Project Cost Risk Analysis: The Risk Driver Approach Prioritizing Project Risks and Evaluating Risk Responses

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Outline

- Some limitations of the traditional 3-point estimate quantitative risk analysis
- Introducing the Risk Driver Method to cost risk analysis
  - Method illustrated
  - Data collection considerations
  - Some benefits of the Risk Driver approach
  - Simple refinery construction example

Risk Prioritization – New approach

- More complete and powerful than the standard qualitative risk analysis using the Probability and Impact approach
- Compute the effect of individual risks on the cost, then sort risks by priority
- Risks are prioritized by probability and impact as they affect the cost through simulating the model of the project
- Assists risk mitigation decisions

Limits of the Traditional 3-point Estimate Approach (1)

- Traditionally we estimated the risk of each line item by applying a 3-point estimate of and a probability distribution to the line item cost
- This approach does not use the results of the qualitative risk analysis well
- We want to know which risks are important to guide risk responses. Instead we find out which line items are important. There is a difference

Limits of the Traditional 3-point Estimate Approach (2)

- What is the probability that the risk will occur? Traditional approach assumes 100% risk occurrence and deals with impact uncertainty only
- What is the correlation between activity costs? We will model it instead of estimate it from interviews
- Which risks (not which line items) are most important? If a risk affects several line items it may be more important than it appears at first

Benefits of the Risk Driver Approach (1)

- Focus on the risks, not their impact on line item costs
- Provide management with prioritized list of risks, not activities, that need mitigation
- Interviews are conducted at the level of risk where people think of risk, not line items. They are more intuitive for all parties and simpler to verify and validate
- Interviews are generally shorter than when using traditional 3-point estimating

Benefits of the Risk Driver Approach (2)

- Correlations occur often in cost risk
  - If steel prices increase, the prices for structural steel, pipe and vessels will increase together
  - If labor productivity declines, direct and indirect labor will cost more, together
- Traditionally we have to estimate correlation coefficients – not easy because no data, concept is not familiar to most people
- Risk Driver method models how correlations come about due to risks affecting more than one line item. No more guessing at correlation coefficients.

Introducing the Risk Driver Method

- Start with the Risk Register risks – the linkage to the qualitative risk analysis exercise is obvious and direct
- Characterize the risks by their probability as well as impact, not just impact range as traditional analysis
- Probability and impact are the TWO dimensions of a risk

Risk Driver Methodology

- Identify risks to be included from Risk Register
- Quantify risks' probability and impact range
  - The impact is a factor
  - The line item costs will be multiplied by the factors
- Assign risks to cost line items
  - Risks can affect several line items
  - A cost line item can be affected by several risks
- Run Monte Carlo simulation for overall cost risk
- Prioritize risks for further mitigation

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Identify Risk Drivers
Use the Risk Register Directly

Risk Register - Model Input Data	
ID	**Risk Name**
R.1	**Contracting Strategy (LSTK) may cause bidders to bid high**
R.2	**Design Changes may be greater than anticipated**
R.3	**Equipment Suppliers may be busy**
R.4	**Quality Key Staff JV / PMT may not be available**
R.5	**Number of Bidders may be limited due to availability of other work**
R.6	**Integration Management of detailed engineering may be inadequate**
R.7	**Labor Rate may differ from expectations**
R.8	**Construction Labor Productivity may differ from expectations**
R.9	**Bulk Material Cost may differ from expectations**
R.10	**Construction Management Staff may be lacking in experience**

Discovery of Risk Factors

- From exploratory interviews w/ all project stakeholders to arrive at their general ideas about what the risks are
- From the project risk register
- From general knowledge about conditions that might affect the project
- Risks should be independent of each other. Related risks may be consolidated

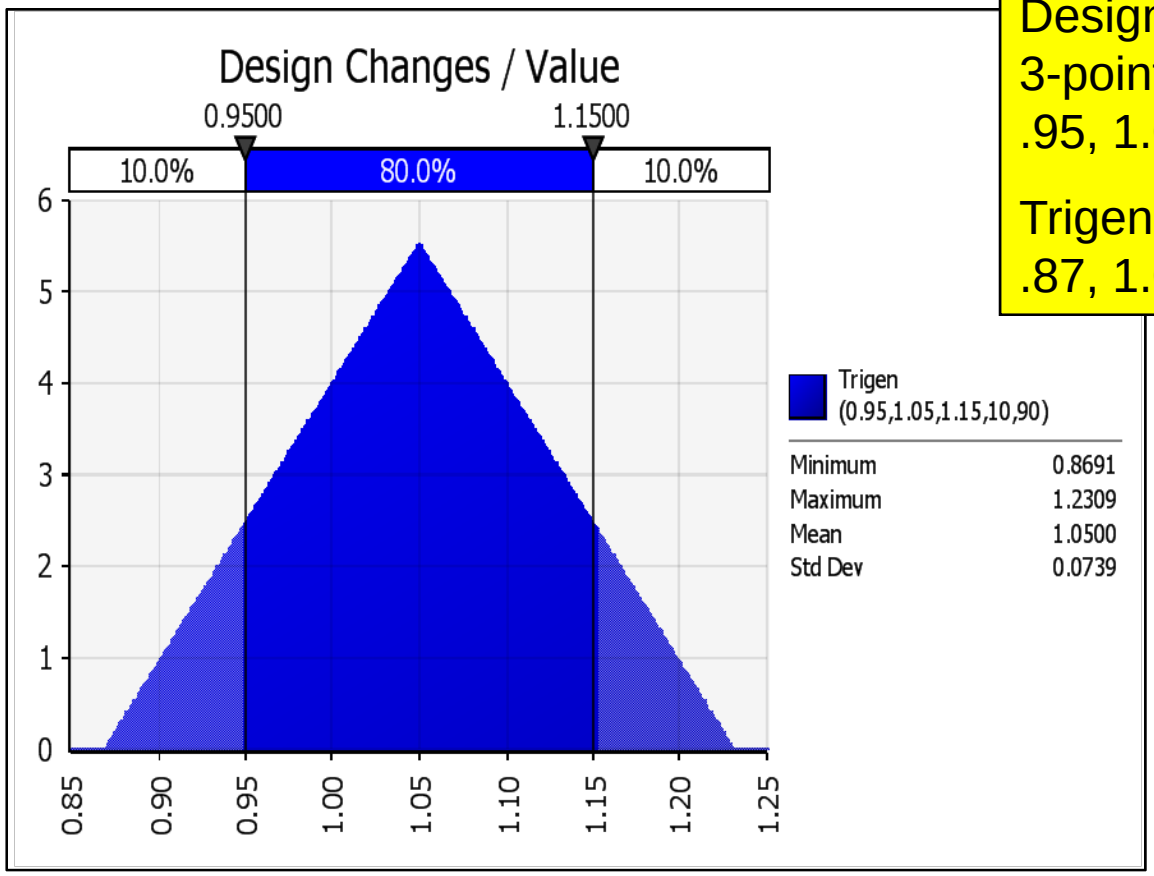
Detailed Interviews for Information about Risk Factors

- Using the arrived at Risk Factors, conduct interviews to assess their likelihood and impact
- Be alert to the discussion of new risks during the interviews
- The use of pre-read information can assist with the amount of information that can be covered in a time limited interview

Applying Risk Factors

- Where possible, cover what type of cost line items the risk factor will apply to
- Be alert to the need for applying the same risk factor with more than one range for different types of costs
- Be alert to the need to divide cost lines in order to discretely apply Risk Factors

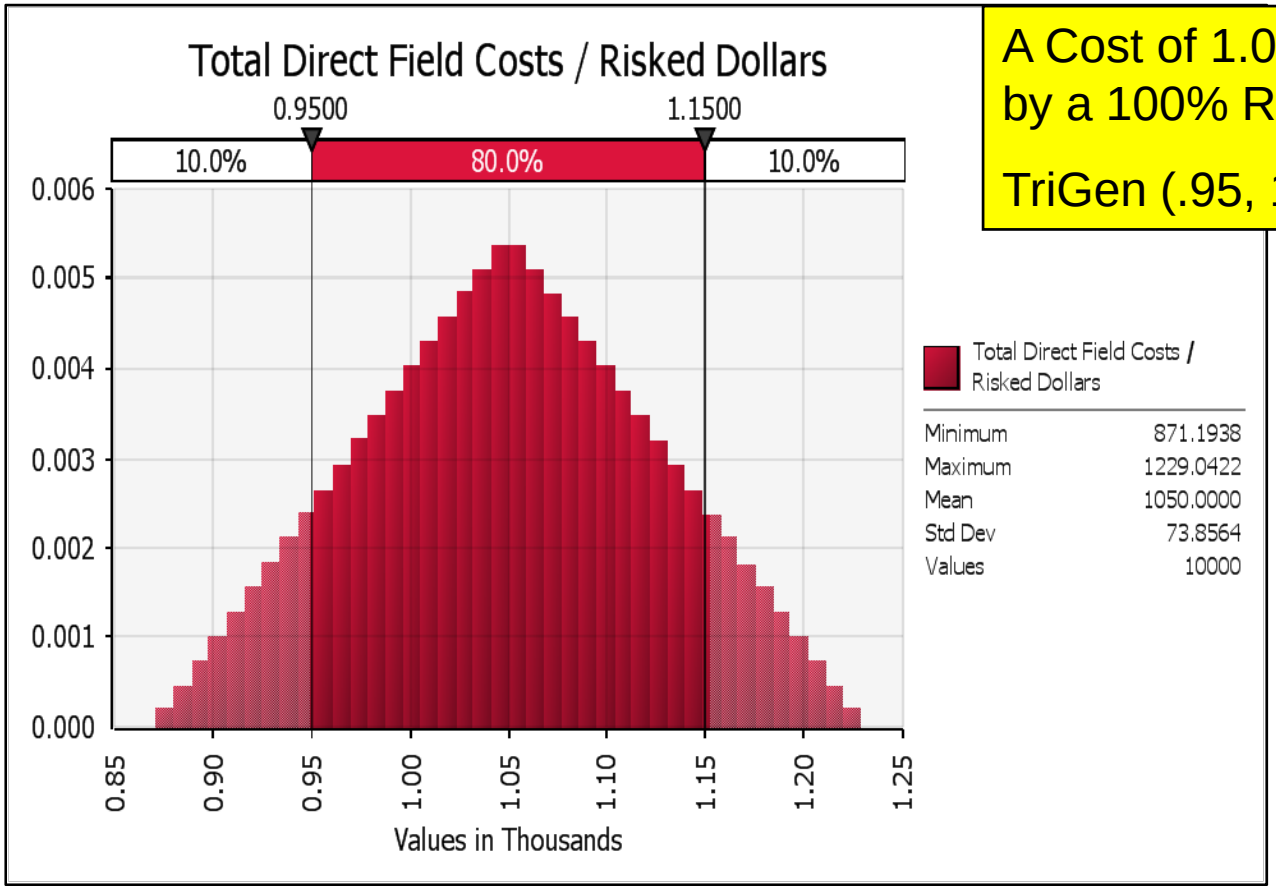
Use Trigen Function to Correct for Narrow Ranges from Interviews



Design Changes 3-point estimate is .95, 1.05, 1.15

Trigen makes it .87, 1.05, 1.23

A 100% Risk Factor Applied to a Cost Line Item of $1 million



A Cost of 1.00 million impacted by a 100% Risk Factor

TriGen (.95, 1.05, 1.15, 10, 90)

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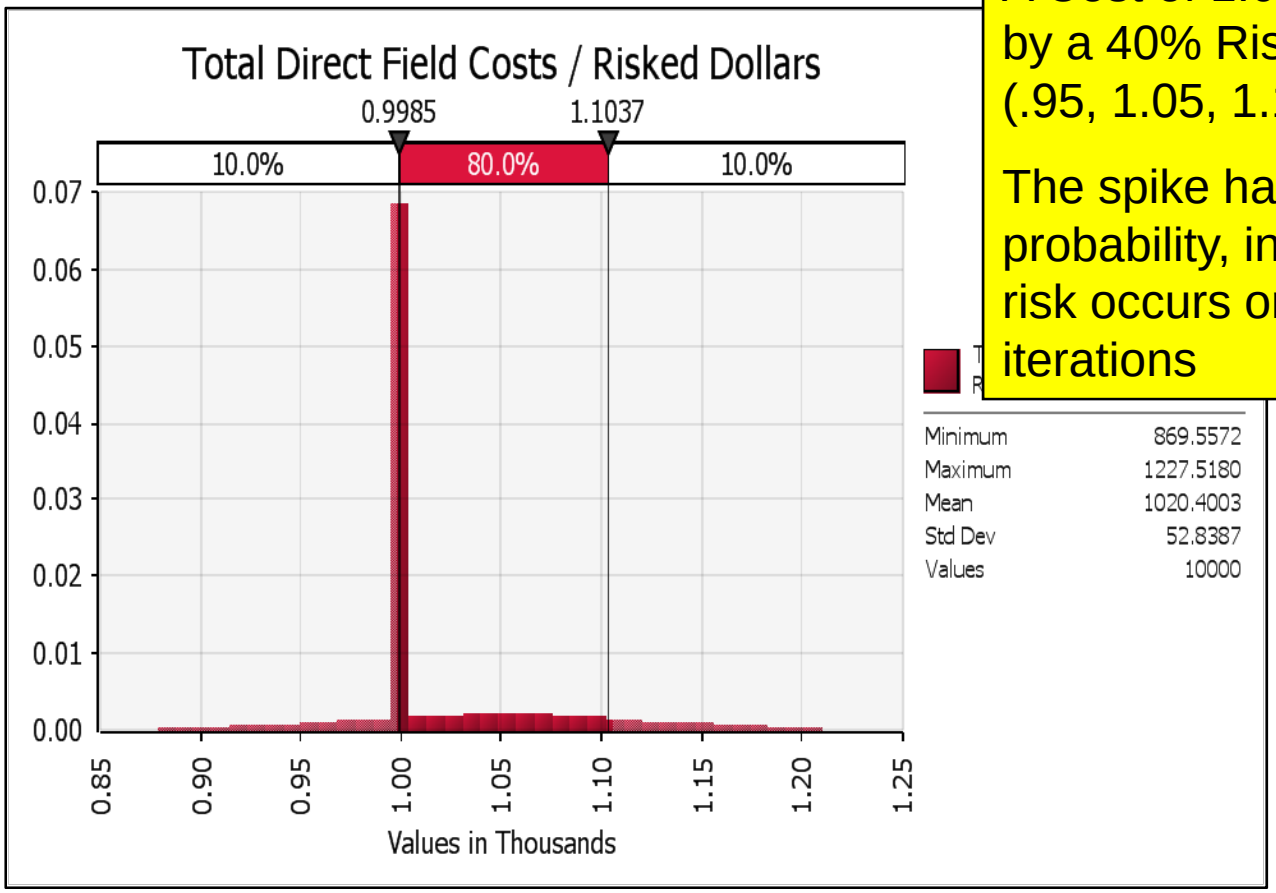
A 40% Risk Factor Applied to Cost Line Item of $1 million



A Cost of 1.00 million impacted by a 40% Risk Factor Trigen (.95, 1.05, 1.15, 10, 90)

The spike has 60% of the probability, indicating that the risk occurs only in 40% of the iterations

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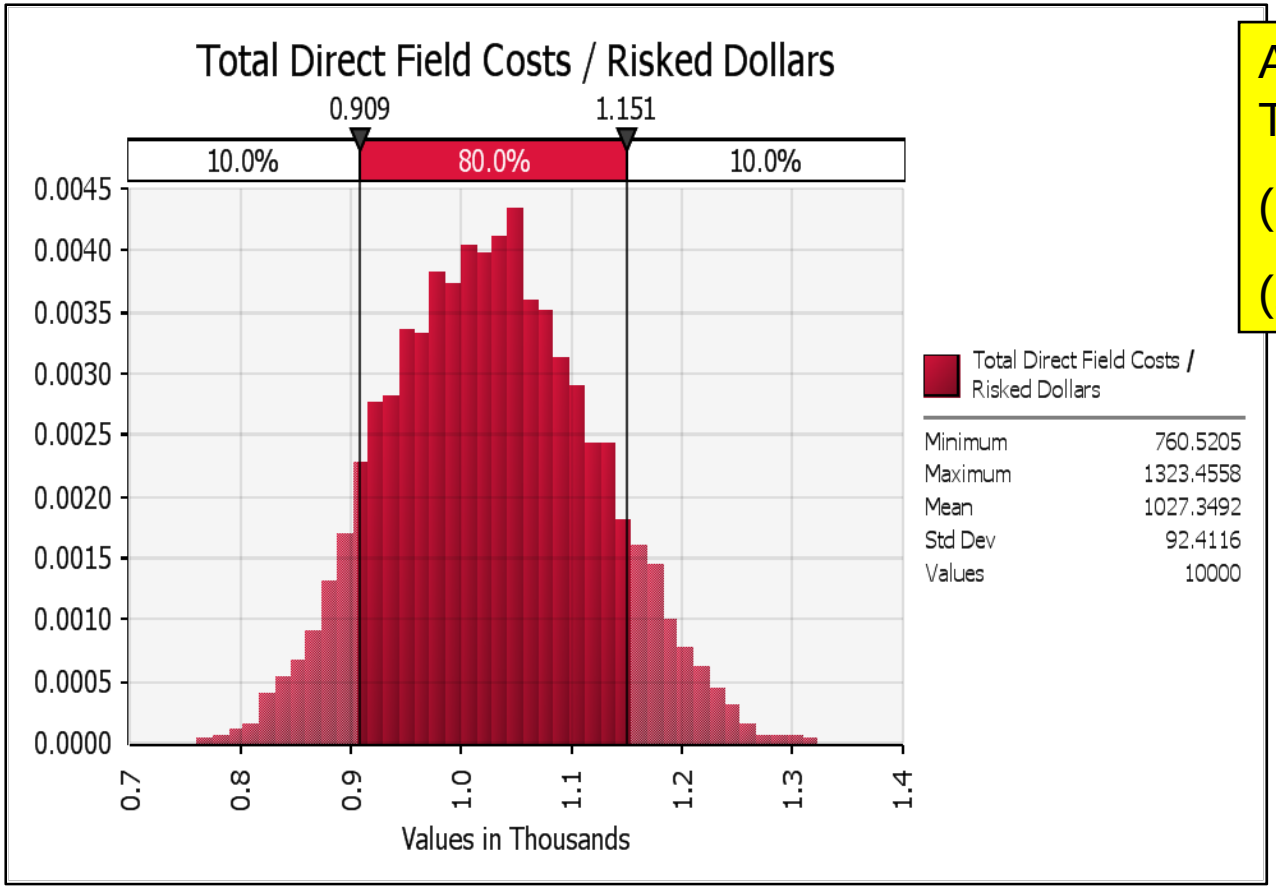
A Cost of $1.0 million
Affected by Two 100% Risk Drivers

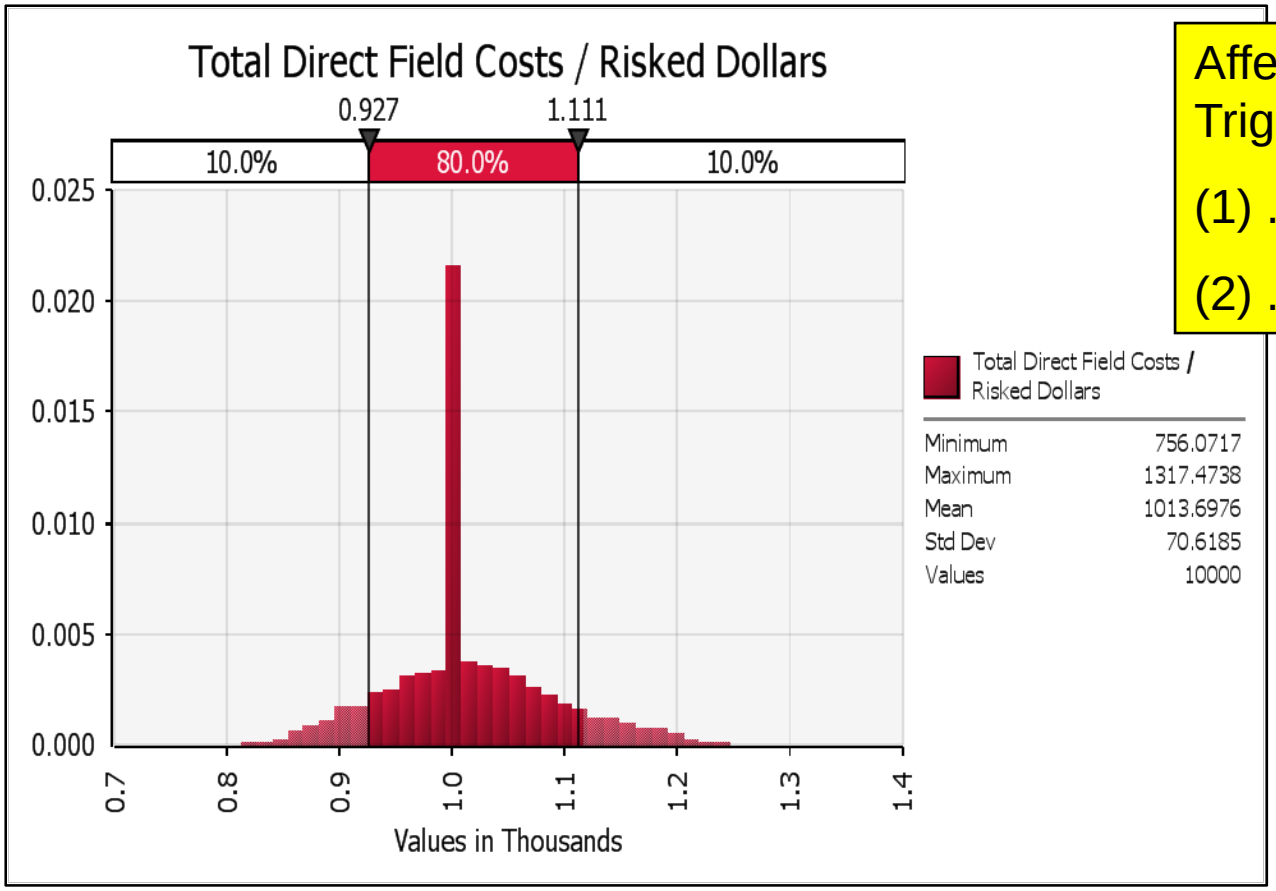


Affected by Two 100% Trigen (10,90) Risks

(1) .95, 1.05. 1.15

(2) .90, 1.00, 1.05

A Cost of $1.0 million
Affected by Two 50% Risk Drivers

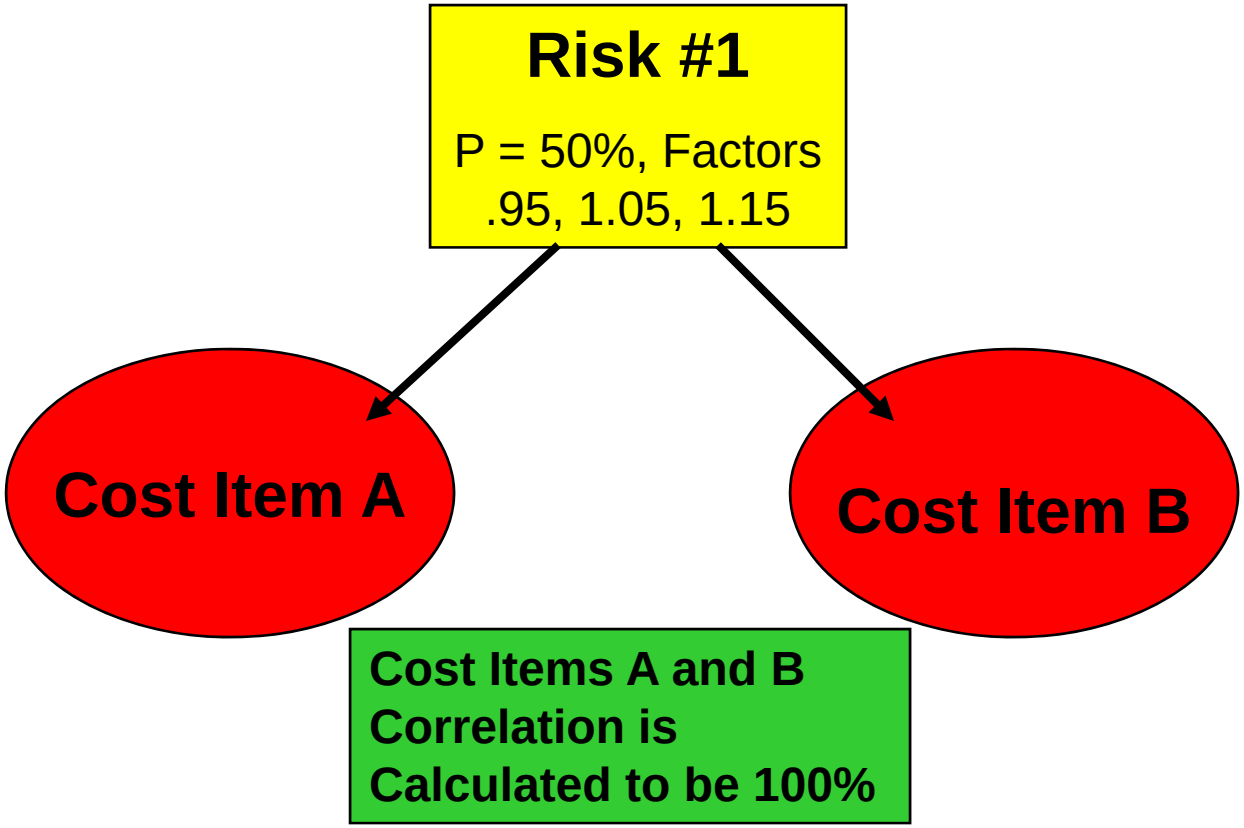


Affected by Two 50% Trigen (10,90) Risks

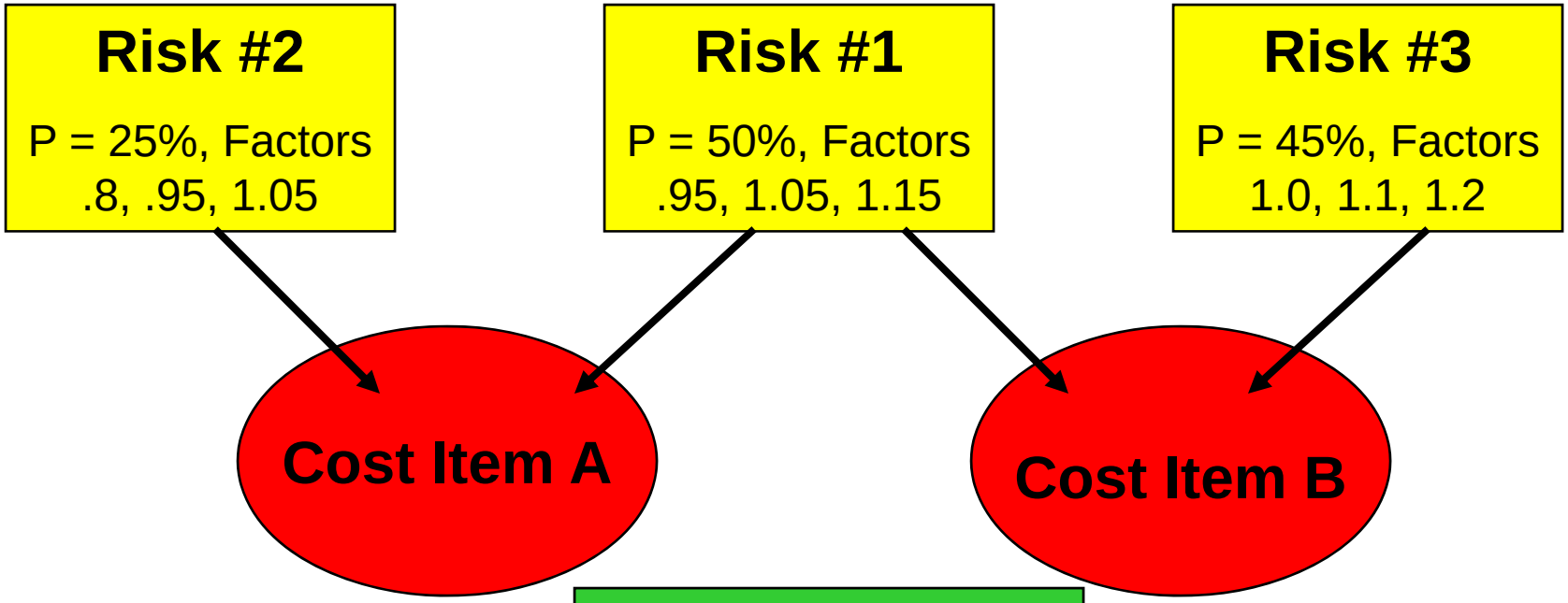
(1) .95, 1.05. 1.15

(2) .90, 1.00, 1.05

Risk Factors Model How Correlation Occurs Coefficients are Calculated (1)



Risk Factors Model How Correlation Occurs Coefficients are Calculated (2)



Cost Items A and B Correlation is Calculated to be 48%

Correlation is modeled as it is caused in the project
Correlation coefficients are generated, not guessed

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Simplified Cost Model of a Refinery Project (1)

Refinery Construction Project Baseline Estimate (1)				
	Cost Category	Labor	Equipment	Total
Direct Field Costs		($ millions)		
	Long Lead Equipment (LLE)	15	330	345
	Equipment	30	1,200	1,230
	Materials	288	1,935	2,223
	Total Direct Field Costs	333	3,465	3,798
Indirect Field Costs				
	Supervision	360	0	360
	Time-Related Overhead	315	0	315
	Total Indirect Field Costs	675	0	675
Total Direct & Indirect Costs		1,008	3,465	4,473

Simplified Cost Model of a Refinery Project (2)

Refinery Construction Project Baseline Estimate (2)				
		Labor	Equipment	Total
	Cost Category	($ millions)		
	Construction Management	630		630
	Material Related	180	540	720
	Home Office Engineering Staff	540		540
	Overhead & Fees			560
Total Contractor Related		2,358	4,005	6,923
Owner-Related				
	Project Management Team	450	0	450
	Materials	0	400	400
	Total Owner-Related	450	400	850
TOTAL BASE ESTIMATE				7,773

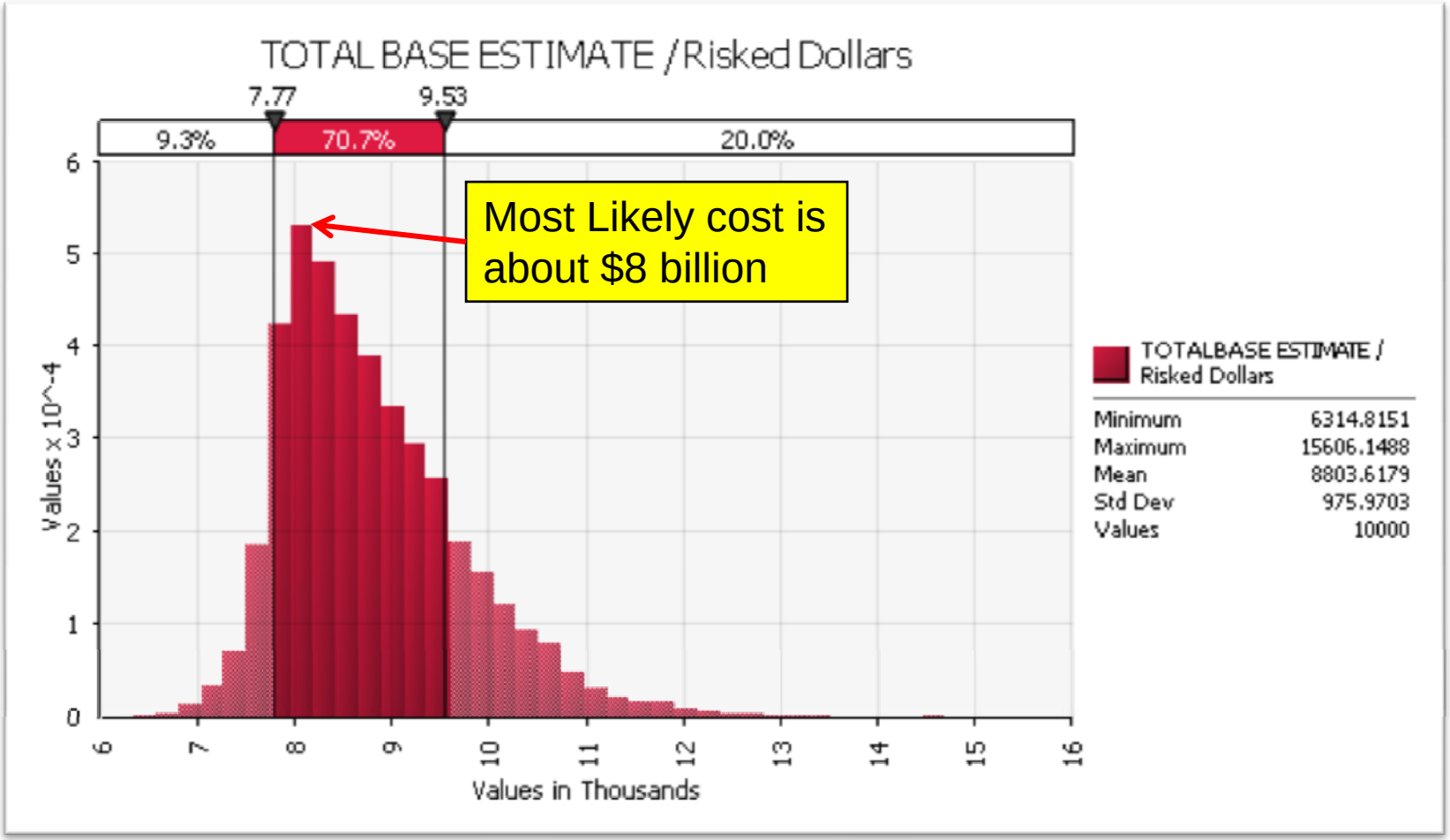
Risk Factors
Probability and Impact Ranges

Risk Drivers and their Properties					
ID	Name	Prob.	3-Point Estimate of RiskFactor		
			Minimum	ML	Maximum
R.1	Contracting Strategy	40%	0.90	1.10	1.25
R.2	Design Changes	60%	0.95	1.05	1.20
R.3	Equipment Suppliers Busy	45%	1.00	1.05	1.30
R.4	Availability of Key Staff JV / PMT	40%	0.95	1.00	1.20
R.5	Number of Bidders	40%	0.95	1.00	1.50
R.6	Integration Management	40%	1.00	1.05	1.15
R.7	Labor Rate	50%	0.90	1.00	1.20
R.8	Construction Labor Productivity	45%	1.00	1.10	1.30
R.9	Bulk Material Cost	40%	0.90	1.05	1.20
R.10	Construction Management Staff	70%	1.00	1.05	1.15

Assign Risk Drivers to Cost Elements

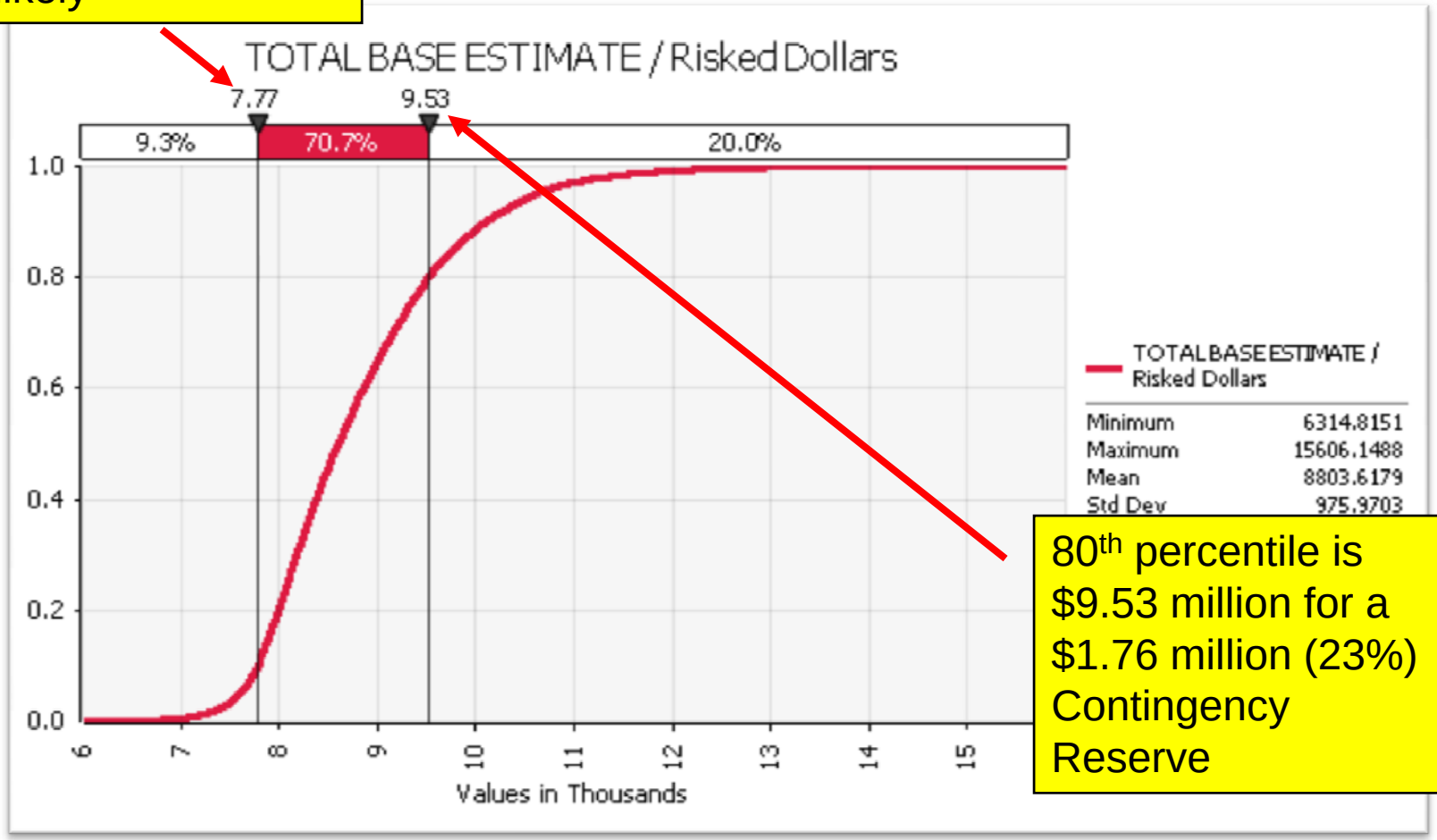
Cost Category	Risks									
Direct Field Costs	Contract Strategy	Design Changes	Equip. Supplier	JV/PMT Staff	# of Bidders	Integ. Mgt.	Labor Rate	Labor Prod.	Bulks Cost	CM Staff
Long Lead Equipment (LLE)	X	X	X							
Equipment	X	X	X		X					
Materials	X		X		X				X	
Total Direct Field Costs										
Direct & Indirect Labor Costs	X						X	X		
Construction Management										X
Material Related			X						X	
Home Office Engineering Staff		X		X		X				
Overhead & Fees	X				x					
Owner-Related										
Project Management Team				X						
Materials									X	

Cost Risk Analysis Results (1)



Cost Risk Analysis Results (2)

Base Cost is 9.3% likely



80th percentile is $9.53 million for a $1.76 million (23%) Contingency Reserve

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Cost Risk Analysis Results (3)

Percentile	$ mill.	%
10%	7,793	0%
20%	7,999	3%
30%	8,183	5%
40%	8,383	8%
50%	8,611	11%
60%	8,866	14%
70%	9,168	18%
80%	9,529	23%
90%	10,118	30%

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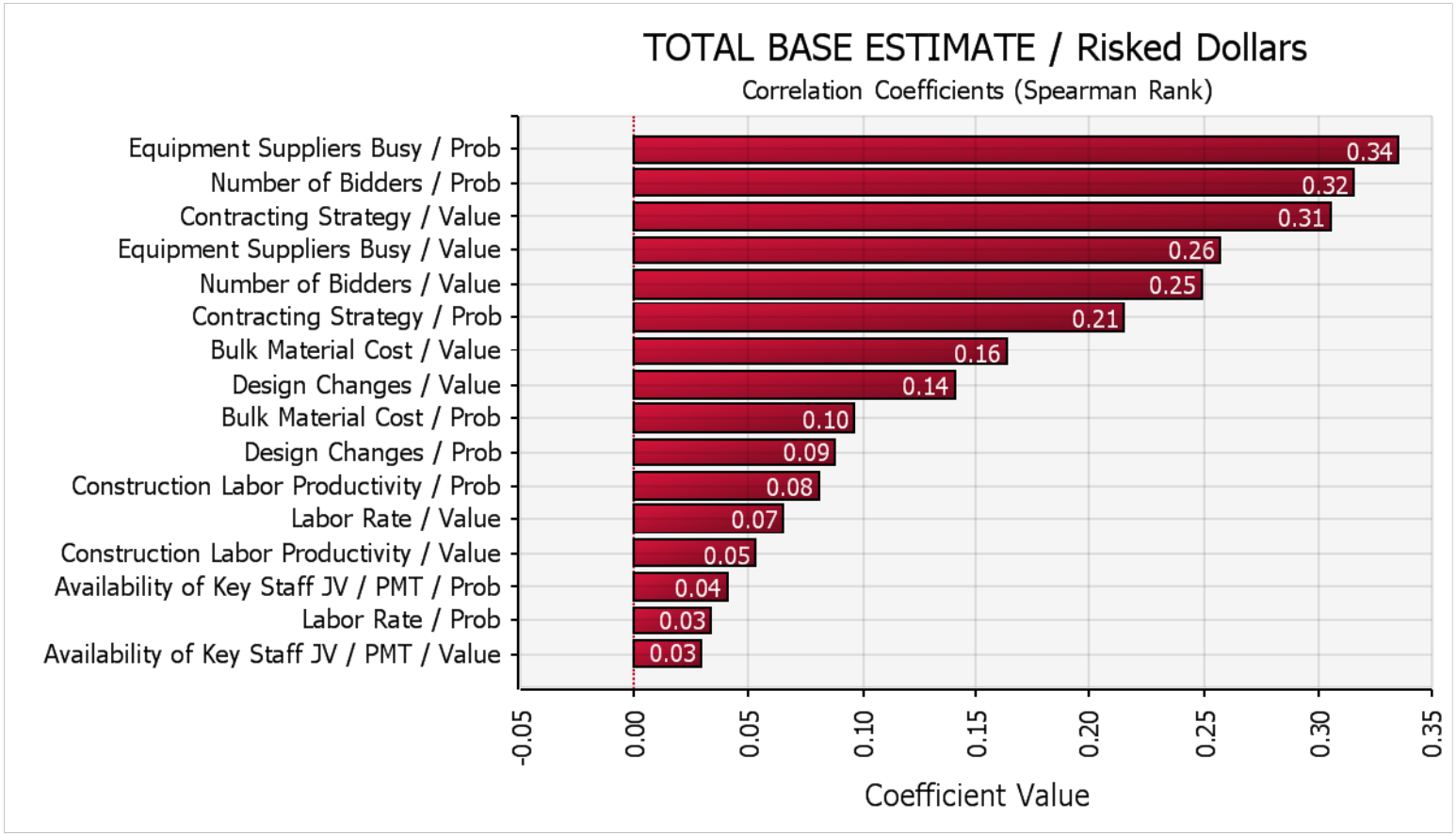
Risk Sensitivity – Beginning of Risk Prioritization



Risk Drivers Listed in Priority Order

All Risks Included	9.53	
Improvement if Mitigated		
Risks	**$ Bill.**	**% Savings**
Number of Bidders	0.42	4%
Equipment Suppliers Busy	0.41	4%
Contracting Strategy	0.30	3%
Design Changes	0.14	1%
Bulk Material Cost	0.12	1%
Construction Labor Productivity	0.10	1%
Availability of Key Staff JV / PMT	0.07	1%
Labor Rate	0.04	0%
Construction Management Staff	0.02	0%
Integration Management	0.01	0%

These risks are prioritized as if they could be completely mitigated. That is not possible, but it indicates the priority for risk mitigation actions.

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Partial Risk Mitigation (1)

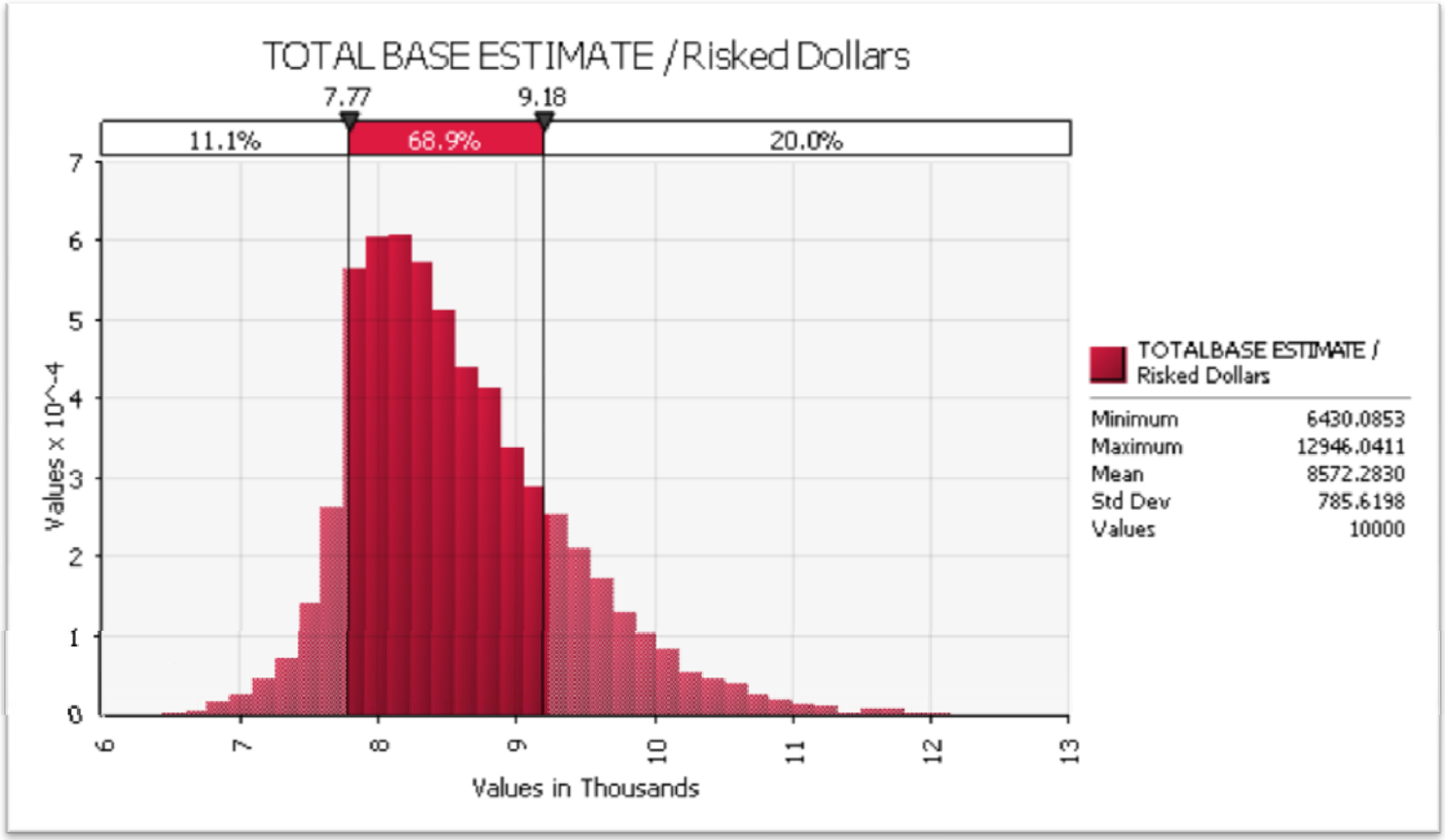
- The number of bidders in today's heated oil and gas building environment is problematic and deemed as an important cost risk driver
- With few bidders we expect contractors to feel freer to include high levels of risk premium and profit into their bids
- A similar observation can be made for equipment suppliers that are busy

Partial Risk Mitigation (2)

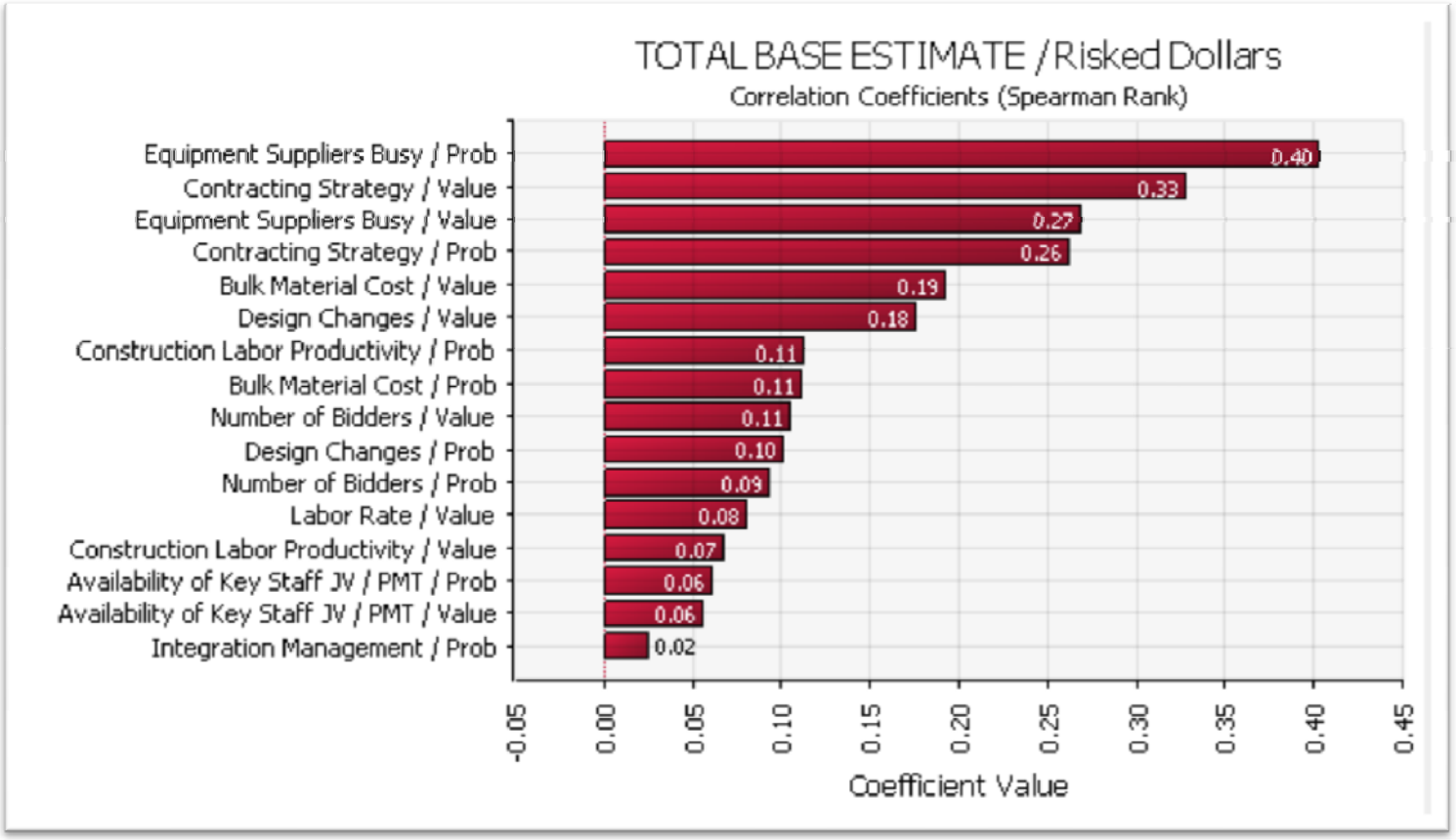
- Suppose that we were willing to allow bidders to form Joint Ventures or funding their bidding expenses?. What could happen?

Example of Risk Mitigation	Prob.	3-Point Estimate of RiskFactor		
		Minimum	ML	Maximum
	Before Risk Mitigation			
Number of Bidders	40%	0.95	1.00	1.50
	After Risk Mitigation			
Number of Bidders	20%	0.90	1.00	1.25

Risk after Mitigating Number of Bidders Risk



Number of Bidders is Now Lower on the Priority List



Impact of Partially Mitigating the Number of Bidders Risk

Percentile	No Mitigation	Partial Mitigation
	$ mill.	
10%	7,793	7,746
20%	7,999	7,920
30%	8,183	8,083
40%	8,383	8,248
50%	8,611	8,424
60%	8,866	8,633
70%	9,168	8,869
80%	9,529	9,185
90%	10,118	9,637

Partially mitigating Number of Bidders Risk improves the risk at the P-80 level

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Summary – Quantitative Risk Analysis Results and Risk Prioritization using Risk Drivers

- Project risks are characterized by their:
  - Probability of occurring
  - Impact range as a multiplicative factor
  - Cost line items they impact if they occur
- Monte Carlo simulation develops:
  - Probability of achieving the cost target (without contingency)
  - Contingency reserve of cost needed to satisfy the organization's appetite for risk
- Risks can be taken out of the simulation one at a time and their marginal impact (through the cost model) calibrated:
  - Risk prioritization is based on this analysis
  - Partial risk mitigation can be studied for benefit/cost analysis

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