

# **Quantitative Cost & Schedule Risk Analyses**

# Work Process and Outcome Summary For An Industrial Project

John Zhao

April 2024 - Canada

### **Experiences and Background**



2



John is a Specialist in Quantitative
Risk Analysis for Cost & Schedule of
Major Projects (\$1B to \$30B); he was
the Estimating Manager for a major
energy firm's Major Project Group
(Firebag Steam Generation for SAGD)
and the Planning Manager for a
major oil pipeline project.
-

Key Positions Held	Key Locations Worked
- Construction Site Coordinator	- 8 Years: Contractor in UAE
- Field and Cost Engineer	- 7 Years: EPC Firms Canada
- Owner Project Risk Manager	- 8 Years: Owner N. America
- QRA Specialist / PMO Advisor	- <b>3</b> Years: Owner Europe
- Principal Risk Consultant	- 7 Years: Consulting World

33 years working experience in construction industry specializing in project risk management, QRA, Estimating & Forecasting.

Member of AACEi, CIOB, CII, and Professional Engineer; Presenter at 50+ conferences / guest speaker at universities;

MSc. in Construction Project Management and BSc. in Building Design / Management at Northumbria University, Newcastle, UK

MPhil / PhD (unfinished) in Thermal Comfort Expert System, UK

## **Objectives of QRA**



3

Quantitative Risk Analysis (QRA) is a scientific approach to identify and mathematically quantify project schedule and cost estimate risks that may result in the schedule delay and budget cost overruns.

Quantitative schedule risk analysis (Q.SRA) and cost risk analysis (CRA) process systematically analyze various risk impacts on schedule and cost estimates, methodically predict a Project's In-Service Date (ISD) and the Cost Estimate-at-Completion (EAC), at a given confidence level, using a Monte Carlo simulation technique.

The QRA Outcomes are achieved through Riscor® simulation process by

- incorporating time delay & project-wide systemic risk impacts;
- quantifying the required amount of cost contingency for risk events;
- Investigating and quantifying market fluctuation on pricing impact;
- highlighting key risk drivers that require effective mitigation actions;

### **QRA Methodology and Process**



Contingency of an estimate is derived via an integrated Riscor® Monte Carlo simulation process, which includes inputs from contract model, risk register, SRA, risky estimate elements, escalation rates and the outputs of key risk drivers.



4



A Master Schedule developed in an office is theoretically planned milestones without incorporating risks. Schedule for execution becomes realistic after SRA is completed.

The schedule needs to be adjusted after risk mitigation actions are implemented.

### **Q.SRA Work-Flow and Process**

- developed
- P6 schedule is developed;
- Sanity Check using PRA;
- Select near Critical Path;
- Remaining Duration vs. Total Finish Float Ratio
- Risky Tasks on Critical & near Critical Path by SME;
- Build Simulation Model c/w binary risk inputs PRA;
- Hold Risk Workshop for risk ranging on Risky Tasks;
- Run simulation Sensitivity;
- Improve P6 Schedule by mitigating delay risk driver.



CORE LTD.

Q.SRA is performed only on risky critical and near activities leading to substantial project completion based on (1) identified singular & binary risk impact in risk register on scheduled tasks and (2) uncertain and risky duration (variability or ranges) of selected activities on critical or near path network.

#### **REDI - Estimate Classification Assessment**





6



I	Level 1 REDI - Maturity of Systemic Deliverables (Weighting CL2=3	0% / CL3=40	%)
I	1. The Firmness of Project Business case, Scope definition, and Feasibilities	6	90
I	2. Percentage of New Technology and Process (R&D) Applied to / Used in Project	6	10% -
I	3. Complexity of Project Location, Logistics, Resources, Construction & Geopolitics	6	Non
I	4. Estimate Referencing Documents meeting Gate Deliverable Requirements	6	Excee
I	5. Completeness of Updated Project Risk Register matching Company Risk Apetite	6	Hig
I	6. Maturity of Project Charter, Execution Plan and Procurement & Contracting Model	6	Comp
I	7. Overall Project Definition, Engineering Design Progress and Deliverables to Estimate	8	50% -
t	8. Material Take-off (MTO) basis and Engineering Data using 3D Model & Isometrics	8	Mode
I	9. Completeness of Schedule & Estimate Basis, key Assumptions & Exclusions	8	Hig
I	10. Techniques and efforts to develop and prepare cost estimates (internal & external)	8	Full-MTC
I	11. Reliability of unit rates, budgetary quotes and historical cost benchmarks used	6	Hig
I	12. Project Management Team Organization Chart and Key Staff Recruited in place	8	>75
I	13. Level of Comprehension of Underground Conditions for the Chosen Project Site	6	Hig
I	14. Strength, Experience, and Capability of Project Estimating & Planning Team	6	Hig
I	15. Project Management Systems, Governance, Assurance & Procedures Applied	6	Strin
I	TOTAL Scoring and Estimate Classification	100	(40 - 70
1			

#### - AACE 18R-97 Cost Estimate Classes

- Estimate Deliverable and Maturity Level
- Systemic & Specific assessment of "REDI"
- Riscor® Simulation Model quantifying Estimate Ranges
- QRA Methodology is applied to Major
  Projects valued to
  \$75Billion worldwide

- Owner takes control

### A Sample Executive Summary – QRA Output at P50



Project Category	ISD Delay	Estimate* Deterministic	Estimate Contingency Escalation		Estimate EAC	M. Risk Reserve
OSBL Reimbursable	2-week	CAD\$300M	\$40M (12%)	\$25M (7.5%)	\$400M	\$12M
ISBL Lump-sum	0-week	CAD\$2,000M	\$60M (3.0%)	\$0.0M (0.0%)	\$2,100M	\$55M
Owner Reimbursable	6-week*	CAD\$500M	\$80M (17%)	\$30M (7%)	\$600M	\$14M
TOTAL	0	CAD\$2,800M	\$190M	\$60M	\$3,100M	\$80M

- 6-week\* delay is used to simulate extra Owner Costs for schedule extension during when Owner team may need to stay longer for close-out and handling claims
- The contingency of \$190M represents 7% of total project ETC, while the escalation of \$60M denotes 2% of project ETC. Risk Reserve is for consideration and awareness only.

#### Note: All numbers in this presentation are modified from the QRA of a real megaproject.

## A Sample OSBL QRA Summary



Confidences	P10	P20	P30	P40	P50	P60	P70	P80	P90
Schedule (SRA) April 01, 2027 OSBL Complete C&SU / ISD		Feb. 01 2027 -60 days			April 03 2027 +2 days			May 01 2027 +26 days	
Estimate (CRA) \$350 Million EAC including contingency & Escalation		\$410 Million <b>9%</b>			\$420 Million <b>12%</b>			\$430 Million <b>15%</b>	

- 8
- The OSBL Facilities Project SRA indicated that there is 44% probability\* to achieve the "System Construction Work Complete" (MT-19000) date by April 1, 2027.
- The Q.CRA of Cost Estimate resulted in 12% contingency and 7.5% escalation at P50 against the ETC of \$350M, excluding management risk reserve.

#### Note: All numbers in this presentation are modified from the QRA of a real megaproject.

### A Sample SRA Model Result - ISD (2028)









300-C-GN-1510 - CWA 10300R4 - Walkdown and Turnover Critical

14%

10

### A Sample QRA Contingency and Probabilities





#### Note: All numbers in this presentation are from the QRA of a real megaproject.

### **A Sample Project Risk Simulation**



12

There are 10 valid risks in ISBL's **Risk Register** that was transposed to Riscor® Model for Systemic Contingency.



Unplanned Construction Delay increases construction indirect costs, hence an additional amount of contingency is simulated.

SRA and CRA integration is achieved in the Riscor® Model.

URI	ESTIMATE SUMMARY	PDF	Estimate	Actual	To Go	Min	Max	PDF	Estimate	\$
COA	Prime Accounts	Mhrs	Mhrs	Mhrs	Mhrs	Range	Range	\$ Value	To Go	
		L	L1	L2	L3	10	90	Pv	Est.	
SDC	Schedule Delays									
	Weeks of Schedule Delayed	22	19		50%	0.75	1.5			
	Duration To-Go in Weeks		165		38	MO	NTH			
49	Labor - Cost of Schedule Delays	1,234	1,159	0	1,159	0.9	1.25	26,644	0	cn
	Labor-Schedule Delays Risk							26,644	0	
500	Project Execution Mgmt									
500	Wage Rate-Project Execution Mgmt	100.0		100.00	]	1	1			
	Labor PF-Project Execution Mgmt	1.0		1.00	]	1	1.15			
52F	Labor - Contractors Management Team	521,930	474,200	0	474,200	0.98	1.25	53,498	47,420	cn
52G	Labor - Dedicated Employees	556,480	556,480	0	556,480	1	1	57,039	55,648	cn
53H	Labor - Travel, Incentives, Pre-Dev. Expenses	0	0	0	0	1	1	0	0	cn
531	Labor - Regulatory & Stakeholder Engagement	367,333	330,600	0	330,600	1	1.25	37,652	33,060	cn
53J	Labor - Procurement & Cost Control Team	319,104	299,160	0	299,160	1	1.15	32,708	29,916	cn
53K	Labor - Tera PM to to 2015 & CH2M work 2016	0	0	0	0	1	1	0	0	cn
53L	Labor - Environmental Team & Archeology	259,524	248,480	0	248,480	1	1.1	26,601	24,848	cn
53M	Labor - Commissioning (Facilities & Pipeline)	0	0	0	0	1	1	0	0	cn
53N	Labor -	0	0	0	0	1	1	0	0	cn
530	Labor -	0	0	0	0	1	1	0	0	cn
50	Labor - Allowances	0	0	0	0	1	1	0	0	cn
	Labor-Project Execution Mgmt Risk	2,024,371	1,908,920	0	1,908,920	1	1	207,498	190,892	



#### ISBL:

13

- Perform cost and benefit analysis for just-in-time strut delivery and crane costs.
- Early contract with Utility Firm for punctual energization to substation & powerline.

#### OSBL:

- Negotiate an aggressive Module delivery time by inserting incentivised clauses.
- Reasonable allocation and share the risks of force majeure risk impacts with EPC.

#### Owner:

- Educate the Owner internal stakeholders to get rid of complacency & optimism.
- Enhance owner internal managerial capability by recruiting megaproject experts.

#### **Overall Project:**

- Foreign Currency Exchange Risk needs to be prudently studied, understood and quantified with effective hedging mechanism in place.
- Adding contingency only to cost estimates will not minimize project's risk exposure. Pro-actively and periodically respond to risks by effective mitigation is the key.

#### Note: This was a set of high-level recommendations for a real megaproject.

### **QRA** Conclusion



14



It is a global trend, which was driven by notorious project cost overruns and also advocated by PMI / AACEi, that project schedule and cost estimate are scrutinized under the microscope of QRA process for Owner team to better understand their risk exposure prior to FID commitment.

We will work with our client team to maximize the probability of their capital project's successes by applying the industry's best practices.



## The Riscor® Model Simulation Package

- Simulation Date Inputs November 16<sup>th</sup>, 2022
- Simulation platform Palisade @RISK ver. 8.0
- Latin Hypercube Simulation Model Riscor®
- Total Variables in the Model >800
- Simulation Iterations >2,000
- 42-page Narrative and Simulation Results

### **THANK YOU**



**OUR PROMISE:** To provide value-added project management and risk analysis, data analytics and benchmarking services

**OUR EXPERTISE:** To focus on specialty and niche skills by working with competent & experienced professionals collaborating as a team

**OUR SERVICES:** To timely deliver promised scope of work with right expertise within the quoted budget for the expected quality

Specializing in Quantitative Risk Analysis of Schedule & Capital Cost Estimates Supported By Proprietary RISCOR™ Monte Carlo Simulation Model

Riskcore