

Canada

**PROJECT
MANAGEMENT
HANDBOOK**



Government
of Canada

Gouvernement
du Canada

Regional
Economic
Expansion

Expansion
Économique
Régionale

**PROJECT
MANAGEMENT
HANDBOOK**

PREFACE

The purpose of this handbook is to provide guidance to project managers on how they can ensure that their projects are well managed.

As such, it does not attempt to be comprehensive. It discusses the fundamentals of project management, illustrates concepts and tools which might be helpful, and directs project managers to other sources of information which may be more detailed.

The handbook is divided into five sections. The purpose of each section is described below.

- Section 1: provides an introduction to the handbook and to project management, and discusses four fundamental principles which are common to all projects.
- Section 2: describes planning and control as the two primary functions of all project managers.
- Section 3: describes and illustrates a set of planning and control tools which project managers may find useful.
- Section 4: describes courses which are available to project managers who might be interested in becoming more knowledgeable in project management tools and techniques.
- Section 5: is a brief bibliography guiding project managers to more comprehensive treatments of the topic at hand.

Briefly, then, this handbook is intended to give project managers an "at-hand" guide and to indicate where more detailed or specific information can be acquired.

*Timothy E. Reid
Assistant Deputy Minister
Planning and Coordination*

TABLE OF CONTENTS

1.0	INTRODUCTION TO PROJECT MANAGEMENT	1
1.1	Definitions	1
1.2	Principles of Project Management	3
2.0	PLANNING AND CONTROL	7
2.1	Project Planning	7
2.2	Project Control	8
3.0	PROJECT MANAGEMENT TOOLS	10
3.1	Project Description	11
3.2	Activity Planning Form	15
3.3	Project Schedule Form	18
3.4	Activity List	21
3.5	Bar Charts	23
3.6	Project Status Report	26
3.7	Networks: CPM and PERT	29
4.0	1981-82 PSC COURSE OFFERINGS IN PROJECT MANAGEMENT	38
5.0	BRIEF BIBLIOGRAPHY	41

1.0 INTRODUCTION TO PROJECT MANAGEMENT

The purpose of this section is to present and discuss the objectives of project management, some basic definitions and four basic principles of managing any project.

1.1 Definitions

Projects differ from on-going activities because of the following three characteristics of a project:

- product: projects are designed to produce a unique piece of work to achieve a specific aim;
- time: there is an identifiable time period allocated to the production of the project product;
- cost: the resources allocated for the task are specific and limited.

Therefore, a project can be defined as follows:

A project is a unique piece of work having a finite life and producing an identifiable product or achieving a specific aim, on time, and within specified resource limits.

This definition of a project implies the following success criteria by which the project manager can be assessed:

- achievement of project objectives, including qualitative ones;
- achievement of project objectives within defined time limits; and
- achievement of project objectives within specified resource limits, including financial and human resources.

The project manager is the person designated responsible for producing the project output. Each project manager should be given a position description containing as much specific information as possible. An example of a position description for a project manager follows.

PROJECT MANAGER POSITION DESCRIPTION

REPORTS TO: designated manager

DIRECTS: project staff

RESPONSIBILITIES:

1. General:

- (a) Ensures assigned projects are completed on time and within established resource limits.
- (b) Ensures work is of an acceptable quality.

2. Planning:

- (a) Ensures a clear statement of objectives, outputs and project manager's terms of reference are available for the project.
- (b) Identifies tasks to be carried out.
- (c) Prepares estimates of time and resources required.
- (d) Arranges for required resources and facilities to be made available to the project and for necessary approvals to be given.
- (e) Establishes, for the responsible senior manager(s), a method of progress reporting against milestones.
- (f) Arranges for opening of files and project records.

3. Control:

- (a) Ensures the project progresses according to appropriate time and cost schedules.
- (b) Ensures the quality of work performed is satisfactory.
- (c) Regularly reports progress with respect to plan to the appropriate senior manager(s).
- (d) Regularly reports critical issues and problems to the appropriate senior manager.
- (e) Initiates action required to correct deviations from plan.
- (f) Updates schedules and resource requirements and obtains the necessary approvals for changes as required.

4. Completion:

- (a) Ensures project reports and other outputs are distributed as required.
- (b) Ensures project files and records are cleaned and closed out as required.
- (c) Evaluates project performance to ensure objectives have been met and to assess reasons for deviations.
- (d) Carries out performance evaluations of project team personnel as required.

1.2 Principles of Project Management

Having defined the project, the project manager, and success criteria, it is now important to look at principles which are common to all projects.

Project size and scope can vary. However, the basic principles of project management are the same for all projects; they are simply applied with differing degrees of formality. Management of a small project is intuitive and based on familiarity through past experience. A more formal structure and tools are required for management of complex, large, and multi-disciplinary projects.

The four principles discussed below deal with project interrelationships, project stages, project authorities and project parameters.

Principle: PROJECTS DON'T EXIST IN A VACUUM.

Projects do not exist on their own. Several factors can act to constrain the project environment:

- Projects are carried out within a defined policy environment. Constraints can be imposed by departmental, sectorial or branch policy.
- Projects must compete with other projects and activities for resources. This leads to budgetary limits, limits in manpower and limits in expertise available to the project.
- Project management information is gathered from, and feeds to other management systems and processes.

Principle: ALL PROJECTS GO THROUGH THE SAME STAGES.

All projects are similar in the sequential stages they pass through. These are:

- **PROPOSAL:** mainly concerned with defining and obtaining approval for the project concept.
- **PLANNING:** includes identification of activities, resources and timing for the project.
- **APPROVAL:** the formal approval between the project manager and project director to proceed according to the plan.
- **EXECUTION:** the actual carrying out of the project — data collection, analysis, drawing conclusions.
- **FINALIZATION:** includes reporting and presenting results and evaluating the success of the project.

Each stage requires management. The planning stage in particular is the key to successful management of the substantive, results-producing portion of the project, and is unfortunately one of the most ignored.

Principle: FOR A SUCCESSFUL PROJECT, YOU MUST IDENTIFY THE PERSON RESPONSIBLE, EXPLAIN THE MISSION, AND GIVE THE PERSON A MANDATE.

A project manager cannot be successful if he or she does not know what to do or have the authority to do it. The project manager has as much obligation as the senior manager to ensure that these elements are well defined, if for no other reason than that of the project manager's own protection.

The first duty of the project manager, therefore, is to negotiate with the manager to whom he or she reports for the project:

- a clear statement of project objectives;
- a clear statement of project outputs; and
- clear terms of reference giving the project manager the authority he or she needs to carry out the PM function.

The following figure outlines the form that the terms of reference might take.

PROJECT MANAGER TERMS OF REFERENCE

PROJECT:

PROJECT MANAGER:

REPORTS TO:

START DATE:

FREQUENCY AND METHOD OF STATUS REPORTING:

BUDGET:

\$	CONSULTING	}	BY F/Y
	EDP		
	TRAVEL		
P/W			

TARGET DATE FOR COMPLETION:

OUTPUTS:

GENERAL DESCRIPTION:

PROJECT TEAM:

The terms of reference are of major importance, since they protect both the project manager and superiors from the consequences of confused lines of authority and responsibility. By defining reporting methods, they also formalize the essential communications link between the project team and the regular organization.

Having obtained the terms of reference, the project manager can begin carrying out the duties described in the position description, employing the following principle:

Principle: A PROJECT MANAGER CONTROLS THREE BASIC PARAMETERS OF ANY PROJECT: RESOURCES, TIMING, QUALITY.

Changes in direction, correction of deviations in plan, and response to new requirements are all affected by pulling one of the three control levers: resources, timing or quality. The choice of which to change depends on:

- the nature of the change required;
- constraints imposed on the project manager (resource limitations, deadlines, etc.); and
- interrelationships among parameters (often a function of the type of project).

The last point can be illustrated by the following example: if the project is to dig a ditch, doubling your manpower will probably halve the expected time for the project. For complex projects involving professionals, the learning curve and increased difficulty of coordination will often give a different result:

“If one person can do it in one month, two people can do it in two months.”

The next two chapters deal with details of the project manager's functions and provide background information on some of the tools available to support project management tasks.

2.0 PLANNING AND CONTROL

The purpose of this section is to provide guidance to project managers in carrying out their two main functions, planning and control.

2.1 Project Planning

"If you can do it, you can plan it."

Planning is the first half of the project manager's job. Planning ensures that available resources will be focussed on the problem at hand and not expended on unrelated tasks.

As well as providing a baseline which will guide the direction of the project, the planning process affords an opportunity for the project manager to ensure that it is indeed feasible for the stated aims to be accomplished within the limits defined for the project.

The project plan should always be considered as a dynamic and evolving tool, and not as immovable and irrevocable. As the project progresses, things will inevitably be late (or, infrequently, early), and constraints on resources or deadlines will change. Replanning to incorporate these changes is a critical part of the project manager's job.

ELEMENTS OF PLANNING

In planning, the project manager must identify:

- activities — what will happen;
- resources — what it will cost;
- timing — when it will be done.

In identifying activities, the project manager will first define the methodology for carrying out the project. From this, a list of detailed activities/tasks can be prepared, their interrelationships (sequence) defined, and their individual objectives, costs, timing and content described.

Resource planning proceeds from the activity list, and includes manpower estimates as well as dollar estimates for Electronic Data Processing (EDP), travel, contracts, and materiel. This is generally provided by fiscal year.

Once the necessary approvals have been given for manpower resources and the project team assembled, it is essential that the project manager familiarize each member of the team with the project's objectives and plans. He must also provide a clear statement of each member's role and responsibilities, including identification of reporting relationships for the duration of the project.

Based on the detailed activity descriptions and their relationships, the project manager can then forecast **timing** of the project in the form of a detailed schedule. For complex projects, tools like CPM and PERT are available. (These are described later.)

Also at the planning stage, the project manager will select the methods to be used to manage the project, and will identify the milestones against which progress will be evaluated and reported.

MILESTONES

Milestones are usually associated with a product or critical decision point. They represent a point in time: for example, the end of an activity, and not the activity itself.

Milestones should be **concrete**, and not subject to change when the project gets into trouble. They must also be **measurable**: for example, "draft report complete" doesn't reflect how many further drafts might be required. "Report approved by DG" gives a better indication of real progress.

There is no rule to specify how many milestones there should be for a given project. However, the following guidelines may be of use:

- Milestones should be appropriate to the level of management being reported to and understood as real events in the project, not simply as the sum of several lower level milestones or activities. In particular, they must relate to the kinds of problems or decisions the manager using them will have to face.
- Milestones should be perceived as genuinely significant so that project staff will make an extra effort to meet them. They should not represent the end of every task in the project plan, for example. Nor should they be so frequent as to result in weekly milestone crises, or people will lose interest rather quickly.

2.2 Project Control

The second half of the project manager's job is project control. This includes the evaluation of project status with respect to planned work achievement, resource consumption and schedule, and the correction of deviations from plan. The project manager must continually be asking:

- Will the project meet its objective?
- Will it be completed on time?
- Will it be completed within budget?
- What must I do to get the project back on track?

Project control is a continuous process, and plans should be continually updated to reflect reality.

The evaluation of progress and estimation of remaining work is carried out through project reviews with team members, ranging from informal chats with individuals to full team evaluations at milestones.

The following review schedule could be used for a medium-sized project (10 to 15 people) that might last four to five months.

- **Daily:** seek out every person who reports to you to check how things are going. Don't call team leaders to your office; go and see them.
- **Weekly:** meet in your office to review status reports. If there are no problems, send your manager a short progress report and get back to work.
- **Monthly:** provide your manager with a detailed progress report of two or three pages.
- **At major milestones:** conduct a project review with your manager and team leaders. Ensure action items are recorded and followed up.
- **On project completion:** you may wish to review problems, the success of your methodology, performance of the project team, etc.

For smaller projects or projects for which team members are not readily available, an "open door" policy on the part of the project manager and senior project staff combined with monthly progress meetings should be an adequate review schedule. It should be noted, however, that team members have a responsibility to report on an "as required" basis. Silence is no excuse for not meeting deadlines or failing to complete a task because of a "problem" of which the project manager was not made aware.

Resource consumption will normally be recorded through branch time reporting systems and by the financial reporting system. The project manager must have access to each of these information sources in order to carry out resource management.

Reporting on progress in relation to plan can be done in detail or on an exception basis by reporting only deviations from plan. A special effort must be made to ensure that reporting obligations are met. Project reporting protects the project manager and the project by recording progress and reasons for delays. It also ensures early identification of problems that will have to be dealt with.

The next section describes the tools which may be of value to the project manager in fulfilling planning and control responsibilities.

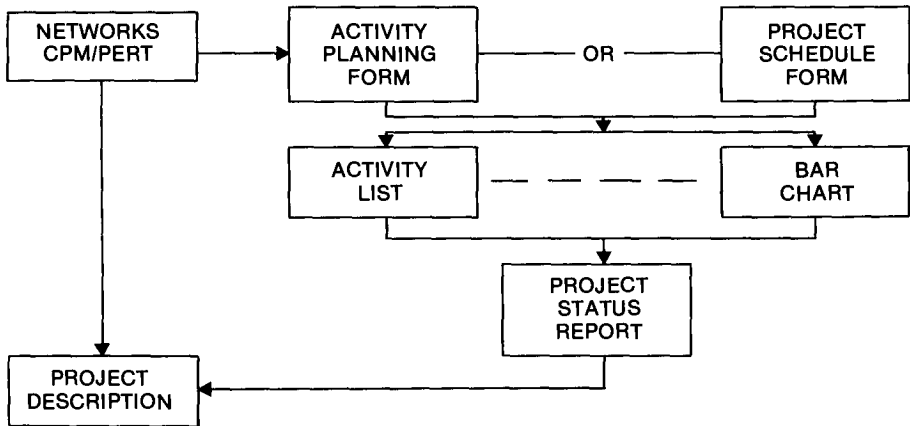
3.0 PROJECT MANAGEMENT TOOLS

This chapter describes and illustrates several forms and methods which can be used for project planning and control. They are intended to be guidelines only, and can be changed to meet the particular requirements of any project.

The following tools are discussed:

- Project Description
- Activity Planning Form
- Project Schedule Form
- Activity List
- Bar Charts
- Project Status Report
- Networks: CPM and PERT

Their interrelationships are illustrated in the following diagram and discussed below.



The foundations of the project manager's tools are the Networks: CPM/PERT (which are discussed at 3.7). Networks provide the basic planning tool which permits project control.

A main output from the Networks is a Project Description (3.1), which is an overview for senior management. The Project Description is updated through control information provided by the Project Status Report (3.6), which is updated as a result of individual activity and project control reports.

Another output from the Network planning exercise is the Activity Planning Form (3.2), or a suggested alternate — the Project Schedule Form (3.3). These are aggregated for reporting at the project level through the complementary tools of an Activity List (3.4) and a Bar Chart (3.5).

These tools provide a continuous flow of appropriate planning and control information for different levels of management.

Before reviewing the tools, it should be noted that they are only aids to project managers. If the tools are not used, or are used improperly, they can become the basis for frustration and discontent during the life of the project. Some common mistakes in using the tools are:

- insufficient time allocated to the planning process at the front end of the project;
- inappropriate involvement of team members in the planning process.

These deficiencies can be minimized through practice and sensitivity on the part of the project manager.

3.1 Project Description

Project Description forms are used by senior managers to obtain an overview of significant projects. The form illustrated here has been designed for the ADM, P&C, but should be redesigned to suit information needs of other managers as necessary.

Information on this form is updated through the Project Status Report, which in turn is updated through information reported to Activity Lists and Bar Charts.

Three sample forms are included: the first is a blank; the second offers guidance on how the form may be completed; the third is a completed sample.

PROJECT DESCRIPTION

PROJECT NUMBER: _____ Designated: _____
 DATE: _____

PROJECT TITLE:

RESPONSIBLE BRANCH:

RESPONSIBILITY CENTRE:

PROJECT LEADER:

OBJECTIVE:

DESCRIPTION:

PRODUCTS:

SENSITIVE ISSUES:

CONSULTATIONS REQUIRED:

MILESTONES	SCHEDULED DATE	
	ORIGINAL	REVISED
Project Start		
TOTAL RESOURCES BUDGETED: P/W \$		

PROJECT DESCRIPTION

PROJECT NUMBER: branch number,
if applicable

Designated: (ADM initial)
DATE: date submitted to ADM

PROJECT TITLE:

RESPONSIBLE BRANCH: can include ADM

RESPONSIBILITY CENTRE: within branch

PROJECT LEADER: individual responsible

OBJECTIVE: what the project is intended to achieve

DESCRIPTION: brief statement of approach, techniques, major elements of project

PRODUCTS: end products to be produced

SENSITIVE ISSUES: potential problems and their impacts, areas of high political visibility

CONSULTATIONS REQUIRED: in-house, OGDs, etc.

MILESTONES	SCHEDULED DATE	
	ORIGINAL	REVISED
Project Start Major occurrences or decision points only, including those where ADM, DM or Minister are involved. Should indicate a point in time, often associated with a product, e.g.: "ADM approval of final draft".	mandatory	to be maintained, based on monthly/ biweekly status reports.
Project Completion	mandatory	
TOTAL RESOURCES BUDGETED: P/W \$		

PROJECT DESCRIPTION

PROJECT NUMBER: Designated: (ADM initial)
 DATE:

PROJECT TITLE: Legislative Policy Review/New Directions

RESPONSIBLE BRANCH: ADM

RESPONSIBILITY CENTRE:

PROJECT LEADER: T. E. Reid

OBJECTIVE: To produce draft legislation governing the operations and directions of DREE in the 1980s.

DESCRIPTION: The project includes preparation of a detailed discussion paper outlining options for regional economic policy and the implications of each option. A Memo to Cabinet will be prepared recommending one option and draft legislation prepared from the approved cabinet document. Planning for implementation of the option chosen and for an appropriate public information program will also be completed as part of this project.

PRODUCTS: Discussion Paper, Memo to Cabinet, Draft Legislation

SENSITIVE ISSUES: Highly visible and sensitive project, both within and outside the department. Will affect DREE organization, budget and mandate and will have impacts on other departments.

CONSULTATIONS REQUIRED: All branches within DREE, selected other government departments, possibly some private sectors. Strategy to be determined as part of project.

MILESTONES	SCHEDULED DATE	
	ORIGINAL	REVISED
Project Start	04 Dec. 80	
Ministerial approval for DP	11 Feb. 81	
Minister receives draft MC	13 Mar. 81	
Start detailed design of project interviews	13 Apr. 81	
Cabinet approval for MC	08 Jun. 81	
Legislation introduced	28 Sept. 81	
Project Completion	28 Sept. 81	
TOTAL RESOURCES BUDGETED:		
P/W	340	
\$		

3.2 Activity Planning Form

Activity Planning Forms are used to clearly define activities and break them down to the level of tasks, including time required, resources required and dependencies. (An alternate form, the Project Schedule Form is discussed in 3.3.)

These forms are completed by the project manager and used to communicate task requirements to project team members. They are also the base for project control against which corrective action can be taken and project accountability can be assured. This information can be updated as the project progresses.

Two forms are provided: the first is a blank; the second provides guidance on how the form is to be completed.

ACTIVITY PLANNING FORM

Original _____
Revised _____

Project: Number Name

 Subproject: _____
 Activity: _____
 Assigned to: _____
 Objective: _____
 Description: _____
 Tasks: _____

No.	Description	Resp.	Elapsed Time	Resources	
				P/W	\$
Total					

Scheduled Start: _____

Finish: _____

Outputs:

Dependent Activities Preceding:

Consultations:

Comments:

ACTIVITY PLANNING FORM

Original _____

Revised _____

Project: Number Name

Subproject: _____ If appropriate

Activity: _____

Assigned to: _____ responsible person

Objective: what the activity should achieve

Description: brief summary of approach, techniques, major elements

Tasks:

No.	Description	Resp.	Elapsed Time	Resources	
				P/W	\$
Total					

Scheduled Start: _____

Finish: _____

Outputs:

Dependent Activities Preceding: those which must be completed before this one can begin

Consultations: who must be consulted in carrying out this activity

Comments: any additional information

3.3 Project Schedule Form

The Project Schedule Form (or the detailed Activity Planning Form discussed in 3.2) is used to supplement the information portrayed graphically in bar charts. Additional information is provided on each activity including who is responsible, current status, and revisions to schedule.

Note that the “% complete” figure must be used very carefully. It is most often calculated as follows:

$$\% \text{ complete} = \frac{\text{hours spent to date}}{\text{total time estimated}}$$

For the resulting figure to be useful, the original estimate must be accurate throughout the project — a rare situation. A more realistic calculation can be made using this formula:

$$\% \text{ complete} = \frac{\text{hours spent to date}}{\text{hours spent to date} + \text{hours estimated to complete}}$$

When used in conjunction with the bar charts, this provides a relatively complete and easily understood summary of status.

Two forms are provided: the first is a blank; the second gives an example which is further illustrated on the Bar Chart Form.

PROJECT SCHEDULE FORM

PROJECT: ANALYSIS COMPANY ABC

STATUS AS AT: 79 February 23

ACTIVITY: _____

TASK: _____

ITEM/ DESCRIPTION	RESP.	PERSON- WEEKS	START DATE			COMPLETION DATE			% COMP.
			PLAN	REVISED	ACTUAL	PLAN	REVISED	ACTUAL	
100 Planning & Research	Smith	2	Jan. 1		Jan. 1	Jan. 12		Jan. 12	100
101 Dept. X Interviews	Jones	2	Jan. 15		Jan. 15	Jan. 26		—	90
102 Summarize Findings (X)	Jones	1	Jan. 29		Feb. 19	Feb. 2		—	50
103 Dept. Y Sect. A Interviews	Smith	4	Jan. 15		Jan. 15	Feb. 9		—	90
104 Dept. Y Sect. B Interviews	Jones	2	Feb. 15		Feb. 5	Feb. 16		Feb. 16	100
105 Dept. Y Sect. C Interviews	Smith	2	Feb. 12		—	Feb. 23		—	0
106 Summarize Findings (Y)	Smith & Jones	4	Feb. 26		—	Mar. 9		—	0
107 Define X-Y Interfaces	Smith & Jones	4	Mar. 12		—	Mar. 23		—	0
108 Prepare Report	Smith & Jones	6	Mar. 26		—	Apr. 13		—	0

3.4 Activity List

The Activity List provides a summary of information on all project activities. This summary information is taken from a tool such as the Activity Planning Form or the Project Schedule Chart. Information on the Activity List can be used to develop a Bar Chart as discussed in 3.5, or to update the original planning network.

Finally, the updated Activity List is used as an input to the Project Status Report which is used by the project manager to inform senior management of progress.

ACTIVITY LIST

Activity No.	Description	Assigned To	Elapsed Time	Start Date Dependencies	Resources	
					P/W	\$

3.5 Bar Charts

Bar charts are used to show, on the same page, work planned and work completed.

Two forms are provided: the first is blank; the second form illustrates an example where two weeks were scheduled for department X interviews (activity 101) and three weeks were spent. It is unknown whether activity 101 is complete.

3.6 Project Status Report

The Project Status Report is used for status reporting to a senior manager on designated projects. It focusses on the identification of problems and major events, especially those which will involve senior departmental managers in the near future.

The example illustrated in the following forms has been designed for the ADM, P&C. The sample form portrays the information requirements as specified by the ADM, P&C; it should, however, be revised to suit the management and organization it is intended to serve.

Two forms are included: the first is a blank; the second gives guidance on how to complete the form.

PROJECT STATUS REPORT DESIGNATED PROJECTS

PROJECT NUMBER:

DATE:

PROJECT TITLE:

PROJECT LEADER:

TEL.:

MILESTONES DUE NEXT TWO WEEKS:

ADM, P&C INVOLVEMENT NEXT TWO WEEKS:

DM INVOLVEMENT NEXT FOUR WEEKS:

MINISTER'S INVOLVEMENT NEXT TWO MONTHS:

CRITICAL ISSUES/PROBLEMS:

CHANGES REQUIRED IN SCHEDULE?
RESOURCES?
TERMS OF REFERENCE?

YES/NO
YES/NO
YES/NO

PROJECT STATUS REPORT DESIGNATED PROJECTS

PROJECT NUMBER: branch project number,
> if applicable

DATE:

PROJECT TITLE:

PROJECT LEADER:

TEL.:

MILESTONES DUE NEXT TWO WEEKS:

ADM, P&C INVOLVEMENT NEXT TWO WEEKS:

include dates

DM INVOLVEMENT NEXT FOUR WEEKS:

include dates

MINISTER'S INVOLVEMENT NEXT TWO MONTHS:

include dates

CRITICAL ISSUES/PROBLEMS:

- current problems and impacts, especially reasons for any delays
- potential problems and implications
- corrective action required

**CHANGES REQUIRED IN SCHEDULE?
RESOURCES?
TERMS OF REFERENCE?**

**YES/NO
YES/NO
YES/NO**

3.7 Networks: CPM and PERT

Network charts are the best means to graphically portray the interrelationships of activities in complex projects.

The Critical Path Method (CPM) permits calculation of the critical (longest time) path of the network and of slack in other paths, using simple elapsed time estimates for each activity.

The Program Evaluation Review Technique (PERT) adds the capability to use statistical techniques to deal with planning uncertainty.

CPM and PERT are especially appropriate for the management of large, complex projects. Using these tools, the project manager can, for example:

- identify opportunities to redistribute resources from activities not on the critical path to those on the critical path, within constraints on total available resources, in order to shorten the schedule. (This is called resource levelling.)
- evaluate the overall effects of delays, early completion of activities, redistribution of resources, etc. (answering "what if" questions).
- determine least cost options by analyzing cost/schedule trade-offs.

Brief descriptions of CPM and PERT follow.

CRITICAL PATH METHOD (CPM)

CPM is a method of network planning that is particularly suited to the planning and scheduling of projects for which the activities are well defined, and the times/resources required to carry them out are known from experience. Network planning techniques show the relationship and sequence of all activities needed to complete a project.

To prepare a network plan:

1. Define the objectives of the project.
2. Divide the project into phases and state their objectives.
3. Write down all the activities that may be required in each phase.
4. Prepare a logic diagram indicating the sequence of activities. (Loops are not allowed.)
5. Identify who will be responsible for each activity.
6. Amend the network, if needed, to eliminate conflicts of responsibility and availability of resources.
7. Define detailed goals for each activity on the network chart: goals should be specific and should address the quality control of the outputs of the work.
8. Define the detailed work elements that comprise each activity.
9. Prepare a detailed logic diagram showing the relationships of all the detailed work elements of each phase of the project.

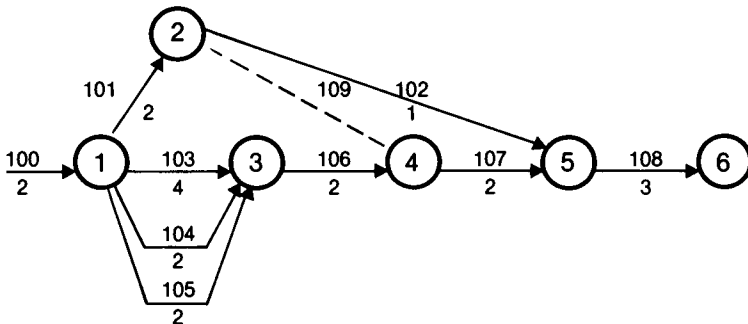
To find the critical path:

1. Keeping in mind the people available to do the work, estimate the likely number of working days needed to complete each work element and mark this on the network chart.
2. Trace each possible path from project start to project finish on the network, adding the durations of each activity on each path.
3. The longest duration path is the critical path: it usually requires the closest management attention to prevent slippage of the project.

Example: Define Activities and Dependencies

ACTIVITY	DEPENDENT ON	ESTIMATED DURATION	ESTIMATED PERSON-WEEKS
100 Planning	nil	2	2
101 Interview Dept. X (total)	100	2	2
102 Summarize Findings Dept. X	101	1	1
103 Interview Dept. Y (Section A)	100	4	4
104 Interview Dept. Y (Section B)	100	2	2
105 Interview Dept. Y (Section C)	100	2	2
106 Summarize Findings Dept. Y	103, 104, 105	2	4
107 Define Interfaces X-Y	101, 106	2	4
108 Prepare Report	102, 107	3	6

Example: Network Diagram



The possible paths are:

100-101-102-108	8 weeks
100-101-109-107-108	9 weeks
100-103-106-107-108	13 weeks – critical path
100-104-106-107-108	11 weeks
100-105-106-107-108	11 weeks

The critical path, totalling 13 weeks (elapsed time) has a shorter time (by two weeks) than the project duration previously determined with the bar or Gantt chart. This is because the network has not been resource-levelled and may require more people than are available to do the work.

The critical path indicates the chain of activities that must not be allowed to slip. The activities of the critical path must be shortened if the work schedule of the project is to be shortened. Network techniques, with CPM or PERT, help the project manager to keep control of his project. His alternatives when the critical path is too long are:

1. to obtain and assign more people (or sometimes other resources such as machines, lab equipment, data terminals)
2. to parallel more activities
3. to change or delete activities
4. to alter quality requirements to permit the work to be done faster.

SLACK TIME

The "slack" available to any single activity is the difference between the latest possible date that it can start without affecting the length of the critical path, and the earliest possible start date for the activity. Activities on the critical path do not have any slack.

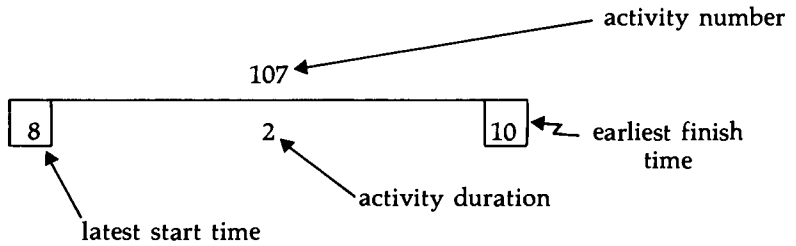
Activity 102, for example, had a slack of 7 weeks when the project started. This is no longer true at 79 February 23, because the entire schedule is behind and must be re-estimated to permit calculation of the new critical path and activity slack times.

Slack is used to best advantage in resource levelling — that is, the assignment of resources evenly throughout the project's duration. It is often possible to reduce the peak size of a project team by judicious scheduling of activities off the critical path.

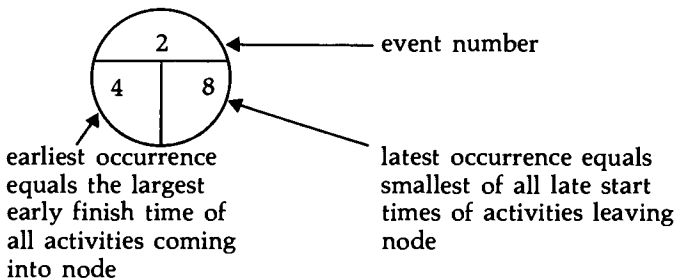
CPM CALCULATIONS

1. Conventions

(a) Activity



(b) Event

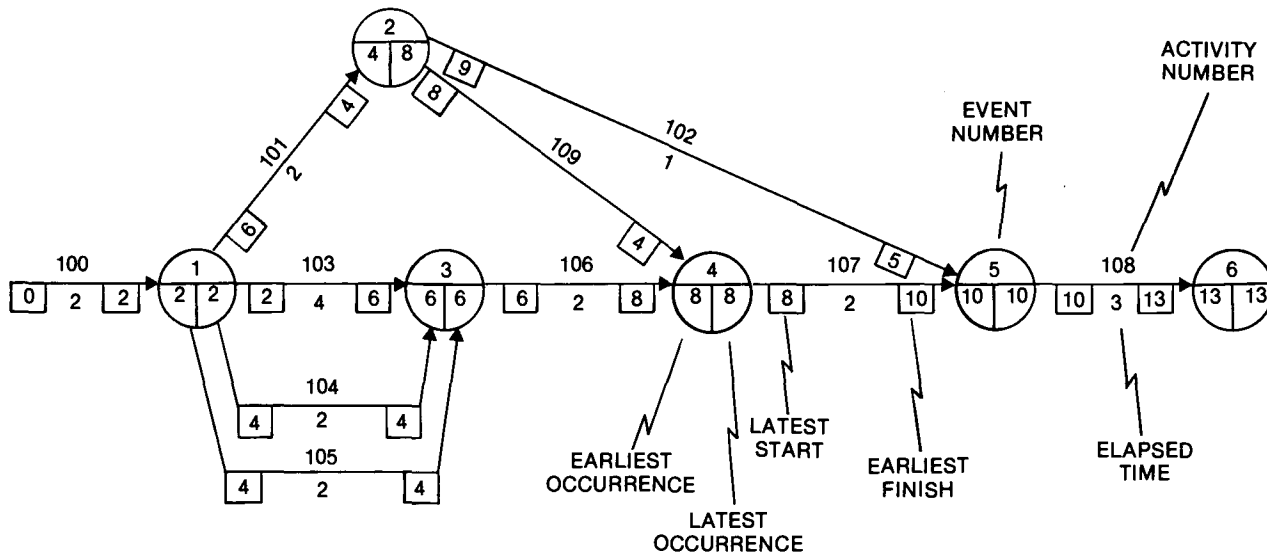


2. Computations

- Set early occurrence of event "zero" as time zero.
- Determine early finish time for all activities leaving, by adding activity duration to early occurrence time for event.
- Determine early occurrence of any events where early finish for all activities entering has been computed, by taking the largest of those early finish times.
- Continue (b) and (c) until all events have an early occurrence time.
- The event with the largest early occurrence time is the last event in the network, and is on the critical path. Set its latest occurrence time equal to its early occurrence time.
- Determine the latest start time for each activity entering the last event by subtracting its duration from the last node's latest occurrence time.
- Determine the latest occurrence for any event where the latest start for every activity leaving the event has been computed, by taking the smallest of those latest start times.
- Continue (f) and (g) until all events have a latest occurrence time.

-
- (i) Events on the critical path will have identical early and late occurrence times. Activities on the critical path will have a late start time equal to the preceding node's late occurrence, and an early finish time equal to the subsequent node's early occurrence time.
 - (j) Slack time for an event is the difference between the late occurrence and the early occurrence times.
 - (k) Slack time for an activity is either "total slack" or "free slack".
 - (1) Total slack for an activity is the slack that it has if other connected activities move, so long as the critical path is not extended. It is calculated by subtracting the early finish time from the subsequent node's late occurrence time.
 - (2) Free slack is the slack available to an activity that will not affect the early start of any other activity. It is calculated by subtracting the activity's early finish from the subsequent node's early occurrence.

NETWORK CHART/CPM CONVENTIONS



PROJECT EVALUATION AND REVIEW TECHNIQUE (PERT)

The PERT technique applies elementary statistics to the times used in network planning. PERT permits better treatment than CPM of the uncertainty inherent in many projects. It is very useful for R&D work and "first time" systems development projects.

With PERT, the "expected time" for each activity is not necessarily the likely elapsed time. The first step in PERT is to calculate the expected time, t_e , for each activity:

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

where a is the minimum elapsed time, b is the maximum elapsed time and m is the likely time needed to complete the activity.

The variance associated with this time (the measure of how likely m really is) is found by:

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

The (non-rigorous) mathematical theory of PERT says that the maximum and minimum times should have a chance of about one in a hundred of actually happening (i.e. "miracle" and "disaster" times).

Example: Analysis Company ABC

Activity	a	m	b	Expected t_e	Variance v
100	1	2	3	2.0	.3
101	1	2	5	2.2	.7
102	.5	1	2	1.1	.2
103	3	4	5	4.0	.3
104	1	2	9	3.0	1.3
105	1	2	7	2.7	1.0
106	1	2	3	2.0	.3
107	1	2	4	2.2	.5
108	1	3	5	3.0	.7

The expected time and the associated total variance for each path through the network are found by summing the t_e and v for activities on the path.

Possible paths through the network are:

	<u>PERT</u>	<u>CPM</u>	<u>PATH VARIANCE</u>
100-101-102-108	8.3 weeks	8 weeks	± 1.9
100-101-109-107-108	9.4	9	± 2.2
100-103-106-107-108	13.2*	13*	± 2.1
100-104-106-107-108	12.2	11	± 3.1
100-105-106-107-108	11.9	11	± 2.8

* In this case the critical paths, as computed by CPM and PERT, are the same path. Note that the variability in activities 104 and 105 are driving the paths through them to higher durations and could, conceivably, become critical themselves.

PERT can also be used to determine the probability of completing the critical path in less than a specified number of days. The probability can be found from:

$$Z = \frac{T_s - t_e}{v}$$

where T_s is the number of days specified for the project. The probability P associated with Z can be found by consulting the Cumulative Normal Probabilities. If we wish to determine the probability of completing the critical path in, say 12 weeks (or less), using the above formula:

$$Z = \frac{12 - 13.2}{2.1} = -0.57$$

This corresponds to a probability P of 27%.

Acceptable probabilities for completion depend on the duration of the project. Longer projects provide greater opportunity for both early and later completion of activities. Various PERT references say different things on this subject, but as a general rule, any probability of completion of less than 40-50 per cent is always unacceptable. A project manager would probably feel quite comfortable in a medium length project (of say, four months duration) if the indicated probability were greater than 75 per cent.

CUMULATIVE NORMAL PROBABILITIES

<u>Z</u>	<u>0.00</u>	<u>Z</u>	<u>0.00</u>
- 3.5	0.00023	+ 0.0	0.5000
- 3.4	0.00034	+ 0.1	0.5398
- 3.3	0.00048	+ 0.2	0.5793
- 3.2	0.00069	+ 0.3	0.6179
- 3.1	0.00097	+ 0.4	0.6554
		+ 0.5	0.6915
- 3.0	0.00135		
- 2.9	0.0019	+ 0.6	0.7257
- 2.8	0.0026	+ 0.7	0.7580
- 2.7	0.0035	+ 0.8	0.7881
- 2.6	0.0047	+ 0.9	0.8159
		+ 1.0	0.8413
- 2.5	0.0062		
- 2.4	0.0082	+ 1.1	0.8643
- 2.3	0.0107	+ 1.2	0.8849
- 2.2	0.0139	+ 1.3	0.9032
- 2.1	0.0179	+ 1.4	0.9192
		+ 1.5	0.9332
- 2.0	0.0228		
- 1.9	0.0287	+ 1.6	0.9452
- 1.8	0.0359	+ 1.7	0.9554
- 1.7	0.0446	+ 1.8	0.9641
- 1.6	0.0548	+ 1.9	0.9713
		+ 2.0	0.9773
- 1.5	0.0668		
- 1.4	0.0808	+ 2.1	0.9821
- 1.3	0.0968	+ 2.2	0.9861
- 1.2	0.1151	+ 2.3	0.9893
- 1.1	0.1357	+ 2.4	0.9918
		+ 2.5	0.9938
- 1.0	0.1587		
- 0.9	0.1841	+ 2.6	0.9953
- 0.8	0.2119	+ 2.7	0.9965
- 0.7	0.2420	+ 2.8	0.9974
- 0.6	0.2743	+ 2.9	0.9981
		+ 3.0	0.99865
- 0.5	0.3085		
- 0.4	0.3446	+ 3.1	0.99903
- 0.3	0.3821	+ 3.2	0.99931
- 0.2	0.4207	+ 3.3	0.99952
- 0.1	0.4602	+ 3.4	0.99966
- 0.0	0.5000	+ 3.5	0.99978

4.0 1981-82 PSC COURSE OFFERINGS IN PROJECT MANAGEMENT

This final section of the handbook is offered to illustrate to the reader courses which are available.

Extracts are from the PSC Staff Development Branch Calendar of Courses and Education Services for 1981-82.

For further information contact:

- In the National Capital Region: 997-3610.
- In other regions: the SDB Regional Staff Officer.

Project and Task Force Organization and Management

Purpose:

The use of project teams and task forces is on the increase in the Public Service. This seminar is designed to examine the fundamentals of a project — its key components, and in particular, the function of the manager of the project. A critical comparison is made between project and task force management.

Of Interest to:

Persons who are ultimately responsible for the success of the project, but who will not be members of the team; managers or key members of a project or task force.

Content:

- Who the client is
- What the contract is
- The control you have
- How you handle conflict
- Managing a project in times of uncertainty
- A comparison of basic organization types and the project concept
- The advantages and disadvantages of using a project organization
- The project manager
- Staffing the project
- Relations between the project and other departments
- Project phasing
- Project organization
- Estimating
- Project planning and scheduling
- Project cost control
- Engineering management
- Procurement
- Project accounting/project reporting
- Managing changes in the environment

Benefits:

- You will learn how to develop a project and task force organization step by step.
- You will learn how to maintain good working relationships between team members and others.
- You will find out how to recognize early "out of control" warning signals.
- You will become aware of project pitfalls like "engineering myopia" and "gimmicky techniques".

Duration and Fees: 4 days, \$360

Project Management

Purpose:

To introduce participants to the concepts and techniques critical to successful project management.

Of Interest to:

Technical and staff specialists, and middle managers who are responsible for setting up project teams, taking part in teams, or who are responsible for preparing project presentations.

Content:

- Characteristics of project management systems
- Problems peculiar to project management
- Operational strategies available to project managers
- Network planning and control
- How to define a project and foresee its impact on performance
- The use of master checklists
- Establishing an effective project team
- Identifying areas of conflict
- How to use problem-solving techniques
- Risk analysis and trade-offs involved

Benefits:

You will

- Learn how to define and clarify project objectives.
- Gain the tools required to translate project objectives into an operational plan for the team.
- Foster collaboration and create an effective team.
- Find out more about decision making as it applies to project management.
- Be able to present a more effective project report.

Duration and fees: 5 days, \$450

Network Planning and Control

Purpose:

To provide participants with a knowledge of the principles and methodology of Program Evaluation and Review Techniques (PERT) and the Critical Path Method (CPM).

Of interest to:

Persons responsible for planning, scheduling and controlling projects.

Objectives:

- To gain an in-depth knowledge of:
 - steps in using Program Evaluation and Review Techniques (PERT) and the Critical Path Method (CPM).
- To acquire an awareness of:
 - potential applications of network techniques.
- To develop the ability to:
 - construct a network
 - use a network as a planning or scheduling tool
 - use networks as a control device
 - use summary diagrams and fragnets

Special features:

Are you already responsible for planning, scheduling and controlling projects? This course will show you how to do a better job in the following areas:

- refinement of networks
- resource levelling
- using networks in meeting deadlines
- summary diagrams and fragnets

Methodology:

Classroom instruction, small group exercises and case studies

Duration and Fees: 5 days, \$435

5.0 BRIEF BIBLIOGRAPHY

Much has been written on project management; three good selections are noted below.

Cleland, David I., and William R. King. *Systems Analysis and Project Management*. 2d ed. New York: McGraw-Hill, 1975.

Very good, simple, easy to scan. Available at DSS library.

Baumgartner, John Stanley. *Project Management*. Homewood Ill.: R.D. Irwin, 1963.

A dated publication, but containing sound basic concepts. Easy to read, short. Available at DSS Library.

Burroughs Corporation. *PERT & CPM: Proven Tools for Management Planning and Control*. A Management Sciences Series Publication. Detroit, 1965.

Good overview of PERT/CPM techniques.

