PERT DATA PROCESSING LESSON PLAN HANDBOOK FOR TECHNICIANS

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SPECIAL PROJECTS OFFICE
BUREAU OF NAVAL WEAPONS
DEPARTMENT OF THE NAVY

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DATA PROCESSING FOR PERT — LESSON PLAN OUTLINE

PART I	INTRODUCTION TO PERT PROGRAM		
Lesson 1	FOREWORD AND ORIENTATION		
	— New Management tool—description (PERT Terms, Exhibit 1)	20 min.	
	— PERT concept	10 min.	
	— PERT does —what	15 min.	
			45 min.
Lesson 2	HOW PERT WORKS		
	— Installation and operation	25 min.	
	— Service to various operating and management levels	20 min.	
	— Discussion period on Lesson 1 and 2 (PERT Summary Report as a text book)	30 min.	
			75 min.
PART II	THE NETWORK (FLOW CHART) FOR PERT		
Lesson 3	ORIGINATING THE NETWORK		
	— Selecting the Events	15 min.	
	— Layout of the chart (events and activities)	45 min.	
	— Connecting events		
	— Activity time intervals		
	— Identifying events (assign numbers)		
	—Completing chart		
			1 hr.
Lesson 4	MAINTAINING AND REVISING CHART	30 min.	
	— Discussion period (on charting methods)	30 min.	
			1 hr.
Lesson 5	PROBLEM—ORIGINATE AND DRAW A SMALL FLOW CHART WITH TITLES (minimum 20 events)		
	— Show all known varieties of connections, e.g., more than one successor. (Provide ruler, compass, appropriate 16" x 21" paper)	60 min.	
	— Discussion of charting problems (Sample PERT chart, Exhibit 2)	30 min.	
	— Chart must have:		
	– Base line and date (time now)		
	– All events connected by activities and ending in one objective or end-item		
	– Titles and numbers for events		
	– Time estimates for each activity		
	– Hand-count of transactions and events		
			1½ hrs.
PART III	ESTABLISHMENT OF EVENT NOMENCLATURE		
Lesson 6	SELECTION OF DEFINITIVE SHORT TITLES FOR EVENTS (limited to 48 typewriter spaces) (Nomenclature Transmittal, Exhibit 3)	15 min.	
	— Problem—check original chart, particularly to revise titles, if new knowledge enables use of shorter, more-meaningful titles	30 min.	
	— Discussion of nomenclature (initial and revised)	15 min.	
			1 hr.

PART IV	**PREPARATION OF INPUT REPORT**		
Lesson 7	**POSTING INPUT DATA AND CODING INITIAL INPUT (Codes and Uses) (PERT Initial Input, Exhibit 4)**	45 min.	
	— Problem: Prepare input (and code) for original chart (20 events)	25 min.	
	— Discussion of coding problems	20 min.	
			1½ hrs.
Lesson 8	**CODING REVISED INPUT (Codes and Uses)**		
	— Problem: Each participant to revise his chart—complete 2 events, re-estimate 2 activities, post schedule date on end-item, delete 1 activity and replace with another	15 min.	
	— Make out input to cover revisions (Revised Input Report, Exhibit 5)	30 min.	
			1¼ hrs.
Lesson 9	**INPUT PREPARATION PITFALLS (After practice inputs for appreciation)**	15 min.	
	— Do's and Don'ts of posting data to input report (accuracy, importance of network No., blank or filled spaces for certain codes, etc.)	30 min.	
	— Comparison of initial vs. revised input preparation—revising initial input before data has been machine processed (watch initial coding—No. 2, 4 or 5 codes)	15 min.	
	— Discussion of special or anticipated pitfalls	15 min.	
			1¼ hrs.
PART V	**ESTABLISHMENT OF DATA CONTROL**		
Lesson 10	**DATA TO BE LOGGED (for control of inputs and outputs) (Data Control Sheet, Exhibit 6)**		
	— Use of data for transmittals and as checks on machine processing	30 min.	
	— Discussion of PERT data logging problems	15 min.	
			1 hr.
PART VI	**REVIEW OF PERT OUTPUT**		
Lesson 11	**PRELIMINARY CHECK OF OUTPUT**		
	— Check immediately for "clean" run or that re-run may be required. (Record, receipt, check machine counts, check machine acceptance of input data, and check chart) (Data Check-out Terms, Exhibit 7)	20 min.	
	— General introduction and orientation Monitor Print as related to output	20 min.	
	— Discussion of initial look at output (Sample PERT output, Exhibit 8)	20 min.	
			1 hr.
Lesson 12	**DETAILED REVIEW OF MONITOR RUN**		
	— Meaning of most-used machine codes as related to output-possible computer program actions as result of review	30 min.	
	— Examine monitor run and discuss story it tells (Monitor Print Codes, Exhibit 9)	30 min.	
			1 hr.

Lesson 13 DETAILED REVIEW OF OUTPUT

— Check slack sort and establish critical path, with constraints—compare with last output for evidence of improvement—mark path, etc, on chart	30 min.	
— Check completions and ear-mark events to be completed and to be so indicated by next input (or re-estimates)	15 min.	
— Discussion of importance of output review since the data is used as the basis for management action. New refinement—Graphic Report Form (1 yr. and 5 yr. by months—Exhibit 10)	60 min.	
		1¾ hr.

PART VII REVIEW OF PERT DATA PROCESSING

Lesson 14 GROUP REVIEW OF INPUT PREPARATION 30 min.

— Network flow chart-nomenclature
— Input report and transmittal control

GROUP REVIEW OF OUTPUT 30 min.

— Monitor Run related to Output
— Output meaning to Management 1 hr.

LIST OF EXHIBITS

1. Definition of Common PERT Terms
2. Sample PERT Flow Chart
3. PERT Nomenclature Transmittal
4. Initial PERT Report of Time Interval and Progress
5. Revised PERT Report of Time Interval and Progress
6. PERT Data Control Sheet
7. PERT Data Check-out Terms
8. Sample PERT Outputs
   a. Sequence "00"
   b. Sequence "10"
9. Monitor Print Codes—Interpreted
10. PERT Graphic Reports
    a. One (1) year graph
    b. Five (5) year graph

COURSE MATERIAL (20 participants)

Copies — 2 PERT Network (Operational Flow Chart)
— 50 PERT Nomenclature Transmittal
— 100 PERT Report of Time Interval, etc.
— 25 PERT Data Control Sheet
— 25 Sheets 16" x 21" paper, pencils, rulers, compasses, scratch pads.

EXTRA COPIES OF EXHIBITS, OUTPUTS AND MONITOR PRINTS

TEXT

Use PERT Summary Report—Phase I as the hard manual for course reference

BIBLIOGRAPHY

Special Projects Office Publications:

Instruction Manual and Systems and Procedures for PERT
PERT Summary Report—Phase I
Program Planning and Control System
Technical Memorandum—Mechanization of PERT—U. S. Naval Weapons Laboratory, Dahlgren, Virginia

FOREWORD

In January 1958, a project team was organized to study the application of statistical and mathematical methods to the planning, evaluation, and control of an R & D program involving a series of tasks scheduled in logical sequence and leading to a final objective. It was recognized at the start that research and development programs are of a pioneering nature and that an attempt should be made to schedule intellectual activity as well as physical activity. Due to these qualities, it was necessary to formulate a system: dynamic in concept, susceptible to rapid analysis and interpretation. The result of the study is called "PERT" (Program Evaluation and Review Technique).

PART 1. INTRODUCTION TO PERT

ORIENTATION — Lesson 1

1. WHAT IS PERT? The Program Evaluation System (PERT) is a management control tool for defining, integrating, and interrelating what must be done to accomplish program objectives on time. PERT is a statistical technique—diagnostic and prognostic— for quantifying knowledge about the uncertainties faced in completing intellectual and physical activities essential for timely achievement of program deadlines. It is a technique for focusing management attention on danger signals that require remedial decisions, and on areas of effort for which "trade-offs" in time, resources, or technical performance might improve the capacity to meet major deadlines.

Initially, the system was developed and applied to the Fleet Ballistic Missile (FBM) Program. The FBM program is composed of a series of activities or tasks scheduled in anticipated sequence culminating in the attainment of an operational weapon system. Product performance and resource allocation operate as constraints on the time of accomplishment.

The problem of evaluating a research and development program is difficult because of the nature of the activities—intellectual, pioneering, and unpredictable. How can the Program Evaluation System (PERT) provide a day-to-day comparison of progress with planned schedule dates? Basically, the system can provide at a minimum:
(1) orderliness and consistency in planning and evaluating;
(2) automatic identification of possible future trouble spots as a result of failure in one area;
(3) speed in integrating progress evaluation; and
(4) accurate portrayal of the dynamic research situation throughout these previous points.

2. PERT CONCEPT. R & D effort is characterized by considerable uncertainty because it is applied at the "edge of the state of the art" in order to move beyond the current "state of the art." Successful achievement of a program's objective requires a plan that identifies specific events or progress benchmarks to be achieved in sequence, based on *interdependencies* among those events.

Three basic factors influence (or constrain) progress toward objectives—time, resources, and technical performance specifications. TIME is a variable that can be used as a common denominator to reflect planned resource applications and performance specifications. Responsible planners and technicians estimate the TIME necessary to move from event to event. They express the range in TIME they believe will be required to complete the activities linking events in the plan. The estimated range of TIME indicates the relative uncertainty for completing different activities in a plan. It provides data for analyzing the variance and margins of error inherent in the successful completion of any plan or program. Briefly, the PERT system is a management control tool which reflects the complex interrelationships of a large number of activities. These activities make up an integrated network of events; their completion leads to the end objective of an operational missile system.

The salient features of the PERT system are as follows:

a. Specific events, which must occur in the process of attaining the final objective, are selected. In the Polaris program, for example, there are many thousand identified events which must be accomplished before the end objective is realized. An event does not necessarily imply the completion of a piece of hardware; it may be the completion of a research task, or even the receipt of money necessary for subsequent activity to begin. In other words, all known constraints, either administrative or technical, can be included in the selection of events. These *selected events* are clear points in time and should be so defined that different interpretations on the part of the Special Projects Office and its contractors are prevented.

b. The sequence and interdependencies between events are established so that a graphic network (chart) of event relationships may be constructed.

c. Elapsed time estimates for all the *activities linking the events* are obtained from technical personnel directly charged with the accomplishment of the activity. Actually, three estimates are obtained for each activity: optimistic, pessimistic, and most likely.

d. The system is so designed that current progress information may be obtained at any point in time, and in a form subject to ready interpretation.

e. A measure of the uncertainty (probability) associated with the accomplishment of events is also determined by using statistical methods.

3. ADVANTAGE OF PERT. PERT application to a large program gives the manager information which he may use for better planning and decision making within the time available to him. Because of time limitation, or lack of information, or both, managers are often unable to evaluate alternate courses of action in advance. Therefore, by use of PERT decisions can be made with knowledge of the overall consequence or effect upon specific objectives.

A major advantage of PERT comes from the adaptability of its concept. Although it was developed and adapted for a particular weapons systems, it can be applied as a management control in other large systems. Another feature is that one can compute and evaluate the effect of alternate decisions under consideration upon any subsystem as well as their impact upon the overall objective.

The PERT concept provides a means for better management of large systems characterized by many complex interrelationships. Efficient operation of any evaluation system is dependent upon the timely receipt, analyses, and use of accurate information. The procedures outlined are designed to obtain the necessary information rapidly and with minimum effort. Its effective analysis and use provided for by updated computer inputs and rapid dissemination of the outputs to management.

4. WHAT DOES PERT DO? With the aid of an electronic computer, PERT reports the current validity of approved plans and schedule, the progress to date against program objectives, and the outlook for meeting ultimate objectives on TIME. More specifically, PERT performs the following functions:

a. Generally depicts the sequence and interrelationship of significant finite events (progress benchmarks) in the plan to achieve end-objectives under planned resource applications and performance specifications.

b. Measures the relative uncertainty for accomplishing activities that link events in the flow plan or network—based on technicians' estimates of TIME and range of TIME necessary to complete each activity.

c. Synthesizes network and TIME data to provide the combined impact of such data on capacity to meet program deadlines.

d. Reveals the relative criticalness among areas of effort required to meet end-objectives. It pinpoints, on the one hand, the activities for which criticalness may require remedial decisions and on the other hand, activities for which surplus time exists and where some delay will not hamper ability to meet end-objective deadlines. "Criticalness" as used here is a relative term; "critical path" means "longest path to end-objective." The longest path based on PERT expectations may be longer or shorter than the scheduled deadline.

e. Computes the current probability for meeting scheduled completion dates, based on the comparison of current expectations with scheduled dates.

f. Tailors outputs and analyses to the appropriate levels of management and technical interests.

g. Provides top-management with the integrated, summary picture of total progress and progress outlook on a continuous basis.

h. Simulates the TIME inpact of proposals for change, and of optional courses for remedial decision, on the outlook for meeting end-objective deadlines.

5. A FAST COMPUTER. While the computational aspects of the PERT program are relatively simple the integration of the subsystems into the whole system involves over ten thousand different events and thus requires a fast computer if adequate capacity is to be available. The most important advantages of a fast computer are:

a. Computation of several alternative program plans in a reasonable time.

b. Provision of results to the manager faster so that many more alternatives may be considered with analysis and evaluation of the relative effects of each on the end objective.

c. Provides more lead time to the manager to take action on critical schedules.

d. Provides capacity for increasing the coverage and complexity of detail required in an expanding system.

(Discuss PERT Terms, Exhibit 1, at an appropriate time to make information more meaningful)

DEFINITIONS OF COMMON PERT TERMS

ACTIVITY

An event is separated from other events by activities. An *activity* is a time-consuming element in the development process or simply stated, "work-in-process." It is represented on a *flow chart* by an arrow. An *activity* cannot be started until its preceding event has been accomplished. A *succeeding event* to an activity cannot be accomplished until the activity is complete.

ACTIVITY TIMES

Estimates of the elapsed time necessary to complete an activity in a specified manner are *activity times*. They are represented by estimates indicating:

- Optimistic times
- Most likely times
- Pessimistic times

CRITICAL PATH

A critical path is that particular sequence of activities in a flow chart that comprise the most rigorous time constraint in the accomplishment of the end event.

EVENT

A meaningful specified accomplishment in the FBM development program. An event should be recognizable as a particular instant in time.

FLOW CHART OR PLAN

The sequenced diagrammatic representation of events and activities.

PRECEDING EVENT
See ACTIVITY

SLACK PATHS
Slack paths are sequences of activities having excess time as opposed to the critical (or negative slack) paths. Slack may exist in varying amounts - positive slack indicates scheduling flexibility within the path. A "slack" column, by event, appears on on the PERT output.

SUCCEEDING EVENT
See ACTIVITY

INPUT
Program data reported by the contractor on a PERT Report, usually biweekly, and used as the basis for machine card-punching.

OUTPUT
The Computer tabulation of PERT input data as of a report date and in three sorts (events, slack time by weeks and scheduled date). Used as a basis for observing the critical path and for current program analysis.

MONITOR RUN
A machine check-sheet to assure accuracy of run (output) - rejections, lack of events, predecessors, etc. are indicated.

PERT TIMES
PERT employs several time variables referred to as:

Te — *expected interval* of time which an activity will require.

TE — *expecied point* in time at which an event will be reached (activity completed).

T1 — *latest point* in time (latest allowable date) at which an event can be reached without delaying the program.

Ts — *scheduled time* - estimated data established independently of PERT, against which progress is measured.

EVALUATION TEAM
The Evaluation Team (Team) is descriptive of a group of designated individuals charged with furthering the SP evaluation effort as it bears on a given sector of the FBM development. Generally, a Team will be comprised of individuals representing the SP Technical and the SP Plans and Program divisions, SP Field Office, and the Contractor.
NOTE: When reference is made to "earliest time" it is synonymous with PERT "expected time (TE)."

HOW DOES PERT WORK? Lesson 2

1. INSTALLATION. PERT supplies a continuous stream of timely and dynamic program evaluations. The cycle begins with inputs from the contractor or agency charged with meeting a major end-objective. Installation of the PERT system for each contractor is accomplished through a team visit by representatives of the SP Program Evaluation Branch, the SP technical branch responsible for the contract, and the appropriate SP field office. Working with the contractor's planning and technical staff, the team draws the flow diagram or network, beginning with the culminating end-objective and moving backward through preceding events to "time now."

2. TIME ESTIMATES. Next, elapsed time estimates are obtained from technicians who will perform, or could perform, the activities linking network events. Such estimates are made in *units* of TIME, e.g., in weeks without regard to schedules or calendar. For each activity, three TIME estimates are required—most likely TIME, optimistic TIME, and pessimistic TIME. The estimated TIME range, optimistic to pessimistic, excludes extremes that cannot reasonably be expected, e.g., unlikely technical breakthroughs or unpredictable "acts of God" such as explosions or bad weather. Contractor networks and time estimates are edited and reviewed for reasonableness by appropriate technicians before computer input sheets are sent to the electronic computer for processing.

3. OUTPUTS. The computer is programmed to process the input data quickly and to provide outputs, both standard and special, to serve different purposes, many levels of management, and various technical-direction interests. These outputs are provided in full detail for technical direction staffs and in a merged and summary form for top managements.

4. REPORTS. Once PERT is installed for a given contractor, the continuity of PERT outputs and program evaluation is maintained through bi-weekly contractor inputs. These are progress reports that provide "up-keep" of original data as progress is made and as events, TIME estimates, resources, and/or performance specifications are adjusted or revised.

5. PRE-MANAGEMENT ANALYSIS. Computer outputs are interpreted and analyzed in the Program Evaluation Branch before transmittal to top management and to technical staff. Such analyses state the qualifications or assumptions pertinent to each specific print-out to insure accurate interpretation and use of the numbers. Such analyses also highlight the danger signals (e.g., events in the critical path) and suggest possible options worthy of consideration for decisions.

6. MANAGEMENT. How does PERT serve various levels of management? Upon receipt of computer outputs with interpretive statements, top management or technical direction staff may choose either:

a. To make adjustments and trade-offs in plans, schedules, resources, or performance specifications or,

b. To test the effects of different options for decision by running through the computer different proposals for change.

In either case, the SP approved decisions for change are recommended to the contractor and the PERT cycle continues. For the highest levels of management, PERT outputs can be summarized to present the integrated progress to date and the outlook on a continuous basis. A more detailed examination of critical areas is required by the technical direction staff. This is accomplished through study of events in the critical or longest path of the network. To serve this purpose, one computer printout specifies events on the critical path, subcritical events, and the probability for meeting the end-objective on schedule. This is a standard printout based on each series of inputs. Another computer print-out shows the latest times by which each event in the network must be completed in order to meet the end-objective schedule. These PERT products serve as bases for program evaluation as originally defined. They improve management's capacity to accomplish program objectives by the deadlines essential for national defense.

PART II THE NETWORK (FLOW CHART)

ORIGINATING THE NETWORK Lesson 3

GENERAL. The preparation of a PERT flow chart begins with the selection of appropriate, meaningful events and activities which are to be accomplished. The events are depicted by circles (or boxes) drawn vertically according to subcomponent. Events are numbered successively (in 3 digits—as "005") and descriptions (titles) are printed in the circles. The contractors' technical personnel should aid in the establishment of events as well as setting up activities connecting these events. Charts with titled events coming under security regulations should be appropriately classified. A detailed explanation of the setting-up of a flow chart follows. (See Exhibit 2 and operational PERT chart)

1. SELECTING EVENT TITLES. It is important to analyze each event description considered for use on the flow chart by asking appropriate questions in the following categories:

Category 1—Does the event represent a definite discernible beginning or ending point of some activity or group of activities? (Such words as firm, finalize, freeze, ship, etc. are to be avoided. In their place use such phrases as, "design release complete," "production prototype design complete," "approve for captive test," "arrival of 1st flight test vehicle at AFMTC," etc.)

Category 2—Is the description detailed and complete? Does it tell who does it? Where and what is done? (Be sure model descriptions are complete. Use specific FTV, CTV, and other available code numbers to name specific components, subsystems, and systems. Use test and model numbers)

Category 3—Does the technical man who is to do the estimating understand the events as beginning and ending points of some clearly defined activity? Is he able to fix in his own mind what has to take place *at the completion* of the preceding event before the immediately succeeding event is reached? (This category is used when interrogation of the estimator takes place in obtaining time interval estimates.)

2. CHART LAY-OUT. After the events have been selected properly, the next step is to place the descriptions on a flow chart. This can be accomplished on a "first cut" basis by drawing a series of circles (or boxes) about 1-1/2 inches across on a large sheet of paper. The event descriptions are printed in the circles. (They may be abbreviated if a complete list of events and their description is maintained.) Events are placed vertically according to category (subcomponent on a component chart, subsystem on a system chart, etc.) and along the horizontal axis in normal sequential relationships. No permanent horizontal date scale should be placed on the chart to avoid influencing judgments as to time estimates and thereby introducing a bias into the estimates. At the conclusion of this step in the process, the chart is nothing more than a series of circles with descriptions (titles) in them. Usually, a sheet of paper about 24 by 36 inches should provide enough space for about 200 events.

3. CONNECTING EVENTS. Qualified technical personnel thoroughly acquainted with the area to be analysed should assist in determination of the interrelationships or interconnections among events. They should be aware of the over-all planning as it applies to the area covered by the flow chart so as to indicate the appropriate connections to reflect present plans and expectations. For example:

"According to present plans it is expected that events numbered 10 and 22 are related and that event number 10 will have to be reached before event number 22 can be accomplished. Events number 10 and 22 are so related and interdependent that unless 10 is completed the activity between them cannot be started. Furthermore, it will be impossible to reach the point in time represented by 22 until the activity represented by the arrow between them is completed. More specifically: an inspection of an assembly cannot be started until it is assembled, the assembly cannot begin until the components are fabricated, etc."

4. It is advantageous to start at the left of the chart where some events may have been completed already or scheduled for completion momentarily. Some events are considered as having no preceding

event. These events start as of the time "O" or "time now." Arrows leading into these events originate at the "O" point. The connecting process is continued across the chart to the extreme right until each event is properly related to all the other events either directly or indirectly. Connections to events (activities) should be clear-cut graphically; with a minimum of "cross-over" lines or "back-tracking." The statement is sometimes made by the technical man, "But this event does not have to be accomplished before we can start the indicated subsequent activity." The question to ask in this case is, "Does the relationship as shown by the arrow, represent current planning within your group?" Event sequence reflects realistic, planned operations. To tie-in at merge points on a network (where no activity is involved) a "dummy" activity with no time interval ("0-0-0") may be established between the events.

5. ESTIMATING ELAPSED TIMES. The contractor's technical representative, who indicated the connections to be made between events, should provide estimates of elapsed times and associated variables for the activities represented by the arrows between pairs of events. He must provide three time estimates as defined below:

1. *Optimistic Time*—The first estimate is an "optimistic" one, in that it gives the best or shortest time. There is little hope of completing the activity in less than the optimistic time.
2. *Most Likely Time*—The "most likely" time estimate is the time that would occur most often if the activity was repeated under *exactly* the same conditions many times. If many knowledgeable people were asked for the most likely time, the value given most often would form the most likely time estimate.
3. *Pessimistic Time*—If significantly worse luck than usual occurs, the "pessimistic time" estimate indicates the longest time that the activity would take.

Time estimates should be entered on the flow charts along the arrows to which they apply. A good form to use is illustrated in the sample PERT Flow Chart, Exhibit 2. When all three time estimates (optimistic, most likely and pessimistic) are equal, the activity should be analyzed carefully for possible errors in estimation.

6. COMPLETING THE CHART—NUMBERING. The flow chart is to be used as the basis for conveying the initial data to a data processing center. In its original "work sheet" form, it must be classified, if required, because of the event description. Events are numbered in three digits (as "005") as part of a system number which also has six identifying digits—an example being 020 - 345 - 005. The first three digits indicate the Special Projects (BuWeps) technical division code—the middle three digits are assigned by SP to avoid duplication and may be assigned as Contractor control figures. The first three digits are selected for systems on the following basis:

011 – FBM TRAINER
022 – LAUNCHING AND HANDLING
023 – FIRE CONTROL AND GUIDANCE
024 – NAVIGATION
025 – SHIP OPERATIONS AND TEST (INSTRUMENTATION)
026 – SHIP INSTALLATION AND DESIGN (CONSTRUCTION)
027 – MISSILE (PROPULSION, REENTRY BODY, etc.)

("020" and "670" are presently used for outside miscellaneous networks, as for BuShips—"010" is reserved for integrated networks)

The chart should be redrawn so that it is readily reproducible. If drawn on tracing paper with India ink lines, it can be reproduced by the diazo process. Original charts and reproducible masters should be kept by the contractor.

7. FROM FLOW CHART TO INPUT REPORT. Information presented on the flow chart cannot be fed directly into the computer, but has to be converted into numerical data. Each activity time and its corresponding boundary events are translated into entries on the Report of Progress and Time Interval Estimates Form, illustrated in Exhibit 4. The conversion should take place in the data flow process as soon as possible after the origination of the chart. A logical place for this routine clerical operation would be in the contractor's program plans group or program analysis group. One copy of the completed input report should be forwarded to Sp-12 (BuWeps), and one copy to the cognizant technical branch (e.g., SP-22) in the Special Projects Office (BuWeps). (Substitute the address of the cognizant data processing center for Sp-12, if a service center is used.)

8. REVISING EXISTING FLOW CHARTS PERIODICALLY. Essentially the same procedure is followed in revising flow charts periodically as is used in setting them up originally. A team, representing the contractor and the Special Projects Office (BuWeps), critically examines all events and times in the existing flow chart. Revisions and re-estimates are made wherever necessary. All changes are incorporated in a revised input report.

MAINTAINING AND REVISING PERT FLOW CHART

Lesson 4

As each input is generated to revise the basic network, the flow chart should be maintained currently to show all revisions in plans. Events and activities added, deleted or changed should immediately be posted on the flow chart. Completed events (with dates) and the current critical path should be indicated clearly by colored crayon or tape on the chart to provide a quick scanning of the current project status. Completed events will not drop out (not shown on printed output) until all successors are completed. The difference in completions should be indicated on the chart by drawing

slanted lines over the event circle for completed events having successors and by cross-hatching these lines for completed events with no active successor. Scheduled dates provided by the contractor should be posted above event circles as received and are particularly urgent for each end-item. (Initiate group discussion of chart revision and need for current network-show all revisions on chart.)

PROBLEM–ORIGINATE A PERT CHART Lesson 5

Provide for group participation in the discussion of PERT networks and then have each individual draw a simple PERT flow chart (minimum 20 events). The object is to visualize a small operation, as an example, from the design to completion of an end-item, and graphically portray events and activities. All known data and a variety of connections (activities) should be utilized to indicate participant's accumulation of PERT knowledge, including activity time estimates and establishment of nomenclature for processing. (Retain original charts of participants for refinement after more knowledge of PERT system-e.g., betterdata or event nomenclature gained during course.)

PERT Chart requirements:

- Base line and date (time now)
- Each event connected by an activity–at least one end-item
- Titles and numbers for event
- Hand count of events and transactions

(Conduct group discussion of flow charts and questions on preparation)

PART III. ESTABLISHMENT OF NETWORK EVENT NOMENCLATURE

SELECTION OF DEFINITIVE SHORT TITLES FOR EVENTS Lesson 6

The network (chart) provides the basis for preparation of a list of event titles. Each event on the chart includes the title as well as number and should be posted to the Nomenclature Transmittal in numerical order with 9 digit identification as per the example nomenclature list, Exhibit 3. Space on the output sheet limits each title to 48 typewriter spaces; therefore, short titles should be spelled out and long titles abbreviated with commonly understood abbreviations. Revisions to the initial nomenclature listing should clearly indicate both (A) changes and (A) additions–with titles or (D) deletions–without titles (see Exhibit 3). Nomenclature should be maintained in a current status by transmitting title changes promptly.

NOTE: Events should have short, definitive titles. Activity definitions to explain operations between events should be a separate submission by the contractor–to be used as an aid in analysis of the system outlook.

Nomenclature use is optional by contractor. If nomenclature is not to be released to a data processing center the nomenclature listing should be submitted to SP-12, only for classified use by BuWeps (SP-12).

PART IV. PREPARATION OF INPUT REPORT

POSTING INITIAL INPUT DATA Lesson 7

(see Definitions, Exhibit 1)

1. INPUT. Since the input report is used directly by card punch operators, the date *must* be accurate, complete, and preferably typed or hand printed legibly. The PERT input report is based on the events and activities shown on the network or chart provided by the contractor. The chart contains all the events, activities and time intervals to be posted in numerical order to the input report including contractor-supplied scheduled dates and event completion dates. Completion dates must be on or before "time now;" and scheduled dates are after "time now" (end of report date as set by input).

2. INPUT REPORTS. As indicated on Exhibits 4 and 5, –the code, complete event numbers, time intervals in four digits (including one decimal place) and dates in six digits are required where appropriate (according to action–e.g. Code 7 needs only an ending event and completion date). Vertical arrows may be appropriately used on the input report to indicate repeated figures, but for clarity (for card punch operators) arrows must not run through blank event spaces i.e., the beginning event space (before the ending event number with a Code 4 or 7) must remain blank–repeat the full event number (9 digits) when required in the transaction following a Code 4 or 7 transaction.

3. INPUT GUIDE. The following guide indicates by Code and "X" the spaces to be completed and by "–" those which are permissive for scheduled dates. Below this is a sample completed input on this portion of the Report of Time Interval Estimates and Progress.

4. CODING THE STANDARD PROGRESS FORM. Certain sections of the Report of Time Interval Estimates and Progress Form are reserved for coding. Code entries in column (1) must be made as follows:

Reason for Line Entry on Form	*Code Number*
New or original estimate of an activity (adding a connecting link)	1
Re-estimate of existing activity	2
Completed activity	3
Scheduled date	4
Deletion of an activity	5
Establish a base or completion date (no predecessor)	7

Columns (2) and (3) are specifically set aside for the SP, FBM managers. These entries will reflect any hypothetical or proposed changes in resources (column 2) and/or performance (column 3). Column (4) is provided for special runs. The first

	(A)			Activity Identification		Time Interval Estimates			Scheduled or Completion Date		
				Beginning Event No.	Ending Event No.	Optimistic (weeks) *	Most Likely (weeks) *	Pessimistic (weeks) *			
(1)	(2)	(3)	(4)	(B)	(C)	(D)	(E)	(F)	(G)		
12	13	14-16	17	18 - 26	34 - 42	44 - 47	48 - 51	52 - 55	60	-	65
									Mo.	Day	Yr.
1	NEW ACTIVITY		X		X	X	X	X	-	-	-
2	RE-ESTIMATE		X		X	X	X	X	-	-	-
3	COMPLETION		X		X				X	X	X
4	SCHEDULED DATE				X				X	X	X
5	DELETION		X		X						
7	COMPLETION				X				X	X	X
1				000-000-004	000-000-008	003.0	005.0	009.0	03	12	60
2				000-000-004	000-000-005	010.0	012.5	015.0	-	-	-
3				000-000-001	000-000-003				01	20	60
4					000-000-010				10	12	60
5				000-000-012	000-000-013						
7					000-000-015				01	10	60

input of data for a new network consists of establishing a starting point and new activities, occassionally with completed events which must be accurately coded.

5. INITIAL INPUT CODING.

a. Code 7 is used to establish the base line at the starting date or to indicate a completed event (on or before "time now") which has no predecessor (beginning event). Only an "ending event" number is indicated on the input form since *the use of* Code 7 is *used when there is no* predecessor event. Some networks may not have a base line due to their origination after the completion of the starting event in each string of events has been completed. Ordinarily, in this instance each beginning-event completion date would be established with a 7 code. A network may initially involve both the establishment of a base line and the establishment of completed events by Code 7.

b. *Code 1* is used to establish a new activity and will be used for nearly all transactions in an initial input, except for the establishment of a base-line date or a completion date of an event (by a code 7). A scheduled date (date after time now) may be included whenever the 1 code is used.

NOTE: If it is desired that the completion date of an event be printed on the output, the completed event must first be established by Code 1, then indicated as completed by Code 3. (Code 7 establishes a completion date for an event, but does not result in a printed completion date on the output.) Codes 2, 4, and 5 will not be used in an initial *input (new chart) since there are no previously established activities to re-estimate or delete and scheduled dates are put in with the Code 1 transaction.*

CODING REVISED INPUT — Lesson 8

1. REVISION. Each input revision should reflect the current status of the network and corrective action taken since the last report to reduce or eliminate restraints or reduce slack in the critical path. Normal actions are to re-estimate activities along the critical path and activities which are taking less or more time than previously estimated, and to report of changes in application of resources, performance, and the completion of events.

2. CODING INPUT.

a. *Code 2* is used to indicate a *total* time re-estimate, regardless of partial completion since it is a previously established activity. A scheduled date (date after "time now") may be included whenever the 2 code is used. The last scheduled date posted erases the previous date and if 00 00 00 is posted as a date this will result in removal of an established scheduled date.

b. *Code 3* is used to establish a completion date for a previously established event only, the date will print out on the output.

c. *Code 4* is used only to establish or change a scheduled date (*after* "time now") on an established event, and is posted on the "ending event"—no beginning event or time interval being involved or posted. Code 4 is not used if the "ending event" has been posted as part of an activity transaction under Code 1 or 2, in which case the scheduled date is indicated in the Code 1 or 2 transaction.

d. *Code 5* is used to delete an activity (between two events) from the established machine data. Post only the beginning and ending events since the activity time interval is unessential.

INPUT PREPARATION PITFALLS — Lesson 9

Pitfalls of major consequence can usually be overcome by legible figures and accurate, complete input report data, properly coded and reflecting the current status of the project. Common input problem areas are the following:

- Improper data in report transaction line (e.g., time intervals in an event completion transaction which should have only an event number and a date
- Improper coding of transaction (e.g., a Code 3 instead of Code 4 to establish a scheduled date (—or is a date wrong—and should be a completion?)
- Transaction, with time intervals, given Code 2 (re-estimate) but activity was not established. (Code 1 establishes a new activity)
- Completion of an event which has an incomplete predecessor (—usually an error in reporting—the beginning event of an activity must be completed first and so reported.)
- Event completions or activity re-estimates due in a report period must be checked-out and reflected in the input report to bring data on schedule.
- When Code 4 or 7 is used there should be no beginning event in the transaction line.
- If arrows are used to repeat identification digits, do not run arrows through beginning event spaces which should remain blank in the case of Code 4 or 7.
- Network identification (the first 6 digits) must appear with each input event number (the last 3 digits of the 9 digit PERT number).
- Use of improper dates for scheduled dates (should be after time now) and for event completions (on or before time now).

e. *Code 7* is used to establish a completion date for an event (without a predecessor) and may be used to reestablish a completion date if the event is *active* (the beginning event of an *uncompleted* activity) and it is desired to change or remove a completion date.

NOTE: Posting of completion or scheduled dates refer to "ending" event, only.

(Group to do problems of coding and completing line entries)

- *Check the addition of new events and activities to ascertain tie-in with established network.*
- *Verify that time estimates (figures from low to high) reflect optimistic, most likely and pessimistic times.*
- *Incorrect hand-count of transactions and events, (especially those dropped from file upon completion)—makes machine check and balance difficult.*

NOTE: Input data in report must be exact, and ready for cardpunch operator's use. It will be mechanically punched since the operator will make no correction but will punch the data directly from the report.

(Conduct group discussion of other possible pitfalls of foreseeable problems.)

PART V ESTABLISHMENT OF PERT DATA CONTROL

CONTROL OF PERT INPUTS AND OUTPUTS — Lesson 10

The maintenance of a data control log is required to account for the receipt and dispatch of PERT data to a designated data processing center (see data control form, Exhibit 6). Inputs are identified and recorded prior to transmittal for machine processcessing and outputs are recorded upon receipt. Date, batch number, number of transactions and number of events are verified upon completion of a log entry and as a preliminary spot check of the output.

NOTE: At the time of transmitting input, the request should include the time now (date of report), required number of output copies, and run-sequence (00 is "expected date" run (TE) and 10 is "latest allowable date" run (T_L) on the NORC). (Re-runs increase the sequence 00 to 01, 02, etc. and sequence 10 to 11, 12, etc.)

PART VI REVIEW OF PERT OUTPUT

PRELIMINARY CHECK OF OUTPUT WITH MONITOR — Lesson 11

Upon receipt of a PERT output (Exhibit 8) the posting of receipt data (number of machine transactions

and events) and comparison with the input data as well as with revisions and current critical slack will indicate, in general an acceptable run or that corrective action, possibly a re-run, should be initiated. The monitor print and flow chart may be brought quickly into the picture to verify selected completion dates and PERT expected dates.
(Orient group with practice session and initial check of output for general acceptance—refer to following Check-out Terms, Exhibit 7)

DETAILED REVIEW OF MONITOR RUN — Lesson 12

Exhibit 9 is self-explanatory and contains codes used on the monitor print which are evaluated in reviewing the output. In addition, the following actions should be taken to complete the review: (Call attention of analysts to critical areas or unsolved problems affecting output, etc.).

a. Check number of machine-count *transactions* indicated in Run #2, Word 7 (upper right-hand corner of monitor print to assure or correct original hand count on input.)

b. Check number of machine-count *events* indicated in Run #9, ending Word 7, to assure or adjust original count (with allowance for those added or deleted on last input).

c. Beginning word of above line (Run #9, Word 1) provides output 16-digit tape number as: 3909 (run date/seq/system). Log this tape number which is noted on transmittal for updating next input.

d. Spot-check critical path and "slack" sort for acceptability in view of last output and the effect of current input.

e. Spot-check several scheduled and completion dates for consistency with operational plan and target date.

f. Check-mark events in output which are scheduled for completion in next report period as basis for one phase of next *input* review—next input should indicate event completions or re-estimates of activities and indication of reasons for activity changes.
(Run through a detailed review of a sample out-put with matching monitor print for group discussion purposes)

DETAILED REVIEW OF OUTPUT — Lesson 13

1. OUTPUT REVIEW. A detailed output review involves checking the output against the machine monitor-print, which lists data acceptances and rejections, and also checking the network to correct discrepancies or errors in the processed data. The monitor-print, by the interpretation of codes described previously, will provide a detailed check of output data. Corrections, if critical, will necessitate a rerun; otherwise, the next run may be noted in the file for additions to the input. Common terms to aid in understanding the monitor print and output are provided in Exhibit 7.
(Review and have group join in check of an output with a monitor print)

2. INTERPRETING OUTPUTS FOR MANAGEMENT DECISIONS. The PERT output sheets (Exhibit 8) provide valuable information on progress to date and anticipated future progress. The 'slack' column indicates the amount of negative or positive slack in a particular event. The presence of a large amount of positive slack in an event is an indication of a place where resources might be available for possible "trade-offs." A slack value approaching zero would indicate that the event in question is likely to be a potential trouble spot. Critical paths are determined by highlighting (drawing in red or otherwise emphasizing) those lines on the chart which pass through events with zero slack. Slippage of an event along the zero slack path will cause a corresponding slip in some major end objective.

Semi-weekly reports on additional data attempt to focus attention on relatively critical paths and to audit a few specified events. Reestimates are requested for all those times that lie along the critical paths. This serves two purposes: (1) emphasis is placed on "tight" areas, and (2) estimates in these areas are marked for critical analysis with an effort to produce more accurate data where it is needed most by management.

Auditing seeks to improve the accuracy of the flow chart by requesting estimates on a small group of selected activities which differ from month to month. It is expected that all events on the chart will be covered at one time or another.

The Probability (Pr) column is the result obtained by comparing on a probability basis the expected or earliest time (TE) for the occurrence of an event with the schedule time. The number in the Pr column indicates the probability of reaching the event on or ahead of schedule. Obviously, if the Pr value is low (below .05), the probability of meeting or beating the schedule is quite remote. Values of about 0.5 are good, while values close to 1.0 are excellent.

3. DEVELOPING NEW OR REVISED PLANS. As a result of examining initial outputs on a particular component or subsystem, the Technical Branch of SP may decide to develop and to test hypothetical plans. Those events that are marked as probably being reached ahead of schedule indicate possible areas where resource trade-offs might be arranged. Events along the critical (zero or negative slack) path indicate possible areas for performance degradation or increased resource application.

If the schedule for a major event is in jeopardy, it may be possible to replan and improve the outlook for meeting the schedule. This replanning could take the form of altering the planned sequence of events. Such an alteration could postpone certain activities to a later point in time, e.g., it might be possible in certain situations to forego some testing before a flight. Thus the replanning would not force the flight to await all of the preliminary tests that were originally planned.

The difficult part of the entire PERT process is the translation of the physical situation envisioned

in the mind of the planner into the objective terms which form the language of the computer. There can be nothing hazy or indefinite about the information or instructions that are fed into the computer if accurate and reliable results are to be obtained. A computer liaison man will be available in SP 12 for comsultation on problems of computer interpretation.

4. INFORMATION ON CRITICAL AREAS. As a result of computer analysis, specific paths on the flow chart will shape up as critical. At the end of each report period, the contractor will be required to submit re-estimates of all time intervals along the critical path. The request will require either completion of a report form and/or a revision of a flow chart since corrective action may require re-estimates, completion, addition or deletion of events, etc.

PART VII REVIEW OF PERT DATA PROCESSING

GROUP REVIEW OF INPUT PREPARATION AND OUTPUT — Lesson 14

—PERT—A new management tool
—Establishing and maintaining a network (flow chart with event titles)
—Completing an input report for machine processing
—Control and review of PERT output, with reference to monitor print and chart
—PERT—of service in management decisions

(Group participation, particularly as a means of feed-back and determining degree of absorption. Group comments and discussion on course benefits, improvements, etc. All participants to write general impression of PERT training on data processing.)

PERT DATA CHECK-OUT TERMS DEFINED

1. MONITOR PRINT

Word (1-7) –
Monitor print has seven columns of figures. Each column is called a word and numbered from left to right.

Run (1-15) –
Identified by series of numbers in first word which apply to Run, e.g., Run 2–a series of 2's.

Predecessor event –
Beginning event of an activity.

Successor event –
Ending event of an activity–more than one may be tied to predecessor event.

File Input Tape –
The number of the previous input tape (3909----(date), etc.)

File Output Tape –
The number of the file tape which produced the current output (3909----(date), etc.)

Transaction –
A line item for machine processing, originally posted to the input report.

Week Now –
Date of input for machine processing, indicated on machine by number of weeks from 1 January 1959 (0.1 weeks) (Wednesday is used as base-day, e.g. Wednesday, 4 May 1960 is 70.0 weeks).

2. PERT OUTPUT

Sort –
Output data tabulation is printed in three sorts:
Sort "S"–By weeks of slack, most negative first
Sort "E"–By event number, numerically
Sort "T"–By PERT scheduled date, chronologically.

Slack –
Negative, positive or zero weeks of time, shown by event (e.g., -2.5 slack–two and one-half weeks delay).

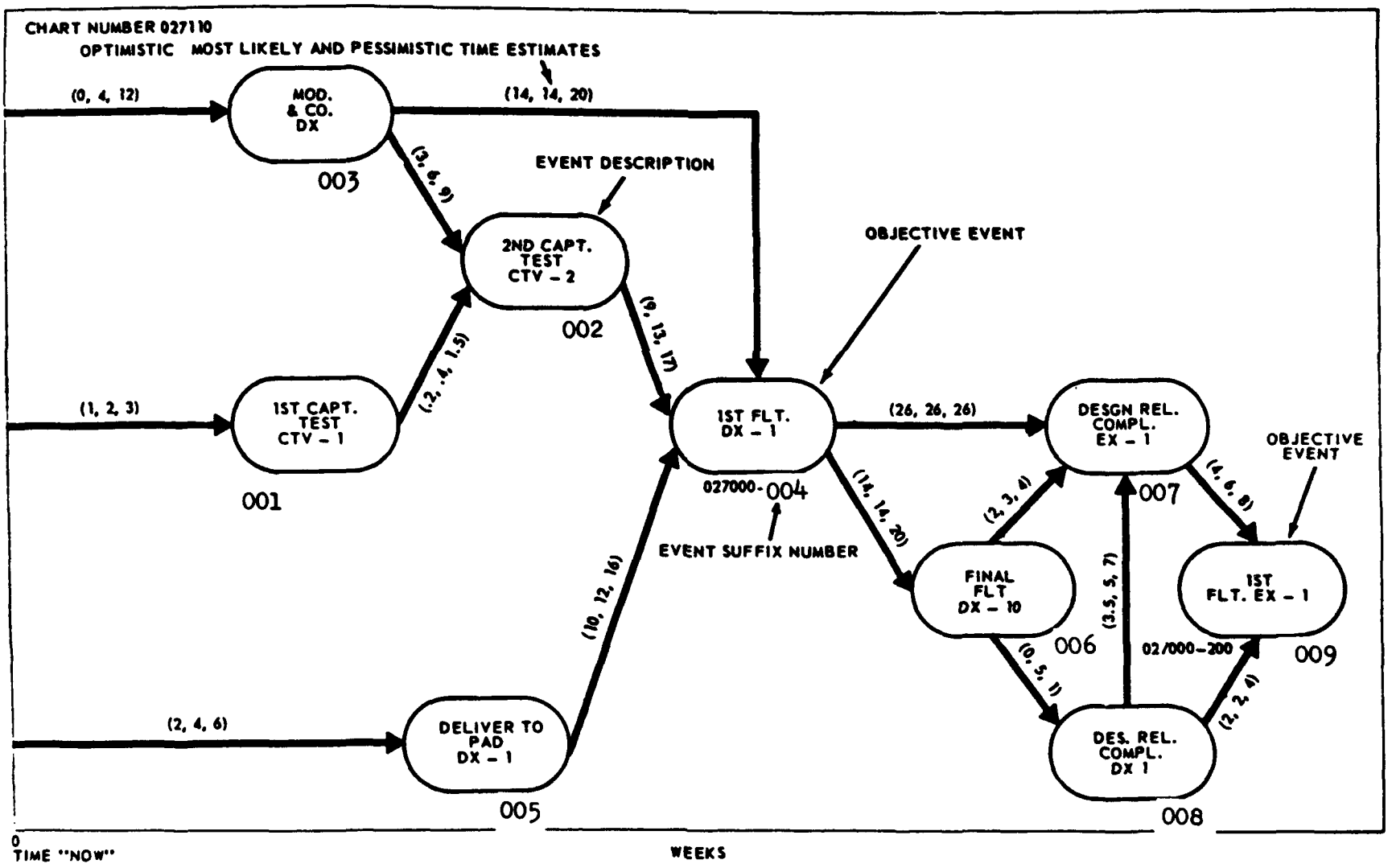
Expected date –
In view of all data which has been machine-processed, this is the PERT expected completion date (accomplished by one-way (forward) processing of data–Sequence 00).

Latest Allowable Date –
In view of all data as related to scheduled end-item date, this is the PERT date for event completion if end-item is to be on schedule (accomplished by two-way processing of data–Sequence 10).

(In addition, see Definitions of Pert Terms, Exhibit I)

EXHIBIT 1

SAMPLE PERT FLOW CHART EXHIBIT 2



PERT NOMENCLATURE TRANSMITTAL
PRNC-NWL-3930/14 (6-59)

DATE: 12 June 1960

DESIGNATOR KEYS
A - ADDITION or CORRECTION

000-000 SAMPLE NETWORK

D - DELETION

EXHIBIT 3

DES	EVENT	NOMENCLATURE (1)	(2)	(3)
A	000-000-005	DESIGN FOR A1XP-2 APPROVED BY NAVY		
A	000-000-006	FABRICATION STARTED FOR #2 COMPUTER & CABINET		
A	000-000-099	ASSEMBLY OF INSTRUMENTATION COMPLETE		
D	000-000-004			
A	000-000-135	CHECK-OUT AND TESTING OF CV 30 WIRING DIAG.		
		ETC.		

PERT
REPORT OF TIME INTERVAL ESTIMATES & PROGRESS

CLASSIFICATION: UNCLASSIFIED

Form Approved
Budget Bureau No. 45-R297
Expires 31 December 1961

INITIAL

From: (Name & Location of Contractor)
General Corporation
Electric Division
Shortstop, Connecticut

To: Special Projects Office (Spl2)
Department of Navy
Washington 25, D.C.

Flow Chart No. 011 - 420

Contract No.

Report Period
From: 6 March
To : 20 March

(A) (1) (2) (3) (4)	Activity Identification		Time Interval Estimates			Schedule or Completion Date			Remarks (See Instructions, over)
	Beginning Event No. (B)	Ending Event No. (C)	Optimistic (weeks) * (D)	Most Likely (weeks) * (E)	Pessimistic (weeks) * (F)	Mo.	Day	Yr. (G)	(H)
12 13-16 17	18 - 26	34 - 42	44 - 47	48 - 51	52 - 55	60	-	65	
7		011-420-000				03	06	60	Base Line
1	011-420-000	011-420-624	011.0	013.0	017.0				New Activity
7		011-420-677				03	09	60	Completion
1	011-420-701	011-420-702	001.0	002.0	003.0				New Activity
3	011-420-701	011-420-702				03	20	60	Completion
1	011-420-703	011-420-704	001.0	002.0	002.5				New Activity
3	011-420-703	011-420-704				03	17	60	Completion
1	011-420-690	011-420-691	013.0	015.0	019.0				New Activity
1	011-420-693	011-420-695	007.0	010.0	015.0				New Activity
1	011-420-694	011-420-695	003.0	005.0	007.0	08	30	60	New Activity - Scheduled Date
1	011-420-695	011-420-698	002.0	003.0	007.0				New Activity
1	011-420-698	011-420-699	003.0	007.0	012.0				New Activity

Signature of Responsible Official:
J. J. McJONES

Date Signed:
20 March 1960

CLASSIFICATION:
UNCLASSIFIED

* Columns D, E, and F. These estimates should be given for the full activity even though the activity has already started.

EXHIBIT 4

PERT
REPORT OF TIME INTERVAL ESTIMATES & PROGRESS

CLASSIFICATION: UNCLASSIFIED

Form Approved
Budget Bureau No. 45-R297
Expires 31 December 1961 REVISION

From: (Name & Location of Contractor)
United Corporation
Electric Division
Pottiek, Connecticut

To: Special Projects Office (Sp12)
Department of Navy
Washington 25, D.C.

Flow Chart No. 011-420

Contract No. N61339-578 (FBM)

Report Period
From: 20 March 1960
To : 2 April 1960

(A) (1) (2) (3) (4)	Activity Identification: Beginning Event No. (B)	Activity Identification: Ending Event No. (C)	Time Interval Estimates: Optimistic (weeks) * (D)	Time Interval Estimates: Most Likely (weeks) * (E)	Time Interval Estimates: Pessimistic (weeks) * (F)	Schedule or Completion Date (G) Mo.	Day	Yr.	Remarks (See Instructions, over) (H)
12 13-16 17	18 - 26	34 - 42	44 - 47	48 - 51	52 - 55	60 - 65			
3	011-420-660	011-420-661				03	31	60	Completion
5	011-420-500	011-420-660							Deletion
4		011-420-715				08	25	60	Scheduled Date
2	011-420-620	011-420-624	011.0	012.0	013.0				Revised Schedule
2	011-420-640	011-420-641	007.0	008.0	009.0				Production Delay
2	011-420-664	011-420-674	010.0	011.0	012.0	05	18	60	Revised Schedule
2	011-420-676	011-420-677	008.0	009.0	010.0				Approval Delay
1	011-420-675	011-420-680	008.0	009.0	010.0				ESO to Schedule - New Activity
2	011-420-699	011-420-702	006.0	007.0	008.0				Approval Delay
2	011-420-614	011-420-622	003.0	003.0	003.0				Reschedule production & Test
2	011-420-622	011-420-623	001.0	001.0	002.0				Reschedule production & Test
7		011-420-635				04	01	60	Completion (no predecessor)

Signature of Responsible Official:
J. J. McJones
J. J. McJONES

Date Signed:
2 April 1960

CLASSIFICATION:
UNCLASSIFIED

* Columns D, E, and F. These estimates should be given for the full activity even though the activity has already started.

EXHIBIT 5

INSTRUCTIONS

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

Submission. Reports will be submitted bi-weekly. Required timing will be specified at the time of installation of the PERT system for the component involved. Reports are required even though no significant developments occurred during the reporting period. Verbal reports will be accepted under unusual circumstances but must be confirmed with written reports. Four copies should be forwarded as f llows:

1. Special Projects Office, Bureau of Ordnance Department of the Navy, Washington 25, D. C. Attn: SP 12 (2); SP Cognizant Technical Branch (1)

Scope of Report. The following items will be reported on and coded in subcolumn (1) of column A: code 1, new activities; code 2, re-estimates of existing activities; code 3, completed activities; code 4, scheduled date for events; code 5, deleted activities.

Column A. Fill in subcolumn (1) as above. Do not fill in subcolumns (2), (3), and (4).

Activity Identification. In columns B and C enter the flow chart identification numbers for the events which constitute the beginning and ending points of the intervening activity (a row) being reported on. The beginning event lies to the left of the tail of the arrow on the PERT flow chart; the ending event lies to the right of the head of the arrow. It is important (for key punching purposes) that all nine digits of each of the two event numbers defining an activity be included. For example, a number might read 027-300-007.

Estimated Time. In columns D, E, and F enter the optimistic, most likely, and pessimistic time estimates for appropriate activities. These estimates should be expressed in weeks and should refer to the full activity time -- whether or not the activity has already started. Each estimate should appear as four digits plus a decimal point (e.g., 009.0, 018.0, 040.0). The three times are defined as follows:

Optimistic Time (Col. D): A minimum time which (1) is attainable only when unusually good luck is experienced and (2) has no more than one chance in 100 of being realized.

Most likely Time (Col. E): A probable time which (1) would reasonably be expected by the person best qualified to judge and (2) would occur most often if the activity could be repeated numerous times under exactly the same conditions.

Pessimistic Time (Col. F): A maximum time which (1) can occur only if unusually bad luck is experienced and (2) has no more than one chance in 100 of being realized. This time should reflect the possibility of initial failure and a fresh start. However, it should not be influenced by the possibility of strikes or "acts of God," e.g., floods, fires, etc.

Completion Dates. In column G enter the exact date (month, day, and year) on which a particular activity was completed. The completion of an activity (flow chart arrow) should be reported even though the event (flow chart circle) to which it leads has not been completed. Six digits, including any necessary zeros -- e.g., 07-04-59 -- should be supplied in reporting completion dates.

Remarks. In column H (1) indicate the nature of the item being reported, e.g., new activity, new event, re-estimate, etc., (2) explain the reasons for re-estimates, (3) provide definitions of new or revised events and activities, and (4) enter any other information which will help clarify the nature and significance of the items reported. A supplemental sheet should be attached where adequate space is not available in the remarks column.

PERT DATA CONTROL SHEET NETWORK EXHIBIT 6

Week Nov	Date	Batch #	Total Trans		Changes in Events			Total Events		File Tape #	Remarks
			Hand	Machine	Delete	Add	Net	Hand	Machine		

SAMPLE PERT OUTPUT

EXHIBIT 8a

Date 5/04/60 Week 70.0 Sequence "00" Page 2 S

EVENT	NOMENCLATURE	EXPECTED DATE	LATEST ALLOWABLE DATE	SCHEDULE DATE	ACTUAL DATE	SLACK	STD DEV	PROB
024-089-015	NOT TITLED	0/00/00			4/27/60	- 0.3	0.0	
024-089-037	NOT TITLED	5/04/60				- 0.3	0.0	
024-089-018	NOT TITLED	0/00/00			4/25/60	0.0	0.0	
024-089-039	NOT TITLED	5/09/60				0.0	0.1	
024-089-017	NOT TITLED	5/09/60				0.0	0.1	
024-089-019	NOT TITLED	5/09/60				0.0	0.2	
024-089-013	NOT TITLED	5/05/60				0.5	0.1	
024-089-016	NOT TITLED	5/05/60				0.5	0.1	
024-089-999	NOT TITLED	0/00/00				0.7	0.0	
024-089-004	NOT TITLED	5/18/60				0.7	0.3	
024-089-031	NOT TITLED	5/29/60				0.7	0.3	
024-089-052	NOT TITLED	6/26/60				0.7	0.5	
024-089-074	NOT TITLED	7/02/60				0.7	0.4	
024-089-084	NOT TITLED	7/30/60				0.7	0.5	
024-089-097	NOT TITLED	9/10/60		9/15/60		0.7	0.6	.88
024-089-064	NOT TITLED	5/26/60		6/01/60		0.8	0.2	.99
024-089-075	NOT TITLED	6/10/60				0.8	0.3	
024-089-076	NOT TITLED	6/17/60				0.8	0.4	
024-089-077	NOT TITLED	6/25/60				0.8	0.4	
024-089-008	NOT TITLED	0/00/00			5/03/60	0.9	0.0	
024-089-003	NOT TITLED	0/00/00			4/21/60	1.0	0.0	
024-089-033	NOT TITLED	0/00/00			5/02/60	1.0	0.0	
024-089-006	NOT TITLED	5/09/60				1.0	0.1	
024-089-027	NOT TITLED	5/19/60				1.0	0.2	
024-089-028	NOT TITLED	5/19/60				1.0	0.2	

SAMPLE PERT OUTPUT

EXHIBIT 8b

Date 5/04/60 Week 70.0 Sequence "10" Page 2 S

EVENT	NOMENCLATURE	EXPECTED DATE	LATEST ALLOWABLE DATE	SCHEDULE DATE	ACTUAL DATE	SLACK	STD DEV	PROB
024-089-015	NOT TITLED	0/00/00	4/25/60		4/27/60	- 0.3	0.0	
024-089-037	NOT TITLED	5/04/60	5/02/60			- 0.3	0.0	
024-089-018	NOT TITLED	0/00/00	4/25/60		4/25/60	0.0	0.0	
024-089-039	NOT TITLED	5/09/60	5/09/60			0.0	0.1	
024-089-017	NOT TITLED	5/09/60	5/09/60			0.0	0.1	
024-089-019	NOT TITLED	5/09/60	5/09/60			0.0	0.2	
024-089-013	NOT TITLED	5/05/60	5/09/60			0.5	0.1	
024-089-016	NOT TITLED	5/05/60	5/09/60			0.5	0.1	
024-089-999	NOT TITLED	0/00/00	0/00/00			0.7	0.0	
024-089-004	NOT TITLED	5/18/60	5/23/60			0.7	0.3	
024-089-031	NOT TITLED	5/29/60	6/02/60			0.7	0.3	
024-089-052	NOT TITLED	6/26/60	6/30/60			0.7	0.5	
024-089-074	NOT TITLED	7/02/60	7/07/60			0.7	0.4	
024-089-084	NOT TITLED	7/30/60	8/04/60			0.7	0.5	
024-089-097	NOT TITLED	9/10/60	9/15/60	9/15/60		0.7	0.6	.88
024-089-064	NOT TITLED	5/26/60	6/01/60	6/01/60		0.8	0.2	.99
024-089-075	NOT TITLED	6/10/60	6/16/60			0.8	0.3	
024-089-076	NOT TITLED	6/17/60	6/23/60			0.8	0.4	
024-089-077	NOT TITLED	6/25/60	6/30/60			0.8	0.4	
024-089-008	NOT TITLED	0/00/00	5/09/60		5/03/60	0.9	0.0	
024-089-003	NOT TITLED	0/00/00	4/28/60		4/21/60	1.0	0.0	
024-089-033	NOT TITLED	0/00/00	5/09/60		5/02/60	1.0	0.0	
024-089-006	NOT TITLED	5/09/60	5/16/60			1.0	0.1	
024-089-027	NOT TITLED	5/19/60	5/26/60			1.0	0.2	
024-089-028	NOT TITLED	5/19/60	5/26/60			1.0	0.2	

MONITOR PRINT CODES – INTERPRETED

RUN #2 *(Designated by series of "2's" on monitor print)*

Code	Meaning	Reviewer's Action
211	"Optimistic" estimate of time interval exceeds "most likely" estimate; rejected (e.g., 005.0, 003.0, 008.0)	Correct and resubmit time estimate on input report
212	"Pessimistic" estimate is less than "most likely;" rejected (e.g., 000.5, 002.0, 000.1)	Correct and resubmit time estimate
213	Decimal in optimistic time interval mispunched (e.g., 000.5 instead of 005.0)	Note or resubmit estimate
214	Decimal in pessimistic time is mispunched (e.g., 080.0 instead of 008.0)	Note or resubmit estimate
215	Transaction has a pessimistic estimate of more than 39 weeks, not rejected, but examine for error	Correct, if appropriate
216	Transaction has a pessimistic estimate greater than zero, but less than two weeks. Not rejected, but examine	Note and check
221	This time estimate range exceeds 60 weeks (008.0, 012.0, 071.0) examine; not rejected	Correct estimate if appropriate
231	Date is earlier than 1 Jan. 1959 and is rejected for NORC processing if transaction code 3, 4 or 7	Correct date and resubmit
232	Month of "00" is impossible and not accepted if transaction code 3, 4, or 7	Correct and resubmit
233	Month–number is greater than 12 and not accepted if transaction code 3, 4, or 7	Correct and resubmit
234	Day of month is "00" and therefore, not accepted if transaction code 3, 4, or 7	Correct and resubmit
235	Day of month is over 31 and therefore, not accepted if transaction code 3, 4 or 7	Correct and resubmit
236	Code 4 (Scheduled Date) transaction is dated *earlier* than time now and therefore rejected (Maybe completion date was meant, but wrong code used?)	Examine and correct
237	Reverse of #236–"Week now" will appear in Word 6 of print opposite rejection date due to use of code 3 or 7 indicating completion date–but date is *later* than time now	Examine and correct
261	Transaction has been rejected because transaction code is "0"	Code and resubmit
262	Transaction has been rejected because Code *9* (not in program) has been used (The erroneous Code *9* appears in Work 5)	Correct by code and resubmit
263	Re-estimate–transaction has no time estimates and should be reviewed; not machine rejected	Examine and correct estimate, if appropriate
265	Completion transaction (Code 3) carries time-estimate therefore rejected–Maybe new or re-estimated activity? (Estimates appear in Work 6 of print)	Correct and resubmit
266	Completion transaction has no completion date; rejected	Correct and resubmit
267	Code 4 (Scheduled Date) transaction carries time-estimate; rejected (maybe wrong code–is it Code 1 or 2?)	Correct and resubmit
268	Code 4 (Scheduled Date) transaction, without scheduled date–removes any previous date; accepted, but review (Perhaps should be Code 5?, or date should be included)	Review and correct as appropriate
269	Code 5 (Deletion) transaction carried a time estimate; rejected (Should be Code 1 or 2?)	Correct and resubmit

EXHIBIT 9

Code	Meaning	Reviewer's Action
270	Code 5 (Deletion) transaction has a date; rejected (Should be Code 3?)	Correct and resubmit
273	Code 7 (Completion) transaction carries time estimates; rejected	Correct and resubmit
274	Code 7 (Completion) transaction carries no completion date—will erase any previous dates—accepted	Review for approval of transaction
299	One of these reasons caused rejection: — No predecessor, unless Coded 4 or 7 — No successor — Predecessor and successor are equal and suffix is 500 or less	Correct and resubmit
	RUN #6 *(See series of "6's" on monitor run)*	
601	Word 6 shows *event* which is not in file—has companion reject #602	Review and establish event, if appropriate
602	Words 3 and 4 show *activity* which is not in file; rejected	Review and establish activity, if appropriate
603	Activity transaction is a duplicate—already in file; rejected	Review to assure correct time interval
605	Duplicate activity transactions result in rejection of one; review for acceptance of correct transaction—usually 2nd transaction	Review and assure establishment of correct activity
606	Activity listed in Words 3 and 4 completed the ending event (Word 4), but another activity beginning in Word 7 has not been completed or deleted—attention is directed (Short path flag is necessary)	Review and correct, if appropriate
611	Code 3 (Completion) transaction removed last predecessor from file and ending event (Word 4) is *completed* —attention is directed	Review for possible action
612	Code 5 (Delete) transaction deleting last predecessor activity—attention is directed	Review for approval
651	Re-estimate is more than 3 weeks *less* or 4 weeks *more* than previous estimate—shows reduction in contractors' estimate to offset late completion Word 6 lists old estimate—Word 7 lists new estimate	Note
652	Re-estimate is more than 4 weeks *greater* than previously—attention invited Word 6 lists old estimate—Word 7 lists new estimate Word 7 lists differences in estimates	Note
702	Indicates event which is dropped from file-review	Note
	RUN #10 *(Series of "10's" on monitor run)*	
1001	Each completed event in file is printed, with up to 4 successors Uncompleted activities may be located by check here ,	Note

NOTE: Rejections indicated by several of above codes include such categories as: date error, time estimate error, coding error, and event or activity error (not in file or duplicate)

EXHIBIT 9 (Continued)

DATE 03-01-60

PERT SYSTEM GRAPHIC REPORT
•=Expected Date - Basis
^=Scheduled Date

PAGE 01

EVENT CODE & DESCRIPTION	1960 JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
020-000-001 Nose Cone Fabrication	••••••• ^^^^^^^
020-000-002 Develop Propellant	••••••• ^^^^^^^
020-000-003 Design Guidance Package	••••••••• ^^^^
020-000-004 Assemble Instrumentation	••••••••• ^^^^
020-000-005 Drop Test Nose Cone	••••••••• ^^^^^^
020-000-006 First Stage Motor Prepared	••••••••• ^^^^^^^^^^^^^^
020-000-007 Second Stage Motor Prepared	••••••••• ^^^^^^^^^^^^^
020-000-008 Guidance Package Assembled	••••••••• ^^^^^^^^^^^^^^
020-000-009 Ship Instrumentation Package	••••••••• ^^^^^^
020-000-010 Complete Wind Tunnel Test of Nose Cone	••••••••• ^^^^^^^^^^^^^^
020-000-011 Ship First Stage Motor	••••••••• ^^^^
020-000-012 Ship Second Stage Motor	••••••••• ^^^^^^^^
020-000-013 Ship Guidance Package	•••••••••• ^^^^^^^^^^^^
020-000-014 Test Guidance-Instrumentation Package	•••••••••• ^^^^^^^^^^^^^^^^^^^^^^^^
020-000-015 Test Motor	•••••••••• ^^^^^^^^^^^^^^^^^^^^^^^^
020-000-016 Assembled Missile for Test	•••••••••• ^^^^^^^^^^^^^^^^^^^^

EXHIBIT 10a

DATE 03-01-60

PERT SYSTEM GRAPHIC REPORT
*=Expected Date - Basis
^=Scheduled Date

EVENT CODE & DESCRIPTION	1959 JFMAMJJASOND	1960 JFMAMJJASOND	1961 JFMAMJJASOND	1962 JFMAMJJASOND	1963 JFMAMJJASOND
020-000-001 Nose Cone Fabrication	^^^^^^^^^^^^ **				
020-000-002 Develop Propellant	^^^^^^^^^^^^ ^^^				
020-00-003 Design Guidance Package	^^^^^^^^^^^^				
020-000-004 Assemble Instrumentation	^^^^^^^^^^^^ ^^^^				
020-000-005 Drop Test Nose Cone	^^^^^^^^^^^^ ^^^^				
020-000-006 First Stage Motor Prepared	^^^^^^^^^^^^ ^^^				
020-000-007 Second Stage Motor Prepared	^^^^^^^^^^^^ ^^^				
020-000-008 Guidance Package Assembled	^^^^^^^^^^^^ ^^^^^				
020-000-009 Ship Instrumentation Package	^^^^^^^^^^^^ ^^^^^^^				
020-000-010 Complete Wind Tunnel Test of Nose Cone	^^^^^^^^^^^^ ^^^^^^^				
020-000-011 Ship First Stage Motor	^^^^^^^^^^^^ ^^^^^^^^^				
020-000-012 Ship Second Stage Motor	^^^^^^^^^^^^ ^^^^^^^^^				
020-000-013 Ship Guidance Package	^^^^^^^^^^^^ ^^^^^^^^^^				
020-000-014 Test Guidance-Instrumentation Package	^^^^^^^^^^^^ ^^^^^^^^^^^^				
020-000-015 Test Motor	^^^^^^^^^^^^ ^^^^^^^^^^^^ ^^^^^^^				
020-000-016 Assembled Missile for Test	^^^^^^^^^^^^ ^^^^^^^^^^^^ **				
020-000-017 Firing Report Prepared	^^^^^^^^^^^^ ^^^^^^^^^^^^ **				

EXHIBIT 10b

☆ U. S. GOVERNMENT PRINTING OFFICE : 1960 O - 577825