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Improve project outcomes using integrated cost and schedule risk analysis

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Key points

- After the global financial crisis, the climate for raising project finance demands more convincing evidence that proposed projects will succeed. Risk management is a widely recognised but poorly practised necessity for improving the likelihood of successful project outcomes.
- This article argues that a practical methodology now in use for integrating qualitative and quantitative risk analysis, and risk response planning, significantly improves the opportunities to enhance the value of project proposals.
- This approach develops realistic project schedules and estimates, and thus minimises project failure due to inadequate cost and schedule contingencies. Previous approaches are compared to this methodology, along with challenges.

Introduction

Better understanding of project management

The requirements for successful management of projects are now much better understood, thanks to the development of an extensive project management body of knowledge and the codifying and documentation of all the elements required.

Gap between best practice and actual performance

But there remains a gap, sometimes large, between "best practice" and actual project management (PM) performance.

A 2010 survey of CEOs and other senior executives included over 400 organisations across the globe in the utilities, oil and gas, chemicals, and mining and metals industries, with companies ranging in size from annual revenue of less than $500 million to more than $100 billion. The survey report[1] found that only 11% reported delivering the expected return on investment from major capital projects more than 90% of the time. Thirty-three percent stated it was between 50% and 74%, and 12% estimated it was less than 50% of the time.

The situation is apparently worse in Australia. A 2009 analysis[2] of large and technically complex projects exceeding $150 million over the preceding 12 years showed that such projects failed significantly more often in Australia than elsewhere, with 23 of 31 classified as failures. The main reason for project failures was inadequate "front-end loading" (essentially, inadequate planning and estimating of the projects) by the project owners. Project owners were found to be seriously deficient in their ability to plan and manage projects.

Poor project outcomes are due to factors including:

- unrealistic expectations and pressures of project owners;
- lack of skills and experience of PM team members; and
- failure to use best practice processes and tools.

This article addresses the third factor — failure to use best practice processes and tools — while acknowledging the importance of the other two.

Limits to conventional planning and estimating

The "critical path" method was a major step forward for planning and managing projects. Similarly, the development of the "project work breakdown structure" and systematic project cost estimating tools and techniques have broadened the use of these methods to improve the accuracy and comprehensiveness of project costings.

But these techniques do not reveal whether the project plan or the project estimate is adequate, because the processes result in single values for the length of the project or the project cost. In fact, we do not know the values or project logic that precisely because of the inherent uncertainty of outcomes.

In reality, projects are made up of hundreds or thousands of uncertain activities with durational and cost probability distributions, and the threat of risk events affecting many of the tasks. So the chances of the project being completed as planned are very low, as it would require that the project be performed in the sequence and the lengths of time assigned to all the activities in the plan without any risk events occurring.

How can project plans and costs be adequately estimated?

We usually only have one chance at the start of the project to set adequate project durations and budgets. We can maximise our chances of getting this right by running Monte Carlo simulations when budgets are to be set.

Cost and schedule risk analyses provide new project insights

We assign ranges (probability distributions) instead of single values to uncertain duration activities and uncertain costs. Durations and costs within the ranges are randomly chosen for all such activities and cost ranges, and critical path calculations run hundreds or thousands of times, storing all the date, duration and cost calculations. The randomly chosen durations and costs are built up to match the probability distribution defined for each activity. The results from the iterations enable probability distributions to be compiled for the project finish date and any milestone or activity start or finish date of interest. Similar outcomes apply for cost risk analyses.

Separate schedule risk analyses (SRAs) and cost risk analyses (CRAs)

CRAs are often performed before a project schedule is in existence. The people who develop project estimates and budgets (estimators and cost controllers) are usually different from those who produce the project schedule (project planners). Those who perform CRAs may not have sufficient planning skills to perform an effective integrated analysis. SRAs are often produced by practitioners with planning rather than cost skills.

But project time and cost are related

But project delays are a major source of project cost overruns. So how can the results of separate SRA and CRA on the same project be shown to be related to each other? Or, to put it another way, how can the cost consequences of delay uncertainty be determined from separate analyses? A conservative way is to assume that all delays occur at the most expensive stage of the project, when the highest rate of expenditure per day is occurring. But that is unlikely to be true in all cases. There are two aspects to delay costs: the amount by which project prolongation costs increase through the delay and, from the owner's perspective, the cost of delayed revenues to flow from the completed project.

Integration of risk management with time and cost management

It is possible to load the project estimate into the project schedule, ensuring that time-dependent costs are separated from fixed or time-independent costs. The costs are spread over the appropriate activities and the uncertain fixed costs have cost ranges applied. The integrated Monte Carlo analysis is then performed, and schedule and cost distributions for milestones and activities of interest are generated. In this way, the cost consequences of delay are assessed, with delay costs assessed at their appropriate stages and cost rates. If revenue activities are included in the schedule, the impact of project income delays can also be simulated, along with probabilistic cash flows, internal rates of return (IRRs) and net present values (NPVs).

For complete coverage of possible cost and schedule outcomes, applicable project risk events must be included in the analysis

Schedule and cost risk analyses are sometimes called range analyses because the emphasis is on the uncertainty ranges, not risk events. But realistic estimates of project duration and project cost require incorporation of the risk events with cost or time impacts that could beset a project. Unless the risk profile of a project is realistically reflected in the estimating of its duration and cost, it is unlikely that adequate contingency provisions will be made for either when the project is initially planned and funded.

This requires that the qualitative risk management process be linked to the quantitative risk management process described above.

Qualitative risk analysis is a systematic process for identifying as many sources as possible of potential threats to the project (along with opportunities, where applicable), assessing their likelihoods and consequences, and rating them — thus enabling the ranking of the risks in descending order of size of the threat. This enables the risks to be considered in order of their threat magnitude, known as risk exposure (likelihood x consequence) to assess the effectiveness of existing controls and develop treatments to reduce the risk exposure, and, where justified, optimise the combination of risk treatments (overall cost of treatments versus their benefits in terms of reduction in probabilistic cost impact and/or probabilistic delay impact).

Risks are generally identified at the project level, rather than at the activity level. The decision to be taken when mapping risks is how the project level risk should be expressed at the activity level, particularly when mapping a duration impact risk to multiple activities. Cost impact risks are more straightforward.

The tools for effective integrated risk analysis enable its widespread adoption

Fast simulation software allowing sizeable schedules to be modelled

A prior limitation on "schedule risk analysis" was slow simulation software that restricted modelling of schedules to those no larger than, say, a hundred activities. Some practitioners in fact were adamant that modelling should not be performed on schedules larger than 25–30 activities. They expressed concern that the central limit theory (the tendency of smaller durations and ranges to result in unduly narrow distributions) was a barrier to the use of larger numbers of activities.

Central limit theory countered by use of correlation and/or risk factors

However, Oracle's Primavera Risk Analysis (PRA, formerly known as Pertmaster), which uses Assembler (essentially, machine language) for the core critical path engine calculations, can deal with schedules containing thousands of activities and enables simulations to be run hundreds, if not thousands, of times in practical simulation times of a few minutes. In addition, the effects of the central limit theory can be countered by the use of risk input correlations of groups of activities (effectively instructing the software that the Monte Carlo method assumption that all activities are completely independent of each other is to be modified by the correlation inputs provided) and/or risk drivers (instructions that groups of activities are being acted upon by common risk factors, which effectively assigns 100% correlation of the groups of activities to the driving risk factors). The mapping of multiple risk factors to overlapping project activities defines varying levels of correlation between them.

Choose between summary schedules or filtering by float

If there is concern about using the master project schedule for modelling because of its size, it is possible to filter the schedule by total float to exclude high float activities and apply duration ranges only to those within the filter — but beware of over-filtering, as criticality can be found in higher float paths.

Alternatively, a summary schedule can be developed if the master schedule is too large or there are several schedules to be included that are not effectively linked. While this may deal with the central limit theory concern, there is the risk that the summary schedule, through lacking the detailed schedule logic, may omit important dependencies that need to be taken into consideration when modelling the project realistically.

Usable software is now available for mapping risks to schedules

PRA has a risk register for receiving risks developed in qualitative risk management applications and mapping them to tasks in the PRA schedule. This has been enhanced since its introduction to enable the user to characterise risks with some sophistication. Our company started developing a means of mapping risk events to PRA in late 2005, before the then Pertmaster Risk Register was created. Subsequently, we developed our own risk management database application to incorporate the features we thought valuable for qualitative risk analysis, in addition to the ability to map risks into Pertmaster. Called RiskIntegrator2™ (RI2), it now forms the basis of our risk management and analysis consulting, with many advantages including ranging risk impacts and treatments.

Integrated cost and schedule risk analysis improves project management capabilities

Integrated cost and schedule risk analysis, or IRA, including the mapping of qualitative risk events to the estimate-loaded schedule, is a powerful means of equipping the project management team with insights into what drives the separate project schedule drivers and project cost drivers. But IRA offers more than that.

IRA enables realistic forecasts of project cost and time to be produced

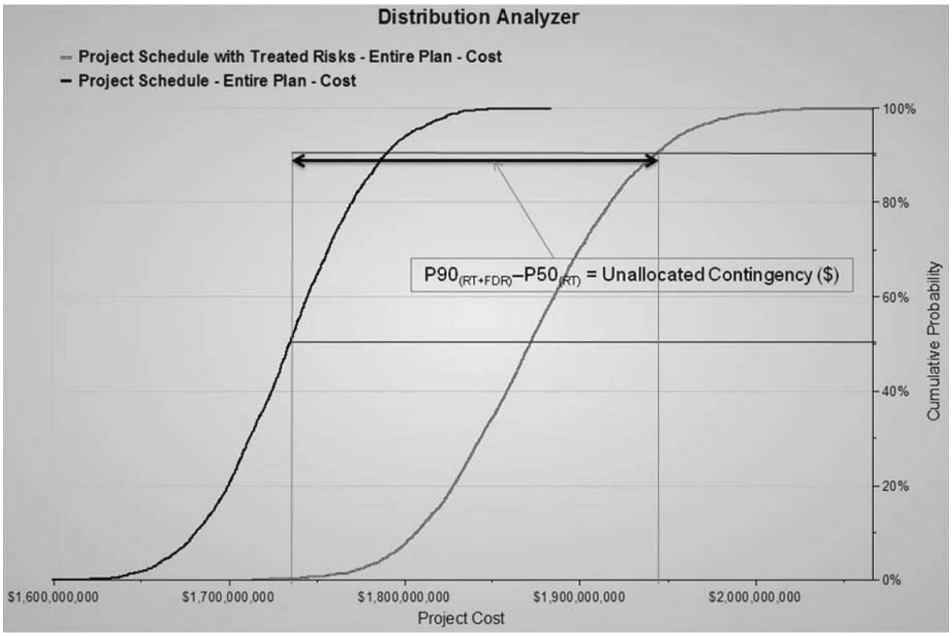
The methodology for assessing appropriate cost and schedule unallocated contingency (UC) provisions integrates the qualitative risk identification, ranking and treatment process with the quantitative risk analysis process described above. It involves separating risk events from analysis of the ranged activities and ranged fixed costs. The method may be summarised as follows.

1. Conduct integrated cost and schedule risk analysis using three-point estimates on each activity and time-independent cost item quantified in a risk workshop.
2. Store the ranged total probability curves (RT) for cost and schedule.
3. Add financial and/or duration risks (FDR) separate from ranged totals and analyse:
   - — not duplicating activity and line item ranges;
   - — dual uncertainties: probability + ranged impacts; and
   - — post-treatment risks.
4. P90 (RT+FDR)–P50 (RT) = unallocated contingency.

The method is illustrated graphically below, in Diagrams 1 and 2.

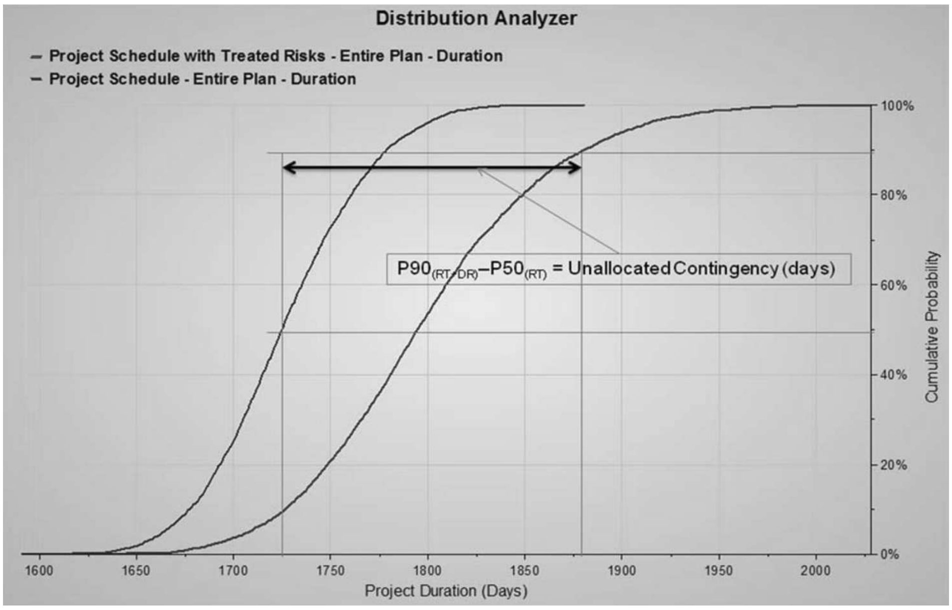
The choice of P90 or P50 can be changed, depending on the organisation's appetite for or aversion to risk.

Diagram 1: Cost estimate S-curves comparison with and without risks (P90–P50)



The same comparison can be made for duration (see Diagram 2).

Diagram 2: Schedule S-curves comparison with and without risks (P90–P50)



The choice of P50 for the ranged total represents an expected outcome for the project, taking into account normal ranges of schedule and cost uncertainties, but excluding risk events. A P90 including risk events represents a conservative provision for probable, possible and even unlikely ranges and risks occurring to the project.

The reliability of this approach depends on the comprehensiveness and accuracy of the process of risk identification, ranking, treatment and mapping of the risks into the estimate-loaded schedule. If this risk process has been properly performed, the riskiness of the project will be reflected in the UCs for both time and cost. In addition, because of the integrated nature of the analysis, the cost allowance will include the cost consequences of delay risks. The method allows the effect of each risk to be measured (analysis with and without the risk).

The technique can also be extended to assist in quantifying management reserve.

Can identify main drivers of cost and time to focus PM effort

The time and cost impact risk events can be assessed against the other sources of project uncertainty. Automation tools have been developed to measure and rank the probabilistic duration and cost contributions to project uncertainty of risk tasks along with normally ranged activities and costs. This is a powerful comparative technique for prioritising project management efforts to drive down the risk profiles for schedule and cost systematically, including risk events.

Use of IRA on projects

The methodology has been used successfully on projects ranging from less than $5 million to more than $15 billion, including:

- a major gas pipeline currently under construction;
- an offshore oil and gas platform expansion;
- a copper mine process plant expansion;
- compressor stations for domestic coal seam gas field expansions (as separate small projects); and
- an entire coal seam gas LNG project comprising:
  - — development of two gas fields;
  - — gas pipeline to Gladstone;
  - — LNG plant; and
  - — port facilities.

Each project has had its own unique characteristics which have emerged during the IRA process and led to new understandings of the drivers of project risk and what could be done about them.

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Footnotes

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2. Merrow E and Young R, *Capital Project Effectiveness in Australia*, 2009 Seminar Series, Independent Project Analysis, Inc, 2009.