

# Project Management

Scheduling and Monitoring  
by PERT / CPM

**B M Naik**

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# PROJECT MANAGEMENT

SCHEDULING AND MONITORING BY PERT/CPM

**B.M. NAIK**

*Principal, Shri Guru Gobind Singhji College of  
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(Maharashtra)*



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**PROJECT MANAGEMENT**  
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*Dedicated to  
My Family*

## FOREWORD



The world over, it is being realised that development depends on how successfully the plan programmes and projects in irrigation, industry, housing, education, etc. are implemented and put into operation. The accomplishment of goals like the economic upliftment of the masses and raising their standard of living depends on how efficiently the national resources like money, men and materials are made use of in the capital formation stage of projects. Optimum utilisation of these resources, as is eagerly desired, demands the use of management techniques like the programme evaluation and review technique and critical path method (PERT/CPM) by our managers. This technique amongst the various management techniques is said to be the largest in use.

Many refresher courses on this aspect for improving Project Management are conducted every year by the national and international agencies for the project personnel in developing countries. Universities and other institutions have recently added this subject in the curricula of Engineering, Management and other courses. But there are not many textbooks and reference books available on the subject especially by the Indian authors. Professor B.M. Naik who has the firsthand experience of practising the management technique in project situations, teaching and consultancy assignments has indeed presented the subject in a very lucid manner. The notable feature of the book is that it contains, besides theory of the management technique PERT/CPM and exercises; case studies from Indian environment. This distinguishes the book greatly from other books and makes it relevant to the Indian situation and for that matter to the situation in any other developing country.

I am sure the students of Engineering and Management courses and professionals in private and public sector organisations concerned with projects would find the book useful.

G.S. KADU

*Director of Technical Education  
Maharashtra State Government*

## PREFACE

The book presents the basic concepts of the management technique, namely PERT/CPM and explains its application to projects in Indian environment. It is addressed primarily to the students studying the technique in various university courses, such as engineering, commerce, management, etc. It will also benefit the students taking professional examinations of the cost and works accountants, chartered accountants and the institution of engineers. The inservice personnel working in projects with clients, contractors, builders, sales agencies, architects, etc. who are often asked to use the technique but are not fully aware of its application and those who are taking short term courses in PERT/CPM at various professional and management institutes would also find the book useful. Equally useful it will be for personnel working for Government and banks who have to appraise project reports, provide finances and subsequently monitor them.

The book is an outcome of the experience gained in organising several courses on project management for project executives, administrators in Central/State Government and public sector corporations at the Administrative Staff College, Bombay and the Indian Institute of Public Administration, New Delhi. While doing so I had a long desire to present the technique, with examples from Indian scene. How far this objective has been attained in for the readers to decide.

Chapter 1 describes the state of affairs in most of our development projects such as irrigation, power, fertiliser, etc. Overrun, in time and cost in these projects are frequent resulting in slowing down the clock of progress. Application of the technique of Network Analysis, in fact, can reduce these overruns if not eliminate them completely. A brief account of the historical development of PERT/CPM and its subsequent spread in various fields is given in this chapter. Also a description of different stages through which a project passes, its linkages with national planning and characteristics of scientific project management are covered.

Chapter 2 explains the basic principles of the technique of network analysis PERT/CPM and development of a network model for a small project. Chapter 3 on project time analysis provides a methodology for computing the duration of the project. Earliest and latest



times at which various intermediate events are expected to be accomplished are also explained. Identification of Critical Path and its significance is stated in detail.

Chapter 4 explains the application of the technique to a large complex project. A case of irrigation project is explained through all stages, namely preparing project (work) breakdown structure, listing activities, developing sub-networks, and integrating them to form a master control network. Various problems associated with the practical application of the technique in such a project are also described.

Chapter 5 deals with the statistics involved in PERT technique. It is especially useful in finding out the probability of completing the project at given point of time.

Chapter 6 presents time cost trade off technique for planning and implementing projects at minimum cost. Project cost includes direct costs such as cost of labour, material, equipment and indirect cost such as overhead and loss of revenue due to delayed completion of the project. Management is often faced with problem of balancing time and cost for which the technique is very useful.

Chapter 7 explains PERT-COST, network based cost planning and control. This approach termed as resource based network is found to be very useful in appraisal of projects and is prescribed by Planning Commission, Government of India. It is useful during execution to contractors for cost control purpose. Use of graphics for higher levels of management in plotting time cost profiles, cost trend chart are some of the highlights of the chapter.

Chapter 8 is on the management of project resources, namely manpower, material, machinery, etc. Availability of resources on time is very important for timely completion of projects. The chapter also throws light on forecasting the need of resources, identifying conflicts and scientific allocation of resources. Multiple Resource Allocation Procedure Technique is explained for a single-project single-resource and multi-project multi-resource situations. Resource scheduling in projects of long duration especially for strategic planning of key resources is also presented.

Chapter 9 explains the principle of project monitoring and control. To operationalise the concept of planning, scheduling and monitoring, it is essential to instal monitoring cells at various levels in an organisation. Management of cells, their location, authority, functions, etc. are explained in detail in this chapter.

Chapter 10 explains the method of measuring physical progress in work units and integrating the same with financial inputs. This



approach is very essential for higher level management especially to avoid discrepancy between financial and physical progress. Concept of status index number is also presented.

Chapter 11 discusses the use of computers in network analysis. Some of the questions discussed in this chapter are: When to use a computer? How to use a computer? What is the cost involved in using a computer and problems associated with it? A few sample output formats are also presented.

Chapter 12 outlines a step by step procedure for introducing the technique in an organisation. It also outlines the factors that are responsible for its successful adoption and implementation. Indian experience in using PERT is given at the end.

Chapter 13 presents PERT charts for a few projects. They are made self-explanatory and so very little description is given on them.

I am grateful to Mr P.R. Dubhashi, Director of the Indian Institute of Public Administration, New Delhi, for constantly encouraging me to publish this book.

My thanks are due to Mr D.M. Sukhthankar, IAS, Secretary to Maharashtra State Government for his encouragement and support, but for which it would not have been possible to complete the book.

I owe thanks to Prof. G.S. Kadu, Director Technical Education, Maharashtra State Government for writing the Foreword to the book.

I am also thankful to Dr Nitini Desai, Advisor, Projects Appraisal Division, Planning Commission, Government of India for providing me very useful comments on the first draft of this book. Thanks are also due to Mrs Jamna Chandana, for meticulously typing the manuscript.

B.M. NAIK

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## Chapter 1

# INTRODUCTION

War is easy, it is waging it that is difficult.

NAPOLEON BONAPARTE

A large number of projects, such as, the construction of a dam, building of a new factory, or the installation of a power plant, are being implemented under the Five-Year Plan Programme in our country. Huge capital investments are being made in these projects. For example, in the Sixth Five-Year Plan out of the total outlay of Rs 97,500 crores, in public sector, a major part, i.e., Rs 84,000 crores were earmarked for developmental projects.<sup>1</sup> Expensive and scarce resources such as materials, equipment, etc., were also spent on them. It is therefore desirable that the projects are completed within the scheduled time and the specified cost, so that benefits from investments start flowing to the nation at an early date and rising aspirations of the people are fulfilled. All out efforts are often made by project personnel at every level to plan, execute, and monitor their progress to complete them in prefixed time frame and with full achievement of project content. Yet experience shows that most of them take longer than the prescribed period. For example, some irrigation projects such as Nagarjunsagar project in Andhra Pradesh, Gandak and Kosi projects in Bihar, etc., have been lingering for more than 15 to 20 years.<sup>2</sup> The list of such projects is quite long so much so that in the Sixth Five-Year Plan a considerable part of investment will be on the ongoing projects,<sup>3</sup> for it has become essential to complete such projects as early as possible.

While similar projects in developed countries are executed in shorter period, in India they take a much longer time. A fertiliser

<sup>1</sup>*Sixth Five-Year Plan, 1980-85, Government of India, Planning Commission, 55.*

<sup>2</sup>*Ibid.*, pp. 1-149.

<sup>3</sup>*Ibid.*, p. 65.

## 2 Project Management—Scheduling and Monitoring

project in India takes 84 months to set up; in Japan it hardly takes 14 months.<sup>4</sup> These may be the extreme cases. But the fact remains that our projects take much longer time to complete.

### Delays in Project Implementation and their Costs

The delays and the consequent additions to cost per year in respect of some projects have been as follows:

TABLE 1  
Cost Escalation in Delayed Projects

<i>Name of the Project</i>	<i>Delay (in months)</i>	<i>Cost of Delay (Rs crores per year)</i>	<i>Final Increase in Cost of Projects (Rs crores)</i>
1. Bokaro Steel Plant	72	51.72	310.32
2. Gujarat Refinery	12	27.99	27.99
3. Panipat Fertiliser	15	27.60	34.50
4. Donimalai Iron Ore	12	19.28	19.28
5. Bongaigaon Refinery	17	16.56	23.36
6. Chandrapura Power Project	18	13.03	19.55
7. Rajhan Cement	11	12.24	11.20
8. Idukki Hydrel Project	48	11.95	47.80
9. Atomic Power Station 2 (220 MW)	39	11.60	37.80
10. Acrylic Fibre (IPCL)	28	6.12	14.28
11. High Pressure Boiler Plant (BHEL)	36	1.92	5.76
12. Basic Chemical Unit (HOCL)	100	0.72	6.00

Source: FICCI, 1981.

Delay in the implementation of one project has a snowballing effect on many others. For example, if a power project is delayed, industries and other ongoing projects, which depend on power, get adversely affected. Compounded delays curtail the tempo of economic growth in general.

The production lost on account of delayed installation of capa-

<sup>4</sup>FICCI, *Cost of Time*, 1981.

cities in the above projects have also been phenomenal. The production loss sustained by them on account of delays is as follows:

TABLE 1.2

## Production Loss Due to Delays in Project Completion

<i>Name of the Project</i>	<i>Production Loss (Estimated) (Rs in Crores)</i>
Bokaro Steel Plant	3018.75
Gujarat Refinery	438.00
Bailadilla	76.50
Panipat Fertiliser	47.43
Bokajan Cement	11.25
Donimalai Iron Ore	7.29
Rajhan Cement	4.12

*Source:* FICCI (1981).

With the delay in completion of projects, huge investment remains in the pipeline, delaying the income and employment generation. The break even point (B.E.P.) analysis on the basis of which the project is approved, because of cost overrun, remains no more valid. It gets prolonged so much so that the payback period is lengthened [see fig. 1.1 (a)] and at times the B.E.P. goes beyond maximum production capacity [figs. 1.1 (b & c)]. It is observed that due to delays in irrigation projects some states have been losing Rs 427 crores per year on their investment.<sup>5</sup> According to the Union Irrigation Minister's statement in Parliament, on 26 November 1980, delay in completion of major and medium irrigation projects will cost the exchequer an additional Rs 3,780 crores.<sup>6</sup> The original estimated cost of these projects was Rs 2,329 crores as against the present estimate (1980-81) of Rs 6,109 crores; besides this there is the loss of foregone production. Similarly, projects of central public sector undertakings are estimated to cost Rs 1,000 crore more.<sup>7</sup> In case of projects executed by central public sector undertakings in Middle East countries this kind of delay has led to large losses because of heavy penalties. The cost of delays is compounding which no undertaking or nation can afford.

<sup>5</sup>Sixth Five-Year Plan, *op. cit.*, p. 149.

<sup>6</sup>*The Economic Times*, 26 November 1980.

<sup>7</sup>*The Statesman*, 5 November 1980.

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### Projects and Planning Process

Project planning and its implementation form a very important part of a larger system of effort towards the cause of national development. It is essential for the project management to keep in view how the project is connected with the entire system of planning so that it could consider the interdependencies and constraints in a realistic manner and then carry it out to accomplish the overall policy goals. Linkage of project planning and implementation with the national planning needs to be understood thoroughly by the field personnel also for their effective, forceful and purposeful execution.

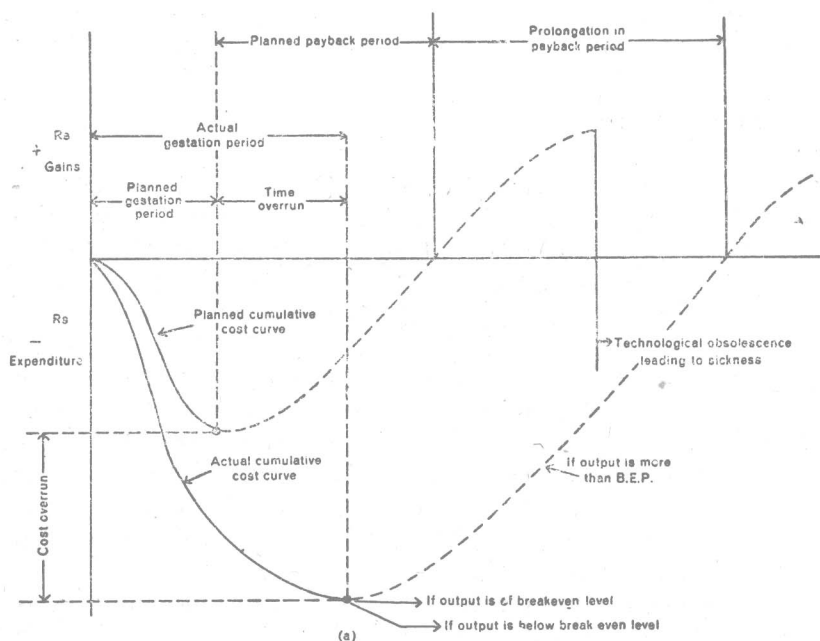


FIG. 1.1(a). Showing cumulative cost time profile before and after project commissioning.

There are various phases involved in the process of national planning and plan implementation. They are (i) policy planning; (ii) sectoral planning; (iii) programme planning; (iv) project appraisal; (v) project implementation; and (vi) project evaluation. They are shown in figure 1.2.

At policy planning stage, overall guidelines are determined by the national planning agency for the fulfilment of overall develop-



ment goals. For example, to remove poverty (see figure 1.2), sectoral planning is done by technical ministries of various sectors such

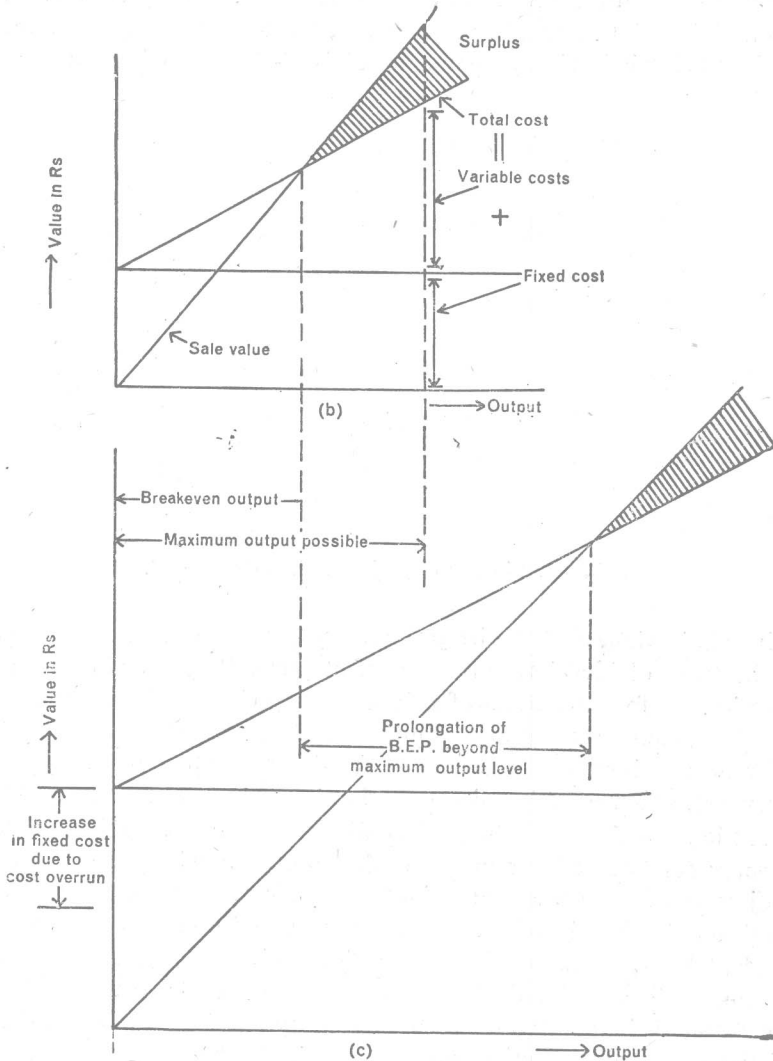


FIG. 1.1 (b+c). Breakeven analysis in planning stage. Breakdown analysis after commissioning project becomes "Nonstarter-sick".

as health, agriculture and irrigation, education, etc. A target of say 130 million tons food production may be set at this stage for agriculture sector. This could be accomplished by increasing irrigation

## 6 Project Management—Scheduling and Monitoring

potential, using high yielding seed, etc. Programmes are then drawn in each sector and funds allocated so as to achieve the target of food production within given time and cost frame. Each programme is then divided into a number of schemes, for example, the programme of increasing irrigation potential is divided into schemes such as

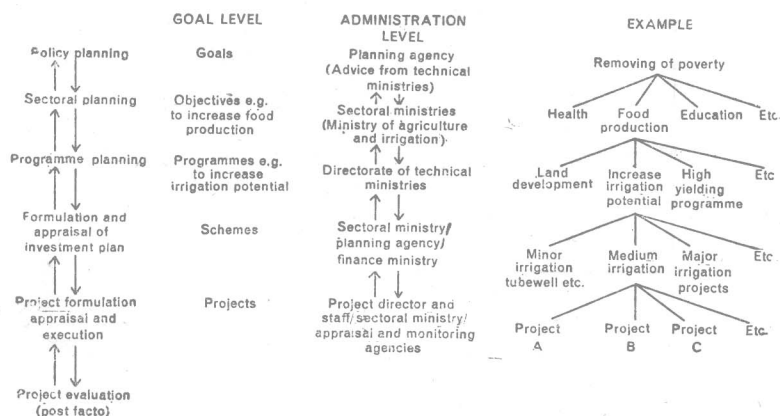


FIG. 1.2. Linkage of project with national goal.

minor irrigation, medium irrigation, major irrigation. Each scheme is in turn divided into a number of projects. Projects with specific location are formulated and feasibility analysis done in respect of financial, technical, economic and social aspects. Detailed analysis of resource inputs is also made at this stage. Once policies, programmes, schemes and projects are finalised they are taken up for execution. At this stage the project director and his staff have to prepare detailed action plans and schedules with reference to which projects are implemented and simultaneously monitored. At project level monitoring is to be done for resource inputs like materials, funds, labour, etc., to achieve the project objectives, namely, completing it in scheduled time and in specified cost. At the level of directorate it is required to see how best, by varying the allocation of financial and physical resources to various schemes, the targetted increase in irrigation potential could be accomplished. At technical ministries monitoring is required of intersectoral constraints and flow of funds to various programmes so as to accomplish the targetted increase in food production in given time and cost. Thus different parameters are to be monitored at different levels so that the overall policy goal of removal of poverty remains in view.