PROJECT MANAGEMENT USING DYNAMIC SCHEDULING: BASELINE SCHEDULING, RISK ANALYSIS & PROJECT CONTROL

By Mario Vanhoucke

ABSTRACT

The purpose of this article is to give the reader a short yet complete overview of my new Project Management book that has recently been published by Springer. The general topic of this book is known as dynamic project scheduling and claims that project scheduling is a dynamic process that involves a continuous stream of changes and is a never ending process to support decisions that need to be made along the life of the project. Therefore, dynamic scheduling puts project control using Earned Value Management and project performance in a central place. More precisely, it focuses on the crucial role of the baseline schedule in order to assure a perfect integration with schedule risk analyses and an efficient project control approach. It is conjectured that this integration is key to support a better corrective action decision making when the project is in trouble.

The academic literature on various subtopics of dynamic scheduling is rich and widespread, but I believe that no overview is made that balances between technical details, an academic state-of-the-art overview, practical relevance and implications shown by numerous illustrative examples. The examples are illustrated by three case studies and a business game and are integrated in an easy-to-use software tool. Although the book has a rather technical look and feel, it is used as background material at various universities, in MBA programs, in company trainings and during consultancy activities. I believe that this makes the book unique and worth reading. Anyway, here's an overview of what you will get, I leave it to the reader to decide how relevant it is.

INTRODUCTION

The aim of the book is to give a detailed technical overview of the literature and best practices on dynamic project scheduling. The focus on scheduling within the field of project management has its roots in the mathematical field of Operations Research that mathematically determines start and finish times of project activities subject to precedence and resource constraints while optimizing a certain project scheduling objective. The initial research done in the late 50s 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. The introduction of a personal computer and the never-ending increasing CPU power has led to a substantial increase of research that has been carried out covering various areas of project scheduling (e.g. time scheduling, resource scheduling, cost scheduling). Today the project scheduling research continues to grow in the variety of its theoretical and practical models, in its magnitude and in its application. The new book gives an overview of this scheduling history until today and provides some general rules of thumb and best practices interesting for both scheduling researchers and project management practitioners.

Rather than a strict focus on project scheduling, the focus of the book lies on integrating the three crucial dimensions of dynamic scheduling which can be briefly outlined along the following lines:

- Baseline scheduling is necessary to construct a timetable that provides a start and finish date for each project activity, taking activity relations, resource constraints and other project characteristics into account, and aiming to reach a certain scheduling objective.
- Risk analysis is crucial to analyze the strengths and weaknesses of the project baseline schedule in order to obtain information about the schedule sensitivity and the impact of potential changes that undoubtedly occur during project progress.

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- Project control is essential to measure the (time and cost) performance of a project during its progress and to 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.

In this article, the content of the book will be briefly discussed along the following sections. All topics are based on more than 15 years of academic research as well as on the collaborations with many colleagues, friends and PM professionals from the fields. Needless to say that many people from the College of Performance Management have supported many of my research endeavors. Section 2 gives a brief overview of the various topics of the book and the project mapping approach used to structure these topics in a relevant and meaningful manner. The next three sections briefly describe how the three dynamic scheduling dimensions have been discussed in the book. Section 3 gives an overview of the baseline scheduling topics, divided in techniques to construct schedules without resources and techniques to construct schedules within the presence of limited resources. In section 4, the risk analysis dimension is discussed using schedule risk analysis and buffer management techniques. In section 5, the link between baseline scheduling and risk analysis is made complete by adding the third and most important dimension of dynamic scheduling. Controlling a project by measuring its performance is discussed in that section. In section 6, I briefly describe how I use this book during teaching and how it is integrated in an online learning-by-doing environment. Section 7 draws general conclusions.

OVERVIEW OF THE BOOK

The integration between project scheduling, risk analysis and project control can be discussed from various angles and points of view and therefore requires a strict structure to guide the reader through the central theme. To that purpose, a simple project mapping approach is used throughout the book to classify the three dimensions of dynamic scheduling (baseline scheduling, schedule risk analysis and project control). The baseline scheduling step involves the construction of a timetable indicating the start and finish time of each project activity, with or without the presence of limited project resources. The risk analysis step is an additional phase necessary to reveal the sensitive parts of the baseline schedule in order to be able to detect the potential influence of uncertainty in the various activity estimates on the project objective. These two dimensions can be considered as preparatory steps to support the project control phase during project progress in order to guide the corrective action process when the project runs into trouble. The integration of these three dimensions is called dynamic scheduling, which can be, due to the complex relation between these three dimensions, best monitored through the use of dedicated project scheduling software tools.

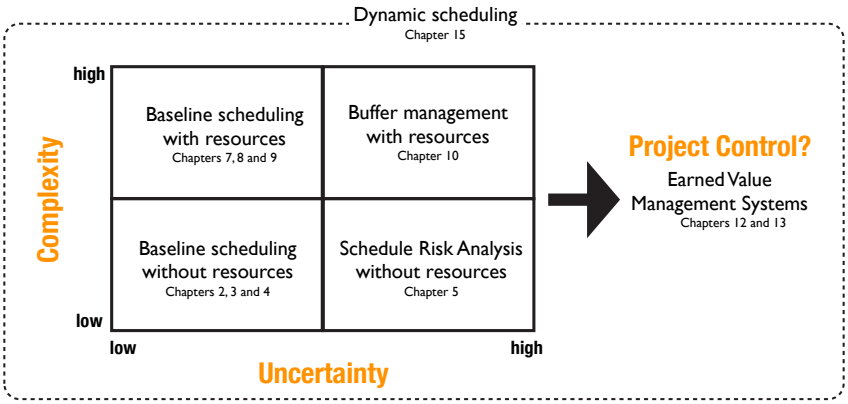

Figure 1: A project mapping approach to reveal the three dimensions of dynamic scheduling

Figure 1 gives a general overview of the three dimensions of dynamic scheduling based on the project mapping approach used throughout the chapters of the book. A reference to the specific chapters of this book is given and a more detailed summary of the three dimensions will be given along the following subsections.

The complexity axis makes a distinction between simple and complex projects from a baseline scheduling point of view and is related to the absence or presence of project resources under limited availability. Therefore, in section 3, a distinction will be made between relatively simple scheduling techniques (low complexity) and more advanced resource constrained scheduling techniques (high complexity). The uncertainty axis

expresses the presence of unknown factors and therefore is related to the need of a project schedule risk analysis to measure and assess the project risk and its impact on the project objectives. This is briefly discussed in section 4. The right part of the figure shows that the construction of a baseline scheduling (from low to high complexity) and measuring the impact of uncertainty through risk analysis (from low to high uncertainty) are two ways to improve the control of a project and are necessary requisites to perform an Earned Value Management control approach. This will be briefly discussed in section 5.

BASELINE SCHEDULING

The art of constructing a baseline schedule given the project data is discussed in detail in this book. This scheduling step is discussed from a complexity point of view where the presence of renewable resources with limited availability is the main driver of this scheduling complexity.

The art of baseline scheduling involves knowledge of some basic scheduling principles, summarized in the network logic approach initiated by the early PERT/CPM scheduling techniques. Since these scheduling techniques assume that activities can be performed without the constraint of limited resource availability, they are labeled as easy scheduling techniques (i.e. low complexity in figure 1) that are still widely used as sub-techniques in more complex scheduling environments. The introduction of renewable resources under limited availability over time leads to an increase in the scheduling complexity (high complexity in figure 1). The main reason lies in the presence of resource overallocations when using the traditional critical path based scheduling approach, which needs to be resolved by shifting certain activities forwards or backwards in time. These activity shifts have an influence on the use of resources as well as on the value of the scheduling objective. Consequently, the need for using scheduling software tools increases along the complexity dimension, due to the inherent increase in complexity to construct a baseline schedule, as shown in figure 2.

The book contains six chapters on baseline scheduling. More precisely, in chapter 2, the traditional PERT technique is discussed. Chapter 3 gives an overview of a project scheduling game that is used at universities, business schools and companies to get acquainted with time and cost optimizations in projects. Parts of this chapter have previously been published in the Project Management Journal (Vanhoucke et al., 2005).

Figure 2: An increasing need for scheduling software tools as the scheduling complexity increases

Chapter 4 gives a real life example of how proper construction of a baseline schedule can improve the net present value of a water purification project in Belgium. Chapters 7 and 8 give basic and advanced topics of resource constrained scheduling and show various techniques that can and are used in software tools. In chapter 9, the relevance of resource optimization is shown on the huge tunnel construction project at the Netherlands.

SCHEDULE RISK ANALYSIS

The efficiency that can be obtained by a clever use of scheduling principles and software tools during the baseline scheduling phase needs to be put in the right perspective. Since a baseline schedule is a deterministic prediction of possible start and finish times, uncertainty during project progress can cause schedule disruptions, which might result in a need to adapt the initial baseline schedule to a new, modified reality. Therefore, a careful balance between the complexity dimension of baseline scheduling and the awareness of project uncertainty involved during its progress is necessary to feed the project control phase to take timely corrective actions during project progress when the project is in danger. The uncertainty dimension of dynamic scheduling is discussed in this book by measuring the potential effect of variation in the activity estimates on the overall project objective (known as schedule risk analysis) and by protecting the most sensitive parts through the use of time and resource buffers (known as Critical Chain/Buffer Management). The need for doing risk analysis and adding safety buffers in order to shift from a reactive scheduling approach to a more proactive approach increases along the uncertainty dimension, as shown in figure 3.

Figure 3: An increasing need for risk analysis as the project uncertainty increases

PROJECT CONTROL

In this book, it is conjectured that the ultimate goal of baseline scheduling and schedule risk analysis is to gather information of the project to support the project control phase during the project's progress. This integration of these three dimensions is known as dynamic scheduling and is the central theme of the book. It is different from static scheduling in the sense that it recognizes that the first two dimensions, baseline scheduling and risk analysis, are only supportive steps to gain information that can be later used during the project control step in order to steer the corrective actions in case of problems to bring the project back on track.

The technique used to monitor time and cost of a project in progress is known as Earned Value Management (EVM). It is a generally accepted methodology used to measure and communicate the real physical progress of a project and to integrate the three critical elements of project management (scope, time and cost management). It takes into account the work completed, the time taken and the costs incurred to complete the project and it helps to evaluate and control project risk by measuring project progress in monetary terms.

The book contains two chapters on project control. The basic principles and the use in practice have been comprehensively described in many sources in literature, albeit mainly from a cost point of view. However, a recent EVM extension, known as the Earned Schedule method (Lipke, 2003), has shown that the time dimension can be better measured through the use of an alternative index. Indeed, it has been shown that the traditional EVM metrics fail in predicting the final duration of a project since its schedule performance index (SPI) provides unreliable results near the end of the project. The alternative Earned Schedule method overcomes this problem and is able to give a correct time prediction along the whole life of the project. In chapter 12, a detailed overview is given of Earned Value and Earned Schedule, based on various sources from literature and my previous book (Vanhoucke, 2010a) for which a summary has been published in the first 2011 edition of the Measurable News (Vanhoucke, 2010b). In chapter 13, an advanced project control study using Monte-Carlo simulation based on the Earned Schedule method and its extensions such as the p-factor approach (Lipke, 2004) has been critically reviewed.

ONLINE LEARNING AND LEARNING BY DOING

In order to stimulate students and young professionals to make use of the principles described in the book, an online learning tool has been created that can be used as an accompanying and additional tool. The so-called PM Knowledge Center (PMKC) is a free and online learning tool to stimulate interaction between researchers, students and practitioners in the field of project management and dynamic scheduling. It is accessible via www.pmknowledgecenter.com and a simple and free registration allows the visitor to interact, share and enjoy new ideas on project management in general and dynamic scheduling in particular. Moreover, in order to stimulate learning by doing, the book also contains a computerized business game as well as three case studies that can be used in class or during company trainings to develop Project Management skills by discussing complex scenarios.

More precisely, the Mutum-Paranà II Bridge project case studies (A, B and C for chapters 6, 11 and 14, respectively) are a series of three case studies to get acquainted with the complexity of dynamic scheduling using fictitious project data on a bridge construction. The first case study (A) puts a clear and strong focus on the integration of baseline scheduling and schedule risk analysis. The primary goal of second case study (B) is to get acquainted with project scheduling software and to construct a feasible resource-constrained project schedule. In the third case study (C), students get acquainted with the Earned Value Management approach to control projects. Students analyze the data of three projects in progress and present their results to the management committee. All case studies and the PMKC online learning tool are integrated in ProTrack (www.protrack.be, chapter 15) for which free academic versions are made available to students following the Project Management course. On top of that, many of the articles published in the

Measurable News are used as background material to tighten the gap between the technical details and the practical relevance. The general appreciation by students is high and hence I believe that these efforts bring theory closer to practice and makes young promising project management professionals enthusiastic for the field.

CONCLUSIONS

The central theme of this book highlights the critical and necessary components of dynamic scheduling in order to steer the project control phase to an overall project success. The main conclusion is that dynamic scheduling leads to a careful balance between optimizing the baseline schedule to obtain efficiency of resources and awareness of uncertainty that can dramatically change the initial expectations as stipulated in the baseline schedule. In the various research projects and consultancy tasks done during the research period before writing this book, it has been shown that project managers often need to fall back on the initial estimates of their dynamic project schedule. The two most important lessons learned during these projects can be briefly summarized along the following lines:

Baseline scheduling and risk analysis go hand in hand and are crucial preparatory components to provide information for the project control phase. One of the central lessons in training sessions to project managers is that scheduling without any form of risk management makes no sense since it then boils down to an academic and deterministic optimization exercise without much realistic value.
A project schedule is a dynamic instrument that needs to be adapted when necessary. Project managers need to deal with a continuous stream of unexpected events and need to take corrective actions to bring projects back on track or to update the initial estimates and expectations to a more realistic scenario. In that respect, a dynamic project schedule is the ideal tool to provide information and to support the corrective actions. Hence, the project baseline schedule acts as a point of reference to support these actions, rather than a forecast of the future that needs to be followed at all times.

It should be noted that dynamic scheduling is only part of the project management discipline that might positively contribute to the overall success of a project. The central theme of the book is on the preparation phase and project control phase, with a strong focus on quantitative tools and techniques for planning and performance measurement. Consequently, it is implicitly assumed that other important drivers of project success are under control or at least taken into account during the project life cycle. Topics such as project scope management, communication management, quality management and human resource management are key factors that affect the success of a project and are related to the success or failure of the dynamic scheduling process. These topics have not been covered in this book and readers who wish to relate the dynamic scheduling principles to the other project management topics need to go beyond the information covered in this book. Enjoy reading it, and feel free to let me know what you think of it. And.... ah, I forgot something: the title of the book is exactly the same as the title of this article: Project Management using Dynamic Scheduling: Baseline Scheduling, Risk Analysis and Project Control (Vanhoucke, 2012).

ABOUT THE AUTHOR

Prof Dr Mario Vanhoucke is Full Professor of Business Management and Operations Research at Ghent University (Belgium), Vlerick Business School (Belgium, Russia, China) and University College London (UK). He has a Master's degree in Commercial Engineering and a PhD in Operations Management from the University of Leuven (Belgium). At Ghent University, he is the program director of the Commercial Engineering program where he teaches Project Management and Applied Operations Research. At Vlerick Business school, he teaches Decision Making for Business and Business Statistics to Master and MBA students.

His main research interest lies in the integration of project scheduling, risk management and project control using combinatorial optimization models. He is an advisor for several PhD projects, has published papers in more than 40 international journals and is the author of two project management books published by Springer (see www.or-as.be/bookstore). He is a regular speaker on international conferences as an invited speaker or chairman. He is also a regular reviewer of articles submitted for publication in international academic journals.

Mario Vanhoucke is also a founding member and director of the EVM Europe Association (www.evm-europe.eu). He is also a partner in the company OR-AS (www.or-as.be) which released a third version of its project management software tool ProTrack 3.0 (www.protrack.be). ProTrack is an advanced scheduling product which focuses on the integration of scheduling, risk, control management and online learning through a PM Knowledge Center (www.pmknowledgecenter.com). He leads a research group which has obtained Concerted Research Actions (CRA) funding of more than € 1 million for an integrated PM research study, that will be carried out in collaboration with Ghent University (Belgium), Vlerick Business School (Belgium), The European Organization for Nuclear Research

(CERN, Switzerland), University College of London (UK) and George Washington University (USA). To that purpose, a derivative of the software tool ProTrack, known as the PM programming tool P2 Engine (www.p2engine.com), has recently been developed that will be used for testing novel ideas by the CRA research team members.

The project management research undertaken by Mario Vanhoucke has received multiple awards including the 2008 International Project Management Association (IPMA) Research Award for his research project "Measuring Time: A Project Performance Simulation Study" which was received at the IPMA world congress held in Rome, Italy. He also received the Notable Contributions to Management Accounting Literature Award awarded by the American Accounting Association at their 2010 conference in Denver, Colorado.

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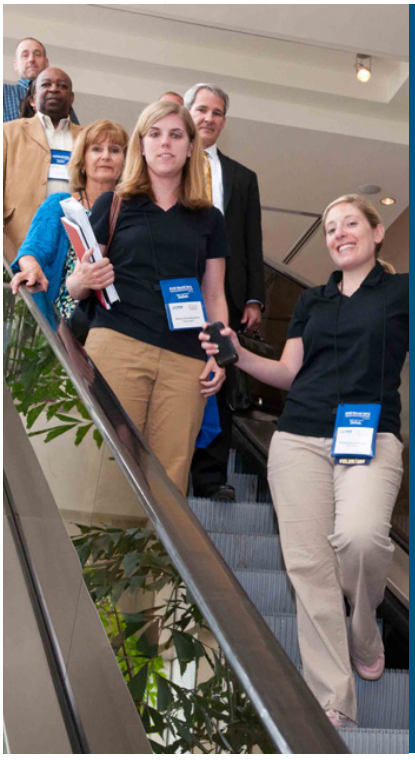

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