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Program Planning With PERT/CPM

RAYMOND E. WILLIS*

ABSTRACT—PERT/CPM, an organizational technique, has more than proved its value in the planning and controlling of large scale projects, but it also can be useful in the planning and direction of research programs and other smaller projects in connection with education and with the work of volunteer organizations. Although this method has seen little use by individuals in the academic communities, to whom project planning is new or infrequent, experience shows it can be applied to their advantage, as this paper indicates.

Since its development in about 1956, PERT/CPM has become an important technique for the planning and control of large scale research and construction programs. The value of PERT/CPM is not, however, limited to large computer-assisted projects. Many smaller undertakings common to educational programs and in the work of volunteer organizations can benefit from applying this technique in planning.

Historically, scientists and teachers have tended to work as individuals. More and more however, they are becoming involved in planning and organizing projects and programs which involve the coordinated activity of many people. Research is becoming more complex; curriculum planning is no longer just the collection of a set of individual and virtually independent courses. Professional associations urge their local chapters to arrange annual meetings and to conduct seminars. For all such undertakings it is necessary to plan and coordinate the activities of people who normally would often prefer to work independently.

In June, 1968, Naval Reserve Research Company 9-6 presented the First Upper Midwest Naval Reserve Research Seminar. Planning for this seminar at the University of Minnesota campus actually started more than a year earlier and involved all of the members of the company. To aid in the planning and control of this activity, the technique of PERT/CPM was used. While this particular application was rather specialized, it does demonstrate some of the advantages of using PERT/CPM for relatively small scale projects.

The Nature of PERT/CPM

The literature of PERT/CPM is now quite extensive, and its concepts are generally known, so these will not be developed in detail here. For the reader whose knowledge of the approach is limited, however, the major elements will be outlined; more extensive treatments can be found in the references noted at the end of this paper.

PERT/CPM is a procedure for analyzing a complex project in terms of its component elements or activities, recognizing the sequential relationships between these elements. Its antecedents are usually traced back to 1914 and the development of the Gantt Chart by Henry Gantt of the Army Bureau of Ordnance. In its present form, however, PERT/CPM is a direct outgrowth of two projects of the late 1950's. In 1956, E. I. duPont de Nemours and Company, working with Remington Rand Univac, began the development of a technique known as CPM (for Critical Path Method) to be applied in planning construction projects. At about the same time, Vice Admiral W. F. Raborn, Director of Special Projects for the U. S. Navy, initiated a study of the management of the Polaris program which resulted in the development of PERT (for Program Evaluation and Review Technique).

While the two procedures differed in detail, they were the same in concept. The last ten years have seen not only a variety of extensions and improvements but also a gradual synthesizing of the two procedures into a single technique, with the combined title, PERT/CPM.

Events and Activities

The basic concept of PERT/CPM is that a complex project may be broken down into a set of activities. Each activity can in turn be related to specific events marking the start and completion of that activity. Sequencing constraints can be included by noting that the event marking the start of an activity cannot occur until certain preceding activities have been completed. These sequential relationships are developed and summarized in terms of a network.

EXAMPLE: In planning a national meeting or seminar, one of the major activities is the preparation of a program to be circulated among participants well in advance of the meeting. The program usually contains not only such information as a listing of papers to be presented but also letters of welcome from various officials, information on housing and registration, and information on activities such as tours or social functions for families of delegates.

A typical activity, "Prepare program for printer," could be marked by the events "Start preparation of program" and "Program preparation completed." This activity in turn must follow the activity "Collect materials for program" and must precede "Mail program to printer."

This can be summarized in a network diagram. In the

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diagram being developed here, circles denote events and arrows represent activities, as in Figure 1. It is usually convenient to assign numbers to events so that activities and/or events may be identified in an accompanying table.

In this example,

![Diagram 1](image)

the diagram and table in Figure 2 would show the activity sequence.

![Diagram 2](image)

More detailed breakdowns in activities are possible. Thus the activity, “Collect materials for program,” could be subdivided into the activities, “Collect letters and pictures,” “Prepare general information,” “Prepare information on tours” and “Prepare information on sessions and speakers.” Those activities, which may occur concurrently, can be shown as concurrent arrows with a pattern as in Figure 3.

These four activities could be shown as four arrows, all connecting events 10 and 11. But identification is made easier by creating new intermediate events. The dotted arrows are called Dummy Activities because they (although it may be convenient) to keep the numbers of intermediate events in sequential order.

**Times and Dates**

Activities require time for completion. Events, on the other hand, mark specific points in time or dates. Once the basic network is completed it is necessary to estimate completion times for the various activities. Along any sequence of arrows, times are additive inputs and may be used to assign dates to events. The sequence of arrows or activities in the network requiring the longest time is called the Critical Path. This determines the time necessary to complete the entire project. The times and dates as well as the Critical Path can be recorded on the network diagram and its accompanying table.

One of the early differences between PERT and CPM related to estimating time for activities. CPM, having been developed for use in construction projects where activity times were generally predictable, used only a single time estimate for each activity. The application of PERT to research activities encountered greater uncertainties, so three time estimates were obtained and used to develop a time probability distribution.

**Responsibility**

Each activity should be assigned for execution to a specific person or committee. This assignment can be noted in the PERT/CPM activity table. Thus the completed network and table can summarize the basic information necessary for coordinating and controlling the project.

**Planning For Meetings and Seminars**

In a typical educational application, PERT/CPM could be used to plan and control projects which are non-routine and which involve concurrent activity by large numbers of individuals. Thus, in evaluating the use of PERT/CPM for planning a national seminar, it is useful to consider some of the special characteristics of this type of project, relative to application of the technique. These might be identified as follows:

1. The local chapter of an academic association, for instance, is essentially a voluntary group. The degree of participation in any special project by individual members is not completely controllable.
2. Planning a meeting is a new experience for many of the members and different from their normal functions.
3. Planning the meeting is, also, a part-time duty which must be fitted in with regular work assignments.
4. Members may not be in daily contact with one another, so coordination must be based on relatively infrequent meetings.
5. Most of the activities do not, in themselves, require great amounts of time but must be scheduled in relation to other responsibilities of the members.

These characteristics give special advantages to the use of PERT/CPM but also require modifications and a shift in emphasis in using the technique.
One of the major problems faced by a chairman under those circumstances is to ensure maximum participation by the members. If the work finally ends up being done by the chairman and a small group of supporters, it is often traceable to a lack of communication and because formal planning has been on a piecemeal, step-at-a-time basis. Because the early steps are seldom time-consuming, they tend to be done by the same individuals and this sets a pattern which may be hard to break. On the other hand, early introduction of PERT/CPM makes it possible for the entire membership to be in on the formal planning, to make suggestions, to accept responsibility for activities and to see how their activities relate to those of the other members. As the planning proceeds and new ideas and problems arise, it is then less difficult to revise the PERT/CPM network and to communicate changes to the members. At the same time, the impact of these changes can be analyzed effectively.

A formal subdivision of responsibility at all stages aids communication because individuals can easily see those activities which precede or depend on their own actions. Communication between meetings can thus be established on a member-to-member basis and need not always be directed through the chairman. Finally, the chairman can have a continuously updated display of the status of the project and direct his efforts toward the currently critical activities.

In comparison with the usual use of PERT/CPM, the concept of the Critical Path assumes much less importance here. The activities in themselves are not overly time-consuming; the problem lies in the individual fitting them in with his other responsibilities. As usual, Parkinson's Law applies; the job will take whatever time is allotted. While some activity times are relatively fixed—printing time and mailing time, for example—the majority are subject to arbitration. In assigning times to activities, dates should be assigned to major events and the times obtained by working backwards from the goal.

**Organization For Using PERT/CPM**

The value of this technique is greatest in the early stages of planning. The chairman should assign one or two members the responsibility for coordinating the development of the network diagram. If no one in the organization is familiar with PERT/CPM, a search of available references will prove useful. In particular, PERT Fundamentals is a good short course of programmed instruction.

After an introductory presentation describing the technique is made to the members of the group, the development of the network can proceed. As the network is developed, responsibilities can be assigned and activity time estimates made. When completed, the network diagram will form a visual display which can be used to record progress. Activity tables can be reproduced for all members to aid in their own planning. No group should try to use a network developed for a previous meeting because one of the major advantages of this technique lies in the educational aspects of developing the network diagram. In balance, of course, one of the principal disadvantages of using PERT/CPM is the time required to create and maintain the network diagram and table.

**Application to Other Projects**

Many projects other than seminar planning appear to have some of the characteristics described here. The planning and development of a research study or of a new curriculum is often done by a group of people who, particularly in the early stages, are actively engaged in teaching or have other responsibilities. If, in addition, the people involved are located at different schools or institutions, problems of coordination can become particularly acute. The 1966 monograph on applications in Education by Cook gives examples of many such projects.

Mr. Donald Wahlund has applied this technique to a unique type of planning for a school addition. This project was concerned less with physical construction than with the contracting for, staffing and equipping of the new addition. The advantage attributed to the PERT/CPM technique was the discovery of the amount of slack time in most of the activities. This enabled the personnel to improve their planning for assigned responsibilities.

**APPENDIX**

**PERT/CPM Network for Naval Seminar**

The network presented here has been abridged by summarizing some parallel activities into a single arrow. Thus the activities between events 6 and 7 and between 6 and 8, "Arrange tours" and "Arrange speakers," should have a listing for each session. Because of the condensation, the interrelationship with activities 6-9, 6-10 and 6-11 is not accurately shown. The multitude of activities which are described as "Seminar sessions" are not detailed because, by then, PERT/CPM will have served its purpose.

Although broken down into three charts for convenience, this is really one network. The major events which should be noted are the following:

- 1—Start organizing for seminar
- 2—Start plans and arrangements
- 13—Program ready for the printer
- 16—Program arrangements complete
- 25—All materials except program collected
- 35—Start check-in
- 40—Start check-out
- 47—End

![Figure 4A](https://example.com/figure4a.png)

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EVENT ACTIVITY
1 2 Outline program and organize committees
2 3 Plan and collect general information for program
2 4 Plan and collect information on special events for program
2 5 Obtain letters and pictures for program
2 6 Plan seminar sessions and assign day chairman
3 12 Prepare layout of general information for program
4 12 Prepare special events information for program
5 12 Prepare layout of letters and pictures
6 7 Plan and arrange tours
6 8 Arrange for speakers
6 9 Arrange for meeting rooms
6 10 Arrange for transportation
6 11 Arrange for visual aids
7 12 Prepare tour information for program
7 16 Confirm logistic support for tours
8 12 Prepare information on speakers for program
8 16 Confirm logistic support for speakers
9 12 Prepare information on meeting rooms for program
9 16 Confirm room plans with day chairman
10 16 Confirm transport plans with day chairman
11 16 Confirm visual aid support with day chairman
12 13 Prepare program for printer
13 14 Mail program to printer
14 15 Print Program
15 35 Mail program to participants
16 35 Final coordination of seminar sessions

EVENT ACTIVITY
18 25 Prepare material on housing, clothing and weekend activities
19 25 Arrange for mailing and handing out materials
20 25 Prepare material on reporting
21 28 Obtain information from Office of Naval Research
22 28 Dummy activity
23 35 Arrange check-in procedures
24 35 Arrange administration procedures
25 26 Prepare material for mailing
25 35 Prepare material for handout at check-in
26 27 Mail material
27 28 Obtain responses from mailing
28 29 Prepare section lists and section leader materials
28 30 Prepare first draft of directory
29 35 Dummy activity
30 35 Dummy activity

EVENT ACTIVITY
2 32 Plan cruise book
2 33 Plan final report
32 34 Plan photographic coverage
32 35 Arrange other material for cruise book
33 35 Arrange for collecting information needed in final report
34 35 Arrange for photographic coverage
35 36 Check-in
35 42 Collect photographs
35 43 Collect other materials for cruise book
36 37 Prepare final directory
36 38 Complete administrative details
36 39 Collect material for final report
36 40 Seminar sessions
37 40 Dummy activity
38 40 Dummy activity
39 40 Dummy activity
40 41 Check-out
41 43 Dummy activity
41 46 Prepare final report
42 43 Dummy activity
43 44 Layout cruise book
44 45 Print cruise book
45 47 Mail cruise book
46 47 Mail final report

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Plants for Classroom Use

ELIZABETH WAGNER REED*

ABSTRACT—The importance of having living plants in the classroom is emphasized. Ways of coping with environmental problems of classroom heat and dryness are outlined, including the making of terraria. Varieties of plants found suitable for the classroom and laboratory are described.

Classrooms always house some living organisms. In many, unfortunately, all are of a single species, Homo sapiens. This population consists of many immature specimens (children) and a few adults, usually female (teachers). This makes for a certain homogeneity, but it can be alleviated by introduction of other living species, animal or plant.

There are minor drawbacks to the presence of some animal species in classrooms, although one could hardly object to such as a culture of mealworms living in a plastic shoe box.

Plants, however, are immobile, quiet, generally either odorless or fragrant; when dead they may be disposed of easily; when alive, plants are interesting, beautiful, and very useful in teaching situations. Yet there are relatively few plants in classrooms.

There seem to be three rather unrelated reasons for this dearth of classroom plants. One is the problem of finding appropriate places for plants in rooms not designed for them. A second is the lack of information about which varieties of plants to grow and how to use them in the schools. The third reason is the apparent lack of appreciation for the value of having beautiful, interesting, living things around the classroom. This is important for all children, but especially so for those from disadvantaged areas. These children need all the beauty and variety they can get in the school, since they often come from drab home environments. Nearly anything can be an enrichment for them—a means of expanding their horizons. Youngsters generally are interested in things that grow.

Suitable classroom plants are not expensive or difficult to provide. Neighborhood stores are full of interesting potted plants suitable for school use, and supplies for them. They also have seeds in the spring and bulbs in the fall. There are plant materials for any situation, even for the windowless room if extra light can be provided.

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Modifying Classroom Conditions

Since plants are living organisms, they impose certain environmental requirements for survival and for growth. They must have adequate moisture, light, and protection from extremes of temperature. Unfortunately, many classrooms resemble deserts with respect to moisture and jungles with respect to light, so adjustments must be made.

Potted plants can be placed in window boxes supplied with a layer of gravel in water to increase the humidity about the plants. Terraria can furnish any desired microclimate with regard to humidity. Adequate conditions can be established in any transparent container with a layer of stones for drainage, a layer of soil for roots, and some sort of adjustable cover to regulate moisture. The terrarium can be as simple as a peanut butter jar planted with a couple of seeds or a plant slip, or it can be as elaborate as a large aquarium with many kinds of plants, landscaped with stones and wood, carpeted with moss and including a tiny pool. A very convenient terrarium can be made in a plastic shoe box. After planting, it should be watered well and kept out of direct sunlight unless the cover is ajar. Condensation is controlled by opening or closing the top. No terrarium needs to last very long, but it may be replanted when the cuttings root, when the plants overgrow it, or when the children's interest wanes.

Desert terraria and bog terraria are interesting, but not as much "happens" in them. The moist woodland terrarium can be used for germinating seeds, rooting slips, keeping wild plants, or conducting experiments on plant propagation, pruning, and the like.

Dealing with Light and Heat

Lighting problems can be solved in several ways. The best situation is found in the old four-square schools where every classroom had windows on two sides. If there are large windows, the plants should be put as close as possible to the glass. Where protection is needed if nights are cold, sheets of cardboard between the plants...