Chapter 1
Introduction

Abstract This chapter gives a short introduction to the central theme of the book and highlights the three components of dynamic project scheduling: the construction of a project baseline schedule, a risk analysis of this schedule and the project's performance measurement and control component. The chapter also gives a short introduction to the *project life cycle* to provide a guidance to the various chapters of the book. A simple and intuitive project mapping approach is briefly described and will be used to put all techniques discussed throughout the various chapters into perspective.

1.1 Introduction

Project management is the discipline of planning, organizing and managing resources to bring about the successful completion of specific project goals and objectives. The project management discipline can be highlighted from various angles and sub-disciplines and contains important issues such as project objective and scope management, human resource management and setting the roles and responsibilities of all participants and stakeholders of a project, planning principles and resource allocation models, etc. The current book does not aim at providing a general overview on project management, but instead has a clear focus on the planning aspect of projects. The topic of the book could be best described as *dynamic project scheduling* to illustrate that project scheduling is a dynamic process that involves a continuous stream of changes and that it is a never ending process to support decisions that need to be made along the life of the project. The focus of the book lies on three crucial dimensions of dynamic scheduling, which can be briefly summarized along the following lines:

- Scheduling: Construct a timetable to provide a start and end date for each project activity, taking activity relations, resource constraints and other project characteristics into account and aiming at reaching a certain scheduling objective.

M. Vanhoucke, *Project Management with Dynamic Scheduling*,
DOI 10.1007/978-3-642-25175-7_1, © Springer-Verlag Berlin Heidelberg 2012

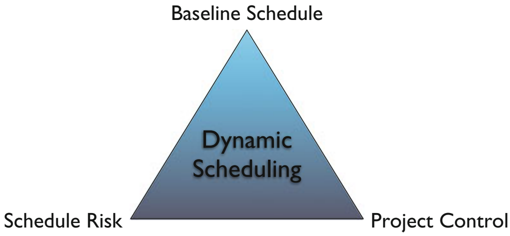

Fig. 1.1 The three components of dynamic project scheduling

- Risk Analysis: Analyze the strengths and weaknesses of the project schedule in order to obtain information about the schedule sensitivity and the impact of unexpected changes that undoubtedly occur during project progress on the project objective.
- Control: Measure the (time and cost) performance of a project during its progress and use the information obtained during the scheduling and risk analysis steps to monitor and update the project and to take corrective actions in case of problems.

The scope and purpose of the book is to bring a mixed message trying to combine theoretical principles from literature with practical examples and case exercises. To that purpose, the reader should take a step back from the buttons and looks of the project management software tools and/or the daily practice of project management to see what the dynamic scheduling principles have to offer. Rather than solely focusing on the latest state-of-the-art scheduling techniques from the academic literature, the reader will be drowned into a wide variety of scheduling and control principles and an often pragmatic project scheduling and monitoring approach, each time illustrated by means of short examples, practical case examples or fictitious integrated exercises. Figure 1.1 highlights the three basic components of dynamic scheduling.

Each of these three dimensions of dynamic scheduling plays an important role in the project life of a project. In the next section, the so-called project life cycle is briefly discussed from different angles and the link with dynamic scheduling is shown.

1.2 The Project Life Cycle (PLC)

Typically, a project goes through a number of different phases, which is often referred to as the project life cycle. In this book "Managing high-technology programs and projects", Archibald (1976) describes the project life cycle as follows:

> The project life cycle has identifiable start and end points, which can be associated with a time scale. A project passes through several distinct phases as it matures. The life cycle includes all phases from point of inception to final termination of the project. The interfaces between phases are rarely clearly separated, except in cases where proposal acceptance of formal authorization to proceed separates the two phases.

Consequently, the PLC is defined by the time window between the initial start of the project and the final termination and consists of a number of phases, separated by major milestones. The number of phases and their corresponding titles differ from industry to industry and from project to project. The next two subsections elaborate on the project life cycle with a number of examples, without having the intention to provide a full literature review.

1.2.1 Project Phases

A project consists of sequential phases. These phases are extremely useful in planning a project since they provide a framework for budgeting, manpower and resource allocation and for scheduling project milestones and project reviews. The method of dividing a project into phases may differ somewhat from industry to industry and from product to product and it can be summarized as follows:

- Concept (initiation, identification, selection).
- Definition (feasibility, development, demonstration, design prototype).
- Execution (implementation, production, design/construct/commission, install and test).
- Closeout (termination and post completion evaluation).

Archibald (1976) argues that the number of phases and the titles are so generic that they are of little value in describing the project life cycle process. Although the construction and presentation of a generic project life cycle seems to be difficult, if not impossible, each PLC shares a number of common characteristics.

- The major milestones between the phases represent high-level decision points.
- The phases may, and frequently will, overlap.

Between the various phases are decision points, at which an explicit decision is made concerning whether the next phase should be undertaken. A major review of the entire project occurs at the end of each phase, resulting in authorization to proceed with the next phase, cancellation of the project, or repetition of a previous phase.

1.2.2 The PLC in PMBOK

In the first edition of PMBOK,[1] the project life cycle concept was not mentioned at all. In the later editions, PMI realized the importance of the "divide and conquer"

[1]The Project Management Body of Knowledge, published by the Project Management Institute (PMI) – www.pmi.org.

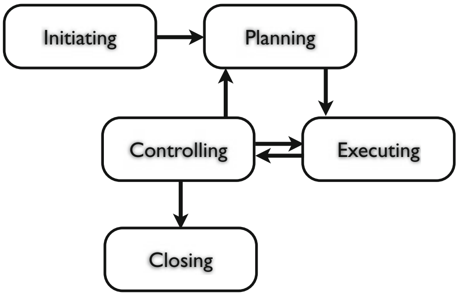

Fig. 1.2 Accomplishment of a project through the integration of five project management processes (PMBOK)

principle as the complexity and the size of the project increase and included the PLC concept in the book. More precisely, PMBOK describes the project life cycle as follows:

> Because projects are unique undertakings, they involve a degree of uncertainty. Organizations performing projects will usually divide each into several project phases to improve management control and provide for links to the ongoing operations of the performing organization. Collectively, the project phases are known as the project life cycle.

Each project is marked by the completion of one or more deliverables, such as a feasibility study or a detail design. These deliverables, and hence the phases, are part of a generally sequential logic designed to ensure proper definition of the project. The conclusion of each phase is generally marked by a review. These reviews, often called milestones, phase exits, stage gates or kill points, are necessary to:

- Determine if the project should continue to the next phase.
- Detect and correct errors cost effectively.

Although PMBOK presents a sample generic life cycle as shown in Fig. 1.2, they argue that many project life cycles have similar phase names with similar deliverables required but few are identical. The next section presents a similar generic project life cycle that will be used throughout all chapters of this book.

1.2.3 The PLC Used in This Book

Figure 1.3 shows an illustrative project life cycle that will be used throughout the remaining chapters of this book. This generic project life cycle was initially constructed and used for a consultancy study summarized in Chap. 4 and serves as an ideal tool to illustrate the dynamic scheduling approach taken in this book.

This generic project life cycle is based on a life cycle description by Klein (2000) and consists of a project conception phase, a project definition phase, a phase in which the project has to be scheduled, the execution of the project, the project control phase and the termination of the project.

At the beginning, in the so-called conceptual phase, an organization identifies the need for a project or receives a request from a customer.

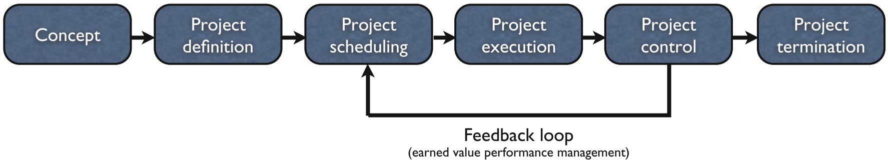

Fig. 1.3 An illustrative Project Life Cycle (PLC)

In the definition phase, the organization defines the project objectives, the project specifications and requirements and the organization of the whole project. The project objectives need to be refined and translated into a list of activities, a set of technological precedence relations and the resource availabilities and requirements. In doing so, the organization decides in detail on how it is going to achieve these objectives. The refinement of these project objectives into a final activity network containing activities and precedence relations is the subject of Chap. 2. The extension to resource availabilities and requirements is discussed from Chap. 7 onwards.

The next phase, the scheduling phase, aims at the construction of a timetable for the project activities. The construction of a precedence and/or resource feasible schedule determines a start and finish time for each activity, and hence, relies on the information obtained by the previous phase. In the following chapters of Parts I and II, a detailed overview of the scheduling principles using different techniques and aiming at reaching different targets is discussed.

During the execution and project control phases, the project has to be monitored and controlled to see whether it is performed according to the existing schedule. If deviations occur, corrective actions have to be taken. This control mechanism has been incorporated in the project life cycle by means of the feedback loop between the control phase and the scheduling phase of Fig. 1.3. This topic is the subject of Part III of this book. An update of a schedule can be done in two basic ways:

1. Reactive scheduling: This principle aims at the construction of a deterministic schedule, without taking possible risk factors or uncertainty events into account. During project execution, the project progress needs to be monitored using the information of the schedule and adaptations to the schedule need to be made when the deviations become too large. A reactive scheduling approach is the subject of Chap. 3.
2. Proactive scheduling: The uncertainty is embedded in the schedule to construct a buffered schedule. This schedule is robust and protected against possible uncertain events. In doing so, the feedback loop can be avoided within certain ranges. A proactive scheduling approach is presented in Chap. 10 of this book.

The termination phase involves the completion and a critical evaluation of the project. This information can then be used during the project life cycle of future, similar projects since the specifications of a project, the estimates of the durations, costs and resource requirements are often determined based on averages of past performance.

1.3 Dynamic Scheduling Methodology

In this section, a simple yet effective guidance is presented to classify projects along two dimensions: complexity and uncertainty. This project mapping approach will be used throughout all chapters of this book during the detailed explanation of the three dimensions of dynamic project scheduling.

1.3.1 Project Mapping

Although project scheduling is often considered to be an art more than a science, a thorough knowledge of the tools and techniques available is necessary to create a realistic project schedule. Obviously, the selection of the right tool and technique depends on the characteristics of the project and the background and knowledge of the project manager.

The approach taken along the various chapters in the book is a very pragmatic and nonscientific way of mapping projects along two dimensions as shown in Fig. 1.4: complexity and uncertainty. The advantage of this simple yet intuitive mapping approach lies in its ability to classify most project planning and scheduling techniques in one of the four quadrants. Although it is recognized that project management is more than a simple reduction to a set of scheduling tools and planning techniques, it creates awareness that techniques need to be put into perspective and need to be used only if the underlying assumptions and corresponding advantages/disadvantages are thoroughly known and understood.

The classification of scheduling techniques along the dimensions of complexity and uncertainty makes sense since dynamic scheduling is, in a way, a careful balance between dealing with complexity (mostly with the help of a commercial software tool to construct a (resource-constrained) project baseline schedule) and coping

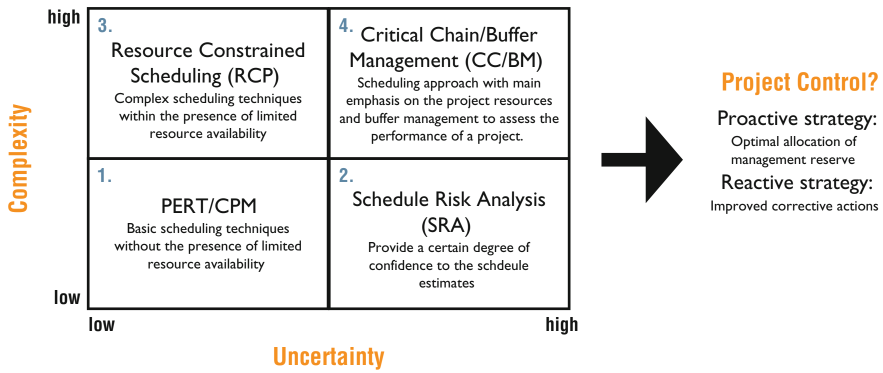

Fig. 1.4 Project mapping approach used throughout the chapters of this book

with uncertainty (realizing that a schedule obtained by a software tool will be subject to changes during the project's progress). This careful balance needs to be made by the project manager/planner and constitutes the basic starting point of this book. The ultimate goal of measuring and coping with complexity and uncertainty is to provide a basic tool to the project manager to monitor the performance of his/her project during progress. Consequently, Fig. 1.4 shows the three dimensions of dynamic scheduling: project scheduling (complexity), risk analysis (uncertainty) and project control. The complexity/uncertainty dimensions as well as their impact on the project control phase are briefly outlined in the following three subsections.

1.3.2 Complexity

The complexity dimension of Fig. 1.4 is completely related to the first dimension of dynamic scheduling: the construction of a project's baseline schedule. More precisely, it is related to the absence or presence of resources during the construction of a schedule and is used to distinguish between Parts I and II of this book.

The basic project scheduling techniques, often known under the general PERT/CPM abbreviation, assume that projects need to be done within the presence of an infinite resource capacity. Despite their simplicity, they still are considered as the basic scheduling techniques, and their principles are applicable to more advanced techniques. Due to this simplicity, their use is obviously restricted to simple and straightforward projects where resources are not assumed to be relatively highly constrained and are ignored during the scheduling process (quadrants 1 and 2 of Fig. 1.4). These resource-unconstrained project scheduling techniques are discussed in Part I of this book in Chaps. 2–6.

However, it is generally accepted that the presence of resources under limited availability is a matter of degree in practical business projects, which results in a dramatic increase in problem complexity when constructing a project baseline schedule (quadrants 3 and 4). Therefore, Part II of this book reviews the resource-constrained project scheduling techniques. The academic literature on resource-constrained project scheduling (RCP) is rich and has a main focus on the development of algorithms and procedures to solve often very complex project models. Although it is not the intention of this book to give a summary of these algorithms, it illustrates that the presence of limited resources in projects leads to an increasing complexity. The topics are discussed in Part II in Chaps. 7–10 of this book.

1.3.3 Uncertainty

When the level of uncertainty is assumed to be high, the schedule of a project becomes more and more subject to unexpected changes during project progress, and a certain knowledge of risk is therefore often indispensable. This second dimension of dynamic scheduling, project risk analysis, is shown by the uncertainty dimension of Fig. 1.4.

Schedule Risk Analysis (SRA) stems from the recognition that the construction of a project schedule is an uncertain art of estimating the set of activities, their network logic and their times and costs. Consequently, in order to provide a certain degree of confidence within each schedule estimate, SRA assigns distributions on top of the schedule to calculate a probability of meeting the scheduled end dates and cost targets (quadrant 2).

The Critical Chain/Buffer Management (CC/BM) approach can be seen as an extended view on schedule risk analysis, since it integrates the uncertainty of schedule estimates within the complexity view of resource scheduling principles (quadrant 4). This integrated view on resource complexity and schedule estimate uncertainty has led to a new scheduling framework that contains valuable principles applicable to practical project settings.

1.3.4 Control

It has been mentioned earlier that the project progress has to be monitored and controlled to measure whether the project is performed according to the original baseline schedule. Both a reactive and a proactive scheduling approach can be mapped into the quadrants of the project mapping approach, in order to allow taking timely corrective actions when the project is in trouble. This third dimension of dynamic scheduling, project control, is extensively discussed in Part III of this book.

1.4 Conclusions

This chapter gave a short and basic introduction to the principle of dynamic scheduling as the main topic of this book. This dynamic scheduling perspective consists of three connected sub-topics, i.e. the art and science of project scheduling, the analysis of risk and sensitivity of a project schedule's estimates and the project monitoring and control during the progress of the project. It has been shown that these three dynamic scheduling dimensions completely fit into the project life cycle concept presented in various sources in the literature.

A simple and straightforward project mapping framework has been presented as a general guidance for the various dynamic scheduling methods and techniques discussed in this book. This complexity/uncertainty framework will be used throughout the chapters of Parts I and II and aims at the construction of a feasible project schedule, which serves as a baseline point of reference for the project monitoring and control chapters discussed in Part III.