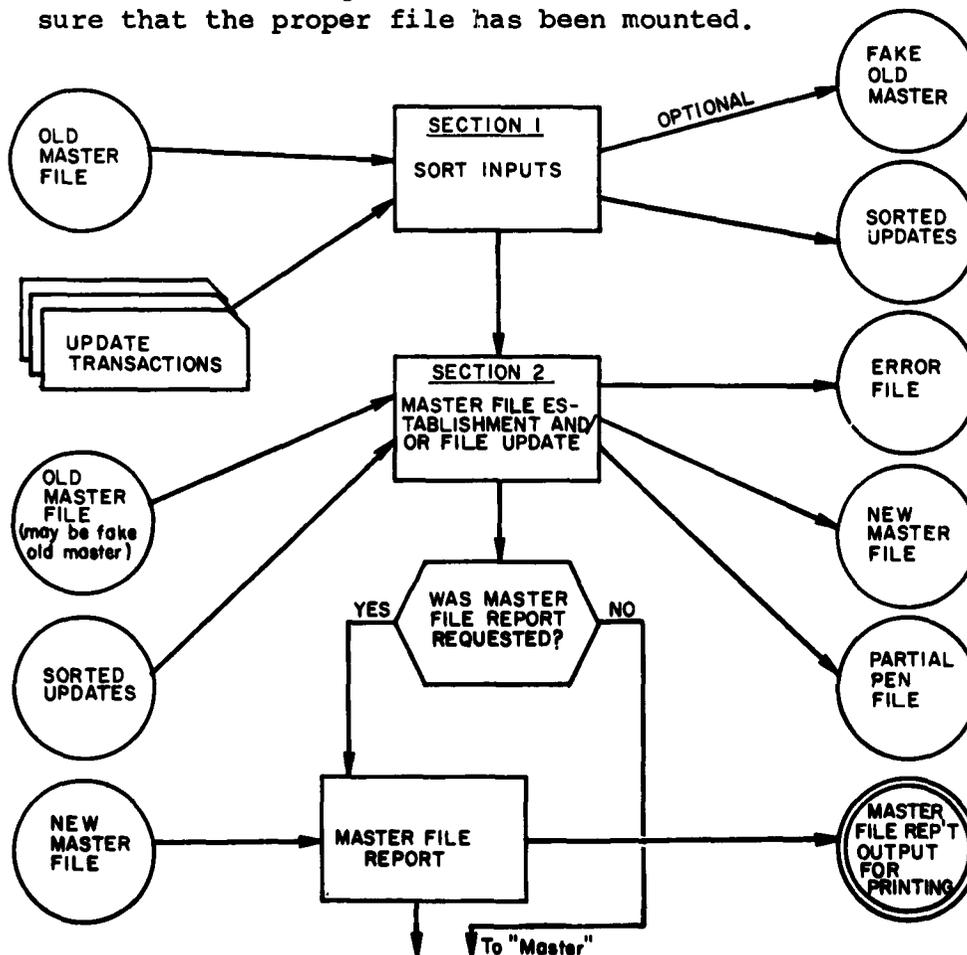
**Summary**

**Date File -** A file that contains the summary events and their a, m, and b.

THE DATA PROCESSING LOGIC

Section 1. The transaction cards are Ending Event-Beginning Event-Transaction Code sorted by (EE)-(BE)-(TC) for merging into the old master file to create a new master file. If the run number was 01, (file establishment), a fake old master file is generated.

Section 2. A new master file is created by adding the change cards to the old master file. Simultaneously, a tape of event numbers is generated to be used by the pseudo event number generator and, if requested, a master file report. Update changes which cannot be processed by this phase are written in a separate tape to be processed by Phase 2. At the start of this phase, the system number and heading on the initial card are checked against the old master initial card to insure that the proper file has been mounted.



Section 3. The error tape generated in Section 2 is read in and an error report is generated on the output tape. This report prints out one of the following 8 messages with each rejected update card:

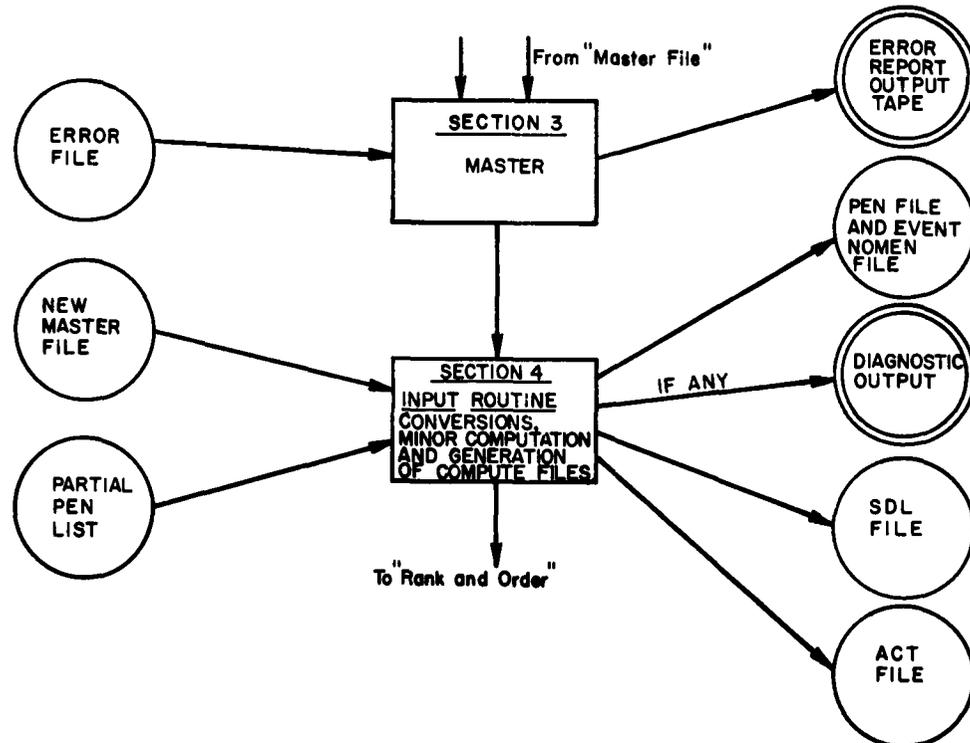
Beginning Event (BE) Incorrect. Ending Event (EE) Incorrect (an alpha character will cause either of these). Level Code (LC) Incorrect (anything other than a letter A through O will cause this message). Times Bad (an alpha punched in a time field or an illegal date will cause this message). Unmatched (any update card without an original in the old master file). Insert Equal (a new activity identical to one already in the file), Non-select (an illegal Transaction Code TC) and Seq Error (caused by not having blanks in the BE field for a TC of 3 or 6).

Section 4. The input routine reads the records from the new master file, assigns pseudo event numbers, creates an SDL file, and creates an activity file with summary control date if requested. The PEN file words consists of eight (8) digit numbers. The position on the list of an event number determines the pseudo event number. The level code, if given, will be converted to a number 0 through 15 and stored in the right 4 bits of the word.

The SDL file consists of an event nomenclature indicator, a successor tally, and actual date tally and a predecessor tally for each event; also, when given, an actual or scheduled time for the event.

The ACT file consists of two words for each activity and contains the two pseudo event numbers,  $t_e/t_a$ ,  $\sigma t_e$ , Short Path (SP), and summary control and actual data flags.

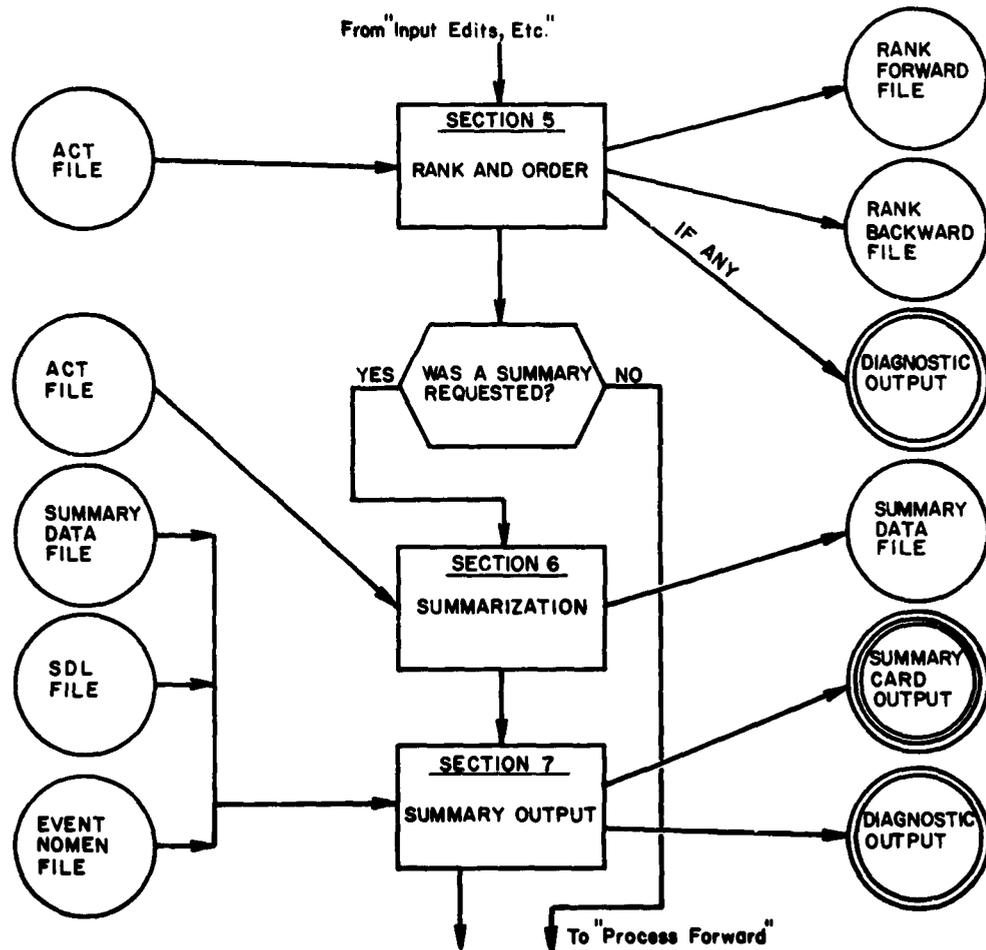
During this process the following errors are checked for and indicated: (1) level code change, (2) times wrong: ( $a > m > b$ ), (3) transaction code wrong, (4) too many predecessors and successors, (5) start date wrong, (6) given dates wrong, (7) number of events or activities exceed limit.



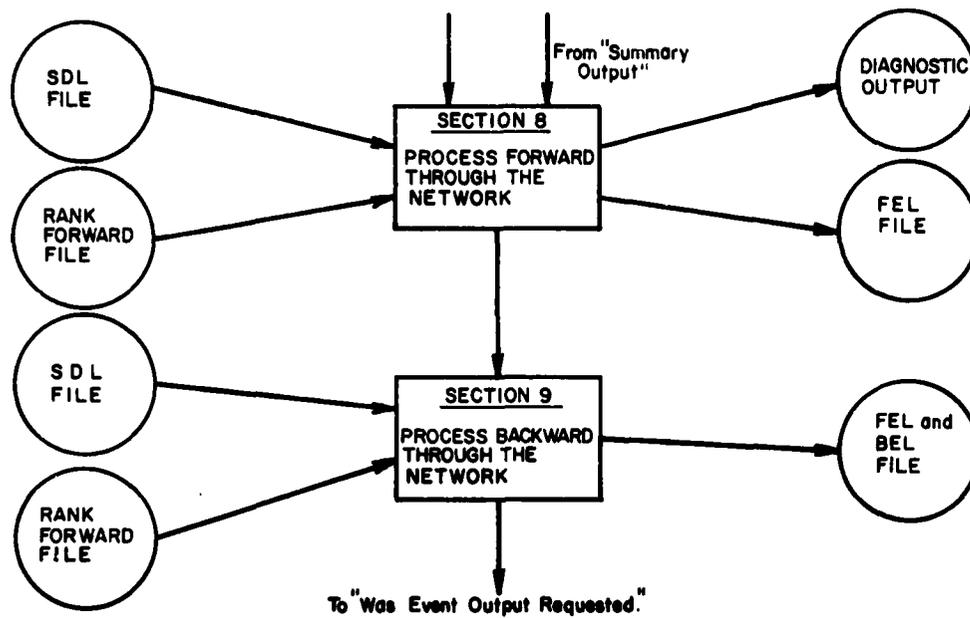
Section 5. A rank is computed for each event and each activity is assigned a rank based on its beginning event number. The above list is ordered by rank and pseudo beginning event number. During this process the network is checked for loops.

Section 6. The summarization process takes a detailed network and, based on preselected events, constructs a summarized version of that network. Included in the summarized network are those preselected events, plus events that are included by the program to insure network consistency. Generally, the program will have to include "time now" type events, and all start, interface, and end events. An activity reported complete before its beginning event is completed will be detected here and will kill the run.

Section 7. The summary output converts the summary data from the previous process and inserts the scheduled dates and event nomenclature.

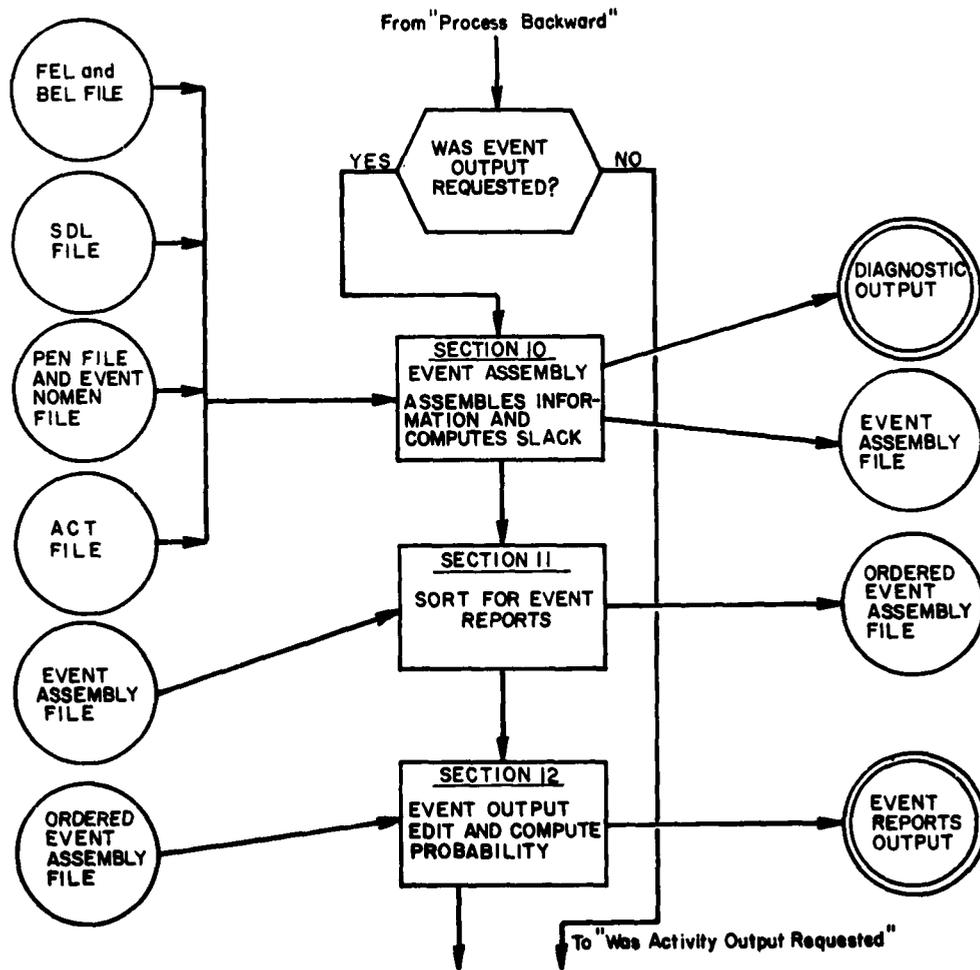


Section 8. The forward process computes  $T_E$  and  $\sigma_{T_E}$  and determines the Critical Predecessor (CP) for each event. These are computed or created by passing once through the forward ordered activity list. An activity reported complete before its beginning event is complete, if not detected during summarization, or an accumulation of too much time for  $T_E$  will be detected and indicated.



Section 9. The backward process computes  $T_L$  and  $\sigma_{T_L}$  for each event. These are computed by passing once through the backward ordered activity list.

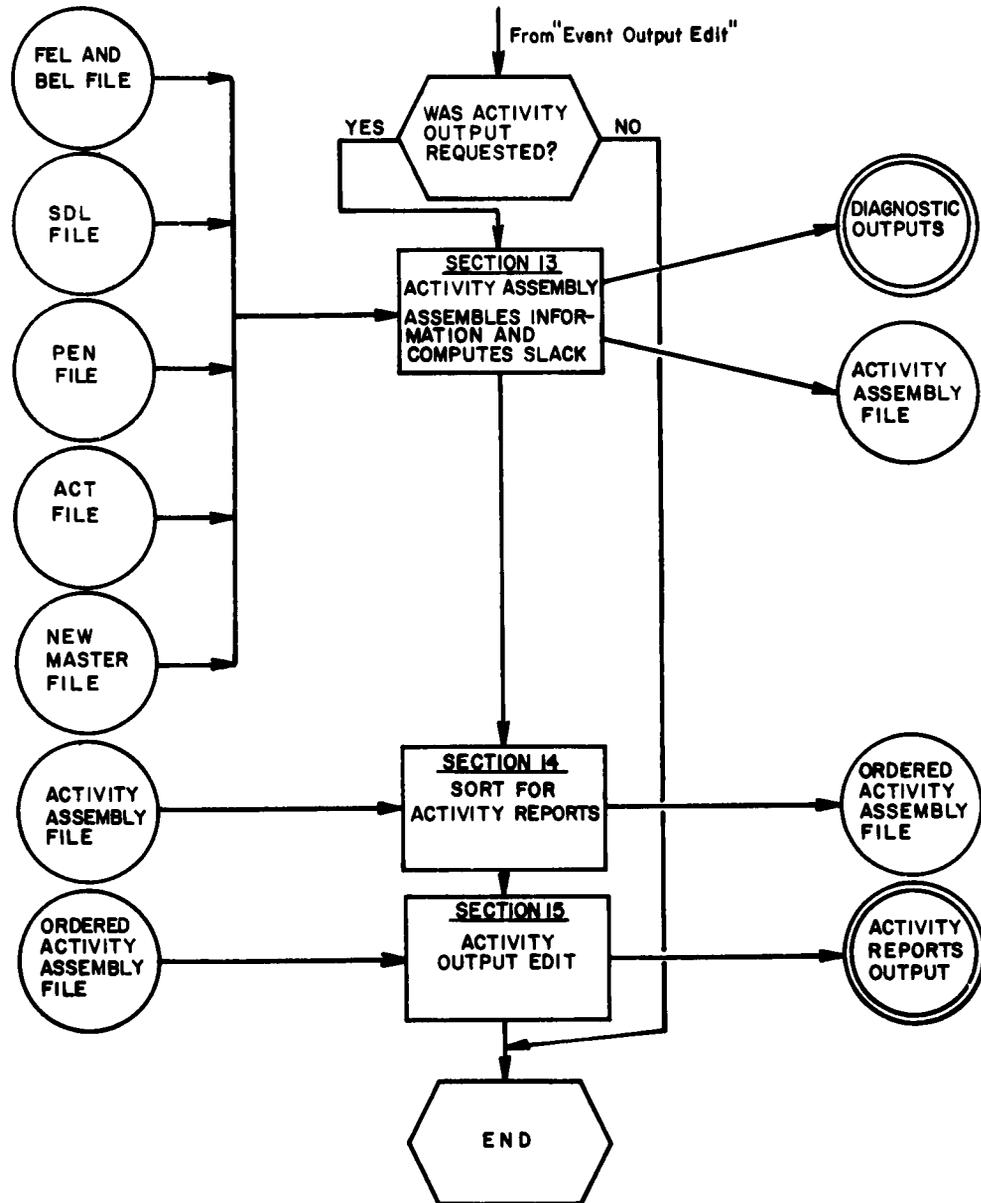
Section 10. The event assembly gathers all of the information concerning each event, computes the event's slack and records them as a record in the event assembly file. The first record in the file will be the header and control information. Then, there will be from one to three records for each event, depending on how many different orderings of the event output are requested. The one, two or three records will be identical except for the first two words of each record which will contain information pertaining to the particular order that was requested.



Section 11. The event assembly information is sorted internally or externally, depending on capacity and number of events.

Section 12. The sorted event assembly file is edited for output as follows. The times, slack, etc., are converted to a decimal, the times are converted to a date, the probabilities are computed, and the event numbers are unpacked. The above information is arranged for printing and sent to the output file.

Section 13-15. These sections follow the same procedure for activities that sections 10-12 follow for events.



**CHAPTER XI**

**OUTPUT REPORTS**

## CHAPTER XI

### OUTPUT REPORTS

This chapter describes the PERT TIME reports that are available as system outputs. The reports required on a periodic basis may be selected from those displayed in this manual. The manager need not request all the reports that are discussed. He will specify which are to be generated for his program.

The basic information generated in the PERT TIME System can be summarized in several ways for program management reporting. The format and detail in which this information is presented will vary, depending upon the planning and control requirements of different levels of management.

The output reports, with explanation of their formats are presented in three groupings as listed below.

#### A. Basic Program Management Reports

- . Event Report
- . Activity Report
- . E-L Chart
- . Summary Network Report

#### B. Validation and File Maintenance Reports

- . Master File Report Summary Sheet
- . Master File Report
- . Error Messages Report
- . PERT Diagnostics Report

#### C. Special Purpose Management Reports

- . Top Management Reports
- . Other Reports

A. Basic Program Management Reports

The basic program management reports are the primary outputs of the USAF PERT TIME Computer Program. They present the PERT data in various formats for management's use in evaluating the status of completed work and in forecasting potential problems.

## PERT TIME Event Report

The Event Report presents the standard PERT TIME data for each event in the network (Figures XI-1 through XI-4). The first three lines are used for report header information. The column headings below identify the data to be presented for each event.

This report is presently sorted in three orders:

- . Sort number one is listed in event number sequence for a catalog listing of events (Figure XI-2);
- . Sort two is by expected date, thereby providing a chronological listing of events (Figure XI-3);
- . Sort three is by slack from the least algebraic value (Figure XI-4).

Figures XI-2 through XI-4 illustrate printouts of the three different sorts of the Event Report. Arrowheads, which do not appear in the computer printouts, have been added in the figures in order to highlight the column on which the sort for that report was made.

Figure XI-1 presents the Event Report format with annotated data headings.

①	SYSTEM NO.	②	EVENT REPORT	③	④	RUN NO. 01	⑤	PAGE NO.	⑥
⑦	START DATE	⑧	EVENT NO.	⑨	⑩	EVENTS	⑪	REPORT DATE	⑫
⑪	END DATE	⑬	ACTIVITIES	⑭	⑮	LATEST DATE	⑯	SCHEDULED DATE	⑰
⑱	EVENT TITLE	⑲	L C	⑳	㉑	ACTUAL DATE	㉒	SLACK TIME	㉓
		㉔	CRITICAL	㉕	㉖	DATE	㉗	STD DEV	㉘
		㉙	C	㉚	㉛	DATE	㉜	PROB	㉝
		㉞	PREDECESSOR	㉟	㊱	DATE	㊲	SCD	㊳
		㊴	C	㊵	㊶	DATE	㊷	POS	㊸
		㊹		㊺	㊻	DATE	㊼	SL	㊽

FIGURE XI-1 — EVENT REPORT FORMAT

## DEFINITIONS

### PERT TIME Event Report

1. System Number

The control number assigned to the program to which PERT is being applied.

2. Name of Output

Event Report, Activity Report, or E-L Chart.

3. Output Heading

A field that may be used as desired.

4. Run Number

A number that provides a convenient method of network control for the user and is printed in the output heading. The run number must be 01 for each initial network run and must be greater than 01 for update runs.

5. Page Number

(self-explanatory)

6. Order of Output

The identification of the means of sorting the data, i.e., event number, expected date or slack which are printed out EVENT, EDATE or SLACK.

7. Start Date

The date from which the computer will start computations. It is the earliest known or established date for the network, e.g., 15JUL63.

8. Computer Program  
The computer program being used.
9. \_\_\_\_\_ Events  
The number of events in the network.
10. User's Identification  
Provision for the user's identification.
11. End Date  
The network completion date, e.g., 02SEP64.
12. Run Date  
The actual processing date.
13. \_\_\_\_\_ Activities  
The number of activities in the network.
14. Report Date  
The cutoff date for the report, e.g., 15JUL63.
15. Event Title  
(self-explanatory)
16. Event Number  
(self-explanatory)
17. LC  
The level code of the event.
18. Critical Predecessor  
The critical predecessor event.

19. LC  
The level code of the critical predecessor event.
20. SP  
The short path flag.
21. Actual Date  
The actual completion date for the event.
22. Expected Date  
The expected date ( $T_E$ ) for the event.
23. Latest Date  
The latest date ( $T_L$ ) for the event.
24. Scheduled Date  
The scheduled date for the event.
25. Slack Time  
The event slack given in weeks.
26. Std Dev  
The event standard deviation in weeks.
27. Prob Scd  
The probability of meeting the scheduled date.
28. Prob Pos Sl  
The probability of having positive slack.

SYSTEM NO. SAMPLE		EVENT REPORT		FAIRWEATHER MISSILE COMP		RUN NO. 01		PAGE 10.		1 EVENT		
START DATE 15JUL63		USAP PERT		RUN DATE 01JUL63		29 EVENTS		ASCEP		REPORT DATE 15JUL63		
END DATE 02SEP64		RUN DATE 01JUL63		LATEST DATE		44 ACTIVITIES		SLACK TIME		STD DEV SCD POS SL		
EVENT TITLE	NO.	L	C	S	P	ACTUAL DATE	EXPECTED DATE	SCHEDULED DATE	SLACK TIME	STD DEV	SCD POS	SL
FMC START 1ST OPER UNIT	34-210-001	A				15JUL63	15JUL63	25JUN63	- 2.6	.0	.0	.27
FMC START MAINT EQUIP FAB	34-210-002	A				06AUG63	16AUG64	16AUG63	35.5	.8	.8	1.00
FMC START MISSILE TRANSP VFH FAB	34-210-003	A				30AUG63	17FAP64	17FAP63	27.6	.5	.5	1.00
FMC START MISSILE FAB	34-210-004	A				16JUL63	21OCT63	16JUL63	13.5	.1	.1	1.00
FMC START MISSILE ERECT EQUIP FAB	34-210-005	A				06AUG63	27APR64	06AUG63	37.0	.9	.9	1.00
FMC START EMPLOY EQUIP	34-210-006	A				19AUG63	31JUL63	19AUG63	- 2.6	.3	.3	.27
FMC START MAINT PERS TRAINING	134-210-007	A				29JUL63	23AUG63	29JUL63	1.7	.3	.3	.84
FMC START SITE CONSTRUCTION	134-210-008	A				12AUG63	25MAR64	12AUG63	31.5	.3	.3	1.00
FMC START GRND EQUIP FAB	34-210-009	A				16JUL63	08OCT63	16JUL63	11.9	.1	.1	1.00
FMC START INSTAL C-O EQUIP FAB	34-210-010	A				05SEP63	20NOV63	05SEP63	19.0	.1	.1	1.00
FMC START TRAINING OPER PERS	134-210-011	A				18FEB64	01OCT63	18FEB64	3.7	.9	.9	.84
FMC START MISSILE FUNCT TESTS	34-210-012	A				06NOV63	22MAY64	06NOV63	13.5	1.2	1.2	1.00
FMC COMP MISSILE TRANSP VEH	34-210-013	A				27APR64	03AUG64	27APR64	13.5	1.3	1.3	1.00
FMC MISSILE LDMP	34-210-014	A				28AUG63	19MAY64	28AUG63	37.0	.9	.9	1.00
FMC COMP MISSILE ERECT EQUIP FAB	34-210-015	A				28APR64	06AUG64	28APR64	13.5	1.3	1.3	1.00
FMC START TRANSPORTATION	34-210-016	A				18MAY64	24AUG64	18MAY64	13.5	1.4	1.4	1.00
FMC MISSILE ON DOCK AT SITE	34-210-017	A				19MAY64	25AUG64	19MAY64	- 2.6	.9	.9	.27
FMC START MISSILE INSTAL	34-210-018	A				09MAR64	19FEB64	09MAR64	45.7	.4	.4	1.00
FMC EMPLOY EQUIP ON DOCK AT SITE	34-210-019	A				01OCT63	24AUG64	01OCT63	31.5	1.2	1.2	1.00
FMC MAINT PERS AVAIL AT SITE	34-210-020	A				13JAN64	24AUG64	13JAN64	- 2.6	.9	.9	.27
FMC SITE CONSTRUCTION COMP	34-210-021	A				10MAR64	20FEB64	10MAR64	3.7	.9	.9	.84
FMC GRND EQUIP ON DOCK AT SITE	34-210-022	A				06DEC63	03JAN64	06DEC63	3.7	.9	.9	.84
FMC PRELIM C-O INSTL/C-O EQUIP	34-210-023	A				27JAN64	20FEB64	27JAN64	4.6	1.1	1.1	.87
FMC INST C-O EQUIP ON DOCK AT SITE	34-210-024	A				17JAN64	19FEB64	17JAN64	- 2.6	.9	.9	.27
FMC OPER PERS AVAIL AT SITE	34-210-025	A				11MAR64	21FEB64	11MAR64	35.5	.2	.2	1.00
FMC START GRND EQUIP INSTALLATION	34-210-026	A				23DEC63	01SEP64	23DEC63	- 2.6	.9	.9	.27
FMC MAINT EQUIP AVAILABLC	34-210-027	A				21SEP64	02SEP64	21SEP64	- 2.6	1.8	1.8	.27
FMC LAUNCH SITE COMP	34-210-028	A				22SEP64	02SEP64	22SEP64	- 2.6	1.8	1.8	.27
FMC 1ST OPER UNIT DELIVERY	34-210-029	A							- 2.6	1.8	1.8	.27

FIGURE XI-2—EVENT REPORT - EVENT NUMBER SEQUENCE

SYSTEM NO. SAMPLE START DATE 15JUL63 END DATE 02SEP64		EVENT REPORT FAIRWEATHER MISSILE CORP USAP PERT RUN DATE 01JUL63		RUN NO. 01 29 EVENTS 44 ACTIVITIES		PAGE NO. 1 ASCEP REPORT DATE 15JUL63							
EVENT TITLE	EVENT NO.	L C	CRITICAL C	L S	ACTUAL P DATE	EXPECTED DATE	LATEST DATE	SCHEDULED DATE	SLACK TIME	STU DEFV	PROB SCD	PRUB POS	SL SL
FMC 1ST OPER UNIT	34-210-001	A				15JUL63	25JUN63		- 2.6	.0	.0		.27
FMC START GRND EQUIP FAB	34-210-009	A				16JUL63	08JUL63		11.0	.1	.1		1.00
FMC START INSTAL C-C EQUIP FAB	34-210-010	A				16JUL63	20NOV63		18.0	.1	.1		1.00
FMC START MISSILE FAB	34-210-004	A				16JUL63	21OCT63		13.5	.1	.1		1.00
FMC START MAINT PERS TRAINING	34-210-007	A				29JUL63	23AUG63		3.7	.3	.3		.84
FMC START MAINT EQUIP FAB	34-210-002	A				06AUG63	16APR64		35.5	.8	.8		1.00
FMC START MISSILE ERECT EQUIP FAB	34-210-005	A				08AUG63	27APR64		37.0	.3	.3		1.00
FMC START SITE CONSTRUCTION	34-210-008	A				12AUG63	29APR64		31.5	.3	.3		1.00
FMC START EMPLOYE EQUIP	34-210-006	A				19AUG63	31JUL63		- 2.6	.3	.3		.27
FMC COMP MISSILE ERECT EQUIP FAB	34-210-015	A				28AUG63	19MAY64		37.0	.7	.7		1.00
FMC START MISSILE TRANSP VEH FAB	34-210-003	A				30AUG63	17MAR64		27.6	.5	.5		1.00
FMC START TRAINING OPER PERS	34-210-011	A				05SEP63	01OCT63		3.7	.5	.5		.84
FMC MAINT PERS AVAIL AT SITE	34-210-020	A				01OCT63	24AUG64		45.7	.4	.4		1.00
FMC COMP MISSILE TRANSP VEH	34-210-013	A				06NOV63	21MAY64		27.6	.9	.9		1.00
FMC PRELIM C-0 INSTL/C-0 EQUIP	34-210-023	A				06DEC63	03MAY64		3.7	.9	.9		.84
FMC MAINT EQUIP AVAILABLE	34-210-027	A				20DEC63	01SEP64		35.5	2.2	2.2		1.00
FMC SITE CONSTRUCTION COMP	34-210-021	A				13JAN64	24AUG64		31.5	1.2	1.2		1.00
FMC OPER PERS AVAIL AT SITE	34-210-025	A				17JAN64	19FEB64		4.6	1.1	1.1		.87
FMC INST C-0 EQUIP ON DOCK AT SITE	34-210-024	A				27JAN64	20FEB64		3.7	1.0	1.0		.84
FMC START MISSILE FUNCT TESTS	34-210-012	A				18FEB64	22MAY64		13.5	1.2	1.2		1.00
FMC EMPLOYE EQUIP ON DOCK AT SITE	34-210-019	A				09MAR64	19FEB64		- 2.6	.7	.7		.27
FMC GRND EQUIP ON DOCK AT SITE	34-210-022	A				10MAR64	20FEB64		- 2.6	.7	.7		.27
FMC START GRND EQUIP INSTALLATION	34-210-026	A				11MAR64	21FEB64		- 2.6	.9	.9		.27
FMC MISSILE COMP	34-210-014	A				27APR64	03AUG64		13.5	1.3	1.3		1.00
FMC START TRANSPORTATION	34-210-016	A				28APR64	04AUG64		13.5	1.3	1.3		1.00
FMC MISSILE ON DOCK AT SITE	34-210-017	A				18MAY64	24AUG64		13.5	1.4	1.4		1.00
FMC START MISSILE INSTAL	34-210-018	A				19MAY64	24AUG64		13.5	1.4	1.4		1.00
FMC LAUNCH SITE COMP	34-210-028	A				21SEP64	01SEP64		- 2.6	1.3	1.3		.27
FMC 1ST OPER UNIT DELIVERY	34-210-029	A				22SEP64	02SEP64		- 2.6	1.3	1.3		.27

FIGURE XI-3 — EVENT REPORT - EXPECTED DATE SEQUENCE

SYSTEM NO. SAMPLE		EVENT REPORT		FAIRWEATHER MISSILE CORP		RUN NO. 01		PAGE NO. 1							
START DATE 15JUL63		USAF PERT		OSAP PERT		EVENTS		ASCEP							
END DATE 02SEP64		RUN DATE 01JUL63		RUN DATE 01JUL63		ACTIVITIES		REPORT DATE 15-JUL-63							
EVENT	EVENT NO.	L	C	L	S	P	ACTUAL DATE	EXPECTED DATE	LATEST DATE	SCHEDULED DATE	SLACK TIME	STD DEV	PROB SCD	PROB POS	SL
FMC START 1ST OPER UNIT	34-210-001	A					15JUL63	15JUL63	25JUN63		- 2.6	.0	.0	.27	
FMC 1ST OPER UNIT DELIVERY	34-210-029	A					22SEP64	22SEP64	02SEP64	02SEP64	- 2.6	3.8	3.8	.27	
FMC LAUNCH SITE COMP	34-210-028	A					21SEP64	21SEP64	01SEP64		- 2.6	3.8	3.8	.27	
FMC START GRND EQUIP INSTALLATION	34-210-026	A					11MAR64	11MAR64	21FEB64		- 2.6	.9	.9	.27	
FMC GRND EQUIP ON DOCK AT SITE	34-210-022	A					10MAR64	10MAR64	20FEB64		- 2.6	.9	.9	.27	
FMC EMPLOYE EQUIP ON DOCK AT SITE	34-210-019	A					09MAR64	09MAR64	19FEB64		- 2.6	.9	.9	.27	
FMC START EMPLOYE EQUIP	134-210-006	A					19AUG63	19AUG63	31JUL63		- 2.6	.3	.3	.27	
FMC PRELIM C-O INSTL/C-O EQUIP	34-210-023	A					06DEC63	06DEC63	03JAN64		3.7	.9	.9	.84	
FMC INST C-O EQUIP ON DOCK AT SITE	34-210-024	A					27JAN64	27JAN64	20FEB64		3.7	1.0	1.0	.84	
FMC START TRAINING OPER PERS	134-210-011	A					05SEP63	05SEP63	01OCT63		3.7	.8	.8	.84	
FMC START MAINT PERS TRAINING	134-210-007	A					29JUL63	29JUL63	23AUG63		3.7	.3	.3	.84	
FMC OPER PERS AVAIL AT SITE	34-210-025	A					17JAN64	17JAN64	19FEB64		4.6	1.1	1.1	.87	
FMC START GRND EQUIP FAB	34-210-009	A					16JUL63	16JUL63	08OCT63		11.8	.1	.1	1.00	
FMC MISSILE COMP	34-210-014	A					27APR64	27APR64	03AUG64		13.5	1.3	1.3	1.00	
FMC START TRANSPORTATION	34-210-016	A					28APR64	28APR64	04AUG64		13.5	1.3	1.3	1.00	
FMC START MISSILE FAB	34-210-004	A					16JUL63	16JUL63	21OCT63		13.5	.1	.1	1.00	
FMC MISSILE ON DOCK AT SITE	34-210-017	A					18MAY64	18MAY64	24AUG64		13.5	1.4	1.4	1.00	
FMC START MISSILE INSTAL	34-210-018	A					19MAY64	19MAY64	25AUG64		13.5	1.4	1.4	1.00	
FMC START MISSILE FUNCN TESTS	34-210-012	A					18FEB64	18FEB64	22MAY64		13.5	1.2	1.2	1.00	
FMC START INSTAL C-O EQUIP FAB	34-210-010	A					16JUL63	16JUL63	20NOV63		18.0	.1	.1	1.00	
FMC START MISSILE TRANSP VEH FAB	34-210-003	A					30AUG63	30AUG63	17MAR64		27.6	.5	.5	1.00	
FMC COMP MISSILE TRANSP VEH	34-210-013	A					06NOV63	06NOV63	21MAY64		27.6	.9	.9	1.00	
FMC START SITE CONSTRUCTION	134-210-008	A					12AUG63	12AUG63	25MAR64		31.5	.3	.3	1.00	
FMC SITE CONSTRUCTION COMP	34-210-021	A					13JAN64	13JAN64	24AUG64		31.5	1.2	1.2	1.00	
FMC MAINT EQUIP AVAILABLE	34-210-027	A					23DEC63	23DEC63	01SEP64		35.5	2.2	2.2	1.00	
FMC START MAINT EQUIP FAB	34-210-002	A					06AUG63	06AUG63	16APR64		35.5	.8	.8	1.00	
FMC COMP MISSILE ERECT EQUIP FAB	34-210-015	A					28AUG63	28AUG63	19MAY64		37.0	.9	.9	1.00	
FMC START MISSILE ERECT EQUIP FAB	34-210-005	A					06AUG63	06AUG63	27APR64		37.0	.8	.8	1.00	
FMC MAINT PERS AVAIL AT SITE	14-210-020	A					01OCT63	01OCT63	24AUG64		45.7	.4	.4	1.00	

FIGURE XI-4 -- EVENT REPORT -- SLACK SEQUENCE

## PERT TIME Activity Report

The Activity Report presents the standard PERT TIME data for each activity in the network (Figures XI-5 through XI-8). As in the Event Report, the first three lines are used for report header information and the column headings below identify the data to be presented for each activity.

This report, also, is presently sorted in three orders:

- . Sort one is by ending event-beginning event number (EE-BE), i.e., where more than one activity has the same ending event, they are further sorted by beginning event number;
- . Sort two is by the expected time (date) of completion of the activity;
- . Sort three is by activity slack from the least algebraic value.

Figure XI-5 presents the Activity Report format with annotated data headings. Examples of the three sorts are shown in Figures XI-6 through XI-8.



## DEFINITIONS

### PERT TIME Activity Report

1. System Number

The control number assigned to the program to which PERT is being applied.

2. Name of Output

Event Report, Activity Report or E-L Chart.

3. Output Heading

A field that may be used as desired.

4. Run Number

A number that provides a convenient method of network control for the user and is printed in the output heading. The run number must be 01 for each initial network run and must be greater than 01 for update runs.

5. Page Number

(self-explanatory)

6. Order of Output

The identification of the means of sorting the data, i.e., ending event-beginning event, expected activity completion time or activity slack which are printed out EE-BE, E TIME or A SLK.

7. Start Date

The date from which the computer will start computations. It is the earliest known or established date for the network, e.g., 15JUL63.

8. Computer Program  
The computer program being used.
9. \_\_\_\_\_ Events  
The number of events in the network.
10. User's Identification  
Provisions for the user's identification.
11. End Date  
The network completion date, e.g., 02SEP64.
12. Run Date  
The actual processing date.
13. \_\_\_\_\_ Activities  
The number of activities in the network.
14. Report Date  
The cutoff date for the report, e.g., 15JUL63.
15. Beginning Event  
The number of the beginning event of the activity.
16. LC  
The level code of the beginning event.
17. Ending Event  
The ending event of the activity.
18. LC  
The level code of the ending event.

19. Expected End Time

The activity expected end time in weeks from the start date. If an "A" precedes this time, the time and date are activity actual times and dates.

20. Expected End Date

The activity expected end time converted to a date.

21. Latest End Time

The activity latest end time in weeks from the start date. If an "A" precedes this time, the time and date are actual times and dates for the ending event.

22. Latest End Date

The activity latest end time converted to a date.

23. Act Time

The activity expected elapsed time  $\frac{(a+4m+b)}{6}$ .

24. Act Sig

The activity standard deviation  $(b-a)/6$ .

25. Act Slack

The latest time ( $T_L$ ) of the activity's ending event minus the activity expected end time.

26. Schedule Time

The event scheduled time in weeks from the base date. If an asterisk precedes this time, the schedule date option was exercised for this ending event.

27. Scheduled Date

The activity scheduled time converted to a date.

28. Critical Predecessor

The critical predecessor of the ending event. This may or may not be the beginning event.

29. SP

The short path flag.

30. Event Slack

The slack of the ending event.

31. End Event Exp Date

The expected date of the ending event. This will be equal to or later than the activity expected end date. An "A" preceding this date indicates an actual date.



SYSTEM NO. SAMPLE		ACTIVITY REPORT		FAIRWEATHER MISSILE CORP		USAF PERT		RUN NO. 01		PAGE NO. 2		
START DATE	END DATE	L	C	EVENT	DATE	ACT	TIME	SIG	ACT	SLACK	ASCEP	
15JUL63	02SEP64										REPORT DATE 15JUL63	
				LATEST END		SCHEDULED		CRITICAL		EVENT END		
				DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	
134-210-006	34-210-019 A	33-2	09MAR64	30-6	19FEB64	28-2	-	2-6	34-210-006	-	2-6	09MAR64
134-210-007	34-210-020 A	11-0	01OCT63	56-7	24AUG64	9-0	-	45-7	34-210-007	-	45-7	01OCT63
134-210-008	34-210-021 A	25-2	13JAN64	56-7	24AUG64	21-2	1-2	31-5	34-210-008	-	31-5	13JAN64
34-210-009	34-210-022 A	19-0	26NOV63	30-8	20FEB64	18-8	-	11-8	34-210-019 A	-	2-6	10MAR64
34-210-019	34-210-022	33-4	10MAR64	30-8	20FEB64	.2	.1	-	34-210-019 A	-	2-6	13MAR64
134-210-007	34-210-023	7-0	03SEP63	24-0	03JAN64	5-0	.7	17-0	34-210-011	-	3-7	06DEC63
34-210-010	34-210-023	6-0	26AUG63	24-0	03JAN64	5-0	.5	18-0	34-210-011	-	3-7	06DEC63
134-210-011	34-210-023	20-3	06DEC63	24-0	03JAN64	13-0	.3	3-7	34-210-011	-	3-7	06DEC63
34-210-023	34-210-024	27-1	27JAN64	30-8	20FEB64	6-8	.5	3-7	34-210-023	-	3-7	27JAN64
134-210-011	34-210-025 A	26-0	17JAN64	30-6	19FEB64	18-7	.7	4-6	34-210-011	-	4-6	17JAN64
34-210-022	34-210-026	33-6	11MAR64	31-0	21FEB64	.2	.1	-	34-210-022 A	-	2-6	11MAR64
34-210-024	34-210-026	27-3	29JAN64	31-0	21FEB64	.2	.1	3-7	34-210-022 A	-	2-6	11MAR64
34-210-025	34-210-026	26-4	21JAN64	31-0	21FEB64	.4	.2	4-6	34-210-022 A	-	2-6	11MAR64
34-210-002	34-210-027 A	22-5	23DEC63	59-0	01SEP64	19-3	2-0	35-5	34-210-002	-	35-5	23DEC63
34-210-018	34-210-028	44-5	27MAY64	58-0	01SEP64	1-1	.2	13-5	34-210-026	-	2-6	21SEP64
34-210-021	34-210-028	25-4	14JAN64	58-0	01SEP64	.2	.1	32-6	34-210-026	-	2-6	21SEP64
34-210-026	34-210-028	60-6	21SEP64	58-0	01SEP64	27-0	3-7	-	34-210-026	-	2-6	21SEP64
34-210-027	34-210-029 A	22-7	24DEC63	58-2	02SEP64	.2	.1	35-5	34-210-026	-	2-6	22SEP64
34-210-028	34-210-029	60-8	22SEP64	58-2	02SEP64	.2	.1	-	34-210-029	-	2-6	22SEP64

FIGURE XI-6 — ACTIVITY REPORT - EE-BE SEQUENCE (cont.)

SYSTEM NO. SAMPLE		ACTIVITY REPORT		FAIRWEATHER MISSILE CORP		USAF PERT		RUN DATE		01 JUL63		RUN NO. 01		29 EVENTS		44 ACTIVITIES		PAGE NO. 1 E TIM		ASCEP		REPORT DATE 15JUL63	
BEGINNING EVENT	L C	ENDING EVENT	L C	EXPECTED TIME	L C	END DATE	L C	LATEST END TIME	ACT TIME	ACT SIG	ACT SLACK	SCHEDULED TIME	CRITICAL PREDECESSOR	S P	EVENT SLACK	END DATE							
34-210-001		34-210-010		.2		16JUL63		18.2	20NDV63	.2	.1	18.0	34-210-001	A	18.0	16JUL63							
34-210-001		34-210-009		.2		16JUL63		12.0	08OCT63	.2	.1	11.8	34-210-001	A	11.8	16JUL63							
34-210-001		34-210-004		.2		16JUL63		13.7	21OCT63	.2	.1	13.5	34-210-001	A	13.5	16JUL63							
34-210-001		34-210-007		2.0		29JUL63		5.7	23AUG63	2.0	.3	3.7	34-210-001	A	3.7	29JUL63							
34-210-001		34-210-002		3.2		06AUG63		38.7	16APR64	3.2	.8	35.5	34-210-001	A	35.5	06AUG63							
34-210-001		34-210-005		3.2		06AUG63		40.2	27APR64	3.2	.8	37.0	34-210-001	A	37.0	06AUG63							
34-210-001		34-210-008		4.0		12AUG63		35.5	25MAR64	4.0	.3	31.5	34-210-001	A	31.5	12AUG63							
34-210-001		34-210-011		4.0		12AUG63		11.0	01OCT63	4.0	.3	7.0	34-210-007		3.7	05SEP63							
34-210-001		34-210-006		5.0		19AUG63		2.4	31JUL63	5.0	.3	2.6	34-210-001	A	2.6	17AUG63							
34-210-010		34-210-023		6.0		26AUG63		24.0	03JAN64	5.8	.5	18.0	34-210-011		3.7	06DEC63							
34-210-005		34-210-015		6.4		29AUG63		43.4	19MAY64	3.2	.5	37.0	34-210-005		37.0	23AUG63							
34-210-015		34-210-016		6.6		29AUG63		53.9	04AUG64	2	.1	47.3	34-210-014	A	13.5	29APR64							
34-210-001		34-210-003		6.8		30AUG63		34.4	17MAR64	6.8	.5	27.6	34-210-001	A	27.6	30AUG63							
34-210-015		34-210-012		6.9		03SEP63		43.9	22MAY64	.5	.1	37.0	34-210-004		13.5	13FEB64							
34-210-007		34-210-023		7.0		03SEP63		24.0	03JAN64	5.0	.7	17.0	34-210-011		3.7	06DEC63							
34-210-007		34-210-011		7.3		05SEP63		11.0	01OCT63	5.3	.7	3.7	34-210-007		3.7	05SEP63							
34-210-014		34-210-016		40.4		28APR64		53.9	04AUG64	.2	.1	13.5	34-210-014	A	13.5	28APR64							
34-210-016		34-210-017		43.2		19MAY64		56.7	24AUG64	2.8	.5	13.5	34-210-016		13.5	18MAY64							
34-210-017		34-210-018		43.4		19MAY64		56.9	29AUG64	.2	.1	13.5	34-210-017		13.5	19MAY64							
34-210-018		34-210-028		44.5		27MAY64		58.0	01SEP64	1.1	.2	13.5	34-210-026		2.6	21SEP64							
34-210-026		34-210-028		60.6		21SEP64		59.0	01SEP64	27.0	3.7	2.6	34-210-026		2.6	21SEP64							
34-210-028		34-210-029		60.8		22SEP64		58.2	02SEP64	.2	.1	2.6	34-210-029		2.6	22SEP64							

FIGURE XI-7 — ACTIVITY REPORT — EXPECTED TIME SEQUENCE

SYSTEM NO.	SAMPLE START DATE	ACTIVITY REPORT	FAIRWEATHER MISSILE CORP	RUN NO.	OF	PAGE NO.	1 A SLK							
END DATE	END DATE	USAP PERT	USAP PERT	EVENTS	ACTIVITIES	ASCEP	REPORT DATE							
02SEP64	01JUL63	01JUL63	01JUL63	29	44	15	15JUL63							
BEGINNING	ENDING	L	EXPECTED	END	LATEST FND	ACT	ACT	SIG	ACT	SCHEDULED	CRITICAL	PREDECESSOR	EVENT	END
EVENT	EVENT	C	TIME	DATE	TIME	TIME	TIME	TIME	TIME	TYPE	DATE	DATE	DATE	DATE
34-210-028	34-210-029	MTC	60.8	22SEP64	58.2	02SEP64	.2	.1	.1	58.2	02SEP64	34-210-028	34-210-028	22SEP64
34-210-026	34-210-028	MTC	60.6	21SEP64	58.0	01SEP64	27.0	3.7	3.7	27.0	01SEP64	34-210-026	34-210-026	21SEP64
34-210-022	34-210-026	SUPY	33.6	11MAR64	31.0	21FEB64	.2	.1	.1	31.0	21FEB64	34-210-022	34-210-022	11MAR64
34-210-019	34-210-022	SUPY	33.4	10MAR64	30.8	20FEB64	.2	.1	.1	30.8	20FEB64	34-210-019	34-210-019	10MAR64
134-210-006	34-210-019	A	33.2	09MAR64	30.6	19FEB64	28.2	.8	.8	28.2	19FEB64	34-210-006	34-210-006	09MAR64
134-210-001	134-210-006	COMT	5.0	19AUG63	2.4	31JUL63	5.0	.3	.3	5.0	31JUL63	34-210-001	34-210-001	19AUG63
134-210-011	34-210-023	ATC	20.3	06DEC63	24.0	03JAN64	13.0	.3	.3	13.0	03JAN64	34-210-011	34-210-011	06DEC63
134-210-007	134-210-011	ATC	7.3	05SEP63	11.0	01OCT63	5.3	.7	.7	5.3	01OCT63	34-210-007	34-210-007	05SEP63
34-210-001	134-210-007	ATC	2.0	29JUL63	5.7	23AUG63	2.0	.3	.3	2.0	23AUG63	34-210-001	34-210-001	29JUL63
34-210-024	34-210-026	SUPY	27.3	29JAN64	31.0	21FEB64	.2	.1	.1	31.0	21FEB64	34-210-024	34-210-024	29JAN64
34-210-023	34-210-024	A	27.1	27JAN64	30.8	20FEB64	6.8	.5	.5	6.8	20FEB64	34-210-023	34-210-023	27JAN64
34-210-025	34-210-026	OPS	26.4	21JAN64	31.0	21FEB64	.4	.2	.2	31.0	21FEB64	34-210-025	34-210-025	21JAN64
134-210-011	34-210-025	A	26.0	17JAN64	30.6	19FEB64	18.7	.7	.7	18.7	19FEB64	34-210-011	34-210-011	17JAN64
34-210-001	134-210-011	ATC	4.0	12AUG63	11.0	01OCT63	4.0	.3	.3	4.0	01OCT63	34-210-001	34-210-001	12AUG63
34-210-001	34-210-009	ATC	.2	16JUL63	12.0	08OCT63	.2	.1	.1	12.0	08OCT63	34-210-001	34-210-001	16JUL63
34-210-001	34-210-005	ENGR	3.2	06AUG63	40.2	27APR64	3.2	.8	.8	3.2	27APR64	34-210-001	34-210-001	06AUG63
34-210-015	34-210-012	MFG	6.9	03SEP63	43.9	22MAY64	.5	.1	.1	43.9	22MAY64	34-210-015	34-210-015	03SEP63
34-210-005	34-210-015	A	6.4	29AUG63	43.5	19MAY64	3.2	.5	.5	43.5	19MAY64	34-210-005	34-210-005	29AUG63
34-210-013	34-210-016	PFG	16.3	07NOV63	53.9	04AUG64	.2	.1	.1	53.9	04AUG64	34-210-013	34-210-013	07NOV63
34-210-020	34-210-018	OPS	11.2	02OCT63	56.9	25AUG64	.2	.1	.1	56.9	25AUG64	34-210-020	34-210-020	02OCT63
134-210-007	34-210-020	A	11.0	01OCT63	56.7	24AUG64	9.0	.3	.3	56.7	24AUG64	34-210-007	34-210-007	01OCT63
34-210-015	34-210-016	PFG	6.6	29AUG63	53.9	04AUG64	.2	.1	.1	53.9	04AUG64	34-210-015	34-210-015	29AUG63

FIGURE 71-8 -- ACTIVITY REPORT - SLACK SEQUENCE

## PERT TIME E-L Charts

The E-L Chart is a graphical presentation of the expected date (E), latest date (L), scheduled date (S) and actual date (A) for each event on a calendar basis. The events are sequenced by expected date and the heading of the charts is similar to that on the Event and Activity Reports.

The date is displayed in terms of weeks from the report date (on an 85-week scale) or months from the report date (on an 85-month scale). For the case where it is shown in terms of weeks from the report date, there is the option of displaying the D--D spread as three standard deviations on each side of (E).

The report is illustrated in Figures XI-9 through XI-11. Note that there are two lines of print for each event except when a scheduled date is given, in which case three lines are given.

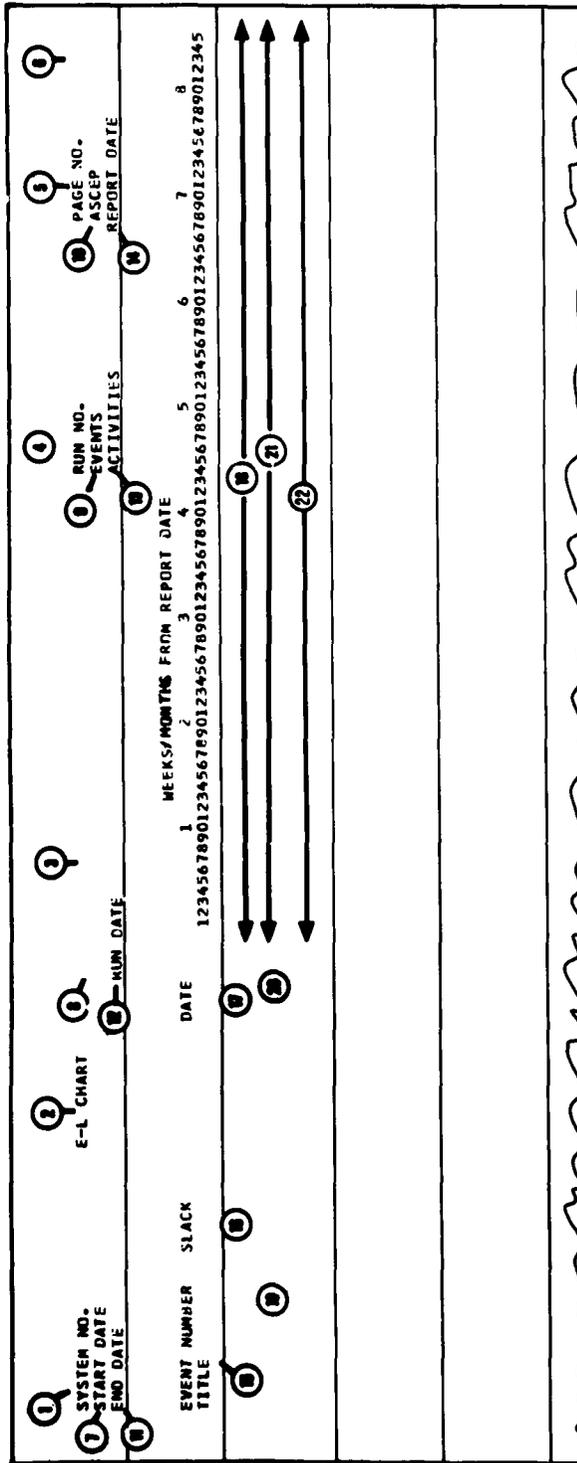


FIGURE XI-9—E-L CHART FORMAT

## DEFINITIONS

### PERT TIME E-L Charts

1. System Number

The control number assigned to the program to which PERT is being applied.

2. Name of Output

Event Report, Activity Report or E-L Chart.

3. Output Heading

A field that may be used as desired.

4. Run Number

A number that provides a convenient method of network control for the user and is printed in the output heading. The run number must be 01 for each initial network run and must be greater than 01 for update runs.

5. Page Number

(self-explanatory)

6. Order of Output

The identification of the means of sorting the data, which for the E-L Chart is expected date.

7. Start Date

The date from which the computer will start computations. It is the earliest known or established date for the network, e.g., 15JUL63.

8. Computer Program

The computer program being used.

9. Events

The number of events in the network.

10. User's Identification

Provisions for the user's identification.

11. End Date

The network completion date, e.g., 02SEP64.

12. Run Date

The actual processing date.

13. Activities

The number of activities in the network.

14. Report Date

The cutoff date for the report, e.g., 15JUL63.

15. Event Number

(self-explanatory)

16. Slack

The event slack.

17. Date

The expected date ( $T_E$ ) for the event.

18. E

An "E", corresponding to the expected date, is printed in the appropriate position under the calendar scale. For the E-L Chart by weeks "D"'s are used to display the three sigma points.

19. Title

The event title.

20. Date

The latest date ( $T_L$ ) for the event.

21. L

An "L", corresponding to the latest date, is printed in the appropriate position under the calendar scale.

22. S

Where a scheduled date is given, an "S", corresponding to the scheduled date, is printed in the appropriate position under the calendar scale.

SYSTEM NO. SAMPLE START DATE 15JUL63 END DATE 02SEP64	E-L CHART	FAIRWEATHER MISSILE CORP USAF PERT RUN DATE 01JUL63	WEEKS FROM REPORT DATE	1	2	3	4	5	6	7	8	9	PAGE NO. 1 ASCLP REPORT DATE 15JUL63
EVENT NUMBER SLACK	DATE	15JUL63	1	2	3	4	5	6	7	8	9		
34-210-001 A - 2.6	15JUL63	E											
FMC START 1ST OPER UNIT	25JUN63												
34-210-002 A - 11.9	16JUL63	EC											
FMC START GRND EQUIP FAB	09OCT63												
34-210-010 A - 18.0	16JUL63	ED											
FMC START INSTAL C-O EQUIP FAB	20NOV63			L									
34-210-004 A - 13.5	16JUL63	ED											
FMC START MISSILE FAB	21OCT63			L									
34-210-007 A - 3.7	29JUL63	DED											
FMC START MAINT PERS TRAINING	23AUG63			L									
34-210-002 A - 35.5	06AUG63	D E D											
FMC START MAINT EQUIP FAB	16APR64					L							
34-210-005 A - 37.0	06AUG63	D E D											
FMC START MISSILE ERECT EQUIP FAB	27APR64						L						
34-210-008 A - 31.5	12AUG63	DED											
FMC START SITE CONSTRUCTION	25MAR64					L							
34-210-006 A - 2.6	17AUG63	DED											
FMC START REPLAC EQUIP	31JUL63	L											
34-210-015 A - 37.0	28AUG63	D E D											
FMC COMP MISSILE ERECT EQUIP FAB	19MAY64							L					
34-210-003 A - 27.6	30AUG63	D E D											
FMC START MISSILE TRANSP VEH FAB	17MAR64					L							
34-210-011 A - 3.7	05SEP63	D E D											
FMC START TRAINING OPER PERS	01OCT63	L											
34-210-020 A - 45.7	01OCT63	D E D											
FMC MAINT PERS AVAIL AT SITE	24AUG64								L				
34-210-013 A - 27.6	06NOV63												
FMC COMP MISSILE TRANSP VEH	21MAY64									L			
34-210-023 A - 3.7	06DEC63									D E D			
FMC PRELIM C-O INSTL/C-O EQUIP	03JAN64									L			
34-210-027 A - 35.5	23DEC63									D E D			
34-210-017 A - 13.5	18MAY64										D E D		
FMC MISSILE ON DOCK AT SITE	28AUG64											L	
34-210-018 A - 13.5	19MAY64												D E D
FMC START MISSILE INSTAL	25AUG64												
34-210-029 A - 2.6	21SEP64												D E D
FMC LAUNCH SITE COMP	01SEP64												
34-210-029 A - 2.6	22SEP64												D E D
FMC 1ST OPER UNIT DELIVERY	02SEP64												L S

FIGURE XI-10 -- E-L CHART (WEEKS)



## PERT TIME Summary Network Report

The Summary Network Report presents the PERT TIME data for the summarized network. As described in Chapter V, a summary network can be constructed using certain of the events that appeared in the detailed network and their constraint relationships. When a summary is requested, the computer program produces the event and activity data for the summary network. While the prime use of this data is in the integration of networks, the data can also be used to produce output reports for the summarized network. Exactly the same reports that are generated for the detailed network can then be generated for the summary network.

B. Validation and File Maintenance Reports

The validation and file maintenance reports audit and validate the input data.

## PERT TIME Master File Report Summary Sheet

The PERT Master File Report Summary Sheet identifies the reports and report options requested and produced for the particular run. This sheet constitutes a table of contents for the computer run. Figure XI-12 presents the Master File Report Summary Sheet format with annotated data headings. Figure XI-13 illustrates a printout of the data.

(2) PAGE
(1) USERS IDENTIFICATION:
(2) SYSTEM NUMBER
(3) OUTPUT HEADING
(4) REPORT DATE
(5) START DATE
(6) REPORT OPTIONS
(7) MASTER
(8) E-L CHART
(9) EVENT
(10) ACTIVITY
(11) SUMMARY

FIGURE XI-12--MASTER FILE REPORT SUMMARY SHEET FORMAT

PART MASTER FILE REPORT SUMMARY SHEET	PAGE	0
USERS IDENTIFICATION	ASCEP	
SYSTEM NUMBER	SAMPLE	
OUTPUT HEADING	PATWEATHER MISSILE CORP	
REPORT DATE	15JUL63	
START DATE	7.15.63	
REPORT OPTIONS	MASTER	E-L CHART
	1	MRS-D MOB
		SL ED EN
		ACTIVITY
		SL ET EN
		SUMMARY
		A

FIGURE XI-13-- DATA PRINTOUT OF MASTER FILE REPORT SUMMARY SHEET

## DEFINITIONS

### PERT TIME Master File Report Summary Sheet

1. Name of Output

PERT Master File Report Summary Sheet.

2. Page

Page number of report.

3. User's Identification

Provision for the user's identification.

4. System Number

The control number assigned to the program to which PERT is being applied.

5. Output Heading

A field that may be used as desired.

6. Report Date

The cutoff date for the report, e.g., 15JUL63.

7. Start Date

The date from which the computer will start computations. It is the earliest known or established date for the network, e.g., 15JUL63.

8. Report Options

An identification of the reports requested in this run.

MASTER - Indicates the selected Master File Report option.

Blank - No Master file report requested.

1 - Master file report requested.

E-L CHART - Indicates the selected E-L Chart option.

Blank - No E-L Chart requested.

WKS-D - An E-L Chart by weeks with the "D"'s to show the three standard deviation spread was requested.

WKS - An E-L Chart by weeks without "D"'s was requested.

MOS - An E-L Chart by months was requested.

WKS-D MOS or WKS MOS - E-L Charts have been requested under both options.

EVENT - Indicates the selected event output sort option.

SL - Slack ordered sort requested.

ED - Expected date ordered sort requested.

EN - A sort by increasing event number requested.

ACTIVITY - Indicates the selected activity output sort options.

SL - Activity slack ordered sort requested.

ET - Activity Expected End Time ordered sort requested.

EN - Activity ending/beginning event number ordered sort, i.e., EE-BE requested.

SUMMARY - Indicates the selected summary report option.

Blank - No Summary Report requested.

A through letter O - A Summary Report summarized to the level of the letter shown was requested.

## PERT TIME Master File Report

The PERT Master File Report, as illustrated in Figures XI-14 and XI-15, is a reproduction of the current master file and is produced upon request. The data contained in this report is compared with previous reports and the last input listing to assure the validity of the current master file.

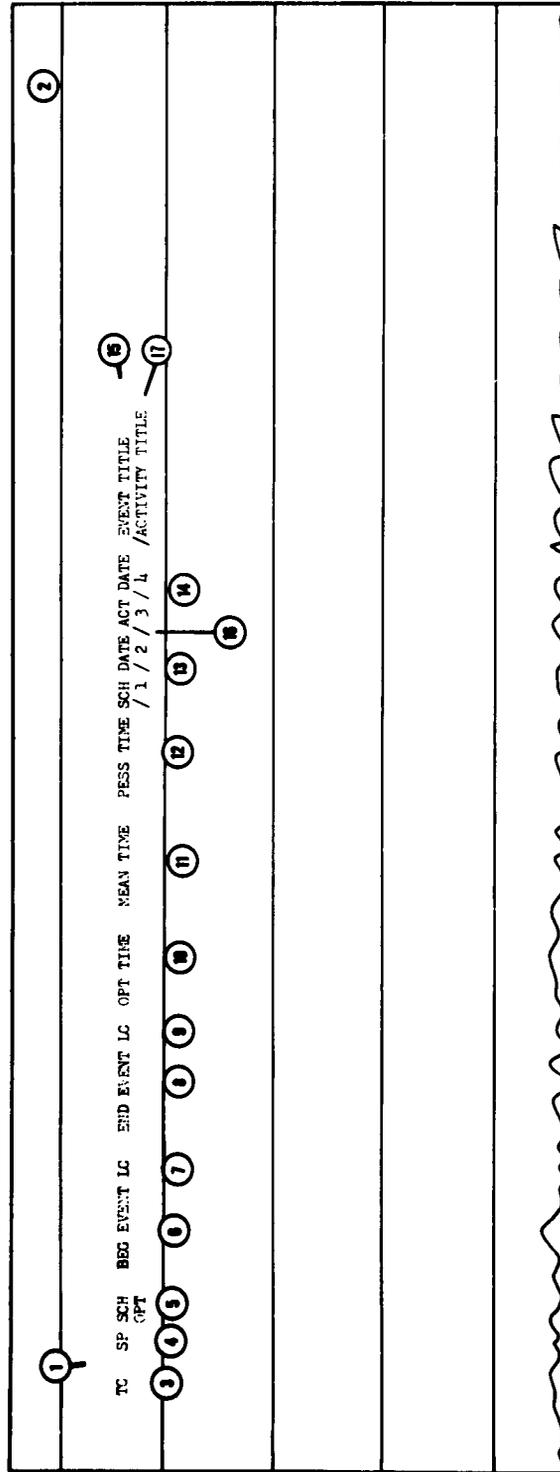


FIGURE XI-14 — PERT MASTER FILE FORMAT

PERT MASTER FILE REPORT										PAGE 1			
TC	SP	SCH	BEG	END	LC	OPT	MEAN	TIME	SCH	ACT	DATE	EVENT	TITLE
3			34.210.001	34.210.002			3.0	6.0	7.15.63			FMC START 1ST OPER UNIT	
1			34.210.001 A	34.210.002		1.0	3.0	6.0	ENGR			FMC START MAINT EQUIP FAB	
1			34.210.001	34.210.003		5.0	7.0	8.0	ENGR			RELEASE SPEC FOR MAINTENANCE EQUIP.	
1			34.210.001	34.210.004		.1	.2	.5	ENGR			FMC START MISSILE TRANSP VEH FAB	
1			34.210.001	34.210.005		1.0	3.0	6.0	ENGR			DESIGN TRANSPORTATION VEHICLE	
1			34.210.001	34.210.006		4.0	5.0	6.0	MTC			FMC START MISSILE FAB	
1			34.210.001	34.210.007		1.0	2.0	3.0	ATC			RELEASE SPEC FOR MISSILE FAB	
1			34.210.001	34.210.008		3.0	4.0	5.0	MTC			FMC START MISSILE ERECT EQUIP FAB	
1			34.210.001	34.210.009		.1	.2	.5	AGE			RELEASE SPEC FOR ERECTION EQUIP	
1			34.210.001	34.210.010		.1	.2	.5	TEST			FMC START EMPLOYEE EQUIP	
1			34.210.001	34.210.011		3.0	4.0	5.0	ATC			LET SUB-CONTRACT FOR ERECTION EQUIP	
1			34.210.001	34.210.012		27.0	30.0	34.0	ATC			FMC START SUB-CONTRACT FOR ERECTION EQUIP	
1			34.210.001	34.210.013		.1	.2	.5	MFG			LET SUB-CONTRACT FOR ERECTION EQUIP	
1			34.210.001	34.210.014		.2	.4	1.0	MFG			FMC START GRND EQUIP FAB	
1			34.210.001	34.210.015		.2	.4	1.0	MFG			RELEASE SPEC FOR GRND EQUIP FAB	
1			34.210.001	34.210.016		.1	.2	.5	TEST			FMC START JUSTAL C/O EQUIP FAB	
1			34.210.001	34.210.017		3.0	4.0	5.0	ATC			RELEASE SPEC FOR INSTL A C/O EQUIP	
1			34.210.001	34.210.018		4.0	5.0	8.0	ATC			FMC START TRAINING OPER PERS	
1			34.210.001	34.210.019		4.0	5.0	8.0	ATC			PREPARE OPER PERSONNEL REQUIREMENTS	
1			34.210.001	34.210.020		27.0	30.0	34.0	ATC			DEVELOP TRAINING CRITERIA	
1			34.210.001	34.210.021		.1	.2	.5	MFG			FMC START MISSILE FUNCT TESTS	
1			34.210.001	34.210.022		.1	.2	.5	MFG			FABRICATE MISSILE	
1			34.210.001	34.210.023		.2	.4	1.0	MFG			RELEASE MISSILE FOR TEST	
1			34.210.001	34.210.024		.1	.2	.5	SUPY			RELEASE GND EQUIP TO INSTALLERS	
1			34.210.001	34.210.025		.1	.3	1.0	SUPY			RELEASE C/O EQUIP TO INSTALLERS	
1			34.210.001	34.210.026		14.0	19.0	26.0	OPS			ASSIGN OPER PERSONNEL TO DUTY	
1			34.210.001	34.210.027		.6	1.0	2.0	MTC			FMC MAINT EQUIP AVAILABLE	
1			34.210.001	34.210.028		.1	.2	.5	SUB			FABRICATE MAINTENANCE EQUIP	
1			34.210.001	34.210.029		18.0	26.0	40.0	MTC			FMC LAUNCH SITE COMP	
1			34.210.001	34.210.030		.1	.2	.5	SUPY			INSTALL MISSILE	
1			34.210.001	34.210.031		.1	.2	.5	MTC			PREPARE SITE ACCEPTANCE FORMS	
1			34.210.001	34.210.032		.1	.2	.5	MTC			INSTALL GRND EQUIP	
1			34.210.001	34.210.033		.1	.2	.5	SUPY			FMC 1ST OPER UNIT DELIVERY	
1			34.210.001	34.210.034		.1	.2	.5	MTC			RELEASE MAINT EQUIP TO OPER UNIT	
1			34.210.001	34.210.035		.1	.2	.5	MTC			RELEASE SITE TO OPER UNIT	

FIGURE XI-15 -- PERT MASTER FILE REPORT

## DEFINITIONS

### PERT TIME Master File Report

1. Name of Output  
PERT Master File Report.
2. Page  
Page number of report.
3. TC  
Transaction Code.
4. SP  
Short path flag.
5. SCH OPT  
Schedule date option flag.
6. Beq Event  
Beginning event number.
7. LC  
Beginning event level code.
8. End Event  
Ending event number.
9. LC  
Ending event level code.
10. Opt Time  
Optimistic time estimate.

11. Mean Time

Most likely time estimate.

12. Pess Time

Pessimistic time estimate.

13. Sch Date

Scheduled date

14. Act Date

Actual

15. Event Title

Ending event title.

16. /1/2/3/4/

Activity information. This field contains the control data information inserted by the user which then appears on the second line of information related to the activity.

17. Activity Title

(self-explanatory)

**PERT TIME Error Messages Report  
and PERT Diagnostics Report**

The Error Messages Report identifies errors, such as duplicate activities, changes to nonexistent activities, etc. The computer program also includes a list of diagnostics and comments which are printed when applicable.

Included are operation instructions and errors found after the master file generation phase. The possible error messages are listed in Table 1. The complete listing of PERT diagnostics is presented in Table 2.

Table 1. Error Messages

1. BE INCORRECT  
Cause - the BE has alpha or blank characters.  
Action - the record is omitted and computation continues.
2. EE INCORRECT  
Cause - the EE has alpha or blank characters.  
Action - the record is omitted and computation continues.
3. LC INCORRECT  
Cause - the LC for BE or EE is other than an A through O or a blank.  
Action - the LC is omitted and computation continues.
4. TIMES BAD  
Cause - an alpha or blank is in the time field.  
Action - the times are omitted and computation continues.
5. INSERT EQUAL  
Cause - the same activity has been entered twice or more.  
Action - the first entry is retained and all others are dropped.
6. UNMATCHED  
Cause - an update has been entered for an activity or event that does not exist in the master.  
Action - the update is omitted.
7. NONSELECT  
Cause - the input card format is not correct.  
Action - the input card is omitted and computation continues.

Table 2. PERT Diagnostics

1. LEVEL CODE CHANGE XX-XXX-XXX<sup>1</sup> L<sup>2</sup>.  
Cause - the level code indicated has been changed.
2. O TIME IS GREATER THAN P TIME. USES M TIME  
XX-XXX-XXX TO XX-XXX-XXX.
3. O TIME IS GREATER THAN M TIME. USES M TIME  
XX-XXX-XXX TO XX-XXX-XXX.
4. M TIME IS GREATER THAN P TIME. USES M TIME  
XX-XXX-XXX TO XX-XXX-XXX.
5. XX-XXX-XXX HAS MORE THAN 63 PREDECESSORS.  
Action - the run is terminated.
6. XX-XXX-XXX HAS MORE THAN 63 SUCCESSORS.  
Action - successor tally is 63 plus number shown.
7. START DATE IS NOT CORRECT.  
Action - the run is terminated.
8. SCHEDULE OR ACTUAL DATE IS BEFORE THE START DATE.  
DELETE DATE XX-XXX-XXX.  
Action - event T<sub>E</sub> is used in the computation.
9. NOE EXCEEDS 12000.  
Action - the run is terminated.
10. NOA EXCEEDS 12000.  
Action - the run is terminated.
11. LOOP IN NET. TAKE PROBLEM OFF MACHINE. LIKELY  
EVENTS IN LOOP ARE (ALL EVENTS IN LOOP).
12. 3SR03, 3SR04  
Cause - the reporting of an activity completion  
prior to the completion of its beginning  
event.  
Action - the run is terminated.

<sup>1</sup>XX-XXX-XXX - will be the event number that is in question  
<sup>2</sup>Level Code

13. 3SR05---3SR14  
Cause -- the network cannot be summarized due  
to the density of selected events.  
Action - the summary run is terminated.
14. TIME HAS EXCEEDED 15.7 YEARS (FWE OR BKE).  
Action - the run is terminated.
15. THESE ACTIVITIES HAVE ACTUAL DATES BUT THE "BE'S"  
ARE NOT COMPLETED (CHECK) XX-XXX-XXX.  
Action - the date is accepted but an indication  
will be given for the BE's on all output  
reports. (The word ERROR will print  
in the slack columns.)

C. Special Purpose Management Reports

The special purpose management reports are generated from available PERT data to satisfy particular management requirements.

## Special Purpose Management Reports

The reports described previously are the basic PERT TIME reports that are presently produced by the USAF PERT TIME computer program. From the same data that was used to generate these reports there is the potential to generate a great variety of special purpose reports.

The USAF program utilizes a shredout routine which, in fact, gives it the capability to produce many such special purpose reports. In this routine, data can be sorted by any column or combination of columns on the output reports' line of print.

An obvious technique for deriving and preparing other special purpose reports is manual translation of data from computer outputs to the desired format.

Discussion and examples of some special purpose reports are presented below.

### Top Management Reports

An important application of special purpose reports is in reporting to higher levels of management.

One means of generating reports more specifically aimed at top management is a shredout routine. This routine will enable the generation of reports in the same format as the basic management reports but includes only the set of events or activities that the manager desires to see. If, for example, the manager wishes to see a report on all events with a scheduled date earlier than some calendar date, he can have a sort made on the scheduled date column to pick only those events out. Only the information for these particular events will then be printed out in the standard output format(s).

Additionally, the use of manually derived reports and displays is of particular importance in presentation to top management. Such reports are discussed in Chapter XII.

### Other Special Purpose Reports

The shredout routine can be used, of course, for the generation of many special purpose reports other than those designated for top management. It can be used to generate individual reports by organization for distribution to the organizations, it could be used to generate reports on interface events only for a study of the status of interfaces, and so forth.

**CHAPTER XII**

**PROGRAM ANALYSIS AND PRESENTATION TO MANAGEMENT**

## CHAPTER XII

### PROGRAM ANALYSIS AND PRESENTATION TO MANAGEMENT

Analysis of the PERT data and the subsequent presentation of the information to management are among the most important aspects of PERT System operation. This chapter presents approaches and guidelines for the performance of these functions.

#### A. The Analysis and Presentation Functions

It is paramount to the success of any program evaluation that the product of the analysis be concise, accurate, and significant for that level of management making use of it. Additionally, the PERT output analysis should:

- . provide continual evaluation of current and projected program status;
- . allow the preparation of program progress and problem reports to management on a cyclical basis; and
- . be regularly used by management in the decision-making process and the taking of necessary corrective management action to secure timely accomplishment of program objectives.

Objectives and plans for their attainment are initially generated at the highest level and become progressively more detailed as they are communicated downward through the organization structure. The reverse is true of progress reporting and evaluation which become progressively less detailed as they are channeled upward through the organization structure.

The analysis and presentation of facts in consistent summary type reports with explanations of problems provides higher levels of management with a basis for program decisions. Management confidence in these summary reports and evaluations depends upon the assurance that the data have been derived on a realistic basis. This realism begins in the detailed network level where estimates and actual measurements are based on relatively small, easily recognized

work segments. It culminates with the ability of the analyst to make effective use of the information available in the PERT output reports.

## B. Analysis of the Output Data

The following analyses are used in determining the possibility of the program plan and the status of the program.

### 1. Feasibility of the Program Plan

The amount of slack time is the first indication of the feasibility of the program plan. If there is zero slack, the planned effort fits exactly into the scheduled time span. If there is excessive positive slack, either the scheduled dates cover too much time, or the time estimates as a whole, are optimistic.

Most frequently, there is excessive negative slack. This may be the result of nonconcurrency and/or low risk in the planned work effort, inadequate planning, or overly pessimistic time estimates. The presence of negative slack means that the present plan as depicted by the network does not conform to the schedule and that replanning is necessary to meet the final scheduled date. This warns the program manager of a schedule problem and the need for corrective action. For example, for the network of Figure IX-1, Chapter IX, where scheduled dates were initially established only for beginning Event 34-210-001 and ending Event 34-210-029, 2.6 weeks of negative slack exists.

When scheduled dates or latest allowable dates are not applied to the network end events, the analyst will observe that the slack value of the critical path is always zero, and that there is no calculating of the probability that the end event will be completed on time. An evaluation of the uncertainty in the network plan may, however, be gained by an examination of the standard deviation for each event or from the D--D spread shown on the E-L Chart.

## 2. Probability of Meeting the Scheduled Date

The scheduled date for an event can be compared with the expected date of that event and its associated standard deviation<sup>1</sup> to compute the probability of the scheduled date being met. In this computation, the following expression is used:

$$Z = \frac{T_S - T_E}{\sigma_{T_E}}$$

where  $T_S$  equals the scheduled date of the event,  $T_E$  equals the expected date of the event, and  $\sigma_{T_E}$  equals the standard deviation of the expected date. The probability of meeting the scheduled date is found by entering a normal distribution probability table with this Z function (see Appendix B).

End Event 34-210-029 from the sample network in Figure IX-1 is scheduled for 2 Sep 64. Its expected date is 22 Sep 64. The slack of -2.6 weeks is the difference between  $T_S$  and  $T_E$ . The standard deviation for the expected date ( $T_E$ ) is calculated to be 3.8 weeks. Thus:

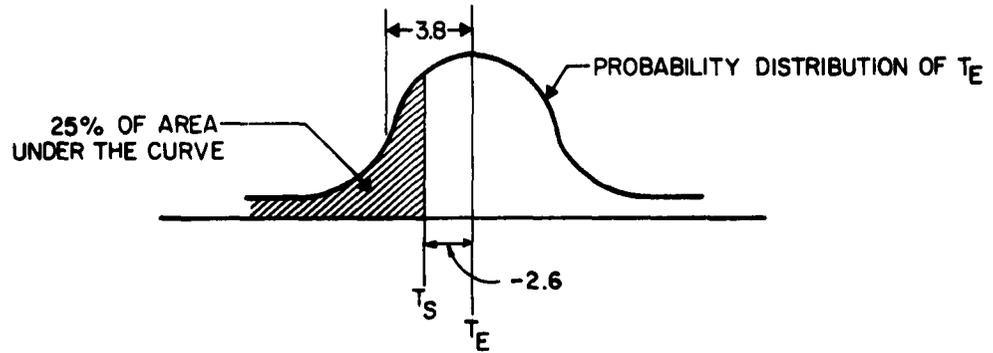
$$Z = \frac{T_S - T_E}{\sigma_{T_E}} = \frac{-2.6}{3.8} = -.68$$

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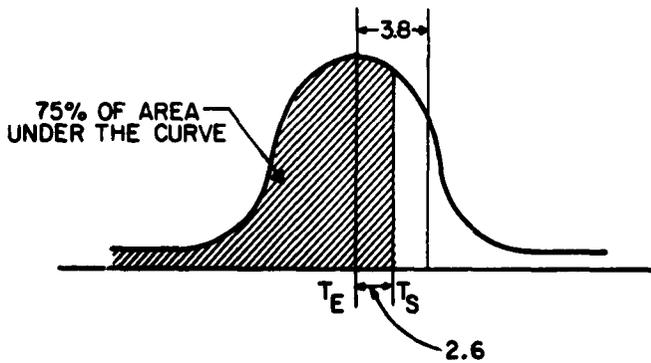
1

See Glossary of Symbols, Standard Abbreviations, and Terms, Appendix D, for definition of the standard deviation of an expected date ( $\sigma_{T_E}$ ).

The area under the curve from minus infinity to minus 0.68 is 25 percent of the total area as can be seen from the table. This means that there is a probability of 0.25 that the end event will be completed on or before the scheduled date. This is illustrated graphically below.



Assuming for illustrative purposes that the difference between  $T_S$  and  $T_E$  were +2.6 instead of -2.6 weeks, the probability would be 0.75, illustrated as follows:



Thus, it can be seen that when  $T_S$  is earlier than  $T_E$ , the probability of the scheduled date being met is less than 50 percent. When  $T_S = T_E$ , the probability is 50 percent and when  $T_S$  is later than  $T_E$ , the probability is greater than 50 percent.

### 3. Conclusions on Reasonableness of the Network

The -2.6 weeks slack indicated for the end objective appears reasonable for a program just starting and planned for completion in 60 weeks. However, a probability of 0.25 of meeting the scheduled date indicates trouble. This combination of -2.6 weeks slack and 0.25 probability should be investigated. One of the very common causes of such a combination concerns the time estimates on activities leading up to this event. Is the spread between "a" and "b" of some of the activities obviously too large? A wide spread indicates either an extreme uncertainty or a guess rather than an estimate by the estimator. Such a spread creates a large standard deviation for those activities which, in turn, will increase the uncertainty in  $T_E$  for all succeeding events. However, if the time estimates for these activities truly represent the uncertainty of the work that is to be accomplished, then the uncertainty in  $T_E$  is, in fact, large.

Several conditions illustrated in the sample network are worthy of management attention; for example, Activity 34-210-011 to 34-210-025 requires about 19 weeks, and according to the network, operating personnel must be available before the start of Ground Equipment Installation, Event 34-210-026. This means operating personnel will be available about 30 months before the Launch Site is complete. The reason for personnel being available in the middle of the program should be established; it is possible that they are to participate in Activity 34-210-026 to 34-210-028. However, this should be clarified with management. This example shows how titles in the output reports help in program analysis.

A similar situation exists with respect to maintenance personnel who start training two weeks after the actual program start date. The expected elapsed time to train these personnel is 9 weeks, and according to the event printout, Event 34-210-020 is expected to be completed by 1 Oct 63;

yet, the latest allowable date that personnel are required is 24 Aug 64, resulting in 45.7 weeks positive slack. The plan as reflected by the network apparently contemplates using these personnel in one of the four contributing activities to the start of Missile Installation, Event 34-210-018, but the presence of so much positive slack implies that this area needs more planning. In fact, the presence of several paths of large positive slack is an indication that resource adjustments for the activities on these paths are permissible and probably desirable. This should be done before arriving at definite scheduled dates for some of these events, especially those that involve the timing of training maintenance personnel. Moreover, the presence of these large positive slack paths is a further indication that some of the activities in these paths may be primarily "waiting", rather than requiring resources. The nature of these activities that are essentially "waiting" periods should be closely examined to determine whether or not they are actually consuming resources or are merely constraints.

The overall appraisal of the sample network is that it is reasonable; however, some time estimates require validation or possible revision.

#### 4. Analysis of the Critical Path(s)

The critical path is located by observing those events with the least algebraic slack value. In the sample network the critical path is defined by the series of events having -2.6 weeks slack. This critical path has been identified in the network shown in Figure XII-1. In addition to indicating the most critical path, the second and third critical paths are shown.

When the three most critical paths are plotted on the network, it can be seen that two common activities are associated with these paths: Activity 34-210-026 to 34-210-028 and Activity 34-219-028 to 34-210-029. If the negative slack could be reduced to zero on these three paths, then the critical path for the program would fit the scheduled dates. Note that Activity 34-210-028 to 34-210-029 cannot be reduced to gain sufficient time to help even if the activity were completely by-passed. Looking at Activity 34-210-026 to 34-210-028, and noting the three time estimates (18-26-40), it can be seen that



high uncertainty is associated with this activity. If means were found to reduce the time for Activity 34-210-026 to 34-210-028, it is possible that the entire program could be improved by special effort in only one area. There should be a reexamination of the time estimates to obtain more precision or at least a justification of the pessimistic estimate of 40 weeks which is more than twice the optimistic estimate of 18 weeks. Figure IX-4, Chapter IX, illustrates the entry of new time estimates for activity 34-210-026 to 34-210-028, which resulted from a replanning of that activity work content.

In analyzing the critical path, it must be realized that though the path shows the longest time through the network, it does not disclose technical criticality. Nevertheless, the analyst or manager should determine these technically critical areas and, if they are on the critical path, give them special attention. Generally, the technically critical activities are characterized by a wide dispersion in the three time estimates.

#### 5. Slack Trend

Analysis of slack in paths other than the most critical path is also important to insure efficient program execution. Premium effort should not normally be used in an area where significant positive slack is indicated. If positive slack is excessive, the possibility of reducing the level of effort in that area and using resources in alternative areas of effort should be considered.

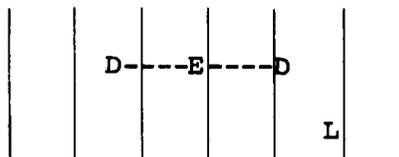
Slack trend, particularly on critical activities or events, should be closely watched. Rapidly decreasing slack or increasing slack should alert management to the need for analysis of causes.

#### 6. E-L Chart Analysis

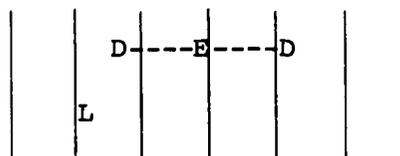
The E-L Chart (Figures XI-10 and 11, Chapter XI) provides management with a quick program orientation and highlights areas which require analysis.

One of the most useful aspects of the E-L Chart is the positioning of the L in respect to the span or spread through which E can be expected to occur. For example,

where L is to the right of the full span of E, as shown below, there is little concern.



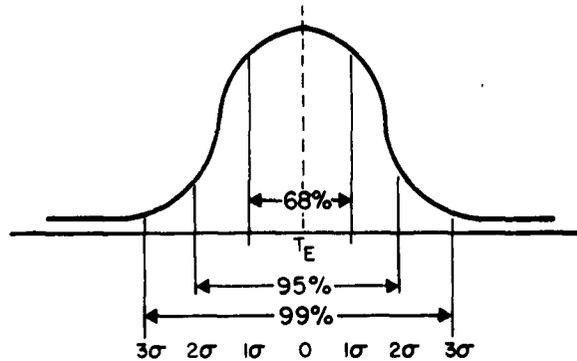
However, if the L is to the left of E and outside the D--D spread, this event will likely delay the program. An example of this is illustrated below:



In Figure XI-10 it can be seen that the L is to the left of E for the series of events having -2.6 weeks slack. Event 34-210-006 shows the L practically under the left D and, therefore, almost outside the spread in which E is expected to occur. The status of this event should be carefully watched. Events 34-210-019, 34-210-022, and 34-210-026 have essentially the same pattern of D--E--D and L relationship except that these events have the L within the spread of D--E--D. They also need watching. The most revealing fact on the E-L Chart in this example concerns the last event, 34-210-029, which could occur 11.4 weeks (3 standard deviations) either side of the expected date of 24 Aug 64. The fact that this end event already has 2.6 weeks negative slack presents the possibility that this event could conceivably be 14 weeks late. This illustrates the importance of using the standard deviations in program analysis.

There is a 68 percent chance that Event 34-210-029 will occur within one standard deviation (3.8 weeks) of the expected date. There is a 95 percent chance it will occur within two standard deviations (7.6 weeks) of the expected date, and it is almost certain to occur in a range of 22.8 weeks which is three standard deviations (11.4 weeks) either

side of the expected date. This is illustrated as follows:



### C. Presentations to Management

Once the basic information requirements have been identified and procedures established for collecting and analyzing the data, means for translating the information into forms and reports suited to the transfer of knowledge must be established. The best approach in determining the information requirements for various levels of management is to consider informational needs of these levels.

The information reporting system should furnish answers to the following kinds of questions for the specific area under consideration and for the program as a whole:

- . Is the actual accomplishment meeting current schedule commitments? If not, what is the extent and significance of the differences?
- . What is the outlook for meeting future schedule commitments?
- . Is the outlook improving or getting worse, and why?
- . What are the controlling factors involved?

Generally, managers at any level want only the information from PERT which concerns their activities and responsibilities. This information must be in understandable form

and easy to use. Quality rather than quantity of the reports should be stressed.

Use of high speed data processing equipment makes it possible to process a number of variables and provide data for evaluating status of large programs involving several networks with several thousand events and activities. This affords comprehensive program information to management in a timely fashion.

Through a progressive summarization process, it is possible to communicate information required by successively higher levels of management on a "management-by-exception" basis. Detailed information is always available to higher organizational units on an "as required" basis. Reports should be accompanied by a brief narrative analysis, including recommendations and alternative solutions by subordinate managers, when appropriate.

Periodically, the entire PERT reporting system should be reviewed to assure that reporting procedures have not become outmoded and that information requirements for management are being satisfied. Regrouping of data from the regular reporting process or the deletion or addition of output reports to individual organizations may be necessary.

In summarizing information for display purposes at higher management levels, the following guidelines should be observed:

- . graphic displays are preferable to tabular numerical values that require study and analysis;
- . all management levels require timely summaries on the overall program status. Specific levels need summaries of specific areas of the program within their jurisdiction as well as summaries of any specific problem. All levels want and need the required information in clear, concise and understandable form;
- . the information should be predictive as well as historical and should be developed only to the level of detail which is essential for appraising specific levels of management.

Several examples of graphical reports that have proven useful for presentation to management are shown below. A trend report, such as that shown in Figure XII-2, provides a summary and historical display of the schedule outlook. Two more trend reports are shown in Figures XII-3 and XII-4.

Figure XII-5 illustrates a typical format for a milestone report. Information for such a report may be obtained from the various computer reports, such as the E-L Chart displayed in Chapter XI. Part of the PERT group's responsibility is to identify in the various networks the key events that may be required for milestone reports.

A format which has proved effective for briefing Air Force management is illustrated in Figure XIII-6. It provides a summary of the most critical problems for management review and action.

A narrative report which supplements reports identifying significant problems is the Problem Analysis Report. It serves as the basis for formulating and assessing solutions that will minimize or eliminate the problems. This report contains three basic sections:

- . a summary analysis of the total contractor/agency portion of the program;
- . an analysis of the tasks in which current or potential problems exist;
- . a description of:
  - . the nature of the problem;
  - . the reason for schedule variance;
  - . the impact of the problem; and
  - . the corrective action taken or planned and the expected effect.

A solution formulated as the result of problem analysis will, in general, take one of the following forms or some combination of them. It will:

- . increase the resources allocated to the program element;
- . trade-off resources from noncritical elements to elements where they may be used more effectively with respect to the program plan;
- . revise planned work sequence;
- . change scheduled completion date.

If a contemplated solution is complex, the complete effect of the proposed changes may not be readily apparent. As an aid to the analyst, proposed changes can be simulated on the computer. Simulation is discussed more fully in the following chapter.

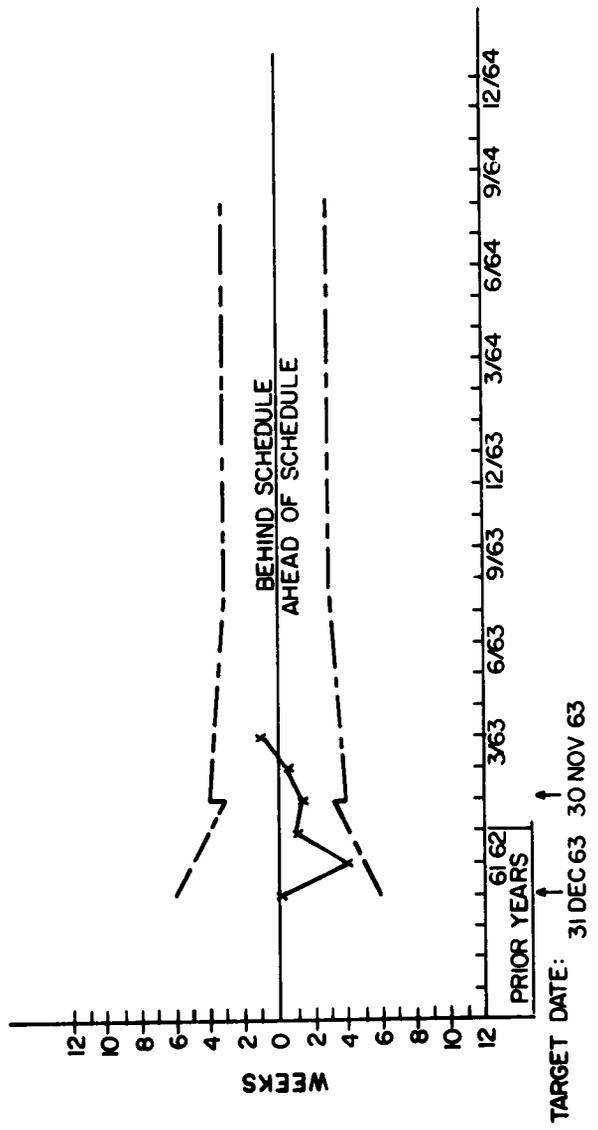


FIGURE XII-2 — SCHEDULE OUTLOOK REPORT

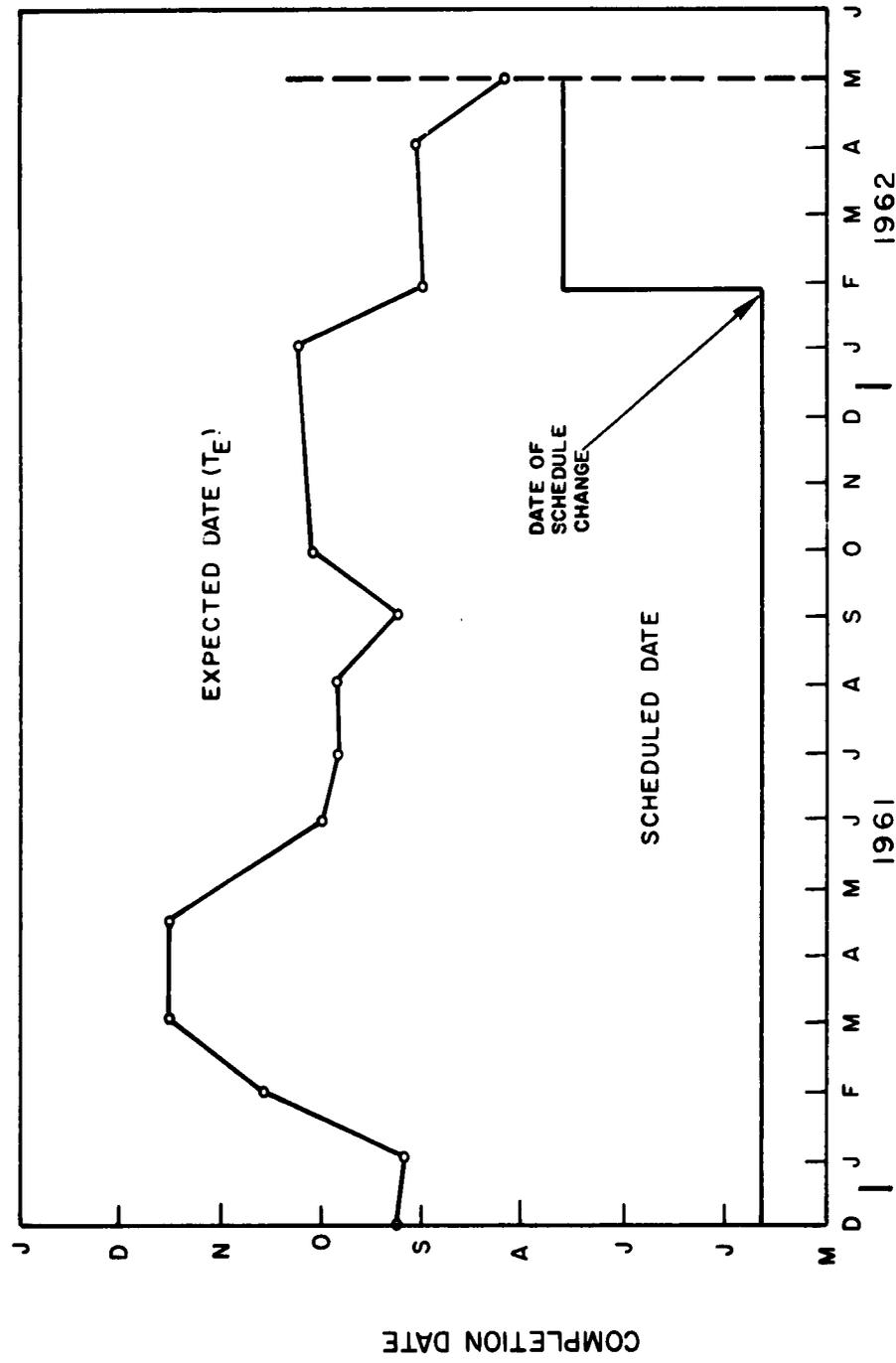


FIGURE XII-3 — EXPECTED COMPLETION TREND

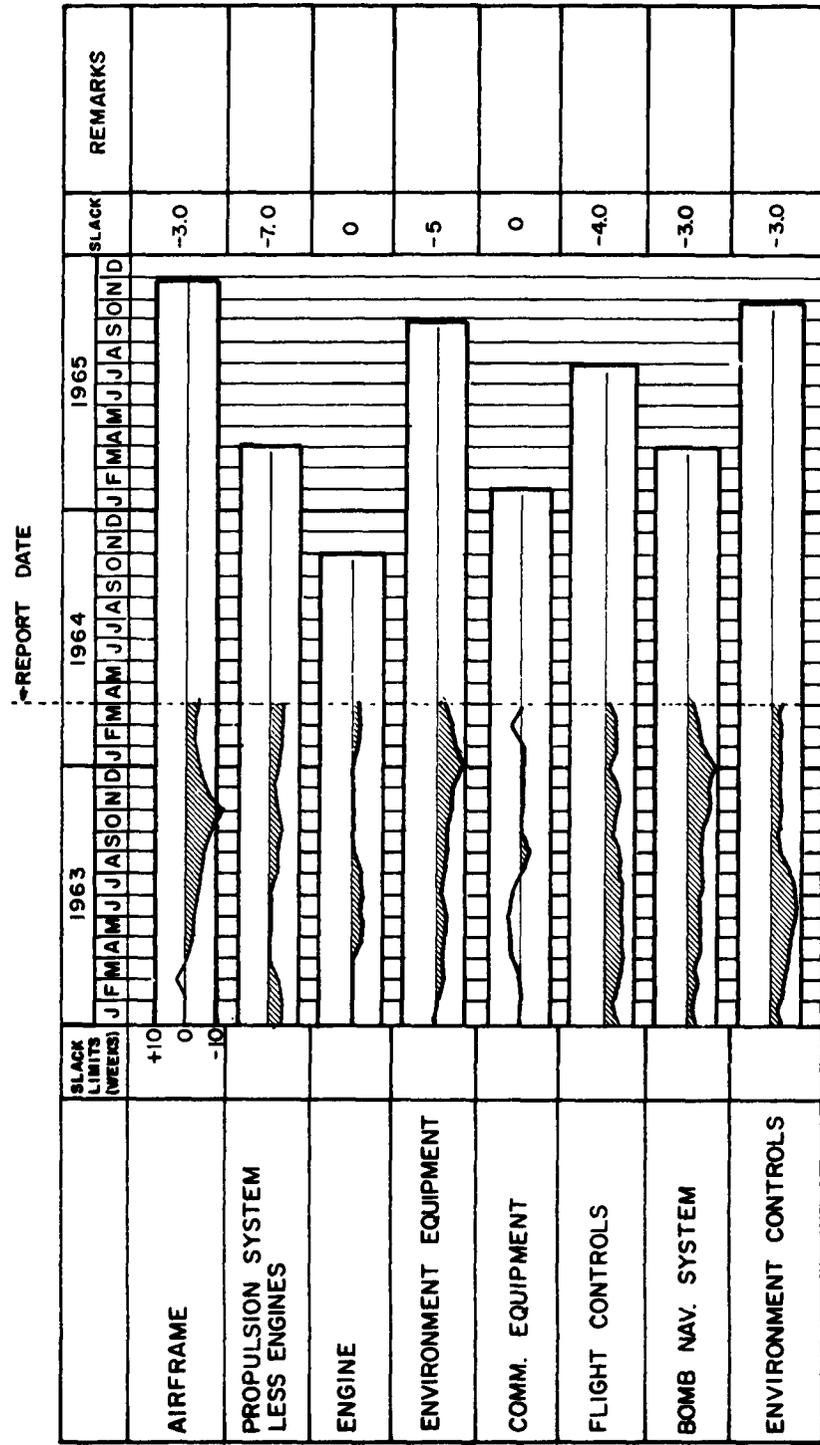


FIGURE XII-4 — SLACK TREND SUMMARY



MANAGEMENT REVIEW AND ACTION				REPORT No. _____
PERT ANALYSIS	ALTERNATIVES	RECOMMENDED ACTION	MANAGEMENT DECISION	DECISION RESULTS
<u>PROBLEM:</u>				
<u>EFFECT:</u>				
<u>PROBLEM:</u>				
<u>EFFECT:</u>				
<u>PROBLEM:</u>				
<u>EFFECT:</u>				

FIGURE XII-6 — MANAGEMENT REVIEW AND ACTION FORMAT

**CHAPTER XIII**

**SIMULATION**

## CHAPTER XIII

### SIMULATION

Despite efforts to adhere to the scheduled plan, requirements for changes in the plan or even in the objectives may arise during the course of accomplishing the program. Consequently, the method by which management seeks to achieve the efficient and economical accomplishment of assigned objectives must include an orderly formal process for the incorporation of program changes. The requirements for change may evolve from the top down or the working level up. However, the point of origin is not as important as is the method of responding in an orderly manner.

In general, adjustments in the scheduled plan should be accomplished with minimum recycling in the management process. Before a decision is made to incorporate a change in the scheduled plan, however, all possible alternatives should first be considered. Inherent in the PERT methodology is a simple means whereby these alternatives may be evaluated. This process is called simulation.

#### A. Purpose and Use

Two basic methods of using the network plans for trade-off studies (or determining optimum plans) are currently in use by government and industry. They are:

- . evaluating alternative network plans; and
- . optimizing application of resources on an established network plan.

Both methods make use of PERT as a simulation technique. PERT can be used for evaluating the initial network plans in the Program Definition Phase and in the source selection process where several alternative plans for arriving at the same end objective will exist. PERT, likewise, can evaluate alternative portions of networks: an activity, a series of activities, or a path or paths through an established network.

Simulation in PERT processing may be used to reduce the overall time span for a network by reducing activity times along the critical path. Repetitive network processing may be used to study the effect of transferring resources from slack path activities to the critical path until some other path becomes the critical path.

Engineering Change Proposals (ECP) which involve significant development effort or which affect interfaces among several lateral responsibilities should be simulated before they are submitted to higher level management for approval. Proposed changes can be injected into existing networks, and simulation runs can be made to determine the impact of the change, either on a portion of the program or on the total program. This process satisfies the schedule impact requirements for ECP's set forth in AFSCM 375-1, Configuration Management.

Simulation is also useful during the early planning stages of a program for testing alternative methods of accomplishing activities, using different techniques or resources which affect time. Such simulation may improve the initial Program Plan and reduce the need for major network reworking.

The ability to simulate changes quickly and present management with alternative courses of action is one of the most valuable features of the PERT simulation technique. A graphic illustration of this process, when a computer is used, is depicted in Figure XIII-1. If more than one cycle of simulation is needed, the process is repeated until management requirements are satisfied.

Simulation is particularly useful when unexpected troubles occur and corrective action is needed in a hurry. The ability to quickly assess the probable impact of proposed or incorporated changes and give rapid evaluations of alternatives to management makes simulation invaluable. However, the simulation process need not always be employed to resolve only the unsatisfactory conditions presented, but rather, to show the impact of alternative courses of action upon the program. For example, when obtaining authority to extend the predetermined program completion date established by higher authority, the program manager can present the simulation exercises to show how he had attempted to accomplish the program within present resources and established completion date, and that it was not possible.

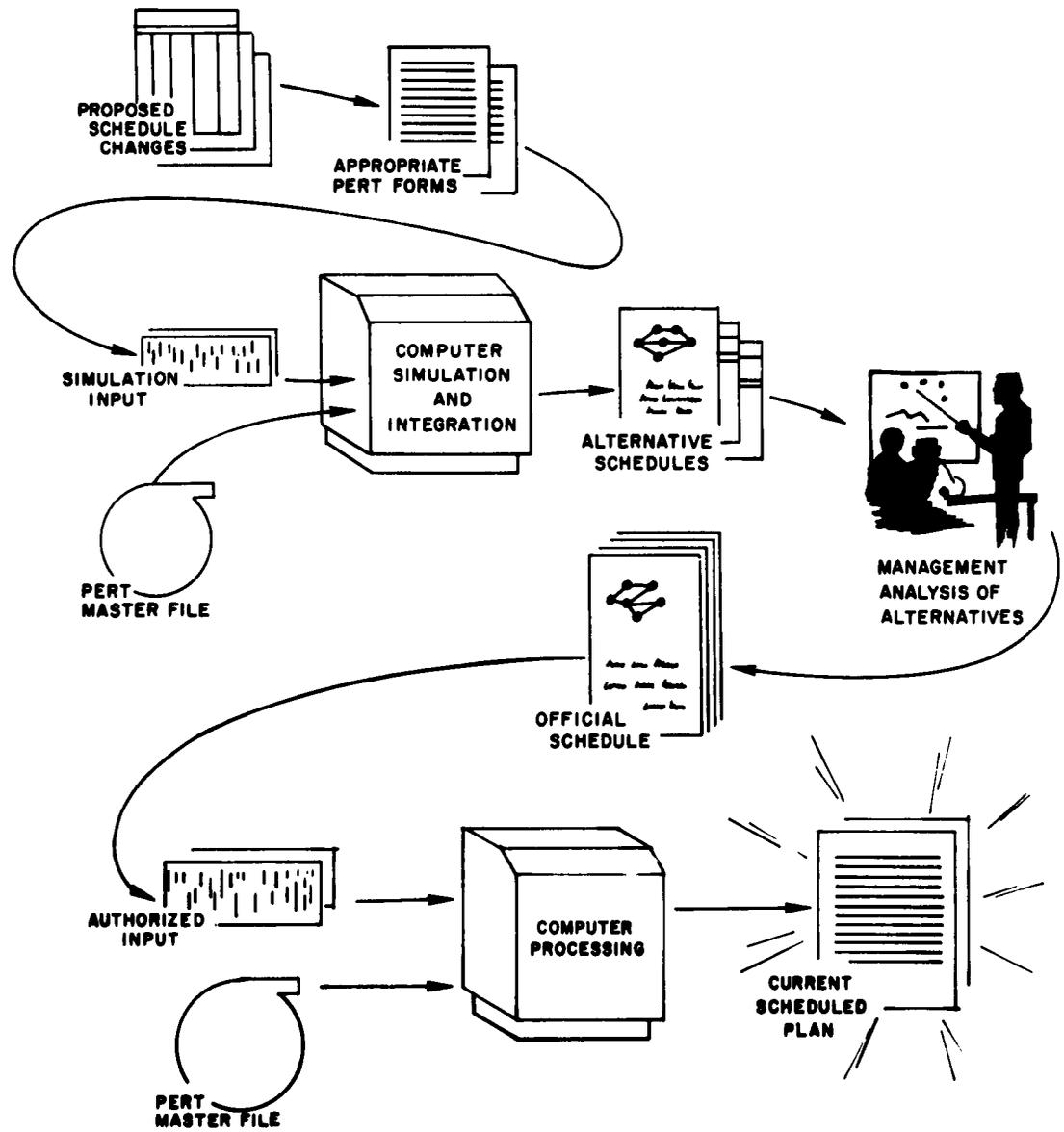


FIGURE XIII-1 — SIMULATION OF PROPOSED PROGRAM CHANGES

Discretion should be used in making simulation runs by a computer. If only a few time estimates are changed, it might be more practical to recompute manually.

B. Reporting

To obtain a simulation run on the computer, AFSC Form 30 is prepared in the normal manner for updating, submitted to the computer, and the outputs examined to evaluate the effects. Since there is no significant code on the AFSC Form 30 to identify a simulation run, the computer operator must be notified of each simulation run. He will then insure that the current computer master record is saved and the updated (simulated) master record is destroyed when it is no longer required.

**APPENDIX A**

**TYPICAL EVENT CODING FOR A MAJOR SYSTEM**

## APPENDIX A

### TYPICAL EVENT CODING FOR A MAJOR SYSTEM

Chapter III discussed briefly the graphics for networking and the manner in which events on the network are identified. This appendix discusses the subject of coding and gives a typical example of event coding for the elements comprising a major aircraft system.

As stated in Chapter III, the USAF PERT Computer Program uses eight digits for event coding. Only three or four digits are used to identify the event itself, the remaining digits being used to further identify or categorize the networks and their related events in areas corresponding to the product and budgeting breakdown structure.

When budgetary requirements are to be considered in the coding structure, reference should be made to AFSC Program Management Instruction, PMI 1-4 and to Air Force Manual, AFM 170-7. These documents become the basis for aligning the major MPC budget codes and their supporting elements (sub-MPC's) with the major elements of work in the program breakdown structure.

An example of the Materiel Program Code (MPC) is as follows:

<u>1</u> 000 0000	Vehicle	Major MPC
1 <u>1</u> 00 0000	Structure	Subordinate MPC
11 <u>1</u> 0 0000	Empennage	Management MPC (Major Subcontractor)

The relationship between the work breakdown structure shown in Figure A-1 and the MPC is readily apparent.

Subordinate, management and functional MPC's are developed for new systems during the program definition phase. The codes are initially reported in the Proposed System Package Program at the end of the program definition.

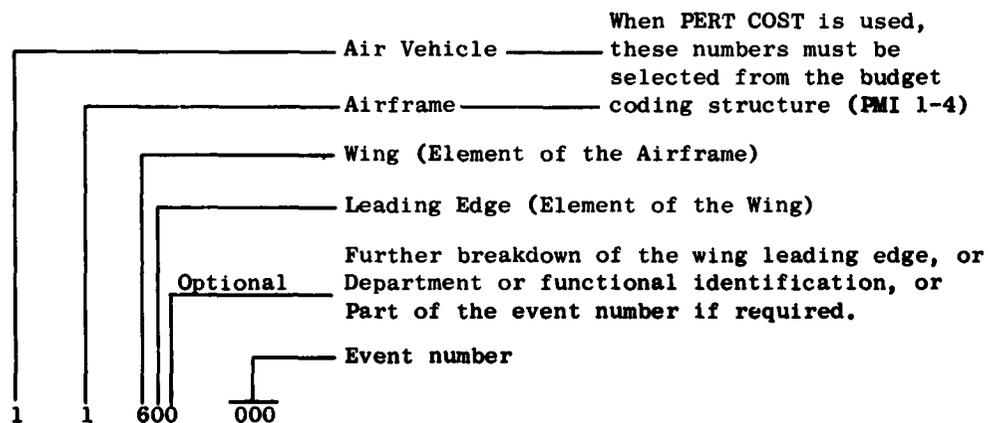
<u>Weapon System</u>	<u>Vehicle</u>	<u>Structure</u>	Re-entry Vehicle Fuselage Wing Empennage Landing Gear	Nose Cone
		<u>Propulsion</u>	Engine Engine Accessories Rotors Propellers	
		<u>Electronics</u>	Mission & Traffic Control Command & Control Firepower Control Penetration Aids Reconnaissance Anti-Submarine Warfare Guidance Other	Communications  Missile Inertial Platform
		<u>Other</u>	Secondary Power Wheels, Brakes, Tires & Tubes Instruments Group Flight Control Electrical Group Armament Group Furnishings & Equipment Group Environmental Control Photographic Group Crew Escape Recovery System Other	
		<u>SUPPORT EQUIPMENT</u>	Maintenance Operational Other	
		<u>TRAINING</u>	Services  Equipment	Films Handbooks QOPRI Training Plans Other MTU's Simulators Other
		<u>INDUSTRIAL FACILITIES</u>		
		<u>SYSTEM TESTING</u>	Wind Tunnel Static Fatigue Preflight Flight	Instrumentation Conduct of Test
		<u>DATA</u>	Vehicle/Support Equip. Compatibility  Engineering Data T.O.'s & Handbooks Reprocurement Data	
		<u>MANAGEMENT</u>	Reliability Configuration Management Value Engineering Maintainability Other	

FIGURE A-1— WORK BREAKDOWN STRUCTURE

The established MPC's must then remain with the system throughout the acquisition phase.

The pages that follow represent the event numbering system as developed for an actual aircraft system. The work breakdown structure was initially developed to correlate with the major MPC budget codes and their supporting elements (sub-MPC's). This established the major elements of the system including air vehicle, spares, AGE, personnel subsystem development, and technical data representing the major MPC items. The Air Vehicle was then divided into the categories of Airframe, Propulsion, Secondary Power, Mission Control, Offensive System, Defensive System, Reconnaissance and "other," (the "other" to identify items not readily classified as a subsystem). Similarly, the other major categories were subdivided into their elements of hardware or function to complete the identification and correlation with sub-MPC items. Thus, an event coding system was evolved that has a direct relationship with budget codes permitting a variety of byproducts to be obtained through mechanized procedures.

As shown below, the coding scheme uses the first digit of the event number to identify a major area or item of a program corresponding to the first level of breakdown. In like manner the second, third, and fourth digits are used for successively lower levels of breakdown, and the fifth digit may be used optionally as illustrated with the remaining digits used for the event number itself.



Coding requirements must be given appropriate consideration during the early stages of implementing PERT. This is especially true on large programs when PERT COST is used and where networks will be generated by a number of companies and government agencies which must eventually be integrated. A well planned coding system will greatly facilitate the summarization and integration of networks. In addition to the illustrated event coding system, there is provision in the USAF PERT System for further identification of activity associated information by using the four activity fields of Forms 30 and 30A as explained in Chapter IX.

EVENT NUMBERING SYSTEM  
FOR A MAJOR  
AIRCRAFT SYSTEM

10 000 000	<u>AIR VEHICLE - DELIVERIES</u>
11 000 000	AIRFRAME (Those items not identified with a specific component such as manufacture and installation of electrical harnesses, tubing, etc.)
11 100 000	Environmental (Refrigeration & Pressurization)
11 200 000	Crew Station & Escape (Pod plus installation of Crew Station equipment)
11 300 000	Mating
11 400 000	Empennage (Horizontal Stag., Rudder, Vert. Fin)
11 500 000	Landing Gear
11 600 000	Wing
11 700 000	Forward Fuselage
11 800 000	Center Fuselage
11 900 000	Aft Fuselage
12 000 000	PROPULSION
12 100 000	Engine Build-up
12 200 000	Fuel System
12 300 000	Spike
12 400 000	Engine Inlet Control
12 500 000	Starter

12 600 000	Engine (Pratt & Whitney)
13 000 000	SECONDARY POWER
13 100 000	Primary AC Power
13 200 000	Electrical System (Engineering)
13 300 000	Hydraulic System & Pneumatic System (Engineering)
13 500 000	Electrical Harnesses (Engineering)
14 000 000	MISSION CONTROL
14 100 000	Flight Controls
14 200 000	Air Data Computer
14 300 000	GFAE
14 400 000	H. F. Radio
14 500 000	Antenna
14 600 000	Antenna Coupler Group
14 700 000	Analog Digital Converter (Navy)
14 800 000	Discrete Message Indicator (Navy)
14 900 000	Approach Power Compensator (Navy)
15 000 000	OFFENSIVE SYSTEM
15 100 000	Attack Radar
15 200 000	Terrain Following Radar
15 300 000	Navigation and Attack

15 400 000	Optical Sight & Missile Launch Computer
15 500 000	Shrike Fire Power Control Set (Navy)
15 600 000	Low Altitude Radio Altimeter
15 700 000	Vertical Display (Navy)
15 800 000	Armament
15 900 000	AMCS (Hughes)
16 000 000	<b>PENETRATION AIDS (DEFENSIVE)</b>
16 100 000	Trackbreakers
16 200 000	Countermeasures Receiver
16 300 000	Countermeasures Dispenser
16 400 000	Radar Homing & Warning
17 000 000	<b>RECONNAISSANCE</b>
17 100 000	Side Looking Radar
17 200 000	IF Line Scanner
17 300 000	Photographic Recon
17 400 000	Recon Data
18 000 000	<b>OTHER</b>
18 100 000	Final Operations
18 200 000	Field Operations
18 300 000	ETMA

20 000 000	<u>SPARES - CATEGORY III &amp; ON</u>
21 000 000	AIRFRAME SPARES
22 000 000	PROPULSION SPARES
23 000 000	SECONDARY POWER SPARES
24 000 000	MISSION CONTROL SPARES
25 000 000	OFFENSIVE SPARES
26 000 000	DEFENSIVE SPARES
27 000 000	RECONNAISSANCE SPARES
30 000 000	<u>ADVANCED BUY - (Production Effort That Requires Funding Prior to FY-65)</u>
40 000 000	<u>AEROSPACE GROUND EQUIPMENT (AGE)</u>
41 000 000	AIRFRAME AGE
42 000 000	PROPULSION AGE
43 000 000	SECONDARY POWER AGE
44 000 000	MISSION CONTROL AGE
45 000 000	OFFENSIVE AGE
46 000 000	PENETRATION AIDS (DEFENSIVE) AGE
47 000 000	RECONNAISSANCE AGE
48 000 000	MULTIPLE USAGE AGE
48 010 000	3rd & 4th digits will be used for
48 190 000	identification of GD/E Multiple Usage AGE End Items.

49 000 000	AGE SPARES
49 100 000	Airframe AGE Spares
49 200 000	Propulsion AGE Spares
49 300 000	Secondary Power AGE Spares
49 400 000	Mission Control AGE Spares
49 500 000	Offensive AGE Spares
49 600 000	Defensive AGE Spares
49 700 000	Reconnaissance AGE Spares
49 800 000	Multiple Usage AGE Spares
50 000 000	<u>PERSONNEL SUBSYSTEM</u>
51 000 000	PERSONNEL EQUIPMENT DATA (PED)
52 000 000	HUMAN ENGINEERING/LIFE SUPPORT (HE/LS)
52 100 000	Dynamic Operator Response Apparatus (DORA)
52 200 000	Other
53 000 000	QUALITATIVE & QUANTITATIVE PERSONNEL REQUIREMENTS INFORMATION (QQPRI)
54 000 000	TRAINING EQUIPMENT PLANNING INFORMATION (TEPI)
55 000 000	TRAINING EQUIPMENT DEVELOPMENT (TED) <sup>1</sup>

---

1

In this example, Training Equipment Development and the Personnel Subsystem are grouped under separate subordinate MPC Codes to distinguish them from the general Training Area for closer management surveillance.

55 100 000	Maintenance Training Equipment
55 200 000	Operator's Training Equipment
55 300 000	Training Film
56 000 000	<b>TRAINING</b>
56 100 000	Training Plan
56 200 000	Airborne Equipment Training Parts
56 300 000	AGE Training Parts
56 400 000	Training Accessories
56 500 000	Training Services to ATC
56 600 000	Training Services to TAC
56 700 000	Training Services to Navy
56 800 000	Contractor Cross-Training
56 900 000	Training Technical Information
57 000 000	<b>PERSONNEL SUBSYSTEM TEST AND EVALUATION<sup>1</sup></b>
60 000 000	<b><u>DEVELOPMENT</u></b>
61 000 000	<b>INTEGRATION ENGINEERING (No known network events)</b>

---

<sup>1</sup>

In this example, Training Equipment Development and the Personnel Subsystem are grouped under separate subordinate MPC codes to distinguish them from the general Training Area for closer management surveillance.

62 000 000	SYSTEM TESTING - DEVELOPMENT (not identifiable to a specific subsystem)
62 100 000	Wind Tunnel
62 200 000	Pre-Flt Flight Test
62 300 000	Flight Test
62 400 000	Static and Fatigue Airframe Test
62 500 000	AGE Competibility Test
62 600 000	Mock-up (DEI)
62 700 000	Lab Test (not identifiable to a specific subsystem)
62 800 000	Other Development Test
63 000 000	RDT&E SPARES
63 100 000	Airframe Spares
63 200 000	Propulsion Spares
63 300 000	Secondary Power Spares
63 400 000	Mission Control Spares
63 500 000	Offensive Spares
63 600 000	Defensive Spares
63 700 000	Reconnaissance Spares
70 000 000	TECHNICAL DATA

**APPENDIX B**

**TABLE OF VALUES OF THE STANDARD  
NORMAL DISTRIBUTION FUNCTION**

## APPENDIX B

### TABLE OF VALUES OF THE STANDARD NORMAL DISTRIBUTION FUNCTION

As described in Chapter XII, the probability that an event with a given expected date ( $T_E$ ) will be completed by a scheduled date ( $T_S$ ) can be found in a probability table for the normal distribution under the appropriate value of the function  $Z$  (Where  $Z = T_S - T_E / \sigma_{T_E}$ ). This table is shown in Figure B-1.

z	0	1	2	3	4	5	6	7	8	9
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7703	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9034	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9278	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9430	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9648	.9656	.9664	.9671	.9678	.9686	.9693	.9700	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9762	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9874	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.	.9987	.9990	.9993	.9995	.9997	.9998	.9998	.9999	.9999	1.0000

FIGURE B-1— TABLE OF VALUES OF THE STANDARD NORMAL DISTRIBUTION FUNCTION

	0	1	2	3	4	5	6	7	8	9
-3	.0013	.0010	.0007	.0005	.0003	.0002	.0002	.0001	.0001	.0000
-2.9	.0019	.0018	.0017	.0017	.0016	.0016	.0015	.0015	.0014	.0014
-2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
-2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
-2.6	.0045	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
-2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
-2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
-2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
-2.2	.0139	.0136	.0132	.0129	.0126	.0122	.0119	.0116	.0113	.0110
-2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
-2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
-1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0238	.0233
-1.8	.0359	.0352	.0344	.0336	.0329	.0322	.0314	.0307	.0300	.0294
-1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
-1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
-1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0570	.0559
-1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0722	.0708	.0694	.0681
-1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
-1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
-1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
-1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
-.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
-.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
-.7	.2420	.2389	.2358	.2327	.2297	.2266	.2236	.2206	.2177	.2148
-.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
-.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
-.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
-.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
-.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
-.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
-.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

FIGURE B-1 — TABLE OF VALUES OF THE STANDARD NORMAL DISTRIBUTION FUNCTION (cont)

**APPENDIX C**

**EVENT COORDINATION PROCESS**

## APPENDIX C

### EVENT COORDINATION PROCESS

This appendix outlines the procedures and operations which are required for the identification and control of events selected for inclusion in the integrated networks.

#### A. Purpose

This process selects, records, coordinates, and stores those events which define and interrelate the overall system. Figure C-1 illustrates the event coordination concept. These events are selected major milestones and interfaces. Specific data for these events is collected by an integrating agency and maintained in a Data File. Events selected from this file make up the control Event Log. This log is issued by the integrating agency to all participating organizations and serves to identify those events which must appear in each organization's summary network. Criteria for selecting these events are:

##### Interface Events:

- . all events signalling the necessary transfer of responsibility, end items, or information from one part of the program effort to another.

##### Major Milestones:

- . all key events designated by the program manager;
- . events selected by reporting agencies for network analysis.

#### B. Output Reports

Several different output reports should be made available from the event coordination process. The reports are as follows:

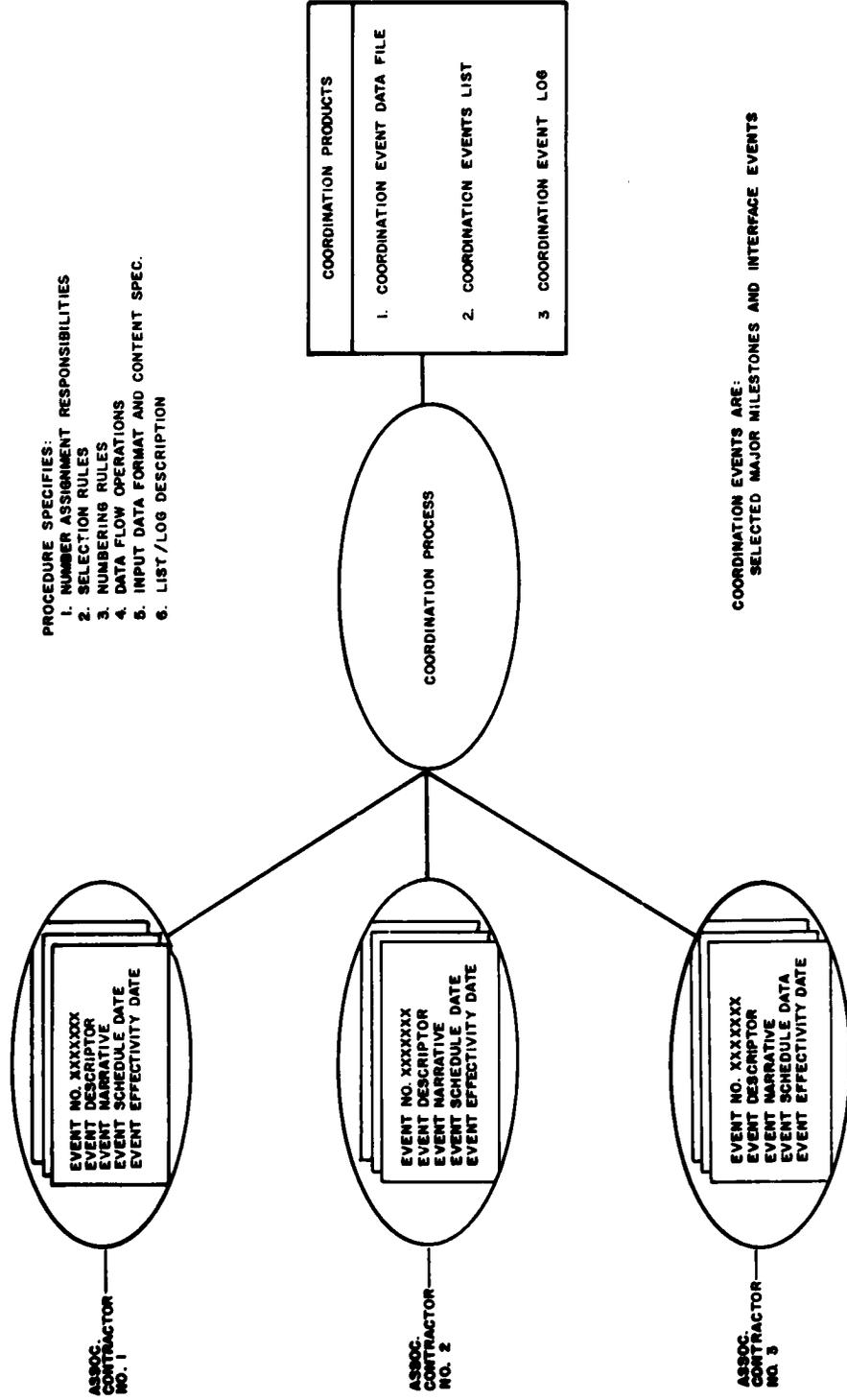


FIGURE C-1 — EVENT COORDINATION CONCEPT

- . The Negotiation Action Required List contains all interface events on which agreement has not been reached among the responsible contractors/agencies.
- . The Approval Action Required List contains those interface events which have been coordinated and agreed to by the responsible contractor/agency and those milestones which have been selected for inclusion in the network.
- . The Approved Event List contains all approved interfaces and milestones sorted by contractor/agency.
- . The Event Log contains those interface and milestone events which must appear on each summary network as of the next processing cycle. These events are selected from the Approval Event List and have effective dates which occur on or prior to the network processing date.
- . The Event Dictionary contains a definition and detailed description of each event in the integrated network.

Figure C-2 illustrates the prescribed format in the first five reports described above. Figure C-3 illustrates the prescribed format for the Event Dictionary Report. Annotated data headings are used to describe the reports further.

①																
② PAGE NO		③ REPORT NO			④ RUN NO		⑤ REVISION		⑥ RUN DATE							
⑦ STATUS	COMP	LETE	EVENT NO	⑧	EVENT DESCRIPTION	⑩	SCHEDULE DATE	⑪	WEEKS FROM GO	⑫	EFFECTIVE DATE	⑬	DELETE DATE	⑭	USERS NAME	⑮

FIGURE C-2— EVENT COORDINATION REPORT FORMAT

## DEFINITIONS

### PERT TIME Event Coordination Reports

1. **Report Description:** The identification of the type report and the program to which the report is applicable.
2. **Page No:** Report Page No.
3. **Report No:** Sequential report number required for control purposes, e.g., 5th, 113th, etc.
4. **Run No:** Identifies the computer run from which the report was generated.
5. **Revision:** Indicates the total number of revisions to the log.
6. **Run Date:** The date of the computer run.
7. **Status:** Indicates the present status of the event.
  - Approved** - Code "A" - Event has been approved by the Program Manager and all agencies involved.
  - Not Coordinated** - Code "N" - Event has not been coordinated with all agencies involved.
  - Coordinated** - Code "C" - Event has been coordinated by all agencies but requires Program Manager approval.
  - Addition** - Code \* - New event has been added to the report.
  - Revision** - Code \*\* - Event data has been revised.
8. **Complete:** Indicates schedule status of the event. Code "C" identifies completed events. A blank in this field indicates that the event has not yet been completed.

9. Event No: 8-digit code identifying the event.
10. Event Description: 31-digit description of the event.
11. Schedule Date: The date the event is scheduled for completion.
12. Weeks From Go: The time in weeks from program start date when the event is scheduled for completion.
13. Effective Date: The date on which the event will be formally established in the summary networks.
14. Delete Date: The date the event is to be deleted from all applicable networks.
15. User's Name: Identification of the user of an event; if the event is an interface, it will contain the identity of each user.



## DEFINITIONS

### PERT TIME Integration Event Dictionary

1. **Report Description:** Identification of the type of report, and the program to which the report is applicable.
2. **Event Number:** 8-digit code identifying the event.
3. **Event Narrative:** The event title and a detailed explanation of the event.

### C. Procedures

The originator or performing source has prime responsibility for control event identification, description, and numbering. Each user of an interface event is responsible for notifying the originator of his intended use and of his agreement or disagreement with the interface event data. The integrating agency maintains a data file and produces control event data reports as described below.

#### Control Event Identification, Coordination and Scheduling Procedures

When an output requirement (outgoing interface event) is identified, the originator supplies the DPA with the following data in punched card format (Figure C-4):

- . Assigned event number, event description, agencies involved, suggested schedule date, suggested effectivity date, and coordinated/non-coordinated status.

The DPA may take the following actions:

- . If the event has been coordinated and agreed upon by all responsible agencies, the DPA includes the event in the Approval Action Required List and forwards it to the System Program Office (SPO) for action.
- . If the SPO approves the event data, the event automatically is included in the next Approval Event List.
- . If the SPO disapproves the event data, each affected agency and the DPA are notified immediately, and the reason for disapproval is given.
- . If the originator of the event and the user(s) cannot agree on the event data, the problem is forwarded to the SPO for resolution. The SPO will notify all parties of its decision, and the event originator forwards the data to the DPA as an approved event.



When an input requirement (incoming interface) is determined, the using agency reviews the current Control Event List for possible interface identification with previously documented control events as follows:

- . If the event has not yet been listed, the user addresses a control event request to the event originator for identification. The originator responds by furnishing the information and processing the event in accordance with instructions above. The DPA adds the data to the Event Data File and prepares the data for inclusion in the appropriate listing.
- . If the event appears on the Control Event List, the user notifies the originator that the event will be used. The user will indicate agreement or disagreement with the scheduled date and the event description. Upon receipt of the notification, the originator forwards the data to the DPA. The DPA adds the new user to the Event Data file and updates the file as follows:
  - . If the user is in agreement with the event data, the DPA includes the change in the next applicable Control Event List.
  - . If the user disagrees with the event data and the event has been previously approved, the event is included in the next Negotiation Required List. The approval Event List and the Control Event Log are adjusted to reflect renegotiation action as required.
  - . If the user disagrees with the event data and the event has been previously coordinated and agreed upon by other users, the event is included in the next Negotiation Action Required List.

- . The Approval Action Required List is adjusted to reflect that renegotiation is required.
- . All changes to the Approval Event List or Log are subject to SPO approval.
- . To obtain the initial set of interface data, each contractor and agency (as appropriate) prepares control event data in accordance with the instructions above for all planned deliveries of hardware and documents. For all interface events which represent a physical transfer between associates, the originator or performing source includes in his network, as prior activities to the interface event, all activities leading to the delivery at the user's door or dock.
- . SPO approval and acceptance action normally are treated within the detailed networks with approval spans agreed upon between individual contractors and the approving agencies. These approval actions are not normally treated as interface events. Instead, each contractor provides the SPO with approval action lists and schedules.

The initial log for the first system run includes all coordinated and approved events, plus any additional events selected by the SPO even if coordination has not been completed.

Upon receipt of event data the DPA establishes and maintains a Control Event Dictionary Card File which will contain the event definition and a detailed description of each event that appears on the Control Event List. The file will be maintained in event number sequence and updated as additions or deletions are received. Each month a listing of the file will be forwarded to the SPO and the appropriate contractor/agency.

**APPENDIX D**

**GLOSSARY OF SYMBOLS, STANDARD ABBREVIATIONS, AND TERMS**

## APPENDIX D

### GLOSSARY OF SYMBOLS, STANDARD ABBREVIATIONS, AND TERMS

#### SYMBOLS

- A = An abbreviation for  $T_A$  used in graphic reports.
- a = Optimistic time estimate for an activity.
- b = Pessimistic time estimate for an activity.
- BE = Beginning event.
- DPA = Designated Processing Agency.
- E = An abbreviation for  $T_E$  used in graphic reports.
- EE = Ending event.
- L = An abbreviation for  $T_L$  used in graphic reports.
- LC = Level code.
- m = Most likely time estimate for an activity.
- S = An abbreviation for  $T_S$  used in graphic reports.
- $S_E$  = Earliest completion date for an activity.
- $S_L$  = Latest completion date for an activity.
- SP = Short path flag.
- SPO = System Program Office.
- $T_A$  = Actual date on which an event occurs or an activity is completed.
- $T_D$  = Directed date for an event.
- $T_E$  = Expected date for an event (based on  $t_e$ ).
- $t_e$  = Expected elapsed time for an activity.

- $T_L$  = Latest allowable date for an event (based on  $t_e$ ).
- $t_s$  = Scheduled elapsed time for an activity.
- $T_S$  = Scheduled completion date for an activity or event.
- $\sigma$  = (sigma) Mathematical symbol for standard deviation.

STANDARD ABBREVIATIONS

Following is a recommended list of abbreviations intended for use in describing events and activities in PERT networks. The list is compatible with and includes the more common abbreviations extracted from AFM 11-2 "Air Force Manual of Abbreviations."

<u>WORD</u>	<u>ABBREVIATION</u>	<u>WORD</u>	<u>ABBREVIATION</u>
Accept, Acceptance	acc	Air Force Logistics Command	AFLC
Acceptance Test	acc tst	Air Force Plant Representative	AFPR
Acceptance Test Procedure	acc tst procd	Air Force Systems Command	AFSC
Acceptance Test Specification	acc tst spec	Air Force Manual	AFM
Activity	acty	Air to Air	A/A
Activation	activ	Air to Ground	A/G
Actuator	actr	Air Training Command	ATC
Acquisition	acqn	Airborne Intercept	AI
Aerospace Ground Equipment	AGE	Airborne Missile Control System	AMCS
Aerospace Vehicle Equipment	AVE	Airborne Support Equipment	ASE
After	aft	Aircraft	A/C
Air Force	AF	Alternating Current	AC

<u>WORD</u>	<u>ABBREVIATION</u>	<u>WORD</u>	<u>ABBREVIATION</u>
Alternator, Alternate	altn	Auxiliary Power Unit	APU
Altitude	alt	Available	avail
Analysis, Analyze, Analyzer	anlys	Award, Awarded	awd
Annex	anx	Battery	btry
Antenna	ant	Beacon	bcn
Approval, Approve, Approved	appr	Bearing	brg
Approximate	aprx	Begin	bgn
Assemble, Assembly	asbly	Block	blk
Assembly Drawing	asbly dwg	Block House	BH
Authenticate, auth Authenticated, Authority	auth	Board	bd
Authorized	authzd	Bomb- Navigation	B/N
Automatic	auto	Bottom	bot
Automatic Frequency Control	AFC	Branch	brch
Auxiliary	aux	Bread Board	BB
Auxiliary Power Supply	APS	Building	bldg
		Bundle	bdl
		Cables	ca
		Calibration	calbr
		Captive Dummy Missile	CDM

<u>WORD</u>	<u>ABBREVIATION</u>	<u>WORD</u>	<u>ABBREVIATION</u>
Captive Electrical Missile	CEM	Electronic Counter Measure	ecm
Captive Mechanical Missile	CMM	Electronic Data Processing	EDP
Category	cat	Electronics	elct
Cathode Ray Tube	CRT	Emplacement	empl
Checkout	C/O	Engine	eng
Circuit	ckt	Engineer, Engineering	enrg
Clear	clr	Equipment	eqp
Command Receiver/Reply Transmitter	CR/RT	Estimated Time of Completion	etc
Communication	comm	Field	fld
Complete	C	Fiscal Year	fy
Contract	contr	Forward	fwd
Contract Technical Compliance Inspection	CTCI	Freight	frt
Control	ctl	Frequency Modulation	FM
Delivery	dlvr	From	frm
Design	dsgn	Functional	fn
Development Engineering Inspection	DEI	Generator	gen
Drawing	dwg	Ground Electronics Engineering & Installations Agency	GEEIA
Electric	elec		

<u>WORD</u>	<u>ABBREVIATION</u>	<u>WORD</u>	<u>ABBREVIATION</u>
Ground to Air	G/A	Infrared	IR
Ground Zero	gz	Initiate	init
Guidance	guid	Inspection	insp
Guided Aircraft Missile	gam	Installation, Install	instl
Guided Aircraft Rocket	gar	Instrumentation	instrum
Guided Launch	GL	Integrate-Assemble-Checkout	IAC
Hardstand	hs	Integration	int
Hardware	hrdw	Interim Missile Auxiliaries	IMA
Heavy	hvy	Intermediate Frequency	IF
High Frequency	HF	Jet-Assisted Take-off	Jato
Home on Jamming	HOJ	Light	lt
Human Factors	HFac	Liquid	liq
Hydraulic	hyd	Logistic	log
Hydraulic Power Unit	hpu	Logistic Support Manager	LSM
Identification Friend or Foe	IFF	Machine	mach
In Accordance With	iaw	Maintenance Bench	MB
		Man Hours	Man hr

<u>WORD</u>	<u>ABBREVIATION</u>	<u>WORD</u>	<u>ABBREVIATION</u>
Management	mgt	Number	nr
Manager	mgr	Operating Location	ol
Manufacture, Manufacturing	mfg	Package	pkg
Masonry	msry	Periodic	perdc
Master Equipment Allowance List	MEAL	Personnel	pers
Material	matl	Phase	ph
Material Release Order	MRO	Plan	pln
Megacycle	mc	Planning	plng
Memorandum	memo	Power	pwr
Missile	msl	Preliminary	prel
Missile Internal Power Supply	MIPS	Prepare	prep
Missile Power Unit	MPU	Presentation & Control System	PCS
Missile Tracker	MT	Primary	prim
Modification	mod	Printout	P/O
Motor	mtr	Priority	prior
Motor Case	mc	Procedure	procd
Nomenclature	nomen	Procure, Procurement	proc
Nozzle	noz	Production	pdn
		Program	prog
		Programmed Launch Missile	PLM

<u>WORD</u>	<u>ABBREVIATION</u>	<u>WORD</u>	<u>ABBREVIATION</u>
Propellant	propl	Requisition	rqn
Property	ppty	Research	rsch
Proposal	prop	Review	rev
Propulsion	prpln	Runway	rnwy
Provision	prov	Schedule	sched
Publication	pub	Security	sec
Pulse Doppler	PD	Seeker	skr
Purchase Order	PO	Segment	seg
Qualifica- tion, Qualify	qual	Shipment	shpmt
Radio	rdo	Special List of Equipment	Sloe
Radio Frequency	RF	Specification	spec
Range	rg	Staging Area	Stg ar
Receive	rcv	Standard	std
Recommend	rcmd	Standard Nomenclature List	snl
Re-Entry Vehicle	REV	Start	S
Release	rel	Storage	stg
Reliability	relia	Strategic Air Command	SAC
Request for Quotation	RFQ	Subcontractor Start	SS
Requirement	requ	Submit	subm

<u>WORD</u>	<u>ABBREVIATION</u>	<u>WORD</u>	<u>ABBREVIATION</u>
Substitute	subst	Training	tng
Subsystems	subs	Transmit	xmit
Super Charger	sup chg	Truck	trk
Surface-to- Air-Missile	sam	Vehicle	veh
System	sys	Verify	vfy
System- Analysis	SA	Visual	vis
System Auxiliaries	saux	Warehouse	whse
System Lab	SL	Weapon	wpn
System Test	ST	Wing	wg
Tactical Air Command	TAC	Year	yr
Tactical Missile	tm	Zone	Z
Tactical Test Equipment	TTE		
Technical	tech		
Technical Bulletin	TB		
Technical Manual	TM		
Temporary	tmpry		
Tentative	tntv		

## TERMS

### Activity

A work effort of a program which is represented on a network by an arrow. An activity may also simply represent a connection or interdependency between two events in the network. An activity cannot be started until the event preceding it has occurred.

### Activity Report

A printout listing activities and related data by activity (EE-BE), activity expected end time and/or activity slack, depending on the code placed in Column 80 of the initial input card.

### Activity Slack (See Slack.)

### Actual Date ( $T_A$ )

The calendar date on which an event occurred or an activity was completed. This date must not be later than the report date and the beginning event must have occurred.

### Beginning Event (BE) (Predecessor Event)

An event which signifies the beginning of one or more activities on a network.

### Completion Date (See Actual Date.)

### 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.

### Critical Path

That particular sequence of events and activities in a path that has the greatest negative or least positive slack; therefore, the longest path through the network.

### Critical Predecessor

The event which immediately precedes the event under consideration on the most time-consuming path leading to that event.

### Dangling Event

Any event other than the start or end events that has either no predecessor or no successor.

### Designated Processing Agency

The military or civilian computer facility which processes the program data.

### Detailed Network

A network which reflects activities at the lowest level of the program breakdown. Detailed networks, while remaining an operating tool of the responsible organization, are related to the program breakdown structure, and their status is reflected in the Program Management Network.

### Directed Date for an Event ( $T_D$ )

Date for a specific accomplishment formally directed by the contracting authority. A schedule date ( $T_S$ ) which has been formally specified by contracting authority.

### E-L Chart

A report showing a chronological display of the expected time (E), the latest time (L), the scheduled time (S) and the actual time (A) for events.

### Earliest Completion Date ( $S_E$ )

The expected completion date for an activity. This date is calculated by:

- . summing the scheduled elapsed times ( $t_s$ ) for activities on the longest path from the beginning of the program to the end of the activity; and
- . then adding this sum to the calendar start date of the program.

For distant time effort where scheduled elapsed times ( $t_s$ ) have not been established, expected elapsed times ( $t_e$ ) will be used to calculate  $S_E$ .

### End Event

That event which signifies the completion of a path through a network.

### Ending Event (EE) (Successor)

The event which signifies the completion of one or more activities.

### Error Report

A list received with the computer printouts which includes identification of data input errors recognized by the computer.

### Event

A specific definable accomplishment in a program plan, recognizable at a particular instant in time. Events do not consume time or resources.

### Event Number

A unique number assigned to each event in the network.

### Event Report

A computer printout listing events and related data in event number, expected date, or event slack sequence, depending on the code placed in Column 21 of the initial input card.

### Event Slack (See Slack.)

### Expected Date ( $T_E$ )

The calendar date on which an event is expected to occur. It is calculated by adding to the date of each start event or completed event of the network activity times along each possible path up to the event under consideration. The latest of these computed dates is the expected date of completion for the event.

### Expected Elapsed Time ( $t_e$ )

A statistically weighted average time estimate, incorporating the optimistic (a), most likely (m), and pessimistic (b) time estimates for the work to be accomplished:

$$t_e = \frac{a + 4m + b}{6}$$

### Interface Event

An event which signals the necessary transfer of responsibility, end items, or information from one part of the program effort to another. Examples of interface events are the receipt of an item (hardware, drawing, specification), or the release of engineering drawings to manufacturing.

### 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 activity 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.

### Latest Completion Date ( $S_L$ )

The latest calendar date on which an activity can be scheduled for completion without creating an expected delay in the completion of the program. This date is calculated by:

- . summing the scheduled elapsed times ( $t_s$ ) for activities on the longest path from end of the activity to the end of the program; and
- . then subtracting this sum from the calendar end date of the program.

For distant time effort where scheduled elapsed times ( $t_s$ ) have not been established, expected elapsed times ( $t_e$ ) will be used to calculate  $S_L$ .

### Level Code

A letter (A through O only) that is associated with an event for shredout purposes or summarization.

### Master File

A file containing all information for a network.

### Master File Report

A listing of all events/activities and associated information for an entire network (printed by request only).

### Master File Report Summary Sheet

Information received with each computer output to identify the user, system number, output heading, report date, start date of the computations and types of reports to be generated by the computer. (Initial card data from the Form 30.)

### Milestone

Synonymous with an event in a network.

### Most Likely Time Estimate (m)

The most realistic estimate of the time an activity might consume. This time would be expected to occur most often if the activity could be repeated numerous times under similar circumstances.

### Network

A flow diagram consisting of the activities and events which must be accomplished to reach the program objectives, showing their planned sequence of accomplishment, interdependencies, and interrelationships.

### Network Integration

The joining of networks by interfacing to produce a master network reflecting the total program.

### Network Summarization

A process of reducing detailed networks to a skeletal or summary network for reporting purposes.

### Node

An event with two or more preceding events.

### Optimistic Time Estimate (a)

The time in which the activity can be completed if everything goes exceptionally well. It is estimated that an activity would have no more than one chance in a hundred of being completed within this time.

### Pessimistic Time Estimate (b)

An estimate of the longest time an activity would require under the most adverse conditions, barring acts of God.

### Predecessor Event (See Beginning Event.)

### Probability of Meeting Scheduled Date

A probability derived from normal probability tables with the entering argument being the event scheduled date in weeks minus the event expected date in weeks divided by the event standard deviation in weeks.

### Program

For the purpose of this manual, defined as the total planned undertaking directed toward accomplishing a specific objective. The end items of a program can be a weapon system, an equipment, or a development objective.

### Program Breakdown Structure (See Work Breakdown Structure.)

### Program Management Network

A network reflecting the total program acquisition plan containing a level of detail required by the Program Manager for overall planning and control of the entire program.

### Program Manager

The person assigned the prime responsibility for overall management of a program, such as a Program Director (SPD) of a SPO or a Project Officer.

### 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,  $S_E = T_S$ .

### Scheduled Elapsed Time ( $t_s$ )

The period of time assigned for performing an activity.

### Scheduling

Determination and assignment of scheduled time to events and activities as compared to "expected time" resulting from network computations.

### Short Path Flag

A flag assigned to all activities leading to a common end event. The minimum time through these activities instead of the maximum time will be taken as the end event's expected date.

### Shredout

The extraction of selected items of pertinent data from the basic computed date for reporting to specific functions areas of levels of management interest.

### Simulation

The processing of alternative actions to determine the effect such actions would have on the program concerned.

### Slack

Activity Slack - The activity's latest end time minus its expected end time. The activity slack is always greater than or equal to the slack of the activity's ending event.

Event Slack - The time difference between the latest and expected dates for an event ( $T_L - T_E$ ).

Slack may be positive, zero, or negative.

### Standard Deviation of an Activity ( $\sigma$ )

A measure of variance about the expected elapsed time for an activity, calculated when using three time estimates. It is computed from the formula  $\frac{b - a}{6}$ .

### Standard Deviation of an Event

A measure of variance about the event expected date. It is calculated by computing the square root of the sum of the squares of the activity standard deviations on the longest time path leading to the event under consideration.

### Successor Event (See Ending Event.)

### Summary Network

A network which represents, with a reduced number of selected events, the relationship of the events to each other and all of the significant characteristics of the detailed network. Lines connecting events on a summarized network are not necessarily true, definable work activities, since they are used to portray only the interdependencies and constraints among selected activities.

### Transaction Code

A one-digit numeric character which indicates action is to be taken to process data from the input card.

### Variance of an Activity ( $\sigma^2$ )

The square of the activity standard deviation.

### Variance of an Event

The sum of the activity variances along the most time-consuming path leading to the referenced event.

### Work Breakdown Structure

A family tree subdivision of a program, beginning with the end objectives and continuing with subdivision of these objectives into successively smaller end items. The work 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.

### Zero-Time Activity

An activity which constrains the completion of the event to which it leads by requiring that the event from which it proceeds be completed first. No elapsed time is associated with it; i.e., the time estimate is zero.