Schedule Best Practice including Schedule Margin and Schedule Risk Analysis

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Learning Objectives

- Use Monte Carlo to model risk mitigation strategies
- Understand why traditional CPM is inherently optimistic
- How to use Schedule Margin to protect deliverables
Exercise 1

The Dice…

Each die represents a task that must be completed to deliver our project.

Tasks can be executed in parallel.

1 – 3 represents early or on-time (50% chance)

4 – 6 represents late (50% chance)

Roll the dice 10 times and count how many times all the dice you have show 1 – 3.
To be clear…

Roll the dice 10 times and count how many times ALL the dice you roll ALL show 1 to 3 dots at the SAME time.

If you have two dice and on the first roll you see a 1 and a 4, that’s a fail. Do not count it.
So why did we do this?

We are modelling a deliverable that is dependent on one or more assemblies.
All the assemblies have to be delivered on time for our contract to be fulfilled.
What are the chances?
Theoretical Results

According to a Critical Path Method analysis, assuming all the assemblies are planned to take the same duration, then all deliveries will be on 9/5. But how realistic is that?
Add some symmetrical uncertainty

There is always some uncertainty associated with project tasks.

With our dice exercise we modelled symmetrical uncertainty (tasks were just as likely to finish early/on-time as they were to finish late).

To save time let’s run 1,000,000 simulations using a computer...
Dependent on one assembly

CPM = 9/5 5pm
Mean Finish = 9/5 5pm
Mean Duration = 10d

50% chance of on-time
P80 = 9/6 4:30pm
Dependent on two assemblies

CPM = 9/5 5pm
Mean Finish = 9/6 1:40pm
Mean Duration = 10.6d

25% of on-time
P80 = 9/7 11:31am
Dependent on three assemblies

CPM = 9/5
Mean Finish = 9/6 4:00pm
Mean Duration = 10.9d
13% chance of on-time
P80 = 9/7 2:05pm
So…

As the number of predecessors for any given task or milestone increase, the chance of it starting/delivering on time decreases.

Our example was a worst case scenario since we had identical parallel predecessors but this effect is the primary reason that dates predicted by Critical Path Method (CPM) models are often overly optimistic.

This effect is called **Merge Bias**.
A real schedule – Hmmm…

Histogram of Early Finish for project '3100 Tasks'.
Mean = 22Dec26 17:00, Standard deviation = 32 days, Deterministic value = 22Dec26 17:00 (50%).

Each bar represents 1 week. (Markers show start of interval.)
End of discrete work

- 3100 Tasks
- All tasks +/- 10%
- 10,000 Simulations (3 mins)
- 38% Chance of deterministic finish
Merge Delay (Bias)

72 tasks out of 3100 had merge delay
Beware ‘odd’ results…

The project clearly has a ‘hard’ constraint (FNLT, FON etc.)

These need to be removed or ignored
Schedule Quality affects SRA

<table>
<thead>
<tr>
<th>Condition</th>
<th>Select</th>
<th>Threshold</th>
<th>Exclude*</th>
<th>Goal</th>
<th>Result</th>
</tr>
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<tbody>
<tr>
<td>Baseline duration exceeds threshold (DCMA metric # 8)</td>
<td>␣</td>
<td>22 days</td>
<td>LSP</td>
<td>&lt; 5%</td>
<td>41.80% (1098 out of 2627 tasks)</td>
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<tr>
<td>Duplicate task names</td>
<td>␣</td>
<td></td>
<td></td>
<td>= 0%</td>
<td>0.00% (0 out of 3145 tasks)</td>
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<tr>
<td>Finish-Start relationships (DCMA metric # 4)</td>
<td>␣</td>
<td></td>
<td></td>
<td>&gt; 90%</td>
<td>93.81% (3516 out of 3748 relations)</td>
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<tr>
<td>Hard constraints (DCMA metric # 5)</td>
<td>␣</td>
<td></td>
<td></td>
<td>&lt; 5%</td>
<td>0.00% (0 out of 3145 tasks)</td>
</tr>
<tr>
<td>Inactive tasks</td>
<td>␣</td>
<td></td>
<td></td>
<td>= 0%</td>
<td>0.00% (0 out of 3145 tasks)</td>
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<tr>
<td>Lags bigger than threshold (DCMA metric # 3)</td>
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<td>1.65% (62 out of 3748 relations)</td>
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<td>= 0%</td>
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<td>Manually scheduled tasks</td>
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<td></td>
<td>= 0%</td>
<td>0.00% (0 out of 3145 tasks)</td>
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<tr>
<td>Milestones with resources</td>
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<td></td>
<td>= 0%</td>
<td>0.00% (0 out of 261 tasks)</td>
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<tr>
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<td>10</td>
<td></td>
<td>= 0%</td>
<td>0.64% (20 out of 3145 tasks)</td>
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<tr>
<td>More than threshold number of successors (Preamble t...)</td>
<td>␣</td>
<td>10</td>
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<td>= 0%</td>
<td>0.29% (9 out of 3145 tasks)</td>
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<td>Negative slack exceeds threshold (DCMA metric # 7)</td>
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<td></td>
<td>= 0%</td>
<td>63.56% (1999 out of 3145 tasks)</td>
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<tr>
<td>No baseline start or finish date (Excluded by most DCM...)</td>
<td>␣</td>
<td></td>
<td></td>
<td>= 0%</td>
<td>0.03% (1 out of 3145 tasks)</td>
</tr>
<tr>
<td>No predecessors (DCMA metric # 1 Part 1)</td>
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<td>S</td>
<td></td>
<td>&lt; 5%</td>
<td>12.33% (324 out of 2627 tasks)</td>
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<tr>
<td>No resources (DCMA metric # 10)</td>
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<td>SM</td>
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<td>= 0%</td>
<td>80.35% (1910 out of 2377 tasks)</td>
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<tr>
<td>No successors (DCMA metric # 1 Part 2)</td>
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<td>S</td>
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<tr>
<td>Summary tasks with relationships (Preamble to DCMA ...)</td>
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<td></td>
<td>= 0%</td>
<td>0.00% (0 out of 518 tasks)</td>
</tr>
<tr>
<td>Summary tasks with resources</td>
<td>␣</td>
<td></td>
<td></td>
<td>= 0%</td>
<td>0.00% (0 out of 518 tasks)</td>
</tr>
</tbody>
</table>

* Exclusions Codes: Complete, LoE, Milestone, No dependencies, Planning package, Summary. (PP limit is Monday, October 16, 2017)
Simulation – is that the best we can do?

- The simple answer is yes
- Modelling the interaction of multiple random variables can only be performed by simulation
- There are no analytical solutions for even three related random variables (although there are numerical solutions which basically break the problem down into many small steps and make some assumptions). These become unworkable for larger numbers of variables (thousands of tasks in a schedule!)
Key Takeaways

• CPM schedules are inherently optimistic because they do not take into account Merge Bias.
• Bias gets worse the more parallel tasks there are.
• All tasks are subject to some uncertainty
• Even using ‘unrealistic’ symmetrical uncertainty has value (identifying merge bias and improving predictions)
• Realistic uncertainty is rarely symmetrical
Planning Packages

... and their impact on risk analysis

A single 60 day task.
CPM Finish is 23Mar18
Apply some uncertainty

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Remaining Duration</th>
<th>Duration Distribution Type</th>
<th>Duration Most Likely</th>
<th>Duration Pessimistic</th>
<th>Duration Confidence Interval (%)</th>
<th>Early Finish Histogram</th>
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<tr>
<td>0</td>
<td>FM2016 Correlation Example</td>
<td>60 days</td>
<td>(None)</td>
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<td></td>
<td>NA</td>
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<tr>
<td>1</td>
<td>High Level Task</td>
<td>60 days</td>
<td>(None)</td>
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<td></td>
<td></td>
<td>NA</td>
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<tr>
<td>2</td>
<td>Planning Package</td>
<td>60 days</td>
<td>Triangular</td>
<td>45 days</td>
<td>60 days</td>
<td>75 days</td>
<td>100%</td>
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<tr>
<td>3</td>
<td>Delivery</td>
<td>0</td>
<td>(None)</td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
</tr>
</tbody>
</table>

- +/- 25%
- 50% Chance of achieving deterministic 23Mar18
- P80 = 2Apr18
- SD = 49 Hours
- Range = 36 Days
Break into more detail

- Original 60 day task split into two 30 day tasks
- CPM Finish is still 23Mar18
Apply Uncertainty

- +/- 25%
- 50% Chance of achieving deterministic 23Mar18
- P80 = 29Mar18 (2Apr18)
- SD = 34.75 Hours (49h)
- Range = 26 Days (36d)
- Central Limit Theorem
Long Duration Tasks

• A single long task does not give the same results as many smaller tasks with the same overall duration.

• Uncertainty tends to ‘cancel out’ when there are multiple serial tasks (reduces standard deviation)

• High level tasks also mask Merge Bias

• SRA should be run on schedules with as much detail as possible. Avoid summary schedules.
But we need Planning Packages..

• Planning Packages (placeholders for future work that has yet to be defined in detail) are necessary for longer programs.

• When you break Planning Packages into more detail expect the SD to decrease but see an increased impact from Merge Bias

• Correlation can solve the reducing Standard Deviation
Correlation

- Correlation allows us to model shared influencing factors – like detail tasks all belonging to the same planning package.

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Remaining Duration</th>
<th>Duration Distribution Type</th>
<th>Duration Optimistic</th>
<th>Duration Most Likely</th>
<th>Duration Pessimistic</th>
<th>Duration Confidence Interval (%)</th>
<th>Duration Correlations</th>
<th>Early Finish Histogram</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>FM2016 Correlation Example</td>
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<td>(None)</td>
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<tr>
<td>2</td>
<td>Task A</td>
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<td>100%</td>
<td>125%</td>
<td>100%</td>
<td>PP (100%)</td>
<td>Graph</td>
</tr>
<tr>
<td>3</td>
<td>Task B</td>
<td>30 days</td>
<td>Triangular</td>
<td>75%</td>
<td>100%</td>
<td>125%</td>
<td>100%</td>
<td>PP (100%)</td>
<td>Graph</td>
</tr>
<tr>
<td>4</td>
<td>Delivery</td>
<td>0</td>
<td>(None)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Graph</td>
</tr>
</tbody>
</table>
Correlation Results

- +/- 25%
- 50% Chance of achieving deterministic 23Mar18
- P80 = 2Apr18 (2Apr18)
- SD = 49 Hours (49h)
- Range = 36 Days (36d)
Key Takeaways

• Correlation can help reduce changes to the results of Schedule Risk Analysis caused by breaking Planning Packages into more detail.

• Schedule Risk Analysis works best when applied to as much detail as possible.

• Avoid the use of summary schedules – they mask the impact of merge bias.
Histograms plot the chance of finishing **on** a specific date/cost while the S-Curve is the probability of completion **by** a date/cost.

Reports produced using Barbecana’s Full Monte for Microsoft Project
Schedule Risk Analysis Outputs

Sensitivity Tornado charts identify the tasks creating the most uncertainty in the target delivery date.

Risk Path analysis groups tasks by their criticality to the target delivery date.

Reports produced using Barbecana’s Full Monte for Microsoft Project.
Key Takeaways

• Histograms have little value
• S-Curves are far more important.
• Sensitivity Analysis helps identify tasks creating uncertainty and opportunities for schedule compression but does not include tasks with no uncertainty.
• Risk Path analysis adds value to sensitivity analysis because it includes tasks with no uncertainty. It helps focus management effort.
Contingency

Nearly every project includes some contingency to handle cost variations.

In fact, many projects have two kinds of cost contingency:-

Contingency – for known-unknowns. For identified risks like rate variations. Often calculated using risk analysis.

Management Reserve – for unknown-unknowns. For unknown issues like missed scope. Often this is a percentage of the project value.

Cost contingency usually exists even if buried in rates etc.

…and yet schedulers are expected to come up with a date - and stick to it!
Schedule Margin

a.k.a. Schedule Contingency, Schedule Buffer, Delay Allowance, Risk Allowance, Risk Buffer…

Schedule Margin is best defined as:

‘The amount of additional time needed to achieve a significant event with an acceptable probability of success’

Significant events are major contract milestones or deliverables.

Do not confuse Schedule Margin with the ‘buffers’ defined by techniques such as ‘Critical Chain’. While there are similarities (protecting deliverables), Schedule Margin is purely focused on Schedule.
Padded Durations

These are BAD BAD BAD! Don’t do it!

Recognizing there is uncertainty in our task duration estimates, it can be tempting to pad or add time to individual duration estimates to increase the chance they will be completed in the budgeted time.

This never works!

Work expands to fill the time available (variously known as Parkinson’s Law or Student Syndrome). Also see Procrastination…

Keep task estimates as realistic as possible. Task Durations should represent the most likely time the task should take.

Contingency belongs to the project, not the task.
Govt’ Accountability Office (GAO)

GAO Best Practices
Schedule Assessment Guide

Most likely conditions for estimated durations imply that duration estimates do not contain padding or margin for risk. Rather, risk margin should be introduced as separate schedule contingency activities to facilitate proper monitoring by management…
Who ‘Owns’ Schedule Margin?

The **Project Manager** owns the Schedule Margin. It does not belong to the client and it should not be negotiated away by the sales team.

This is one reason to CLEARLY identify the Schedule Margin in the schedule. It is there to protect the project deliverable(s). That’s good for contractor and client alike.

Unlike cost contingency, schedule margin is not typically allocated to over-running tasks, but remains as a buffer (which may change in size if the project slips) to protect the project deliverable.
Where to add Schedule Margin

Going back to our definition for Schedule Margin.

‘The amount of additional time needed to achieve a significant event with an acceptable probability of success’

We can/should add Schedule Margin to our schedule before any major contract event/deliverable. The aim is to protect that deliverable.

Schedule margin must be clearly identified!

Schedule margin tasks **must not** represent any work!
How to ‘size’ Schedule Margin

- Experience based on past project history
- Some percentage of the project duration
- Based on project complexity/risk
- Use Schedule Risk Analysis!
Perform a Schedule Risk Analysis

Based on the uncertainty in the schedule, risk analysis will predict a range of dates for project delivery.
A more detailed look

The Deterministic finish calculated by CPM was 04Aug17 at 5pm.

Based on the specified uncertainty, the simulation is predicting only a 25% chance of achieving that date,

However, a more realistic 80% confident date would be 9Aug17 at 4:12pm.
Sizing the Schedule Margin

• The difference between the Deterministic Finish and the finish date at the required level of confidence is a good value for the Schedule Margin.

• Deterministic Finish: 4Aug17 at 5pm

• 80% (80th Percentile) Finish Date: 9Aug17 at 4:12pm

• Schedule Margin suggested value: 3 days (5 day calendar)
We need to deliver on 4Aug17…

The most common concern with techniques like Schedule Risk Analysis (SRA) and Schedule Margin is that the revised delivery dates are beyond commitments already made/required.

This in no way invalidates the techniques.

What the SRA tells us in our example is that, based on our estimates of uncertainty, we only have a 25% chance of delivering by 4Aug17.

This should concern us. The time to take action is NOW. Revise the scope, revise the schedule, or reduce the uncertainty, to bring in the delivery date of the schedule so that the 80% confidence date moves to 4Aug17.
After revising the schedule (working in parallel), which while increasing the total work, reduces the total duration, the Deterministic Finish is now 1Aug17 giving us an 80% chance of finishing by the originally agreed date of 4Aug17.

### Project Summary

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Schedule Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Summary</strong></td>
<td>20 days</td>
<td>7/10/17 8:00 AM</td>
<td>8/4/17 5:00 PM</td>
<td>No</td>
</tr>
<tr>
<td>Start</td>
<td>0 days</td>
<td>7/10/17 8:00 AM</td>
<td>7/10/17 8:00 AM</td>
<td>No</td>
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<tr>
<td>Work Team 1</td>
<td>7 days</td>
<td>7/10/17 8:00 AM</td>
<td>7/18/17 5:00 PM</td>
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<tr>
<td>Work Team 2</td>
<td>5 days</td>
<td>7/10/17 8:00 AM</td>
<td>7/14/17 5:00 PM</td>
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<tr>
<td>Integration</td>
<td>10 days</td>
<td>7/19/17 8:00 AM</td>
<td>8/1/17 5:00 PM</td>
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<td>Schedule Margin</td>
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<td>8/2/17 8:00 AM</td>
<td>8/4/17 5:00 PM</td>
<td>Yes</td>
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<tr>
<td>Delivery</td>
<td>0 days</td>
<td>8/4/17 5:00 PM</td>
<td>8/4/17 5:00 PM</td>
<td>No</td>
</tr>
</tbody>
</table>
Interim Deliverables

Schedule Margin can protect interim deliverables as well as project completion.

Note: Some agencies (DCMA) may prefer interim milestones to have no tasks representing work following any margin. Use a constraint to resume work after the deliverable. Check with your compliance officer.
Key Takeaways

Schedule Margin is used to protect deliverables from delays. It allows an allowance for ‘risk’ to be clearly identified in the schedule.

It doesn’t affect float or techniques like Earned Value.

It belongs to the Project Manager/Contractor.

It protects both contractor and client.

It should be zeroed out during risk analysis.
Modelling Risk Mitigation

Estimate and Threat modelling can highlight that project deliverables may not be achievable. It might be possible to reduce durations (more/better resources), reduce uncertainty (re-estimate), change logic to achieve a required delivery date at the required level of confidence. But what if you would rather only change the logic if necessary…
Alternate Points of Incorporation…

- Presentation by Rick Price (LMCO) at EVM World 2016.
- Mr. Price suggested using Monte Carlo simulation to model risk mitigation to protect key deliverables that require a high level of confidence.
- Rather than create two models we can use Conditional Branching in a single model.
Conditional Branching

Conditional branching allows the model to include alternate logic based on the date a predecessor finishes.

A good use for conditional branching is to model alternate points of incorporation if key work items are delivered late (as a risk mitigation).

For example, if integration testing requires two sub-assemblies, one of which has a high risk of being delivered late, then conditional logic could be used to model additional unit testing before integration later in the test program in order to avoid a project delay.
Click Branching and then choose ‘Conditional’.

Enter the date(s) the task must complete for successors to be included.

One successor must have no date (NA).

In this example, the successor will be Integration Testing if Assembly A completes on or before 1Nov16.
The conditional logic increases our chance of achieving the required end date from under 2% to over 95%.
Key Takeaways

- Conditional Branching allows risk mitigation logic to be incorporated into the schedule to protect key deliverables.
- This is especially useful where schedule parameters do not allow sufficient margin to be used to achieve a required level of confidence.
Thank you.

Risk Free trial software
www.barbecana.com

Questions about the presentation or Schedule Risk Analysis
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