SPINST P5000.11
25 OCTOBER 1965

SP PERT HANDBOOK

"This Document conforms to the guidance represented by the 'DoD and NASA Guide PERT Cost Systems Design', June 1962, and the 'PERT Guide for Management Use', June 1963".

DEPARTMENT OF THE NAVY
SPECIAL PROJECTS OFFICE
WASHINGTON, DC 20360

SPECIAL PROJECTS OFFICE

SPINST P5000.11
25 October 1965

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RECORD OF CHANGES

Change No.	Date of Change	Date of Entry	Signature

DEPARTMENT OF THE NAVY
SPECIAL PROJECTS OFFICE
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SP INSTRUCTION P5000.11

From: Director, Special Projects
To: Distribution

Subj: SP PERT Handbook

Ref: (a) PERT Guide for Management Use of Jun 1963
(b) NAVMATINST 5200.11 of 24 Feb 1965, Subj: Guide for the Preparation of Project Master Plans
(c) SPINST 7720.1B of 22 Jun 1965, Subj: Program Progress Reporting in the Special Projects Office

1. Purpose. The purpose of this Instruction is to establish uniformity within the Special Projects Office for the application, implementation, and interpretation of PERT as a management tool.

2. Background. Reference (a) was published and distributed to establish a basic reference on management and PERT concepts as an improved communication system for all management levels. It has become increasingly clear during the latter stages of the POLARIS FBM Weapon System and with the assignment of new projects to the Special Projects Office, that the Office of the Secretary of Defense is paying very close attention to the development of new weapon systems, especially to the techniques used in their management. For this reason, it is necessary to issue this Instruction to supplement reference (a).

3. Application. Application of PERT shall be in accordance with the specifications listed on page 5C-1 of reference (b) and in reference (c).

SPECIAL PROJECTS OFFICE

4. Action. This Instruction and The PERT Guide for Management Use (reference (a)) are the basic documents for use by the Special Projects Office for the application of PERT. All personnel involved in weapon system development, planning, budgeting, contracting, negotiating, and reporting, shall make themselves familiar with the provisions of these two documents. Branch Heads are responsible for supplying their contractors with copies of this Instruction.

5. Definition. PERT (Program Evaluation and Review Technique) refers to the application of both Time and Cost. In those cases where Time only is required, it must be so specified.

6. Effective Date. This Instruction is effective as of date of issue.

P. L. LACY, Jr.
Deputy Director

Distribution:
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This Directive is stocked at:
Director, Special Projects, SP 41
Department of the Navy
Washington, D. C. 20360

FOREWORD

Management of major space, weapons, construction, military, or other programs is accomplished through organizations of professional personnel in such fields as engineering, science, production, administration, and finance. Any program can be managed effectively if it is carefully planned, scheduled, budgeted, evaluated, and continually guided toward attainment of specific program objective. Conventional management techniques of planning and control have been found to be inadequate in numerous programs because of the complexity, the extraordinary size, the rapid response time required, as well as the requirement for simulation of alternate management decisions.

Significant schedule slippages and cost overruns have been experienced on government and commercial programs. This is an indication that managers at all levels may need improved techniques for effective program management of time and cost in relation to performance requirements. Excessive deviations from planned expenditures of time and cost indicate major problems with planning and control if uncertainty in future strategic plans is created.

Problems in effective program planning and control are not confined to only weapon system acquisition. They are inherent in any complex program, but can be resolved through a team effort approach by professional groups working within the discipline of an effective management system. However, no management technique or device, regardless how sophisticated, will become an effective management instrument unless properly designed, implemented and supported.

PERT 1/ is most useful in one-of-a-kind projects, such as engineering and development or building construction. When properly used, it aids managers from the inception to the completion of such projects.

1/Program Evaluation and Review Technique - refers to both TIME and COST unless otherwise specified.

PERT is most effective if used before the Request for Proposal is developed and proceeds through the

- Pre-Contract Phase;
- Contract Negotiating Phase;
- Contract Management Phase.

A most important aspect of PERT is that it enables an integrated approach to all phases of the acquisition process.

Government use of PERT in the early planning phases of the project assures industrial managers that:

- the objectives of the project and interrelated aspects are defined, evaluated, and communicated before a Request for Proposal is issued; and
- contract awards are made on the basis of several factors, including definitive analyses and improved evaluations.

Similarly, government management is assured that industry has improved opportunity to plan, bid, and manage a project, and more precise planning and control over resources exists.

It assures government and industry alike that negotiations can be conducted in a more informed manner; and contracts will reflect better agreement on what is to be done, what it will cost, and when it will be completed.

A total integrated project management system should encompass the fundamental program variables of TIME and COST. PERT, as originally developed, included the planning and reporting of time only. The development of PERT Cost was the next step as it enabled both time and cost to be planned and reported in the PERT framework.

Although the PERT System encompasses time and cost, it is flexible enough to allow operation of the time portion independently of the cost portion. PERT Time is described in Chapters I through VI and XIII. Chapters VII, VIII, IX, X and XIV discuss the integration of the TIME and COST aspects. The remaining chapters relate to the use of PERT insofar as its implementation.

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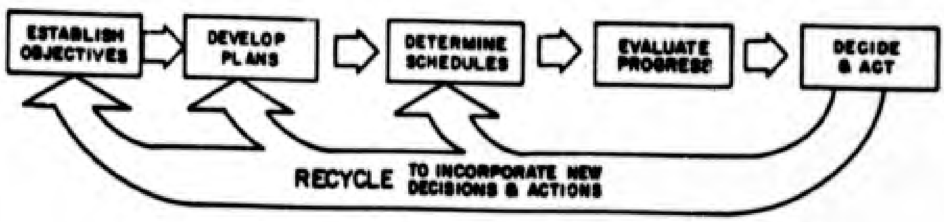
FIGURES

CHAPTER I

PERT AND THE MANAGEMENT PROCESS



A management device or technique, regardless of the degree of sophistication, is only a tool and can never be a substitute for effective managers. The tool or technique must be an integral part of the entire management process. Logically, therefore, in any presentation of a management technique such as PERT, a sound concept of the management process must first be established.

The management process is the result of evolution over many generations of trial and error. Much has been written about the function, environment, and the role of management. Very little has been done to develop and describe an orderly process by which good managers can go about getting things done. This manual develops and describes a management process as the foundation for utilizing PERT.

The function of management entails the continuous, intelligent direction of others by determining and communicating the prime and supporting objectives of an organization. This function necessarily includes the development and utilization of an integrated time-phased plan of action, demanding reasonable requirements in the way of resources and the subsequent balancing of resources as they are made available and used.

This document emphasizes the distinct form of the cycle of applied effort. The basic steps of this process follow:

- the determination and effective communication of the prime and supporting objectives;
- the development of a coordinated plan of action for the accomplishment of the objectives;
- the conversion of the plan into integrated schedules within allocable resources;
- the regular reporting and concurrent evaluation of progress against the scheduled plan cost estimates;
- the recycling of the above process to achieve the incorporation of a desired new action into a new cohesive scheduled plan.

* * * * * *

A. Establish Objectives

The determination and definition of objectives is the initial and most important step in the management process, largely because the objectives of an organization are its sole reasons for existence. All organized activity must have as its motivating and guiding force the attainment of some predetermined objective or objectives. The current purpose or purposes of the organization must be the yardstick against which all requirements and accomplishments are measured and evaluated. The progressive passing down of specific coordinated objectives from higher to lower levels of management sets the target for and the authorization of detailed planning effort on the part of the receiving organization.

The importance of the effective communication of concise planning objectives from level to level of responsible management cannot be over-emphasized.

B. Develop Plans

Given the determination or assignment of an objective, the next step is the development of a plan. The planning function sets forth the nature, sequence, and interrelationships of the supporting objectives which must be accomplished to achieve the prime objective. Planning is primarily concerned with the structuring and relationships of units of required effort. It considers and answers questions of capability by determining in-house versus sub-contracting effort. It establishes the feasibility of meeting the directed due date for the successful attainment of the objective. There must be a broad operating plan in existence at the highest level of management to serve as a guide for selection of specific supporting objectives.

This plan must be realistic in its requirements and consistent with the available resources and time. The planning function at each level sets forth the important objectives of the kind, quality, and quantity for the work to be performed. If this planning is not accomplished, there can be no assurance of a coordinated, balanced use of resources. Initial planning considers the resources normally required including elapsed time, but does not consider the competition for these resources.

C. Determine Schedules

Scheduling is the bridge from the planning stage to coordinated, effective implementation. It is the translation of the plan, with its expected elapsed time estimates, to a scheduled calendar time. The scheduling function considers the competition for available resources both within and between programs. If the earliest attainable scheduled completion date of the current plan within available resources, is later than the desired date, the manager will pass the plan to the planners for readjustment. If the planners cannot achieve this, they must determine a new completion date with the next higher level of management.

The goal of the scheduling function is to produce a calendar time-phased plan consistent with desired completion dates for the assigned objectives. This schedule is the vehicle for authorizing resources to be expended. It serves as a basis for the continuous evaluation of progress.

D. Progress Evaluation

Once the scheduled plan has been activated a formal procedure for the regular reporting of progress against the scheduled plan is necessary. A process for the early detection and specific description of a potentially significant problem area while there is still time for management to seek solutions to that problem is required. The process emphasizes:

- regular, continuous, evaluation of actual performance against current scheduled plans;

- detection and isolation of significant deviations from the scheduled plan as a forecast of time and cost overrun.

The principle of "significant reporting" can effect a great reduction in the volume of statistical reports. By considering only the significant deviations from the scheduled plan, the manager need only obtain a detailed analysis of the specific problem covering:

- what remedial action is being taken and by whom?

- what results may be expected and when?

E. Management Decisions and Actions

The magnitude and relationships of all desired changes must first be examined through simulation when possible in the light of their effect on the scheduled plan. Changes may result from alteration of prime objectives or isolation of the problems at any level of effort. The point of origin of the changes is not so important as the orderly method of authoritative approval and implementation.

Deviations from the scheduled plan may require only a change in schedule. Deviation could, however, require a change in plans, or even a change in objectives. By concentrating on the most important current or forecasted problems, management can expend its efforts to achieve the maximum potential returns relative to the assigned objectives.

A clear distinction must be made as to new action that is within the authority of the operating organization, and action which calls for lateral or higher authority. The first can be handled by direction; the second calls for a careful presentation of the facts and a request for the action desired.

F. Recycle

The incorporation of change is achieved by a recycling of the management process to provide a revised scheduled plan. Dynamic recycling is the method of achieving and maintaining management control of objective-oriented effort. The formal progress reviews and evaluation meetings held by management with their supporting managers as well as simulation provide an opportunity to accomplish the mechanics of the recycling process.

Programs can be managed most effectively only if managers have a common framework from which to plan and to control the schedules and costs of the work required to achieve the performance objectives. Benefits can be increased when PERT 1/ is included as part of the total planning and control system.

Managers at all levels need techniques at all stages of a project to:

- define the work to be performed;
- develop realistic estimates based on the resources planned to perform the work;
- determine where resources should be applied to best achieve the time, cost, and performance objectives;
- identify developing problem areas in time to permit corrective action.

1/PERT refers to both TIME and COST unless otherwise specified.

For example, managers at each level must be able to determine:

- whether the current estimates for completing the entire program are realistic;
- whether the program is meeting the scheduled plan; and, if not, the extent of any difference;
- whether requirements for manpower and other resources have been planned realistically;
- how manpower and other resources made available by changes in the program tasks can be best utilized;
- the consequences of alternative courses of action.

PERT serves these purposes.

G. PERT

1. Definition

PERT is a set of principles, methods, and techniques for effective planning of objective-oriented work, thereby establishing a sound basis for effective scheduling, costing, controlling, and replanning in the management of programs or projects.1/

The PERT technique is flexible and can be tailored to the specific work to be managed and the managers need for information. Elements of PERT include:

- management policy and procedures for the operation of the PERT system;
- an orderly definition of the objectives in the form of a product-oriented 2/ work breakdown structure;
- a specification for each end-item subdivision of the work breakdown structure;

1/The term "project" or "program" is used interchangeably in this document.
2/Product-oriented may be interpreted as end item or objective-oriented.

- an account code structure which establishes number codes for the charging and summation of costs;
- the work packages 1/ required to complete the objectives;
- a network flow plan that consists of the activities and events and displays the interdependencies and logical planned sequence of accomplishment to reach the project objectives;
- expected elapsed time estimates for activities and identification of critical paths in the networks;
- a schedule for the accomplishment of the work efforts required to achieve project objectives that is based on the network plan and resource availability;
- cost estimates for the work packages associated with the end-item subdivisions of the work breakdown structure;
- budgets keyed to work accomplishment and task schedules;

1/The work required to complete a specific job or process, such as a report, a design, a documentation requirement or portion thereof, a piece of hardware, or a service. A work package may consist of one or more cost significant activities. The content of a work package may be limited to the work which can be performed by a single operating unit in an organization or may require the contributing services of several operating units. The overall responsibility for the work content of a work package should be assigned to a single organization or responsible individual. It is the lowest level of cost collection and is represented by a charge number related to a single summary number. In this way, the work package couples to the cost accounting system through the charge number, and to the PERT network through the beginning and ending event numbers of the package.

- analysis of the interrelated networks, schedules and slack values as a basis for evaluation of project status, forecast of overruns and underruns, and the identification of problem areas in time for management to take corrective action;

- summary reporting to meet the varying cost and schedule information requirements for the different levels of management;

- continued forecasting through simulation of the effects of both planned and actual decisions and actions on the total project.

2. Basic Concept

PERT utilizes the objective-oriented work breakdown structure as the common framework for network development, planning, scheduling, costing, evaluating, as well as the simulation and recycling of management process.

The program planning begins with the development of the product-oriented work breakdown structure. The end items 1/ objectives of the structure are broken down into lower level end items subdivision, then subdivided into the tasks required to accomplish them. These tasks are called "work packages." When the work packages associated with each individual end item are identified, flow plans in the form of networks for the corresponding parts of the program can be constructed. Network activities are identified with the work packages they represent. Separate cost estimates are not necessary for each activity in the work package since this could result in excessive detail and unrealistic accounting effort. Each work package will normally be represented by one or more activities. The beginning and ending of the work package can be identified by the first and last events in time associated with this work package. The estimates are analyzed to eliminate unnecessary manpower costs and premium payments for materials and services. For example, the estimated monthly manpower requirements can be totaled by skills

1/The term "end item" is used to represent the hardware, documents, services, equipment, or facilities that are deliverable to the government or that are a commitment on the part of the supplier.

and examined to minimize needless overtime and hiring caused by unrealistic requirements. Therefore, manpower redistribution is accomplished by the judicious scheduling of slack activities when possible. The summarization of the work packages into an overall plan can then be costed and compared to a proposed schedule plan.

After a scheduled plan has been prepared, a firm cost estimate is developed for each work package. This cost is based on the resources required to perform the work package within its scheduled time. Summarization up through the work breakdown structure provides cost estimates for each end item and for the total program.

The PERT system requires periodic evaluation of:

- estimated, budgeted, and actual costs for each work package;
- estimated and actual time of each work package and associated activities.

This comparison significantly improves cost and schedule control by establishing the cost and time status of the program and identifying any potential cost overruns and schedule slippages for work in process. Estimates of the cost and time needed to complete work not yet started are also obtained in order to predict future schedule slippages and future cost overruns. This enables the identification of difficulties in the performance of critical work in sufficient time for corrective management action.

The level of detail to which it is desirable to apply PERT is largely a matter of judgment, and varies from program to program, from one part of a program to another, and from the proposal preparation stage to the execution stage of the same project. Effective results from PERT depend on judicious application in depth and breadth relative to the characteristics of the program. Programs with significantly more complex variables of performance, cost and schedules should receive a broader and deeper application than other programs. Where uncertainty of program output does not exist, other conventional systems may be desirable.

3. Reports to Management

Periodic management reports make it possible for managers to anticipate cost overruns and underruns.1/ An example is the Management Summary Report (Figure I-1) which shows the overall schedule and cost status of both the program as a whole and of each of the major component items. It also indicates the problem areas that require management attention.

The Report provides each manager with the following information relative to his areas of responsibility:

- the cost overrun or underrun to date (a measure of cost performance), through a comparison of the planned costs with actual costs for the work performed;
- the projection of total cost overrun or underrun which is obtained by comparing a planned cost with the latest revised estimate for the work segment or program;2/
- the amount of schedule slippage is indicated by the difference between the established schedule and the earliest scheduled completion date;
- the identification of trouble spots - that is, identification of those areas of the program where the cost or time status requires management attention.

Management Summary Reports are prepared for managers at each level of the program structure. Each Management Summary Report will normally be accompanied by a brief written analysis. One report is prepared, for example, for the entire System (level 0) based on the product-oriented work breakdown structure shown in Figure I-2. At level 1, a similar report is prepared for each major element of the program, such as Facilities, Missile, Training Program, Guidance, Systems Integration, etc. At the next lower level, level 2,

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1/A detailed discussion of these reports is contained in Chapter IX.
2/The planned cost and latest revised estimate will include approved but "still-to-be" negotiated changes within fund limitations.

CMWS - AIO MISSILE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ	61-9865	TERM (SPAN): TOTAL PROJECT CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 1 /MISSILE			

ITEM	COST OF WORK $(000)						SCHEDULE	
	WORK PERFORMED TO DATE			TOTALS AT COMPLETION				
	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED EST	PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK (WKS)	COMPL DATE
LEVEL 1 MISSILE 302	31,000	32,300	(.04) (1,300)	48,000	51,400	(.07) (3,400)	-8.0	29 MAR 64 01 FEB 64 10 MAY 64
LEVEL 2 PAYLOAD 302DEV121	13,300	13,200	.01 100	16,700	16,700	--	-1.3	22 OCT 63 12 OCT 63 12 OCT 63
LEVEL 2 FLIGHT CONTROLS 302DEV122	3,700	4,000	(.08) (300)	5,600	6,100	(.09) (500)	-2.2	13 DEC 63 29 NOV 63 20 FEB 64
LEVEL 2 MISSILE BODY 302DEV123	1,100	1,100	--	4,200	4,000	.04 200	1.2	01 JAN 64 10 JAN 64 10 JAN 64
LEVEL 2 PROPULSION 302DEV124	4,400	4,900	(.11) (500)	8,600	9,600	(.11) (1,000)	-8.0	29 MAR 64 01 FEB 64 01 FEB 64
LEVEL 2 INSTRUMENTATION 302DEV125	3,100	3,100	--	7,200	7,200	--	0.0	10 MAY 64 10 MAY 64 10 MAY 64

S - SCHED COMPL DATE -- } TOTAL ITEM
A - ACTUAL COMPL DATE --
E - EARLIEST COMPL DATE -- } CRITICAL ITEM
L - LATEST COMPL DATE --

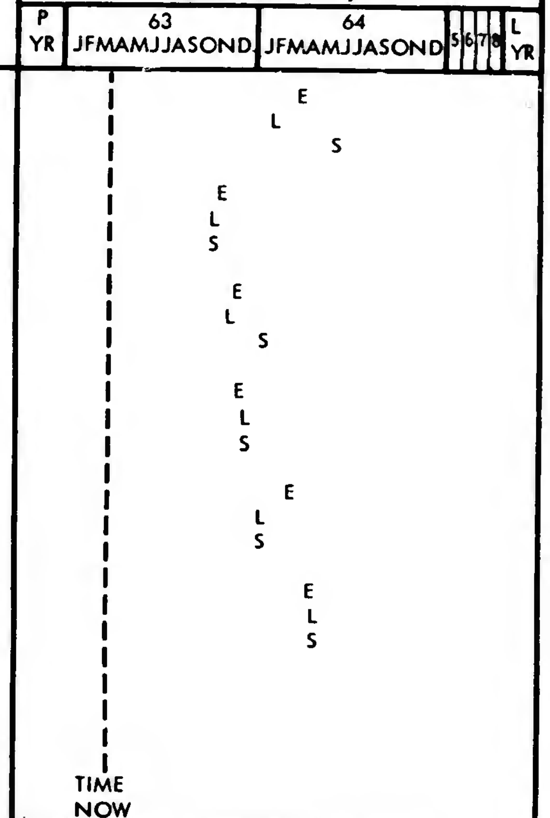

FIGURE I-1 PERT MANAGEMENT SUMMARY REPORT

WORK BREAKDOWN STRUCTURE, LEVEL 4

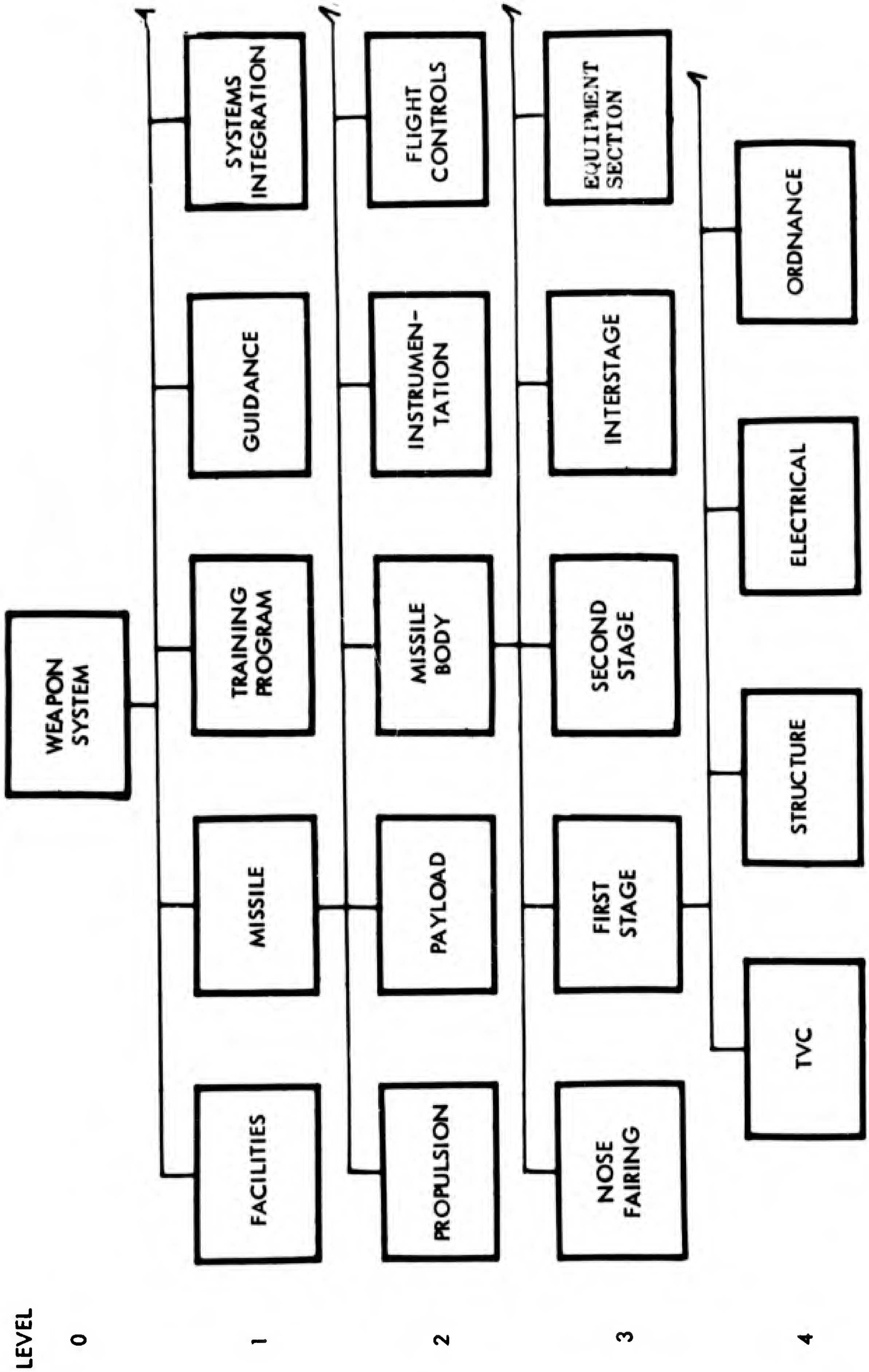

FIGURE 1-2

the major elements of the program are subdivided again and a Management Summary Report is prepared for each manager to whom responsibility is assigned. The Missile, for example, is divided into elements such as Propulsion, Payload, Missile Body, Instrumentation, etc. The Missile Body is further subdivided and management reports are prepared at such lower levels of the program as are considered necessary by the program manager. In analyzing the status of a program, the responsible manager would examine the reports for those end items where trouble is indicated. He would then refer to the lower level reports as required to isolate the trouble. These reports present back-up detail for all levels of management summary report in various analytical formats.

Another management report is the Cost of Work Report which shows the appropriate manager:

- the planned costs to perform the work;
- the actual costs to date;
- the value of work performed to date;
- the projection of costs to program completion, based on actual costs to date and the latest revised estimates for work not yet performed.

A comparison of the actual costs to date and the value of work performed to date will show whether the work is being performed at a cost which is greater or less than planned. Figure I-3 illustrates an example of the Cost of Work Report.

The Cost Outlook Report (Figure I-4) and the Schedule Outlook Report (Figure I-5) show the trend of successive monthly projections of the time and cost to complete the work. Each month, new projections are obtained and these projections provide new entries for the Cost and Schedule Outlook Reports.

The manager can obtain these reports for the total program or any element of the work breakdown structure. By relating the trend of these projections to previous management decisions, the manager can observe the

COST OF WORK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATE: 3/31/63
CMWS	XYZ CORP	61-9865	TERM: PROGRAM
LEVEL/SUMMARY: 1/MISSILE			CUT OFF DATE: 31 MAR 63
			RELEASE DATE: 10 APR 63

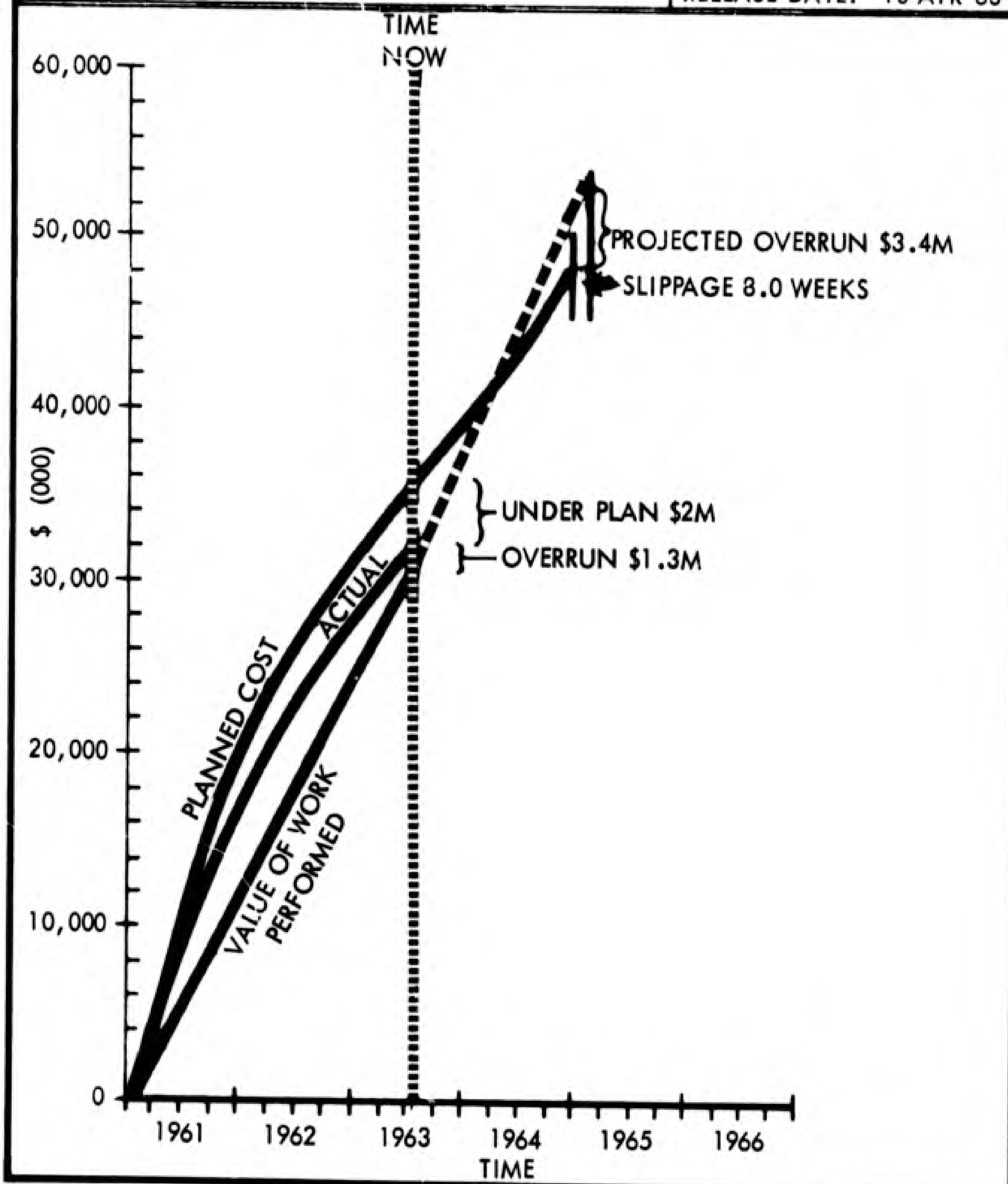

FIGURE I-3

COST OUTLOOK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
CMWS - AIO MISSILE	XYZ CORP.	61-9865	TERM (SPAN): TOTAL PROG. CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 1/MISSILE			

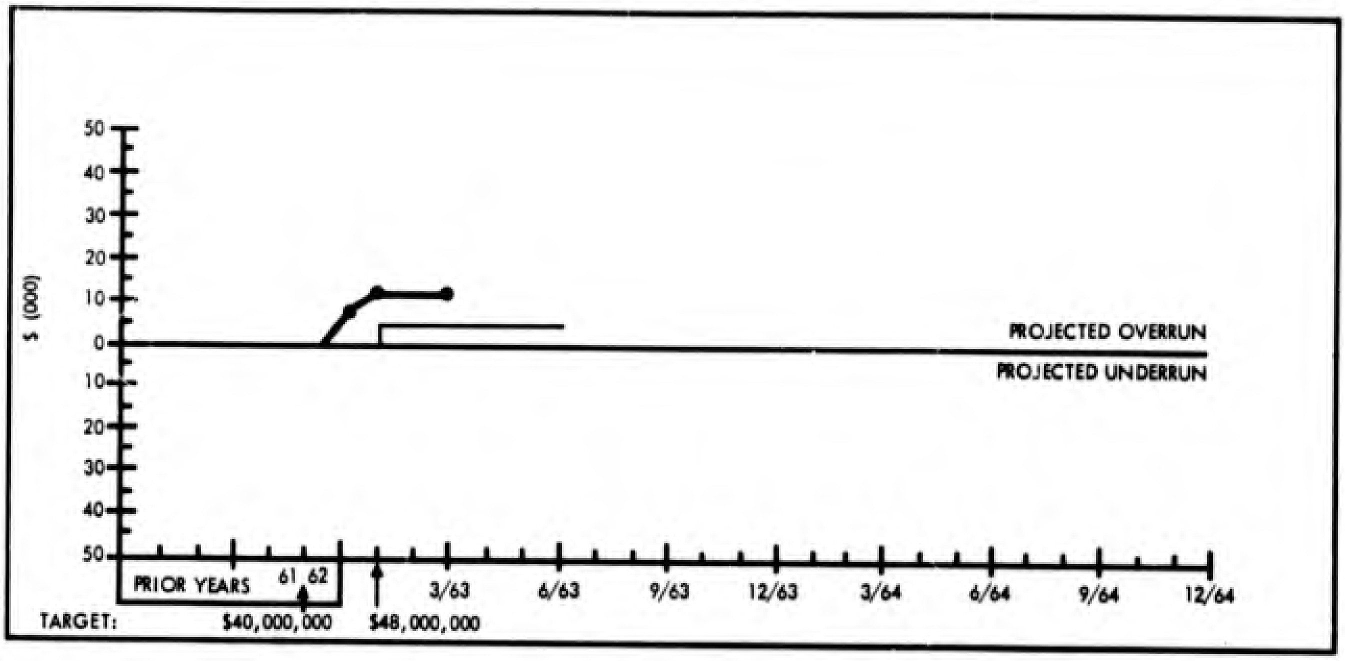

FIGURE I-4

SCHEDULE OUTLOOK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
CMWS AIO MISSILE	XYZ CORP.	61-9865	TERM (SPAN): TOTAL PROG. CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 1/MISSILE			

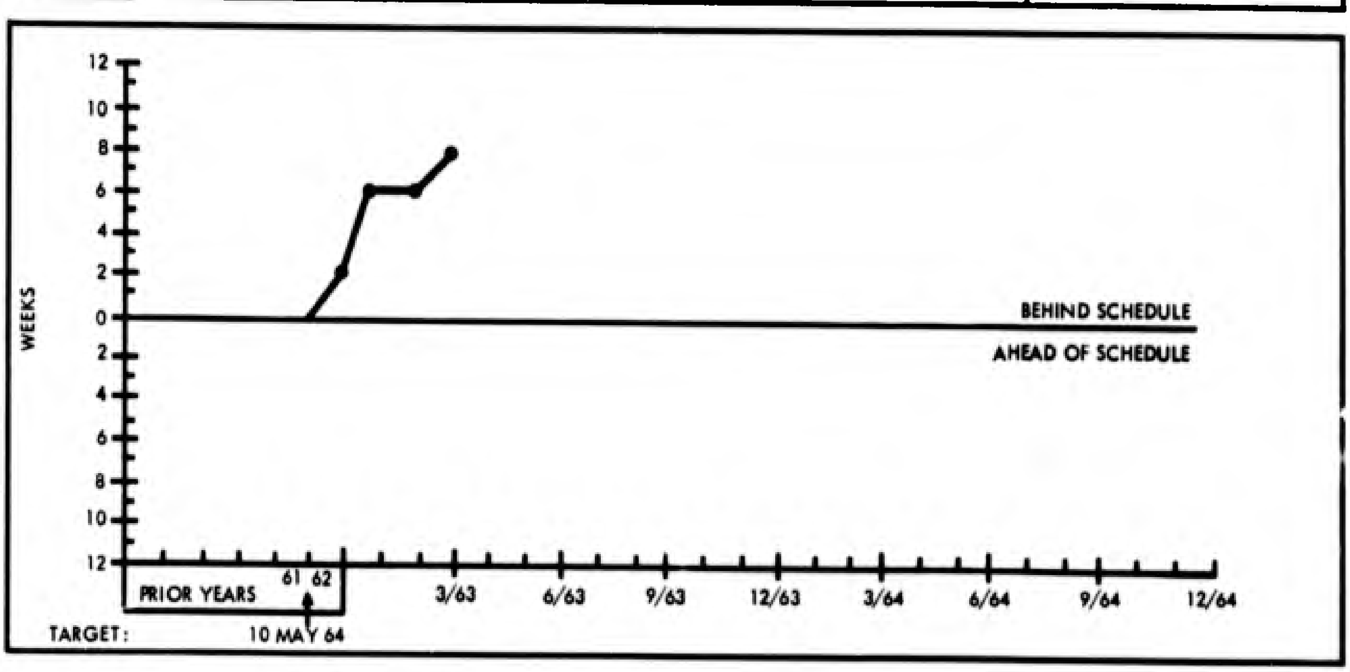

FIGURE I-5

effects of these decisions on the cost and schedule for the project. He can determine, on a month-to-month basis, whether or not the actions taken to control schedules and costs are producing the desired results.

The evaluation of these reports enables a manager to take any of the following actions within his area of responsibility:

- adjust the schedule of slack path activities to minimize the need for overtime or additional hiring;
- redistribute funds from areas of underrun to more critical areas;
- revise the planned resources for work packages by:
  - trading off interchangeable resources between critical and slack path activities;
  - increasing or reducing the planned resources for activities.

  revise network sequence or content by:
  - employing a greater or lesser amount of concurrence in performing activities;
  - modifying the specifications or methods of performing the work, thereby altering or deleting or adding activities.

Since the actions that management takes to correct problems often involve revising plans, schedules, and budgets, provision is made in PERT for necessary recycling through use of the simulation process. The process of simulation of alternative courses of action can be carried out at any point in the management process cycle by any level of management.

PERT is a management tool which, when used by a manager:

- measures accomplishment against current scheduled plans and objectives;

- assists in identifying real time requirements and provides limits for detailed scheduling;
- fixes responsibility and assures continuity of effort despite turnover in personnel, either executives or operating personnel;
- is a discipline which assures complete program coverage and provides visibility from the total program objective down to the lowest supporting task;
- spots potential future problem areas in time for preventive action or for improvement;
- uses the management by exception principle in reporting to higher levels of management;
- permits essential rescheduling and provides periodic evaluation of plans;
- provides capability for consideration of trade-offs in funds, manpower, performance, and time between critical and non-critical areas of effort as a means of improving schedule and cost situations for one or more programs;
- makes it possible through its simulation techniques to evaluate and forecast outcome of alternate plans before implementation. Simulates and measures the effect of proposed changes in scheduled plans and permits an early identification of the most efficient plan when parallel approaches are used;
- provides historical data banks for the programs which can be drawn upon for new programs.

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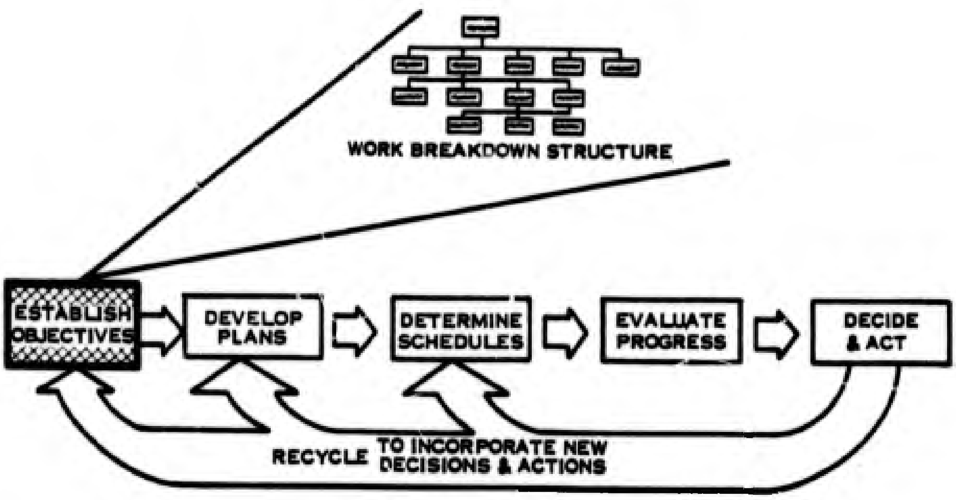
CHAPTER II

IDENTIFICATION AND ORGANIZATION OF OBJECTIVES



Management may be defined as a process of identifying and organizing objectives, and planning and employing resources to accomplish them. An operating organization and its management provide means to accomplish an objective. The responsibilities of an operating manager are the organization and supervision of the work required to meet the objective.

The manager must be alert to opportunities to achieve the required objective with the efficient use of resources and time. The effectiveness of an operation is a measure of the manager's ability to attain the required objective within the quantity, quality, time, and cost goals established in the planning to reach the objective.

* * * * * *

A. Identification and Definition of Objectives

The following steps are important before work on any program begins:

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

Answers to the following questions will help to determine and define the prime and supporting objectives by working from the overall program objectives and downward in detail:

- What operational system(s) or end item(s) will this level of operational management and its units be responsible for producing?
- What are the major phases of work and significant objectives through which the operational system(s) must move to accomplish?
- How are these objectives related?

Each management level develops supporting objectives for the next lower level. After defining the supporting objectives each level reviews them with the next higher level to assure consistency before final decision.

B. Communication of Objectives

The prime and supporting objectives must be communicated, in writing. This communication is the essential basis for plans, schedules, and later management operations. The following are minimal requirements:

- prime and supporting objectives must be determined and defined in sufficient number to provide the basis for outlining the step-by-step process by which the qualitative and quantitative objectives of the program are to be attained;

- the projected divisions of labor must be detailed among responsible organizations in the manner consistent with the objective of higher authority;

- relationships between supporting objectives and prime objectives must be indicated in order to obtain the proper perspective on the attainment of integration in prime objectives.

C. Organization of Objectives

Objectives may relate to equipment, services, facilities, decisions, or data. In PERT, these objectives are organized and specified in terms of end items which are either deliverable or constitute a commitment from the organization. For example, the development of a weapon system having certain specifications is the objective for the program shown in Figure II-1. Since the program is complex, it has been subdivided into items (e.g., Facilities, Missile, Training Program, Guidance, and Systems Integration, etc.) at the first level. End objectives must then be defined for each of these items. Each first level item can be subdivided into other items defined at successively lower levels, as is shown in Figure II-2 for the Missile.

In order to assure integration, the objectives must be based on the total program first, and then extended downward to the more detailed level. Three reasons for this top-down approach are:

- it assures that the program objectives are fully supported by lower level objectives. Planning from the bottom up may not assure that complete coverage is obtained;

WORK BREAKDOWN STRUCTURE, LEVEL 1

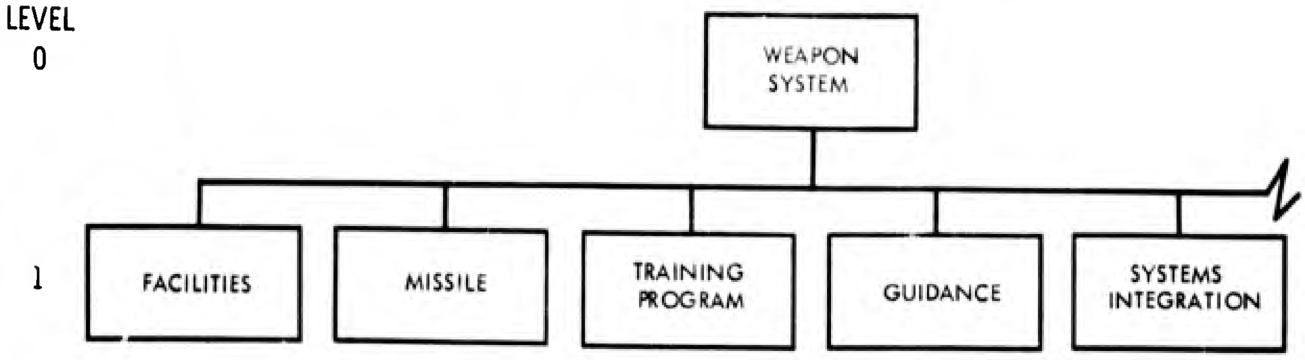


FIGURE II-1

WORK BREAKDOWN STRUCTURE, LEVEL 2

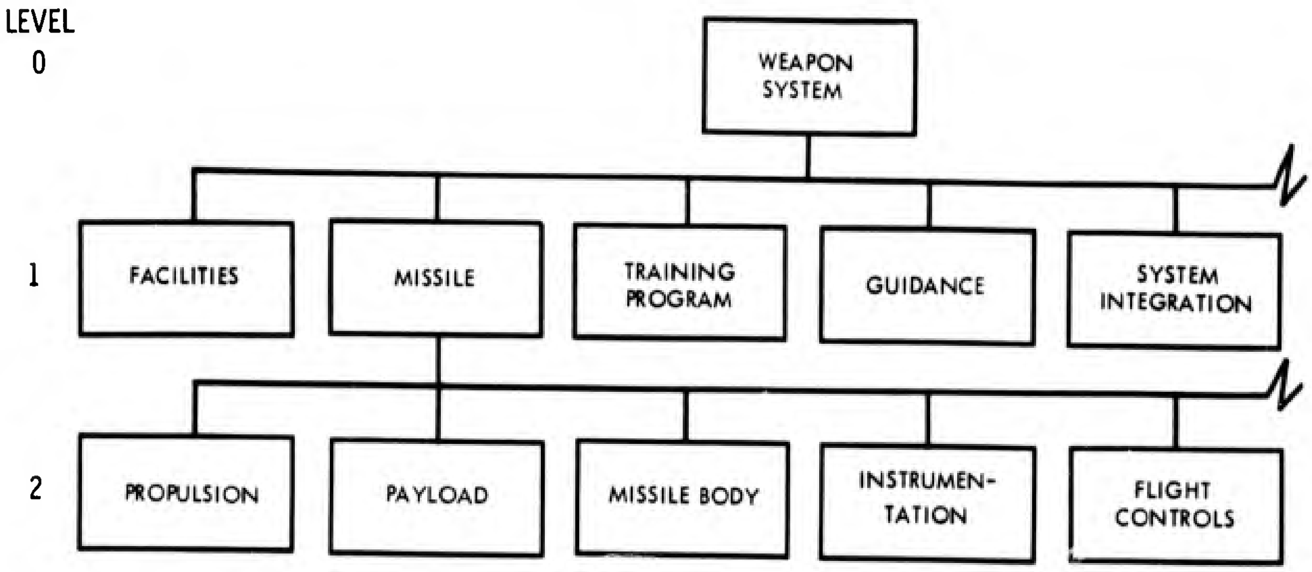


FIGURE II-2

- it assures that the program structure is totally integrated and that each part of the program is consistent with and related to the program as a whole. Planning from the bottom up might allow the individual components to become ends unto themselves and be developed according to conflicting objectives;

- it helps assure that useful summaries of program information can be made. The selection of information, meaningful to successive higher levels of management, is difficult unless the data is summarized upward according to the structure lines of a top-down plan.

D. Work Breakdown Structure

A product-oriented work breakdown structure reflecting the organization of objectives is essential to any PERT installation. The structure is developed downward by proceeding from the definition of the program objective through successive levels to the lowest level of detail required for effective program management. As the objective is developed in greater detail and translated into the project end item submission, they form the work breakdown structure.

This produces a graphic representation of the program structure and establishes a common framework for the accomplishment of all the work to be performed. It enables assignment of responsibilities, delineates objectives for monitoring progress, and provides a basis for uniform planning and program visibility. It establishes a structure for the identification of contract line items and a basis for relating the performance specification to those line items.

This structure of the program thus identifies the major program end items (hardware, decisions, services, equipment, or facilities). The major end items are then divided into their component parts (e.g., systems, subsystems, components), and the component parts are further divided and subdivided into more detailed units.

A top-down approach to planning is used so that detailed plans will not be generated outside a common framework. The work breakdown structure establishes the basis for constructing networks at any desired level of indenture by identifying and defining the end items to be accomplished at that level. It also determines their relationship with other end items at higher and lower levels. It is apparent that networks constructed without the use of a work breakdown structure are likely to be incomplete or inconsistent with project objectives.

In Engineering or Operational System Development programs, there will normally be an extensive technical systems analysis effort, resulting in a formal hierarchy of System End Item Specifications, or a Specification Tree. The Specification Tree and the Work Breakdown Structure must be compatible and thereafter remain aligned with each other. The formal association of these specifications with appropriate end items paves the way for the use of the work breakdown structure as the common framework for planning and control of performance as well as schedule and cost.

In the planning of an engineering development project, it is apparent that the work breakdown structure is constructed in stages. As more and more of the project's end-item subdivisions are identified, the work breakdown structure is developed in more detail in the early planning processes. For example, during the preproposal phase, the work breakdown structure serves the project manager as a basis for preparing the Work Statement and the Request for Proposal. At this point, the structure may be carried down to only the second or third level for most parts of the project.

The work breakdown structure can provide the bidders with a more definitive base for developing their technical cost and schedule proposals. During the proposal preparation process, the bidders may be expected to extend the work breakdown structure to lower levels of detail.

In defining the project the work breakdown structure is continued to lower levels until sufficiently detailed units for management purposes have been defined. Caution should be exercised during all phases to avoid over-detailing the work breakdown structure to the point beyond adequate control. The detail should be commensurate with a reasonable expense for maintenance and an assurance of timely program change response. Necessary lower levels of detail should be progressively developed on an "as required" basis, rather than "across the board" at program beginning.

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 the program objectives;
- 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;
- constructing networks at any desired level of detail;
- establishing contract line items.

A program is illustrated in Figure II-3. The subdivision of the work breakdown structure is continued to successively lower levels, until it reaches that level where the end item subdivisions finally become manageable units for planning and control purposes.1/

E. Work Packages

The next logical subdivision for planning and control is a breakdown of each of the end item subdivisions into work packages.

A work package is the unit of work required to complete a specific job or process, such as a report, a design, a documentation requirement or portion thereof, a piece of hardware or a service. A work package may consist of one or more cost significant activities. The content of a work package may be

1/The use of the work breakdown structure is not intended as the frame of reference to establish the organizational structure of management.

WORK BREAKDOWN STRUCTURE, LEVEL 4

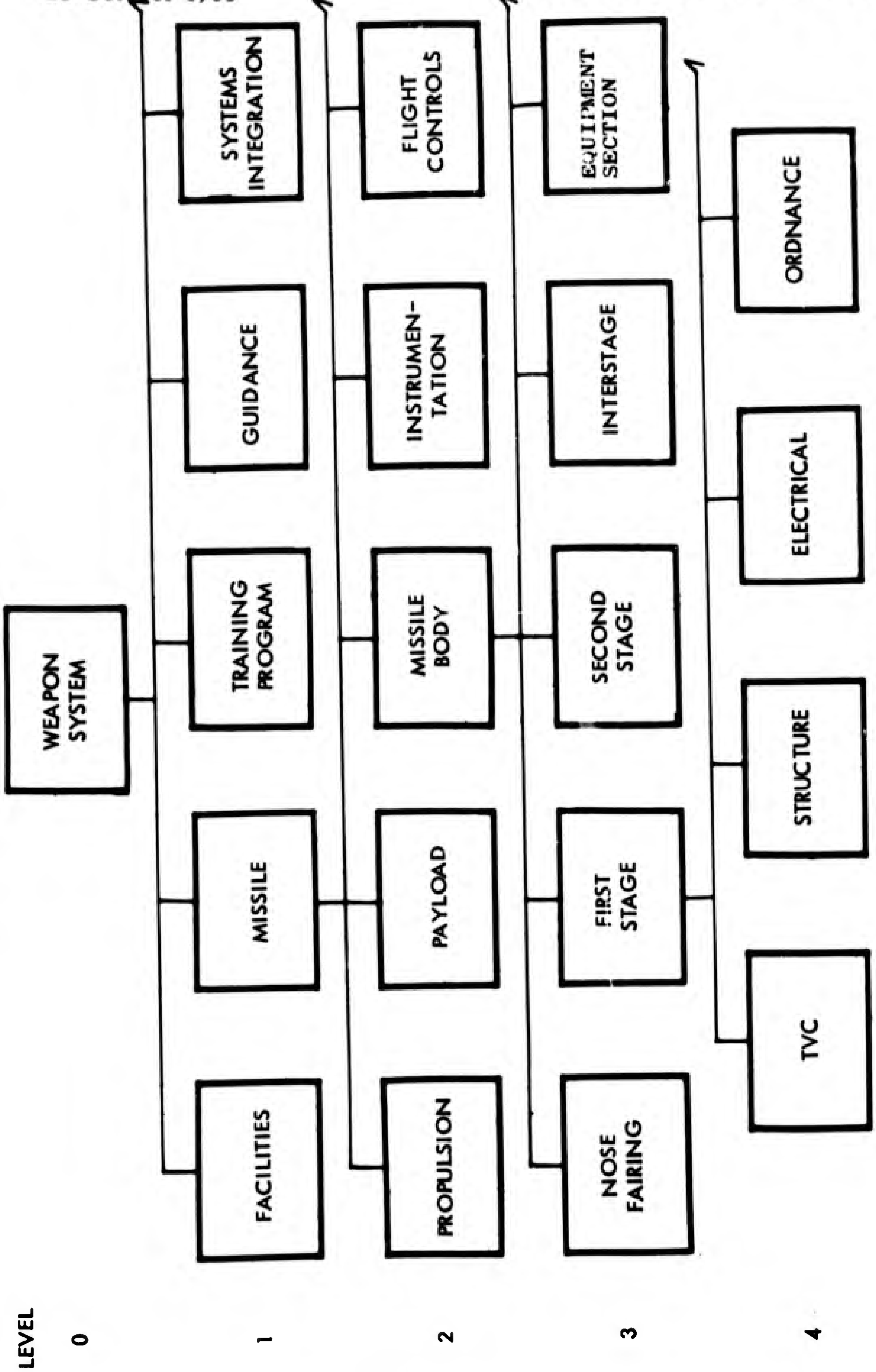


FIGURE II-3

limited to the work which can be performed by a single operating unit in an organization or may require the contributing services of several operating units. The overall responsibility for the work content of a work package should be assigned to a single organization or responsible individual. It is the lowest level of cost collection and is represented by a charge number related to a single summary number. In this way the work package couples to the cost accounting system through the charge number and to the PERT network through the beginning and ending event numbers of the package.1/

The configuration, content and detail of the specific work packages to be identified will vary and will depend upon:

- the status of the program;
- the size and complexity of the program;
- the structure of the participating organizations;
- the assignment of responsibility for the work, according to the judgment of the manager.

These considerations will also determine the number of end item subdivisions that will be created on the work breakdown structure before the work packages or activities are identified and responsibility for them is assigned to operating units. The amount of detail is a matter of judgment for joint consideration by the managers of the program.

Similarly, sections of the work breakdown structure may vary in the number of levels into which they are subdivided, even in different parts of the same program. For example, "Training Program" may be subdivided only to two levels, whereas portions of "Missile" extend to six or more levels.

1/A good target figure for most work packages is a maximum dollar content of $100 K and a maximum time duration of three months.

As the work breakdown structure is defined, any interfaces between the various subdivisions on the structure should be identified and subsequently recorded as events on the appropriate network. Interfaces are defined as events which signal the transfer of responsibility, end items, or information from one part of the plan to another.

Figure II-4 illustrates the relationship of program objectives through the work breakdown structure and work packages to networks.

The degree of detail required for planning and control during the execution phase of a program may be greater than that required for proposal preparation. This does not mean that the technique is applied in a different manner, but rather, that the work breakdown structure is developed initially only to the level of detail specified by agency policy as essential for proposal evaluation. The work breakdown structure is later expanded into the lower levels of detail needed for effective planning and control of the work.

F. Recycling

Discussion of the identification and organization of objectives is incomplete without consideration of the recycling process.1/ Objectives may be changed by higher level authority, or they may have to be changed as a result of failures or successes in accomplishment at lower levels in the program. If changes occur, it may be necessary to recycle the process which lead to the determination of some objectives.

1/Chapter VI discusses the recycling process in detail.

RELATIONSHIP OF SYSTEM WORK BREAKDOWN STRUCTURE THROUGH WORK PACKAGES TO NETWORKS

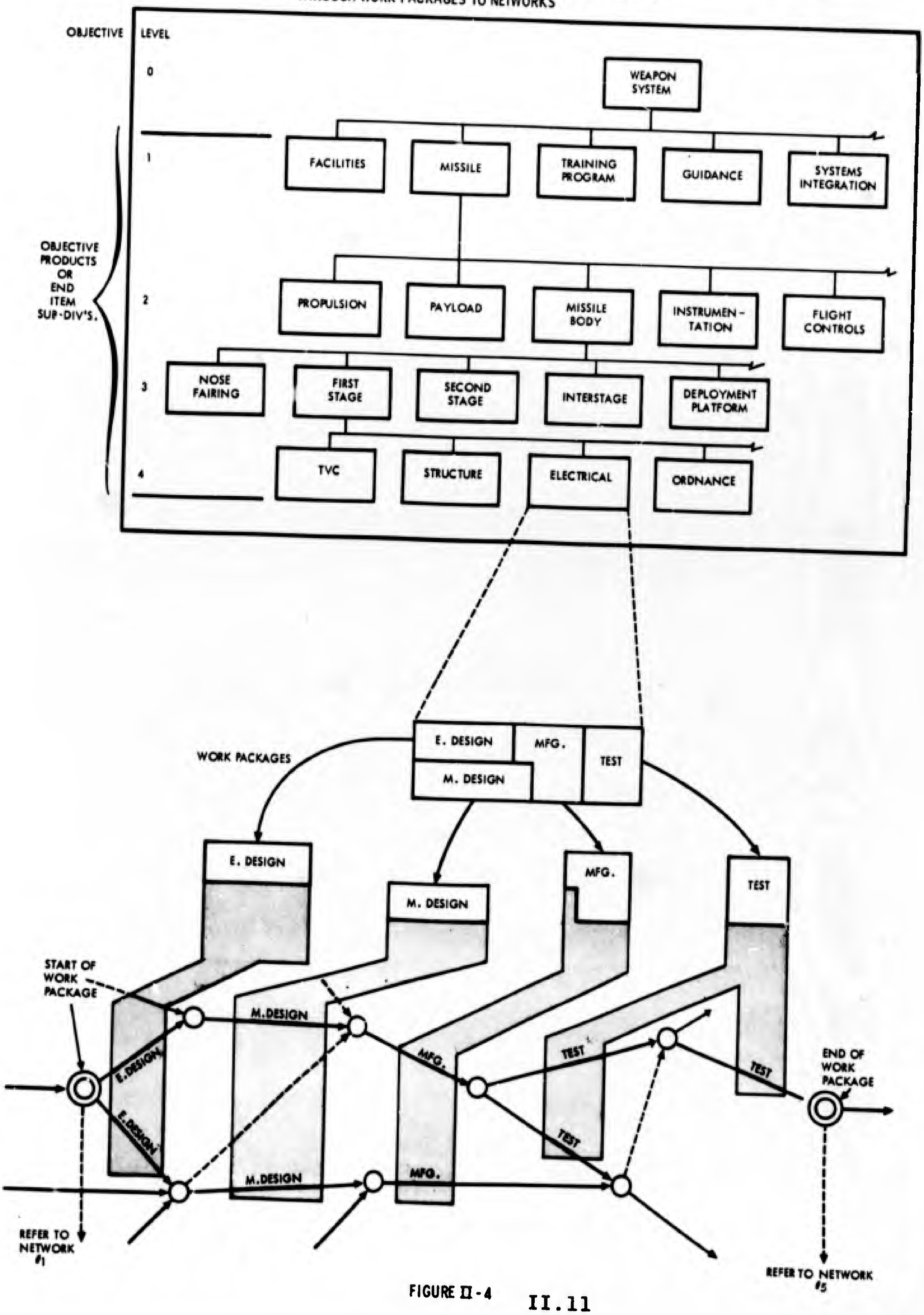


FIGURE II-4

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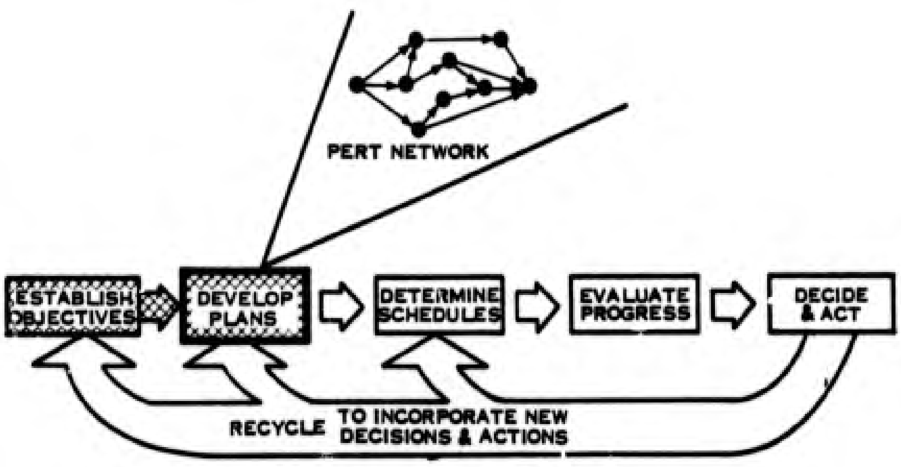
CHAPTER III

PLANNING TO ATTAIN OBJECTIVES



A plan consists of documentation, preferably made before an operation begins, which delineates the various tasks required to achieve a predetermined objective. The manner and order in which these tasks are to be accomplished is indicated. The plan shows what task is expected of each component of the team organization. The plan is converted to a schedule when it is assigned to calendar periods or points of time in order to meet an objective date. The schedule dictates when this task must be started and completed. In PERT, the function of planning is separated clearly from that of scheduling. When a plan is converted to a schedule a base is established against which to evaluate progress and to assess the impact of uncertainty in a program.

Once the program objectives are identified and translated into the product-oriented work breakdown structure, a work plan for achieving each objective in the most desirable manner must be developed. Since not all activities can begin simultaneously, due to technical constraints and resource limitations, they must be put in logical sequence according to the desired relationships and interdependencies. They are shown in a schematic form on the PERT network.

* * * * * *

A. PERT Networks

The PERT network is a flow diagram consisting of the activities and events which must be accomplished to reach the program objectives showing their planned sequences of accomplishment, interdependencies, and interrelationships. The network must be comprehensive and include all significant interdependencies and interactions required to perform all the work packages in the program. However, judgment must be exercised to limit the level of detail to that which will best serve the objectives of management.

After the network plan has been developed, managers may use network information to assist in determining the current status, predicting future status, and re-planning as required to meet current objectives.

1. Network Responsibilities

The development of the PERT network is inseparable from the function of planning as understood by management. The PERT network must be created by personnel in the manager's organization who are normally responsible to him for performance of the program planning function, If responsibilities are clearly assigned to these personnel, the network will be more complete and accurate than plans prepared in other forms and formats. 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.

The network must be developed and maintained 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. A valid network must be based upon direction by higher levels of management.

2. Events

By definition, an event is a specific definable achievement, either the beginning of or the completion of one or more activities. Events, as shown on Figure III.1, are meaningful, specific accomplishments, either physical or intellectual, which do not consume time or resources but rather occur at points in time. Any geometric figures may be used to represent events in the network.

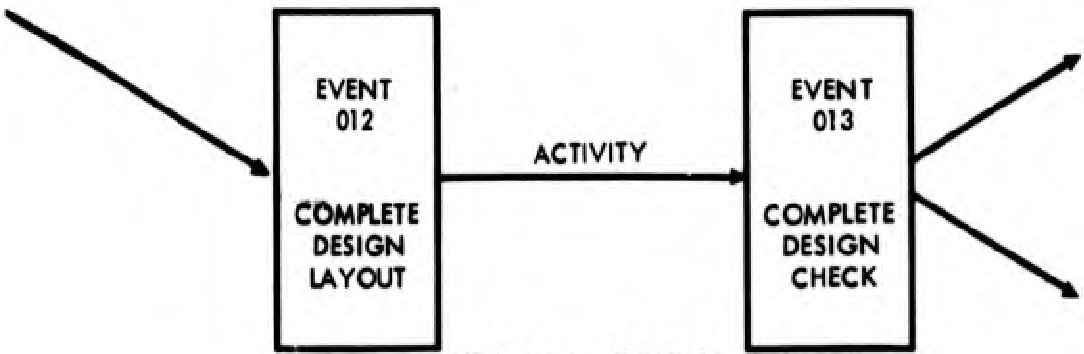


Figure III-1

Events are the basis for status monitoring and often for partially describing the activities which lie between them. In many cases, they may be simply "Begin Activity X" or "Complete Activity X." In other cases, they may represent the accomplishment or beginning of a significant phase of the total job, or the transfer of responsibility from one organization to another. Often they may be points of decision, where alternatives are eliminated or chosen. In addition, events often indicate the completion or initiation of several activities.

Care must be exercised that an event is clearly defined and therefore meaningful. For instance, the event might be "systems budget estimates completed," and the evidence would be the release of the document by the responsible office. In order to be assured that the event is truly defined, it is desirable to specify the evidence of accomplishment and the reporting office when initially describing the event.

3. Activities

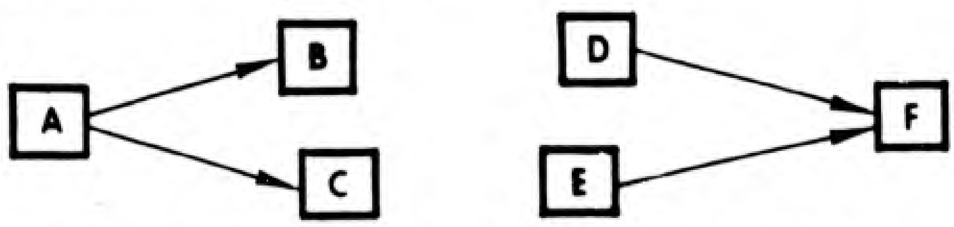
An activity is a task or job to be done, characterized by persons using resources for some period of time in order to accomplish a stated objective. Such an activity might be preparing, researching, building, negotiating, deciding, testing, or other similar actions. Activities are the channels for the vital "flow" of the network, and it is this vital flow of human effort, use of materials and facilities, investment, expenses, and progress toward a timed objective that is controlled by the manager.

An activity is represented on a PERT network by an arrow which links two successive events, as shown in Figure III-1. An activity, normally time consuming, may simply represent a connection or interdependency between two events on the network.

The rules of logic for the PERT network require that activities be clearly defined. They 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. Further, the activities in a series with each other must also be independent; that is, the time which one takes should not affect the time which any of the following take. Networks are based on the assumption that an activity cannot be started until its preceding event has occurred. The event succeeding an activity cannot occur until all activities leading to the event are accomplished.

4. Constraints

The activities and event relationships illustrated in Figure III-2 are termed constraints



EVENT A CONSTRAINS ACTIVITIES A—B AND A—C.

ACTIVITIES D—F AND E—F CONSTRAIN EVENT F.

Figure III-2

In some instances, there is no specific activity required between two events connected by a constraint line, and the result may be a "zero-time" activity, also known as "dummy" activities and denoted by a broken line. Such constraint relations may be used to tie the completion of several activities to the beginning of a single activity, or vice versa. Constraints 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. Figure III-3 illustrates a zero-time activity between two events to show the completion of one activity and the beginning of another activity.

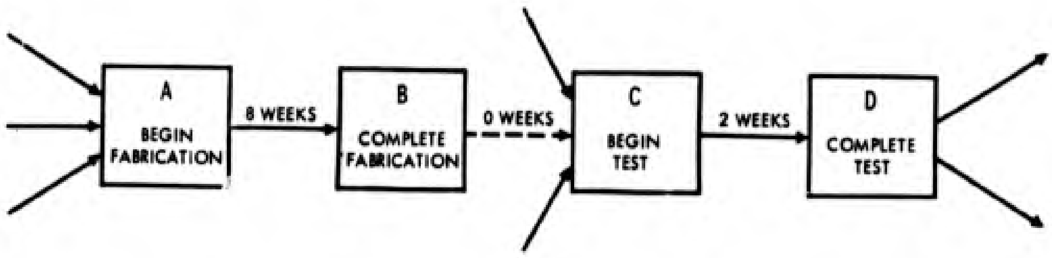


Figure III-3

B. The Selection of Program Events

Once the objectives are defined, the means of attaining them must be devised. Specifically, a plan in the form of a PERT network is evolved. The first step in this process is the identification and selection of events of the project. Many events may already have been established by earlier and higher level planning processes. However, additional major events, peculiar to the particular project, will also have to be identified.

Along with the work breakdown structure, these events serve as the base upon which the networks are developed. Additionally, they provide anchor points for the establishment of schedules. It can be considered that the work breakdown structure is a vertical framework for the networks, identifying the project objectives in the form of end items at all levels of detail. When sequentially arranged, these events constitute a horizontal framework for the networks, outlining the work-phased plan for the attainment of these objectives. The adopted events should include not only those events depicting the progress of the design and hardware, but also key management-decision or action events and the major logistic events involved in making the system operational. They should also include events corresponding to the determination by tests that major performance specifications on major hardware items have been met successfully. These serve as gross planning markers during the conceptual phase of a program. When the program is defined, they also serve as control points, establishing standards against which actual or anticipated performance can be measured.

Before a network can serve as an efficient tool, the major program events on which it is based must be clearly established. These should be events that are significant to the completion of the total program. Each of these events must clearly be identified with:

- what is accomplished or expected to be accomplished;
- the organization responsible for insuring its accomplishment; and
- the time allowed, or schedule for completion.

The identification and selection of events are an evolutionary process, beginning with the establishment of events by government and concluding with the identification of program events within the operating departments of the contractor. The networks at any management level will contain all the events established at higher levels.

C. Program Management Network

A Program Management Network is a top-level network, reflecting the total system acquisition plan. This network, in preliminary form, is initially prepared by the government program manager's office as part of the pre-contractual planning effort.

This network, which describes the development, production, logistics support, training, and operation of the system, must reflect coordination of the responsible organizations. Therefore, it is necessary for the operating organization to provide an operations plan, the logistics organization to provide a logistics plan, and the training organization to provide a personnel and training plan.

Upon completion of this network, directed schedule dates are assigned to selected events, such as Initial Operating Capability, Category I Test, Critical Design Review, etc., to guide the contractors in preparing a related plan including the intermediate objectives required for the accomplishment of the designated tasks and milestones.

A preliminary Program Management Network is included in the Request for Proposal (RFP) and provides the contractor with a perspective of how his particular effort relates to the total program. Each contractor expands the preliminary Program Management Network based on the work breakdown structure, related work statement, and master plan and schedule. The network is progressively expanded by identifying all internal events of major significance that must occur to meet the proposed plan. Each of the contractor's internal organizations then prepares subnetworks which portray the logical relationships among those events for which it is primarily responsible. The subnetworks are then integrated into one network from which the contractor's proposal network is derived. Since this network will be considered when evaluating the contractor's response, the amount of detail contained in the network should be consistent with the level of detail defined by the government's work statement. Calculated network event dates are then compared with the government schedules, and appropriate revisions are made to the activity times and to the network logic. When all time differences are resolved, the network is ready for inclusion in the contractor's proposal.

The Program Management Network is an overall or simplified network; yet, it must contain the level of detail required by the program manager for planning and control. When properly constructed, this single network should enable the manager's staff to survey the entire program and quickly ascertain the critical schedule areas. The Program Management Network is primarily event-and-date oriented (i.e., concerned with identifying and tying together all the events of the program and their scheduled dates).

D. Interrelated Networks

In most large programs it will be desirable to prepare a number of separate networks describing individual segments of a program and delineating the detailed plan of work in these areas.

Although the basic logic for the construction of a network is the same regardless of its use in a program, there are differences in the density and types of information included in the networks prepared in different phases and levels of programs.

The networks which are commonly recognized in programs are the Program Management Network and the detailed networks. These networks may be:

- summary networks, which have been prepared from more detailed networks by retaining selected events, including those required to maintain program logic; or

- integrated networks, which have been constructed by connecting two or more detailed networks together.

On some programs, the Program Management Network is a program status display device which was prepared by summarization of several levels of detailed networks. At the opposite extreme are programs which use one Program Management Network as the single network for all levels of government/contractor management. For example:

- a 500-activity Program Management Network is maintained by an integrating contractor and is submitted regularly to the government with time status analysis. The Program Management Network is updated mechanically by integrating the summary networks received from the associate contractors. Detailed networks support eighty percent of the summary networks.

- a 5000-activity Program Management Network is maintained and updated by a government agency. Activity flow times are submitted by contractors for government processing. Detailed networks are prepared by the government or contractors in key areas of the network.

This is only an illustration of a possible approach. Each application should be evaluated on an individual basis to satisfy its program requirements.

E. Establishment of Interface Events

It is imperative that interface events be identified, defined, scheduled, and controlled in an orderly manner. Interface events must be identified before the networks are completed and provided for at each level, working from the top to the bottom.

An interface event is an event which signals the necessary transfer of responsibility, end items, or information from one part of the plan to another. Examples of interface events are the receipt of an item (hardware, drawing, specification), or the release of engineering drawings to manufacturing. Figure III-4 is a simplified example of interfaces between networks. In this example, Event 168 is constrained by an event on another network (No. 1) while Event 177 is constraining an event on still another network (No. 3). (For simplicity and ease of identification, special geometric figures can be utilized to denote interfaces; e.g., double outlines, hexagons, etc.) In some programs it is useful to maintain a special network for the program as a whole which shows only the interface events. In more complex programs in which the number of interface events is too large to show on an interface network, it has been found helpful to use computers to maintain interface information.

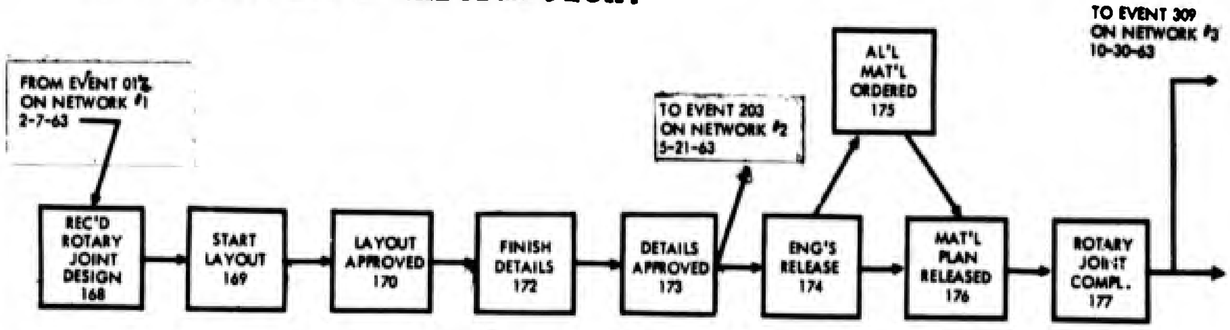


Figure III-4

Careful interface identification and control must exist at all management levels down to and including the contractor's operating departments. The successful integration of networks and program plans is dependent upon these connecting points. Their identification and control must, therefore, begin in the planning phase of a program when responsibility for accomplishment of related major program elements is determined. During the planning phase, the government agencies and the contractor must participate in interface coordination meetings to identify, precisely define, and schedule the major interface events of the Program Management Network.

To assure that technical descriptions of interface events are not subject to widely divergent interpretations by program participants, the government program manager should standardize terminology through the preparation and distribution of a glossary or dictionary defining these common tasks.

The event coordination process should continue with lessening activity throughout the acquisition phase, although coordination meetings will generally not be required after the program is stabilized.

F. Detailed Networks

Subsequent to contract award, each successful contractor is required to prepare a detailed network based on the proposal network, the detailed work breakdown structure, the additional government events required for program control purposes, master schedules, and the work statement. Since these detailed networks are the basis for status reporting to contractor and government managers, they must realistically respond to program progress. They should be prepared in sufficient detail to enable managers at operating levels of the program to monitor and control the planning and scheduling of their areas of responsibility.

The amount of detail on these networks must be carefully controlled. The depth to which the detail is carried is at least that level required to define the start and completion of each work package. The detailed networks should contain such additional events and activities as are required to present a complete plan. If too much detail is permitted, the networks become large and unwieldly, incorporation of changes becomes extremely involved, and updating becomes too time consuming. However, if the networks are too sketchy, too much time elapses between monitoring points, and there is loss of control.

The degree of detail in the networks need not be the same for all parts of the network. For instance, that part of the plan in the near future should be maintained in more detail than the parts of the plan in the distant future. As time passes, more detail is added gradually to the near term parts of the network. This method is natural, 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 the maintenance of more detail for the most critical areas of the program.

At this point, the networks should be reviewed by both government and contractor managers to assure that all requirements are distinctly portrayed. If unplanned efforts are discovered during the review, the network and program plans must be modified to reflect these changes.

When the networks are approved, the appropriate contractor personnel estimate the activity elapsed times. The network is then processed, and the results are analyzed to evaluate the directed event dates. Replanning and processing are repeated until the activity times and the schedules are in agreement.

G. <u>Procedures</u>

The fundamental rule of logic for network construction lies in the observance of the constraint relationship.

There are several approaches to network construction. One approach requires the network (or network segment for a task) be developed by beginning with the start event and working toward the final or end event. Another approach requires starting with the end event and working backwards to the start event. A third approach involves the construction of several small networks, say 8 to 10 events each, one for each end item in a work breakdown structure. Using this approach, each subnetwork is simple enough to construct since it does not require a rigid order of assembly. The subnetworks are then assembled and joined together with related activities.

In constructing the network, certain other mechanical procedures should be carefully observed:

- all activity paths must be completed. Activities may never represent alternative paths from one event to another, but mandatory tasks that have to be accomplished before the succeeding event can occur;
- the activities in a series must be independent; i.e., the time which one activity takes must not affect the time which any other activity in the series takes.
- an event cannot occur until every activity preceding it has been completed;
- an activity succeeding an event cannot be started until the event has occurred;
- an event cannot occur twice, nor supersede itself; i.e., a path of activities may not form a loop that returns to any event;
- only one activity or constraint line may connect any pair of events.

1. <u>An Example of Network Development</u>

In the example network to be developed, the delivery of the first operational unit of a project is the objective, or end event. The event is placed on the network worksheet at the far right as depicted below. The activities that must be accomplished to complete the end event are added, and the events which must be complete before these activities can begin are then added as beginning events. This procedure is repeated until the "Program Start" or first event of the network is reached.

Although the network does suggest the chronology of events from left to right, the length of the activity line is not proportional to the time estimated to complete it. For this reason, it is best not to attempt to place a time scale on the network.

No time estimates are made during the initial networking phase. The entire effort is concentrated upon ensuring that all necessary events and activities are included in their proper sequence and that their interdependencies are correctly reflected.

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 is the objective, or end event. The event is placed on the network worksheet at the far right, as depicted in Figure III-5.

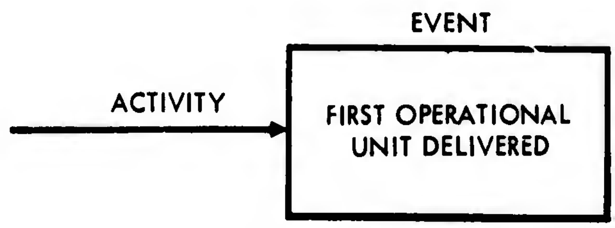


Figure III-5

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. Thus, to achieve the delivery of the first operational unit, all five components must be developed first. Figure III-6 shows the dependency of completion of the first unit on the delivery of the five components.

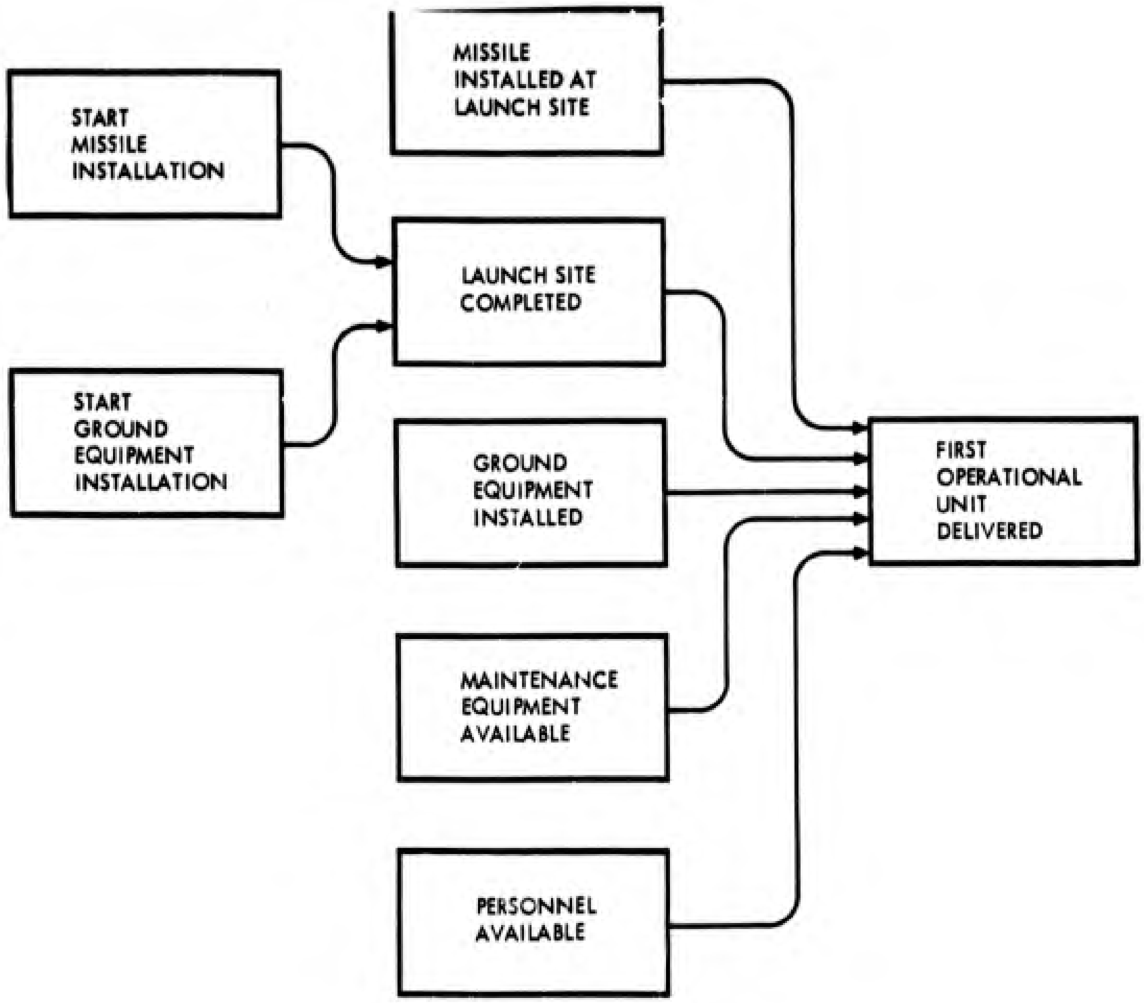


FIGURE III-6

Further analysis reveals, however, that the launch site may not be considered complete until the missile and ground equipment have been installed.

Earlier activities on the network (Figure III-7) indicate that the Site Construction Complete event, constrains both the Start Missile Installation and the Start Ground Equipment Installation as well as the Launch Site Completion events.

At this point, the series of activities and events that lead up to each of the events now existing in the network may be established. In establishing the activities and events preceding the Missile on Dock at Site event, the planner might follow a sequence of thoughts such as the following:

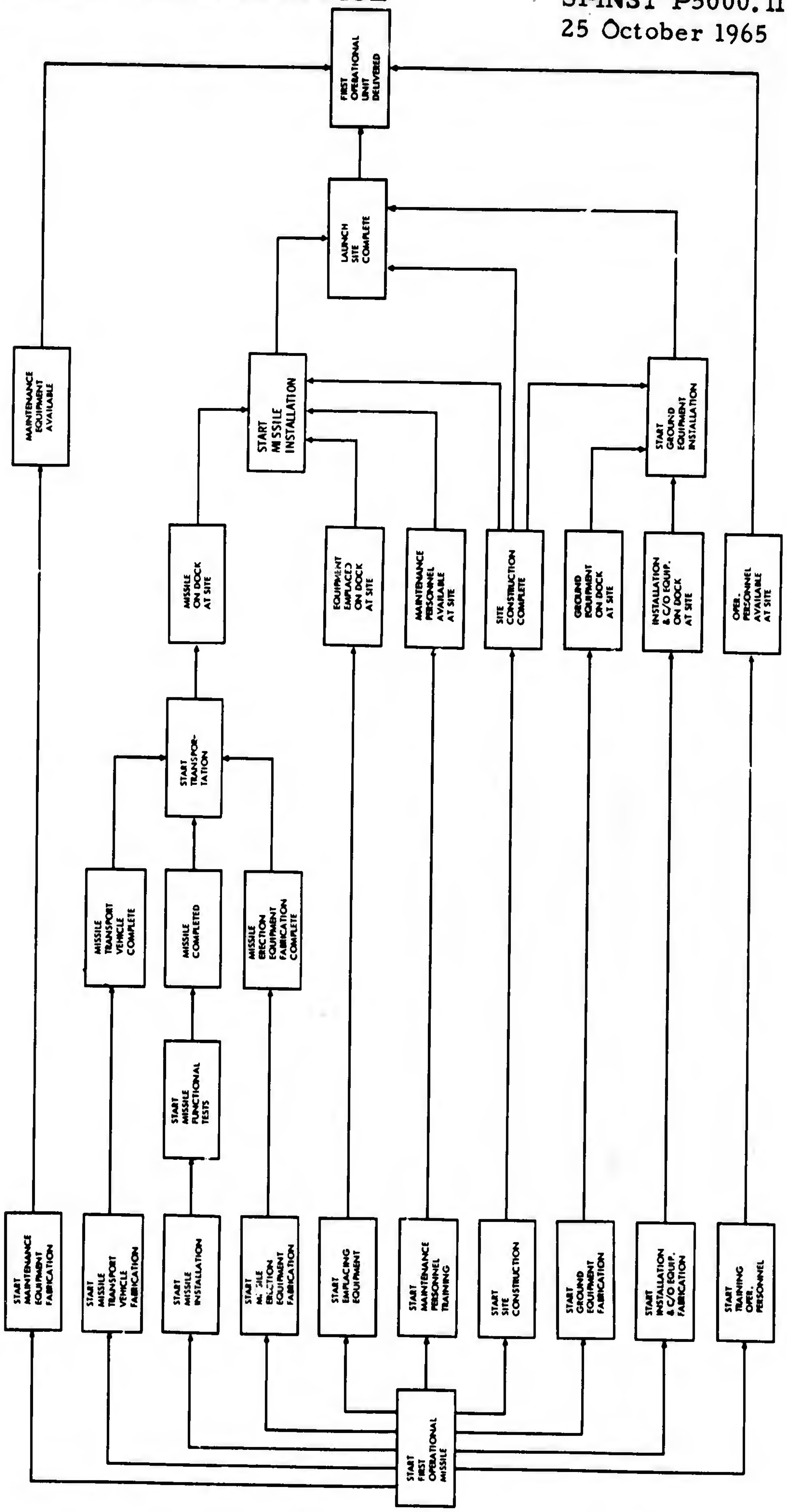


FIGURE III-7 COMPLETED DETAILED NETWORK

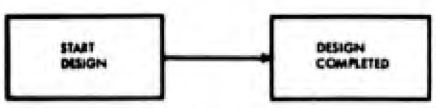
- "What is necessary to get the missile on dock at the site?" The missile, a transportation vehicle, and equipment to place the missile on the vehicle are required. All of these must be available and, consequently, are shown as completed events in Figure III-7.

- "What is necessary to have the missile completed for loading?" It needs to be tested (Figure III-7).

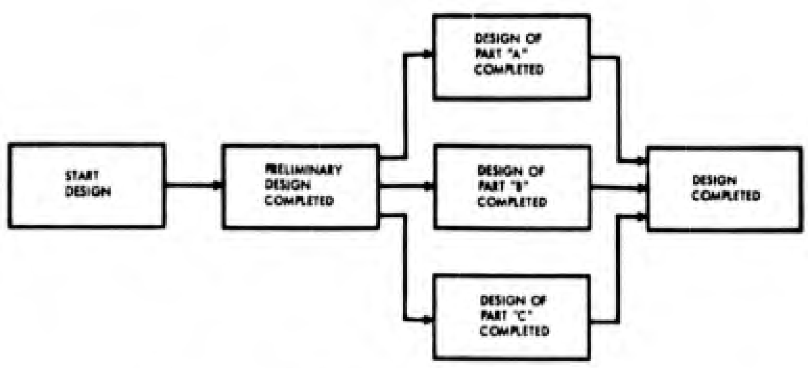
- "What is necessary to start the testing operation?" The fabrication of the vehicle must be completed.

This analysis results in a progressively more complex network eventually leading back to the start event. The predecessor of some events will be start events; e.g., Operating Personnel Available at Site is constrained by Start Training of Operating Personnel.

Figure III-8 is an example of a simple, or broadly defined, network which might be drawn in the early planning phase of a program. Detail may be added progressively by inserting related events between those already established in the broad network. The figure below illustrates this process.



EXAMPLE OF SIMPLE ACTIVITY



INSERTION OF ADDITIONAL DETAIL

FIGURE III-8

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

The following network segment, Figure III-9, illustrates these dependencies and indicates that certain preliminary missile data must be made available to the group designing handling equipment before they can begin detailed design.

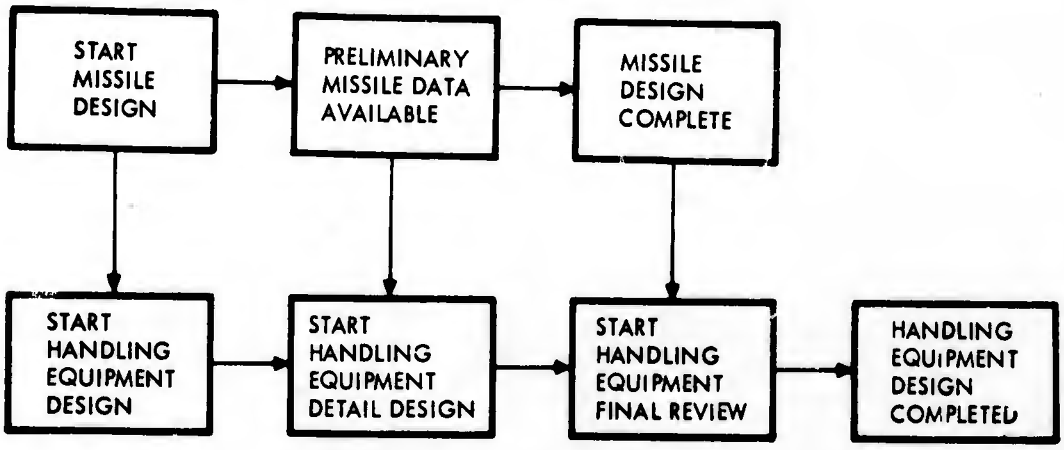


FIGURE III-9

A series of activities can be replanned in parallel. The following shows an example of a network segment for which this has been done.

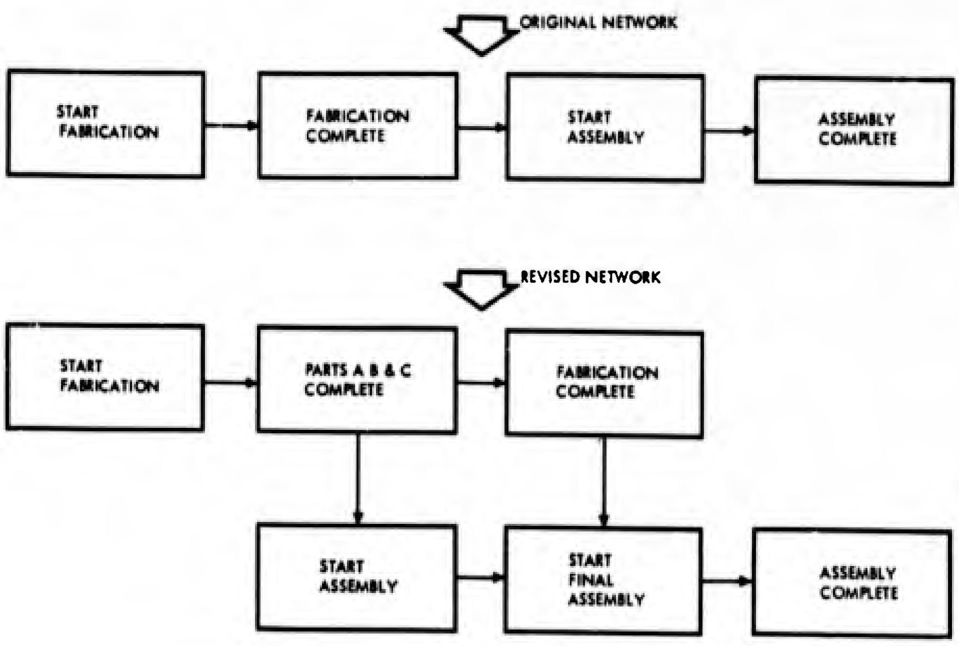


FIGURE III-10

Greater visibility of dependencies is displayed in Figure III.11. Note that events which are internal to a function have been added for the sole purpose of expressing interrelationships with other functions. The initial layout of the sample network is now completed.

2. Event and Activity Definition

Precise event identification and definition are necessary to properly determine event occurrence which indicates the actual progress made in the program. Correct activity identification and definition are equally important so that the best possible time and resource estimates can be obtained. It is good practice to define explicitly each activity and each event while the network is being developed and to list the responsible office and the evidence of activity completion.

3. Time Estimating and Network Calculations

Concepts and Principles. The estimated time required to perform each activity in the network is based on the following:

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

This time value 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.

Time estimates are normally given in weeks and tenths of weeks, but depending on the program, other time units (e.g., days or months) may be used. For the majority of applications, however, the week is commonly used.

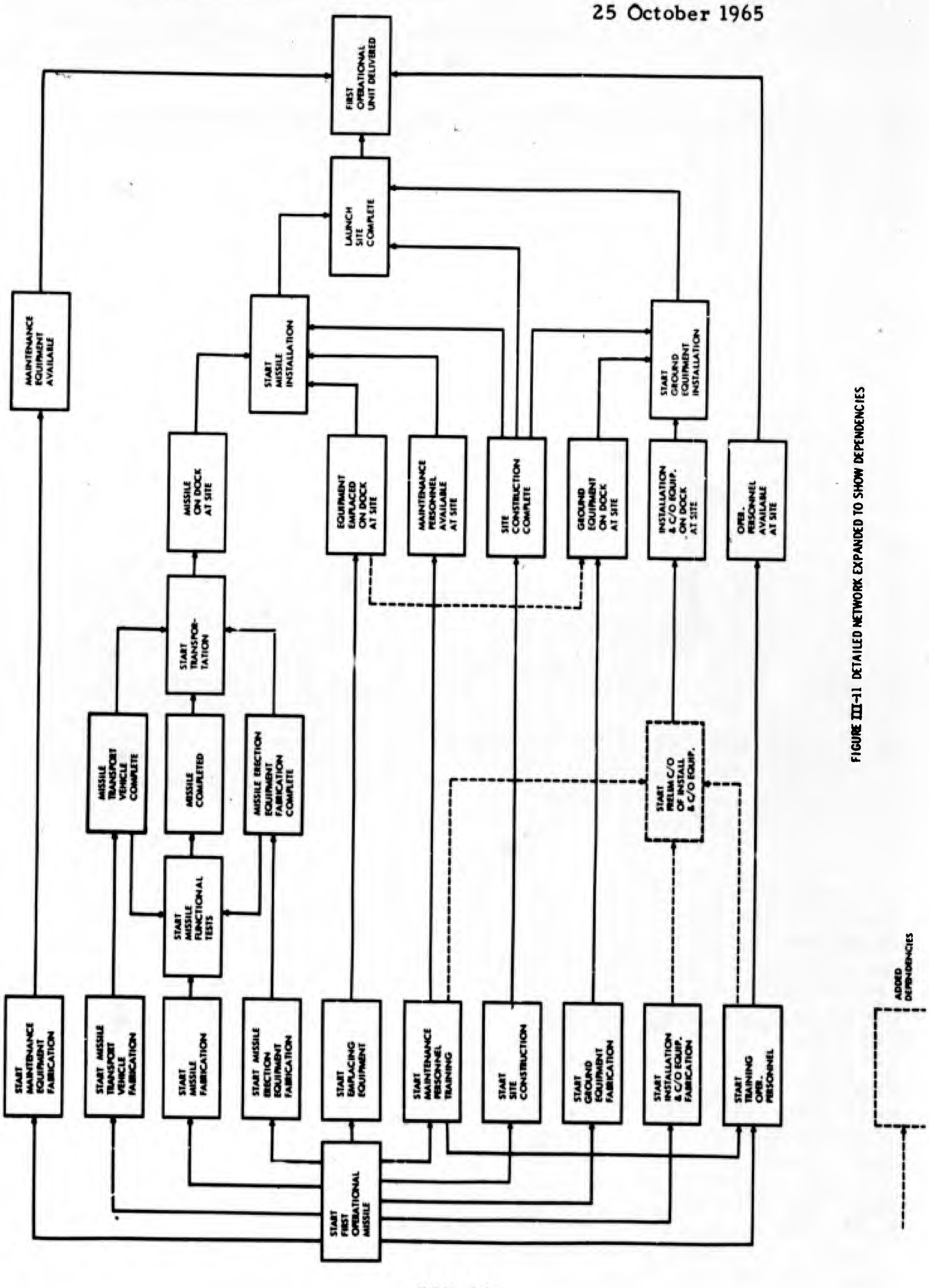


FIGURE III-11 DETAILED NETWORK EXPANDED TO SHOW DEPENDENCIES

Each estimate should be based on all known factors affecting completion of the activity under normal conditions. As the program progresses, the estimates should be reviewed periodically and adjusted for changing conditions.

4. Expected Elapsed Time (t_e) [1]

Where substantial uncertainty is involved in the duration of activities, one method which PERT can utilize is a procedure involving three time estimates. The time required to complete some future task is more realistically stated in terms of a likelihood rather than a positive assurance. To apply this concept in a probability sense, three time estimates are stated as a future range of time, during which the activity may be completed. In this case, Optimistic,[1] Most Likely,[1] and Pessimistic time[1] estimates should be used. They can represent points on a distribution curve where the mode is the 'most likely,' and where the extremes (optimistic and pessimistic) correspond to the probability distribution of time involved to complete the activity.

An estimator may elect to use three time estimates depending upon his judgment as to its usefulness to reflect the degree of uncertainty. When a single time estimate is used, this evidences assurance on the part of the estimator that uncertainty is not a problem in carrying out accomplishment of the activity. If the state of the art is being explored, many complex human and organizational interdependencies are required -- all making for higher uncertainty of the successful accomplishment of the activity -- then three time estimates may be advantageous to use.

When a single time estimate is given for an activity, it is used in all subsequent calculations in the same manner as the expected elapsed time (t_e) calculated from the three time estimates. In subsequent discussion then, t_e can be construed either as a single time estimate or as though derived from three time estimates. Time estimates must be as accurate as possible, since all other calculations depend upon them.

Activities of high uncertainty should be identified for the benefit of all users of the data such as schedulers.

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[1]See Glossary

5. Earliest Expected Time (T_E) [1]

After determining the expected elapsed time for each activity, these expected times are then accumulated from the start through the completion of the various network paths. In this way the earliest expected time for each event in the paths and total elapsed time for each path is determined. The earliest expected time for program completion is identified by the T_E for the final event of the network.

6. Latest Allowable Time (T_L) [1]

Latest allowable times are then determined for each event in the network starting with a predetermined time (often T_E=T_L) for the end event and subtracting the expected elapsed time estimates (t_e), moving backward through the various network paths. The T_L (latest allowable time) for each event in the network will then indicate the latest time that a particular event can be started without causing the end event to slip beyond the predetermined target time.

7. Slack and Critical Paths

The concept of "slack" and "critical path" are interrelated and applies to a network path and not to an individual activity (except in the one-activity path).

Slack is the difference between the latest allowable time (T_L) and the earliest expected time (T_E). In this respect, each path throughout the network has a measurable "degree of criticality" which can be either positive, zero or negative. This path of criticality can be event or activity oriented. The selection of the computer output option will produce the desired listing. The listing desired is normally a function of the level of management reviewing the data.

By definition, the longest time path or the most time-consuming path in the network is called the critical path. All other paths which are of less time duration than the critical path are called "subcritical paths" or "slack paths."

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[1]See Glossary

While, by definition, positive slack is "time to spare" it should be added that it is "time to manage" or "time requiring management." Unnecessary funds can be expended and unneeded risks taken unless management pays particular attention to network paths exhibiting large amounts of positive slack.

8. Activity Slack

The difference in time, comparing the earliest expected time (T_E) and the latest allowable time (T_L) for a given activity. This slack indicates the range of time within which an activity can be scheduled for completion provided the plan agrees with the directed dates for the overall plan.

9. Event Slack

The difference in time, comparing the earliest expected time (T_E) and the latest allowable time (T_L) for an event. In instances where more than one activity constrains the completion of an event, the slack for the event is determined by that activity which lies on the most critical path to that event (one that yields the least algebraic slack for that event).

10. Directed Date

A date established by the cognizant authority for specific events or the end event(s) of a program.

11. Variance[1]

Following the determination (or statistical derivation) of activity elapsed times (t_e), a statistical variance can be derived for each activity by solving $\sigma^2 = \left(\frac{b-a}{6}\right)^2$. Variance may be descriptive of uncertainty associated with the three time estimate interval. A large variance implies greater uncertainty of an event's accomplishment. Use of variance is made only when multiple time estimates of activities and events are used and in reality is the communication media between the planner and the scheduler. That is, the scheduler should not shorten the schedule beyond

[1]See Glossary

the t_e value when the variance is small. On the other hand, care should be exercised in scheduling when the variance in large sense does indicate an area of technical uncertainty.

H. Evaluation and Refinement of the Plan

From the time estimates, the expected elapsed times (t_e), the earliest expected times (T_E), the latest allowable times (T_L), slack (T_L-T_E), and the critical path can be determined. From this data, the feasibility of the plan can be judged. Subsequently, the data can be modified to a calendar date if desired for a more thorough analysis.

The first consideration in the evaluation of the plan is whether the earliest expected date of the end event is on or before the directed date for the end of the project. Frequently, a directed completion date (T_D) for the entire program is established by government or industry. In many cases, this directed completion date may be earlier in time than the earliest expected time (T_E) for the initial planning networks. Under these circumstances, the total time required by the network plans must be reduced, if possible, to equal or be less than the directed completion date. Possible ways of shortening the planned time for the programs are:

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

Consideration of the network plan and possible replanning should center about the critical path and the sub-critical paths. In many cases, several paths will have nearly the same slack as the critical path. Paths of large positive slack should also be identified and investigated to determine whether the planned level of effort in that area can be reduced and the resources more appropriately used in more critical areas.

Most often, evaluation reveals that the plan is not satisfactory, and revisions to it must be made. However, the network should not be changed arbitrarily to meet desired dates, but genuine replanning of the effort should take place. Some 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;

- optimizing application of resources on an established network plan.

These methods make use of PERT as a simulation technique. PERT can be used where several alternative plans for arriving at the same end objective will exist. PERT, likewise, can be used to 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.

Following the analysis and replanning, new time estimates reflecting the revised plan are made. Once more the time estimates are processed, and the output data is prepared for analysis.

This process is iterative and continues until a plan resulting in sufficient conformity with directed or desired dates is obtained. This plan, expressed in PERT network form, provides the basis for management determination of the project schedules.

Subsequent to the establishment of an acceptable planned schedule the conversion to a scheduled plan can be undertaken. The simplest conversion is the changing to the earliest expected time (t_e) to a scheduled elapsed time (t_s) thereby developing the earliest completion time (S_E) and latest completion time (S_L) similar to the earliest expected time (T_E) and latest allowable time (T_L). When firm dates have been established either for the beginning or the ending of the program, or intermediate events the planned schedule or scheduled plan can be converted to a calendar date base and a costed planned schedule can be developed.

Realistically management normally requires more rigid scheduling and costing of objectives beyond those dictated in order to exercise true program control. As a result scheduling which involves the allocation of resources (manpower, facilities and dollars) in any multi-project environment is not a direct conversion of a planned schedule to a scheduled plan because of the competition for these resources. Therefore, the schedule is established based on the availability of the resources. It is the costed scheduled plan which represents the true cost of any program since the competition for resources may increase the overall cost. These costs are affected by the scheduled date of the end item and by the scheduled dates of any intermediate events.

Although the information and symbols associated with the conversion of a planned schedule to a scheduled plan are similar, rescheduling due to a slack indication is not as simple as one would suspect. Rescheduling in the areas of a scheduled plan is definitely more complex and involves the higher levels of management.

I. Summarization and Integration of Networks

Since detailed networks are constructed to the depth required for control at the operating departmental level, they generally contain more detail than is required at higher levels of management. Therefore, the detailed networks are usually summarized to provide the upper levels with the optimum detail needed to monitor and control their areas of responsibility. The resultant summary network is logically consistent with the detailed networks and contains the preselected government events, contractor events, and interfaces that are essential for higher level management. Figure III-12a illustrates the summary process.

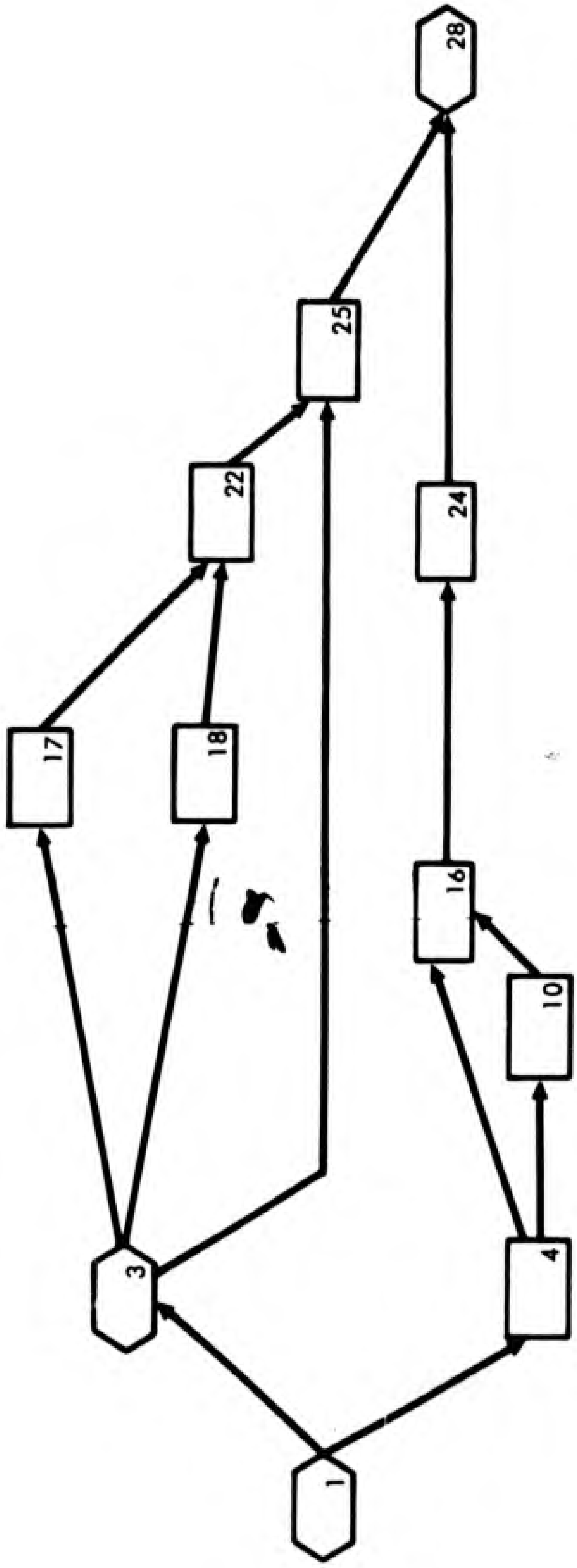
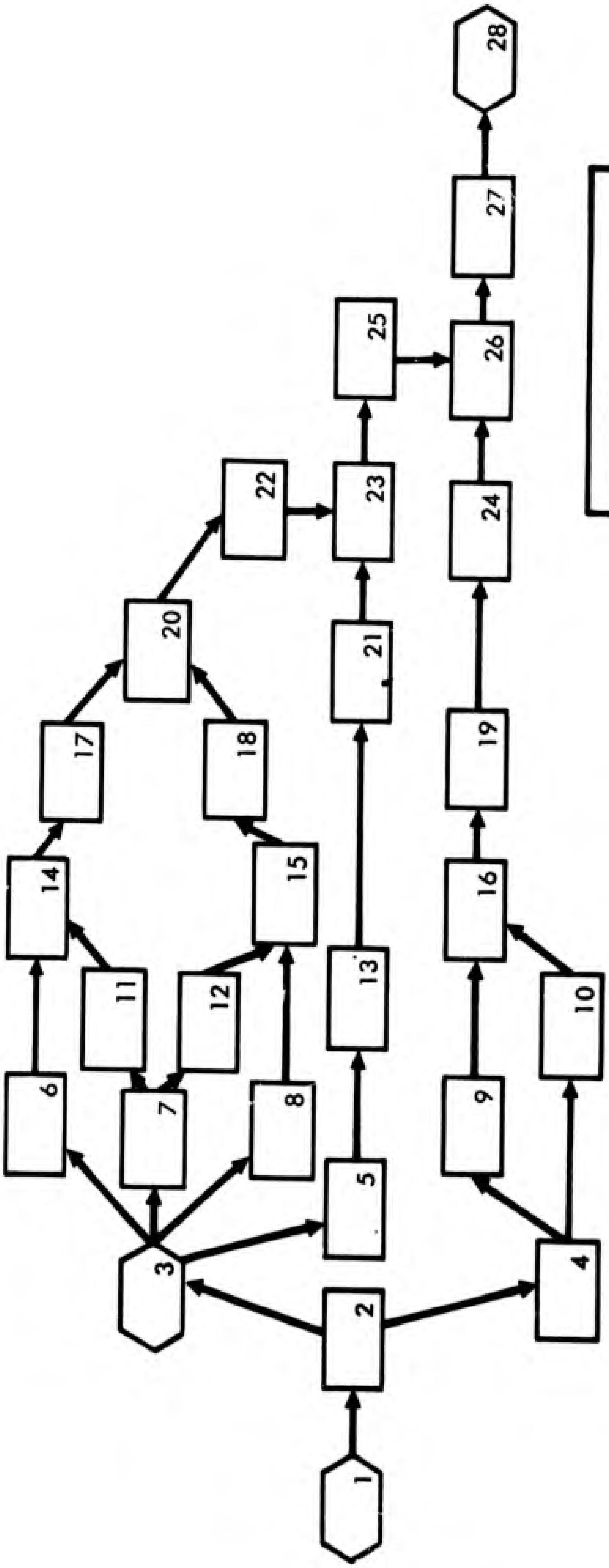


FIGURE III-12 SAMPLE SUMMARY NETWORK (LIFT TO COMPARE WITH DETAILED NETWORK BELOW)



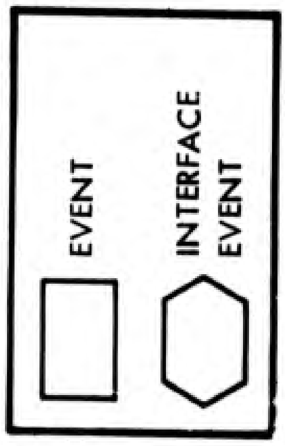


FIGURE III-12a SAMPLE DETAILED NETWORK

After the networks are summarized they should be reviewed by the responsible government and contractor managers to assure that:

- the logic of the detailed networks was retained;

- time values on the summary network are mathematically equivalent to the time values on the detailed networks; and,

- interface events which signify a relationship or transfer of responsibility to another network are retained.

The final step in networking is the integration of summary networks into a total Program Management Network. Each participating government agency (Logistics Command, Training Command, Operating Command, etc.) and the central designated agency are responsible for the integration process. The central agency may be a prime contractor, integrating contractor, a participating government agency, or the government itself. The resultant network should provide an over-view of the total program plan and progress. It also provides a means for identification of potential problem areas and for evaluation of alternatives for corrective or preventative action.

J. Sample Calculation

To fully understand and analyze PERT output data, it is essential that one be familiar with the logic and be capable of accomplishing the calculations manually. These calculations can be accomplished on the network itself provided the network is extremely simple. However, this simplicity does not exist in normal day-to-day operations.

Figure III.13 represents a simplified high management level network. The information presented would normally be expected as basic input. Subsequent to the approval of these inter-relationships and time estimates based on coordination, the information can be tabulated and the necessary calculations completed. For simplicity, the calculations are illustrated in Figure III.14.

Starting with the end event and proceeding backward through the network and considering the activities and events in a counter-clockwise direction, the predecessor event when a single activity generates from it is listed, in this case events 9 and 10, together with the time estimates for each activity. This process is followed by listing in the successor column the previous predecessor, namely 9 with its predecessors, 1 and 8. Then the predecessor 10 is listed since it has only one activity from it and its predecessors are 1 and 8. The next successor would be 1; however, since it has two activities leading from it, we so note it as, event 1 has 2 activities leading from it and we have noted it once; i.e., written 1 (2) 1. The next successor would then be 8; however, it also has two activities leading from it and we so note it; 8 (2) 1. The next successor would again be 1 and we can now use it since we had 1 (2) 1 which is now 1 (2) 2 balancing the number of activities leading from it as to the number of times we have analyzed the event. Therefore, from successor 1 we have the predecessor 0. The next successor should be 8. Since we now balance our observance of the previous rule, we can use it and the predecessor is 6. The next successor would be 0; however, it has three activities leading from it and it is noted 0 (3) 1. The next successor is 6, it has one activity leading from it; however, its predecessors are 2, 3, and 7.

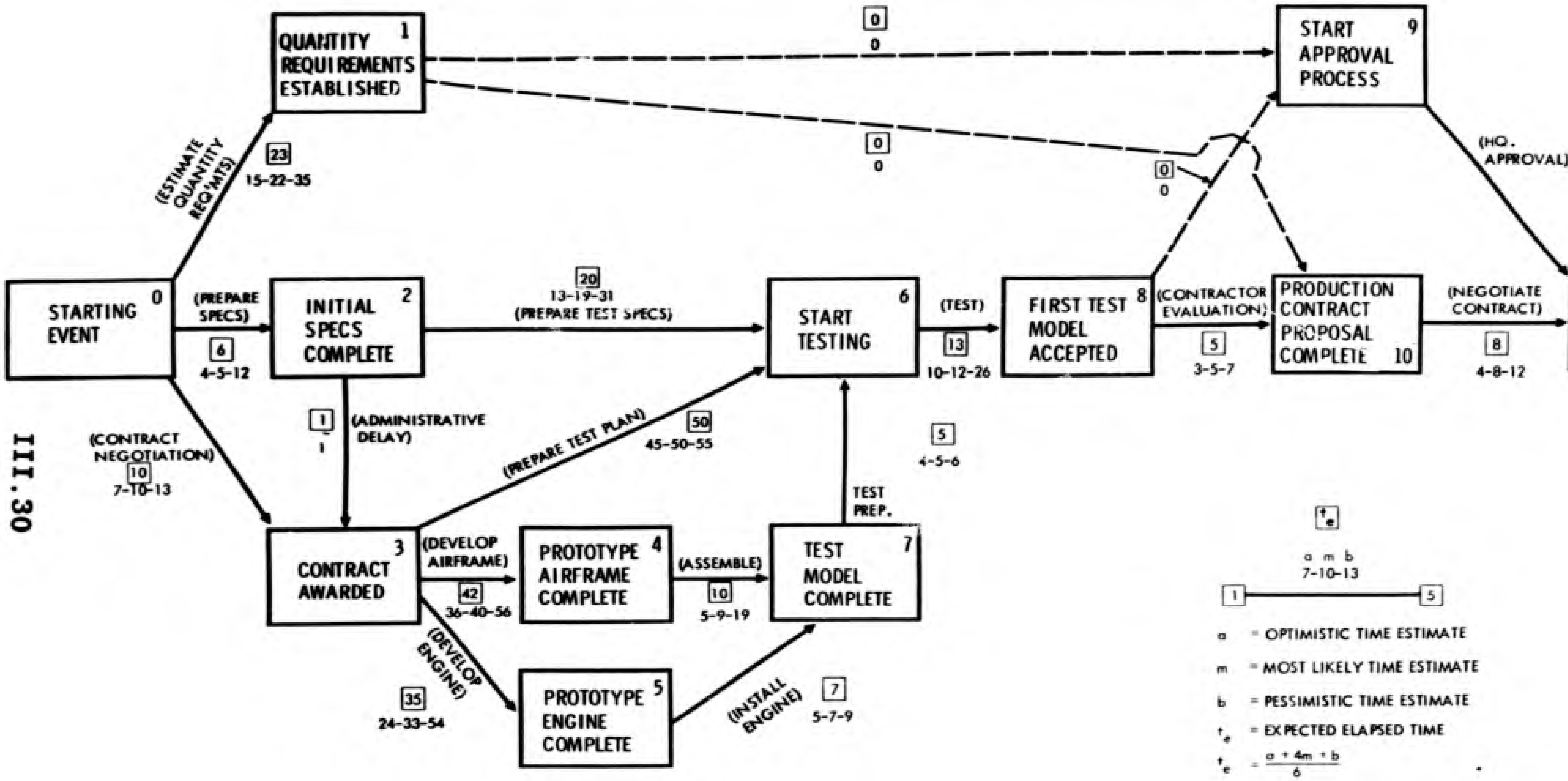


FIGURE III-13 PERT NETWORK WITH TIME ESTIMATES & EXPECTED ELAPSED TIMES

Successor	Predecessor	Optimistic	Most Likely	Pessimistic	Expected Elapsed Time te	Expected Earliest Time T_E	Latest Allowable Time T_L	Slack T_L-T_E
11	9	2	5	8	5	85	93	8
	10	4	8	12	8	(93)	93	0
9	1	0	0	0	0	23	88	65
	8	0	0	0	0	(80)	88	8
10	1	0	0	0	0	23	85	62
	8	3	5	7	5	(85)	85 (85)	0
1	0	15	22	35	23	23	88 (80)	62
8	6	10	12	20	13	80	88	0
6	2	13	19	31	20	26	67	41
	3	45	50	55	50	60	67	7
	7	4	5	6	5	(67)	67	0
7	4	5	9	19	10	(62)	62	0
	5	5	7	9	7	52	62	10
4	3	36	40	56	42	52	52	0
5	3	24	33	54	35	45	55 (10)	10
3	2	1	1	1	1	7	22 (17)	3
	0	7	10	13	10	(10)	10 (9)	0
2	0	4	5	12	6	6	57	3

FIGURE III-14 SAMPLE CALCULATIONS

Following this procedure, you can develop the entire listing noted in Figure III.14. Now that the successor and predecessor listing together with the activities times have been noted, there is no further need for the network. The expected elapsed time (t_e) can be calculated for each activity which has a multiple time estimate.

Remembering the basic rules for determining the Earliest Expected Time (T_E) we must add the expected elapsed times (t_e) from the beginning of the network. Therefore, we start from the bottom of the calculations of Figure III.14. From events 0 to 2, the activity time (t_e) equals 6. Therefore T_E equals 6 for event 2. From event 0 to 3, the activity time (t_e) equals 10. Therefore T_E equals 10 for event 3. Both of these t_e figures can be used since they have no other activities prior to event 0. Now since the activity time, t_e equals 1 from event 2 to 3, and since T_E for event 2 equals 6, then T_E for event 3 equals 1 + 6 or 7. Since two T_E values for event 3 have been obtained, namely 7 and 10, the rules state that an event cannot be started until all the activities leading to it have been completed. Therefore, the T_E value for event 3 for the determination of other T_E values equals 10. Following the above, t_e for the activity between event 3 and 5 equals 35. The T_E value for event 3 equals 10; therefore, the T_E for event 5 equals 35 + 10 = 45. This process is continued until the T_E for the end event is calculated.

The latest allowable time T_L is calculated similar to the T_E; however, the t_e value must be subtracted from the T_L. In the example, we have assumed for simplicity that $T_L = T_E$; therefore, T_L equals 93. To proceed backward through these calculations, we use the same step checking of going from the predecessor listing to the successor. Therefore, for predecessor event 9 the T_L for successor event 9 equals $T_L - t_e$ or 93 - 5 = 88. For predecessor event 10, the T_L for successor event 10 equals $T_L - t_e$ or 93 - 8 = 85. Since we have determined the T_L for event 9 which is equal to 88, we use this in these calculations since additional values for this event will not be determined. For the predecessor event 1, the T_L for the successor is $T_L - t_e$ or 88 - 0 = 88. For the predecessor event 8, the T_L for the successor is $T_L - t_e$ or 88 - 0 = 88. For the predecessor event 1, the T_L for the successor is 85 - 0 = 85. Since we have multiple values of T_L for event 1, we select the smallest value. For the predecessor event 8, the T_L value for the successor is 85 - 5 = 80. Since this also has a multiple choice of T_L we select the smallest. This process is continued until the T_L column is completed.

The remaining calculation is to determine slack which is determined by subtracting the earliest expected time from the latest allowable time (T_L-T_E). In determining slack, the T_L value should be the smallest selected value. However, the T_E value should be normal value calculated for each event. When the slack value is calculated, we actually determine the various paths through the network. The critical path will be outlined as that having the least algebraic slack. In this particular case, zero illustrates the critical path. The example shown has the following paths: zero slack path - events 0, 3, 4, 7, 6, 8, 10, 11 plus three slack path events 0, 2, 3; plus eight slack path events 8, 9, 11; plus ten slack path events 3, 5, 7, etc.

To convert these data to a calendar base, the Julian Calendar* can be used. The makeup of the calendar should be on a 7-day and a 5-day work week basis in view of the flexibility required for the calculations of certain activities. This conversion does permit the development of a planned schedule on a calendar date base so that the plan can be evaluated as to the availability of resources or the replanning of the slack. Such a planned schedule should retain the T_E and T_L notation in order to differentiate between the planned schedule and the scheduled plan, the latter using t_s, S_E and S_L. It is recognized that both the planned schedule and the scheduled plan can be costed for comparative purposes.

*See Appendix A

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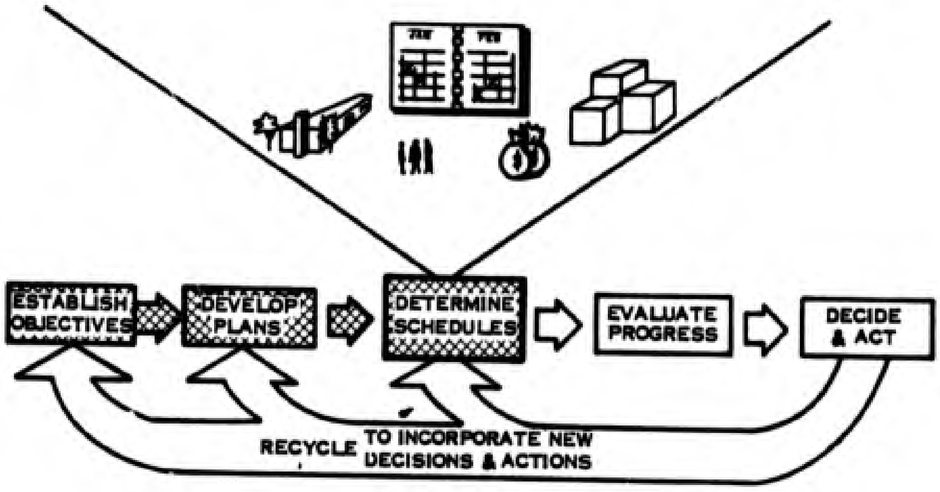
CHAPTER IV

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 on activities in the plan. The scheduled plan, when approved by responsible management:

- alerts lower level organizations and authorizes the use of resources including money and time;

- permits continuous comparative analysis of scheduled plan 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 scheduled plan. Scheduling requires a high degree of skill and knowledge of the requirements of the activities to be accomplished and the capacities available. Scheduling is the function by which resources required by several programs or projects are established and managed as opposed to the functions of individual program managers. The balancing of these multiple and competing requirements for resources is a responsibility of top local management.

Emphasis is placed on the scheduled start date as well as on the scheduled completion date for a planned activity. 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;
- 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 to accomplish the planned tasks during specific calendar time periods. A major constraint in scheduling is the requirement to conform to the plan. If the start and completion date, for the planned effort and its desired completion date are scheduled using the same amount of time as the plan, the critical path becomes a demanding priority requirement. In the scheduling process a manager and scheduler must consider:

- the availability of the required resources (manpower, equipment, facilities) during specific calendar time periods;
- general sequencing of the work;
- consideration of resource requirements of other present or future programs;

- consideration of differing or conflicting demands on the same resources;
- preclusion of peak loads for particular skills or resources;
- adequacy of available local capacity and its augmentation potential vs. the "buy" instead of the "make";
- funding limitations and requirements;
- the minimization of premium costs and idle time for manpower, equipment, and facilities;
- the necessary integration through scheduling of several plans using the same resources;
- 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 vs. multiple shifts, union contract provisions, vacation policy, etc.);
- laws governing work practices;
- difficulties involved in scheduling the detailed contents of the work packages 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 and each must be weighed and balanced against other off-setting 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 a large work package may then be scheduled until ultimately the entire work package 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. This approval requires a management appraisal of the risks involved in the various parts of the program and the advisability of reserving time and resources for unanticipated problem areas.

This document 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.

B. <u>Relationship of PERT to Scheduling</u>

An important function of scheduling involves validation of the plan depicted by PERT networks. Calculation of the total elapsed time for accomplishment of the entire plan also provides other useful information. These calculations were made on the basis of expected elapsed times associated with individual activities, which considered technical uncertainties and assumed availability of normal resource requirements. They were not based on elapsed time which would be consumed, following scheduling, in the actual performance of the work. The time period for completion of each of the activities in the network is of particular use in scheduling because of the technical constraints present in the plan.

Given unlimited resources, the "expected elapsed times" and the "expected dates," derived in planning, could be automatically used as the schedule. It is unlikely that this situation will occur. The calculations using individual expected elapsed time values do not automatically produce a realistic schedule for the individual activities in the plan. The scheduling process may require a change in the configuration of the networks to enable the effort to be performed with the specific resources available.

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

- keying the calendar start date of the program to the initial event or activity;
- "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.

C. Expected Elapsed Time vs. Scheduled Elapsed Time 1/

The process of estimating during the planning cycle must be clearly separated from the process of scheduling, since planning does not consider the competition for resources. However, in the scheduling function the availability of the resources together with the schedule end and intermediate dates must be considered. In this environment, the scheduled elapsed time (t_s) may be shorter, the same as, or even longer than the expected elapsed time (t_e) determined in the planning process.

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

D. Validating the Plan through Scheduling

Greatly improved use of scheduling in major programs is needed. As a minimum, when PERT is used, scheduling should always be accomplished to the work package level.

Practical problems in some organizations may prevent establishing schedules for individual activities below the work package level. When a program is of long duration it may not be possible to schedule the commitment of resources in detail to specific time

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1/ See Glossary for further definition of T_E, T_L, S_E, S_L, T_S.

periods through an entire plan. Where either situation prevails, expected elapsed time values should be processed as scheduled elapsed time values until scheduling is actually accomplished.

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. It is not to be confused with "scheduled" date, although they may coincide. If the "directed" date cannot be met, the scheduling activity must notify the planning activity so that higher level planning can be adjusted. The scheduler does not alter the plan.

There are several levels of schedule detail associated with each level of responsibility in a major program. Each of these levels may require a different approach to scheduling. Government scheduling requires the establishment of target dates for major and intermediate events within the constraint of directed dates set by higher authority. Prior to issuing an RFP, the government managers prepare a Master Program Schedule identifying events which subsequently become key events on the Program Management Network. By this process, the directed plan, consistent with those dates, is outlined for the contractors.

Master scheduling, which involves the blocking out of large packages of work, is performed by both the government and the contractors. Government master scheduling is done during initial program planning to provide detail in support of the directed date plan. Contractor master scheduling also is performed during initial program planning when a contractor scheduling group establishes key events. These events then provide the framework for establishing more detailed scheduling.

The detailed schedules are developed within the limitations of master schedule dates, and are usually expressed in terms of task durations, as well as completions. To assure a compatible program plan, the PERT networks must be capable of recognizing and linking together all levels of schedules.

Master scheduling by the government requires the coordinated efforts of all the agencies and offices (functional and project) involved in the program. Because of the significant impact that the government Master Schedule has on the future planning and operational phases of the program, the master scheduling team must be made up of highly competent personnel, experienced in program planning. Further, the participants must have the authority to commit the resources of their respective organizations.

The derived schedules must represent the negotiated position of all the participants, rather than a unilateral schedule decision by one agency. Scheduling done out of total program context may result in unreasonable constraints on parts of the program. When schedule conflicts arise, they must be referred to the government program manager for resolution.

Historical information of other programs should be used. However, this historical data must be modified by:

- technical differences among the various programs considered;
- advances in the state of the art;
- funding restrictions;
- priority of the program.

Historical information can serve not only as a base for developing a Master Schedule for a new program, but also as a warning of the pit-falls in the sequencing of the various phases of a particular program.

Each event in the Master Schedule limits the government agencies' and contractors' capability to allocate their resources to achieve the most desirable trade-offs within their area of responsibility. The Master Schedule should be limited to those events which are actually required and for which a real constraint exists; e.g., the availability of test facilities at a launch center. In effect, then, the government Master Schedule informs the program participants of key program constraints and phase relationships which will govern the logic of the total program.

Although the government Master Schedule is a directive to the government and contractor agencies, it may undergo changes as improved task definition occurs. This Master Schedule attempts to achieve an effective trade-off of schedules, cost, and performance for the total program; however, more detailed program planning may indicate that a revision is required. In the same manner, schedules imposed by higher authority may be invalidated by subsequent detailed program planning. Approval to change directed schedule dates must be received from the appropriate higher level authority.

Functional schedules normally are developed after the project schedules have been established. Basically, each organization providing project support (e.g., Engineering, Test, etc.) develops operating schedules. These schedules are often displayed in bar chart or Gantt chart format, because functional schedules are closely related to manpower planning. Regardless of the display used, the information must be consistent with the schedules established for project control.

Validation of the plan should, through scheduling, involve the following:

- analysis of the network and associated expected elapsed 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 elapsed 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.

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 adjust the demands of other planned activities to stay within the constraints of the time availability of capacities required. This point is stressed even though slack values are based on elapsed time estimates. In refining the earliest expected date to the scheduled date for start or completion for an individual activity or path the scheduler must understand the slack values in areas of the plan before taking action to schedule.

Slack values may be found in any plan. If not present at the start of work, they invariably develop as the program progresses. 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 high level management.

F. Study of PERT Dates for Events and Activities

Both slack values and the actual PERT calculated calendar dates are of significance to schedulers. Schedulers should completely understand these dates and how they were derived in planning before scheduling actually begins. These dates facilitate any necessary coordination with planning in adjusting the plan to feasible schedules.

G. Decision on Start and Completion Dates for Planned Activities

The network and associated Output Reports comprise the frame of reference against which all scheduling constraints must be studied. In order to make decisions on start and completion dates for planned activities, the scheduler must consider the plan in relation to each of the constraints outlined under Section A of this chapter. Effective use of PERT should tend to make these decisions occur earlier and for more detailed activities, particularly in development programs. These decisions must be reflected in the PERT networks and data.

H. Validation or Change of PERT Networks and Data

As a result of scheduling, changes in the plan will frequently result. Changes to the network or plan is the responsibility of planning, but once the schedule has been established, 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. Before these decisions are placed in 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. The impact of the newly developed schedule on the plan can be assessed by both scheduling and planning personnel prior to its official adoption. A graphic illustration of this process, when a computer is used, is depicted in Figure IV.1. If more than one cycle of simulation is required, this can be continued until the schedule is consistent with management requirements.

I. 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

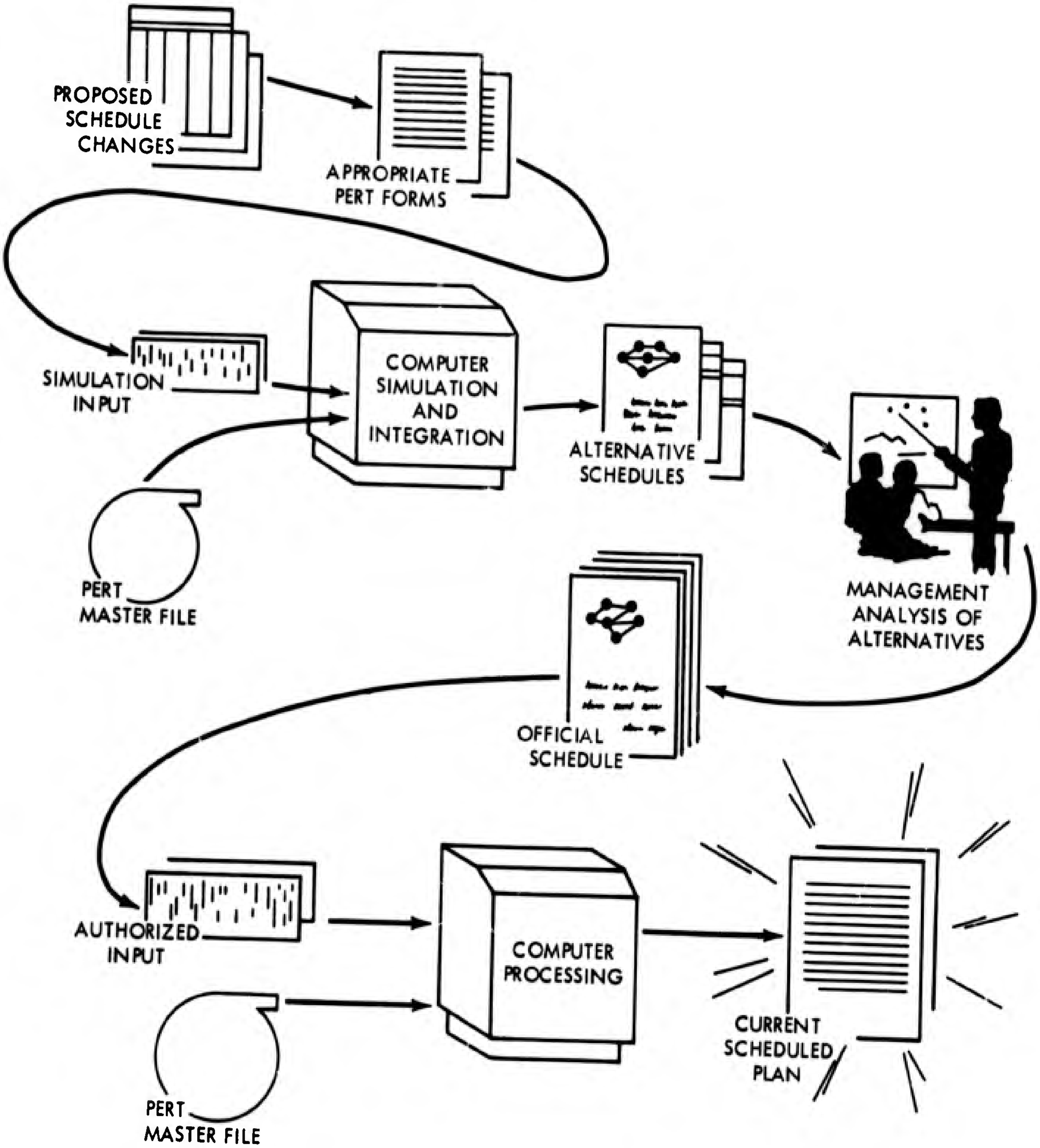


FIGURE IV-1 – SIMULATION OF PROPOSED PROGRAM CHANGES completion date. Once the program is underway and changes occur, the calculated earliest completion date may move ahead or behind the assigned scheduled completion date for an activity. Since this calculated date is likely to change frequently as the 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 reappraising 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 paths containing them are automatically calculated by the computer and printed. Scheduled elapsed time values and expected elapsed time values for those parts of the plan not yet scheduled, are merged in slack path calculations. Positive slack as originally used to signal automatically the presence of excessive resources 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 attempting schedule revisions to offset negative slack conditions. There should also be an awareness that critical areas of the program may regularly be found in areas of the program having a positive slack condition. Accordingly, only experienced personnel should be used in interpreting slack and attempting to translate it into schedule or resource allocation changes.

J. PERT Coordination

Continuing coordination between the planning and scheduling functions cannot be over-emphasized. Other organizations also will become more closely involved with scheduling as the regular cycle of PERT operations continue and become a "way of life." By the regular use of networks and data in scheduling meetings, they become primary management tools in scheduling.

K. Rescheduling

The need for updating the schedule occurs 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.

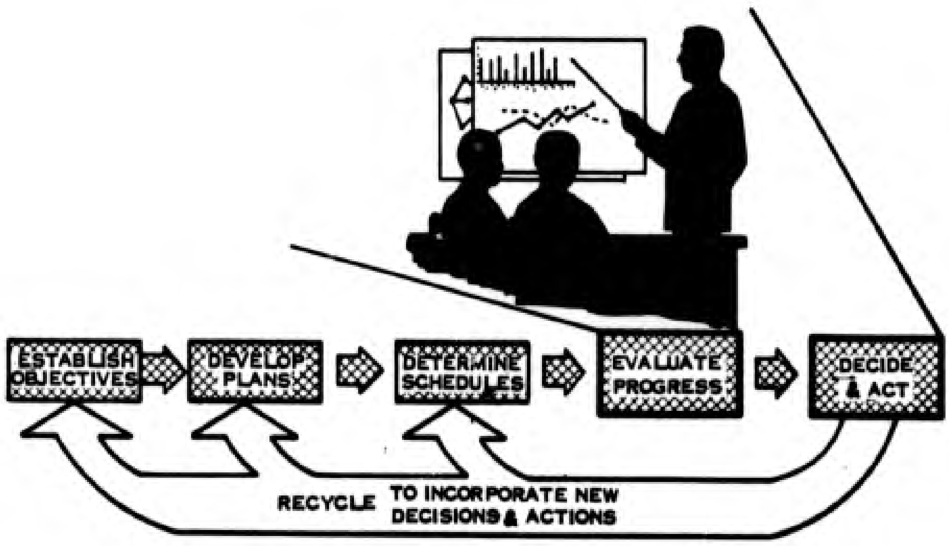
L. Simulation

The simulation process is not peculiar to any one area of the management process cycle. It can be accomplished at any time subsequent to establishing the objectives. Through the use of the simulation process early in the planning cycle the result would be the development of a more effective plan. In reality this tool is in actual use during the development of the plan when the various iterations of the plan are undertaken to meet the intermediate and/or end event dates.

In practice the scheduled plan is limited in the depth of actual application; however, it does vary widely between contractors. The overall program utilizes a scheduled plan in near time and a planned schedule in distant time. Therefore, through the use of simulation the planned schedule can be continually refined as the program progresses based on projected forecasts. These forecasts aid in refining both the schedule as well as the financial aspects. Further it will permit the establishment and refinement of resource application based on the factors; i.e., workload, manpower, financing, etc., which are normal variables in any industrial multi-project environment.

CHAPTER V

REGULAR PROGRESS REPORTING, ANALYSIS, AND MANAGEMENT ACTION



The program evaluation process is the means by which management can assure that:

- all participants in a program are working together toward a common goal or goals;
- intelligent use is made of resources, priorities, and delegated authority;
- staff and functional specialist work is integrated, coordinated, and evaluated to support the timely decisions required at various levels of responsibility;
- all component efforts are proceeding so that they will integrate, when required, into a workable end item.

Effective program administration and control requires an upward flow of selective data. It is used by progressively higher levels of management in supporting and guiding the efforts of those responsible for specific program elements. Each successive supervisory or operating manager has a responsibility corresponding to his delegated authority to:

- assess progress and performance;
- take action within his responsibility;
- provide status information and unresolved problems with relevant interpretative material to the next higher level of management.

From this flow of data, the need for action and essential changes in level of effort can be determined. New direction and actions altering schedules, technical performance or costs for the overall program objectives must originate at the proper level of program management and be communicated to the operating organizations.

* * * * * *

A. Objectives and Requirements

Decisions for solving management problems are based on expert opinions and judgments developed from the facts presented and the related past experience of the managers. Objectives, and plans for their attainment, stem from the work breakdown structure and become progressively more detailed as they are communicated downward through the organization structure. The reverse is true of progress reporting and evaluations which are communicated upward through the organizational structure.

The best approach to determine the information requirements for various levels of management is to consider their needs for specific information. Once the basic requirements have been identified and procedures established for collecting and summarizing the data, it then becomes necessary to develop means for translating the information into forms and reports suited to the transfer of knowledge. There is nothing to be served by the accumulation of unessential statistics, and voluminous collection and recording of useless information is wasteful and expensive. Generally, managers at any level want only the information from PERT which concerns their activities and responsibilities. This information must be in a form which is easy to understand and use, and quality rather than quantity of the reports must be stressed.

The flow of information must be maintained at all times. Program managers must provide top-down orders or instructions specifying what is to be done and the information they require. The upward flow must provide facts on actual progress and forecasts for efforts not yet completed or undertaken. These facts, in turn, generate new or revised top-down instructions.

The analysis and presentation of facts in consistent summary type reports with explanation of problems, provide higher levels of management with a reliable basis for program decisions. Features of PERT which contribute to effective reporting and evaluation include the following:

- networks, against which accomplishments can be reported;
- automatic identification of deviations from scheduled plan and potential trouble areas;
- use of a common format and language.

With PERT, a program is considered in detailed segments as well as in the aggregate. Definitive measurements of progress and assessments are first obtained for each detailed segment of the program. This information summarized at successively higher levels until an evaluation or synthesis can be made for all program elements and the whole program. A uniform reporting format must be used by all participating organizations, as well as common units of measurement (e.g., time, manhours, etc.), to facilitate consolidation and summarization of the data, either manually or by computer.

Progress reports provide (a) information on activities completed or scheduled for completion during reporting period, (b) a forecast of those scheduled for the next reporting period, (c) any changes in the scheduled plan and (d) any changes in the estimated activity times. This places emphasis on the serious schedule problems of the performing units and their supervisory levels of management. It also pinpoints the areas for critical analysis in terms of planned application of resources, productiveness, accuracy of estimates, and the effectiveness of all levels of management.

B. Data Summarization and Output Reports

Management confidence in 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. Requirements can be estimated and progress measured more precisely for a task of approximately one-month duration than for one which may involve four months or more.

Through a progressive summarization process, it is possible to communicate information required by successively higher levels of management on the significant "management-by-exception" basis. Detailed information is always available to higher organizational units on an as required basis. All organization elements concerned with interface events should receive information on the status and outlook for interface events. Each report should be accompanied by a brief narrative analysis, including recommendations and alternative solutions by subordinate managers, when appropriate.

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

The information reporting system furnishes 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 performance, schedule, and cost commitments? If not, what is the extent and significance of the differences?

- What is the outlook for meeting future performance, schedule, and cost commitments?

- Is the outlook improving or getting worse, and why?

- What major factors are controlling time and cost requirements?

Corrective decisions cannot be made, nor actions taken until the fact that a problem exists is first recognized. The problem must be defined in terms of its origin, scope, and relative importance. Management can then consider all relevant factors and decide how and when to resolve the problem. The possible alternative solutions must be identified and the impact should be assured through simulation before a final decision is made.

Reports to management may be presented either graphically, orally, written or in any combination of these three forms. Although different levels of management have different requirements, a universal rule application to all reports may be stated. For greatest effectiveness, presentation reports should be presented graphically with a concise written analysis. All presentations should include a narrative explanation as an integral part of the chart located on the same page or be accompanied by a more detailed narrative if the situation warrants.

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, clear and concise 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;

- the information should be predictive as well as historical, and should be developed only to the level of detail which is essential for apprising specific levels of management.

The Output Reports permit an immediate appraisal of status against the scheduled plan by comparison of the actual or expected completion dates against latest allowable dates for the major events. The principal problem areas can be isolated through critical and slack path analyses, and identified to the lowest level of management responsibility.

The standard PERT computer Output Reports should include:

- an event report. This report is commonly sorted by event number sequence for a catalog listing of events; expected date sequence which provides a chronological listing by events; and slack sequence beginning with the least algebraic value.

- an activity report. This report is commonly sorted by ending event sequence for a catalog listing by ending event; beginning event sequence for a catalog listing by beginning event; expected date sequence which provides a chronological listing of activities; and slack sequence beginning with the least algebraic value.

Examples of these Output Reports are shown in Figure V.1. These are considered basic and minimal. Others can be developed to meet the needs of specific users.

Accompanying analytical reports and back-up interpretation material must supplement these Output Reports with the following information:

- summaries of the current status in relation to scheduled plan as well as the outlook for achieving major goals; brief explanation of the reasons when current outlook for project completions differs from the preceding outlook;

- statements of problems (the causes, the preventive or corrective action being taken and by whom, the anticipated date of problem solution, and impact on other sequential work);

- recommendations for action on the part of higher levels of management, and alternative solutions to technical problems which may have arisen.

Outlook Reports (Figures V.2. and V.3.), based on actual or projected schedule information, provide situation summary and historical comparisons of the schedule dates of the project with outlook completion dates, and are extremely effective in presentations.

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. The PERT reporting system should be aimed at reduction in paperwork by use of original source documents (time cards, vouchers, etc.), reduction in the opportunity for human error in the handling of source data, and user comprehension of the data.

SYSTEM TITLE - TEST SYSTEM 999000
PERT EVENT REPORT
SORT SEQUENCE - EVENT

REPORTING ORG. NWLKPO
NETWORK NO. 999000
LEVEL NO. 1

AS OF DATE 08AUG65 PAGE NO. 1
RUN DATE 15AUG64
RUN NUMBER 1

EVENT DESCRIPTION	EVENT NUMBER	SLACK TL-TE	EXPECTED DATE	LATEST DATE	SCHEDULE DATE	ACTUAL DATE
START	999000001	.0	30AUG64	30AUG64		30AUG64
TEST A COMPLETE	999000002	6.0	13SEP64	25OCT64		
TEST B COMPLETE	999000003	.0	08NOV64	08NOV64		
TEST C COMPLETE	999000004	2.0	22NOV64	06DEC64		
TEST D COMPLETE	999000005	.0	13SEP64	13SEP64		
TEST E COMPLETE	999000006	.0	20DEC64	20DEC64	20DEC64	
TEST F COMPLETE	999000007	1.0	01NOV64	08NOV64		
TEST G COMPLETE	999000008	.0	22NOV64	22NOV64		
TEST H COMPLETE	999000009	.0	27SEP64	27SEP64		
INTERFACE	999000010	1.0	06SEP64	13SEP64		06SEP64
PUBLISHED DOCUMENTATION AVAILABLE	999000011	1.0	15NOV64	22NOV64	22NOV64	

SYSTEM TITLE - TEST SYSTEM 999000
PERT EVENT REPORT
SORT SEQUENCE - SLACK

REPORTING ORG. NWLKPO
NETWORK NO. 999000
LEVEL NO. 1

AS OF DATE 08AUG64 PAGE NO. 1
RUN DATE 15AUG64
RUN NUMBER 1

EVENT DESCRIPTION	EVENT NUMBER	SLACK TL-TE	EXPECTED DATE	LATEST DATE	SCHEDULE DATE	ACTUAL DATE
START	999000001	.0	30AUG64	30AUG64		30AUG64
TEST D COMPLETE	999000005	.0	13SEP64	13SEP64		
TEST H COMPLETE	999000009	.0	27SEP64	27SEP64		
TEST B COMPLETE	999000003	.0	08NOV64	08NOV64		
TEST G COMPLETE	999000008	.0	22NOV64	22NOV64		
TEST E COMPLETE	999000006	.0	20DEC64	20DEC64		
INTERFACE	999000010	1.0	06SEP64	13SEP64		06SEP64
TEST F COMPLETE	999000007	1.0	01NOV64	08NOV64		
PUBLISHED DOCUMENTATION AVAILABLE	999000011	1.0	15NOV64	22NOV64	22NOV64	
TEST C COMPLETE	999000004	2.0	22NOV64	06DEC64		
TEST A COMPLETE	999000002	6.0	13SEP64	25OCT64		

SYSTEM TITLE - TEST SYSTEM 999000
PERT ACTIVITY REPORT
SORT SEQUENCE - ENDING EVENT BY BEGIN EVENT

REPORTING ORG. NWLKPO
NETWORK NO. 999000
LEVEL NO. 1

AS OF DATE 08AUG64
RUN DATE 15AUG64
RUN NUMBER 1

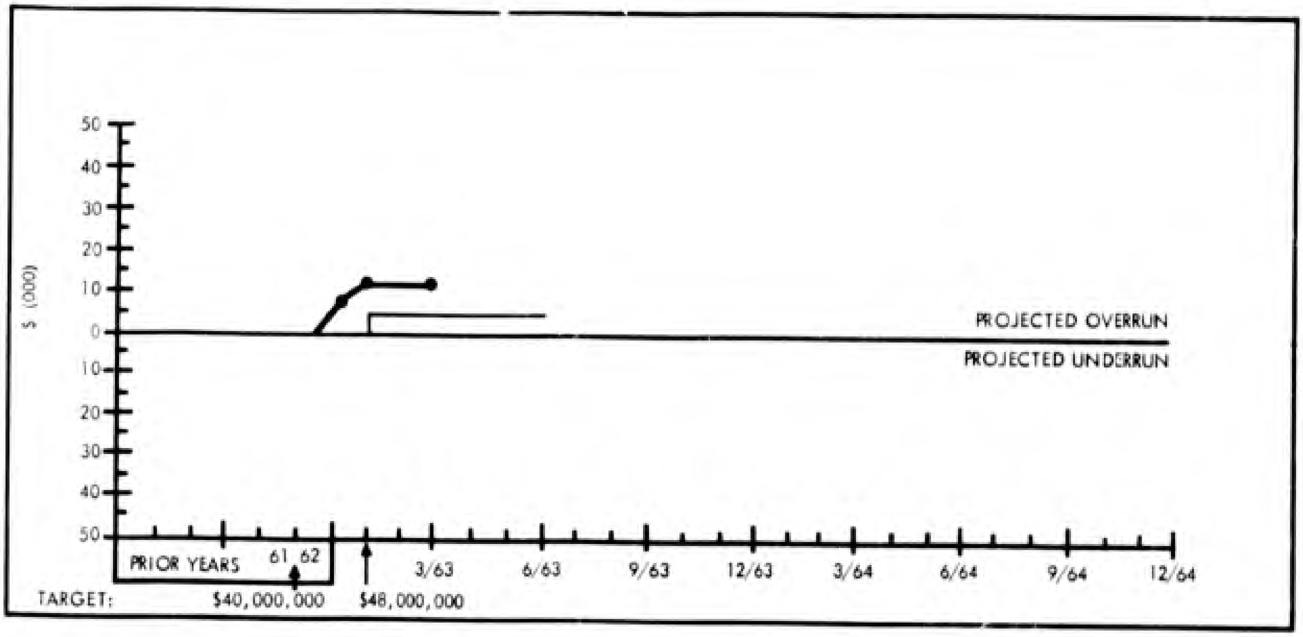
PAGE NO. 1

ACTIVITY DESCRIPTION	BEGINNING EVENT NO.	ENDING EVENT NO.	SLACK TL-TE	EXPECTED DATE	LATEST DATE	LITTLE TE	LITTLE TS	SCHEDULE DATE	ACTUAL DATE
START	000000000	999000001	.0	30AUG64	30AUG64	.0	.0		30AUG64
TESTING A	999000001	999000002	.0	13SEP64	25OCT64	2.0	1.0		
TESTING D	999000001	999000005	.0	13SEP64	13SEP64	2.0	1.5		
TESTING B PART 1	999000002	999000003	2.0	08NOV64	08NOV64	2.0	2.0		
TESTING C	999000003	999000004	.0	22NOV64	06DEC64	2.0	1.5		
TESTING G	999000003	999000008	.0	22NOV64	22NOV64	2.0	1.5		
TESTING E PART 1	999000004	999000006	.0	20DEC64	20DEC64	2.0	2.0	20DEC64	
TESTING H	999000005	999000009	.0	27DEC64	27DEC64	2.0	1.0		
PREPARE DOCUMENTATION	999000007	999000011	.0	25OCT64	25OCT64	2.0	1.5		
TESTING E PART 2	999000008	999000006	.0	20DEC64	20DEC64	4.0	5.0	20DEC64	
TESTING B PART 2	999000009	999000003	.0	08NOV64	08NOV64	6.0	5.0		
TESTING F	999000009	999000007	.0	11OCT64	11OCT64	2.0	2.0		
SPECIFICATIONS IN TRANSIT	999000010	999000007	.0	11OCT64	11OCT64	4.0	3.5		

FIGURE V-1 – EXAMPLES – PERT COMPUTER READOUT REPORTS

COST OUTLOOK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
CMWS - AIO MISSILE	XYZ CORP.	61-9865	TERM (SPAN): TOTAL PROG. CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 1 /MISSILE			



SCHEDULE OUTLOOK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
CMWS AIO MISSILE	XYZ CORP.	61-9865	TERM (SPAN): TOTAL PROG. CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 1 /MISSILE			

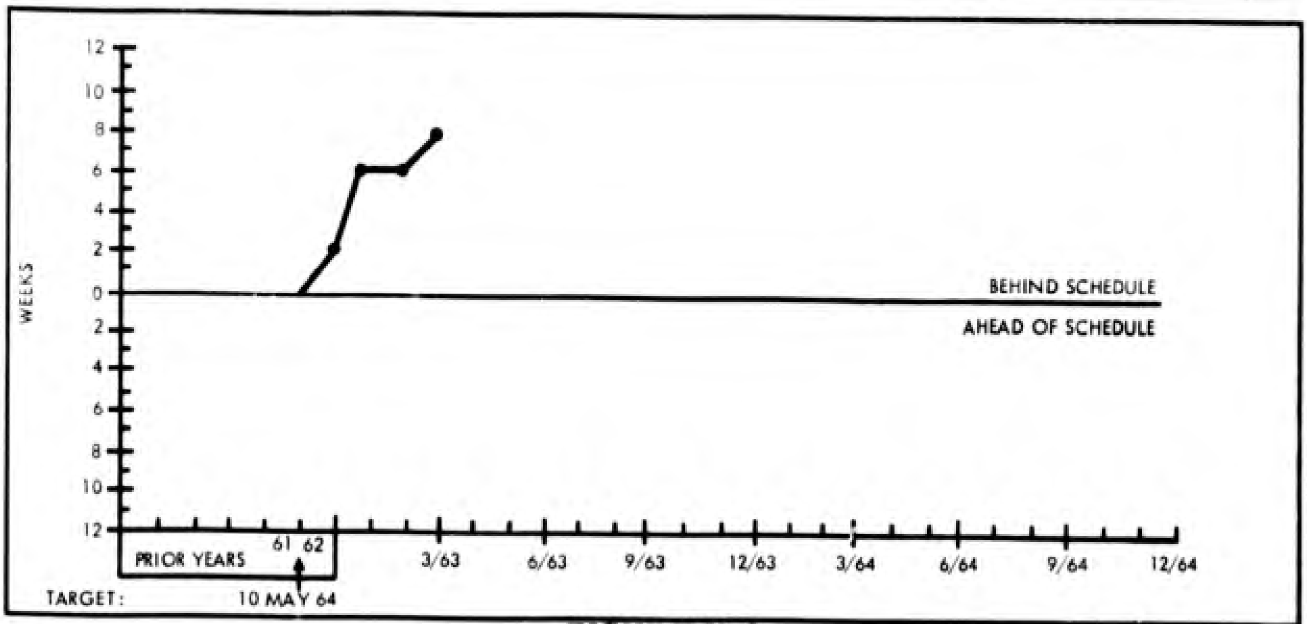


FIGURE V-2

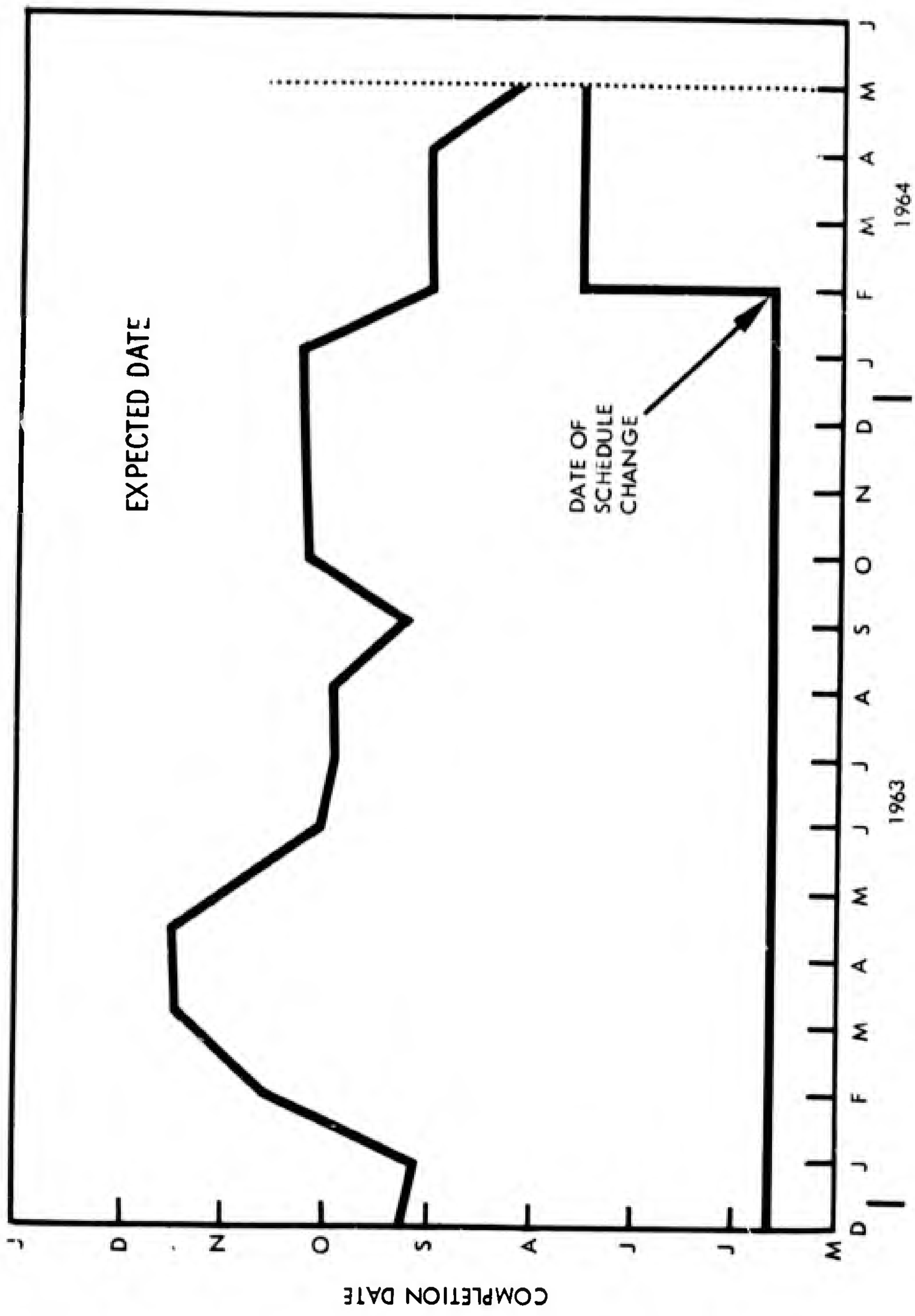


FIGURE V-3 – COMPLETION TREND

C. Analysis of Project Status

A primary measure for the analysts' review of project schedule status is provided by the slack figures for various network paths. The foremost object of the analyst's attention is the date for the end event of the project and the slack associated with the critical path and near critical paths. The activity and event reports specify the slack values and locate the areas where negative slack exists. This information immediately focuses the analyst's attention on those areas where problems exist or are predicted, thus truly enabling management by exception. Once the problem is located, an investigation can be made which will ultimately lead to the determination of alternative courses of corrective action and then to management decision.

Various analyses can be used by the analyst to locate problems and conflicts which are not automatically identified by the analytical aids described above.

Slack trend analysis is used for early identification of slack paths which are growing more negative and for monitoring the effect of management action in critical areas that were previously identified. Slack trend charts show not only the value of the negative slack, but whether that slack is increasing or decreasing in some steady pattern. Where a path shows steadily increasing negative slack over a period of time, the development of a true problem is indicated. The dwindling of negative slack along a path may be interpreted as a sign that management action has been effective in relieving the problem. Usually, the analyst will be familiar with the recent history of the critical and near-critical paths. Often, however, slack trend charts will indicate the development of a problem that is not yet serious and, for that reason, may not have been noticed otherwise.

The use of special scheduled facilities outside the control of the program manager must be monitored very closely. An apparently small schedule deviation may result in a serious slippage because of the unavailability of the facility at any time other than that scheduled. For example, Program A is scheduled during the first two weeks in March to use a special test facility not under the control of the program. If Program A slips two weeks and the test facility is scheduled for use by other programs from mid-March for several months, it can be seen that Program A will slip by considerably more than two weeks (unless the test facility can be rescheduled to accommodate it). Thus, the analyst must pay particular attention to situations in which a facility not under control of the program must be used in a specific scheduled time. This is relatively easy when the situation involves the use of a very large facility in one of the major efforts of the program; i.e., a test center facility for a major flight test. However, when the situation exists in a contractor's plant, it may be more difficult for the analyst to keep abreast of the problem.

Functional area analysis of individual activities along the negative slack paths for an organization may reveal that a particular department or section within the organization lies on all or several of the negative slack paths and, in fact, is the real bottleneck. For example, some contractor may find that the negative slack in several different paths is arising from activities for which work is to be performed by the Drafting Department. This discovery directs management attention to alleviating the problem in the Drafting Department, rather than to separate solutions of the problem along each negative slack path. In this case, a simple augmenting of the Drafting Department's work force might solve the problem on several paths. Likewise, an overload of work on a key facility, such as a test rig or a special machine, can bottleneck several different paths in a network.

The artificial downward revision of future activity time estimates to compensate for slippage in a completed activity is another situation for which the analyst must be alert. Some estimators have used this device to hide schedule slippage until some significant milestone has been missed. To counter this practice, the analyst may record original latest allowable dates for interim events and then compare actual completion dates for these events against the originally planned latest allowable dates.

Critical technical areas that are not on the critical path should also be scrutinized by the analyst. In many cases, the path that involves the most difficult engineering accomplishments may not show negative slack until late in the development process. One example of this situation occurs when the engineering design seemingly progresses well, until a test well downstream in the program demonstrates a failure caused by some basic design fault. At this point, the problem first appears in the PERT reports as a large increase in negative slack. Thus, paths which do not show significant negative slack may nevertheless pose a significant threat to the accomplishment of program schedule objectives because of the nature of the work being done. Therefore, the PERT analyst should have a means, supplementing the formal PERT output reports, for staying abreast of the program's critical technical problems.

A number of techniques for analyzing the status of the program were described above. However, the analyst can generate additional techniques that will help him monitor and understand the problems in his particular situation.

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 non-critical 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.

D. Reporting Frequency

Due consideration must be given to the reporting interval or frequency by operating management. A bi-weekly reporting cycle is quite common, although weekly and monthly cycles are often used. The performing levels and middle managers may require more frequent reporting than top level management. The frequency of reporting may be influenced by the following:

- requirements of the customer;
- program duration;
- magnitude and complexity of the program;
- criticality and dynamic nature of the program;
- time required for data processing;
- degree of detail in the report;
- status of this program in relation to other priority programs.

Progress reports must be timely in relation to the cut-off date used in preparing reports. An indication of an approaching problem today is more valuable than a detailed blueprint of the situation weeks later.

E. Information Center

An information or management center can serve a variety of purposes, such as a display room for program status and outlook, a conference room, a means of keeping participants aware of the need for the review and control functions of management, or ideally, as a complete coordination, communication, and evaluation center for program managers. Management in government and industry typically has found it desirable to hold weekly briefings. Higher levels of review are conducted on a monthly and on-call basis.

Presentations in the information center should be timely and concise and should employ the most efficient communication techniques. The various levels of managers responsible for the work should explain the significance of any change from plan and its effects on the ultimate objective. It is their responsibility to provide appropriate and meaningful information for management review and decisions by distilling information transferred up from working levels of management.

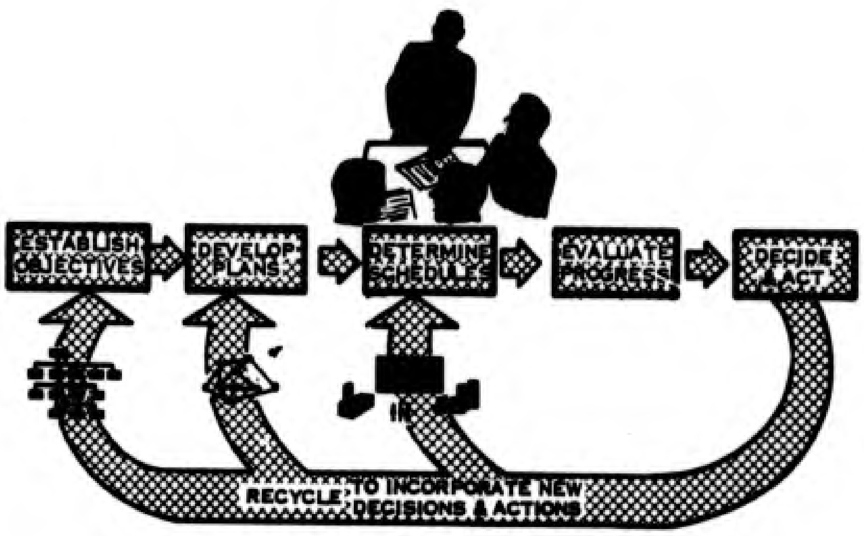
Visual aids in the form of PERT outlook reports, or similar briefing charts, films, and other appropriate materials should be utilized during the briefings. This serves to illustrate problem areas quickly and thus avoid lengthy discussions concerning the definition and relationships of these problems. Physical progress of important installations, assemblies, etc., can be demonstrated by weekly photographs. On other charts, color codes or other related devices should be used to highlight any planned or scheduled event which may potentially delay or impede the program. This might include such things as labor, material, and funding shortages, as well as technical difficulties.

Regularly scheduled meetings conducted within an information center provide continuous effective communication. As a meeting place for responsible managers, their key assistants, and representatives of higher and lateral authority, the information center can provide an effective means for periodic transfer of information to assure program integration. It can serve as the focal point where management can bring together results from channels of reporting, key participants, and higher levels of management for program review. Executive attention can be drawn to actual and potential problems, alternative or recommended solutions, policy decisions, problems of coordination, or any other situation which requires higher level management decision or action. Major problems requiring action on the part of higher or lateral authority can be identified and communicated to those involved. On-the-spot decisions can be made and communicated to those responsible.

Decisions and observation of the program manager and other key personnel are recorded and subsequently transmitted to those responsible for action. The immediate objective of these meetings is to correlate all efforts and keep them moving toward the program objective, thus assuring that effective and efficient control over the program will be maintained.

CHAPTER VI

RECYCLING OF THE MANAGEMENT PROCESS TO INCORPORATE NEW ACTION



Despite efforts to adhere to the scheduled plan as originally developed, requirements for changes in the scheduled plan, or even the objectives, arise during the course of accomplishing a program. In some instances these may stem from higher authority. Normally, requirements for changes will result from one or more of the following typical reasons:

- inaccurate estimates of scheduled times or required resources;
- inability to apply resources as planned;
- unanticipated technical problems;

- inadequate plan;
- insufficient definition of objectives;
- other unforeseen adverse events (strikes, fire, etc.);
- necessary or desirable technical redirection.

Each requirement for change constitutes an opportunity for early improvement of the conduct of the program. If the scheduled plan is changed, intelligent and expeditious effort is required to assure that the corrective action decided upon will correct causes of the problem rather than treat the symptoms. An alert manager will remain sensitive to the possible opportunities present in these requirements for change. He may be capable of making or recommending adjustments in the program which will offer increased benefits in performance or decreased time and cost.

* * * * * *

A. Incorporating New Management Action

Identification of problems pinpointed by program evaluation as discussed in Chapter V will frequently signal the need for the origination of changes or recommendations for changes by a manager.

When management at any level desires to incorporate a new management action in the scheduled plan, several problems arise. The change must be:

- documented as a recommended change;
- coordinated with concerned organizations;
- authorized as an approved change;
- incorporated in the scheduled plan and other related official documents.

Procedures should provide clear guidelines for documentation of proposed changes, authorization for change approval, and the processes by which new management actions are to be incorporated in the scheduled plan and other related documents. The procedures must clearly distinguish the degree of authority of a particular manager from that of higher levels of management. Proposed changes must be communicated up to the management level which authorizes the changes. Conversely, direction and authorization must be communicated back to the operating level. Incorporation of any new action in the scheduled plan requires understanding of the delegation of authority by the organization controlling the entry of changes into official documents governing the conduct of the program.

Formal procedures are required and the same or possibly greater control over these must be exercised as was exercised in evolving the original scheduled plan. Since the changes may occur at any level in a multi-project organization, these procedures must be effective for all levels of the organization responsible for conducting the program. Otherwise, more than one schedule of activities may result with management unaware that more than one schedule is currently governing the same organization. This must be avoided by whatever means become necessary.

When recycling action is of a drastic nature requiring a change in more than one level of the work breakdown structure (i.e., because of replanning or redetermination of objectives) close liaison with all affected management levels is essential. Conferences must be held to assure an understanding of the problems of participating organizations. Subsequently, documents summarizing the results and outlining required changes should be produced.

A particular level of management may recognize the need for new action and require help or authority from a higher level. In this case, when immediate approval of the required change is not possible, a statement of the problem and related pertinent facts should be prepared. Required specification and adequate justification should be included. Such requests may accompany management summary reports to higher levels.

B. Simulation

The ability to simulate changes 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 VI-1. If more than one cycle of simulation is needed, the process is repeated until management requirements are satisfied. 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.

The simulation process is not such that it is peculiar to any one block of the management process described herein. It can be undertaken at any time subsequent to establishing the objectives. Through the use of the simulation process beginning with development of the plans, the normal result would be in better, more effective management cycle. This tool is in actual use during the development of the plan when the various iterations of the plan are undertaken to meet the basic directed date. Subsequent to this iteration, the schedule area can be simulated to determine the various competitive points of critical resources. The natural benefit of this simulation is the downstream areas.

It can be seen that these simulation processes are being taken at a time when there is sufficient time for planning and the development of schedules. There are, however, areas which do not lend themselves to simulation because of lack of time. This area in particular is the progress evaluation portion of the management cycle. During the normal evaluation of progress the problems represent management by exception areas based on the data available and its projection downstream. The

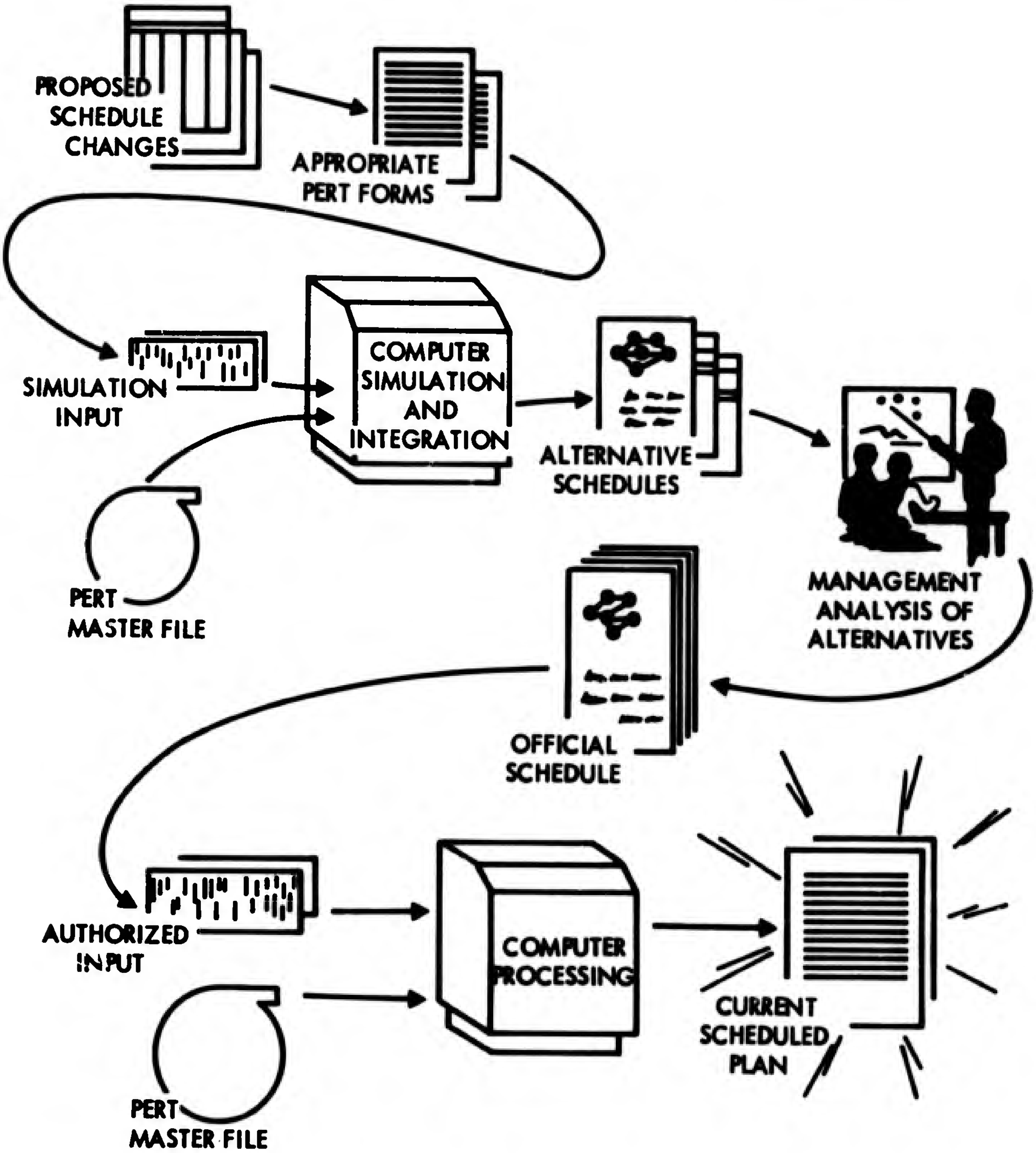


FIGURE VI-1 SIMULATION FLOW CHART

problem and its impact is as a result of time-now information which must be presented to the highest levels of management. It is these areas that cannot be simulated when the impact of the problem is of a "time-now" or "near-time" basis; i.e., next week or within the same month. However, for those problems which are being projected downstream; i.e. three months to one year, the benefit of simulation can be realized. It is recognized that these simulations may or may not represent the final decisions of the upper levels of management. However, they can and do show alternatives which are available to management should they elect to use the parameters selected. It is only natural that alternatives specified by top level managers will come to light immediately. Normally these will result either in a completely different approach or a combination of alternatives presented by the evaluator.

Normally, a number of alternative actions are contemplated by management, and only one can be chosen as a realistic solution. Simulation offers a method for testing these alternatives and evaluating the effects of each. Simulated time changes in activities, or the addition or deletion of activities may be fed into the computer in the same manner as up-dating information. Analysis of the outputs of the simulation will indicate the new situations which would be expected to occur. Simulation can frequently be accomplished manually if small networks or portions of networks only are involved.

This tool 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. Simulation can show the impact of alternative decisions on the total program thereby permitting the highest levels of management to evaluate various courses of action as they affect the final objective.

Simulation of the effect of proposed changes to scheduled plans before incorporation of them as new management action should be required. 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 before they are submitted to higher level management for approval.

C. Recycling of the Management Process

The recycling process, as it affects the formal scheduled plan, will vary in complexity from a simple rescheduling process back through replanning and possibly even the redetermination of objectives.

These types of management action are listed in order of increasing management complexity:

- rescheduling within the manager's authority;
- rescheduling affecting authority in other organizational components;
- replanning within the constraints of the established plan;
- replanning without the constraints of the established plan;
- redetermination of supporting objectives;
- redetermination of prime objectives;
- some combination of these.

A change involving management action of any greater complexity than "rescheduling within the manager's authority," will require the taking of all interrelated actions appearing above it in the list shown. It is emphasized that there is no shortcut to this procedure.

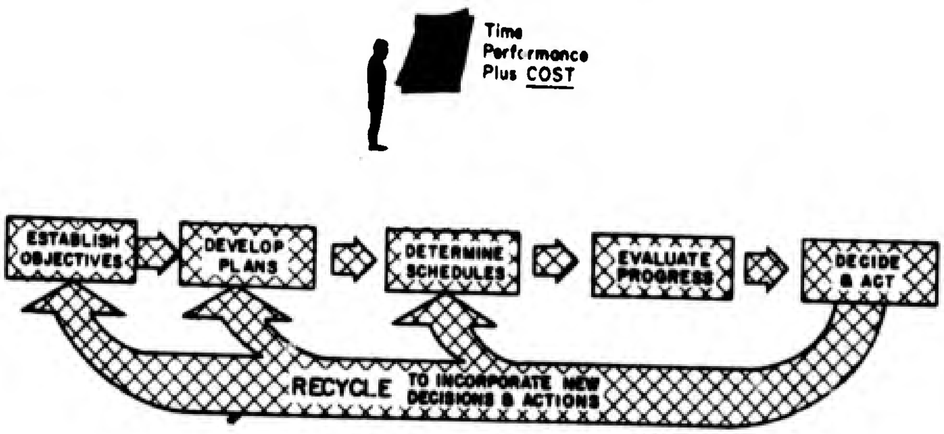
As a principle, effective adjustments in the scheduled plan should be accomplished with minimal recycling in the management process. Before a particular change or set of changes is decided upon for incorporation in the scheduled plan, possible alternatives can be rapidly assessed with simulation methods before adoption. After study of possible alternatives, the management process of objective determination, planning and scheduling must be recycled to the degree necessary to incorporate logically the new management action in the scheduled plan.

D. Actions Resulting from the Recycling Process

Generally, as a result of the recycling process, management decisions could result in a change of the schedule, the network, costs, the prime or supporting objectives, or some combination. Although recycling is not completely accomplished by PERT, making decisions regarding changes and the communication of change are facilitated.

CHAPTER VII

PERT COST



PERT as a management tool can help provide realistic cost estimates and periodic cost reports which relate costs incurred to progress achieved, and it can forecast the total cost of the program.

Complex programs can be managed most effectively only if project managers have a common framework from which to plan and to control the schedules and costs of the work required to achieve the performance objectives. Benefits can be increased when the PERT system of cost management is included as part of the total planning and control system.

Managers at all levels need techniques at all stages in a project to:

- define the work to be performed;
- develop realistic cost estimates based on the resources planned to perform the work;
- determine where resources should be applied to best achieve the time, cost, and performance objectives;
- identify those areas developing cost overruns in time to permit corrective action.

For example, managers at each level must be able to determine:

- whether the current estimated cost for completing the entire program is realistic;
- whether the program is meeting the committed cost estimates, and, if not, the extent of any difference;
- whether requirements for manpower and other resources have been planned realistically to minimize premium costs and idle time;
- how manpower and other resources can be shifted to expedite critical activities;
- how manpower and other resources made available by changes in the program tasks can be best utilized;
- the consequences of alternative courses of action.

* * * * * *

A. Characteristics of the System

PERT utilizes the work breakdown structure and the network as the common framework for planning the schedule and cost of the program. The program is first defined, broken down into its hardware items, then broken down into end item subdivisions and then into the work packages to be assigned to first-line supervisors. These work packages are then represented by activities (one or more) on a conventional network to identify the interdependencies in the program and the sequence in which the work will be performed.

The account code structure consists of numbers which are used for charging and summarizing the costs of a program. Charge numbers are assigned to each work package at the lowest level of subdivision, and summary numbers are assigned to each end item subdivision on the project work breakdown structure. All costs are first collected or recorded under the charge numbers assigned to the work packages and are later summarized for each end item subdivision in the work breakdown structure for use by higher levels of management.

After the network has been prepared and the schedule for the program has been established, the responsible operating and management personnel develop firm cost estimates for each work package, basing the costs on the manpower and other resources required to perform the program on schedule. These estimates are made by first determining the manpower, material, and other resources required to perform each work package. The resources estimates are then converted to dollars to determine the direct cost of each work package. Indirect costs are added to work packages where such accumulation is possible by existing accounting procedure, or as required by contract. All other indirect costs are prorated at summary level of the program on the basis of total program indirect costs less indirect cost already accumulated or assigned. Data submitted to the government will understandably include all cost.

Separate cost estimates are not, as a rule, necessary for each activity in a work package since this could result in excessive detail and unrealistic accounting effort.

The cost estimate for a work package is affected by both the elapsed time required to perform the work package and the calendar period during which the work package is scheduled to occur. The latest schedule status is considered in preparing cost estimates for work packages and in planning the allocation of manpower and other resources. Operating and management personnel analyze the estimates to eliminate unnecessary manpower costs and premium payments for materials and services.

For example, monthly manpower requirements are totaled by skills and examined to minimize unnecessary overtime and unnecessary hiring caused by manpower peaks followed by layoffs. Manpower "smoothing" is accomplished by scheduling activities to periods when the skills are not required by critical activities. Scheduling slack activities can also eliminate or reduce premium payments for materials and services.

Periodic comparisons are made of the actual costs incurred for each work package with their current estimates. This comparison establishes the cost status of the program and identifies any incurred cost overruns. Estimates of the cost needed to complete work not yet performed are also obtained in order to predict future cost and to identify difficulties in the performance of critical work packages early enough to take constructive management action.

The level of detail to which it is desirable to apply cost management is largely a matter of judgment, and varies from program to program, from one part of a program to another, and from the proposal preparation stage to the execution stage of the same project.

B. Reporting

PERT provides reports for managers at all levels of the project. For example, it has been demonstrated that the Management Summary Report generates information for end-item subdivisions at all levels of the project and, therefore, can be used by managers at all levels. There are a number of such reports in PERT. Some reports, however, are designed primarily for use at the lower project management levels.

The Program/Project Status Report contains information similar to that of the Management Summary Report. However, where the Management Summary Report highlights information for a manager, the Program/Project Status Report provides it in detailed form for an analyst. The Organization Status Report is directed toward providing operating level managers with detailed information by various combinations of Responsible Organization, Performing Organization, Charge Number, and Resource Code.

Graphic reports, such as the Cost of Work Report, Cost Outlook Report, and Schedule Outlook Report as referenced in Chapter I, are used for rapid evaluation of project status at all levels of the project.

In general, cost management reporting in the PERT System involves the concept of a cost being generated in the work package, the work package being summed into its parent lowest level end-item subdivision, and subsequent automatic summarization up through the work breakdown structure. Thus, reports can be generated at any level for the different end-item subdivisions.

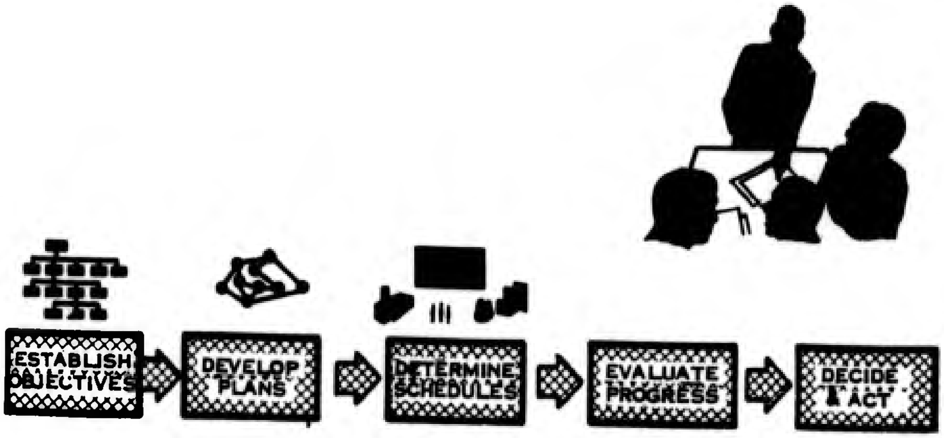
It is not necessary that the data submitted on these reports be presented to managers in these formats. Rather the data, with these reports and this system to back it up, should be presented to management in the most accustomed form possible in order to take full advantage of the manager's experience.

In addition to this kind of end-item reporting, however, there is often the desire on the part of management to see reports by more traditional functional or organizational breakdowns. For instance, the manager might desire the total cost of engineering. However, if engineering charges have been accumulated into various work packages, which, in turn, were summed into their parent end-item subdivisions, then the total cost of engineering does not appear in any one place.

The need to collect costs, other than by end-item subdivision, is accommodated by the Cost Category Status Report. For this report, cost categories are established by relating work packages or elements of cost within work packages to the specified categories of cost that the manager wishes reported (e.g., engineering). Thus, summation of functional and organizational type costs can be made without distortion of the work breakdown structure.

CHAPTER VIII

THE COST APPLICATION AND CONTROL



The budgeting of costs by only calendar time period does not provide an adequate base for measuring cost performance. To evaluate cost performance, the manager must be able to compare actual costs to the costs budgeted for the work that was completed. In PERT, this need is met by estimating, budgeting, and collecting costs by specific work accomplishments (work packages). In order to provide a realistic base and accurate information, low-cost, short-term work packages are essential. This combination provides the common base that industry has utilized for years in its efficient dealings with its subcontractors.

Therefore, with the capability of providing more accurate costs and reports which relate actual costs to progress achieved, it is feasible to forecast the total cost of the program. However, such an advantage cannot be derived without the integration of time and cost in the planning and control cycles. This advantage can be derived from PERT through the work package concept where time and cost are integrated at such a manageable level.

* * * * * *

A. Relationship to the Product-Oriented Work Breakdown Structure

The work breakdown structure as described in Chapter II provides a base for uniform planning and project visibility. It defines the major project objectives, their supporting objectives, and the organization interrelationships and subdivisions of these objectives.

In the Cost System, the same work breakdown structure that was used in the Time System aids in establishing:

- a framework for the integration of cost, schedule planning and control; 1/
- an end-item framework for summarizing the cost status of the project for progressively higher levels of management; and
- basic units (work packages) for estimating, budgeting, and charging costs.

B. Preparing the Account Code Structure

The account code structure is a framework of numbers which is used for summarizing and charging the costs of a project. It follows the pattern of the work breakdown structure.

1/To do so, the contract items must be compatible with the end items as defined in the work breakdown structure.

A summary number is assigned to each end-item subdivision of the work breakdown structure. It is used for summarizing costs at each level of the work breakdown structure, thereby providing the cost figure for each end item. Thus, cost data for use by progressively higher levels of project management is provided.

A charge number is assigned to each work package. It is against these charge numbers(and, therefore, against the work packages) that budgets are established and actual costs are accumulated. These costs are later compared with the budgets for purposes of cost control.

PERT does not require the contractor to develop a new cost accumulation system, although some modification may be necessary to his current estimating and budgeting system. Most contractors and government agencies have cost accumulation systems that permit summarization of costs by contract, function (e.g., design, fabrication, etc.), and task, or job. This same structure, with minor modification, can serve as the cost accumulation system for PERT. In any event, the contractor or government agency can continue to assign charge numbers that have significance to its existing cost accumulation system. The PERT summary numbers can regroup the assigned charge numbers for summarizing costs in parallel with the work breakdown structure.

The account code structure may be a completely structured numbering system so that the digit and its position convey considerable information about the subdivision the digit represents. Such a structure is illustrated in Figure VIII.1. Structuring does, however, introduce some inflexibility into the numbering system, which may be disadvantageous at some later point in the project.

C. Developing the Work Packages

The work package serves as the basic unit for:

- estimating costs;
- establishing budgets;

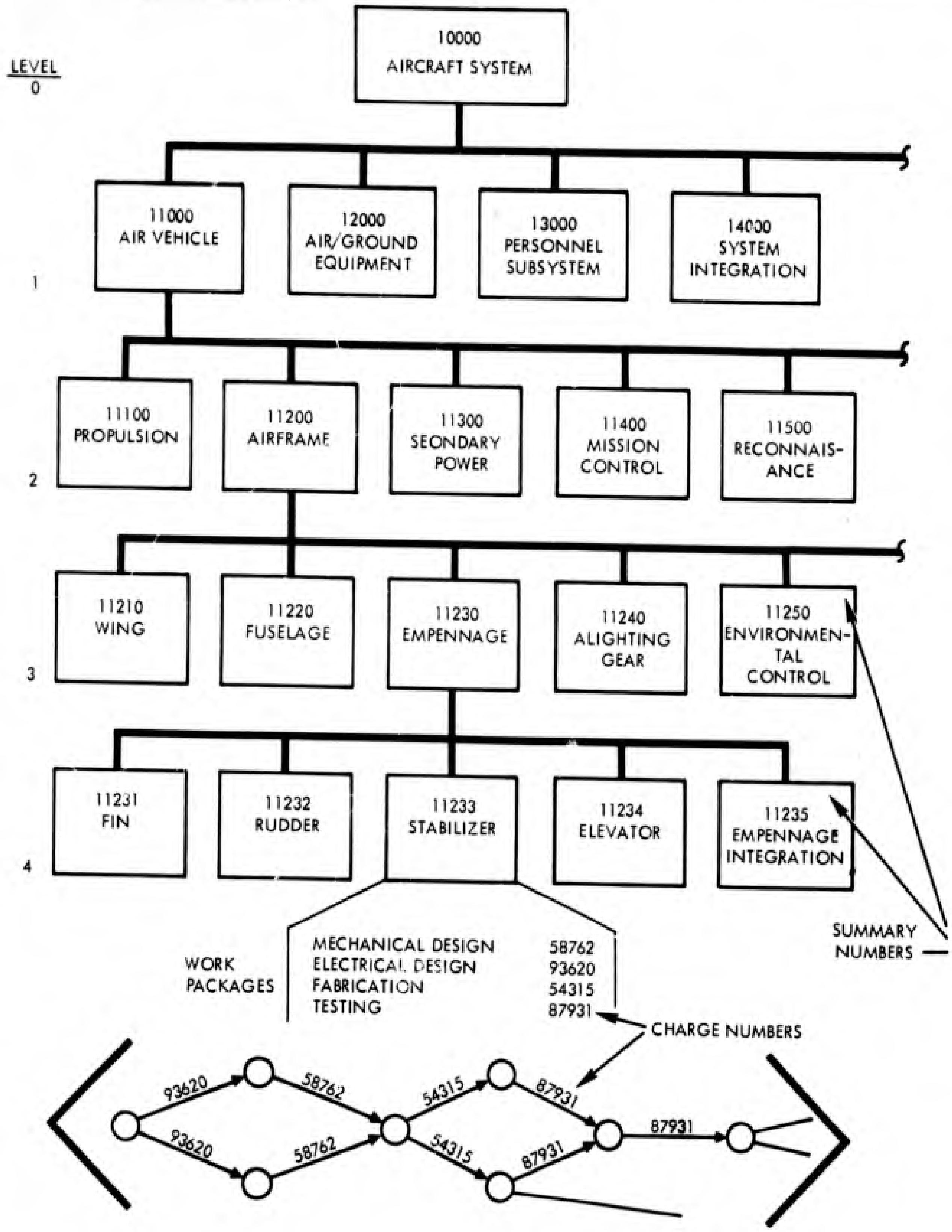


FIGURE VIII-1 — ILLUSTRATION OF ACCOUNT CODE STRUCTURE AND WORK PACKAGE/NETWORK CORRELATION

- accumulating actual costs; and
- comparing actuals and estimates with budgets.

Therefore, the task description should be written and, ultimately, work should be authorized by work package.

Of major importance to the accuracy of the PERT System is the size of the work package; i.e., the dollar amount and the time duration of the work package. It is obvious that the dollar amounts must be small for the work packages to do their intended jobs. Not quite so obvious is the importance of a short time duration for the work packages.

A valid cost variance for a work package can be determined only when the work package has been completed, so that its total actual cost can be compared with its total budgeted cost. At the end of each report period, however, a number of work packages will be in process; i.e., the job will have been started but not completed. For each in-process work package, an estimate is made of the value of that portion of the work package that is completed. This value is computed from the estimate-to-complete for the work package. Since such estimates are imperfect, they introduce some error. Short work packages are advantageous, because with shorter work packages:

- work packages are completed sooner, so that at any particular report date a greater percentage of the work done is represented by completed work packages for which valid cost variances can be determined; and
- the errors in the estimates-to-complete for the individual in-process work packages will be smaller, because the estimates are being made for a shorter duration in the future.

Thus, the shorter the work package, the better is the measure of cost performance to date that results.

A good target figure for most work packages is a maximum dollar content of $100,000 and a maximum time duration of three months. In the determination of work package size, the following must be considered:

- The work package should be a clearly defined recognizable task. If a work package has a "clean" ending event which extends its life beyond three months but provides better work definition and cost control, the longer time duration is desirable.

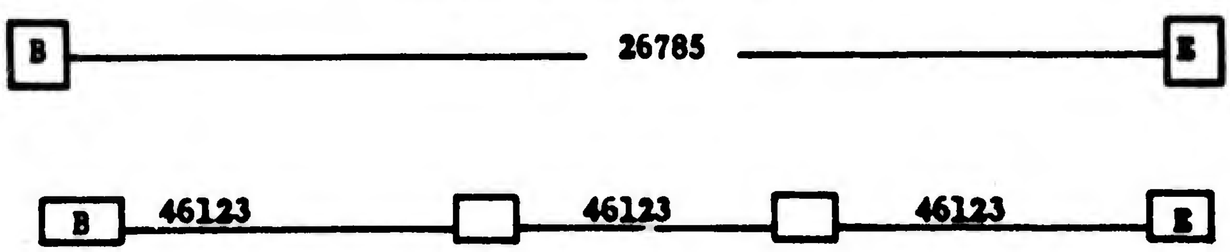
- Some level-of-effort functions are not amenable to, nor require the same degree of cost control that most of the project efforts require. Engineering support is such a level of effort that extends over the life of a contract. However, even in this case the effort should be broken down into smaller work packages by defining separate areas of engineering support between key events in the network.

Thus, while short work packages are a very important part of the system, judgment must be exercised to insure that they are logical and recognizable tasks.

D. Interrelating Time and Cost at the Work Package Level

Activities on the PERT network are identified with the work package they represent. A work package may sometimes be represented by only one activity with a beginning (B) and ending (E) event. For example:

Mechanical Design 26785



It is in this manner that time and cost are correlated at the basic planning and control level. The first and last events for the activity or group of activities representing the work package identify the beginning and end of the work package effort on the network. Thus, when schedules are established, scheduled dates for the beginning and ending of work packages are also established.

There are some work efforts in a project that do not constrain progress toward the end objectives; e.g., day-to-day project administration. In the PERT System, these efforts need not be represented on the network. However, in the use of PERT to plan and control both time and cost, all efforts must be represented by work packages and by activities contained in the network. This is necessary to maintain the complete integration of time and cost. For example, if day-to-day program administration is a direct charge to the contract, it must be represented by a work package and by network activities that are identified with that work package. Additionally, the requirement that the effort be contained in the network will often result in greater definition of the effort than would otherwise result.

To prevent a work package which represents non-constraining effort from extending over too long a duration, it should be broken into short segments that are related to key events in the network. Its overrun or underrun will then be a function of schedule progress on the project as well as the level of effort being applied, since the overrun or underrun for some level of effort is determined by the length of time which the task requires.

One way that the effort can be incorporated into the network is by extending single activities from one key event to another. Such activities must have artificially small time estimates so that they do not erroneously constrain other activities. These activities will be contained in the computer master file as part of the network. However, they need not be shown on network displays.

E. Preparing Cost and Other Resource Estimates

Once the scheduled elapsed times are determined, cost estimates are made by determining the manpower, material, and other resources required to perform each work package in its scheduled period. Estimates are made by month, starting with the month in which the work package is scheduled to start and terminating in the month that the work package is scheduled to be completed. These resource estimates are converted to dollars to determine the direct cost of each work package. Indirect costs are added either to each work package or at summary levels of the work breakdown structure, depending upon the accounting practices of the contractor. The cost estimates subsequently serve as the basis for developing budgets for each work package. Separate cost estimates are not necessary for each activity in a work package, since this would result in excessive detail and might lead to unrealistic accounting allocations. Costs may, however, be estimated by elements within a work package such as performing organization and resource skill.

For instance, although there is only one organization responsible for the work package, there may be more than one organization performing work on the work package. Estimates, therefore, may be by performing organization within the work package. Additionally, these estimates may be further broken down by resource; that is, they may be broken down into types of manpower, material, etc. The cost estimates for the more distant part of the project shall be identified against the higher levels of the work breakdown structure. Progressively each quarter, the detail work packages shall be defined as applicable to the lower level tasks and the estimates against the summary level numbers proportionately reduced. This "rolling wave" concept shall be utilized to maintain accurate control of the overall planned cost of the project while recognizing that only the next few months work can be planned at a finite level.

The cost estimates for all work are entered on basic estimating forms which are peculiar to the contractor or the computer program unit. All estimated costs for each work package are derived from the information entered on such computer input forms.

When costs are prepared, the estimator must be fully aware of the activities that make up the work package and of the status of these activities. Therefore, a listing such as the Work Package/Activity Listing must be provided as an aid to the estimator. This report lists the activities which contribute to a work package and provides significant time information about them.

Manpower estimates are entered on the estimating form by man-months or man-hours, and dollar estimates are entered for materials, subcontracts, special equipment, and services. Generally, in the data processing mechanism there are rate extension capabilities so that man-months can be converted to dollars, and, if it is the local practice, direct dollars may be converted to total dollars at the work package level.

Although it is desirable to prepare manpower estimates for each skill category, composite manpower estimates are acceptable under the PERT System. The appropriate labor rates for each skill category or composite labor rates are applied manually or by the computer, and all direct costs are totaled by months for the work package.

In some cases in the past, cost estimates have been only loosely related to the specific work to be performed. By counting organization personnel and multiplying the total figure by the scheduled duration of the work package, a contractor can estimate man-hours and cost to satisfy outwardly the requirements of PERT. This type of cost estimate, however, does not reflect the actual man-hours required to perform a specific work package. Instead, it represents the payroll required in each department for performing a type of effort over a precalculated elapsed time. This practice will render PERT or any other planning and control technique ineffective for generating basic source data to measure cost versus progress in achieving the project objectives.

F. Evaluating and Refining the Plan

When the cost for each work package has been prepared, the first PERT data processing run can be made. (A time run will already have been made prior to arriving at scheduled elapsed times.) From this run, the PERT reports (see Chapter XIV) are generated, and a review is conducted by management to determine the feasibility of the project plan.

If the proposed project plan in the form of a planned schedule does not achieve the objectives established, the manager may replan the effort using the following techniques:

- The schedule of slack path activities can be adjusted to minimize overtime requirements or additional hiring.
- The work package content can be revised.
- The planned resources for work packages can be revised by trading off interchangeable resources between critical and slack paths.
- The network sequence or content can be revised or rescheduled by:
    - employing a greater or lesser amount of concurrence in performing activities;
    - modifying the specifications or method of performing the work, thereby altering, deleting, or adding activities.

This replanning cycle continues until the proposed project planned schedule is in agreement with the required objectives of time, cost, and technical performance.

When the program plan has been approved (preferably at the signing of the contract), work commences and the measurement and evaluation of progress begin. At this point, the application and control cycle has started. In the control cycle the scheduled plan which includes the program directed dates is used as the standard against which actual and predicted task completions are evaluated. Budgets are developed from the work package cost estimates. Work authorizations are issued that permit charges against individual work packages starting with the scheduled date for the beginning of the work package. (The account will be closed out when the end event of the work package is completed.)

G. Accumulating Actual Costs

Costs are accumulated against work packages by charge numbers which reflect performing unit and type of resource expended. However, the manner of breakdown of costs within a charge number is optional and is a function of the degree of control desired by the individual contractor. Actual costs may be collected in more detail for traditional accounting purposes.

Expenditures and specified unliquidated commitments are incorporated in the term "actual costs." PERT does not distinguish between expenditures and commitments but reports both as "aggregate" actual costs. A practical difficulty, as in other cost systems, is the reporting of a cost as both an expenditure and a commitment.

Since the PERT reports must be timely, actual cost figures must be accepted prior to audit and formal release of accounting data. The small loss in accuracy that results is more than compensated for by the timeliness of the data. Actual costs for previous report periods will be updated to reflect the final audit for that period.

H. Updating Estimates-to-Complete

As a development project progresses, activities are added or deleted, work is completed behind or ahead of schedule and over or under the budget, and time and cost estimates for unfinished work are revised. Rapid updating of estimates-to-complete based on the work yet to be done and subsequent comparison against plan are necessary to insure the success of a management information system. This updating and comparison process constantly focuses management attention on the work to be done and on potential problems.

PERT allows systematic updating by:

- requiring re-estimates-to-complete for work not yet performed;
- establishing specific review dates;
- requiring the assignment of responsibility for estimate preparation and revisions;
- supplying the current schedule and cost status to the individuals responsible for developing revised estimates.

Each report period, the updating process includes obtaining estimates-to-complete for the work in process and, where needed, revised estimates for work not yet begun. Cost estimating, as previously described, is done by work package over the period of the work package. The scheduled beginning and ending dates of the work package appear on the estimating form. It is not necessary that each entry for the estimate-to-complete be revised every report period. The updating of an entry is required only if the existing entry does not reflect the current requirements.

Work packages in process usually will require an updating for each reporting period. However, reestimates for future work packages are made only when current information indicates changes in the initial estimates of manpower, material, and other resources necessary to perform the work. In projects of long duration, many future work package cost estimates are untouched each month.

As work progresses, cost estimates are revised on an as-required basis. Budgets, however, are less flexible and generally will be revised only when the content of the work package changes as a result of modifications such as revision of the contract work statement, revision of departmental responsibility, or replanned and rescheduled effort.

Budgets may be established at levels lower than the work package, but do not necessarily have to be established at a level as low as that for the cost estimates or actuals. The basic comparison of budget with actuals and estimates will be at the work package level.

The achievement and maintenance of an effective updating system relies on the issuance of formal updating procedures which indicate the data cut-off dates, processing cycles, and report delivery dates. Follow-up is required to insure that the dates are met.

I. Accounting for Changes in Contract Scope

One of the most important contributors to cost increases on a project is the constant change made to the original scope of the contract. When the changes are made, increases in cost often result that are greater than warranted for the change that was made. This has been possible because under traditional contract task structures it is often difficult to evaluate the cost impact of a change on some hardware item. There is the need, therefore, for a means of more precisely determining the warranted change in cost due to changes in scope of the contract.

PERT, by structuring project contracting, planning, and costing by end-item subdivisions and the tasks (work packages) required to accomplish these end items, provides a better basis for contract amendment at the time that changes are incorporated.

J. Processing Information

The processing of the input information required to produce the PERT output reports is complex and, on all but the smallest projects, will require a computer program. The manner in which a computer program would typically operate on the input data to produce the output reports is demonstrated in Chapter XIV.

K. Preparing Output Reports

The basic information generated in the PERT System is summarized in several ways for project management reporting. The resultant uniform PERT output reports are presented in Chapter XIV. Based upon these reports, the schedule and cost data are prepared for management illustrating program status, and projected trouble spots that require management analysis and action. The reports provide the following information in varying degrees of detail:

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

The information shown in the output reports together with the problem analysis report make it possible to identify and locate present problems and anticipate future slippages and overruns or underruns. Since the reports rank these problems (via the slack and overrun/underrun figures), the manager's attention is directed to the critical items. The reports summarize current information from the bottom up, without distortion, for each level of project management, thereby relieving a manager of the need to review detailed data from subordinate levels. However, if any specific area requires more detailed analysis, the detailed information is available without additional processing.

All PERT reports are interrelated: they deal with the same basic data, but each one emphasizes a different aspect of the project status. Not only are different kinds of problems emphasized; e.g., cost overrun to date, projected cost overrun, schedule slippage, etc., but specific problems as related to the different levels of management are highlighted. The Management Summary Report presents these problems in summary fashion for the highest level of management (as well as for other levels of management); the Organization Status Report presents information most pertinent to managers at the lowest supervisory level of the project; and the Financial Report is directed to the financial personnel associated with the project.

Periodic management reports make it possible for managers to anticipate cost overruns and underruns. An example is the Management Summary Report which shows the overall schedule and cost status of both the program as a whole and of each of the major component items. It also indicates the problem areas that require management attention relative to areas of responsibility:

- <u>the cost overrun or underrun to date</u> (a measure of cost performance), through a comparison of the planned costs with actual costs for the work performed;

- <u>the projection of total cost overrun or underrun</u> which is obtained by comparing a planned cost with the latest revised estimate for the work segment or program; 1/

- <u>the amount of schedule slippage</u> is indicated by the difference between the established schedule and the earliest scheduled completion date;

- <u>the identification of trouble spots</u> - that is, identification of those areas of the program where the cost or time status requires management attention.

1/The planned cost and latest revised estimate will Include approved but "still-to-be" negotiated changes within fund limitations.

The determination of the projected overrun or underrun at completion of the project is straightforward. Planned cost, i.e., budgeted costs for the project, are compared to the sum of actual costs to date and the estimate-to-complete for the project. Each report period, estimates-to-complete are recorded for that portion of each in-process work package that is not yet completed and for each work package that has not yet been started. Summation of these costs gives an estimate-to-complete for the project that is based on the work yet to be done. When this estimate-to-complete is added to the actual cost for the work performed to date, an estimated cost at completion is derived which is based on the association of costs with work accomplishment. This estimated cost at completion is compared to total planned cost to arrive at the projected overrun or underrun.

The overrun or underrun to date is the more elusive cost figure and has not, in general, been adequately measured under traditional systems. In PERT, the derivation of this figure begins with the budgeted or planned cost for a work package. This amount is the value of a work package. Thus, if a work package is budgeted for $100,000, its value is $100,000. If $110,000 is spent to complete the work package, there is an overrun of $10,000. If three work packages are budgeted at $100,000 each, and a total of $320,000 is spent in completing them, the total overrun is $20,000. The calculation of the value of work performed to date and the overrun/underrun to date is that simple for most of the work that is completed.

However, suppose that, at a particular report date, not all three work packages are completed: two of the work packages are completed and one is in process. The amount spent to date is $260,000. How is the cost variance to date computed? A comparison of the actual cost of $260,000 to the value for work performed to date needs to be made. It is known that, for each of the two completed work packages, the value is $100,000. However, the value of these two work packages must be added to the value for that part of the third work package which is completed. Making an exact determination of the value of the in-process work package is very difficult. This difficulty is met in PERT, not through the establishment of an exact means of determining the value (which would require considerable accounting effort each report period), but through the limiting of the in-process work packages to a small portion of the total work completed. In this way, the error introduced in estimating the value is kept to an acceptable minimum. This limiting is accomplished by the definition of short work packages, as previously described. With sufficiently small work packages, a simplified method for approximately determining the value for in-process work packages can be used that is adequate for project control purposes.

This method is as follows: the ratio of the actual cost to date of the work package (A) to the latest revised estimate of the cost at completion of the work package (R) is multiplied by the original planned cost for the work package (C) to determine the value of the work performed to date for the in-process work package.

To determine the total value of the work performed to date for the project or for the end-item subdivision under consideration, the value of the work performed to date for each in-process work package as computed by the A/R x C formula is summed and is added to the value of the completed work packages. This figure is then compared to actual cost to date to determine the overrun or underrun for the work that has been completed.

With short work packages, most of the total value figure is derived from completed work packages for which valid value figures are known. As the project progresses, an increasingly larger percent of the work completed is made up of completed work packages.

Management Summary Reports are prepared for managers at each level or echelon of the program structure (reference Figure VIII-1). Each Management Summary Report will normally be accompanied by a brief written analysis. One report is prepared, for example, for the entire System (level 0). At level 1, a similar report is prepared for each major element of the program, such as Air Vehicle, Air/Ground Equipment, System Integration, etc. At the next lower level, level 2, the major elements of the program are subdivided again and a Management Summary Report is prepared for each manager to whom responsibility is assigned. The Air Vehicle, for example, is divided into elements such as Propulsion, Airframe, Secondary Power, etc. The Airframe is further subdivided and management reports are prepared at such lower levels of the program as are considered necessary by the program manager. In analyzing the status of a program, the responsible manager would examine the reports for those end items where trouble is indicated. He would then refer to the lower level reports as required to isolate the trouble.

Another management report is the Cost of Work Report which shows the appropriate manager:

- the planned costs to perform the work;
- the actual costs to date;
- the value of work performed to date;
- the projection of costs to program completion, based on actual costs to date and estimates-to-complete for work not yet performed.

A comparison of the actual costs accumulated to date and the value for work performed to date will show whether the work is being performed at a cost which is greater or less than planned. The Cost Outlook Report and the Schedule Outlook Report show the trend of successive monthly projections of the time and cost to complete the work. Each month, new projections are obtained and these projections provide new entries for the Cost and Schedule Outlook Reports.

By relating the trend of these projections to previous management decisions, the manager can observe the effects of these decisions on the cost and schedule for the project. He can determine, on a month-to-month basis, whether or not the actions taken to control schedules and costs are producing the desired results.

Not all reports in Chapter XIV are presented to the government by the prime contractor or other suppliers. The reports which are submitted and the degree of detail of these reports are a matter of negotiation. The government manager must designate the lowest level of report summarization required for his own management visibility. The level of detail required should not be the same throughout the whole program. The level of breakdown required should vary, depending on such factors as complexity of technical problems, dollar value, pacing items, etc. Thus, the government manager should require routine reporting of the minimum amount of data needed to meet the goals of effective program management. He should also retain the right to obtain additional detailed information, whenever required, to investigate problems shown on the higher level reports.

Whenever possible, the cost report periods requested by the government should correspond to the supplier's accounting period. Time reports may be required more often than once during the accounting period.

L. Evaluating Status

The output reports identify the problems for management. The Problem Analysis Report (see Chapter XIV), a narrative report supplementing the other reports, contains a summary analysis of the project, an analysis of tasks in which current or potential problems exist, and a description of the nature, reasons for, and impact of the problems, along with the corrective action being taken and the expected results.

With the output reports, project evaluation personnel are then able to formulate solutions that, in general, take the form of one or more of the following alternatives:

- trading off resources (time, money, manpower, materials, facilities, etc.) from noncritical areas to problem areas where they may be used more effectively;

replanning the effort in a manner to obviate the problem. For instance, the replanning might include more concurrence of activities than originally planned. This alternative often involves taking on a higher risk plan than was originally developed;

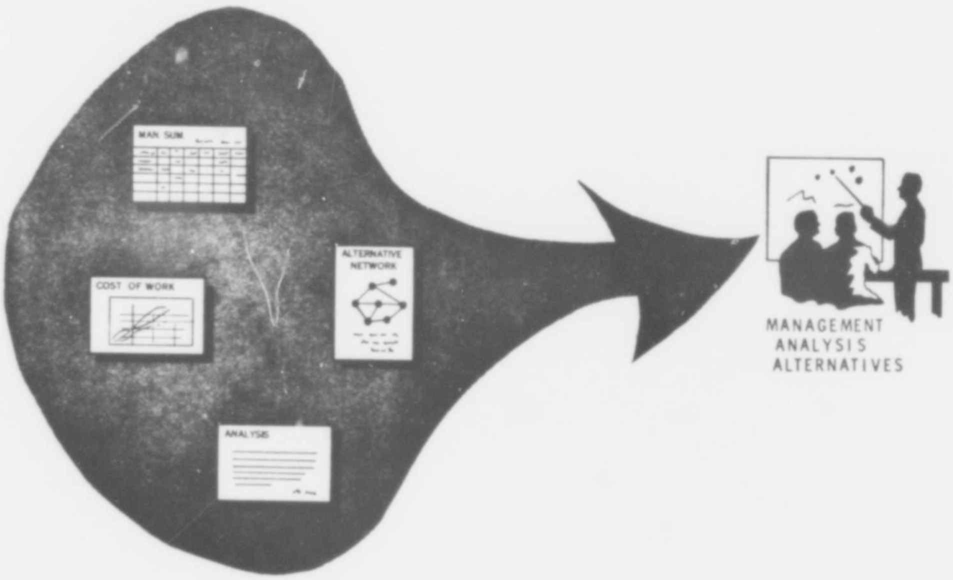
modifying the technical objectives and, therefore, the work content of the work packages; and

changing the projected total project cost and/or scheduled completion date.

If the contemplated solution is complex, the complete effect of the proposed changes may not be readily apparent. As an aid to the analyst, the proposed changes can be simulated on the computer.

CHAPTER IX

ANALYSIS



Effective analysis of the PERT data prior to presentation of information to management is one of the keys to the successful application of PERT. While many PERT reports are brought together at the Program Office to provide total program cost and schedule information, most of these reports are machine produced. Furnishing these reports to the program director would require that he conduct his own analysis; therefore, he should not receive information generated directly by computer systems. The computer program can do little pre-analysis, and the computer outputs contain only raw data or partially interpreted data. Consequently, the function of the analysis group in the Program Office is to analyze the data, ascertain the status of the program, and then present this status to the program manager in the form that best enables him to carry out his decision-making function.

To provide this information, the analyst must examine each indicated potential problem area and:

- verify the reasonableness of the indication by using cross-checking methods designed to uncover data input or processing errors;

- validate the existence of the problem through discussions with the responsible organization;

- document alternate solutions through discussion with the responsible organization; and

- prepare management reports and displays which will present the problems and solutions in a format suitable to each management level.

Some problems are of such a nature that they are not apparent until reports are merged at the government or integrating contractor level. Therefore, the analyst is often first to see the total problem. Other problems are visible at the contractor level and should be well documented in his Problem Analysis Report which is received by the government.

The complete array of reports are not required by the government; therefore, care must be exercised in selecting the appropriate level of reporting.

It is possible to produce any of the PERT reports at any level of the work breakdown structure. If a Program Office required monthly submissions of all reports at all levels, they would be overwhelmed with paper. Much of this would be redundant information and, because of the volume, could never be reviewed. The government must exercise judgment in requesting only what is useful.

* * * * * *

A. Problem Analysis Report

The Problem Analysis Report is manually prepared and presents an analysis of the Management Summary Report. It serves as a basis for formulating and assessing solutions that will minimize or eliminate the problems presented. It also provides information to the analyst that would not be otherwise available for consideration. The analysis must be concise, accurate, and significant for that level of management making use of it. This report contains three basic sections:

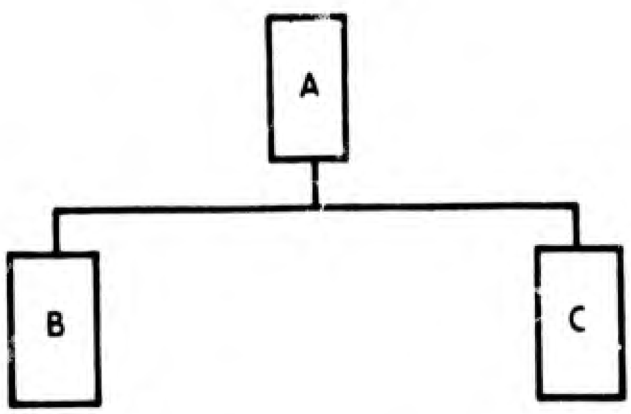
- a summary analysis of the total contractor's portion of the program;
- an analysis of the tasks in which current or potential problems exist;
- a description of:
    - the nature of the problem,
    - the reason for schedule or cost variance,
    - the impact of the problem, and
    - the corrective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

B. Management Summary Report

The Management Summary Report tells management which area or areas of the program may be in need of management attention. It shows current and projected cost and schedule status of the total program. and of each of the major component items or elements within the program. The report may be prepared for any level(s) of the work breakdown structure and for all contracts or a specified combination of contracts, depending upon the needs of management.

1. Cost Section

The Management Summary Report presents total costs in the form of planned and latest revised estimates. These costs are shown by summary number for any level of the work breakdown structure and are summed through it. The value of work performed to date is computed for each summary item appearing on this report. The following example illustrates the calculation of this value on the work breakdown structure shown below:



The computation for the value of work performed is started at the work package level associated with charge number B. The sum of these values then becomes the value of work performed for charge number B.

The value of work performed is then computed for each work package associated with charge number C. The sum of these values then becomes the value of work performed for charge number C. This sum of the work package value then becomes the value of work performed for summary number A.

For those combinations that are not yet in progress, the value of work performed is zero. For those combinations that are completed, the value is the actual total cost.

For those combinations that are in progress, the value is computed as follows:

$$\text{Value of Work Performed} = \frac{\text{Actual Cost} \times \text{Planned Cost}}{\text{Latest Revised Estimate}}$$

(Overrun)/underrun to date is also expressed as a percentage of the value of work performed and is computed as follows:

$$\%\text{(Overrun)Underrun to date} = \frac{\text{(Overrun)Underrun}}{\text{Value}} \times 100$$

The latest revised estimate is computed for each charge/summary number appearing in this report. For those charge/summary numbers not yet in progress, this figure represents the estimated total costs. For those combinations in progress, this figure represents the actual costs incurred to date plus the amount of total costs estimated for completion. For those combinations that are completed, this figure represents the actual total costs incurred.

The projected (overrun)/underrun is also computed for each charge/summary number. This figure represents the planned costs minus the latest revised estimate. An underrun condition exists when:

$$\text{Latest Revised Estimate} - \text{Planned Costs} < 0$$

An overrun condition exists when:

$$\text{Latest Revised Estimate} - \text{Planned Costs} > 0$$

(Overrun)/underrun is also computed as a percentage of the planned costs and is computed as follows:

$$\%\text{(Overrun)Underrun} = \frac{\text{(Overrun)Underrun} \times 100}{\text{Planned Total Costs}}$$

Cost overruns and negative slack, shown on the high-level Management Summary Reports, must be examined to locate, rank, and validate the problem. The overrun shown for some first or second-level summary items may be due to one or two specific problems in summary items much farther down the work breakdown structure. The analyst must use lower-level reports and other follow-up analyses to determine specifically where the overrun is, to what it is due, and what is being done about it.

All overrun indications must be examined and validated. False overrun indications may be caused by incorrectly phased cost reporting. For instance, if a large commitment which was planned for February becomes an actual cost in January, the 31 January report may include the commitment as both an actual cost to date and an estimate-to-complete. The resulting calculation would indicate an overrun equal to the amount of the commitment, when, in fact, there should be no projected overrun. This kind of error should be identified by the contractor's analyst so noted in the Problem Analysis Report; the government analyst, nevertheless, should be sensitive to its possibility.

Another false overrun indication can be caused by engineering changes. Often, when changes are made to the program, the increased cost is reflected in the estimates-to-complete, even though the contract has not yet been modified and the costs cannot be shown in the Planned Cost column. The analyst should be aware of the proposed changes and be able to identify their contribution to the increased latest revised estimate. He should then be able to modify, change, or explain to higher management the increased latest revised estimate.

The analyst must understand the product which is the subject of the summary item he analyzes. In particular, he must be aware of the changes which occur in its design and configuration so that he can relate increased planned cost indications in the Management Summary Report to approved engineering changes. If approved engineering changes are made without regard to their compatibility with the work breakdown structure, and cost allocations are made to items on this breakdown, only the analyst with intimate knowledge of the product can judge the validity of such "planned cost" increases.

The full significance of a problem can only be assessed when the time and cost effects of a problem are considered together. When the analyst has examined the Management Summary Report problem indication, he must determine whether the problem involves either a cost problem or a time problem, or a combination of both. He must consider recommended management action in terms of its effect on both the time and the cost parameter, as well as on achievement of the program's technical objectives.

2. Schedule Section

The Management Summary Reports present schedule information for each level of the work breakdown structure; i.e., level 1 Management Summary Report provides level 1 and 2 schedule data; level 2 Management Summary Report provides level 2 and 3 schedule data, etc., summed upward through it.

The most critical slack is computed for each summary number appearing in the report. It represents the slack with the lowest algebraic value, derived from the activities associated with the corresponding charge/summary number.

Completion dates are computed for each summary number appearing on the report. These values represent the actual, scheduled, earliest and latest completion dates. These dates are derived as follows:

- The scheduled date (S) is derived in the following manner:
  - All activities associated with the charge or summary item are examined to determine the event having the latest S_E.
  - If this activity has a scheduled date (T_S) assigned to it from the PERT Time System, then this date will be used as the scheduled date.

If this activity does not have a scheduled date, then S_E is used as the scheduled date.

If S_E or the scheduled date are not available, then the charge number completion date is used. This date is entered on a Charge or Summary Number Identification Input Form.

The actual date is derived from the last activity to be completed in the corresponding charge/summary number.

The earliest and latest dates are derived from the activity bearing the most critical slack. These dates represent the S_E and S_L values respectively for this activity. These dates are also shown in graphical form.

The negative slack indication given for a summary item can be misleading, because it may refer only to a relatively insignificant element within the summary item. For the high-level Management Summary Reports, 98 percent of the critical path may run through one summary item; but because small parts of the path may touch parts of other summary items, the worst negative slack may be shown in the Management Summary Report for all of these items. Thus, the analyst must often look beyond the Most Critical Slack listing to determine whether the summary item as a whole is in schedule difficulty. This is done by consulting the PERT Time reports in which the status of events, activities, and network paths can be examined to identify precisely the time problems.

To trace this problem from the Management Summary Report to the PERT Time reports, the analyst must use the Program Status Report which identifies the event numbers of both the last event in a summary item and the event at the end of the most critical slack path within that summary item. With this information, the analyst can find the applicable slack path in the Event Report - Slack Sort to study the true time status of work in the summary item.

The analyst must be aware of the significance of the scheduled completion date (S) of the total item. If the event for which S is shown is the delivery of that summary item, then the S has schedule performance significance in itself. However, if the S refers to the completion of some auxiliary task (e.g., completion of documentation which occurs long after the significant completion occurs), then this date may have some cost control significance; but if the analyst wishes to monitor schedule performance, he must find another more significant event in the time reports.

Another situation in which S loses significance is when the event to which this date applies is too far in the future. It is usually more useful to measure slack from a major milestone within the year. The Schedule Date Option is often used to facilitate this analysis problem. Significant events are chosen which represent the completion of the major effort in selected summary items in the near future. A scheduled date is assigned to each selected event, and the Schedule Option is exercised for the corresponding network event during processing. Thus, the most critical path related to cost status of the summary item would be anchored to this significant milestone completion and would be easily detected.

3. Analysis

Simple identification of the existence of a problem is not difficult. The analyst need only scan the Overrun/Underrun column of the Management Summary Report to locate a cost overrun, and he need only examine the Most Critical Slack column to find where negative slack exists. However, this problem identification is not sufficient to complete an analysis. An example of analytical procedures pertinent to the Management Summary Report is described below.

From the Management Summary Report, the manager can determine:

- The extent of any cost overrun or cost underrun to date by comparing the value of work performed to date with the actual cost of the work performed;

- the projected cost overrun or underrun for the total project, by comparing the planned cost for the project with the latest revised estimate at completion for the project; and

- the amount of schedule slippage, by determining the difference between the expected completion date for the most critical item within the end item and the latest allowable completion date for that most critical item.

The Management Summary Report is prepared for managers at each level or echelon of the project structure. For examine, at Level 1, a report is prepared for the missile portion of the project (Figure IX-1) and at Level 2 a similar report is prepared for each manager of a major element of the project such as propulsion (Figure IX-2). At the next lower level, Level 3, the end items are subdivided again, and a Management Summary Report is prepared for each responsible manager (Figure IX-3).

When the responsible manager analyzes the status of a project, he examines the report for those end items for which trouble is indicated. He then refers to the next lower level of the report to isolate the trouble spot.

In the example shown in Figures IX-1 through 3, the manager responsible for the A 10 Missile at Level 1 can review the Management Summary Report and determine that:

- there is a projected slippage of eight weeks in the scheduled completion and a projected overrun of $3,400,000. The major contributing system is the propulsion system in level 2;

CMWS - AIO MISSILE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ	61-9865	TERM (SPAN): TOTAL PROJECT CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: 1 /MISSILE			

ITEM	COST OF WORK $(000)						SCHEDULE		
	WORK PERFORMED TO DATE			TOTALS AT COMPLETION			MOST CRIT SLACK (WKS)	COMPL DATE	S - SCHED COMPL DATE -- } TOTAL ITEM A - ACTUAL COMPL DATE -- } E - EARLIEST COMPL DATE -- } CRITICAL ITEM L - LATEST COMPL DATE -- }
	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED EST	PROJECTED (OVERRUN) UNDERRUN			P YR | 63 JFMAMJJASOND | 64 JFMAMJJASOND | 5 6 7 8 | L YR
LEVEL 1 MISSILE 302	31,000	32,300	(.04) (1,300)	48,000	51,400	(.07) (3,400)	-8.0	29 MAR 64 01 FEB 64 10 MAY 64	E L S
LEVEL 2 PAYLOAD 302DEV121	13,300	13,200	.01 100	16,700	16,700	--	-1.3	22 OCT 63 12 OCT 63 12 OCT 63	E L S
LEVEL 2 FLIGHT CONTROLS 302DEV122	3,700	4,000	(.08) (300)	5,600	6,100	(.09) (500)	-2.2	13 DEC 63 29 NOV 63 20 FEB 64	E L S
LEVEL 2 MISSILE BODY 302DEV123	1,100	1,100	--	4,200	4,000	.04 200	1.2	01 JAN 64 10 JAN 64 10 JAN 64	E L S
LEVEL 2 PROPULSION 302DEV124	4,400	4,900	(.11) (500)	8,600	9,600	(.11) (1,000)	-8.0	29 MAR 64 01 FEB 64 01 FEB 64	E L S
LEVEL 2 INSTRUMENTATION 302DEV125	3,100	3,100	--	7,200	7,200	--	0.0	10 MAY 64 10 MAY 64 10 MAY 64	E L S
									TIME NOW

FIGURE IX-1 PERT MANAGEMENT SUMMARY REPORT

CMWS - A10 MISSILE	REPORTING ORGN.	CONTRACT NO.	REPORT DATE
	XYZ	61-9865	TERM (SPAN): TOTAL PROJECT CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: (2) PROPULSION			

ITEM	COST OF WORK $(000)						SCHEDULE		
	WORK PERFORMED TO DATE			TOTALS AT COMPLETION			MOST CRIT SLACK (WKS)	COMPL DATE	S-SCHED COMPL DATE--TOTAL A-ACTUAL COMPL DATE-- ITEM E-EARLIEST COMPL DATE -- CRITICAL L-LATEST COMPL DATE -- ITEM P YR 63 JFMAMJJASOND 64 JFMAMJJASOND 5 6 7 8 L YR
	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED EST	PROJECTED (OVERRUN) UNDERRUN			
LEVEL 2 PROPULSION 302 DEV 124	4,400	4,900	(.11) (500)	8,600	8,600	(.01) (1,000)	-8.0	29 MAR 64 01 FEB 64 01 FEB 64	E L S
LEVEL 3 CONTROLS 302 DEV 124-1	300	760	(.15) (460)	1,220	1,940	(.59) (726)	-8.0	29 MAR 64 01 FEB 64 01 FEB 64	E L S
LEVEL 3 SERVO 302 DEV 124-2	730	740	(.01) (10)	930	940	(.01) (10)	10.0	20 JUL 63 26 OCT 63 26 OCT 63	E L S
LEVEL 3 CASE 302 DEV 124-3	1,360	1,390	(.04) (30)	2,450	2,890	(.18) (440)	2.0	18 FEB 64 01 FEB 64 01 FEB 64	E L S
LEVEL 3 NOZZLES 302 DEV 164-4	60	50	.02 10	540	370	.03 170	-3.0	21 FEB 64 01 FEB 63 01 FEB 63	E L S
LEVEL 3 PROPELLANT 302 DEV 124-5	1,920	1,930	(.05) (10)	3,230	3,230	---	5.0	28 JUN 63 02 AUG 63 02 AUG 63	E L S
LEVEL 3 IGNITION 302 DEV 124-5	30	30	---	230	230	---	4.0	28 DEC 63 25 JAN 64 25 JAN 64	E L S
									TIME NOW

FIGURE IX-2 — PERT MANAGEMENT SUMMARY REPORT

CMWS - A10 MISSILE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ	61-9865	TERM (SPAN): TOTAL PROJECT CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63
LEVEL/SUMMARY ITEM: (3) CONTROLS			

ITEM	COST OF WORK $(000)						SCHEDULE	
	WORK PERFORMED TO DATE			TOTALS AT COMPLETION				
	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED EST	PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK	COMPL DATE
LEVEL 3 CONTROLS 302 DEV 124-1	300	760	(1.5) (460)	1,220	1,940	(.50) (720)	-8.0	28 MAR 64 01 FEB 64 01 FEB 64
LEVEL 4 THERMAL TRANSDUCERS 302 DEV 124-1-111	241	283	(.17) (42)	274	310	(.13) (36)	-1.6	04 APR 63 23 MAR 63 23 MAR 63
LEVEL 4 RELIABILITY 302 DEV 124-1-121	10	10	---	126	120	6	0.0	01 FEB 64 01 FEB 64 01 FEB 64
LEVEL 4 PRESSURE TRANSDUCERS 302 DEV 124-1-131	21	441	(2.0) (420)	453	975	(1.1) (522)	-8.0	11 SEP 63 17 JUL 63 17 JUL 63
LEVEL 4 CABLES 302 DEV 124-1-141	17	15	2	108	41	.60 62	8.4	08 NOV 63 11 JAN 64 11 JAN 64
LEVEL 4 INSTRUMENTATION (PECULIAR) 302 DEV 124-1-151	11	11	---	264	494	(.87) (230)	-2.7	31 JAN 64 14 JAN 64 14 JAN 64

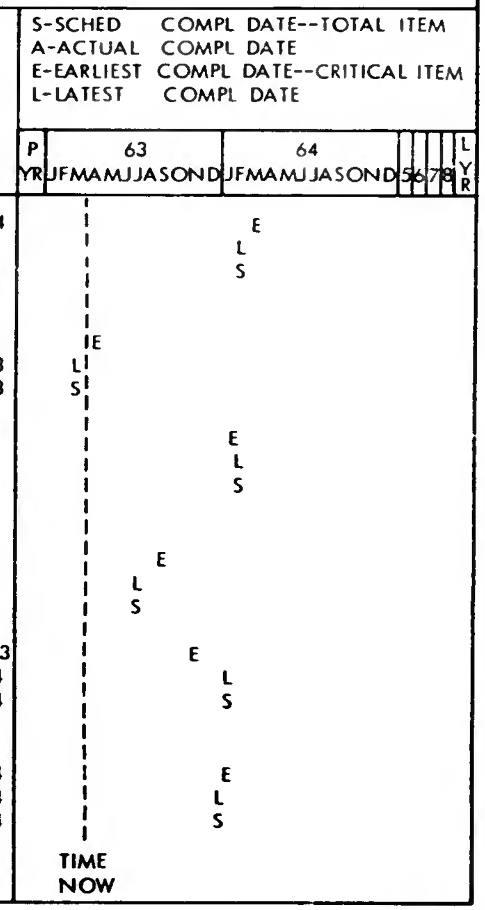


FIGURE IX-3 — PERT MANAGEMENT SUMMARY REPORT

- there is a projected cost overrun to date of $500,000 and a projected overrun of $1 million for project completion;

- in reviewing the propulsion system at Level 2, Management Summary Report, it can be seen that the controls at Level 3 are the major cause of the projected cost overrun and schedule slippage.

- in reviewing the controls at Level 3, Management Summary Report, it can be seen that the major cause of the projected overrun and schedule slippage is the Pressure Transducers.

In view of the wide divergence of slack at Level 1 of 1.3 to -8.0, the reallocation of funds appears warranted to bring the program in line.

At first glance it appears that the reassignment of funds at Level 2; i.e., from the Missile Body to the Propulsion area is warranted. However, it must be remembered that the funds are assigned from the top down and the actuals are reported from the bottom up. This assignment and accumulation insures that the control of any project is at the lower levels insofar as the contractor is concerned.

An approach to consider would be a transfer of funds of at least 200K from the Missile Body to the Propulsion System at Level 2. Within Level 3 a transfer of 170K from the Nozzles to the Controls appears feasible while at Level 4 a transfer of only 62K from the Cables to the Pressure Transducer is possible.

This manipulation does not reduce the overrun status but it can help in bringing the program back towards the original schedule.

The areas of positive slack should also be investigated to determine if funds can be reallocated to assist in returning the program to schedule.

It should be noted that the Level 3 report which involves the Pressure Transducer is indicating that a major effort is required on this item. The overrun to date based on the work performed to date amounts to 420K. This amount represents a major portion of the overall overrun and cannot be recovered.

Cost and schedule control can be significantly improved by the Management Summary Report, which provides timely identification of current and developing cost and schedule problems.

C. Cost of Work Report

A Cost of Work Report is illustrated in Figure IX-4. This report is a graphic representation of the current and projected cost status. Curve A is the planned cost for the project. The planned cost is determined at the beginning of the project and is derived from the budgets for the scheduled work packages. If no changes take place in the contract provisions, this planned cost would be constant throughout the life of the project.

Curve B is comprised of the actual costs to date and the estimates-to-complete for the project. The solid-line part of the curve extending to "time now" depicts the actual costs. The dotted extension of Curve B represents the estimate-to-complete.

Curve C depicts the value for the work performed to date. The intervals between the curves along the "time now" line (brackets 1 and 2) represent useful information. The vertical distance indicated by bracket 1 is the difference between the planned cost and actual cost to date. This value is traditionally considered the overrun/underrun value. According to this method, the project shown in Figure IX-4 is $300,000 underrun ($1,300,000-$1,000,000). However, if the actual cost is compared to the value for the work that was actually performed to date, it can be seen as indicated by bracket 2 that $200,000 too much ($1,000,000-$800,000) was spent for the work that was performed. Thus, there is actually a $200,000 overrun on the work performed to date. The remarkable difference between the apparent overrun/underrun as

COST OF WORK REPORT

PROGRAM	REPORTING ORGN.	CONTRACT NO.	REPORT DATE: 3/31/63
CMWS	XYZ CORP	61-9865	TERM: PROGRAM
LEVEL/SUMMARY: 1/MISSILE			CUT OFF DATE: 31 MAR 63 RELEASE DATE: 10 APR 63

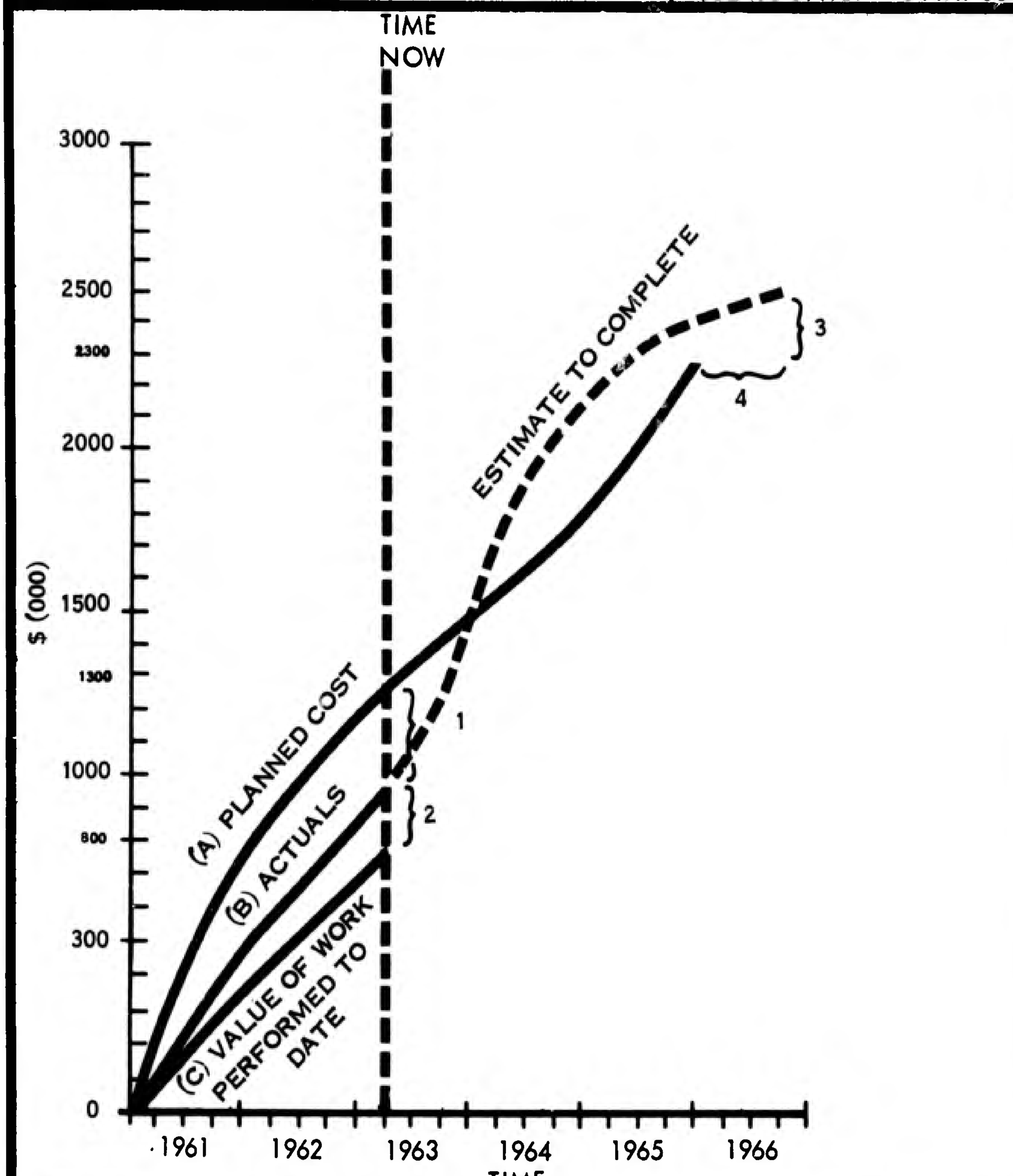


FIGURE IX-4

measured by the difference between planned cost and actuals, and the actual overrun/underrun as represented by the difference between the actuals and the value for work performed to date is one that is apt to occur in many large development projects.

This situation often arises in cases where a contractor is having difficulties and is, therefore, behind schedule and overspending. If he is far enough behind schedule, actual cost will be less than planned cost to date in spite of poor cost performance, and traditional accounting methods will show an underrun instead of an overrun.

The ends of Curves B and C disclose two other important elements of information. Bracket 3, which includes the vertical distance from the estimate-at-completion ($2,500,000) to the planned cost ($2,300,000) represents the predicted overrun at completion of $200,000. The horizontal distance indicated by Bracket 4 from the beginning of January 1966 to the beginning of October 1966 indicates that the project is expected to be completed nine months later than scheduled.

D. Program/Project Status Report

The primary purpose of the Program/Project Status Report is to back up the Management Summary Report. The two reports contain similar information, but where the Management Summary Report highlights information for a manager, this report retains detail for an analyst. The Management Summary Report is divided for distribution and the Program/Project Status Report remains intact as reference material for the entire portion of the program for which reports are prepared. This report serves as the tie to the networks since it contains the beginning and ending event number for every summary item as well as the end event which appears on the most critical path. With this information, the analyst can go directly to the proper portion of the network, and the PERT Time Reports, for additional information.

1. Time Data

The Program/Project Status Report shows the first and last event for each charge/summary number appearing on this report. It also shows the actual, scheduled, earliest, and latest completion dates, as well as the slack for each of the charge/summary numbers. These schedule values are summed upward through the work breakdown structure.

The first and last event numbers represent those activities whose start and end dates mark the start and end of the corresponding charge/summary number. These events are determined as follows:

- The activity start date ($S_E - t_S$) is computed for each of the activities associated with the corresponding charge/summary number. The predecessor event of the activity having the earliest start date is designated as the first event.

- The last event is the successor event of the activity with the latest S_E.

The scheduled or actual completion date represents the scheduled (T_S) or actual dates (A) associated with the last event number shown in the preceding column.

The earliest/latest completion dates represent the S_E and S_L, respectively, of the last event number (shown previously).

The most critical slack represents the lowest algebraic slack value that occurs among the activities associated with corresponding charge/summary number. It should be noted that this most critical slack value may not refer to the last event associated with the corresponding charge/summary number.

2. Total Costs

This report presents total costs in the form of planned and latest revised estimates. These costs are shown by charge/summary number for any level of the work breakdown structure.

These costs are summed upward through the work breakdown structure. When a specific level is selected, this report will show all of the charge/summary numbers connected to those numbers on the desired level.

E. Organization Status Report

There are several options of this report available broken down by Responsible Organization Resource Code, Performing Organization, Charge Numbers or Network Code (Project Number). The report is a shredout of the data base from which the Management Summary Report is developed. Its primary use is within a contractor's organization.

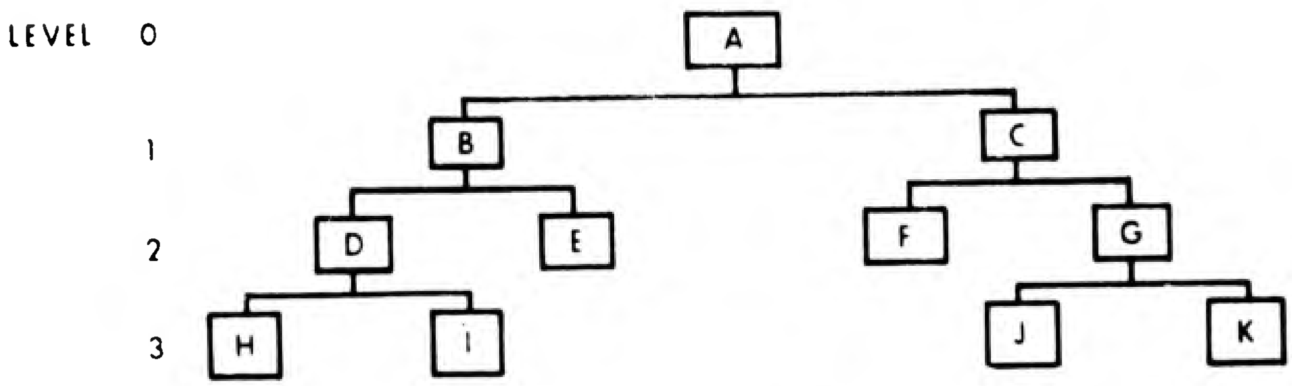
1. Man-Hours

This report also displays man-hours in the form of actual hours, planned hours, and latest revised estimates.

The latest revised estimate is computed for each charge number performing organization, responsible organization, resource code combination appearing in this report. For those combinations not yet in progress, this value represents the actual man-hours (months) expended to date plus the total number of man-hours (months) estimated for completion. For those combinations that are completed, this value represents the actual number of man-hours (months) that were expended.

The projected (overrun)/underrun is also computed for each combination. This value represents the planned man-hours (months) minus the latest revised estimate.

On this report man-hours (months) are not summed upward through the work breakdown structure. For example, an Organization Status Report is requested for Level 2 of the work breakdown structure shown below.



The report would show Item B as the summary item at the top of the page. The body of the report would then show man-hours associated with each of the performing organization-resource code combinations tied to charge or summary numbers B, D, E, H. I. The sequence in which the charge number-performing organization-resource code combinations appear in the body of this report is controlled by the user.

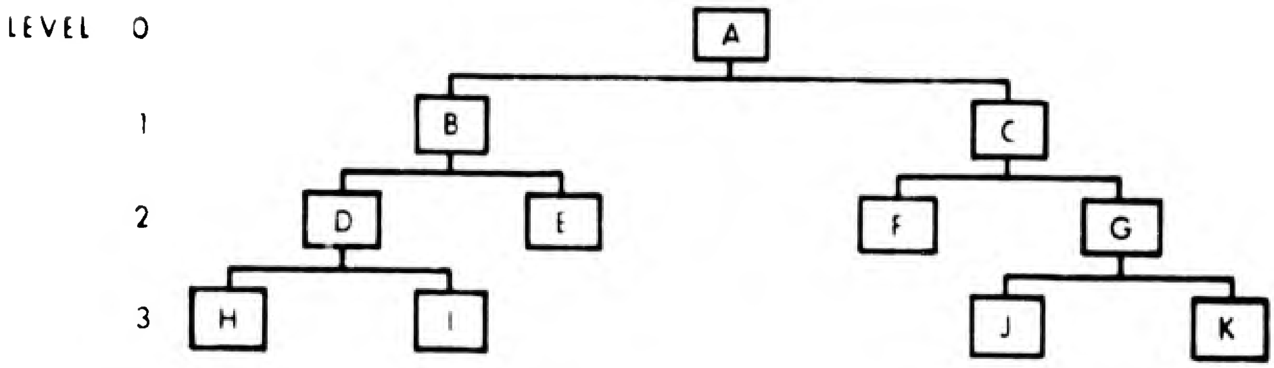
After all man-hours related to Items B, D, E, H, and I are listed, the report would then show Item C as the summary item at the top of the next page. The body of the report would then show the man-hours (months) associated with each of the performing organization-resource code combinations tied to charge or summary numbers C, F, G, J, and K.

To obtain man-hours for each of the combinations in the entire system, only one level of this report must be selected. This is the top level at which man-hours or man-months are entered in the system.

2. Direct Costs

The Organization Status Report displays direct costs in the form of actual costs, planned costs, and latest revised estimates. These costs are displayed by level for each charge number-performing organization-responsible organization-resource code combination that contains direct costs. This report does not distinguish direct direct labor costs from other direct costs.

These costs are not summed upward through the work breakdown structure. For example, an Organization Status Report is requested for Level 2 of the work breakdown structure shown below:



The report would show Item B as the summary item at the top of the page. The body of the report would then show the direct costs associated with each of the performing organization-resource code combinations tied to charge or summary numbers B, D, E, H, and I. It would also show the total direct costs for each of these numbers.

The sequence in which the charge number-performing organization-resource code combinations appear in the body of the report is controlled by the user.

After all direct costs related to Items B, D, E, H, and I have been listed, the report would then show Item C as the summary item at the top of the next page. The body of the report would show the direct costs associated with each of the performing organization-resource code combinations that are related to charge or summary numbers C, F, G, J, and K. It would also show the total direct costs for each of these numbers.

To obtain the direct costs for each of the combinations in the entire system, only one level of this report must be selected. This is the top level at which direct costs are entered in the system.

The latest revised estimate is computed for each charge number-performing organization-responsible organization-resource code combination appearing in this report. For those combinations not yet in progress, this value represents the total amount of estimated direct costs. For those combinations in progress, this value represents the actual direct costs incurred to date plus the amount of direct costs estimated for completion. For those combinations that are completed, this value represents the actual amount of direct costs that were incurred.

The projected (overrun)/underrun is also computed for each combination. This value represents the planned direct costs minus the latest revised estimate.

3. Time Data

This report presents the most critical slack and the scheduled or completion date for each charge number appearing on this report. The most critical slack represents the slack with lowest algebraic value, derived from the activities associated with the corresponding charge number. If this event has a scheduled date (T_S) associated with it, this date will appear in this column. If this event has been completed, an actual date (A) will appear in this column.

F. Financial Plan and Status Report

The Financial Plan and Status Report provides data for a monthly comparison (at any given level) of actual costs and/or latest revised estimates against planned costs, and thus serves as a tool for monitoring the financial plans. It shows historical (prior month) cumulative costs and both incremental and cumulative costs for each future month within the time period identified in the Report Dates. It is the source of data for generating the actual and planned expenditure curves of the Cost of Work Report.

1. Total Costs

The total costs shown on this report have not been summed up through the work breakdown structure. They are costs that are associated directly with the corresponding charge numbers appearing on this report.

This report is generated in two formats. The first format shows each charge on the chosen level as the summary item at the top of the page. The body of the report contains the total costs for each charge number connected to the summary through all of the lower levels of the work breakdown structure. Costs are displayed by month under the heading "Incremental Costs" and cumulatively under the heading "Cumulative Costs."

The other format in which this report is generated shows total costs by month for each of the summary items on the chosen level. Other charge/summary numbers do not appear in the body of this format. Costs are displayed by month under the heading "Incremental Costs" and cumulatively under the heading "Cumulative Costs."

The latest revised estimate is computed both incrementally and cumulatively by month for each summary item at a chosen level by summing all of the monthly cost estimates for that item.

(Over)under plan is also computed both incrementally and cumulatively. This figure represents the planned total costs minus that latest revised estimate.

G. Cost Category Status Report

The Cost Category Status Report presents a grouping of functional, hardware, or other significant cost elements in specified categories for reporting purposes. It provides for each cost category a manpower and total dollar comparison of:

- planned versus actual expenditure to date;

- planned versus latest revised estimate at completion.

1. Man-Hours

The latest revised estimate is computed for each charge number on the chosen level by cost category. For those cost categories whose combinations are not yet in progress, this value represents the total number of estimated man-hours. For those categories whose combinations are in progress, this value represents the actual man-hours expended to date plus the total number of man-hours estimated for completion. For those categories whose combinations are completed, this value represents the actual number of man-hours that were expended.

The projected (overrun)/underrun is also computed for each category. It is unlikely that the analysis can be accomplished from only an examination of the reports. The analyst generally has to follow his reports analysis with action such as:

- personal communication with the operating personnel involved in the problem (e.g., via a telephone call);
- first-hand examination of the problem by personnel at the location where the work is being performed;
- analysis of lower level or other PERT reports not submitted on a regular basis.

H. Manpower Loading Report

The Manpower Loading Report is intended for use by contractors to report manpower loading for various summary levels within the program. The Manpower Loading Report lists actual, planned, and latest estimated monthly man-hours by type of manpower. This provides data which depicts man-hour utilization by month for each labor skill and/or performing organization.

1. Man-Hours

The Manpower Loading Report presents man-hours by level and month for each charge number-performing organization-responsible organization-resource code combination. Only those combinations bearing man-hours or man-months appear on this report.

Actual, planned, and latest revised estimates are shown for each combination. Total man-hours are shown for each charge number.

The latest revised estimate is computed by month for each combination at a chosen level by summing all of the monthly manpower estimates for that item. Planned man-hours (months) is computed in the same manner.

The (overplan)/underplan is also computed for each combination. This value represents the planned man-hours minus the latest revised estimate. An underplan condition exists when:

$$\text{Latest Revised Estimate} - \text{Planned Man-hours} < 0$$

An overplan condition exists when:

$$\text{Latest Revised Estimate} - \text{Planned Man-hours} > 0$$

2. Time Data

The Manpower Loading Report shows the most critical slack with respect to all of the activities associated with the corresponding charge number.

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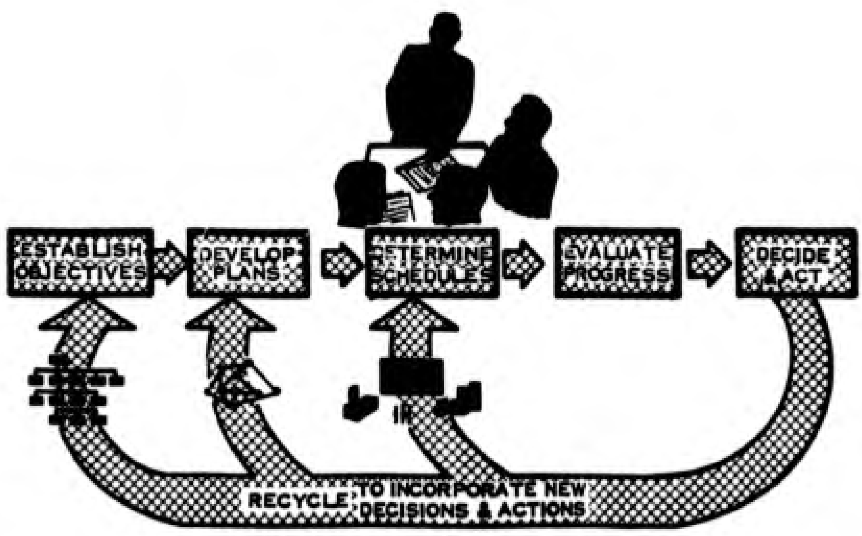
CHAPTER X

COST SIMULATION IN
RECYCLING OF THE MANAGEMENT PROCESS



Despite efforts to adhere to the project plan, requirements for changes in the plan or even in the project objectives will arise. Consequently, an orderly formal process for the incorporation of project changes must be established. The requirements for change may evolve from the top down or from the working level up. However, the point of origin is not so important as the method of responding in an orderly manner.

In general, adjustments in the plan should be accomplished with minimum recycling of the management process. Before a decision is made to incorporate a change in the plan, the impact of that change should be investigated. PERT includes a simple means by which these alternatives may be evaluated. This process is simulation.

* * * * * *

A. Recycling of the Management Process

The recycling process, as it affects the formal scheduled plan, will vary in complexity from a simple rescheduling process back through replanning and possibly even the redetermination of objectives.

These types of management action are listed in order of increasing management complexity:

- rescheduling within the manager's authority;
- rescheduling affecting authority in other organizational components;
- replanning within the constraints of the established plan;
- replanning without the constraints of the established plan;
- redetermination of supporting objectives;
- redetermination of prime objectives;
- some combination of these.

A change involving management action of any greater complexity than "rescheduling within the manager's authority," will require the taking of all interrelated actions appearing above it in the list shown. It is emphasized that there is no short cut to this procedure.

As a principle, effective adjustments in the scheduled plan should be accomplished with minimal recycling in the management process. Before a particular change or set of changes is decided upon for incorporation in the scheduled plan, possible alternatives should be considered. The effect of each of the possible alternatives can be rapidly assessed with simulation methods before adoption. After study of possible alternatives, the management process of objective determination, planning, and scheduling must be recycled to the degree necessary to incorporate logically the new management action in the scheduled plan.

B. Simulation of Alternative Management Actions

Normally, a number of alternative actions are contemplated by management, and only one can be chosen as a realistic solution. Simulation offers a method for testing these alternatives and evaluating the effects of each. Simulated time changes in activities, or the addition or deletion of activities may be fed into the computer in the same manner as updating information. Analysis of the outputs of the simulation will indicate the new situations which would be expected to occur. Simulation can frequently be accomplished manually if small networks are involved.

This tool 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. Simulation can show the impact of alternative decisions on the total program thereby permitting the highest levels of management to evaluate various courses of action as they affect the final objective.

Simulation of the effect of proposed changes to scheduled plans before incorporation of them as new management action should be required. Specifically, Engineering Change Proposals (ECPs) should be simulated before they are submitted to higher level management for approval.

1. PERT Simulation of Alternative Plans

A PERT simulation process is illustrated in Figure X-1. For a proposed course of action to be tested, the appropriate network input data for the changes to be made are fed into the data processing system; i.e., the deletion and addition of activities and events and the revised activity times that reflect the tentative plan. The resultant PERT Time output reports portray the new network plan that would result.

Situations that would typically require the simulation of proposed courses of action include:

- reprogramming due to significant slips in schedule or budget;
- reprogramming due to changes in the project objectives;
- evaluation of vendor plans;
- evaluation of Engineering Change Proposals which involve significant effort or which affect interfaces among several lateral responsibilities; and
- rapid determination of corrective action when unanticipated troubles occur.

So that cost estimates for a plan may be arrived at, new schedules must be developed for the affected part of the plan. This scheduling need not be as detailed as it would be for a finally adopted plan, but must be sufficient to allow for reestimating. When the scheduling is complete, cost reestimates are made. If the proposed program plan falls short of the objectives established, the manager may adjust costs and schedules by one or more of the following techniques:

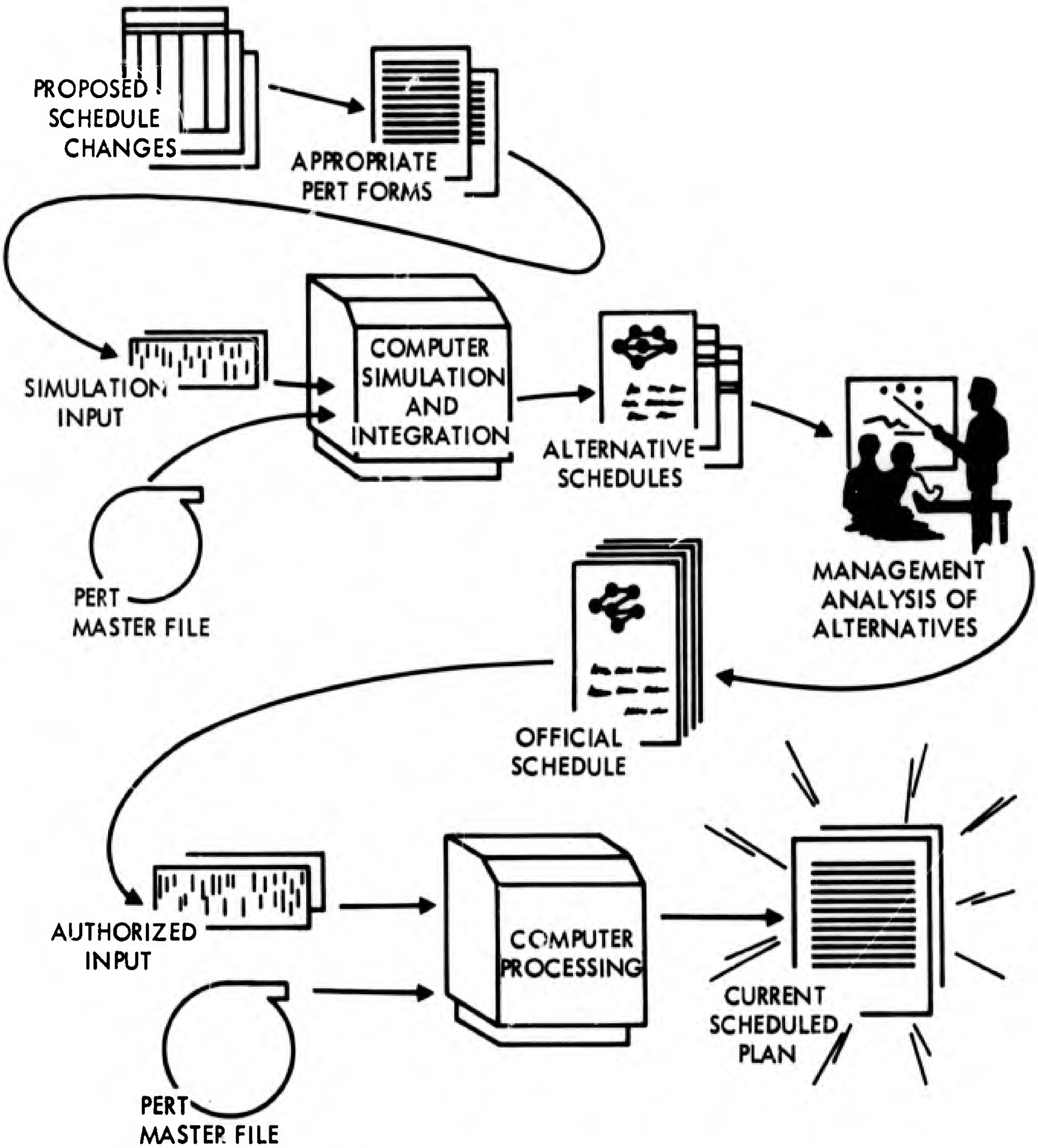


FIGURE X-1 SIMULATION OF PROPOSED PROGRAM CHANGES

- the schedule of slack path activities can be adjusted to minimize overtime requirements or additional hiring;

- the planned resources for work packages can be revised by trading off interchangeable resources between critical and slack paths;

- a greater or lesser amount of concurrence in performing activities can be employed;

- the specifications or method of performing the work can be modified, thereby altering, deleting, or adding activities.

This cycle continues until the proposed program plan is in agreement with the required objectives of time and cost.

For that portion of the project under consideration or for the total project, new total costs, rates of expenditure, and resource loadings are developed. (Actually, all of the PERT reports can be generated.) With this information, management is now able to evaluate the cost as well as the schedule impact of the proposed course of action.

2. Accounting for Changes in Contract Scope

One of the most important contributors to cost increases on a project is the constant change made to the original scope of the contract. When the changes are made, increases in cost often result that are greater than warranted for the change that was made. The contributing factor was that under a traditional functional contract task structure, it was difficult to evaluate the cost impact of a change the hardware items involved. PERT, by structuring project contracting, planning, and costing by end-item subdivisions and the work packages required to accomplish these end items, provides a better basis for contract amendment at the time that changes are incorporated. The costs of the changes involved can be estimated in a more realistic environment than the use of the work breakdown structure and the network.

The inter-relationships between and among the various items involved can be determined and the cost involved in the various areas can be segregated. Through the use of this technique a separate accounting of the cost of change is feasible. It is possible to account for cost growth of a contract based on the association of responsibility of the change.

Since configuration control is essential in any program, PERT provides the tool for this control based on the changes.

C. Actions Resulting from the Recycling Process

Generally as a result of the recycling process, management decisions could result in a change of the schedule, the network plan, costs, the prime or supporting objectives, or some combination. Although recycling is not completely accomplished by PERT, making decisions regarding changes and the communication of change are facilitated.

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CHAPTER XI

IMPLEMENTATION AND OPERATION OF PERT

In planning for PERT application, the desired objectives should be stated as specifically as possible. These objectives should answer such questions as:

- What are the expected or desired results from using PERT?
- What organizations will report PERT information?
- What existing reports, procedures, and methods will be replaced?
- Who will be responsible for operation of PERT, and what will be his authority?
- What will be the scope of the application: total program, selected critical sub-areas, etc.?

What are the system performance characteristics in terms of time required to go through one cycle of operation, operating costs, etc.?

The initial and most significant step in the establishment of PERT is the issuance of policy statements by management. Such statements serve to endorse the use and benefits of PERT and officially acknowledge it as an authorized technique for program planning and control. Experience has shown that such statements can also serve as incentive to middle and working level management in effective initial acceptance and successful implementation.

In order to translate general policies into working operations, specific procedures must be developed for the operation of PERT within an organization. The responsibility for developing the initial procedures generally rests with an implementation team. The procedures should be designed to expedite the operation of PERT and must be fully compatible with the requirements of operating personnel and the capabilities of the data processing operation. Some of the areas where procedures should be specified are:

- preparation nd transmittal of input data;
- reporting of status information and updating;
- distribution of output data.

Specific instructions for preparation of input forms and for interpretation of output forms should be issued. The responsibilities for the preparation and analysis of the forms, as well as the distribution of the forms and frequency in input and reporting, must also be specified. Although computers can be used to assist in processing large quantities of data, the computer is secondary.

* * * * * *

A. Organization and Personnel Requirements

The functional operation of a PERT system should be the responsibility of the normal supervisory staff and management personnel. The necessary skills are usually available within the organization. The performance of specific functions may be assigned to individuals who become the PERT operating group. The members of this group must be thoroughly knowledgeable in the mechanics of PERT including network development, calculations, analyses, and applications.

The presence of a small specialized PERT Staff Group or implementation team is normally required for the indoctrination and training of operating personnel. This Group also recommends procedures and usually monitors the implementation effort. On a continuing basis it provides guidance in:

- indoctrinating additional personnel;
- maintaining networks;
- preparing input data;
- analyzing outputs;
- preparing of management displays;
- assisting managers in identifying problem areas and suggesting alternative solutions supported by the available data.

The PERT Group may report to corporate management, to a program manager, or to an operating manager if the effort is solely within the province of one operating organization. The group acts in an advisory capacity; line management has the responsibility for the implementation of PERT and for the effectiveness with which it is used.

PERT Staff personnel who have been most successful in the implementation and operation of PERT are found to have widely different backgrounds. The following characteristics seem to be paramount:

- interest in planning work;
- ability to deal effectively with people at all levels;
- analytical ability.

For large programs at least one member of the PERT Group should be familiar with data processing operations and procedures. Such a person can assist in suggesting good procedures and in solving the difficulties which will arise if a computer is used.

The task of preparing valid network plans, or of working with technical personnel in preparing such plans, requires a person who has the broadest possible knowledge of the work to be done, and the organization structure. Persons who have had experience with the organization and who are technically qualified in at least some areas of the operation are very effective in network plan preparation.

Personnel who have experience and responsibility for performing the work are invaluable in determining the specific input data, such as time estimates for the activities. Clerical assistance is required to transcribe the data to the data transmittal work sheets.

The importance of managerial support in making PERT work cannot be overstressed.

B. Operating Standards

The PERT operation must meet certain fundamental criteria. These criteria are stated below in relation to the product work breakdown structure, network(s), data, and analysis outputs.

1. The product work breakdown structure must consist of:

- end-item subdivisions which are related to identifiable program objectives;
- end-item subdivisions which cover all the work contained in the summary item from which they were developed;
- end-item subdivisions which will allow the establishment of manageable work packages;
- subdivisions which are compatible with the account code structure, system and subsystem identifications, the technical proposal, cost proposal breakouts, and contract line items;
- work packages which do not exceed 3 months or $100,000 as a general rule;
- work packages having well-defined beginning and ending points;
- work packages which are compatible with the contractor's present cost collection system;
- work packages which have been assigned a unique charge number.

2. The Network(s) must:

- include directed and contractor initiated program milestones and interface events required to monitor the program;
- outline the complete, current, approved scheduled 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, plans, and schedules of higher level authority;

- break the program objectives into sequential and parallel activities and events which actually schedule, measure, and govern the conduct of work by responsible organization;

- indicate the relationships between supporting objectives and the end of work objectives;

- include only activities and events which have been explicitly defined by competent authority;

- provide the structure for a meaningful reporting system for 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.

3. The 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;

- indicate accomplishments to date in terms of the events and activities in the network(s);

- retain the integrity of data through the manual or computer processing or handling to produce analytical reports;
- be regularly (normally bi-weekly or monthly) audited and updated.

4. Analysis output must:

- enable continual evaluation of current and projected program status;
- enable the preparation of program progress and problem reports to management on a cyclical basis;
- 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.

C. Data Flow

Since each program requires a different data flow, no standard definition of data flow elements is possible. However, certain elements, criteria, and conditions are applicable to all programs.

Reporting Organization. The organization responsible for reporting data to the government on each program item must be specified, so that a mutual agreement of responsibility may be established before the project commences. The reporting organization may be either an individual job title or a department within a contractor's organization or another government agency.

Frequency of Submission. It is usually convenient to define the frequency of reports in terms of regular periodic submission and of exceptions to that regular timing. When reports are to be submitted by exception, the "exception" conditions should be carefully defined.

Level of Detail. The level of detail required in each report should be specified in relation to the work breakdown structure, contract line items, or other basic standard.

Change Control. Limitations and authority for changing data flow should be planned, particularly the level of information at which changes must be approved by the government.

Means of Transmittal. The physical means of report transmittal and the number of copies should be established.

Report Dates. Specific accounting cut-off dates for data and report submission dates should be established. The data cut-off date is generally the same as the reporting organization's normal cut-off date for internal accounting data. It is desirable to make the data cut-off date and the due date of the report as close as possible.

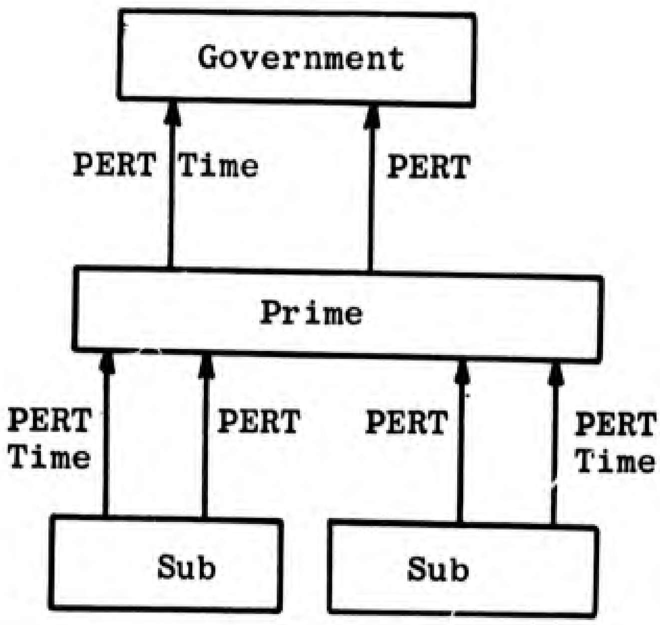
Internal Data Cycle. The process for handling PERT data received by the government should be clearly outlined and specified for each program. Specific procedures and responsibilities should be established for review, analysis, and presentation of the data within the government and for feedback of pertinent information to the reporting organizations.

D. Conditions Which Affect Data Flow

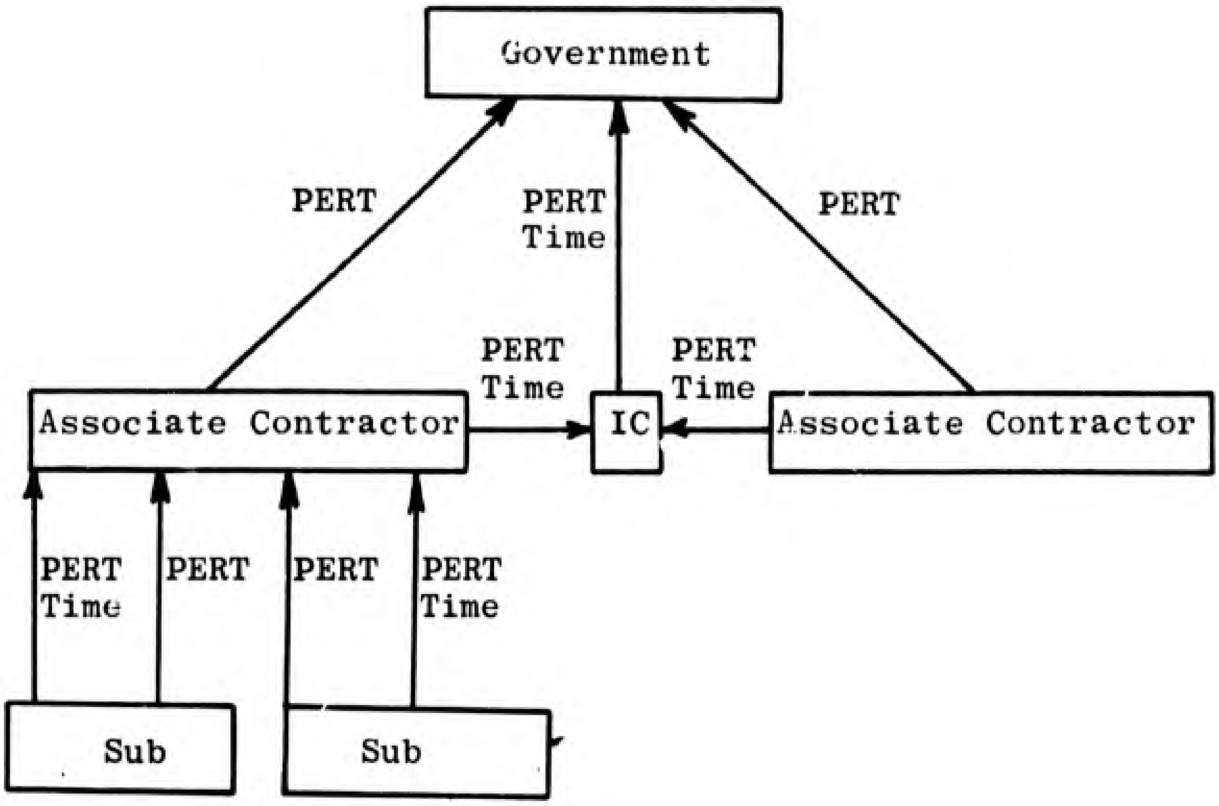
Many circumstances and variations in the type of program to which PERT is applied will modify the data flow procedure. Since there is no "standard" data flow procedure, it is not possible to discuss the precise effect of a given condition. This section, however, identifies some of these conditions and the kinds of impact that they may have. In some cases, simple graphic examples are presented to indicate the situation more clearly, but not to prescribe "correct flow."

1. Contractual Relationships

Data flow is affected by the contractual relationship. The government/single prime contractor relationship allows a relatively uncomplicated data flow, since most subcontractor's PERT will be processed by the prime contractor and integrated with his data into a single set of reports. In this case, the government must integrate a small amount of data from the participating government agencies and the occasional associate contractor who does not report to the prime contractor. The government/prime contractor relationship is shown below.

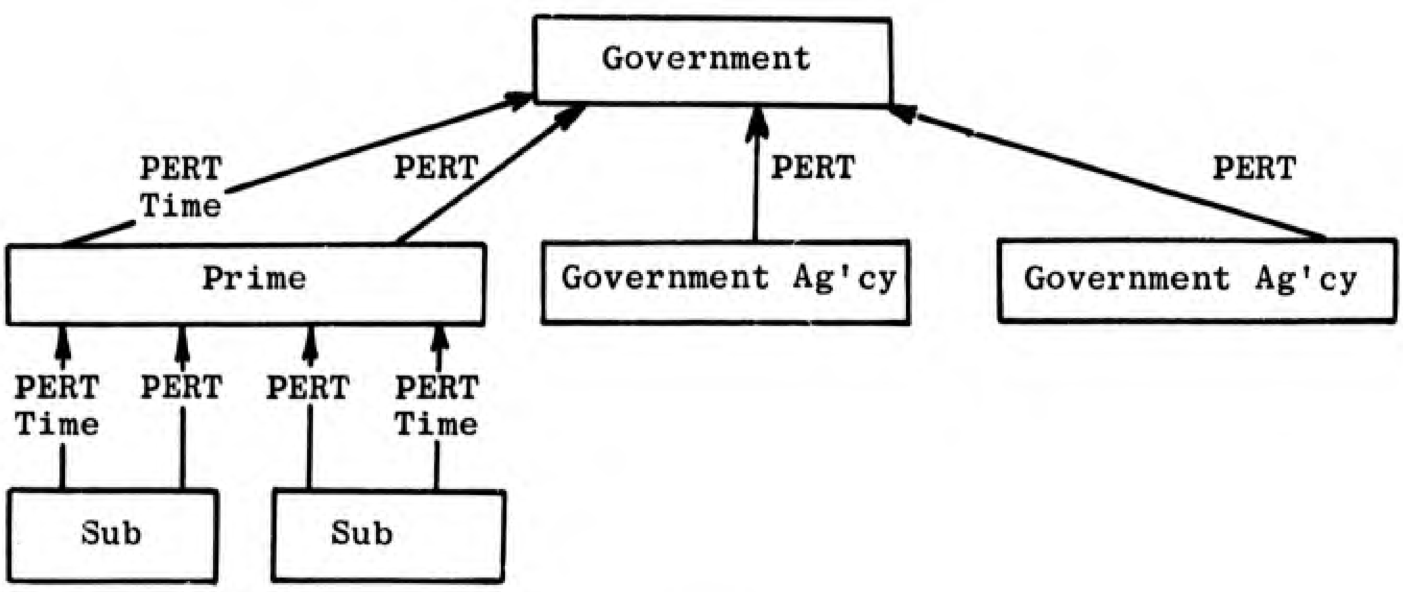


The government/integrating contractor (IC) relationship involves associate contractors who may report time but not cost information through the IAC. This relationship is shown below.



2. <u>Number of Participating Organizations</u>

Closely related to the contractual relationship in its effect on data flow is the number of participating organizations. When many organizations are involved in a program, as is shown below, data integration becomes more difficult and may affect the timeliness of the reported data as well as the ability to merge data easily.



3. Length of Reporting Chain

Both the timeliness and reliability of PERT data are affected when the information passes through several organizational levels before reaching the government. When this condition exists and when there may be high-risk areas at low levels of the reporting chain, consideration should be given to requiring that some critical areas report directly to the government on an exception basis.

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CHAPTER XII

PERT IN THE PRE-AWARD

PERT has been described as a management technique to improve contractor's, and consequently government, control of time, cost and the contractor's performance when dealing with major weapons contracts. In this connection, the Secretary of Defense established an objective of improving cost estimating techniques so that overall costs on major programs will be estimated within 10% of the final cost on an average. This objective can only be accomplished by improving the pre-award phases of the procurement process. The greatest potential value of PERT may well lie in the disciplines it imposes on government and industry when used in the pre-award phases of procurement action to better:

- define the objectives of the system;
- develop an overall plan to acquire, use and dispose of equipment;
- establish communication between government and industry contract negotiators;
- specify the relationship of such functional programs as maintenance, training and general support; and
- establish more precisely the ultimate cost of the development and production contracts in the initial bids or contract negotiations.

The proper application of PERT will:

- improve the preparation, understanding and submission of Request for Proposal, Requests for Quotations, Definitized Work Statements, Definitized Work Breakdown Structures, Networks, Trade-offs, Incentive Contracting Targets, Realistic Cost Estimates and plans for final contract negotiation;

- improve the effectiveness of Proposal Analysis, Source Selection and Definition of Contract Line Items.

Further, PERT when used in the pre-award phase should serve the following objectives:

- Promote the uniform application of this technique within and among the governmental agencies and industrial concerns engaged in government sponsored projects requiring the use of PERT for more effective and economical management of such projects.

- Set out requirements for the systematic and orderly application of PERT procedures.

* * * * * *

A. Program Management Planning

1. Objective:

The objectives of any project should be clearly defined during the conceptual phase in which a product-oriented work breakdown structure is established. These objectives are continuously developed and redescribed until an acceptable work breakdown structure and level of detail has been reached. Quite clearly an informal exchange between government and industry of conceptual information based on technological state-of-the-art is desirable.

2. Network:

The next step in development of the program prior to initiation of procurement action is the preparation of a Program Management Network by the government program management. This network must be based upon the objectives as established by the work breakdown structure outlined above. Accordingly, the network establishes the plan for the acquisition process and provides a framework or guidance for the subsequent development of more detailed specific plans.

The network, which describes the development, production, logistics support, training and operation of the system, must reflect coordination of the responsible organizations. Utilizing this breakdown and the network which provides the description of intermediate and more detailed objectives the overall estimated program costs can be developed. This serves as the basis to obtain program approval from the highest levels of authority including ultimately an appropriation from the Congress. To be most effective, all of the above planning must be completed in advance of the preparation of Request for Proposals or equivalent procedures so that interfaces and other important data may be incorporated into the document and thereby serve as guidance to the contractor.

B. Procurement Action

1. The Request for Proposal, which explains to a potential developer, producer or manager the objective of the project, is probably the most important communication government can make to industry. It must include the most detailed information and guidance which the government can provide.

a. Work Statement

It is essential that information be included in the Request for Proposal (RFP) on which potential contractors may base realistic proposals. Both technical and managerial aspects of the proposed development must be considered thoroughly in the RFP and the resultant proposals. The RFP shall include, but shall not be limited to, the following items:

1. System requirements based upon approved program guidance.

2. Results of prior studies (including feasibility, cost effectiveness, major trade-offs, operational analysis, logistics analysis, etc.) deemed necessary for adequate background information for the contractors.

3. Criteria against which proposals will be evaluated, and their relative importance in general terms.

4. Outline of the Government's plan for project management, including identification of pertinent Government organizations and communications channels within the Government and between Government and contractors.

5. The line items in the proposed contract which can be identified in the work breakdown structure.

6. A network showing planned activities, information submissions, reviews, approvals, and decisions indicating their interdependence and approximate time phasing.

7. Documentation that will be required. Incentive features (if applicable) desired in the proposal, including relative importance of incentives and specific schedule and performance items that will be subject to incentives.

8. Statement of the Government's requirements for project management.

9. Quantitative reliability and maintainability goals and demonstration concepts.

10. Concurrency considerations, production quantities and similar information provided as a basis for schedule and cost estimating purposes.

11. Identification of specifications related to the work breakdown structure with any waivers or deviations, planned to be written into the resulting contract.

12. Mandatory Subsystem Breakdown.

13. Government Furnished Equipment/Facilities.

14. A request for other information that the Department or Agency requires.

15. Requirement for a PERT implementation plan.

Industry will not be able to provide a proposal to meet the objectives of the PERT system unless it receives carefully developed guidance through this medium. Therefore, the Request for Proposal should include as guidance to the prospective bidders the:

a. Product-oriented work breakdown structure: This is prepared by the Government Program Management in order to provide guidance to all contractors on the specific level at which cost and schedule information will be required to permit direct comparison between the contractor and government's estimates. The best interests of the program are served when the RFP defines within this framework the lower levels of detail as guidance to the contractor.

b. The Program Management Network: A program management network which is related to the work breakdown structure and includes all the milestones and interactions of all major elements of the program is necessary. This will indicate all the objectives or goals and the associated schedules against which the performance of the selected contractor will be measured. This network will also serve as a guide for the contractor to visualize, plan and schedule their effort and participation including such items as value engineering, operational and maintenance training and other government sponsored programs. The requirements for response will be directly related to this network.

2. The Contractor Proposal

The contractor's proposal in response to the RFP will define the capabilities of the contractor in terms meeting the requirements of the government. Unless this proposal is developed carefully, the government cannot make an adequate evaluation. This and the RFP can guide the entire future of the system. Exchange of these two documents determines whether time and cost overrun or unanticipated growth will occur. The contractor proposal in response to the RFP will contain the following information:

a. A list of each of the end items required for operation and maintenance.

b. Performance specifications for each of the end items.

c. The work breakdown structure for the development as a whole (primarily oriented to hardware or product rather than to function); the statement of work in the proposal and the resulting authorizing document will be itemized in accordance with the work breakdown structure.

d. A PERT network plan for the development of all items contained in the system or subsystem on which the participant proposed indicating events which interface with the work of other participants. In addition, a planning and decision network for the period beyond development, including production, training maintenance, etc.)

e. An event schedule for development consistent with the PERT network and validated by recycling the PERT planning process, together with planning schedules for the period beyond development (investment and operation for five years, including production, training, maintenance, etc.)

f. Quantitative reliability and maintainability specifications for the system and major subsystems and proposed test plans to demonstrate their achievement.

g. Time/cost/performance trade-off decisions which have been made with respect to major alternatives, including subsystems and components, and back-up information showing the operational and cost effectiveness of these alternatives.

h. Required new designs and technology, if any, and a proposed test plan to demonstrate feasibility, including justification of the decision that existing designs or techniques are not applicable.

i. Foreseeable technical problems and proposed solutions including back-up efforts, if necessary.

j. Other problems that cannot be defined or resolved during pre-award.

k. Technical specifications and performance requirements for those items of system and subsystem support for which early development is required (such as facilities, training equipment, documentation, etc.); and analysis and delineation of the remaining major aspects relating to system and subsystem support (such as logistics planning, spare parts planning, etc.)

l. Requirements and delivery schedules for data and documentation.

m. Proposed schedule of production engineering and production tooling with relation to the development, if appropriate.

n. Participant commitments for managing the project including:

(1) Planned participant project-management structure and organization.

(2) Key project management and technical personnel by name and experience, together with statements of responsibility and authority for development.

(3) Management-control and cost-control techniques, including reporting procedures.

(4) Make-buy subcontracting procurement plan and gold-flow implications, if any.

(5) Facility requirements, if any.

o. Developing Agency-Participant coordination networks.

p. Contractor proposals on the specific features of an incentive contract. (This arrangement is considered important because it will permit the negotiation or targets and incentive patterns into the contract while competitive proposals are still available and furnish the basis for incentive provisions in the contract.)

q. Specific reference to those government specifications requiring waiver or deviation, including a statement of such waiver or deviation.

In order to fulfill the PERT requirements noted above, the contractor should develop the following in his response:

a. Product-Oriented Work Breakdown Structure: The contractor should submit a more detailed work breakdown structure with summary numbers to a level suitable for establishing work packages from which detailed cost estimates can be derived. This structure will be prepared so that there is an identical relationship between the performance specifications of the equipment structure (specification tree) and the hardware items of the work breakdown. It is an advantage if government requires this work breakdown structure to reflect direct correlation to government budget and programming code structures. The contractor should be prepared to demonstrate that the source documents for cost estimating and cost accumulation are based upon short-term discrete work packages as opposed to types of effort beginning and ending with calendar dates. The contractor should also be able to demonstrate that cost accounts will be of sufficiently short duration, approximately 3 months, to provide a reasonable measure of cost-progress relationship throughout the course of the program. Cost estimates should be submitted on a Management Summary Report Form corresponding to the Work Breakdown Structure (and with the Planned Cost Column and schedule information shown.) The level of indenture must have been specified in the RFP or be a matter of agreement between the agencies and contractors.

b. Networks: Detailed and integrated contractor PERT networks must portray the plan for accomplishing the objective of the project. This will include contractor inputs into the Program Manager's Network. The critical path should be identified. A problem analysis of the critical path and other limiting terms should also be submitted.

c. Incentive Plan: Where an incentive contract is required, the suggested incentive plan, based on service criteria for cost, schedule and technical performance targets, should relate to PERT plans.

d. Trade-offs: Through the use of PERT, evaluate the cost and time elements involved in the various technical approaches and trade-offs. These trade-offs can take the form of risks involved versus time gains in the modification of test programs; non-availability of hardware when desired versus the use of alternative hardware; delays resulting from the lack of completion of programs, etc. Results of test failures on the program may be simulated as to time-cost effects on downstream events.

e. Reports:

As a minimum, PERT reports shall consist of:

Management Summary Reports
Problem Analysis Report
Cost Outlook Reports
Schedule Outlook Report
Cost Category Status Report

All necessary back-up information shall be immediately available in depth on an exception basis when and if the government desires to review the problems being highlighted.

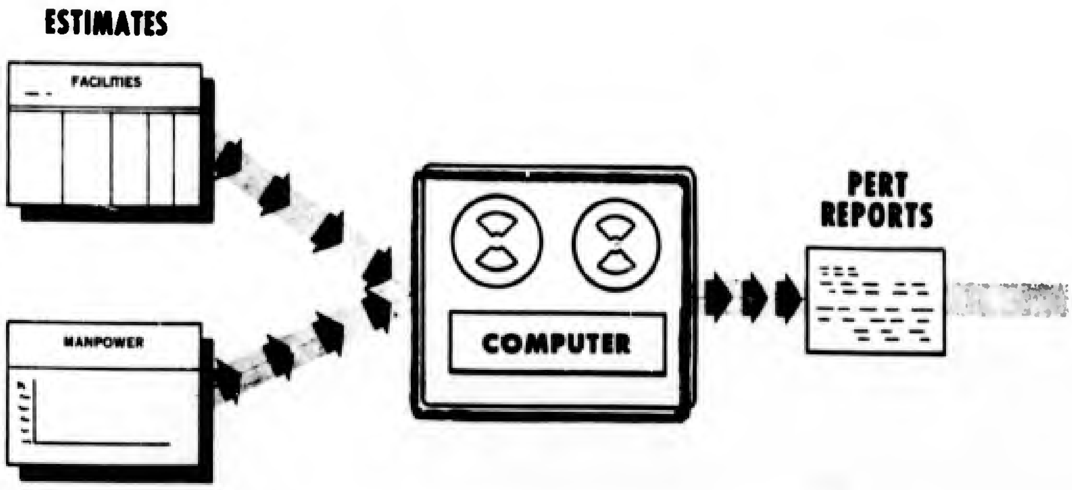
f. Discuss in detail for planning purposes the contractor's relationship with associate, and/or sub-contractors and the controls that will be used to provide PERT reporting information in a timely fashion for integration and submission in the form of management summary and detailed reports as necessary. Timing of the overall reporting system and the reaction time to provide the reports shall be documented.

g. Financial Plan and Status Report: A funding plan utilizing PERT data will be prepared to reflect the cash flow required by the contractor for optimum project accomplishment within the parameters established by imposed ceilings and other budget restrictions.

h. A System Description: If the contractor is to use PERT to manage the program, a verifiable detailed system description of the contractor's PERT system should be submitted.

CHAPTER XIII

EDP PROCEDURES FOR PERT TIME



The users of the information generated from the PERT Time portion of PERT should be knowledgeable, at least in general terms, with the Electronic Data Processing procedures involved. To provide an insight into this procedure, a description of the basic processes is provided below in terms of:

- input,
- logic,
- output.

This discussion is directed at the user of PERT Time and is not intended to serve the needs of the computer programmer or operator.1/

* * * * * *

A. Input

The basic PERT Time Input Form is used to transmit information from the network to data processing. The preparation of this input data begins after the network is constructed, events are coded, and time estimates are established for the activities.

The government PERT Time Input Form shown in Figure XIII-1 may be used to enter "PERT Time Data," "Event," and/or "Activity" descriptions. PERT Time data line entries supply all the information (one activity at a time) that is necessary to allow the computer to reconstruct the network and to calculate values of t_e, T_E/S_E, T_L/S_L, slack, etc. The event and/or activity description line entries provide the narrative definition of the event or activity. Figure XIII-2 displays the computer input format with columnar descriptions.

INSTRUCTIONS FOR COMPLETION OF THE PERT TIME INPUT FORM

The columns below refer to the columns on the Form and those on the corresponding punch card.

Column 1 Card Code.

1 - Time Data card.

2 - Activity Description card.

3 - Ending Event Description card.

1/Technical programming and computer operation information may be obtained from the PERT computer program manuals published by USAF, NWL, computer manufacturers, etc.

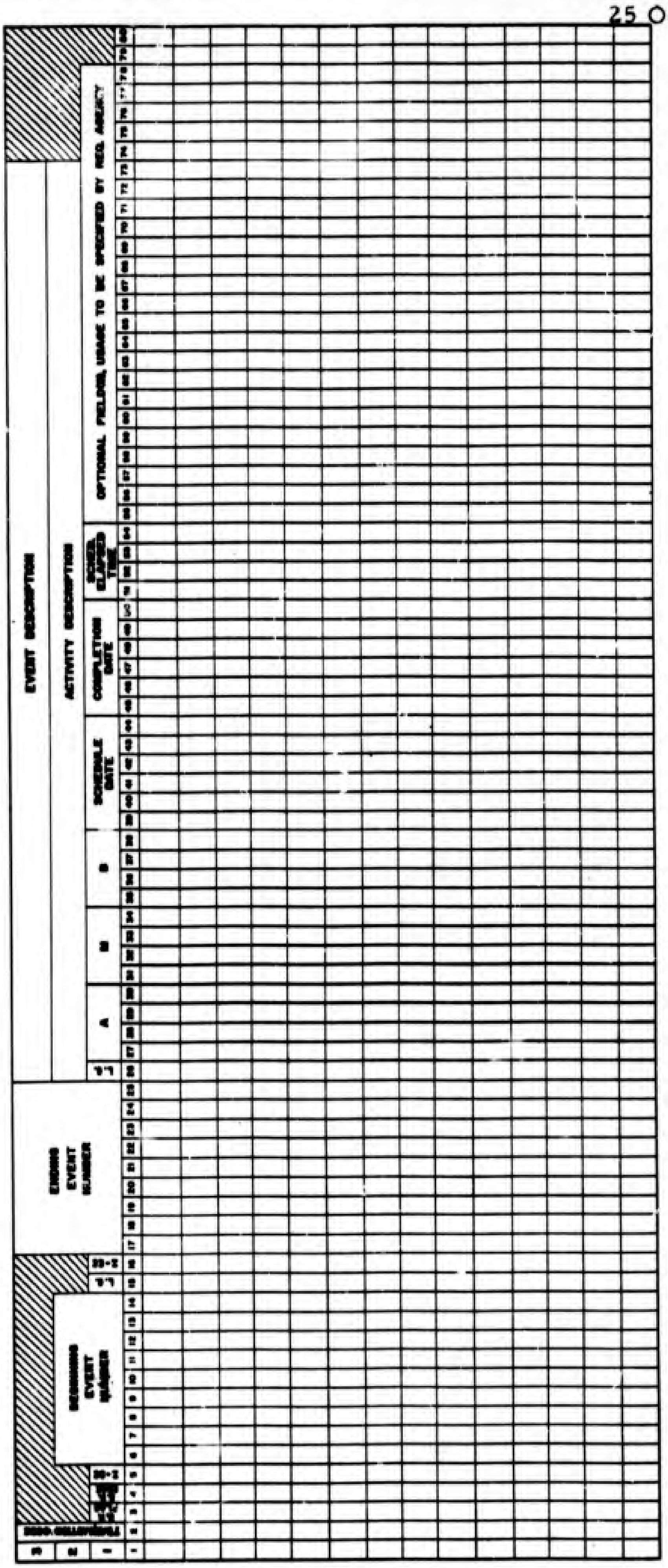


FIGURE XIII-1 PERT TIME INPUT FORM

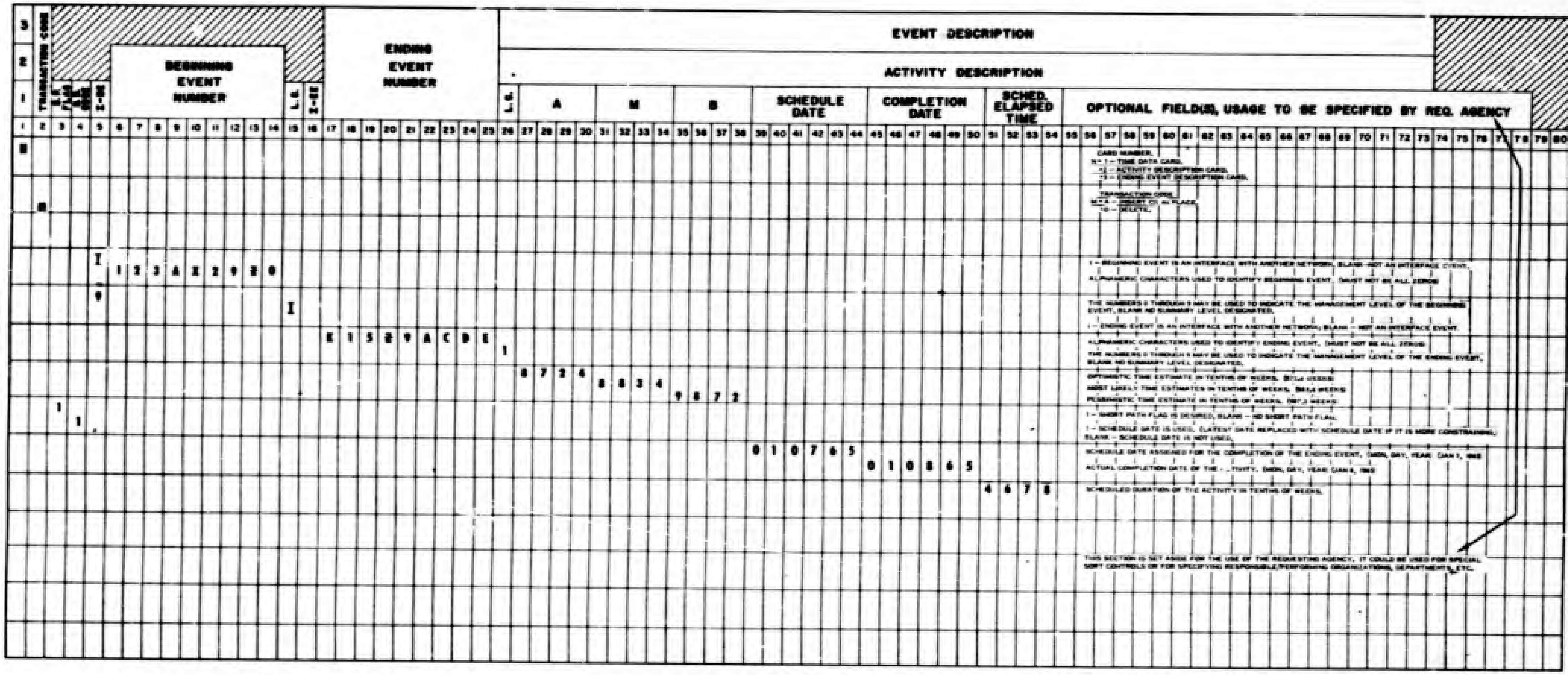


FIGURE XIII-2 PERT TIME INPUT FORMAT

Column 2 Transaction Code.

A - This code is used to insert any data element into the master file. This code is also used to replace any data element in the master file with the exception of the Event codes, as the Event codes are the control elements for the master file. Zeros entered in any data element will delete the corresponding data element from the master file. Data elements left blank will remain unchanged.

D - This code is used to delete an activity record from the master file. Only the card code, the update code "D", and the Beginning and Ending Event codes are entered on this line.

Column 3 Short Path Flag.

Blank - No short path flag.

1 - Short path flag is desired.

Column 4 Scheduled Date Code.

Blank - The scheduled date is not used in the latest allowable date computation.

1 - The scheduled date is used in the latest allowable date computation.

The program will replace the computed latest allowable date with the scheduled completion date if it is earlier than the latest allowable data (T_L/S_L) and continue computing latest allowable dates with this new restraining date.

Column 5 Interface for Beginning Event.

Blank - The beginning event is not an interface event.

1 - The beginning event is an interface with another network.

Column 6-14 Beginning Event Number.

Alphameric characters, used to identify the beginning event, must not be all zeros.

Column 15 Level Code for the Beginning Event.

A number (0-9) 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.

0-9 - as assigned.

Column 16 Interface for Ending Event.

Blank - The ending event is not an interface event.

1 - Ending event is an interface with another network.

Column 17-25 Ending Event Number.

Alphameric characters, used to identify the ending event, must not be all zeros.

Column 26 Level Code for Ending Event.

A number (0-9) 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.

0-9 - as assigned.

Column 27-30 Optimistic Time Estimate (A). In weeks and tenths of weeks. (003.5 equals a time of 3½ weeks). Four digits must be used.

Columns 31-34 Most Likely Time Estimate (M). In weeks and tenths of weeks. (003.5 equals a time of $3\frac{1}{2}$ weeks). Four digits must be used.

Columns 35-38 Pessimistic Time Estimate (B). In weeks and tenths of weeks. (003.5 equals a time of $3\frac{1}{2}$ weeks). Four digits must be used.

Columns 39-44 Scheduled Date. These columns are used to enter a scheduled date for the ending event shown. The date 30 Jan 1965 would be entered as 013065.

Columns 45-50 Completion Date. These columns are used to enter the actual completion date of the activity shown.

Columns 51-54 Scheduled Elapsed Time. Scheduled duration of the activities shown in weeks and tenths of weeks.

Columns 55-78 These columns are set aside for the use of the requesting agency. They could be used for special sorts or for specifying responsible/performing organizations, departments, etc.

An Activity Description is entered on a separate line in columns 26-73. The Card Code in column 1 must be "2". The Transaction Code in column 2 must be "A". The Beginning and Ending Event numbers are entered in columns 6-14 and 17-25, respectively. All other columns are left blank.

An Event Description is entered on a separate line in columns 26-73. The Card Code in column 1 must be "3". The Transaction Code in column 2 must be "A". The ending event number is entered in columns 17-25. All other columns are left blank.

B. Logic

PERT Time users are often unaware of how their data inputs are acted upon by the computer to produce the output reports returned to them. To provide this knowledge and to improve communications between the user and the data processing personnel, a generalized description of a possible series of steps for processing PERT Time data is presented. This description includes basic processes representative of a typical computer program that will produce the outputs displayed in Section C. The basic computer logic is described in steps or phases, which are frequently separate modules or independent parts, of the total computer program. The computer steps and their relationship to the basic PERT Time data flow are summarized in Figure XIII-3. This computer logic is representative of one approach only and is not the only method of PERT Processing. Each step is explained in detail.

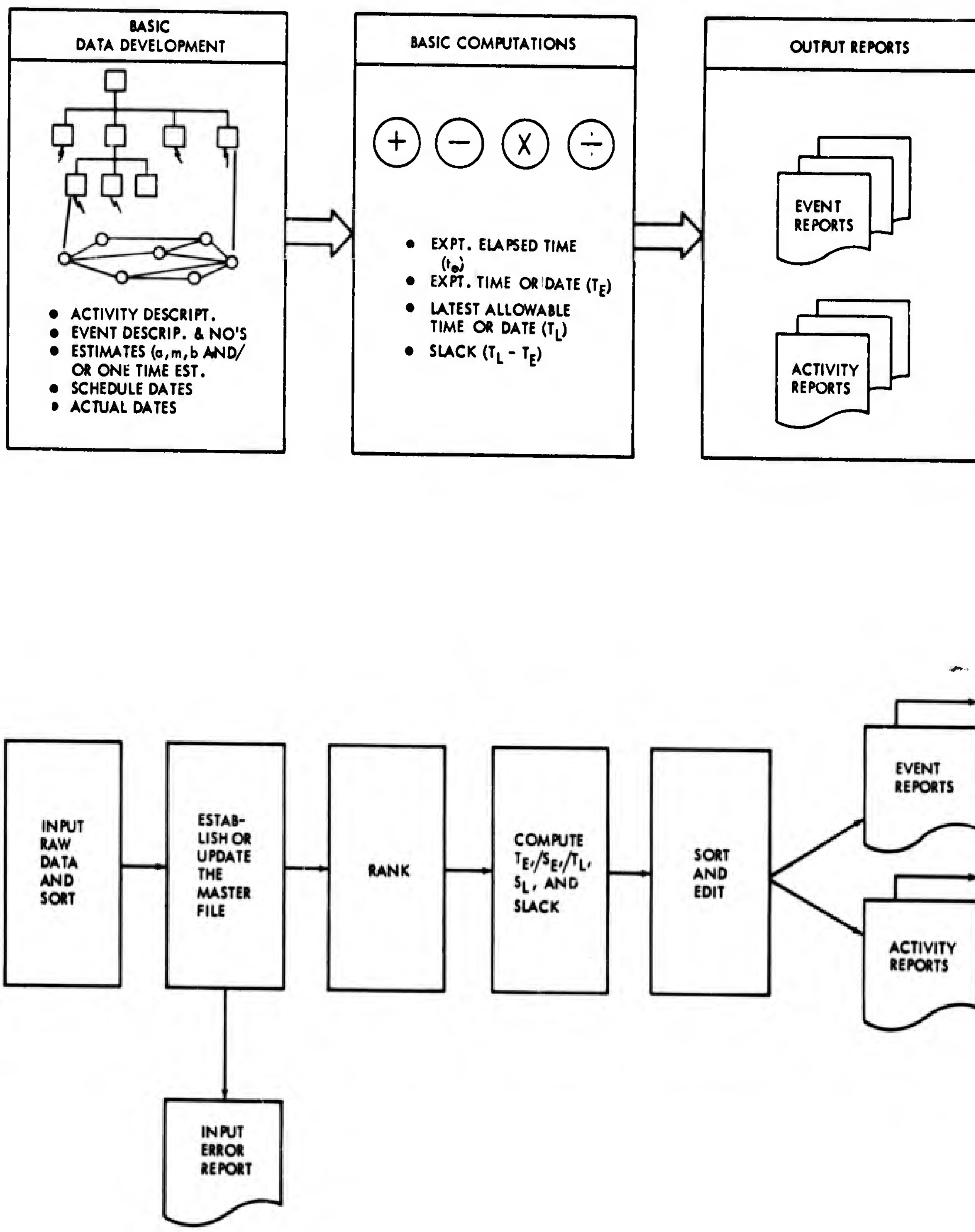
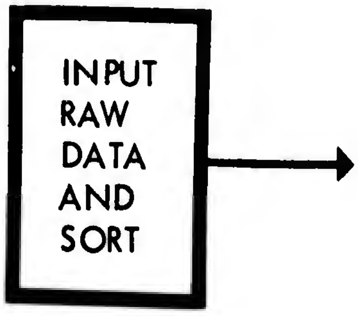


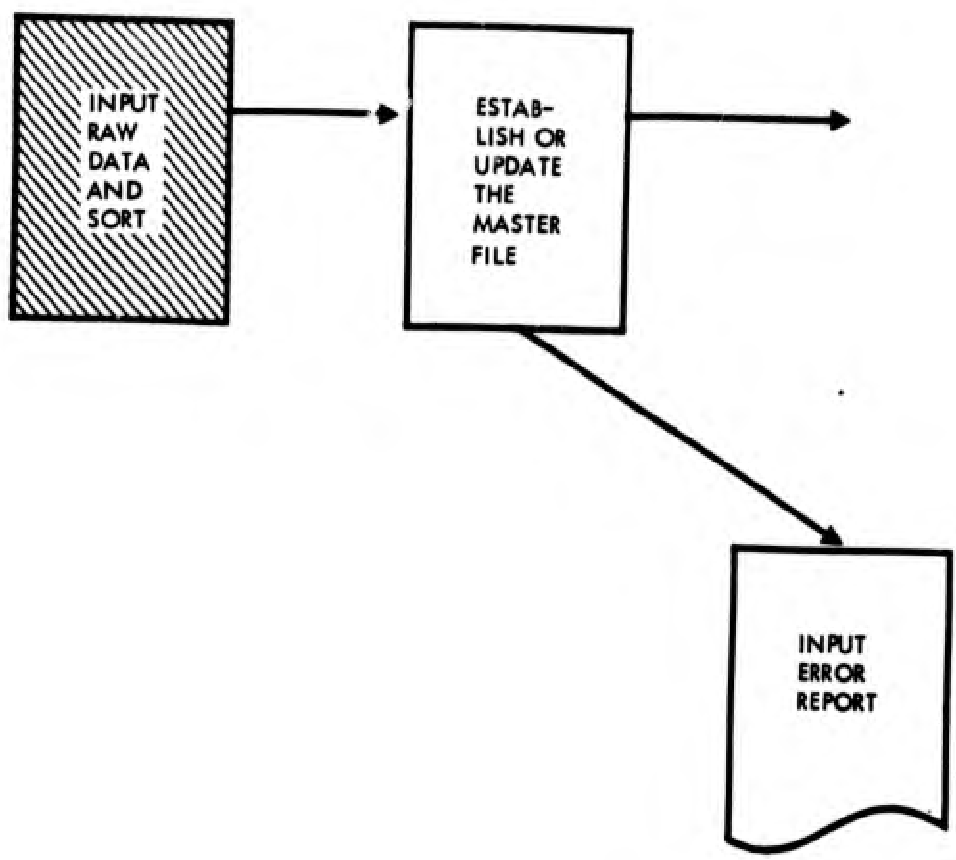
FIGURE XIII-3 – PERT TIME SYSTEM - BASIC DATA FLOW

DATA INPUT



The first step in the computer process is the input of data taken from the PERT Time Input Form. This data is transferred from the PERT Time Input Form to punched cards, paper tape, etc. The computer then sorts these data into the proper sequence for establishing or updating the master file of PERT Time data.

MASTER FILE

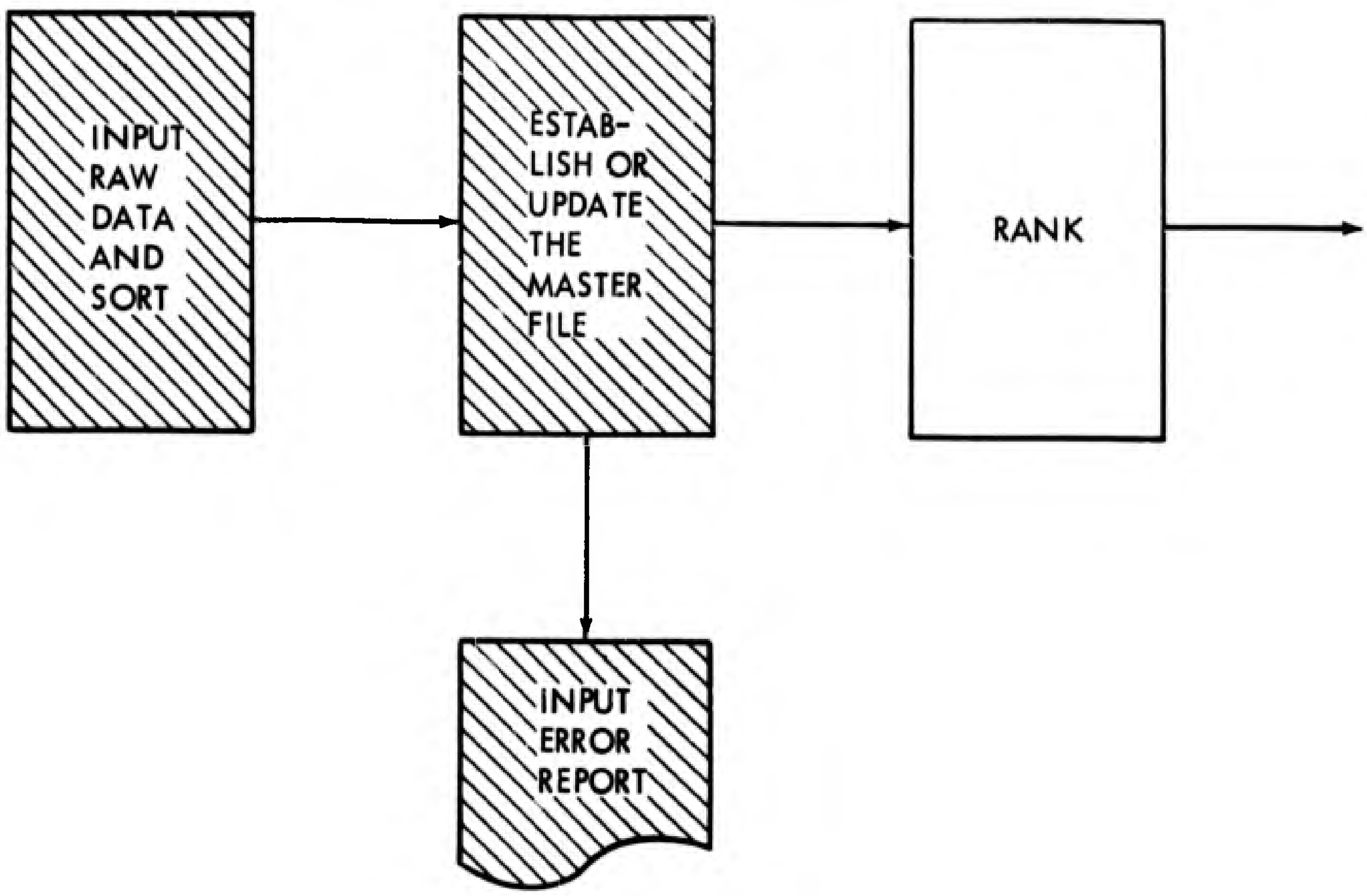


The master file is a record of all the network data which must be retained from one computer run to the next. Between computer runs it is maintained on an external storage medium such as magnetic tape or a deck of cards; during each computer run it is returned to the computer's internal storage, along with new input data.

The computer program matches the input data with the corresponding master file data and makes the necessary changes, corrections, insertions, and deletions as specified by these input data. If a master file does not exist, the input data is used to establish the initial master file.

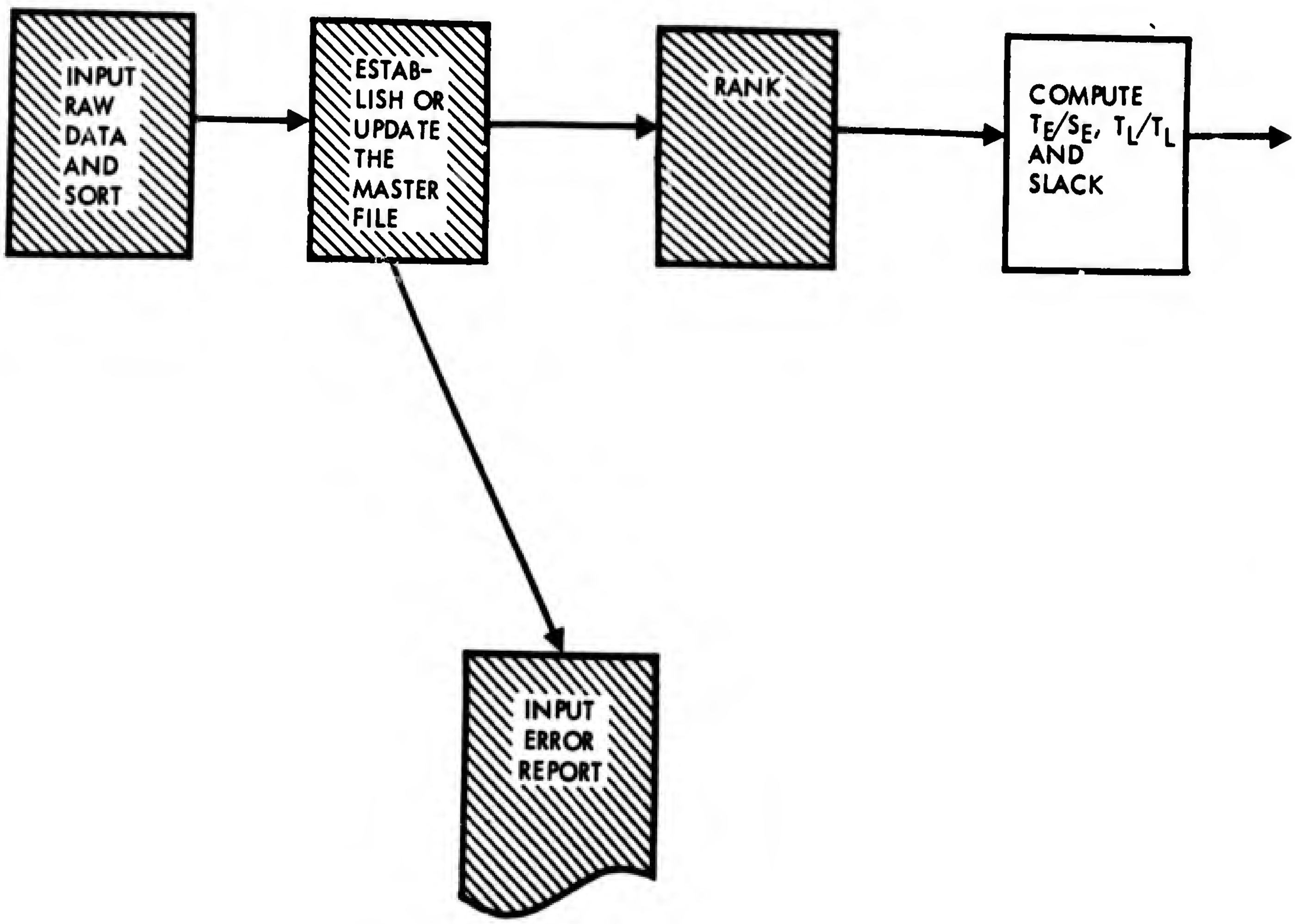
An Error Report that identifies improperly prepared input data is also generated.

RANKING ROUTINE



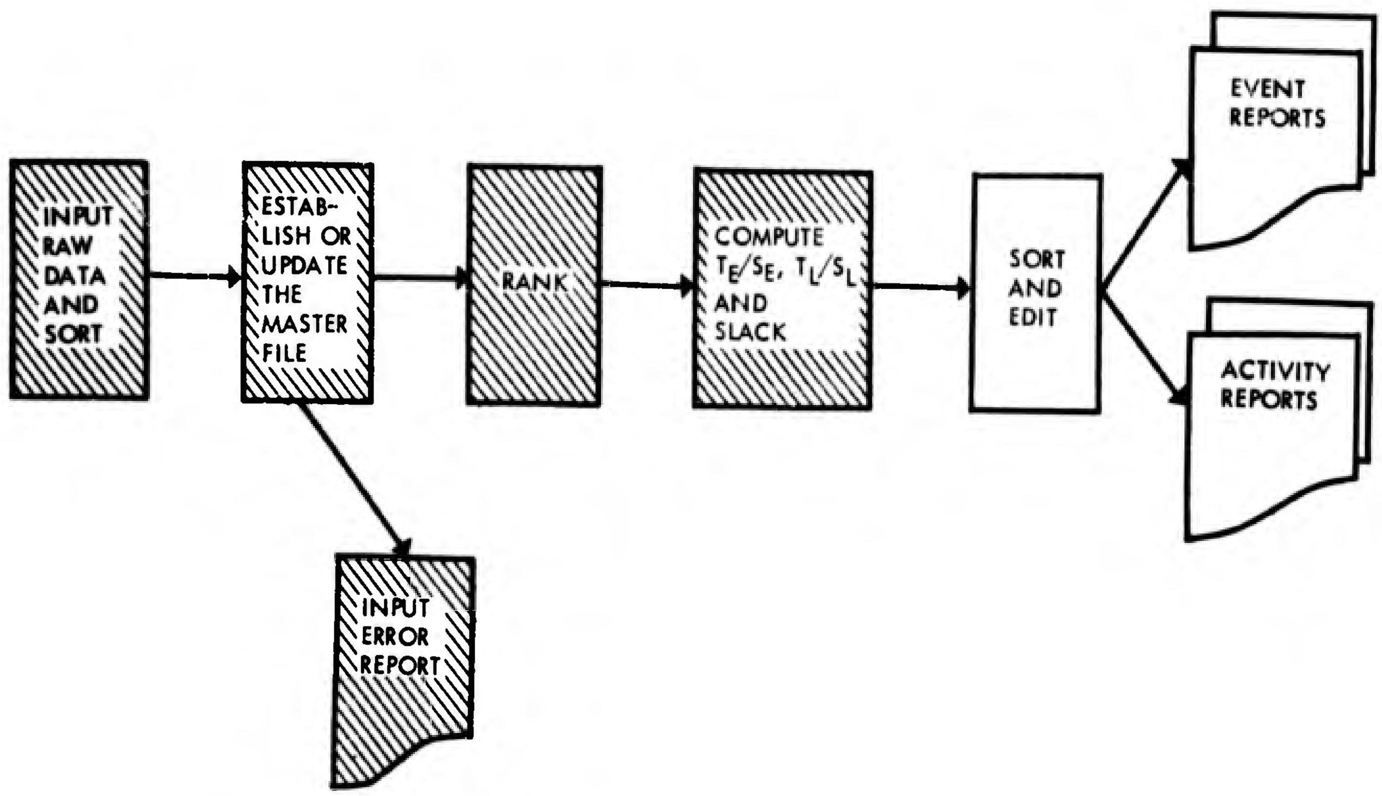
A rank is assigned to each event in the master file. The master file is ordered by the rank so that the computation for T_E/S_E and T_L/S_L may be done in a straightforward and efficient manner. The use of the rank permits random numbering of network events and the detection of network loops.

COMPUTATION OF T_E/S_E, T_L/S_L AND SLACK



This routine uses the ranked file to compute the Earliest Expected Time or Date or the Earliest Scheduled Date (T_E/S_E, the Latest Allowable Time or Data or the Latest Scheduled Date (T_L/S_L). Then, slack is calculated (T_L/S_L-T_E/S_E) and inserted into the master file.

SORT AND EDIT



The sorting and editing of the master file data for preparation of the output reports is the final step in the PERT Time computer process. The desired report data are selected for Activity and/or Event Lists in the computer's internal storage. These data are sorted, edited and put into proper format with page headings, page breaks and page numbers. The required reports are either printed directly by the computer, or written on an output medium (tape, cards, film) to be transcribed by an "official" printer.

C. Output

The two standard PERT Time output reports for use in evaluating the status of completed work and in forecasting potential problems are the

- Event Report
- Activity Report

The Event and Activity reports may be ordered in several different sequences according to the needs of the user. Figure XIII-4 describes the common headings used for both the PERT Time Event and PERT Time Activity Reports.

EVENT REPORT

The Event Report, Figure XIII-5, presents the basic PERT Time data for each event in the network. This report is commonly sorted in three orders:

- Event number sequence for a catalog listing of events.
- Expected date sequence which provides a chronological listing of events.
- Slack sequence beginning with the least algebraic value.

PERT TIME ACTIVITY REPORT

The Activity Report, Figure XIII-6, presents the basic PERT Time data for each activity in the network. This report is commonly sorted in four orders:

- Ending Event sequence for a catalog listing by Ending Events;
- Beginning Event sequence for a catalog listing by Beginning Events;
- Expected data sequence which provides a chronological listing of activities;
- Slack sequence beginning with the least algebraic value.

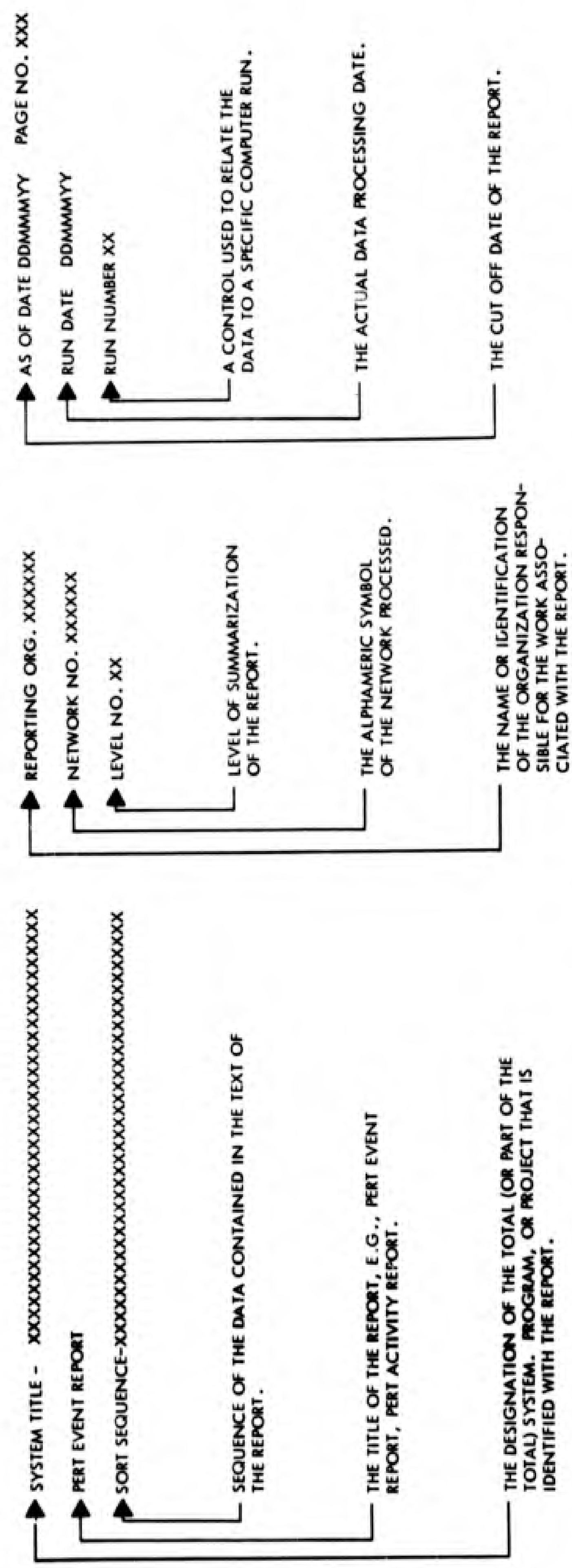


FIGURE XIII-4 – COMMON HEADINGS FOR PERT TIME EVENT & ACTIVITY REPORTS

SYSTEM TITLE - TEST SYSTEM 999000 PERT EVENT REPORT SORT SEQUENCE - EVENT	REPORTING ORG. NWLKPO NETWORK NO. 999000 LEVEL NO. 1			AS OF DATE 08AUG64 RUN DATE 15AUG64 RUN NUMBER 1	PAGE NO. 1	
EVENT DESCRIPTION	EVENT NUMBER	SLACK TL-TE	EXPECTED DATE	LATEST DATE	SCHEDULE DATE	ACTUAL DATE
START	999000001	.0	30AUG64	30AUG64		30AUG64
TEST A COMPLETE	999000002	6.0	13SEP64	25OCT64		
TEST B	999000003	.0	08NOV64	08NOV64		
TEST C	999000004	2.0	22NOV64	06DEC64		
TEST D	999000005	.0	13SEP64	13SEP64		
TEST E	999000006	.0	20DEC64	20DEC64	20DEC64	
TEST F	999000007	1.0	01NOV64	08NOV64		
TEST G	999000008	.0	22NOV64	22NOV64		
TEST H	999000009	.0	27SEP64	27SEP64		
INTERFACE	999000010	1.0	06SEP64	13SEP64		06SEP64
PUBLISHED DOCUMENTATION AVAILABLE	999000011	1.0	15NOV64	22NOV64	22NOV64	
	NUMBER OF DIGITS					
48	9	6	7	7	7	7
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX	XXXX.X	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX

FIGURE XIII-5 – PERT TIME EVENT REPORT

SYSTEM TITLE - TEST SYSTEM 999000 PERT ACTIVITY REPORT SORT SEQUENCE - ENDING EVENT BY BEGIN EVENT	REPORTING ORG. NWLKPO NETWORK NO. 999000 LEVEL NO. 1				AS OF DATE 08AUG64 RUN DATE 15AUG64 RUN NUMBER 1			PAGE NO. 1	
ACTIVITY DESCRIPTION	BEGINNING EVENT NO.	ENDING EVENT NO.	SLACK TL-TE	EXPECTED DATE	LATEST DATE	LITTLE TE	LITTLE TS	SCHEDULE DATE	ACTUAL DATE
START	000000000	999000001	.0	30AUG64	30AUG64	.0	.0		30AUG64
TESTING A	999000001	999000002	.0	13SEP64	25OCT64	2.0	1.0		
TESTING D	999000001	999000005	.0	13SEP64	13SEP64	2.0	1.5		
TESTING B PART 1	999000002	999000003	2.0	08NOV64	08NOV64	2.0	2.0		
TESTING C	999000003	999000004	.0	22NOV64	06DEC64	2.0	1.5		
TESTING G	999000003	999000008	.0	22NOV64	22NOV64	2.0	1.5		
TESTING E PART 1	999000004	999000006	.0	20DEC64	20DEC64	2.0	2.0	20DEC64	
TESTING H	999000005	999000009	.0	27DEC64	27DEC64	2.0	1.0		
PREPARE DOCUMENTATION	999000007	999000011	.0	25OCT64	25OCT64	2.0	1.5		
TESTING E PART 2	999000008	999000006	.0	20DEC64	20DEC64	4.0	5.0	20DEC64	
TESTING B PART 2	999000009	999000003	.0	08NOV64	08NOV64	6.0	5.0		
TESTING F	999000009	999000007	.0	11OCT64	11OCT64	2.0	2.0		
SPECIFICATIONS IN TRANSIT	999000010	999000007	.0	11OCT64	11OCT64	4.0	3.5		
NUMBER OF DIGITS									
48	9	9	6	7	7	5	5	7	7
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXX	SXXX.X	XXXXXXX	XXXXXXX	XXX.X	XXX.X	XXXXXXX	XXXXXXX

FIGURE XIII-6 – PERT TIME ACTIVITY REPORT

Sample printouts are illustrated in Figure V-12. These computer printouts can be transformed into various presentations for management. Trend charts are illustrated in Figures V-1 and V-2. The familiar milestone chart is merely a PERT Event Report utilizing a slack sort as shown in Figure V-12; however, the expected date, latest date, scheduled and actual date are transformed into a graphic layout.

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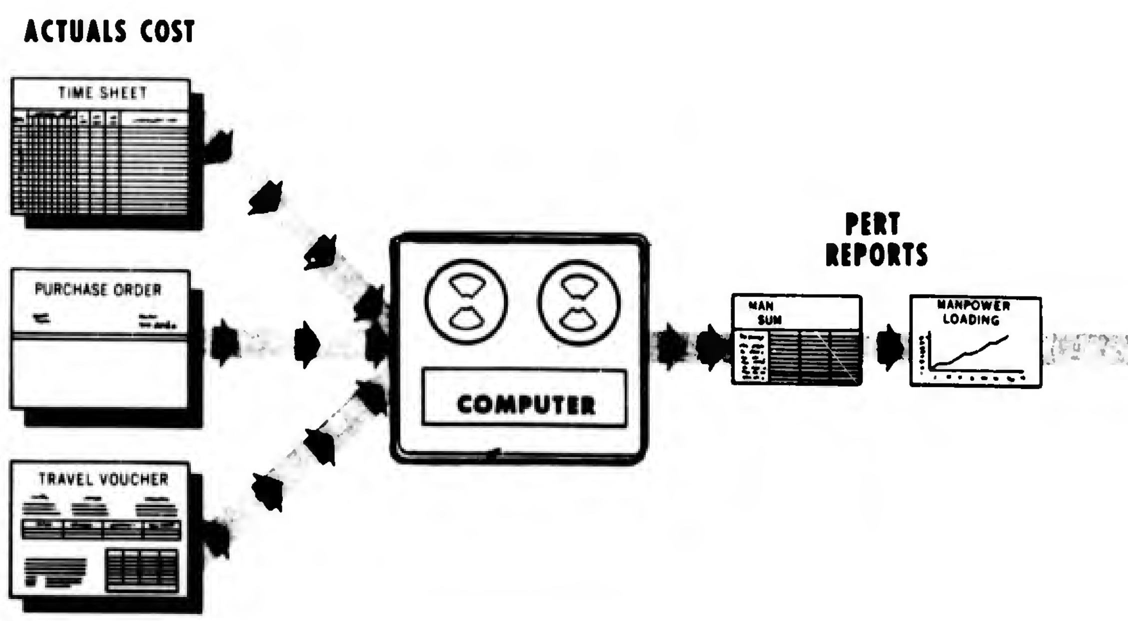
CHAPTER XIV

EDP PROCEDURES FOR PERT



The users of PERT 1/ data are often unaware of how the TIME and COST information is integrated and how their data inputs are acted upon by the computer to produce the output reports. To provide an insight into this process, a description of the processing of PERT data by the computer program is presented below in terms of:

1/ PERT refers to TIME and COST unless otherwise specified.

. input,

. logic,

. output,

. other.

This discussion is directed at the user of PERT and is not intended to serve the needs of the computer programmer or operator.1/

* * * * * *

A. Input

It is desired that basic uniformity among PERT systems be achieved without placing rigid specifications on input formats. The use of standard COST input forms will not be required. However, the attainment of uniform data elements for PERT is an objective.

A list of the uniform data elements to be used for PERT inputs are shown in Figure XIV-1.

The following forms illustrate how PERT data elements might be used to provide a computer program with adequate data to prepare the required outputs. The forms are keyed to the data elements appearing in Figure XIV-1. Uniform data elements, previously defined but not appearing on these forms, are obtained from the PERT Time output.

Budget Estimate and Actual Input Card (Figure XIV-2)

This form is used to insert budget estimate and/or actual cost data. If additional time periods are required, multiple lines may be used.

1/ Technical programming and computer operation Information may be obtained from the PERT computer program manuals published by USAF, NWL, computer manufacturers, etc.

	DATA ELEMENT	DESCRIPTION
1	Activity Slack	The activity's latest completion time minus its earliest completion time.
2	Actual Completion Date	The calendar date on which an event occurred or an activity was completed.
3	Actual Cost	The expenditures incurred plus any pre-specified types of unliquidated commitments charged or assigned to a work effort. (Entered as Direct, Indirect Dollars, Man-hours or Man-months, other units.)
4	Approved by	Signature and organizational designator of person approving the data.
5	Beginning Event	The event designating the start of one or more activities.
6	Budget-to-Complete	The budgeted man-hours and cost, required to complete a work package or summary item.
7	Card Code	A code to indicate type and format of data contained in card.
8	Charge Number	A number used for identifying the costs charged to a work package.
9	Charge Number Descriptors	A description of the units of work identified by a charge number.

FIGURE XIV-1 UNIFORM PERT DATA ELEMENT

DATA ELEMENT	DESCRIPTION
10 Cost Category	The name and/or number of a functional, hardware, or other significant identification for which costs are to be summarized.
11 Earliest Completion Date	The earliest calendar date on which an activity can be scheduled.
12 Ending Event	The event designating the completion of one or more activities.
13 Estimate-to-Complete	The estimated man-hours and costs, required to complete a work package or summary item.
14 Expected Elapsed Time	The expected time for an activity (t_e).
15 Indirect Rate	An overhead rate normally applied at a level higher than the work package level.
16 Latest Completion Date	The latest calendar date on which an activity can be scheduled for completion without creating an expected delay in the completion of the project (S_L).
17 Level	The tier or level on the work breakdown structure at which a charge or summary number appears (0-9).
18 Network Code	An alphameric code used to identify a network.
19 Parent Summary Number	A number which identifies an item in the work breakdown structure which has at least one subordinate summary number or charge number.

FIGURE XIV-1 UNIFORM PERT DATA ELEMENT

DATA ELEMENT	DESCRIPTION
20 Performing Organization	The organization which will perform the work associated with a work package.
21 Project	The designation of the total or part of the total program/project that is identified with the reporting organization.
22 Quarter	Three-month calendar period.
23 Rate	A factor applied to manpower estimates to extend them to direct dollars and to extend direct dollars to overhead dollars.
24 Resource Code	A code for a particular manpower skill or resource type.
25 Responsible Organization	The contractor or government organization responsible for management of a work package(s).
26 Scheduled Elapsed Time	The period of time scheduled for the performance of an activity (t_s).
27 Start/End Dates	Dates assigned for start and end of a work package. These dates are not derived from the network.
28 Summary Number	A number which identifies an item in the work breakdown structure.
29 Unit Description Code	A code to indicate the type of costs reported; i.e., H - Man-hours, M - Man-months, D - Direct Dollars, T - Total Dollars, U - Other Units.

FIGURE XIV-1 UNIFORM PERT DATA ELEMENT

DATA ELEMENT	DESCRIPTION
30 Update Code	A code used to indicate the action to be taken in processing each line entry.
31 Year	Self-explanatory.

FIGURE XIV-1 UNIFORM PERT DATA ELEMENT

PROJECT: (21)

PAGE ____ OF ____

CARD CODE	UPDATE CODE	UDC	PERF. ORGN.	RES. CODE	START DATE	MONTHS BEGINNING WITH START DATE											
						1	2	3	4	5	6	7	8	9	10	11	12
(7)	(30)	(29)	(20)	(24)	(27)		(6)		(13)	(3)							

APPROVED BY (4) ____________ DATE ____________

FIGURE XIV-2 – ILLUSTRATIVE - BUDGET, ESTIMATE AND/OR ACTUAL INPUT FORM

Cost Category Input Form (Figure XIV-3)

This form is used to relate cost categories with their respective charge numbers. This, also, provides the means for entering the description of the cost category. This form is initially prepared to establish the cost categories; are thereafter to insert changes to the cost categories.

Rate Table Form (Figure XIV-4)

This input document provides rate information used in cost extensions. This form is initially prepared when the rate structure has been determined and thereafter only to input rate changes.

The Project Breakdown Form (Figure XIV-5)

The Project Breakdown Form is an input form which is used to establish the relationship among items in the work breakdown structure and to provide descriptions for the charge and summary numbers. This form is prepared initially when the project breakdown is defined. Thereafter, the form is used only when changes are required.

Activity to Charge Number Statistics Input Form (Figure XIV-6)

This form provides the data which associates network activities with charge numbers. This relationship enables the computer to generate integrated time and cost reports. This form is also used to input charge number status information, such as start dates, actual completion dates, etc.

Indirect Rate Input Form (Figure XIV-7)

This form provides the means of inserting those overhead rates which are applied at a summary level (above the work package level). This form is initially prepared to establish the indirect rates and thereafter to insert charges to the rate tables.

PROJECT: (21) PAGE ____ OF ____

CARD CODE	UPDT CODE	CHARGE NUMBER	PERT ORGN	RES CODE	COST CATEGORY DESCRIPTION
(7)	(30)	(9)	(19)	(23)	(10)

APPROVED BY (4) ____________ DATE ____________

FIGURE XIV-3 — ILLUSTRATIVE COST - CATEGORY INPUT FORM

PROJECT: (21)

PAGE ______ OF ______

CARD CODE	UPDATE CODE	PERF. ORGN.	RES. CODE	QTR	YR	UNIT RATE	OVHD RATE	QTR	YR	UNIT RATE	OVHD RATE	QTR	YR	UNIT RATE	OVHD RATE	QTR	YR	UNIT RATE	OVHD RATE
(7)	(30)	(20)	(24)	(22)	(31)	(23)	(23)												

APPROVED BY (4) ____________________ DATE ____________________

PROJECT (21) PAGE ____ OF ____

CARD CODE	UPDATE CODE	CHARGE OR SUMMARY NUMBER	LEVEL	DESCRIPTION	PARENT SUMMARY NUMBER
(7)	(30)	(8) (28)	(17)	(9)	(19)

APPROVED BY: (4) ____________ DATE ____________

FIGURE XIV-5 — ILLUSTRATIVE - PROJECT BREAKDOWN FORM

PROJECT (21) PAGE ____ OF ____

CARD CODE	UPDATE CODE	CHARGE OR SUMMARY NUMBER	PERF. ORGAN.	RESOURCE CODE	NETWORK CODE	BEGINNING EVENT	ENDING EVENT	SCHED START DATE	SCHED END DATE	ACTUAL COMPL DATE	RESP. ORGAN
(7)	(30)	(8) (28)	(20)	(24)	(18)	(5)	(12)	(27)	(27)	(2)	(25)

APPROVED BY (4) ____________ DATE ____________

FIGURE XIV-6 – ILLUSTRATIVE ACTIVITY TO CHARGE NUMBER STATUS INPUT FORM

PROJECT (21) PAGE ____ OF ____

CARD CODE	UPDATE CODE	CHARGE OR SUMMARY NUMBER	UDC	QTR	YR	INDIRECT RATE	QTR	YR	INDIRECT RATE	QTR	YR	INDIRECT RATE	QTR	YR	INDIRECT RATE	QTR	YR	INDIRECT RATE	QTR	YR	INDIRECT RATE
(7)	(30)	(8) (28)	(29)	(22)	(31)	(15)															

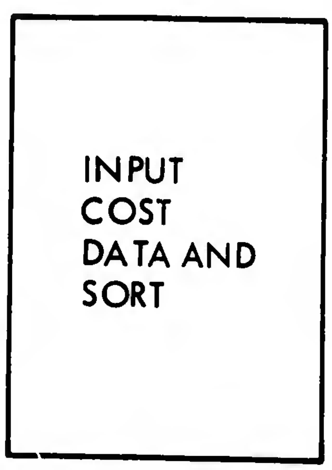
APPROVED BY (4) ____________ DATE ____________

FIGURE XIV-7 — ILLUSTRATIVE INDIRECT RATE INPUT FORM

B. Logic

PERT users are often unaware of how their data inputs are acted upon by the computer to produce the output reports returned to them. To provide this knowledge and to improve communications between the user and the data processing personnel, a generalized description of a possible series of steps for processing Cost data is presented below. This description includes basic processes representative of a typical computer program that will produce the outputs displayed in Section C. The basic computer logic is described in steps or phases, which are frequently separate modules or independent parts, of the total computer program. The computer steps and their relationship to the basic PERT data flow are summarized in Figure XIV-8. This computer logic is representative of one approach only and is not the only method of PERT Processing. Each step is explained in detail below.

COST DATA INPUT



The first step in the computer process is the input of data as shown on the uniform data element chart. (See figure XIV-1.) This data is transferred from the PERT input forms to the computer via punched cards, paper tape, etc. The computer sorts this data so that it is segregated within charge numbers. These numbers are then sequenced numerically so that they can be merged into a master file.

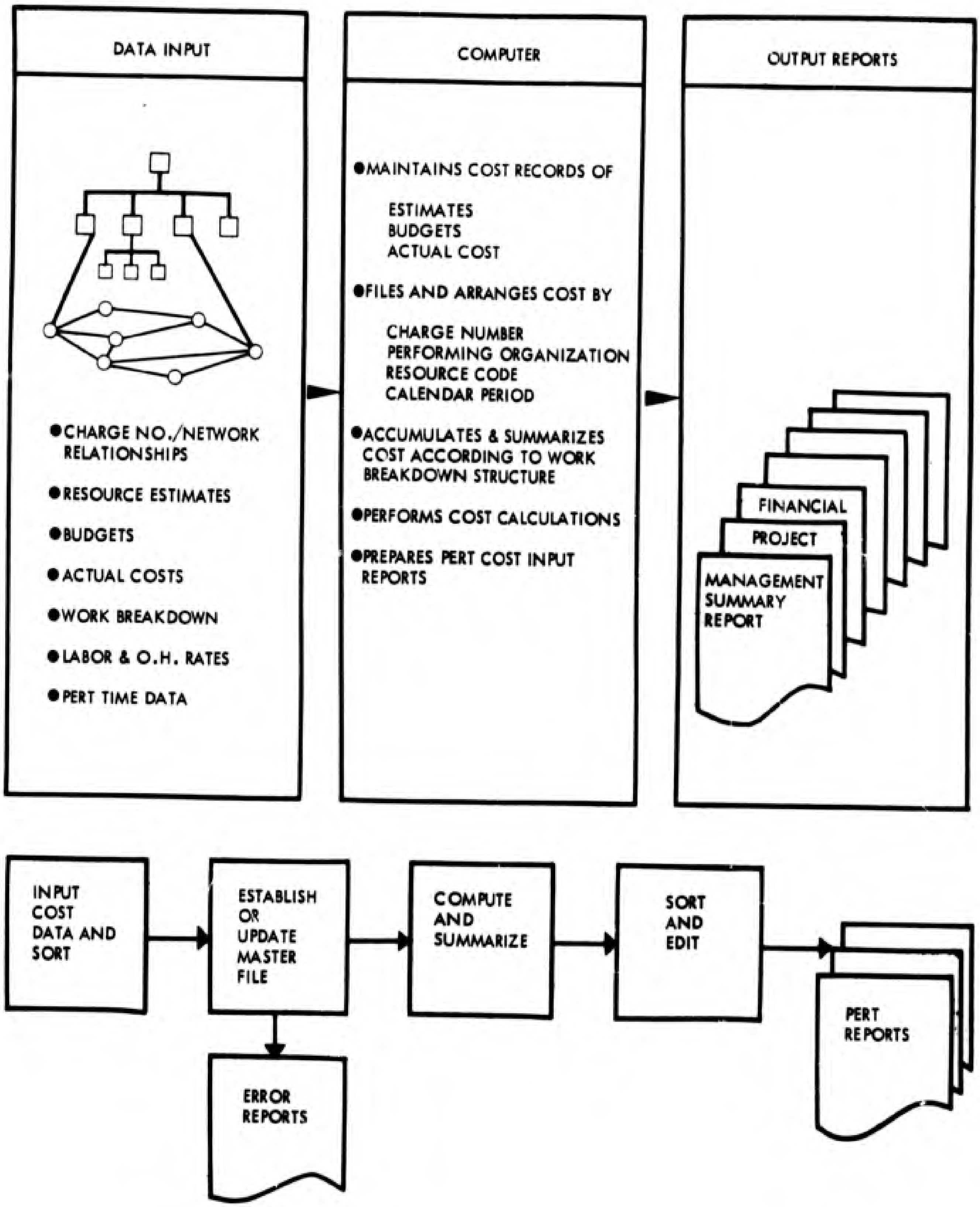
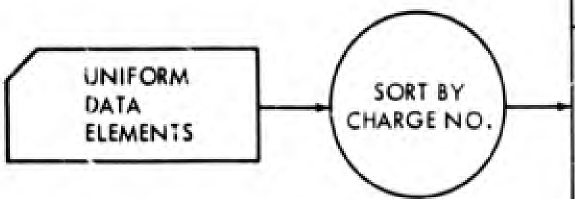
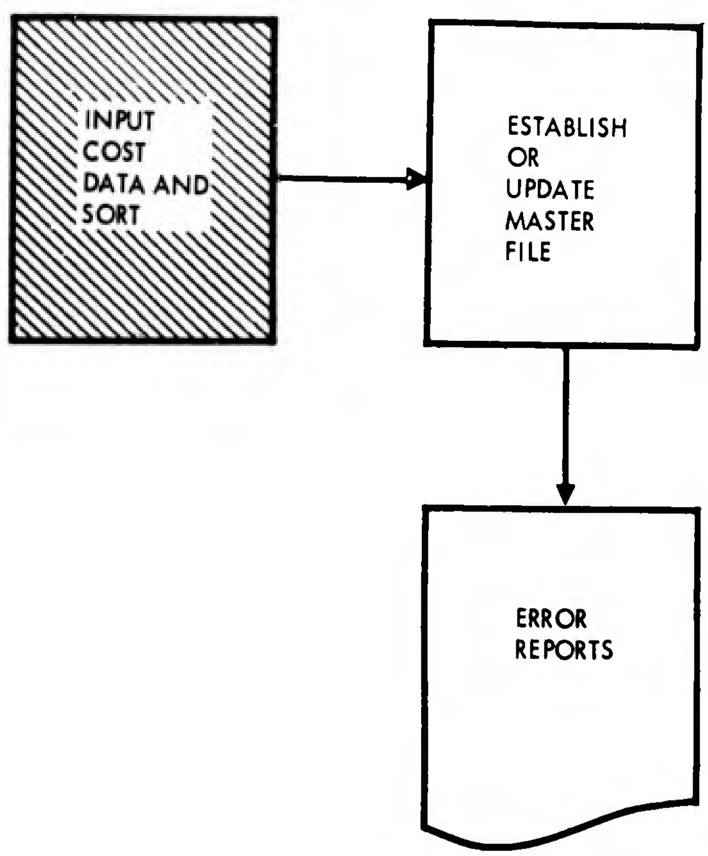


FIGURE XIV-8 – DATA FLOW



CHARGE NO. LISTING					
CHARGE NO.	COST DATA				NETWORK ACTIVITIES
		HRS.	DIRECT $	TOTAL $	
1.	ESTIMATES				
	BUDGETS				
	ACTUALS				
2.	ESTIMATES				
	BUDGETS				
	ACTUALS				
3.	ESTIMATES				
	BUDGETS				
	ACTUALS				

MASTER FILE

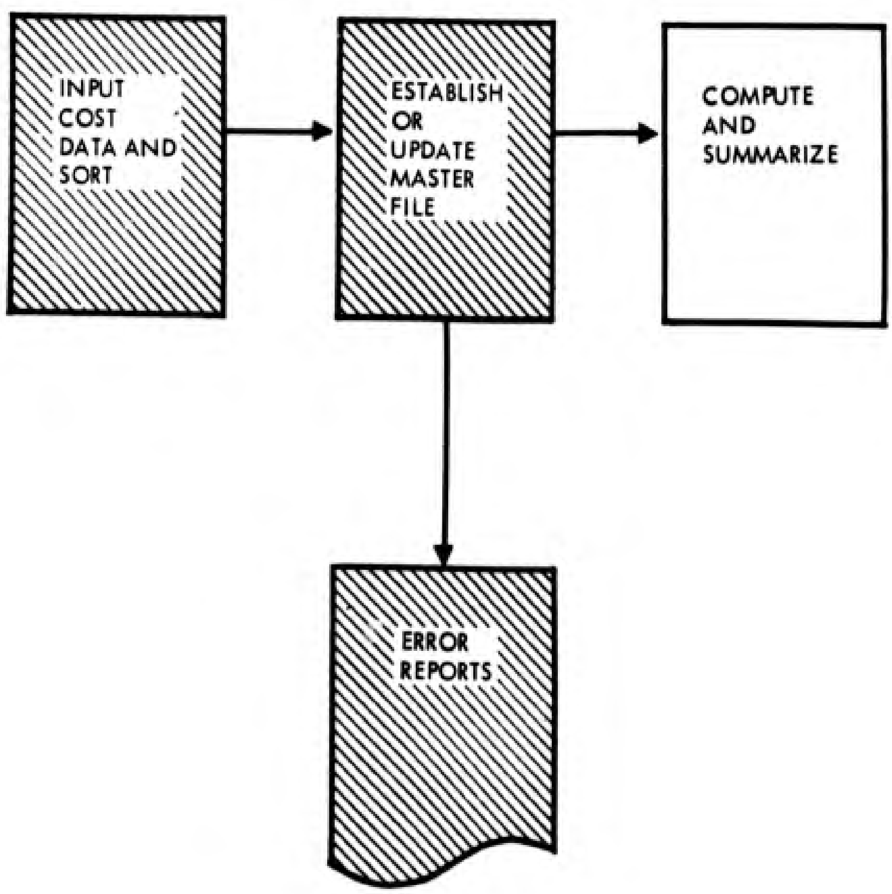


The master file is a record of all the Cost and Time data which must be retained from one computer run to the next. Between computer runs it is maintained on an external storage medium such as magnetic tape or a deck of cards; during each computer run it is returned to the computer's internal storage, along with new input data.

The computer program matches the input data with the corresponding master file data and makes the necessary changes, corrections, insertions, and deletions as specified by these input data. If a master file does not exist, the input data is used to establish the initial master file.

An Error Report that identifies improperly prepared input data is also generated.

COMPUTE AND SUMMARIZE



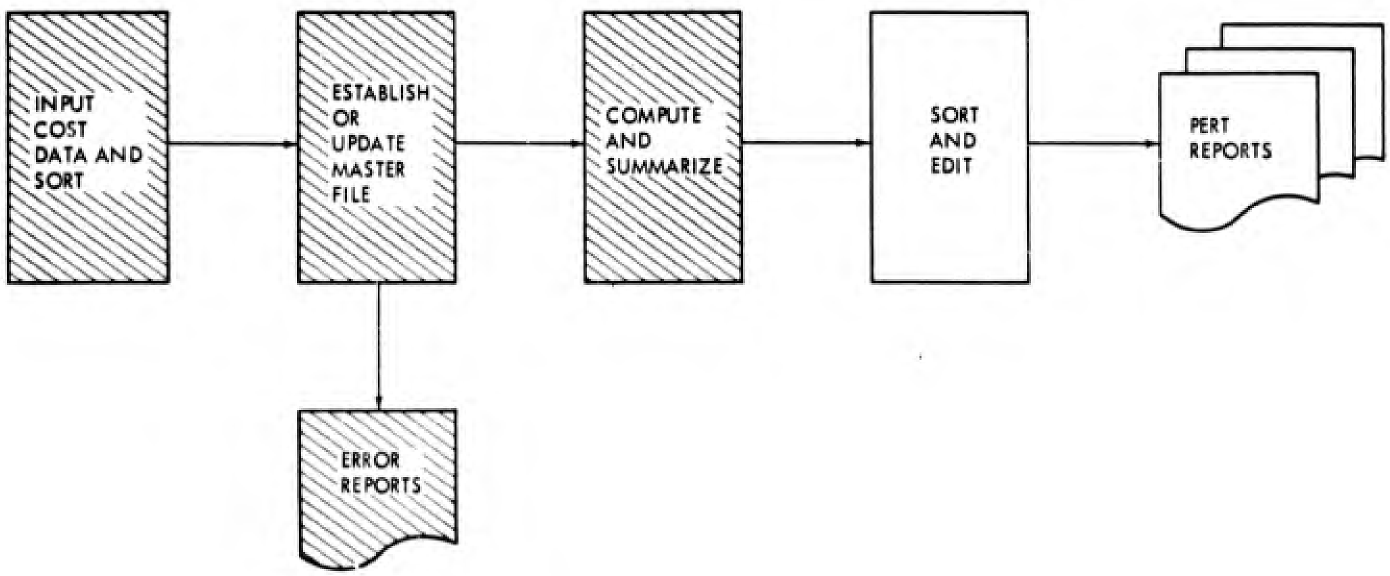
This routine examines all activities associated with each charge number and, for each charge number, identifies the earliest date on which a beginning event will occur and the latest expected date on which an ending event will occur. These two dates are now considered as the calculated beginning and end of the work package.

This routine converts man-hour and direct cost values to total dollar values. The computer makes these extensions, using labor and overhead rates available from the Rate Table Form. Actual costs are not normally converted and must be entered as man-hours, direct dollars, and indirect dollars.

In addition, costs are summarized up the work breakdown structure and the following calculations performed.

- Latest Revised Estimate to Complete
- Value of Work Performed
- Over/Under Runs

SORT AND EDIT



Output report preparation is the final step in the PERT process. The desired report data is selected for each report which has been requested. This data is sorted and put into proper format with page breaks, page numbers, columns/page headings, and other editing. The required reports are either printed directly by the computer, or they are written on an output medium (tape, cards, film) to be transcribed by an off-line "printer."

C. PERT Output Reports

This chapter presents the uniform PERT output reports specified by the Department of Defense. The major objective of this uniform set of PERT output reports is to prevent conflicting requirements on industry by various government agencies.

The output reports are not designed for any particular computer program. The maximum utilization of electronic data processing equipment to serve the needs of PERT is encouraged.

The format used in presenting each report includes a brief description of the report, an annotated example of the report format, an example of the report format with sample data included, and definitions of the headings appearing in the formats. The following reports are included:

- Management Summary Report (Figure XIV-9)
- Program/Project Status Report (Figure XIV-10)
- Organization Status Report (Figure XIV-11 and XIV-12)
- Financial Plan and Status Report (Figure XIV-13 and XIV-14)
- Manpower Loading Report (Figure XIV-15 and XIV-16)
- Cost Category Status Report (Figure XIV-17)

MANAGEMENT SUMMARY REPORT

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

ABC - MISSILE AND GHE ①	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ - A&S DIVN ③	33(600)28369A ④	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63 ⑤
LEVEL/SUMMARY ITEM: 3/BALLISTIC SHELL 22300 ②			

ITEM	COST OF WORK $(000)						SCHEDULE			
	WORK PERFORMED TO DATE			TOTALS AT COMPLETION						
	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED EST	PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK (WKS)	COMPL DATE	S-SCHED COMPL DATE--TOTAL A-ACTUAL COMPL DATE--ITEM E-EARLIEST COMPL DATE--CRITICAL L-LATEST COMPL DATE--ITEM P YR ⑮ 1963 JFMAMJJASOND 1964 JFMAMJJASOND 5 6 7 8 L YR	REMARKS
BALLISTIC SHELL LEV 3 22300	19,600	20,500	(.05) (900)	35,200	39,650	(.13) (4,450)	0.0	10DEC64 31DEC63 31DEC63	S E L	SEE PROBLEM ANALYSIS RPT ITEMS 1-3
NOSE FAIRING LEV 4 22310	27	25	.07 2	175	175		8.6	10DEC64 10JUN63 10AUG63	S E L	ITEM 6
FIRST STAGE LEV 4 22320	6,700	6,400	.04 300	9,200	9,700	(.05) 500	0.0	30APR64 31DEC63 31DEC63	S E L	ITEMS 9-12
SECOND STAGE LEV 4 22330	1,645	1,650	(5)	3,500	3,570	(.02) (70)	0.0	15JUN64 31DEC63 31DEC63	S E L	ITEM 15
⑥	⑦	⑧	⑨	⑩	⑪ NUMBER OF DIGITS	⑫	⑬	⑭	⑯	⑰
18 xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx	7 xxxxxxxx xxx,xxx	7 xxxxxxxx xxx,xxx	9 xxxxxxxxxx (.xx) (xxx,xxx)	7 xxx,xxx	7 xxx,xxx	9 (.xx) (xxx,xxx)	5 -xx.x	8 xxxxxxxx xxxxxxxx xxxxxxxx	33	
									TIME NOW	

FIGURE XIV-9 – MANAGEMENT SUMMARY REPORT

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

ABC - Missile and GHE

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

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

4 CONTRACT NUMBER: The numeric designation of the contract(s) or agreement(s) included in each report (e.g., 33(600)28369A). When a report is prepared for a large program or project, several contracts may be included. Therefore, each contract number (or its representative code) would be indicated in this space. It may be noted that by sorting on contract number, a report can be prepared for each individual contract.

5 REPORT DATES:

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

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

CUT-OFF DATE: The accounting cut-off date for the period of actual costs being reported.

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

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

7 VALUE (Work Performed to Date): The total planned cost for work completed within the summary item. This value is determined by summing the Planned Cost 10 for each completed work package. If a work package is in process, the part of its total planned cost which applies to work completed is approximated by applying the ratio of Actual Cost 8 to Latest Revised Estimate 11 for that work package.

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

9 (OVERRUN) UNDERRUN (Work Performed to Date): The value 7 for the work performed to date minus the Actual Cost 8 for that same work. When value exceeds actual cost, an underrun condition exists. When actual cost exceeds value, an overrun condition exists. The (overrun) underrun is also expressed as a percentage of the value of work performed to date immediately above the dollar amount. Parentheses are used as a notational device to indicate overruns.

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

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

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

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

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

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

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

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

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

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

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

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

PROGRAM/PROJECT STATUS REPORT

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

For each work package and summary item shown on the report there is a line of item description followed by a line of significant time and cost information.

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

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

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

ABC - Missile and GHE

ABC - MISSILE AND GHE (1)	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ - A&S DIVN (3)	33(600)28369A (4)	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63 (5)
LEVEL/SUMMARY ITEM: 4/FIRST STAGE 22320 (2)			

IDENTIFICATION				TIME STATUS			COST OF WORK $(000)					
							WORK PERFORMED TO DATE			TOTALS AT COMPLETION		
CHARGE OR SUMMARY NUMBER	LEVEL	FIRST EVENT NO.	LAST EVENT NO.	SCHED OR ACT (A) COMPL DATE	EARLIEST & LATEST COMPL DATE	MOST CRIT SLACK (WKS)	VALUE	ACTUAL COST	(OVERRUN) UNDERRUN	PLANNED COST	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN
FIRST STAGE 22320	4	12000999	12000199	30APR64	31DEC63 31DEC63	0.0 12000612	6,700	6,400	.04 300	9,200	9,700	(.05) (500)
INSTRUMENTATION 22322	5	12000700	12000400	10JAN64	31DEC63 31DEC63	0.0 12000612	165	172	(.04) (7)	415	430	(.04) (15)
POWER CABLE ASSY. 22323	5	12000899	12000800	15FEB64	15JUN63 15JUN63	0.0 12000783	270	200	.26 70	1,250	1,180	.06 70
ELECTRICAL DESIGN 32164	6	12000700	12000420	25JUL63	10JUN63 25JUN63	2.1 12000682	110	112	(.02) (2)	205	209	(.02) (4)
ELECTRICAL DESIGN 32165	6	12000869	12000360	12JAN64	15JUN63 15JUN63	0.0 12000783	22	20	.10 2	175	175	
MANUFACTURING 52073	6	12000690	12000410	22AUG63	10JUN63 25JUN63	2.1 12000682	55	60	(.11) (5)	125	137	(.10) (12)
TESTING 78340	6	12000622	12000400	10JAN64	31DEC63 31DEC63	0.0 12000612				85	84	.01 1
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
NUMBER OF DIGITS												
18	2	9	9	8	8	9	7	7	9	7	7	9
xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx	xxx xx	xxxxxxxxx xxxxxxxxx	xxxxxxxxx xxxxxxxxx	xxxxxxxx	xxxxxxxx xxxxxxxx	-xx.x xxxxxxxxx	xxx,xxx	xxx,xxx	(.xx) (xxx,xxx)	xxx,xxx	xxx,xxx	(.xx) (xxx,xxx)

FIGURE XIV-10 – PROGRAM/PROJECT STATUS REPORT

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

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

4 CONTRACT NUMBER: The numeric designation of the contract(s) or agreement(s) included in each report (e.g., 33(600)28369A). When a report is prepared for a large program or project, several contracts may be included. Therefore, each contract number (or its representative code) would be indicated in this space. It may be noted that by sorting on contract number, a report can be prepared for each individual contract.

5 REPORT DATES:

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

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

CUT-OFF DATE: The accounting cut-off date for the period of actual costs being reported.

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

6 CHARGE OR SUMMARY NUMBER: The noun description and charge or summary number of each work package or summary item for which time information and cost information are presented in the report. For a work package, the charge number is the contractor or government charge number (shop order number, work order number) used to identify the work package for

purposes of estimating and accumulating costs. The title or short description of the charge number is printed immediately above the number itself. For the summary item, the summary number is the identification of an end item on the work breakdown structure above the work package level. The title or description of the summary item is also printed directly above the summary number.

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

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

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

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

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

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

summing the scheduled elapsed time (t_s) values for activities on the longest path from the beginning of the program or project to the end of the work effort; and

then adding this sum to the calendar start date of the program or project.

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

summing the scheduled elapsed time (t_s) values for activities on the longest path from the end of the work effort to the end of the program or project; and

then subtracting this sum from the calendar end date of the program or project.

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

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

13 VALUE (Work Performed to Date): The total planned cost for work completed within the summary item or work package. This value is determined by summing

the Planned Cost 16 for each completed work package. If a work package is in process, the part of its total planned cost which applies to work completed is approximated by applying the ratio of Actual Cost 14 to Latest Revised Estimate 17 for that work package.

14 ACTUAL COST (Work Performed to Date): The actual expenditures incurred plus any pre-specified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned to a work package. For summary items, the appropriate work package data is summed.

15 (OVERRUN)UNDERRUN (Work Performed to Date): The Value 13 for the work performed to date minus the Actual Cost 14 for that same work. Where value exceeds actual cost, an underrun condition exists. Where actual cost exceeds value, an overrun condition exists. The (overrun)underrun is also expressed as a percentage of the value of work to date immediately above the dollar amount. Parentheses are used as a notational device to indicate overruns.

16 PLANNED COST (Totals at Completion): The approved planned cost for the total work package. For summary items, the appropriate work package data is summed.

17 LATEST REVISED ESTIMATE (Totals at Completion): The latest estimate of cost for the total work package. This estimate is the sum of actual costs plus estimates-to-complete for each work package. For summary items, the appropriate work package data is summed. This estimate is also known as anticipated final cost. For a completed work package or summary item the latest revised estimate equals the Actual Cost 14 .

18 PROJECTED (OVERRUN)UNDERRUN (Totals at Completion): The Planned Cost 16 minus the Latest Revised Estimate 17 . When planned cost exceeds latest revised estimate, a projected underrun condition exists. When latest revised estimate exceeds planned cost, a projected overrun condition exists. The projected (overrun)underrun is also expressed as a percentage of the planned cost immediately above the dollar amount. Parentheses are used as a notational device to indicate overruns.

ORGANIZATION STATUS REPORT

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

Several types of reports may be produced within this format by changing the sorting sequence of Charge Number 6 , Responsible Organization 7 , Performing Organization 8 , and Resource Code 9 .

Following are several examples of possible reports:

Responsible Organization 1, Charge Number 2, Performing Organization 3, Resource Code 4.

This report shows, for each responsible organization, all work packages which are within its responsibility and a breakout of organizations and skills which will actually perform the work. (Figure 6)

Performing Organization 1, Charge Number 2, Responsible Organization 3, Resource Code 4.

This report shows, for each performing organization, that portion of each work package assigned to it for accomplishment, with a further identification of the organization responsible for each work package and the resources required.

Performing Organization 1, Charge Number 2.

This report is another version of the above. It shows less detail and is more suitable for higher levels of management. (Figure 7)

Charge Number 1, Performing Organization 2.

This report is a work package listing (shop order ledger) commonly used as an accounting aid.

	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
ABC - MISSILE AND GHE (1)	XYZ - A&S DIVN (3)	33(600)28369A (4)	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63 (5)
LEVEL/SUMMARY ITEM: 3/BALLISTIC SHELL 22300 (2)			

IDENTIFICATION				MANHOURS				DIRECT COSTS $(000)				TIME	
				WORK TO DATE	TOTALS AT COMPLETION			WORK TO DATE	TOTALS AT COMPLETION				
CHARGE NUMBER	RESP ORGN	PERF ORGN	RES CODE	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK (WKS)	SCHED OR ACT (A) COMPL DATE
	2217												
ELECTRICAL DESIGN, INSTRU 32164		2217	E1	16,900	30,000	31,100	(1,100)	41	90	94	(4)	2.1	25JUL63
			E2	16,800	20,000	20,100	(100)	40	60	60			
		4422	A10	3,500	7,000	7,000		12	25	25			
			M60					5	5	5			
		5514	DI	1,200	5,000	5,000		5	15	15			
				2,800	3,300	3,300		9	10	10			
TOTAL								112	205	209	(.02) (4)		
ELECTRICAL DESIGN, PWR CABLE ASSY 32165		5514	DI	2,200	4,200	4,200		6	12	12		4.2	15JUL63
	TOTAL							1,300	2,600	2,500	.04 100		
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
				NUMBER OF DIGITS									
18 xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx	6 xxxxxx xxxxxx	6 xxxxxx xxxxxx	4 xxxxx xxxx	7 xxx,xxx	7 xxx,xxx	7 xxx,xxx	9 (.xx) (xxx,xxx)	7 xxx,xxx	7 xxx,xxx	7 xxx,xxx	9 (.xx) (xxx,xxx)	5 -xx.x	8 xxxxxxx

FIGURE XIV-11 – ORGANIZATION STATUS REPORT BY RESP ORGN, CHARGE NUMBER, PERF ORGN, RES CODE

ABC - MISSILE AND GHE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ - A&S DIVN	33(600)28369A	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10 APR63
LEVEL/SUMMARY ITEM: 3/BALLISTIC SHELL 22300			

IDENTIFICATION				MANHOURS				DIRECT COSTS $(000)				TIME	
				WORK TO DATE	TOTALS AT COMPLETION			WORK TO DATE	TOTALS AT COMPLETION				
CHARGE NUMBER	RESP ORGN	PERF ORGN	RES CODE	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	MOST CRIT SLACK (WKS)	SCHED OR ACT (A) COMPL DATE
32163		2217		9,200	25,000	25,000		22	75	75		3.6	15JUL63
32164				33,700	50,000	51,200	(1,200)	81	150	154	(4)	2.1	25JUL63
		TOTAL						382	825	831	(.01) (6)		
32163		4422		500	1,200	1,200		2	7	7		3.6	15JUL63
32164				3,500	7,000	7,000		12	25	25		2.1	25JUL63
		TOTAL						297	622	622			

FIGURE XIV-12 – ORGANIZATION STATUS REPORT BY PERF ORGN, CHARGE NUMBER

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

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

ABC - Missile and GHE

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

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

4 CONTRACT NUMBER: The numeric designation of the contract(s) or agreement(s) included in each report (e.g., 33(600)28369A). When a report is prepared for a large program or project, several contracts may be included. Therefore, each contract number (or its representative code) would be indicated in this space. It may be noted that by sorting on contract number, a report can be prepared for each individual contract.

5 REPORT DATES:

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

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

CUT-OFF DATE: The accounting cut-off date for the period of actual costs being reported.

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

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

6 CHARGE NUMBER: The noun description and charge number for each work package for which time information and cost information are presented in the report. This is the charge number (shop order number, work order number) used to identify the work package for purposes of estimating and accumulating costs. The title or short description of the charge number is printed immediately above the number itself.

7 RESPONSIBLE ORGANIZATION: The organization responsible for management of the work package 6 .

8 PERFORMING ORGANIZATION: The department or organization which will perform work on the work package.

9 RESOURCE CODE: The code for a particular manpower skill or material type.

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

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

11 PLANNED (Totals at Completion): The approved planned manhours for the work package or work package subdivision.

12 LATEST REVISED ESTIMATE (Totals at Completion): The latest estimate of manhours for the work package or work package subdivision. This estimate is the sum of actual manhour expenditures plus estimates-to-complete. This estimate is also known as anticipated

final cost. For a completed work package or work package subdivision the latest revised estimate equals the Actual to Date 10 .

13 PROJECTED (OVERRUN) UNDERRUN (Totals at Completion): The Planned Manhours 11 minus the Latest Revised Estimate 12 . When planned manhours exceed latest revised estimate, a projected underrun condition exists. When latest revised estimate exceeds planned manhours, a projected overrun condition exists. Parentheses are used as a notational device to indicate overruns.

14 - 17 DIRECT COSTS $(000): Cost information in this area of the report represents materials and other direct costs as well as the direct labor dollar value of costs shown in 10 - 13 . Total dollar costs (including overhead) may be used when they are more appropriate to a contractor's normal operation than direct costs.

14 ACTUAL COST (Work to Date): The actual expenditures incurred plus any pre-specified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned to a work package or work package subdivision.

15 PLANNED COST (Totals at Completion): The approved planned cost for the work package or work package subdivision.

16 LATEST REVISED ESTIMATE (Totals at Completion): The latest estimate of cost for the work package or work package subdivision. This estimate is the sum of actual costs plus estimates-to-complete. This estimate is also known as anticipated final cost. For completed work the latest revised estimate equals the Actual Cost 14 .

17 PROJECTED (OVERRUN) UNDERRUN (Totals at Completion): The Planned Cost 15 minus the Latest Revised Estimate 16 . When planned cost exceeds latest revised estimate, a projected underrun condition exists. When latest revised estimate exceeds planned cost, a projected overrun condition exists. The projected (overrun)underrun is also expressed as a percentage of the planned cost immediately above the dollar amount on total lines. Parentheses are used as a notational device to indicate overruns.

18 MOST CRITICAL SLACK (WEEKS): The smallest (least algebraic) slack with respect to designated program or project end points, in weeks, for any of the activities within the work package 6 . Slack pertains only to the work package (charge number) itself, not to the further cost element breakouts shown in this report. If the work package has been completed, this column is blank.

19 SCHEDULED OR ACTUAL (A) COMPLETION DATE: The calendar date on which all the work contained in the work package is scheduled for completion or was actually completed. The scheduled completion date (T_S) is established by management as an internal control on the completion of the work. If no scheduled completion date has been established for the work package, the column is blank. The actual completion date (T_A) is the date on which all work in the work package has been completed. When the date in this column is an actual completion date, an "A" is printed in front of the date. Completion date pertains only to the work package (charge number) itself, not to the further cost element breakouts shown in this report.

FINANCIAL PLAN AND STATUS REPORT

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

Historical (prior month) cumulative costs are shown for each charge number. Both incremental and cumulative costs by charge number are shown for each future month within the time period identified in the Report Dates block 5 .

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

1 The designation of the total (or a part of the total) system program or project that is identified with the reporting organization. For example, if

ABC - MISSILE AND GHE (1)	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	(3) XYZ - A&S DIVN	33(600)28369A (4)	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63 (5)
LEVEL/SUMMARY ITEM: 4/FIRST STAGE, BALLISTIC SHELL 22300 (2)			

MONTH	CHARGE NUMBER	INCREMENTAL COST $(000)				CUMULATIVE COST $(000)			
		ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN
PRIOR	32163					24	24	24	
	32164					92	93	92	1
	52072					12	12	12	
	52073					2	8	2	6
	78339						2		2
	TOTAL					6,150	6,200	6,150	50
MAR63	32163	1	1	1		25	25	25	
	32164	20	19	20	(1)	112	112	112	
	52072	3	2	3	(1)	15	14	15	(1)
	78339	2	2	2		2	4	2	2
	TOTAL	250	300	250	50	6,400	6,500	6,400	100
APR63	32163		1	1			26	26	
	32164		2	6	(4)		16	21	(5)
	TOTAL		98	140	(42)		6,598	6,540	58
TOTAL PERIOD						6,400	9,200	9,700	(500)
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
			NUMBER OF DIGITS						
12	18	7	7	7	9	7	7	7	9
xxxxxxxxxxxx	xxxxxxxxxxxxxxxxxx	xxx,xxx	xxx,xxx	xxx,xxx	(xxx,xxx)	xxx,xxx	xxx,xxx	xxx,xxx	(xxx,xxx)

FIGURE XIV-13 – FINANCIAL PLAN AND STATUS REPORT BY MONTH, CHARGE NUMBER

ABC - MISSILE AND GHE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ - A&S DIVN	33(600)28369A	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63
LEVEL/SUMMARY ITEM: 4/FIRST STAGE, BALLISTIC SHELL 22320			

MONTH	CHARGE NUMBER	INCREMENTAL COST $(000)				CUMULATIVE COST $(000)			
		ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN
PRIOR						6,150	6,200	6,150	50
MAR63		250	300	250	50	6,400	6,500	6,400	100
APR 63			98	140	(42)		6,598	6,540	58
TOTAL PERIOD						6,400	9,200	9,700	(500)

FIGURE XIV-14 – FINANCIAL PLAN AND STATUS REPORT BY MONTH reporting organization XYZ has the Missile and GHE part of weapon system ABC, the program or project definition would read:

ABC - Missile and GHE

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

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

4 CONTRACT NUMBER: The numeric designation of the contract(s) or agreement(s) included in each report (e.g., 33(600)28369A). When a report is prepared for a large program or project, several contracts may be included. Therefore, each contract number (or its representative code) would be indicated in this space. It may be noted that by sorting on contract number, a report can be prepared for each individual contract.

5 REPORT DATES:

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

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

CUT-OFF DATE: The accounting cut-off date for the period of actual costs being reported.

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

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

7 CHARGE NUMBER: The contractor or government organization charge number (shop order number, work order number) used to identify the work package for purposes of estimating and accumulating costs.

8 ACTUAL (Incremental Cost): The actual expenditures incurred plus any pre-specified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned during the indicated Month 6 . This value is shown for individual Charge Numbers 7 when they are included in the report. This column is used only for the month preceding "cut-off date."

9 PLANNED (Incremental Cost): The approved planned cost for the indicated time period 6 . This value is shown for individual Charge Numbers 7 when they are included in the report. No information appears in this column for prior months.

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

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

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

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

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

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

MANPOWER LOADING REPORT

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

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

The report is prepared for higher levels of management by printing only totals for each month (Figure XIV-16). When the Government requires reporting in categories other than those identified by contractors' resource codes, the report is prepared by grouping resource codes within the specified categories by use of a translation table.

① ABC - MISSILE AND GHE	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	③ XYZ - A&S DIVN	33(600)28369A ④	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10APR63 ⑤
LEVEL/SUMMARY ITEM: 3/BALLISTIC SHELL 22300 ②			

IDENTIFICATION				MANHOURS				TIME
MONTH	RES (SKILL) CODE	PERF ORGN	CHARGE NUMBER	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	MOST CRIT SLACK (WKS)
PRIOR	E1	2217 4422	32163 32164 32166 32163 32166	800 13,000 2,200 400 600	2,100 14,000 2,200 400 600	800 13,000 2,200 400 600	1,300 1,000	0.0 2.1 16.2 0.0 16.2
TOTAL				175,000	179,000	175,000	4,000	
MAR63		2217	32163 32164	400 3,900	400 4,100	400 3,900	200	0.0 2.1
TOTAL				95,000	97,000	95,000	2,000	
APR63		2217	32163 32164		400 4,500	400 4,500		0.0 2.1
TOTAL					86,000	98,000	(12,000)	
	TOTAL			270,000	850,000	856,000	(6,000)	
⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭
NUMBER OF DIGITS								
12	6	6	18	10	10	10	12	5
xxxxxxxxxxxx	xxxxxx	xxxxxx	xxxxxxxxxxxxxxxxxx	xx,xxx,xxx	xx,xxx,xxx	xx,xxx,xxx	(xx,xxx,xxx)	-xx.x

FIGURE XIV-15 – MANPOWER LOADING REPORT BY RESOURCE, MONTH, PERF ORGN, CHARGE NO.

	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
ABC - MISSILE AND GHE	XYZ - A&S DIVN	33(600)28369A	TERM (SPAN): TOTAL PROGRAM CUT OFF DATE: 30MAR63 RELEASE DATE: 10 APR63
LEVEL/SUMMARY ITEM: 3/BALLISTIC SHELL 22300			

IDENTIFICATION				MANHOURS				TIME
MONTH	RES (SKILL) CODE	PERF ORGN	CHARGE NUMBER	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	MOST CRIT SLACK (WKS)
	EI							
PRIOR				175,000	179,000	175,000	4,000	
MAR63				95,000	97,000	95,000	2,000	
APR63					86,000	98,000	(12,000)	
	TOTAL			270,000	850,000	856,000	(6,000)	

FIGURE XIV-16 – MANPOWER LOADING REPORT BY RESOURCE, MONTH

The sequence of sort and the categories included in the report are indicated in the report title. In addition to the examples shown, the report may be prepared by Performing Organization 8 , Month 6 , and Resource Code 7 , to show organizational loading.

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

ABC - Missile and GHE

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

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

4 CONTRACT NUMBER: The numeric designation of the contract(s) or agreement(s) included in each report (e.g., 33(600)28369A). When a report is prepared for a large program or project, several contracts may be included. Therefore, each contract number (or its representative code) would be indicated in this space. It may be noted that by sorting on contract number, a report can be prepared for each individual contract.

5 REPORT DATES:

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

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

CUT-OFF DATE: The accounting cut-off date for the period of actual costs being reported.

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

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

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

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

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

9 CHARGE NUMBER: The contractor or government organization charge number (shop order number, work order number) used to identify the work package for purposes of estimating and accumulating costs.

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

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

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

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

14 MOST CRITICAL SLACK (WEEKS): The smallest (least algebraic) slack with respect to designated program or project end points, in weeks, for any of the activities within the work package 9 . Slack pertains only to the work package or charge number itself, not to the further cost element shown in this report. If the work package has been completed or if the charge number is not shown, this column is blank.

COST CATEGORY STATUS REPORT

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

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

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

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

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

ABC - MISSILE AND GHE (1)	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
	XYZ - A&S (3)	33(600)28369A (4)	CUT OFF DATE: 30MAR63 TERM (SPAN): TOTAL PROGRAM RELEASE DATE: 10APR63 (5)
LEVEL/SUMMARY ITEM: 3/BALLISTIC SHELL 22300 (2)			

IDENTIFICATION	MANHOURS					TOTAL COST $(000)				
	TO DATE		TOTALS AT COMPLETION			WORK TO DATE		TOTALS AT COMPLETION		
COST CATEGORY	PLANNED	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN	PLANNED	ACTUAL	PLANNED	LATEST REVISED ESTIMATE	PROJECTED (OVERRUN) UNDERRUN
1010 ENG A&S	117,000	120,000	220,000	225,000	(.02) (5,000)	2,500	2,700	3,500	3,900	(.11) (400)
1012 DEV D&T	172,000	172,000	380,000	380,000		2,100	2,100	4,300	4,300	
2010 EQUIP FA&C	211,000	212,000	420,000	421,000	(1,000)	3,100	3,800	5,200	5,900	(.13) (700)
301? ENG FLD SPT	63,000	61,000	170,000	169,000	(.01) 1,000	980	900	2,800	2,700	.04 100
TOTAL						18,620	20,500	35,200	39,650	(.13) (4,450)
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
NUMBER OF DIGITS										
18 xxxxxxxxxxxxxxxxxx	11 xxxxxxxxxxxx xxx,xxx,xxx	11 xxxxxxxxxxxx xxx,xxx,xxx	11 xxxxxxxxxxxx xxx,xxx,xxx	11 xxxxxxxxxxxx xxx,xxx,xxx	9 (.xx) (xxx,xxx)	7 xxx,xxx	7 xxx,xxx	7 xxx,xxx	7 xxx,xxx	9 (.xx) (xxx,xxx)

FIGURE XIV-17 – COST CATEGORY STATUS REPORT

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

ABC - Missile and GHE

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

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

4 CONTRACT NUMBER: The numeric designation of the contract(s) or agreement(s) included in each report (e.g., 33(600)28369A). When a report is prepared for a large program or project, several contracts may be included. Therefore, each contract number (or its representative code) would be indicated in this space. It may be noted that by sorting on contract number, a report can be prepared for each individual contract.

5 REPORT DATES:

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

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

CUT-OFF DATE: The accounting cut-off date for the period of actual costs being reported.

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

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

7 - 11 <u>MANHOURS</u>: Information shown in this area of the report may represent services and facilities usage, as well as direct labor. Totals are shown only for each cost category.

7 <u>PLANNED</u> (To Date): The approved planned manhours assigned to all work packages or work package subdivisions identified with the indicated Cost Category 6 from the beginning of the Term 5 to the Cut-Off Date 5 .

8 <u>ACTUAL</u> (To Date): The actual manhour expenditures incurred, charged, or assigned to all work packages or work package subdivisions identified with the indicated Cost Category 6 .

9 <u>PLANNED</u> (Totals at Completion): The approved planned manhours assigned to all work packages or work package subdivisions identified with the indicated Cost Category 6 .

10 <u>LATEST REVISED ESTIMATE</u> (Totals at Completion): The latest estimate of manhours for all the work packages or work package subdivisions identified with the indicated Cost Category 6 . This estimate is the sum of actual manhour expenditures plus estimates-to-complete. When all work packages associated with the cost category are completed, Latest Revised Estimate 10 equals Actual to Date 8 .

11 <u>PROJECTED (OVERRUN) UNDERRUN</u> (Totals at Completion): The Planned Manhours 9 minus the Latest Revised Estimate 10 . When planned manhours exceed latest revised estimate, a projected underrun condition exists. When latest revised estimate exceeds planned manhours, a projected overrun condition exists. The projected (overrun) underrun is also expressed as a percentage of the planned cost immediately above the number of manhours. Parentheses are used as a notational device to indicate overruns.

12 - 16 TOTAL COST $(000): Cost information in this area of the report represents materials, other direct costs, labor dollar value of manpower (shown in 7 - 11), and overhead.

12 PLANNED (To Date): The approved planned cost assigned to all work packages or work package subdivisions identified with the indicated Cost Category 6 from the beginning of the Term 5 to the Cut-Off Date 5 .

13 ACTUAL (To Date): The actual expenditures incurred plus any pre-specified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned to work packages or work package subdivisions identified with the indicated Cost Category 6 .

14 PLANNED (Totals at Completion): The approved planned cost assigned to all work packages or work package subdivisions identified with the indicated Cost Category 6 .

15 LATEST REVISED ESTIMATE (Totals at Completion): The latest estimate of cost for all the work packages or work package subdivisions identified with the indicated Cost Category 6 . This estimate is the sum of actual expenditures plus estimates-to-complete. When all work packages associated with the cost category are completed, Latest Revised Estimate 15 equals Actual to Date 13 .

16 PROJECTED (OVERRUN) UNDERRUN (Totals at Completion): The Planned Cost 14 minus the Latest Revised Estimate 15 . When planned cost exceeds latest revised estimate, a projected underrun condition exists. When latest revised estimate exceeds planned cost, a projected overrun condition exists. The projected (overrun) underrun is also expressed as a percentage of the planned cost immediately above the dollar amount. Parentheses are used as a notational device to indicate overruns.

D. Other

The output reports illustrated in Section C represent the normal machine printouts and can be utilized by various levels of management. From these data additional presentations can be developed. However, the reports shown do not stand by themselves.

The Problem Analysis Report is a narrative report which completes the logic necessary for a thorough evaluation of any program by supplying the specifics involved. This report aids in determining how the computer information should be presented to the higher levels of management in order to comprehend the full impact of any problem.

The report contains three basic sections:

- a summary analysis of that portion of the program covered by the Management Summary Report;
- an analysis of tasks where current or potential problems exist;
- a narrative description of:
  - the nature of the problem,
  - the reasons for cost and/or schedule variance,
  - the impact of the immediate task,
  - the impact on the total program, and
  - the corrective action.

As noted in the early chapters these data can be transformed in a Cost of Work Report (Figure I-3), a Cost Outlook Report (Figure I-4), or a

Schedule Outlook Report (Figure I-5). These reports are normally prepared manually; however, there are computer programs which have the capability of developing such presentations when required. The Manpower Loading Report can also be developed manually or by the computer when the latter has been programmed to do this operation.

In view of the different levels of management and the alternative means of both presentation and evaluation, the need for an Alternate Management Summary Report has been considered necessary. For simplicity, this format can be prepared manually for the intermediate and upper levels of management to present information which will, in general, satisfy different basic concepts of management; i.e., government, industry, etc.

The Alternate Management Summary Report, Figure XIV-18, is designed to integrate overall work schedules and costs and point up, through the use of the problem analysis, technical problems requiring management attention. It may be used at the several levels of contract and program management, and on contracts of any value including those requiring PERT application.

The procedures for processing this report, as well as the establishment of report items associated with the product-oriented work breakdown structure or milestones and cost breakouts, should be determined by previous agreement of the participating agencies.

The product-oriented work breakdown structure and milestone 1/ reporting are the key elements in planning and managing a project. The systematic division of the total effort into smaller, more manageable pieces to identify the major items, tasks, or significant problem milestones, shall be in accordance with the guidelines provided in the PERT Guide for Management Use. The interrelationship of the Work Breakdown Structure as well as the milestones shall be based on the PERT network logic. Since events are accomplished on

1/Used interchangeably with the term event.

PERT ALTERNATE MANAGEMENT SUMMARY REPORT	NAME AND LOCATION OF ACTIVITY				PROJECTS CONTRACT NO.		REPORT PERIOD			☐ DIRECT COST ☐ TOTAL COST		FORM APPROVED BUDGET BUREAU NO.		
☐ WORK BREAKDOWN STRUCTURE	ACTUAL COST	WORK PERFORMED TO DATE (In Thousands)			☐ COST EXP.	TOTALS COMPLETION (In Thousands)				SLACK	SCHEDULE DATA			
												COMPLETION DATE		
☐ MILESTONE (1)	(MONTHS) (In Thous.) (2)	VALUE (3)	ACTUAL COST (4)	(OVER-RUN) UNDER-RUN (5)	☐ COMMIT-MENTS (6)	ORIG. CONTR. ESTIMATE (7)	PLANNED COST (8)	LATEST REVISED ESTIMATE (9)	PROJ. (OVERRUN) UNDER-RUN (10)	(11)	START (12)	SCHED-ULED (13)	ESTIMATED (14)	ACTUAL (15)
16. SUB-TOTAL DIRECT COSTS														
17. TOTAL PROGRAM COSTS														

18. TOTAL PROGRAM EXP. ($000)	NEXT MONTH	MO. 2	MO. 3	MO. 4	MO. 5	MO. 6	MO. 7	MO. 8	MO. 9	MO. 10	MO. 11	MO. 12

19. ANALYSIS REPORT OF SIGNIFICANT PROJECT END ITEM AND COMPONENT VARIANCES AND PROBLEMS
(Use reverse side if more space is necessary)

20. Signature and Title:

Replacing Cost Planning Appraisal, BOB Form 22R233 and Milestone Form NAVEXOS4153 (e.g. Cost, Schedule, Performance, etc.)

FIGURE XIV — 18 ALTERNATE MANAGEMENT SUMMARY REPORT a general calendar base date and the financial reporting dates are specific time periods, the concurrent completion of events on the exact financial reporting date is extremely unlikely. Cost information furnished as of the end of the reporting period does not represent the cost associated with milestones.

In reporting, costs must be specific to the item reported in the Work Breakdown Structure. Conversely, cost reporting, insofar as milestones, extends over the entire program as of the date of the report and is not specific to the events completed during the reporting period. The time for accomplishment of individual work packages comprising any end item subdivision of the Work Breakdown Structure for that reporting level of management should not exceed three months duration. It is recognized in contrast that the milestones for the life of the contract are initially determined during the pre-award stages of contracting. At least one milestone should be scheduled for accomplishment in each report period.

ALTERNATE MANAGEMENT SUMMARY REPORT

Heading

Name and Location of Activity - self-explanatory.

Project Contract Number - Insert contract number; if submission is a proposal, write PROPOSAL, followed by the Request for Proposal number or other appropriate identification.

Report Period - Show the monthly or other period stipulated in the contract; and check (x) in either Direct or Total Cost to indicate the coverage of the amounts reported.

Column 1 Work Breakdown Structure/Milestone

Check (x) whether reporting on a work breakdown structure or milestone basis.

For the work breakdown structure report, list the contract line items and associated tasks and sub-tasks in indenture level breakdown form as derived from the product-oriented work breakdown structure. For the milestone report, list the milestones or events scheduled for accomplishment as listed in the contract or proposal. A minimum of one milestone or event will be scheduled for accomplishment in each report period. Important Note: Milestone events are not individually costed. The cost figures are associated with the milestone events on a calendar basis only. Therefore, when reporting on a milestone, these figures should represent the Total Program Cost Status as of the reporting date -- not just the cost status of the reported milestone or event -- and entered in the "Total Program Cost" Line 17 as a single entry in each column.

Column 2 Actual Cost

Enter the actual cost for the month reported.

Column 3 Value (Work Performed to Date): The total planned cost for work completed with the summary item. This value is determined by summing the planned cost, column 8, for each completed work package. If a work package is in process, the part of its total planned cost which applies to work completed is approximated by applying the ratio of Actual Cost, column 4, to the Latest Revised Estimate, column 9, for that work package.

Column 4 Actual Cost (Work Performed to Date): The actual expenditures incurred plus any pre-specified types of unliquidated commitments (unliquidated obligations or accrued liabilities) charged or assigned to the work packages within the summary items.

Column 5 (Overrun)Underrun (Work Performed to Date): The Value, column 3, minus the Actual Cost, column 4, for the same work. When value exceeds actual cost, an underrun condition exists. When actual cost exceeds value, an overrun condition exists.

Column 6 Cost Exposure - Commitments: Check (x) as to reporting basis. When Actual Costs, column 4, only reflect the true actuals that have been expended to date on work performed, and it is desired to reflect the grand total which a contractor has extended himself, too, for planning and scheduling purposes, this value is cost exposure. It reflects the amount of funds involved, should termination of a contract be considered. When Actual Costs, column 4, do not include commitments, then these planned costs can be included in this column when this portion is checked.

Column 7 Original Contract Estimate (Totals at Completion): Extend the original contract negotiated cost for each contract line item and associated task and sub-tasks in indenture level breakdown form as derived from the product-oriented work breakdown structure.

Column 8 Planned Cost (Totals at Completion): This is the approved planned cost for the summary item and represents the cost for all work packages within the summary item.

Column 9 Latest Revised Estimate (Totals at Completion): This is the latest estimate of cost for the total summary item. It is the sum of the actual cost plus estimates-to-complete for all the work packages in the summary item. This estimate is also known as the anticipated final cost for the completed item. For a completed item, the latest revised estimate equals the Actual Cost, column 4.

Column 10 Projected (Overrun)Underrun (Totals at Completion): The planned cost, column 8, minus the Latest Revised Estimate, column 9, for the total summary item. When Planned Costs, column 8, exceeds the Latest Revised Estimate, column 9, a projected underrun condition exists. When the Latest Revised Estimate, column 9, exceeds the Planned Cost, column 8, a projected overrun condition exists.

Column 11 Slack: This represents the most critical slack in weeks with respect to designated program or project end points for any of the activities within the summary item or milestone event.

Column 12 Start (Schedule Data): Enter the date (day, month, year - 011265, 1 Dec 1965) that work is scheduled to start on the summary item or milestone.

Column 13 Scheduled (Completion Date): Enter the scheduled completion date (day, month, year, 011265, 1 Dec 1965) for the specific milestone or event or the scheduled date for the summary item.

Column 14 Estimated (Completion Date): Enter any changes to the scheduled date based on PERT logic and highlighted as to its effect on the overall program in the problem analysis report.

Column 15 Actual (Completion Date): Enter the actual date of completion of the summary item or milestone. In milestone reporting, a schedule change that effects the completion dates of milestones remaining to be accomplished will require the listing of these milestones in column 1, and completion of columns 12 through 14 to adjust planned completion dates. These dates must be identified through the use of parentheses indicating that they were not the original dates.

Line 16 — <u>Sub-Total Direct Costs</u>: This line will be completed only when the "Direct Cost" box has been checked for columns 2 through 10.

Line 17 — <u>Total Program Costs</u>: This line will be completed when the "Total Cost" box has been checked for columns 2 through 10. Milestone cost information shall be presented as total program costs.

Line 18 — <u>Total Program Expenditure</u>: Provide (a) the total program expenditure and (b) forecasts the expenditures planned in each of the ensuing 12 months. Enter in the first box under line 18 the total planned expenditure; in the following boxes; i.e., next month, month 2, month 3, etc., enter the identification of the month, Jan., Feb., Mar., along with the programmed expenditure.

Line 19 — <u>Analysis Report of Significant Project End Item and Component Variances and Problems</u>: Submitted concurrently an explanation of the reasons for cost, over/under run situation, schedule adjustment, imparts and variances, in technical performance, etc., as appropriate.

Line 20 — <u>Signature and Title</u>: The individual responsible for the summary item or project shall sign the report prior to submission. The responsible individual shall be capable of explaining the information presented, as well as supplying additional information upon request.

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APPENDIX A

In many instances, the use of PERT TIME has been associated to a computer. Whether this association was to glamorize the use of this management technique is not very evident. However, the more imaginative users of the technique in both industry and government have developed methods which circumvent the continual use of a computer.

For complex networks the computer is used on a monthly basis to update the complete network. However, on a day-to-day base the critical and near-critical paths can be analyzed, replanned and scheduled on a timely base without the use of a computer. An analysis of the timing required to recycle or replan any potential problem areas will demonstrate that the availability of computer time is the controlling factor. The replanning and preparation of the information for processing by the computer is usually negligible when compared to the waiting period for "computer time."

To overcome the restriction only two basic steps need be mastered. The first is the understanding of the computer logic as well as the capability of doing the detailed calculations. The second is the use of the Julian calendar to aid in completing or converting the details to a calendar base.

The sample calculation and explanation is illustrated in Chapter III.

The Julian calendar is provided herein for the following conditions:

a. Normal Week on an elapsed time base.
b. Five-Day Week for normal base.
c. Weekly and Bi-Weekly
d. Semi-Monthly

The use of the Julian calendar in converting time estimates to a calendar base following the basic calculations simplifies the overall calculations and permits the conversion of a planned schedule to a scheduled plan for management action.

NORMAL WEEK NUMERIC CALENDAR 1965

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29		88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK

NUMERIC CALENDAR

1966

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	366	397	425	456	486	517	547	578	609	639	670	700
2	367	398	426	457	487	518	548	579	610	640	671	701
3	368	399	427	458	488	519	549	580	611	641	672	702
4	369	400	428	459	489	520	550	581	612	642	673	703
5	370	401	429	460	490	521	551	582	613	643	674	704
6	371	402	430	461	491	522	552	583	614	644	675	705
7	372	403	431	462	492	523	553	584	615	645	676	706
8	373	404	432	463	493	524	554	585	616	646	677	707
9	374	405	433	464	494	525	555	586	617	647	678	708
10	375	406	434	465	495	526	556	587	618	648	679	709
11	376	407	435	466	496	527	557	588	619	649	680	710
12	377	408	436	467	497	528	558	589	620	650	681	711
13	378	409	437	468	498	529	559	590	621	651	682	712
14	379	410	438	469	499	530	560	591	622	652	683	713
15	380	411	439	470	500	531	561	592	623	653	684	714
16	381	412	440	471	501	532	562	593	624	654	685	715
17	382	413	441	472	502	533	563	594	625	655	686	716
18	383	414	442	473	503	534	564	595	626	656	687	717
19	384	415	443	474	504	535	565	596	627	657	688	718
20	385	416	444	475	505	536	566	597	628	658	689	719
21	386	417	445	476	506	537	567	598	629	659	690	720
22	387	418	446	477	507	538	568	599	630	660	691	721
23	388	419	447	478	508	539	569	600	631	661	692	722
24	389	420	448	479	509	540	570	601	632	662	693	723
25	390	421	449	480	510	541	571	602	633	663	694	724
26	391	422	450	481	511	542	572	603	634	664	695	725
27	392	423	451	482	512	543	573	604	635	665	696	726
28	393	424	452	483	513	544	574	605	636	666	697	727
29	394		453	484	514	545	575	606	637	667	698	728
30	395		454	485	515	546	576	607	638	668	699	729
31	396		455		516		577	608		669		730
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK

NUMERIC CALENDAR

1967

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	731	762	790	821	851	882	912	943	974	1004	1035	1065
2	732	763	791	822	852	883	913	944	975	1005	1036	1066
3	733	764	792	823	853	884	914	945	976	1006	1037	1067
4	734	765	793	824	854	885	915	946	977	1007	1038	1068
5	735	766	794	825	855	886	916	947	978	1008	1039	1069
6	736	767	795	826	856	887	917	948	979	1009	1040	1070
7	737	768	796	827	857	888	918	949	980	1010	1041	1071
8	738	769	797	828	858	889	919	950	981	1011	1042	1072
9	739	770	798	829	859	890	920	951	982	1012	1043	1073
10	740	771	799	830	860	891	921	952	983	1013	1044	1074
11	741	772	800	831	861	892	922	953	984	1014	1045	1075
12	742	773	801	832	862	893	923	954	985	1015	1046	1076
13	743	774	802	833	863	894	924	955	986	1016	1047	1077
14	744	775	803	834	864	895	925	956	987	1017	1048	1078
15	745	776	804	835	865	896	926	957	988	1018	1049	1079
16	746	777	805	836	866	897	927	958	989	1019	1050	1080
17	747	778	806	837	867	898	928	959	990	1020	1051	1081
18	748	779	807	838	868	899	929	960	991	1021	1052	1082
19	749	780	808	839	869	900	930	961	992	1022	1053	1083
20	750	781	809	840	870	901	931	962	993	1023	1054	1084
21	751	782	810	841	871	902	932	963	994	1024	1055	1085
22	752	783	811	842	872	903	933	964	995	1025	1056	1086
23	753	784	812	843	873	904	934	965	996	1026	1057	1087
24	754	785	813	844	874	905	935	966	997	1027	1058	1088
25	755	786	814	845	875	906	936	967	998	1028	1059	1089
26	756	787	815	846	876	907	937	968	999	1029	1060	1090
27	757	788	816	847	877	908	938	969	1000	1030	1061	1091
28	758	789	817	848	878	909	939	970	1001	1031	1062	1092
29	759		818	849	879	910	940	971	1002	1032	1063	1093
30	760		819	850	880	911	941	972	1003	1033	1064	1094
31	761		820		881		942	973		1034		1095
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK NUMERIC CALENDAR 1968

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1096	1127	1156	1187	1217	1248	1278	1309	1340	1370	1401	1431
2	1097	1128	1157	1188	1218	1249	1279	1310	1341	1371	1402	1432
3	1098	1129	1158	1189	1219	1250	1280	1311	1342	1372	1403	1433
4	1099	1130	1159	1190	1220	1251	1281	1312	1343	1373	1404	1434
5	1100	1131	1160	1191	1221	1252	1282	1313	1344	1374	1405	1435
6	1101	1132	1161	1192	1222	1253	1283	1314	1345	1375	1406	1436
7	1102	1133	1162	1193	1223	1254	1284	1315	1346	1376	1407	1437
8	1103	1134	1163	1194	1224	1255	1285	1316	1347	1377	1408	1438
9	1104	1135	1164	1195	1225	1256	1286	1317	1348	1378	1409	1439
10	1105	1136	1165	1196	1226	1257	1287	1318	1349	1379	1410	1440
11	1106	1137	1166	1197	1227	1258	1288	1319	1350	1380	1411	1441
12	1107	1138	1167	1198	1228	1259	1289	1320	1351	1381	1412	1442
13	1108	1139	1168	1199	1229	1260	1290	1321	1352	1382	1413	1443
14	1109	1140	1169	1200	1230	1261	1291	1322	1353	1383	1414	1444
15	1110	1141	1170	1201	1231	1262	1292	1323	1354	1384	1415	1445
16	1111	1142	1171	1202	1232	1263	1293	1324	1355	1385	1416	1446
17	1112	1143	1172	1203	1233	1264	1294	1325	1356	1386	1417	1447
18	1113	1144	1173	1204	1234	1265	1295	1326	1357	1387	1418	1448
19	1114	1145	1174	1205	1235	1266	1296	1327	1358	1388	1419	1449
20	1115	1146	1175	1206	1236	1267	1297	1328	1359	1389	1420	1450
21	1116	1147	1176	1207	1237	1268	1298	1329	1360	1390	1421	1451
22	1117	1148	1177	1208	1238	1269	1299	1330	1361	1391	1422	1452
23	1118	1149	1178	1209	1239	1270	1300	1331	1362	1392	1423	1453
24	1119	1150	1179	1210	1240	1271	1301	1332	1363	1393	1424	1454
25	1120	1151	1180	1211	1241	1272	1302	1333	1364	1394	1425	1455
26	1121	1152	1181	1212	1242	1273	1303	1334	1365	1395	1426	1456
27	1122	1153	1182	1213	1243	1274	1304	1335	1366	1396	1427	1457
28	1123	1154	1183	1214	1244	1275	1305	1336	1367	1397	1428	1458
29	1124	1155	1184	1215	1245	1276	1306	1337	1368	1398	1429	1459
30	1125		1185	1216	1246	1277	1307	1338	1369	1399	1430	1460
31	1126		1186		1247		1308	1339		1400		1461

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

NORMAL WEEK — NUMERIC CALENDAR — 1969

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1462	1493	1521	1552	1582	1613	1643	1674	1705	1735	1766	1796
2	1463	1494	1522	1553	1583	1614	1644	1675	1706	1736	1767	1797
3	1464	1495	1523	1554	1584	1615	1645	1676	1707	1737	1768	1798
4	1465	1496	1524	1555	1585	1616	1646	1677	1708	1738	1769	1799
5	1466	1497	1525	1556	1586	1617	1647	1678	1709	1739	1770	1800
6	1467	1498	1526	1557	1587	1618	1648	1679	1710	1740	1771	1801
7	1468	1499	1527	1558	1588	1619	1649	1680	1711	1741	1772	1802
8	1469	1500	1528	1559	1589	1620	1650	1681	1712	1742	1773	1803
9	1470	1501	1529	1560	1590	1621	1651	1682	1713	1743	1774	1804
10	1471	1502	1530	1561	1591	1622	1652	1683	1714	1744	1775	1805
11	1472	1503	1531	1562	1592	1623	1653	1684	1715	1745	1776	1806
12	1473	1504	1532	1563	1593	1624	1654	1685	1716	1746	1777	1807
13	1474	1505	1533	1564	1594	1625	1655	1686	1717	1747	1778	1808
14	1475	1506	1534	1565	1595	1626	1656	1687	1718	1748	1779	1809
15	1476	1507	1535	1566	1596	1627	1657	1688	1719	1749	1780	1810
16	1477	1508	1536	1567	1597	1628	1658	1689	1720	1750	1781	1811
17	1478	1509	1537	1568	1598	1629	1659	1690	1721	1751	1782	1812
18	1479	1510	1538	1569	1599	1630	1660	1691	1722	1752	1783	1813
19	1480	1511	1539	1570	1600	1631	1661	1692	1723	1753	1784	1814
20	1481	1512	1540	1571	1601	1632	1662	1693	1724	1754	1785	1815
21	1482	1513	1541	1572	1602	1633	1663	1694	1725	1755	1786	1816
22	1483	1514	1542	1573	1603	1634	1664	1695	1726	1756	1787	1817
23	1484	1515	1543	1574	1604	1635	1665	1696	1727	1757	1788	1818
24	1485	1516	1544	1575	1605	1636	1666	1697	1728	1758	1789	1819
25	1486	1517	1545	1576	1606	1637	1667	1698	1729	1759	1790	1820
26	1487	1518	1546	1577	1607	1638	1668	1699	1730	1760	1791	1821
27	1488	1519	1547	1578	1608	1639	1669	1700	1731	1761	1792	1822
28	1489	1520	1548	1579	1609	1640	1670	1701	1732	1762	1793	1823
29	1490		1549	1580	1610	1641	1671	1702	1733	1763	1794	1824
30	1491		1550	1581	1611	1642	1672	1703	1734	1764	1795	1825
31	1492		1551		1612		1673	1704		1765		1826
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK NUMERIC CALENDAR 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1827	1858	1886	1917	1947	1978	2008	2039	2070	2100	2131	2161
2	1828	1859	1887	1918	1948	1979	2009	2040	2071	2101	2132	2162
3	1829	1860	1888	1919	1949	1980	2010	2041	2072	2102	2133	2163
4	1830	1861	1889	1920	1950	1981	2011	2042	2073	2103	2134	2164
5	1831	1862	1890	1921	1951	1982	2012	2043	2074	2104	2135	2165
6	1832	1863	1891	1922	1952	1983	2013	2044	2075	2105	2136	2166
7	1833	1864	1892	1923	1953	1984	2014	2045	2076	2106	2137	2167
8	1834	1865	1893	1924	1954	1985	2015	2046	2077	2107	2138	2168
9	1835	1866	1894	1925	1955	1986	2016	2047	2078	2108	2139	2169
10	1836	1867	1895	1926	1956	1987	2017	2048	2079	2109	2140	2170
11	1837	1868	1896	1927	1957	1988	2018	2049	2080	2110	2141	2171
12	1838	1869	1897	1928	1958	1989	2019	2050	2081	2111	2142	2172
13	1839	1870	1898	1929	1959	1990	2020	2051	2082	2112	2143	2173
14	1840	1871	1899	1930	1960	1991	2021	2052	2083	2113	2144	2174
15	1841	1872	1900	1931	1961	1992	2022	2053	2084	2114	2145	2175
16	1842	1873	1901	1932	1962	1993	2023	2054	2085	2115	2146	2176
17	1843	1874	1902	1933	1963	1994	2024	2055	2086	2116	2147	2177
18	1844	1875	1903	1934	1964	1995	2025	2056	2087	2117	2148	2178
19	1845	1876	1904	1935	1965	1996	2026	2057	2088	2118	2149	2179
20	1846	1877	1905	1936	1966	1997	2027	2058	2089	2119	2150	2180
21	1847	1878	1906	1937	1967	1998	2028	2059	2090	2120	2151	2181
22	1848	1879	1907	1938	1968	1999	2029	2060	2091	2121	2152	2182
23	1849	1880	1908	1939	1969	2000	2030	2061	2092	2122	2153	2183
24	1850	1881	1909	1940	1970	2001	2031	2062	2093	2123	2154	2184
25	1851	1882	1910	1941	1971	2002	2032	2063	2094	2124	2155	2185
26	1852	1883	1911	1942	1972	2003	2033	2064	2095	2125	2156	2186
27	1853	1884	1912	1943	1973	2004	2034	2065	2096	2126	2157	2187
28	1854	1885	1913	1944	1974	2005	2035	2066	2097	2127	2158	2188
29	1855		1914	1945	1975	2006	2036	2067	2098	2128	2159	2189
30	1856		1915	1946	1976	2007	2037	2068	2099	2129	2160	2190
31	1857		1916		1977		2038	2069		2130		2191
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK

NUMERIC CALENDAR

1971

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2192	2223	2251	2282	2312	2343	2373	2404	2435	2465	2496	2526
2	2193	2224	2252	2283	2313	2344	2374	2405	2436	2466	2497	2527
3	2194	2225	2253	2284	2314	2345	2375	2406	2437	2467	2498	2528
4	2195	2226	2254	2285	2315	2346	2376	2407	2438	2468	2499	2529
5	2196	2227	2255	2286	2316	2347	2377	2408	2439	2469	2500	2530
6	2197	2228	2256	2287	2317	2348	2378	2409	2440	2470	2501	2531
7	2198	2229	2257	2288	2318	2349	2379	2410	2441	2471	2502	2532
8	2199	2230	2258	2289	2319	2350	2380	2411	2442	2472	2503	2533
9	2200	2231	2259	2290	2320	2351	2381	2412	2443	2473	2504	2534
10	2201	2232	2260	2291	2321	2352	2382	2413	2444	2474	2505	2535
11	2202	2233	2261	2292	2322	2353	2383	2414	2445	2475	2506	2536
12	2203	2234	2262	2293	2323	2354	2384	2415	2446	2476	2507	2537
13	2204	2235	2263	2294	2324	2355	2385	2416	2447	2477	2508	2538
14	2205	2236	2264	2295	2325	2356	2386	2417	2448	2478	2509	2539
15	2206	2237	2265	2296	2326	2357	2387	2418	2449	2479	2510	2540
16	2207	2238	2266	2297	2327	2358	2388	2419	2450	2480	2511	2541
17	2208	2239	2267	2298	2328	2359	2389	2420	2451	2481	2512	2542
18	2209	2240	2268	2299	2329	2360	2390	2421	2452	2482	2513	2543
19	2210	2241	2269	2300	2330	2361	2391	2422	2453	2483	2514	2544
20	2211	2242	2270	2301	2331	2362	2392	2423	2454	2484	2515	2545
21	2212	2243	2271	2302	2332	2363	2393	2424	2455	2485	2516	2546
22	2213	2244	2272	2303	2333	2364	2394	2425	2456	2486	2517	2547
23	2214	2245	2273	2304	2334	2365	2395	2426	2457	2487	2518	2548
24	2215	2246	2274	2305	2335	2366	2396	2427	2458	2488	2519	2549
25	2216	2247	2275	2306	2336	2367	2397	2428	2459	2489	2520	2550
26	2217	2248	2276	2307	2337	2368	2398	2429	2460	2490	2521	2551
27	2218	2249	2277	2308	2338	2369	2399	2430	2461	2491	2522	2552
28	2219	2250	2278	2309	2339	2370	2400	2431	2462	2492	2523	2553
29	2220		2279	2310	2340	2371	2401	2432	2463	2493	2524	2554
30	2221		2280	2311	2341	2372	2402	2433	2464	2494	2525	2555
31	2222		2281		2342		2403	2434		2495		2556
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK

NUMERIC CALENDAR

1972

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2557	2588	2617	2648	2678	2709	2739	2770	2801	2831	2862	2892
2	2558	2589	2618	2649	2679	2710	2740	2771	2802	2832	2863	2893
3	2559	2590	2619	2650	2680	2711	2741	2772	2803	2833	2864	2894
4	2560	2591	2620	2651	2681	2712	2742	2773	2804	2834	2865	2895
5	2561	2592	2621	2652	2682	2713	2743	2774	2805	2835	2866	2896
6	2562	2593	2622	2653	2683	2714	2744	2775	2806	2836	2867	2897
7	2563	2594	2623	2654	2684	2715	2745	2776	2807	2837	2868	2898
8	2564	2595	2624	2655	2685	2716	2746	2777	2808	2838	2869	2899
9	2565	2596	2625	2656	2686	2717	2747	2778	2809	2839	2870	2900
10	2566	2597	2626	2657	2687	2718	2748	2779	2810	2840	2871	2901
11	2567	2598	2627	2658	2688	2719	2749	2780	2811	2841	2872	2902
12	2568	2599	2628	2659	2689	2720	2750	2781	2812	2842	2873	2903
13	2569	2600	2629	2660	2690	2721	2751	2782	2813	2843	2874	2904
14	2570	2601	2630	2661	2691	2722	2752	2783	2814	2844	2875	2905
15	2571	2602	2631	2662	2692	2723	2753	2784	2815	2845	2876	2906
16	2572	2603	2632	2663	2693	2724	2754	2785	2816	2846	2877	2907
17	2573	2604	2633	2664	2694	2725	2755	2786	2817	2847	2878	2908
18	2574	2605	2634	2665	2695	2726	2756	2787	2818	2848	2879	2909
19	2575	2606	2635	2666	2696	2727	2757	2788	2819	2849	2880	2910
20	2576	2607	2636	2667	2697	2728	2758	2789	2820	2850	2881	2911
21	2577	2608	2637	2668	2698	2729	2759	2790	2821	2851	2882	2912
22	2578	2609	2638	2669	2699	2730	2760	2791	2822	2852	2883	2913
23	2579	2610	2639	2670	2700	2731	2761	2792	2823	2853	2884	2914
24	2580	2611	2640	2671	2701	2732	2762	2793	2824	2854	2885	2915
25	2581	2612	2641	2672	2702	2733	2763	2794	2825	2855	2886	2916
26	2582	2613	2642	2673	2703	2734	2764	2795	2826	2856	2887	2917
27	2583	2614	2643	2674	2704	2735	2765	2796	2827	2857	2888	2918
28	2584	2615	2644	2675	2705	2736	2766	2797	2828	2858	2889	2919
29	2585	2616	2645	2676	2706	2737	2767	2798	2829	2859	2890	2920
30	2586		2646	2677	2707	2738	2768	2799	2830	2860	2891	2921
31	2587		2647		2708		2769	2800		2861		2922
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK NUMERIC CALENDAR 1973

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2923	2954	2982	3013	3043	3074	3104	3135	3166	3196	3227	3257
2	2924	2955	2983	3014	3044	3075	3105	3136	3167	3197	3228	3258
3	2925	2956	2984	3015	3045	3076	3106	3137	3168	3198	3229	3259
4	2926	2957	2985	3016	3046	3077	3107	3138	3169	3199	3230	3260
5	2927	2958	2986	3017	3047	3078	3108	3139	3170	3200	3231	3261
6	2928	2959	2987	3018	3048	3079	3109	3140	3171	3201	3232	3262
7	2929	2960	2988	3019	3049	3080	3110	3141	3172	3202	3233	3263
8	2930	2961	2989	3020	3050	3081	3111	3142	3173	3203	3234	3264
9	2931	2962	2990	3021	3051	3082	3112	3143	3174	3204	3235	3265
10	2932	2963	2991	3022	3052	3083	3113	3144	3175	3205	3236	3266
11	2933	2964	2992	3023	3053	3084	3114	3145	3176	3206	3237	3267
12	2934	2965	2993	3024	3054	3085	3115	3146	3177	3207	3238	3268
13	2935	2966	2994	3025	3055	3086	3116	3147	3178	3208	3239	3269
14	2936	2967	2995	3026	3056	3087	3117	3148	3179	3209	3240	3270
15	2937	2968	2996	3027	3057	3088	3118	3149	3180	3210	3241	3271
16	2938	2969	2997	3028	3058	3089	3119	3150	3181	3211	3242	3272
17	2939	2970	2998	3029	3059	3090	3120	3151	3182	3212	3243	3273
18	2940	2971	2999	3030	3060	3091	3121	3152	3183	3213	3244	3274
19	2941	2972	3000	3031	3061	3092	3122	3153	3184	3214	3245	3275
20	2942	2973	3001	3032	3062	3093	3123	3154	3185	3215	3246	3276
21	2943	2974	3002	3033	3063	3094	3124	3155	3186	3216	3247	3277
22	2944	2975	3003	3034	3064	3095	3125	3156	3187	3217	3248	3278
23	2945	2976	3004	3035	3065	3096	3126	3157	3188	3218	3249	3279
24	2946	2977	3005	3036	3066	3097	3127	3158	3189	3219	3250	3280
25	2947	2978	3006	3037	3067	3098	3128	3159	3190	3220	3251	3281
26	2948	2979	3007	3038	3068	3099	3129	3160	3191	3221	3252	3282
27	2949	2980	3008	3039	3069	3100	3130	3161	3192	3222	3253	3283
28	2950	2981	3009	3040	3070	3101	3131	3162	3193	3223	3254	3284
29	2951		3010	3041	3071	3102	3132	3163	3194	3224	3255	3285
30	2952		3011	3042	3072	3103	3133	3164	3195	3225	3256	3286
31	2953		3012		3073		3134	3165		3226		3287
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

NORMAL WEEK NUMERIC CALENDAR 1974

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	3288	3319	3347	3378	3408	3439	3469	3500	3531	3561	3592	3622
2	3289	3320	3348	3379	3409	3440	3470	3501	3532	3562	3593	3623
3	3290	3321	3349	3380	3410	3441	3471	3502	3533	3563	3594	3624
4	3291	3322	3350	3381	3411	3442	3472	3503	3534	3564	3595	3625
5	3292	3323	3351	3382	3412	3443	3473	3504	3535	3565	3596	3626
6	3293	3324	3352	3383	3413	3444	3474	3505	3536	3566	3597	3627
7	3294	3325	3353	3384	3414	3445	3475	3506	3537	3567	3598	3628
8	3295	3326	3354	3385	3415	3446	3476	3507	3538	3568	3599	3629
9	3296	3327	3355	3386	3416	3447	3477	3508	3539	3569	3600	3630
10	3297	3328	3356	3387	3417	3448	3478	3509	3540	3570	3601	3631
11	3298	3329	3357	3388	3418	3449	3479	3510	3541	3571	3602	3632
12	3299	3330	3358	3389	3419	3450	3480	3511	3542	3572	3603	3633
13	3300	3331	3359	3390	3420	3451	3481	3512	3543	3573	3604	3634
14	3301	3332	3360	3391	3421	3452	3482	3513	3544	3574	3605	3635
15	3302	3333	3361	3392	3422	3453	3483	3514	3545	3575	3606	3636
16	3303	3334	3362	3393	3423	3454	3484	3515	3546	3576	3607	3637
17	3304	3335	3363	3394	3424	3455	3485	3516	3547	3577	3608	3638
18	3305	3336	3364	3395	3425	3456	3486	3517	3548	3578	3609	3639
19	3306	3337	3365	3396	3426	3457	3487	3518	3549	3579	3610	3640
20	3307	3338	3366	3397	3427	3458	3488	3519	3550	3580	3611	3641
21	3308	3339	3367	3398	3428	3459	3489	3520	3551	3581	3612	3642
22	3309	3340	3368	3399	3429	3460	3490	3521	3552	3582	3613	3643
23	3310	3341	3369	3400	3430	3461	3491	3522	3553	3583	3614	3644
24	3311	3342	3370	3401	3431	3462	3492	3523	3554	3584	3615	3645
25	3312	3343	3371	3402	3432	3463	3493	3524	3555	3585	3616	3646
26	3313	3344	3372	3403	3433	3464	3494	3525	3556	3586	3617	3647
27	3314	3345	3373	3404	3434	3465	3495	3526	3557	3587	3618	3648
28	3315	3346	3374	3405	3435	3466	3496	3527	3558	3588	3619	3649
29	3316		3375	3406	3436	3467	3497	3528	3559	3589	3620	3650
30	3317		3376	3407	3437	3468	3498	3529	3560	3590	3621	3651
31	3318		3377		3438		3499	3530		3591		3652
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

FIVE-DAY WEEK NUMERIC CALENDAR 1965

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1	22	42	65	Sat	108	130	Sun	174	196	217	239
2	Sat	23	43	66	Sun	109	131	152	175	Sat	218	240
3	Sun	24	44	Sat	87	110	Sat	153	176	Sun	219	241
4	2	25	45	Sun	88	111	Sun	154	Sat	197	220	Sat
5	3	26	46	67	89	Sat	132	155	Sun	198	221	Sun
6	4	Sat	Sat	68	90	Sun	133	156	177	199	Sat	242
7	5	Sun	Sun	69	91	112	134	Sat	178	200	Sun	243
8	6	27	47	70	Sat	113	135	Sun	179	201	222	244
9	Sat	28	48	71	Sun	114	136	157	180	Sat	223	245
10	Sun	29	49	Sat	92	115	Sat	158	181	Sun	224	246
11	7	30	50	Sun	93	116	Sun	159	Sat	202	225	Sat
12	8	31	51	72	94	Sat	137	160	Sun	203	226	Sun
13	9	Sat	Sat	73	95	Sun	138	161	182	204	Sat	247
14	10	Sun	Sun	74	96	117	139	Sat	183	205	Sun	248
15	11	32	52	75	Sat	118	140	Sun	184	206	227	249
16	Sat	33	53	76	Sun	119	141	162	185	Sat	228	250
17	Sun	34	54	Sat	97	120	Sat	163	186	Sun	229	251
18	12	35	55	Sun	98	121	Sun	164	Sat	207	230	Sat
19	13	36	56	77	99	Sat	142	165	Sun	208	231	Sun
20	14	Sat	Sat	78	100	Sun	143	166	187	209	Sat	252
21	15	Sun	Sun	79	101	122	144	Sat	188	210	Sun	253
22	16	37	57	80	Sat	123	145	Sun	189	211	232	254
23	Sat	38	58	81	Sun	124	146	167	190	Sat	233	255
24	Sun	39	59	Sat	102	125	Sat	168	191	Sun	234	256
25	17	40	60	Sun	103	126	Sun	169	Sat	212	235	Sat
26	18	41	61	82	104	Sat	147	170	Sun	213	236	Sun
27	19	Sat	Sat	83	105	Sun	148	171	192	214	Sat	257
28	20	Sun	Sun	84	106	127	149	Sat	193	215	Sun	258
29	21		62	85	Sat	128	150	Sun	194	216	237	259
30	Sat		63	86	Sun	129	151	172	195	Sat	238	260
31	Sun		64		107		Sat	173		Sun		261
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

SPINST P5000.11
25 October 1965

SPECIAL PROJECTS OFFICE

FIVE-DAY WEEK NUMERIC CALENDAR 1966

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Sat	283	303	326	Sun	369	391	412	435	Sat	478	500
2	Sun	284	304	Sat	347	370	Sat	413	436	Sun	479	501
3	262	285	305	Sun	348	371	Sun	414	Sat	457	480	Sat
4	263	286	306	327	349	Sat	392	415	Sun	458	481	Sun
5	264	Sat	Sat	328	350	Sun	393	416	437	459	Sat	502
6	265	Sun	Sun	329	351	372	394	Sat	438	460	Sun	503
7	266	287	307	330	Sat	373	395	Sun	439	461	482	504
8	Sat	288	308	331	Sun	374	396	417	440	Sat	483	505
9	Sun	289	309	Sat	352	375	Sat	418	441	Sun	484	506
10	267	290	310	Sun	353	376	Sun	419	Sat	462	485	Sat
11	268	291	311	332	354	Sat	397	420	Sun	463	486	Sun
12	269	Sat	Sat	333	355	Sun	398	421	442	464	Sat	507
13	270	Sun	Sun	334	356	377	399	Sat	443	465	Sun	508
14	271	292	312	335	Sat	378	400	Sun	444	466	487	509
15	Sat	293	313	336	Sun	379	401	422	445	Sat	488	510
16	Sun	294	314	Sat	357	380	Sat	423	446	Sun	489	511
17	272	295	315	Sun	358	381	Sun	424	Sat	467	490	Sat
18	273	296	316	337	359	Sat	402	425	Sun	468	491	Sun
19	274	Sat	Sat	338	360	Sun	403	426	447	469	Sat	512
20	275	Sun	Sun	339	361	382	404	Sat	448	470	Sun	513
21	276	297	317	340	Sat	383	405	Sun	449	471	492	514
22	Sat	298	318	341	Sun	384	406	427	450	Sat	493	515
23	Sun	299	319	Sat	362	385	Sat	428	451	Sun	494	516
24	277	300	320	Sun	363	386	Sun	429	Sat	472	495	Sat
25	278	301	321	342	364	Sat	407	430	Sun	473	496	Sun
26	279	Sat	Sat	343	365	Sun	408	431	452	474	Sat	517
27	280	Sun	Sun	344	366	387	409	Sat	453	475	Sun	518
28	281	302	322	345	Sat	388	410	Sun	454	476	497	519
29	Sat		323	346	Sun	389	411	432	455	Sat	498	520
30	Sun		324	Sat	367	390	Sat	433	456	Sun	499	521
31	282		325		368		Sun	434		477		Sat
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

SPECIAL PROJECTS OFFICE

SPINST P5000.11
25 October 1965

FIVE-DAY WEEK

NUMERIC CALENDAR

1967

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Sun	544	564	Sat	607	630	Sat	673	696	Sun	739	761
2	522	545	565	Sun	608	631	Sun	674	Sat	717	740	Sat
3	523	546	566	587	609	Sat	652	675	Sun	718	741	Sun
4	524	Sat	Sat	588	610	Sun	653	676	697	719	Sat	762
5	525	Sun	Sun	589	611	632	654	Sat	698	720	Sun	763
6	526	547	567	590	Sat	633	655	Sun	699	721	742	764
7	Sat	548	568	591	Sun	634	656	677	700	Sat	743	765
8	Sun	549	569	Sat	612	635	Sat	678	701	Sun	744	766
9	527	550	570	Sun	613	636	Sun	679	Sat	722	745	Sat
10	528	551	571	592	614	Sat	657	680	Sun	723	746	Sun
11	529	Sat	Sat	593	615	Sun	658	681	702	724	Sat	767
12	530	Sun	Sun	594	616	637	659	Sat	703	725	Sun	768
13	531	552	572	595	Sat	638	660	Sun	704	726	747	769
14	Sat	553	573	596	Sun	639	661	682	705	Sat	748	770
15	Sun	554	574	Sat	617	640	Sat	683	706	Sun	749	771
16	532	555	575	Sun	618	641	Sun	684	Sat	727	750	Sat
17	533	556	576	597	619	Sat	662	685	Sun	728	751	Sun
18	534	Sat	Sat	598	620	Sun	663	686	707	729	Sat	772
19	535	Sun	Sun	599	621	642	664	Sat	708	730	Sun	773
20	536	557	577	600	Sat	643	665	Sun	709	731	752	774
21	Sat	558	578	601	Sun	644	666	687	710	Sat	753	775
22	Sun	559	579	Sat	622	645	Sat	688	711	Sun	754	776
23	537	560	580	Sun	623	646	Sun	689	Sat	732	755	Sat
24	538	561	581	602	624	Sat	667	690	Sun	733	756	Sun
25	539	Sat	Sat	603	625	Sun	668	691	712	734	Sat	777
26	540	Sun	Sun	604	626	647	669	Sat	713	735	Sun	778
27	541	562	582	605	Sat	648	670	Sun	714	736	757	779
28	Sat	563	583	606	Sun	649	671	692	715	Sat	758	780
29	Sun		584	Sat	627	650	Sat	693	716	Sun	759	781
30	542		585	Sun	628	651	Sun	694	Sat	737	760	Sat
31	543		586		629		672	695		738		Sun
	JAN	[illegible]	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

FIVE-DAY WEEK NUMERIC CALENDAR 1968

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	782	805	826	847	869	Sat	912	935	Sun	978	1001	Sun
2	783	806	Sat	848	870	Sun	913	936	957	979	Sat	1022
3	784	Sat	Sun	849	871	892	914	Sat	958	980	Sun	1023
4	785	Sun	827	850	Sat	893	915	Sun	959	981	1002	1024
5	786	807	828	851	Sun	894	916	937	960	Sat	1003	1025
6	Sat	808	829	Sat	872	895	Sat	938	961	Sun	1004	1026
7	Sun	809	830	Sun	873	896	Sun	939	Sat	982	1005	Sat
8	787	810	831	852	874	Sat	917	940	Sun	983	1006	Sun
9	788	811	Sat	853	875	Sun	918	941	962	984	Sat	1027
10	789	Sat	Sun	854	876	897	919	Sat	963	985	Sun	1028
11	790	Sun	832	855	Sat	898	920	Sun	964	986	1007	1029
12	791	812	833	856	Sun	899	921	942	965	Sat	1008	1030
13	Sat	813	834	Sat	877	900	Sat	943	966	Sun	1009	1031
14	Sun	814	835	Sun	878	901	Sun	944	Sat	987	1010	Sat
15	792	815	836	857	879	Sat	922	945	Sun	988	1011	Sun
16	793	816	Sat	858	880	Sun	923	946	967	989	Sat	1032
17	794	Sat	Sun	859	881	902	924	Sat	968	990	Sun	1033
18	795	Sun	837	860	Sat	903	925	Sun	969	991	1012	1034
19	796	817	838	861	Sun	904	926	947	970	Sat	1013	1035
20	Sat	818	839	Sat	882	905	Sat	948	971	Sun	1014	1036
21	Sun	819	840	Sun	883	906	Sun	949	Sat	992	1015	Sat
22	797	820	841	862	884	Sat	927	950	Sun	993	1016	Sun
23	798	821	Sat	863	885	Sun	928	951	972	994	Sat	1037
24	799	Sat	Sun	864	886	907	929	Sat	973	995	Sun	1038
25	800	Sun	842	865	Sat	908	930	Sun	974	996	1017	1039
26	801	822	843	866	Sun	909	931	952	975	Sat	1018	1040
27	Sat	823	844	Sat	887	910	Sat	953	976	Sun	1019	1041
28	Sun	824	845	Sun	888	911	Sun	954	Sat	997	1020	Sat
29	802	825	846	867	889	Sat	932	955	Sun	998	1021	Sun
30	803		Sat	868	890	Sun	933	956	977	999	Sat	1042
31	804		Sun		891		934	Sat		1000		1043
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

FIVE-DAY WEEK NUMERIC CALENDAR 1969

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1044	Sat	Sat	1108	1130	Sun	1173	1196	1217	1239	Sat	1282
2	1045	Sun	Sun	1109	1131	1152	1174	Sat	1218	1240	Sun	1283
3	1046	1067	1087	1110	Sat	1153	1175	Sun	1219	1241	1262	1284
4	Sat	1068	1088	1111	Sun	1154	1176	1197	1220	Sat	1263	1285
5	Sun	1069	1089	Sat	1132	1155	Sat	1198	1221	Sun	1264	1286
6	1047	1070	1090	Sun	1133	1156	Sun	1199	Sat	1242	1265	Sat
7	1048	1071	1091	1112	1134	Sat	1177	1200	Sun	1243	1266	Sun
8	1049	Sat	Sat	1113	1135	Sun	1178	1201	1222	1244	Sat	1287
9	1050	Sun	Sun	1114	1136	1157	1179	Sat	1223	1245	Sun	1288
10	1051	1072	1092	1115	Sat	1158	1180	Sun	1224	1246	1267	1289
11	Sat	1073	1093	1116	Sun	1159	1181	1202	1225	Sat	1268	1290
12	Sun	1074	1094	Sat	1137	1160	Sat	1203	1226	Sun	1269	1291
13	1052	1075	1095	Sun	1138	1161	Sun	1204	Sat	1247	1270	Sat
14	1053	1076	1096	1117	1139	Sat	1182	1205	Sun	1248	1271	Sun
15	1054	Sat	Sat	1118	1140	Sun	1183	1206	1227	1249	Sat	1292
16	1055	Sun	Sun	1119	1141	1162	1184	Sat	1228	1250	Sun	1293
17	1056	1077	1097	1120	Sat	1163	1185	Sun	1229	1251	1272	1294
18	Sat	1078	1098	1121	Sun	1164	1186	1207	1230	Sat	1273	1295
19	Sun	1079	1099	Sat	1142	1165	Sat	1208	1231	Sun	1274	1296
20	1057	1080	1100	Sun	1143	1166	Sun	1209	Sat	1252	1275	Sat
21	1058	1081	1101	1122	1144	Sat	1187	1210	Sun	1253	1276	Sun
22	1059	Sat	Sat	1123	1145	Sun	1188	1211	1232	1254	Sat	1297
23	1060	Sun	Sun	1124	1146	1167	1189	Sat	1233	1255	Sun	1298
24	1061	1082	1102	1125	Sat	1168	1190	Sun	1234	1256	1277	1299
25	Sat	1083	1103	1126	Sun	1169	1191	1212	1235	Sat	1278	1300
26	Sun	1084	1104	Sat	1147	1170	Sat	1213	1236	Sun	1279	1301
27	1062	1085	1105	Sun	1148	1171	Sun	1214	Sat	1257	1280	Sat
28	1063	1086	1106	1127	1149	Sat	1192	1215	Sun	1258	1281	Sun
29	1064		Sat	1128	1150	Sun	1193	1216	1237	1259	Sat	1302
30	1065		Sun	1129	1151	1172	1194	Sat	1238	1260	Sun	1303
31	1066				Sat		1195	Sun		1261		1304
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

FIVE-DAY WEEK

NUMERIC CALENDAR

1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1305	Sun	Sun	1369	1391	1412	1434	Sat	1478	1500	Sun	1543
2	1306	1327	1347	1370	Sat	1413	1435	Sun	1479	1501	1522	1544
3	Sat	1328	1348	1371	Sun	1414	1436	1457	1480	Sat	1523	1545
4	Sun	1329	1349	Sat	1392	1415	Sat	1458	1481	Sun	1524	1546
5	1307	1330	1350	Sun	1393	1416	Sun	1459	Sat	1502	1525	Sat
6	1308	1331	1351	1372	1394	Sat	1437	1460	Sun	1503	1526	Sun
7	1309	Sat	Sat	1373	1395	Sun	1438	1461	1482	1504	Sat	1547
8	1310	Sun	Sun	1374	1396	1417	1439	Sat	1483	1505	Sun	1548
9	1311	1332	1352	1375	Sat	1418	1440	Sun	1484	1506	1527	1549
10	Sat	1333	1353	1376	Sun	1419	1441	1462	1485	Sat	1528	1550
11	Sun	1334	1354	Sat	1397	1420	Sat	1463	1486	Sun	1529	1551
12	1312	1335	1355	Sun	1398	1421	Sun	1464	Sat	1507	1530	Sat
13	1313	1336	1356	1377	1399	Sat	1442	1465	Sun	1508	1531	Sun
14	1314	Sat	Sat	1378	1400	Sun	1443	1466	1487	1509	Sat	1552
15	1315	Sun	Sun	1379	1401	1422	1444	Sat	1488	1510	Sun	1553
16	1316	1337	1357	1380	Sat	1423	1445	Sun	1489	1511	1532	1554
17	Sat	1338	1358	1381	Sun	1424	1446	1467	1490	Sat	1533	1555
18	Sun	1339	1359	Sat	1402	1425	Sat	1468	1491	Sun	1534	1556
19	1317	1340	1360	Sun	1403	1426	Sun	1469	Sat	1512	1535	Sat
20	1318	1341	1361	1382	1404	Sat	1447	1470	Sun	1513	1536	Sun
21	1319	Sat	Sat	1383	1405	Sun	1448	1471	1492	1514	Sat	1557
22	1320	Sun	Sun	1384	1406	1427	1449	Sat	1493	1515	Sun	1558
23	1321	1342	1362	1385	Sat	1428	1450	Sun	1494	1516	1537	1559
24	Sat	1343	1363	1386	Sun	1429	1451	1472	1495	Sat	1538	1560
25	Sun	1344	1364	Sat	1407	1430	Sat	1473	1496	Sun	1539	1561
26	1322	1345	1365	Sun	1408	1431	Sun	1474	Sat	1517	1540	Sat
27	1323	1346	1366	1387	1409	Sat	1452	1475	Sun	1518	1541	Sun
28	1324	Sat	Sat	1388	1410	Sun	1453	1476	1497	1519	Sat	1562
29	1325		Sun	1389	1411	1432	1454	Sat	1498	1520	Sun	1563
30	1326		1367	1390	Sat	1433	1455	Sun	1499	1521	1542	1564
31	Sat		1368		Sun		1456	1477		Sat		1565
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

SPECIAL PROJECTS OFFICE

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FIVE-DAY WEEK

NUMERIC CALENDAR 1971

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1566	1587	1607	1630	Sat	1673	1695	1717	1739	1761	1782	1804
2	Sat	1588	1608	1631	Sun	1674	1696	1718	1740	Sat	1783	1805
3	Sun	1589	1609	Sat	1652	1675	Sat	1719	1741	Sun	1784	1806
4	1567	1590	1610	Sun	1653	1676	Sun	1720	Sat	1762	1785	Sat
5	1568	1591	1611	1632	1654	Sat	1697	1721	Sun	1763	1786	Sun
6	1569	Sat	Sat	1633	1655	Sun	1698	Sat	1742	1764	Sat	1807
7	1570	Sun	Sun	1634	1656	1677	1699	Sun	1743	1765	Sun	1808
8	1571	1592	1612	1635	Sat	1678	1700	1722	1744	1766	1787	1809
9	Sat	1593	1613	1636	Sun	1679	1701	1723	1745	Sat	1788	1810
10	Sun	1594	1614	Sat	1657	1680	Sat	1724	1746	Sun	1789	1811
11	1572	1595	1615	Sun	1658	1681	Sun	1725	Sat	1767	1790	Sat
12	1573	1596	1616	1637	1659	Sat	1702	1726	Sun	1768	1791	Sun
13	1574	Sat	Sat	1638	1660	Sun	1703	Sat	1747	1769	Sat	1812
14	1575	Sun	Sun	1639	1661	1682	1704	Sun	1748	1770	Sun	1813
15	1576	1597	1617	1640	Sat	1683	1705	1727	1749	1771	1792	1814
16	Sat	1598	1618	1641	Sun	1684	1706	1728	1750	Sat	1793	1815
17	Sun	1599	1619	Sat	1662	1685	Sat	1729	1751	Sun	1794	1816
18	1577	1600	1620	Sun	1663	1686	Sun	1730	Sat	1772	1795	Sat
19	1578	1601	1621	1642	1664	Sat	1707	1731	Sun	1773	1796	Sun
20	1579	Sat	Sat	1643	1665	Sun	1708	Sat	1752	1774	Sat	1817
21	1580	Sun	Sun	1644	1666	1687	1709	Sun	1753	1775	Sun	1818
22	1581	1602	1622	1645	Sat	1688	1710	1732	1754	1776	1797	1819
23	Sat	1603	1623	1646	Sun	1689	1711	1733	1755	Sat	1798	1820
24	Sun	1604	1624	Sat	1667	1690	Sat	1734	1756	Sun	1799	1821
25	1582	1605	1625	Sun	1668	1691	Sun	1735	Sat	1777	1800	Sat
26	1583	1606	1626	1647	1669	Sat	1712	1736	Sun	1778	1801	Sun
27	1584	Sat	Sat	1648	1670	Sun	1713	Sat	1757	1779	Sat	1822
28	1585	Sun	Sun	1649	1671	1692	1714	Sun	1758	1780	Sun	1823
29	1586		1627	1650	Sat	1693	1715	1737	1759	1781	1802	1824
30	Sat		1628	1651	Sun	1694	1716	1738	1760	Sat	1803	1825
31	Sun		1629		1672		Sat			Sun		1826
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

FIVE-DAY WEEK NUMERIC CALENDAR 1972

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Sat	1848	1869	Sat	1912	1935	Sat	1978	2001	Sun	2044	2066
2	Sun	1849	1870	Sun	1913	1936	Sun	1979	Sat	2022	2045	Sat
3	1827	1850	1871	1892	1914	Sat	1957	1980	Sun	2023	2046	Sun
4	1828	1851	Sat	1893	1915	Sun	1958	1981	2002	2024	Sat	2067
5	1829	Sat	Sun	1894	1916	1937	1959	Sat	2003	2025	Sun	2068
6	1830	Sun	1872	1895	Sat	1938	1960	Sun	2004	2026	2047	2069
7	1831	1852	1873	1896	Sun	1939	1961	1982	2005	Sat	2048	2070
8	Sat	1853	1874	Sat	1917	1940	Sat	1983	2006	Sun	2049	2071
9	Sun	1854	1875	Sun	1918	1941	Sun	1984	Sat	2027	2050	Sat
10	1832	1855	1876	1897	1919	Sat	1962	1985	Sun	2028	2051	Sun
11	1833	1856	Sat	1898	1920	Sun	1963	1986	2007	2029	Sat	2072
12	1834	Sat	Sun	1899	1921	1942	1964	Sat	2008	2030	Sun	2073
13	1835	Sun	1877	1900	Sat	1943	1965	Sun	2009	2031	2052	2074
14	1836	1857	1878	1901	Sun	1944	1966	1987	2010	Sat	2053	2075
15	Sat	1858	1879	Sat	1922	1945	Sat	1988	2011	Sun	2054	2076
16	Sun	1859	1880	Sun	1923	1946	Sun	1989	Sat	2032	2055	Sat
17	1837	1860	1881	1902	1924	Sat	1967	1990	Sun	2033	2056	Sun
18	1838	1861	Sat	1903	1925	Sun	1968	1991	2012	2034	Sat	2077
19	1839	Sat	Sun	1904	1926	1947	1969	Sat	2013	2035	Sun	2078
20	1840	Sun	1882	1905	Sat	1948	1970	Sun	2014	2036	2057	2079
21	1841	1862	1883	1906	Sun	1949	1971	1992	2015	Sat	2058	2080
22	Sat	1863	1884	Sat	1927	1950	Sat	1993	2016	Sun	2059	2081
23	Sun	1864	1885	Sun	1928	1951	Sun	1994	Sat	2037	2060	Sat
24	1842	1865	1886	1907	1929	Sat	1972	1995	Sun	2038	2061	Sun
25	1843	1866	Sat	1908	1930	Sun	1973	1996	2017	2039	Sat	2082
26	1844	Sat	Sun	1909	1931	1952	1974	Sat	2018	2040	Sun	2083
27	1845	Sun	1887	1910	Sat	1953	1975	Sun	2019	2041	2062	2084
28	1846	1867	1888	1911	Sun	1954	1976	1997	2020	Sat	2063	2085
29	Sat	1868	1889	Sat	1932	1955	Sat	1998	2021	Sun	2064	2086
30	Sun		1890	Sun	1933	1956	Sun	1999	Sat	2042	2065	Sat
31	1847		1891		1934		1977	2000		2043		Sun
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

FIVE-DAY WEEK NUMERIC CALENDAR 1973

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2087	2110	2130	Sun	2173	2196	Sun	2239	Sat	2282	2305	Sat
2	2088	2111	2131	2152	2174	Sat	2217	2240	Sun	2283	2306	Sun
3	2089	Sat	Sat	2153	2175	Sun	2218	2241	2262	2284	Sat	2327
4	2090	Sun	Sun	2154	2176	2197	2219	Sat	2263	2285	Sun	2328
5	2091	2112	2132	2155	Sat	2198	2220	Sun	2264	2286	2307	2329
6	Sat	2113	2133	2156	Sun	2199	2221	2242	2265	Sat	2308	2330
7	Sun	2114	2134	Sat	2177	2200	Sat	2243	2266	Sun	2309	2331
8	2092	2115	2135	Sun	2178	2201	Sun	2244	Sat	2287	2310	Sat
9	2093	2116	2136	2157	2179	Sat	2222	2245	Sun	2288	2311	Sun
10	2094	Sat	Sat	2158	2180	Sun	2223	2246	2267	2289	Sat	2332
11	2095	Sun	Sun	2159	2181	2202	2224	Sat	2268	2290	Sun	2333
12	2096	2117	2137	2160	Sat	2203	2225	Sun	2269	2291	2312	2334
13	Sat	2118	2138	2161	Sun	2204	2226	2247	2270	Sat	2313	2335
14	Sun	2119	2139	Sat	2182	2205	Sat	2248	2271	Sun	2314	2336
15	2097	2120	2140	Sun	2183	2206	Sun	2249	Sat	2292	2315	Sat
16	2098	2121	2141	2162	2184	Sat	2227	2250	Sun	2293	2316	Sun
17	2099	Sat	Sat	2163	2185	Sun	2228	2251	2272	2294	Sat	2337
18	2100	Sun	Sun	2164	2186	2207	2229	Sat	2273	2295	Sun	2338
19	2101	2122	2142	2165	Sat	2208	2230	Sun	2274	2296	2317	2339
20	Sat	2123	2143	2166	Sun	2209	2231	2252	2275	Sat	2318	2340
21	Sun	2124	2144	Sat	2187	2210	Sat	2253	2276	Sun	2319	2341
22	2102	2125	2145	Sun	2188	2211	Sun	2254	Sat	2297	2320	Sat
23	2103	2126	2146	2167	2189	Sat	2232	2255	Sun	2298	2321	Sun
24	2104	Sat	Sat	2168	2190	Sun	2233	2256	2277	2299	Sat	2342
25	2105	Sun	Sun	2169	2191	2212	2234	Sat	2278	2300	Sun	2343
26	2106	2127	2147	2170	Sat	2213	2235	Sun	2279	2301	2322	2344
27	Sat	2128	2148	2171	Sun	2214	2236	2257	2280	Sat	2323	2345
28	Sun	2129	2149	Sat	2192	2215	Sat	2258	2281	Sun	2324	2346
29	2107		2150	Sun	2193	2216	Sun	2259	Sat	2302	2325	Sat
30	2108		2151	2172	2194	Sat	2237	2260	Sun	2303	2326	Sun
31	2109		Sat		2195		2238	2261		2304		2347

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

FIVE-DAY WEEK NUMERIC CALENDAR 1974

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2348	2371	2391	2412	2434	Sat	2477	2500	Sun	2543	2566	Sun
2	2349	Sat	Sat	2413	2435	Sun	2478	2501	2522	2544	Sat	2587
3	2350	Sun	Sun	2414	2436	2457	2479	Sat	2523	2545	Sun	2588
4	2351	2372	2392	2415	Sat	2458	2480	Sun	2524	2546	2567	2589
5	Sat	2373	2393	2416	Sun	2459	2481	2502	2525	Sat	2568	2590
6	Sun	2374	2394	Sat	2437	2460	Sat	2503	2526	Sun	2569	2591
7	2352	2375	2395	Sun	2438	2461	Sun	2504	Sat	2547	2570	Sat
8	2353	2376	2396	2417	2439	Sat	2482	2505	Sun	2548	2571	Sun
9	2354	Sat	Sat	2418	2440	Sun	2483	2506	2527	2549	Sat	2592
10	2355	Sun	Sun	2419	2441	2462	2484	Sat	2528	2550	Sun	2593
11	2356	2377	2397	2420	Sat	2463	2485	Sun	2529	2551	2572	2594
12	Sat	2378	2398	2421	Sun	2464	2486	2507	2530	Sat	2573	2595
13	Sun	2379	2399	Sat	2442	2465	Sat	2508	2531	Sun	2574	2596
14	2357	2380	2400	Sun	2443	2466	Sun	2509	Sat	2552	2575	Sat
15	2358	2381	2401	2422	2444	Sat	2487	2510	Sun	2553	2576	Sun
16	2359	Sat	Sat	2423	2445	Sun	2488	2511	2532	2554	Sat	2597
17	2360	Sun	Sun	2424	2446	2467	2489	Sat	2533	2555	Sun	2598
18	2361	2382	2402	2425	Sat	2468	2490	Sun	2534	2556	2577	2599
19	Sat	2383	2403	2426	Sun	2469	2491	2512	2535	Sat	2578	2600
20	Sun	2384	2404	Sat	2447	2470	Sat	2513	2536	Sun	2579	2601
21	2362	2385	2405	Sun	2448	2471	Sun	2514	Sat	2557	2580	Sat
22	2363	2386	2406	2427	2449	Sat	2492	2515	Sun	2558	2581	Sun
23	2364	Sat	Sat	2428	2450	Sun	2493	2516	2537	2559	Sat	2602
24	2365	Sun	Sun	2429	2451	2472	2494	Sat	2538	2560	Sun	2603
25	2366	2387	2407	2430	Sat	2473	2495	Sun	2539	2561	2582	2604
26	Sat	2388	2408	2431	Sun	2474	2496	2517	2540	Sat	2583	2605
27	Sun	2389	2409	Sat	2452	2475	Sat	2518	2541	Sun	2584	2606
28	2367	2390	2410	Sun	2453	2476	Sun	2519	Sat	2562	2585	Sat
29	2368		2411	2432	2454	Sat	2497	2520	Sun	2563	2586	Sun
30	2369		Sat	2433	2455	Sun	2498	2521	2542	2564	Sat	2607
31	2370		Sun		2456		2499	Sat		2565		2608
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1965

JAN

Day	We	Bi
1	1	
8	2	1
15	3	
22	4	2
29	5	

FEB

Day	We	Bi
5	6	3
12	7	
19	8	4
26	9	

MAR

Day	We	Bi
5	10	5
12	11	
19	12	6
26	13	

APR

Day	We	Bi
2	14	7
9	15	
16	16	8
23	17	
30	18	9

MAY

Day	We	Bi
7	19	
14	20	10
21	21	
28	22	11

JUN

Day	We	Bi
4	23	
11	24	12
18	25	
25	26	13

JUL

Day	We	Bi
2	27	
9	28	14
16	29	
23	30	15
30	31	

AUG

Day	We	Bi
6	32	16
13	33	
20	34	17
27	35	

SEP

Day	We	Bi
3	36	18
10	37	
17	38	19
24	39	

OCT

Day	We	Bi
1	40	20
8	41	
15	42	21
22	43	
29	44	22

NOV

Day	We	Bi
5	45	
12	46	23
19	47	
26	48	24

DEC

Day	We	Bi
3	49	
10	50	25
17	51	
24	52	26
31	53	

"Day" indicates normal date of the Friday on which each weekly or bi-weekly period ends. "We" is the Julian number of the weekly interval, and "Bi" is the Julian number of the bi-weekly interval.

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1966

JAN

Day	We	Bi
7	54	27
14	55	
21	56	28
28	57	

FEB

Day	We	Bi
4	58	29
11	59	
18	60	30
26	61	

MAR

Day	We	Bi
4	62	31
11	63	
18	64	32
26	65	

APR

Day	We	Bi
1	66	33
8	67	
15	68	34
22	69	
29	70	35

MAY

Day	We	Bi
6	71	
13	72	36
20	73	
27	74	37

JUN

Day	We	Bi
3	75	
10	76	38
17	77	
24	78	39

JUL

Day	We	Bi
1	79	
8	80	40
15	81	
22	82	41
29	83	

AUG

Day	We	Bi
5	84	42
12	85	
19	86	43
26	87	

SEP

Day	We	Bi
2	88	44
9	89	
16	90	45
23	91	
30	92	46

OCT

Day	We	Bi
7	93	
14	94	47
21	95	
28	96	48

NOV

Day	We	Bi
4	97	
11	98	49
18	99	
25	100	50

DEC

Day	We	Bi
2	101	
9	102	51
16	103	
23	104	52
30	105	

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1967

JAN

Day	We	Bi
6	106	53
13	107	
20	108	54
27	109	

FEB

Day	We	Bi
3	110	55
10	111	
17	112	56
24	113	

MAR

Day	We	Bi
3	114	57
10	115	
17	116	58
24	117	
31	118	59

APR

Day	We	Bi
7	119	
14	120	60
21	121	
28	122	61

MAY

Day	We	Bi
5	123	
12	124	62
19	125	
26	126	63

JUN

Day	We	Bi
2	127	
9	128	64
16	129	
23	130	65
30	131	

JUL

Day	We	Bi
7	132	66
14	133	
21	134	67
28	135	

AUG

Day	We	Bi
4	136	68
11	137	
18	138	69
25	139	

SEP

Day	We	Bi
1	140	70
8	141	
15	142	71
22	143	
29	144	72

OCT

Day	We	Bi
6	145	
13	146	73
20	147	
27	148	74

NOV

Day	We	Bi
3	149	75
10	150	
17	151	76
24	152	

DEC

Day	We	Bi
1	153	77
8	154	
15	155	78
22	156	
29	157	79

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1968

JAN

Day	We	Bi
5	158	
12	159	80
19	160	
26	161	81

FEB

Day	We	Bi
2	162	
9	163	82
16	164	
23	165	83

MAR

Day	We	Bi
1	166	
8	167	84
15	168	
22	169	85
29	170	

APR

Day	We	Bi
5	171	86
12	172	
19	173	87
26	174	

MAY

Day	We	Bi
3	175	88
10	176	
17	177	89
24	178	
31	179	90

JUN

Day	We	Bi
7	180	
14	181	91
21	182	
28	183	92

JUL

Day	We	Bi
5	184	
12	185	93
19	186	
26	187	94

AUG

Day	We	Bi
2	188	
9	189	85
16	190	
23	191	96
30	192	

SEP

Day	We	Bi
6	193	97
13	194	
20	195	98
27	196	

OCT

Day	We	Bi
4	197	99
11	198	
18	199	100
25	200	

NOV

Day	We	Bi
1	201	101
8	202	
15	203	102
22	204	
29	205	103

DEC

Day	We	Bi
6	206	
13	207	104
20	208	
27	209	105

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1969

JAN

Day	We	Bi
3	210	
10	211	106
17	212	
24	213	107
31	214	

FEB

Day	We	Bi
7	215	108
14	216	
21	217	109
28	218	

MAR

Day	We	Bi
3	219	110
10	220	
17	221	111
24	222	
31	223	112

APR

Day	We	Bi
4	224	
11	225	113
18	226	
25	227	114

MAY

Day	We	Bi
2	228	
9	229	115
16	230	
23	231	116
30	232	

JUN

Day	We	Bi
6	233	117
13	234	
20	235	118
27	236	

JUL

Day	We	Bi
4	237	119
11	238	
18	239	120
25	240	

AUG

Day	We	Bi
1	241	121
8	242	
15	243	122
22	244	
29	245	123

SEP

Day	We	Bi
5	246	
12	247	124
19	248	
26	249	125

OCT

Day	We	Bi
3	250	
10	251	126
17	252	
24	253	127
31	254	

NOV

Day	We	Bi
7	255	128
14	256	
21	257	129
28	258	

DEC

Day	We	Bi
5	259	130
12	260	
19	261	131
26	262	

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1970

JAN

Day	We	Bi
2	263	132
9	264	
16	265	133
23	266	
30	267	134

FEB

Day	We	Bi
6	268	
13	269	135
20	270	
27	271	136

MAR

Day	We	Bi
6	272	
13	273	137
20	274	
27	275	138

APR

Day	We	Bi
3	276	
10	277	139
17	278	
24	279	140

MAY

Day	We	Bi
1	280	
8	281	141
15	282	
22	283	142
29	284	

JUN

Day	We	Bi
5	285	143
12	286	
19	287	144
26	288	

JUL

Day	We	Bi
3	289	145
10	290	
17	291	146
24	292	
31	293	147

AUG

Day	We	Bi
7	294	
14	295	148
21	296	
28	297	149

SEP

Day	We	Bi
4	298	
11	299	150
18	300	
25	301	151

OCT

Day	We	Bi
2	302	
9	303	152
16	304	
23	305	153
30	306	

NOV

Day	We	Bi
6	307	154
13	308	
20	309	155
27	310	

DEC

Day	We	Bi
4	311	156
11	312	
18	313	157
25	314	

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1971

JAN

Day	We	Bi
1	315	158
8	316	
15	317	159
22	318	
29	319	160

FEB

Day	We	Bi
5	320	
12	321	161
19	322	
26	323	162

MAR

Day	We	Bi
5	324	
12	325	163
19	326	
26	327	164

APR

Day	We	Bi
2	328	
9	329	165
16	330	
23	331	166
30	332	

MAY

Day	We	Bi
7	333	167
14	334	
21	335	168
28	336	

JUN

Day	We	Bi
4	337	169
11	338	
18	339	170
25	340	

JUL

Day	We	Bi
2	341	171
9	342	
16	343	172
23	344	
30	345	173

AUG

Day	We	Bi
6	346	
13	347	174
20	348	
27	349	175

SEP

Day	We	Bi
3	350	
10	351	176
17	352	
24	353	177

OCT

Day	We	Bi
1	354	
8	355	178
15	356	
22	357	179
29	348	

NOV

Day	We	Bi
5	359	180
12	360	
19	361	181
26	362	

DEC

Day	We	Bi
3	363	182
10	364	
17	365	183
24	366	
31	367	184

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1972

JAN

Day	We	Bi
7	368	
14	369	185
21	370	
28	371	186

FEB

Day	We	Bi
4	372	
11	373	187
18	374	
25	375	188

MAR

Day	We	Bi
3	376	
10	377	189
17	378	
24	379	190
31	380	

APR

Day	We	Bi
7	381	191
14	382	
21	383	192
28	384	

MAY

Day	We	Bi
5	385	193
12	386	
19	387	194
26	388	

JUN

Day	We	Bi
2	389	195
9	390	
16	391	196
23	392	
30	393	197

JUL

Day	We	Bi
7	394	
14	395	198
21	396	
28	397	199

AUG

Day	We	Bi
4	398	
11	399	200
18	400	
25	401	201

SEP

Day	We	Bi
1	402	
8	403	202
15	404	
22	405	203
29	406	

OCT

Day	We	Bi
6	407	204
13	408	
20	409	205
27	410	

NOV

Day	We	Bi
3	411	206
10	412	
17	413	207
24	414	

DEC

Day	We	Bi
1	415	208
8	416	
15	417	209
22	418	
29	419	210

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1973

JAN

Day	We	Bi
5	420	
12	421	211
19	422	
26	423	212

FEB

Day	We	Bi
2	424	
9	425	213
16	426	
23	427	214

MAR

Day	We	Bi
2	428	
9	429	215
16	430	
23	431	216
30	432	

APR

Day	We	Bi
6	433	217
13	434	
20	435	218
27	436	

MAY

Day	We	Bi
4	437	219
11	438	
18	439	220
25	440	

JUN

Day	We	Bi
1	441	221
8	442	
15	443	222
22	444	
29	445	223

JUL

Day	We	Bi
6	446	
13	447	224
20	448	
27	449	225

AUG

Day	We	Bi
3	450	
10	451	226
17	452	
24	453	227
31	454	

SEP

Day	We	Bi
7	455	228
14	456	
21	457	229
28	458	

OCT

Day	We	Bi
5	459	230
12	460	
19	461	231
26	462	

NOV

Day	We	Bi
2	463	232
9	464	
16	465	233
23	466	
30	467	234

DEC

Day	We	Bi
7	468	
14	469	235
21	470	
28	471	236

WEEKLY AND BI-WEEKLY NUMERIC CALENDAR 1974

JAN

Day	We	Bi
4	472	
11	473	237
18	474	
25	475	238

FEB

Day	We	Bi
1	476	
8	477	239
15	478	
22	479	240

MAR

Day	We	Bi
1	480	
8	481	241
15	482	
22	483	242
29	484	

APR

Day	We	Bi
5	485	243
12	486	
19	487	244
26	488	

MAY

Day	We	Bi
3	489	245
10	490	
17	491	246
24	492	
31	493	247

JUN

Day	We	Bi
7	494	
14	495	248
21	496	
28	497	249

JUL

Day	We	Bi
5	498	
12	499	250
19	500	
26	501	251

AUG

Day	We	Bi
2	502	
9	503	252
16	504	
23	505	253
30	506	

SEP

Day	We	Bi
6	507	254
13	508	
20	509	255
27	510	

OCT

Day	We	Bi
4	511	256
11	512	
18	513	257
25	514	

NOV

Day	We	Bi
1	515	258
8	516	
15	517	259
22	518	
29	519	260

DEC

Day	We	Bi
6	520	
13	521	261
20	522	
27	523	262

SEMI-MONTHLY NUMERIC CALENDAR
(based on 15th and last day of the month)

		1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Jan	15	1	25	49	73	97	121	145	169	193	217
	31	2	26	50	74	98	122	146	170	194	218
Feb	15	3	27	51	75	99	123	147	171	195	219
	28	4	28	52	76	100	124	148	172	196	220
Mar	15	5	29	53	77	101	125	149	173	197	221
	31	6	30	54	78	102	126	150	174	198	222
Apr	15	7	31	55	79	103	127	151	175	199	223
	30	8	32	56	80	104	128	152	176	200	224
May	15	9	33	57	81	105	129	153	177	201	225
	31	10	34	58	82	106	130	154	178	202	226
Jun	15	11	35	59	83	107	131	155	179	203	227
	30	12	36	60	84	108	132	156	180	204	228
Jul	15	13	37	61	85	109	133	157	181	205	229
	31	14	38	62	86	110	134	158	182	206	230
Aug	15	15	39	63	87	111	135	159	183	207	231
	31	16	40	64	88	112	136	160	184	208	232
Sep	15	17	41	65	89	113	137	161	185	209	233
	30	18	42	66	90	114	138	162	186	210	234
Oct	15	19	43	67	91	115	139	163	187	211	235
	31	20	44	68	92	116	140	164	188	212	236
Nov	15	21	45	69	93	117	141	165	189	213	237
	30	22	46	70	94	118	142	166	190	214	238
Dec	15	23	47	71	95	119	143	167	191	215	239
	31	24	48	72	96	120	144	168	192	216	240
		1965	1966	1967	1968 Leap Year*	1969	1970	1971	1972 Leap Year	1973	1974

*Julian Number for Feb should read 29 February in lieu of 28 February.

APPENDIX B

GLOSSARY OF SYMBOLS AND TERMS

SYMBOLS

a — The optimistic time estimate for an activity when three time estimates are used.

b — The pessimistic time estimate for an activity when three time estimates are used.

E — An abbreviation for S_E used in graphic reports.

L — An abbreviation for S_L used in graphic reports.

m — The most likely time estimate for an activity when three time estimates are used.

S_E — The earliest scheduled completion time or date based on the scheduled plan for an activity.

S_L — The latest scheduled completion time or date based on the scheduled plan for an activity.

t_e — The expected elapsed time based on the plan for an activity.

t_s — The scheduled elapsed time based on the scheduled plan for an activity.

S — An abbreviation for T_S used in graphic reports.

T_A — The actual date an event occurs or an activity is completed.

T_D — The directed date for an event.

T_E — The earliest expected time or date based on the plan on which an event will occur.

T_L — The latest allowable time or date based on the plan on which an event will occur.

T_S — The scheduled completion date for an activity or event.

TERMS:

Account Code Structure

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

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.

Actual Costs

The incurred expenditures plus any unliquidated commitments charged or assigned to a work effort.

Charge Number

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

Commitment

An obligation within a corporate or government organization to charge cost against a specific work package. This may be in advance of a legal obligation against the contract.

Constraint

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

Cost Activity

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

Cost Category

The name and/or number of a functional, hardware, or other significant identification for which costs are to be summarized.

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 the event.

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.

Earliest Completion Date (S_E)

The earliest scheduled calendar date on which a work effort (activity, work package, or summary item) can be completed. This date is calculated by:

- summing the scheduled elapsed times (t_s) for activities on the longest path from the beginning of the program or project to the end of the work effort; and

- then adding this sum to the calendar start date of the program or to a previous event for which a directed date has been assigned.

Earliest Expected Time (T_E)

The earliest time for planning purposes which an event can be expected to occur. The T_E value for a given event is equal to the sum of the expected elapsed time (t_e) for the activities on the longest path from the beginning of the program to the given event. When transposed to a calendar date base, this notation is referred to as an earliest expected date and is calculated the same as the earliest expected time.

Estimate-to-Complete

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

Event

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

Expenditure

Actual disbursement of funds of a contractor for in-plant or subcontract expense pertaining to a contract.

Expected Elapsed Time (t_e)

The time which an activity is predicted to require. The expected elapsed time often referred to as expected time or elapsed time is identical to a single time estimate for the work to be accomplished, or is derived from the calculation of a statistically weighted average time estimate, incorporating the optimistic (a), most likely (m), and pessimistic (b) estimates for the work to be accomplished.

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

Indirect Cost

Cost which is pro-rated or allocated to a contract (see ASPR 15-203).

Interface Event

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

<u>Joint Cost Activity</u>

Joint cost activity is one which shares resources in such a way that it is impractical to further allocate them to individual activities.

<u>Latest Allowable Time</u> (T_L)

The latest time for planning purposes on which an event can occur without delaying 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 time allowable for completing the program. When transposed to a calendar base utilizing T_D, this notation is referred to as the latest allowable date and is calculated the same as the latest allowable time. T_L for the end event in a program is equal to the directed date (T_D) of the program. If a directed date is not specified, $T_L = T_E$ for the end event.

<u>Latest Completion Date</u> (S_L)

The latest calendar date on which a work effort (activity, work package, or summary item) can be scheduled for completion without delaying the completion of the program or project. This date is calculated by:

- summing the scheduled elapsed times (t_s) for activities on the longest path from the end of the work effort to the end of the program or project; and

- then subtracting this sum from the calendar end date of the program.

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.

Latest Revised Estimate

The sum of the actual incurred costs plus the latest estimate-to-complete for a work package or summary item as currently reviewed and/or revised (including applicable overhead except where direct costs are specified.)

Milestone

Milestones are synonymous with events in a network.

Most Likely Time (m)

The most realistic estimate 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 sequences of accomplishment, interdependencies, and interrelationships.

Network Integration

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

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.

(Overrun)Underrun (Work Performed to Date)

The value for the work performed to date minus the actual cost for that same work. Where value exceeds actual cost, an underrun condition exists. When actual cost exceeds value, an overrun condition exists.

Performing Organization

The contractor, department, or organization which will perform work on a work package.

Pessimistic Time (b)

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

Planned Cost

The approved planned cost for a work package or summary item. This cost, when totaled with the planned costs for all other work packages, results in the total cost estimate, committed under contract, for the program or project.

Product Work Breakdown Structure

A family tree subdivision of a program, beginning with the end objectives and then subdividing these objectives into successively smaller deliverable 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;
- identifying contractual line items.

Program Management Network

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

Projected (Overrun)Underrun

The planned cost minus the latest revised estimate for a work package or summary item. When planned cost exceeds latest revised estimate, a projected underrun condition exists. When latest revised estimate exceeds planned cost, a projected overrun condition exists.

Scheduled 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.

Simulation

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

Slack

The difference between the latest allowable time or date and the earliest expected time or date (T_L-T_E), or the difference between the latest completion date and earliest completion date (S_L-S_E). Slack is a characteristic, as such, of the network paths. Slack may be positive, zero, or negative.

Starting Event (Beginning Event)

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

Summary Item

An item appearing in the work breakdown structure.

Summary Network

A network which represents, with a reduced number of selected events, the relationships 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.

Summary Number

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

Value (Work Performed to Date)

The planned cost for completed work, including that part of the work in process which has been finished. This value is determined by summing the planned cost for each completed work package. If a work package is in process, the part of its total planned cost which applies to work completed is approximated by applying the ratio of actual cost to latest revised estimate for that work package.

Work Package

The work required to complete a specific job or process, such as a report, a design, a documentation requirement or portion thereof, a piece of hardware or a service. A work package may consist of one or more cost significant activities. The content of a work package may be limited to the work which can be performed by a single operating unit in an organization or may require the contributing services of several operating units. The overall responsibility for the work content of a work package should be assigned to a single organization or responsible individual. It is the lowest level of cost collection and is represented by a charge number related to a single summary number. In this way, the work package couples to the cost accounting system through the charge number and to the PERT network through the beginning and ending event numbers of the package.