RISK CORE LTD.

CIQS - Seminar

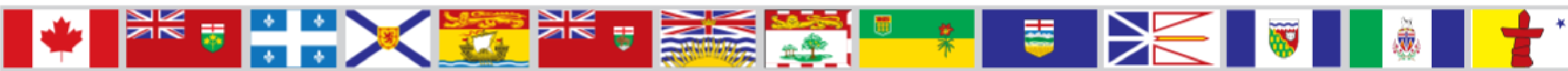
John Zhao
Principal Consultant

Riskcore Ltd.
Calgary, Alberta,
Canada, T3Z 3N5

Scientifically derive Project Contingency

www.riskcore.ca jzhao@riskcore.ca 1 587 352 6698

Major Capital Projects – Natural Resources Canada



Status	Energy		Minerals and Metals		Forest		Total	
	#	$B	#	$B	#	$B	#	$B
Planned	191	$403	88	$59	18	$2.6	297	$465
Announced	42	$90	29	$12	13	$1.3	84	$104
Under Review	73	$139	35	$22	2	$0.7	110	$161
Approval Received	51	$166	22	$24	0	$0.0	73	$190
Planned – Status Unknown	25	$9	2	$1	3	$0.5	30	$11
Under Construction	96	$106	20	$13	5	$0.2	121	$120
Total	**287**	**$510**	**108**	**$72**	**23**	**$2.9**	**418**	**$585**

Source: Major Projects Inventory, as of June 2018.

- **418** projects under construction or planned over the next 10 years, totaling **$585 billion**;
- **87** percent of total projects are for energy projects, 12% for minerals and metals projects;
- **99** projects valued at $48 billion were added to the inventory since 2018;
- **80** major projects ($76 billion, including 12 pipelines) were completed for production;
- **37** major projects ($77 billion) were cancelled or suspended from previous inventory);
- **35** projects worth $15 billion were removed from the inventory for various data reasons;
- **$99** billion decline in the value of projects in the inventory in the oil and gas sector;

Investing in Canada Plan – Infrastructure Projects

Government of Canada is investing over $180 billion over 12 years in infrastructure projects in Canada

Delivery Department/Agency	Program introduced	Program Name	Total program allocation	Number of projects approved
Infrastructure Canada	EXISTING FUNDING	Multiple Programs xii	$57,513,000,000	16,943
Infrastructure Canada	BUDGET 2017	Investing in Canada Infrastructure Program	$33,555,000,000	878
Canada Mortgage and Housing Corporation	EXISTING FUNDING	Existing Housing Programs	$17,262,000,000	
Indigenous Services Canada	EXISTING FUNDING	Multiple Programs xiii	$16,157,000,000	200
Canada Infrastructure Bank	BUDGET 2017	Canada Infrastructure Bank	$15,000,000,000	4
Canada Mortgage and Housing Corporation	BUDGET 2017	FPT Housing Partnership Framework	$7,740,000,000	4,752
Employment and Social Development Canada	BUDGET 2017	Early Learning and Child Care (Budget 2017) iii	$7,000,000,000	26
Canada Mortgage and Housing Corporation	BUDGET 2017	National Housing Co-Investment Fund	$5,134,000,000	185
Indigenous Services Canada	BUDGET 2017	Improving Indigenous Communities	$4,000,000,000	583
Infrastructure Canada	BUDGET 2016	Public Transit Infrastructure Fund	$3,400,000,000	1,162
		Page Total:	$166,761,000,000	24,733
		Total:	$187,999,770,000	65,671

Future Trends of Capital Investments

Clean Technology – Green Focused Projects

Recent drivers of major clean technology projects in Canada include implementation of carbon pricing under the Pan-Canadian Framework on Clean Growth and Climate Change, and progress on the Clean Fuel Standard, which is to be billions of dollars worth of investment.

The federal's investments in the Clean Growth Program and provincial funding in clean technology innovation with significant investments in renewable energy projects, and export-oriented clean technology projects are expected to double in size from over US$1 trillion today to **US$2.5 trillion** by 2022.

In the current NRC projects, the value of clean technology projects over next 10 years remained robust, at **$100 billion**.

A Reality in the World

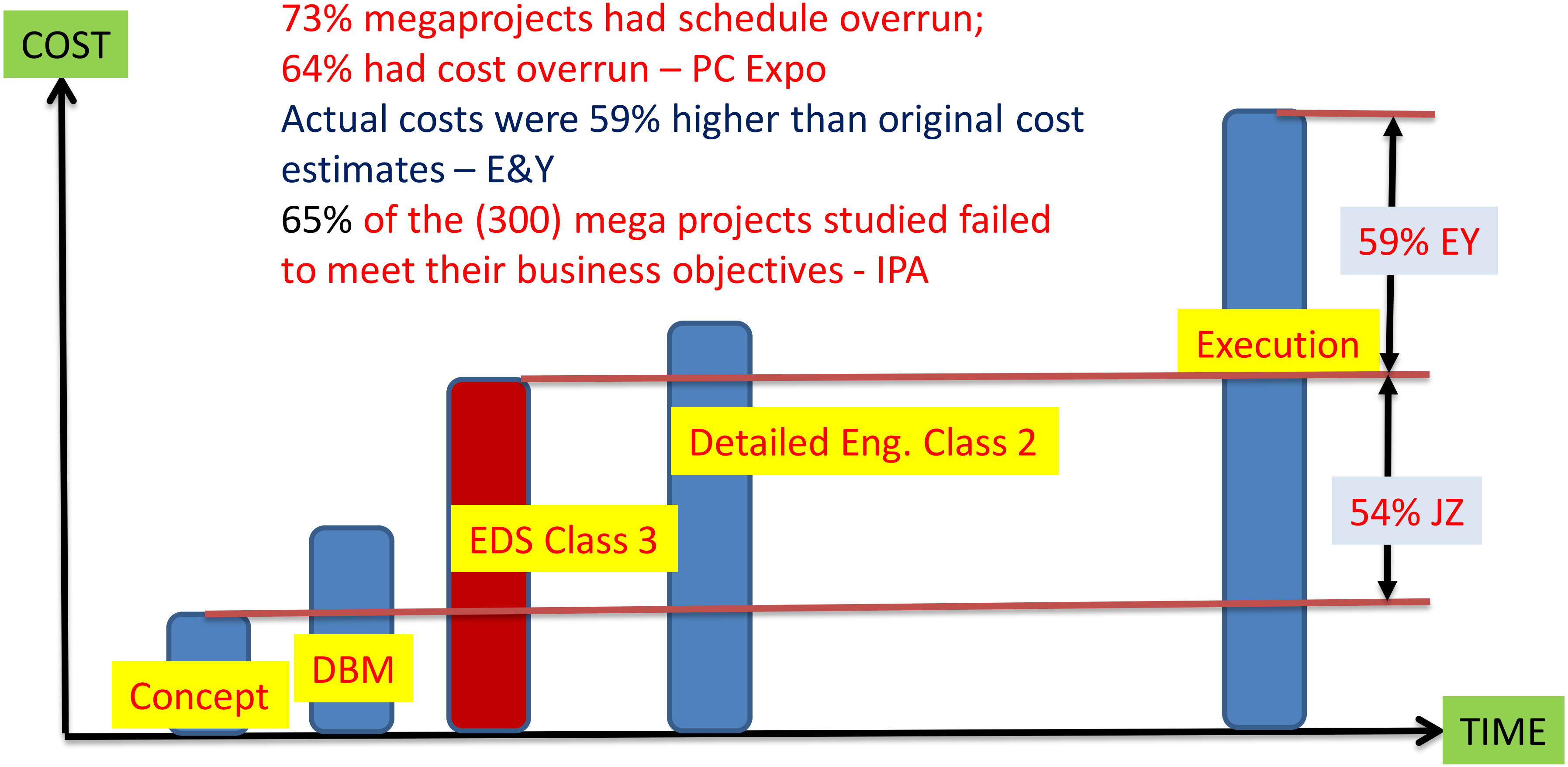
Program	AFE	Final cost
Canadian Firearms program	$119 million	$1 billion
International Space Station	$8 billion	$26 billion
Channel Tunnel	£4.9 billion	£10 billion
The Concorde	£90 million	£1.1 billion




A Reality of Capital Projects

FACTS

73% megaprojects had schedule overrun;
64% had cost overrun – PC Expo
Actual costs were 59% higher than original cost estimates – E&Y
65% of the (300) mega projects studied failed to meet their business objectives - IPA



A main cause of overruns is a lack of realism in initial cost estimates. The length and cost of delays are underestimated, contingencies are set too low, changes in project specifications and designs are not sufficiently

Are We Ready for Project Success?

Of 245 large hydro dam projects in 65 countries, the cost escalated on average by **90%** between the final approved budget and the completed project. **Cost escalation appears a global phenomenon. Estimates have not improved and cost escalation not decreased over the past 70 years; Estimates used in decision-making are misleading … but such financial risks are typically ignored….**

Dr. B. Flyvbjerg – Oxford University

“A project is considered a failure when it has not delivered what was required, in line with expectations. Therefore, in order to succeed, a project must deliver to cost, to quality, and on time; and it must deliver the benefits presented in the business case”.

“Success" in megaproject management is typically defined as projects being delivered on budget, time, and benefits.

The following factors are deemed significant threats to successful delivery of major projects:

- An **unrealistic** time and cost budget without risk reserves for contingencies;
- Unstable and delayed decision-making processes with weak project delivery organization;
- Frequent changes in key personnel in project organization;
- **Manipulated** and late communication with stakeholders;
- Weak contract management and knowledge in contract law;

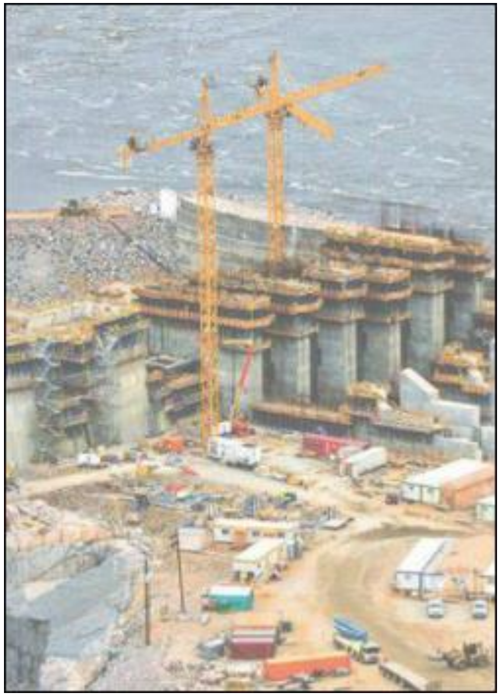
Why did so many Projects Fail? – IPA (2012)

- Sponsors are not to share risks and rewards with others.
- Unrealistic schedules for engineering and construction.
- Insufficient preparation of investment proposal & definition.
- Insufficient upfront investment planning and preparation.
- Unrealistic budget reduction / cost estimate cuts (because of owner's pre-defined investment budget).
- The contractors should carry the risks - relatively little risk is actually passed but a substantial premium is paid, nonetheless.
- Beat up project managers for **cost overruns & schedule delays**.

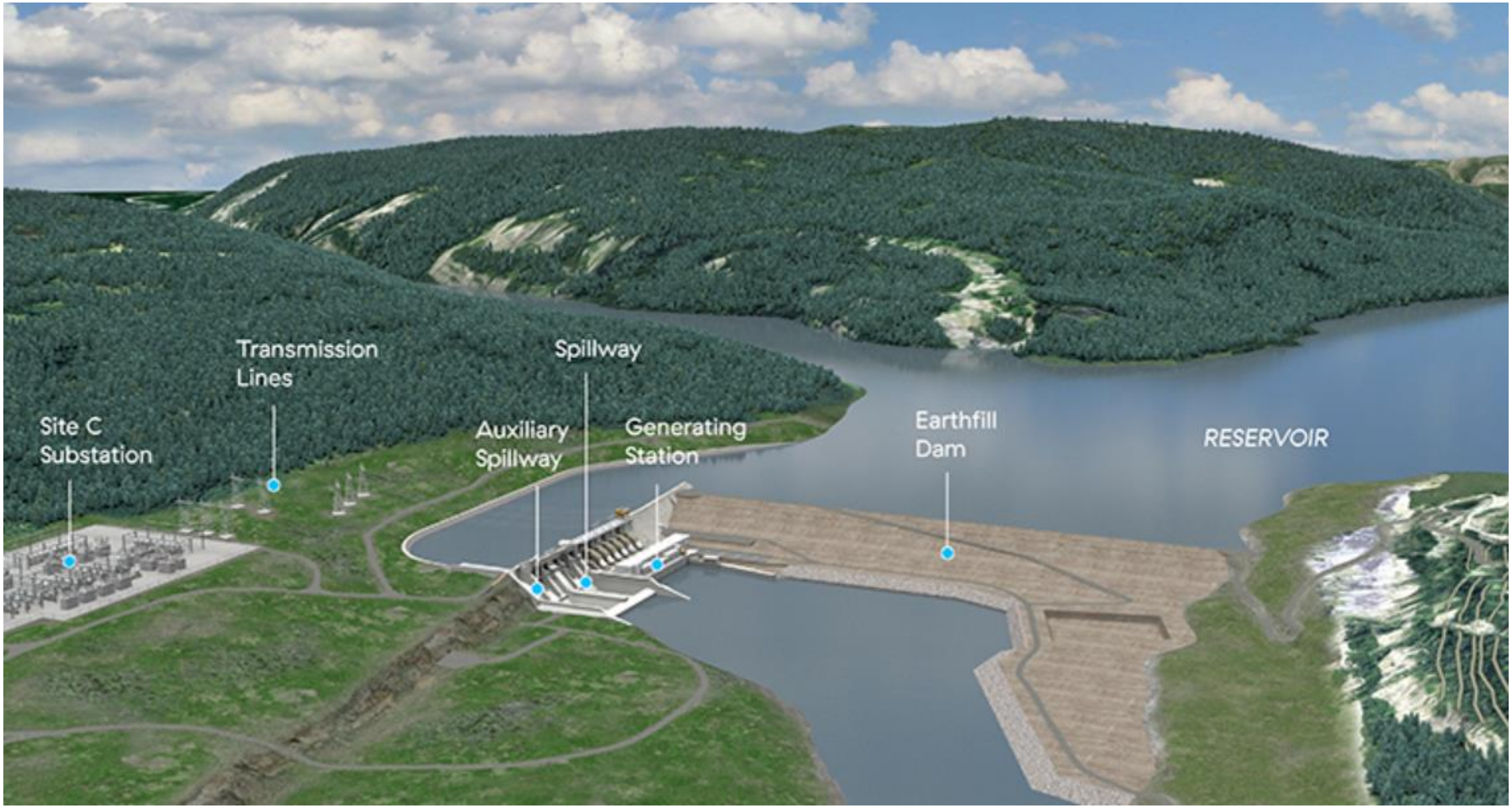
Muskrat Falls Dam Project in Labrador - Reality

Muskrat Falls, a hydroelectric 824MW dam project on Churchill River, Labrador, is scheduled to begin operation in 2020, has a cost of **C$13.1bn** to build, from the original estimate of **C$5bn.**

“Over a half-billion-dollar *strategic risk* allowance (**$497M**) was excluded from the final cost estimates for Muskrat Falls - **A deliberate strategy to lower costs”**



Site “C” Clean Energy Dam Project - Challenge



Initial estimate $7.9 billion in 2011, revised cost to $10.7 billion in 2018, Deloitte warned that any further delays (beyond 2024) could push the final cost of the dam as high as $12.5 billion. The contingency & reserve are $1.5 billion dollars.

Follow the Industry's Best Practices - Opportunity

Project Management Institute (**PMI**)
Advanced Association of Cost Engineers (**AACE**)
Construction Industry Institute (**CII**)

Royal Institution of Chartered Surveyors (**RICS**)
Canadian Institute of Quantity Surveyors (**CIQS**)

- As a globally recognised professional body, RICS is designed to effect positive change in the built and natural environments;
- Its development and enforcement of leading international standards protects consumers and businesses by ensuring the utmost level of professionalism is employed across the built and natural environment;
- CIQS promotes and advances the professional status of quantity surveyors in Canada to the highest standards of competence and integrity to ensure the protection of the public in all matters concerning the profession;

Contingencies – Official Definition

PMBOK Guide 6th Edition:

Budget within cost baseline or performance measurement baseline that is allocated for identified risks that are accepted and for which contingent or mitigated responses are developed.

AACE, Skills and Knowledge of Cost Engineering, 6th Edition:

"An amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs".

Unofficial Contingency Definitions

Contingency provision is an allowance and forms an integral part of the cost estimate and project funding. It is to off-set known unknowns (i.e. risks) that may materialize over the life-cycle of project affecting different project phases.

Contingency is added to a project estimate to cover the inherent project risks. The common purpose of determining contingency is to account for the uncertainty or unexpected events.

An amount of money for goods and services which at current state of project definition can not be accurately quantified, but which history and experience show will be necessary to achieve the given project scope.

Amount added to engineering, design and construction subtotal cost estimates to account for unforeseen elements that can occur without changes in project scope.

Adding more contingency to your base estimate

- does NOT make the cost estimate more accurate

BUT

- does increase the confidence level of under-running approved project budget

BUT

- does jeopardize project economic returns (ROI) or / and chances of winning bids

What is contingency used for?

Contingency is for:

- normal & minor planning and estimating variability, and minor omissions;
- slight market-driven budgetary pricing and quotation fluctuations other than general escalation; equipment / bulk delivery time;
- design developments other than specified design allowances and quantity variations; small changes (time and cost) within the defined scope, and variations in market and environmental conditions;
- Schedule delay identified and quantified via SRA (schedule risk analysis);

Contingency is not for:

- Major scope changes such as changes in end product specification, capacities, building sizes, and location of the asset or project
- Extraordinary / rare events such as major strikes and natural disasters
- Management / risk reserves (for some organizations)
- Escalation and currency effects (dependent on QRA modeling technique)

Contingency amount and associated p-factor are typically determined by the combination of following methods:

- **Expert Judgment**
  [a qualitative assessment process based on heuristics – possibly leading to cognitive biases]

- **Predetermined Guidelines**
  [with varying degrees of judgment and empiricism used – relying on past historic experiences or benchmark with subjectivity]

- **Simulation analysis**
  [primarily quantitative risk analysis technique using simulation method – combination of specific and systemic risks in a scientific way]

- **Parametric Modeling**
  [empirically-based algorithm derived through regression analysis – based on past project data but limited for its accuracy].

What if contingency is derived from "gut feel"?

Contingency amount may be given using one of the methods below but it is not practical to link contingency with P-Factor.

- **Expert Judgment - SME's Subjective Opinions**
  how to measure the confidence level of somebody's opinion?

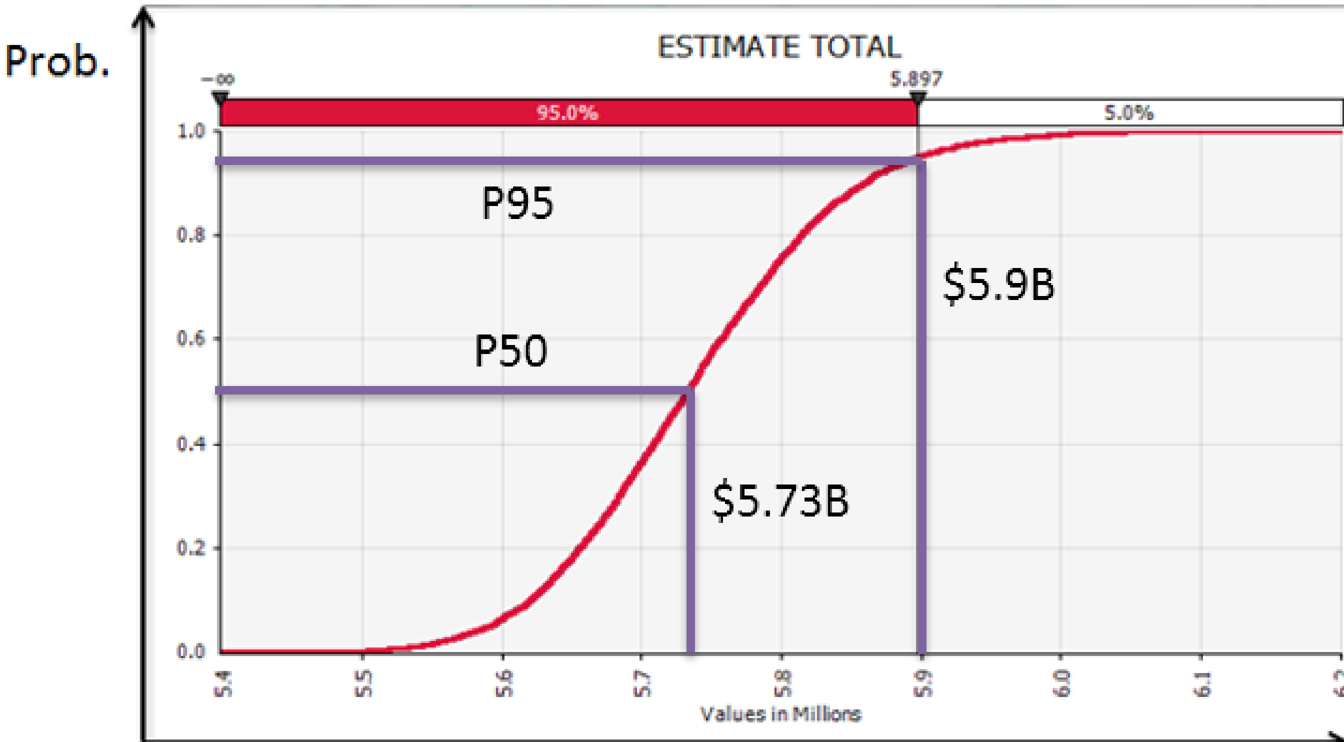
- **Predetermined Guidelines – Easy Formula or Curves**
  How is a project's unique risk profile considered for contingency?

- **Parametric Modeling – Empiricism & Algorithm**
  How could past experience be used to "predicate" a project's risks?

Are the above ways of determining contingency by means of scientific methods and in a systematic or methodical manner?

How important is it to derive estimate contingency scientifically?

Without simulation technique it is impossible to determine contingency scientifically at any given confidence / probability.

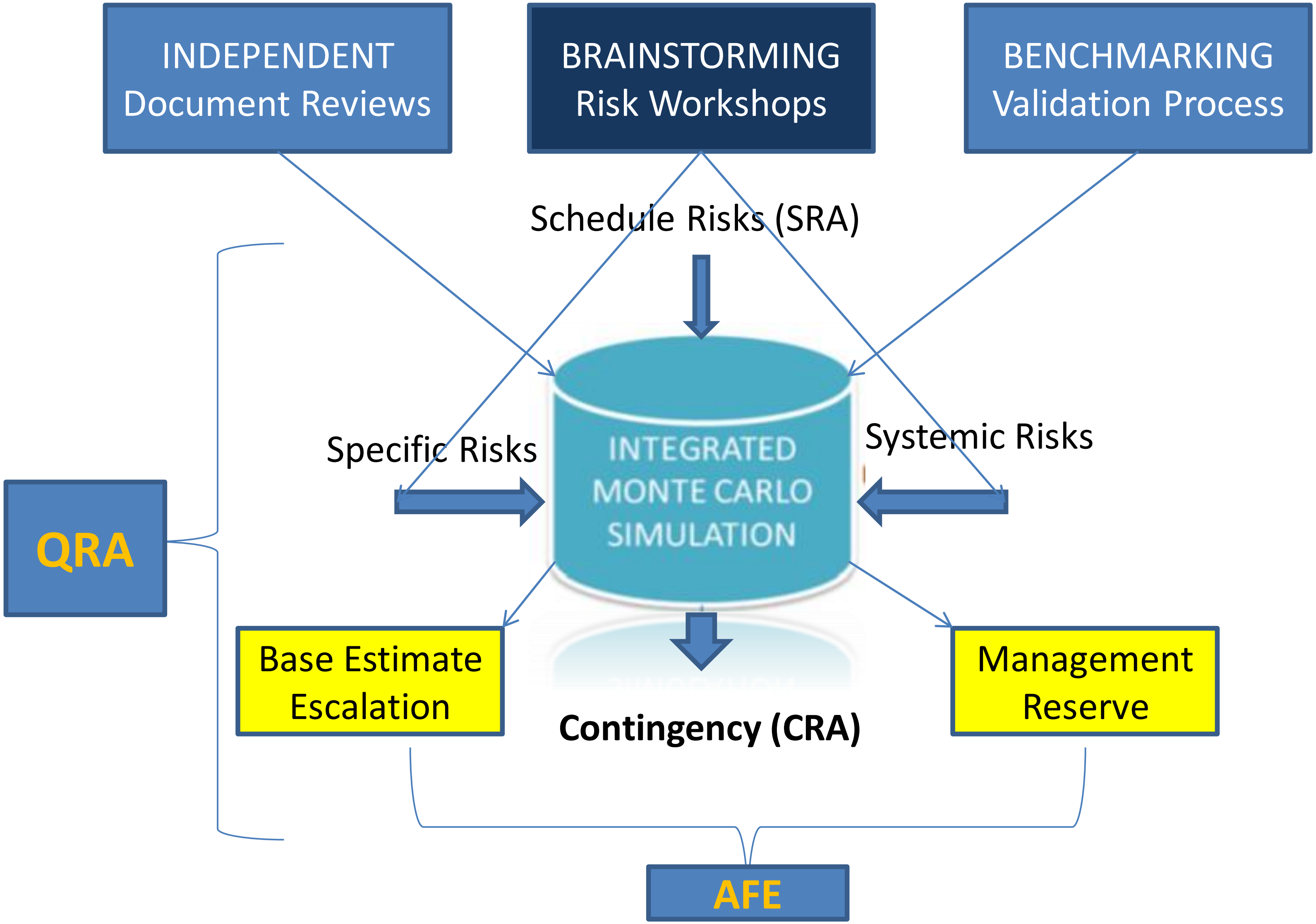


Statistics Grid

	ESTIMATE TOTAL
Minimum	5,446,673.95
Maximum	6,127,580.11
Mean	5,737,013.43
90% CI	± 2,187.17
Mode	5,738,892.07
Median	5,733,076.81
Std Dev	94,006.87
Skewness	0.2864
Kurtosis	3.1085
Values	5000
Errors	0
Filtered	0
Left X	−∞
Left P	0.0%
Right X	5,897,138.45
Right P	95.0%
Dif. X	+∞
Dif. P	95.0%
1%	5,540,584.35
	5,591,354.80

How much contingency is based on P-factor, or the probability of cost overrun.

Quantitative Risk Analysis, a Scientific Way



Heuristics:

- Intuitively responding to risks;
- Statically analyzing math models;
- Blindly accepting the base estimate as "most likely";
- Subjective inputs lacking evidence (SME Opinions);
- Minimal area-specific business knowledge;

Sciences:

- ✓ Selecting key estimate variables based on risk profile;
- ✓ Correlating risk variables to include interdependences;
- ✓ Considering global & project wide systemic risk impact;
- ✓ Deploying parametric and empirical validation process;
- ✓ Challenging deterministic & promoting stochastic thinking;

Key Input Elements to derive Contingency

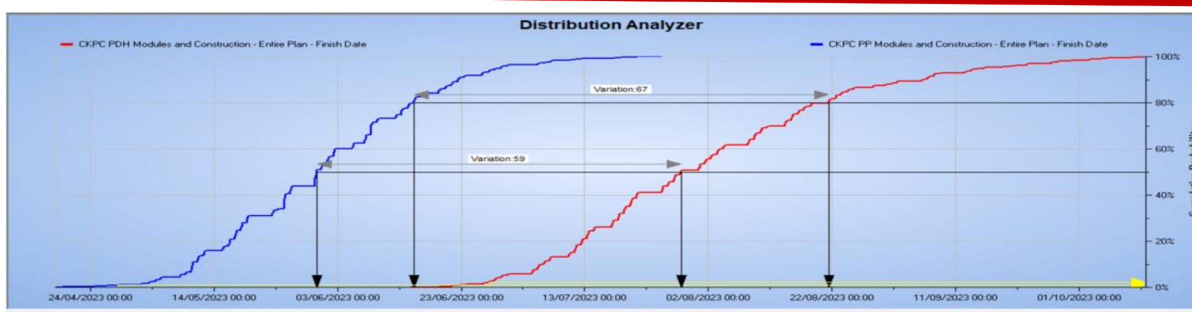
- Identified Systemic Risks in Risk Register

Project Risk Identification as of Dec. 2016			Risk Probability				Cost Impact (x $1,000)				
RISK ID#	RISK Title	RISK Brief Description	Prob. 0.1-0.9	1 - Prob. 1 - P	Simulated Occurrence	Occurs (?)	Minimum 10	Most Likely	Maximum 90	Mean Cost	Simulated Cost impact
RSK-1	Additional Washing Station	Number of required washing stations & standby equipment at the time when cost estimates were prepared were not known; actual requirements due to land owners' demands and AEP, BCEAO may be much higher. Estimated 10 at $500K each.	70%	30%	0	No	3,750	5,000	6,750	1,564	5,215
RSK-2	Labour Skills Dilution in local market	Lack of skilled tradespeople due to competing pipeline projects starting around the same time (e.g. Line 3) may require hiring more workers to maintain production. 10% of labour force is assumed to be affected ($2M per contractor)	30%	70%	0	No	4,500	6,000	8,100	4,380	6,258

- Variability of Risky cost estimate items

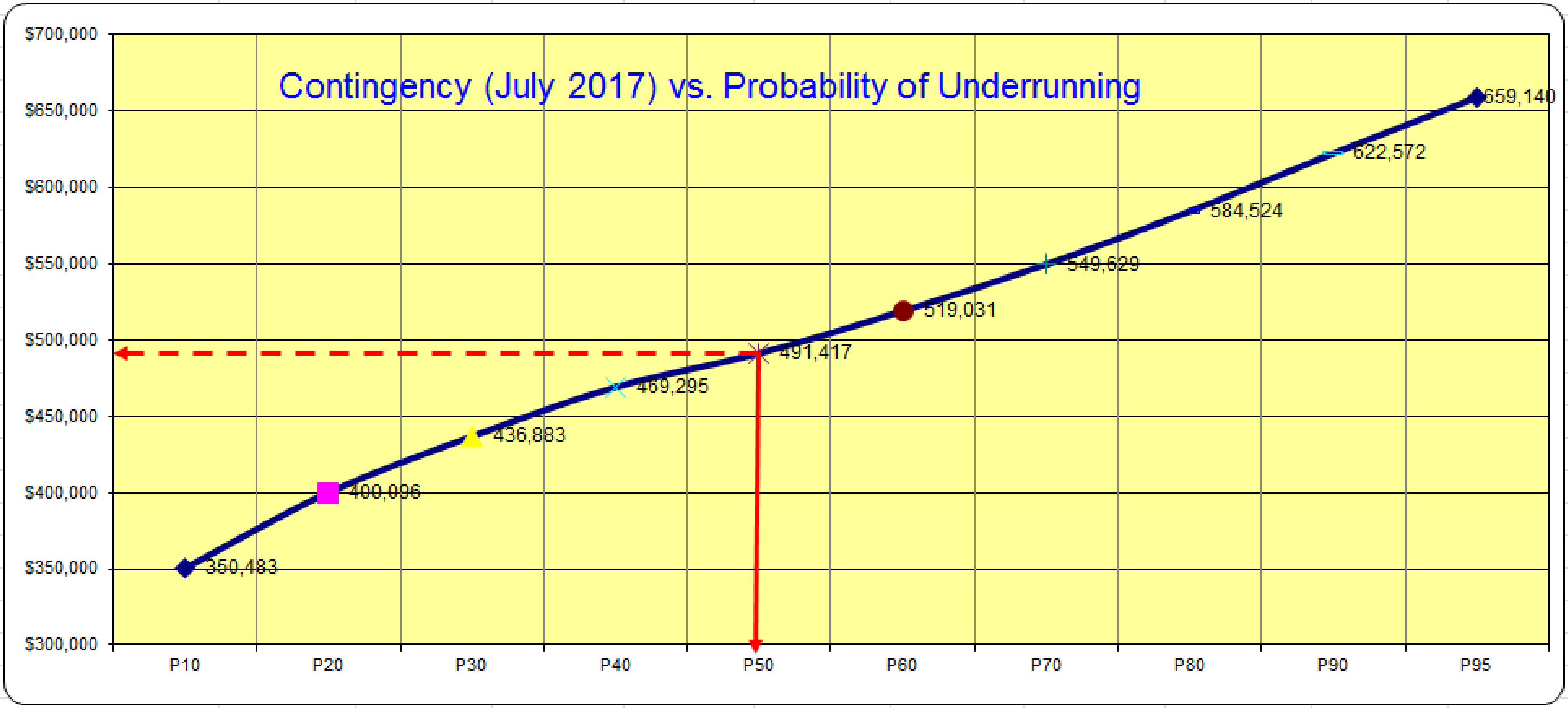
ESTIMATE SUMMARY Prime Accounts	PDF Mhrs	Estimate Mhrs	Actual Mhrs	To Go Mhrs	Min Range	Max Range	PDF $ Value
Civil & Piping Installation							
Wage Rate-Civil & Piping Installation	66.0		66.0		1	1.1	
Labor PF-Civil & Piping Installation	1.0		1.00		1	1	
Labor - Module Setting & Interconnects	7,350	7,350	0	7,350	1	1	485
Labor - Concrete Grade Beams, Piers & Slabs	54	54	0	54	1	1	4
Labor - *Onsite Structural Steel	13,012	13,012	0	13,012	1	1	859
Labor - *Above Ground Piping & Welding	67,376	67,376	0	67,376	1	1.15	4,735

- Construction Delay (SRA) Consideration



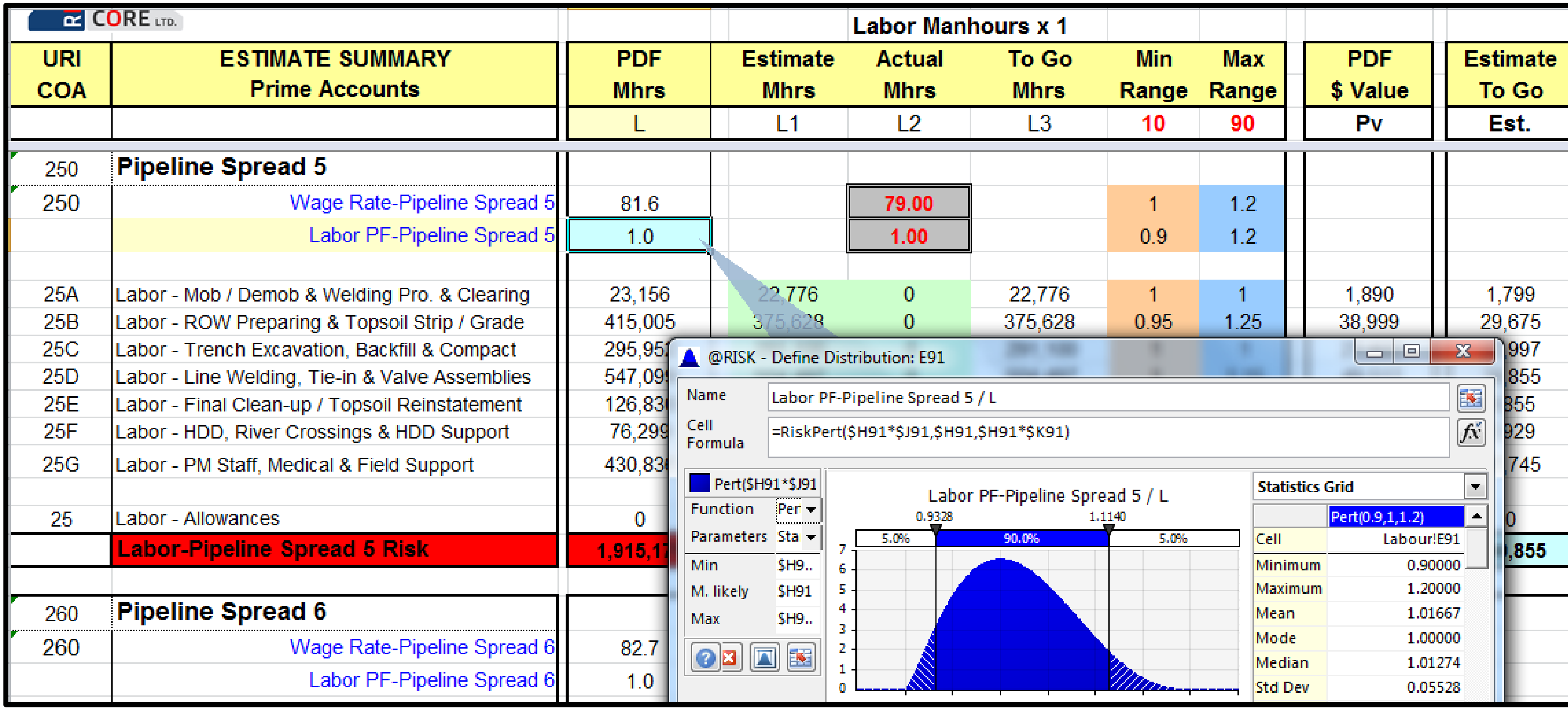
	Show	Deterministic Value	Deterministic probability	Minimum	Maximum	Selected: 50%	80%
CKPC PDH Modules and Construction - Entire Plan - Finish Date	☑	27/06/2023 13:00	2%	14/06/2023 15:00	11/10/2023 16:00	28/07/2023 13:30	21/08/2023 09:30
CKPC PP Modules and Construction - Entire Plan - Finish Date	☑	28/04/2023 14:00	1%	18/04/2023 09:00	25/07/2023 10:00	30/05/2023 16:25	15/06/2023 09:36
			☑			☑	☑

Outcome of Contingency and Probabilities (P-Factor)



Probability	P10	P20	P30	P40	P50	P60	P70	P80	P90	P95
TIC$ @Probability	5,599,277	5,650,630	5,688,693	5,722,155	5,745,111	5,773,738	5,805,231	5,841,654	5,881,483	5,919,509
Systemic Contingency	113,466	130,688	143,029	154,979	164,870	176,126	188,264	203,894	220,867	238,637
Specific Contingency	237,017	269,408	293,854	314,316	326,547	342,905	361,366	380,630	401,704	420,503
Total Contingency	**350,483**	**400,096**	**436,883**	**469,295**	**491,417**	**519,031**	**549,629**	**584,524**	**622,572**	**659,140**
Escalation	248,794	250,533	251,809	252,860	253,694	254,707	255,602	257,130	258,912	260,369
Incurred To date	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000

Estimate Specific Risk – Labor Cost



URI COA	ESTIMATE SUMMARY Prime Accounts	PDF Mhrs	Estimate Mhrs	Actual Mhrs	To Go Mhrs	Min Range	Max Range	PDF $ Value	Estimate To Go
		L	L1	L2	L3	10	90	Pv	Est.
250	**Pipeline Spread 5**								
250	Wage Rate-Pipeline Spread 5	81.6		79.00		1	1.2		
	Labor PF-Pipeline Spread 5	1.0		1.00		0.9	1.2		
25A	Labor - Mob / Demob & Welding Pro. & Clearing	23,156	22,776	0	22,776	1	1	1,890	1,799
25B	Labor - ROW Preparing & Topsoil Strip / Grade	415,005	375,628	0	375,628	0.95	1.25	38,999	29,675
25C	Labor - Trench Excavation, Backfill & Compact	295,95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	997
25D	Labor - Line Welding, Tie-in & Valve Assemblies	547,09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	855
25E	Labor - Final Clean-up / Topsoil Reinstatement	126,83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	855
25F	Labor - HDD, River Crossings & HDD Support	76,299	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	929
25G	Labor - PM Staff, Medical & Field Support	430,83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	745
25	Labor - Allowances	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
	Labor-Pipeline Spread 5 Risk	1,915,17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	,855
260	**Pipeline Spread 6**								
260	Wage Rate-Pipeline Spread 6	82.7							
	Labor PF-Pipeline Spread 6	1.0							

Labor cost is calculated based on wage rate (risk #1), productivity (risk #2) and estimated man-hours (risk #3). Estimated labor cost of topsoil grade of $29.7Million became $39Million due to low PF in difficult terrain and likely increased field hours (estimated 375.6K to simulated 415K mhour).

Estimate Specific Risk – Subcontractor Performance

RISKCORE ANALYSIS INPUT WORKSHEET - SUBCONTRACT

URI COA	ESTIMATE SUMMARY Prime Accounts	PDF Pricing	Unit Rate Estimate	Actual Cost	To-Go Cost	Min Range	Max Range	Mean $ Value	Estimate To Go	$	Std Deva
		S	S1			10	90	Pv	Est.		
290	**Facilities (On-shore)**										
	S/C PF-Facilities (On-shore)	1.0	1.00			1	1.25				0.1768
29A	Subcon. - Group A PS (Cardiff & Redwater)	66,001	61,876	0	61,876	1	1.15	76,390	61,876	cn	0.1061
29B	Subcon. - Group B PS (Moncton & Hargreaves)	68,809	61,928	0	61,928	1	1.25	71,676	61,928	cn	0.1768
29C	Subcon. - Group C PS (Blue River & Hamshire)									cn	0.1414
29D	Subcon. - Group D PS (Saskateen & Hope)									cn	0.0000
29E	Subcon. - Utility Power (Black Pines, & Whitemud)									cn	0.0000
29F	Subcon. - Remote Mainline Block Valves									cn	0.0000
29G	Subcon. - Mainline I&C Work & Electrical / SCADA								0	cn	0.0000
29H	Subcon. - Facility EPC Common Cost								10,072	cn	0.3182
29I	Subcon. - Termimal Tank Fnd., Constr. & Testing								17,244	cn	0.1061
29J	Subcon. - Receiving Station, Piping, CM & NDE								6,455	cn	0.0000
29K	Subcon. - Central Process, EI&C, CM Inspection								0	cn	0.0000
29L	Subcon. - Major Connector - Transferred Cost								0	cn	0.0000
29	Subcon. - Allowances								0	cn	0.0000
	S/C-Facilities (On-shore) Risk								**334,866**		**0.3182**

No Data Entry
Calculated by Formula

Function Arguments

RiskTrigen

Bottom value	H165*I165	= 61928
Most likely value	H165	= 61928
Top value	H165*J165	= 77410
Bottom %	I7	= 10
Top %	J7	= 90

= 68808.88889

Specifies a triangular distribution with three points--one at the most likely value and two at the specified bottom and top percentiles.

Top % is a value between 0 and 100 that gives the percentage of the total area under the triangle that falls to the left of the entered top value.

When a subcontract is of "lump-sum" fixed price, risks of claims need to be considered , hence risk range P10 and P90; when a contract is cost plus, the performance and quoted prices are all at risk, hence their PF (productivity) is to be risked along with the estimated prices. TRIGEN is used herein.

Case Study – Contingency due to Systemic Risks

RISK CORE LTD.

RISCOR SYSTEMIC RISK IMPACTS (TOP 20 IN THE RISK REGISTER)											
	Project Name	Pioneer Major Project						Date Simulated			30-Jul-17
RSK	Project Location	East Coast, Canada						Estimate Class			Class III
Project Risk Identification as of May 2017			Risk Probability				Cost Impact (x $1,000)				
RISK ID#	RISK Title	RISK Brief Description	Prob. 0.1-0.9	1 - Prob. 1 - P	Simulated Occurrence	Occurs (?)	Minimum 10	Most Likely	Maximum 90	Mean Cost	Simulated Cost impact	Extra Costs to Base Estimate
RSK-1	Project Team's Experience & PM Processes	Weak project management team assigned to Pioneer may not have worked together on large scaled major projects with the required competence and experience resulting in much higher costs due to frequent key staff turnovers and lacking strigent PM processes.;	70%	30%	0	No	37,500	50,000	67,500	15,644	52,148	0
RSK-2	Rework due to Engineering error	The costs of repeated field re-work may incur due to engineering errors or delays of timely responses to site RFIs.	70%	30%	0	No	22,500	30,000	40,500	9,387	31,289	0
RSK-3	Wildlife and Rare Plants	Construction activities may be delayed due to encountering wildlife and rare plants along the pipeline route. $500K per spread is allowed for.	90%	10%	0	No	22,500	30,000	40,500	3,129	31,289	0
RSK-4	Labor Productivity	The skills and experiences of pipeline labour force have decreased over past several years (as a general trends) resulting in lower PF and higher costs. It is covered in specific cost estimate risk analysis modeling (P90=1.2).	90%	10%	0	No	15,000	20,000	27,000	2,086	20,859	0

=RiskDiscrete({1,0},E9:F9,RiskStatic(0))

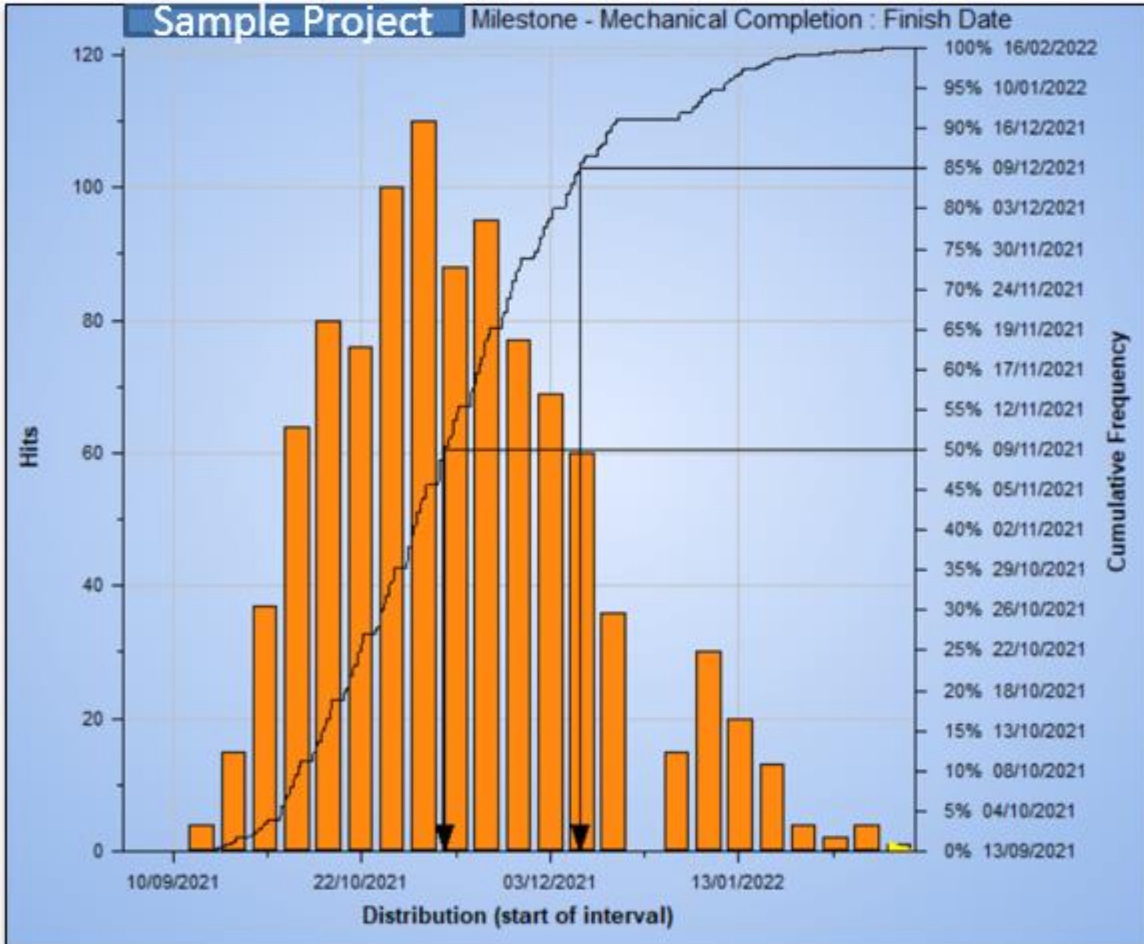
=RiskTrigen(I9,J9,K9,I7,K7,RiskName(D9&"/"&M7))

=RiskMakeInput(G12*M12,RiskName(D12&" Cost Impact"))

Probability Associated Risk Impacts	Mean	10%	20%	30%	40%	50%	60%	65%	70%	75%	80%	85%	90%
Systemic Contingency (Cost)	167,164	113,466	130,688	143,029	154[illegible]79	164,870	176,[illegible]26	182,085	188,264	197,510	203,894	211,042	220,867
Systemic Contingency (Time)	101	61	72	83	9[illegible]	99	10[illegible]	112	117	120	126	135	145

The sum of probabilistic cost impacts from selected top 20 systemic risks (from Brainstorming Workshop or risk register) using Discrete Distribution is $164.9Million at 50% confidence (P50), instead of $239.5Million in total.

Schedule Risk Analysis – Delay Contingency

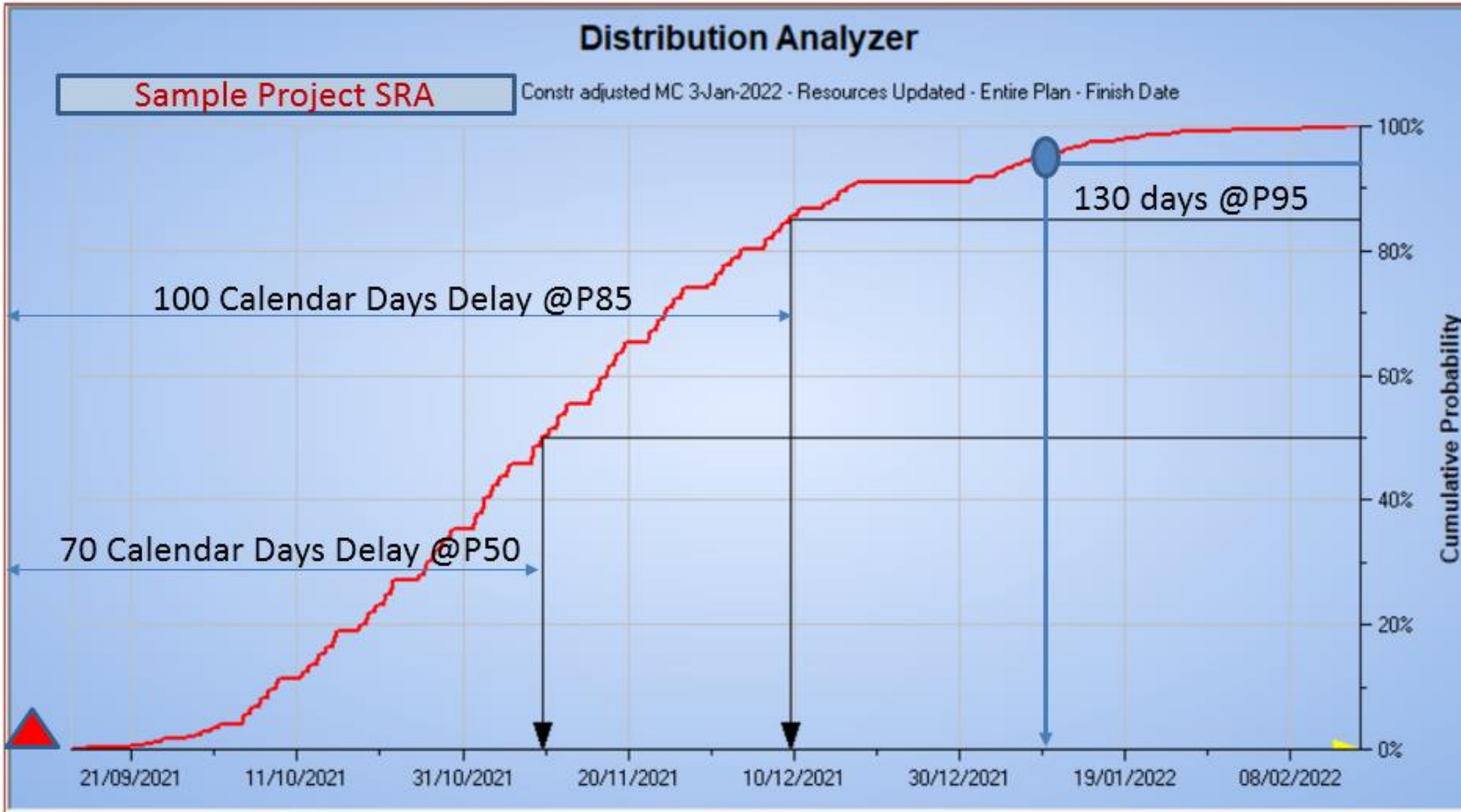


Finish Date of:	
	Milestone - Mechanical Com...
Analysis	
Iterations:	1000
Statistics	
Minimum:	13/09/2021
Maximum:	16/02/2022
Mean:	12/11/2021
Bar Width:	week
Highlighters	
Deterministic (30/08/2021)	<1%
50%	09/11/2021
85%	09/12/2021

There is a 75% probability that the project has three months delay in MC date.

SRAs are conducted using Primavera Risk Analysis (PRA) software to analyze the schedule for the probabilities of meeting planned Project Finish dates.

Project Schedule Delays at various P-Factors



	Show	Deterministic probability	Deterministic Value	50%	85%
Sample Project SRA – Finish Dates:	☑	<1%	30/08/2021	09/11/2021	09/12/2021
		☑		☑	☑

Contingency - SRA & CRA Integration

RISKCORE ANALYSIS INPUT WORKSHEET - LABOUR

Pioneer Major Project

Labor Manhours x 1

URI COA	ESTIMATE SUMMARY Prime Accounts	PDF Mhrs	Estimate Mhrs	Actual Mhrs	To Go Mhrs	Min Range	Max Range	PDF $ Value	Estimate To Go	$	Std Deva
		L	L1	L2	L3	10	90	Pv	Est.		
SDC	**Schedule Delays**										
	Weeks of Schedule Delayed	22	20		50%	0.75	1.5				
	Duration To-Go in Weeks		165		38	MONTH					
49	Labor - Cost of Schedule Delays	1,234	1,159	0	1,159	0.9	1.25	27,196	0	cn	0.2475
	Labor-Schedule Delays Risk							27,196	0		0.2475
500	**Project Execution Mgmt**										
500	Wage Rate-Project Execution Mgmt	100.0		100.00		1	1				0.0000
	Labor PF-Project Execution Mgmt	1.0		1.00		1	1.15				0.1061
52F	Labor - Contractors Management Team	521,930	474,200	0	474,200	0.98	1.25	53,498	47,420	cn	0.1909
52G	Labor - Dedicated Employees	556,480	556,480	0	556,480	1	1	57,039	55,648	cn	0.0000
53H	Labor - Travel, Incentives, Pre-Dev. Expenses	0	0	0	0	1	1	0	0	cn	0.0000
53I	Labor - Regulatory & Stakeholder Engagement	367,333	330,600	0	330,600	1	1.25	37,652	33,060	cn	0.1768

P50 = 70 days Delay

Contingency is needed to cover additional field indirect costs due to construction schedule delay, or to cover extra costs of schedule crash.

Riscor Model simulated extra field indirect cost for labor and subcontract due to delay in total project duration (38 month / 165 weeks + 10 weeks).

Rare-Event Driven Risks for Management Reserve

RISK CORE LTD.

ID	Uninsurable Rare Risks Accepted or Ignored Risks	Probability Happen	Status	Estimated Impact	EV-Mean Simulated	Opt. & Pess. Ranges Low %	High %
	Uncertainty Events	P %	Discrete	$ Cost	$ Value	5	95
1	Extreme weather conditions (e.g. floods, heavy snowm fire, bridge washout) may significantly result in much lower construction PF than what is estimated.	5%	0	5,000	0	0.6	1.75
2	Vendors may go bankrupt due to economic downturn (Vendors inability to complete the package) despite prequalification	10%	0	10,000	0	0.7	1.5
3	During construction phase, pipes, valves or construction equipment may be severely vandalized by "activists" or "upset workers" (e.g.. drill holes to pipe)	2%	0	30,000	0	0.8	1.6

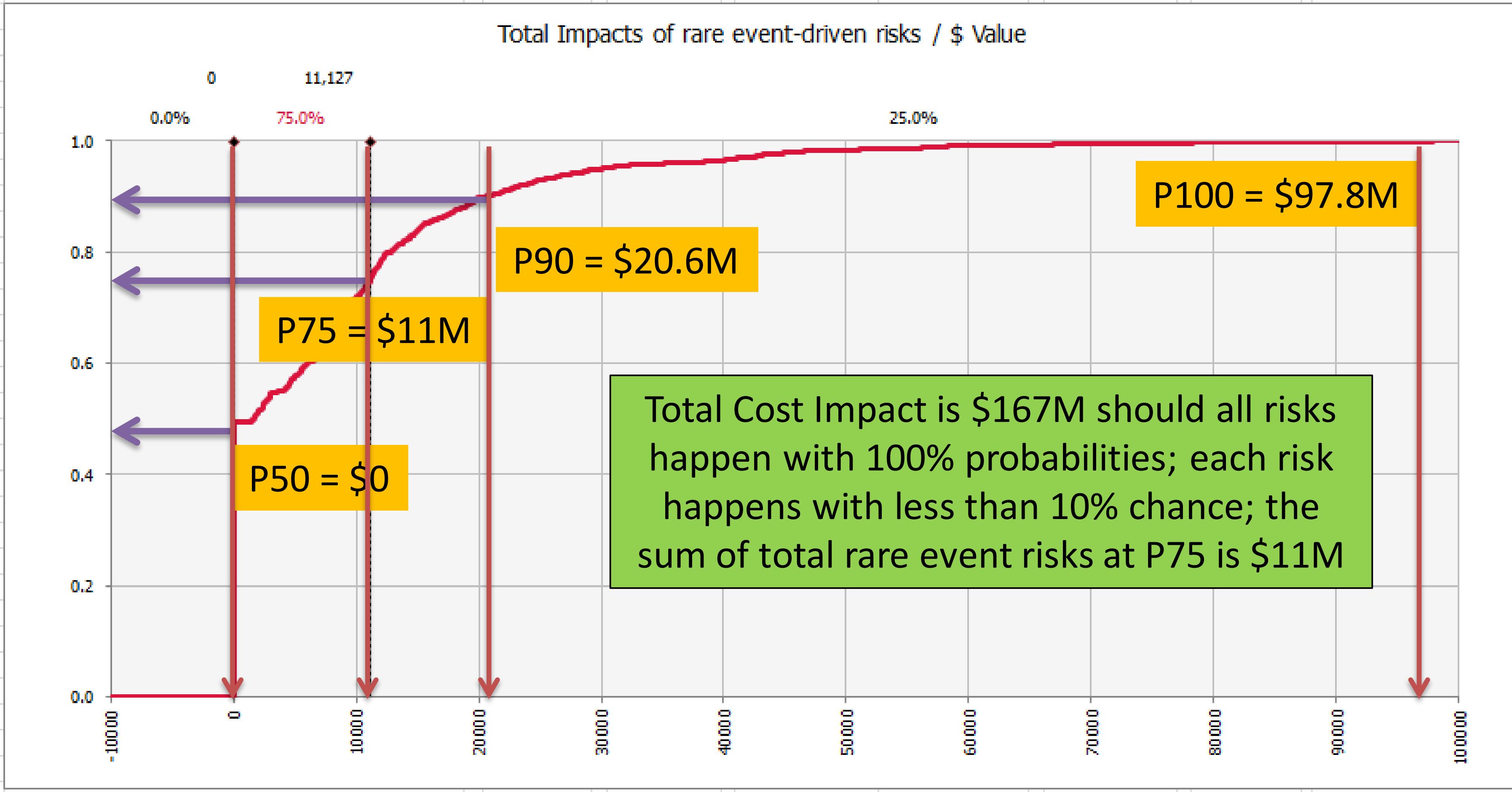
Total Impacts of rare event-driven risks	167,000	0
Rare-event Risk Reserve @ P75		11,127

Summary statistics

Total impact with a Confidence of	75%		***$11,127***
Mean Value of total impact			$7,555
Maximum value of total impact			$97,815
Standard Deviation of total impact			$12,213
Probability of total impact equals zero			50%
Probability of an impact equals (10%) to		$ 16,700	14%

Recommended Project Risk Reserve % and $ (P75)	11,127
	6.7%

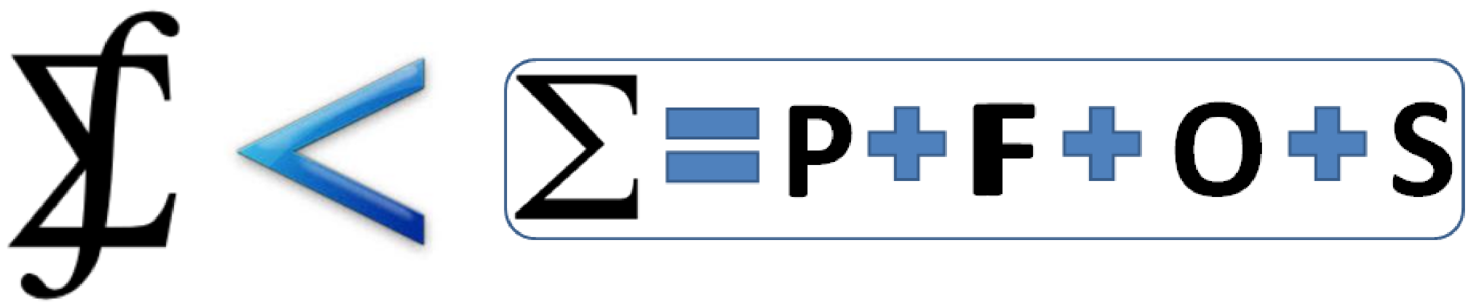
Management Reserve



The Management Reserve is the simulation result of residual risks and rare-event driven risks at chosen confidence level. It is not a part project contingency but an addition.

Worth Noting - Total Project and Subprojects

The Sum of Individual Subproject Risk Analysis Results at P50 or higher is more conservative than the integrated QRA of several subprojects in terms of contingency amount at the probability of >50% (under-running the budget).



The case study "Pioneer Project" chose to select an contingency amount at P50, and use the integrated QRA approach.

P50 is deemed a risk "neutral" position, and it may be considered as a balanced approach from contractor's point of view.

Summary of Contingency Simulation

- Contingency should be simulated, not calculated, for capital projects' cost estimates; it is not only a science but also an art therefore a combined "Scientific Art" technique.

- To properly derive a contingency amount, following items must be considered, modeled and analyzed:
  - Estimate Specific Risks (e.g. labor, materials, etc.)
  - Project Systemic Risks (e.g. weather, team, regulatory)
  - Schedule Delay Risk (e.g. overall critical path delay)
  - Market driven Escalation Fluctuation risk
  - Strategic and Enterprise risks (for public sectors)

- A well-built, scientific-research based risk simulation model needs tested, verified and validated for trustworthy results.

THANK YOU, CIQS Members for the Opportunity

The mission of CIQS is to:

- Promote and advance professional quantity surveying and construction estimating;
- Establish and maintain national standards;
- Recruit, educate and support our members.

Project Risk Management and Quantitative Risk Analysis (QRA)
Supported By Proprietary RISCOR™ Monte Carlo Simulation Model

www.riskcore.ca jzhao@riskcore.ca 1 587 352 6698