Preface

Project scheduling began as a research track within the mathematical field of Operations Research in order to determine start and finish times of project activities subject to precedence and resource constraints while optimizing a certain project objective (such as lead-time minimization, cash-flow optimization, etc.). The initial research done in the late 1950s mainly focused on network based techniques such as CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique), which are still widely recognized as important project management tools and techniques.

From this moment on, a substantial amount of research has been carried out covering various areas of project scheduling (e.g. time scheduling, resource scheduling, cost scheduling). Today, project scheduling research continues to grow in the variety of its theoretical models, in its magnitude and in its applications. While the focus of decennia of research was mainly on the static development of algorithms to deal with the complex scheduling problems, the recent research activities gradually started to focus on the development of dynamic scheduling tools that are able to respond to a higher uncertainty during the project’s progress.

The topic of this book is known as dynamic scheduling and is used to refer to three dimensions of project management and scheduling: the construction of a baseline schedule and the analysis of a project schedule’s risk as preparation for the project control phase during the progress of the project. This dynamic scheduling point of view implicitly assumes that the usability of a project’s baseline schedule is rather limited and only acts as a point of reference in the project life cycle. Consequently, a project schedule should especially be considered as nothing more than a predictive model that can be used for resource efficiency calculations, time and cost risk analyses, project control and performance measurement. In all upcoming chapters, the project control phase will also be called project tracking or project monitoring.

In this book, the three dimensions of dynamic scheduling are highlighted in detail and are based on and inspired by a combination of academic research studies at Ghent University (www.ugent.be), in-company trainings at Vlerick Business School (www.vlerick.com) and consultancy projects at OR-AS (www.or-as.be).
First, the construction of a project baseline schedule is a central theme throughout the various chapters of the book. This theme is discussed from a complexity point of view with and without the presence of project resources. Second, the creation of an awareness of the weak parts in a baseline schedule is highlighted, known as schedule risk analysis techniques that can be applied on top of the baseline schedule. Third, the baseline schedule and its risk analyses can be used as guidelines during the project control step where actual deviations can be corrected within the margins of the project’s time and cost reserves.

Scope

The goal of this book is not to compete with excellent handbooks on general project management principles nor to give an extensive overview of all project management aspects that might contribute to the overall success of a project. Instead, the aim is to bring a clear and strong focus on the preparatory phases, the project baseline scheduling and the schedule risk analysis phases, to support the project control phase where project performance measurement is a key issue for a project’s success. The intention is to hold the middle between a research handbook and a practical guide for project schedulers or project management software users. To that purpose, the content of this book is brought in such a way that it is able to inform a wide audience about the current state-of-the-art principles in dynamic project scheduling. The target audience can consist of undergraduate or MBA students following a project management course, participants of company trainings with a focus on scheduling or software users who search for added value when using software tools.

Book Overview

Chapter 1 gives a short introduction to the central theme of the book and highlights the three components of dynamic project scheduling: project scheduling, risk analysis and project control. The chapter gives a brief overview of the project life cycle and makes a distinction between project complexity and uncertainty using a project mapping matrix. The complexity dimension is related to the absence or presence of project resources under limited availability, as discussed in Parts I (low complexity) and II (high complexity) of the book. The uncertainty dimension is related to the need of a project’s schedule risk analysis and is discussed in individual Chaps. 5 and 10 of both parts. Example files and more information can be downloaded from www.or-as.be/books.
Part I. Scheduling Without Resources

Part I is devoted to dynamic scheduling principles for projects without resources. It is assumed that project resources are not limited in availability, which leads to simple and straightforward scheduling tools and techniques that can be considered as basic techniques for the more complex resource-constrained scheduling methods of Part II.

Chapter 2 gives an overview of the basic scheduling principles without using resources and thereby lays the foundation for all future chapters to predict the timing and cost outline of a project. The basic critical path calculations of project scheduling are highlighted and the fundamental concept of an activity network is presented. Moreover, the Program Evaluation and Review Technique (PERT) is discussed as an easy yet effective scheduling tool for projects with (low) variability in the activity duration estimates.

Chapter 3 presents an interactive game that acts as a training tool to help practitioners and project management students to gain insight in the basic project scheduling techniques. The game involves the iterative re-scheduling of a project within the presence of uncertainty. Each project activity can be executed under different duration and cost combinations, which is known as the critical path method (CPM). The game is set up to highlight the importance of a thorough knowledge of baseline scheduling techniques and to create an awareness of the need for schedule risk analyses (discussed in Chap. 5).

Chapter 4 serves as an illustrative chapter based on a case study of a capacity expansion project at a water production center in the northern part of Belgium. It shows that the clever use of basic critical path scheduling algorithms can lead to a realistic baseline schedule once the scheduling objective is clearly defined. It will be shown that scheduling the project with certain techniques will improve the financial status of the project, as measured by its net present value.

Chapter 5 highlights the importance of a schedule risk analysis (SRA) once the baseline schedule has been constructed. This second dimension of dynamic scheduling connects the risk information of project activities to the baseline schedule and provides sensitivity information of individual project activities as a way to assess the potential impact of uncertainty on the final project duration and cost. When management has a certain feeling of the relative sensitivity of the project activities on the project objective, a better management focus and a more accurate response during project control should positively contribute to the overall performance of the project.

Chapter 6 describes the first part of a series of three case exercises (Parts II and III can be found in Chaps. 11 and 14). Each case description is an integrated exercise to get acquainted with the scheduling principles discussed in the previous chapters. The case of Chap. 6 assumes the construction of a baseline schedule and knowledge of basic critical path scheduling principles and allows the extension to basic calculations of risk in order to take protective actions. The solution and the educational approach depend on the wishes and needs of the students who solve the
case and the teacher who can act as the moderator during the case teaching session. A teaching session should allow enough freedom to extend the original topic to various other dynamic scheduling related issues.

**Part II. Scheduling with Resources**

Part II extends the previously discussed dynamic scheduling principles to projects with resources that have a limited availability. In these complex scheduling settings, activities are executed by resources that are restricted in availability over time. This resource restriction leads to an increase in scheduling complexity, as will be shown in the various chapters of this part.

Chapter 7 gives an extensive overview of tools and techniques for resource-constrained project scheduling. It is shown that the introduction of resources in project scheduling leads to an increase in scheduling complexity. The importance of the choice of a scheduling objective is highlighted in detail by showing various resource-constrained scheduling models. The ability to assess the quality of the resource feasible schedule as well as a basic knowledge about scheduling software functionalities are discussed throughout the sections of this chapter.

Chapter 8 further elaborates on the resource-constrained project scheduling topics of the previous chapter and presents some advanced results obtained by various research projects. This chapter extends the resource models to other scheduling objectives, studies the effect of activity splitting and setup times and introduces learning effects in a resource-constrained project environment. These topics are brought together in a separate chapter such that the reader can skip these advanced topics without losing overview of the general dynamic scheduling theme.

Chapter 9 presents, similar to Chap. 4, an illustrative case study of a practical project scheduling study. The project to construct a tunnel to connect the two sides of the Westerschelde in the Netherlands is used to illustrate the importance of the scheduling objective as discussed intensively in the previous chapters. More precisely, it will be shown that the minimization of a bottleneck resource’s idle time during the scheduling phase can lead to important cost savings.

Chapter 10 elaborates on the construction of a resource feasible project schedule as discussed in the previous chapter, but extends this scheduling approach to a more flexible baseline schedule protected against unexpected events. The Critical Chain/Buffer Management (CC/BM) approach incorporates a certain degree of flexibility in the activity start times in order to easily monitor schedule deviations and quickly respond by taking corrective actions to keep the whole project on schedule. The technique is initiated by E. M. Goldratt in his groundbreaking book “Critical Chain” as a practical translation of the so-called Theory of Constraints in a project scheduling environment.

Chapter 11 presents the second part of a fictitious case exercise introduced in Chap. 6 that aims at the construction of a resource feasible project schedule using project scheduling software tools. The goal of the student is to go further
than submitting software print-outs to the project team. Instead, the purpose is the integration of the resource-constrained scheduling principles of the previous chapters within the features of a project scheduling tool in order to provide an easy and understandable information sheet on the predicted project execution to the various members of a project team. It allows the integration of CC/BM techniques of the previous chapter to highlight the advantages and potential weaknesses.

**Part III. Project Control**

Part III uses the schedules constructed in the previous chapters as inputs for the project execution phase where project’s progress needs to be measured and monitored in order to take corrective actions when the project runs into trouble. This third dimension of dynamic scheduling completely relies on the quality of the two other dimensions (baseline scheduling and risk analysis) discussed in the previous chapters. The construction of a baseline schedule based on a sound methodology as well as the knowledge of the sensitivity of each project activity on the project’s time and cost dimensions act as inputs during the project control step to better support corrective actions in case the project is in danger.

Chapter 12 gives an overview of the Earned Value Management (EVM) method to measure a project’s time and cost performance. It gives an overview of all EVM metrics and performance measures to monitor the time and cost dimension of a project’s current progress to date. Moreover, it also illustrates how this performance information can be used to predict the expected remaining time and cost to finalize the project that serve as triggers to take corrective actions to bring the project back on track, when needed.

Chapter 13 is a summary chapter of a large simulation study to predict the final duration of a project in progress using EVM forecasting methods. The chapter briefly discusses results that give an idea of the accuracy of different EVM forecasting methods along the life cycle of the project. It also presents an extension to the classical use of EVM to measure the adherence of a project in progress to the original baseline schedule. The main results of this chapter have been awarded by the International Project Management Association (www.ipma.ch) with the IPMA 2008 Research Award.

Chapter 14 is a third fictitious case exercise that allows the integration of EVM reports in the project control phase in order to get acquainted with the terminology and characteristics of EVM. It assumes a dynamic multi-project setting where three projects are executed in parallel. The purpose is the clever use of EVM methods and metrics and the critical review of these methods as a dynamic time/cost performance measurement system.
Part IV. Scheduling with Software

Part IV presents the main features of a software tool that integrates the three dynamic scheduling dimensions (scheduling, risk analysis and control) discussed in the previous sections.

Chapter 15 gives a brief overview of the main features of the software tool ProTrack (acronym for Project Tracking). Although ProTrack is a commercial software tool and is therefore not free of charge, a student friendly version with time-limited functionalities can be freely downloaded from www.protrack.be such that the main dynamic scheduling principles discussed in this book can be easily tested in a fictitious project environment.

Part V. Conclusions

Part V contains Chap. 16 and provides overall conclusions on dynamic scheduling. It provides an overall summary of all chapters and gives directions for practical use of software tools and suggestions for further actions on research and practical applications.

Acknowledgements

This book is the result of several research projects, consultancy tasks and fruitful discussions with both academics and practitioners. I am therefore indebted to many people who have helped me in writing this book.

I would like to thank my father, Robert Vanhoucke, for the fruitful discussions while writing Chap. 4 during the final stages of my PhD period. He helped me with the technical details of the project at a water production center (Vlaamse Maatschappij voor Watervoorziening) and provided me with useful information about it. I am also grateful to Dr. Stan Beernaert, chief executive at the Vlaamse Maatschappij voor Watervoorziening at the time of the project scheduling phase, for giving me the permission to use the data of the project. Last but not least, I would like to thank ir. Paul Suenens, project leader for the project, for providing me with a detailed description of the project by means of a Microsoft Project file.

I would like to thank Iris Vodderie for drawing my attention to the construction project in the Netherlands as described in Chap. 9. I am also grateful to Karel De Bel, Senior consultant Plancon and Theun Steinfort, projectmanager “Ontwerp en Voorbereiding”, for giving me the permission to use the data of the project and for providing me with a detailed description of the project. I want to especially thank Koen Van Osselaer for the nice and pleasant collaboration during this project.

I am also thankful to Prof. Dr. Bert De Reyck from London Business School (UK) and University College London (UK) who allowed me to use the project description
that was used during the writing of the Chaps. 6, 11 and 14. Although the case exercises of these chapters go far beyond the original purpose of his bridge project example, the general project characteristics of this bridge example were used as the foundation to describe the three case exercises.

I also would like to thank Prof. Dr. Roel Leus from the Katholieke Universiteit Leuven (Belgium) for the co-writing of parts of Chap. 10 as a foundation article used in the Project Management course at Ghent University.

I am obviously very much indebted to Tom Van Acker, partner at OR-AS, for the co-development of our software tool ProTrack as described in Chap. 15. Obviously, without his help, this book was not what it is now. The close relation between the various chapters of the book and the features and characteristics of the software tool is the results of years of work, both at the programming side of our software tool as at the consultancy side when dealing with real project schedules and all corresponding difficulties related to that. Both the software and the book is therefore the result of joint efforts of all OR-AS customers, a team of volunteers (both researchers as people from practice) and PhD students in project scheduling who all contributed in one way or another. A special thank you goes to Stephan Vandevoorde, who always supported and motivated the OR-AS team when our activities progressed slower than expected. A special word of thank goes to Sylvain Beernaert, Vincent Van Peteghem, Broos Maenhout, Veronique Sels, Thomas De Jonghe, Jeroen Colin, Christophe Van Huele and Mathieu Wauters for their careful attention during proofreading the final manuscripts. Thank you, all.

I acknowledge the support by the Research collaboration fund of PMI Belgium received in Brussels in 2007 at the Belgian Chapter meeting, the support for a research project funding by the Flemish Government (2008), Belgium, the research support of the National Bank of Belgium (NBB) as well as the support given by the “Fonds voor Wetenschappelijk Onderzoek (FWO), Vlaanderen, Belgium” and the “Bijzonder Onderzoeksfonds (BOF)” at Ghent University. Parts of the research topics in this book have been awarded by the IPMA Research award in 2008 during the 22nd world congress in Rome (Italy) with the study “Measuring Time – An Earned Value Simulation Study”. Thanks to this support and these financial sources, I was able to write parts of Chap. 12 based on data from various real-life consultancy projects.

It goes without saying that all of this took a lot of time, both during the weeks and the weekend. I am therefore especially thankful to Gaëtane for the many hours of proofreading and editing and the kids, Joyce and Thierry, for their never-ending patience when I was working on the software tool often 7 days a week.

London, UK

Ghent, Belgium

Mario Vanhoucke
Project Management with Dynamic Scheduling
Baseline Scheduling, Risk Analysis and Project Control
Vanhoucke, M.
2013, XVIII, 318 p. 123 illus., Hardcover
ISBN: 978-3-642-40437-5