

Use of network techniques in project management

Part 2. Guide to the use of graphical and estimating techniques

Committees responsible for this British Standard

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Operational Research Society
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Foreword

This Part of BS 6046 has been prepared under the direction of the Quality, Management and Statistics Standards Policy Committee. It is a revision of BS 6046 : Part 2 : 1981, which is withdrawn.

The aim of BS 6046 is to be of practical use to the manager who wishes to use project network techniques as a tool for project management. A project manager meets many problems of which only some can be foreseen; even those familiar with planning and controlling projects will encounter unexpected difficulties and will often be forced into management by crisis.

BS 6046 is designed to draw attention to the problems that project management can resolve in advance, and does this by helping those involved to ask the right questions. Although the use of project network techniques is not a prerequisite for project management and many of the aspects discussed apply whether or not such techniques are used, BS 6046 is principally concerned with their use. BS 6046 deals in some detail with the circumstances under which project network techniques are appropriate and stresses the management problems that arise in their application.

BS 6046 systematically examines the area of application of project network techniques in project management. It guides the less experienced reader logically through the more fundamental questions, while the structure enables those more experienced in project management to progress rapidly through to more advanced topics. The best way of using BS 6046 is for the reader to become acquainted with its structure and the sequence in which various problems are approached.

BS 6046 concentrates on practical problems and possible methods of solving them and, as a guide to practice and application, it does not discuss theoretical aspects, neither does it provide detailed explanations. The reader's attention is drawn mainly to the questions that arise during project management and the use of networks. In particular, the general problem of communication, between different parts of the same organization and between different organizations, is stressed as is the importance of knowing the right questions to ask. The answers given here are a guide, based on long and wide-ranging experience; they are, however, opinions and not absolute facts. BS 6046 is a general interpretation and, as such, the views expressed should be examined critically in the light of particular circumstances to which they are applied. The main value claimed is that widely discussed and agreed answers to frequently met problems tend to be well suited for most situations and provide an authoritative basis for inter-organizational project management arrangements.

BS 6046 is published in the four following Parts.

Part 1 Guide to the use of management, planning, review and reporting procedures

The important functions and organization of project management, as distinct from general management, are emphasized. Descriptions are given of the involvement of management as the project develops from the initial planning of the project and review systems to the procedures to be adopted in setting the stages and frequency of project review and methods of reporting.

Part 2 Guide to the use of graphical and estimating techniques

Practical considerations for the estimation of values needed for the analysis of project networks are discussed. Guidance is given on the factors to be considered in choosing between activity-on-arrow or activity-on-node techniques. Network drawing methods for the presentation of the two types of network are discussed and recommendations given for the conventions to be used and the level of detail to be included as well as practical hints.

Part 3 Guide to the use of computers

Guidance is given on *when* and *when not* to use computers in conjunction with project networks. The different ways in which a computer may be used for processing project networks are described and assistance is given on how to select the actual computer package. This Part then refers to the purpose and significance of coding systems for use with project networks.

Part 4 Guide to resource analysis and cost control

This Part covers the use of resource analysis and project cost control as a natural extension to the use of time analysis in project network techniques. The two techniques are treated separately for the purpose of providing more effective management information.

In addition to a general editorial update of the standard, the major changes in this revision of BS 6046 : Part 2 are the introductory clause, which has been rewritten, a re-arrangement of the items in table 1, the relocation of the section on project estimating techniques, and the inclusion of a diagram illustrating typical project management procedures.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Guide

Section 1. General

0 Introduction

Providing a guide to the application of project network techniques based on accumulated practical experience, BS 6046 supplements BS 4335 first published in 1968 and subsequently revised in 1972 and 1987. BS 6046 concentrates on network-based systems, but also discusses related aspects of project organization and management insofar as they influence the application of such methods.

Projects differ from other enterprises in several ways, in particular by their transient nature, by the speed with which they normally have to be executed and by their relative complexity. Other features which distinguish projects include the following.

- (a) What happens during a project often affects the rest of the subsequent life of the end product (hardware or service).
- (b) The duration of the project is normally predetermined (finite) with definite start and termination dates specified.
- (c) The project organization is often temporary and may change from one phase to the next.
- (d) Most projects contain some elements of uncertainty and risk.
- (e) Many projects are non-repetitive, and often include some essentially unique features, often beyond the current state of the art.
- (f) Projects are normally not isolated, they interact with other projects, organizations and departments; their structures and systems are interactive organizationally, technically, economically and socially.

Two basic aspects are present in a project: first, the operational activities, e.g. the functions of design, procurement and construction, and secondly, management systems that are needed to plan and control the operational activities. BS 6046 deals primarily with the management systems, the details of which will depend on the type of project and the particular industrial sector in which they are applied. These systems also need to be adaptive as changes in project environment and phase occur. However, most projects, by their nature, contain similar stages, phases and procedures, which are diagrammatically summarized in figure 1 which is reproduced from BS 6046 : Part 1.

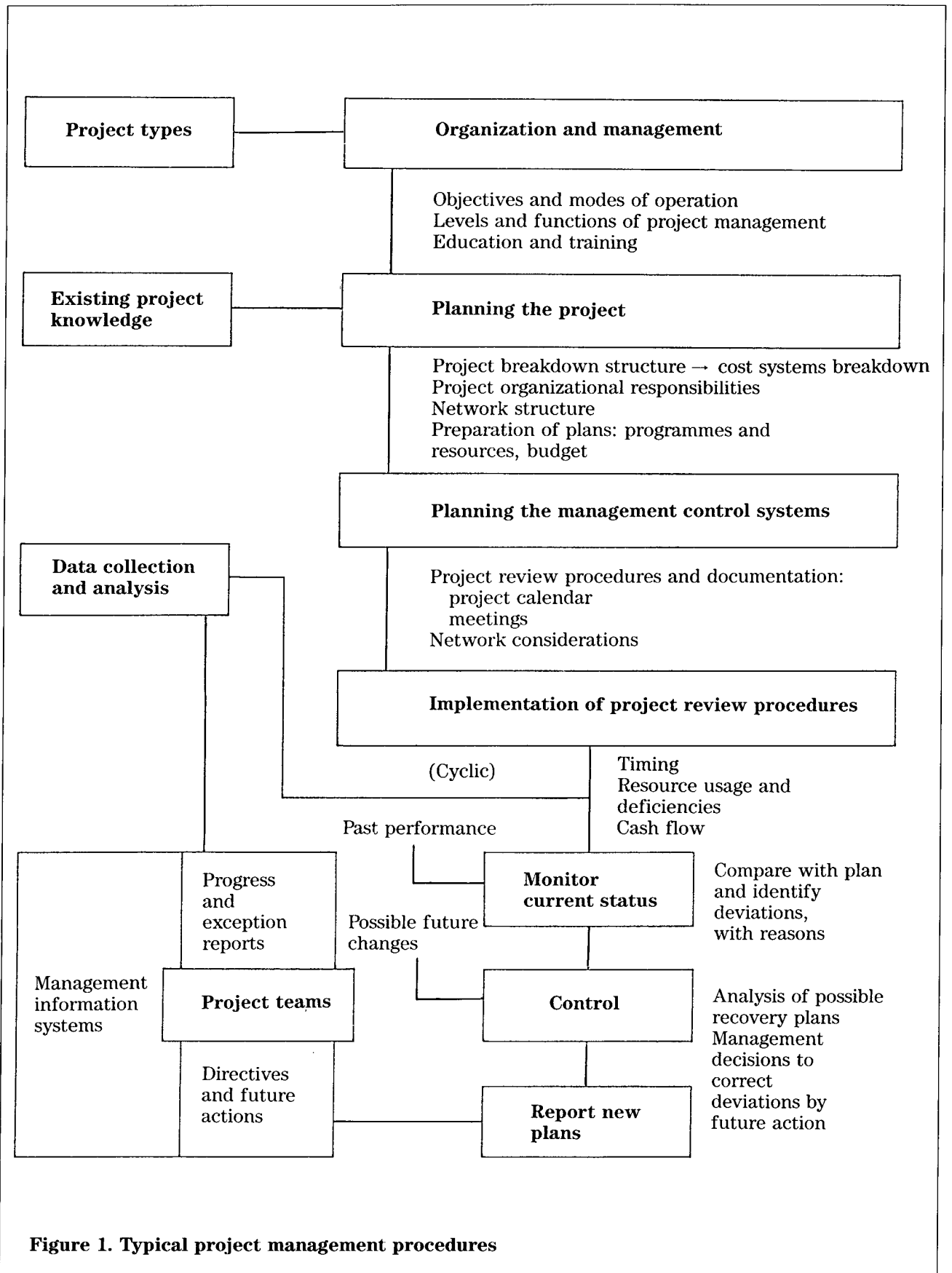
BS 6046 as a whole concentrates on the parameters of time, resources and hence costs in general. It deals with the basic requirements of project organization and management with project planning (where the datum conditions for the future conduct of the project are set down) and finally it deals with methods of controlling the subsequent performance of the project and some ways by which control may be maintained when changes occur.

Project network techniques as used now were developed in the USA, the UK and France more or less simultaneously in the mid 1950s. These developments included both activity-on-arrow and activity-on-node systems. A comparison between these alternative modes and detailed guidance on graphical and estimating techniques is given in sections 2 and 3 respectively. With the exception of programme evaluation and review technique (PERT), which contained probabilistic elements appropriate to the research and development (R & D) area for which it was designed, the developments were aimed at improving the ability to plan and control complex engineering projects.

Since then the techniques have been extended to handle resources, uncertainty of outcome as well as of duration and many other specific applications.

The benefits of using such techniques can include:

- (1) clearer definition of the scope of the project and the complex interrelationships between tasks;
- (2) better coordination between different organizations within the project, and provision of information about each organization's progress and future plans to the others (communication links);
- (3) ease of preparing schedules of work to be carried out;
- (4) ready means of reviewing the project and exercising control over time, resources and costs;
- (5) clearer identification of critical and risk areas, an excellent model for 'what if' exercises and resultant management decisions.



Networks are more informative and can be easier to develop and maintain than bar charts. They provide a simple means of assessing the combined effects of activity logic constraints, limited resources, etc. in meeting a required project end date. For most time analysis, and resource analysis especially, computer processing is desirable and for this many computer packages are now available.

NOTE. Means of assessing these computer packages and advice on coding systems are given in BS 6046 : Part 3, and BS 6046 : Part 4 covers the use of resource analysis and project cost control in more detail.

The network techniques described enable the main functions of the management of projects, i.e. planning, coordination, monitoring and control, to be conducted in an efficient and logical manner, in order to control a project, rather than merely monitor what is taking place. If effective decisions are to be made by project management, it is necessary that these decisions are based on the most accurate and up-to-date information available; this requires an adequate communication system together with defined objectives and procedures. It also implies that management has to look at future plans as well as using past experience, to anticipate problems.

Communications have to be such that rapidly changing situations are quickly recognized for corrective action to be effected by management.

BS 6046 is intended to provide guidance to a number of groups of people as follows:

(i) *general management*: in organizations that operate projects; when setting policies, awareness of available techniques and also their limitations; encouragement to use such techniques where suitable; the importance of being fully involved when projects are managed by these techniques;

(ii) *project managers*: responsible for project performance, so that they may better cope with the many problems they meet (only some of which may be foreseen) and encourage better integration between the different disciplines involved, aiming for a common goal;

(iii) *project support staff*: coordinators, planners, cost engineers, etc., so that they may better appreciate the techniques available and their potential pitfalls;

(iv) *educators*: those engaged in the teaching of, or research on, network-based techniques for project management who may need a basic reference on accepted practice.

BS 6046 is designed to draw attention to the problems that project management can resolve in advance by helping those involved to ask the right questions. Although the use of project network techniques is not a prerequisite for project management and many of the aspects discussed apply whether or not network techniques are used, the guide is principally concerned with their use.

Although BS 6046 has this emphasis on network-based techniques, project managers can, and often do, make use of other techniques, e.g. operational research, work study, organization and methods (O & M), quality control, production control, data processing, computer and information systems and value engineering. It is the responsibility of project management to select and use these techniques as appropriate and to balance their impact on the project so that this is not jeopardized by over-enthusiasm for any single aspect or by conflict between opposing objectives. For example, equipment should not be over-designed or over-engineered at the expense of failing to meet a delivery date when equipment which performs quite satisfactorily can be delivered on time.

As with all management techniques, it is desirable that the use of a network-based project management system should receive full management backing within the company or organization and that there should be an adequate training programme for all personnel concerned with network and other techniques for project management.

1 Scope

This Part of BS 6046 gives guidance on the two graphical methods of representing the activities in a project, namely *activity-on-arrow* and *activity-on-node*. A checklist highlights the main factors to be considered before the network mode is chosen. The guidance on network drawing methods defines two distinct purposes to which a network drawing may be applied and recommendations are given on the level of detail to be included, conventions and symbols to be used, and the preparation of drawing layout for the two types of network mode.

NOTE 1. The techniques presented were originally designed to provide clarity in hand-drawn network presentations. Computer-drawn presentations should be such as to provide the same clarity.

Practical considerations associated with the estimation of values required for the analysis of project networks, the errors and difficulties associated with such estimates (and how these may be reduced or eliminated) are given in section 3.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard, the definitions given in BS 4335 apply.

Section 2. Graphical techniques

3 Choice of network mode

3.1 General

The potential user of project network techniques has a choice between two basic methods of representing the activities in a project. Variations exist, but the two basic modes are as follows:

- (a) activity-on-arrow (see 3.2);
- (b) activity-on-node (see 3.3).

The necessity for choice will normally arise only when network techniques are being introduced for the first time, or possibly when the customer requires it. Any reason for changing from the use of one existing mode to another should be strong enough to outweigh the problems of retraining that would be needed for the entire organization.

Neither of the two basic methods is superior to the other and the advantage of one system over the other is wholly dependent on the prevailing conditions within the user's organization and the use to which the analysis is to be put. Factors affecting the decision include the following:

- (1) requirements of the user;
- (2) information format;
- (3) experience of personnel concerned;
- (4) location of the project;
- (5) type of project;
- (6) resources available.

The activity-on-arrow mode tends to be more firmly established in English-speaking countries, whilst activity-on-node networks are favoured in France, Germany and some other European countries. Activity-on-arrow networks are more popular within the engineering industries whereas in computer system projects and the electronics and construction industries activity-on-node methods are becoming more familiar.

The two modes of representation are evenly balanced. The activity-on-node method shows greater scope for logical representation and has been found most useful at the original brainstorming session at which the basic project logic is developed. At the working level the activity-on-arrow diagram may have greater appeal because of its explicit representation of events and legibility of the logic. Network-plotting programs are available from a number of computer manufacturers and software houses for both activity-on-arrow and activity-on-node methods.

Table 1 highlights the main factors that should be considered before the network mode is chosen.

3.2 Activity-on-arrow

The arrows in the network represent the activities and the nodes represent events. The logical relationships of timing are depicted by the connection of the arrows. (See figure 2.)

3.3 Activity-on-node (precedence)

The nodes in the network represent the activities and arrows are used to logically link these activities. (See figure 3.)

4 Recommended drawing methods

4.1 General

The network drawing can serve the following two distinct functions:

- (a) as a device used only within a planning department to define the logical links between the constituent parts of a project; or
- (b) as a vehicle for communication between planners and management, or between various levels of management, or between separate organizations, including subcontractors and suppliers.

For function (a), the presentation need not be very elaborate provided the logic implied in the drawing is totally explicit and unambiguous.

For function (b), the presentation of the network is of vital importance if the following apply:

- (1) acceptance of the network method is to be gained;
- (2) the anticipated communication between personnel involved with the project is to be successfully achieved.

The recommended procedure for compiling a working document is given in 4.2.

4.2 Compiling a working document

4.2.1 Start by identifying the objectives of the project and keep them in mind during the compilation of the network. These objectives may define the full network, or the interfaces where a subnetwork joins the full network.

4.2.2 Assume that the network will be unlike any other network. Make the network fit the plan; do not make the plan fit the network. Approach 'library' networks with caution and take care that they truly represent the project.

4.2.3 Prepare a list (in any order) of those jobs that can be recognized as contributing to the project; this should preferably be done at a group meeting of the contributors to the project. Standard checklists should be developed and used wherever possible.