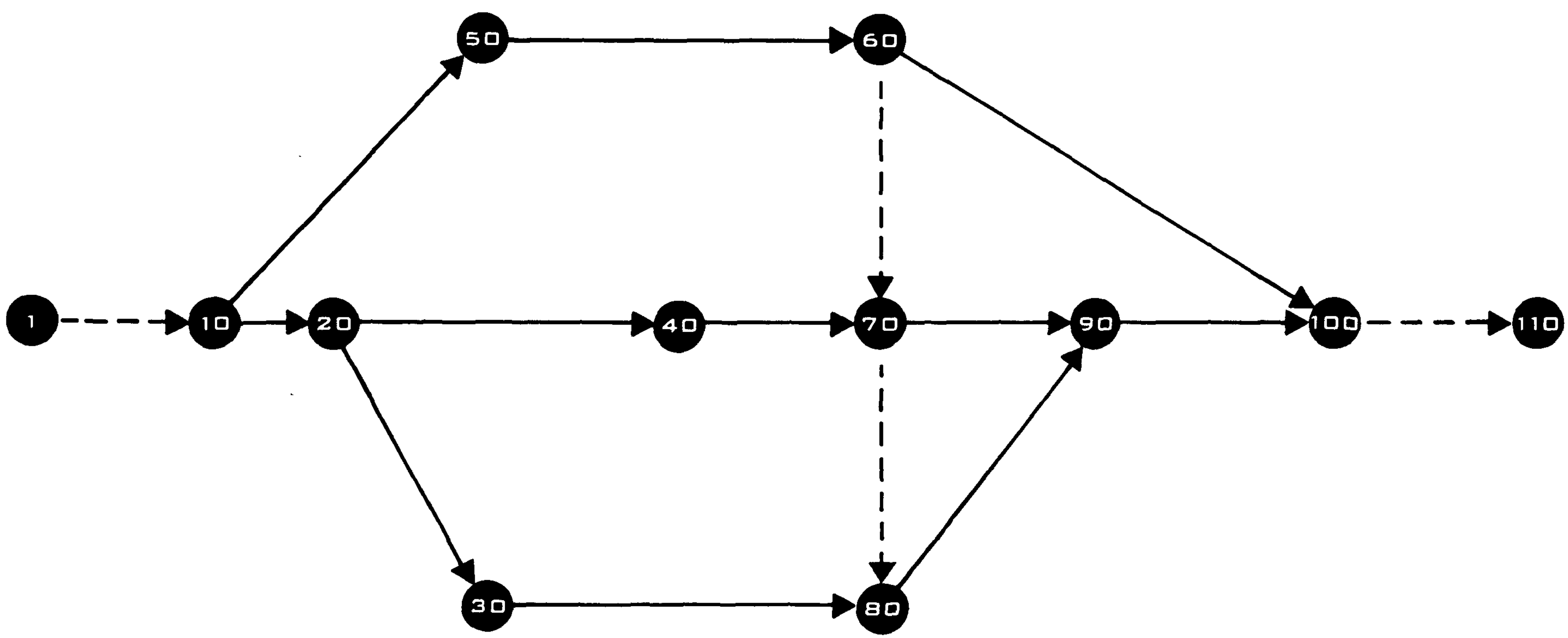
PROGRAM EVALUATION AND REVIEW TECHNIQUE

CONCEPTS AND APPLICATION TO SOLID WASTE MANAGEMENT



P E R T

CONCEPTS AND APPLICATION TO SOLID WASTE MANAGEMENT

This report (SW-35ts) was written by

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A NEW APPROACH IN SOLID WASTE MANAGEMENT

Solid waste management is a complex activity requiring the allocation of limited resources, one of which is managerial talent itself. Many solid waste related activities involve the design and construction of sizable engineering projects. In order to keep pace with increasing demands on the time and talents of management, tools must be developed and applied that will increase the effectiveness of project supervision and control.

Problem areas must be identified and objective decisions made to achieve effective and efficient coordination of men, machines, and other resources in solid waste management. Program Evaluation and Review Technique (PERT) is one method used to plan and control projects. It has been in general use in many fields but has been applied only recently to solid waste management problems.

The Federal solid waste management program (the Bureau of Solid Waste Management) is responsible for awarding grants and supervising their progress and needs to evaluate selected information for timely but comprehensive decision making. It has, therefore, begun applying PERT to planning and demonstration projects. The

City of San Diego received a demonstration grant to investigate the feasibility of baling solid waste. The Bureau used PERT to help in planning and developing the project.

The purpose of this paper is to: (1) give the Bureau staff and grantees a general outline of the PERT technique; (2) show how it could be applied to a typical solid waste management problem; (3) illustrate how PERT was applied to a Bureau demonstration project.

--RICHARD D. VAUGHAN, *Director*
Bureau of Solid Waste Management

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Rationale

PERT is a systematic approach that forces those involved to look closely at their information before making a decision. The interrelationships of activities* and events† making up the project and the estimated duration of each activity enable the project's scheduled completion date and its intermediate phases to be calculated. Those activities that, if delayed, will cause the completion of the project to slip are clearly indicated. The allowable leeway for each of the other activities is calculated. Information is periodically updated as the project progresses.

PERT has been used successfully since early 1959 when the U.S. Navy developed it to monitor the progress of the POLARIS Fleet Ballistic Missile program. PERT's ability to coordinate the activities of more than 2,000 contractors advanced the

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*An activity is a task that consumes such resources as time, men, money, or equipment; it is represented graphically by an arrow. An activity cannot begin until the event preceding it has occurred.

†An event represents a point in time when one or more activities has been completed. Its diagrammatic symbol is a circle (node). An event cannot occur until all the activities leading to it have been completed.

POLARIS program by two years. PERT is now used routinely in defense programs and in the aerospace, construction, and chemical industries.

PERT's underlying principle is that controlling a few critical activities will better the control of time and costs for the entire project. The systematic approach followed leads to a better exploitation of information than that achieved by less-structured methods, such as bar charts.

PERT is most effective when used with new, infrequently repeated activities in which costs and schedule controls are critical. The technique is applied primarily to projects in which a first-time effort, such as research and development work, is involved. Since time and cost estimates are uncertain, simple probabilistic procedures are employed.

Methodology

Four basic steps are followed in applying PERT to a project:

1. A project diagram, called a network, is constructed. This shows the sequence and interrelationships of all the events and activities that must be accomplished to complete the project. During the construction, a logical set of rules must be used to determine the sequence of events and activities.

2. Time estimates are assigned to the activities. Because the duration of an activity is uncertain, optimistic (a), most likely (m), and pessimistic (b) time estimates are made. They should be formulated by the individual or group most familiar with the activity. The three estimates are combined statistically to provide an expected duration (weighted mean), using the formula $\frac{a+4m+b}{6}$.

3. The network is analyzed. This procedure may be done manually for small projects or by computer for larger ones. If more than about 40 activities are involved, it is usually more convenient to have a computer make the numerous arithmetic calculations. The analysis determines the estimated completion dates for both the intermediate phases and the entire project. The critical path* is identified, and the float† for each activity is calculated. Analysis is undertaken periodically during the life of the project, and the latest status is recorded so that new expected completion dates, float times, and critical paths (if changed) can be generated by PERT's routines.

*The critical path is the longest sequence of activities in the network and is the path that takes the most time. A delay in an activity on the critical path will delay the project completion date.

†Float is the difference between the latest time and the earliest time at which an activity can begin. It is a measure of the leeway or flexibility of an activity--the difference between the time available for an activity and its expected duration. Each activity has a calculated float, and the sequence of activities having zero float is the critical path.

4. If the analysis indicates that slippages have occurred or are developing, resources are shifted to those activities that are most critical to completing the project on schedule.

Benefits to Management

PERT proves beneficial by:

1. Forcing logical thinking. Network preparation provides definition and understanding of the project's interrelated activities and events.

2. Providing data for making objective decisions.

3. Identifying problem areas. This focuses attention on those activities which are critical to project completion.

4. Providing analysis to determine the most efficient allocation of resources.

5. Defining responsibilities. This, in effect, eliminates "buck passing."

6. Measuring work performance.

7. Utilizing simple probabilistic procedures. Schedules are, therefore, more realistic because the uncertainty of time estimates is taken into account.

8. Enabling a large amount of information to be presented and analyzed in a systematic manner, either manually or by computer.

9. Allowing complex projects to be planned well in advance.

10. Providing an information flow. Individuals and sections can see how their efforts affect other groups and project completion.

Computer "Package" Available

A Project Control System package is available for use on most computers to plan, schedule, and control project-type work. A program for the IBM 1130 computer has been used and is available within the Bureau. The system consists of a set of routines stored on a disc, and it performs the data processing required to use PERT. After the network has been prepared, the program calculates scheduled completion dates and prints out various reports. The input is straightforward and relatively easy to prepare. Output reports are designed to help project analysts, first-line supervisors, and high-level managers. The user can either look at the project's general progress or examine details. Reports can be customized to highlight areas of special interest.

PERT APPLIED TO SAMPLE PROJECT

Approach Employed

To illustrate how PERT can be applied, one phase of an overall project involving the construction of a solid waste transfer station is outlined. The example is considered a small project, even though it is, in fact, a simplified first part of a larger undertaking. The project has, of course, more interrelationships than are shown and is actually more complicated than presented. For example, engineering design is normally modified after equipment specifications and site selection have been evaluated, but this has not been shown in the example. This was done deliberately because the PERT method can be understood better by considering an entire project which is oversimplified than by examining only a small part in great detail.

Activities and Events

The tasks, called activities, describe the project completely (Table 1). It is assumed that the project engineers had previously agreed on the activities and the precedence they would be given. As time passes, activities are accomplished from left to right on the network (Figure 1). Some must be performed sequentially, some

TABLE 1

ACTIVITY BREAKDOWN FOR SAMPLE PROJECT

Activity listing	Precedence requirements	Time estimates* (weeks) a	m	b	(wm)	Estimated cost† ($)
a. Engineering design	none	9	10	12	(10.2)	20,000
b. Specifications for equipment	none	3	4	4	(3.8)	5,000
c. Construction drawings	a	10	12	14	(12.0)	10,000
d. Site selection	a	4.2	8	8	(7.4)	2,000
e. Approval of construction drawings	c	2	4	6	(4.0)	2,000
f. Approval of selected site	d	2	4	6	(4.0)	2,000
g. Evaluation and approval of equipment specifications	b	8	10	13	(10.2)	3,000
h. Final detailed construction drawings	e,g	0.6	1.2	4	(1.6)	5,000
i. Site acquisition	e,f,g	2.4	3	4	(3.6)	5,000
j. Building construction and award	h,i	7.2	8	10	(8.2)	1,000
k. Equipment bid and award	g	7.2	8	10	(8.2)	500

*See page 3.
†Optional.

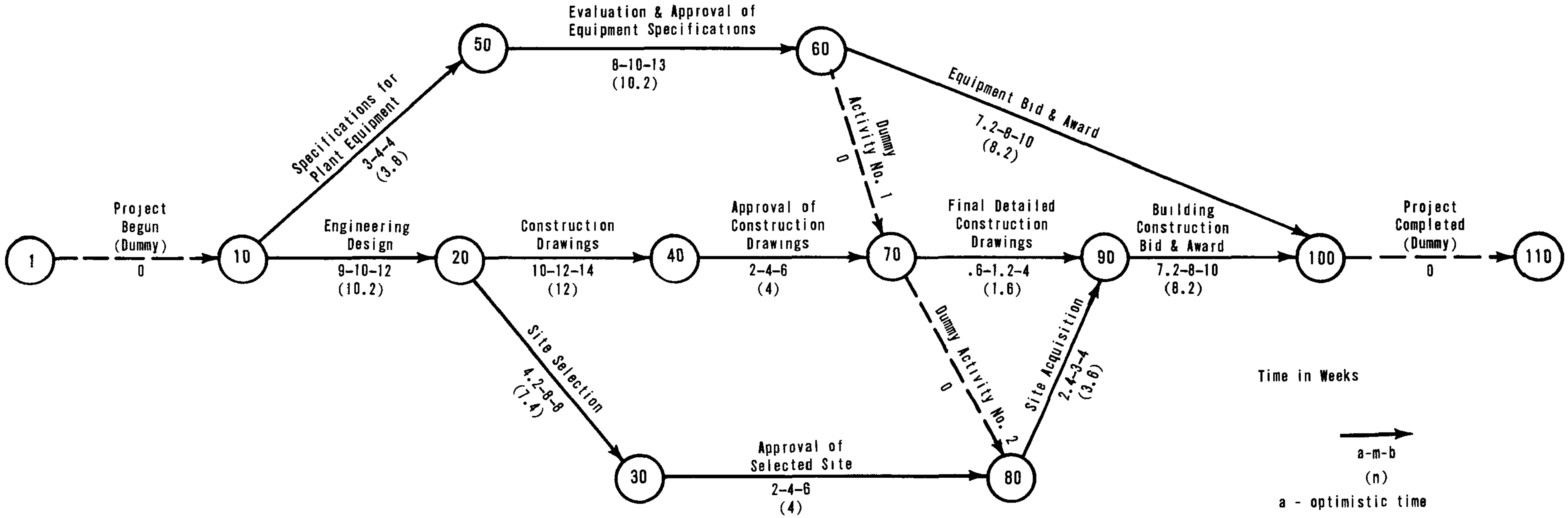

FIGURE 1. SAMPLE PROJECT NETWORK (Design Of and Preparation For Construction of a Solid Waste Transfer Station)

can be undertaken simultaneously, and some can be initiated only after several others have been completed. An activity which has a dependency relationship only and does not accomplish a task or consume resources is called a dummy activity. It is used to maintain logic and is shown as a broken arrow.

Events are arbitrarily numbered so that an activity can be uniquely identified by referring to the events immediately preceding and following it. For example, in the network illustrated, "Engineering Design of Plant" is called activity 10-20. When the project begins (event 10), activity 10-20 and 10-50 can start immediately; nothing needs to be done beforehand, and they can go on simultaneously. On the other hand, event 70 can occur only after activities 40-70 and 60-70 (and hence 50-60) have been completed. Then 70-90 and 70-80 (and hence 80-90) may begin. When event 100 occurs, the project is completed.

Critical Path

All possible paths in the example can be determined by inspection, the expected duration times (weighted means) along each path summed, and the longest selected as the critical path.

Path	Event Numbers	Total Time
1	10-50-60-100	22.2
2	10-50-60-70-90-100	23.8
3	10-20-40-70-90-100	36.0*
4	10-20-30-80-90-100	33.4
5	10-20-40-70-80-90-100	38.0†
6	10-50-60-70-80-90-100	25.8

*Lesser critical path.
†Critical path.

Since many possible paths can be found in a large project, a computer should be used to make the required arithmetic calculations, rather than accomplishing this by hand. The method employed in the sample appears in Appendix A.

Resources, such as men and equipment, can be allocated using float times as a guide to ensure the completion of critical activities as scheduled. As new time estimates or changes in activities are made and progress toward project completion occurs, new float times and completion dates are calculated. Resources can then be shifted to effect the most efficient use.

It should be noted that sources of error may be introduced by the physical structure of the network itself. If a number of paths of similar length but having few activities in common comprise a network, the resulting project mean (and standard deviation, if calculated) will have a greater error. (See Reference 3 for discussion and examples.) If, however, the critical path is significantly longer than the others, the PERT method will give approximately correct results.

Reports

From the information discussed earlier, the computer makes all network calculations and prints out reports which can be easily read and understood. Although many types of reports and modifications can be obtained, the following three are the most useful.

1. The project's network identification number and descriptive title appear at the top of the Schedule Report (Table 2). The Run Date is the date computer analysis was made using the information prepared on the Data Date. The project is scheduled to begin February 1, 1969, and to be completed October 29, 1969. The first three columns in the table list all the activities in the project. The third row, for example, contains the data for activity 10-50, Specification for Plant

TABLE 2

IBM PROJECT CONTROL SYSTEM

RUN DATE 01 FEB 69   * *   S C H E D U L E   R E P O R T   * *   DATA DATE 01 FEB 69

RUN SEQUENCE 1   NETWORK ID 9999   DESIGN AND PREPARATION FOR CONSTRUCTION   FROM 01 FEB 69 TO 29 OCT 69

SEQUENCE E S   PAGE 1

(I)	(J)	D E S C R I P T I O N	TOT DURAT	CAL	START EARLY	START LATE	ST FLOAT	FINISH EARLY	FINISH LATE	FIN FLOAT
01	10	PROJECT BEGIN DUMMY ACTIVITY	0.0	51 6	3FEB69	3FEB69	0.0	3FEB69	3FEB69	0.0
10	20	ENGINEERING DESIGN OF PLANT	51.0	51 6	3FEB69	3FEB69	0.0	14APR69	14APR69	0.0
10	50	SPECIFICATIONS FOR PLANT EQUIPMENT	19.0	51 6	3FEB69	29APR69	61.0	27FEB69	23MAY69	61.0
50	60	EVALUATION AND APPROVAL OF EQUIPMENT SPECS	51.0	51 6	28FEB69	26MAY69	61.0	9MAY69	6AUG69	61.0
20	30	SITE SELECTION	37.0	51 6	15APR69	16MAY69	23.0	5JUN69	9JUL69	23.0
20	40	CONSTRUCTION DRAWINGS	60.0	51 6	15APR69	15APR69	0.0	9JUL69	9JUL69	0.0
60	70	DUMMY ACTIVITY ONE	0.0	51 6	9MAY69	6AUG69	61.0	9MAY69	6AUG69	61.0
60	100	EQUIPMENT BID AND AWARD	41.0	51 6	12MAY69	3SEP69	79.0	9JUL69	29OCT69	79.0
30	80	APPROVAL OF SELECTED SITE	20.0	51 6	6JUN69	10JUL69	23.0	3JUL69	6AUG69	23.0
40	70	APPROVAL OF CONSTRUCTION DRAWINGS	20.0	51 6	10JUL69	10JUL69	0.0	6AUG69	6AUG69	0.0
70	80	DUMMY ACTIVITY TWO	0.0	51 6	6AUG69	6AUG69	0.0	6AUG69	6AUG69	0.0
70	90	FINAL DETAILED CONSTRUCTION DRAWINGS	8.0	51 6	7AUG69	21AUG69	10.0	18AUG69	2SEP69	10.0
80	90	SITE ACQUISITION	18.0	51 6	7AUG69	7AUG69	0.0	2SEP69	2SEP69	0.0
90	100	BUILDING CONSTRUCTION BID AND AWARD	41.0	51 6	3SEP69	3SEP69	0.0	29OCT69	29OCT69	0.0
100	110	PROJECT COMPLETED DUMMY ACTIVITY	0.0	51 6	29OCT69	29OCT69	0.0	29OCT69	29OCT69	0.0

PROJECT BASE DATE 1 FEB 69   PROJECT DURATION 271.0   PROJECT COMPLETION DATE 29 OCT 69

Equipment. The next column shows total duration time (19.0 days). CAL is the heading for the type of calendar used: five-day week (5), work week begins on Monday (1), no work is done on holidays specified (blank), and the time unit originally specified for the activities in weeks (6). Other options are available.

The earliest activity 10-50 can begin is February 3, 1969, and the latest is April 29 (not to delay the completion date). In the next column is the calculated float (61.0 days). [The ST FLOAT in this column is always identical to the FIN FLOAT in the last column.] The early finish date, February 27, is the scheduled completion date if the activity begins on the early start date. If the activity begins on the late start date, April 29, the expected late finish date is May 23. The last line of the schedule report shows: (1) the date the project is to begin (February 1, 1969); (2) project duration (271 days); (3) calculated project completion date (October 29, 1969). The SEQUENCE ES notation in the upper left of the report indicates that the activities are listed in the order of their early start dates (other options are available).

The schedule report is updated to June 10, 1969 (Table 3, see Data Date). Actual start and finish dates (indicated by the letter A to the right) replace the

TABLE 3

IBM PROJECT CONTROL SYSTEM

RUN DATE 10 JUN 69 * * S C H E D U L E R E P O R T * * DATA DATE 10 JUN 69

RUN SEQUENCE 1 NETWORK ID 9999 DESIGN AND PREPARATION FOR CONSTRUCTION FROM 01 FEB 69 TO 12 NOV 69

SEQUENCE E S PAGE 1

(I)	(J)	D E S C R I P T I O N	TOT DURAT	CAL	START EARLY	START LATE	ST FLOAT	FINISH EARLY	FINISH LATE	FIN FLOAT
01	10	PROJECT BEGIN DUMMY ACTIVITY	0.0	51 6	3FEB69 A	3FEB69	0.0	3FEB69 A	3FEB69	0.0
10	20	ENGINEERING DESIGN OF PLANT	10.2	51 6	3FEB69 A	3FEB69	0.0	14APR69 A	14APR69	0.0
10	50	SPECIFICATIONS FOR PLANT EQUIPMENT	3.8	51 6	3MAR69 A	3MAR69	0.0	31MAR69 A	31MAR69	0.0
20	30	SITE SELECTION	7.4	51 6	15APR69 A	15APR69	0.0	4JUN69 A	4JUN69	0.0
20	40	CONSTRUCTION DRAWINGS	69.0	51 6	15APR69 A	15APR69	0.0	22JUL69	22JUL69	0.0
50	60	EVALUATION AND APPROVAL OF EQUIPMENT SPECS	57.6	51 6	1MAY69 A	1MAY69	0.0	23JUL69	19AUG69	19.4
30	80	APPROVAL OF SELECTED SITE	20.0	51 6	5JUN69	22JUL69	32.0	3JUL69	19AUG69	32.0
40	70	APPROVAL OF CONSTRUCTION DRAWINGS	20.0	51 6	23JUL69	23JUL69	0.0	19AUG69	19AUG69	0.0
60	70	DUMMY ACTIVITY ONE	0.0	51 6	23JUL69	19AUG69	19.4	23JUL69	19AUG69	19.4
60	100	EQUIPMENT BID AND AWARD	41.0	51 6	23JUL69	16SEP69	37.4	19SEP69	12NOV69	37.4
70	80	DUMMY ACTIVITY TWO	0.0	51 6	19AUG69	19AUG69	0.0	19AUG69	19AUG69	0.0
70	90	FINAL DETAILED CONSTRUCTION DRAWINGS	8.0	51 6	20AUG69	4SEP69	10.0	29AUG69	15SEP69	10.0
80	90	SITE ACQUISITION	18.0	51 6	20AUG69	20AUG69	0.0	15SEP69	15SEP69	0.0
90	100	BUILDING CONSTRUCTION BID AND AWARD	41.0	51 6	16SEP69	16SEP69	0.0	12NOV69	12NOV69	0.0
100	110	PROJECT COMPLETED DUMMY ACTIVITY	0.0	51 6	12NOV69	12NOV69	0.0	12NOV69	12NOV69	0.0

PROJECT BASE DATE 1 FEB 69 PROJECT DURATION 285.0 PROJECT COMPLETION DATE 12 NOV 69 scheduled dates. Activity 10-50, for example, actually began March 3, 1969, took 3.8 weeks, and ended March 31.

The "early" and "late" dates will be the same since they are actual dates. The float is set equal to zero. The project completion date is now calculated to be November 12, 1969.

2. The Milestone Report presents the phases as they progress toward completion (Table 4). The degree of detail has been previously determined. The format is similar to the Schedule Report, and description and identification are listed in the first three columns. Note that the activity identification (node) numbers are sometimes called IJ or WI in this program. The calculated completion date (replaced by the actual date if completed) is in the next column, and the float is specified to the right.

3. Estimated and actual costs to date are shown as the project progresses in the Lump Sum Cost Report (Table 5). The upper portion is similar to the previous reports and the Data Date shows that the project has been updated to June 10, 1969. For example, activity 30-80, Approval of Selected Site, had an actual (A) start date of June 5, 1969 (early start sequence). As of June 10 the remaining duration is 19.8 working days with 1.0 percent complete and a calculated August 19 finish

TABLE 4

IBM PROJECT CONTROL SYSTEM

RUN DATE 10 JUN 69 * * M I L E S T O N E R E P O R T * * DATA DATE 10 JUN 69

RUN SEQUENCE 1 NETWORK ID 9999 DESIGN AND PREPARATION FOR CONSTRUCTION FROM 01 FEB 69 TO 12 NOV 69

SEQUENCE E S PAGE 1

MILESTONE DESCRIPTIONS	WI	CALC/ACTUAL	SCHEDULED	T	FLOAT	REMARKS
PROJECT BEGUN	(01 10)	03 FEB 69 A				
APPROVAL OF SELECTED SITE OBTAINED	(30 80)	08 JUL 69			30.2	
APPROVAL OF CONSTRUCTION DRAWINGS OBTAINED	(40 70)	19 AUG 69				
PROJECT COMPLETED	(100 110)	12 NOV 69				

PROJECT BASE DATE 01 FEB 69 PROJECT DURATION 285.0 PROJECT COMPLETION 12 NOV 69

END OF REPORT

TABLE 5

IBM PROJECT CONTROL SYSTEM

RUN DATE 10 JUN 69 * * LUMP SUM COST REPORT * * DATA DATE 10 JUN 69

RUN SEQUENCE 1 NETWORK ID 9999 TITLE DESIGN AND PREPARATION FOR CONSTRUCTION FROM 01 FEB 69 TO 12 NOV 69

SEQUENCE E S ORGANIZATION PAGE 1 PART 1

W	I	DESCRIPTION	START DATE	REMAI DURAT	PERCNT COMPLT	FINISH DATE	FLOAT	I	ESTIM D COST	ACTUAL COST T-D
01	10	PROJECT BEGIN DUMMY ACTIVITY	A03FEB69		.0000 A	03FEB69		I		
10	20	ENGINEERING DESIGN OF PLANT	A03FEB69		.0000 A	14APR69		I	20000	20000
10	50	SPECIFICATIONS FOR PLANT EQUIPMENT	A03MAR69		.0000 A	31MAR69		I	5000	5500
20	30	SITE SELECTION	A15APR69		.0000 A	04JUN69		I	2000	3000
20	40	CONSTRUCTION DRAWINGS	A15APR69	30.0	.5000	22JUL69		I	10000	5000
50	60	EVALUATION AND APPROVAL OF EQUIPMENT SPECS	A01MAY69	30.6	.4000	19AUG69		I	3000	1500
30	80	APPROVAL OF SELECTED SITE	A05JUN69	19.8	.0100	19AUG69		I	2000	20
40	70	APPROVAL OF CONSTRUCTION DRAWINGS	23JUL69	20.0		19AUG69		I	2000	
60	70	DUMMY ACTIVITY ONE	23JUL69			19AUG69	19.4	I		
60	100	EQUIPMENT BID AND AWARD	23JUL69	41.0		12NOV69	37.4	I	500	
70	80	DUMMY ACTIVITY TWO	19AUG69			19AUG69		I		
70	90	FINAL DETAILED CONSTRUCTION DRAWINGS	20AUG69	8.0		15SEP69	10.0	I	5000	
80	90	SITE ACQUISITION	20AUG69	18.0		15SEP69		I	5000	
90	100	BUILDING CONSTRUCTION BID AND AWARD	16SEP69	41.0		12NOV69		I	1000	
100	110	PROJECT COMPLETED DUMMY ACTIVITY	12NOV69			12NOV69		I		
						TOTAL			$55500	35020

TOTAL PROJECT ESTIMATED COST $55500. TOTAL PROJECT ACTUAL COST TO DATE $35020.

END OF REPORT

date. Twenty of the $2,000 estimated cost had been spent as of the Data Date. The project's total estimated cost and the total cost to date are printed on the last line.

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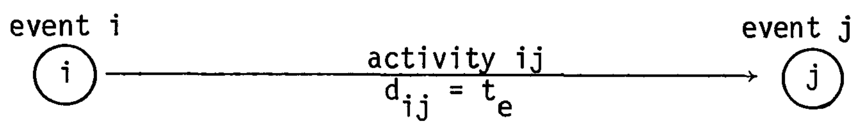
APPENDICES

APPENDIX A

PERT CALCULATIONS FOR SAMPLE PROJECT

The technique involves drawing a network of the project showing the interrelationship among the activities and assigning time values (d_{ij}, the expected time calculated from the three time estimates) to each activity (i, j).



$(T_E)_j$ = Earliest time for event j

$(T_L)_j$ = Latest time for event j

d_{ij} = Duration time of activity ij (= expected duration time, t_e)

The time calculations involve a forward pass to obtain the earliest time $(T_E)_j$ of successive events using the formula

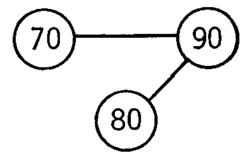
$$(T_E)_j = \max_i \{(T_E)_j + d_{ij}\} \qquad \text{Forward Pass } (\rightarrow)$$

Examples (Refer to Table A-1)

$$(T_E)_j = \max_{i} \{(T_E)_i + d_{ij}\}$$

Forward Pass

i (→) j



$$(T_E)_{90} = \max_{70,80} \{(T_E)_{70,80} + d_{(70,80),90}\}$$

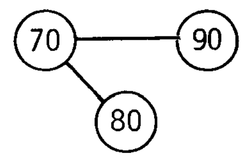
$$= \text{Max } \{(26.2 + 1.6) \text{ or } (26.2 + 3.6)\}$$

$$= 29.8$$

$$(T_L)_i = \min_{j} \{(T_L)_j - d_{ij}\}$$

Backward Pass

i (←) j



$$(T_L)_{70} = \min_{80,90} \{(T_L)_{80,90} - d_{70,(80,90)}\}$$

$$= \text{Min } \{(26.2 - 0) \text{ or } (29.8 - 1.6)\}$$

$$= 26.2$$

Note: Total float differs from that shown on the printout reports; the latter take into account the nonwork calendar weekends.

APPENDIX B

PERT APPLIED TO SAN DIEGO DEMONSTRATION PROJECT

The City of San Diego received a demonstration grant from the Bureau of Solid Waste Management to investigate the feasibility of refuse baling. The full title is "Investigate and Evaluate Feasibility of Refuse Baling as a Means of Conserving Sanitary Fill Space--Phase II." The primary objective of the two-year undertaking is to construct and operate a pilot baling transfer station in order to test the technical and economic feasibility of baling municipal refuse. Other objectives--to be sought during the latter part of the first year and all of the second year--include developing and evaluating data on the economics and techniques of the pilot operations and on techniques for efficiently and effectively disposing of refuse bales. The complexities of the project made the use of PERT highly desirable.

A meeting was held with the project coordinator and his staff to obtain the required information for applying the PERT technique. The network was developed showing the interrelationships of all the activities, and three time estimates (optimistic, most likely, pessimistic) were made for each. The development of the PERT chart necessitated logical thinking about the project and forced the obtaining of more information to clarify vague areas. The construction of the network alone was very beneficial and demonstrates the prior planning effort.

It should be emphasized that the preliminary network (Figure B-1) and the two printout reports (Tables B-1 and B-2) that follow are included for illustrative purposes only and do not necessarily represent the project's current status. The reports were made before the project began and the calculated completion date was based on the assumption that a minimum of six months of regular plant operation was required. The following printout reports use the same format as those that were explained in detail in the Sample Project section.

For example, the fourth activity listed on the schedule report (Table B-2) is 10-260, Specs. Prepared for Conveyors. This activity is expected to take 21.0 days. If begun on March 3, 1969 (the earliest it could start), the scheduled completion date is April 1. The latest it could begin so as not to delay the final completion of the project is March 25, with a scheduled completion date of April 23. The amount of float or leeway for Activity 10-260 is 16.0 days.

TABLE B-1

IBM PROJECT CONTROL SYSTEM

RUN DATE 24 APR 69 * * M I L E S T O N E R E P O R T * * DATA DATE 01 MAR 69

RUN SEQUENCE 1 NETWORK ID 188 SAN DIEGO BALING DEMONSTRATION PROJECT FROM 01 MAR 69 TO 24 DEC 70

SEQUENCE E S PAGE 1

MILESTONE DESCRIPTIONS	WI	CALC/ACTUAL	SCHEDULED	T	FLOAT	REMARKS
PROJECT BEGUN AWARD OF DEMO GRANT	(5 10)	28 FEB 69			0.0	
BALER AND SHREDDER BID AND AWARD COMPLETED	(220 230)	01 JUL 69			16.0	
CONVEYORS BID AND AWARD COMPLETED	(270 280)	01 JUL 69			16.0	
FINAL REPORT COMPLETED	(380 420)	11 SEP 69			325.0	
DETAILED ENGR DESIGN PRELIM 2 COMPLETED	(30 50)	17 JUL 69			4.5	
CONSTRUCTION DRAWINGS PRELIM 2 COMPLETED	(40 60)	24 JUL 69				
BALE DISPOSAL EQUIPMENT TESTED	(370 200)	23 JUN 69			189.0	
REHAUL EQUIPMENT DELIVERED	(320 330)	09 DEC 69			40.5	
CONSTRUCTION BID AND AWARD COMPLETED	(80 90)	04 NOV 69				
PHASE 1 OF CONSTRUCTION COMPLETED	(150 160)	05 FEB 70				
PLANT CONSTRUCTION COMPLETED	(180 200)	24 MAR 70				
MIN SIX MOS REG PLANT OPERATION COMPLETED	(400 420)	22 OCT 70			42.5	
PROJECT COMPLETED	(420 430)	24 DEC 70				

PROJECT BASE DATE 01 MAR 69 PROJECT DURATION 663.5 PROJECT COMPLETION 24 DEC 70

END OF REPORT

TABLE B-2

IBM PROJECT CONTROL SYSTEM

RUN DATE 24 APR 69 * * S C H E D U L E R E P O R T * * DATA DATE 01 MAR 69

RUN SEQUENCE 1 NETWORK ID 188 SAN DIEGO BALING DEMONSTRATION PROJECT FROM 01 MAR 69 TO 24 DEC 70

SEQUENCE E S PAGE 1

(I)	(J)	D E S C R I P T I O N	TOT DURAT	CAL	START EARLY	START LATE	ST FLOAT	FINISH EARLY	FINISH LATE	FIN FLOAT
10	20	PRIVATE ENGR NEGOTIATION CONSTRUCTION DESIGN	36.0	51 6	3MAR69	3MAR69	0.0	22APR69	22APR69	0.0
10	200	SCHEDULE MANPOWER AND WORKER ORIENTATION	16.5	51 6	3MAR69	2MAR70	251.0	25MAR69	24MAR70	251.0
10	210	SPECS PREPARED FOR BALER AND SHREDDER	21.0	51 6	3MAR69	25MAR69	16.0	1APR69	23APR69	16.0
10	260	SPECS PREPARED FOR CONVEYORS	21.0	51 6	3MAR69	25MAR69	16.0	1APR69	23APR69	16.0
10	300	REQUISITION INTERNAL REHAUL EQUIPMENT	21.0	51 6	3MAR69	29APR69	40.5	1APR69	28MAY69	40.5
10	350	CANYON FILL PREPARATION	21.0	51 6	3MAR69	20FEB70	246.5	1APR69	24MAR70	246.5
10	360	BALE DISPOSAL EQUIP DEVELOPMENT AND DESIGN	42.5	51 6	3MAR69	1DEC69	189.0	1MAY69	30JAN70	189.0
10	370	OBTAIN RENTED CRANE	11.0	51 6	3MAR69	20FEB70	246.5	17MAR69	10MAR70	246.5
10	380	PREPARATION OF FIRST YEAR REPORT	46.0	51 6	3MAR69	15JUN70	325.0	6MAY69	18AUG70	325.0
10	420	INVESTIGATE EFFECTS AND DEVELOP STANDARDS	244.5	51 6	3MAR69	8JAN70	215.0	18FEB70	24DEC70	215.0
1	5	D1 PRELIMINARY PLANT DESIGN PREVIOUSLY DONE	0.0	51 6	28FEB69	28FEB69	0.0	28FEB69	28FEB69	0.0
5	10	D2 AWARD OF DEMO GRANT PREVIOUSLY DONE	0.0	51 6	28FEB69	28FEB69	0.0	28FEB69	28FEB69	0.0
350	200	D12 DUMMY ACTIVITY	0.0	51 6	1APR69	24MAR70	246.5	1APR69	24MAR70	246.5
210	220	PHS APPROVAL OF BALER AND SHREDDER SPECS	21.0	51 6	2APR69	24APR69	16.0	30APR69	22MAY69	16.0
260	270	PHS APPROVAL OF CONVEYOR SPECS	21.0	51 6	2APR69	24APR69	16.0	30APR69	22MAY69	16.0

(I)	(J)	DESCRIPTION	TOT DURAT	CAL	START EARLY	START LATE	ST FLOAT	FINISH EARLY	FINISH LATE	FIN FLOAT
300	310	SPECS PREPARED REHAUL EQUIPMENT	42.5	51 6	2APR69	28MAY69	40.5	2JUN69	29JUL69	40.5
20	30	DETAILED ENGINEERING DESIGN PRELIM NO 1	22.0	51 6	23APR69	23APR69	0.0	22MAY69	22MAY69	0.0
20	40	CONSTRUCTION DRAWINGS PRELIM NO 1	20.5	51 6	23APR69	24APR69	1.5	21MAY69	22MAY69	1.5
220	30	D4 DUMMY ACTIVITY	0.0	51 6	30APR69	22MAY69	16.0	30APR69	22MAY69	16.0
270	30	D3 DUMMY ACTIVITY	0.0	51 6	30APR69	22MAY69	16.0	30APR69	22MAY69	16.0
220	230	BALER AND SHREDDER BID AND AWARD	42.5	51 6	1MAY69	23MAY69	16.0	1JUL69	24JUL69	16.0
270	280	CONVEYOR BID AND AWARD	42.5	51 6	1MAY69	23MAY69	16.0	1JUL69	24JUL69	16.0
360	370	BALE DISPOSAL EQUIP FABRICATION	26.0	51 6	1MAY69	30JAN70	189.0	9JUN69	10MAR70	189.0
380	420	PREPARATION OF FINAL REPORT	88.5	51 6	7MAY69	19AUG70	325.0	11SEP69	24DEC70	325.0
30	40	D5 DUMMY ACTIVITY	0.0	51 6	22MAY69	22MAY69	0.0	22MAY69	22MAY69	0.0
30	50	DETAILED ENGINEERING DESIGN PRELIM NO 2	38.0	51 6	23MAY69	29MAY69	4.5	17JUL69	24JUL69	4.5
40	60	CONSTRUCTION DRAWINGS PRELIM NO 2	42.5	51 6	23MAY69	23MAY69	0.0	24JUL69	24JUL69	0.0
310	320	REHAUL EQUIPMENT BID AND AWARD	42.5	51 6	2JUN69	30JUL69	40.5	31JUL69	29SEP69	40.5
370	200	BALE DISPOSAL EQUIP TESTING	10.0	51 6	9JUN69	10MAR70	189.0	23JUN69	24MAR70	189.0
230	50	D7 DUMMY ACTIVITY	0.0	51 6	1JUL69	24JUL69	16.0	1JUL69	24JUL69	16.0
280	50	D6 DUMMY ACTIVITY	0.0	51 6	1JUL69	24JUL69	16.0	1JUL69	24JUL69	16.0
230	240	BALER FABRICATION AND DELIVERY	87.0	51 6	1JUL69	2OCT69	64.5	3NOV69	5FEB70	64.5
230	250	SHREDDER FABRICATION AND DELIVERY	117.0	51 6	1JUL69	20AUG69	34.5	17DEC69	5FEB70	34.5
280	160	CONVEYORS TYPE 1 FABRICATION AND DELIVERY	117.0	51 6	1JUL69	20AUG69	34.5	17DEC69	5FEB70	34.5

(I)	(J)	DESCRIPTION	TOT DURAT	CAL	START EARLY	START LATE	ST FLOAT	FINISH EARLY	FINISH LATE	FIN FLOAT
280	290	CONVEYORS TYPE 2 FABRICATION AND DELIVERY	117.0	51 6	1JUL69	25SEP69	59.5	17DEC69	13MAR70	59.5
280	340	CONVEYORS TYPE 3 FABRICATION AND DELIVERY	117.0	51 6	1JUL69	19SEP69	56.0	17DEC69	10MAR70	56.0
50	60	D8 DUMMY ACTIVITY	0.0	51 6	17JUL69	24JUL69	4.5	17JUL69	24JUL69	4.5
50	70	DETAILED ENGINEERING DESIGN FINAL	6.5	51 6	18JUL69	29JUL69	7.0	28JUL69	6AUG69	7.0
60	70	CONSTRUCTION DRAWINGS FINAL	9.0	51 6	24JUL69	24JUL69	0.0	6AUG69	6AUG69	0.0
320	330	DELIVERY OF REHAUL EQUIPMENT	90.0	51 6	1AUG69	29SEP69	40.5	9DEC69	6FEB70	40.5
70	80	PHS APPROVAL OF ENGR DESIGN AND CONST DRAW	21.0	51 6	6AUG69	6AUG69	0.0	5SEP69	5SEP69	0.0
80	90	CONSTRUCTION BID AND AWARD	42.5	51 6	5SEP69	5SEP69	0.0	4NOV69	4NOV69	0.0
240	160	D10 DUMMY ACTIVITY	0.0	51 6	3NOV69	5FEB70	64.5	3NOV69	5FEB70	64.5
90	100	CONTRACTORS MOBILIZATION	14.0	51 6	5NOV69	5NOV69	0.0	25NOV69	25NOV69	0.0
100	110	STRUCTURAL EXCAVATION	8.5	51 6	26NOV69	26NOV69	0.0	9DEC69	9DEC69	0.0
110	120	CONCRETE FORMS	10.5	51 6	9DEC69	9DEC69	0.0	23DEC69	23DEC69	0.0
330	340	FABRICATION OF ADDITIONAL PARTS	21.0	51 6	10DEC69	6FEB70	40.5	9JAN70	10MAR70	40.5
250	160	D9 DUMMY ACTIVITY	0.0	51 6	17DEC69	5FEB70	34.5	17DEC69	5FEB70	34.5
290	200	MOUNT TYPE 2 CONVEYORS	6.5	51 6	17DEC69	16MAR70	59.5	26DEC69	24MAR70	59.5
120	130	POUR CONCRETE INCL CONDUITS WATER LINE BOLTS	6.5	51 6	24DEC69	24DEC69	0.0	5JAN70	5JAN70	0.0
130	140	CONCRETE CURES	4.0	51 6	5JAN70	5JAN70	0.0	9JAN70	9JAN70	0.0
140	150	STRUCTURAL BACKFILL	5.0	51 6	9JAN70	9JAN70	0.0	16JAN70	16JAN70	0.0
340	200	CONVEYORS TYPE 3 FITTED ONTO REHAUL EQUIP	10.0	51 6	12JAN70	10MAR70	40.5	23JAN70	24MAR70	40.5

(I)	(J)	DESCRIPTION	TOT DURAT	CAL	START EARLY	START LATE	ST FLOAT	FINISH EARLY	FINISH LATE	FIN FLOAT
150	160	CONSTRUCT BALER ROOM WALLS	14.5	51 6	16JAN70	16JAN70	0.0	5FEB70	5FEB70	0.0
160	170	INSTALL PLANT EQUIPMENT	12.5	51 6	6FEB70	6FEB70	0.0	25FEB70	25FEB70	0.0
160	200	PAVE AREA AROUND PLANT	4.5	51 6	6FEB70	18MAR70	27.0	12FEB70	24MAR70	27.0
170	180	INSTALL STEEL PLATE SKIRTS DUMPING PIT	5.0	51 6	25FEB70	25FEB70	0.0	4MAR70	4MAR70	0.0
170	190	INSTALL ELECTRICAL ITEMS MAKE CONNECTIONS	6.5	51 6	25FEB70	16MAR70	12.5	5MAR70	24MAR70	12.5
170	200	INSTALL PLANT MECHANICAL ITEMS	5.5	51 6	25FEB70	17MAR70	13.5	4MAR70	24MAR70	13.5
180	200	CONSTRUCT ROOFS ON SHREDDER AND BALER ROOMS	14.0	51 6	4MAR70	4MAR70	0.0	24MAR70	24MAR70	0.0
190	200	D11 DUMMY ACTIVITY	0.0	51 6	5MAR70	24MAR70	12.5	5MAR70	24MAR70	12.5
200	390	EVALUATE TECHNIQUES FOR EFFICIENT BALE DISPOS	149.5	51 6	24MAR70	22MAY70	42.5	22OCT70	24DEC70	42.5
200	400	PLANT SHAKEDOWN	22.0	51 6	24MAR70	24MAR70	0.0	23APR70	23APR70	0.0
200	420	BALE DISPOSAL OPERATIONS	149.5	51 6	24MAR70	22MAY70	42.5	22OCT70	24DEC70	42.5
400	410	EVALUATE TECHNIQUES AND ECONOMICS OF PLANT	170.0	51 6	23APR70	23APR70	0.0	24DEC70	24DEC70	0.0
400	420	REGULAR PLANT OPERATION	127.5	51 6	23APR70	24JUN70	42.5	22OCT70	24DEC70	42.5
390	420	D13 DUMMY ACTIVITY	0.0	51 6	22OCT70	24DEC70	42.5	22OCT70	24DEC70	42.5
410	420	D14 DUMMY ACTIVITY	0.0	51 6	24DEC70	24DEC70	0.0	24DEC70	24DEC70	0.0
420	430	D15 DUMMY ACTIVITY PROJECT COMPLETED	0.0	51 6	24DEC70	24DEC70	0.0	24DEC70	24DEC70	0.0

PROJECT BASE DATE 1 MAR 69 PROJECT DURATION 663.5 PROJECT COMPLETION DATE 24 DEC 70

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