Risk and Uncertainty Management

Best Practices and Misapplications for Cost and Schedule Estimates

SPE 97269

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We have an important message for engineers and managers

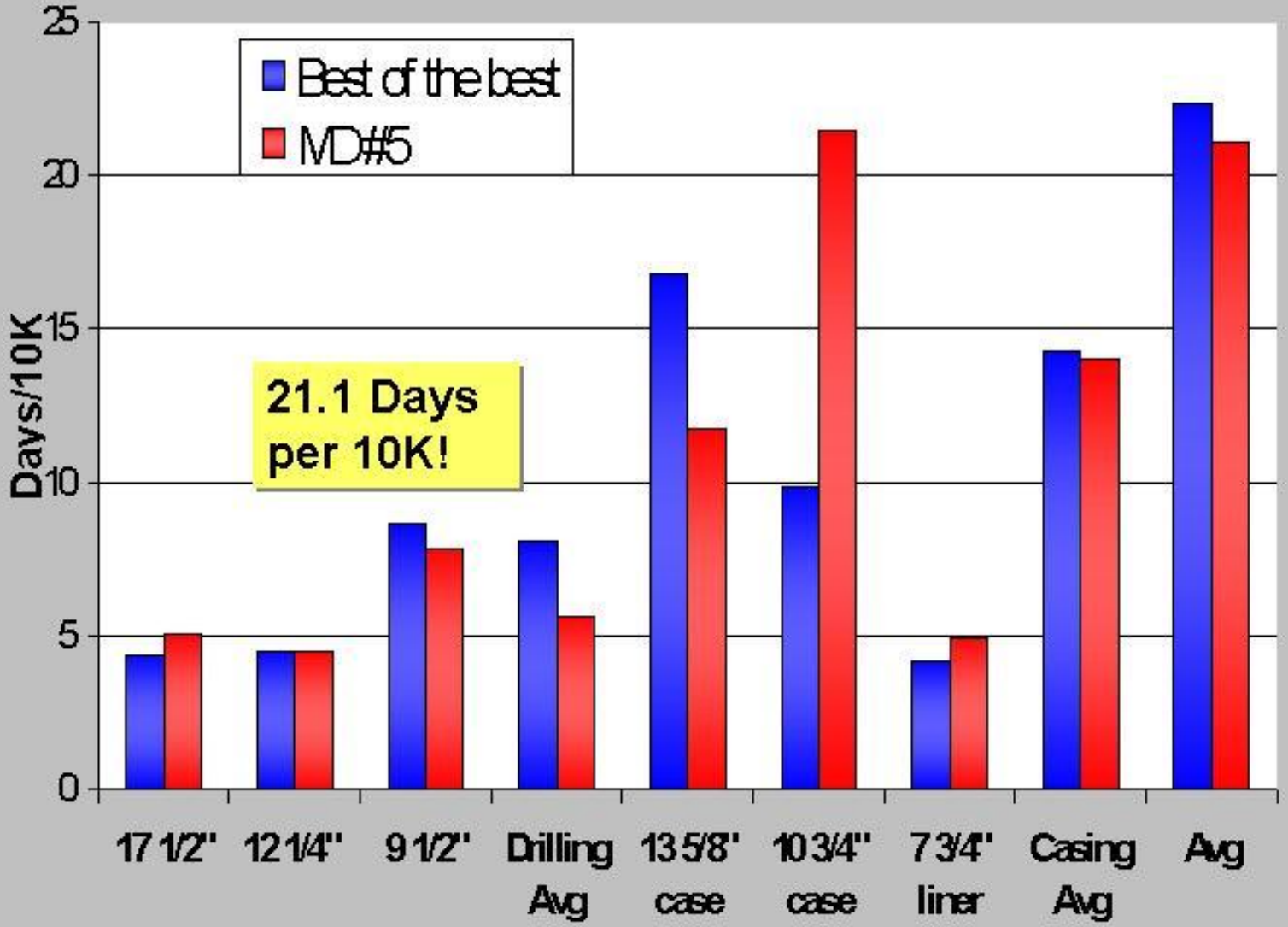
- Risk and uncertainty management is a powerful tool that improves project outcome
- The two stages are qualitative and quantitative:
  - Managing risk and uncertainty
  - Understanding project outcome ranges
- Misunderstandings and misapplications are losing huge performance opportunities
- Our recommendations will ensure correct application with improved project outcomes

N Sea development well in active faulting area

- Drilling problems threatened project economics
  - trouble costs approached 35% and occasionally 50%
  - 1 in 3 wells failed to reach objectives
  - extended drilling time – delayed production
- Operator / supplier team risk / uncertainty management
  - very challenging ERD well 25% below historic cost
  - slot recovery in 18 vs 29 days
  - drilled well 30% ahead of past performance
  - repeated performance overcame failed wells

Deepwater GOM

Improvement



Start by developing the Qualitative process as the first phase

- Identification is a critical & continuous process
  - Group of people representing full cross section
  - Brainstorming meetings, interviews or similar
- Assessment
  - Develop a risk / uncertainty matrix that is relevant to the project
  - Rank the risks to identify those that are project critical
  - Develop mitigation plans
    - Design / re-plan to reduce or remove
    - Contingency plan to offset
- Management
  - Build and maintain a log (register)

An example of an assessment matrix

HSE	Schedule	Capital cost	Operating cost	Functionality	Production	Reputation					
Fatality or serious permanent injury	1 week	$ 1 mill		Loss of >50%	PI Reduction 50%	Prosecution Possible loss of operating license	25	25	50	75	100
Serious injury	1 day	$100,000		Loss of 10 to 50%	PI Reduction 25%	Regulator involvement	10	10	20	30	40
Lost Time Incident	6 hours	$25,000		Loss of <10%	PI Reduction 10%	Complaints from local community	5	5	10	15	20
First Aid	1 hour	$5,000		Little impact	Little impact	Little impact	1	1	2	3	4
								1	2	3	4

Impact

Probability / Frequency

> 5 years	1 year	6 months	< 14 days
< 5%	5 - 25%	25 - 50%	> 50%

Key headings in the Qualitative Risk Log

- Risk identifier
- Project phase
- Risk event
- Risk cause
- Estimate of risk probability (from the matrix)
- Estimate of risk impact
- Identification of type of impact
  - (safety, cost (opex / capex), schedule, functionality)
- Risk ownership
- Mitigation actions
  - Plan it out, develop contingency
- Cost / benefit of mitigation
- Timing of mitigation

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Risk ID	Project sub group	Project phase	Description of event	Description of cause	Risk or Uncertainty	Impact type	Impact rating	Probability rating	Risk rating
1		Proj Specification	NAPIMS approval later than scheduled	Delays beyond expected duration	Risk	Schedule	25	3	75
2			Poorly understood process requirement	Uncertainty of process rate and stream conditions is interpreted as chnages in design parameter	Uncertainty	Functionality	10	4	40
3			Work not completed according to schedule	Resources assigned late, insufficient resources assigned	Risk	Schedule	25	4	100
4	Subsurface	Proj Specification	Gas volumes are larger than base case used in FEED	Oron production	Uncertainty	Functionality	5	1	5
5	Subsurface	Proj Specification	Gas volumes are larger than base case used in FEED	Additional upside production	Uncertainty	Functionality	5	2	10
6	Facilities	Proj Specification	Current structures unable to take additional loads of risers, etc	Structures inadequate for additional use	Risk	Capital cost	10	2	20
7	Facilities	Proj Specification	Loss of oil production	Shut down required for interfacing the CPU 2 to current production	Risk	Production	10	3	30
8	Facilities	Proj Specification	Insufficient reserves to meet sales contract	Non associated gas less than expected					0
10									

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Misunderstandings and misapplications in the qualitative process

- Single person compiles the register and leaves many risks unidentified
- Risk events are overlooked because they are trivialized (“That never happens”)
- Register is not linked to quantitative analysis
- Register is built but insufficient action to mitigate
- Complex computer programs act like black boxes – open, visible spreadsheets work very well

Transition from Qualitative to Quantitative analysis

- Qualitative analysis prioritizes risks and uncertainties for action
- Quantitative analysis evaluates the risks and uncertainties using the following methods:
  - Deterministic
    - Decision trees
  - Stochastic
    - Monte Carlo simulation

Risk and Uncertainty Management

Misunderstandings in Cost and Schedule Estimating

- **That it is possible to have enough information and/or data to do a deterministic analysis, yet not enough to do uncertainty and risk analysis.**

Risk and Uncertainty Management

Misunderstandings in Cost and Schedule Estimating

- That it is possible to have enough information and/or data to do a deterministic analysis, yet not enough to do uncertainty and risk analysis.

- Uncertainty and risk analysis are only useful once the program or project is underway and well-defined.

Risk and Uncertainty Management

Misunderstandings in Cost and Schedule Estimating

- **There must be an agreed deterministic estimate prior to creating a probabilistic estimate.**

Risk and Uncertainty Management

Misunderstandings in Cost and Schedule Estimating

- **There must be an agreed deterministic estimate prior to creating a probabilistic estimate.**

- **The deterministic estimate has some statistical relevance.**

Risk and Uncertainty Management

Misunderstandings in Cost and Schedule Estimating

- **Risk and uncertainty analysis will lead to more accurate estimates.**

Risk and Uncertainty Management

Misunderstandings in Cost and Schedule Estimating

- **Risk and uncertainty analysis will lead to more accurate estimates.**

- **All risks can, or should, be explicitly listed.**

Additional items in Risk Register for Quantitative Model

- Relation to other risks
- Mitigation success probability
- Cost / benefit of mitigation
- Timing of mitigation

Risk Register – Link to Quantitative Model

No	Risk Description	L M H Likelihood	Cost Impact	Grade	Change	Related Risks	Mitigation Strategy	Owner	Mitigation P(Success)	Mitigation Cost Ratio	Date Reported	Date Closed
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

Related Risks (correlation and mutual exclusivity)

Risk Register – Link to Quantitative Model

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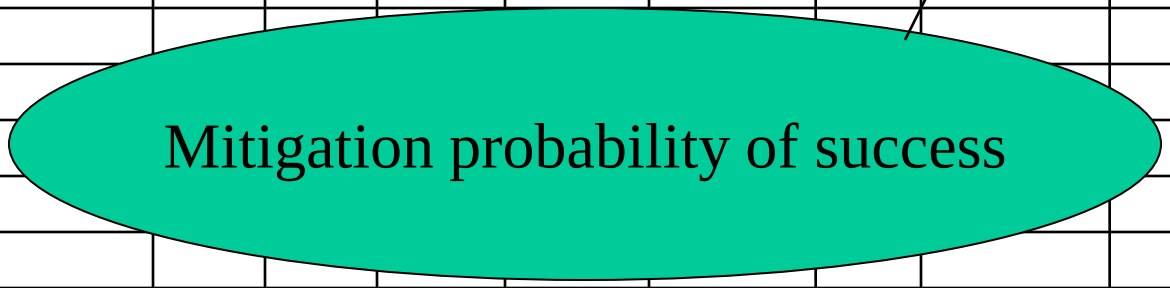

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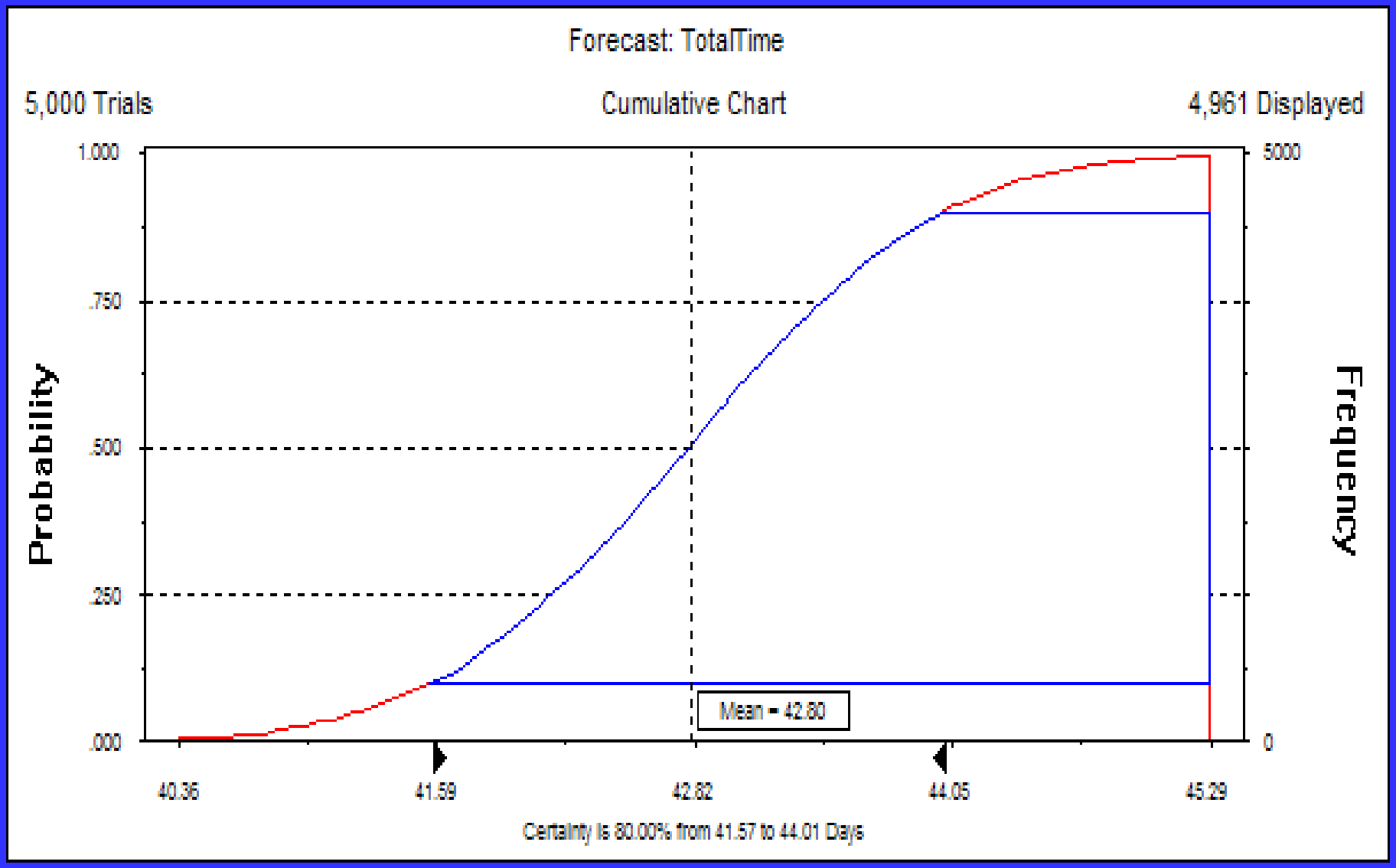
Mitigation Cost Ratio (cost of mitigation to risk cost)

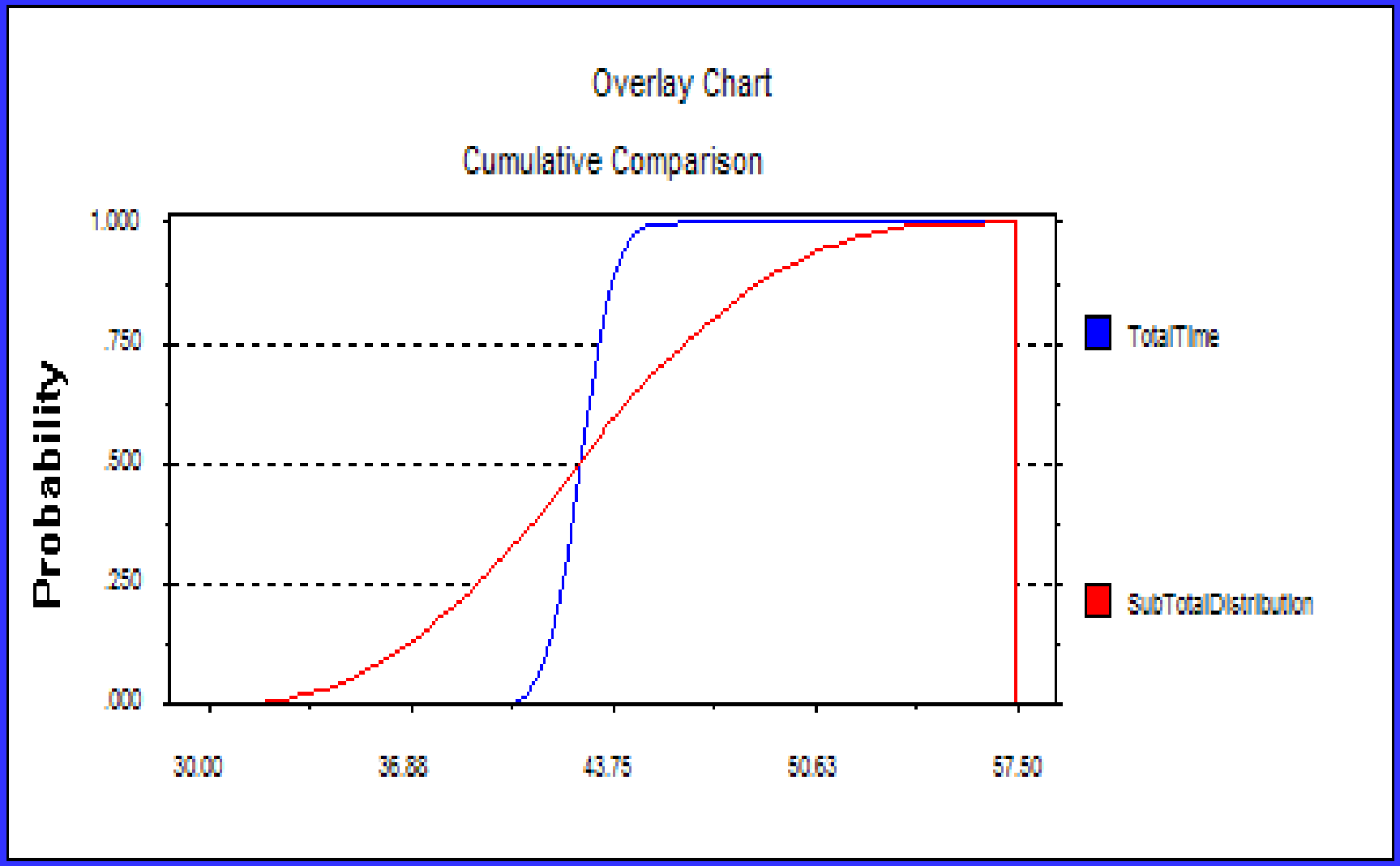
Misapplications in the quantitative analysis

- Risk register not linked to the quantitative risk and uncertainty model.
- Distributions assigned to all the inputs, just because we can.

Distributions on every entry

Operation	Min time	Avg time	max time		Min NPT	Avg NPT	Max Npt	Avg NPT
	hrs	hrs	hrs		hrs	hrs	hrs	hrs
Mobilize Rig Job								
Move Equipment	1.00	2.00	3.00	2.00	0.10	0.30	0.75	0.30
Transit Rig	8.00	12.00	24.00	12.00	0.80	1.80	6.00	1.80
Inspect Area	0.50	1.00	2.00	1.00	0.05	0.15	0.50	0.15
Safety Meeting	0.25	0.50	0.75	0.50	0.03	0.08	0.19	0.08
Position Rig	1.00	2.00	3.00	2.00	0.10	0.30	0.75	0.30
Rig Up Land Rig	4.00	8.00	12.00	8.00	0.40	1.20	3.00	1.20
Rig Up Surface Equipment	2.00	4.00	6.00	4.00	0.20	0.60	1.50	0.60
Pick Up And Make Up Tubular	1.00	2.00	3.00	2.00	0.10	0.30	0.75	0.30
Drill Wellbore Job								
Drive Conductor								
Safety Meeting	0.25	0.50	0.75	0.50	0.03	0.08	0.19	0.08
Assemble Equipment	1.00	2.00	3.00	2.00	0.10	0.30	0.75	0.30
Drive Conductor	4.30	5.74	7.17	5.74	0.43	0.86	1.79	0.86
Disassemble Equipment	0.50	2.00	2.00	2.00	0.05	0.30	0.50	0.30
Drillout								
Safety Meeting	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Pick Up And Make Up Bha	2.00	3.00	4.00	3.00	0.10	0.30	0.60	0.30
Run In Hole	0.09	0.12	0.16	0.12	0.00	0.01	0.02	0.01
Circulate	0.25	0.50	0.63	0.50	0.01	0.05	0.09	0.05
Drill Shoe Track	0.50	1.00	2.00	1.00	0.03	0.10	0.30	0.10
Drill Surface								
Drill Rotary	1.86	2.48	3.10	2.48	0.09	0.25	0.47	0.25
Circulate	0.63	0.78	0.94	0.78	0.03	0.08	0.14	0.08
Short Trip	0.17	0.26	0.35	0.26	0.01	0.03	0.05	0.03
Circulate	0.63	0.78	0.94	0.78	0.03	0.08	0.14	0.08
Pull Out Of Hole	0.16	0.21	0.32	0.21	0.01	0.02	0.05	0.02
Pull Out And Lay Down BHA	2.00	3.00	4.00	3.00	0.10	0.30	0.60	0.30
Run Surface								
Clear Rig Floor	0.30	0.50	1.00	0.50	0.02	0.05	0.15	0.05
Assemble Equipment	0.30	0.50	1.00	0.50	0.02	0.05	0.15	0.05
Safety Meeting	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Pick Up And Make Up Tubular	0.50	1.00	2.00	1.00	0.03	0.10	0.30	0.10
Run Tubular	0.74	0.98	1.23	0.98	0.04	0.10	0.18	0.10
Circulate	0.06	0.11	0.17	0.11	0.00	0.01	0.03	0.01
Cement Surface								
Rig Up Surface Equipment	0.50	1.00	2.00	1.00	0.03	0.10	0.30	0.10
Safety Meeting	0.30	0.50	0.75	0.50	0.02	0.05	0.11	0.05
Test Equipment	0.30	0.50	1.00	0.50	0.02	0.05	0.15	0.05
Circulate	0.09	0.11	0.14	0.11	0.00	0.01	0.02	0.01
Pump Spacer	0.09	0.12	0.15	0.12	0.00	0.01	0.02	0.01
Mix And Pump Slurry	0.27	0.35	0.44	0.35	0.01	0.04	0.07	0.04
Displace Slurry	0.09	0.11	0.14	0.11	0.00	0.01	0.02	0.01
Rig Down Surface Equipment	0.50	1.00	2.00	1.00	0.03	0.10	0.30	0.10
Planned Wait	3.00	5.00	8.00	5.00	0.15	0.50	1.20	0.50
Install BOP								
Safety Meeting	0.25	0.50	0.75	0.50	0.03	0.08	0.19	0.08
Inspect Area	0.25	0.50	0.75	0.50	0.03	0.08	0.19	0.08
Inspect Equipment	0.25	0.50	0.75	0.50	0.03	0.08	0.19	0.08
Install Blow Out Preventer	4.00	8.00	12.00	8.00	0.40	1.20	3.00	1.20
Test BOP Stack	2.00	4.00	6.00	4.00	0.20	0.60	1.50	0.60
Drillout								
Safety Meeting	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Pick Up And Make Up Bha	2.00	3.00	4.00	3.00	0.10	0.30	0.60	0.30
Run In Hole	0.16	0.21	0.26	0.21	0.01	0.02	0.04	0.02
Circulate	0.63	0.78	0.94	0.78	0.03	0.08	0.14	0.08
Drill Shoe Track	0.50	1.00	2.00	1.00	0.03	0.10	0.30	0.10
Conduct FIT or LOT								
Rig Up Surface Equipment	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Safety Meeting	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Test Equipment	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Circulate	0.63	0.78	0.94	0.78	0.03	0.08	0.14	0.08
Perform LOT	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Rig Down Surface Equipment	0.25	0.50	0.75	0.50	0.01	0.05	0.11	0.05
Drill Intermediate								
Drill Rotary	75.91	101.22	126.52	101.22	3.80	10.12	18.98	10.12
Circulate	0.82	1.03	1.23	1.03	0.04	0.10	0.18	0.10
Short Trip	3.57	5.35	7.13	5.35	0.18	0.53	1.07	0.53
Circulate	0.82	1.03	1.23	1.03	0.04	0.10	0.18	0.10
Pull Out Of Hole	2.91	3.88	4.85	3.88	0.15	0.39	0.73	0.39
Pull Out And Lay Down Bha	2.00	3.00	4.00	3.00	0.10	0.30	0.60	0.30


Forecast: TotalTime
5,000 Trials
Cumulative Chart
4,961 Displayed
1.000
.750
.500
.250
.000
Probability
5000
0
Frequency
Mean = 42.80
40.36
41.59
42.82
44.05
45.29
Certainty is 80.00% from 41.57 to 44.01 Days


Overlay Chart
Cumulative Comparison
Probability
1.000
.750
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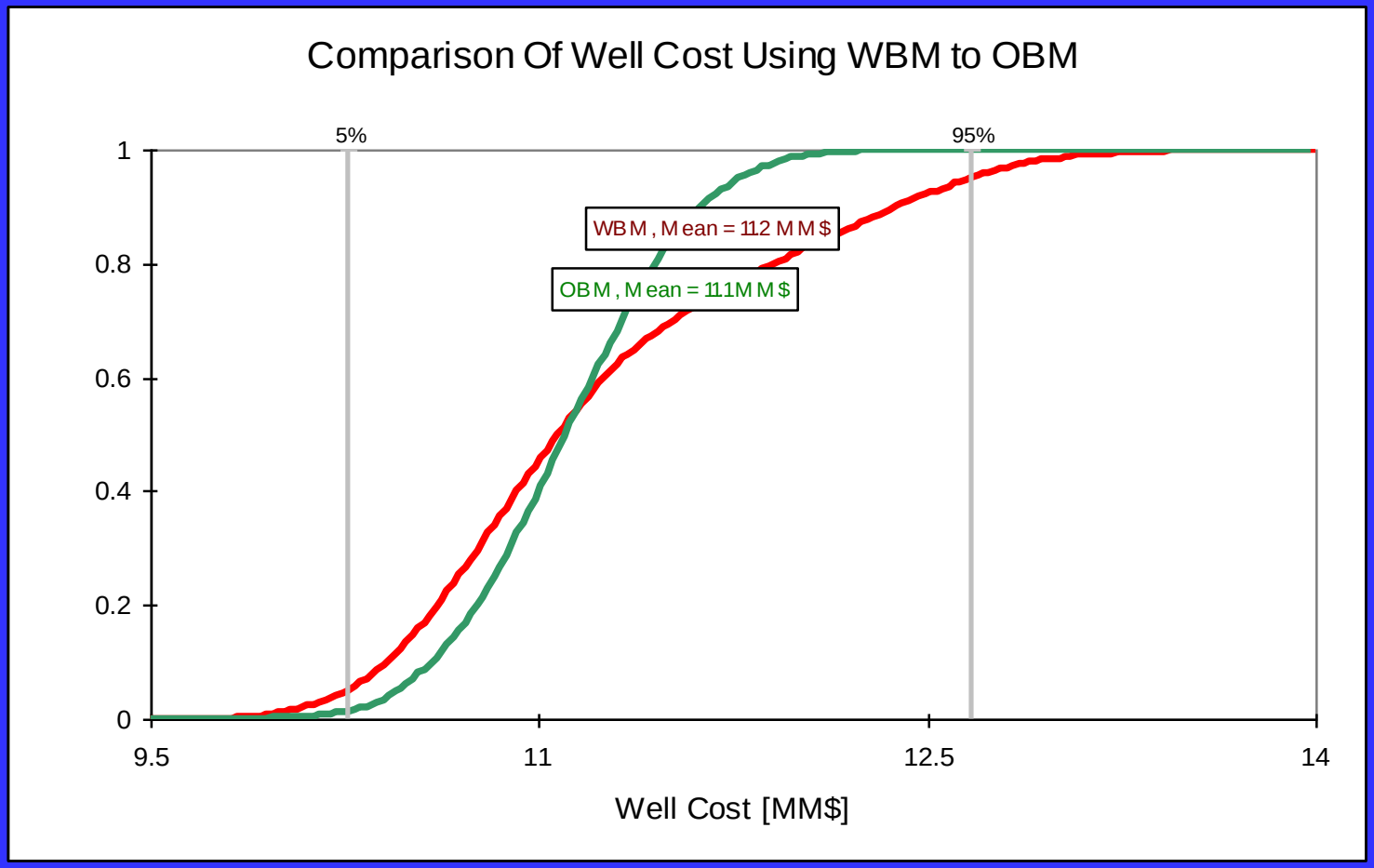
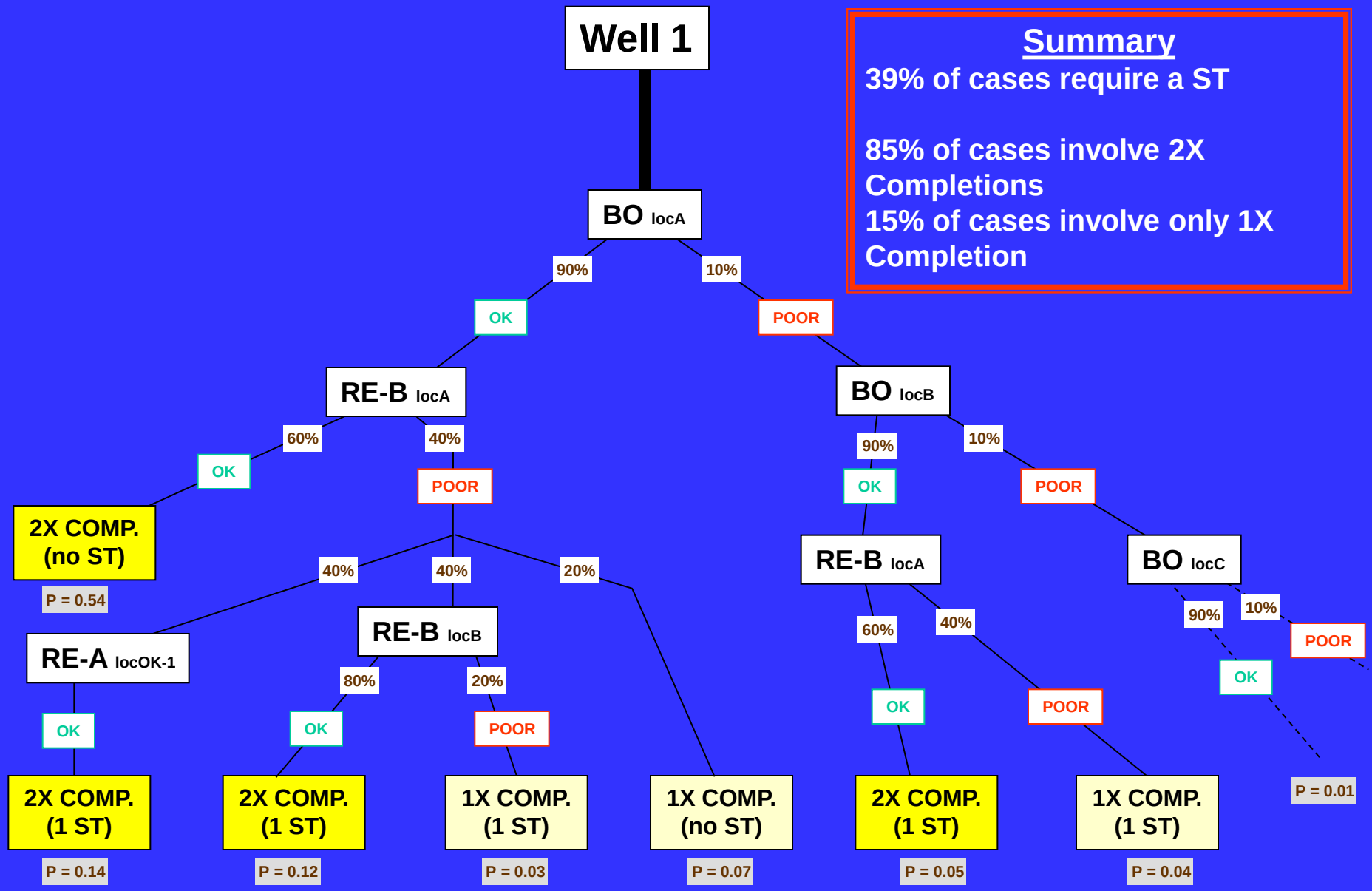
30.00
36.88
43.75
50.63
57.50
TotalTime
SubTotalDistribution

Misapplications in the quantitative analysis

- Risk register not linked to the quantitative risk and uncertainty model.
- Distributions assigned to all the inputs, just because we can.
- Models not used for decision-making.

Use Models for Technology Decision-Making….





Summary

39% of cases require a ST

85% of cases involve 2X Completions

15% of cases involve only 1X Completion

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- **Abandoning uncertainty and risk analysis because the desired deterministic estimate falls at an embarrassing point in (or off) the probabilistic distribution.**

Misapplications in the quantitative analysis

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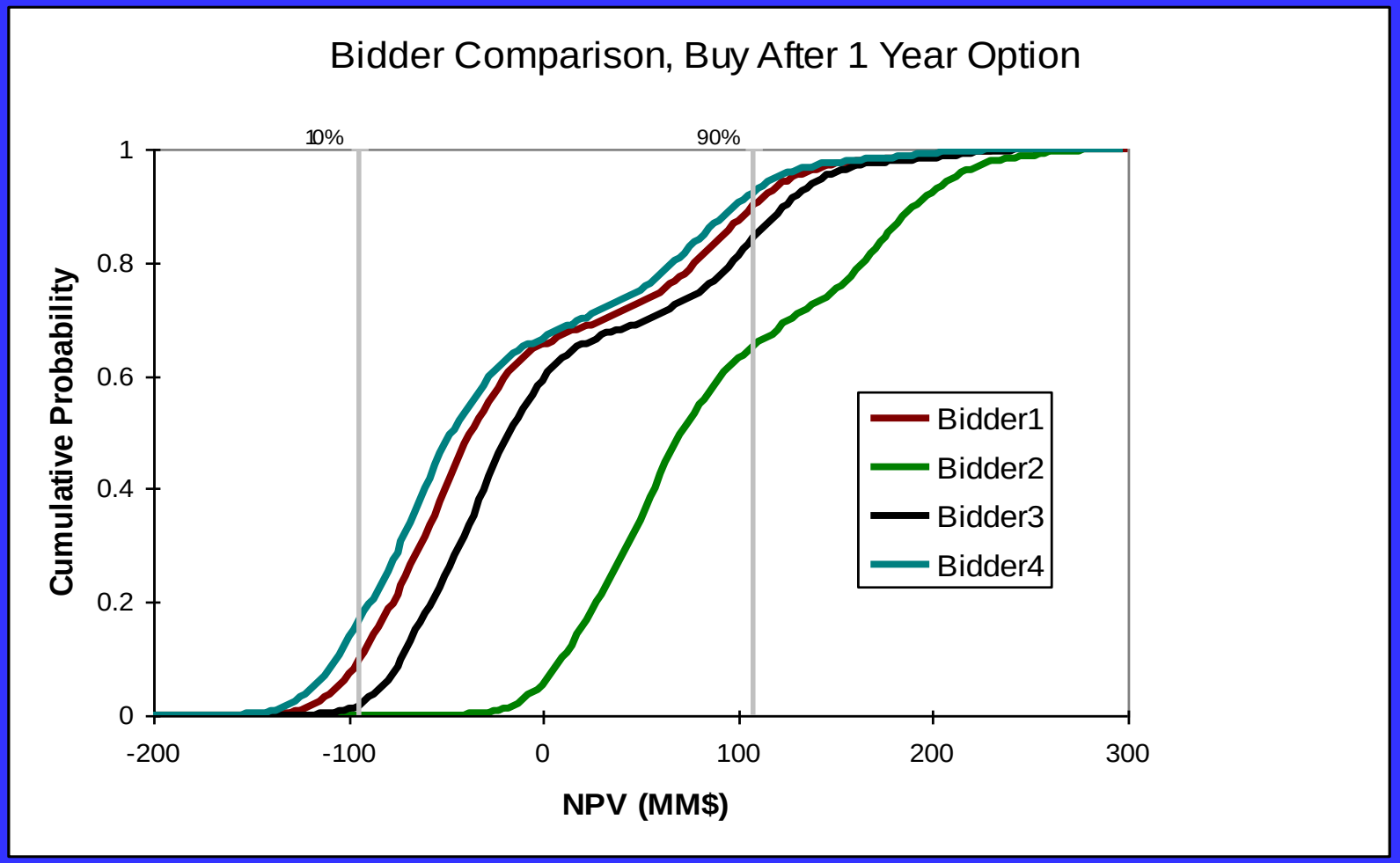
- Distributions assigned to all the inputs, just because we can.
- Models not used for decision-making.
- Abandoning uncertainty and risk analysis because the desired deterministic estimate falls at an embarrassing point in (or off) the probabilistic distribution.
- Cost and schedule risk isolated from production and market risk.

Use Models for Bid Evaluations…. Including Production and Schedule Risk!



Conclusions

- Best practice projects out perform the norm
- Correct application enables re-design, re-planning and contingencies for improved performance
- Quantitative analysis enables significantly improved decision making
- Realistic cost and schedule estimates can only be generated through correct probabilistic analysis
- Correct understanding of qualitative and quantitative analysis is linked to company performance through project delivery