Inappropriate Separation of Risk and Uncertainty in Probabilistic Assessments*

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Abstract

Assessment of exploration prospect resource potential has traditionally focused on two activities: uncertainty estimation (the range of success case volumes and their associated probabilities), and risking (estimation of the chance of success). The calculations of chance of success and uncertainty estimation are often carried out in near-isolation, independently of one another. Typically, one risks the chance of exceeding the P100 or P99 volume, or “the chance of getting on the curve.”

The process may lead to inaccurate representations of success case volumes. Since all success case probabilities are subsequently multiplied by the chance of success, focusing only on the minimum volume, without regarding the impact of the chance of success on success case probabilities such as the P90, P50, and P10, may create success case volumes with unreasonably high probabilities. As a result, economic decisions are made based on an overly optimistic assessment.

Problems may arise when an optimistic P50 to P10 range (in other words, the upper portion of the uncertainty range) is coupled with a very conservative P100 or P99 volume. The “chance of getting on the curve” may approach 100%. The chance of exceeding the P50 and P10 volumes, however, may be much less than, respectively, 50% and 10%. Since economic value, and therefore the decision to pursue the opportunity, is typically driven by volumes in the upper portion of the uncertainty curve, focusing only on the chance of exceeding the P100 or P99 volume creates an incorrect assessment of the prospect’s economic potential.

In multiple zone prospects, a traditional separation of risk and uncertainty is not possible. The success case size of the prospect is often a function of the number of zones that succeed. The number of zones that succeed is in turn a function of the chance of success estimated for each individual zone, and the geologic relationships between the zones. The size of the prospect, then, is determined by the chance of success assigned to each zone. The prospect’s uncertainty may be driven more by risk than by volume parameters such as productive area and thickness.
Inappropriate Separation of Risk and Uncertainty in Probabilistic Prospect Assessments
Probabilistic prospect assessment processes

Definition of Uncertainty

- \( P(\text{Trap}) \)
- \( P(\text{Reservoir}) \)
- \( P(\text{Source}) \)
- \( P(\text{Migration}) \)

Definition of Risk

- \( P(\text{Success}) \)
- \( P(\text{Area}) \)
- \( P(\text{Pay}) \)
- \( P(\text{Recovery}) \)

"Unrisked" case

Chance of Success

GCOS, POS, Ps, Pg
Exceedance probability vs. volume

- **P90**: 90% chance of exceeding (discovering more than) the P40 volume
- **P50**: 50% chance of exceeding (discovering more than) the P40 volume
- **P40**: 40% chance of exceeding (discovering more than) the P40 volume
- **P10**: 10% chance of exceeding (discovering more than) the P40 volume

40% chance of exceeding (discovering more than) the P40 volume.
Typical exploration prospect

- Exceedance Probability
- Potential Resource Volumes
- Small to Large
  - Dry Holes
  - Shows
  - Undetectable
  - Unrecoverable
  - Unassessable
- Uneconomic Discoveries
  - Technically recoverable
- Economic Discoveries
  - Economically recoverable
Typical exploration prospect

- Chance of Success = 50%
- Chance of Economic Success = 30%

- Dry Holes
- Shows
- Undetectable
- Unrecoverable
- Unassessable
- Uneconomic Discoveries
- Economic Discoveries

Potential Resource Volumes

Small — Large
In the risked case:

- Potential Resource Volumes are divided into non-commercial and commercial discoveries.

- Unassessed volumes are assumed to be zero.

- Assessed volumes (success case) = Product of uncertainty process.

- Chance of Success = Product of risking process.

The diagram shows the exceedance probability with two thresholds:

- COS = 50%
- COES = 30%

These thresholds indicate the probability of achieving non-commercial or commercial discoveries. The diagram visually represents the risked case for potential resource volumes, with small and large volume categories.
Risked case and success (unrisked) case

1) Create success case

- Risked probability = Success case probability x COS

2) Risk by COS

COS = 50%

- P100
- P90
- P50
- P45
- P25
- P10
- P5

Exceedance Probability

Potential Resource Volumes

Non-Commercial Discoveries

Commercial Discoveries

Small

Large
The chance of exceeding 10 MMBO is 20%.

If MEFS = 100 MMBO, COES = .20 x .20 = 4%

COS risks the entire curve!
The chance of exceeding 1 MMBO is 50%!

If MEFS = 100 MMBO, COES = .50 * .20 = 10%

COS risks the entire curve!

Tertiary Foredeep Play
Azov-Kuban Basin
USGS 2000
Strange behavior

I'll keep the P10 and move the P90!

Field Size Distribution (including dry holes)

MEFS = 100 MMBO
COES = .20 x .10 = 2%
Mean above MEFS: 137 MMBO

MEFS = 100 MMBO
COES = .50 x .10 = 5%
Mean above MEFS: 197 MMBO

Tertiary Foredeep Play
Azov-Kuban Basin
USGS 2000
Multiple-zone prospect

• Assume zones are independent
• Success = at least one zone succeeds

<table>
<thead>
<tr>
<th>Segment</th>
<th>Success Mean</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand A</td>
<td>100 MMBO</td>
<td>COS = .30</td>
<td>COS = .60</td>
</tr>
<tr>
<td>Sand B</td>
<td>200 MMBO</td>
<td>COS = .30</td>
<td>COS = .60</td>
</tr>
</tbody>
</table>
Zone COS = .30

- Sand A risked mean = .30 x 100 = 30 MMBO
- Sand B risked mean = .30 x 200 = 60 MMBO
- Prospect risked mean = 30 + 60 = 90 MMBO
- Prospect COS = 1 – (.70 x .70) = .51
- **Prospect success mean = 90 / .51 = 176 MMBO**
Zone COS = 0.60

COS = 0.84

A only
100 MMBO

B only
200 MMBO

A + B
300 MMBO

Success Mean
214 MMBO
Zone COS vs. prospect success mean

- **Model 1**
  - Sand A: 100 MMBO
  - Sand B: 200 MMBO

- **Model 2**
Impact of risk dependency

- Risk dependency decreases COS and increases success case mean

Totally independent
Prospect COS = 0.51
Success Mean = 176 MMBO

Totally dependent
Prospect COS = 0.30
Success Mean = 300 MMBO
Impact of risk dependency

<table>
<thead>
<tr>
<th>Level of Dependency</th>
<th>Prospect Success Mean (MMBO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totally dependent</td>
<td>P(shared) = 1</td>
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<tr>
<td>P(shared) = .30</td>
<td>150</td>
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<tr>
<td></td>
<td>200</td>
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<td></td>
<td>250</td>
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<td></td>
<td>300</td>
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</tbody>
</table>
Impact of communication

Two channels with independent seal risks

- Assume Channel B seal chance = 50%

OWC cannot be below communication depth

Seal succeeds

Seal fails
Impact of communication

- Size of Channel A is controlled by risk on Channel B

- Assume Channel B seal chance = 50%
Summary

• Single zones
  – The chance of success is the exceedance probability associated with the smallest volume in the success case
  – When we risk the minimum volume, we risk the entire success case

• Multiple zones
  – Traditional views of risk vs uncertainty may not be applicable
  – Prospect risk and uncertainty are impacted by zone COS, and relationships between zones