ICPMA Conference 2018: Building Futures

Risk-based Cost and Schedule Analysis for Megaprojects

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1. Introduction
2. Standard vs Integrated Approach
3. Integrated Cost and Schedule Model
4. Results and Alternative Delivery Methods

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RIAAT
Risk Administration and Analysis Tool

RiskConsult GmbH

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Megaprojects follow different rules, thus tailored processes and tools are required.

- Cost and Risk Management
- Team Alignment
- RAMS Analysis
- Software Development
- Training

Experience with major infrastructure projects in Europe, North and South America.

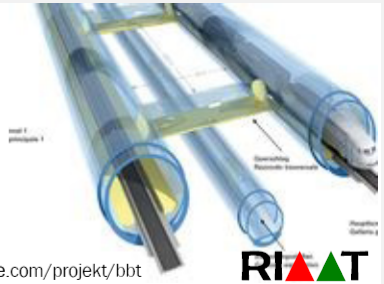
Selected Projects

Brenner Base Tunnel

The Brenner Base Tunnel is the main element of the new Brenner railway from Munich to Verona. At 64 km, it is the longest underground railway connection in the world, a pioneering work of engineering and it will markedly improve passenger travel and freight transport through the heart of Europe.

Services: Support and validation probabilistic risk assessment

Project costs: approx. $ 12 Billion



Source: http://www.bbt-se.com/projekt/bbt

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Subway New York: Canarsie Tunnel

New York City Transit

Flooding caused by Superstorm Sandy inundated the Canarsie Tunnel with seven million gallons of salt water. The rehabilitation includes upgrading of the Canarsie Tunnel facilities from 1st Avenue Station in Manhattan to Bedford Avenue Station in Brooklyn and three substations.

Service: Risk assessment, identifying and quantifying risks for project cost and schedule, quantify potential reduction in risk through mitigation.

Source: New York Times

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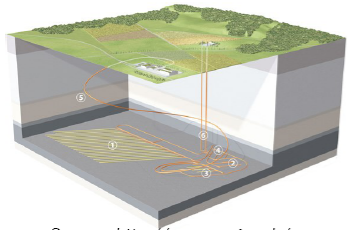
NAGRA - Swiss National Cooperative for the Disposal of Radioactive Waste



Source: http://www.nagra.ch/

Safe long-term disposal of radioactive waste in deep geological repositories is a challenging task that NAGRA has committed to implementing in the interests of man and the environment.

Services: Probabilistic cost estimation and risk analysis, software development, process development, staff training

nagra.

RIAAT

BMVI (German Ministry of Transportation and Digital Infrastructure)

Bundesministerium für Verkehr und digitale Infrastruktur

The German Ministry for Transport and Digital Infrastructure (BMVI) initiated the "Construction of Mega Projects" commission. Their task is to identify problems in the planning and construction phase of large projects and reveal reasons for cost increases and delays.

Services: Development of an integrated risk management approach in accordance with ISO 31000 and ISO 31010 for four pilot projects.

RIAAT

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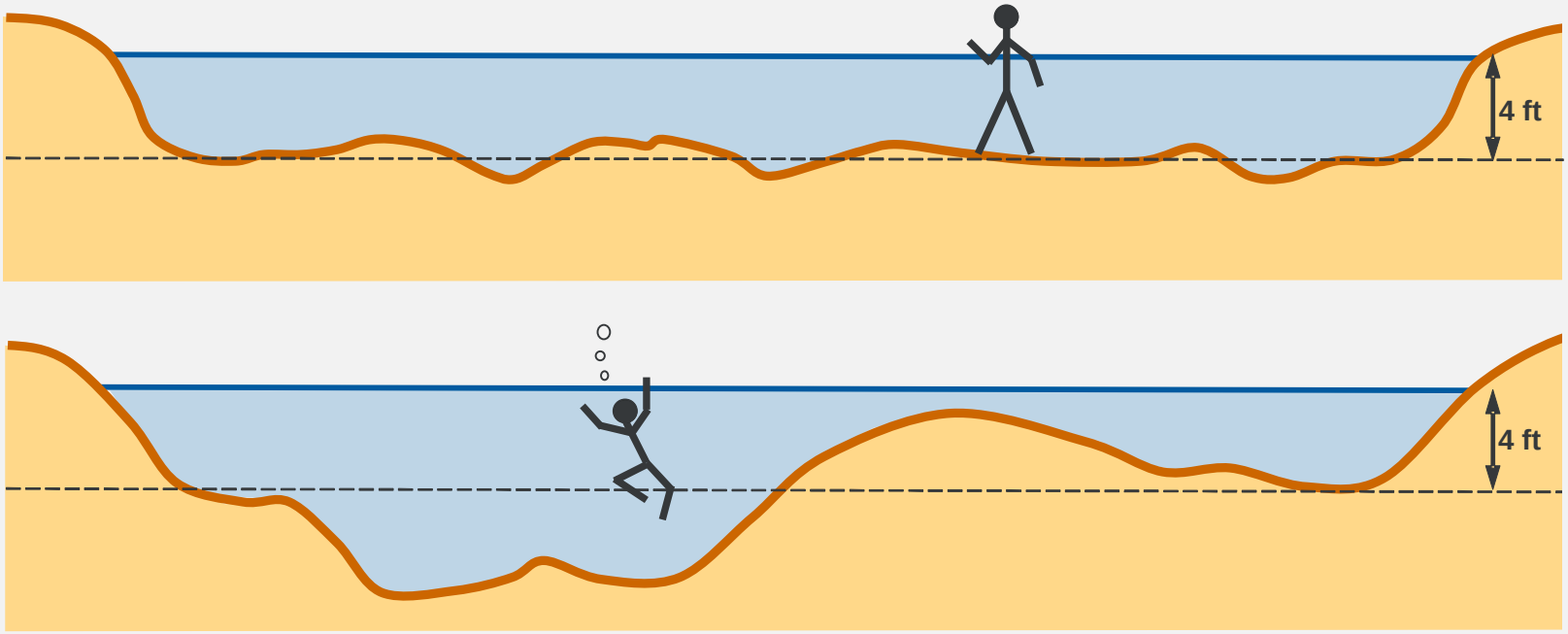
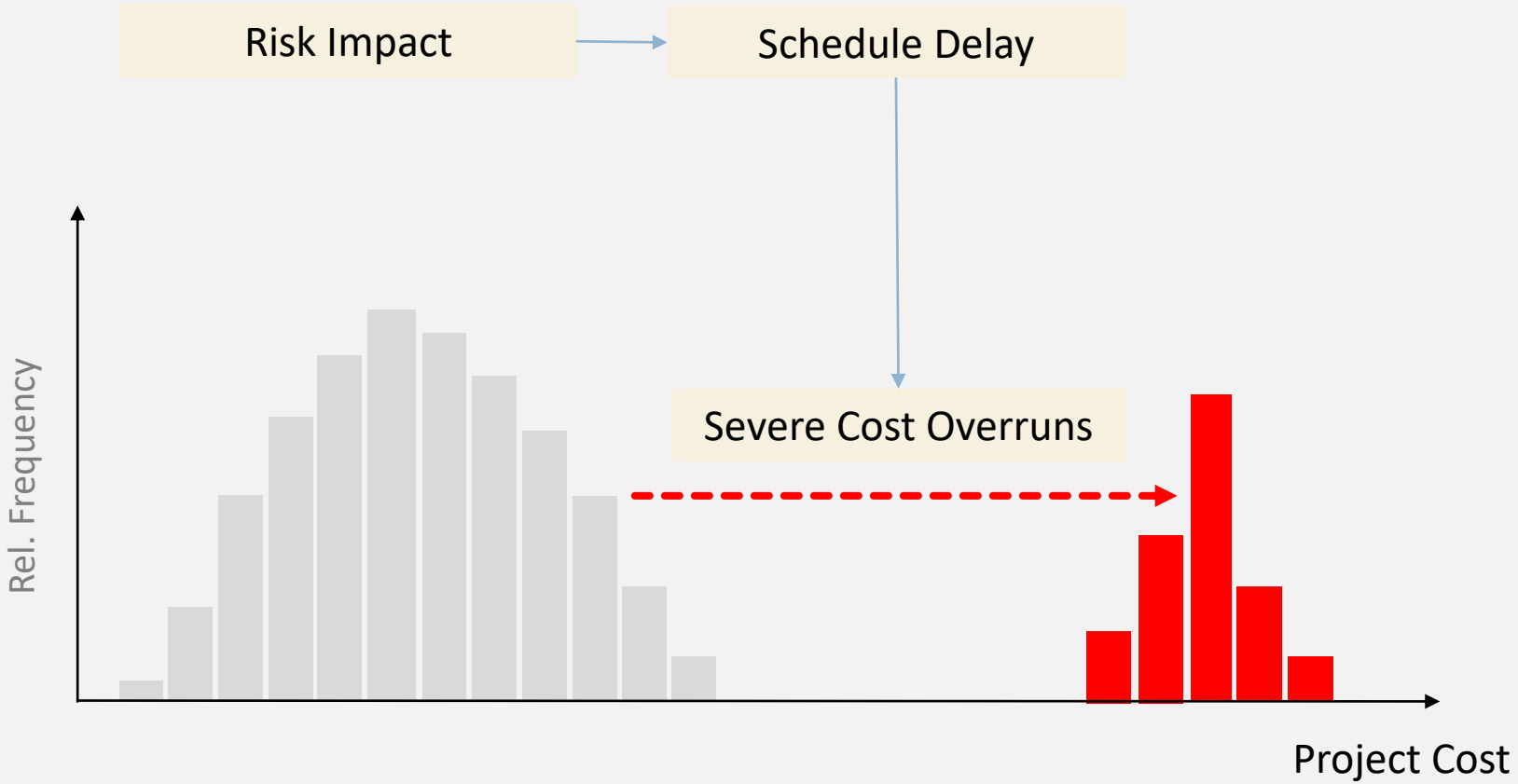
„Would you wade through a river 4 feet deep on average?"



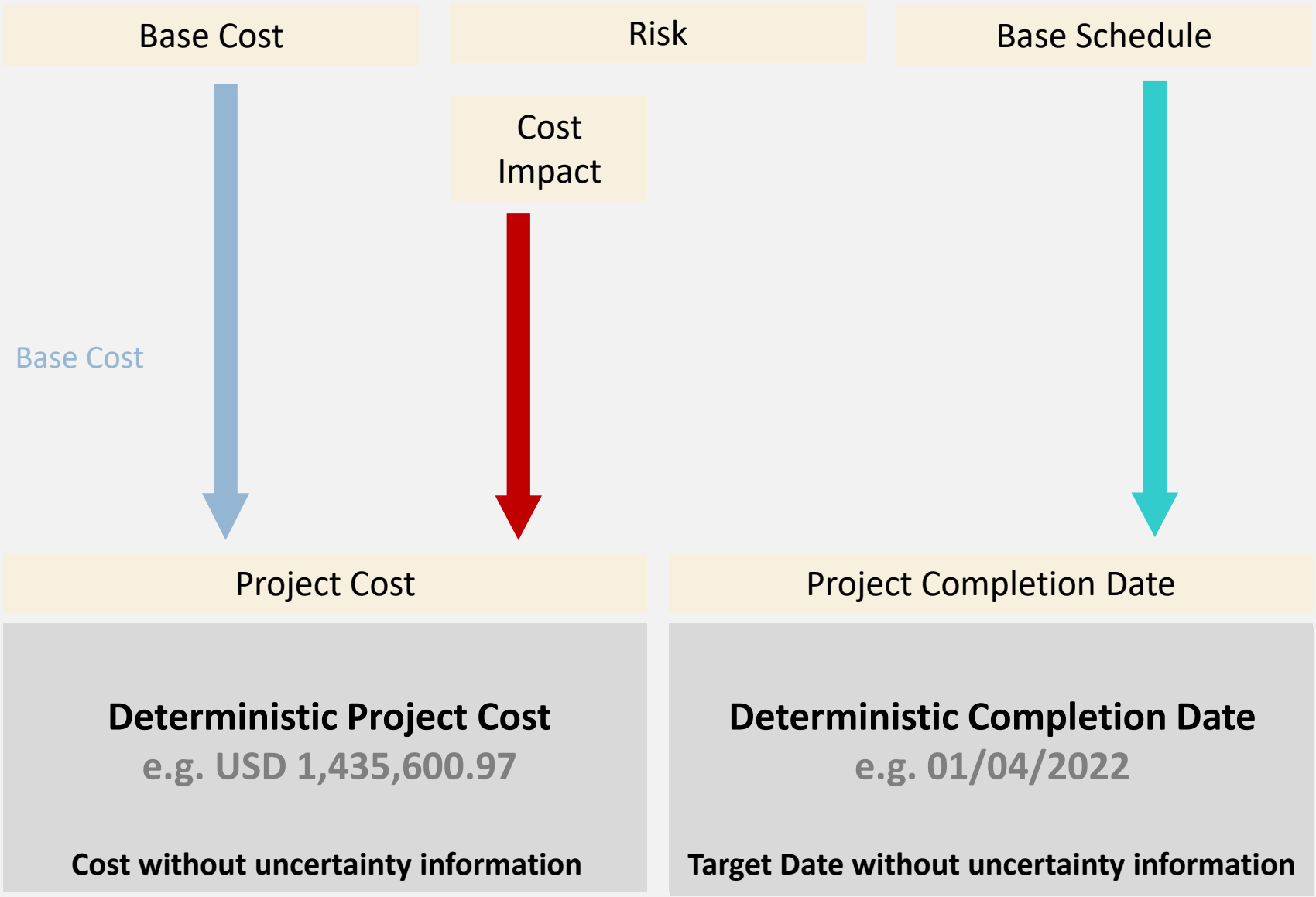
Information about uncertainty is necessary!

Nassim Nicholas Taleb: The Black Swan

Impact of Delays on Project Cost



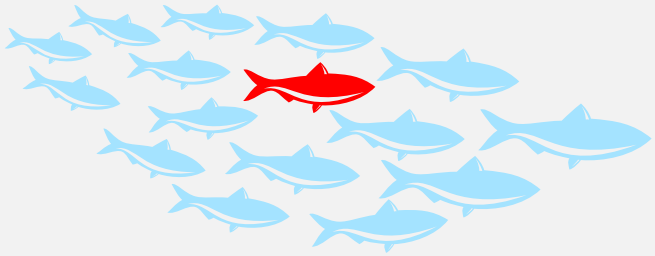
Standard Approach



Large-Scale Projects Follow Different Rules

→ Complex entities cannot be understood by breaking them down into independent parts.

Even at the simplest level, studying a fish cannot explain how a school of fish works.



complexity

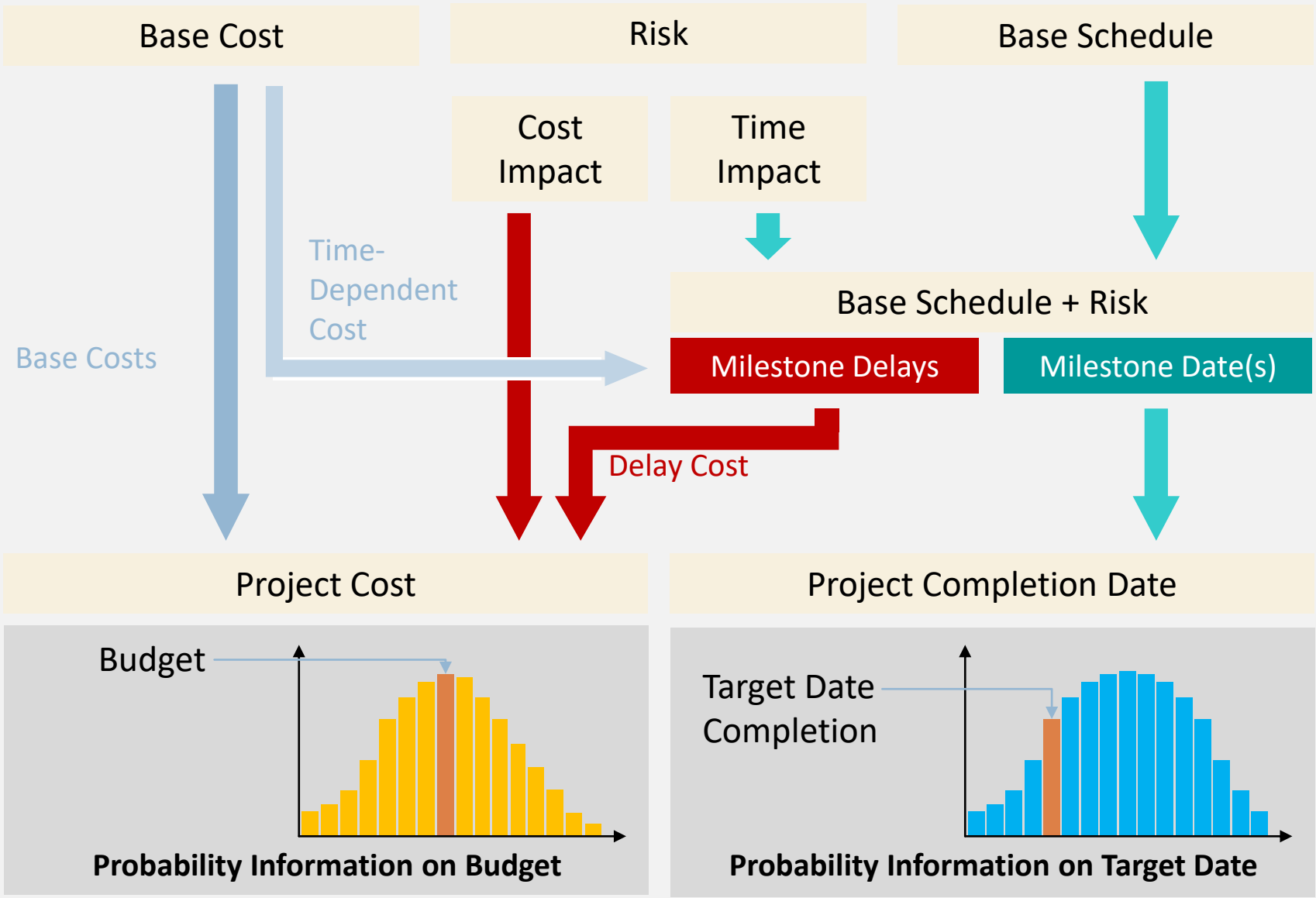
dynamics

Statement

→**Integrate cost and schedule.**

→Consider **uncertainties.**

Integrated Cost & Schedule Model



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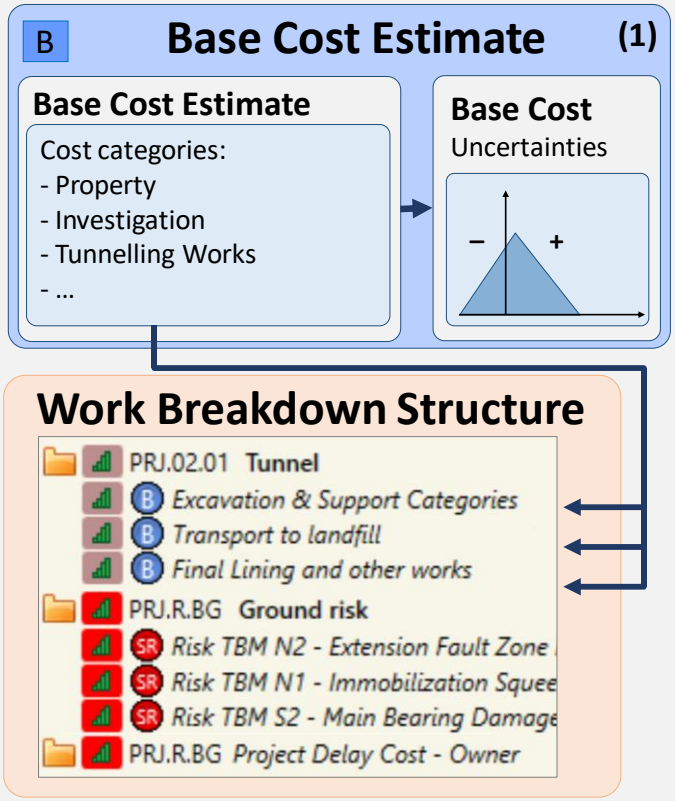
Integrated Cost and Schedule Analysis - Process



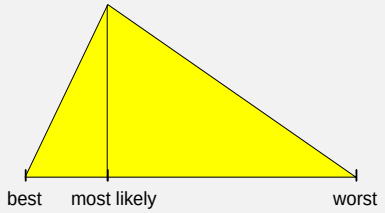
Validation of Base Cost Estimate

- Assign cost elements to WBS structure
- Review relevant Base Cost elements (quantities, prices, completeness)
- Add Base Cost variabilities (uncertainties)

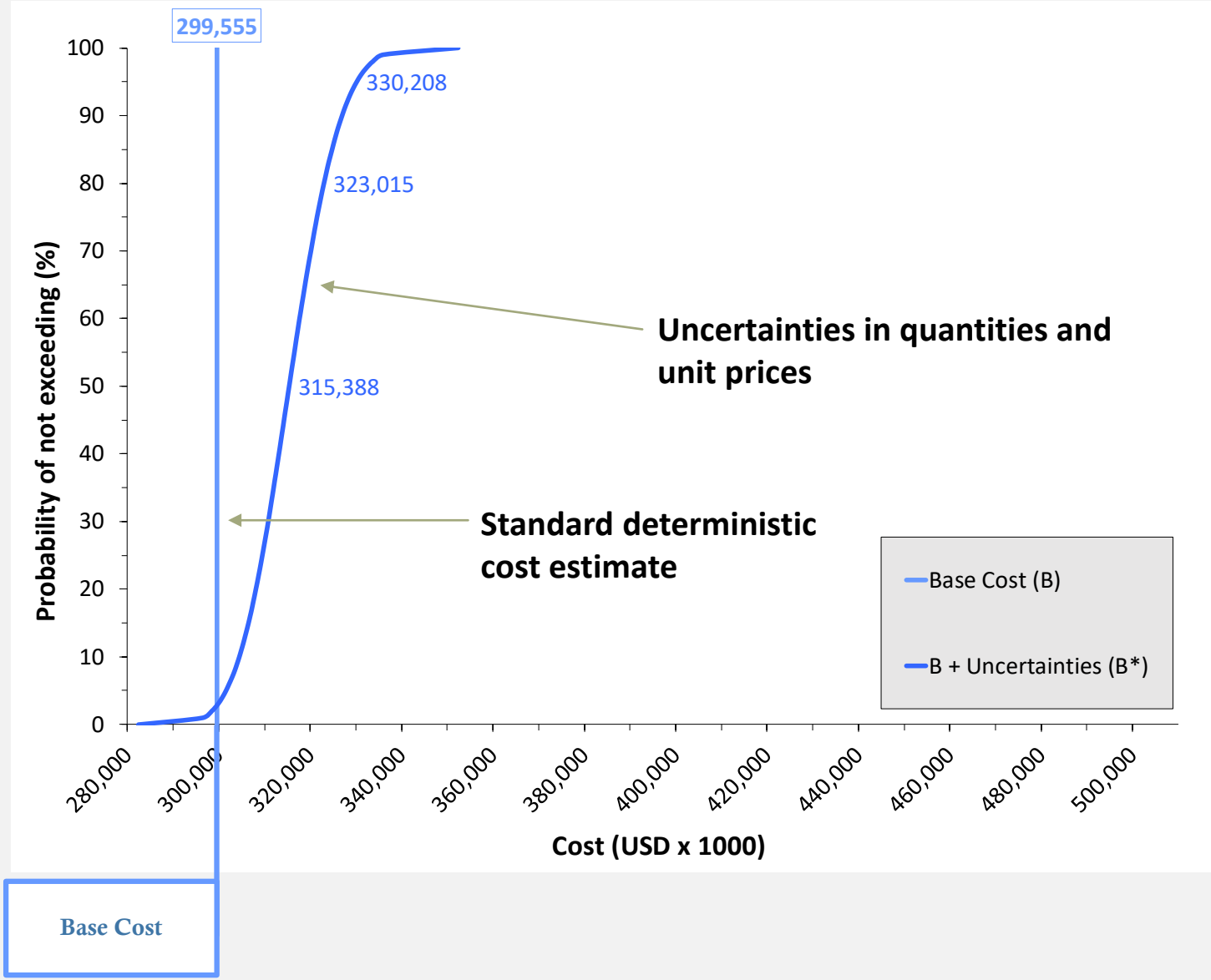
3-Point Estimate

- Reality can be described much better with bandwidths than with single numbers.
- Triangle or Beta-Pert distribution is easy to understand.
- More complex modeling is possible at any point in the process.

Triangle Distribution



Base Cost + Base Cost Uncertainty



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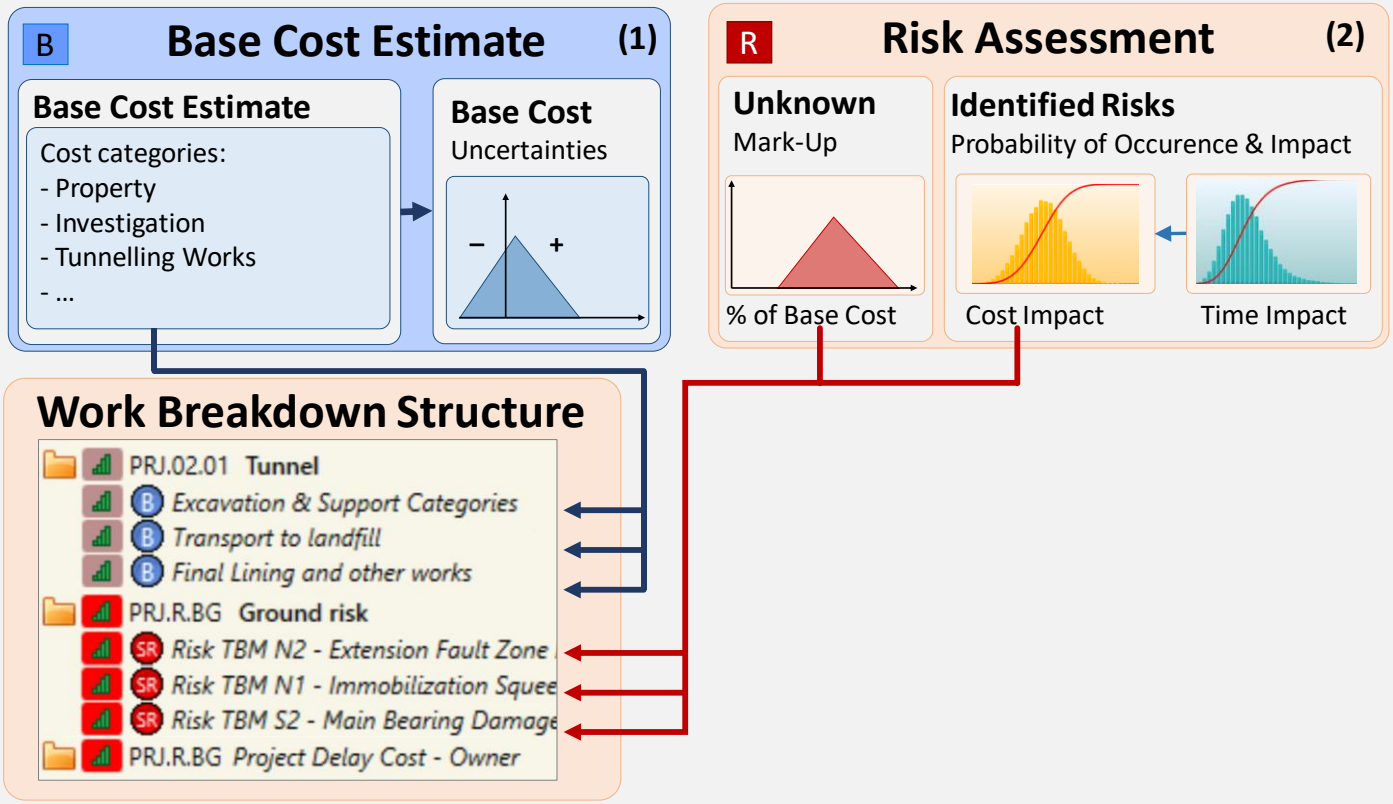
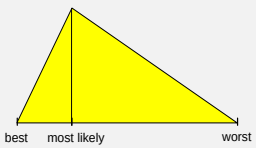
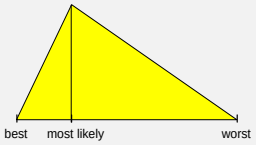


Risk Assessment Workshops

- Facilitated interdisciplinary workshops
- Identification and quantification of risks
- Populate risk register
- Supported by appropriate tools

Impact (cost and time)

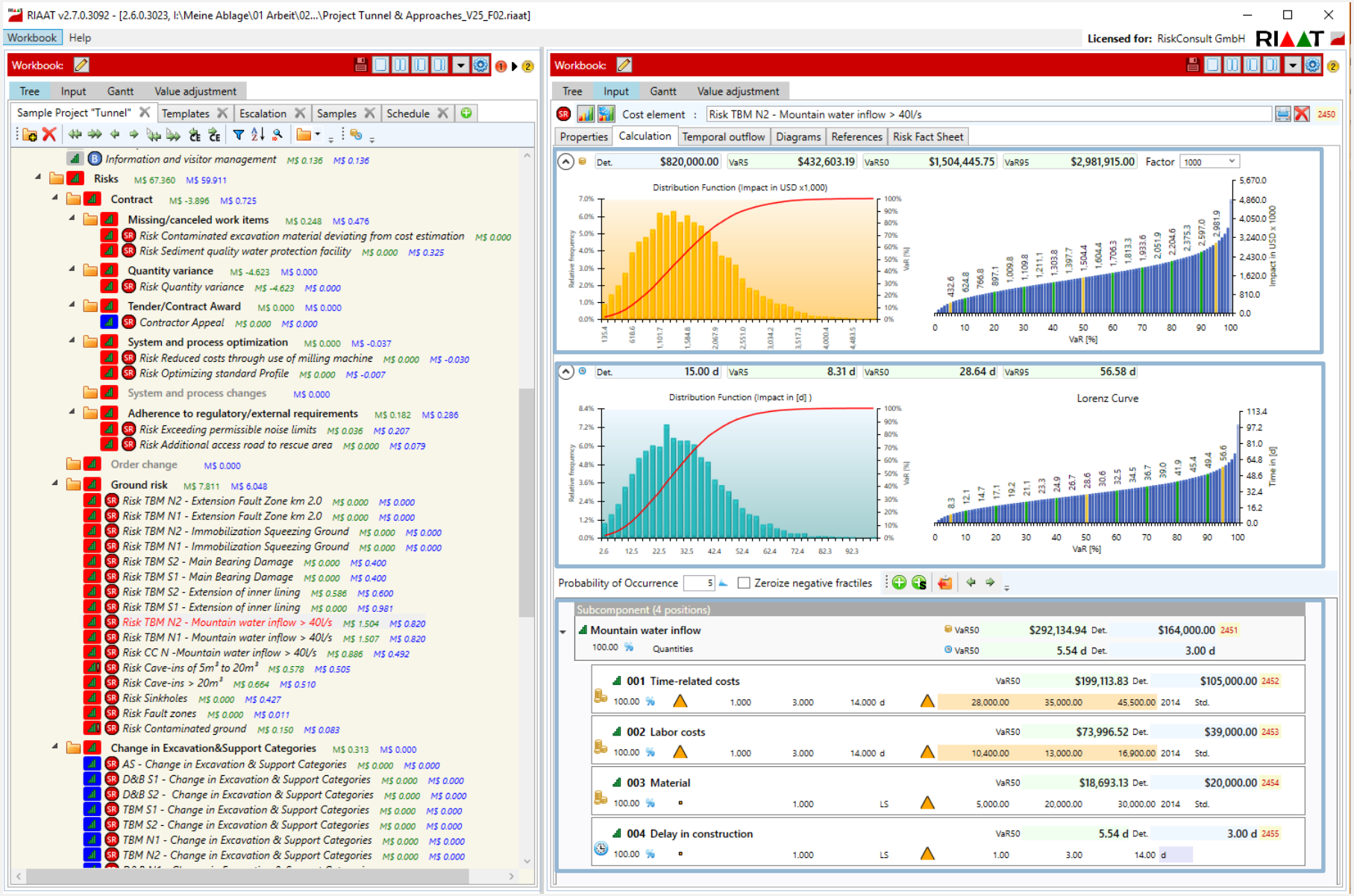




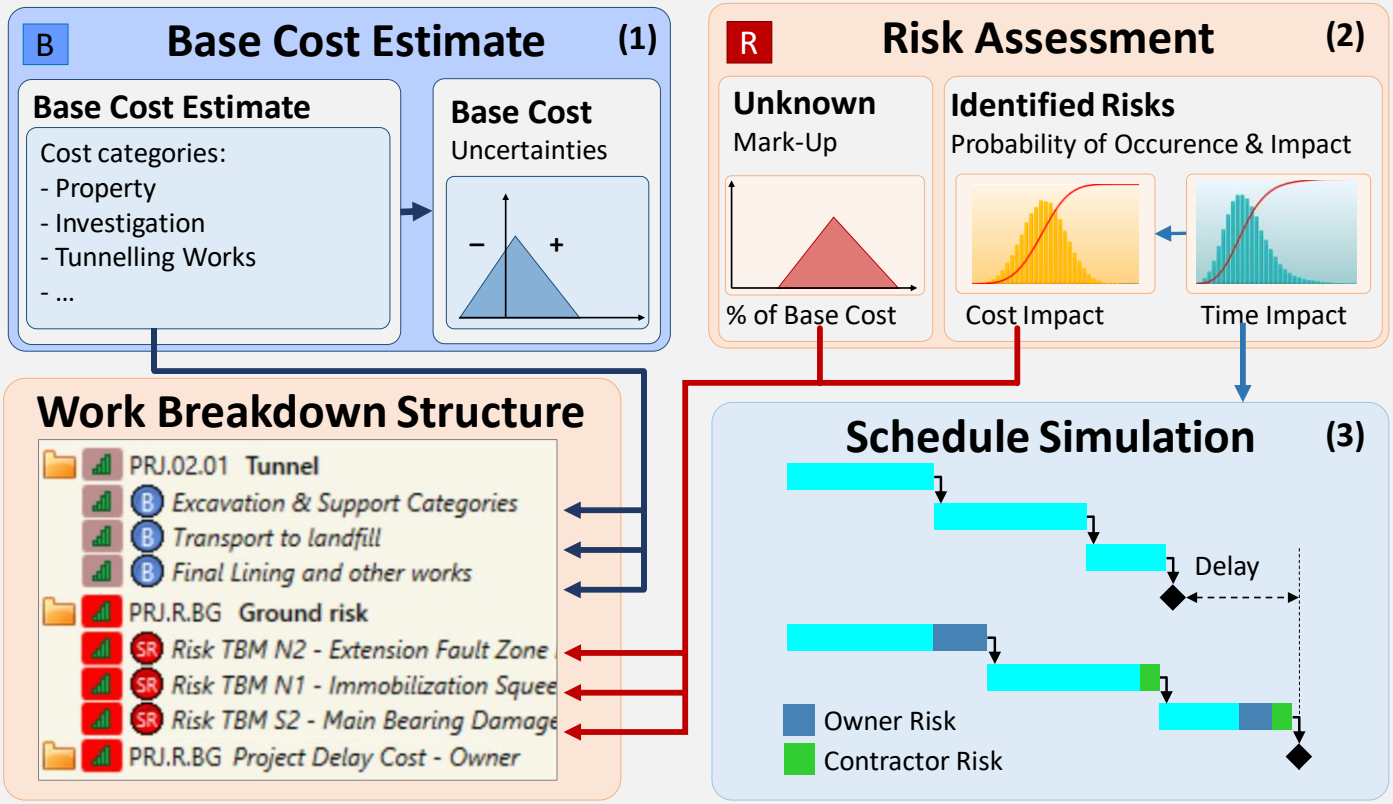
Probability of occurence (%) or expected occurrence rate (multiple occurring risks)

#	Identified Risk	Probability of Occurence	Rate of Occurence	cost impact (USD x 1000) best	cost impact (USD x 1000) most likely	cost impact (USD x 1000) worst	time impact (d) best	time impact (d) most likely	time impact (d) worst
1	TBM S2 - Main Bearing Damage	20%	-	1000	2000	3000	90	180	400
2	TBM N1 - Change in Exc.&Sup. Categ.	70%	-	500	3000	4500	20	120	180
3	TBM N1 - Immobilization Squeezing	25%	-	1500	3000	5000	60	120	200
4	Contractor Appeal	50%	-	-	-	-	30	90	180
5	No Release of Design	30%	-	225	900	1350	30	120	180
6	TBM N - Delay installation	25%	-	400	1200	2000	20	60	100
7	Extension Fault zone km 2.0	80%	-	0	840	1660	0	42	83
8	TBM S2 - Extension of inner lining	-	3	150	200	250	5	10	20
9	Logistic Problems Crosscut S (13-25)	30%	-	150	375	600	20	50	80
10	CC N - Mountain water inflow >40l/s	-	3	222	886	1782	1	3	14

Integrated Cost and Schedule Analysis

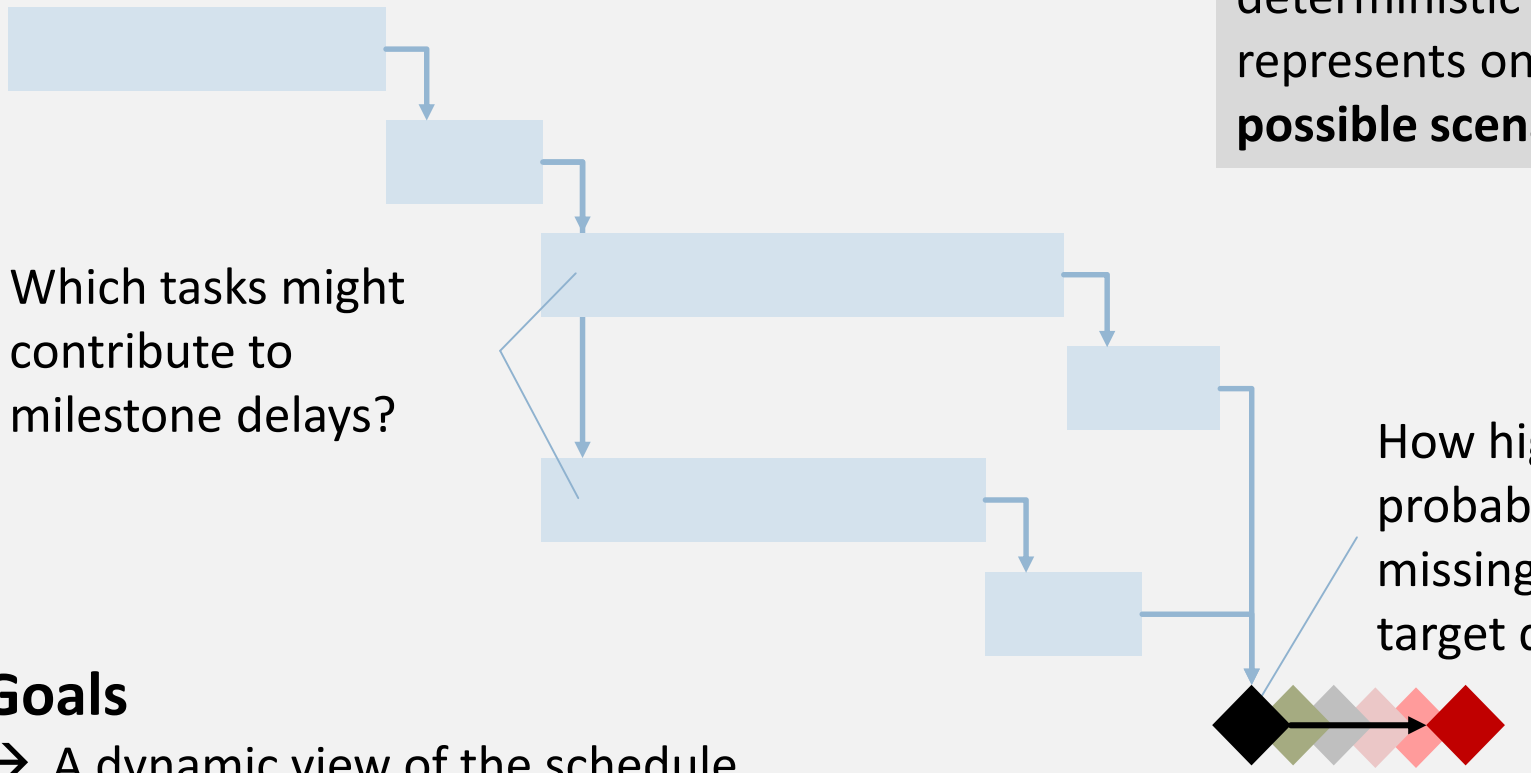


Integrated Cost and Schedule Analysis - Process



Deterministic Schedule Approach

The classic deterministic schedule represents only **one possible scenario**.



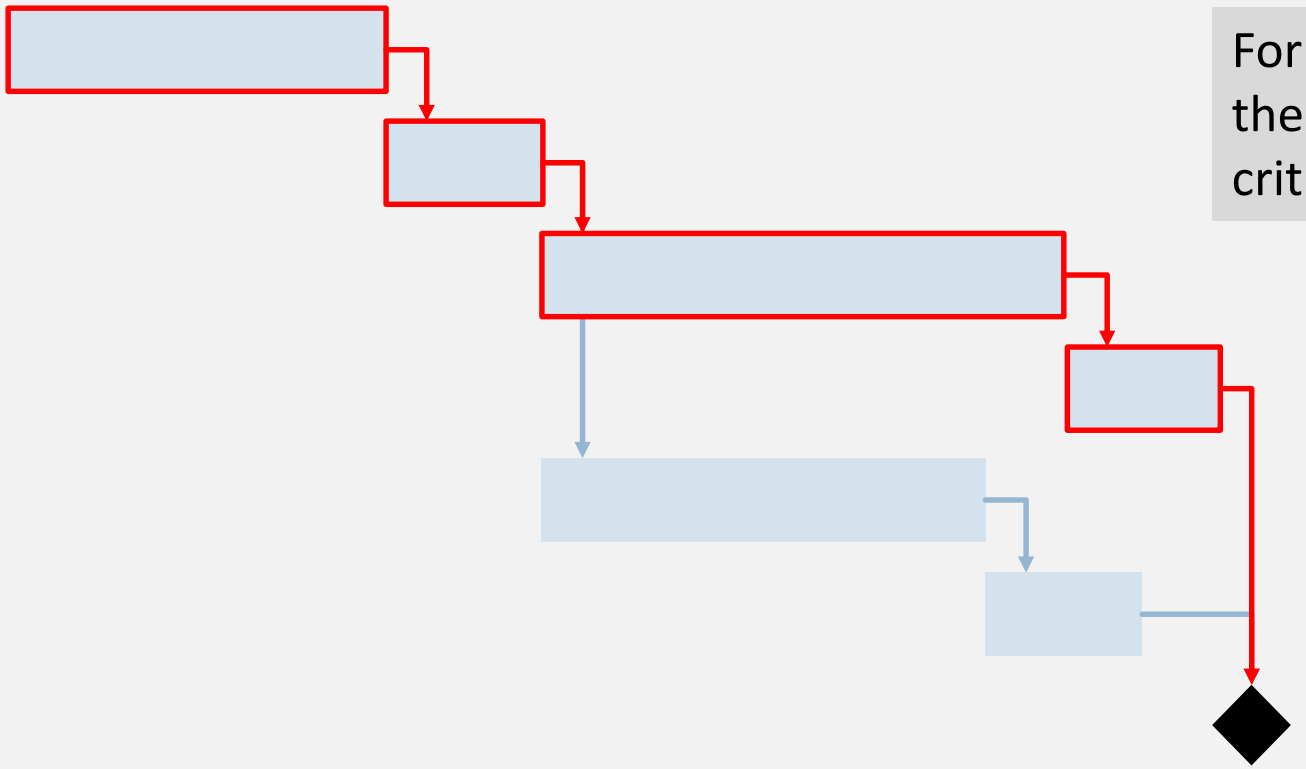
Which tasks might contribute to milestone delays?

How high is the probability of missing the target date?

Goals

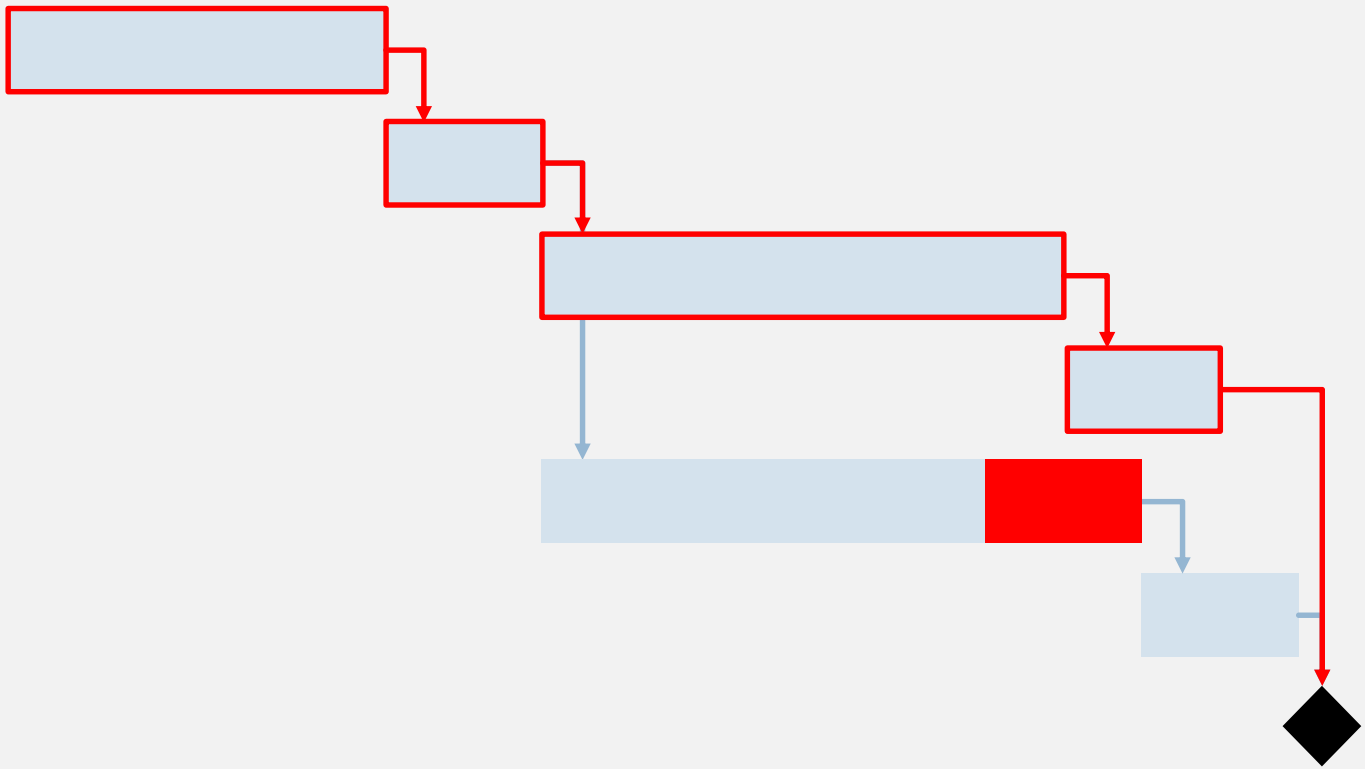
→ A dynamic view of the schedule
→ Integrate risks – link them to tasks
→ Implement risk mitigation measures based on results of the schedule analysis
→ Optimize construction processes

CPM in Deterministic Schedule



For **one** scenarios there is only **one** critical path.

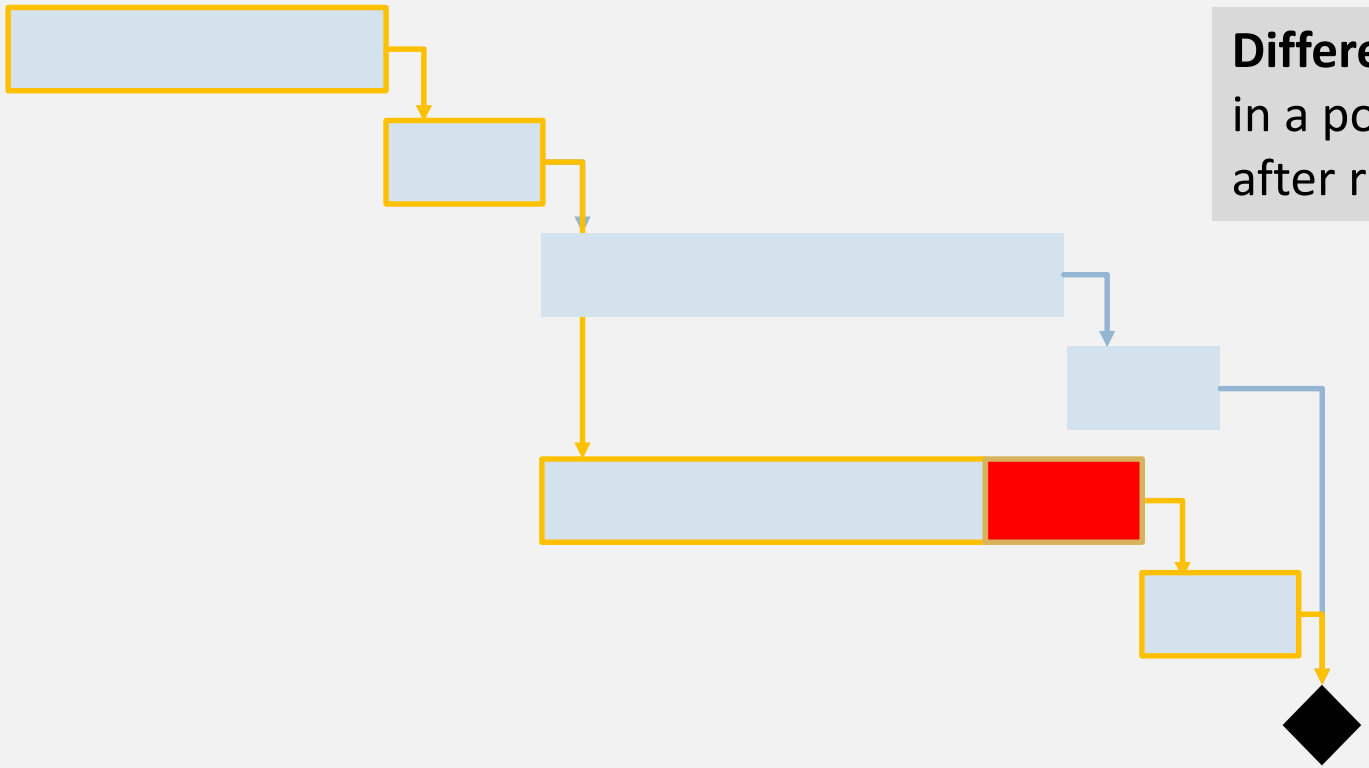
Critical Path Shifting due to Risk Impact



What If

risk impacts change task durations?

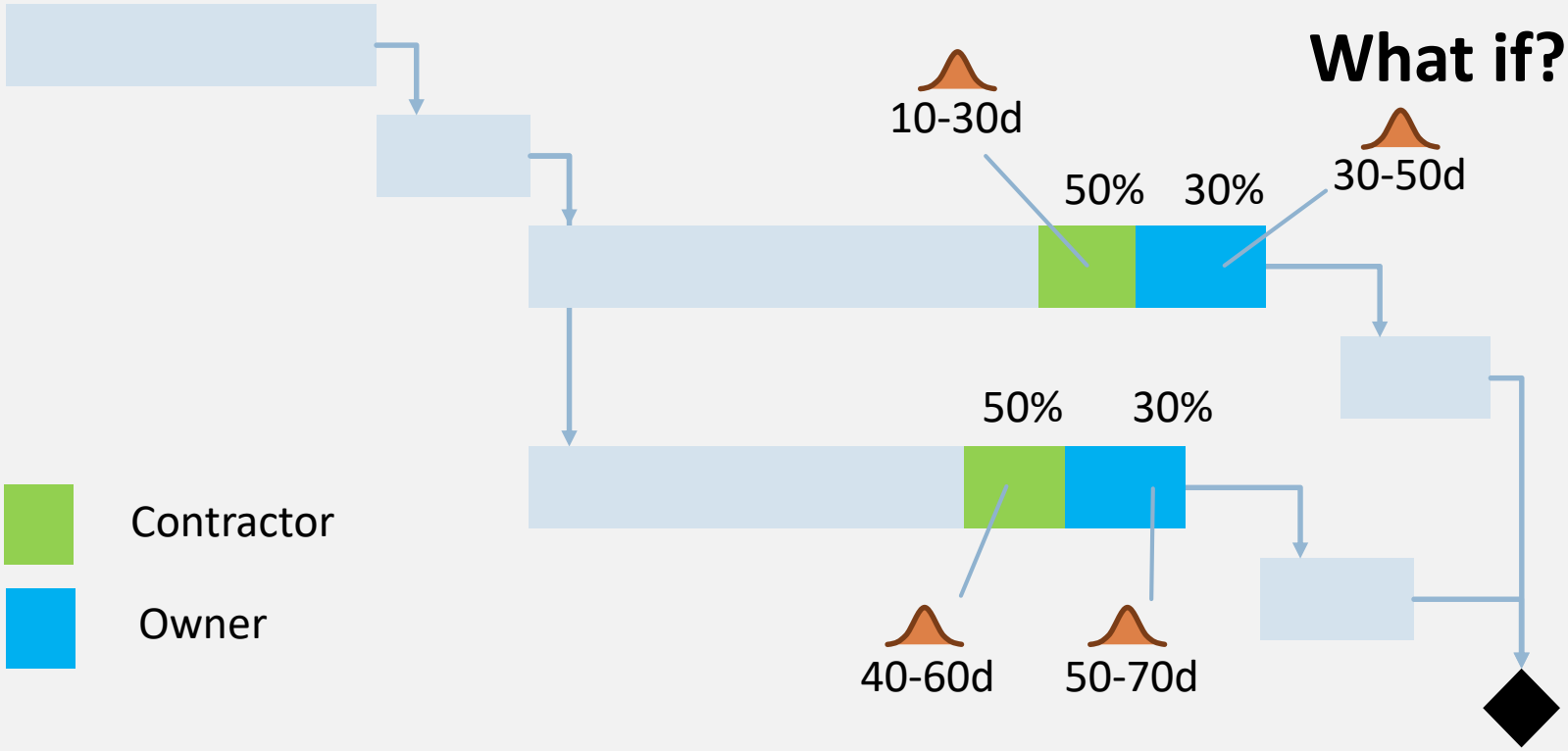
Critical Path Shifting due to Risk Impact



Different critical path in a possible scenario after risk impact(s).

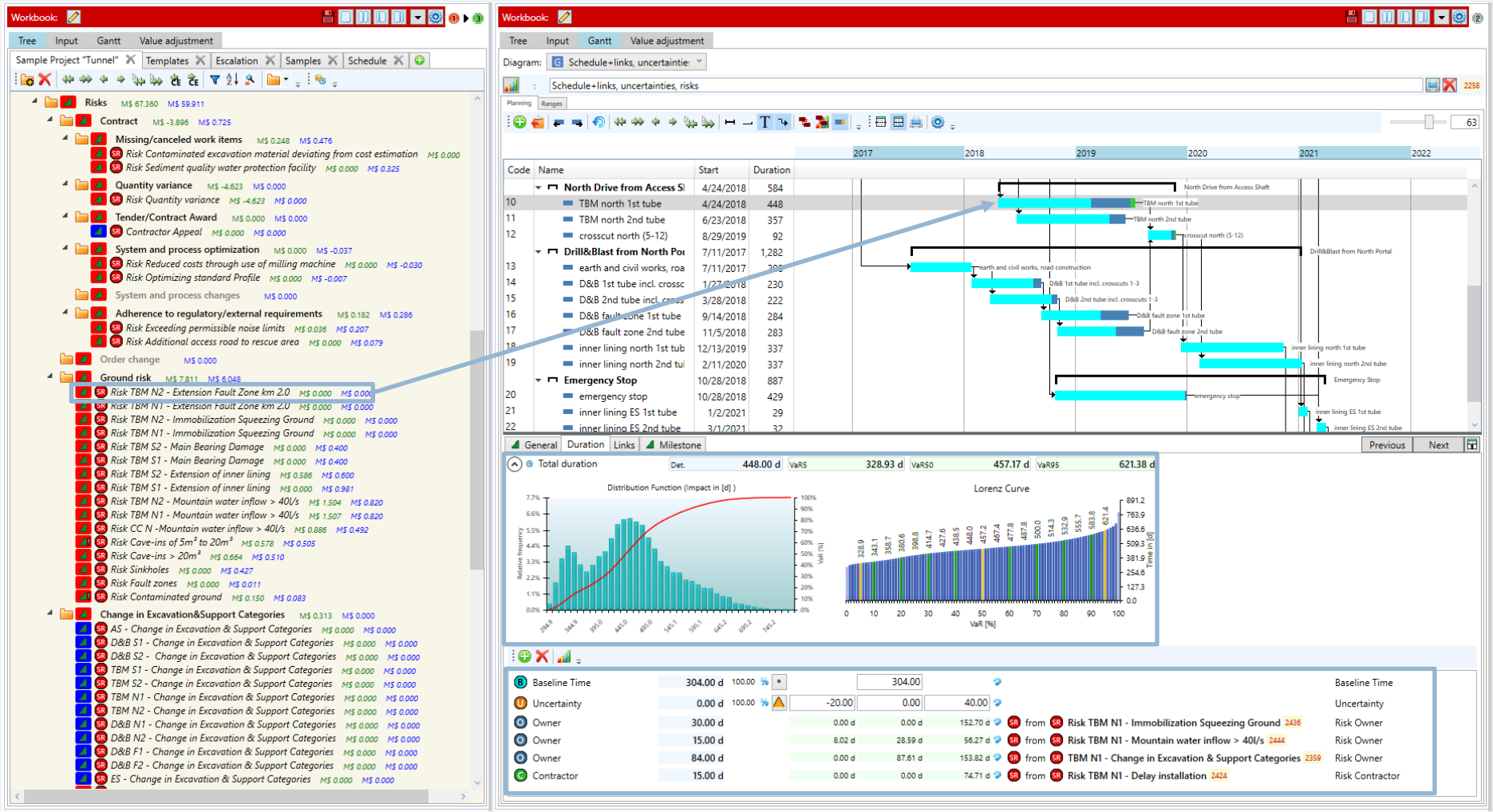
Assigning Risks to Tasks

#	Identified Risk	Probability of Occurence	Rate of Occurence	time impact (d) best	most likely	worst
1	TBM S2 - Main Bearing Damage	20%	-	90	180	400

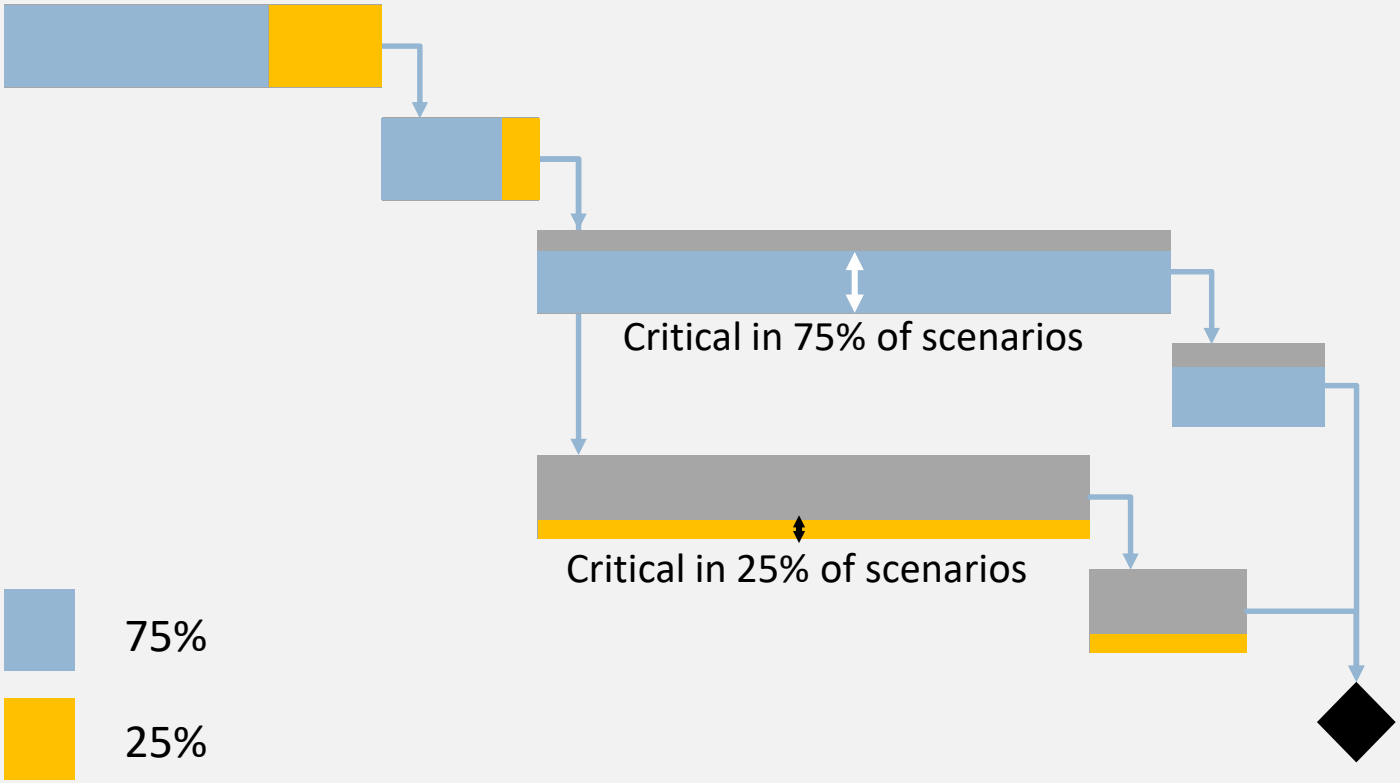


→ Monte Carlo simulation will generate thousands of realistic scenarios, each depicting a possible project outcome.

Application: Assigning Risks to Schedule Activities



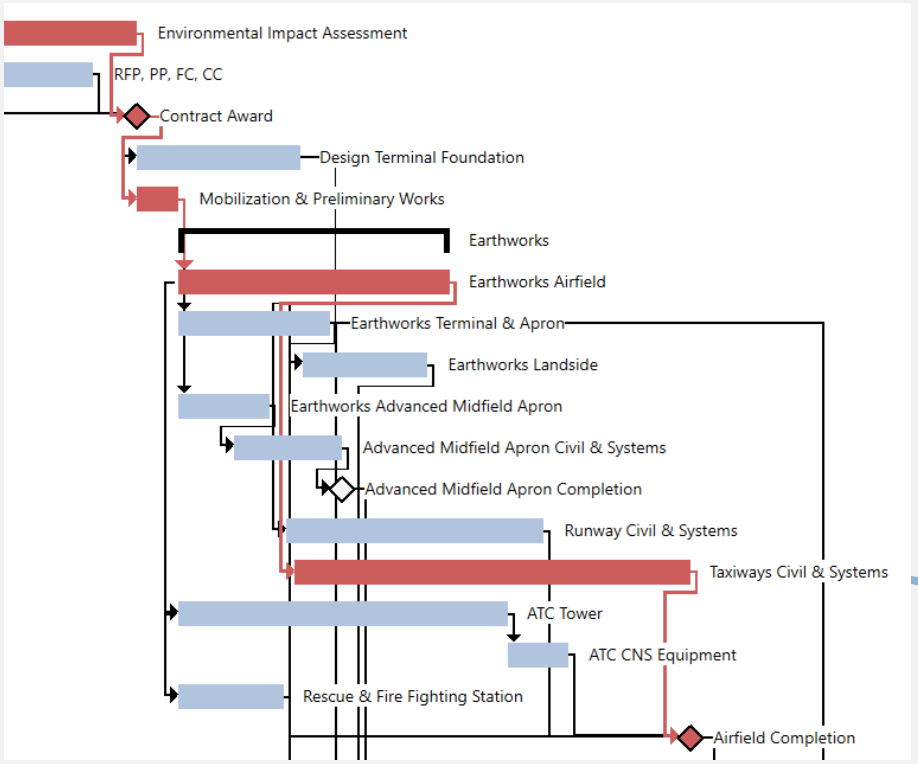
Critical Paths after Monte Carlo Simulation



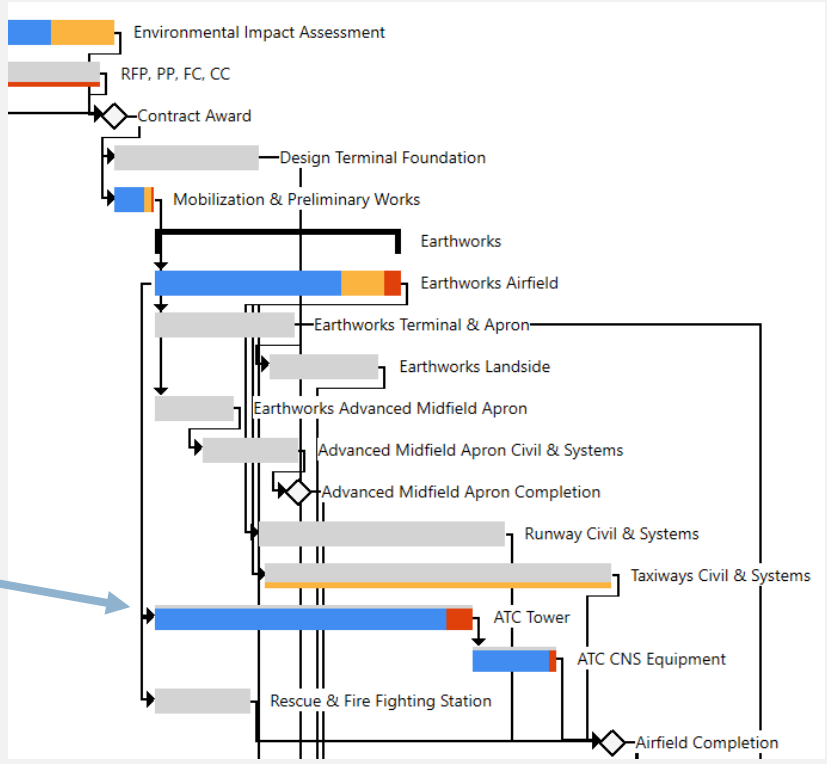
→ Due to uncertainties, **numerous** critical paths become possible, each with a different probability.

Example: Lima Airport Extension Project

Base Schedule



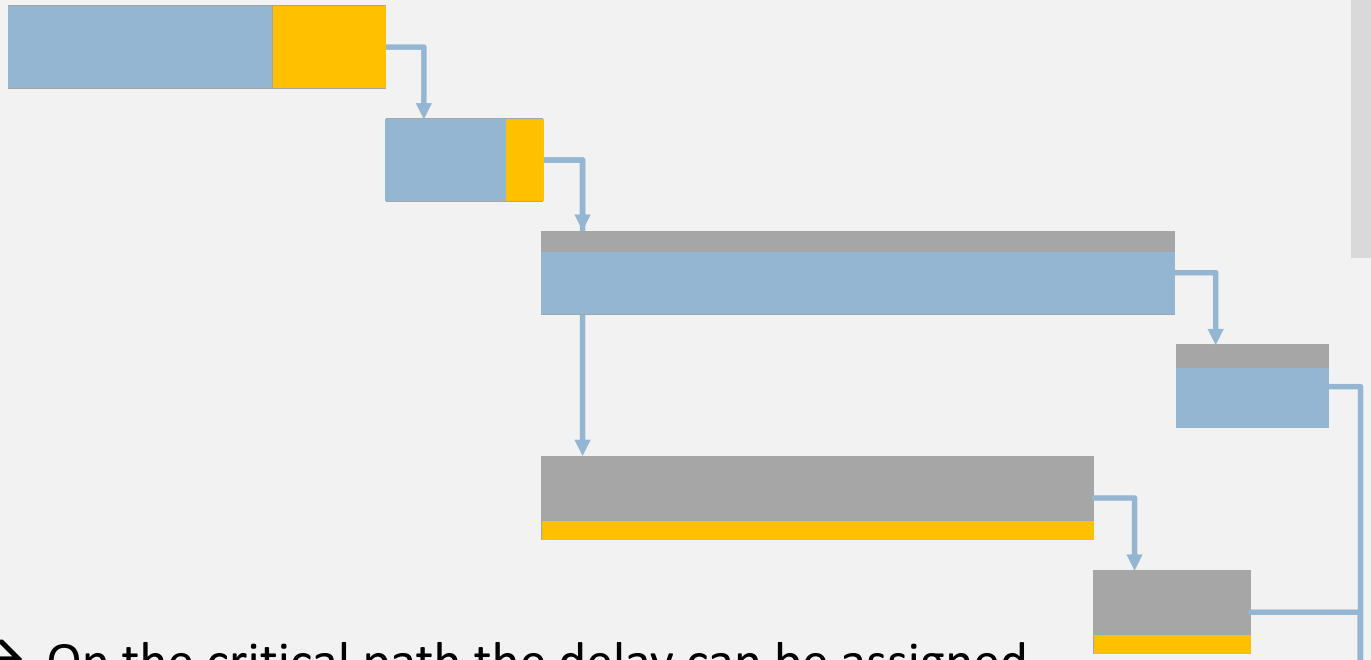
Base Schedule + Risk

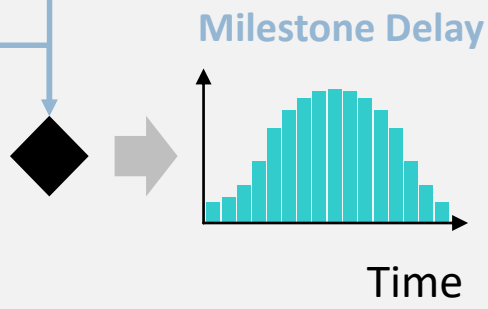


Main critical path is changing to ATC tower due to risk impact

Milestone Results after Monte Carlo Simulation

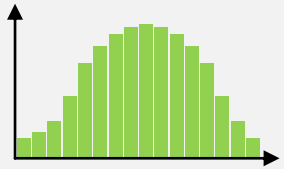
Each simulated scenario yields a different milestone delay, with respect to a given target date.



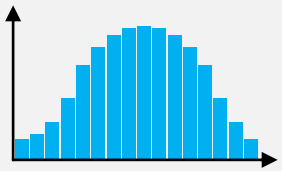


→ On the critical path the delay can be assigned to different responsibilities (cost components):

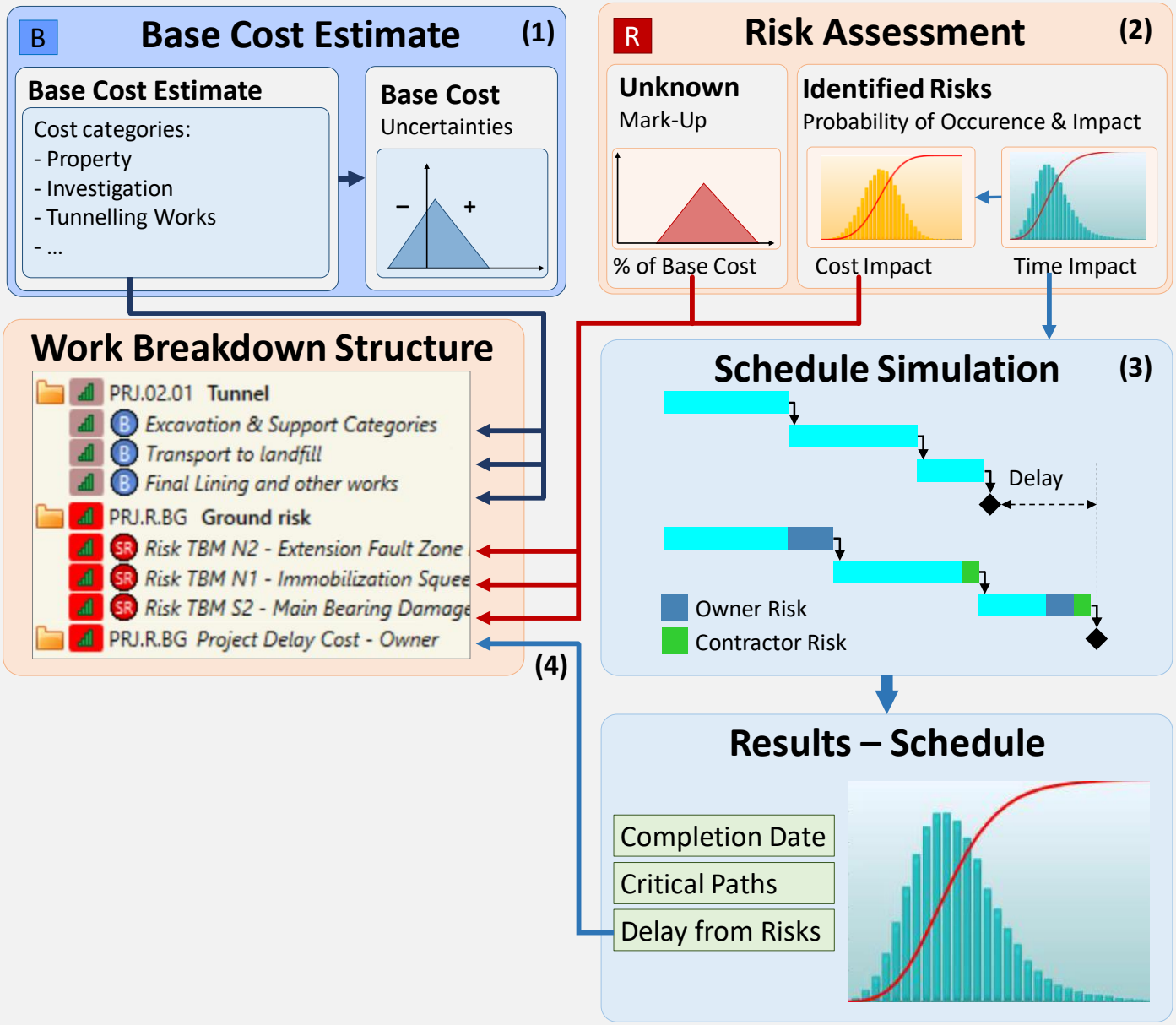
Contractor Delay



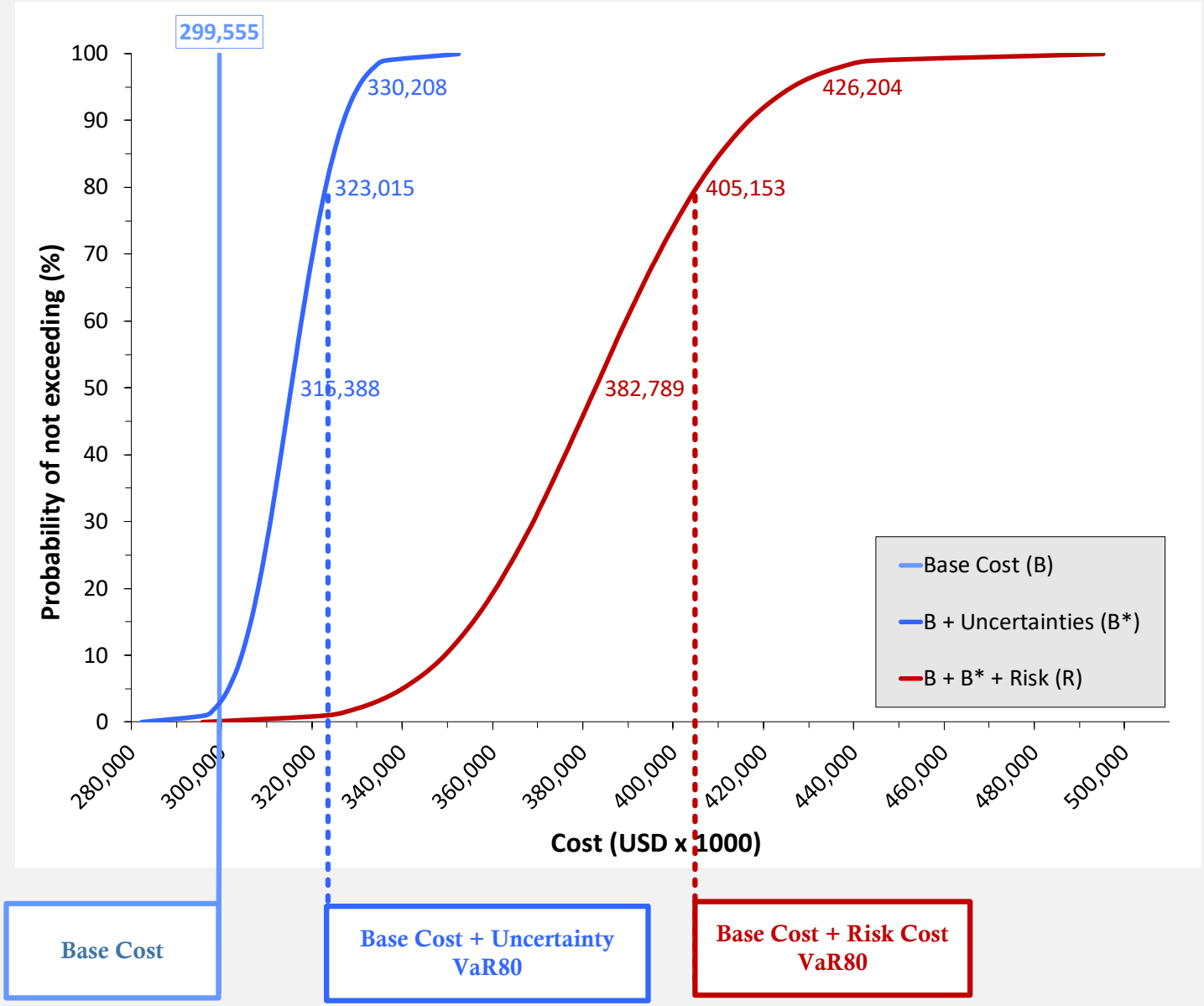
Owner Delay



Integrated Cost and Schedule Analysis - Process



Base Cost + Base Cost Uncertainty + Risk



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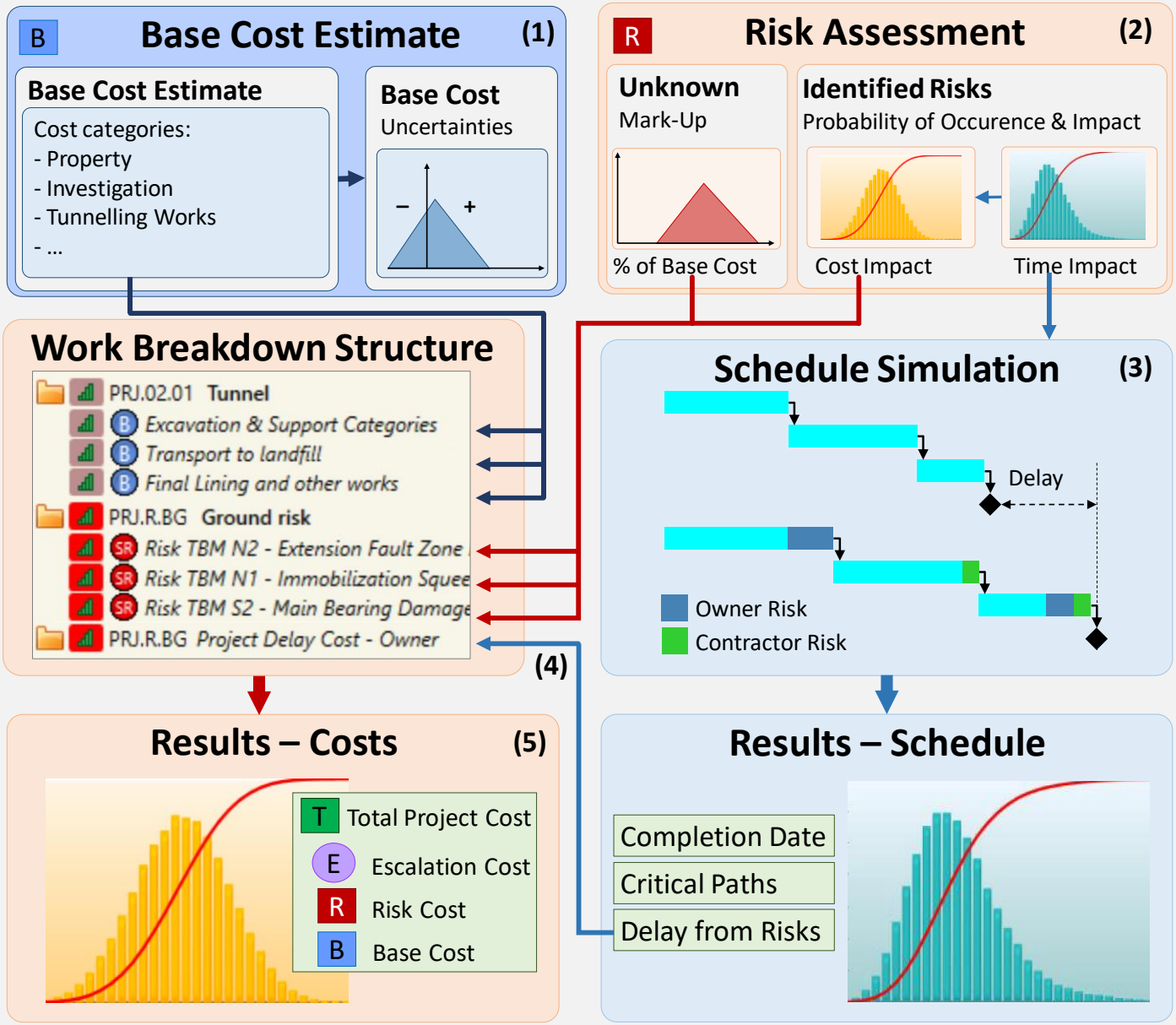
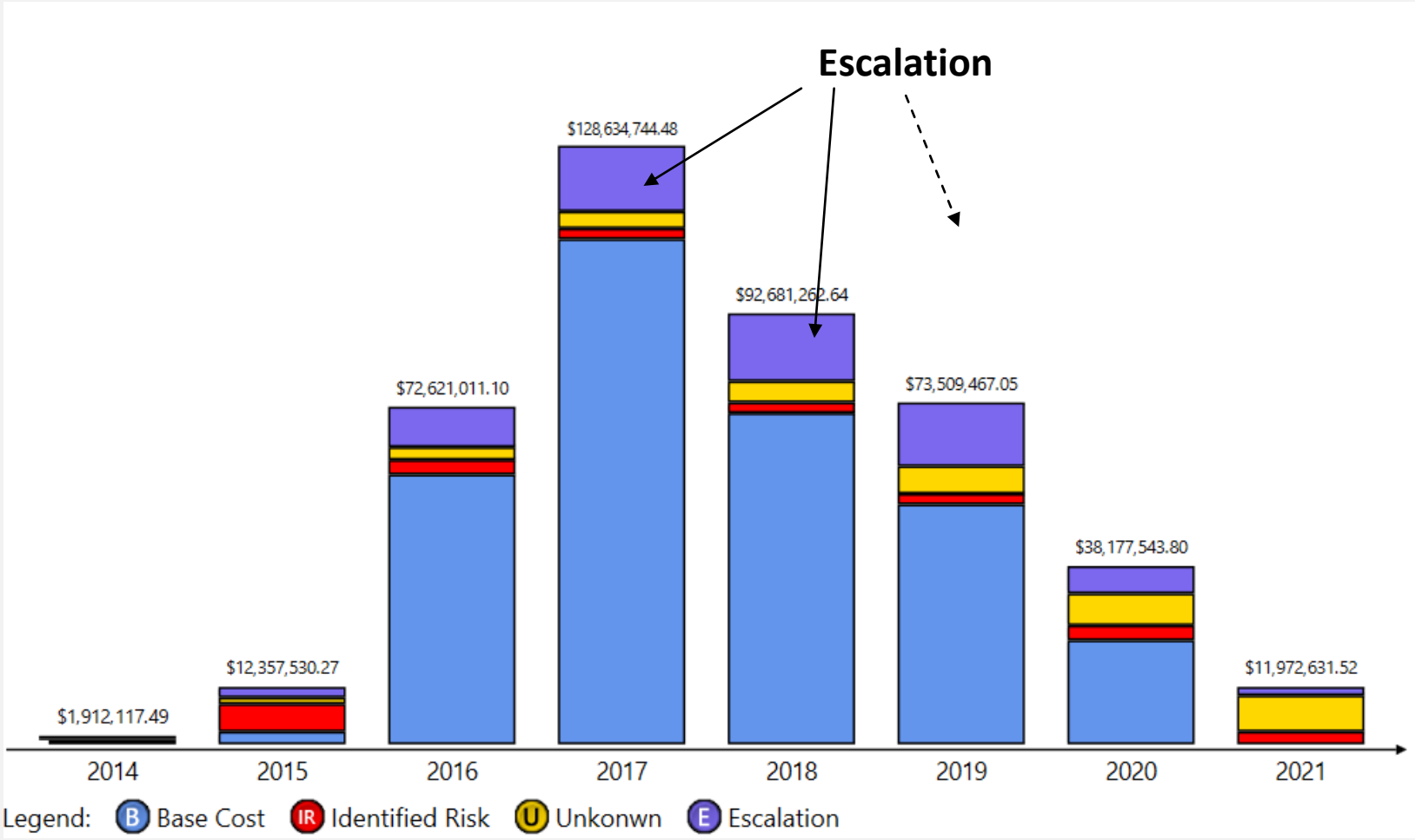
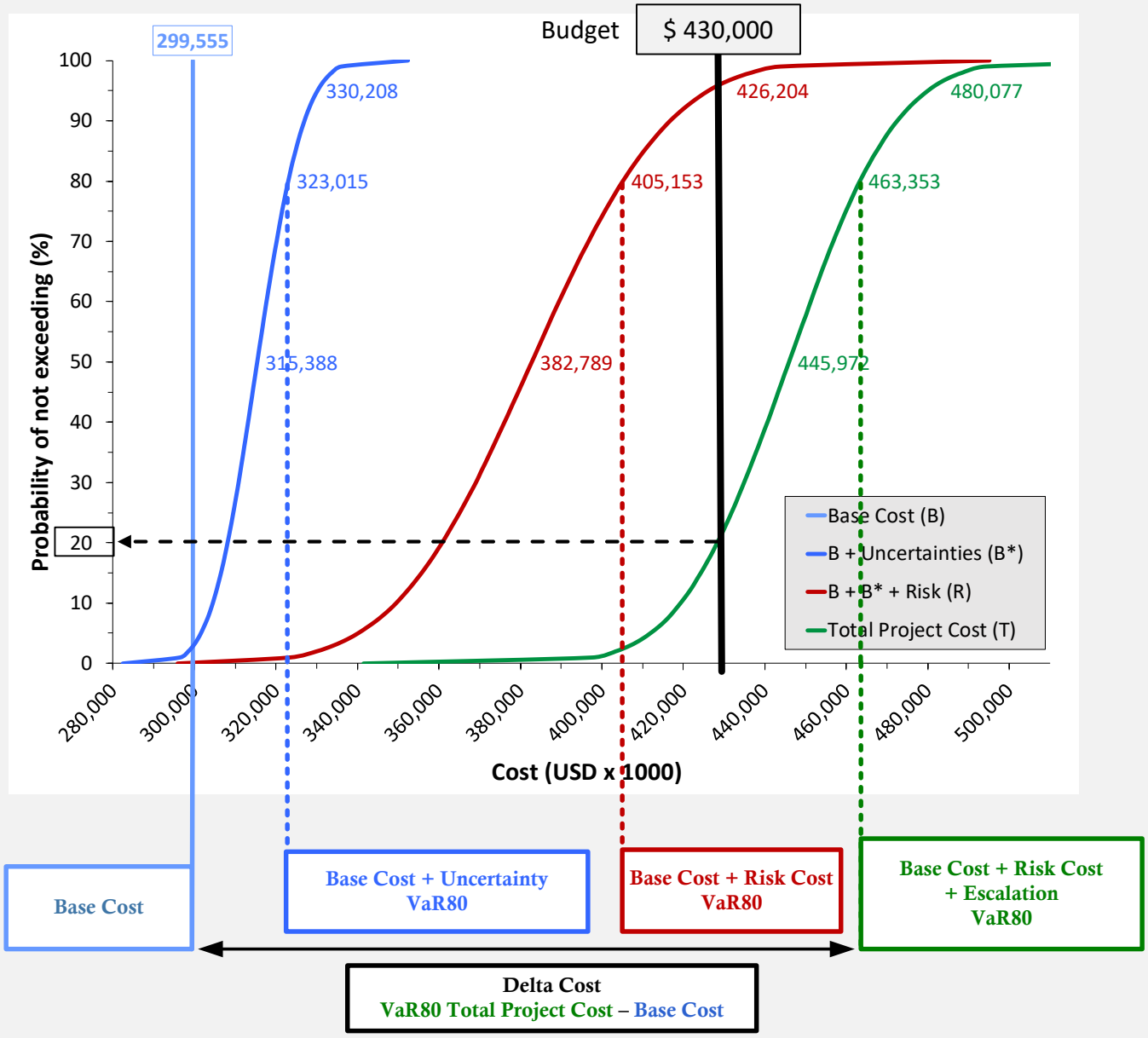


Escalation calculated from Cash Flow

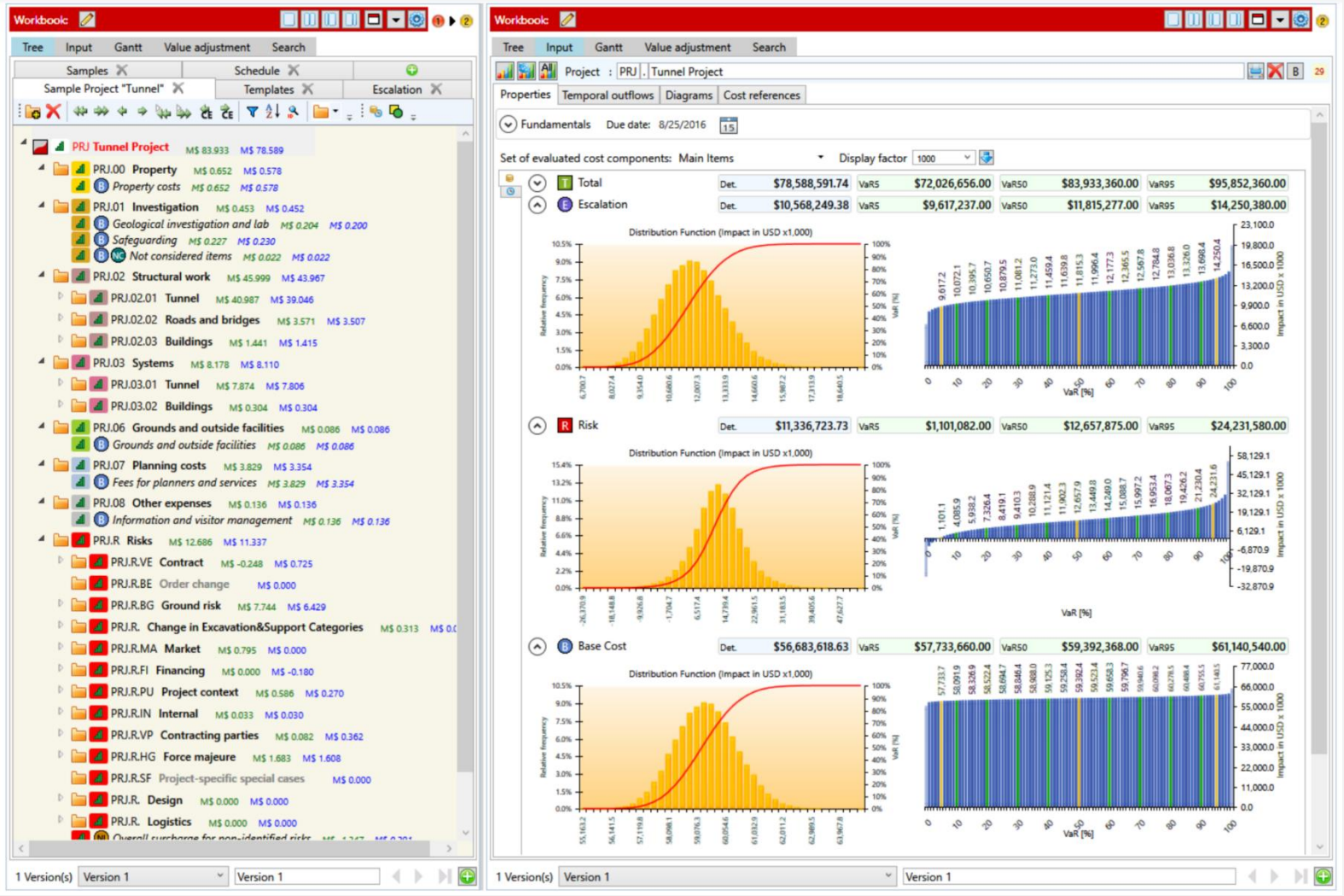


Total Project Costs



Results in RIAAT – Risk Administation and Analysis Tool

RIAAT is an advanced project management software, which integrates and links information from **cost management**, **risk management** and **schedule planning.**



Further Information: http://riaat.riskcon.at

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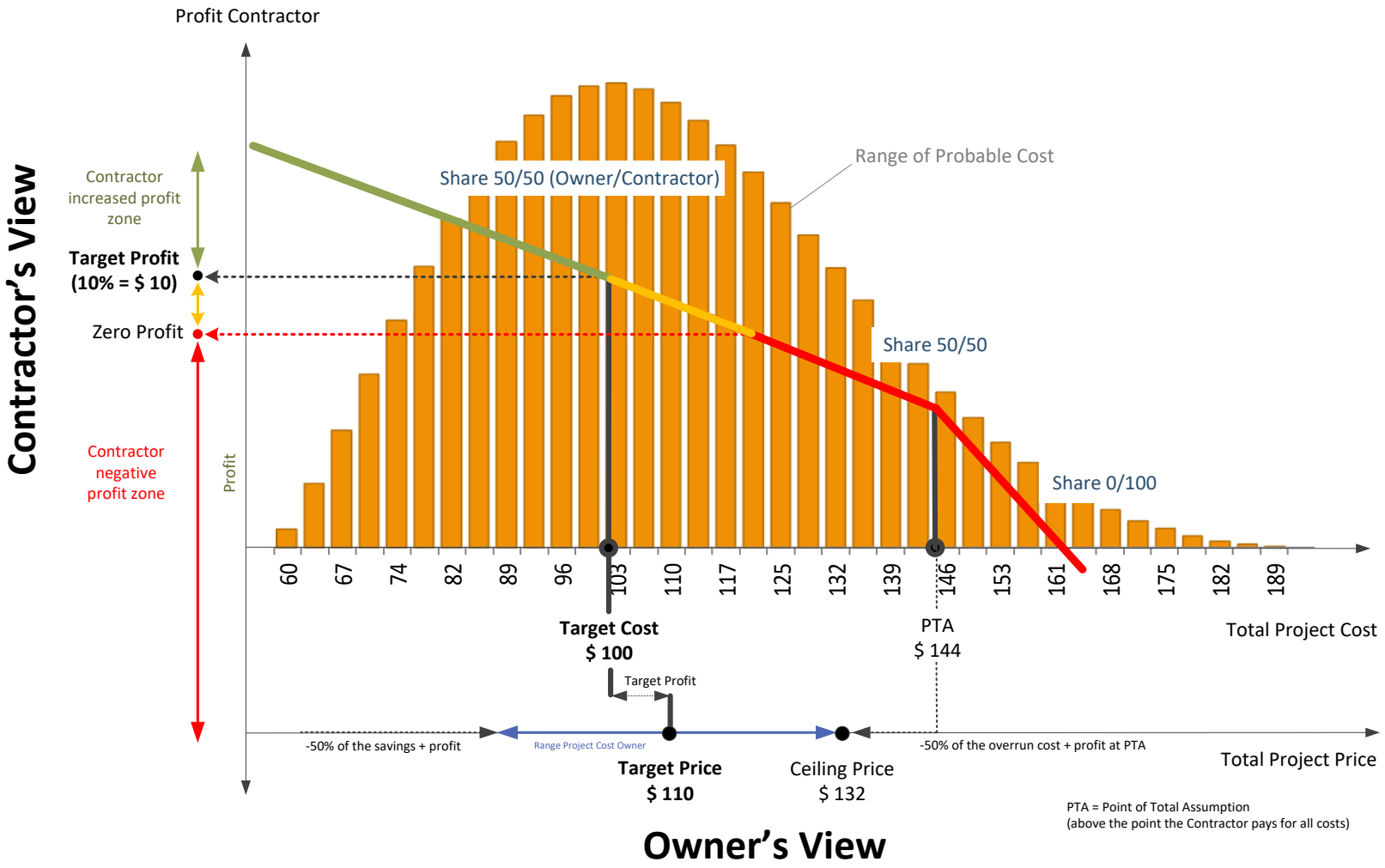
Alternative Delivery Methods – Fix Price Incentive Fee (FPIF)

- The delivery method is a critical determinant
- We need to match the delivery process to the project environment (considering risk, applicable regulations, agency practice, experience and capability)
- Delivery procedures generally used for Infrastructure:
  - Design-Bid-Build (DBB) – most common
  - Design-Build (DB) – substantial number of projects
- Newer delivery procedures being used or of interest:
  - Early Contractor Involvement
  - **Fixed Price Incentive Fee**
  - Alliancing / Relationship / Consensus Contracting
- Other international contract applications (FIDIC, NCE-3c, PPC2000 Docs)

Alternative Delivery Methods – Fix Price Incentive Fee (FPIF)



Alternative Delivery Methods – Fix Price Incentive Fee (FPIF)