

# Construction Project Management

宇德明 编 著

工程项目管理



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随着我国“一带一路”、铁路“走出去”等战略的稳步实施,我国工程设计、咨询、施工等企业的国际工程业务不断扩大,迫切需要大量具有全球视野、熟悉工程管理国际惯例的高素质国际工程管理人才。为了满足国际工程管理人才市场的需要,我国有条件的高等学校正在通过工程管理专业综合改革,调整和优化培养方案,其中包括工程项目管理、工程招投标与合同管理、工程项目风险管理等课程尽可能采用纯英语或英/汉双语教学。

*Construction Project Management* 一书分为 10 章,分别是:第 1 章 Introduction(导论),第 2 章 Organizing for Project Management(项目管理的组织),第 3 章 The Design and Construction Process(设计和施工过程),第 4 章 Labor, Material and Equipment Utilization(劳工、材料和设备利用),第 5 章 Cost Estimation(成本估算),第 6 章 Construction Planning(施工规划),第 7 章 Scheduling Techniques(进度计划技术),第 8 章 Construction Quality Management and Safety Management(施工质量管理和安全管理),第 9 章 Project Impact on the Environment(项目对环境的影响)和第 10 章 Project Monitoring and Control(项目监控)。

本书素材均选自国外权威的工程项目管理教材、手册和期刊文献,具有权威性、新颖性、案例多等特点,真实反映了工程管理国际惯例。书中所有章节标题、图表标题、重点词语和疑难词语都有中文注释,便于读者理解教材内容。每章后面都有英语思考题或练习题,便于读者理论联系实际,提高利用理论知识解决实际问题的能力;可作为工程管理、工程造价、土木工程规划与管理、项目管理、土木工程等专业本科生或研究生课程“工程项目管理”双语教材,也可作为国际工程培训班课程“国际工程项目管理”双语教材;对从事国际工程业务的我国工程设计、咨询、施工等企业的管理人员和技术人员也有重要参考价值。

在编写过程中,本书使用和参考了大量的文献资料,作者对这些文献的作者(尤其是 C. Hendrickson, T. Au, N. Munier 和 A. D. Marco)表示衷心感谢。本书的出版得到了教育部和湖南省教育厅“高等学校工程管理专业综合改



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作者水平有限,书中如有错误和不妥之处,欢迎读者指正。

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宇德明

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# 1

## *Introduction* (导论)

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### 1.1 Some Definitions(若干定义)

#### 1.1.1 Project and Project Management(项目和项目管理)

##### 1. Project(项目)

Project is a finite, specific and usually unique undertaking with a precisely defined goal, requiring the execution of a series of activities in a certain order. It is finite because it requires a start date and a finish date; specific, since it is executed for a defined purpose or goal; and unique as it is seldom repeated, and even if it is, the next project will be different from the former.

We have thusly defined a project as with respect to its “physical” components, but in reality what is a project? A project is a “system”; it has all the elements that qualify for this assertion. INCOSE (2000) defines it as: A system can be broadly defined as an integrated set of elements that accomplish a defined objective.

A project can be then considered as an integrated set of actions, many of them linked in a feedback structure(反馈结构), defining the latter as an output of a subprocess that is fed back to the same or to other subprocesses. For instance, in the initiation process, sales for the product to be manufactured by the project are assumed; then the financial procedure determines—based on this sales estimate, and together with other variables such as raw material and production costs, transportation, risks, etc.—what will be the rate of return. If the resulting figure is not satisfactory, for instance because it is too low when compared with other potential investments, new values and perhaps expectations are entered into the initiation process which is run again.



## 2. Project Management(项目管理)

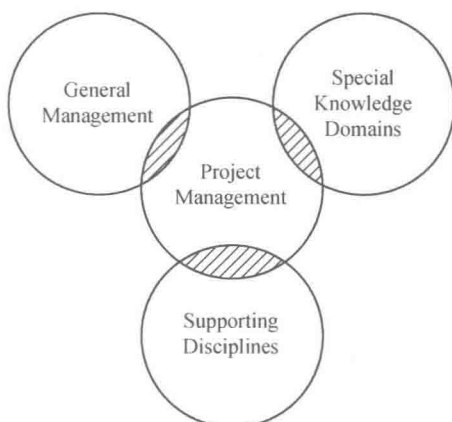
The management of construction projects requires knowledge of modern management as well as an understanding of the design and construction process. Construction projects have a specific set of objectives and constraints such as a required time frame for completion. While the relevant technology, institutional arrangements or processes will differ, the management of such projects has much in common with the management of similar types of projects in other specialty or technology domains such as aerospace, pharmaceutical(制药的,配药的) and energy developments.

Generally, project management is distinguished from (有别于) the general management of corporations by the mission-oriented nature of a project. A project organization will generally be terminated when the mission is accomplished. According to the Project Management Institute, the discipline of project management can be defined as follows: Project management is the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participation satisfaction.

By contrast, the general management of business and industrial corporations assumes a broader outlook(前景) with greater continuity of operations. Nevertheless, there are sufficient similarities as well as differences between the two so that modern management techniques developed for general management may be adapted for (适合) project management.

The basic ingredients(要素) for a project management framework may be represented schematically in Figure 1.1. A working knowledge of general management and familiarity with the special knowledge domain related to the project are indispensable. Supporting disciplines such as computer science and decision science may also play an important role. In fact, modern management practices and various special knowledge domains have absorbed various techniques or tools which were once identified only with the supporting disciplines. For example, computer-based information systems and decision support systems are now commonplace tools(常用工具) for general management. Similarly, many operations research techniques such as linear programming and network analysis are now widely used in many knowledge or application domains. Hence, the representation(表示,表现) in Figure 1.1 reflects only the sources from which the project management framework evolves.

Specifically, project management in construction encompasses a set of objectives which may be accomplished by implementing a series of operations subject to resource constraints. There are potential conflicts between the stated objectives with regard to scope, cost, time and quality, and the constraints imposed on human material and financial



**Fig. 1.1 Basic Ingredients in Project Management**  
(项目管理的基本组成部分)

resources. These conflicts should be resolved at the onset of a project by making the necessary tradeoffs or creating new alternatives. Subsequently, the functions of project management for construction generally include the following: (1) specification of project objectives and plans including delineation(描绘) of scope, budgeting, scheduling, setting performance requirements, and selecting project participants; (2) maximization of efficient resource utilization through procurement of labor, materials and equipment according to the prescribed schedule and plan; (3) implementation of various operations through proper coordination and control of planning, design, estimating, contracting and construction in the entire process; (4) development of effective communications and mechanisms for resolving conflicts among the various participants.

The Project Management Institute focuses on nine distinct areas requiring project manager (PM) knowledge and attention: (1) project integration management to ensure that the various project elements are effectively coordinated; (2) project scope management to ensure that all the work required (and only the required work) is included; (3) project time management to provide an effective project schedule; (4) project cost management to identify needed resources and maintain budget control; (5) project quality management to ensure functional requirements are met; (6) project human resources management to develop and effectively employ project personnel; (7) project communications management to ensure effective internal and external communications; (8) project risk management to analyze and mitigate potential risks; (9) project procurement management to obtain necessary resources from external sources.

These nine areas form the basis of the Project Management Institute's certification program for PMs in any industry.



### 1.1.2 Construction Project Management and Construction Management(工程项目管理和施工管理)

#### 1. Construction Project Management

It involves the management of the whole cycle of life of a project, that is from its inception until the expiration of the guaranty(担保). Its primary authority is the PM.

#### 2. Construction Management

It involves the construction phase of the project. Its primary authority is the construction manager.

### 1.1.3 Project Charter(项目宪章)

This is the document that constitutes the authorization to commence the project and that also serves as the project's basic reference. It is also very important because its context must reflect everything related with the execution of the project, therefore, it is a reference document(参考文件). There is not a standard format for it, however, it must contain at least the following data and information, but not limited to: (1) vision and aims or objective of the project; (2) description of the project establishing its boundaries, that is where it commences, what its scope is, and where it finishes; (3) environmental factors which are the main internal and external factors that may influence the project, examples of internal factors are the firm's capability to undertake the project, experience, facilities, personnel skills, etc., and examples of external factors are market conditions (such as a large international demand for copper), new government measures, etc.; (4) stakeholders identification and their function, with roles and responsibilities; (5) the PM's name, together with the board formal appointment and his/her range of authority and responsibility; (6) details of deliverables to the client as well as milestones schedule(里程碑进度); (7) acceptance procedures and criteria for partial and final deliverables; (8) organization structure; (9) project budget; (10) known risks assumed; (11) ways in which the environment is protected.

### 1.1.4 Project Management Plan(项目管理计划)

This is a document normally prepared by the PM explaining the way the project will be executed, how the monitoring will take place and measures taken to control the work. It includes, but is not limited to: (1) staffing; (2) staff training; (3) general procedures for materials management; (4) frequency and type of communications and reports scheduling; (5) procedures to be followed for changes in the scope or in the original plans, either by reducing or enlarging a task, or adding new ones; (6) units of measures to be used [metric or imperial system(公制或英制)], as well as currency (Euros, Dollars,



etc.); (7) language to be utilized in reports and communications; (8) procedures to be followed for inspections and issuing of progress payments to contractors; (9) techniques and tools to be used, for instance, Critical Path Method, Critical Chain Project Management, the Gantt Chart, Earned Value, etc.; (10) frequency of monitoring and tests (for instance, for steel hardness); (11) hardware and software to be used for different aspects, such as for quantities takeoff(工程量测量), planning and scheduling, communications, materials management, financing and accounting, etc.; (12) quality and safety plan.

### 1.1.5 Statement of Work (SOW)(工作说明)

This is a different document from the project charter. The SOW is only related with the product to be delivered and the corresponding work to be done; it points out its scope, stipulates who will be in charge of its execution, in what location, and provides a detailed planning and tasks and activity schedule as well as estimated associated costs, consequently it is abundant in technical information.

## 1.2 Sequence of Processes in the Project(项目中的过程顺序)

The reasons for a company to set up or introduce a new project in its strategic plans may obey different drivers(动因), which could “kick off”(开始) the construction of an industrial plant, develop a new software, expand an existing facility, launch a new product, or start a mining complex. For instance, a company may have discovered that there is a niche in the market for a product that they have been developing just at laboratory level, and then they think that it would be profitable to build a plant to produce it, or perhaps there is an opportunity in a project akin with(同源的,关系密切的) the company expertise in large construction undertakings.

It could also be an innovation—such as Google, Facebook or iPad—that the company considers profitable and achievable. Whatever these sources the ideas reach a stage that merit consideration by the board of directors, which after rough estimates can give the green light to spend some money in a more profound research. Somebody with enough skills and expertise is needed to take the helm of(开始掌管,掌舵) the new potential undertaking(事业,企业), and then appears the necessity of leadership, which materializes in the person of the PM.

The PM, together with other high level staff probably begins in thinking about policies, phases and ways of actions to develop the project, whatever it might be, i.e., he needs a strategic plan, that defines a strategy based in organization, procedures and methods to execute the project, considering its strengths and weakness, and that will



allow him to realize what aspects and things need to be considered, in order for the company to be where it wants to be in the future, at least regarding this specific project. For instance, the idea could be attractive, but will its impacts on the environment be acceptable? What about its effects on society? Which are the risks that this project can encounter, and more importantly, is it safe and economically affordable? Therefore, he needs information from sources about these two issues, and once he has them, he must analyze in detail their consequences. Assume that environment issues and risks can be, if not completely eliminated, at least reduced considerably, and for both he must establish some acceptable thresholds(閾值).

What about financing the project? Most likely at this stage, the PM possesses enough information as to have a rough idea regarding the order of magnitude of the required investment for the project spanning its life cycle, including both the construction and the operations period. Most probably the PM will not be responsible for the execution of the economic and financial analysis, which surely will be in the hands of the accounting and financial departments, but he/she must be able to furnish the information and calculations that these departments might require, and to do that he must be knowledgeable on the meaning and the importance of the information requested, and especially about their accuracy and reliability, since the execution of the project or its rejection by the board of directors greatly depend on this analysis.

Most projects do not have a unique course of action, since more often than not there are different alternatives or options, each one with their costs (economic, social and environmental), with impacts or consequences in the same areas, as well as their inherent technical difficulties and risks. Therefore the PM must usually play the role of a decision-maker to propose the higher echelons(等级, 阶层) of the firm, the selected alternative that conforms most of stakeholders(利益相关者). This leads to the analysis of the project using decision-making techniques, and although it is not necessarily expected that the PM be an expert on this discipline, he must at least have an idea of how it can help him, in making the “right” decision.

Consequently, knowing the selected option, the technical data and environmental constraints, estimated risks (and tolerances), and resources available, his/her people can now start with the project planning stage, detailing the tasks and activities to perform, relationships between them, their timing, and the necessity or not to call for contractors, suppliers and hire new personnel.

According to the nature of projects they often depend in large measure on material and equipment deliveries coming from suppliers and manufacturers, therefore the procurement activity is essential. In addition, if the project is a complex one that will be developed in different places simultaneously, the PM must examine the existing communications system



in the company and determine its adequacy or lack of it, and also considering to what extent the stakeholders want to be informed about the developing of the project.

Well, at this stage the PM is fully conscious about the complexity of the venture, and probably he has most of the elements he needs to compute costs. Once they are estimated, preparation of the project budget follows (not necessarily in Dollar or Euro values, for it can also be in manpower), i. e. to determine how much money the company needs for pursuing this project and perhaps more importantly—when it is needed—and verify if it coincides with what the board of directors has in mind or can afford.

Assume that this is accepted; now the PM needs people to manage and to execute this project, a resource that perhaps the company has, and if not, must get; that is, he consults human resources, naturally furnishing information about the positions to be filled and the qualifications required for each of them. Of course he also points out specific aspects of the project such as safety for the personnel working in the job site and quality demands of the job, and how to control them. The PM is aware that the project has to be finished on time and within budget, therefore he must establish a rigid control not only on these two subjects but also on environment, risks and procurement. Then a project monitoring and control subsystem must be established.

Once the project planning is near completion, the PM has one final “closing of the loop” responsibility: completion of the issue and deliverance of closing out documents. These documents include a project history, data, tables, sketches(素描,速写,草图), such as built drawings, etc, that have been used in the project. The purpose of this documentation is to capitalize on lessons learnt, as well as to preserve information about particular aspects, problems and situations that can be used perhaps for other projects in the future, and also to leave a clean track record for anyone who might need to know in the future how the project was developed. These documents should also include a post-evaluation of the complete project as well as an assessment of how well or completely the result complied with the goals established, difficulties encountered and aspects that were not considered in the initial plan. If the project did not attain the preset goals, there must be an explanation of why it did not.

### 1.2.1 The Five Essential Functions in Project Management(项目管理五大基本功能)

These functions are: planning, scheduling, execution and overseeing, monitoring and control, and closing (PSEMC).

They are the core of project management, which can be considered a system, since it receives inputs in form of information, materials, and labor, all of them interrelated, and injects this data into the system. The system processes them in building a factory,



constructing a ship or developing new software, and delivers a product, which is the goal of the project. Like any other system, project management uses a lot of feedback, making adjustments, changing the scope, deleting or adding activities, modifying labor, etc, and the results of these changes must be analyzed, and actions taken if necessary. In reality a critical component of the PSEMC, “project controls”, acts as a continuous feedback mechanism, in an effort to keep the project on the right track, that is to finish it on time, under budget, with the highest quality standards, and to the entire satisfaction of the owner or promoter of the project, whoever it may be.

Naturally, all other functions such as financing, safety, environment, etc, are not only very important, but essential too, and no project can be successful without them. However, the PSEMC, is the backbone (支柱) because everything is structured around them. The latter is a complex issue since it involves many different procedures, a variety of techniques, many internal characteristics as well as usually unpredictable external influences. It requires using many different tools and very importantly, it requires keeping stakeholders informed about the developing of the project.

It depicts the interrelationships between the different processes and within them. Naturally, it would be quite impossible to represent all possible connections, and because of that, it only shows the most significant ones. One important aspect to consider is that a project is not an independent entity within a large organization, it is a part of a system, because it must be related with other departments within the company such as human resources or research and development (R&D) and then these areas, and others, must be incorporated in the whole process. One of the reasons for this link is that the project must aim at owner satisfaction, and from that point of view usually some departments not directly involved in the project are more in contact with the client and even can anticipate his/her wishes. For instance, when an architectural and engineering (A/E) consultant working for a client in a construction project approves the schedule submitted by the main or general contractor, it is wise to consider also the point of view of the owner's technical staff, because they can have different ideas regarding some aspects of the schedule.

### 1.2.2 General and Useful Points to Be Taken into Account (需要考虑的一般事项)

In considering a new project, it helps to bear in mind the following general aspects:

(1) Establish the objective. It starts with the nature of the project, for it can refer to a product manufacturing, a construction project, a gadget design, or a consulting service to be rendered. If the objective deals with a new product or service, such as a new engine, a residential housing development, a new car model, a new book, an improvement on an existing product, etc., make sure that it will not hurt sales of another company's product