SPE Distinguished Lecturer Program

Primary funding is provided by

The SPE Foundation through member donations and a contribution from Offshore Europe

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Economic and Risk Analysis Applied to Petroleum Engineering

Recent Developments and Application Examples

J. C. Cunha

PETROBRAS AMERICA INC.

Outline

- Introduction
- Definitions
- Risk Analysis and the Oil & Gas Industry
- Application Examples
- Final Remarks

Introduction

- "Decision Analysis"
  - 1964 by Ronald Howard, Stanford University.
- Decision analysis
  - Procedures, methods and tools
    - Identify, clearly represent, and formally assess important aspects of a decision situation.

Risk Analysis

- Systematic use of information to determine how often specified events may occur and the magnitude of their likely consequences.*
- Quantitative Risk Analysis
  - It is a numerical approach to assess project risks.

*AS/NZS 4360:2004: Australian/***New Zealand** Standard on Risk Management

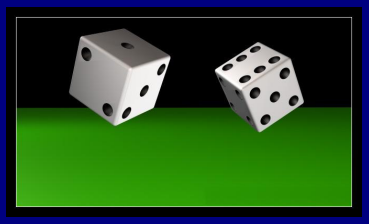
Risk Analysis and the Oil & Gas Industry

- One of the first applications for the oil industry:
  - Paul Newendorp, 1967
  - "Application of Utility Theory on Drilling Investment Decisions"

Risk and Uncertainty - Definitions

Risk is uncertainty based on a well grounded (quantitative) probability.

Example



Misconception on the Use of Risk Analysis

Risk analysis will not eliminate risk in the decision making process.

Risk and Economic Analysis Applications for Petroleum Engineering

- Examples:
  - Reserve quantification;
  - Reservoir characteristics;
  - Recovery factor;
  - Expected production;
  - Operations schedule;
  - Budget;
  - Etc.

Risk and Economic Analysis Tools

- Monte Carlo Simulation;
- Decision trees;
- Commercial Software;
- Engineering Economy;
- Economic Indicators;
- Database.

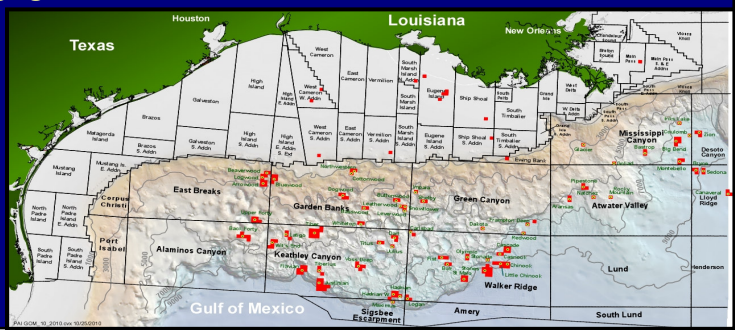
Application Examples

- Well Drilling – Planning and Budget
- Heavy Oil Field Development
  - Reservoir
  - Production
  - Economics
- Well Completion – Time and Cost Estimate

Well Drilling – Planning and Budget

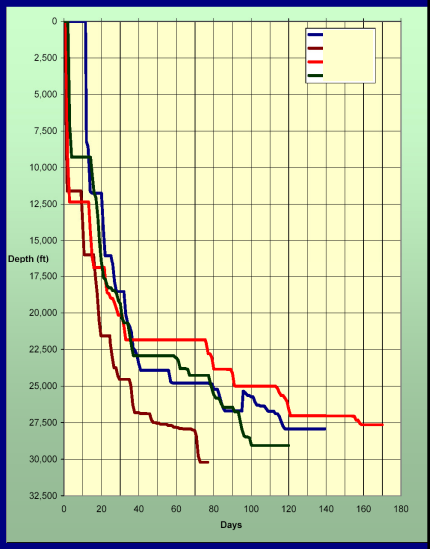
- The challenge:
  - Two fields (GOM);
  - Four wells (three areas);
  - Ultra-deepwater;
  - Deep wells.

Planning and Budgeting for Field Development.



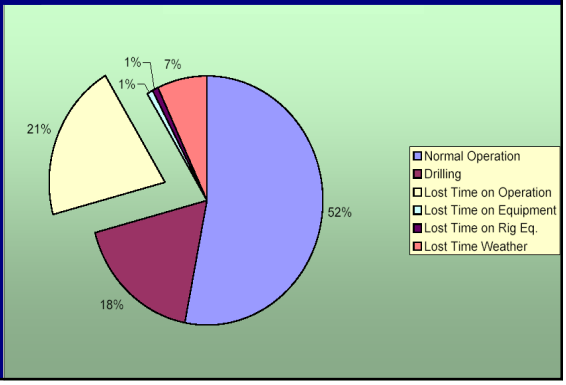
Basis for Analysis

- For each well:
  - Summary of operations;
  - Time and cost analysis;
  - NPT analysis;
  - Well Planning;
  - Cost and time estimates.



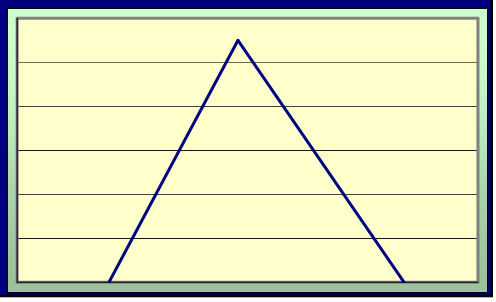
Summary of Operations

- Summary by well section
  - Problems, possible solutions, lessons learned;
  - Monte Carlo simulation to estimate for each well section:
    - Time;
    - Total cost;
    - Cost excluding NPT;
    - Cost per foot x Feet per day.



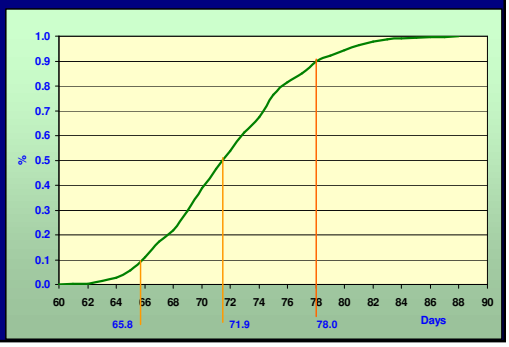
Simulation

- Monte Carlo Simulation was performed:
  - For each well section, a value for cost per foot and feet per day was obtained;
  - Using these values and the planned depth of the well section, it was determined the cost and period of time expected for the section;
  - 1000 runs;



Simulation (cont.)

- Results of each run in one well section were added to correspondent results for the other sections;
- Table containing 1000 results for cost and time;
- Histograms for cost and time;
- Cumulative Probability Function (CDF).



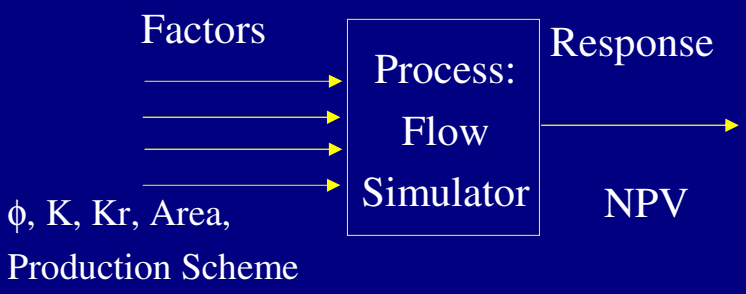
Deliverables

- Estimates of costs and time to perform operations;
- Sensitivity analysis to types of NPT;
- Easy adaptation to new realities;
- Partners relationship.

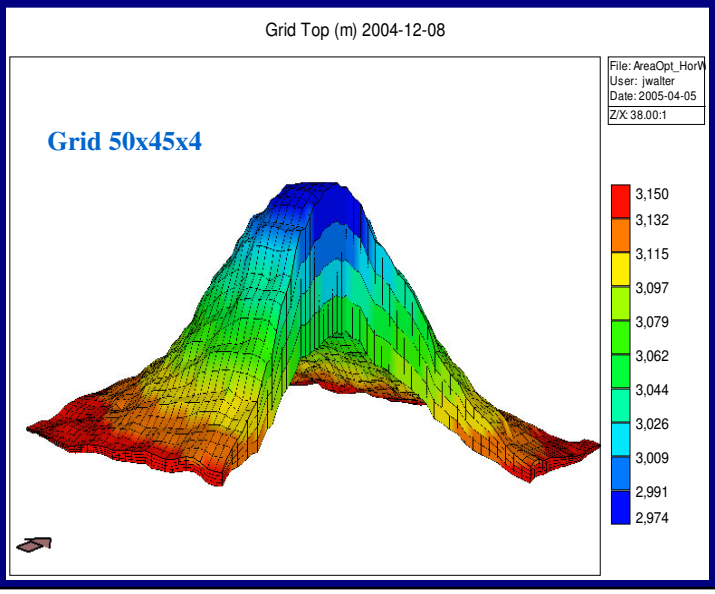
Example 2
Offshore Heavy Oil Recovery

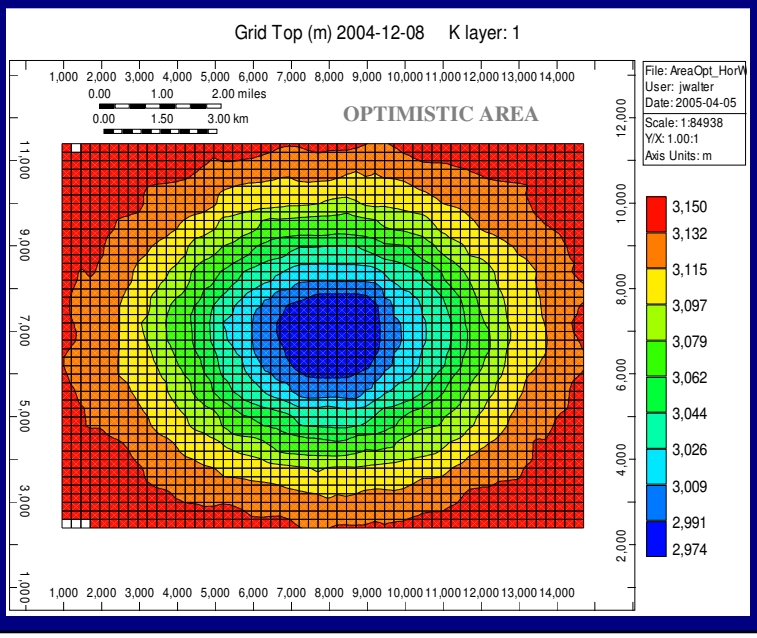
- Objective:
  - Risk Analysis techniques to assess the uncertainty of NPV for an offshore heavy oil field during its initial development stage;
  - Reservoir, Production, Economics.

Methodology



Reservoir Model and Uncertain Parameters





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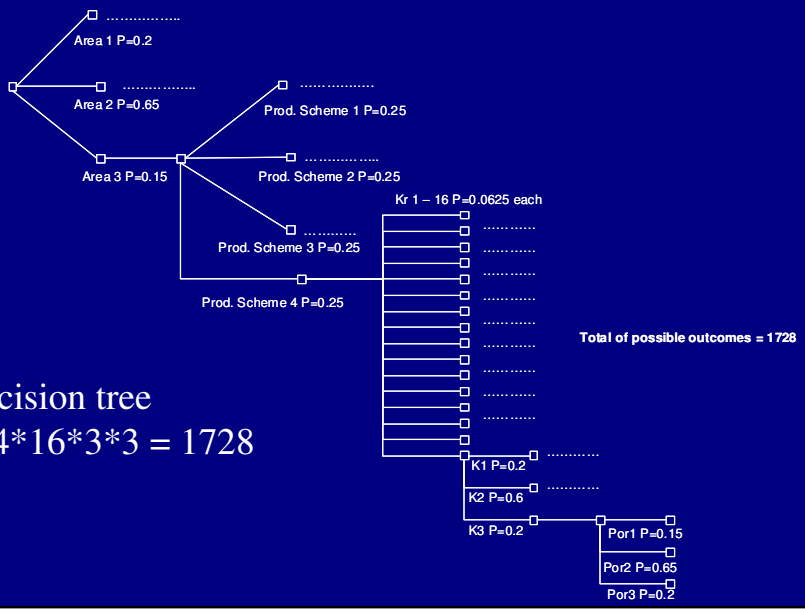
Uncertainty Analysis



Decision tree

3*4*16*3*3 = 1728

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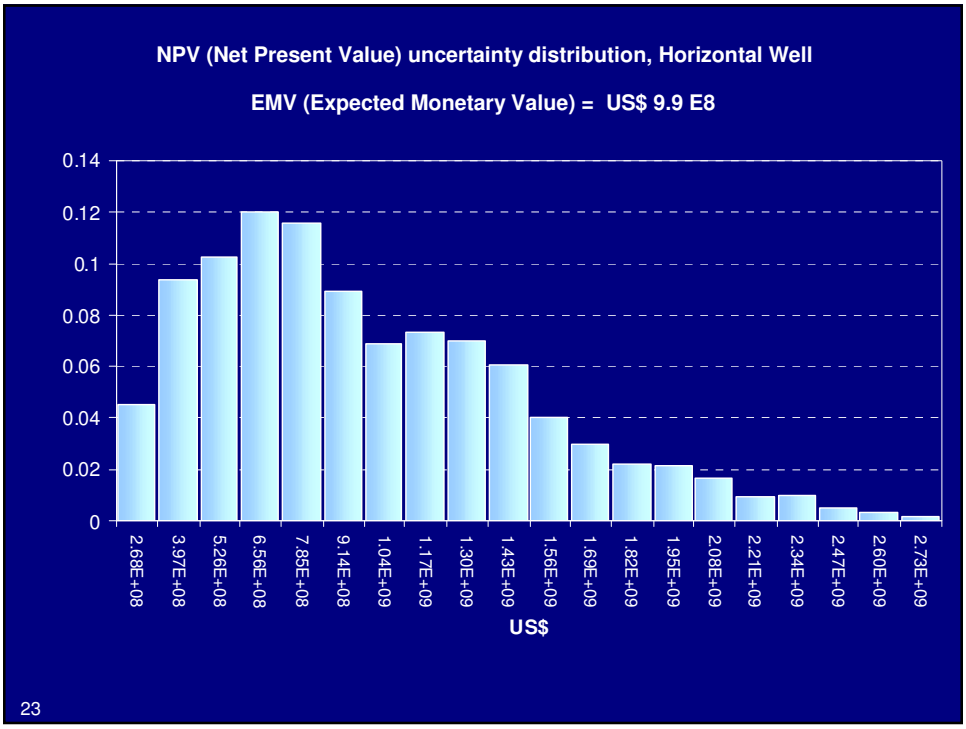


Deliverables

- Expected Monetary Value (EMV) for project;
- Easy sensitivity analysis;
- Consideration of:
  - Reservoir characteristics;
  - Production scheme;
  - Economic conditions.

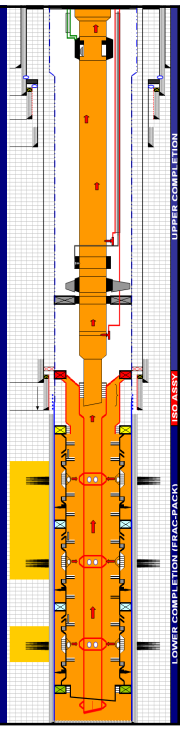
Example 3
Well Completion – Time and Cost Estimate

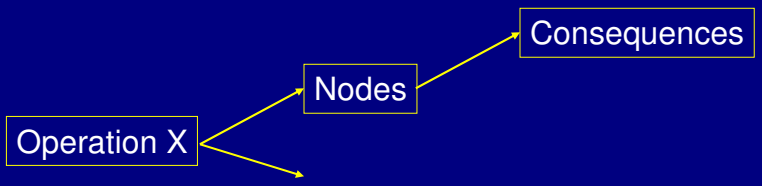
- GOM deepwater completion;
  - Rig factor;
  - Efficiency factor;
  - Cost factor.

Completion Program

Probabilistic Model

- Detailed completion time study;
- NPT assumptions built in the model;
- Probability analysis approach.
  - Decision tree (commercial software).
  - Sensitivity Analysis.

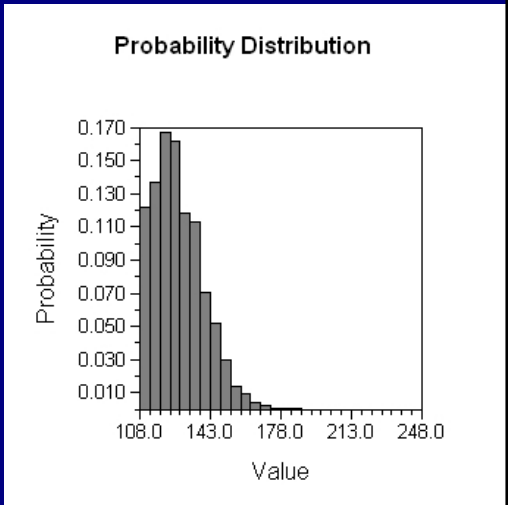




Probabilistic Model

- Decision Tree
  - 116,734 events

DISTRIBUTION STATISTICS (days)	
Mean	126.84
Mode	109.72
Std. Dev	12.45
Min	108.08
2.5%	108.08
10%	111.50
50%	124.75
90%	145.50
97.5%	154.48
Max	243.15

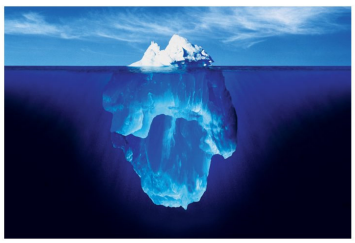


Deliverables

- Sensitivity analysis:
  - Very important due to rig uncertainty;
- Estimates of costs and time;
- First oil.

Final Remarks

- Just the tip of the iceberg;



- Useful tool for cost/budgeting;
- Allow better timing prediction;
- Gives information about chances of success and failures;
- Various applications;
- Recommended reading.

SPE 20908
Quantitative Risk Assessment of Subsurface Well Collisions
J. Thorogood et al.

SPE 52864
Borehole Stability Assessment Using Quantitative Risk Analysis
S. Ottesen et al.

SPE 9414
Risk Analysis of Well Completion Systems
Alan Woodyard

SPE 139628
Challenging Multilateral and Completion Design for a Deepwater Well in Italy: Decision Support through Risk Analysis
C. Repetto et al.

SPE/PS-CIM/CHOA SPE-97917-PP
Uncertainty Assessment Using Experimental Design and Risk Analysis Techniques, Applied to Offshore Heavy Oil Recovery
J.W. Vanegas Prada, J.C. Cunha and L.B. Cunha

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University of Alberta

QUANTIFICATION OF RESERVOIR UNCERTAINTY FOR OPTIMAL DECISION MAKING

by

Alshehri, Naeem Salem

http://repository.library.ualberta.ca/dspace/bitstream/10048/833/1/Alshehri_Naeem_Spring+2010.pdf

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SPE 28726

Risk Analysis Theory Applied to Fishing Operations: A New Approach on the Decision-Making Problem

J.C.S. Cunha, Petrobrás S.A.

SPE Member

Thank you!!!

Questions???

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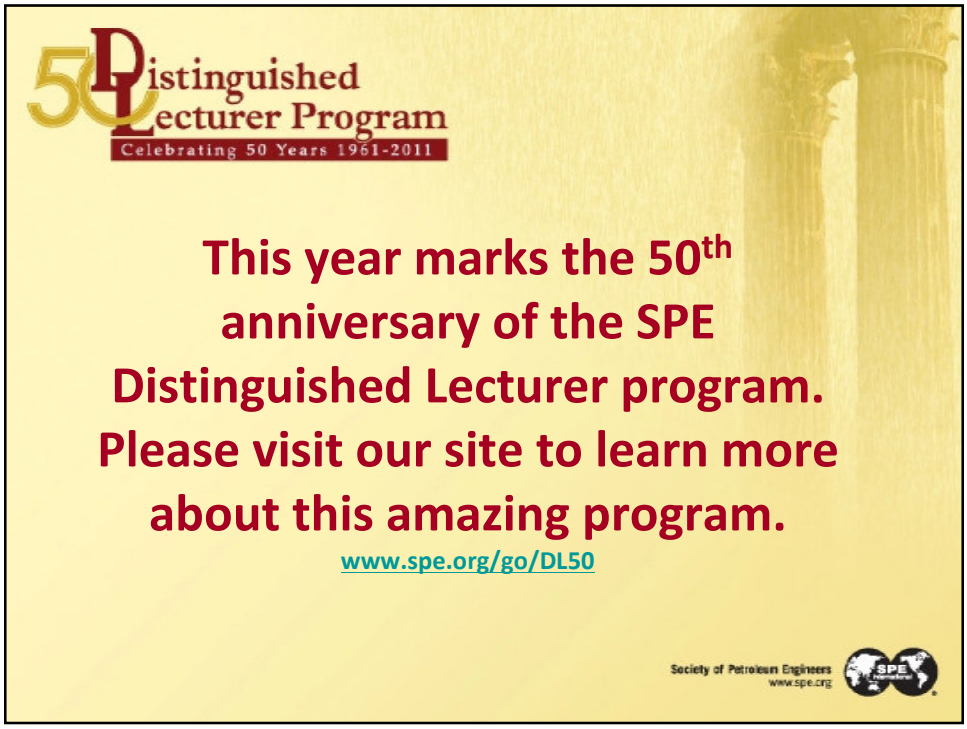
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