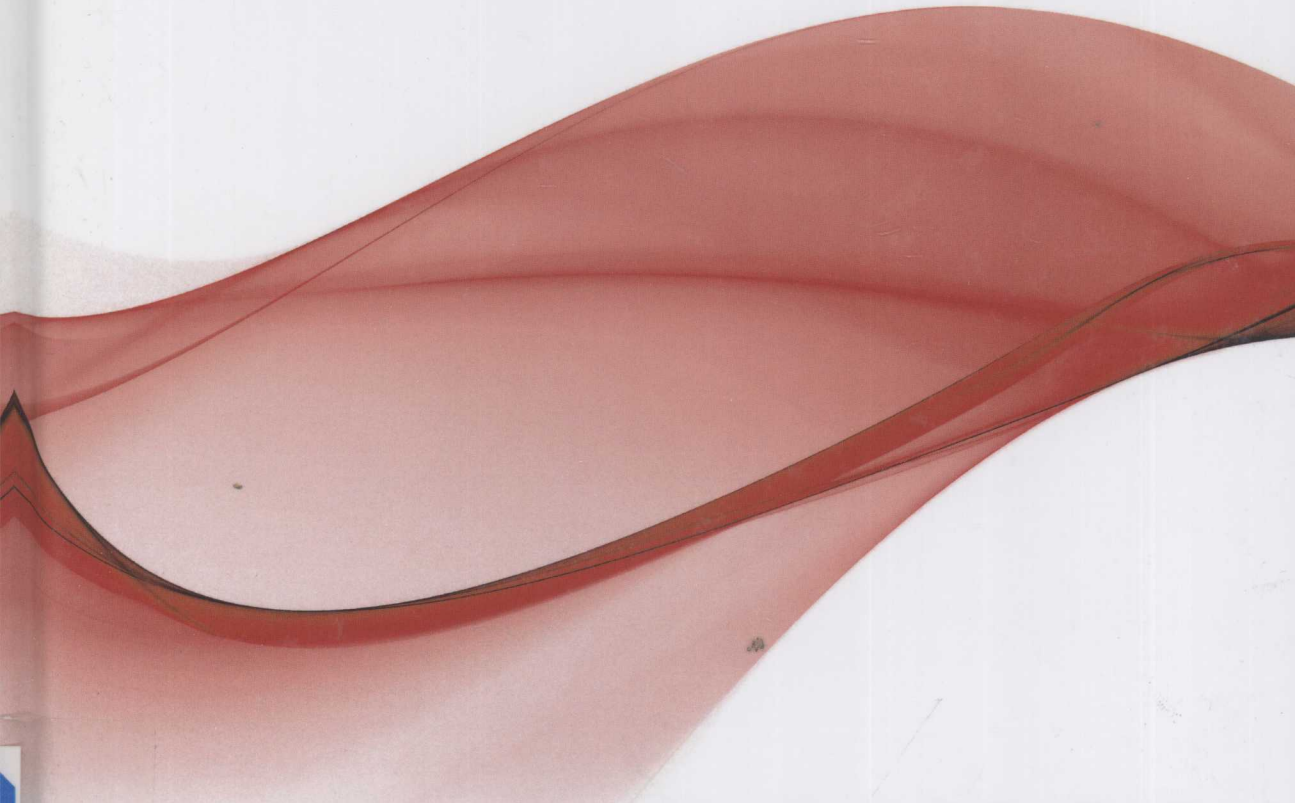
Integrated Cost-Schedule Risk Analysis



DAVID HULETT

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To my wife Judie, who always thought that integrating cost and schedule risk analysis was important

Foreword

PHILIP RAWLINGS
Director, Euro Log Ltd, Teddington, UKl

It is a truth universally acknowledged (or at least fairly-commonly accepted) that the cost of any project is to some extent influenced by the time taken to complete the project; if we are delayed by bad weather we still have to pay the project manager; if construction takes longer, there will be some extra costs, notwithstanding that we may have negotiated a fixed-price contract (we have additional management costs and will expect to see some claims – inevitably, not all of those can be rejected). In an uncertain environment, i.e. on real projects where risk and uncertainty is the expectation, the link between time, cost and risk is all too clear.

A familiar approach to quantitative risk analysis is to conduct analyses of the risks and uncertainties as separately applied to the schedule and to the cost; just maybe, there will be some line item in the cost analysis to account for project overruns – this will necessarily be a crude and clumsy approximation to the true impact.

A far more realistic approach is to integrate all aspects of the analysis into a single model such that the inter-relationships between cost, time, risk and uncertainty can be modelled in a way that is representative of the real-world situation, and which is itself readily presented for validation. In this way, time-dependent costs (cost items whose magnitude varies as the time taken to perform those tasks) may be individually modelled and related to their particular schedule drivers.

David Hulett is well-known for his practical approach to risk management; his previous book "*Practical Schedule Risk Analysis*" introduced a practical approach to developing risk models to account for risks and uncertainties that are inevitably encountered in "real-world" projects: that is the ones that you and I actually get involved with. Hulett's approach is a very hands-on exposition of dealing with the Quantitative analysis portion of the Analyse step of the Risk Management Process – how to translate the risks and uncertainties that you have identified into possible schedule outcomes of the project.

Many is the book or learned paper describing the risk management process and many are the standards leading you on the way to setting up an environment that will encourage you and your organisation to identify, analyse and manage the risks that conspire to de-rail your venture, or to give you the opportunity to seize the advantage over competitors.

Not so common is the medium that will show or tell you how to perform those steps. There seems to be an assumption that integrated cost and schedule in a single model is in some way too difficult – perhaps it is now time to lay that idea to rest and to emphasise the benefits of a more realistic predictive analysis of the venture. Only in this way can informed decisions be made as to the optimum scenario in which to pursue the project's objectives.

Hulett's latest book takes the approach further and describes how one can (and really should) develop risk models that consider both cost and schedule and, more importantly, the interaction between the two.

Although the approach considered in this book uses Primavera Risk Analysis software from Oracle (which used to be called Pertmaster not that long ago) to demonstrate the ideas within, models could be built in other software. Hulett's exposition here, though, makes considerable use of Risk Drivers, a facility to apply common risks or uncertainties across many project components – this takes us some way from the seemingly high overhead of attempting to assign uncertainty distributions to each and every cost and duration in the model.

The Risk Drivers approach (particularly as now implemented in Primavera Risk Analysis) encourages the analyst to concentrate on those uncertainties or risks (i.e. uncertainties that may or may not happen and with an associated finite probability of occurrence) that are key to successful project completion. A Risk Driver may be applied to several components of the model – e.g. productivity uncertainty applies to all relevant construction activity durations. Further, this method applies an implicit correlation between parameters using the same Risk Driver, thus avoiding the problematic estimating of correlation factors to be applied between various risk distributions. It is to be hoped that Primavera Risk Analysis will be further developed to extend Risk Driver capability to *all* risk parameters and to allow drivers to be added/multiplied as well as applied in parallel and series to further extend this very effective and transparent method.

Using Risk Drivers as a sensitivity tools (i.e. by suppressing Risk Drivers one-by-one) highlights those risks that are worth serious mitigation attention, thus focussing effort (which usually translates into money) onto those risks that will best improve project prospects if they can be reduced.

It is to be hoped that Hulett's approach will be adopted, no doubt adapted to suit each individual practitioner, to produce more realistic (let us not say 'accurate') projections of project outcomes – to set more achievable targets and to point towards more effective risk mitigation actions.

Foreword

CHARLES BOSLER
Chairman of the Risk Management SIG (www.risksig.com) and
President of RiskTrak International

Over the years, I have worked together with David Hulett on a number of projects but one in particular comes to mind as I read this book. The Architect of the Capitol (AOC) hired me to do risk assessment on the U.S. Capitol Visitor Center Project while David was analyzing the cost and schedule risk for the US Government Accountability Office (GAO). This project was the largest construction project in the government, at that time. The requirements for this project were real and immediate. The scale was large however pre-9/11 the funding was questionable.

The Capitol Visitor Center (CVC) is located underground below the East Capitol Grounds, to enhance rather than detract from the appearance of the Capitol and its' historic Frederick Law Olmsted landscape. The completed CVC contains over 580,000 square feet on three levels, requiring a 196,000-square-foot excavation, or "footprint" for purposes of comparison, the Capitol itself encompasses 775,000 square feet.

The CVC was designed to preserve and maximize public access to the Capitol while greatly enhancing the experience for the millions who come each year to walk its historic corridors and experience the democratic process in action.

Despite the clear need for this project Congress was pilloried in the press for the changes to the schedule and the projected cost over-runs. In 2005 Congress demanded an assessment and analysis of the project. David was hired by the GAO to provide quantitative risk analysis of cost and schedule and I was contracted by the AOC to provide an Independent Verification and Validation (IV&V) of the project that was to be presented to the CPC and Congress before the project could proceed.

When I finished reading David's book I began to consider the impact of the Risk Driver method on those of us who perform cost and schedule risk analysis. We work everyday to help people understand uncertainty and improve our estimates of the "unknowable" —the *future impacts* of the risks we face on every project.

We can consider all of the; "known-knowns" these are the risks and events that we know, then all of the "known-unknowns" which are those things that we know we don't know, we can even find ways to consider the "unknown-knowns" those things that we aren't aware that we actually already know, and there will always be the remaining "unknown-unknowns" those risks or events that we don't know. However, the real "unknowable" is the impact of these risks or opportunities on our project. Yet that is our task—to estimate the *future impact* of risk and events based on the best available information at our disposal. This was the very reason that the AOC contracted me to work on this project for Congress.

Along the way, as the CVC project progressed from an idea to an operating part of the government it was a very large construction project which included; an antiquities preservation project, a large IT project, a couple of food services projects, a security project, a human resources project, commissioning of the safety, fire and smoke systems,

etc., and each of these project efforts, at some point, faced the same constraints as any other project. They all had to conform to the "iron-triangle" of project management ... scope, cost and schedule. All of which was unknown in the beginning and became a virtual certainty as time progressed and the date for the "Grand Opening" approached.

Obviously since each of these projects relate to the same government facility the risks and costs are all inter-related and the costs and impacts can be correlated using the Risk Driver approach, which allows us to consider the cross-project risks and dependencies of each of the sub-projects.

Additionally, when we perform a sensitivity analysis using the Risk Driver approach we can tell the Program Executive of the CVC, the CPC and Congress which risks drive the greatest overall risk to the project. Using the Risk Driver approach to risk analysis is a significant improvement over the more traditional 3-point estimate because it uses the high priority risks identified in the Risk Register that have been rank ordered through qualitative risk factors.

Congress conducts the business of our Nation. David reminds us what every businessman knows ... "Time is Money" and as such they can not, or better yet, should not be considered separately and exclusively, since they are the very same thing. To consider one without the other surely misses half the equation, which will lead to errors in both cost and schedule estimates. David gives us an effective means to integrate cost & schedule risk, which allows us to realize and analyze cost risks that cause schedule uncertainty and vice versa. Regardless of the cause, as schedule slips to the right cost will increase accordingly so we *must* look at the integrated cost and schedule risk (and/or opportunities) in a new way if we are ever to succeed.

Congress knows that they are ultimately accountable to the people of the United States and that their every action will face scrutiny in the press. That's why they take a deliberative and careful approach to planning. The reasons are many but the fact is—the Congress values analysis. Analysis that prioritizes and allocates 100's of Billions of dollars every year. So we know that analysis works. Why then do so many of us ignore this monumental testament to the success of statistics, modeling and simulation? I ask this because in this book David gives us an effective approach and all the tools we need to improve our cost and schedule estimates, which will increase the chance for success in our projects. Once armed with the tools and techniques necessary we can all improve. We can never know the "unknowable" ... the future will always be uncertain, but we can surely decrease the cone of uncertainty to a manageable level.

Preface

This book, *Integrated Cost and Schedule Risk Analysis*, is a logical successor to *Practical Schedule Risk Analysis* (Gower, 2009), though it can be read separately. Logically the integration of cost and schedule risk analysis is performed on a resource-loaded project schedule, so the issues surrounding project scheduling and the notions of schedule risk analysis were introduced in the first book.

In the early chapters of this book there is a fair amount of commonality with the earlier book for two reasons:

- First, many of the concepts of project risk and methods of its analysis are the same whether one is analyzing schedule risk or cost risk. Since the first six chapters of this book deal with cost risk analysis by itself without reference to project schedule there is some repetition. The methods of analysis have similarities, though the schedule risk analysis in the first book uses the schedule as a platform and the early chapters of this book use a cost spreadsheet as the platform.
- Second, I cannot be sure that the reader of this book has also read the earlier book on schedule risk analysis, so some of the material, for example on risk concepts, risk data, basic Monte Carlo simulation and corporate risk culture, which are common to both cost and schedule risk analysis are covered in both books. Also, in introducing the project schedule as a platform to the integrated cost and schedule risk, beginning in Chapter 7, some material specifically what makes up a good schedule is essentially summarized from the earlier book.

If the main issue with the project is timely completion of the schedule, schedule risk analysis can be performed without considering cost risk. However, in my view, cost risk cannot be fully analyzed without considering the implication of schedule risk. Many activities require resources that are paid more if they work longer (time-dependent resources such as labor, rented equipment and the like), so any activity that takes longer or shorter than scheduled will have a cost that is different from its baseline estimate. We often find that the most important risks to cost are actually important because they affect the schedule. Put another way, a significant amount of the cost contingency reserve should be held against uncertainties in schedule that, if they happen, will cause individual work activities as well as level of effort (LOE) activities to cost more.. It is not possible confidently to estimate the effect of schedule risk on cost risk without combining the resources into the schedule and evaluating the schedule uncertainty simultaneously with any cost-type risks in a Monte Carlo simulation. Resources may be specified at a summary level (we have used as few as eight resources for multi-billion dollar projects), if they can put the entire budget (free of embedded contingency and not including below-the-line contingency reserve) onto the right activities of the schedule.

In addition to uncertainty in the activity duration there are other factors that affect project cost risk. Even if the project worked to the original schedule, the cost might be uncertain because of the uncertain number of resources and their compensation, leading to an uncertain cost or "burn rate" per day. Also, some inputs such as procured equipment and raw materials have costs that are uncertain for reasons other than uncertainty in burn rate or activity duration, such as those stemming from uncertainty in the markets for raw materials or equipment because of industry-specific activity or the general economic uncertainty. These other cost risk factors are also analyzed, along with the analysis of the schedule uncertainty's implication for cost.

In addition to explaining a powerful approach to integrating cost and schedule using resource-loaded schedules, I have introduced, as I did in *Practical Schedule Risk Analysis*, the use of the project risks to drive the analysis. The Risk Driver Method of analysis starts with the risks in the risk register and characterizes them by their probability of occurring, the range of impacts they will have on the activity durations, burn rates and uncertainty of cost of equipment and raw materials, assigning them to affect specific activities that are included in the schedule if they occur. The benefits of the Risk Driver Method include that a risk can be applied to one or many activities and we can estimate the whole impact of a risk on all the activities that it affects through the analysis. Also, the risk is characterized by its probability as well as impact, which is natural given the definition of project risk. Finally, correlations between activity durations are caused during the Monte Carlo simulation if there is a risk that is applied to more than one activity, as many of the risks are. The Risk Driver Method can be applied to simple cost risk analysis on a spreadsheet (see Chapter 6) or to both schedule and cost when simulating the resource-loaded schedule (see Chapter 8 and following).

The Risk Driver Method contrasts with the traditional approach that starts with uncertainty in the activity durations or project component costs using 3-point estimates of activity durations that combine the impact of potentially several risks on an activity, do not maintain any linkage with other activities that those risk may affect, and generally does not take account of the probability that the risk will or will not occur. Fundamentally, the 3-point estimate approach deals with an intermediate product, the impact of risks or multiple risks on an activity duration or project element cost, not the risks themselves.

The Risk Driver Method takes one step back to fundamentals to the actual risks that are causing those impacts, and models how the activity durations or element costs might vary as they are influenced by risks that may or may not occur and have a range of possible impacts if they do occur. In short, the Risk Driver Method models how the uncertain durations of activities or costs of the project elements arise based on the fundamental risks.

Since a 3-point estimate combines in an often-murky way the influences of multiple risks on specific activities, and does not model the impact of any risk on multiple activities or costs, the traditional approach cannot determine which risks are important, only which activities are important. Specifically, if a risk affects multiple activities its importance may far exceed its impact on any one activity. Hence, the Risk Driver Method results flow naturally into risk mitigation by allowing us to prioritize the risks, which management can manage, so the analysis becomes a tool for project performance improvement.

Of course other methods of cost and schedule risk analysis can be combined with the Risk Driver Method. Some risks, analyzed as risk register risks by some Monte Carlo software systems, can be added when a risk under given circumstances causes an activity

or several activities to appear in the schedule. These are sometimes called probabilistic branches or existence activities. In addition, uncertainties such as schedule or cost estimating error, due to the immaturity of the data available at any point, can be added as 3-point estimates because the uncertainty has a 100 percent chance of existing in all iterations (there is always cost estimating error until financial completion of the project). The Risk Driver Method applies to duration and cost uncertainty of activities and resources that are already in the schedule.

These methods are in use today and have provided clarity of analysis leading to acceptance by project managers and owners. The field of project risk analysis is dynamic and these methods of integrating cost and schedule risk and of using the Risk Drivers Method are becoming accepted.

Many thanks go to Charles Bosler and Philip Rawlings for reading the book in manuscript form and providing the forewords.

David T. Hulett, Ph.D.
Los Angeles, CA
January 23, 2011

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