Risk Mitigation: Some Good News after the Cost / Schedule Risk Analysis Results

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Agenda

- Introduction
- Offshore gas production platform project
- Adding uncertainty – most likely irreducible
- Adding risk events – could be mitigated
- Adding costs
- Risk Prioritization – methodology
- Example of risk mitigation
- Conclusion

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Introduction

- Project risk can be caused by uncertainty and risk events
  - Uncertainty (common cause) is unlikely to be reduced
  - Some risk events (special cause) can be mitigated at least partially, improving on the schedule delay from the “all risks in” case
- Risk mitigation actions often cost money, dampening the improvement from schedule risk mitigation

Uncertainty, Estimating Error and Estimating Bias

- Uncertainty, the inherent variability in project activities that arise because people and organizations cannot do things reliably on plan
- Estimating error – attaches to all types of estimates
- Estimating bias – estimates may be slanted, usually toward shorter durations, to make desired project results

"There are No Facts About the Future"

(source: Lincoln Moses, Statistician and Administrator of Energy Information in the US DOE 1977 Annual Report to Congress)

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Inherent Variability is Similar to Common Cause Variability

- Inherent variability is similar to “common cause” variation described by Walter A. Shewhart and championed by W. Edwards Deming
- Common cause variability is a source of variation caused by unknown factors that result in a steady but random distribution of output around the average of the data
- Common cause variation is a measure of the process’s potential, or how well the process can perform when special cause variation is removed
- Common cause variation is also called random variation, noise, non-controllable variation, within-group variation, or inherent variation. Example: Many X’s with a small impact.
- (source: http://www.isixsigma.com/dictionary/common-cause-variation/ cited February 6, 2015)

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Estimating Error (1)

- Estimating error is often attributed to a lack of information concerning specific issues needed to make up a duration or cost estimate for a WBS element
  - We may not have specific vendor information until the vendors bid. Vendor information is required for completed engineering
  - Ultimately we do not necessarily have contractor bids
- Each of these sources of information can be helpful to narrow the estimating error. Still, the estimates and even contractor bids are uncertain

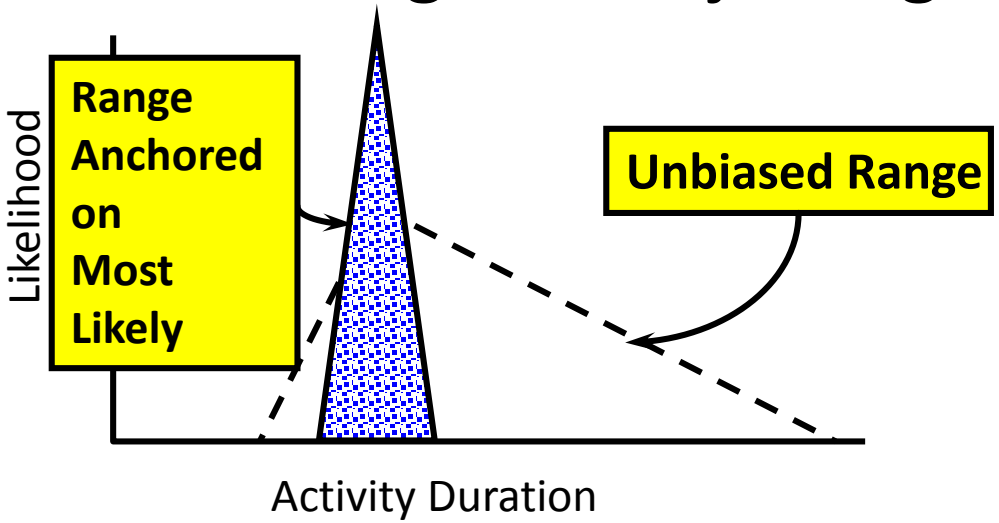
Estimating Error (2)

- The estimating range is often related to the “class” of estimate, determined by the level of knowledge and the method of estimating
- With less knowledge the “plus and minus” range would be large, but as more information is known it may become smaller
- Research shows that the actual range of uncertainty around estimates is larger than recommended by professional associations (including AACEI)

(Source: John Hollmann, 2012 AACE INTERNATIONAL TRANSACTIONS, RISK.1027: Estimate Accuracy: Dealing with Reality)

3-point Impact Estimation Provided by Project Team may be too Narrow

- Underestimation of uncertainty ranges is common
- E.g., the Anchoring and Adjusting bias



(Source: A. Tversky and D. Kahneman, "Judgment under Uncertainty: Heuristics and Biases," *Science*, Sept. 26, 1974)

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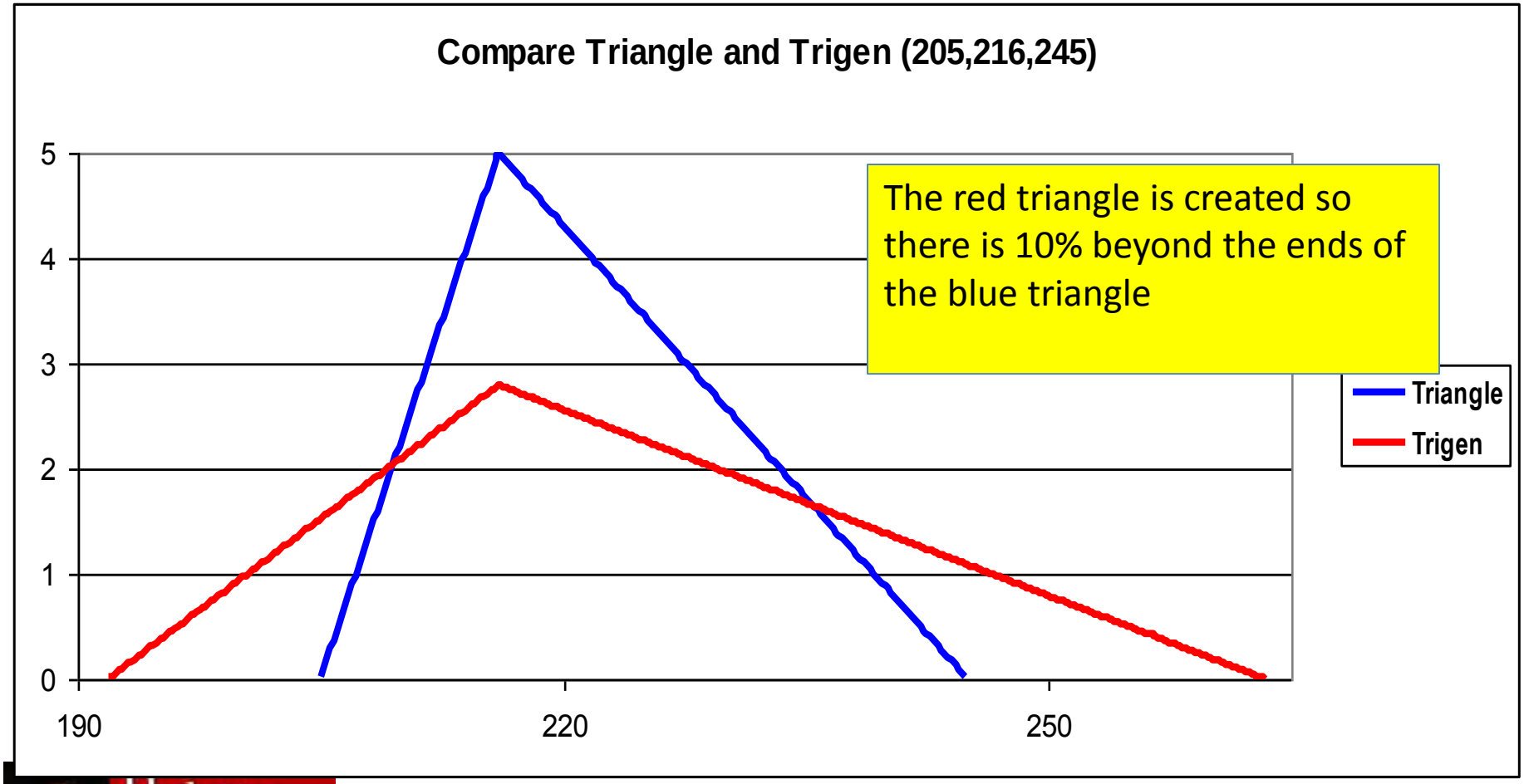
Use “Trigen” Function to Correct for Underestimating Ranges



Estimating Bias is Common for Schedule and for Cost

"I want it NOW!"

- "Schedule pressure dooms more megaprojects than any other single factor"
- Ambitious managers see early completion as ways for promotions. But, every megaproject has an appropriate pace that becomes known early. Pronouncements do not change this pace

"We need to shave 20 percent off that cost number!"

- Construction task force is a counterproductive exercise
- May just reduce estimates, this is foolish
- Alternatively, may actually identify scope to come out, but the scope needs to be added back in later, so only temporary reduction in cost

(source: Edward W. Merrow, Industrial Megaprojects (2011)

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Ask Yourself these Questions about the Duration Estimates

- Was there pressure put on the estimator or scheduler by prior expectations, statements by management or the customer, or was pressure for early finish implicit in the competitive process?
- How long would this scope of work take if no pressure for an earlier date were brought to bear?
  - How long would this scope of work take and how much would it cost if the estimates were purely professional, without prior expectations
  - Contractors claim that the schedule would take longer without pressure, “But, we can do it!”

Handling Estimating Bias

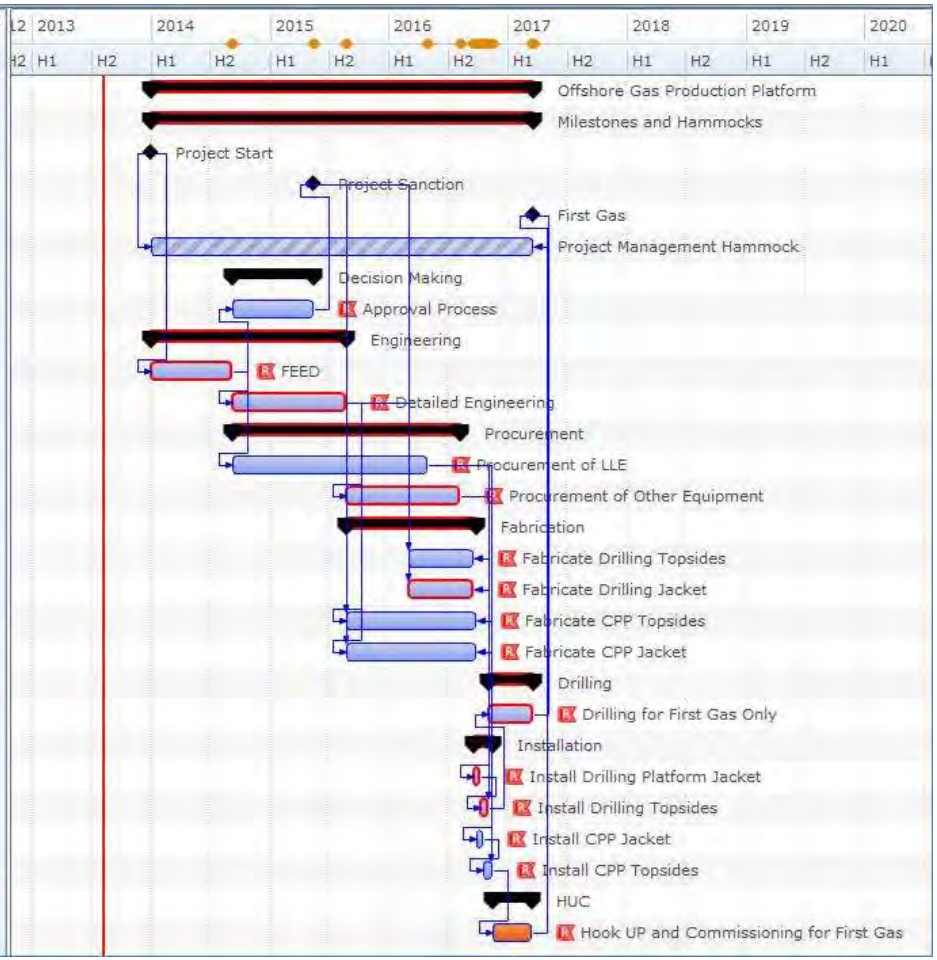
- When talking with project participants (management, team leaders, SMEs) we often find that they do not believe the values in the schedule
  - Motivational bias and cognitive bias are present
- With a range represented by optimistic, most likely and pessimistic values, these people present that the "most likely" duration or cost is not the value in the schedule for activities or estimate for cost elements
  - Often the "most likely" multiplier is 1.05 or 1.1 or more, indicating that the estimates are viewed as being 5%, 10% or more above those in the project documents

Summary of Inherent Variability and Estimating Error / Bias

- These sources of uncertainty have already occurred and are “baked in the cake” of the schedule and cost estimate being risked
- They are 100% likely so they can be represented by a 3-point estimate (min, most likely, max) of multiplicative factors applied directly to activities’ durations
- Under-reporting may be corrected and 3-point estimates may be correlated

Introducing the Gas Production Platform Schedule

UID	Task	Start Date	End Date	Duration	Cost
Gas Pla	▼ Offshore Gas Production Platfor	1/1/2014	3/20/2017	1,175	$1.57M
Gas Pla	▼ Milestones and Hammocks	1/1/2014	3/20/2017	1,175	$200,000
A1000	Project Start	1/1/2014		0	$0
A1010	Project Sanction		5/15/2015	0	$0
A1020	First Gas		3/20/2017	0	$0
A1030	Project Management Ham	1/1/2014	3/20/2017	1,175	$200,000
Gas Pla	▼ Decision Making	9/8/2014	5/15/2015	250	$80,000
B1000	Approval Process	9/8/2014	5/15/2015	250	$80,000
Gas Pla	▼ Engineering	1/1/2014	8/23/2015	600	$96,000
C1000	FEED	1/1/2014	9/7/2014	250	$16,000
C1010	Detailed Engineering	9/8/2014	8/23/2015	350	$80,000
Gas Pla	▼ Procurement	9/8/2014	8/7/2016	700	$425,000
D1000	Procurement of LLE	9/8/2014	4/29/2016	600	$250,000
D1010	Procurement of Other Equ	8/24/2015	8/7/2016	350	$175,000
Gas Pla	▼ Fabrication	8/24/2015	9/26/2016	400	$576,000
E1000	Fabricate Drilling Topsides	3/1/2016	9/16/2016	200	$160,000
E1010	Fabricate Drilling Jacket	3/1/2016	9/16/2016	200	$80,000
E1020	Fabricate CPP Topsides	8/24/2015	9/26/2016	400	$240,000
E1030	Fabricate CPP Jacket	8/24/2015	9/26/2016	400	$96,000
Gas Pla	▼ Drilling	11/1/2016	3/20/2017	140	$80,000
F1000	Drilling for First Gas Only	11/1/2016	3/20/2017	140	$80,000
Gas Pla	▼ Installation	9/17/2016	11/15/2016	60	$47,200
G1000	Install Drilling Platform Ja	9/17/2016	10/6/2016	20	$8,000
G1010	Install Drilling Topsides	10/7/2016	10/31/2016	25	$13,600
G1020	Install CPP Jacket	9/27/2016	10/16/2016	20	$9,600
G1030	Install CPP Topsides	10/17/2016	11/15/2016	30	$16,000
Gas Pla	▼ HUC	11/16/2016	3/15/2017	120	$64,000
H1000	Hook UP and Commission	11/16/2016	3/15/2017	120	$64,000



Three year+ schedule costing $1.57 billion

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Applying Different Uncertainty Reference Ranges to Categories of Tasks

Each category of activity may have different levels of uncertainty, called “reference ranges.”

Uncertainty includes inherent variability, estimating error and estimating bias. All are implicit with 100% probability, unlikely to be reducible within one project

Five of the ranges have “most likely” values that differ from the durations in the schedule

Three (Engineering, Drilling and HUC) use the Trigen function to correct for suspected under-reporting impact ranges

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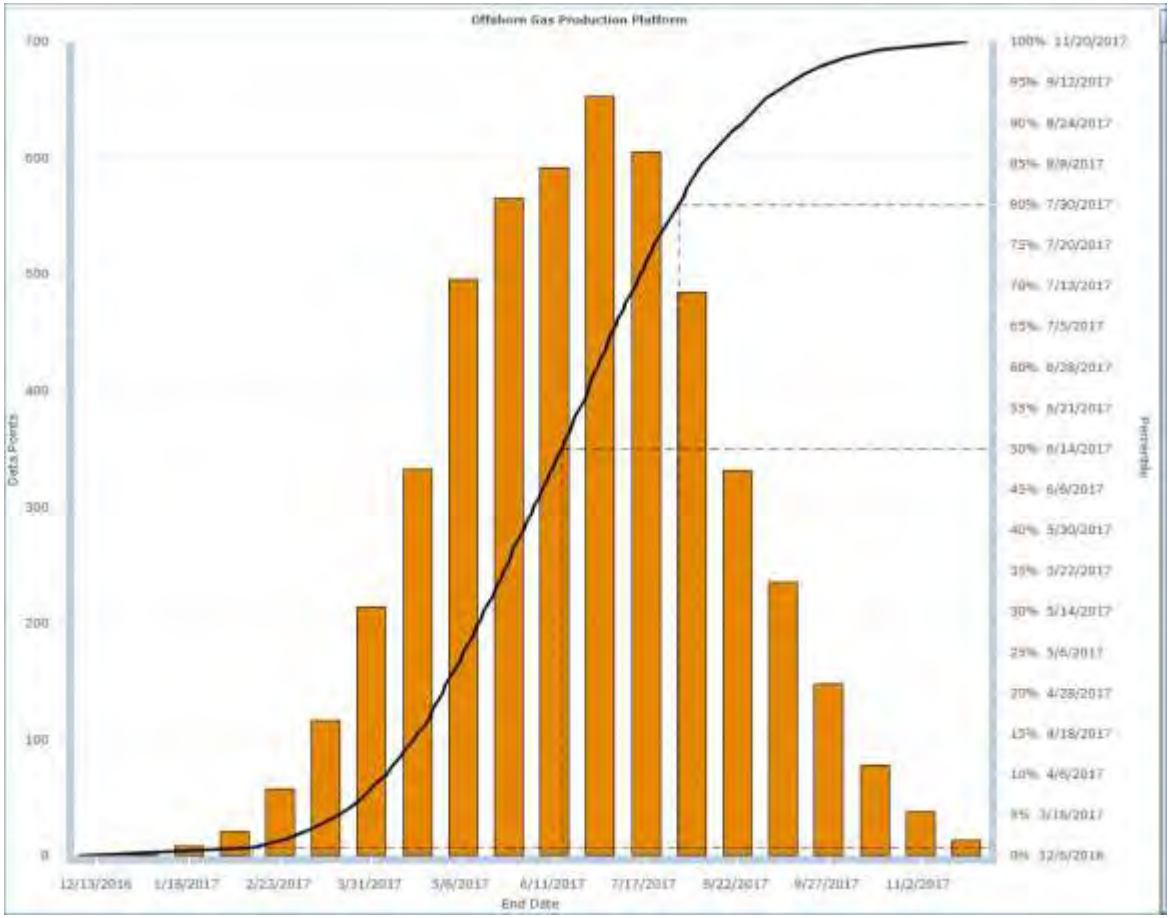
Risk on the Offshore Gas Production Platform - Reference Range Uncertainties



With Uncertainty by category of task representing:

- Inherent variability
- Estimating error
- Estimating bias

The CPM date is 20 March 2017

The P-80 date is 30 July 2017 for a contingency just with Uncertainty of 4 + months

This is very likely irreducible. It represents the base that cannot be mitigated

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Discrete Risks is Similar to Special Cause Variation

- Unlike common cause variability, special cause variation is caused by known factors that result in a non-random distribution of output. Also referred to as “exceptional” or “assignable” variation. Example: Few X’s with big impact.
- Special cause variation is a shift in output caused by a specific factor such as environmental conditions or process input parameters. It can be accounted for directly and potentially removed and is a measure of process control.

(source: http://www.isixsigma.com/dictionary/variation-special-cause/ cited February 6, 2015)

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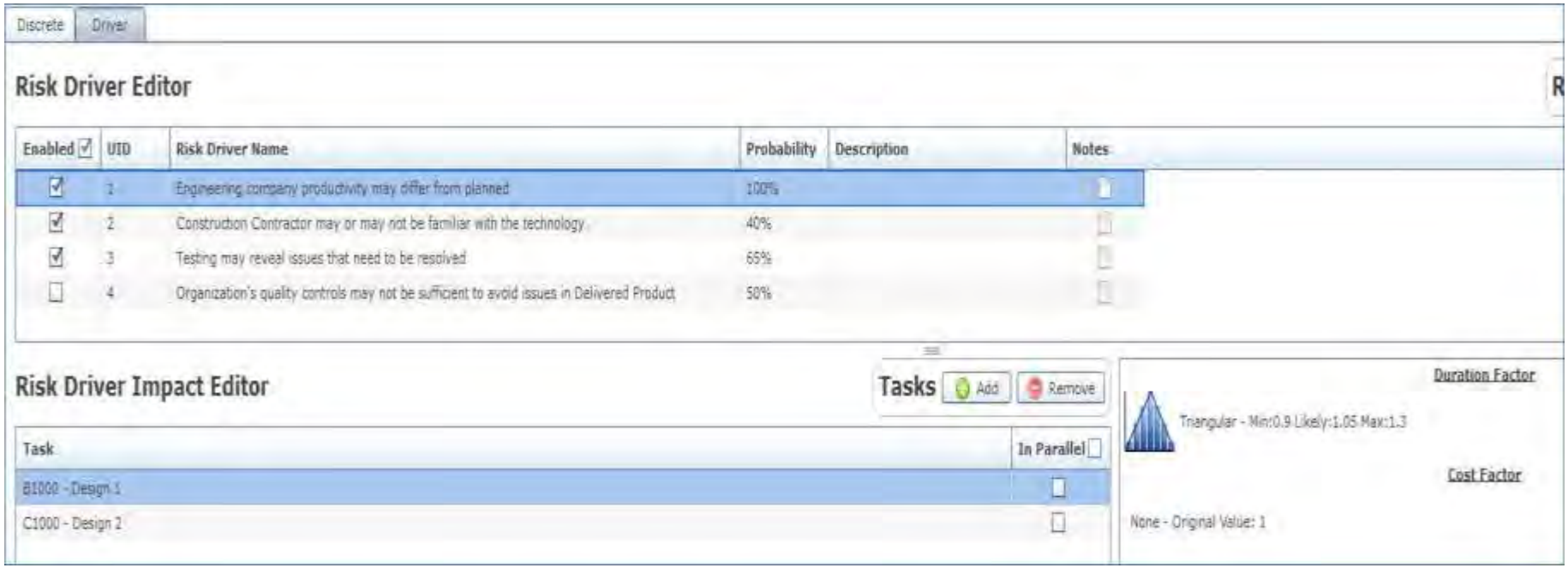
Introducing the Risk Driver Method for Causing Additional Variation in the Simulation



Four risks are specified. The first is a general risk about engineering productivity, which may be under- or over-estimated, with 100% probability. It is applied to the two Design activities

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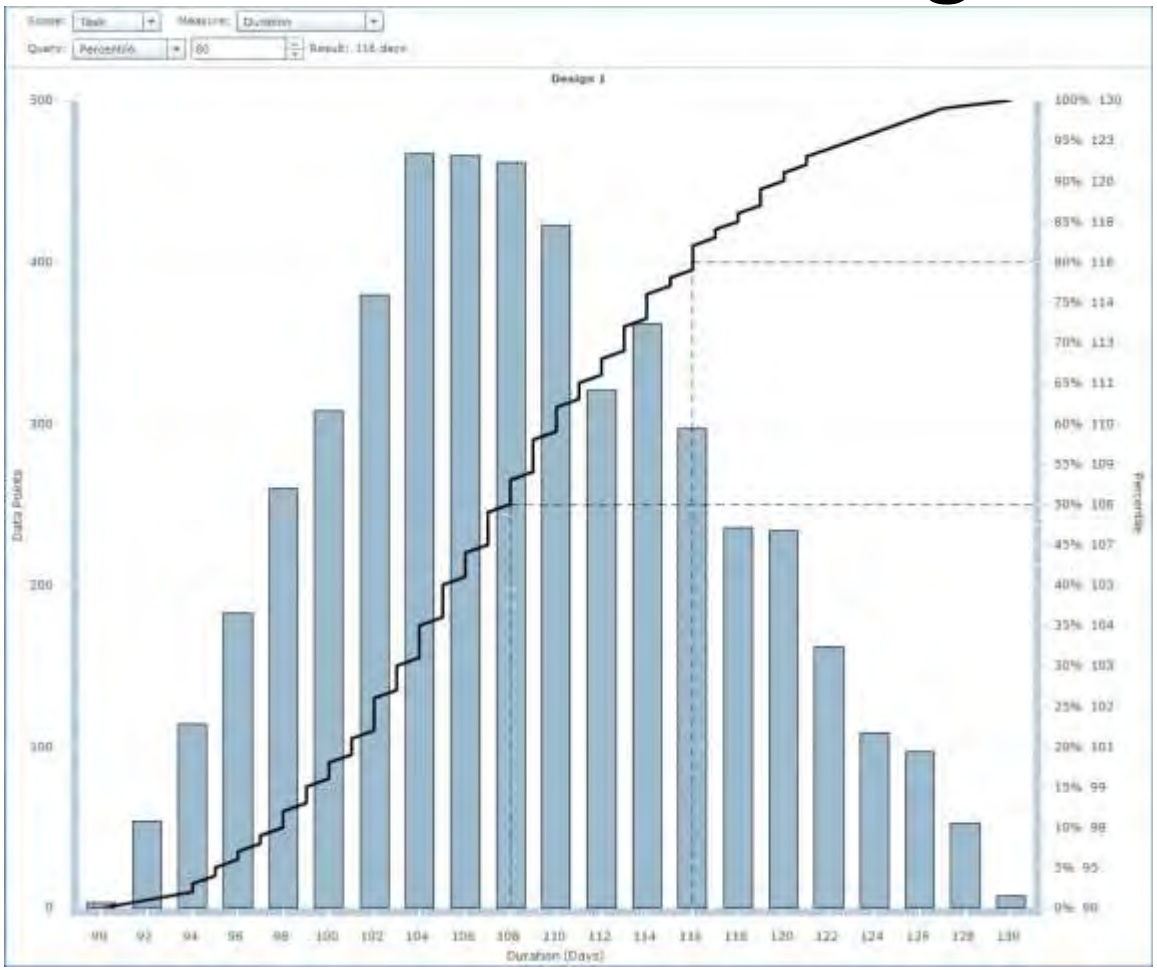
100% Likely Risk Driver's Effect on Design Duration



With a 100% likely risk the probability distribution of the activity's duration looks like a triangle. Not any different from placing a triangle directly on the activity

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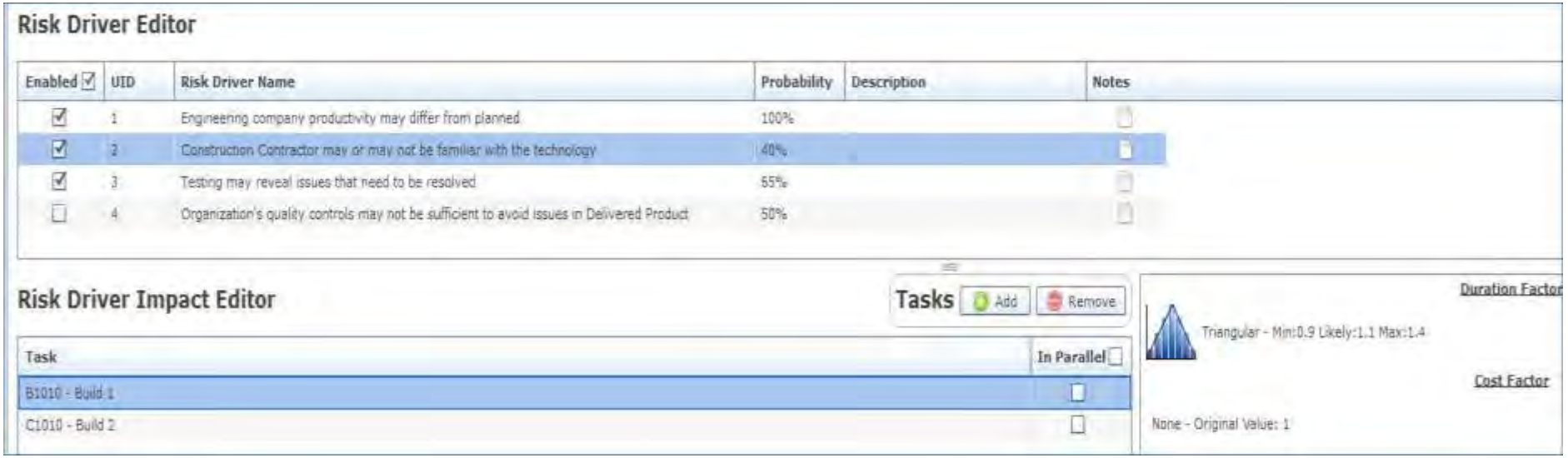
Risk Driver with Risk at < 100% likelihood



With this risk, the Construction Contractor may or may not be familiar with the technology, the probability is 40% and the risk impact if it happens is .9, 1.1 and 1.4. It is applied to the two Build activities

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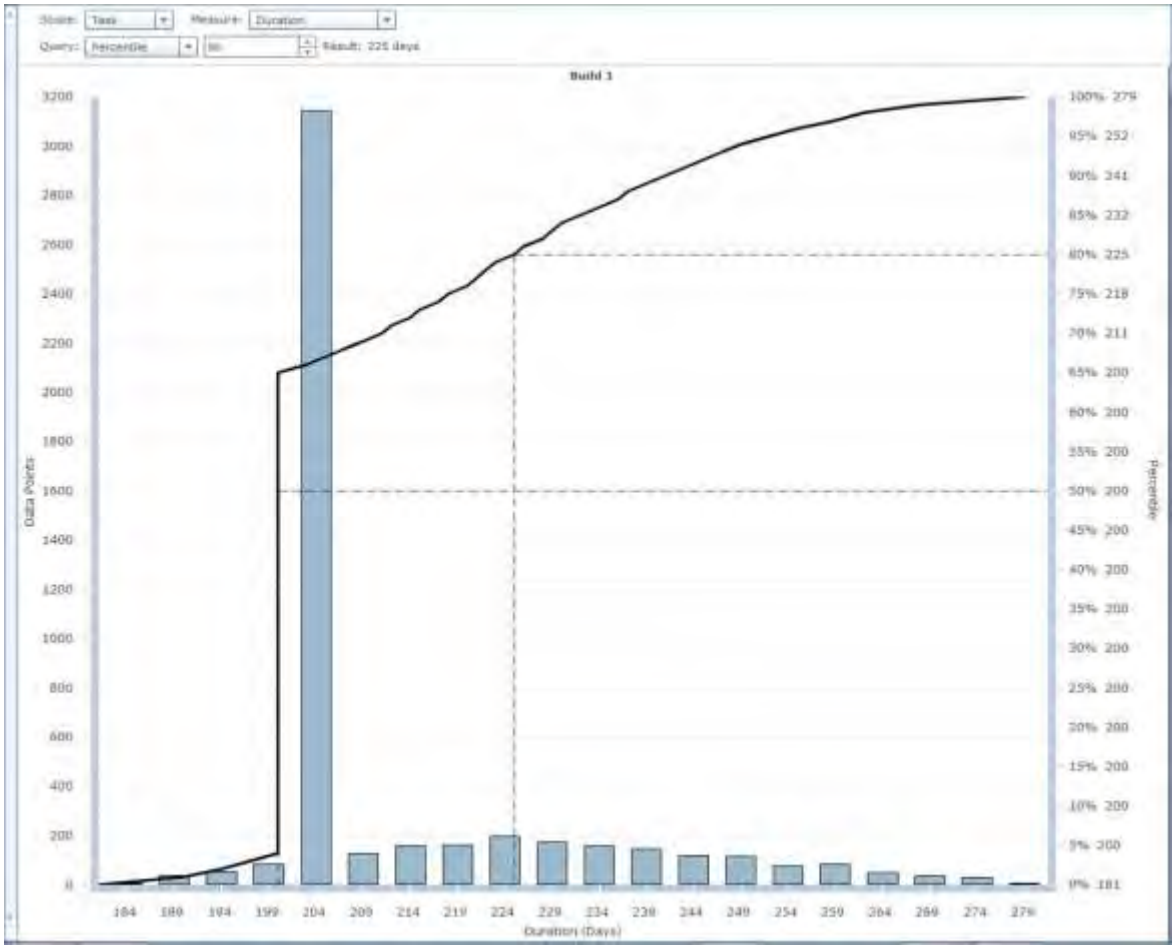
With a 40% Likelihood, the "Spike" in the Distribution Contains 60% of the Probability



Here is where the Risk Driver method gets interesting. It can create distributions that reflect:

- Probability of occurring
- Impact if it does occur

Cannot represent these two factors with simple triangular distributions applied to the durations directly

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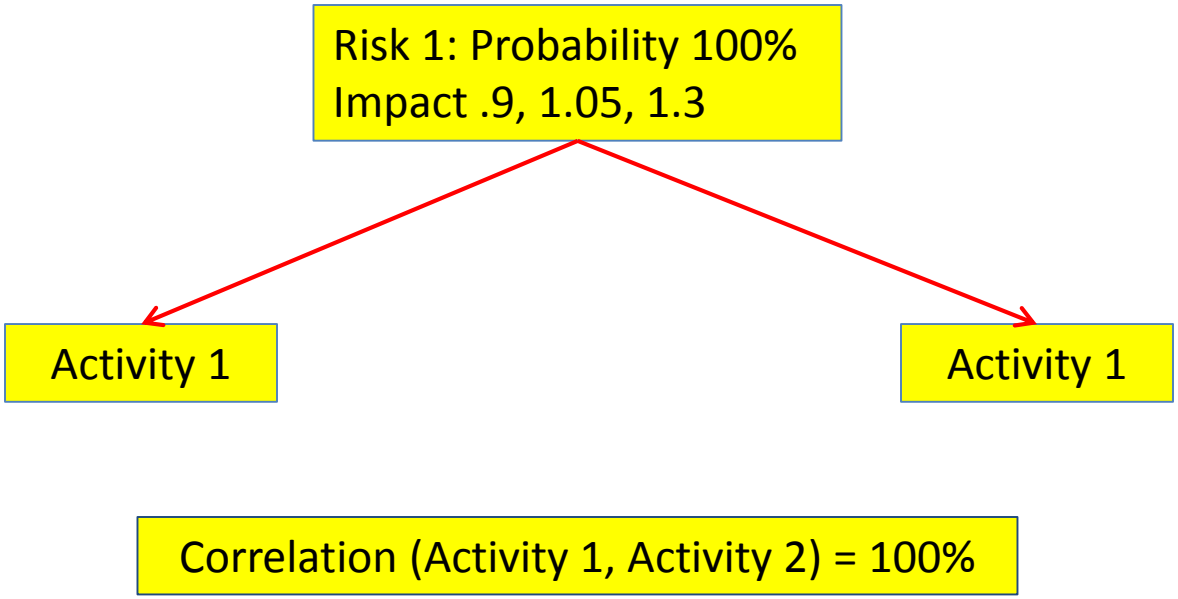
Risk Drivers Models how Correlation Occurs

- Correlation can be caused by identifiable risks that are assigned to two different activities
  - If the risk occurs it occurs for each activity
  - If the risk impact multiplier is X% it is X% for each activity
- We are not very good at estimating correlation coefficients, so generating them within the simulation is a better approach
- There still may be correlations among uncertainty (3-point estimates)

Risk Drivers Generate Correlation between Activities (1)



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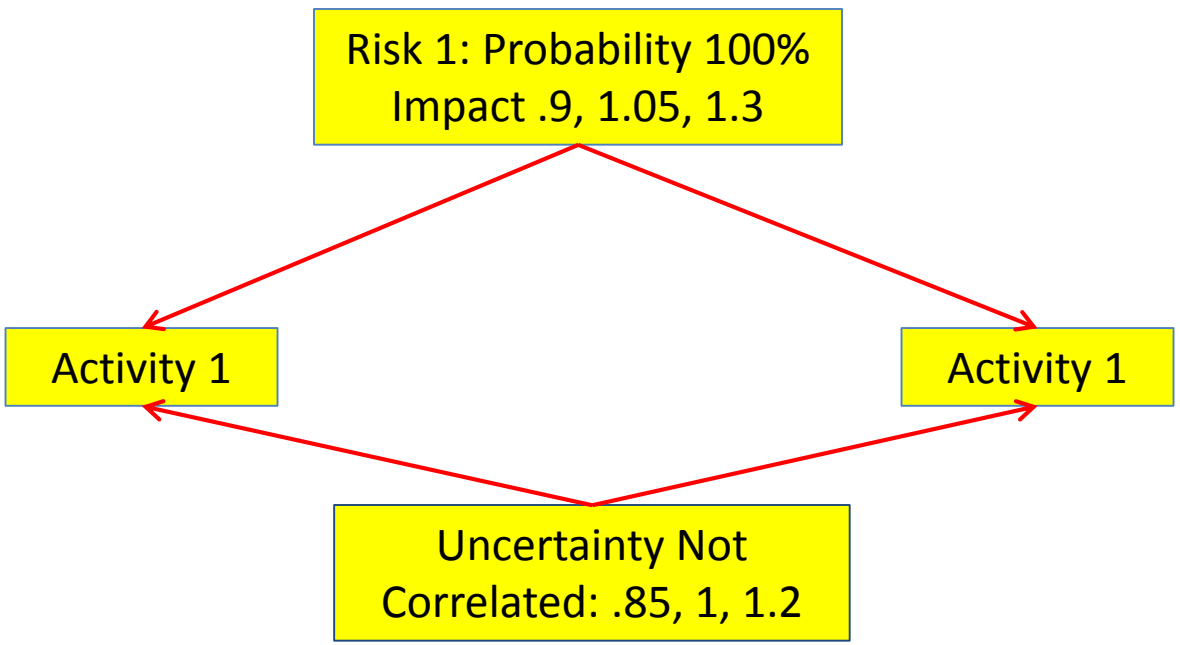
Risk Drivers Generate Correlation between Activities (2)

But there is no such thing as 100% correlation



Adding uncorrelated uncertainty reduces correlation (Activity 1, Activity 2) to 86%

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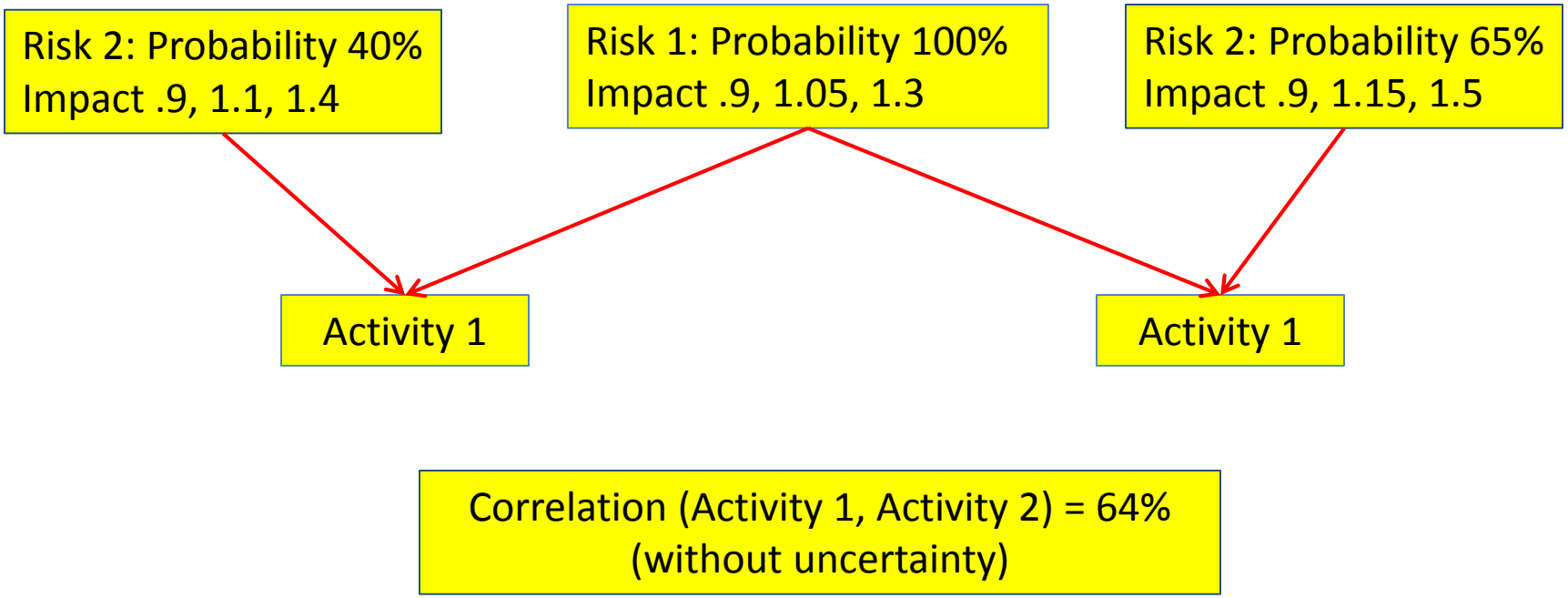
Risk Drivers Generate Correlation between Activities (3)



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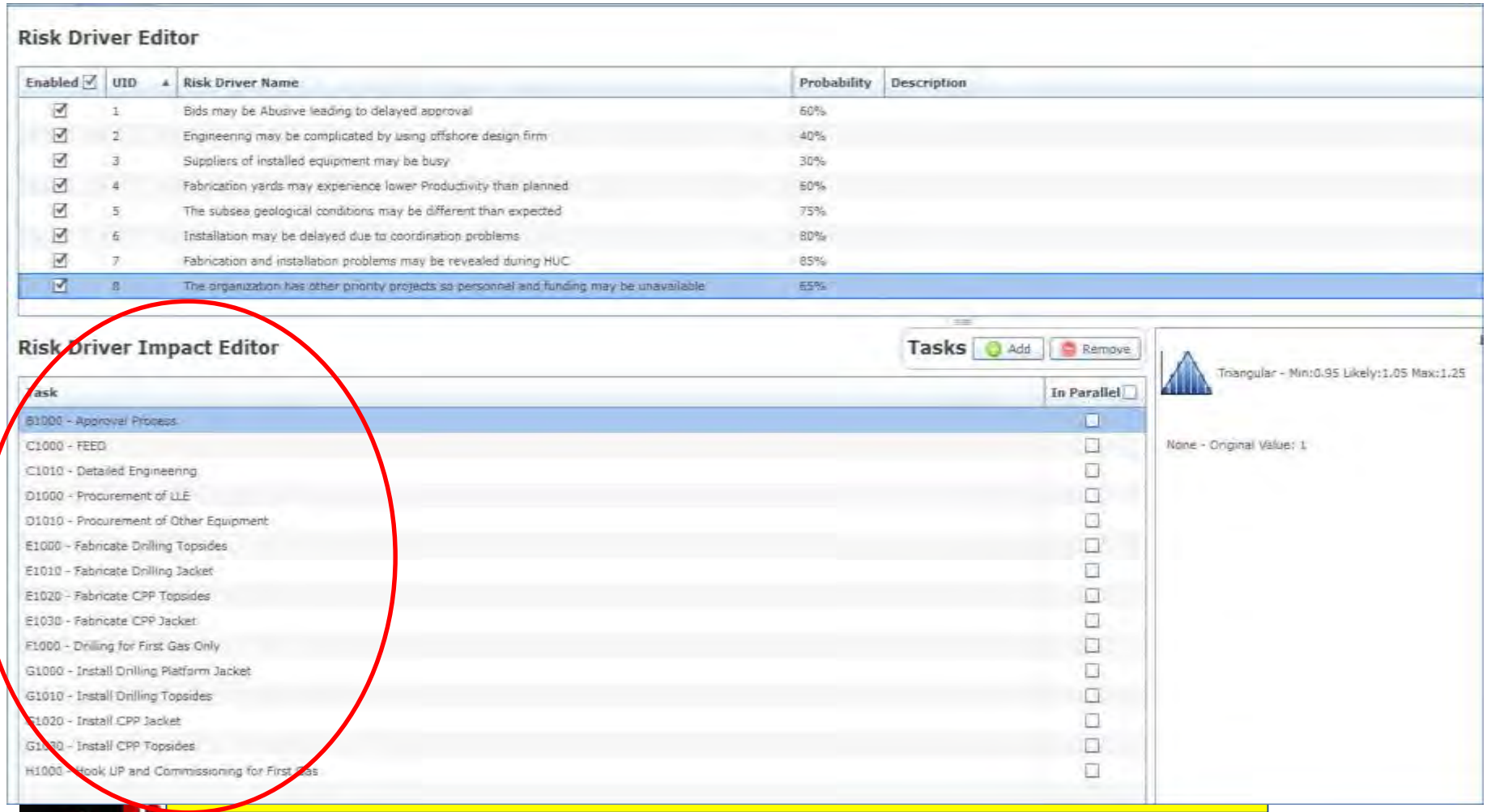
Activities Can be Influenced by More than One Risk Driver



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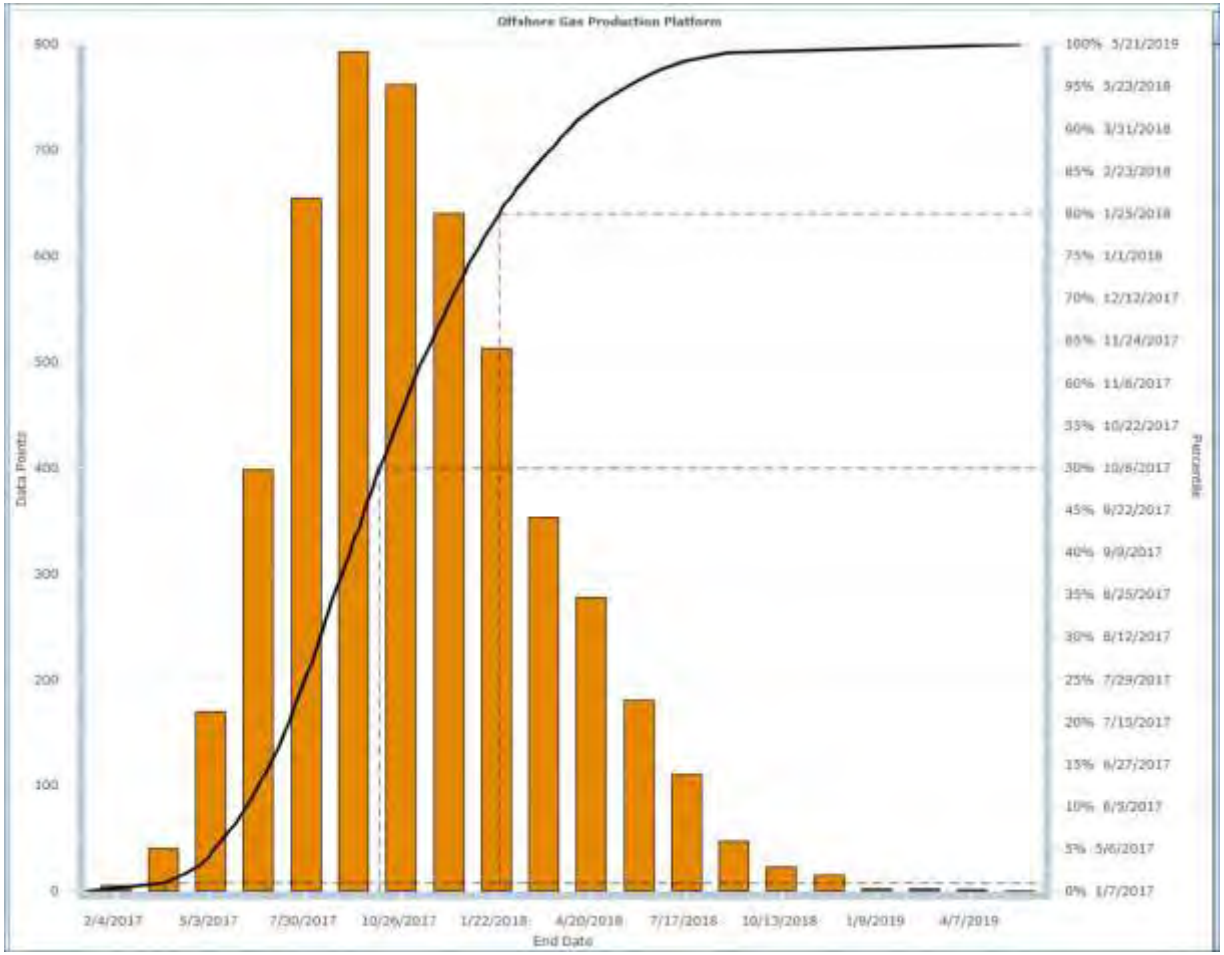
Adding Risk Drivers to Every Activity



With all risk Drivers including the Organizational Risk the P-80 result is 25 January 2018, an additional 7 months

With Uncertainty the P-80 was 30 July2017

The scheduled date is 20 March 2017

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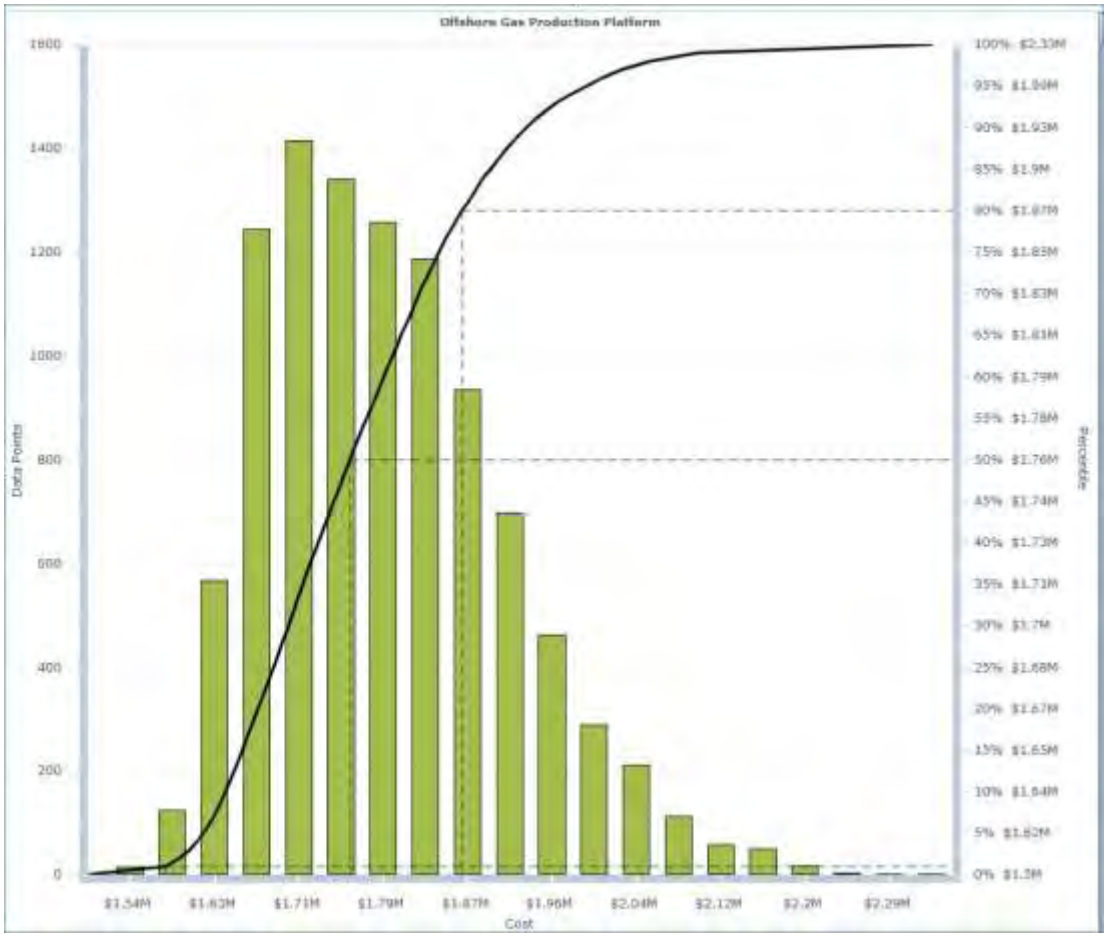
Cost Risk with Uncertainty, Estimating Error and Bias and Risk Drivers



Total Cost P-80 value is $1.87 billion

Planned cost is $1.57 billion

Schedule risk alone adds $300 million

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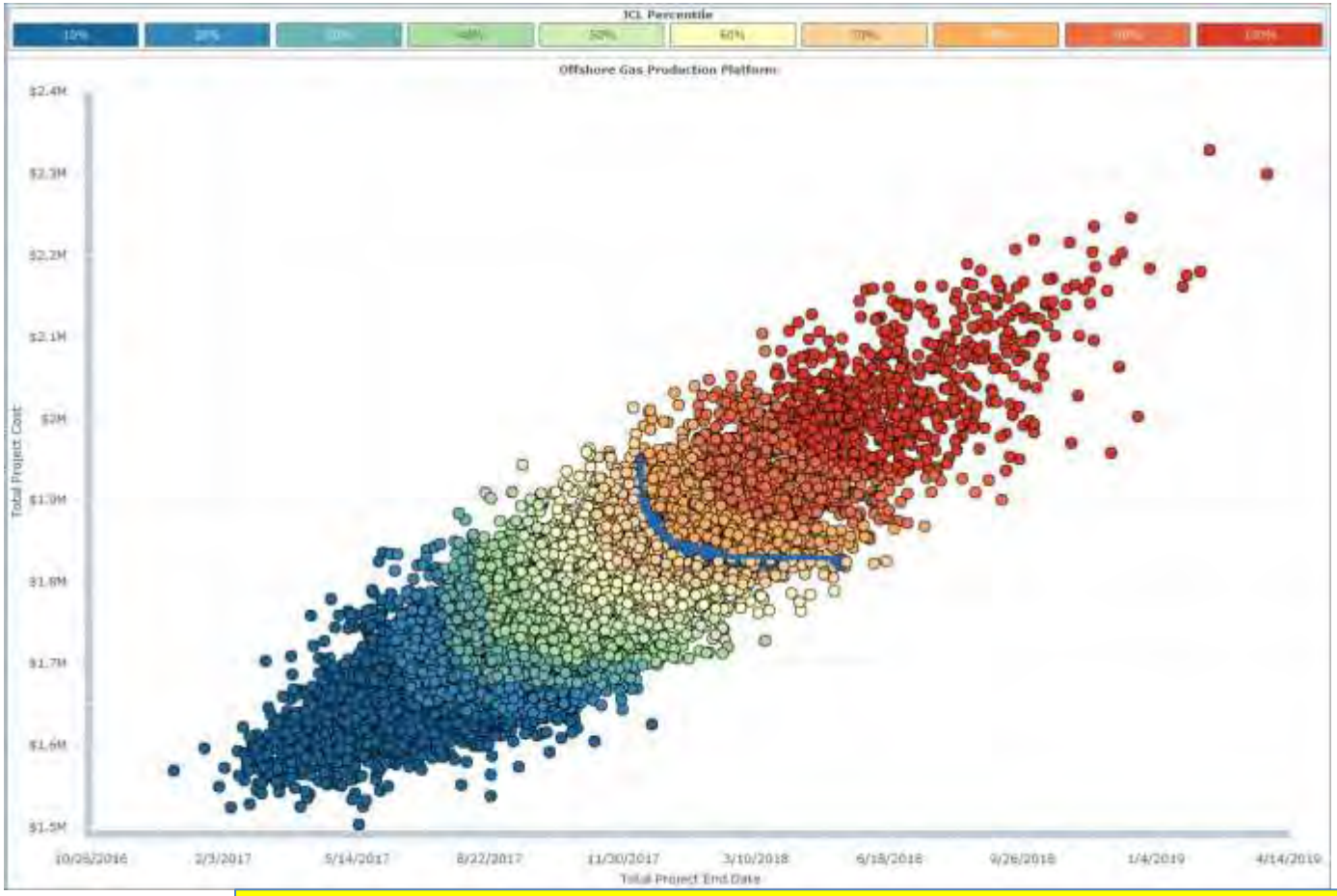
Cost and Schedule are Related when Schedule is the Only Driver of Cost



When Schedule alone drives Cost the correlation is 84%

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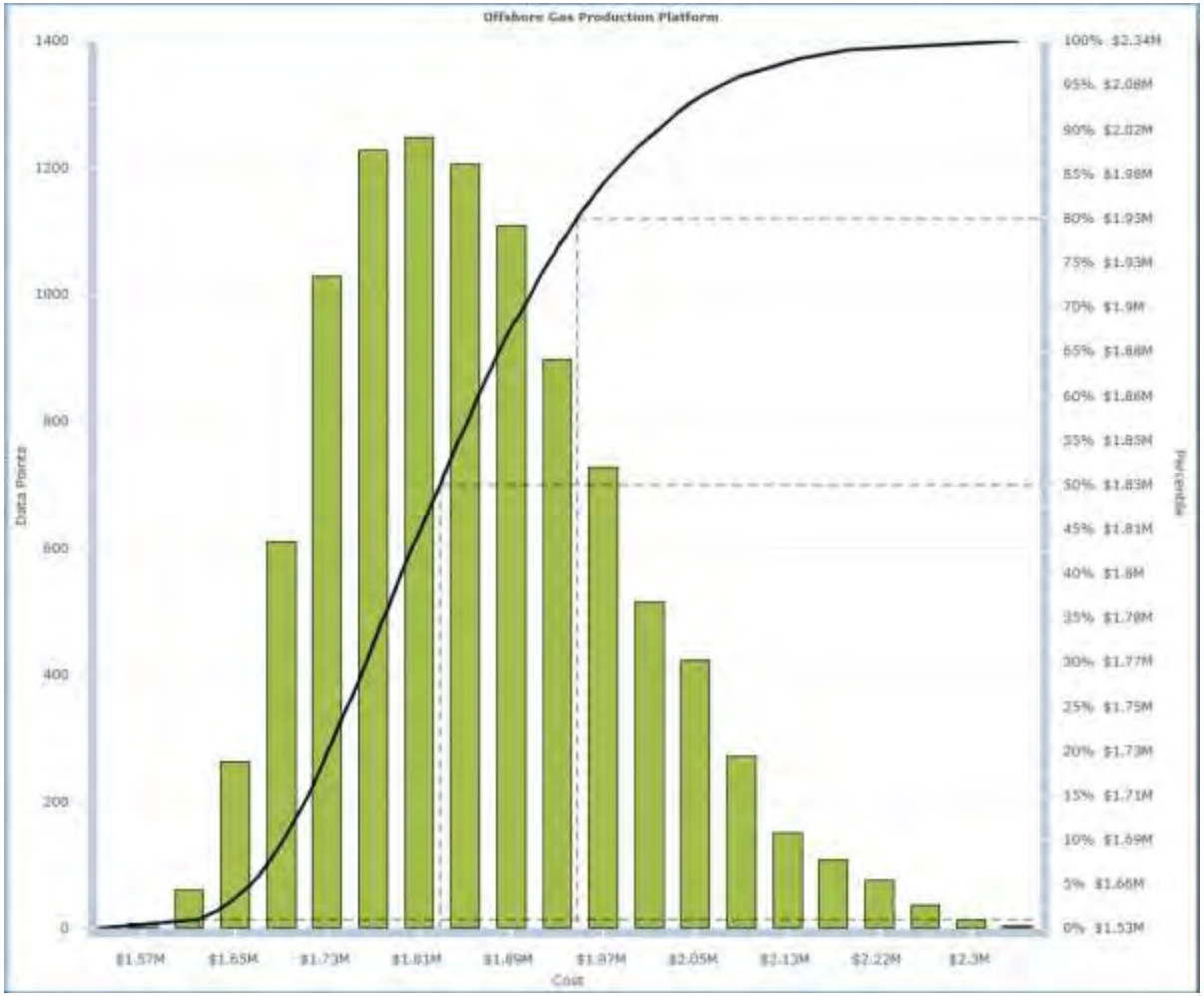
Add Cost Risks to the Model

- There are cost risks and uncertainties that could affect total costs
  - If time dependent – Labor and Rented Equipment / Facilities that cost by the day – will affect the daily “burn rate”
  - If time independent resources – Material and Installed Equipment – will affect their total cost
- These risks may be the same as those that affect the durations or they may be different

Adding Resource Cost Uncertainty



Adding uncertainty to resource costs puts the P-80 cost at $1.95 billion

This is up from $1.87 billion with just schedule risk impacting costs

The cost estimate is $1.57 billion

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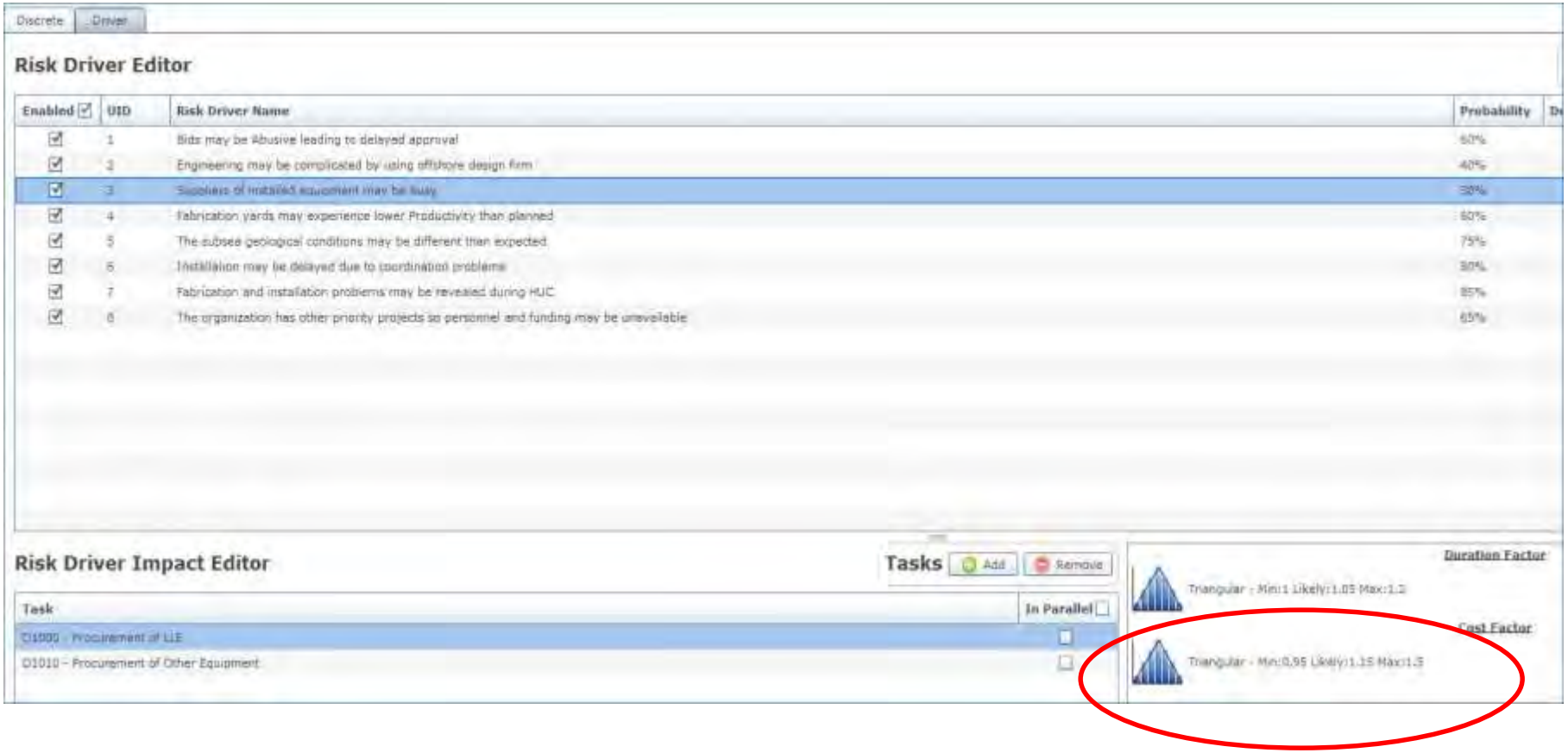
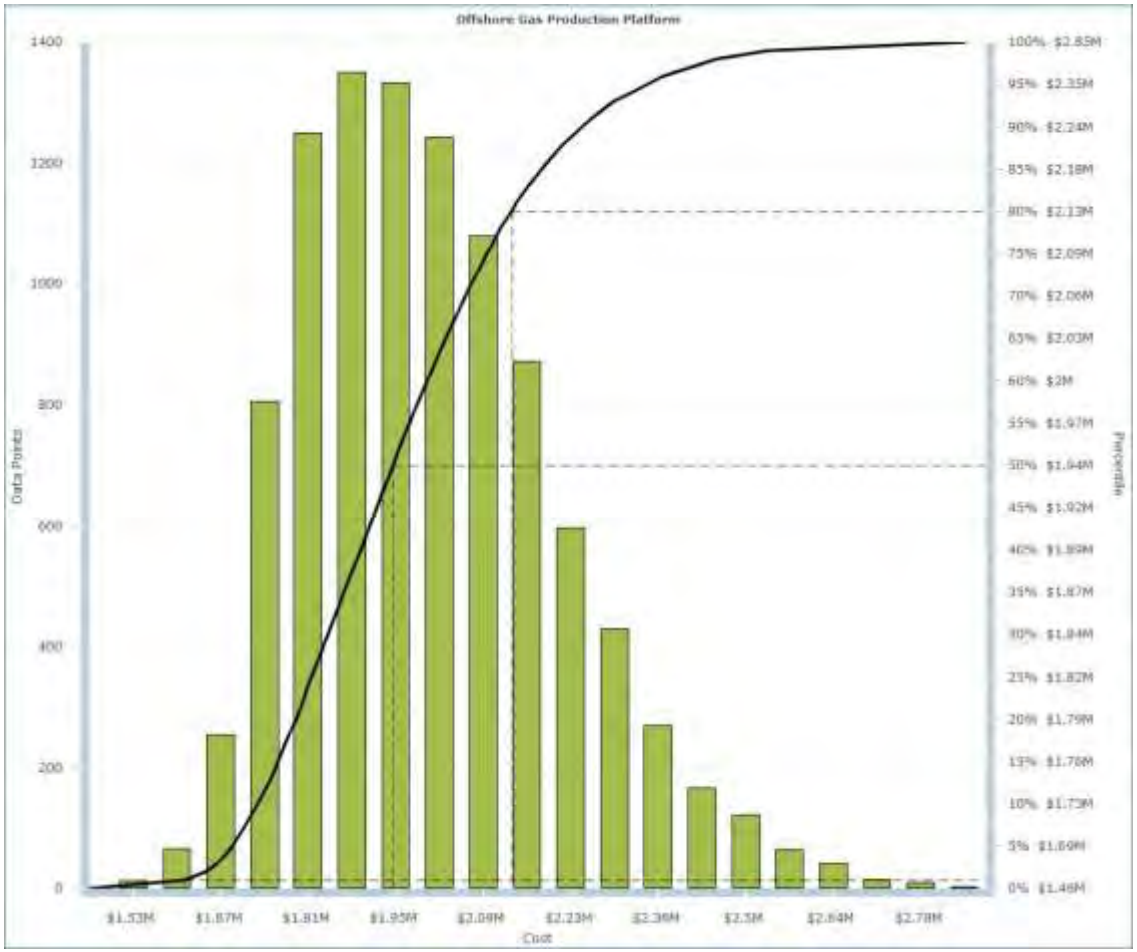
Add Burn Rate (TD resources) and Total Cost (TI resources)



Adding Burn Rate and Total Cost Impacts to the Risk Drivers



Adding:

- Burn Rate risks to the schedule risks for Time Dependent resources
- Total Cost risks to the Time Independent Resources

The P-80 total cost is $2.13 billion

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Adding Burn Rate and Total Costs to the Risk Drivers

Adding burn rate and total cost uncertainty drops the correlation between time and cost to 64%

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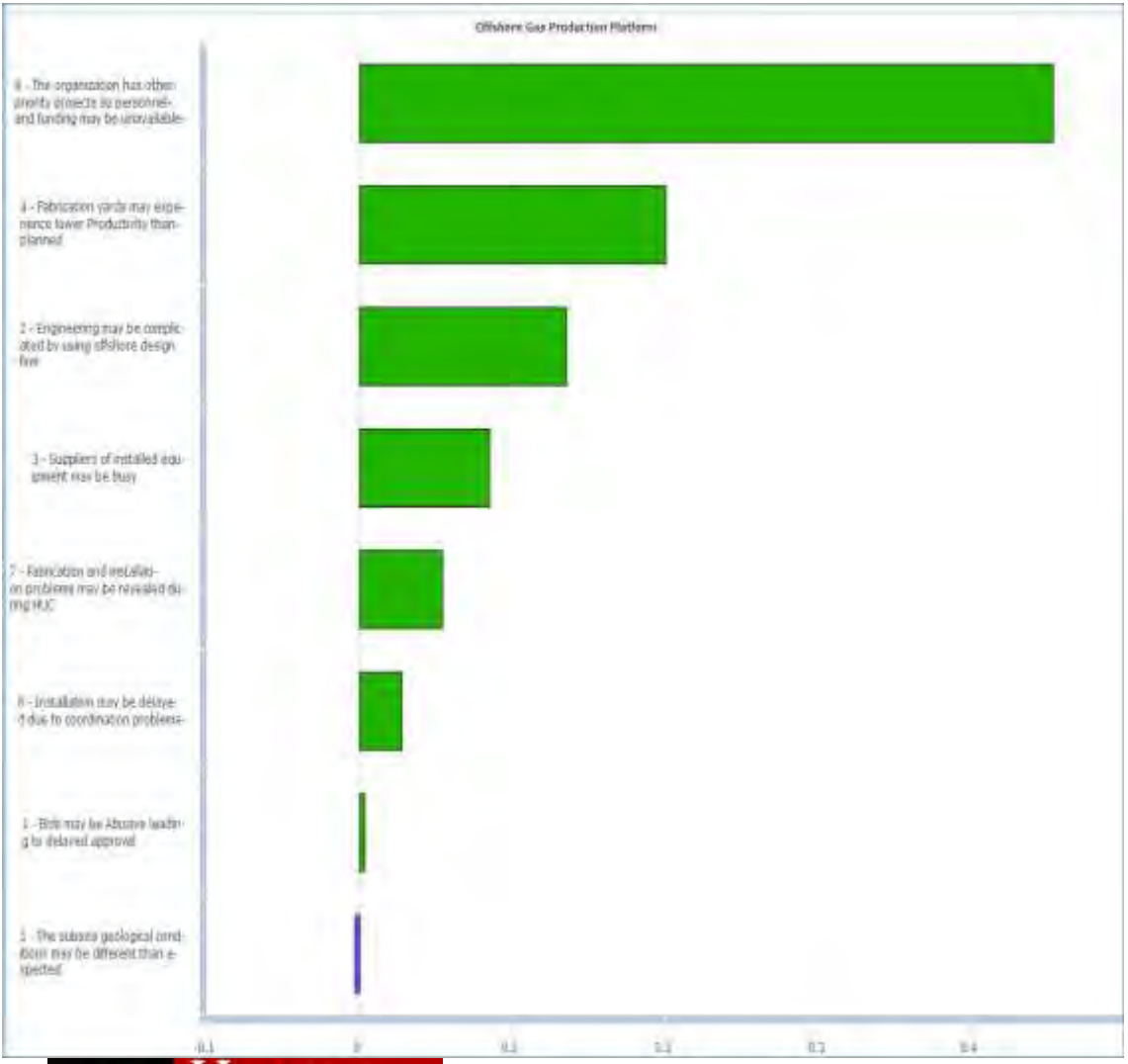
Risk Mitigation Requires some Direction – Prioritize the Risks

- Unlike the qualitative risk analysis (5 X 5 red-yellow-green probability and impact matrix) that populates the Risk Register, this prioritization approach:
  - Uses the project schedule and cost estimate, the documents that represent the project plan
  - Uses quantitative estimates of probability and impact of risks
  - Uses Monte Carlo simulation

Risk-Based Tornado Diagram



This diagram says the risk: "The organization has other priority projects so personnel and funding may be unavailable" has the highest correlation with the total project duration

This is correlation coefficients, not actionable by management, whereas they need to know days

Correlation is based on calculations of squared differences from the mean, whereas we need the measure of priority at the P-80

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Iterative Approach to Prioritizing the Risk

- Purpose, which risks contribute the most days at the P-80 level
- Compute the Baseline with All Risks In
- Iteration # 1: Simulate with each risk disabled in turn, recording the P-80 date
  - The risk with the earliest P-80 date is 1st priority
  - Take it out for Iteration # 2
- Iteration # 2: Simulate the remaining risks, disabling each in turn, recording P-80, choose earliest. Take it out for Iteration # 3
- Etc.

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Picture of Risks Iterated, Selected by their Days Saved

Iterative Approach to Prioritizing Risks (Based on Days Saved at P-80)								
Risk #	1	2	3	4	5	6	7	8
Priority Level (Iteration #)	Abusive Bids	Offshore design firm	Suppliers Busy	Fab productivity	Geology unknown	Coordination during Installation	Problems at HUC	Resources may go to other projects
1	X	X	X	X	X	X	X	**X**
2	X	X	X	**X**	X	X	X	
3	X	**X**	X		X	X	X	
4	X		X		X	X	**X**	
5	X		**X**		X	X		
6	X				X	**X**		
7	**X**				X			
8					**X**			

Risk Tornado with Days Saved

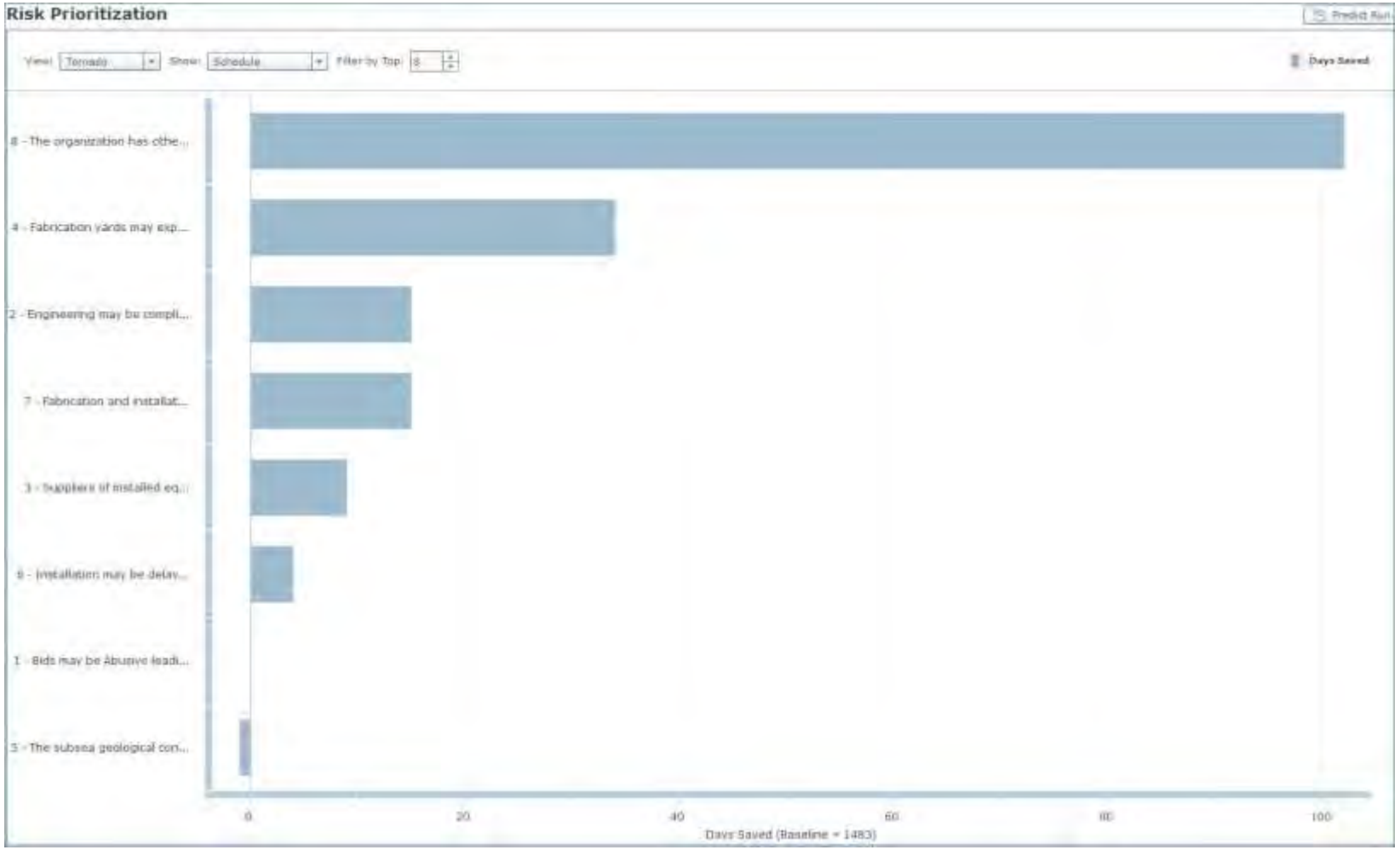

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Table Showing Risks' Days Saved

Gas Platform-1 - Risk Prioritization (80%)		
UID	Name	Days Saved
8	The organization has other priority projects so personnel and funding may be unavailable	102
4	Fabrication yards may experience lower Productivity than planned	34
2	Engineering may be complicated by using offshore design firm	15
7	Fabrication and installation problems may be revealed during HUC	15
3	Suppliers of installed equipment may be busy	9
6	Installation may be delayed due to coordination problems	4
1	Bids may be Abusive leading to delayed approval	0
5	The subsea geological conditions may be different than expected	-1
	TOTAL DAYS SAVED WITH FULL MITIGATION OF RISKS	**178**
	Uncertainty (inherent, estimating error / bias)	130
	TOTAL CONTINGENCY DAYS WITH UNCERTAINTY & RISKS	**308**

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Target for Mitigations is 178 days, risk-by-risk

Risk Mitigation Workshop(s)

- This is a workshop with the project manager, deputy PM, team leads, controls personnel, SMEs with experience
- Use the prioritized risk list
  - Start at the top
  - Working on risks lower on the priority list will not be effective. Those risks are not important until the top risk is dealt with as much as possible
  - Determined by the structure of the schedule and which paths are risk critical – changes as risks are mitigated

Sample Risk Mitigation Entry

Risk: The organization has other priority projects so personnel and funding may be unavailable							
		Pobability	Low	Most Likely	High	P-80 Date	P-80 Cost ($ billions)
Pre-Mitigated parameters		65%	95%	105%	125%	1/22/2018	$2.13
Mitigation Action	Establish this project as top priority - needs top management action and commitment						
Post -Mitigated parameters		**15%**	**95%**	**100%**	**115%**	**10/20/2017**	**$1.99**
Risk Owner:	S. Smith					Days saved	Cost Saved
Date of Action:	Within 1 month				Results	94	$0.14
Risk Action Owner:	B. Blake				Cost of Mitigation		$0.02

Risk is not completely mitigated. Cost saved is the reduction of cost contingency reserve held for schedule risk

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Conclusion (1)

- The schedule and cost are affected by uncertainty and risks
- Uncertainty, including inherent variability, estimating error and bias, is unlikely to be reduced on one project – maybe over time
- Risks, here represented by Risk Drivers with their probability and impact, are assigned to activities and resources
- Risks may be candidates for risk mitigation

Conclusion (2)

- Risk mitigation workshop:
  - Involves the project leaders, top team members
  - Deal with the risks in the order of the risk priority
  - Risks are unlikely to be fully mitigated
- The organization needs to be committed to the mitigation actions
  - People and deadlines assigned
  - Periodic monitoring with top staff
  - Include mitigation steps in the schedule and budget
- Or else the risk mitigation exercise will be ineffective and the “all risks in” scenario becomes a forecast

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