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Creating Value from Uncertainty: Specialists in Managing Strategic, Enterprise and Project Risk

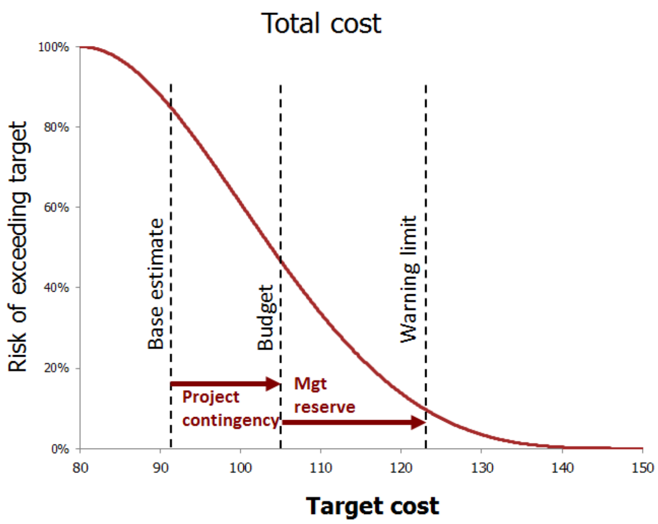
PROJECT COST & SCHEDULE MODELLING
Keeping it simple – Keeping it real

1 Introduction

For over twenty years Monte Carlo simulation to analyse risk in project cost and schedule forecasts has been open to anyone with a PC. The basic ideas seem simple but, while twenty years is long enough for many people to have tried it, there is still a lot of variety in how analyses are carried out. This paper describes how the relatively crude initial methods have developed and how you can avoid reinventing the wheel by taking advantage of good ideas that have only really matured in the last few years.

To make it clear what we are talking about here, it is the sort of analysis that might produce an output such as that shown in Figure 1. This is the kind of analysis that is typically used to decide how much contingency we need for a project.

Figure 1: Characteristic output of a cost risk model



All we need to do is take an estimate, think about the risks affecting it, assess possible variations in costs and plug them into @Risk. It seems simple – and it can be – but there are some pitfalls to avoid if you want it to be realistic rather than simplistic.

Some of the challenges we see in making analysis realistic while keeping it as simple as possible are:

– Linking risks to an estimate so that causes and effects are clear and the effects can be assessed efficiently;
– Making a realistic assessment of the amount of variation that could arise in a quantity.

Transparency is critical if you want people to believe the results of an analysis and efficiency underpins the cost of carrying it out. If no one can understand the relationship between the inputs and outputs of a model, it will be easy to reject any uncomfortable findings it produces and, if it feels like a long and difficult process, stakeholders will be reluctant to become engaged with it.

2 Linking Risks to Estimates

As an example, here are a few of the risks that might affect a major project that involves earthworks and civil works upon which a processing plant is to be constructed.

1. Geotechnical conditions
2. Survey data
3. Ground loading

We can think about each of these and try to figure out how much time and money each one could cost us. This is difficult though. Geotechnical problems could force us to do more earthworks or use piles where we hadn't intended to, among other things. If the site survey is inaccurate, we might have to move more material and import or export more of it. If the plant design changes, we might find the ground loading changes and foundations have to be altered.

Each of these could be complicated matters in themselves and they also interact, yet it is not uncommon to see a list of risks such as this with a probability and a range of outcomes, expressed in dollars, against each one. We need a way for people who understand the job to form a view on the effect of the risks, in terms that we can use in a model, without absorbing too much of their time.

If we put these risks next to an estimate and look for connections between them we might see that all of them could affect:

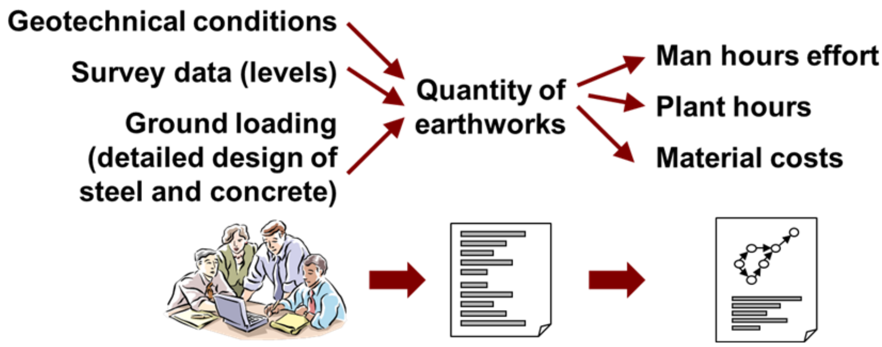
- The number of man hours on some parts of the job;
- The number of hours of earthmoving and related equipment operation;
- The cost of bulk materials.

These are all quantities that we should be able to see in an estimate, but it is still a fragmented picture and in some cases there may be no way around that. However, one common factor among all these risks will be their effect on the quantity of earthworks to be carried out. They might also affect earthworks rates as well of course but in a different way. The overall relationship between these risks and parts of the estimate could be as in Figure 2.

Figure 2: Finding the link between risks and an estimate

The obvious place to grasp this group of factors is in the middle. The effect of variations in earthwork quantities on the items at the right of the figure can be represented in an @Risk model using simple functional relationships, and the possible variation in that quantity can be assessed by experienced personnel who know the plan and the estimate. This is illustrated in Figure 3. Here we have the key to simplifying the modelling, completing the assessment efficiently and maintaining the realism of the analysis.

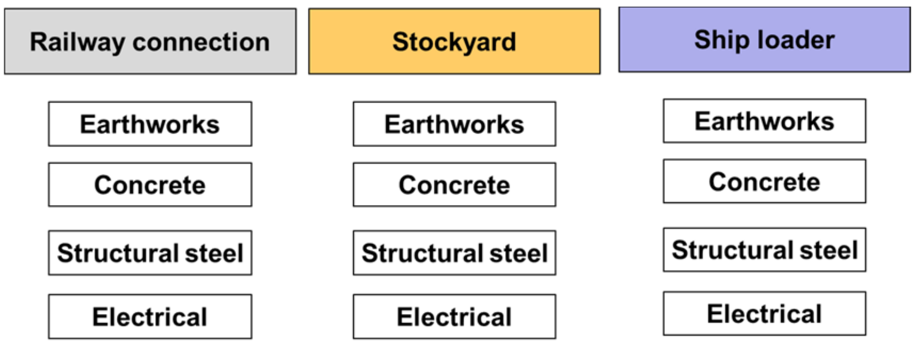
Figure 3: Assessment process



This approach is often referred to as a risk factor method. Rather than try to analyse each of the initial risks and work out how they might interact, we identify factors that consolidate diverse sources of uncertainty and link these into the model using straightforward Excel and @Risk formulae.

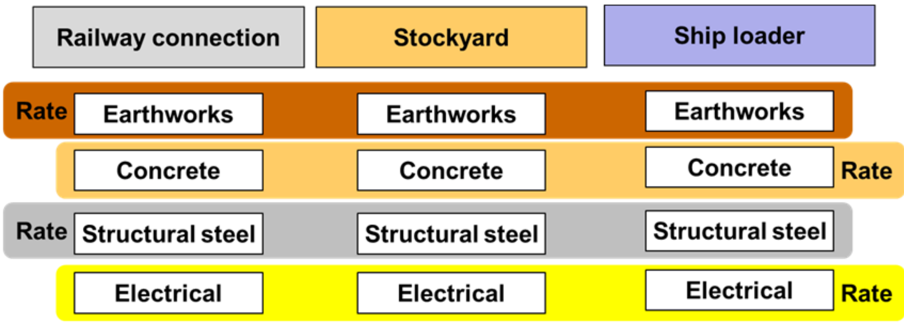
To illustrate how this can be done, although every case is different, consider a simplified view of a project to expand a mineral export facility consisting of a new rail spur, a stockyard and a ship loader. In each area there will be costs associated with earthworks, concrete, structural steel and electrical work, as illustrated in Figure 4.

Figure 4: Cost breakdown



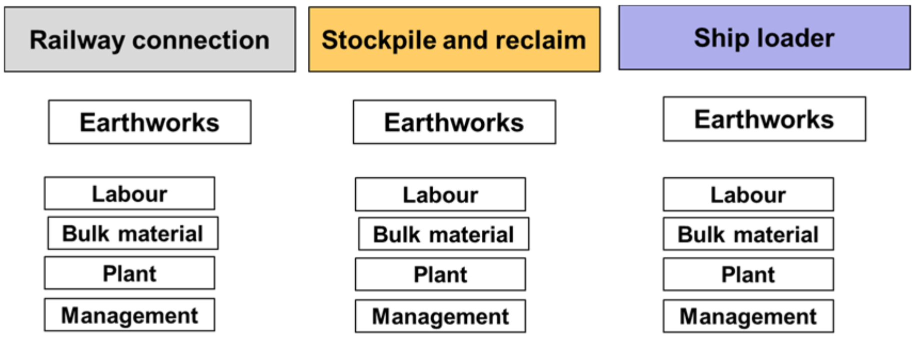
Uncertainty in market rates for bulk materials in each discipline (earthworks, concrete, steel and electrical) will generally affect all areas of the project in the same way, as illustrated in Figure 5. If we can assess the uncertainties in those rates, we can apply them once across all areas. This is simple, efficient and realistic as the market will affect them all in the same way.

Figure 5: Rate uncertainty cutting across areas



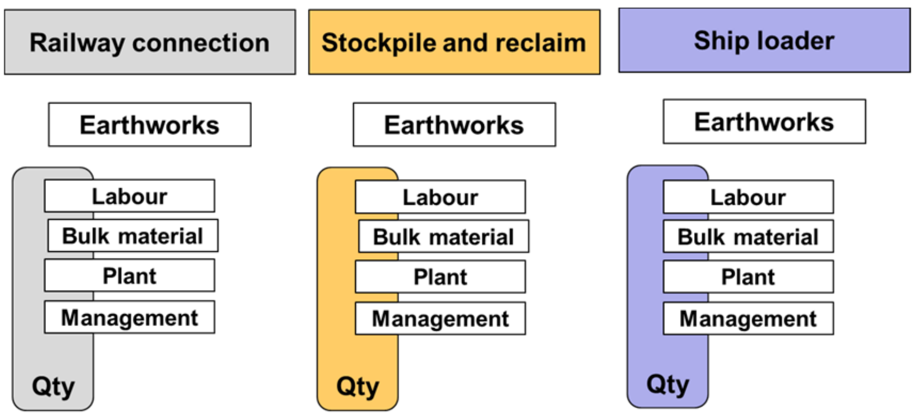
If we now focus on earthworks for a moment and break those costs out, we might find cost items in the estimate associated with labour, bulk materials, plant and supervision or management, as illustrated in Figure 6.

Figure 6: Breakdown within a discipline



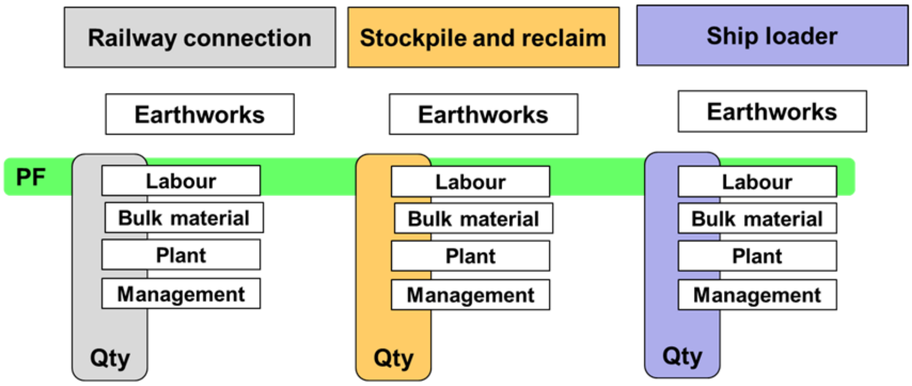
Bulk material quantities are often uncertain and especially so in earthworks estimates. The amount of uncertainty in one area will generally have little or nothing to do with the uncertainty in the others but it will affect labour, bulk materials, plant and supervision or management costs within the one area. This is illustrated in Figure 7.

Figure 7: Quantity uncertainty cutting across cost categories



Now looking at the cost categories, we will often find that our assumptions about labour force productivity (PF) will be equally uncertain across all areas of the job, as illustrated in Figure 8. Productivity uncertainty might stem from uncertainty about the demand for labour, the quality of the contractor's supervision and the intrinsic difficulty of the work, among other things. Once again, we can see a single factor that we only need analyse once and can then apply across all affected parts of the model.

Figure 8: Productivity uncertainty cutting across areas



With this approach, it is generally possible to make a realistic assessment of the uncertainty in a major project using just twenty to thirty factors. As well as yielding relatively simple models that are both realistic and easy to understand, the use of risk factors also removes the need for complex overlapping correlations that might arise otherwise. For instance, if we represented the uncertainty in each of the costs shown in Figure 8 directly in dollar terms, we would have to consider:

- Correlation arising within each area associated with the common dependency on quantity uncertainty; and,
- An overlapping correlation between all the labour costs associated with the uncertainty in productivity factors.

There may be more than two sources of overlapping uncertainties that, without the use of risk factors, we would have to represent using correlations. Assessing correlations is hard enough, but ensuring that a set of linked correlations are consistent with one another is extremely difficult. Demonstrating to others that the correlations you have used are meaningful can be all but impossible.

Finding a way to link an estimate to a set of risks by identifying the key drivers or factors makes risk modelling simpler, less time consuming, more realistic and easier to understand. The most useful model structure might change as a job progresses from concept through definition and into execution and the estimate moves from being based on factored costs and benchmarking through a build up from early designs to material take-offs based on drawings issued for construction.

A similar approach applies just as well to schedule modelling and produces the same benefits.

3 Assessing Ranges of Uncertainty

Whether we are dealing with costs and durations directly or the factors that drive them, such as quantities and market rates, there are well-known challenges to arriving at a realistic assessment of the range of outcomes we might face. Some people advocate workshop processes where a facilitated discussion can bring together the collective judgement of an expert team. Others prefer individual interviews where group pressure is avoided and people feel free to express their concerns. Both have strengths and weaknesses but, no matter how we ask people questions about uncertainty, participants will struggle with two serious challenges:

– The difficulty of thinking clearly about extreme values that represent very rare outcomes; and,
– The innate human tendency to limit how far we stray from the initial estimate or forecast, known as anchoring.

If people are asked to say what is most likely, how much higher the outcome could be and how much lower it could be, in that order, they might produce the three values illustrated in Figure 9. Very often, as events unfold, they might realise that the picture should have been as shown in Figure 10, somewhat wider than first thought. This is a common experience.

Figure 9: Working out from the centre

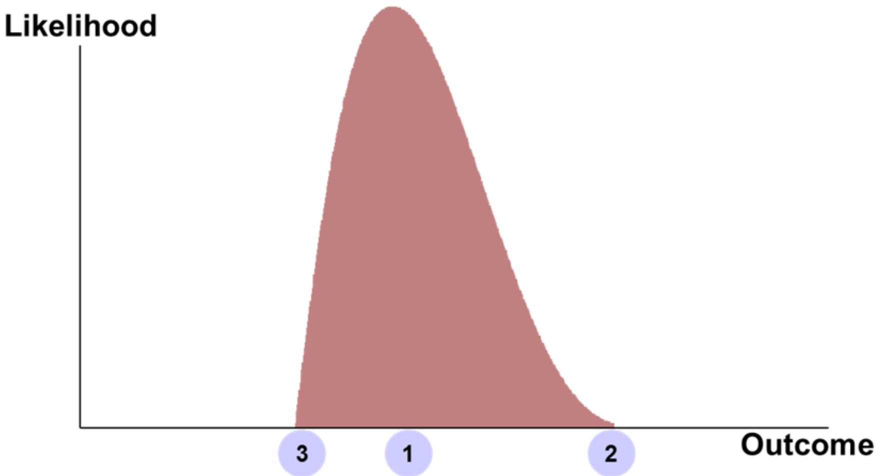
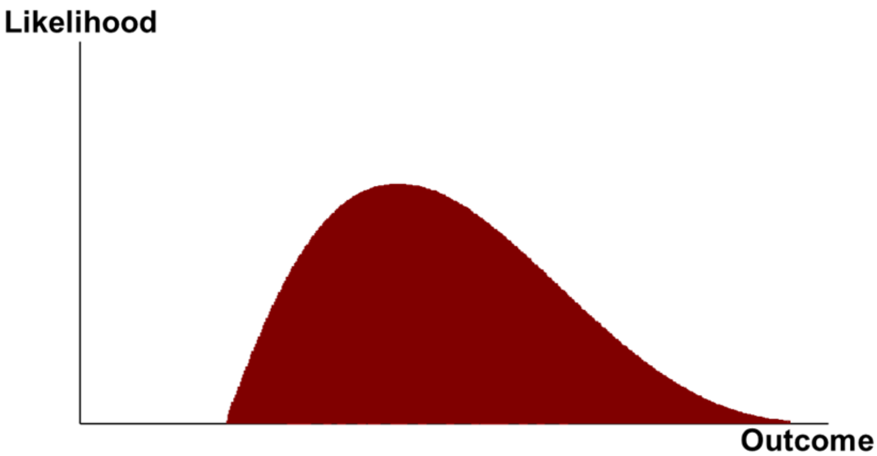


Figure 10: Real distribution



To overcome the twin challenges of extreme values and anchoring, two techniques are found to be beneficial:

– Framing the assessment with an exploration of the sources of uncertainty; and,
– A five point assessment of the possible variation.

Framing helps to bring everyone involved to a common understanding of the sources of uncertainty. It often reveals differences of opinion and information that, prior to the assessment, are known to some and not to others. It might take the form of documenting, briefly:

– The critical assumptions underpinning the values used in an estimate or plan;
– What the real sources of the uncertainty are, such as the original risks listed in the previous section; and,
– A description of what would be happening if things were going badly, going well and going as expected.

A few minutes spent discussing these three sets of information will often expose significant risks that had not been fully appreciated beforehand or reveal just how severe a variation a project might face. There may still be spirited debate when it comes to putting numbers on the variation but it will proceed much more smoothly than it would have otherwise and the outcome will be a lot more stable.

When this is complete, for a particular assessment, a five-point numeric assessment takes the form shown in Figure 11. The values are assessed in the order indicated by the numbers; Worst, Best, Pessimistic, Optimistic and Most Likely.

Figure 11: Five point quantitative assessment

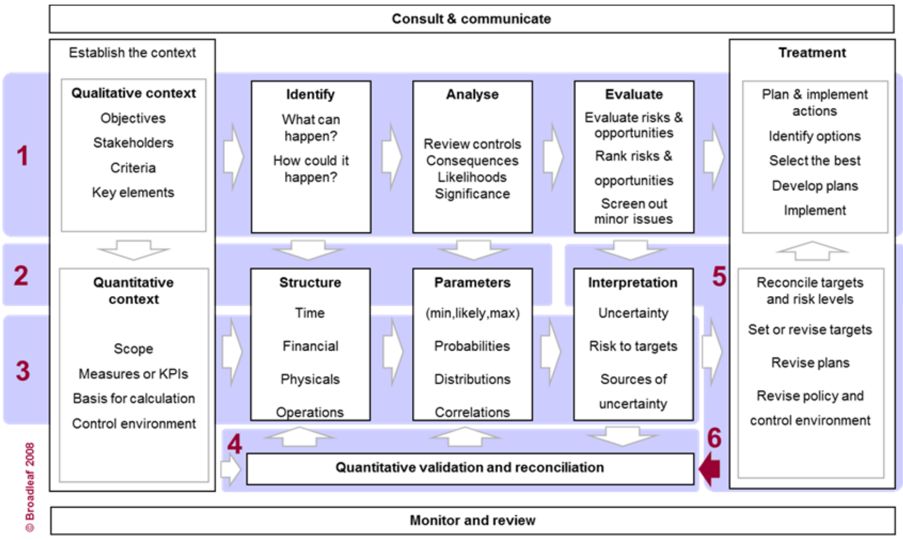
It is important to press the Worst and Best cases to break open the anchoring, although these remain vulnerable to the challenge of assessing very rare events. However, once they have done their job, we can use the Pessimistic and Optimistic values to describe the spread of the distribution using RiskTrigen or one of the alternate forms of other distributions that can take percentile points as parameters.

The combination of framing and the five-point assessment typically results in significantly wider ranges than would otherwise be produced. While the Worst and Best are extreme cases, working through them not only improves the realism of the assessment, it also enables a team to understand how much scope there is to improve and how much exposure there is to an undesirable outcome.

4 Pulling It All Together

Risk modelling can seem a black art that is difficult to plan and manage, but the approaches outlined here can all be integrated into a smooth flow of work that can be planned and executed as a project itself. The uncertainty factors have to be chosen with care to link the main sources of uncertainty to the estimate or plan being analysed. Once this structure is defined, data requirements for the analysis are clear and a process to meet them can be planned and executed. This can all be set in relation to the Standard approach to risk management ISO 31000:2009 in the way illustrated in Figure 12.

Figure 12: Integrated overview



The shaded areas indicate stages in a typical analysis and are numbered in the order in which they are taken. Stage 1 represents a pass through a conventional qualitative risk assessment or equivalent.

Stage 2 covers designing a model so that it will link sources of uncertainty to the estimate or plan efficiently through a set of risk or uncertainty factors. The structure has to provide a means to represent the risks described in the qualitative assessment although it will not usually represent each one as a separate item in the model.

Stage 3 represents gathering the framing and numeric information about the uncertainty factors and building them into the model for the first time. Stage 4 is a conscious validation step to compare the outcome against other views of the project, not least the opinions of the project team, and reconcile any inconsistencies.

Stage 5 is where we accept the outcome and plan accordingly or, if the outcome is not acceptable, change the plan to improve the outcome and repeat the analysis. Stage 6 represents subsequent revisions and updates that might flow from changes to the plan or updates to take account of actual developments on a project.

Using framing and the five-point elicitation of quantitative variation, in Stage 3, results in transparent models that are easy to understand and a cost-effective analysis process for all concerned.

5 Contacts

If you require more information about project cost and schedule modelling please contact one of the members of Broadleaf shown below. More information about us and what we do is provided on our web site at www.Broadleaf.com.au.

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6 Additional Note

This tutorial note is based on a presentation by Dr Stephen Grey to the Palisade Risk Conference in Sydney, Australia, on 29-30 May 2012.