29-30 November, Melbourne Cricket Ground

Introduction
To
Schedule Risk Analysis

Project Controls EXPO
Melbourne, Australia

Presenter Introduction

- Civil Engineer and certified AACE Planning and Scheduling Professional, 20+ years' experience in project planning and controls in the infrastructure and construction industry
- Sydney, Australia based Independent consultant offering specialist planning and scheduling services including Schedule Risk Analysis
- Co-founder of Turbo-Chart, to visualise linear project schedules in Time Location format

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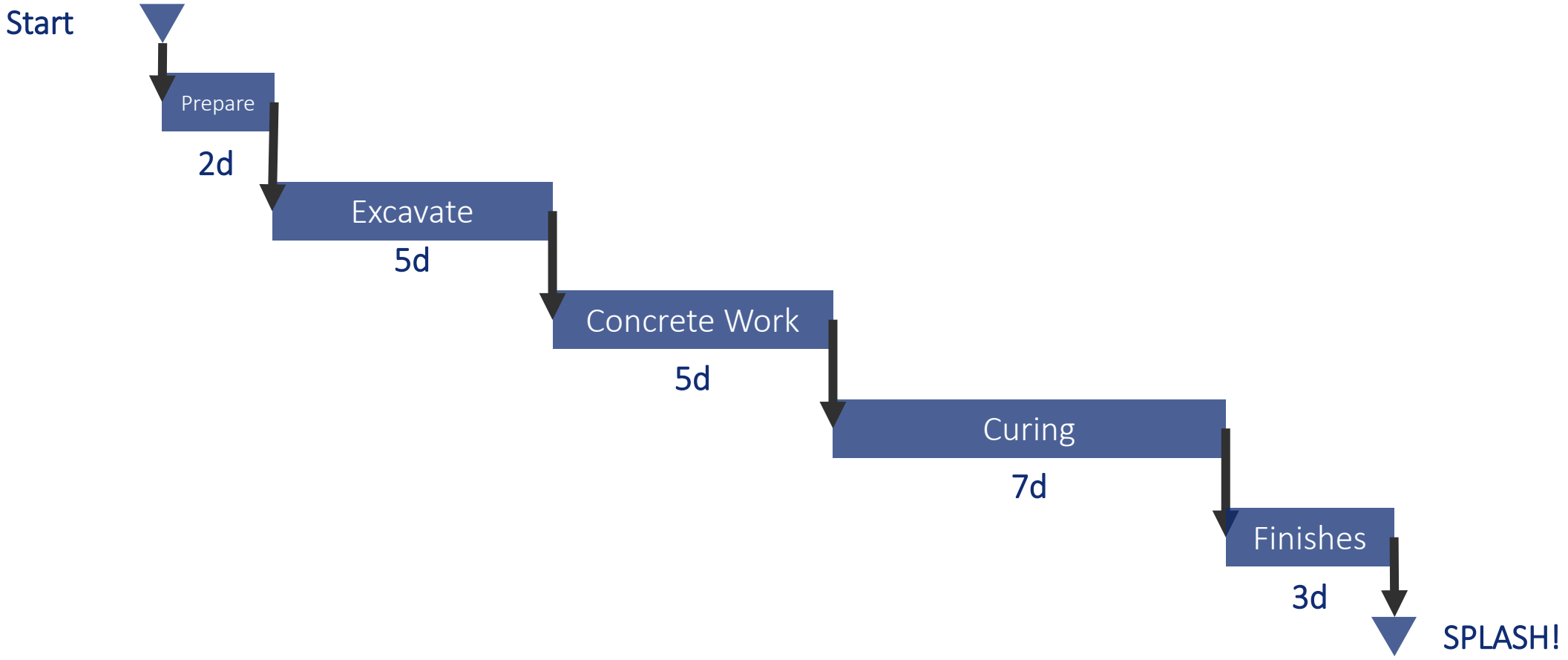
Workshop Overview & Objectives

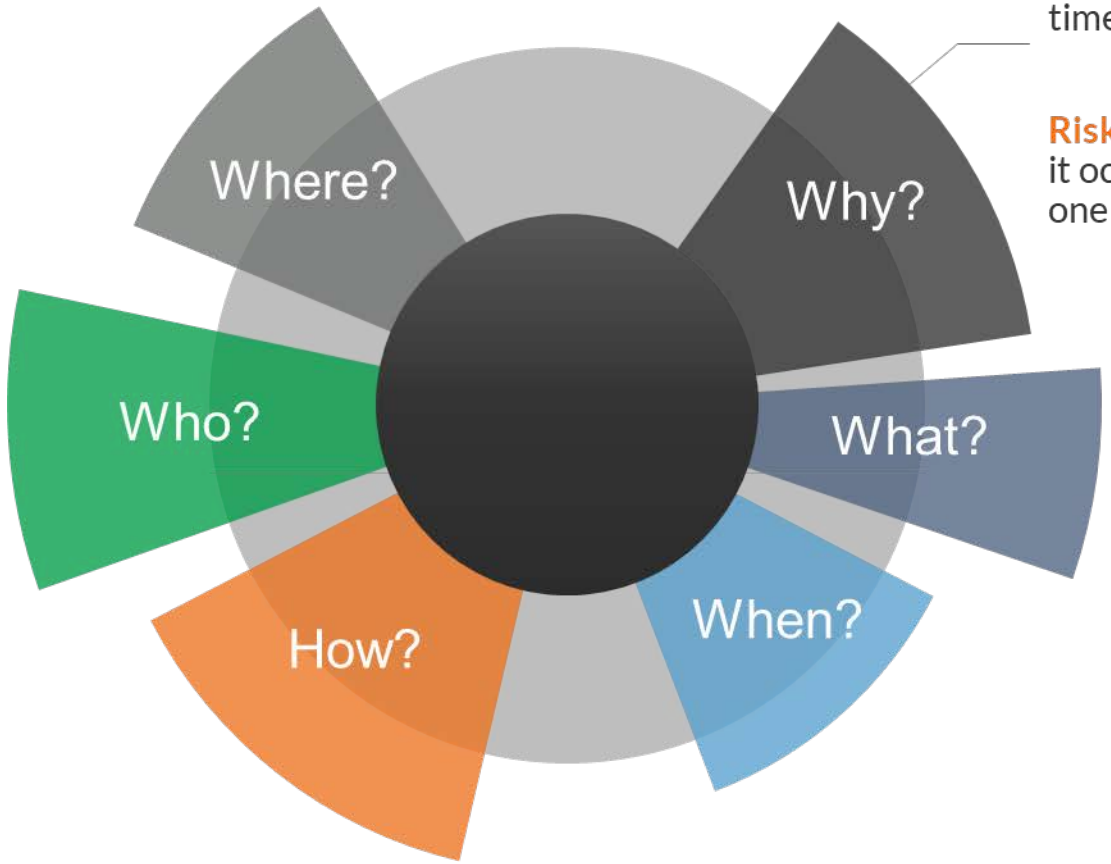
- Introduction to Schedule Risk Analysis, benefits and issues
- Use worked examples to explain the concept, techniques and outputs of schedule risk analysis
- Demonstrate use of specialised tools for risk analysis
- Walk away with greater knowledge of the methods for application on your projects

What are your objectives?

EXERCISE 1: Simple Schedule Example, total 22days



Why might we need Schedule Risk Analysis?

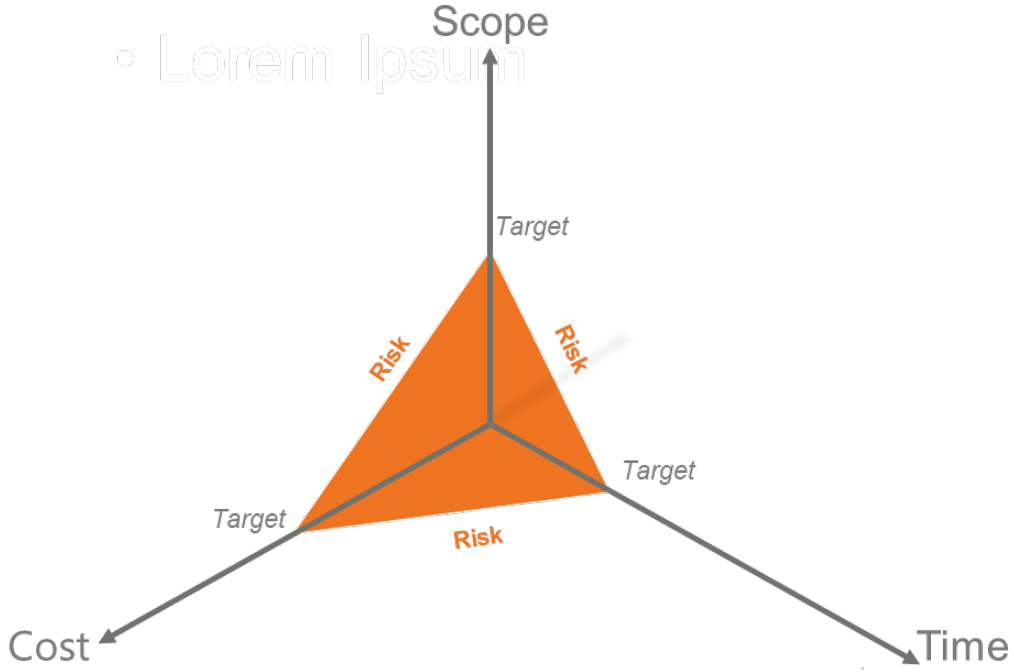


Projects are **probabilistic** in nature and risk analysis information can **help** set **realistic** timescales

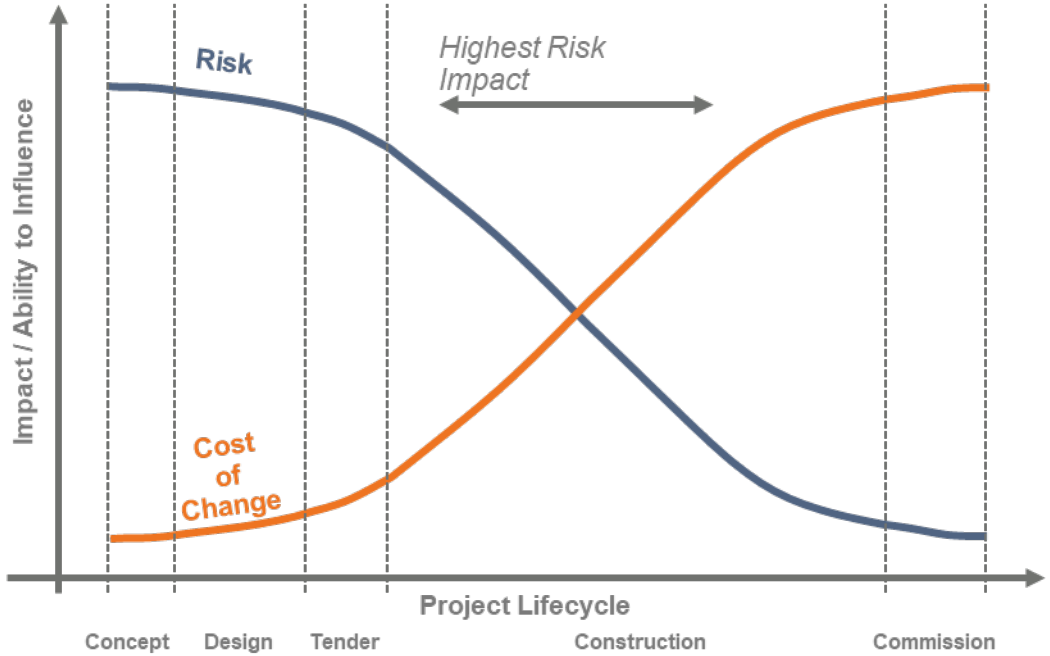
Risk is an uncertain event or condition that, if it occurs, has a **positive or negative** effect on one or more **project objectives**

Why do we do Schedule Risk Analysis?

Project Management Triple Constraint



Degree of Influence and cost of Change through Project Lifecycle



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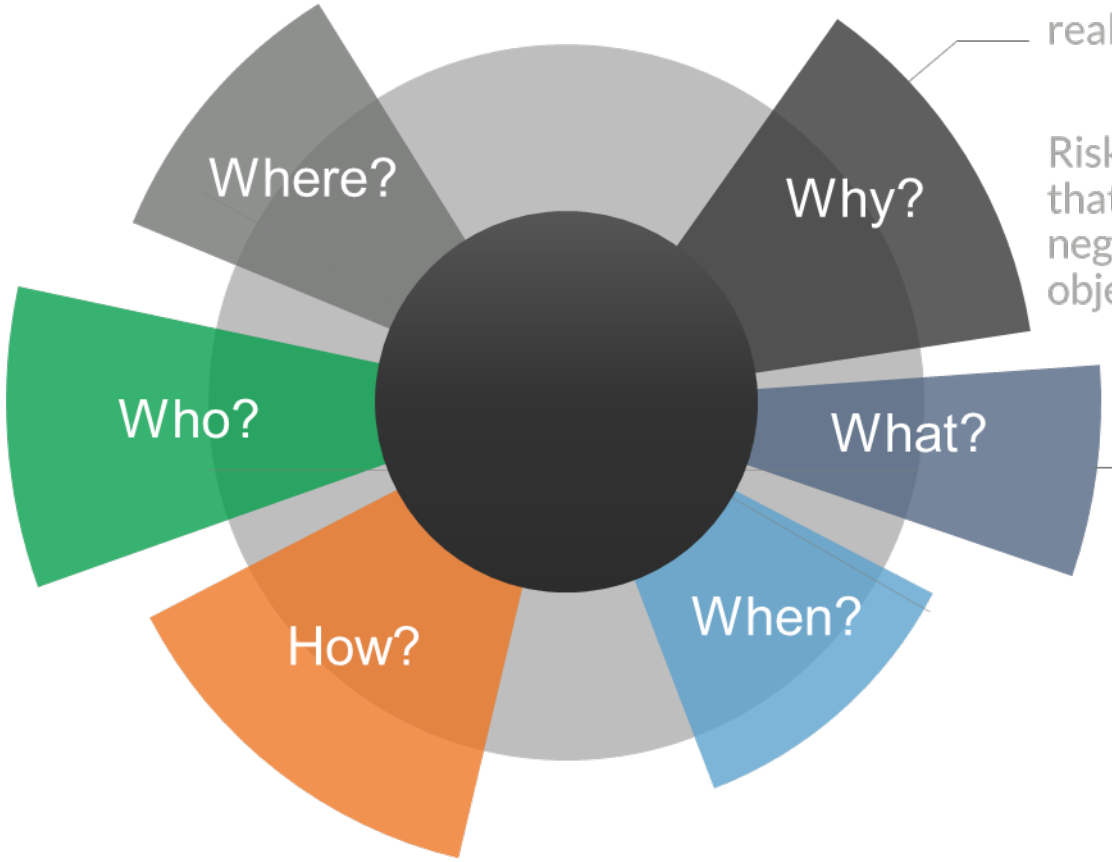
What is Schedule Risk Analysis?



Projects are probabilistic in nature and risk analysis information can help set realistic timescales

Risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives

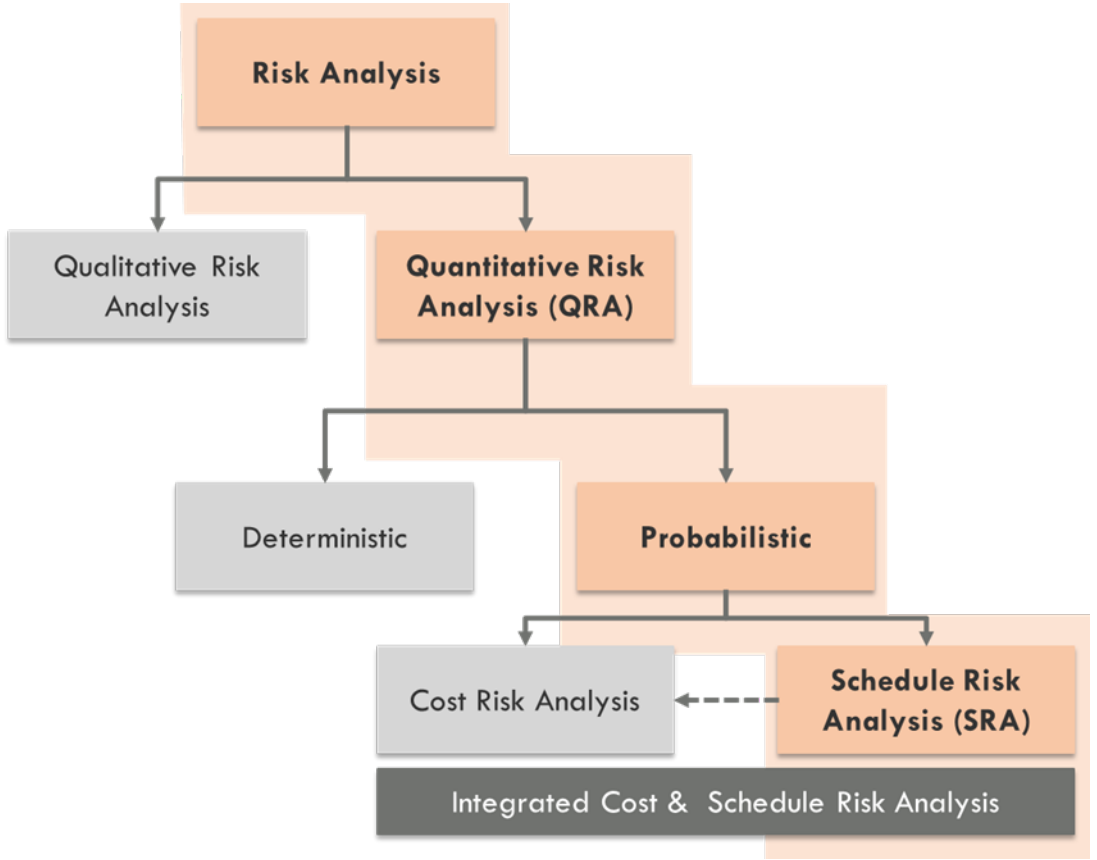
Schedule Risk Analysis offers a method for **managing time related** risks on projects

***More* realistic information** on project durations taking into **account risk**

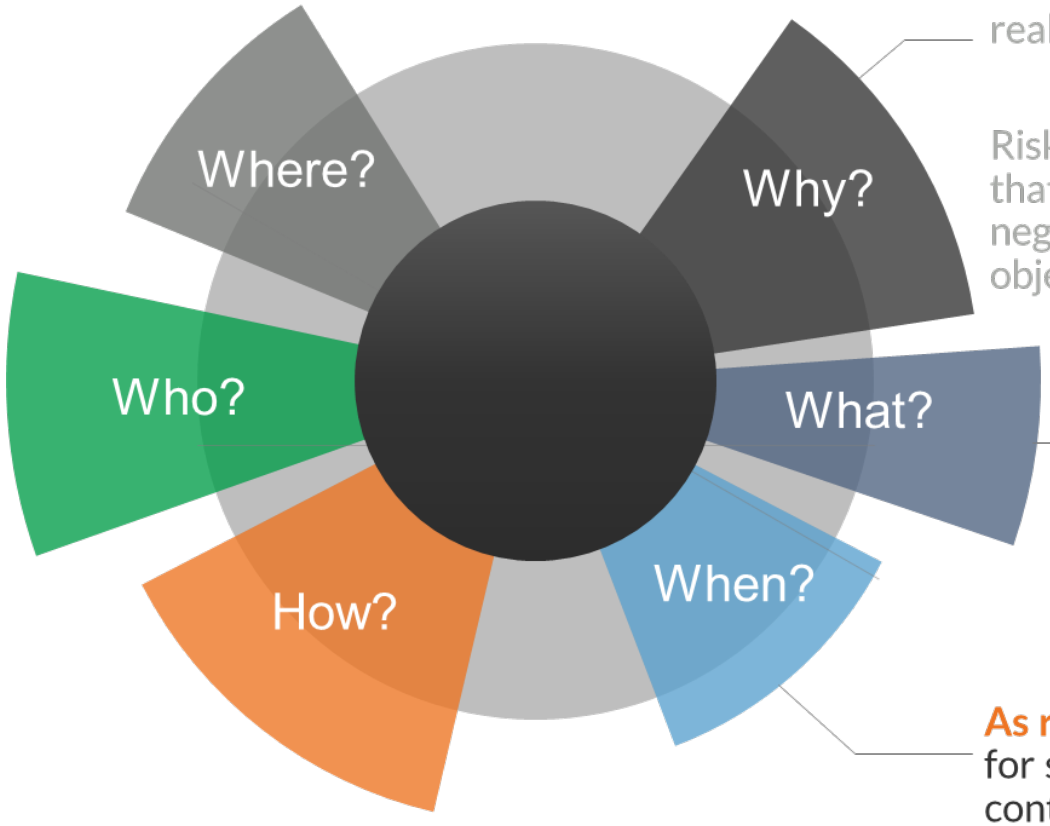
What are Schedule Risk Analysis outcomes?

Schedule Risk Analysis Outcomes

- Improved quality of schedule, ensure schedule robustness, expose issues
- Challenge or confirm assumptions inherent in the deterministic schedule, e.g. “the critical path”
- Model uncertainty associated with schedule durations and scenarios around these
- Assess confidences of achieving dates, or alternatively dates for specified confidence, e.g. “P80”
- Identify driving risks and opportunities to mitigate
- Establish targets and inputs to project contingency requirements



When to perform a Schedule Risk Analysis?



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Schedule Risk Analysis offers a method for managing time related risks on projects

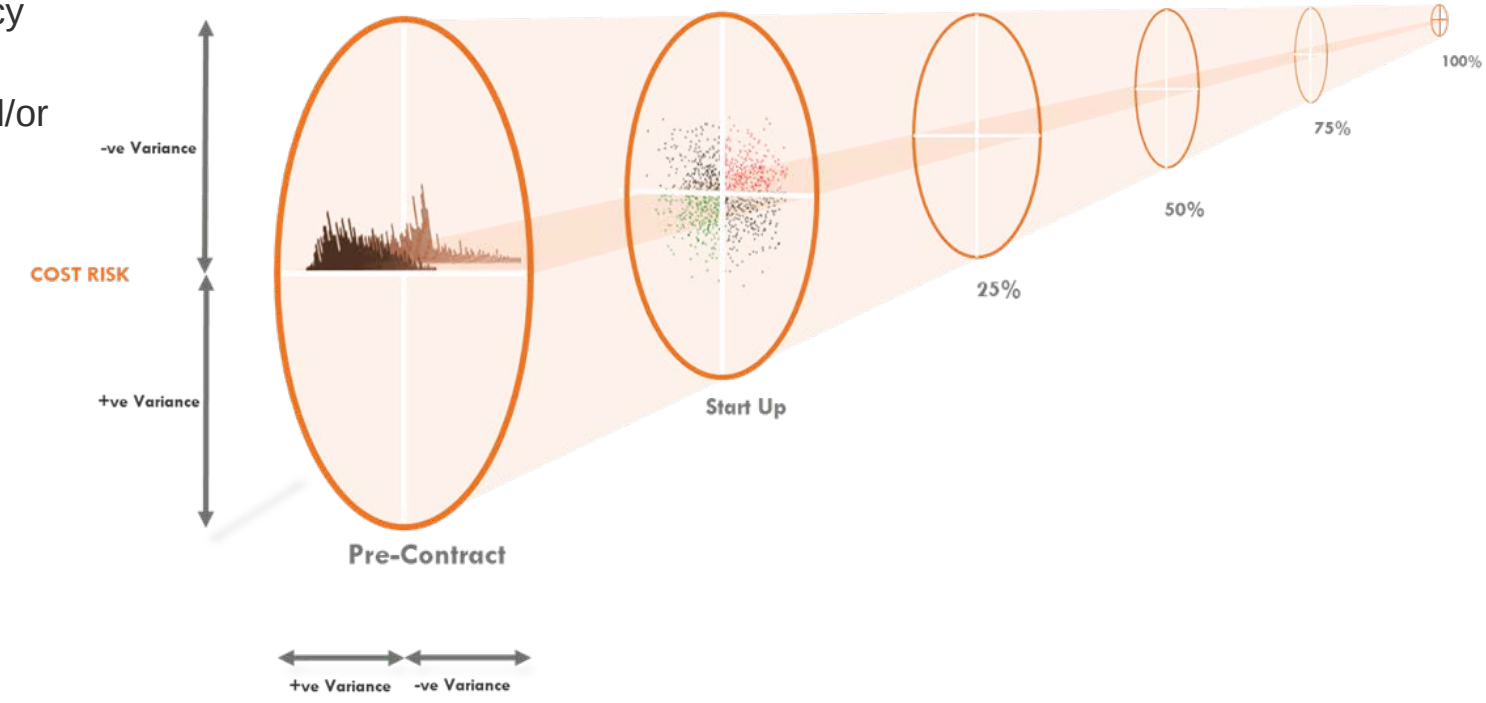
More Realistic information on project durations taking into account risk

As required through the project lifecycle, for setting timescales, budgets and contingency before execution and to **aid project controls** forecasting during execution

When to conduct Schedule Risk Analysis?

When to:

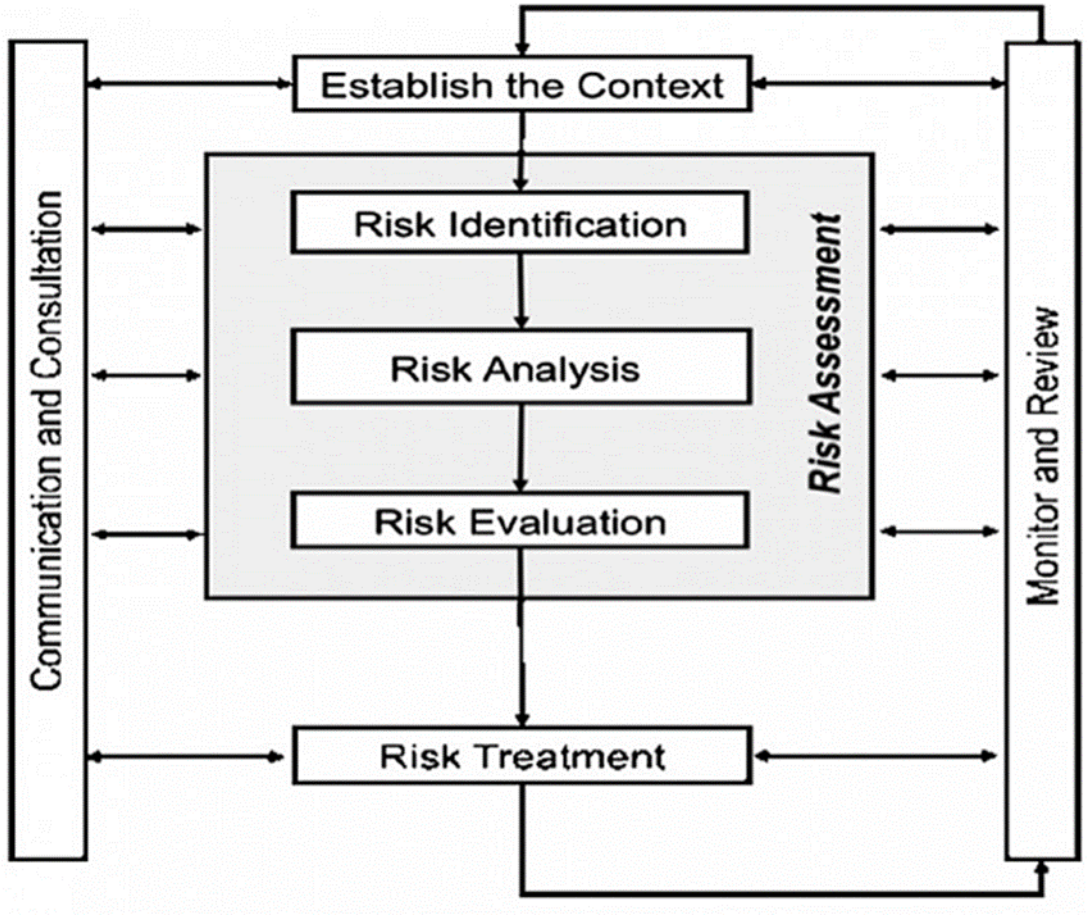
- Establishing baselines and contingency requirements
- Any significant changes to Scope, and/or
- Any significant changes to project risk
- Regular updating and/or reforecasting



When to conduct Schedule Risk Analysis?

Risk Management Process

- Schedule Risk Analysis is one component of an overall risk management process



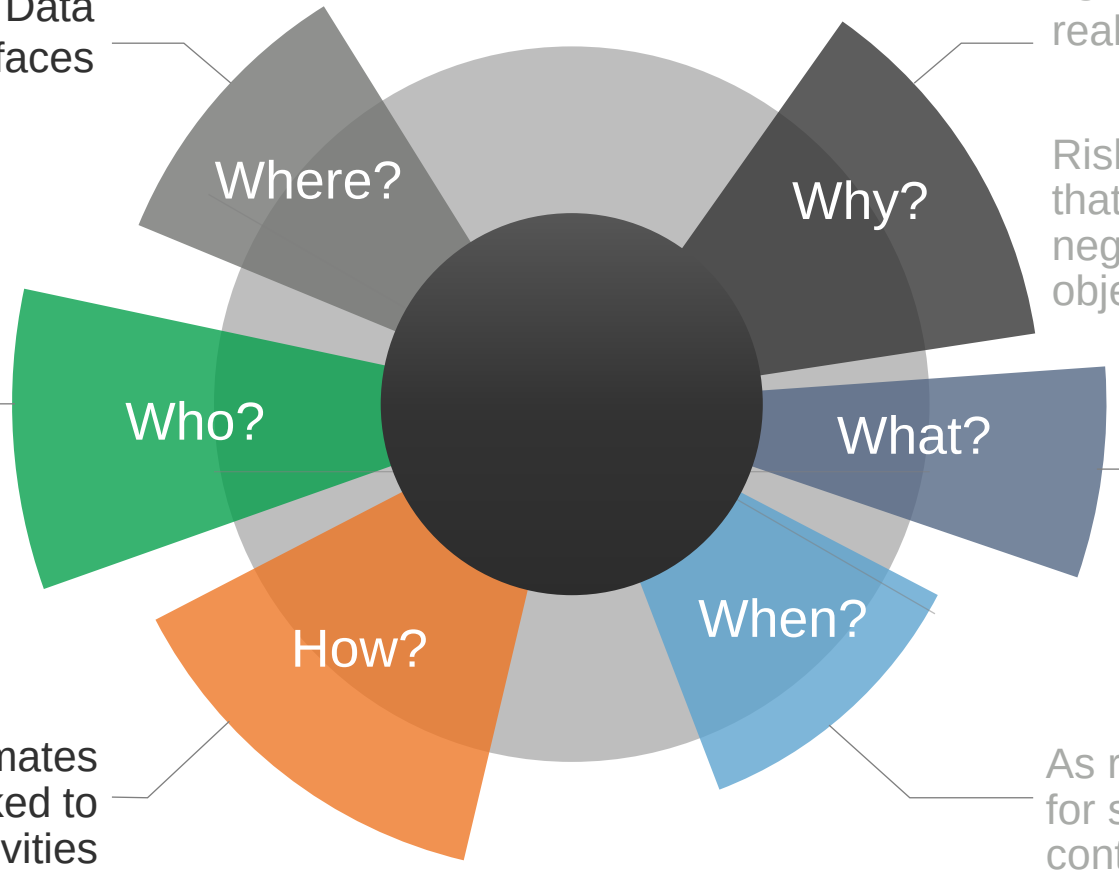
Risk Management Process AS / NZS ISO 3100:2009 Risk Management (Principles and Guidelines)

Schedule Risk Analysis

Planning Tools, Risk Data
SRA Tool, Interfaces

Project Controls Teams (Cost/Schedule/Risk), Operations & Delivery, Project & Senior **Management**

Monte Carlo sampling on estimates with **risks** and their **impacts** linked to **schedule** activities



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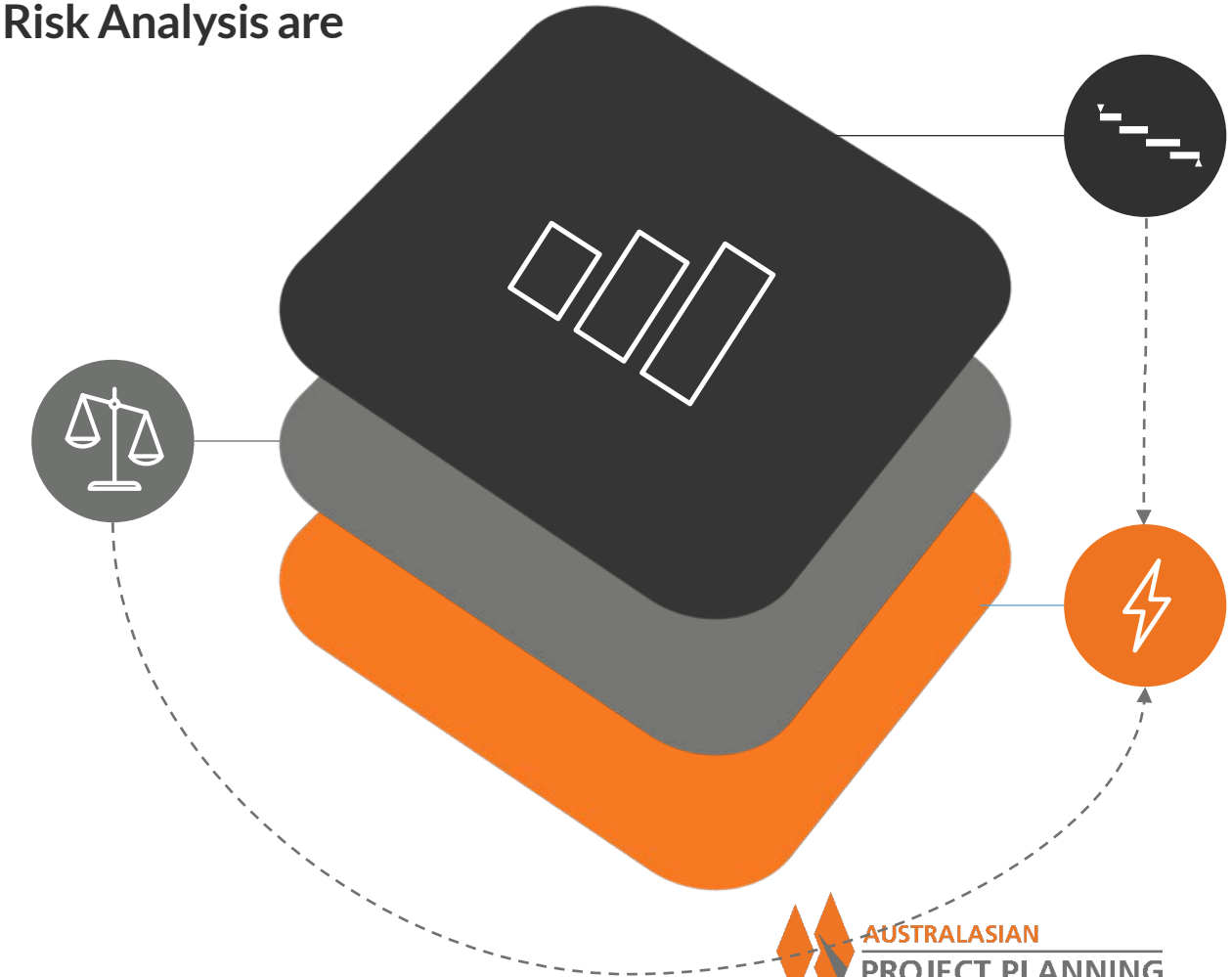
Examples of Project Time Risk

- Consider examples of when projects have taken much longer than expected
  - Why?
  - Was this delay identified or analysed?
  - Was there any contingency in place?
  - If so, how was the contingency determined?

What might delay our pool example?

Building a Schedule Risk Analysis Model

Inputs to a Schedule Risk Analysis are



Schedule

Model representing project methodologies and outcomes

Risks

Quantified time related uncertainties that will affect the project schedule

Risk Impacts

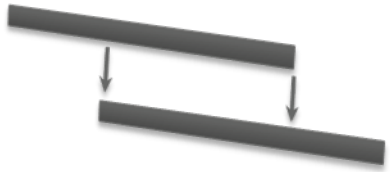
The distribution of risks across the project schedule

Schedule Inputs

Scope / Work Breakdown

Activities

- Works to be undertaken
- Durations
- Milestone Events
- Summaries
- Levels of Detail



Dependencies

Relationships

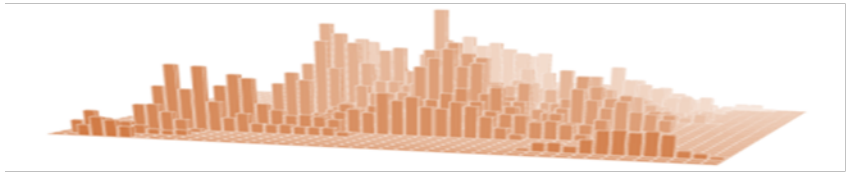
- Links between activities
- Relationship type
  eg. Finish to Start
- Determines time-phasing of activities

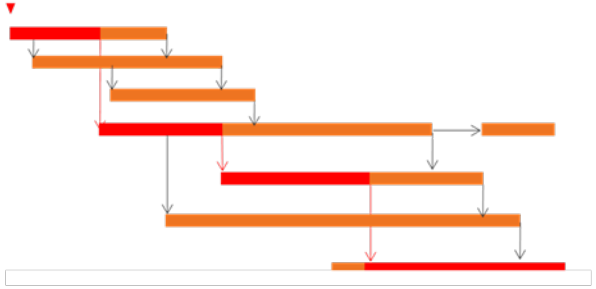
Work Periods

Calendars

- Available Work periods
- Non – Available
  eg. Holidays, RDO's
- Weather
- Applicable Scope

Schedule Outputs





Time Phased Distribution

- Scope
- Resources
- Costs
- Risks

Float

- Drivers to achieving key completion milestones
- Critical activities and dependencies
- Near-Critical paths

SRA Inputs – Schedule Considerations

- Schedule Quality
  - Is it built correctly?
  - Will it react to risks?
- Completeness
  - Is the project scope captured?
- Accuracy
  - Is it realistic in reflecting the position of the project

Schedule Inputs – Schedule Quality

Key Schedule Quality Issues

- **Open Ends and High Floats**: risk impacts will have no effect
- **Constraints**: Hard Constraints (Mandatory or Must Start/Finish on) ignore activity relationships and hold dates. As Late As Possible activities may simply start earlier rather than delaying finish
- **Negative or Excessive Lags**: Lags may not represent realistic behaviour of relationships
- **Out of Sequence Activities**: may effect activity behaviour by retaining logic
- **Calendar changes**: Multiple calendars can cause unrealistic results on activities

SRA Inputs – Risks and Risk Impacts

Project Risk Register

- May be high level for schedule risks and/or inadequate for SRA, e.g. ubiquitous “Schedule Delay” risk,
- Qualitative vs Quantitative risks?

Other Sources Include

- Risk workshops
- Risk interviews
- Empirical data

Motivational Bias in Risk Data collection

- Reasons to avoid making outcome negative, “influencing” the result
- Hostility to risk assessments

Cognitive Bias

- Representative Bias: ignoring the past
- Availability Bias: Easily recalled or significant past events including recent events
- Anchoring/Adjustment Bias: initial values determine uncertainty

Sources of Schedule Risk

Typical Risks for **Infrastructure** Projects

01

Approvals

Environmental, Planning and Regulatory Approvals
Site Access / Land Acquisition
Financing

02

Design

Review and Approval periods
Design Scope Growth (time for design)
Sustainable design

03

Procurement

Equipment Availability
Production / Manufacturing Lead times
Shipping / Transit

04

Site Establishment / Enabling Works

Land Acquisitions and access to Sites
Utilities
Demolition / Contamination

05

Operations

Productivity
Resource Availability
Material Supply
Access Restrictions
Interfacing and Interferences from other operations
Plant & Equipment Failure

06

Project Wide Issues

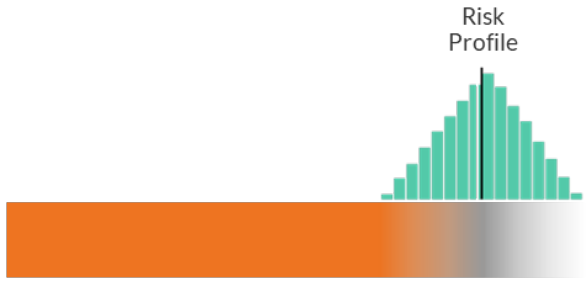
Weather
Industrial
Safety
Community
Environmental
Multi-Project Interfaces

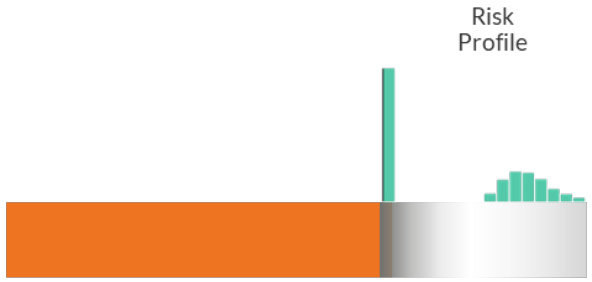
07

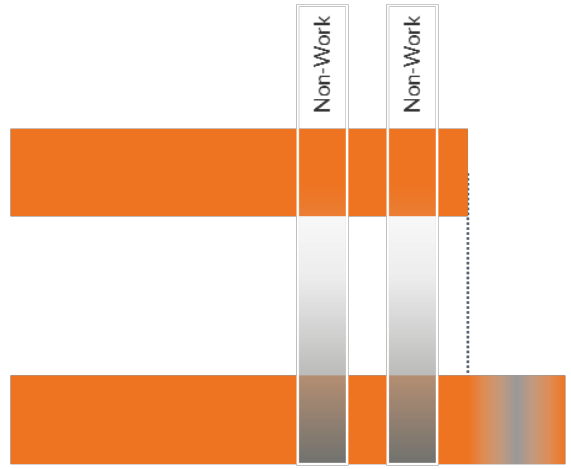
Systemic Risks

Company Culture
Maturity
Complexity
Political

SRA Inputs – Time Related Risks







Inherent Risks

Duration Uncertainty

- Uncertainty in the scope of work or variance in the delivery method from the base schedule. The likelihood of occurrence of is 100%.

Contingent Risks

Discrete Risks

- Unforeseen events that are not included in, but may impact the base schedule. The likelihood of occurrence is under 100%. Also known as discrete risks

Calendar Risks

Probabilistic Calendars

- Uncertainty in the available work periods of the base schedule. Also known as probabilistic calendars

EXERCISE 2: Example Schedule - Modify Durations

- Using Exercise 1 Schedule, modify activity durations, note results

EXERCISE 3: Example Schedule – Modify Durations

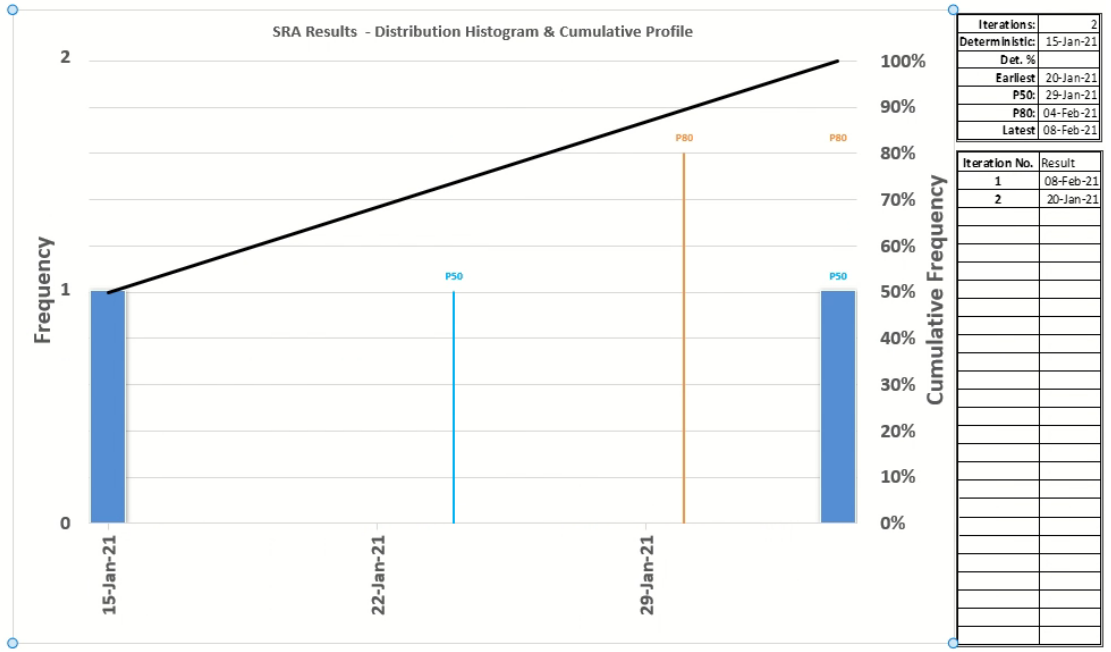
- Each duration change, results in a revised project duration and therefore, revised finish date
- It is possible to repeat this as many times as required, noting the result each time

Iterations:	1
Deterministic:	15-Jan-21
Det. %	
Earliest	08-Feb-21
P50:	08-Feb-21
P80:	08-Feb-21
Latest	08-Feb-21

Iteration No.	Result
1	08-Feb-21

Schedule Modification x1000 iterations

- Continue changing durations for the example schedule, 1,000 times (iterations)
- Each time charting the resulting finish date (or duration)



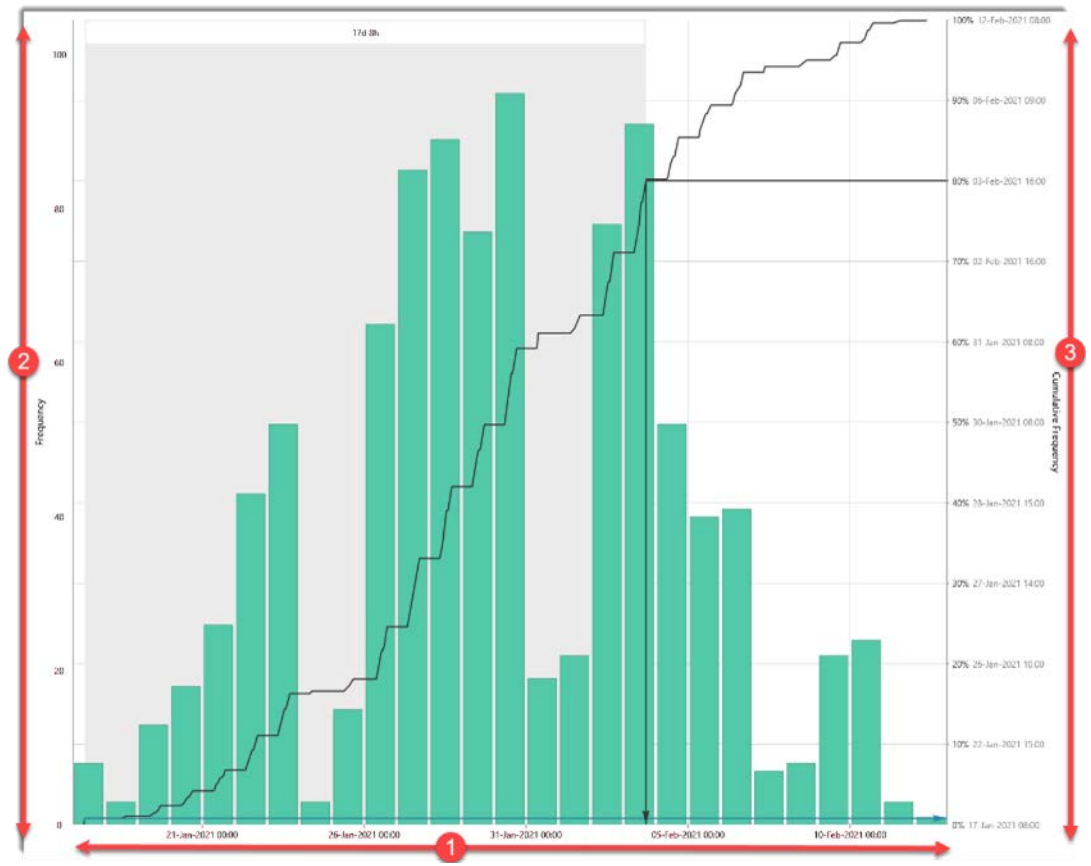
Iterations:	2
Deterministic:	15-Jan-21
Det. %:	
Earliest:	20-Jan-21
P50:	29-Jan-21
P80:	04-Feb-21
Latest:	08-Feb-21

Iteration No.	Result
1	08-Feb-21
2	20-Jan-21

SRA Outputs – Distribution Graphs

Distribution Graphs present the results of the Monte-Carlo analysis for a chosen activity (or summary)

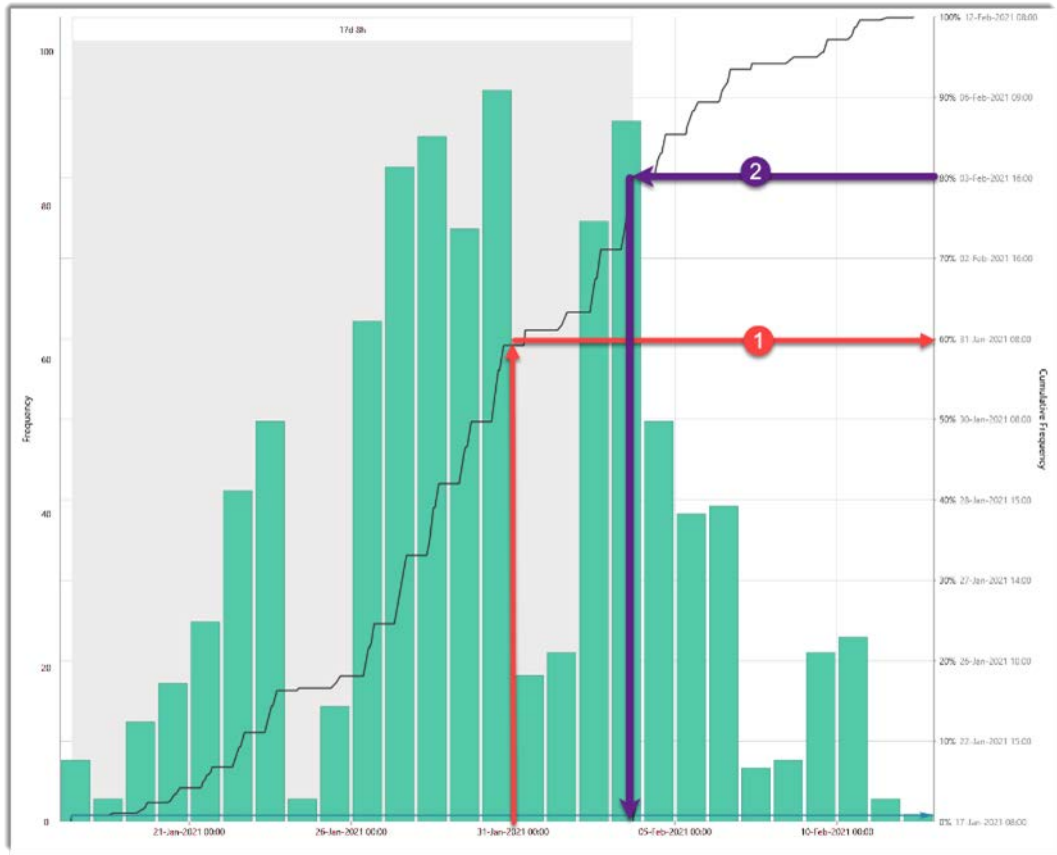
1. Horizontal axis is the range of results, from minimum (earliest) to the maximum (latest).
2. Left hand axis represents the **Frequency** of each result, as shown by the vertical bars
3. Right hand axis represents the **Cumulative Frequency** of results expressed as percentage of total results, as shown by the distribution curve.



SRA Outputs – Distribution Graphs

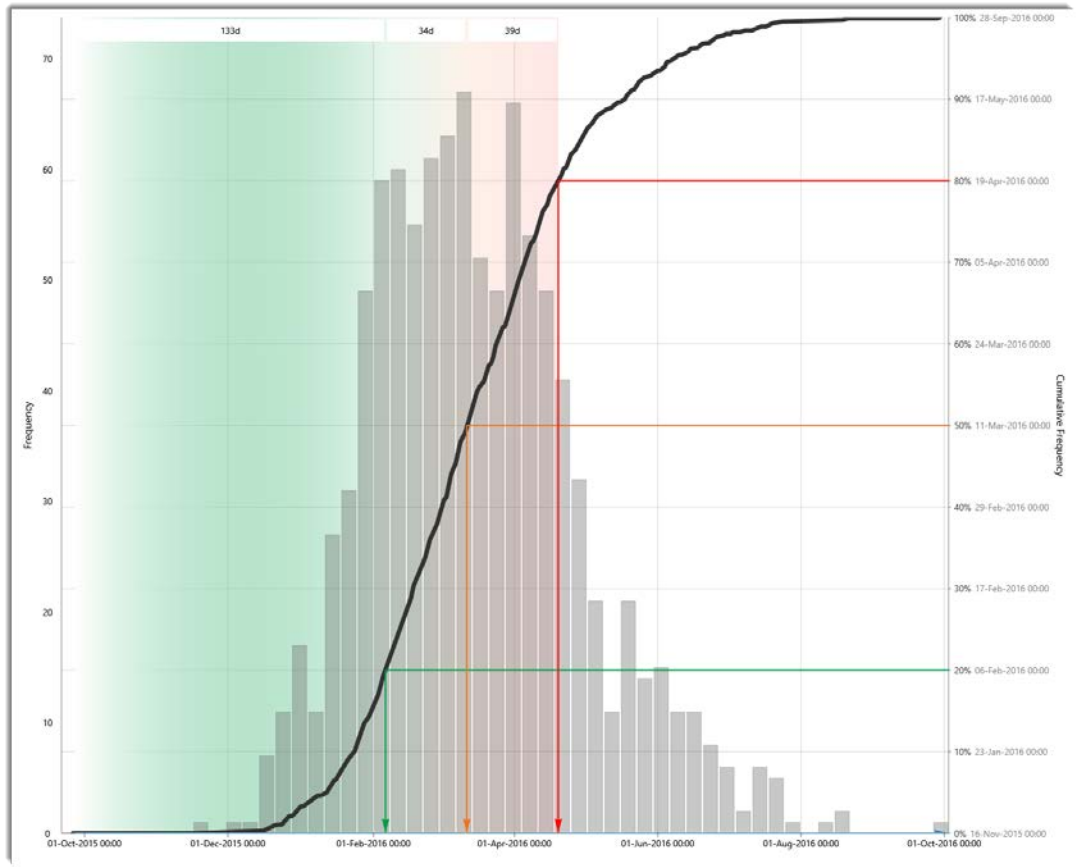
Distribution Graphs provide two key pieces of information from the analysis

1. For a specific date, the frequency or probability of achieving that date (or earlier). For example 31-Jan-21 (or earlier) was achieved in 60% of results. 31-Jan-21 represents a P60 confidence level date.
2. The date that satisfies a desired level of confidence (probability) of being achieved. For example, the date to have 80% confidence of being achieved is 3-Feb-21. The P80 date is 3-Feb-21.



Distribution Graphs

- Is the shape of the distribution significant?
- Is the increase in cumulative % linear? (long tails)
- Why isn't the deterministic result shown at all?
- Why isn't the 0% equal to the deterministic date?



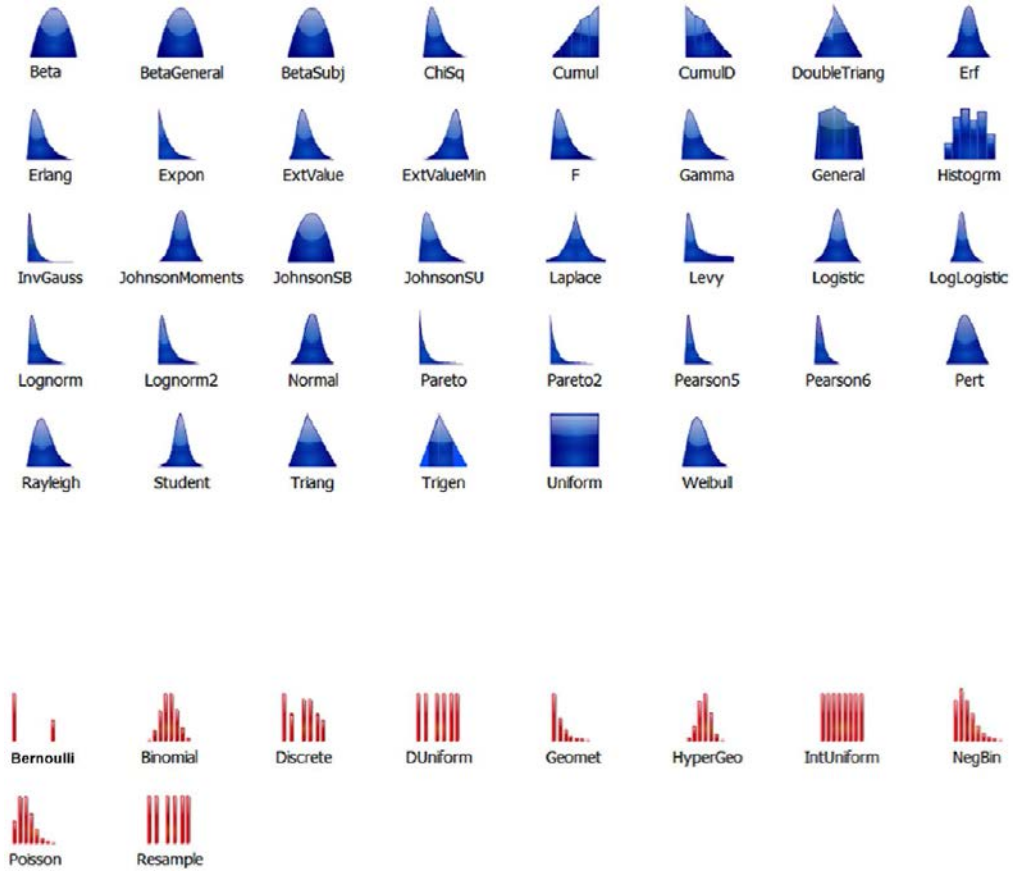
EXERCISE 4: Activity Duration Ranging

- For each activity, rather than modifying the duration, we can enter a range of durations, for random sampling:
  - Minimum
  - Most Likely
  - Maximum

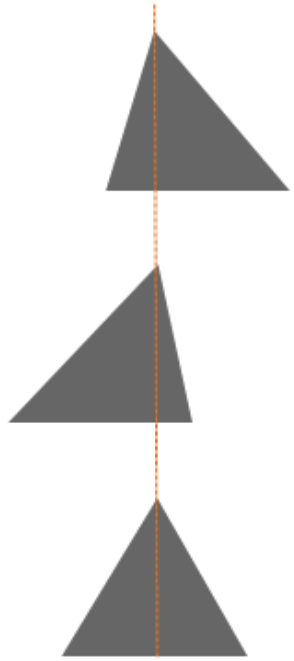
- Also select a distribution profile

Id	Description	Distribution	Min	ML	Max
CIV	Civil Works				
START	Start Pool				
CIV010	Prepare Site	Triangle	1d	2d	3d
CIV020	Excavate	Triangle	4d	5d	8d
CIV030	Concrete Work	Triangle	4d	5d	10d
CIV040	Curing				
CIV050	Finishes	Triangle	2d	3d	5d
FINISH	Finish Pool				

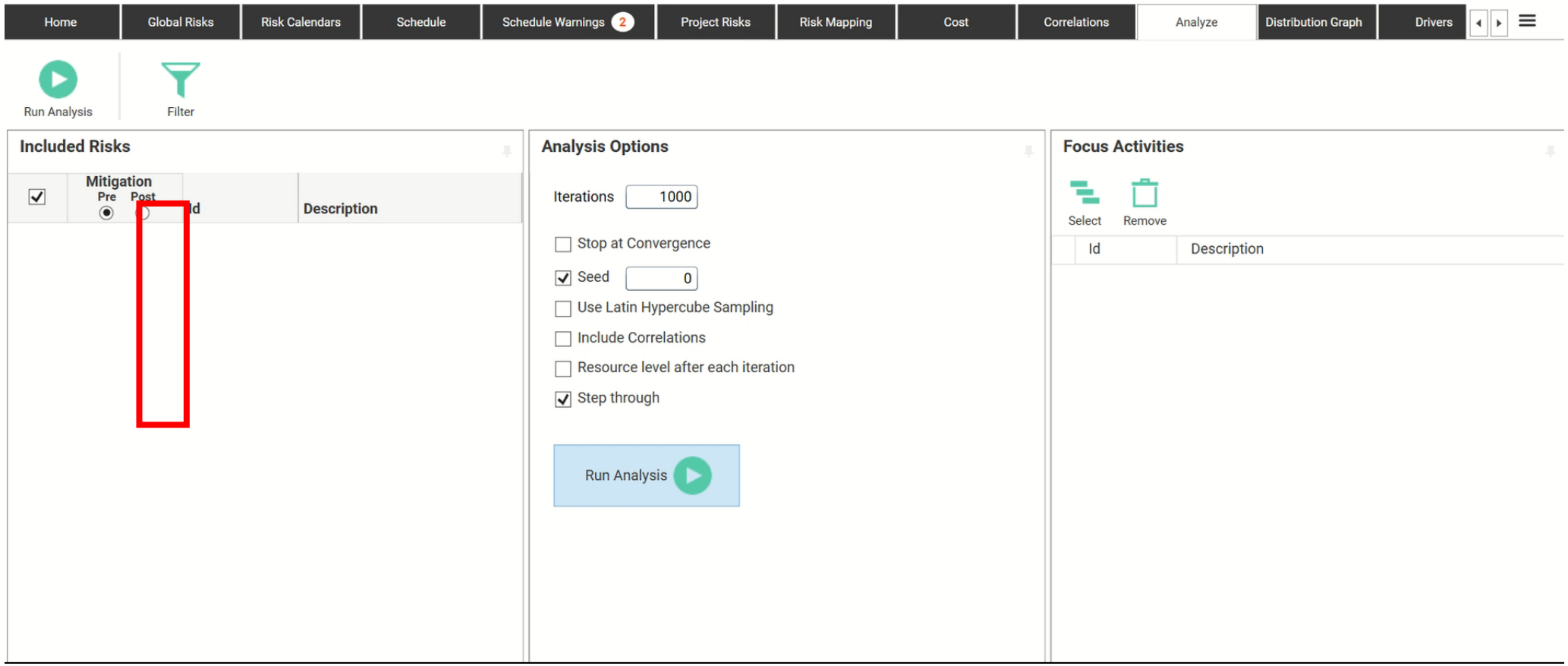
Distribution Types



Triangle Distribution

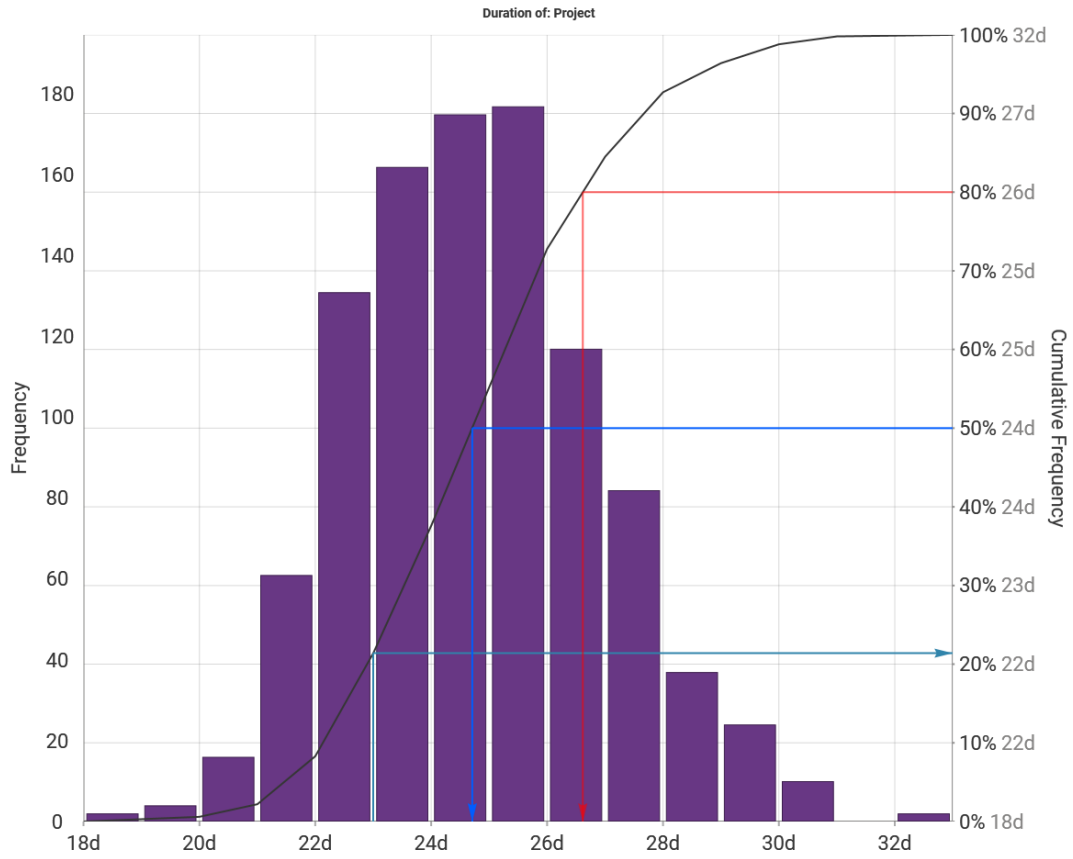


EXERCISE 4: Run analysis and observe iterations of analysis



EXERCISE 4: View Results (Duration & Finish Date)

- What is the probability of achieving the original 22days?
- What is the P80 result?
- How much extra time would you allow?



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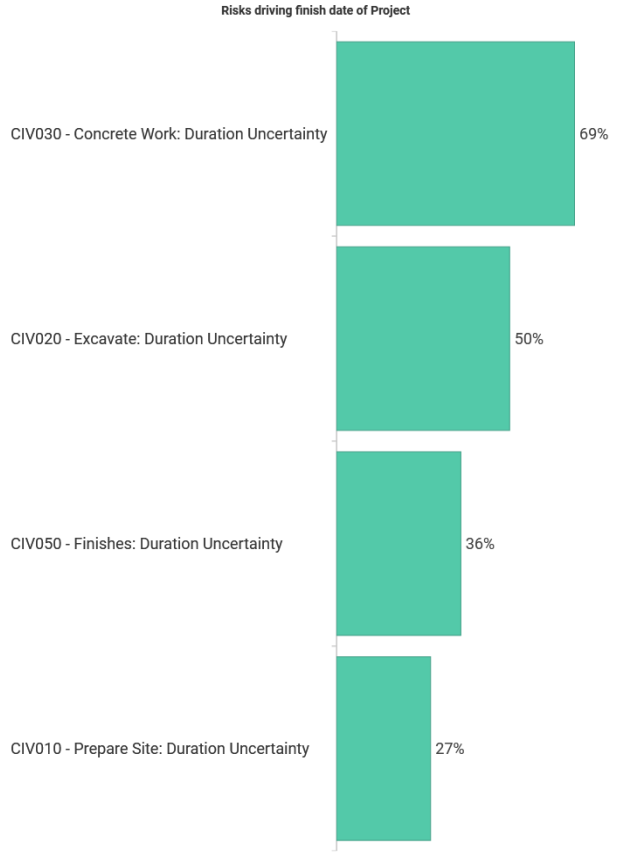
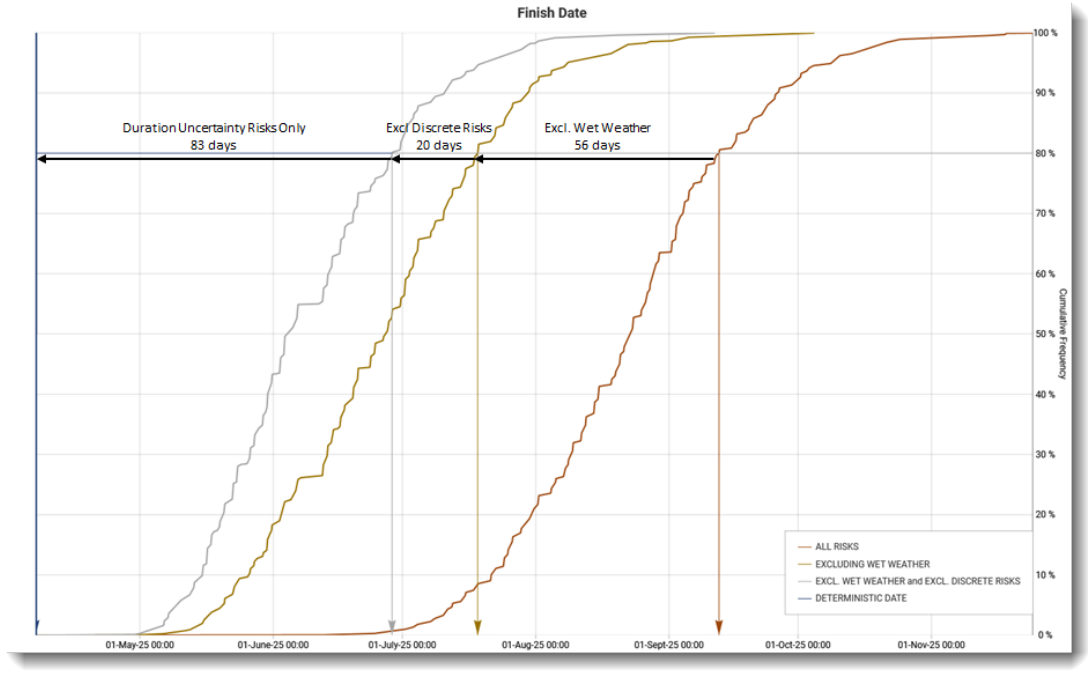
SRA Outputs – Tornado Charts (Correlation)

- Tornado charts rank the risks/activities by their degree of correlation to the delays to the project finish date, or specified activity.



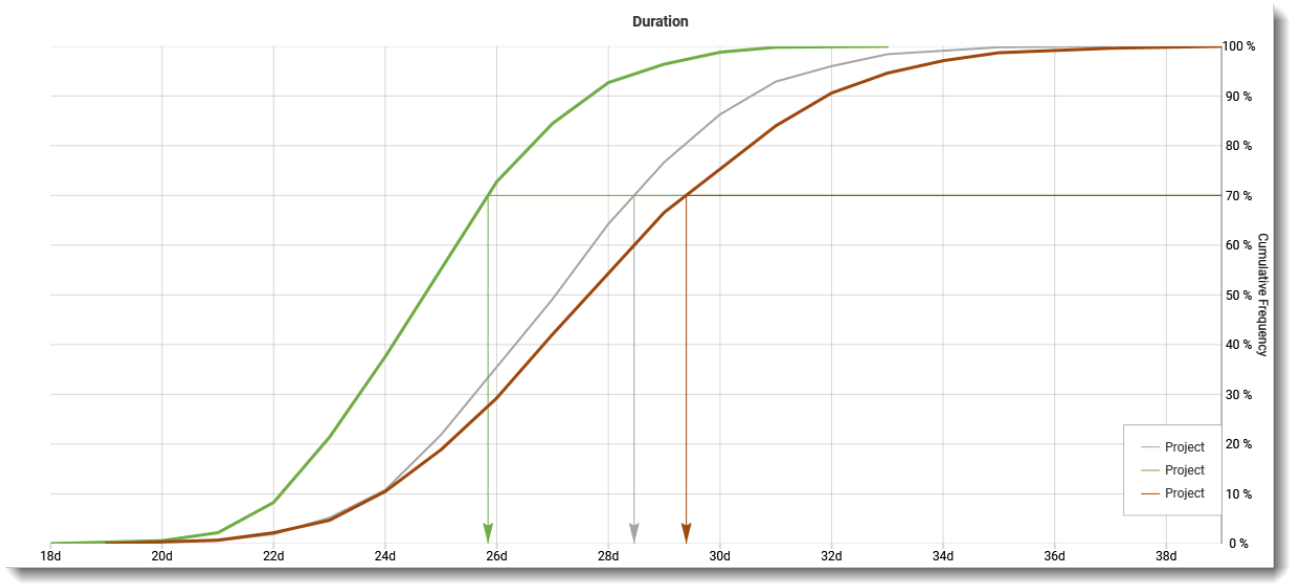
SRA Outputs – Distribution Comparisons

- Distribution Comparisons plot multiple cumulative frequencies to compare results for:
  - The same activity across different analyses
  - Different activites within the same analysis
- Used to compare the results at chosen confidence levels



EXERCISE 5: Compare Results

- Use distribution comparisons to understand the result from varying the inputs



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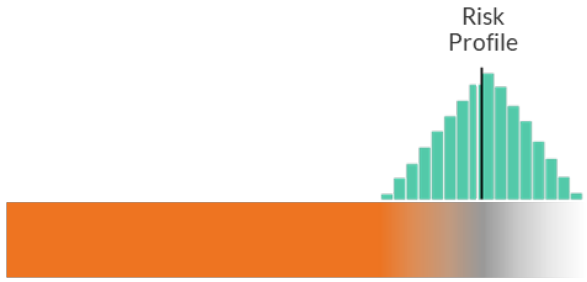
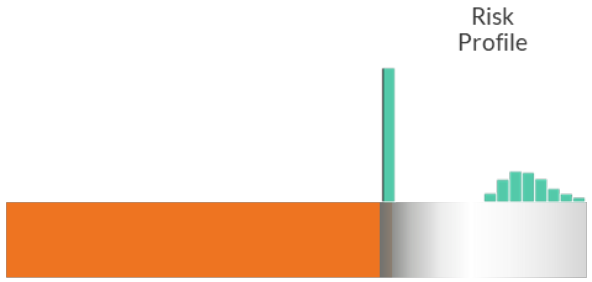
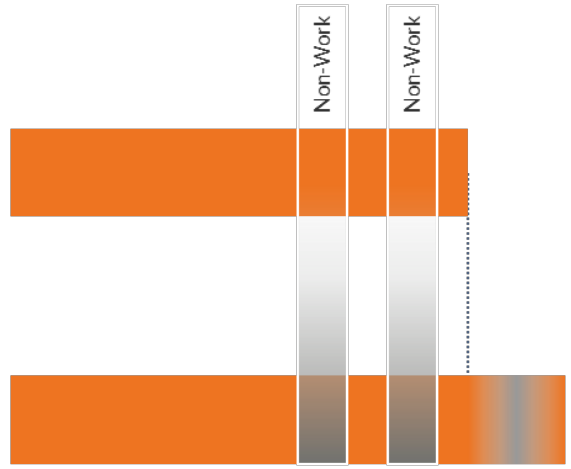
SRA Inputs – Time Related Risks







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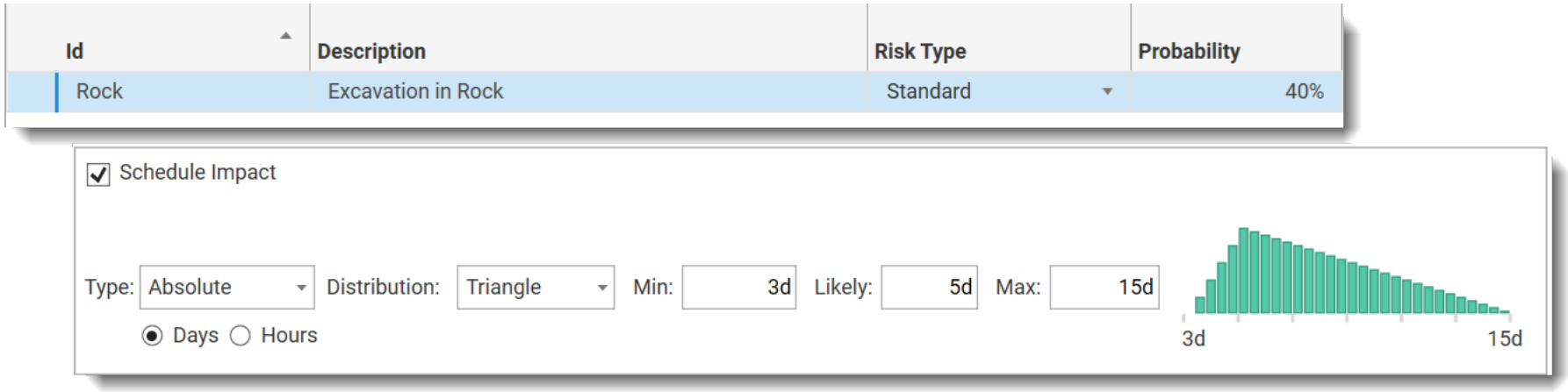
Adding Discrete Risks to the Analysis

- In exercise 2 we asked “What could go wrong”
- Consider the example of hitting rock when excavating for the pool
- We might know that 2 out of the last 5 pools in the area hit rock
- If that occurs, we will need more time to:
  - Organise additional equipment
  - Excavate at a slower rate

Exercise 6: Adding Discrete Risks to the Analysis

- Include a Risk with 20% probability
- Impact (absolute) of Minimum 3 days, Most Likely 5days and Maximum 15days.



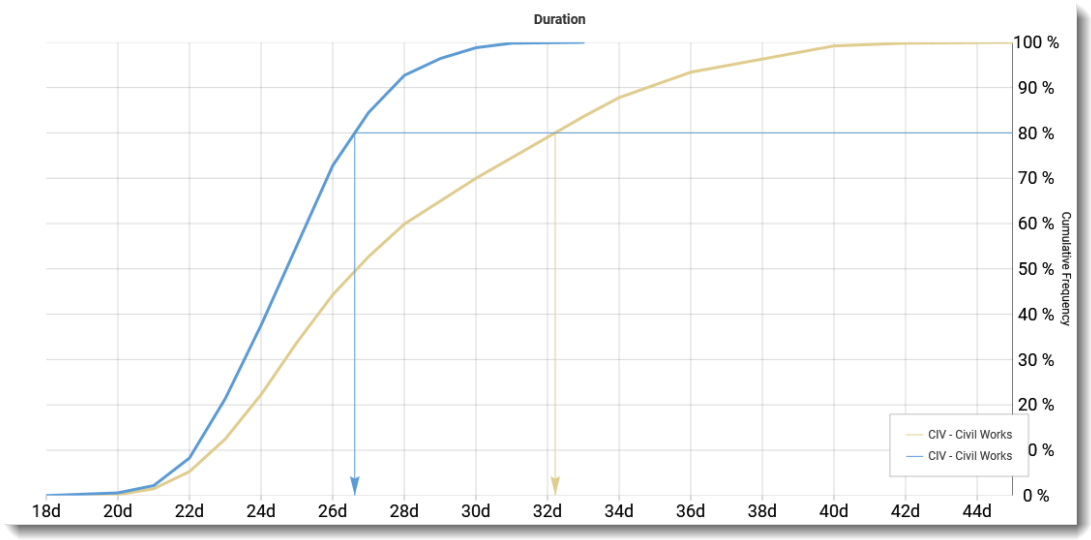
Exercise 6: Adding Discrete Risks to the Analysis

- Map this risk to the Excavate Activity

Id	Description	Distribution	Min	ML	Max	Rock
CIV	Civil Works					☐
START	Start Pool					☐
CIV010	Prepare Site	Triangle	1d	2d	3d	☐
CIV020	**Excavate**	**Triangle**	**4d**	**5d**	**8d**	☑
CIV030	Concrete Work	Triangle	4d	5d	10d	☐
CIV040	Curing					☐
CIV050	Finishes	Triangle	2d	3d	5d	☐
FINISH	Finish Pool					☐

Exercise 7: Step through and compare analysis

- Observe the excavate activity.
- The Rock risk will only impact the excavate activity in 40% of iterations
- Turn off this risk in the analysis and compare results, note P80 difference



Recap: Introduction and Overview of Schedule Risk Analysis

- What, why, when etc..
- Inputs: Schedule, Risks
- Simple Schedule with Activity Duration ranging as risks.
- Outputs:
  - Distribution Histogram
  - Cumulative Frequency Curves
  - Correlation Tornadoes
  - Distribution Comparisons

10min Break

So far..

- Used a simple schedule
- Applied Duration Ranging only
- We want to better understand what are the risks that might affect our project schedule

Risk Driver Method

Risk Drivers

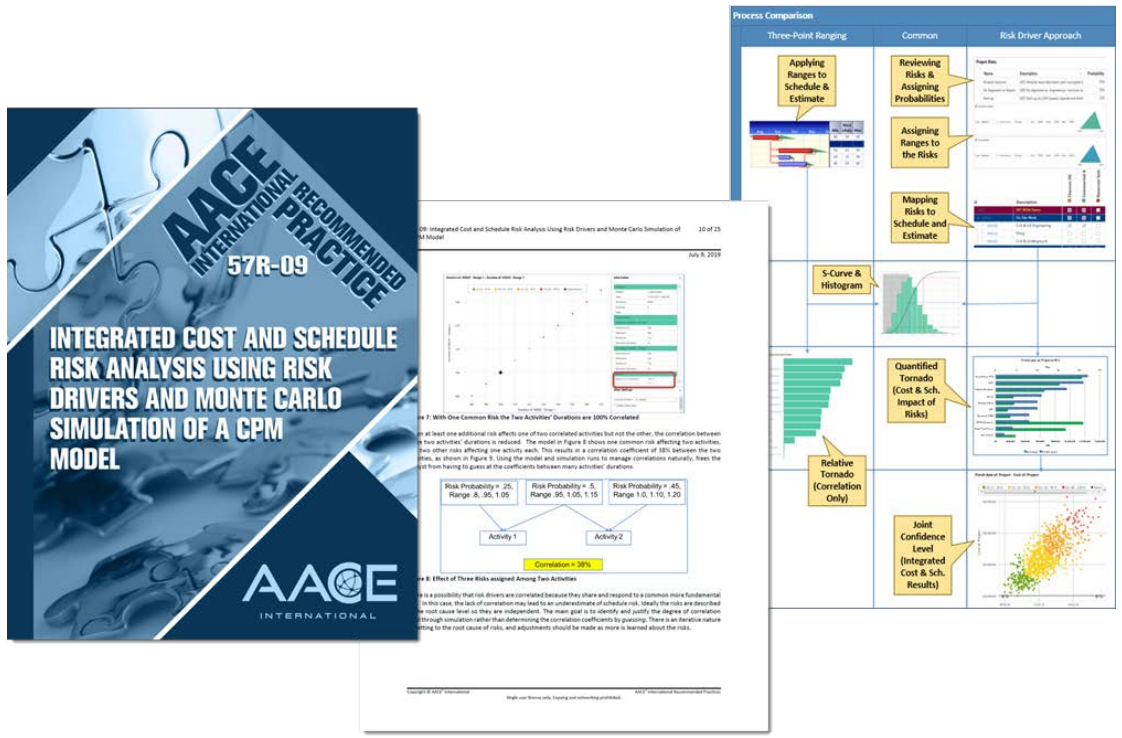
- Undertake analysis focusing on the risks **causing** delays.
- Activity duration ranging only analyses the **consequence**s of uncertainty on activity duration

	Activity Ranging	Risk Driver
Focus	Consequence	Causes
Relationship to Risks	Unclear	Clear many-to-many
Risk Registers	Not required	Required
Risk Prioritisation	Tornado correlation	Risk by exclusion to determine contribution

Risk Driver Method

More Information

- Dr David Hulett: http://www.projectrisk.com/schedule_risk_analysis_using_risk_drivers.html
- AACEi Recommended Practice 57R-09 Integrated Cost and Schedule Risk Analysis Using Risk Drivers and Monte Carlo Simulation of a CPM Model
- AACEi 2017 International Technical Paper “From Activity-Based Ranging to Risk Driver Approach” by Craig Veteto



Risk Driver Method Steps

- Identify Root Cause Risks
- Define the Probability of the risk
  - 100% probability is similar to Duration Ranging/uncertainty
  - <100% probability is similar to Discrete Risks
- Define the **Impact** the risk will have upon schedule activities
  - Expressed as absolute values (days/hours), or
  - Expressed as relative % to schedule duration
  - Can reduce duration (opportunity) or increase (threat), even both.
- Assign Risks to schedule activities

Exercise 8: Create Risk Driver and apply to more detailed schedule

Id	Description	Risk Type	Probability
Tunnelling	Tunnelling Production Uncertainty	Standard	100%

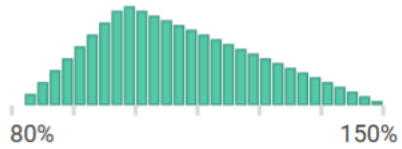
Impacts of Tunnelling

☑ Impact independently ☐ Correlate

Pre-Mitigated Position

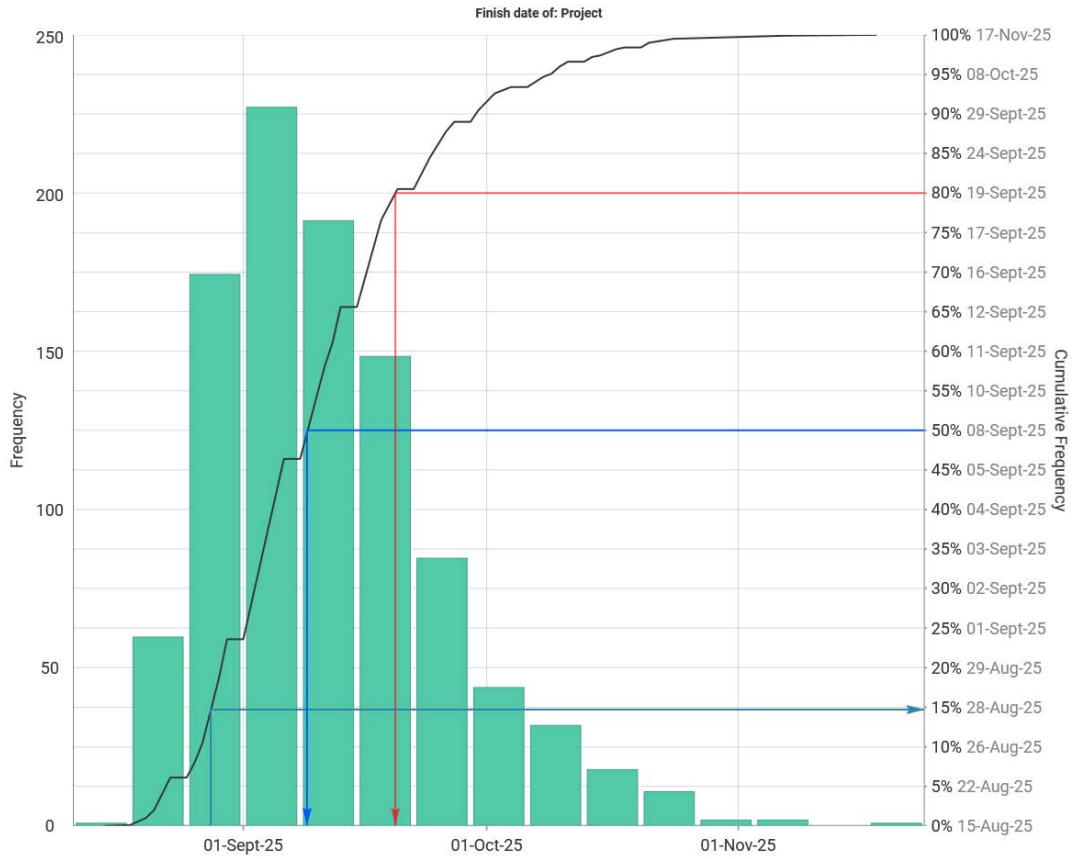
☑ Schedule Impact

Type: Relative | Distribution: Triangle | Min: 80% | Likely: 100% | Max: 150%



Exercise 8: Create Risk Driver and apply to Schedule

Id	Description	Tunnelling
SRA_TUNNEL	SRA TUNNEL EXAMPLE	☐
SRA_TUNNEL.M	Key Milestones	☐
SRA_TUNNEL.1	Procurement	☐
SRA_TUNNEL.2	Launch Shaft	☐
SRA_TUNNEL.3	Tunnel	■
SRA_TUNNEL.3.1	Tunnel - TBM	■
TC_SRA_02	Assembly	☐
TC_SRA_02	**Learning Curve 140m**	☑
TC_SRA_21	Drive 1 605m	☑
TC_SRA_22	Drive 2 220m	☑
TC_SRA_23	Drive 3 770m	☑
TC_SRA_24	Drive 4 825m	☑
TC_SRA_25	Drive 5 765m	☑
TC_SRA_26	Dis-assembly	☐
SRA_TUNNEL.3.2	Tunnel - Fitout	☐
TC_SRA_31	Tunnel Infill Concrete (DR1-3)	☐
TC_SRA_38	Tunnel Infill Concrete (DR4-5)	☐
TC_SRA_32	Tunnel Fitout	☐
SRA_TUNNEL.4	Cut & Cover Structure	☐
TC_SRA_300	C&C - Stage 1	☐
TC_SRA_330	C&C - Stage 2	☐
TC_SRA_340	Reinstatement Works	☐
SRA_TUNNEL.5	Ground Improvement	☐
TC_SRA_0080	Ground Improvement Works	☐



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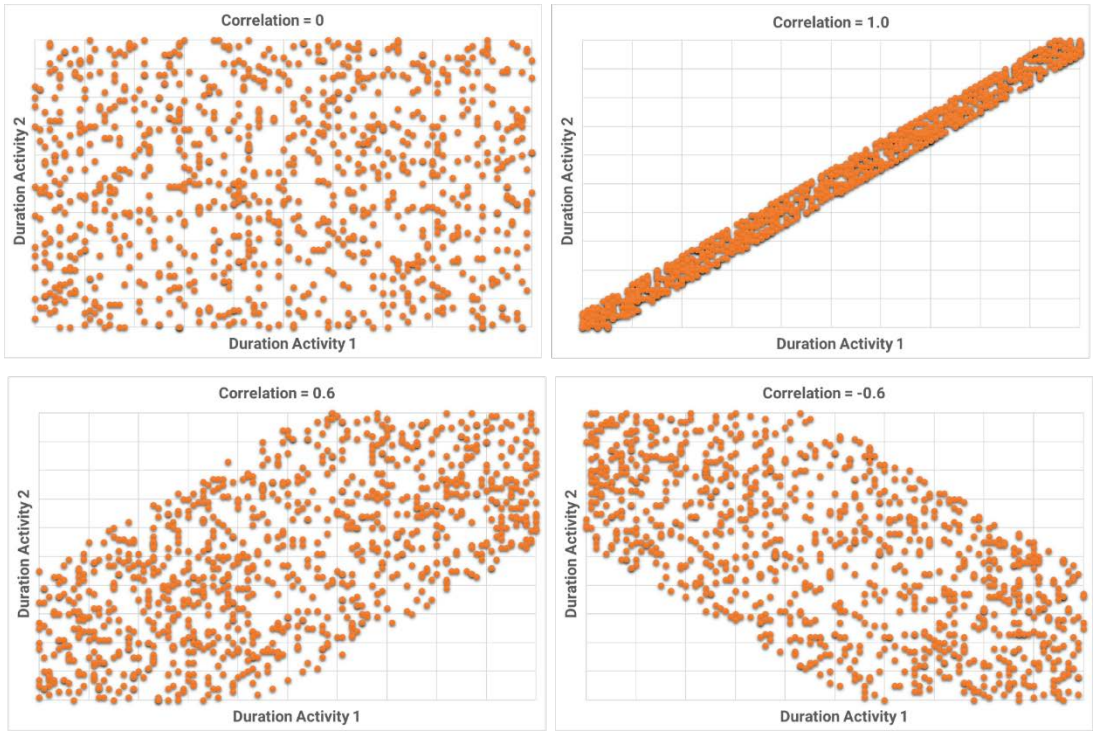
Correlation

- Correlation is a statistical measure that indicates the extent to which two or more variables Increase or decrease together
- Positive correlation indicates the degree to which variable increase or decrease together
- The inclusion of correlation can be much more significant to the results than selection of distribution profiles (triangle, beta etc)
- Traditionally correlation occurred at the activity level. Using the **Risk Driver** method, correlation can occur between the probability of risks occurring or their impacts upon activities

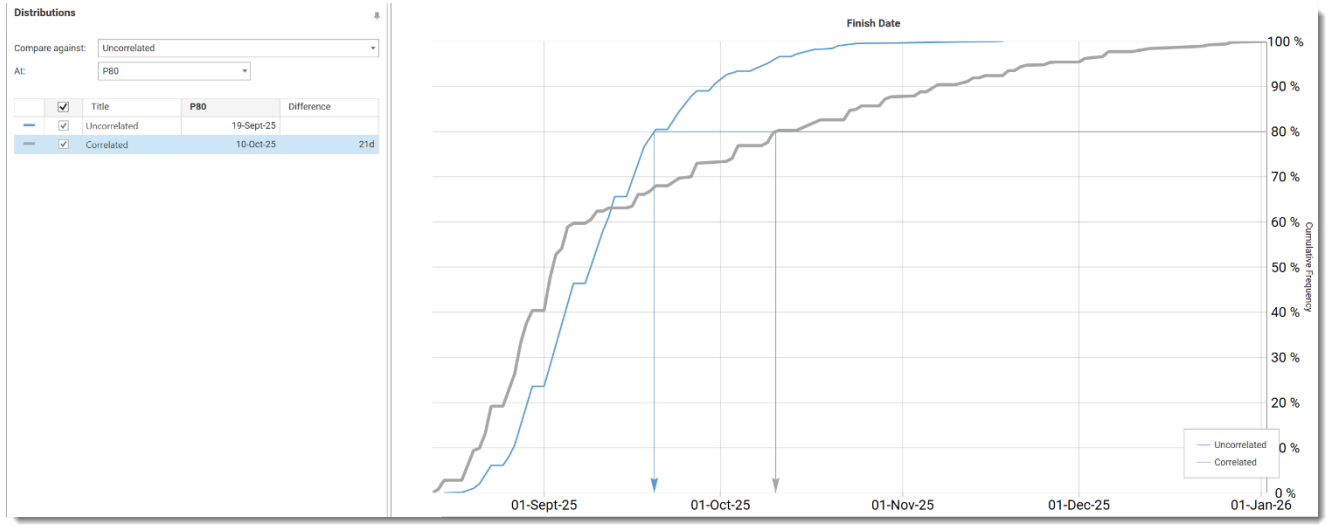


Correlation

- In the previous exercise the impact of the single risk on the 6 mapped activities mapped was uncorrelated (or correlation = 0).
- Ie. Each activity's impact was randomly assigned within the risk impact values in each iteration
- If Correlated, all activities would have the same assigned impact in each iteration

Exercise 9: Compare Correlated and Uncorrelated Result

- Correlation has the affect of earlier/lower values when selecting Confidence levels lower than P50, or later/higher values when selecting Confidence levels greater than P50



Schedule Risk Input Register

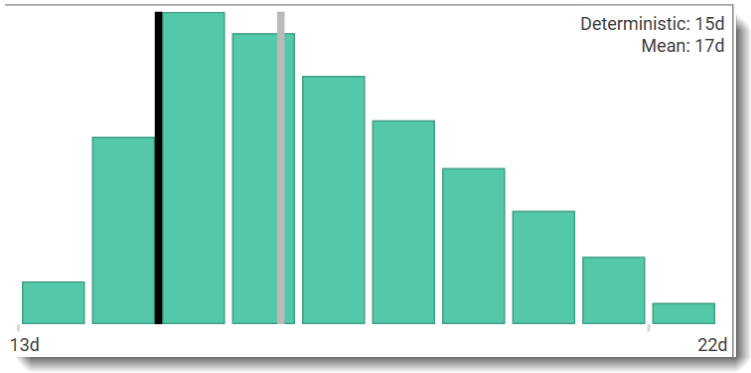
Category	ID	Description	Probability	Min impact	Most Likely Impact	Max Impact	Risk Impacts
Short description of the category risk applies to	Unique identifier	Provide a short text description of the risk	Define the probability of the risk occurring	The Minimum value of the risk impact	The most likely value of the risk impact	The maximum value of the risk impact	Identify the activities within the program affected by the risk
Design Approvals Construction – Utilities Construction – Surface Works Site1 Construction – Surface Works Site 2 Construction – Tunnelling Site 1 M&E Commissioning Etc	SRA Analyst will provide		▪ 100% risk also known as Duration Uncertainty ▪ <100% known as Discrete Risks ▪ Can also be calendar risks if required	Relative value in % of existing activity duration (e.g. 80%/100%/120%) Absolute value in days (e.g. +2d / +10d / +2weeks) can be negative also			Identify using ▪ Activity ID's ▪ WBS/activity code groups ▪ Coded activities ▪ Descriptions
EXAMPLES							
Construction – Surface Works	SW01	Delays due to Piling rig availability (ie threat only)	100% (Duration Uncertainty)	100% (of existing Duration)	120%	150%	Apply to all Piling Activities (use Coding and/or Descriptions)
Construction – Tunnelling	TU01	Tunnelling Production Uncertainty	100%	80% (of Existing Duration	100% (ie most likely to be original duration)	120%	Apply to Tunnelling from a certain site
Construction Tunnelling	TU51	Unexpected Ground conditions	20% (Discrete risk)	+2days (ie if risk occurs, min. impact is extra two days)	+5d	+10d (ie two weeks on 5d calendar)	Apply to excavation through known poor ground conditions (identify individual IDs)

Exercise 10: Using more detailed schedule, include more risks

Id	Description	Risk Type	Probability
DISASSEMBLY	Delays to TBM Disassembly	Standard	20%
EXCAVATION	Excavation Opportunities	Standard	70%
GND_IMPROV	Additional Ground Improvements Required	Standard	40%
TBM_BUILD	TBM Manufacturing Delays	Standard	30%
TBM_FAIL	Major Failure of TBM Equipment	Standard	10%
TBM_RATE	TBM Production Rate	Standard	100%
CONCRETE_SUPPLY	Concrete Supply Issues to Infil Works	Standard	100%

Risk Driver Method with multiple Risks on single activity

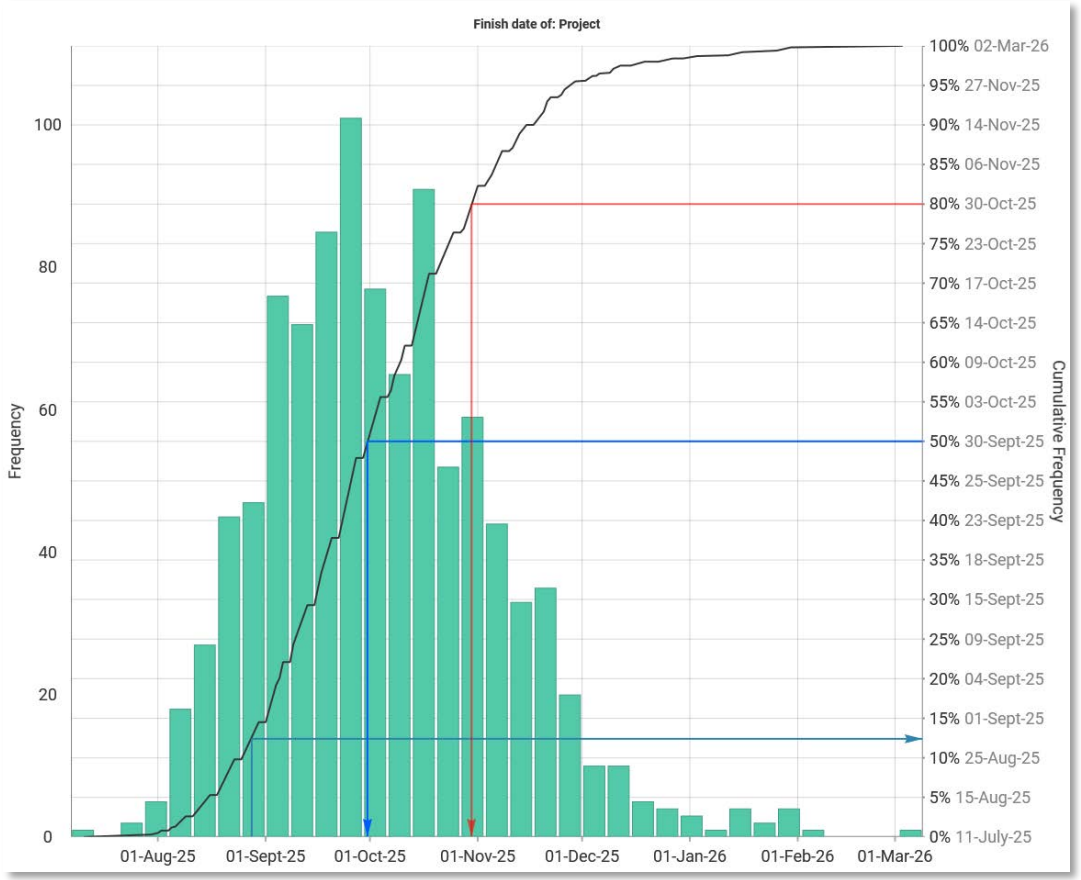
Tunnel Productivity Risk Alone

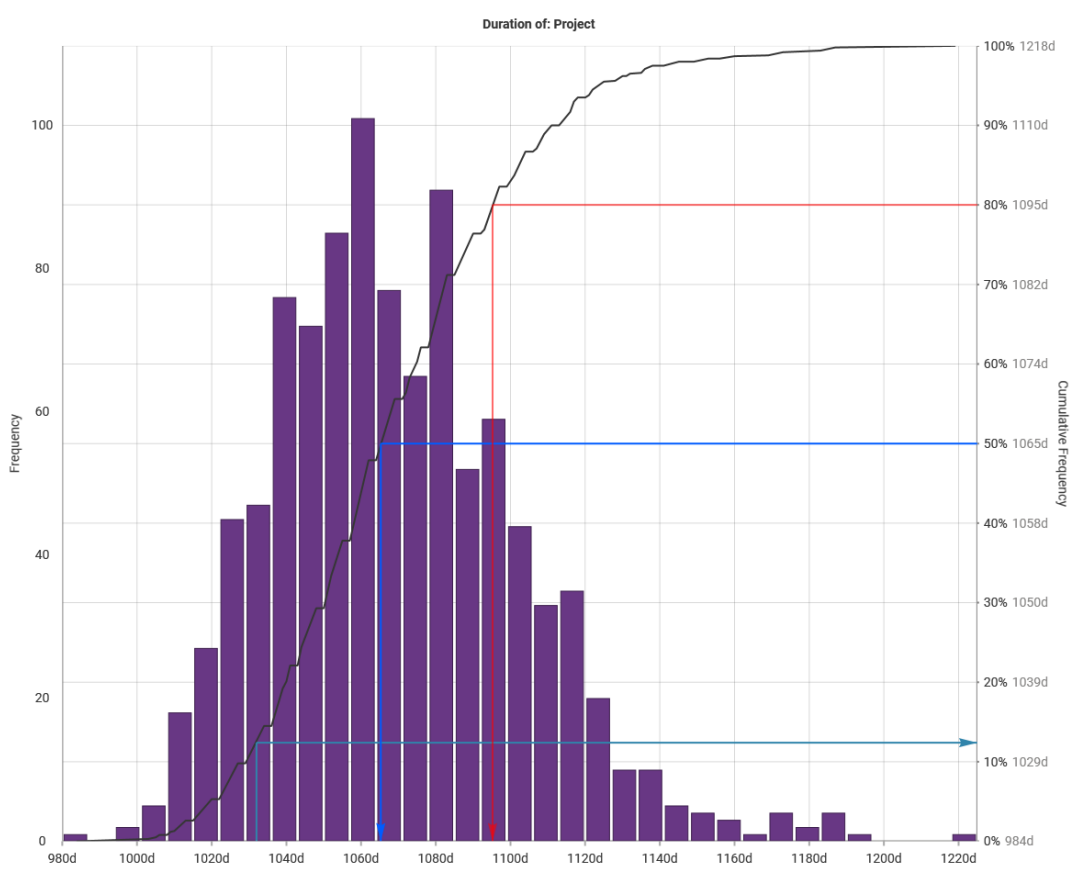


TBM Failure Risk Alone

Combined Risks

Exercise 11: Run Analysis, review results





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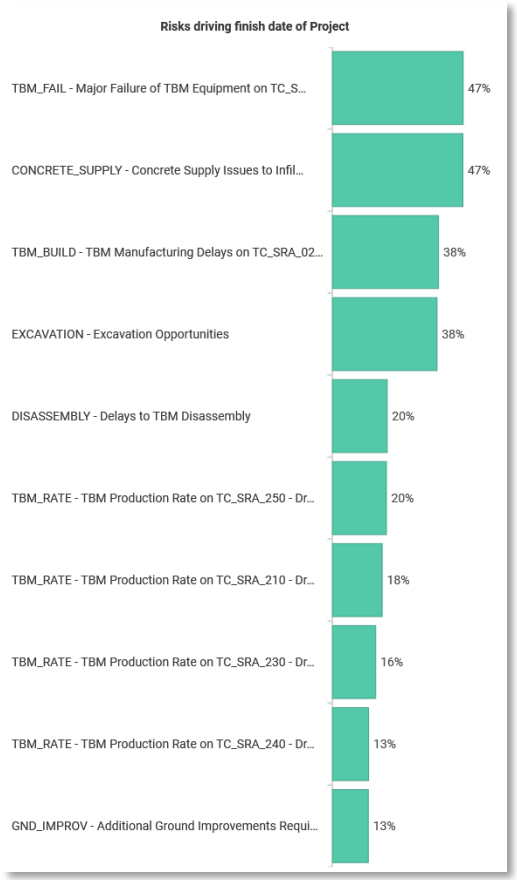
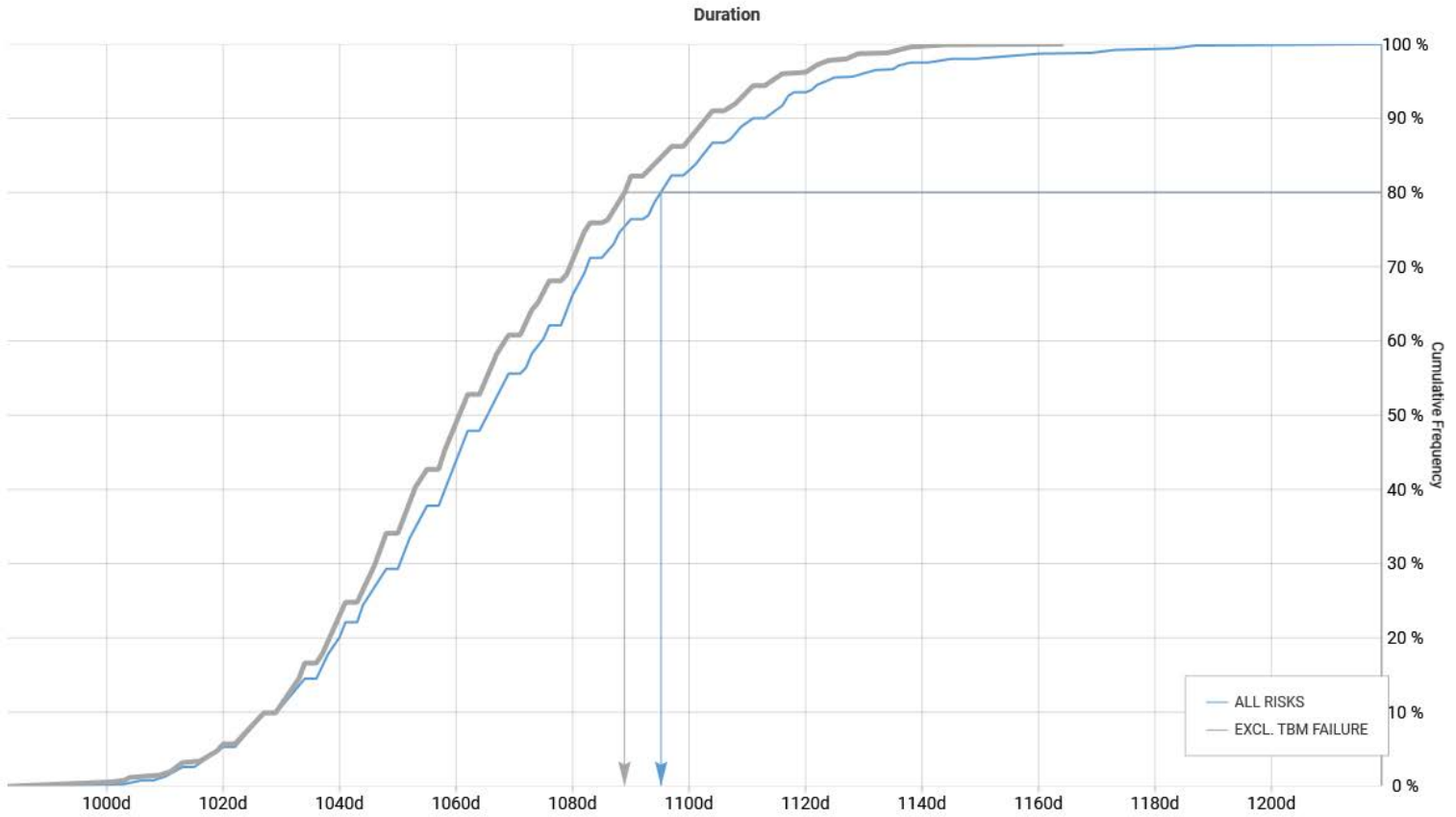
Analysis Results

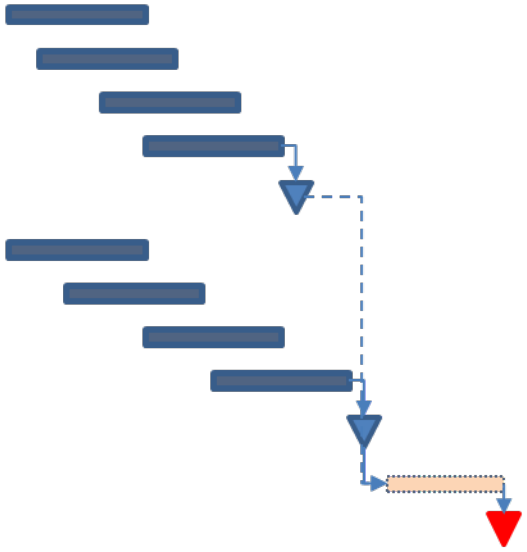
- This analysis suggests that using a P80 level of confidence, the project completion will be approximately 60days later than our planned schedule finish.
- What is the main risk driving this?
- Consider the tornado Graph on the previous slide – suggests that TBM failure is the top risk driving the result.



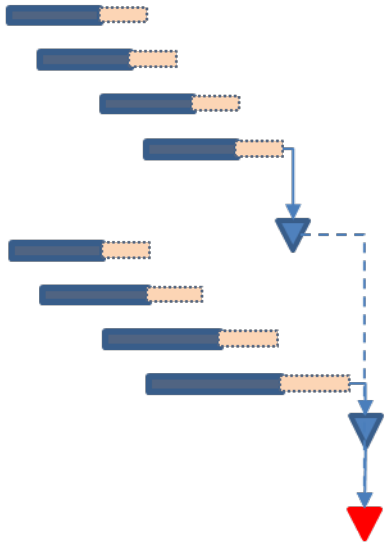
Exercise 12: Run Analysis, turning off one risk at a time & compare



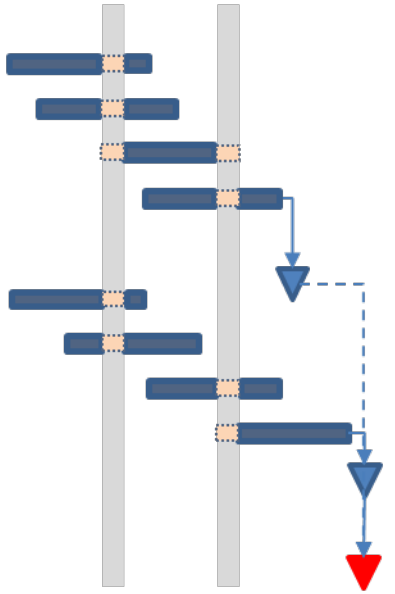
Special Note on Calendar Risks



SINGLE ACTIVITY BEFORE
FINISH MILESTONE



SPLIT AND PORTION TO
DURATION OF ACTIVITIES

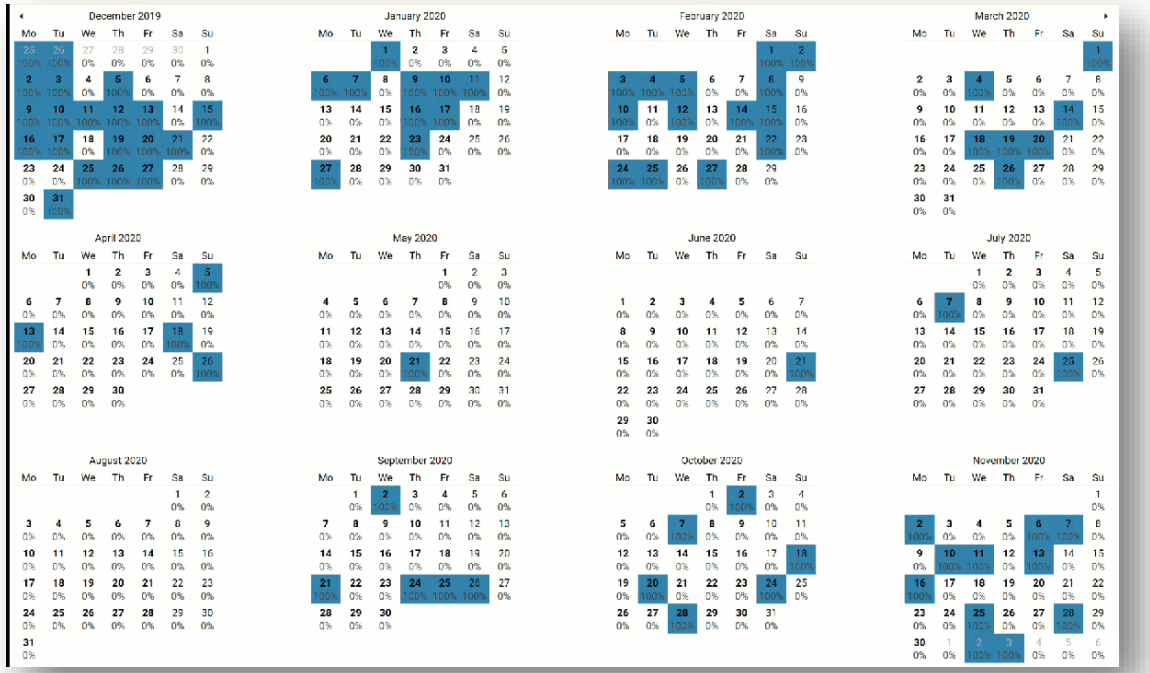


ALLOCATION OF
NON-WORK DAYS

Special Note on Calendar Risks

- Generate Weather as Probabilistic Calendars
- **NOTE** these do not affect activity durations, only the available work periods

Name	Year	Earliest Start	Latest Start	Block Size	Nbr of Blocks
Jan	All Years	01/01	31/01	1	Triangle(8;10;12)
Feb	All Years	01/02	28/02	1	Triangle(8;13;16)
Mar	All Years	01/03	31/03	1	Triangle(5;7;10)
Apr	All Years	01/04	30/04	1	Triangle(2;5;8)
May	All Years	01/05	31/05	1	Triangle(0;1;3)
Jun	All Years	01/06	30/06	1	Triangle(0;1;3)
Jul	All Years	01/07	31/07	1	Triangle(0;1;3)
Aug	All Years	01/08	31/08	1	Triangle(0;1;3)
Sep	All Years	01/09	30/09	1	Triangle(2;5;10)
Oct	All Years	01/10	31/10	1	Triangle(5;7;10)
Nov	All Years	01/11	30/11	1	Triangle(8;13;16)
Dec	All Years	01/12	31/12	1	Triangle(10;15;20)



Exercise 13: Run Analysis, including weather risk

Id	Description	Risk Type	Probability
CONCRETE_SUPPLY	Concrete Supply Issues to Infil Works	Standard	100%
DISASSEMBLY	Delays to TBM Disassembly	Standard	20%
EXCAVATION	Excavation Opportunities	Standard	70%
GND_IMPROV	Additional Ground Improvements Required	Standard	40%
TBM_BUILD	TBM Manufacturing Delays	Standard	30%
TBM_FAIL	Major Failure of TBM Equipment	Standard	10%
TBM_RATE	TBM Production Rate	Standard	100%
WEATHER	Weather Risk	Calendar	100%

Impacts of WEATHER

☑ Impact independently ☐ Correlate

◉ Combine with deterministic calendar ○ Replace deterministic calendar

Pre-Mitigated Position

Risk Calendar: Weather

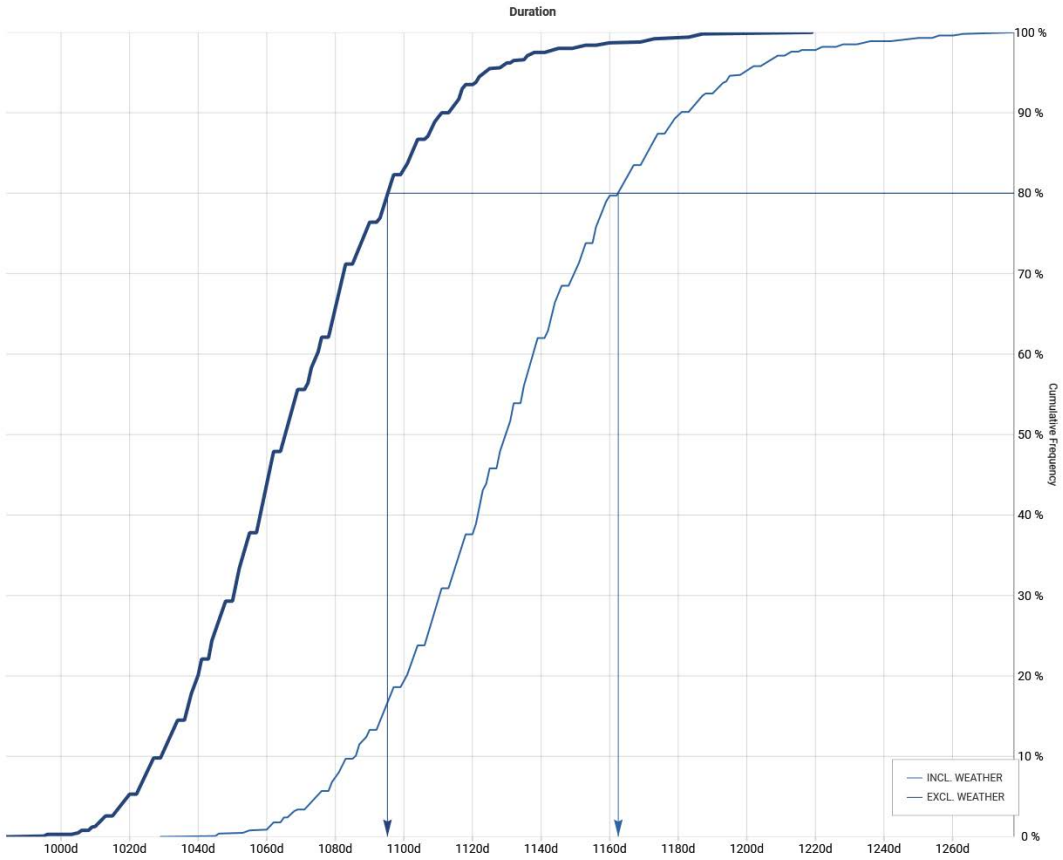
Description: Weather Risk

Period: 01-Oct-22 - 30-Dec-26

Number of Samples: 1000

Notes: This probabilistic calendar was generated from template: Downtime Template

Jan	Feb	Mar	Apr
12%	12%	12%	12%
May	Jun	Jul	Aug
12%	12%	12%	12%
Sep	Oct	Nov	Dec
12%	12%	12%	12%



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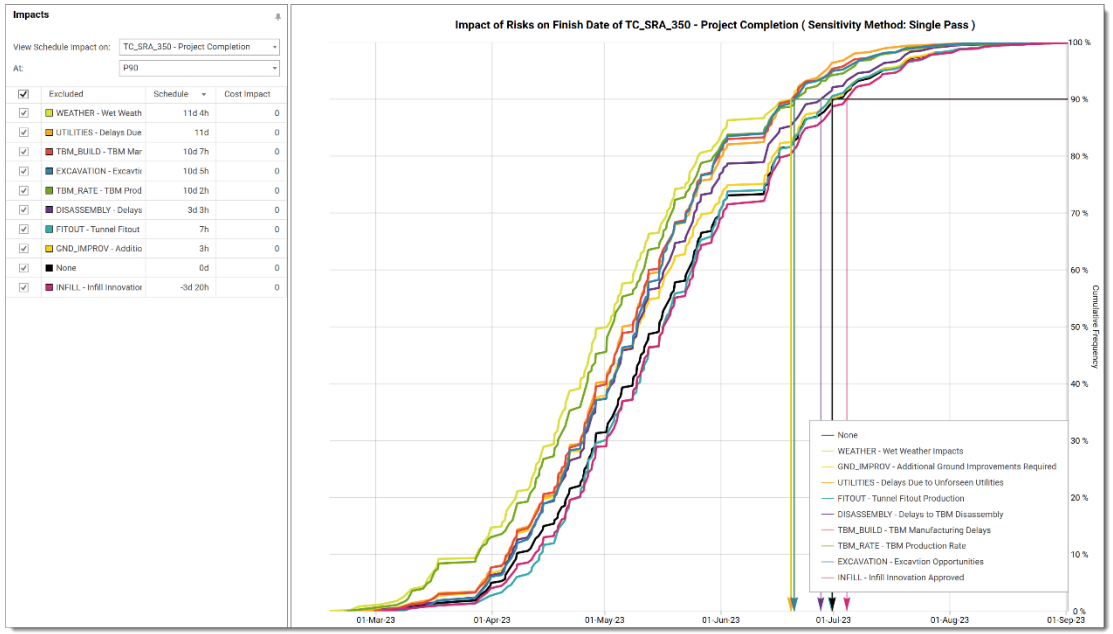
How to find the driving risks?

- Activity Duration Ranging does not relate risks to the resulting durations
- Correlation tornado graphs may produce odd results, and do not indicate the risks as a value of time, or at a specified confidence level
- However, using the Risk Driver Method, it is possible to turn on/off risks to understand the impact of that risk

Risk by Exclusion Method

Which Risks to prioritize?

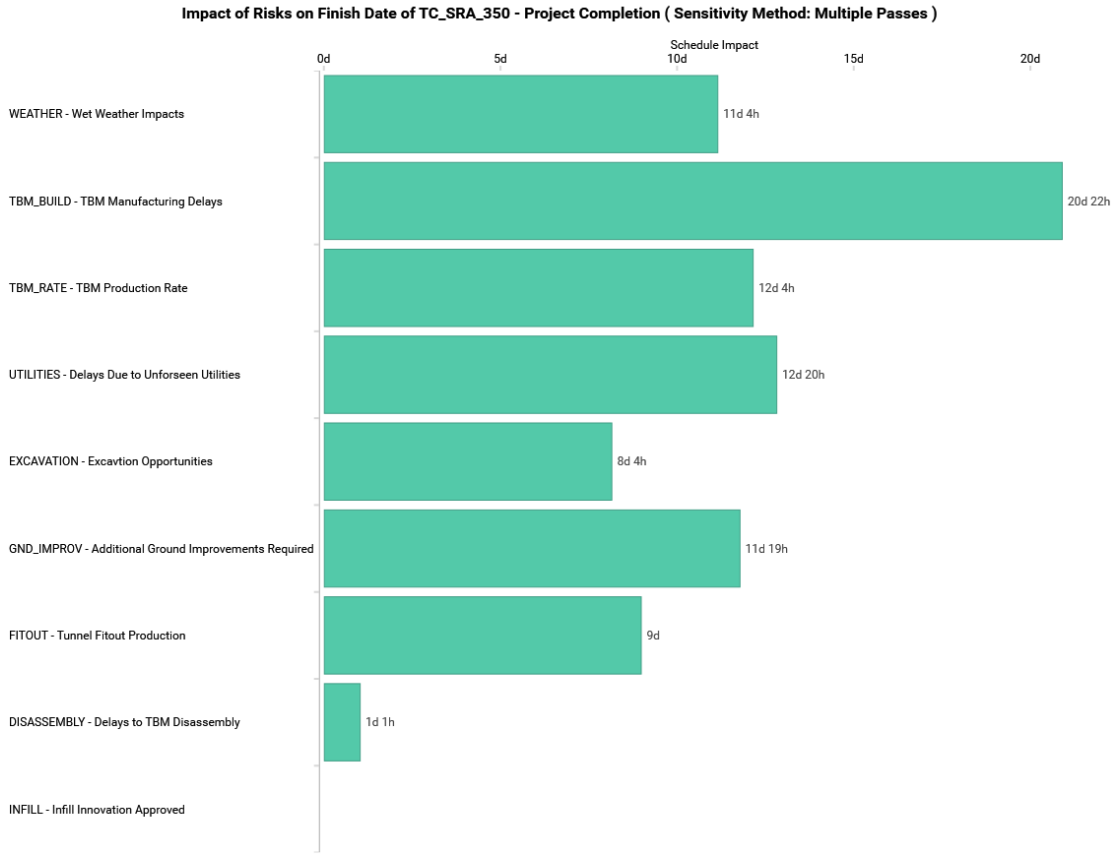
- Select the schedule task to analyse
- Select the confidence level to analyse
- Run full analysis, each time excluding one risk at a time from register



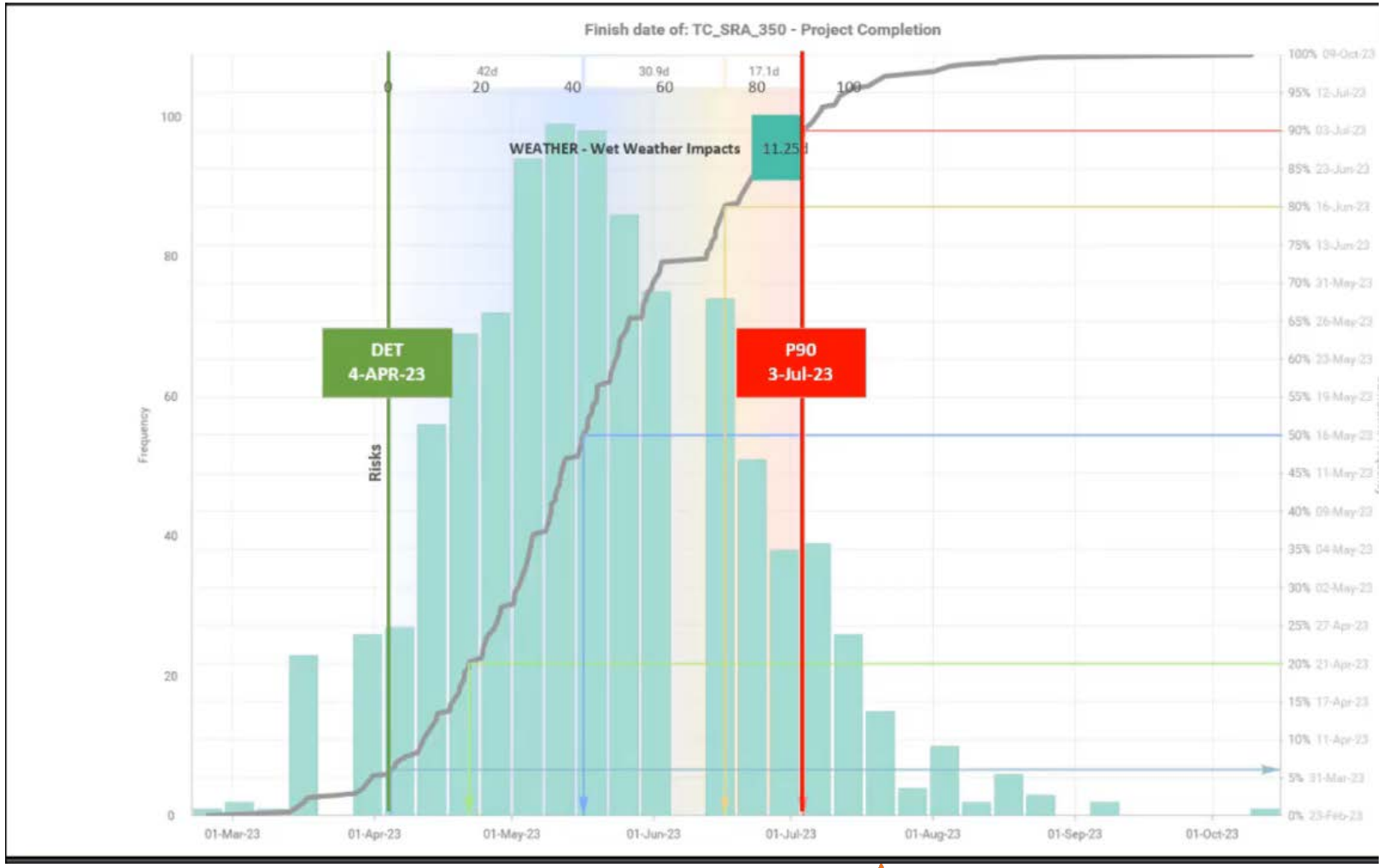
Risk by Exclusion Method

Which risks to prioritize?

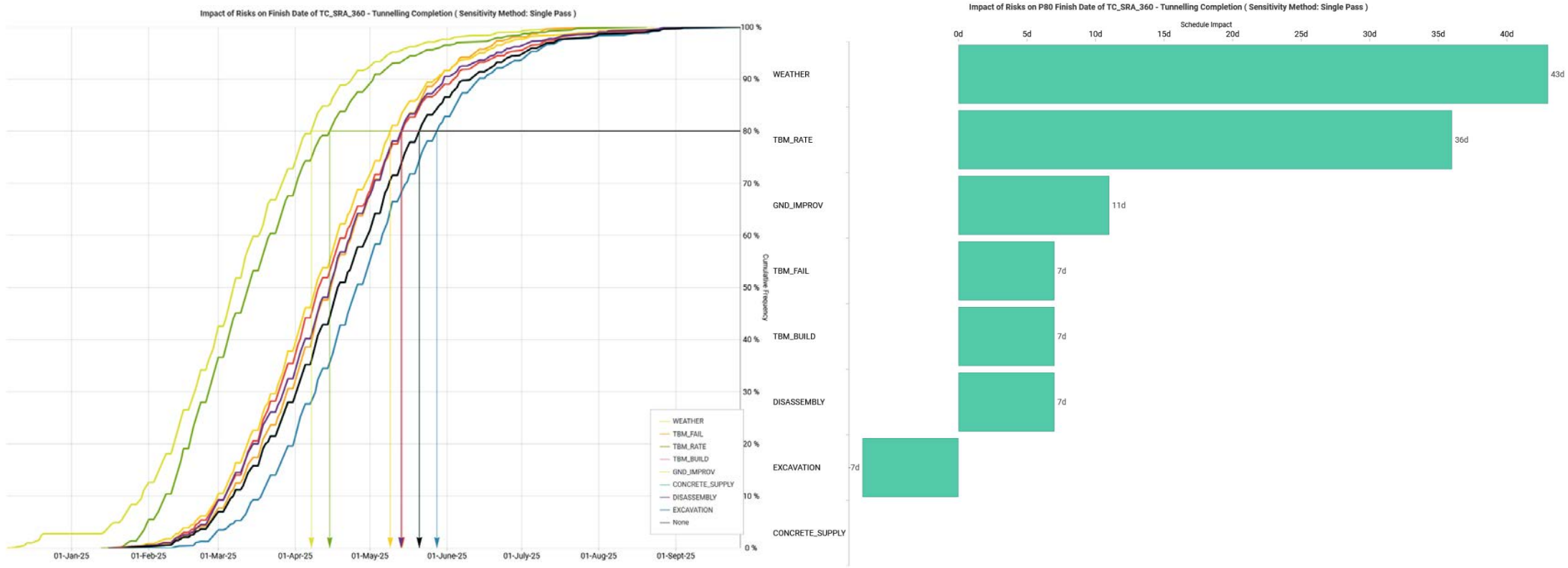
- Once the largest contributing risk is identified, then re-run analysis excluding each of the remaining risks.
- Repeat process until all risks are removed, or until a set% of the variance is achieved.



Outputs – Risk by Exclusion - Walkthrough



Exercise 14: Run Risk by Exclusion to find Top contributing Risk



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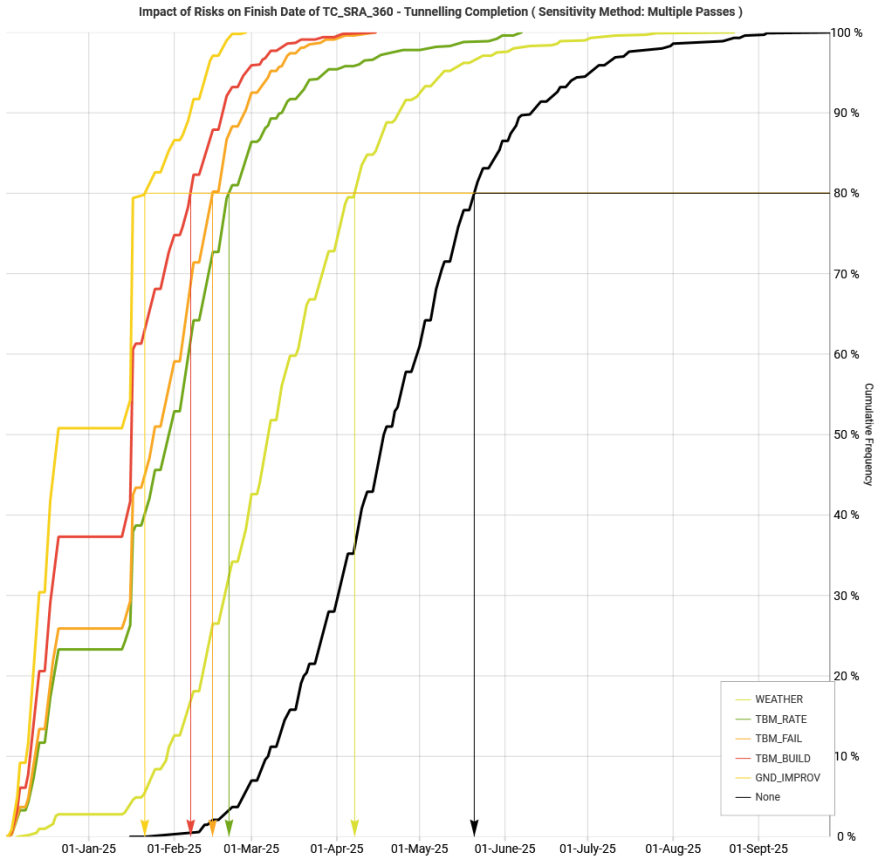
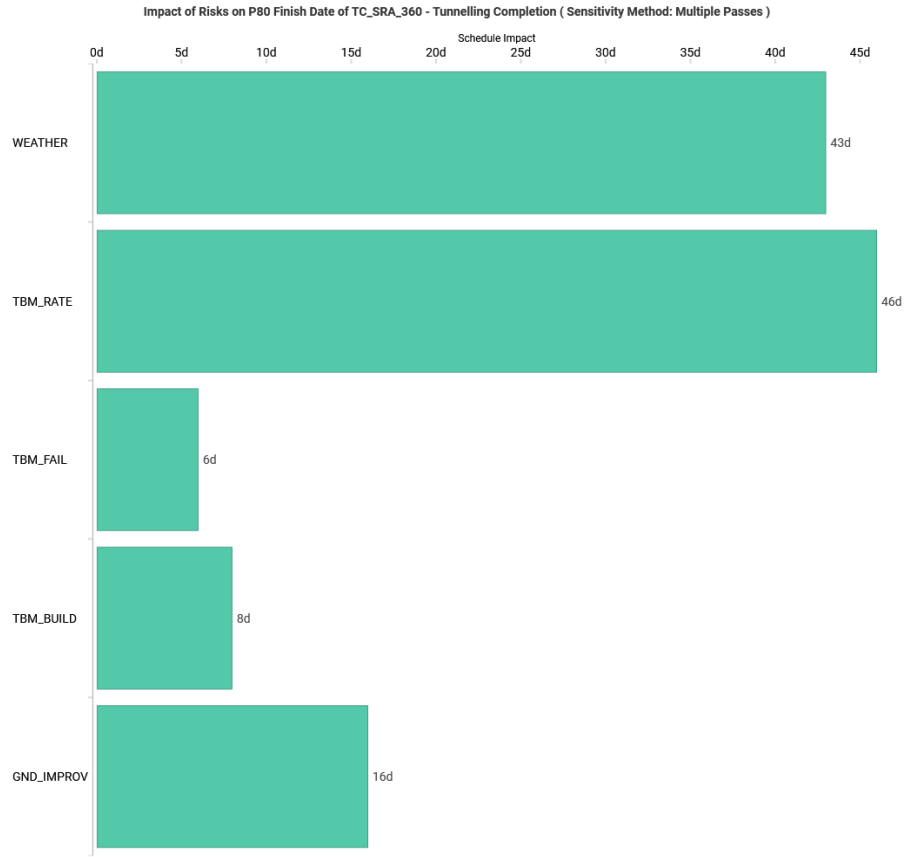
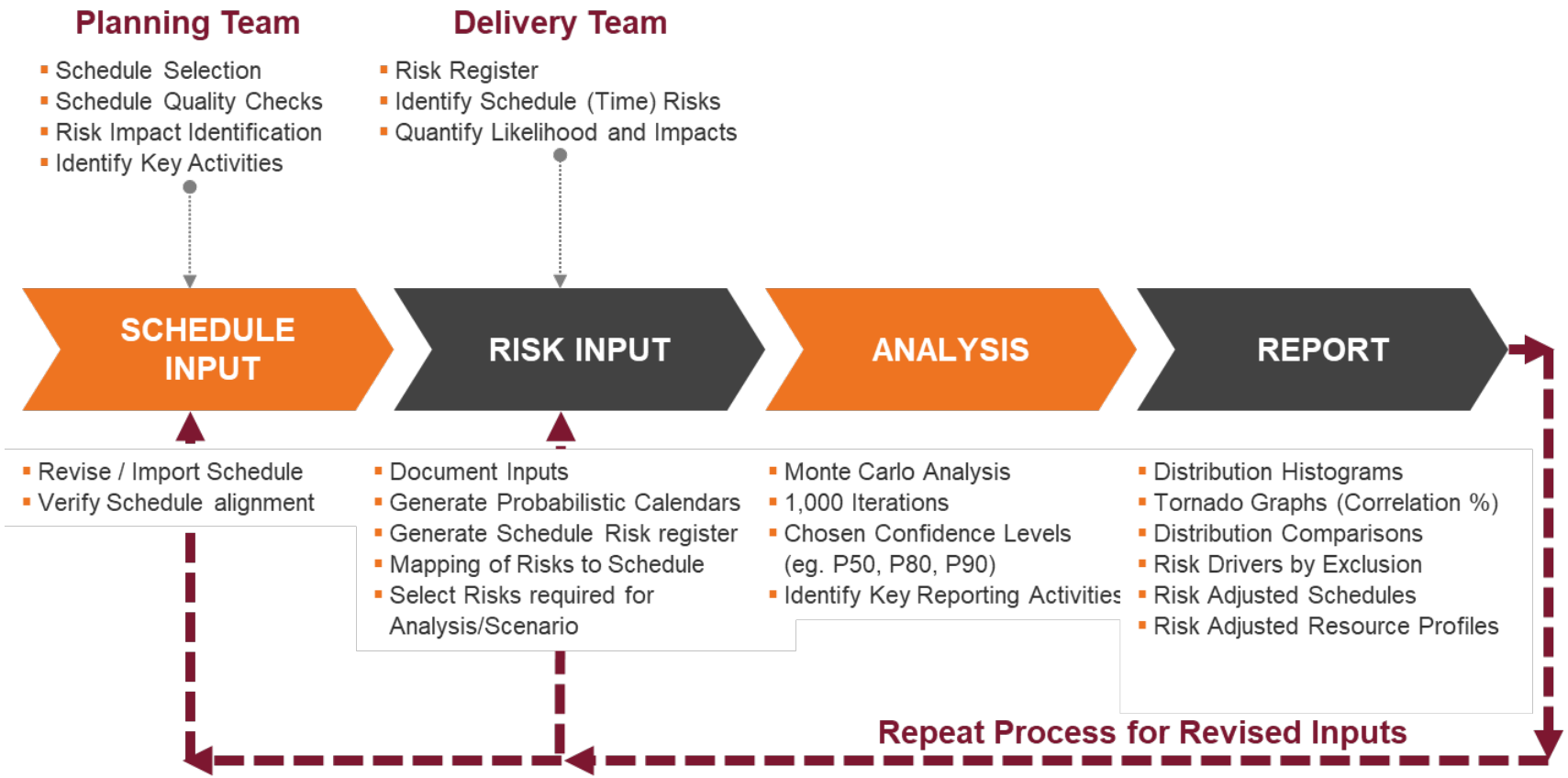
Exercise 15: Run Risk by Exclusion to find Top 5 Contributing Risks





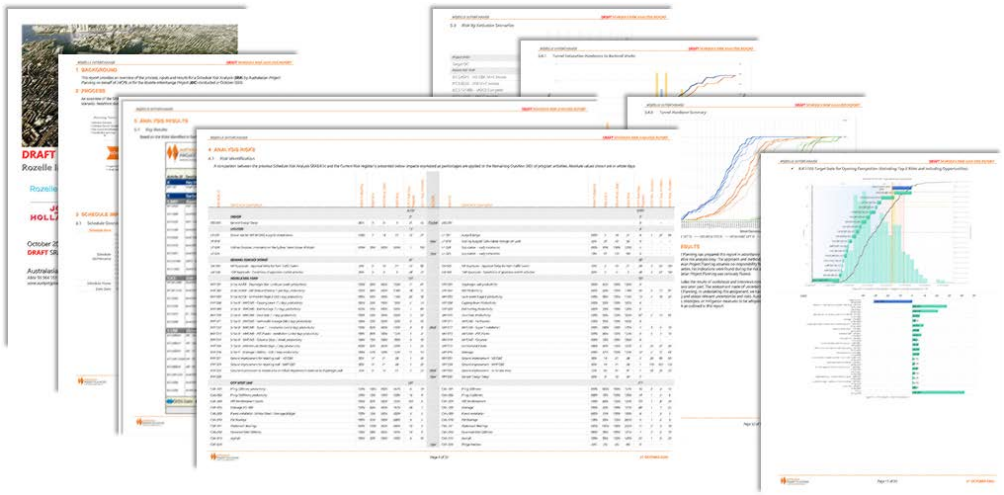
Scenarios and Senstivities



Outputs – SRA Report

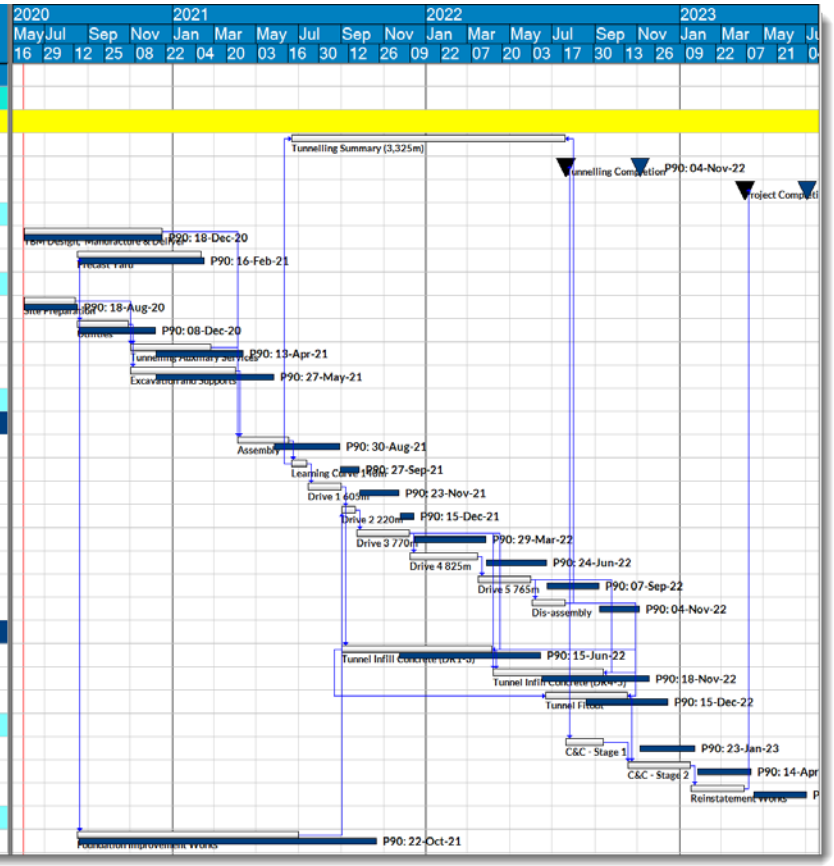
Contents of a Schedule Risk Analysis Report

- **Overview/Background**: the purpose for the analysis
- **Schedule**: Identify the schedule, key details (e.g. Id, data date, No. of Activities etc) , schedule quality. Any modifications made to the schedule for SRA requirements
- **Key Activities**: Identify the key milestones or activities that the analysis will monitor and their corresponding deterministic date
- **Risks**: clearly document the risks being analysed, with key details (e.g. name, description, probability, impact values, impacted activities)
- **Results**: Selected confidence levels, distribution graphs, comparisons, sensitivities, risk adjusted schedules
- **Commentary**: Conclusions, key driving risks, further actions



Outputs – Risk Adjusted Schedule

Activity ID	Description	Start	Finish	Duration	Risk Impacted	Risk P90 Start	Risk P90 Finish	Risk P90 Duration
TC_TUNNEL	TC SRA TUNNEL EXAMPLE	01-Jun-20	04-Apr-23	656.75 d		01-Jun-20	03-Jul-23	3381.75 d
TC_TUNNEL.TC_SRA	SRA TASKS	01-Jun-20	04-Apr-23	656.75 d		01-Jun-20	03-Jul-23	3381.75 d
TC_TUNNEL.TC_SRA.M	Key Milestones	21-Jun-21	04-Apr-23	411.75 d		30-Aug-21	03-Jul-23	2070.62 d
TC_SRA_370	Tunnelling Summary (3,325m)	21-Jun-21	20-Jul-22	253 d		30-Aug-21	04-Nov-22	289.87 d
TC_SRA_360	Tunnelling Completion	20-Jul-22	20-Jul-22	0		04-Nov-22	04-Nov-22	0
TC_SRA_350	Project Completion	04-Apr-23	04-Apr-23	0		03-Jul-23	03-Jul-23	0
TC_TUNNEL.TC_SRA.1	Procurement	01-Jun-20	12-Feb-21	165 d		01-Jun-20	16-Feb-21	781 d
TC_SRA_0090	TBM Design, Manufacture & Delive	01-Jun-20	18-Dec-20	140 d		01-Jun-20	18-Dec-20	140 d
TC_SRA_0100	Precast Yard	17-Aug-20	12-Feb-21	110 d		19-Aug-20	16-Feb-21	110 d
TC_TUNNEL.TC_SRA.2	Launch Shaft	01-Jun-20	02-Apr-21	195 d		01-Jun-20	27-May-21	1080.37 d
TC_SRA_0050	SIte Preparation	01-Jun-20	14-Aug-20	55 d	WEATHER	01-Jun-20	18-Aug-20	55 d
TC_SRA_270	Utilities	17-Aug-20	30-Oct-20	50 d	ILITIES, WEATHER	19-Aug-20	08-Dec-20	73.37 d
TC_SRA_290	Tunnelling Auxiliary Services	02-Nov-20	26-Feb-21	70 d		08-Dec-20	13-Apr-21	70 d
TC_SRA_280	Excavation and Supports	02-Nov-20	02-Apr-21	90 d	VATION, WEATHER	08-Dec-20	27-May-21	113.75 d
TC_TUNNEL.TC_SRA.3	Tunnel	05-Apr-21	18-Oct-22	361.75 d		27-May-21	15-Dec-22	1784.62 d
TC_TUNNEL.TC_SRA.3.1	Tunnel - TBM	05-Apr-21	20-Jul-22	303 d		27-May-21	04-Nov-22	1638.25 d
TC_SRA_0200	Assembly	05-Apr-21	18-Jun-21	50 d	TBM_BUILD	27-May-21	30-Aug-21	75 d
TC_SRA_0210	Learning Curve 140m	21-Jun-21	14-Jul-21	18 d	TBM_RATE	30-Aug-21	27-Sep-21	20.75 d
TC_SRA_210	Drive 1 605m	15-Jul-21	01-Sep-21	35 d	TBM_RATE	27-Sep-21	23-Nov-21	40.62 d
TC_SRA_220	Drive 2 220m	02-Sep-21	22-Sep-21	15 d	TBM_RATE	24-Nov-21	15-Dec-21	17.37 d
TC_SRA_230	Drive 3 770m	23-Sep-21	08-Dec-21	50 d	TBM_RATE	15-Dec-21	29-Mar-22	57.87 d
TC_SRA_240	Drive 4 825m	09-Dec-21	16-Mar-22	55 d	TBM_RATE	29-Mar-22	24-Jun-22	63.62 d
TC_SRA_250	Drive 5 765m	17-Mar-22	01-Jun-22	50 d	TBM_RATE	24-Jun-22	07-Sep-22	57.75 d
TC_SRA_260	Dis-assembly	02-Jun-22	20-Jul-22	30 d	DISASSEMBLY	07-Sep-22	04-Nov-22	50 d
TC_TUNNEL.TC_SRA.3.2	Tunnel - Fitout	02-Sep-21	18-Oct-22	258.75 d		23-Nov-21	15-Dec-22	1266.12 d
TC_SRA_310	Tunnel Infill Concrete (DR1-3)	02-Sep-21	06-Apr-22	130 d	FITOUT, INFILL	23-Nov-21	15-Jun-22	133 d
TC_SRA_380	Tunnel Infill Concrete (DR4-5)	07-Apr-22	14-Sep-22	110 d	FITOUT, INFILL	16-Jun-22	18-Nov-22	112.5 d
TC_SRA_320	Tunnel Fitout	21-Jun-22	18-Oct-22	80 d	FITOUT	19-Aug-22	15-Dec-22	83.37 d
TC_TUNNEL.TC_SRA.4	Cut & Cover Structure	21-Jul-22	04-Apr-23	158.75 d		04-Nov-22	03-Jul-23	771.25 d
TC_SRA_300	C&C - Stage 1	21-Jul-22	14-Sep-22	40 d	WEATHER	04-Nov-22	23-Jan-23	40 d
TC_SRA_330	C&C - Stage 2	18-Oct-22	17-Jan-23	50 d	WEATHER	26-Jan-23	14-Apr-23	50 d
TC_SRA_340	Reinstatement Works	17-Jan-23	04-Apr-23	50 d	WEATHER	17-Apr-23	03-Jul-23	50 d
TC_TUNNEL.TC_SRA.5	Ground Improvement	17-Aug-20	02-Jul-21	200 d		19-Aug-20	22-Oct-21	1290.5 d
TC_SRA_0080	Foundation Improvement Works	17-Aug-20	02-Jul-21	200 d	MPROV, WEATHER	19-Aug-20	22-Oct-21	266.62 d



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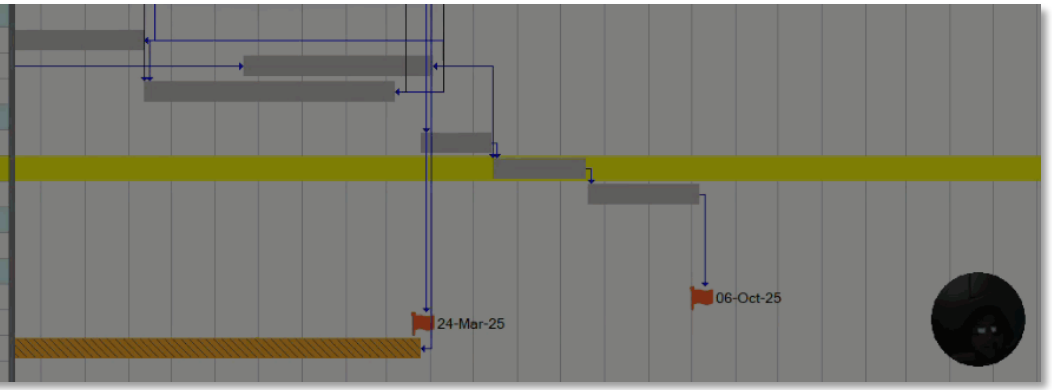
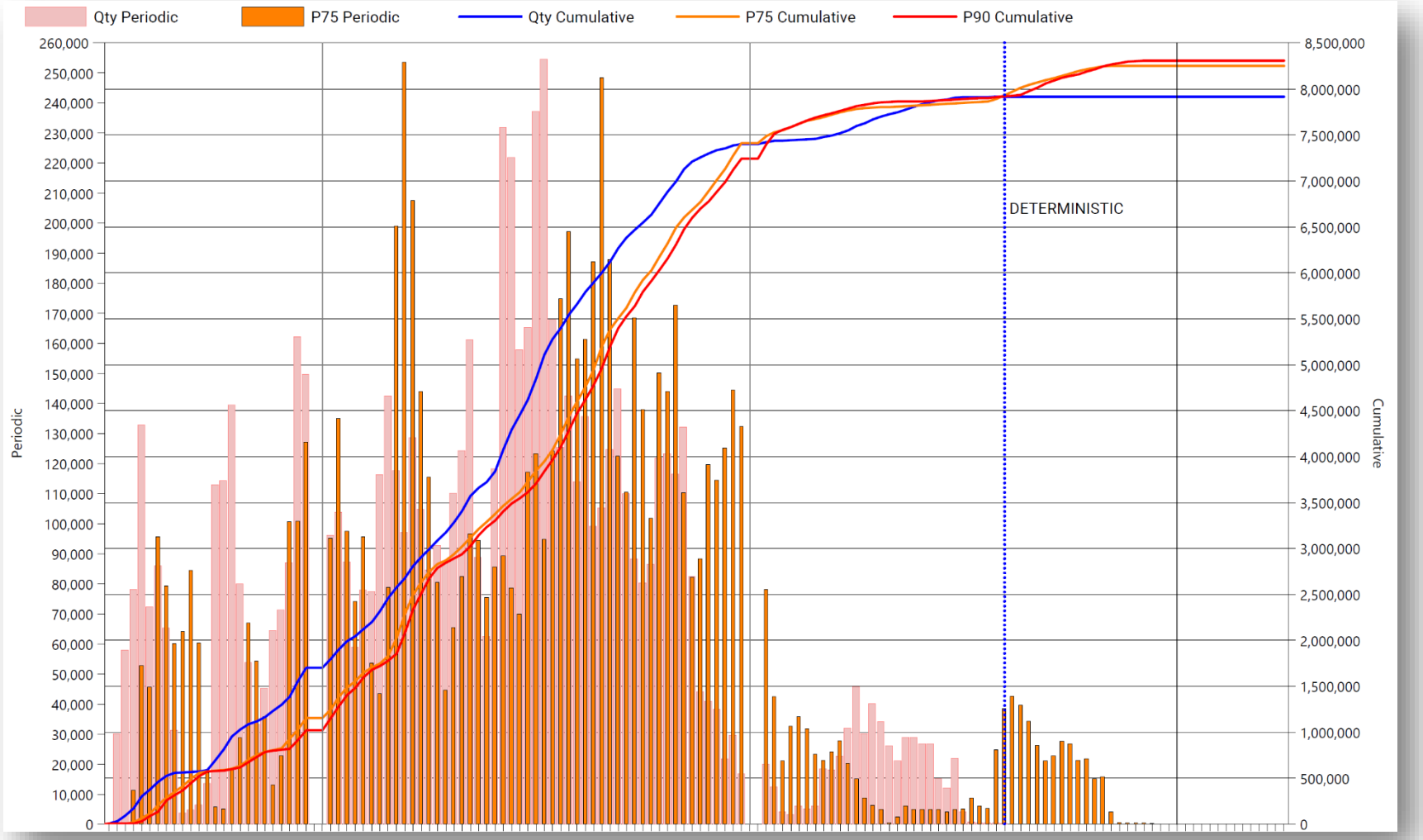
Exercise 16: Can the P80 dates be a “Risk Adjusted Schedule?”

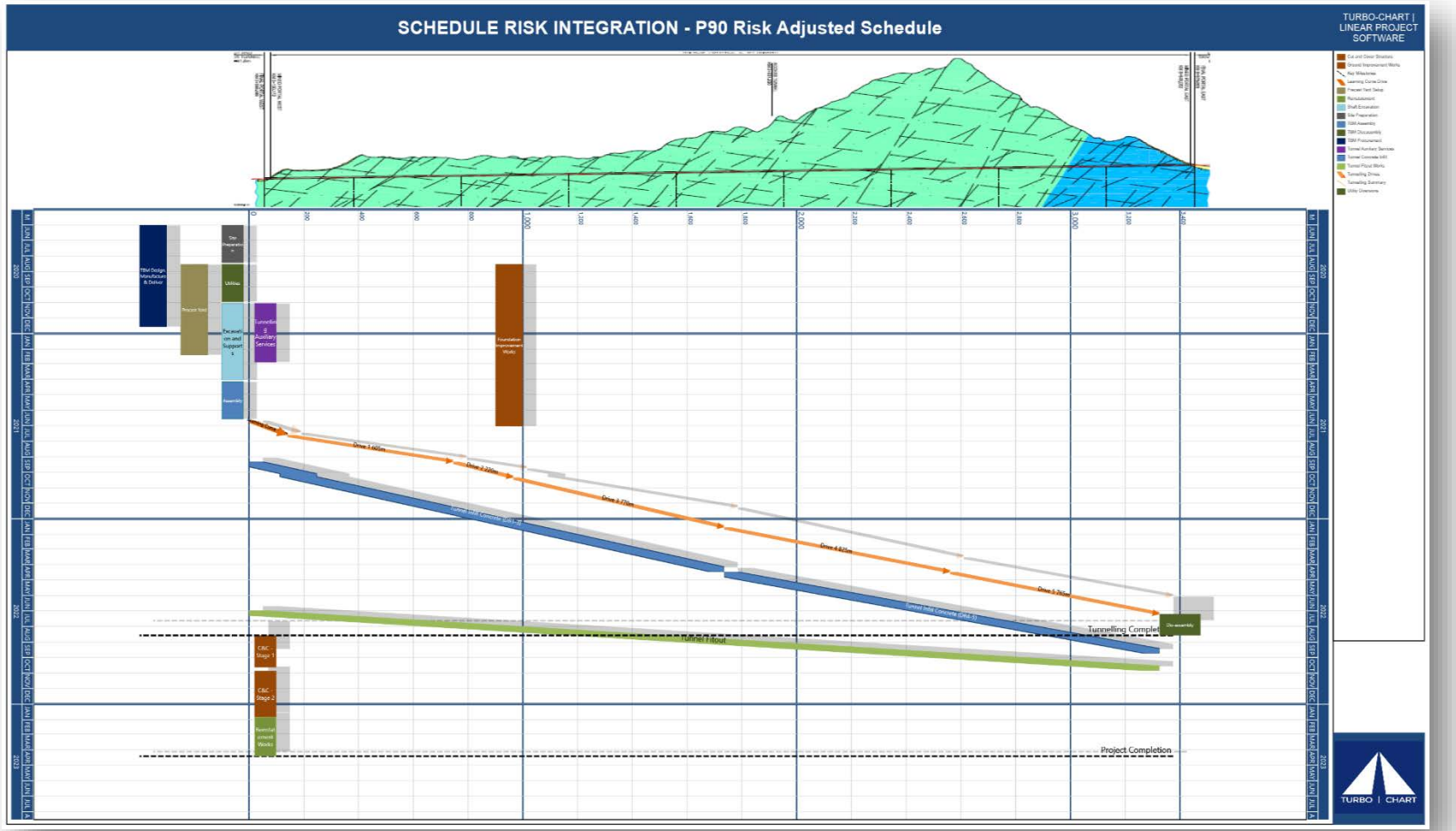
SRA_TUNNEL.3	Tunnel - Fitout	07-Mar-24	02-Apr-25	250 d		0
TC_SRA_310	Tunnel Infill Concrete (DR1-3)	07-Mar-24	11-Sep-24	125 d	CONCRETE_SUPPLY	
TC_SRA_320	Tunnel Fitout	21-Nov-24	02-Apr-25	80 d		
TC_SRA_380	Tunnel Infill Concrete (DR4-5)	12-Sep-24	06-Mar-25	106 d	CONCRETE_SUPPLY	
SRA_TUNNEL.4	Cut & Cover Structure	25-Mar-25	06-Oct-25	140 d		0
TC_SRA_300	C&C - Stage 1	25-Mar-25	13-May-25	32 d	_SUPPLY;EXCAVATION	
TC_SRA_330	C&C - Stage 2	15-May-25	18-Jul-25	40 d	_SUPPLY;EXCAVATION	
TC_SRA_340	Reinstatement Works	21-Jul-25	06-Oct-25	50 d	WEATHER	
SRA_TUNNEL.5	Ground Improvement	10-Feb-23	12-Apr-24	271 d		0
TC_SRA_0080	Ground Improvement Works	10-Feb-23	12-Apr-24	271 d	GND_IMPROV	
SRA_TUNNEL.M	Key Milestones	21-Nov-23	06-Oct-25	445 d		0
TC_SRA_350	Project Completion	06-Oct-25	06-Oct-25	0		
TC_SRA_360	Tunnelling Completion	24-Mar-25	24-Mar-25	0		
TC_SRA_370	Tunnelling Summary (3,325m)	21-Nov-23	24-Mar-25	305 d		



Outputs – Risk Adjusted Resource Histogram



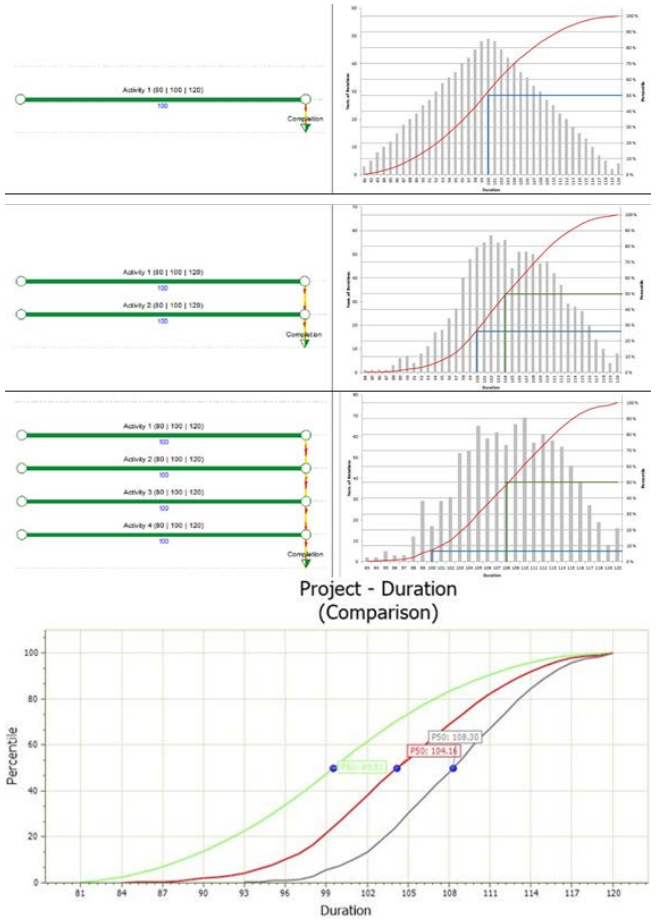
Outputs – Risk Adjusted Linear Schedule



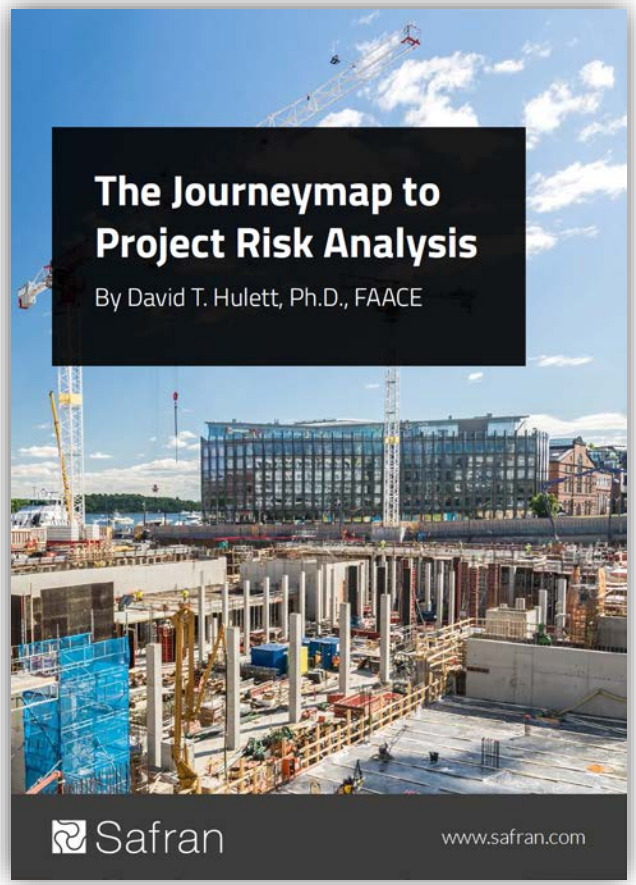
Note on Merge Bias

Merge Bias is an intrinsic feature of schedules

- Due to the **logical relationships between activities**. Has no equivalent in Cost Risk analysis
- Consider a milestone driven by four activities. Each activity has a 50% probability of being early, or 50% of being late. What is the probability of the milestone finishing early?
- Given that the completion milestone is driven by all four activities, the only situation where the completion is early, occurs, when ALL four activities are completed early. This only occurs 50% * 50% * 50% * 50%, i.e. in **6.25%** of possible outcomes
- This is the merge bias effect, and the results for project completion are **compounded by the number of merge bias points** through a schedule that are effected by schedule risk



Where to?



Further Reading

AUSTRALASIAN PROJECT PLANNING
www.austprojplan.com.au

Project Controls EXPO
Melbourne, Australia

Workshop Overview & Objectives

- Introduction to Schedule Risk Analysis, benefits and issues
- Use worked example to explain the concept, techniques and outputs of schedule risk analysis
- Demonstrate use of specialised tools for risk analysis
- Walk away with greater knowledge of the methods for application on your projects

What are your objectives?

Q+A

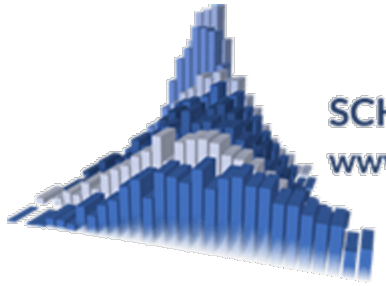
More Information

Upcoming Website

- Articles
- Tutorials
- Community Forum

Contact me

- santosh@auaspp.com.au



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