Presenting:

How to Value Imperfect Information (?)

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DAAG Conference 2003

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How to Value Imperfect Information
(?)

Some very suspicious thinking by Ron and Jon

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Decision & Risk Analysis

Information about Ron and Jon

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Strategy and Portfolio Characterization

Leader – Decision Quality

Responsibilities: Strategy planning, project support, D&RA training

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Topics covered in presentation

- Decision Analysis
- Value of Information
- Case Study
- Decision Tree Solution
- Simulation Solution
- Observations and Conclusions

Decision Analysis

Recognizing a "Value of Information" situation

Decision making under uncertainty

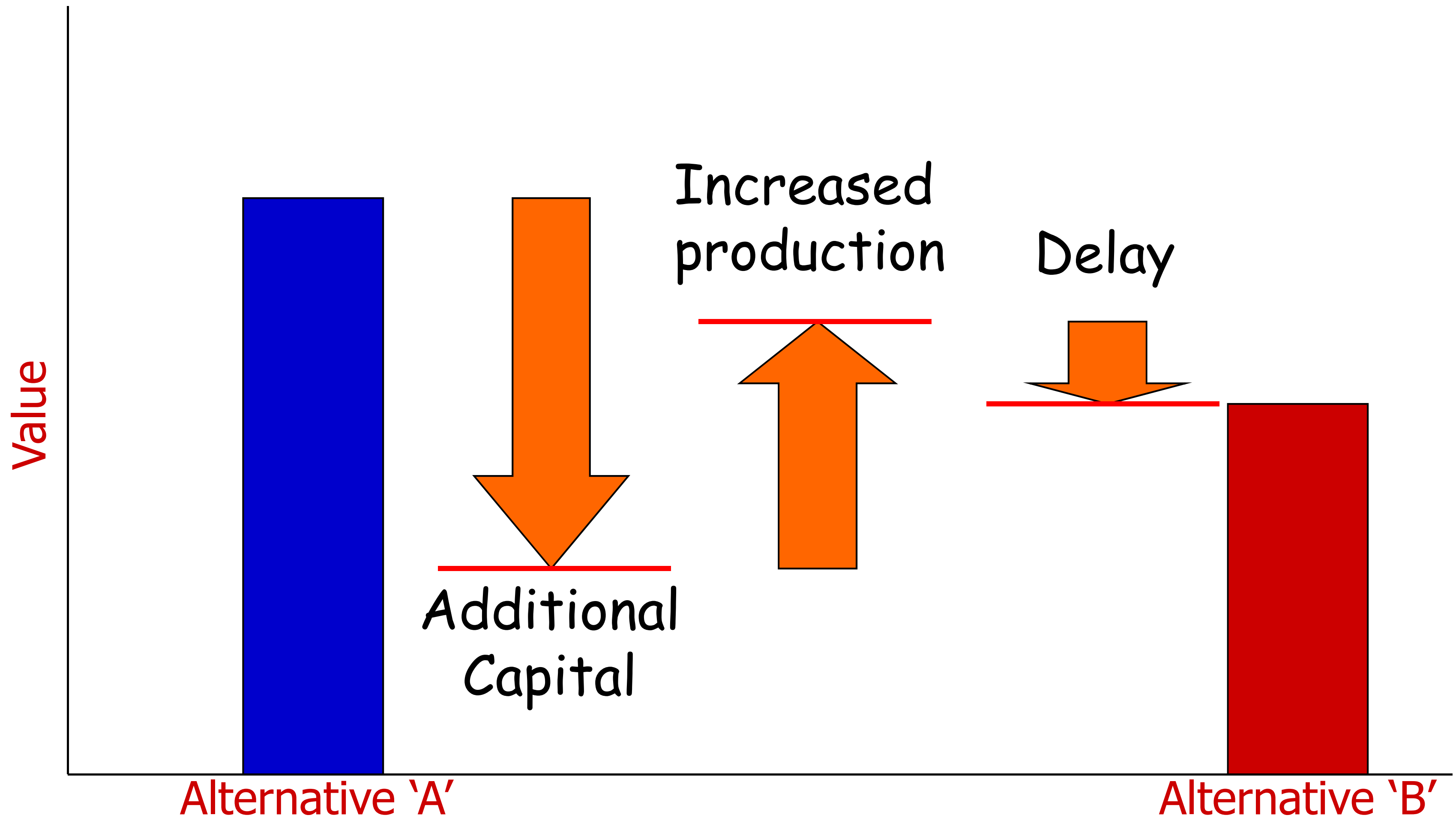
Nearly all important decisions, business or personal, are made under conditions of uncertainty.

We lack **information** about factors that could significantly affect the outcomes of our decisions.

The decision maker must choose one course of action from all that are available.

The difficulty is in understanding the consequences or outcomes of the different courses of action.

Understanding the differences between alternatives (value drivers)



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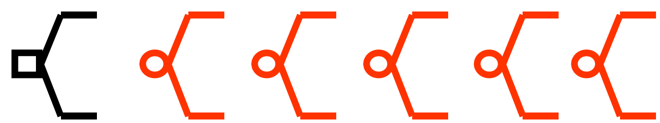
Two general patterns with regards to decision-making

<u>A general EMV pattern</u>, where the decisions occur up front and then all the uncertainties occur after those decisions are made.



<u>A phased decision pattern</u>, where the decisions are interspersed with the uncertainties.

A phased decision pattern is indicative of a "Value of Information" situation

Value of Information

Some background information

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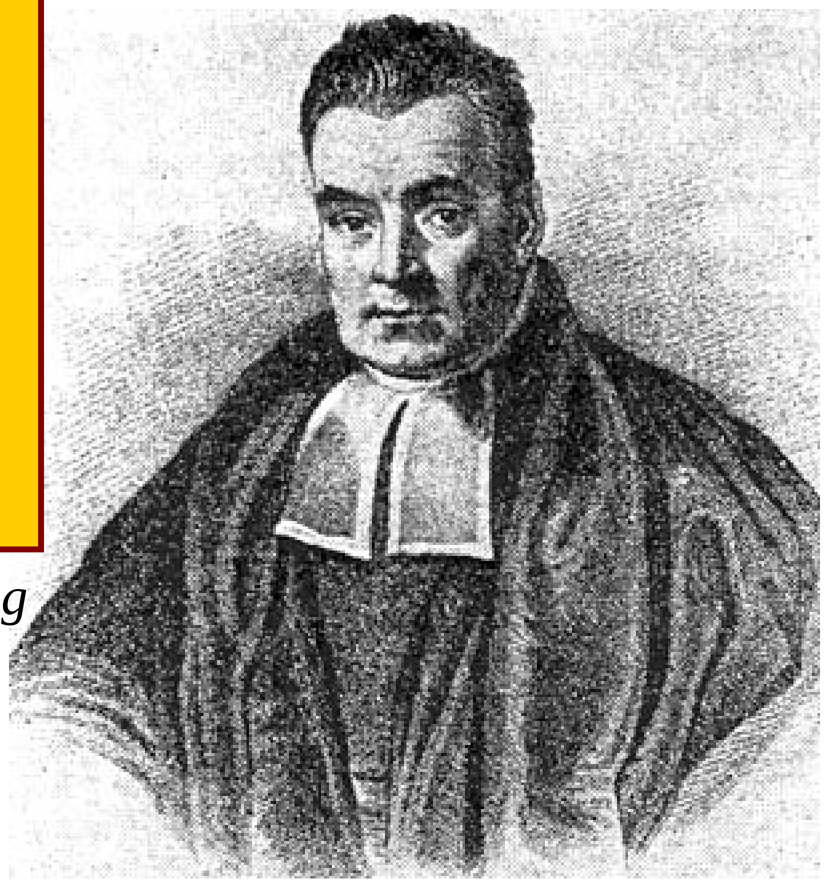
History lesson

Bayes' Theorem

A statistical method to revise probability estimates from new information.



"a method by which we might judge concerning the probability that an event has to happen, in given circumstances, upon supposition that we know nothing concerning it but that, under the same circumstances, it has happened a certain number of times, and failed a certain other number of times."

Value of information

general principles

There must be a decision which can change as a result of the information

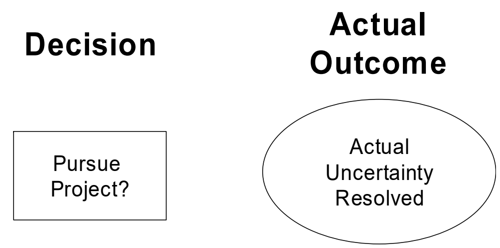
Confidence has no intrinsic value. Value is added by making better, higher EMV decisions

The state of the world can not change w/out new information

Value of information is the difference between the project with the information and the project without information

Perfect / Imperfect information

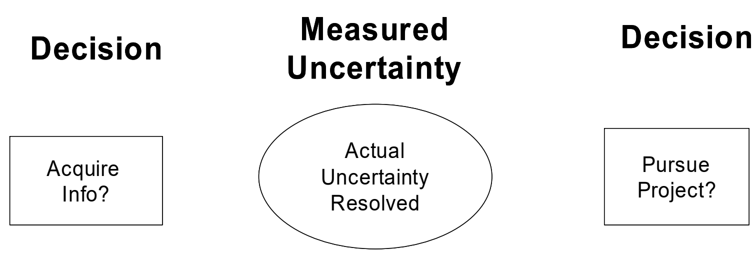
The baseline, what is the value of the project without the information?



Just Make the Decision – no effort to resolve uncertainty before making the decision.

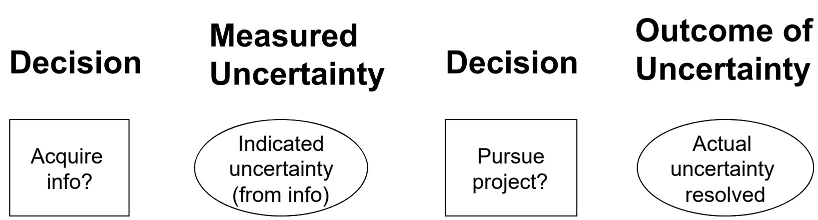
Phased decision patterns:

Perfect information



Perfect information -- completely resolve uncertainty before making the decision.

Imperfect information



Imperfect information – cannot completely resolve uncertainty. The prediction may be wrong, uncertainty remains.

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Most of the information we deal with is imperfect information

Imperfect information sources:

- Market research or surveys
- Analysis of historical data (past trends)
- Testing or pilot projects
- Indirect measurements
- Expert opinion
- Past experiences (gut feel)

Why worry about imperfect information?

The value of perfect information can be calculated, but actually acquiring this type of information is rare.

Imperfect information must be risked. Must take into account the possibility of an untrue (inaccurate) prediction.

The magnitude of the difference between the value of perfect and imperfect information relates to the risk of untrue predictions from imperfect information.

Failure to take into account the impact of imperfect information can result in incorrect estimations of value.

Imperfect information "Bayes' Theorem"

<u>Three types of probabilities we need to be concerned with:</u>

Prior probabilities **-** the probabilities established for some actual event before we gather additional information

Conditional probabilities - the probabilities predicted by some test if an actual event really happens

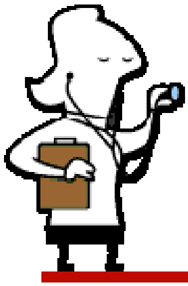
Posterior probabilities - the probabilities of the outcome of an actual event (with some prior probability) following a test with known conditional probability

"Bayes' Theorem" the basics

$$P(Ei \mid B) = \frac{P(B \mid Ei) * P(Ei)}{\sum_{i=1}^{n} \left[P(B \mid Ei) * P(Ei) \right]}$$

The probability of Ei given the outcome of event B

(posterior probability)



What is the probability?

1 person out of 1000 will have the rare “buga” disease.

A test is available to determine if you have the disease, it is 99% accurate.

Given a positive test result, what is the probability that you actually have the disease?

$$P(E_1 \mid B) = \frac{P(B \mid E_1) * P(E_1)}{P(B \mid E_1) * P(E_1) + P(B \mid E_2) * P(E_2)}$$

$$P(E_1 \mid B) = \frac{(0.99) * (0.001)}{(0.99) * (0.001) + (0.99) * (0.999)} = 0.09$$

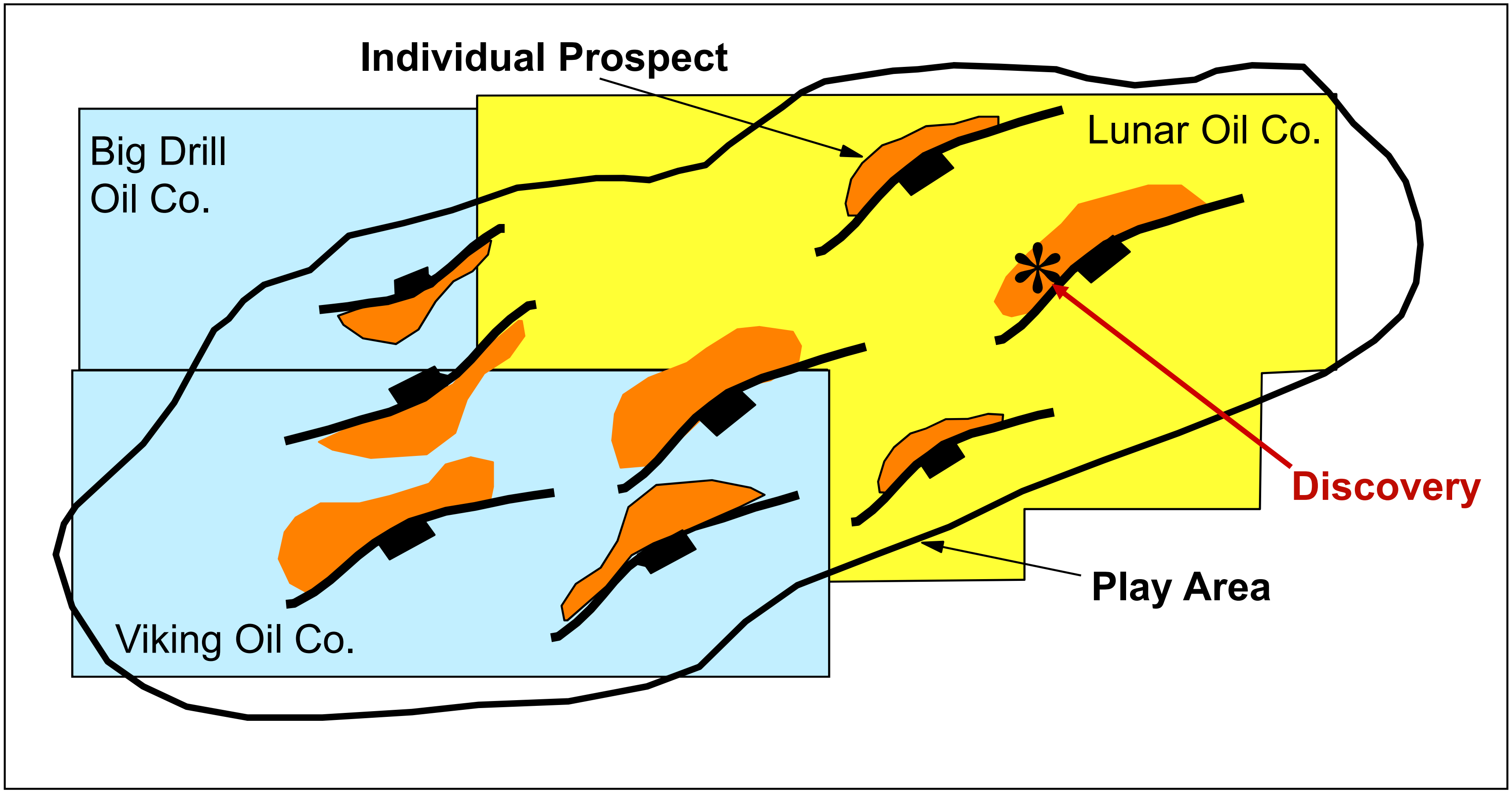
Calculating the value of information

- Value of information is the difference between the project with the information and the project without information
- The value of both perfect and imperfect information can be calculated.

Specific Scenario	EMV
A) Value of the project without information	$MM
B) Value of the project - Perfect Information	$MM (B>A)
C) Value of the project - Imperfect Information	$MM (C>A, C<B)

Case Study

Lunar Oil Company has made a discovery – should they appraise or go straight to development?



What is the value of acquiring appraisal information?

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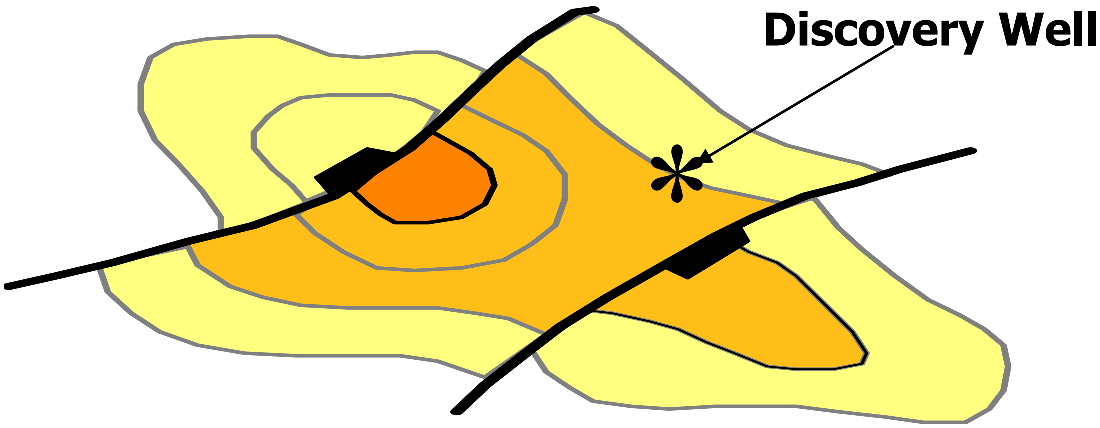
Reserve uncertainty



You are evaluating whether or not you should drill an appraisal well before developing an oil discovery.

Concept Selection	
Fixed Platform Development	Greater than 180 MMbbls
Floating Production, Storage and Offtake (FPSO)	Greater than 110 MMbbls, but less than 180 MMbbls
Tie-back to Existing Facility	Less than 110 MMbbls

p50 (Medium) 130 MMbbls (prob .4)

p90 (High) 200 MMbbls (prob .3)

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Information from appraisal Well

- Appraisal drilling will tell you net effective pay and thus provide some information on reserves. The decision that might change as a result of the information is the concept selection.

- Data from the expert:

  If actual reserves are 200 MMBO (Fixed Platform)

  75% chance of predicted reserves > 180 MMbbls (Fixed Platform)
  20% chance of predicted reserves > 110 MMbbls (FPSO)
  5% chance of predicted reserves < 110 MMbbls (Tie-back)

  If reserves are 130 MMBO (FPSO development)

  15% chance of predicted reserves > 180 MMbbls (Fixed Platform)
  75% chance of predicted reserves > 110 MMbbls (FPSO)
  10% chance of predicted reserves < 110 MMbbls (Tie-back)

  If reserves are 80 MMBO (Tie-back development)

  5% chance of predicted reserves > 180 MMbbls (Fixed Platform)
  10% chance of predicted reserves > 110 MMbbls (FPSO)
  85% chance of predicted reserves < 110 MMbbls (Tie-back)

Decision Tree Solution

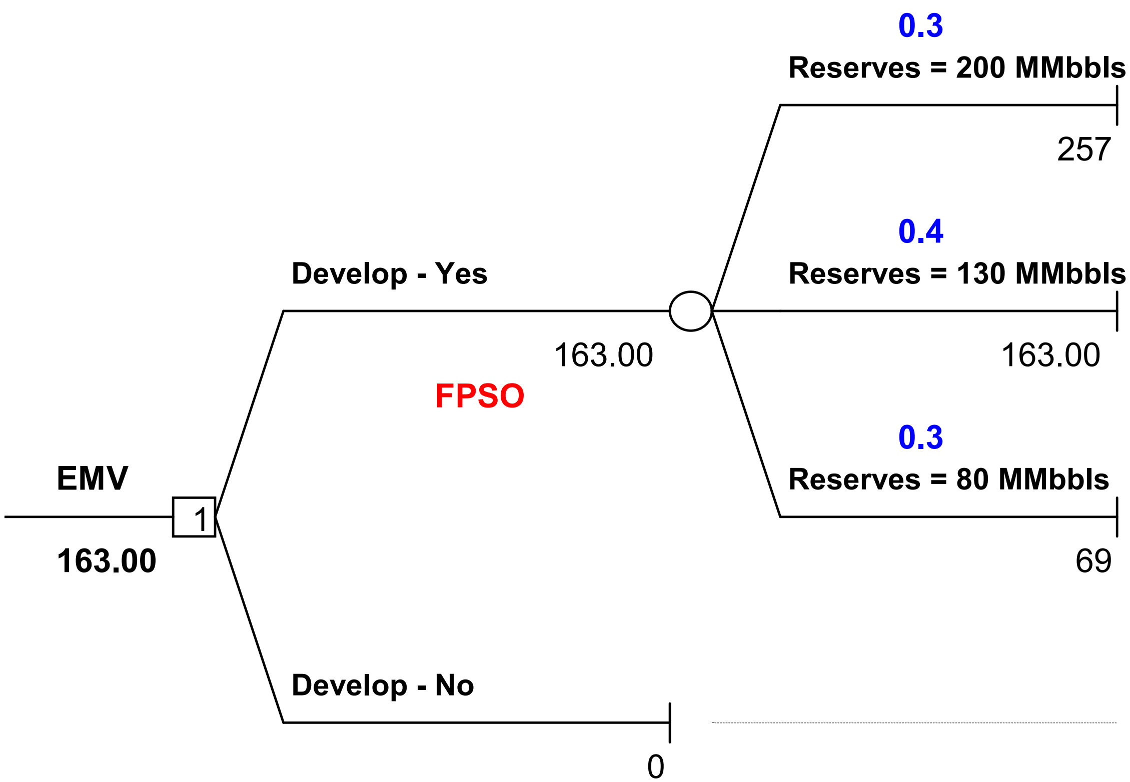
Case Study

Advantages of decision trees

- A chronological sequence of decisions to be made and the uncertainties which affect them
- A graphical means of displaying key alternatives and options available to the decision maker
- A diagnostic tool to map how outcomes are generated.
- Communicates the decision-making process to others in a clear and concise succinct manner
- Outcome values easily obtained (hand solution feasible)

No appraisal drilling

EMV = 163 $MM

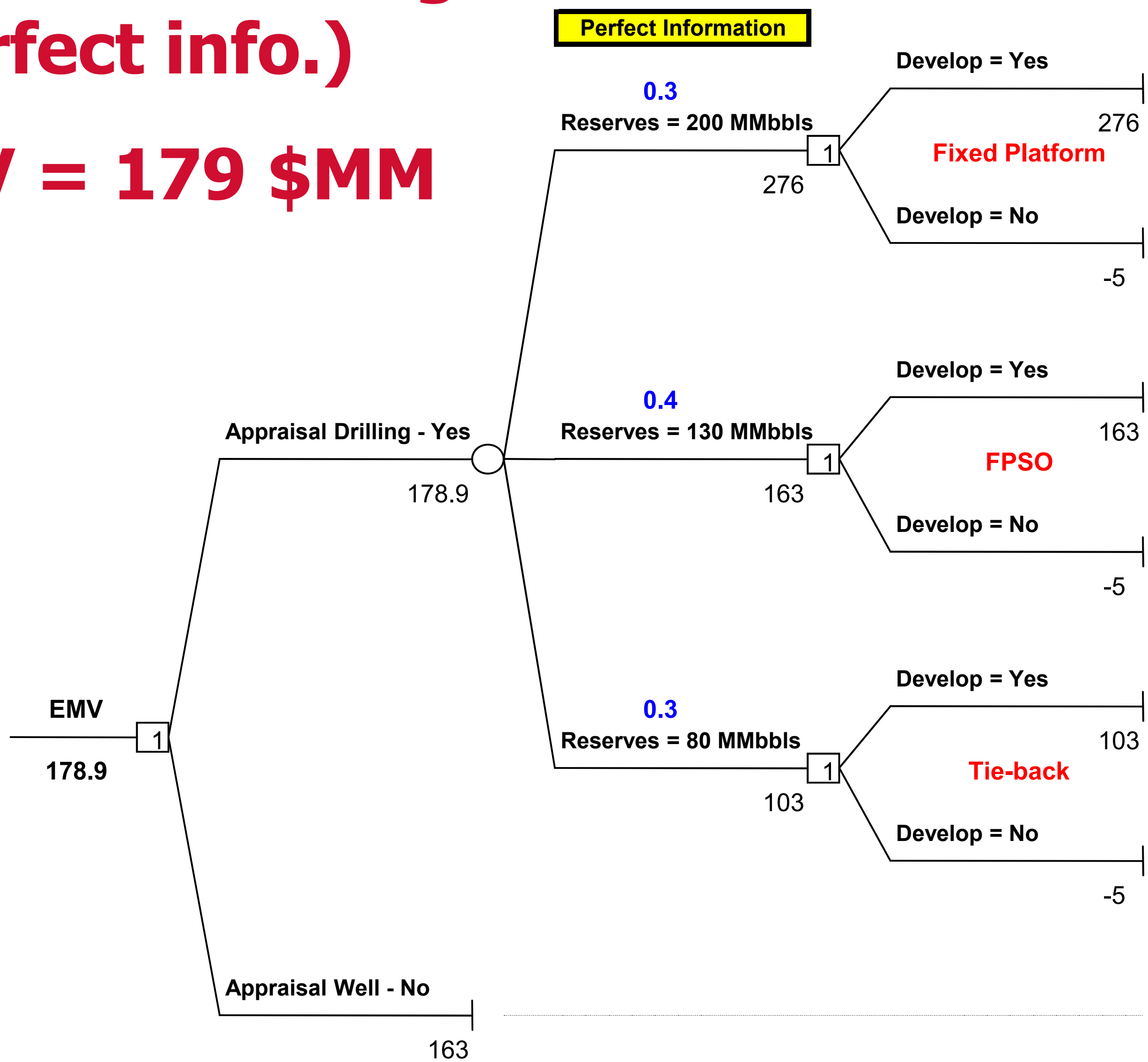


NPV	Cum. Prob.
257 $MM	0.3
163 $MM	0.4
69 $MM	0.3
0 $MM	

Assumptions: Development decision based on FPSO solution

Appraisal drilling (perfect info.)

EMV = 179 $MM



NPV	Cum. Prob.
276 $MM	0.3
-20 $MM	
163 $MM	0.4
-20 $MM	
103 $MM	0.3
-5 $MM	
163 $MM	

Assumptions: Cost of appraisal program equals 5 $MM

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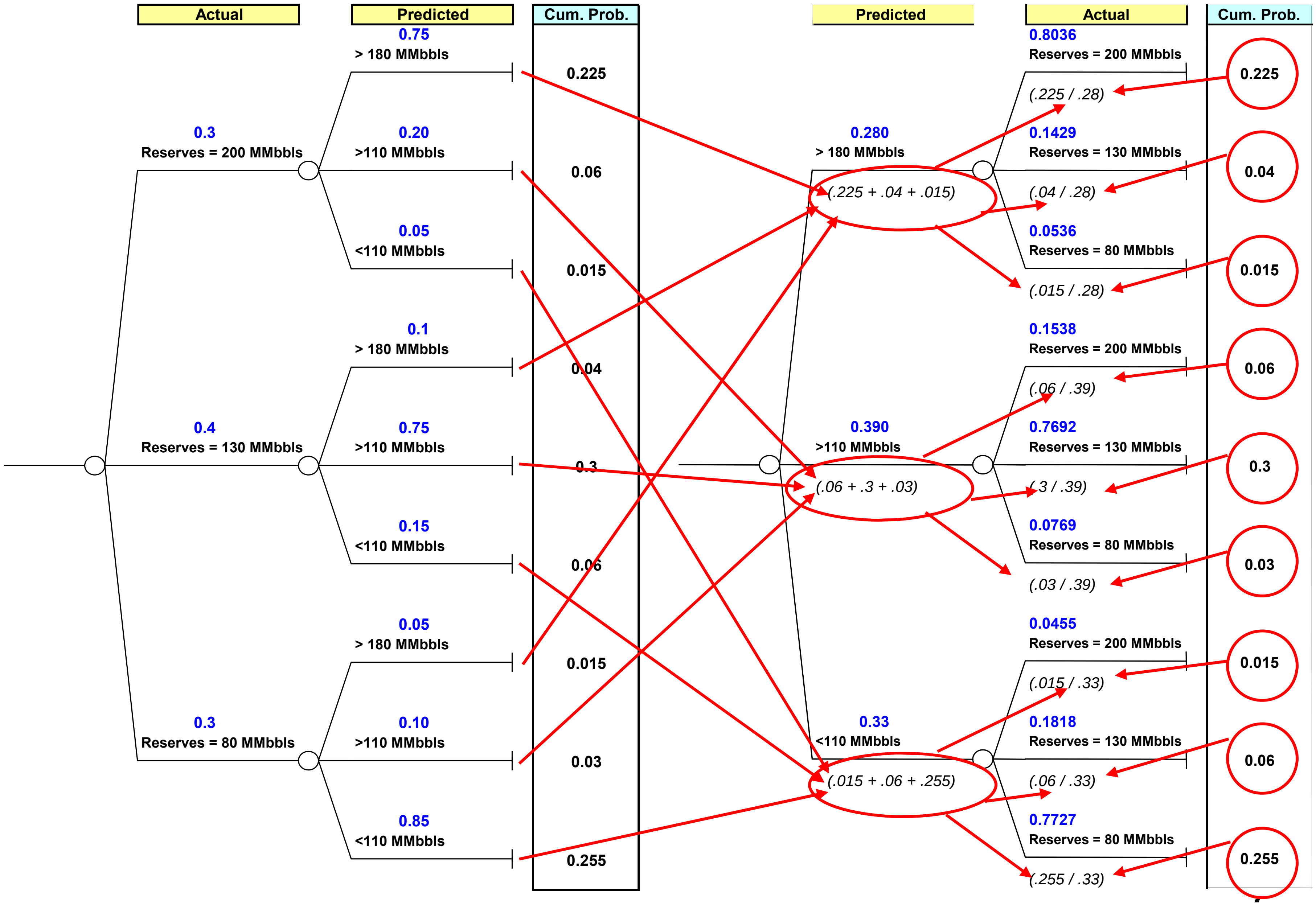
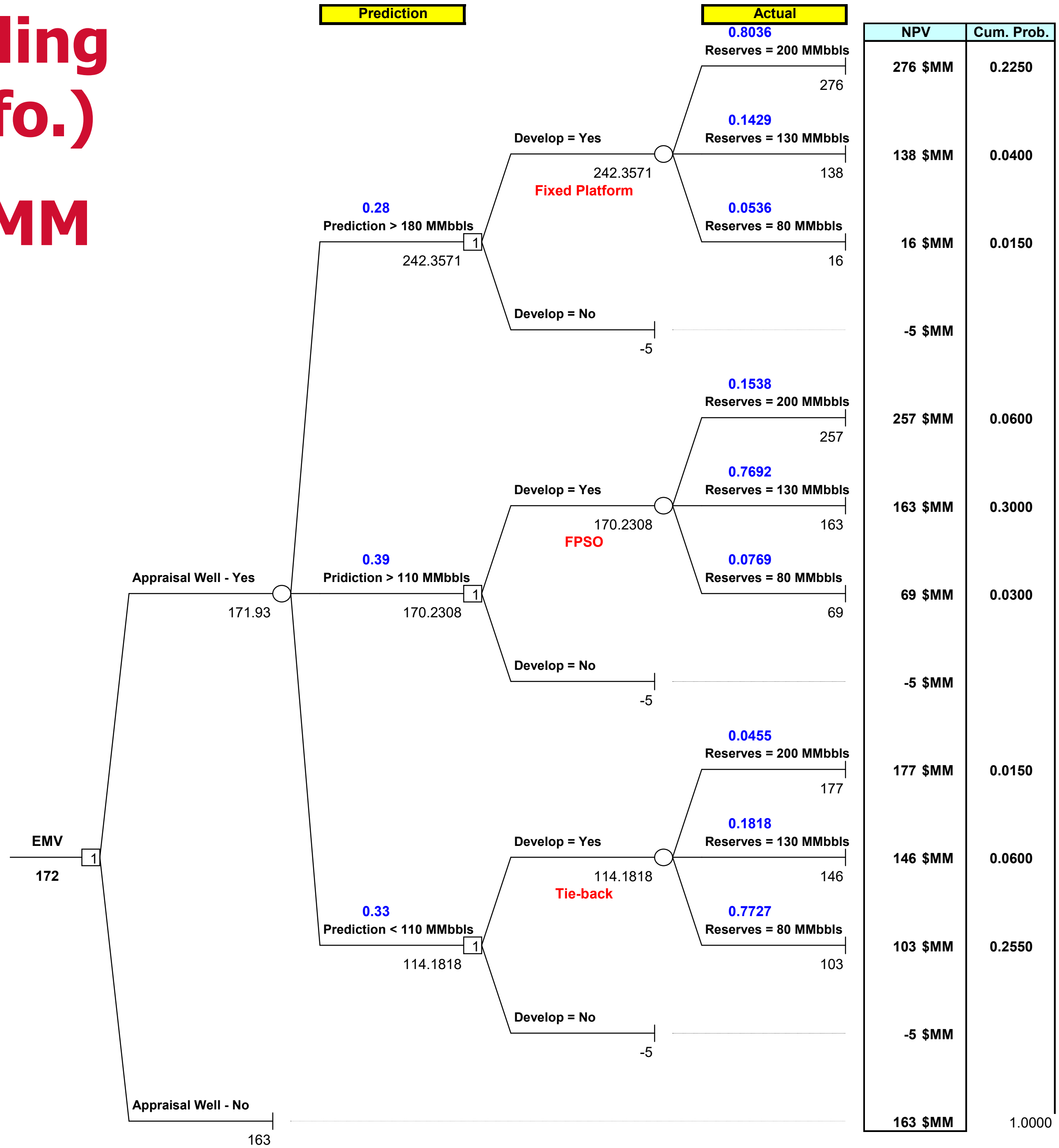
Bayes' Theorem - Inversion of Probabilities



Appraisal drilling (imperfect info.)

EMV = 172 $MM



Decision tree - VOI calculations

Specific Scenario	EMV
No Appraisal Drilling	163 $MM
Appraisal Drilling - Perfect Information	179 $MM
Appraisal Drilling - Imperfect Information	172 $MM

Bayes' Theorem is the basis for revising the original perceptions of the possible states of nature, given the new information that we have acquired.

VOI = project value w/info - project w/out info

The state of the world can not change

Simulation Solution

Case Study

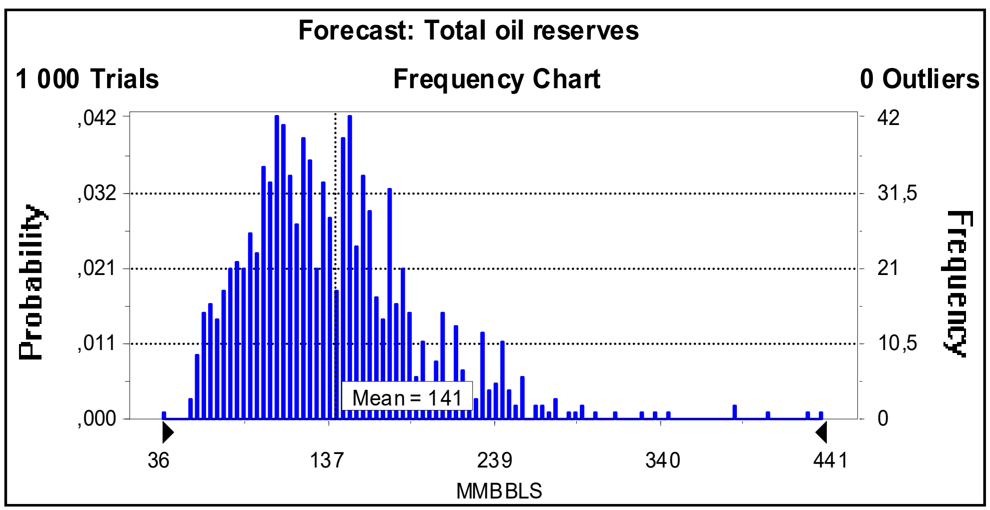
Crystal Ball

- Forecasting and risk analysis program
- Excel add-in
- User friendly tool for modelling uncertainty in you excel spreadsheet
- Simulation by the Monte Carlo technique
- Applicable to all kinds of decision involving uncertainty
- Easy to use, easy to misuse

Modeling parameters

Development Costs and Minimum Rates

	Capital Expenditure MMUSD	Production rate BBLS/DAY
Tie in to existing platform	80	20 000
FPSO	300	50 000
Fixed installation	450	100 000



Logic of model – fit development concept to reserve level

Example: Low reserves => the appropriate development solution would be a tie-in facility to an existing platform

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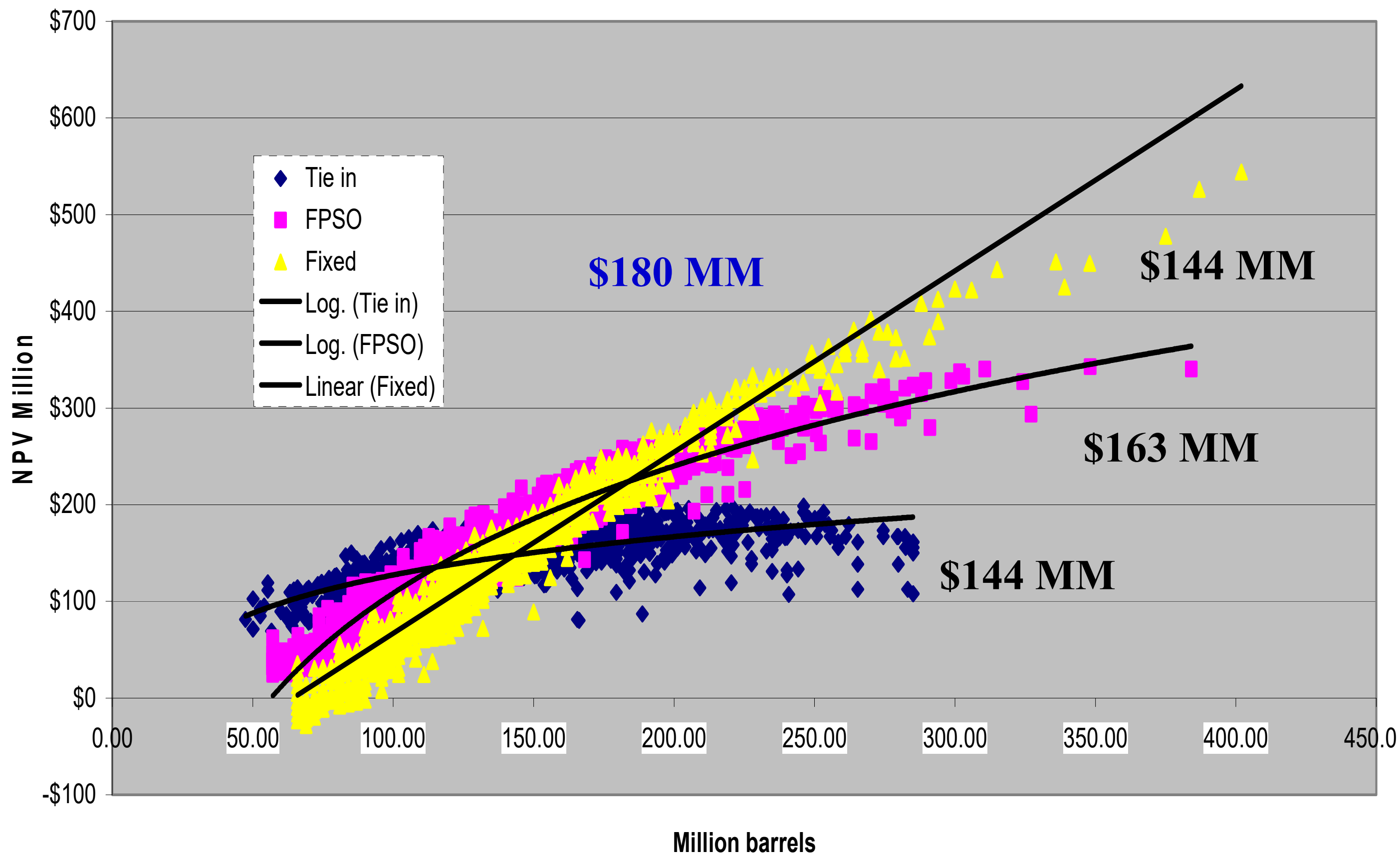
Reserves versus NPV



Value of Information

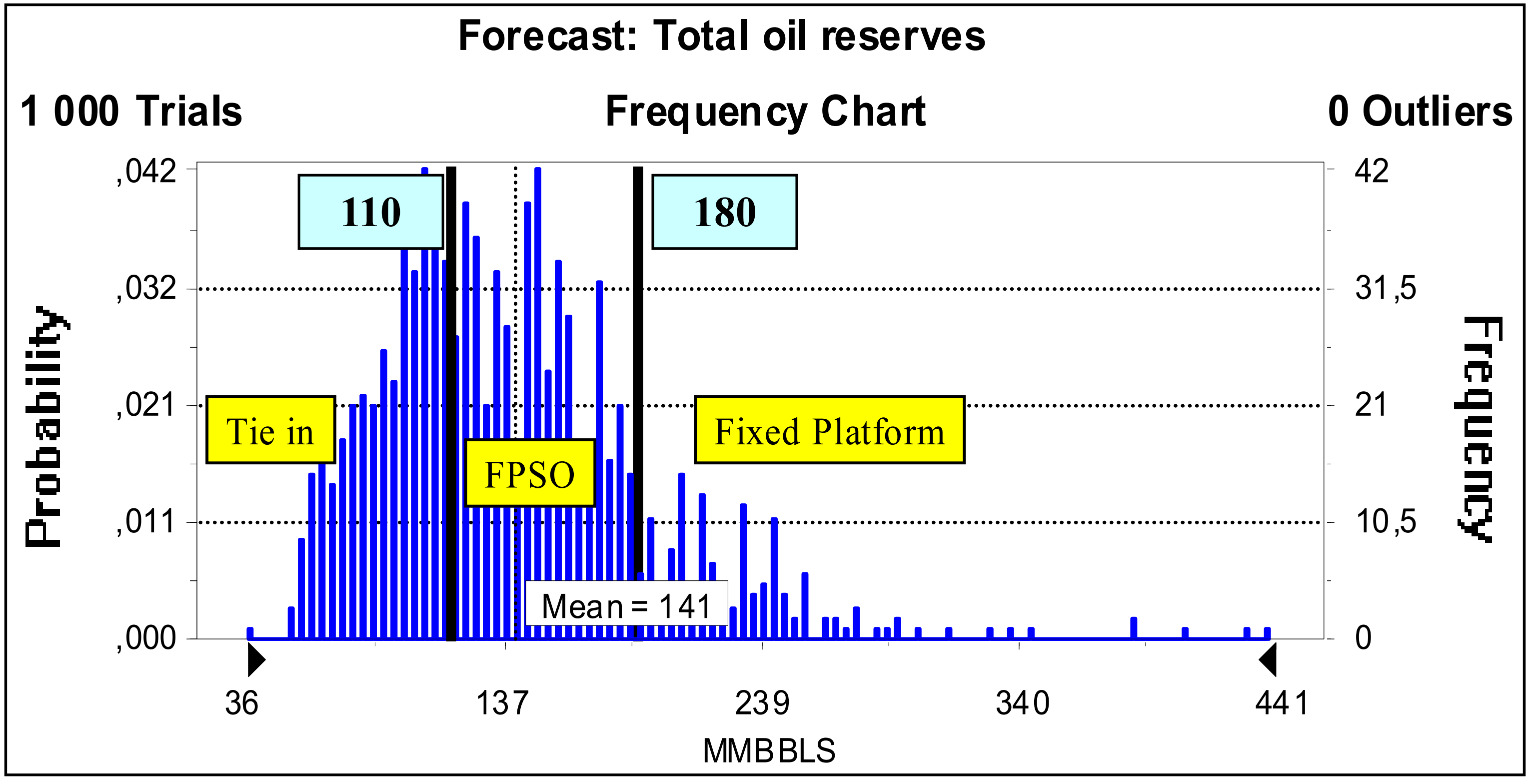
Value from optimized solution

Increase your EMV

Reduce your risk

Choose the optimal path

Optimum development solution



Reserve distribution with development "thresholds"

35% Tie-in, 50% FPSO, 15% Fixed platform

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Incorporating imperfect information into simulation modeling

Bayes' theorem provides the correct reasoning for incorporating imperfect information into models. Decision trees and Monte Carlo runs are simply methodologies for implementing the solution.

Mathematically, posterior distributions can be calculated. We are presenting a more "practical" approach in solving for the value of imperfect information.

Model overview

Panel Case study

COP equity

100 %

Discount rate

10 %

Exchange rate
- ○ NOK
- ◉ USD

Tie in	FPSO	Fixed platform
2006	2006	2007
Start up year		**2006**

Imperfect information

Run mode
- ○ on
- ◉ off

Appraisal wells	
☑ Well 1	1
☑ Well 2	1
☑ Well 3	1
☐ Well 4	0
	3

Concepts

Consepts
- ○ Tie in
- ◉ FPSO
- ○ Fixed platform

Concepts

Trigger MMBBLS	Plateau rate BBLS/day
	22 000
110	50 000
180	100 000

Choose concept based on reserves

Link to production profile generator, costs and NPV

Simulate with crystal ball

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Modeling imperfect information

Imperfect information			
Value from crystal ball run	**125**		
Uncertainty in estimate	**25 %**		
Uncertainty range	**Min**	**Mean**	**Max**
	94	**125**	**156**
Value used for conspet selection	**108**		

- Adds some uncertainty around the reserves estimate
- Will not always choose the optimal solution
- Important to understand the uncertainty estimate
- Reduces the value of information compared to perfect information

Simulation - VOI calculations

Specific Scenario	EMV
No Appraisal Drilling	163 $MM
Appraisal Drilling - Perfect Information	180 $MM
Appraisal Drilling - Imperfect Information	174 $MM

Sampling routine built to simulate Bayes' Theorem

VOI = project value w/info - project w/out info

The state of the world can not change

Conclusions / Observations

Hopefully our thinking was not too suspicious

- The importance of valuing information and taking into account imperfect information
- Bayes' Theorem is more easily applied using decision tree analysis in comparison to Monte Carlo simulations
- We presented a simple methodology for the application of Bayes' Theorem in simulation modeling
- Using the case study presented, the VOI comparison between decision tree analysis and simulation modeling is very similar

Acknowledgements

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