Improve Confidence with Schedule Risk Analysis
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- Please put your phone on silent mode
- Q&A will be taken at the close of this presentation
- There will be time at the end of this presentation for you to take a few moments to complete the session survey. We value your feedback which allows us to improve this annual event.
John Owen

1981-1986  Worley Engineering (Planning Systems Manager)
1986-2006  Welcom (VP Development)
2006-2014  Deltek (Director Products and Strategy – Schedule & Risk)
2014-      Barbecana Inc. (COO)

Producing tools for organizations where outstanding project execution is a critical business requirement
Risk Management

Everyone Can and Should Practice Risk Management (even my dog does!)
Improve CONFIDENCE With EASILY IMPLEMENTED Schedule Risk Analysis
Define Schedule…

For our purposes a schedule is a way of constructing a model of an endeavor (project) in order to understand the work that must be completed and how long it will take.

The most common project modelling technique is Critical Path Method (CPM)
The trouble with CPM…

Critical Path Method calculates a single deterministic suggestion for a project completion date. Every project, no matter how similar to projects before it, is always subject to some uncertainty. This means that the only sure fact, for the project end date calculated by CPM, is that it will almost certainly be wrong. Worse, the end date calculated by CPM is usually overly optimistic.

Let’s find out why…
A simple CPM example…

Assuming Task A starts on Day 1 of our project, Task A will finish on Day 5. Because of the Finish-to-Start relationship between Task A and B, the earliest Task B can start is Day 6. Adding the 5 days duration for Task B means that the project will complete on Day 10.

A delay to Task A will cause a delay to the start of Task B but we have an opportunity to make up the lost time by completing Task B in less than the estimated duration, so that the project can still be completed on time.
Those same two activities...

In this example, Tasks A and B can both start when the project starts. However, the project will only be complete when both Tasks A and B have been completed. A delay for Task A will cause a delay for the project, even if Task B is not delayed or finishes early (and vice versa).
The Chance of Project Success

Let’s tabulate the possible outcomes for Task A and B (and to simplify the table we’ll count an on-time finish as early).

<table>
<thead>
<tr>
<th>Task A</th>
<th>Task B</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>Early</td>
<td>Early</td>
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<tr>
<td>Late</td>
<td>Early</td>
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<td>Late</td>
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</tbody>
</table>

We know that the project will only complete on time if both Task A and B finish early or on time. Of our four possible outcomes we can see this only happens one time. Any of the other three possible outcomes results in a late project completion.
One reason projects fail...

As the number of predecessors for any given activity increases, it becomes less likely that it will start on time. This effect is called Merge Bias.

Merge Bias is the single biggest reason that project models, built using Critical Path Method (CPM), inherently produce an unrealistic forecast for project completion.

As the complexity of the project model increases, and the number of activities with multiple predecessors grows, the probability of attaining the deliverable dates, suggested by CPM, decreases.

So project failure may not be caused by poor execution, but simply by the fact that the plan was never realistic or achievable in the first place.
Should we add contingency?

Task duration estimates can be made using a variety of techniques (expert judgment, parametric estimating etc.). The duration represents the time you expect the task to take. A good estimate equates to a 50/50 chance of finishing the work in the time allotted.

So why not add a contingency to each task duration. Wouldn’t that improve our chance of finishing each task on time?

The problem is Parkinson’s law. “Work expands so as to fill the time available for its completion”.

Never plan work using padded durations that include contingency.
Improving the model

So if a standard Critical Path Method (CPM) project model results in an unrealistically optimistic ‘deterministic’ deliverable date and adding contingency to task durations is a bad idea, what can we do to improve matters?

The biggest flaw with CPM is that a single estimated duration is captured for each task. This is very unrealistic. Even for tasks that have been performed before there will be some uncertainty, even if it is completely external (for example high absenteeism when the USA played in the 2014 World Cup).

So a better model would be based on a range of estimates for each task.
P.E.R.T

The Performance Evaluation and Review Technique (PERT) captures an Optimistic, Most Likely, and Pessimistic duration for each task. This is a big improvement in our estimating technique. We can then use the three points to calculate an expected duration for each task.

Expected Duration = (Optimistic + (4 x Most Likely) + Pessimistic) / 6

The expected duration is then used with a regular CPM algorithm to calculate an expected project completion date.

PERT also calculates a Standard Deviation (Error) around the expected finish date so practitioners can select a possible completion date based on a desired level of confidence (probability).
The trouble with P.E.R.T

Because the range of values for each task are distilled into a single forecast duration for each task, followed by a regular CPM style calculation, PERT does not model the effect of Merge Bias.

PERT also calculates a single deterministic Critical Path (just like CPM) whereas, referring back to our simple parallel Task A and B example earlier, we can see that in reality the Critical Path may vary and that would be good to know from a management perspective.

So how can we improve on PERT?
Deterministic solutions like CPM and PERT cannot model the interaction of uncertainty on the various tasks in the project.

But what if we could simulate the execution of the project thousands of times to see how the uncertainty inherent to each task interacts?

This is what Monte Carlo Simulation (aka Schedule Risk Analysis) allows us to do.

The technique is named after Monte Carlo, a European city that is famous for games of chance.
Simulation?

Can’t we just ‘calculate’ the correct answer?

Unfortunately no. Modelling the interaction of many ‘randomly’ changing variables can’t be handled by an equation.

Even apparently straightforward tasks, like predicting the future position of the Moon relative to the Sun and Earth, have to be handled by simulation (Three Body Problem).

A Monte Carlo Risk Analysis will consist of many individual simulations (sometimes called trials or iterations) and the results of each individual simulation will be tallied for reporting.
How does it work?

A Monte Carlo algorithm will simulate the execution of the project many times.

For each simulated execution (aka Trial or Iteration), the algorithm will substitute task durations with sample values chosen from within the range of uncertainty specified by the optimistic, most likely, and pessimistic estimates.

Each simulation is a complete Critical Path Method calculation and gives us a possible project outcome. By repeating the simulation many times, and recording the number of times the simulated project outcome occurs on a specific date we can derive the chance of the project completing by that date.
The effect of uncertainty

Variation of the project completion date
Variation of the project cost
Changes to the Critical Path
Merge Bias (tendency for CPM to be optimistic)
**Reduction in the perceived value of the project**
**Increased management effort**

So the purpose of modelling uncertainty is not just to understand the impact but also to help focus efforts to **reduce uncertainty** and **increase confidence**
Uncertainty

There are two basic types of uncertainty that we can consider

**Estimate Uncertainty (Epistemic)**

Estimate uncertainty is caused by a lack of knowledge

– We don’t know exactly how long something will take
  
  • We can capture a range of estimates

**Event Uncertainty (Aleatoric) (Threats/Opportunities)**

The impact of random events

– Something may or may not happen
  
  • We can plan for different eventualities
Estimate Uncertainty

Option 1 - Capture a range of estimates for each activity
- Best case / Optimistic estimate
- Worst case / Pessimistic estimate
- Most Likely estimate (optional and used to ‘skew’ the most likely closer to either the optimistic or pessimistic values)

Option 2 – Gauge Confidence in the original estimate
For example:-
- High Confidence expected variance of ±10%
- Low Confidence expected variance of -5% to +50%
Probability Distributions

The durations sampled in the range specified by the optimistic, most likely, and pessimistic durations, can be weighted using a probability distribution.

This allows us to define how likely sampled durations are to be closer to the Most Likely vs Optimistic and Pessimistic values.
Which Distribution?

General Guidance

• Use historical data to determine an appropriate distribution
• Unless there is a compelling reason, do not use Uniform
• In the absence of specific guidance, use Triangular or Lognormal
• Use Beta or Triangular if you need to specify the degree of skew
• Use Confidence Limits if the estimator wants to hedge

It really doesn’t make a lot of difference…
Distribution Types
Event Uncertainty

Event uncertainty allows us to model Threats or Opportunities that may modify the execution of our project.

Threats might include a new prototype not meeting design criteria while opportunities could include a new manufacturing process becoming available.

Several different techniques can be used to model event uncertainty.

- **Probabilistic branching** allows us to specify a probability that a particular path through the project may be taken (useful for opportunities)

- **Existence probability** allows us to model threats as activities that may occur.

- **Conditional branching** allows us to specify that specific activities will be included if desired dates are not achieved
Probabilistic Branching

Allows us to model alternate plans
Conditional Branching

Allows us to revise the plan as dates change
Existence Probability

Useful for modelling threats

Make 1 week → Test Failure 1 week → Ship 1 week

10% Chance
And the result is…

Despair and Disbelief!
The Histogram shows the probability of the project completing on a specific date. The S-Curve shows the probability of completion by a specific date. CPM expected finish Jan 23. 6% chance by Jan 23. 50% chance by Feb 27. 80% chance by Mar 18. 100% chance by May 28. Most likely date Feb 19 (12.5%) although only 36% chance of finishing by then.
Why is SRA so depressing?

Forecasts from a project management process that includes schedule risk analysis are often unpalatable for two reasons:

1. Practitioners are more likely to validate the quality of the schedule which tends to push dates to the right

2. Schedule Risk Analysis tends to push dates even further to the right. This is true even if estimates reflect the fact that historically an organization has been very good at estimating individual tasks (Actual/Estimate=1)

The Critical Path Method (CPM) technique is inherently and unrealistically optimistic...

Like it or not, the results from SRA are probably more realistic.
Is there good news?

Yes!
Sensitivity Analysis

Sensitivity Analysis (often portrayed as a Tornado chart) identifies:

- Which activities are creating variability in deliverables
- Where to focus estimating effort
- Opportunities for schedule compression
- Where to focus management effort
Risk Adjusted Schedules

A Risk Adjusted Schedule shows when work will be performed at a specific level of confidence (e.g. P80)

Make commitments using the Risk Adjusted Schedule but manage using the original schedule
Schedule Margin

Contingency for Schedulers!

Schedule Risk Analysis is one of the best techniques for quantifying schedule contingency (aka schedule margin).

The project manager/scheduler owns the margin and will track incursion/consumption of the margin in exactly the same way as a cost engineer allocates and tracks fiscal contingency.
Preparing for Schedule Risk Analysis
Schedule Quality

Just as with standard CPM, the validity of any results calculated by Schedule Risk Analysis are entirely dependent on the quality and realism of the underlying schedule. Software Tools can help.
Schedule Preparation

- Ensure status Information is current
- Remove ‘hard’ constraints
- Ensure Level of Effort work is not driving the critical path
How many simulations?

Just about any number of simulations will give a reasonable indication of the expected (mean) finish date. More simulations improve the fidelity of the information around the mean.

100 Simulations: Mean 3/9, P80 3/27
1000 Simulations: Mean 3/6, P80 3/24
100,000 Simulations: Mean 3/3, P80 3/23
Analyze Past Performance

Histogram of Actual over Estimated Duration for project 'Task 0'.
(Mean = 117%, Standard deviation = 64%)
Combined Cost and Schedule
Summary

• Schedule Risk Analysis is a valuable tool for making schedule more realistic and improving confidence.
• It’s an iterative process. Initial results may be depressing but the technique helps identify areas for improvement.
• Schedule Risk Analysis has almost no value if you just produce a histogram to satisfy a contract requirement.
• Many organizations chose to commit to P80 delivery dates and have a high success rate which boosts confidence and profitability.
• It doesn’t have to be hard!
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Thank You