The Cost of Risks

Essence of Risk Quantification

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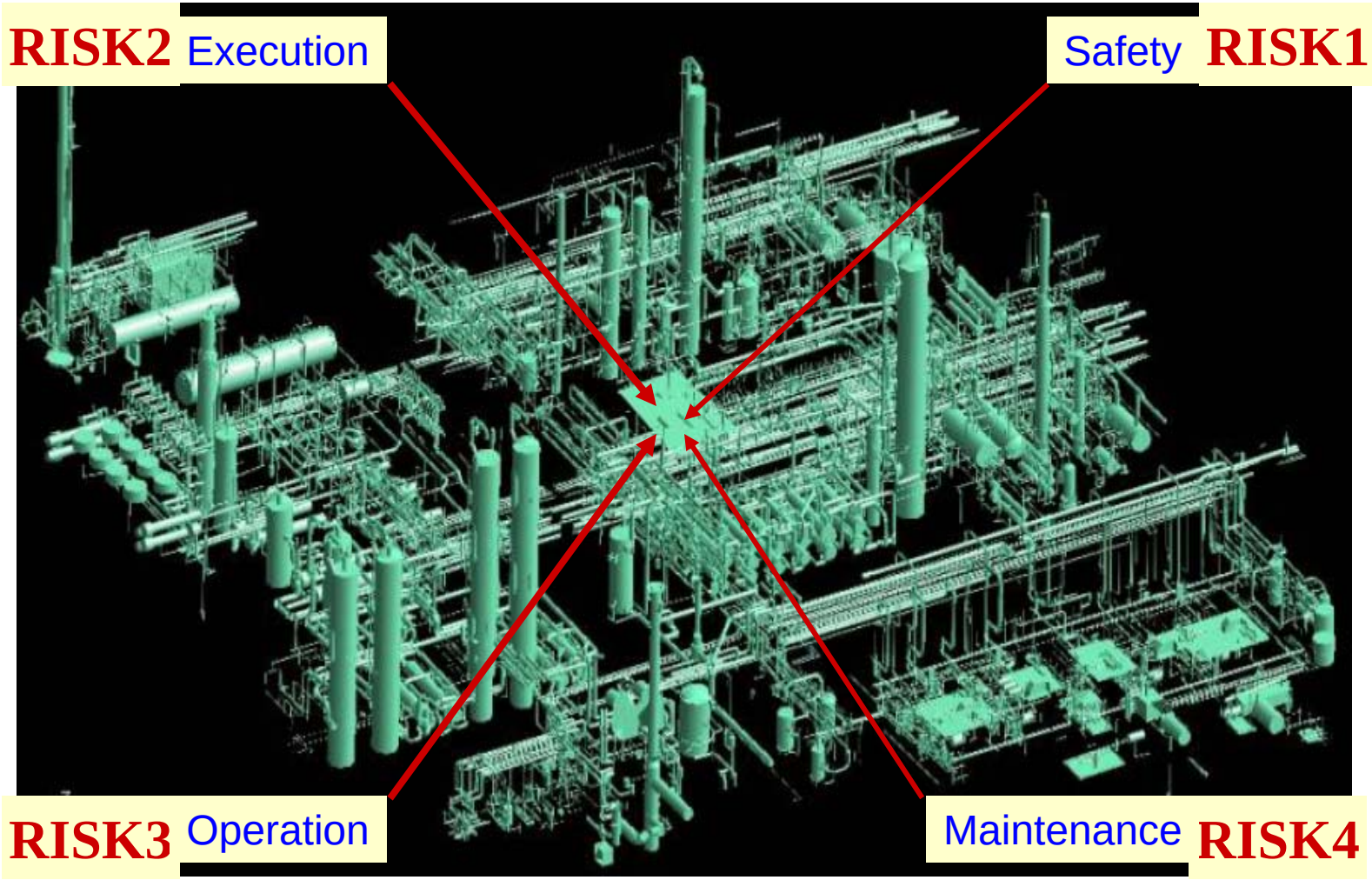
John G. Zhao, 2008

Energy Plants are Complex and Sophisticated



Warnings: only qualitative or semi-quantitative risk assessments are not sufficient for complex energy projects & operations !

Measurement Philosophy

- Operation Philosophy

  “Flexible” annual budgeting

- Project Philosophy

  “Fixed” budget & duration

Definition of “Project” - the investment by an organization to achieve an objective within a programmed time that returns added value to the business activity of the organization.

Kelly, et al 2004

KEY WORDS:	Investment (cost)	Time (schedule)
COMMONALITY:	Quantitatively Measurable	

Quantified Project Cost Overruns

Major Oilsands Projects (2006 >$1B)

Suncor Millennium – 100K BPD (Brown Field)

§ 2002 startup – six (6) months behind schedule

§ $3.5 billion – seventy percent (70%) over budget

Shell Albian Sands – 155K BPD (Green Field)

§ 2003 startup – six (6) months behind schedule

§ $5.7 billion – sixty percent (60%) over budget

Syncrude UE-1 – 100K BPD (Brown Field)

§ 2006 startup – Eighteen (18) months behind schedule

§ $8.55 billion – one hundred percent (100%) over budget

Project	Budget (£millions)	Final Account (£millions)
Thames Barrier	23	461
Barbican Arts Centre	17	80
Natwest Tower	15	115
Humber Bridge	19	120
British Library	164	450
Sydney Opera House	2.5	87
BNFL Thorpe	300	2800
Trans-Alaska Pipeline	900	8,500
Channel Tunnel	4,000	11,000
Scottish Parliament	40	400

… many major / mega projects cost overruns were due to unrealistic cost estimates …

Flyvbjerc *et al,* 2003, Cambridge University, UK

But, how about rigorous risk assessment ??

In a recent survey, 6 of the 10 factors that were found to be significant for project success (in terms of time, cost & scope) were related to the adequacy of the risk management practices employed!

David Greenwood, Professor

Northumbria University
Newcastle-upon-Tyne,
United Kingdom

Risks and Decisions – Strong Correlation

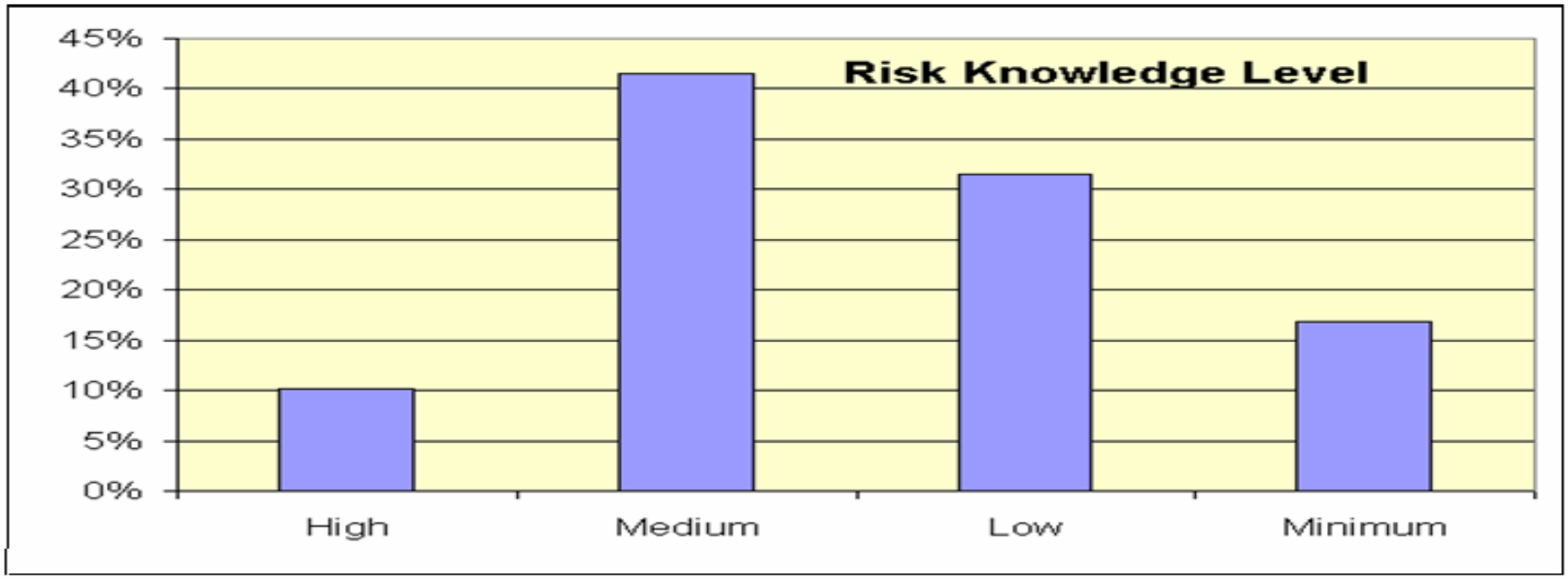


Figure 7-1 Combined Results of Participants' Risk Mgmt Knowledge Level

TABLE 7: Decision Quality Improvement using Risk

D. Quality	# (USA)	# (UAE)	# (Canada)	Total	%
100%	3	7	9	19	**21%**
75 - 50%	5	10	37	52	**58%**
50-25%	3	4	6	13	**15%**
<25%	2	0	3	5	**6%**
TOTAL	13	21	55	**89**	

TABLE 4: Importance of Risk in Making Decisions

Importance	# (USA)	# (UAE)	# (Canada)	Total	%
Very	8	18	42	68	**78%**
Somewhat	2	3	8	13	**15%**
Not Very	3	0	3	6	**7%**
Neglible	0	0	0	0	**0%**
TOTAL	13	21	53	**87**	

Table 7-1 Decision Quality and Importance of Risk in Making Decisions

Based on 100 Questionnaires Survey by John G. Zhao year 2007

Decisions to Approve Mega Projects – Oil Price

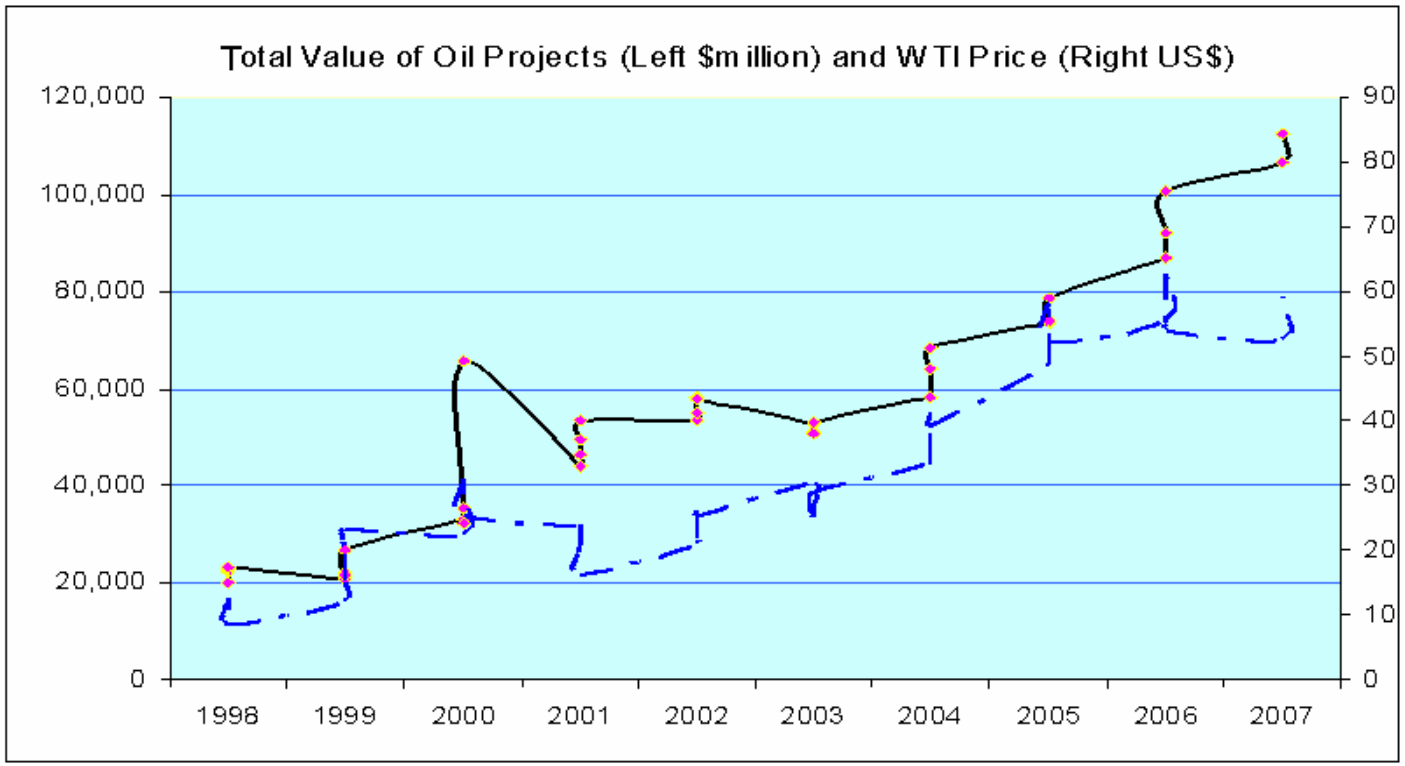


Figure 1-2: Value of oil-related major projects in Alberta vs. the World Oil Price
Solid line denotes total dollar value of projects; broken line indicates WTI

Profit hungry oil companies accelerate their capital projects to generate revenue when oil prices are high; they often suspend, defer or stop projects when oil prices fall. Only those sensible ones with risk minds eventually win.

Even Strategic Decisions Not by Quantified Risk Assessment

Major Strategic Decisions in Canada:

1) Petro-Canada's decision to invest $33.4 Billion on its Fort Hill Oilsands Project – Canada Year 2007

2) Royal Dutch Shell's decision to build $27 Billion Scotford 2 Refinery Project – Canada Year 2007

3) The buyout of Telecom giant BCE Inc. - one of the largest targeting at $51.7 Billion – Canada year 2007

4) Rio Tinto PLC (USA) $45 Billion buyout of Canadian mining giant Alcan Inc. – Canada Year 2007

- Statistics Canada 2007
- National Post Canada 2007

Few organizations care to attempt the rigorous risk analyses in approving AFE for mega projects, instead, a throw-in amount of contingency is used as "cover-all" for all potential decision risks.

Story: a $24B NASA project – $8B of Budget was "Contingency"

The Enchanted Stories of Contingency

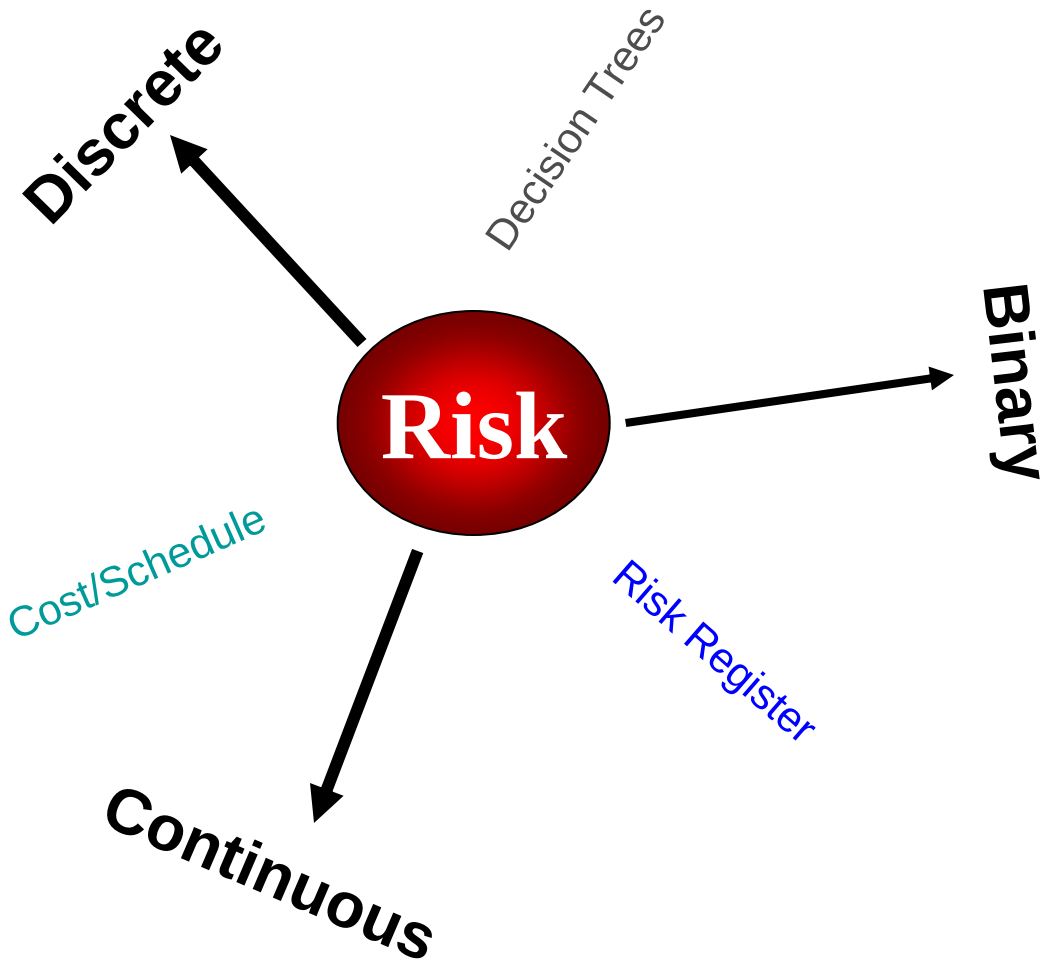
- Brave project managers don’t need contingency, estimates are fat;
- We hide & bury contingency in estimate details fearing to loose it;
- Contingencies belong to Senior VP, we projects have no controls;
- Contingency is a bag of slush fund that nobody knows the details;
- We use contingency to cover overruns, first come first serve basis;
- A few of us talked about and came up with a 10% contingency !
- What do you mean we can not advance contingency? PM says OK;
- Contingency draw-down follows cashflow, not execution schedule;

Risk Taxonomy and Application

Project Manager's
RISK REGISTER

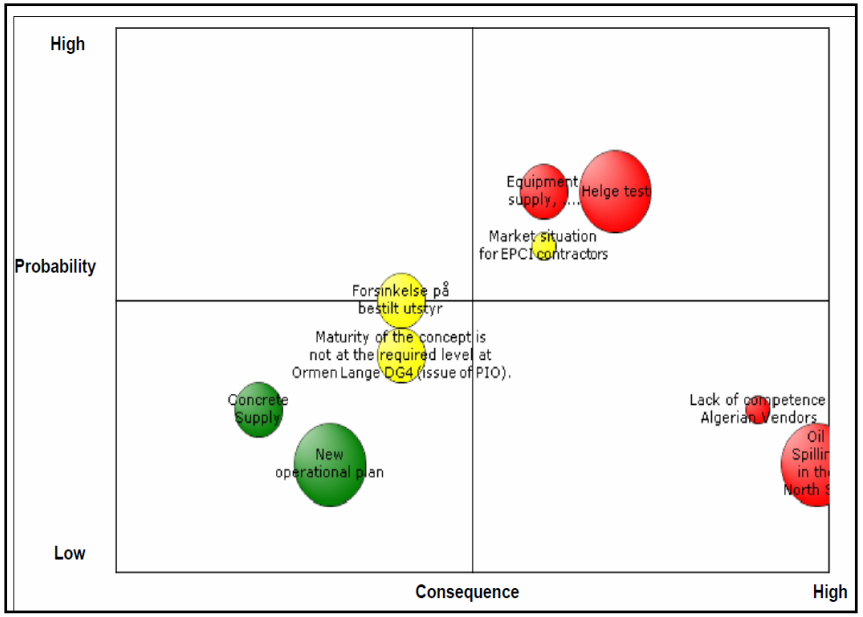
Project Controls'
CONTINGERNCY

Project Executive's
DECISIONTREE



Project Management Perspective – Qualitative Risk

Probability of Occurrence	Severity of Risk = Proability x Consequence					
Likely (> 90% Chance)	5	Tolerable III	Tolerable III	Undesirable II	Unacceptable I	Unacceptable I
Possible (70% - 90%)	4	Workable IV	Tolerable III	Tolerable III	Undesirable II	Unacceptable I
Unlikely (~ 50%)	3	Workable IV	Workable IV	Tolerable III	Tolerable III	Undesirable II
Rare (10% - 30%)	2	Workable IV	Workable IV	Workable IV	Tolerable III	Tolerable III
Remote (< 10% Chance)	1	Workable IV	Workable IV	Workable IV	Workable IV	Tolerable III
		1	2	3	4	5
% of AFE	Economic Impact	Negligible <1%	Low 1%-3%	Moderate ~5%	Tolerable 5%-7%	Serious >9%



- A risk Log / Register is generated through risk identification process;
- A typical Risk Matrix is established to rank risks' severity (P x C);
- Risk response action plans are produced to deal with high risks;

- Lack of serious numerical and analytical measurements in P & C;
- Ambiguous and vague comparison between risks for their ranking;
- Top 10 risks are largely subjective "President's Choice" w/o calculus;

A close Look at Qualitative Risk Register

Risk Identification	Initial Risk Ranking									
Risk Description	Probability	Initial Impact Assessment (I - VI)				Consequence	Priority	Initial	Risk	Cost
Symptoms and Root Causes	(A): I - VI	EH&S	Cost	Schedule	Social	(B): I - VI		Score	Level	Impact
Inability to operate plant competitively in emerging markets given changes in technology	3	1	4	2	1	4	2	12	III	
Lead time for plant power supply exceeds available window for construction and commissioning	4	1	3	5	1	5	2	20	I	
1) Re-work due to un-approved equipment being installed. 2) Contractor submitting C.O.'s for work not included in original SOW.	3	1	3	3	1	3	2	9	III	

Most traditional Risk Registers, being operations or projects, stop at ranking the risk levels at the best.

Because the monetary impacts are not estimated and often Omitted, the cost and benefit analysis can not be properly Performed, hence the risk response actions and monitoring Become only Qualitative Paper Exercise.

Without numbers, risks are just gut feels.

"Against the Gods", 1996 Peter Bernstein

Use Pareto's Law (80 / 20 rule) to manage massive risk Items and their response actions (spend money effectively):

Traditionally,

- Top risks subjectively selected by managers or superiors;
- Chosen top risks may not have quantified risk impacts;
- Unknown if risk response action costs are reasonable;
- Even semi-ranked top risks (PxC) lack of true "estimate";
- Top risks selected may not have regression or correlation;

Bettered Project Risk Register – Discrete Monte Carlo Simulation

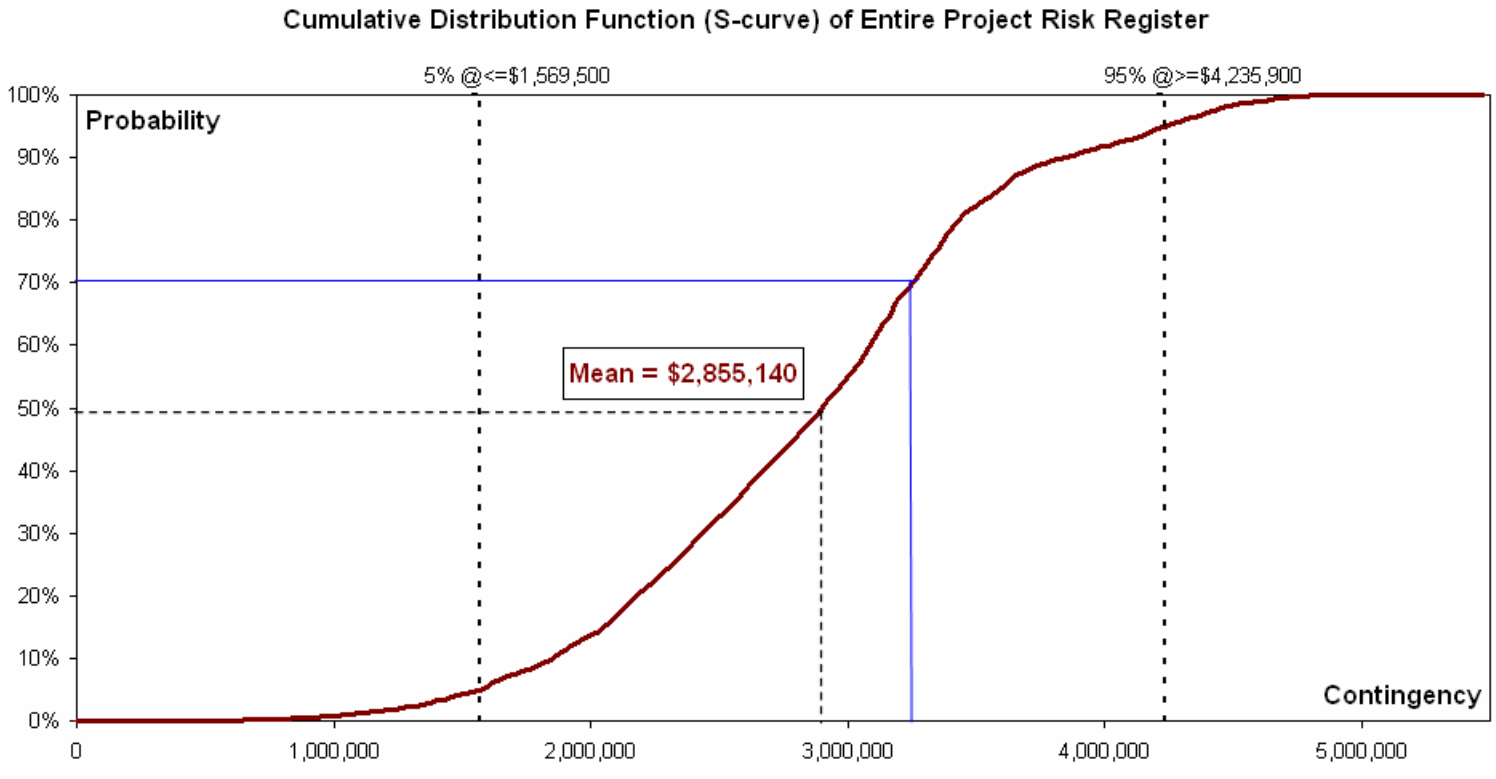
Risk Identification		Risk Ranking						Risk Response Action	
RISK ID#	RISK Brief Description	(1 - P)	Probability 0.1 - 0.9	N/A	Risk Impacts & Action ($)	"Mean" Cost Impact ($)	Simulated Cost of Actions $	Risk Response Action Plan	50% of Action Cost
1	July 1 2007 resulting in renting external	0.2	0.8	0	562,500	450,000	562,500	to rent outside camps 150manx25daysx10hr/day @$15/hr (1 month delay)	281,250
2	Excessive rework in fab shops or on site due to poor quality controls from EPCM	0.8	0.2	0	1,080,000	216,000	0	20% of 2M mhrs at 1.5% re-work ratio @ $180/hr	540,000
3	Potential lack of skilled trades and qualified supervision from local ABT	0.3	0.7	0	1,000,000	700,000	1,000,000	pay $5/hr retention for 10% of total 2M mhrs	500,000
4	Additional site work due to shipping of incomplete modules as poor workmanship	0.8	0.2	0	270,000	54,000	0	10 incomplete modules at 150 extra mhrs each @180/hr	135,000
7	Potential delays in key equipment supply due to vendor's manpower shortage	0.9	0.1	0	9,600	960	0	2 expediting personnel for a week @ $120/hr	4,800
8	Further delay in IFC drawings and CWP issuance causing construction delays	0.3	0.7	0	86,400	60,480	86,400	six engineers work extra 3 weeks @ $120/hr	43,200
9	Potential further delays of vendor information	0.6							
10	Potential financial difficulties encountered by contractor	0.9							
20	Rule of Credit not put into contract T&C	0.8	0.2	0	0	0	0	causing early payments but no extra costs	0
21	Lack of NCR and backcharge procedure causing re-work, returns and delays	0.3	0.7	0	270,000	189,000	270,000	hiring a full-time QC person on site to ensure NCR audits	135,000
22	Current system allows invoice payments to exceed committed values	0.2	0.8	0	200,000	160,000	200,000	$200K allowance for change orders that not approved	100,000
24	Increased ENG manhours to answer RFI's (not in original staff plan)	0.2	0.8	0	691,200	552,960	691,200	4 engineers of 8 months @ $120/hr (180hrs / month)	345,600
25	Lack of project controls resources for field cost control functions	0.3	0.7	0	67,200	47,040	67,200	OT pay and 2 consulting estimators for 1 month	33,600
26	Lack of updated project organization and well communicated	0.2	0.8	0	20,000	16,000	20,000	confusing and efficiency allowance	10,000
28	Lack of enforced D&A policy on project may cause remobilizing contractors / trades	0.3			25,000	17,500	25,000	100 trades to be re-hired for extra $250 per head	12,500
	SUM of Total Risk Cost Impacts				**5,193,900**	**2,855,140**	**3,364,300**		**2,596,950**
	Assuming All risks would occur				5,193,900				
	Statistical Risk Occurrence (PxC)					2,855,140			
	Assuming Risks >P50 would occur						3,364,300		
	Probability Associated Risk Impacts		Mean		Mode	10%	50%	70%	90%
			2,855,140		3,172,300	1,854,200	2,901,800	3,252,900	3,845,900

Impact estimate = 2000000x0.2x0.015x180 = 1080000

RiskDiscrete({0, $},{(1-P),P}) or RiskDiscrete(F9:G9,D9:E9)

Contingency

Project Contingency based on bettered Risk Register



Probability associated (risk tolerance level) Project Contingency

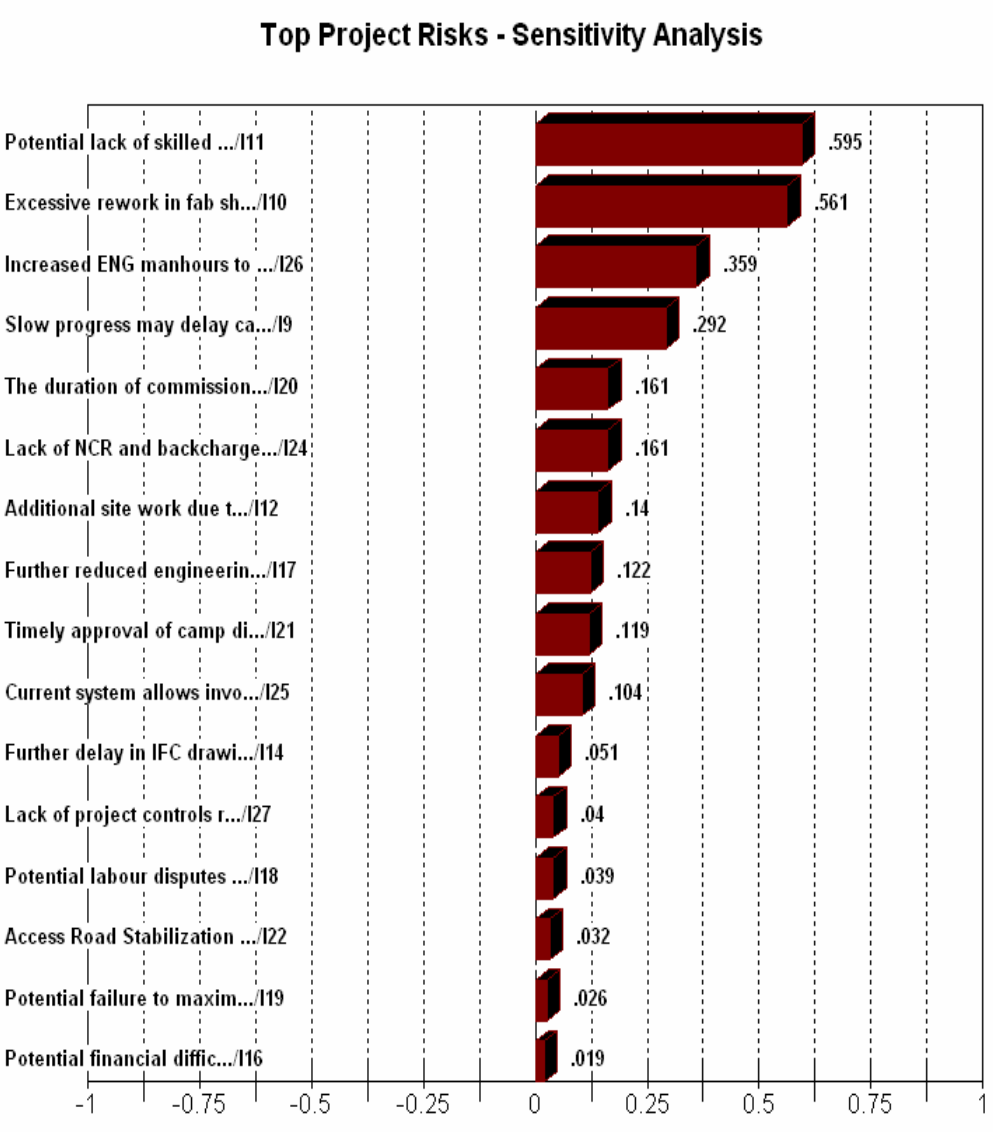
- Not to cover ALL risks identified in the Project Risk Register;
- Not necessarily the statistical mean value as contingency (too easy);
- Not to include only risks with >50% chance of occurrence;
- BUT, select the Probability aligned with company risk tolerability.

Scientific Selection:

- Monte Carlo simulation;
- Systematic & Consistent;
- Serious “thinking” on P;
- Numerical estimate on C;
- Respond to risk Tolerance;
- Considering Co-efficiency;
- Removing subjective bias;
- Statistical level Ranking;

Dynamic Iteration:

- Periodical risk reviews;
- Frequent simulation (6 mth);
- Update existing Accept new;



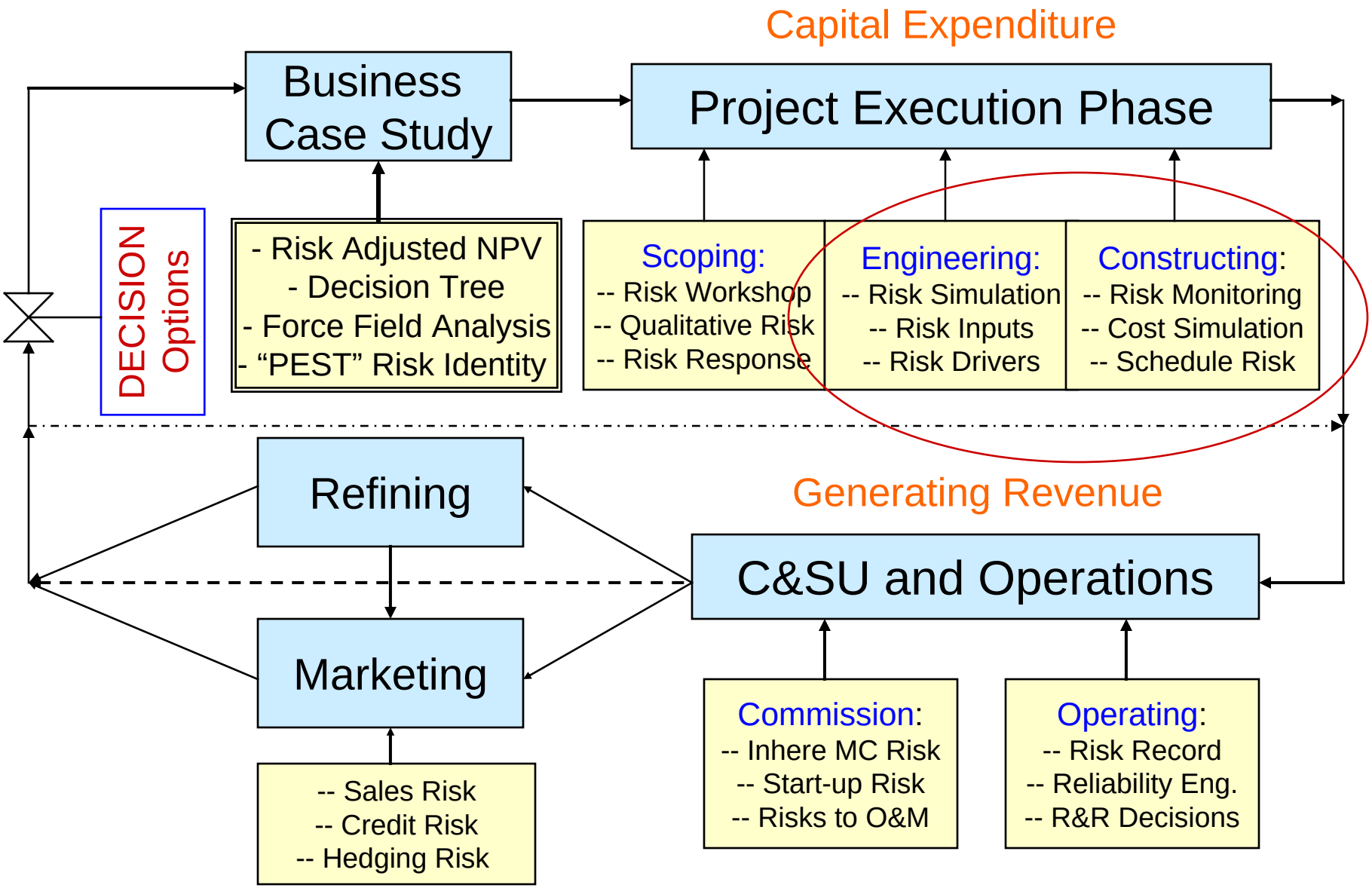
Top 10 Risks Deserve All “Contingency” ?

	Top 10 Project Risks based on Sensitivity		
Weighing	Risk Items and Description	Coeff.	Contingency
23%	Potential lack of skilled trades and qualified supervision	0.595	$ 660,577
21%	Excessive rework in fab shops or on site due to poor quality	0.561	$ 622,830
14%	Increased ENG manhours to answer RFI's (not in original staff	0.359	$ 398,567
11%	Slow progress may delay camp turnover on July 1 2007	0.292	$ 324,183
6%	The duration of commissioning period is not well defined	0.161	$ 178,744
6%	Lack of NCR and backcharge procedure causing re-work, return	0.161	$ 178,744
5%	Additional site work due to shipping of incomplete modules	0.14	$ 155,430
5%	Further reduced engineering productivity at the tail end of	0.122	$ 135,446
5%	Timely approval of camp disposal waste / of Actions $	0.119	$ 132,115
4%	Current system allows invoice payments to exceed committed v	0.104	$ 115,462

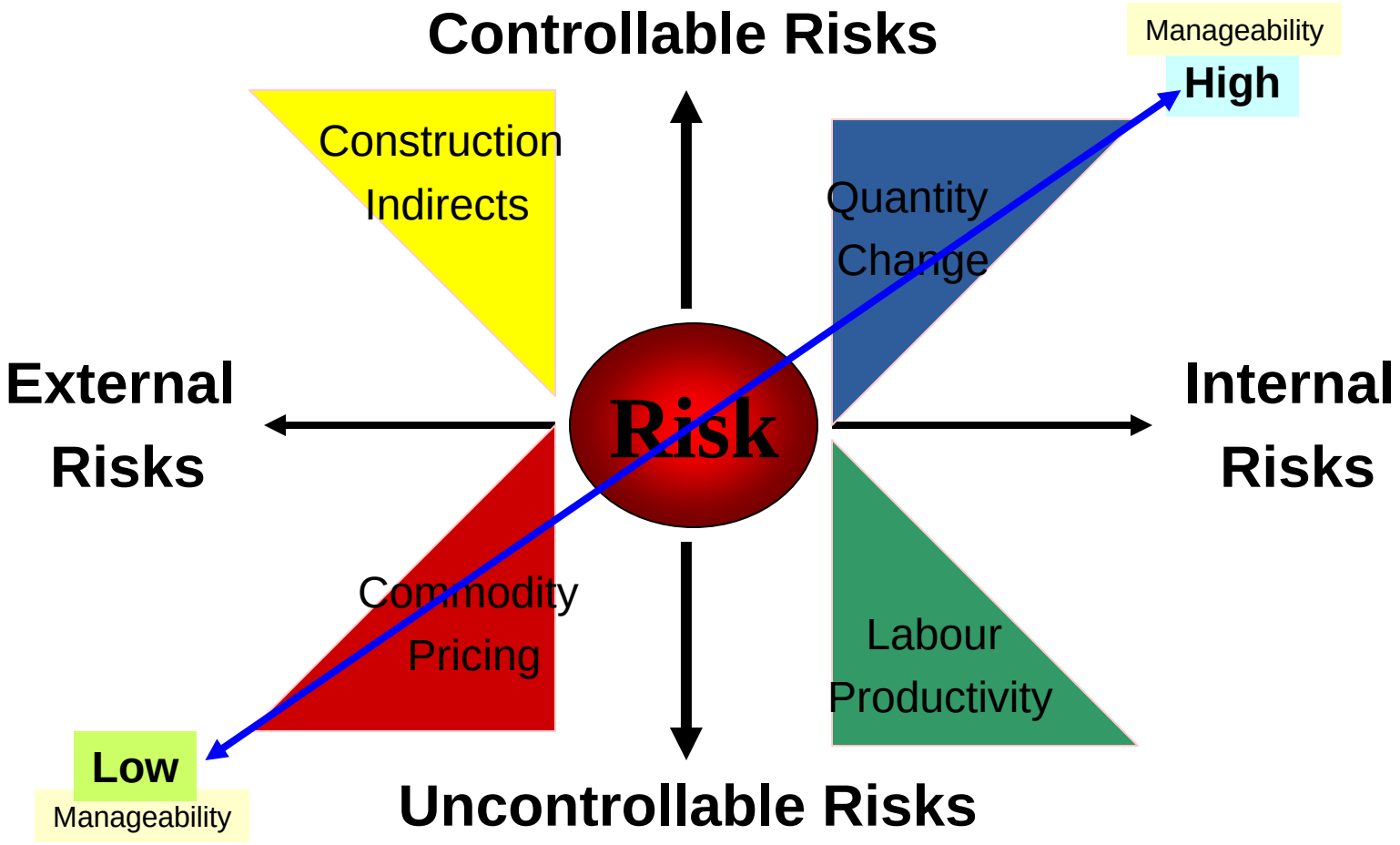
Cautions:

- Project Register based Contingency is only used as “supplementary”;
- Contingency amount for each risk item (Top 10) is not “true” risk value;
- The contingency amount can not be used as main project cost contingency;
- Register contingency draw-down plan / curve can not be effectively plotted;
- The Risk register contingency shall not duplicate cost risk analysis result;
- It is suggested the risk register “contingency” be included in ETC/Base;
- Don’t use Risk Register for Schedule and Cost Risk Analyses twice;

Business Process Mapping in Oil Industry



Investments to High Manageable Risks



Risk Analysis Model Building & Inputs – Continuous Monte Carlo

NO	Estimate Items	Static Estimate	Simulation Range 10	Simulation Range 90	Simulated Results
1	**Install Pipes on Racks**				
	Pipefitter Wage Rate	50			
	Labour Productivity	1			
	Field Piping Manhours	1,500	95%	125%	1,630
	Total Pipe Installation Cost	**75,000**			81,504
1	**Shop Fab for Spools**				
	Shop Pipefitter Wage Rate	40			
	Labour Productivity	1	95%	120%	1.06
	Shop Piping Manhours	800			
	Total Pipe Spool Cost	**32,000**			34,077
2	**Scaffolding Labour**				
	Wage Rate	50			
	Labour Productivity	1			
	Total DFL Manhours	1,500			
	Labour Hour %	17%	95%	150%	19.55%
	Total Indirect Cost	**12,750**			14,663
3	**Field Construction Indirects**				
	Temp Facilities	15,000			
	Small Tools & Equip	20,000	95%	108%	22,500
	Janitorial Labour	8,000			
	Total Indirect Cost	**43,000**			45,500
4	**Home Office Engineering**				
	Eng Staff Wage Rate	85	98%	115%	89.8
	Eng Productivity	1			
	Estimated Manhours	600			
	Total Eng. Cost	**51,000**			53,887
	Total Estimated Cost	**213,750**			**229,630**

```
=RiskTrigen(D8*F8, D8, D8*G8, 10, 90,
RiskCorrmat(Scaffolding,1))
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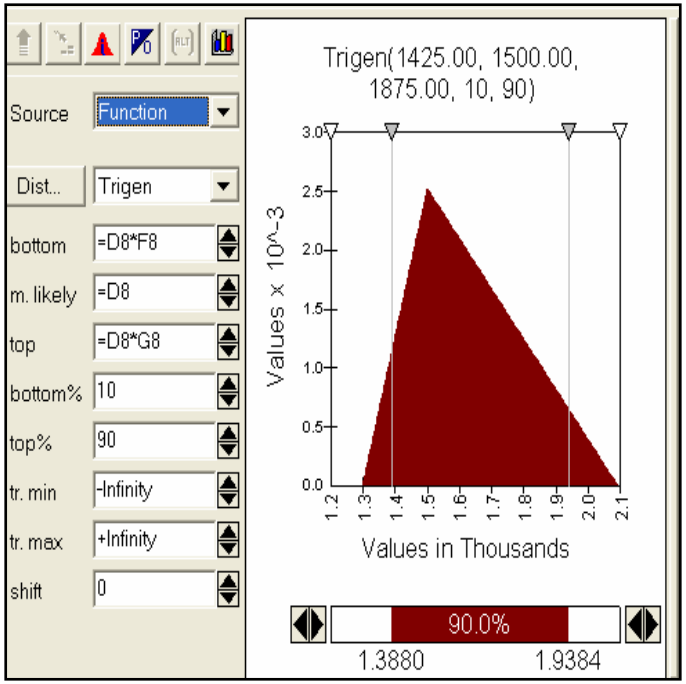


Note: It is assumed that the static Estimate represents the most likely case scenario.

P10 value estimate			214,683
P50 value estimate			228,673
P90 value estimate			246,138
Contingency based on P50	0.0%	7%	14,923

***Excluding from the model the rare prob. high impact risks**

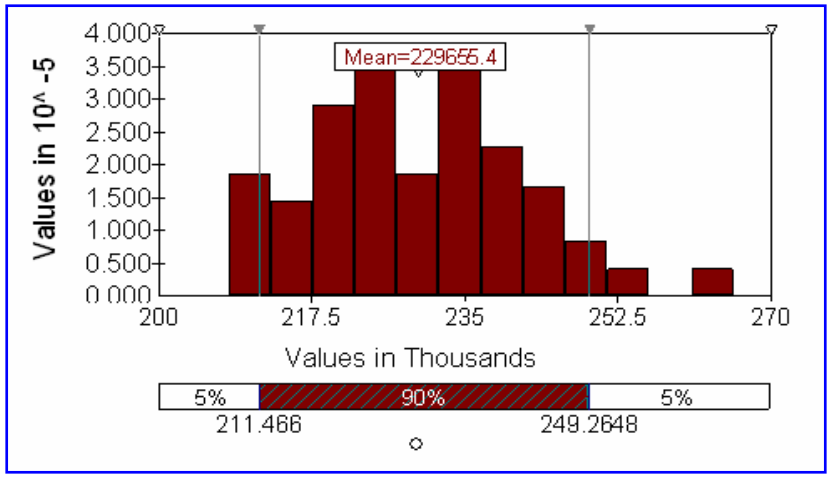
Risk Analysis Outputs – Project Contingency

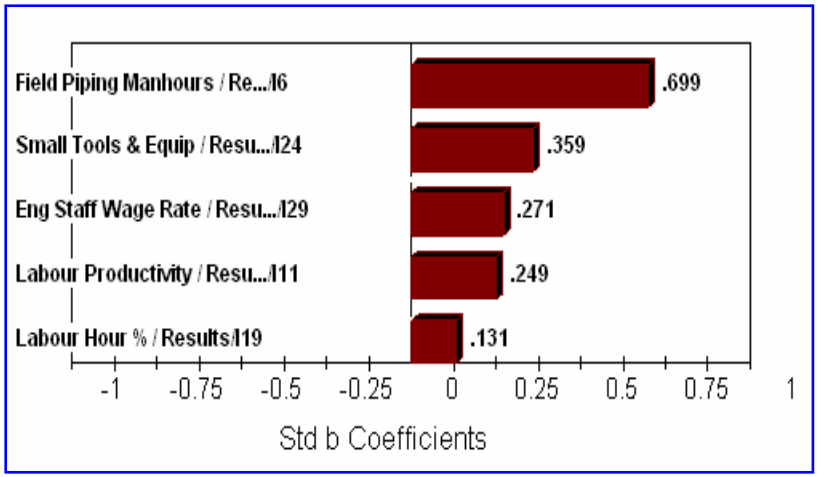
Correlations:

- Dependencies;
- Relationships;
- Logical connections;
- Strengths (co-eff.);

Sensitivity Ranking
Correlation Coefficient

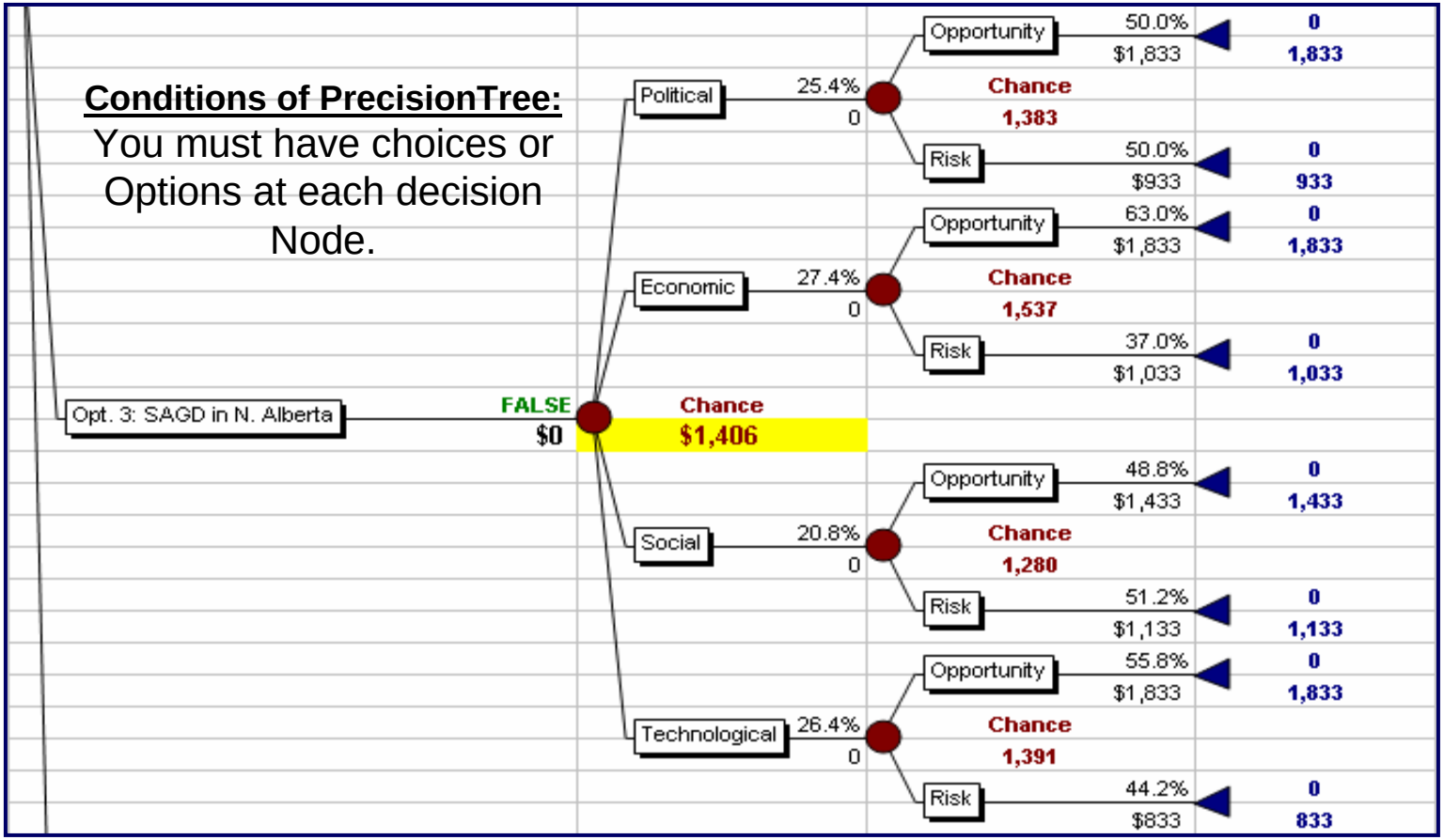
Rank	Name	Cell	Function	Regression	Correlation
Total Simulated Estimate Cost at I34, for Simulation 1					
1	Field Piping Manhours	I6	RiskTrigen(D6*F6, D6, D6*G6	0.698685905	0.829510951
2	Small Tools & Equip / F	I24	RiskUniform(15000, 30000, Ri	0.359344502	0.6210021
3	Labour Hour % / Resul	I19	RiskTriang(D19*F19, D19, D1	0.131223844	0.55019502
4	Eng Staff Wage Rate /	I29	RiskTrigen(D29*F29,D29,D29	0.271066652	0.302910291
5	Labour Productivity / R	I11	RiskTrigen(D11*F11, D11, D1	0.248590964	0.113819382





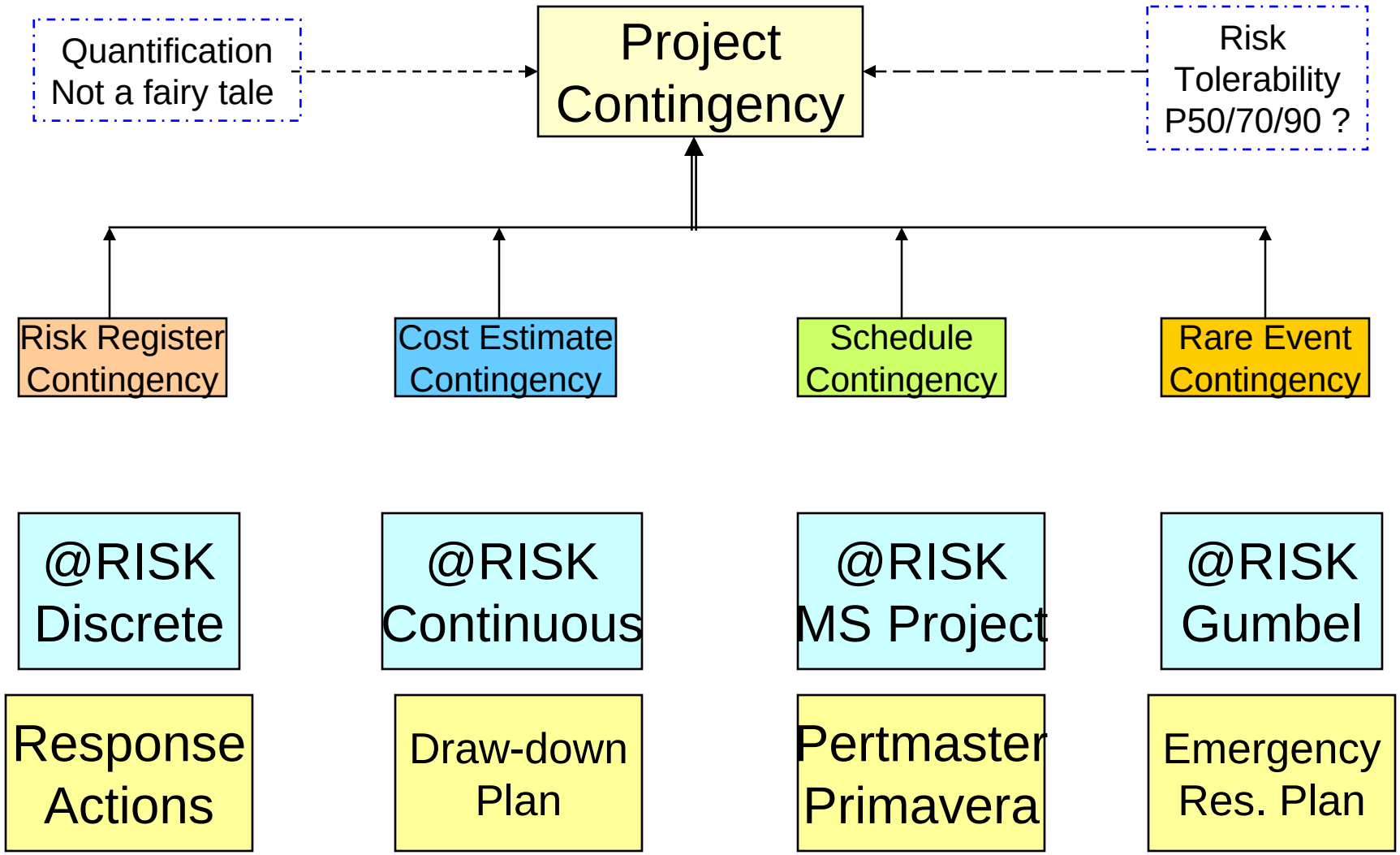
Project Contingency is derived from risk based histogram associated With corporation's risk tolerability level; Top project risks are obtained From quantified sensitivity analysis based on risk profiles.

Decision Tree – Both Probability and Consequences



The Decision Tree methodology using P & C concepts but focus on Cascading effects or strong cause-effect relationships for “decisions”.

The End Results of Project Risk Analyses



Final Conclusion …

Almost by definition, the future is uncertain.
We can reduce that uncertainty to some extent
but never remove it completely.

Jonathan Ashley-Smith, Professor

- How much money and time do we want to invest to reduce the risk / uncertainty?
- How much is enough to keep it as contingency fund?
- To what extent do we stop risk reduction efforts?
- How much can we tolerate risks?
- Does traditional “higher risk higher reward” hold true?

We will never agree to the answers to above questions !

THANK YOU !

Questions and Answers

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