

San Francisco Peninsula Rail Program Executive Steering Committee

Item 7 - Downtown Rail Extension Project Quantitative Risk Analysis and Capital Cost Estimating Processes

June 17, 2022



San Francisco
County Transportation
Authority

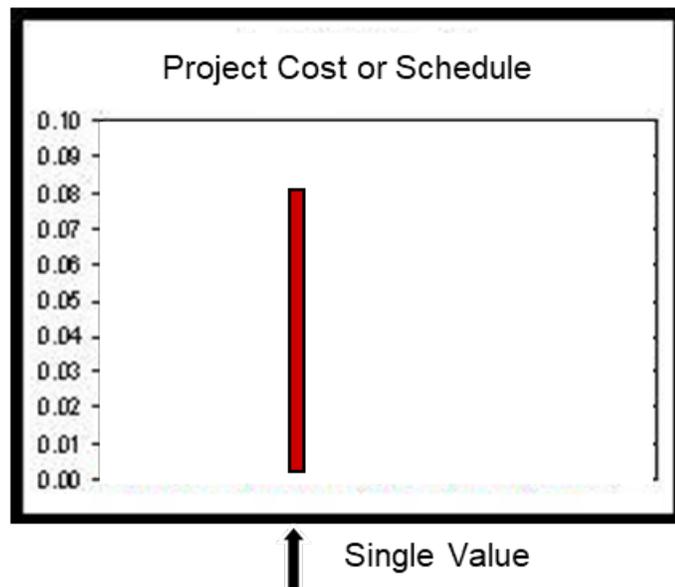
Agenda

- Quantitative Risk Analysis
- FTA Risk Assessment Process
- Capital Cost Estimating Process

Quantitative Risk Analysis (QRA)

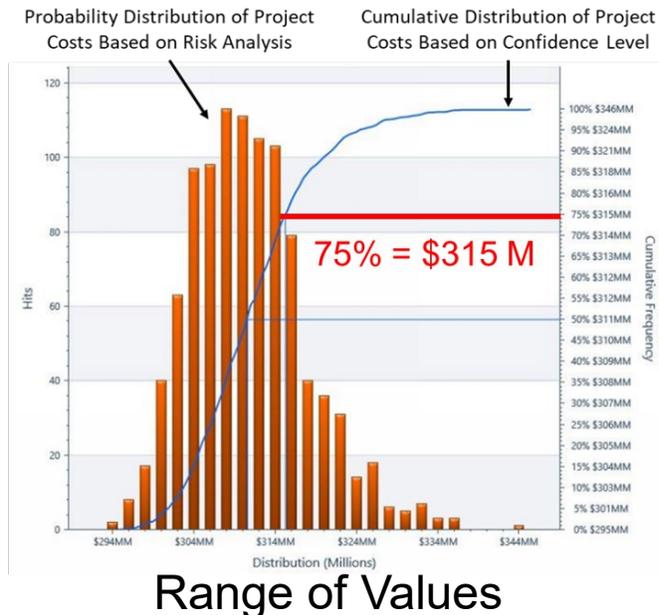
- Produces a numeric estimate of the overall effect of risk on the project cost and schedule
- Considers both **uncertainty** and **risks**
- Examines **confidence** levels and provides the basis for determining **contingency**

Static Model

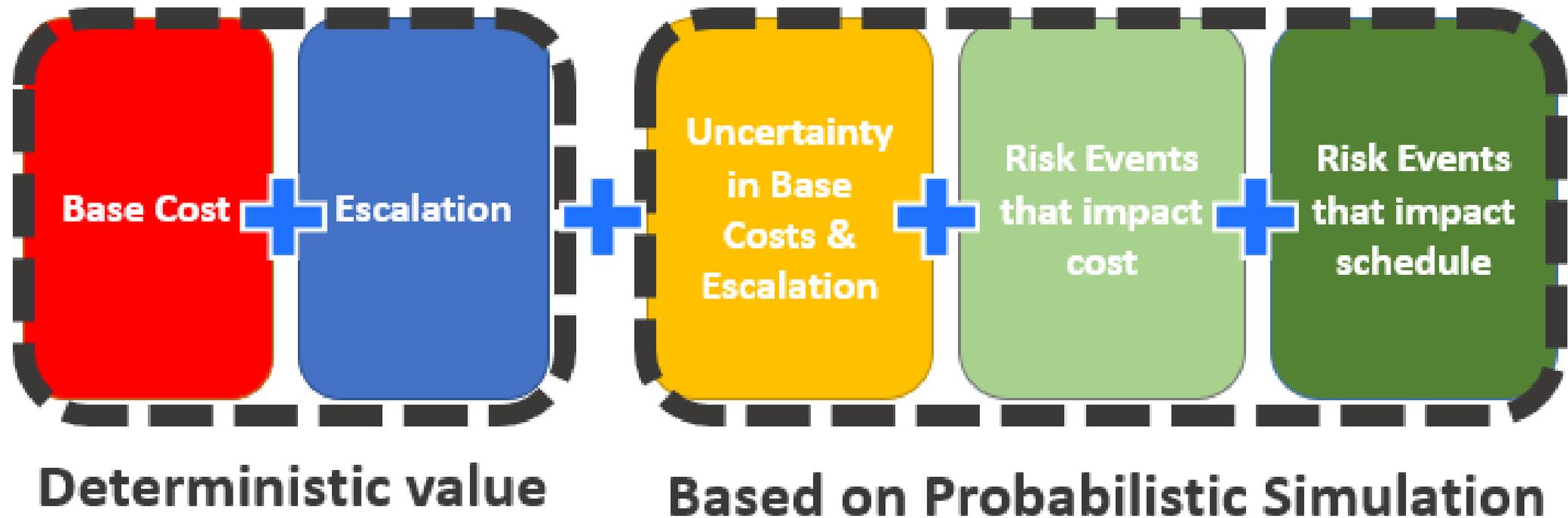


VS.

QRA Model



Components of Contingency



Probability and Consequence Basis for QRA

- Risk / opportunity details
- Initial risk state
 - Pre-mitigation risk analysis / assessment
- Mitigated risk state
 - Mitigation measures required (if any)
 - How effective do you think they will be?

Example of probability and consequence risk matrices

Probability of Occurrence

Rating	Description	Probability
5	Very high	> 75%
4	High	50-75%
3	Medium	25-50%
2	Low	5-25%
1	Very low	< 5%

Severity / Consequence

Rating	Life Safety (L)	Schedule (S)	Cost (C)
5	Loss of Life	> 6 months	> \$10M
4	Permanent Disability	3-6 months	\$5-10M
3	Lost Time Injury	1-3 months	\$1-5M
2	First Aid	0.5-1.0 months	\$0.5-1.0M
1	None	< 0.5 months	< \$0.5M

Example of risk scoring / ranking for the purposes of assessment

		Probability/Likelihood				
		1	2	3	4	5
Consequence / Severity	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Unacceptable - eliminate or mitigate
Undesirable - minimize and/or control
Acceptable - subject to MV concurrence

Comprehensive Risk Register

Starting point

Risk / Opportunity Details

Initial State

Mitigated Risk State

Responsibilities

Risk ID	RISK EVENT	RISK CAUSES / DRIVERS	POTENTIAL CONSEQUENCE	Opportunity (Op) Risk (Risk)	INITIAL ASSESSMENT					PROPOSED MITIGATION	POST-MITIGATION ASSESSMENT					DOCUMENT MITIGATION TO BE CAPTURED IN	ACTION BY	DATE REQUIRED	COMMENTS
					Probability	Consequence			Risk Score		Probability	Consequence			Risk Score				
						Life Safety	Schedule	Cost				Life Safety	Schedule	Cost					
500	CONSTRUCTION: General																		
501	Delays in delivery of critical equipment / materials (non pipe related)	- Roadheader, LDCC delays affect critical path schedule	- Delays during construction	Risk	2		1		2	- Confirm delivery timelines with vendors	2		1		2	Schedule	C Langford	1-Nov-20	
502	Delays in delivery of critical equipment / materials (pipes and valves)	- Delay in fabrication / delivery of pipe and / or valves (including poor quality or shopping / storage damage)	- Delays during construction	Risk	2		3		6	- Confirm delivery timelines with vendors	2		2		4	Schedule	A Le	1-Nov-20	
503	Poor quality / workmanship	- Inexperienced workers - Lack of construction supervision / management	- Rework leads to delays during construction and additional costs	Risk	3		2	2	6	- Include qualifications for Contractor's QC Manager - Include stringent quality requirements within the contractor's proposed work plans and hold points for approval of key areas - Provide full time inspectors as part of QA - Impose early requirements / meetings / letters with respect to Contractor milestones - Construction management, quality checks	2		2	2	4	RFQ Specifications	C Langford	1-Sep-22	
504	Damage to critical existing utilities/facilities during construction	- Improper protection / relocation completed ahead of construction	- Delays during construction - Loss of water supply COV and/or Park - Safety risk (e.g. pressurized water)	Risk	2	3	4	4	8	- Carry out pre-construction surveys / inspections of sensitive utilities - Early engagement of utility providers to define acceptable loading requirements - Prepare dwgs with locations, load restrictions etc. - Include reference mitigation designs (remove and replace CA4, structural slab) as part of design docs and payment items with submittals so this is not missed - Require shoring approach that minimizes settlement for structures near critical infrastructure (secant piles) - Undertake identification and protection of utilities as part of an early works contract	2		2	3	6	Design Dwgs Specifications	C Langford	16-Oct-20	Mar 27, 2020: critical utilities being identified as part of 60% design. Will then proceed with protection/relocation design between 60-90%. Risk to be revisited at next workshop. Jun 19, 2020: MV to look into the process / timing to inspect the West End Interceptor No. 1 before the end of design (summer months likely to be preferred) Sept 27, 2020: additional steps taken to mitigate this risk. Will discuss at risk workshop.
505	Damage to existing utilities during construction - other (minor)	- Improper protection / relocation completed ahead of construction	- Delays during construction - Cost to replace - Safety risk (e.g. gas lines)	Risk	4		1	2	8	- Carry out pre-construction surveys - Restrict loads over critical infrastructure - Prepare dwgs with locations, load restrictions etc. - Include reference mitigation designs as part of design docs and payment items with submittals so this is not missed - Use shoring approach that minimizes settlement for structures near critical	2		1	2	4	Design Dwgs Specifications	A Le	16-Oct-20	

QRA approach

Step 1: Develop a Model

Cost or schedule (or both)

Step 2: Define Uncertainty & Risk Impacts

Assign an accuracy level to costs/durations

Import the risk register

Step 3: Analyze the Model

Monte Carlo Assessment

Step 4: Use Results to:

Verify confidence in Project budgets/schedule

Focus on risk mitigation strategies

Define contingencies appropriately

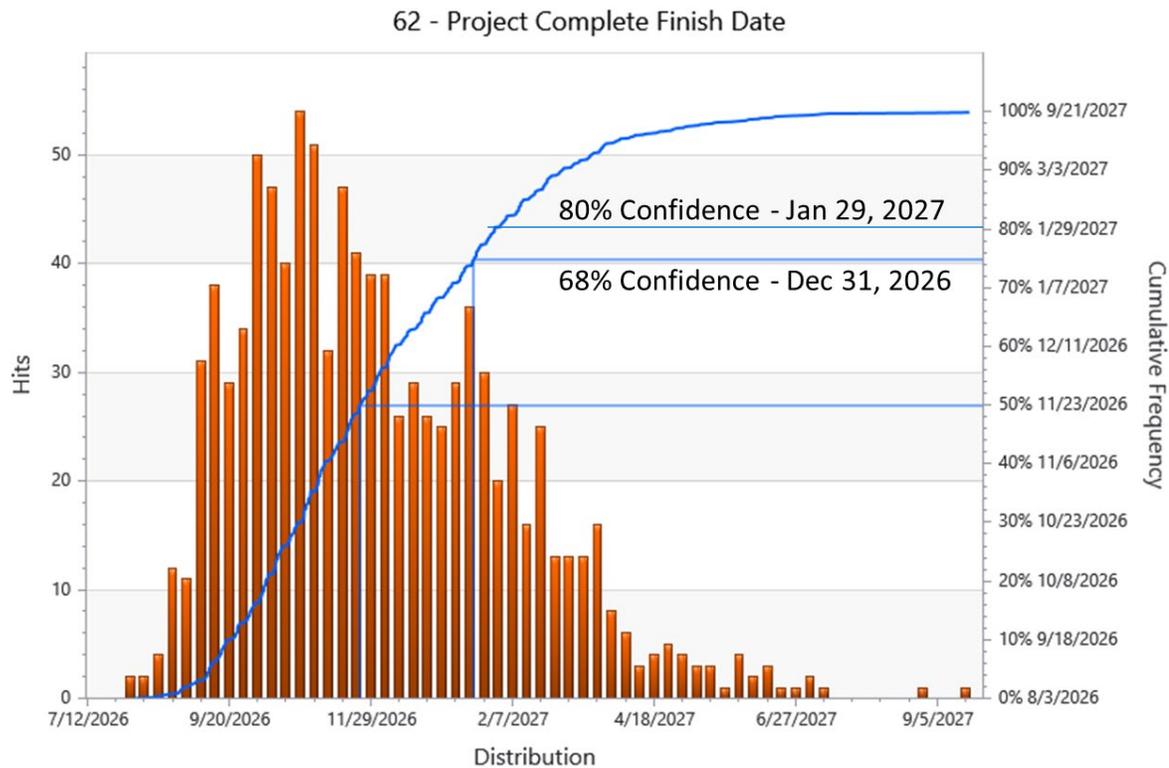
The screenshot displays the Acumen Risk software interface. At the top, there are tabs for 'S2 // Benchmarking', 'S3 // Risk', 'S4 // Acceleration', 'S5 // Dashboard', 'Forensics', and 'Metrics'. Below the tabs is a toolbar with icons for 'Risk Adviser™', 'Mitigation Analysis', 'Add Risk Event', 'Delete Risk Event', 'Exchange Panels', 'Run Risk Analysis', 'Build Scenario', 'Uncertainty', 'Risk Matrix', 'Create Cost Estimate', and 'Print Preview'. The main window is divided into several sections:

- Risk Register:** A table with columns for 'Remaining...', 'Duration Uncertainty', and 'Type'. It contains several rows of data, including durations like 17d, 0d, 6d, 2d, 2d, 10d, 2d, and 2d.
- Simulation:** A panel with settings for 'Number of Iterations' (1000), 'Complete Automatically' (checked), 'Automatic Accuracy' (1%), and 'Convergence Iterations' (100).
- Scenarios:** A list of analysis scenarios:
 - Uncertainty Only (No Risk Events):** Perform the risk analysis including only duration uncertainty.
 - Uncertainty and Risk Events (No Mitigation):** Perform the risk analysis including both uncertainty and pre-mitigated risk events. This option is selected with a checkmark.
 - Uncertainty and Risk Events (Mitigated, Excluding Overhead):** Perform the risk analysis including both uncertainty and pre-cost/schedule effort.
 - Mitigated, Including Overhead:** Perform the risk analysis including both uncertainty and pre-cost/schedule effort.
- Network Diagram:** A project network diagram showing a sequence of tasks. A 'Discrete Risk Event with Impact Range' is shown as a red bell curve affecting a task. A 'Duration Uncertainty Range' is shown as a blue bell curve affecting another task. The diagram is enclosed in a red dashed box.

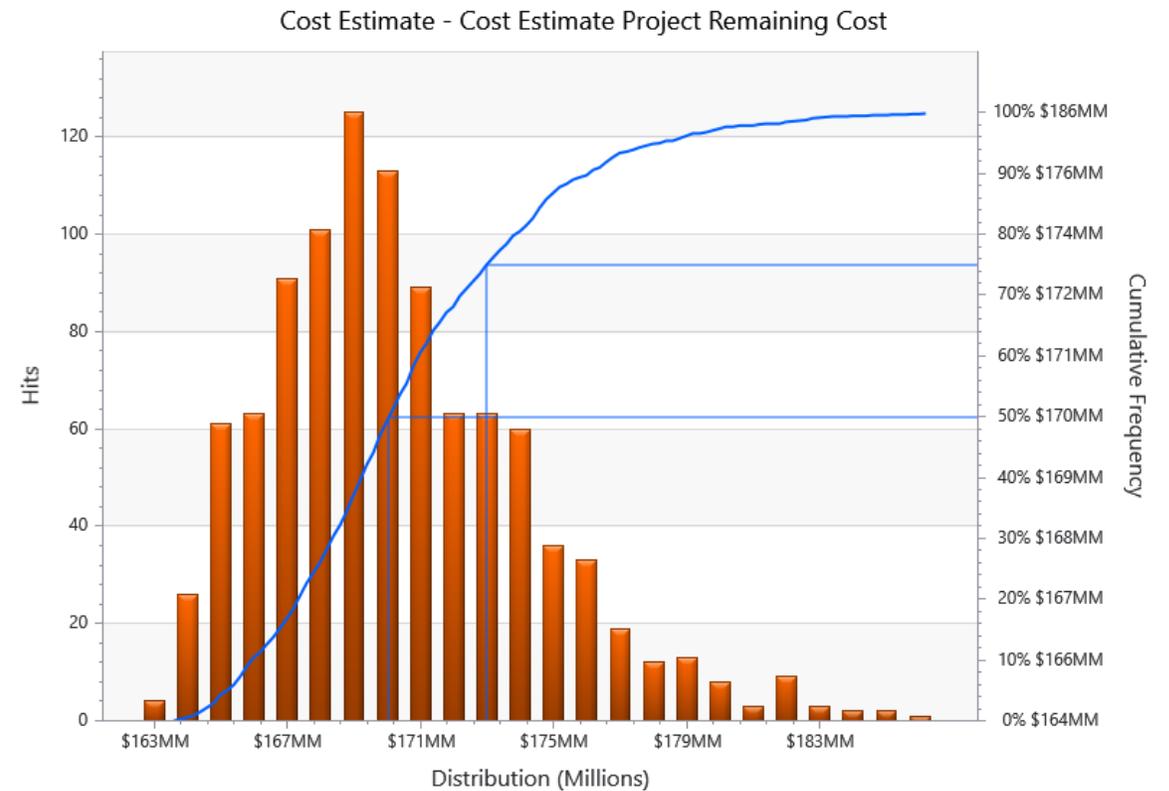
Acumen Risk – workflow approach

QRA Outputs

- Schedule Estimate QRA



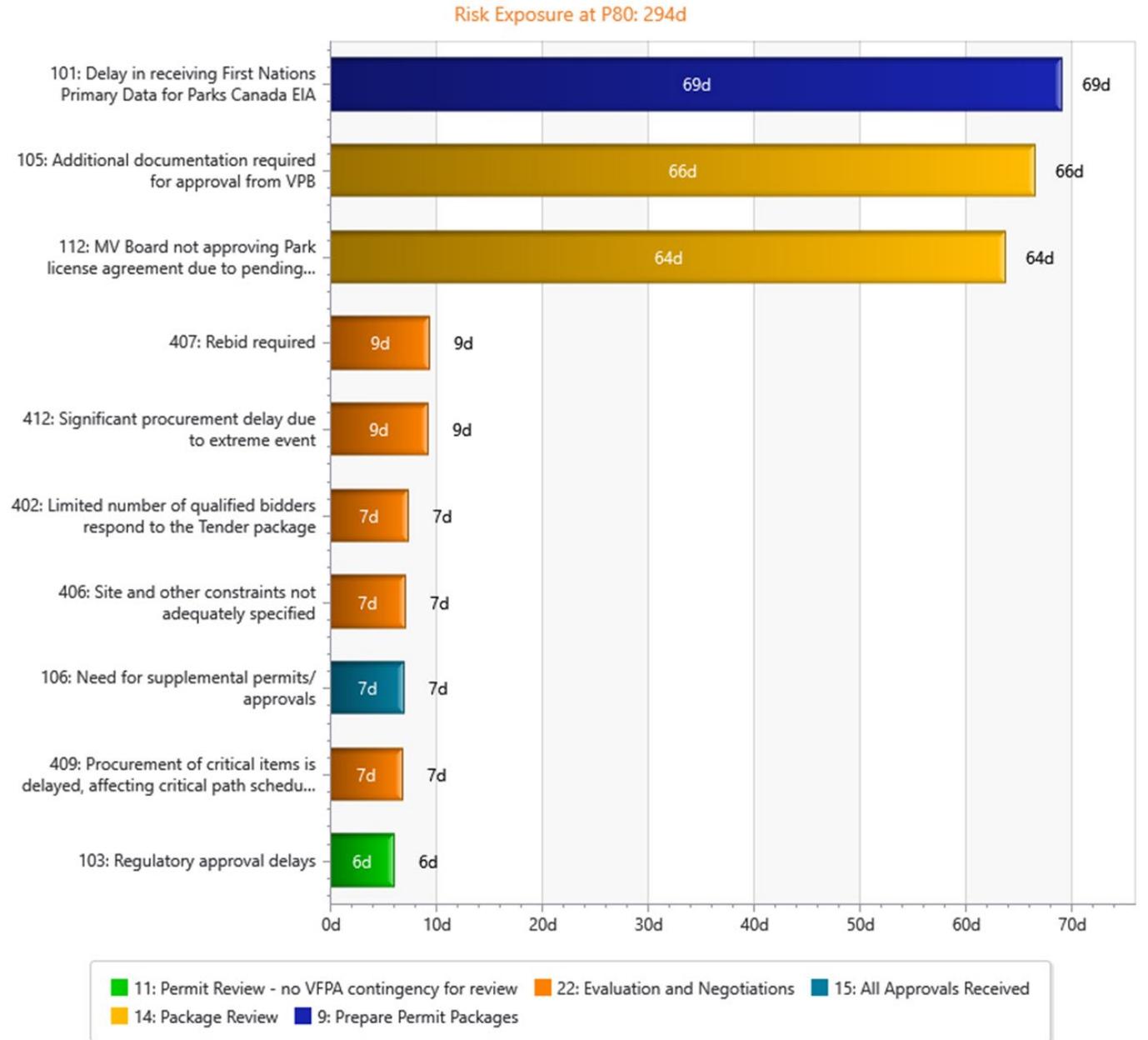
- Cost Estimate QRA



Owner can determine Contingency based upon risk appetite and confidence level required

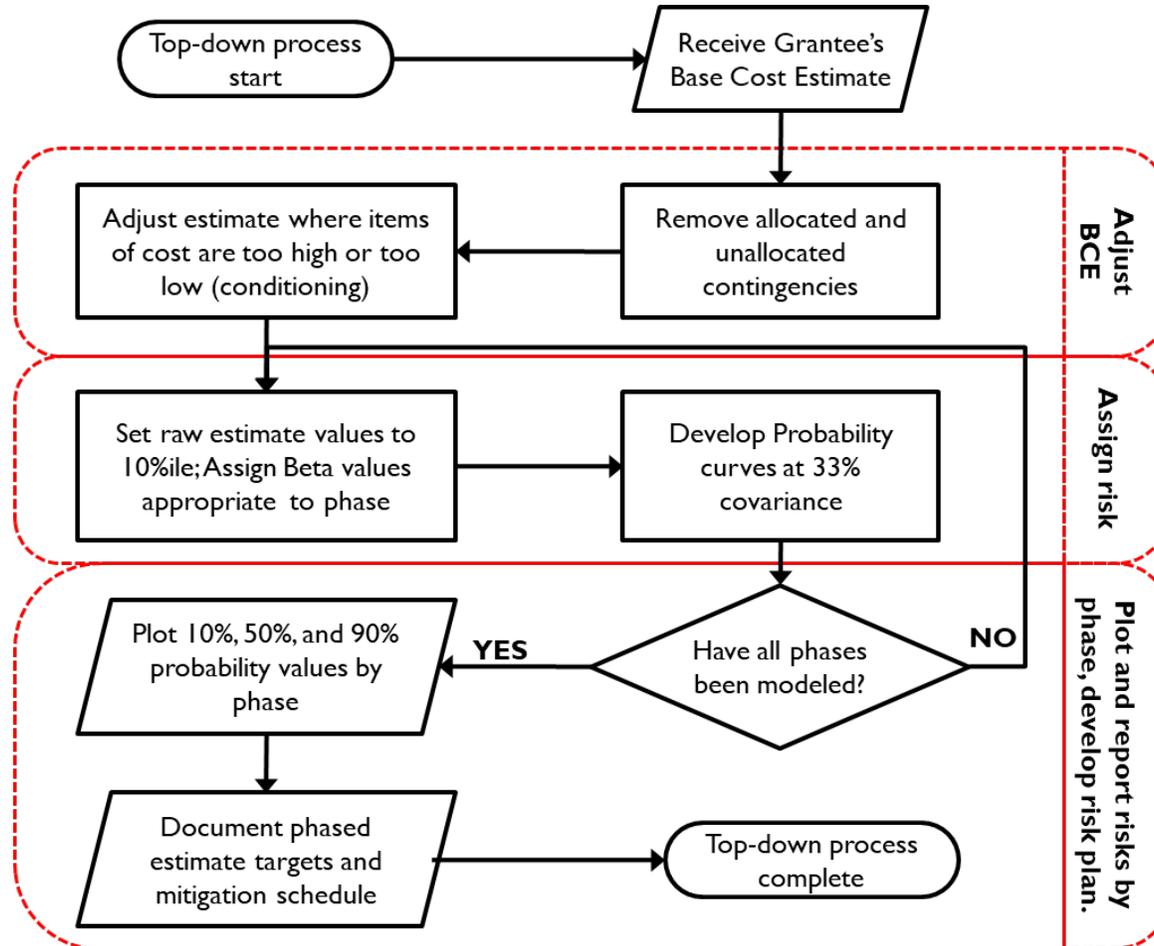
QRA Highlights

Areas for attention



FTA Risk Assessment Process

Top-Down Beta Factor Approach



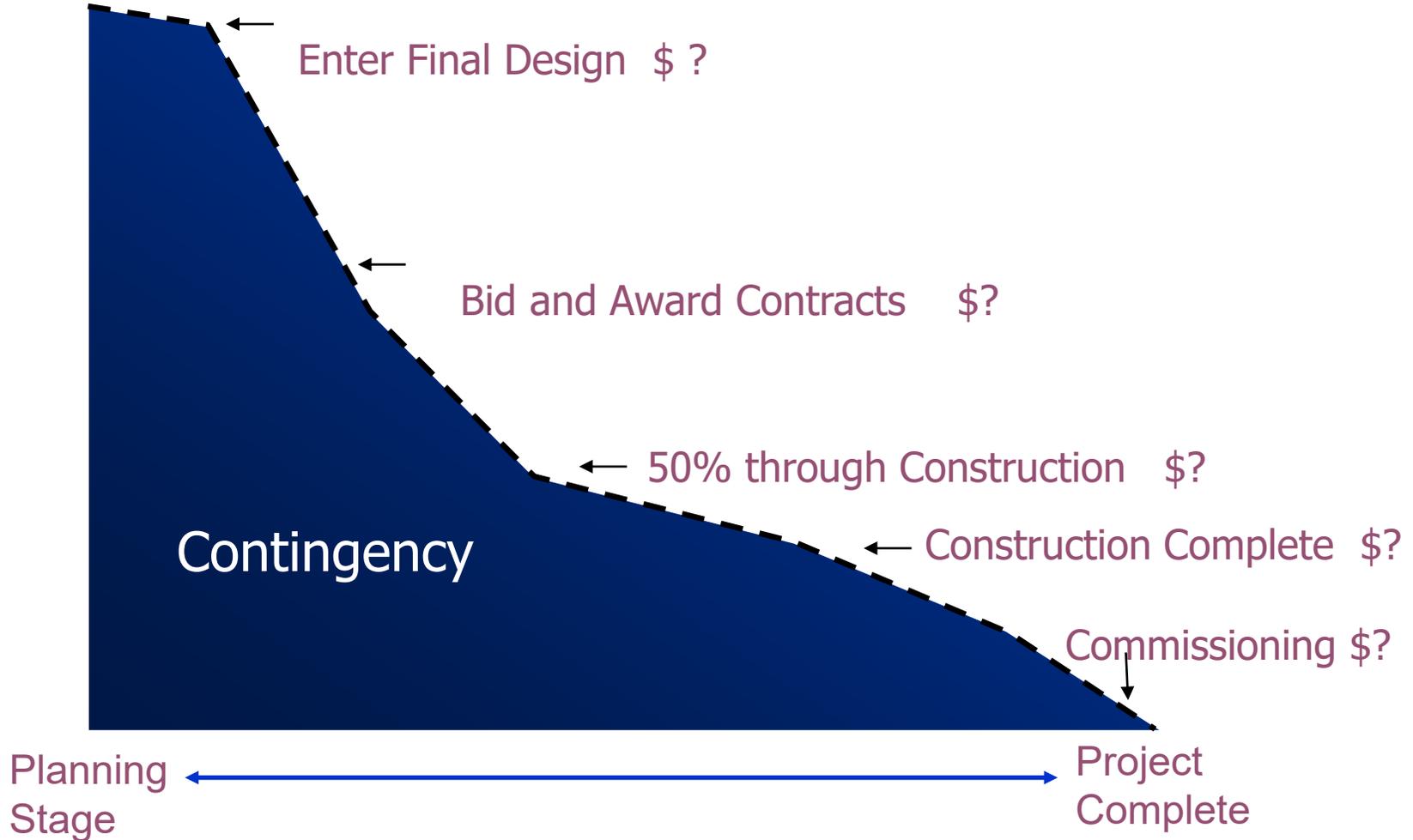
FTA PMOC Validation of Budget

- Detailed review of project estimate (base and stripped)
- Bottom-up risk analysis based on the TJPA estimate and risk register
- Parametric (Top Down) risk assessment based on FTA guidance FG40
- Apply 'Beta' factors at each milestone to produce a recommended project budget
- Determine from their analysis the requirement for an additional \$ value to the budget if required.

FTA Risk Categories

- **Requirements risk:** risks associated with project development activities, stakeholders' requirements, additional scope, etc.
- **Design risks:** allowances, non-conformances in designs, assumptions, etc.
- **Market risks:** related to procurement of construction services, materials, and equipment.
- **Construction risks:** geotechnical/utility activities, coordination of contractors, start-up/substantial completion risks.

Contingency Drawdown Schedule



Schedule of Activities

- Quarterly Risk Reviews – commenced September 2020
- Quantitative Risk Review Process
 - Prepare Workshop Materials July - August 2022
 - Conduct Workshop August 2022
 - Model and Prepare Report August – October 2022

30% DTX Capital Cost Estimate

- Bottom-up estimate for materials and labor rates in 2022\$
- Process will include a review of construction schedule and staging as well as constructability
- Prepared by GEC with participation by:
 - PMPC Subject Matter Experts
 - SFCTA Staff and Subject Matter Experts
 - TJPA

Bottom-up Estimating

- Construction costs and design contingency provided by GEC
- Design contingency varies by risk associated with project element
- Quantities taken from 30% design drawings/memoranda/reports
- Unit costs collected from manufacturers and contractors
- Productivity rates based on construction schedule, available staging, and review of constructability
- Organized by project segment
- Costed utilizing FTA Standard Cost Codes

Programmatic Cost Assumptions*

- Escalation (to mid-point of construction)
- Right-of-way
- Programwide (on escalated construction cost): 22.5%
- Construction Contingency (on escalated construction cost): 10%
- Program Reserve (on total program less construction contingency): 15%

** In line with 2015 MTC Cost Estimate Peer Review*

Next Steps

- Quantitative Risk Assessment using Draft – mid July thru mid August
- Value Engineering using Draft – mid August thru mid October
- GEC Final Cost Estimate based on Review Comments – mid September
- Independent Peer Review on Final – Late September thru late December
- Update of Program Cost Estimate after Peer Review
- Adoption of Updated Program Budget by TJPA Board – January 2023
- Submittal to FTA with Request to Enter Engineering – February 2023

Questions

