Supplementary Materials: Successful Control of Major Project Budgets

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A typical basic procedure

Step A. Project owner clarify the goals and objectives, as well as any firm preconditions

The analysis management team prepares a draft of what the main goals and objectives for the subject under discussion are, and whether there are any important preconditions which have to be understood. However, it is important to discuss these properly in the following workshop group and to make adjustments so that full understanding and consensus are reached.

Step B. Selection of the participants

The selection of the analysis group should be based on obtaining a suitably diverse range of disciplines, personality types and ages. Some participants will bring specialist knowledge about the task and should represent "both halves of the brain". Others will bring balance or an external perspective. This enables a rich exchange of views and information, as well as a more balanced decision-making capability, especially in difficult situations.

The above preparations end with an introduction to the participants before the workshop.

The following steps C to H are carried out in a workshop

Step C. Identify all issues of potential importance

The first subject in the workshop after a mutual presentation is a clarifying discussion on the analysis goal, the nature of the project and its situation.

One primary aim of the following qualitative analysis is to determine what the planning references are for the particular situation under discussion, so that the context and basis of the quantitative analysis which follows are properly understood.

The analysis group carries out a brainstorming exercise in order to establish the spectrum of issues that are involved and it usually results in 50 to 100 different issues being identified. These issues can be technical issues, 'people' issues or commercial/financial issues, and they may include 'fuzzy' or 'painful' ones. They may be project-level issues, organisational/partner-level issues, or issues out in the wider business and/or political environment.

Step D. Organize the many issues into independent categories

The issues from the brainstorming are then grouped under various categories, Overall Influences, each of which has a largely independent influence on the project (i.e., they should be statistically-independent of each other). Typical categories may include Skills & Know-how, Procurement, and Technological Solution. Each category of issues is then considered by the Analysis Group in order to determine the planning reference (base case) assumptions that are being made, and how these could vary both for better or worse. Highly simplified examples of how this 'Scenario Analysis' is done are shown below:

Table S1. Example of a Scenario analysis as described in step D in the text.

Category	Planning Reference (Base Case)	How it Could be Better (Potential Improvements)	How it Could be Worse (Potential Risks)
Skills and Resources	Personnel will be available as and when required by the project.	Key personnel are dedicated to the project.	Key personnel are unavailable due to work on other projects, customer support and work on new bids.
Project Priority	No different from any other project.	Strategic importance results in Board-level support.	Other projects take precedence.
etc.			

It is very important to understand that in the quantitative modelling that follows, the base case assumptions in the Scenario Analysis are used when assessing the uncertainty ranges (triple estimates) for the estimate line items. In the base case 'world', the line items are largely statistically-independent of one another. The impact of the potential opportunities and risks in each category are added in afterwards in order to model the systematic interdependences and potential upsides and downsides to the stated base case. An example of a systematic influence on a base case is scope change—the scope is assumed to be fixed in the base case 'world', but of course it could change, especially if the project is in its early stages before the sanction decision. The scope could increase, but it could also decrease.

'Soft' factors so far have been difficult to convert into "hard data". The use of the Bayesian statistical theory however allows us to express our intuitive evaluations of their effect (which can be large) in a triple estimate. This will be calculated and handled as a normal "hard data" together with all other data. Even lack of knowledge can be transformed into data in this manner, and thus inform us about areas with a need of knowledge. Participants will often have different opinions about certain matters. Instead of such disagreements block the advances it now results in a large uncertainty, reflecting the different opinions. In this manner this subject is likely to materialize at the top ten list. It safeguards the such matters are properly discussed. It also allows the group to continue while accepting the uncertainty so far.

Step E. Quantitative modelling using triple estimates and good evaluation techniques

A high level model of the estimate will have been prepared before the analysis group comes together (or its equivalent if a schedule uncertainty analysis is being carried out). Each main item is quantified using the triple estimating technique. As noted above, these triple estimates are all evaluated under the relatively firm base case assumptions that have been set out the qualitative Scenario Analysis. This ensures a sufficient degree of statistical independence.

In some cases, these uncertainties are obviously so much smaller that the effects from the Overall Influences, that the original values may be accepted as they are, eventually adding a single triple estimate to express the overall uncertainty of the basis estimate.

Once this has been completed, the systematic uncertainty from each category of Overall Influences in the Scenario Analysis is added, also using the triple estimates. For example, future changes to scope could reduce the base cost by (say) 5 per cent, but if scope increases, it could add up to (say) 20 per cent to the overall cost. Each of these 'Overall Influences' is evaluated assuming that everything else is as stated in the base case scenario.

This approach to the modelling allows a simple yet sufficiently accurate statistical calculation to be made according to normal rules. The triple estimates procedure, however, has to follow a set of specific rules in order to compensate for the various evaluation pitfalls. They are described in [10]

Step F. Calculate a provisional overall result and draw up a top ten list of the most critical elements

The model is then calculated, following the Bayesian statistical theory, but using the normal statistical formulas. In addition to the total mean value and its uncertainty (usually expressed as a Standard Deviation), a top ten list is generated, showing the most important and critical local sources of uncertainty (the Uncertainty Profile). These are generally presented graphically as probability distribution or a Tornado diagram.

Step G. Specify the most critical elements in successive steps, guided by the top ten list

The initial estimate model is now detailed and/or clarified in successive steps, with the most critical elements being specified at every step, using the updated Uncertainty Profile as a guide. It leads to an optimal breakdown structure and evaluation of only those elements which warrant attention.

After a number of such cycles, some key uncertainties which cannot be specified into more detail will increasingly dominate the Uncertainty Profile: after no more than 5–8 cycles they usually account for 80 to 90 per cent of total uncertainty. Consequently, we are close to the minimum uncertainty of the grand total and similarly close to a successful conclusion of the analysis. At this stage, the number of items (variables) in the model generally involves fewer than fifty items, including the overall influences.

Step H. After the final result has been generated, an action plan is developed

The analysis group will usually be prompted by the top ten list and supported by the information and discussion met in the workshop to draw up a suggested action plan to conclude the analysis process. The aim is to identify actions which may either exploit opportunities, protect the task against financial risks, or simply reduce uncertainty. A brainstorming process at this point is a highly appropriate means of identifying such ideas.

The above overview is further described in [10,14,22].