# International Expectations for Reserves and Due Diligence Reports

**The Petroleum Club of Houston**

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Society of Petroleum Engineers
*Gulf Coast Section*


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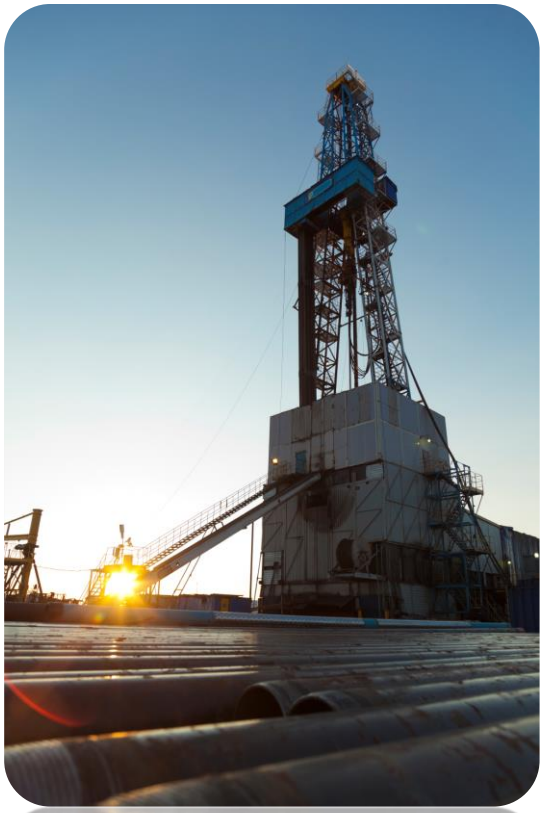
# International Expectations for Reserves and Due Diligence Reports

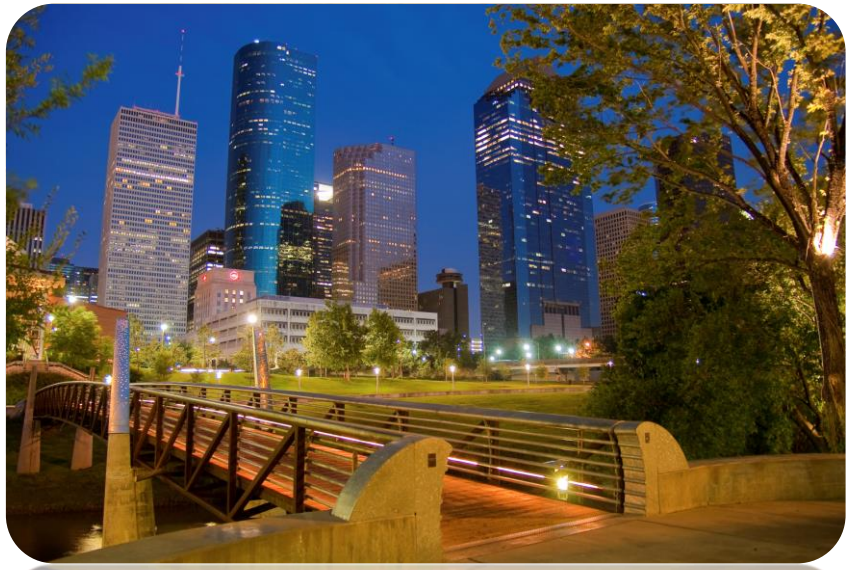
## Outline

- Introduction
- Overview of PRMS – The International Standard
  - Reserves and the Principles of PRMS
  - Why Risk and Uncertainty are Not the Same
  - What causes uncertainty in Reserves?
- Overview of SEC – The US Standard
- Traditional approaches to high-well count Reserves estimation.
  - Common throughout the Americas and blurs the distinction between Reserves and Resources
  - Does not reliably capture performance uncertainty
- Recent advances in predictive analytics have been applied to production modelling for Reserves *sensu stricto*.
- Removal of location proxy allows proper consideration of Contingent Resources which do have value and are of keen interest to the International community.



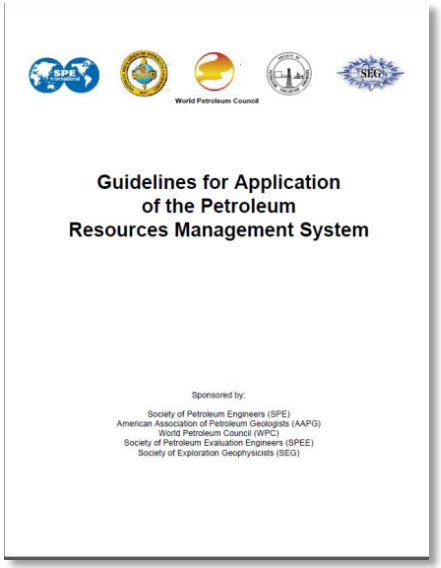
# Introduction - Reserves and Resources are Important to:

- E&P Company Operating Divisions
  - Budgets, staffing, field abandonment planning
- Merger and Acquisition Teams
  - Buyer and Seller
- Independent  investors
- Capital providers
  - Banks
  - Private lenders
  - Underwriters
- Regulators
- Important that we can all be clear on what we mean when we quote ‘Reserves’



# International Efforts in Standardization

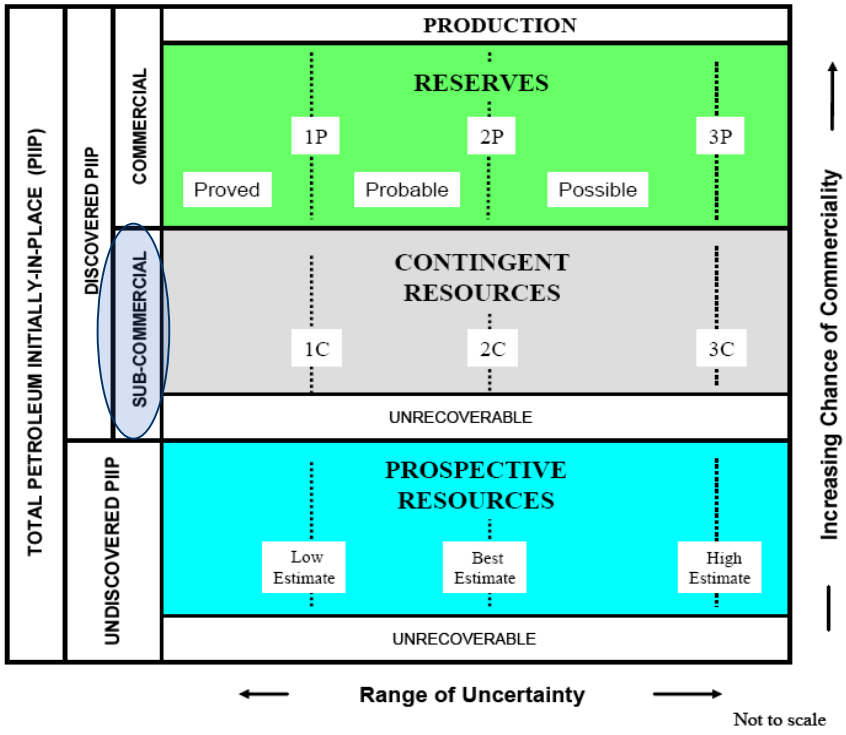
| | |
|---|---|
| 1965 | SPE Definition of Proved Reserves |
| 1972 | McKelvey Box |
| 1987 | SPE Definitions for Proved and Probable |
| 1990s | ECE starts work on UNFC |
| 1997 | SPE & WPC joint definitions |
| 2000 | AAPG, SPE & WPC joint classification system |
| 2001 | Joint Guidelines published |
| 2007 | SPE/WPC/AAPG/SPEE publish Petroleum Resources Management System ('PRMS') |
| 2010 | New SEC rules – significant 'nod' to PRMS |
| 2011 | Guidelines for Application of the PRMS |
| 2017? | Revision of PRMS? |



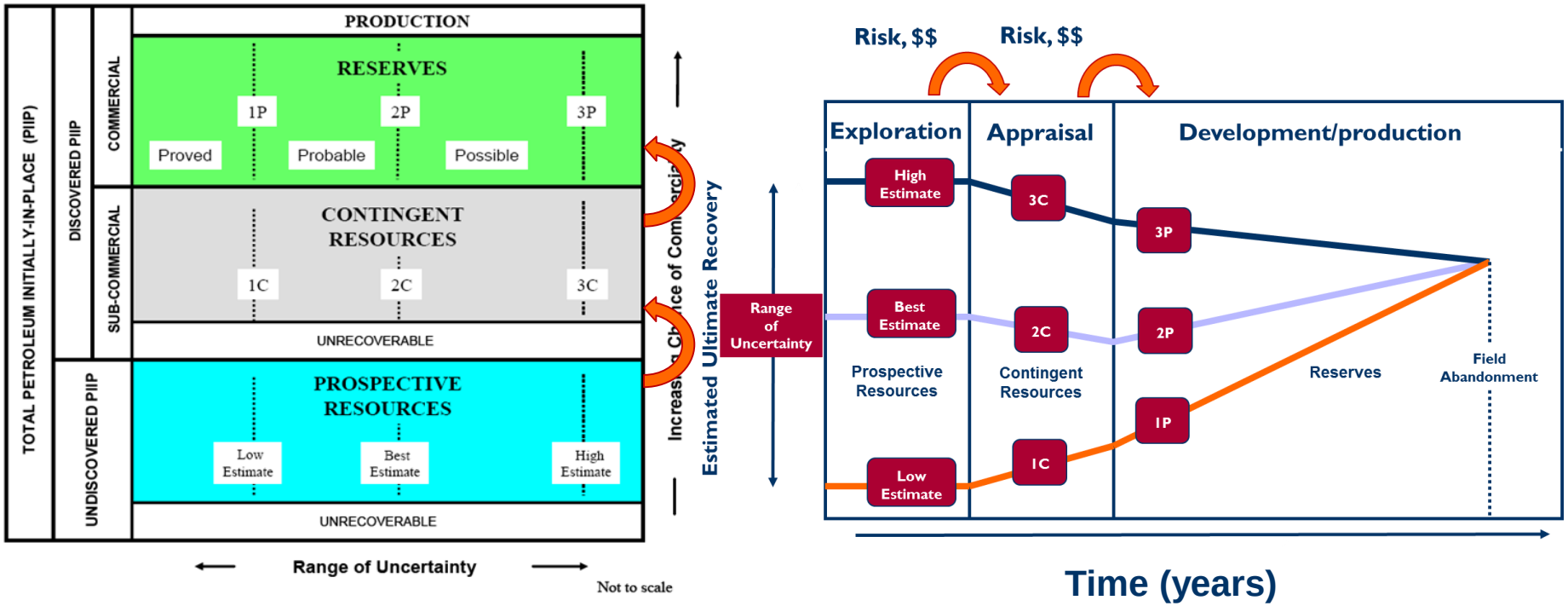

2011 is guideline for 2007 system

# PRMS – Overview of Key Concepts

- The "unit of currency" is **The Project**. This is the key to resolving many tricky issues
- "**Classification**"
  - into Prospective Resources, Contingent Resources or Reserves
  - is based solely on an estimate of Chance of Commerciality (Risk), which equates to level of maturity
- "**Categorization**"
  - into low, best, high, or 1C, 2C, 3C, or 1P, 2P, 3P, respectively
  - is based solely on the range of uncertainty, as captured by three discrete estimates

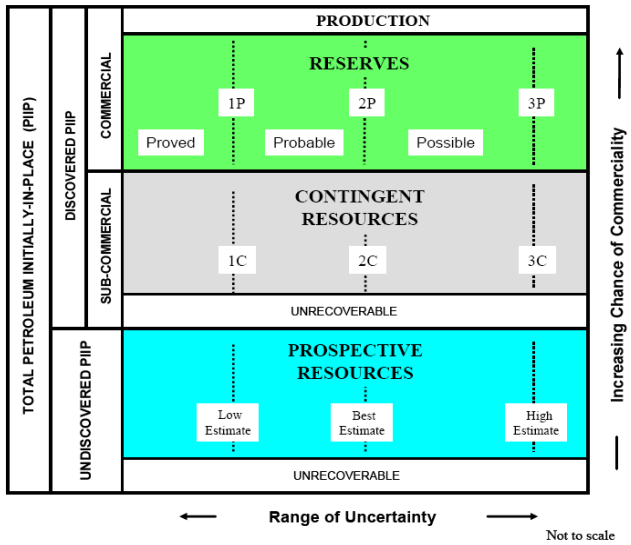


# Risk vs. Uncertainty



# Reserves are:

- Those quantities anticipated to be commercially recoverable by application of a **defined development project(s)** to known accumulations from a given date forward under defined conditions
- They must satisfy 4 criteria:
  - Discovered
  - Recoverable
  - Commercial
  - Remaining
- Reserves are a subset of Resources
- Reserves are subject to an economic limit test (ELT)
- Contingent Resources - Those quantities estimated, as of a given date, to be potentially recoverable from **known accumulations**, but the applied **project(s)** are not yet considered mature enough for commercial development due to one or more contingencies.



# Reserves – They Still Have Uncertainty

"provided that the project satisfies the requirements to have Reserves, there should always be a low (1P) estimate, a best (2P) estimate, and a high (3P) estimate"

- **Proved Reserves:**
  - **high degree** of confidence that the quantities will be recovered.
  - there should be at least a **90% probability** that the quantities actually recovered will equal or exceed the estimate.
- **Probable Reserves:**
  - It is **equally likely** that actual remaining quantities recovered will be greater than or less than the estimated Proved plus Probable Reserves (2P).
  - there should be at least a **50% probability** that the actual quantities recovered will equal or exceed the estimate.
- **Possible Reserves:**
  - **low probability** that the quantities recovered will exceed the estimated Proved plus Probable plus Possible Reserves (3P)
  - there should be at least a **10% probability** that the actual quantities recovered will equal or exceed the 3P estimate.

# Causes of Reserves Uncertainty

- The range is variably influenced by
  - In-place volumes
  - Field-wide recovery factor
    - General reservoir conditions
    - Compartmentalization/connectivity
    - Individual well performance (local recovery variation)
  - Interventions
    - Shut-ins
    - Work-overs
    - Recompletions
    - Acts of nature
    - Surprises!

Generally subject to the physics of fluid flow through permeable pore-space

Often unpredictable and difficult to model – but we know they're going to happen

# SEC Reserves Definitions – Regulations S-X and S-K

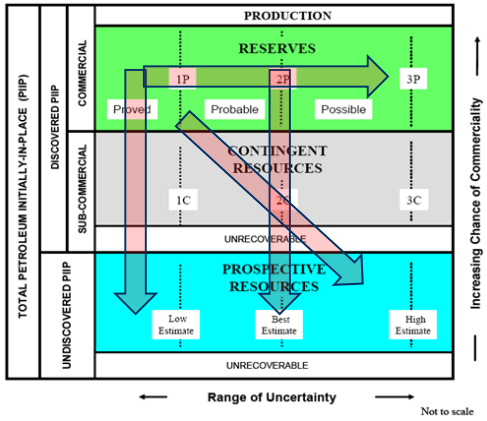
- Prior to January 2010, Proved Reserves only:
  - Engineering dominated approach (e.g. Lowest Known Hydrocarbon)
  - linked to Developed and Undeveloped defined by offset “drilling units”;
- Substantially revised after extensive consultation with the industry (Oil & Gas and Finance);
- Effective Date – 1st January 2010;
- Extensive discussion of inclusion of PRMS principles:
  - Recognition of Geology and Geophysics (“Reliable Technology”)
  - Recognition of Probable and Possible categories (optional)
  - Concept of “Reasonable Certainty” for ‘Proved’ and link to 90% exceedance expectation (“P90”) for probabilistic estimates
  - Reasonably clear for ‘Developed Producing’ Reserves

# SEC Reserves Definitions – Regulations S-X and S-K

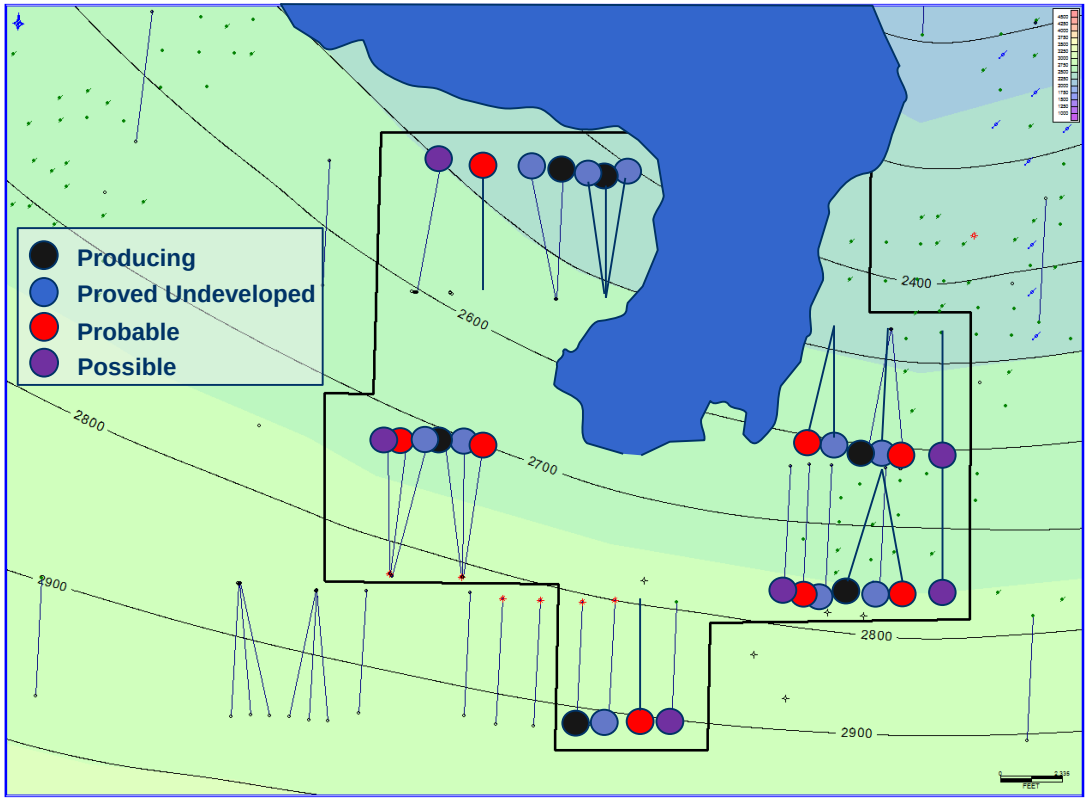
- BUT…
  - For Undeveloped Reserves, the concept of “Reasonable Certainty” remained linked to the concept of immediately offsetting “development spacing area” (previously known as “drilling units”).
  - Interestingly, in the “Modernization of Oil and Gas Reporting” posted on the Federal Register on January 14th, 2010, there is discussion of the term “within the immediate area” and its deletion from the regulation (page 2165).
- Confusing!
- As a consequence, it seems the offset location methodology to define “Proved” locations has prevailed, not only in high well count developments (typically onshore) but also more conventional developments.
- So we have the word “Proved”:
  - Proved = 90% exceedance confidence (probablity), &
  - Proved = an immediately offsetting location

# SEC Reserves Definitions – Regulations S-X and S-K

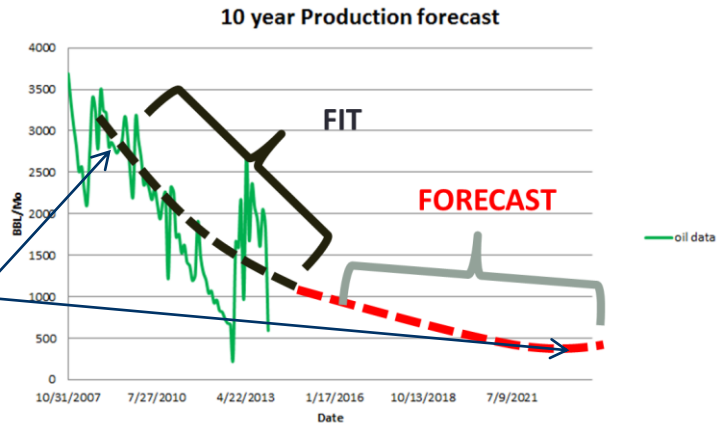
- As a result…
  - "Probable" reserves have become associated with those step out locations that will 'probably' be drilled assuming the production characteristics of the 'Proved' locations extend that far. In PRMS terms, these wells would be Contingent Resources i.e. discovered but requiring appraisal.
  - "Possible" reserves have become associated with those step out locations that will 'possibly' be drilled assuming the productive trend proves to extend that far. In PRMS terms, such wells would be bordering on Prospective Resources i.e. subject to geological risk with "Chance of Discovery".
- The exceedance confidence (P50 and P10) that should be based on "performance uncertainty" becomes wrapped up in development risk ("Chance of Development") and geological risk ("Chance of Discovery").



# Establishing an Uncertainty Range by 'Distance Proxy'



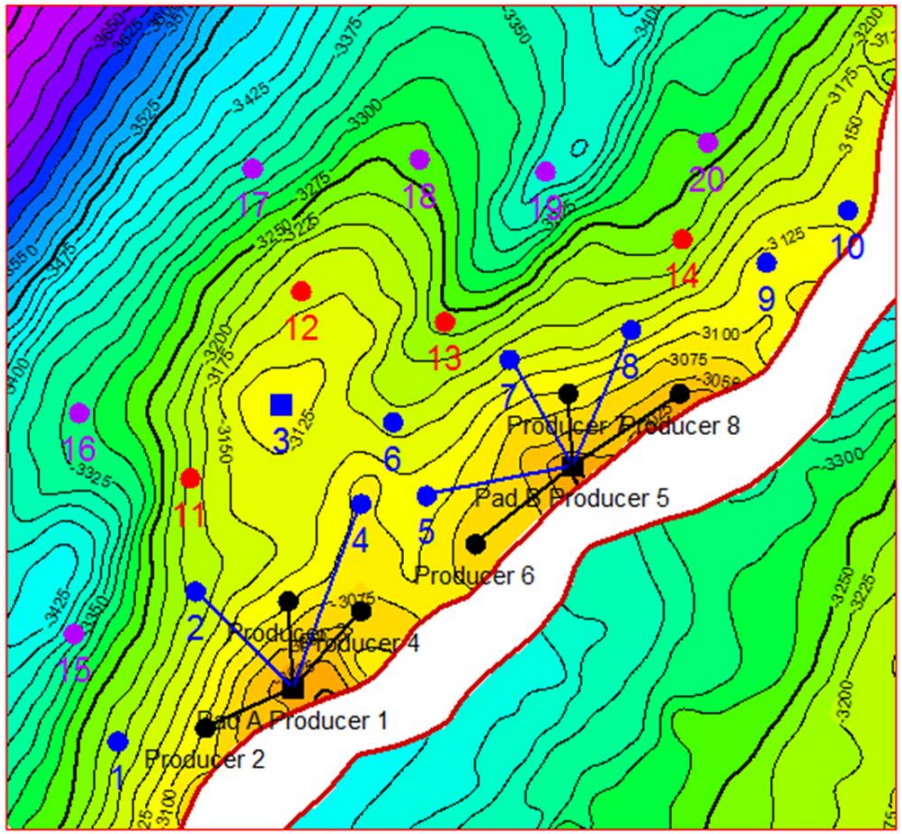

Type Curve



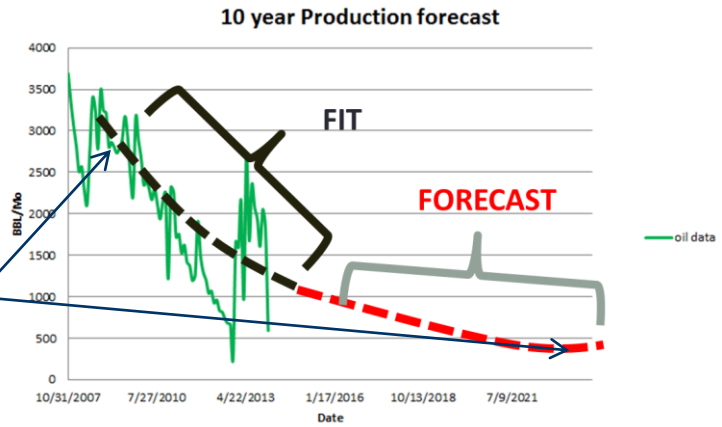

EUR = 360,000 bbls

Remaining = 60,000 bbls

# Establishing an Uncertainty Range by 'Distance Proxy'




Type Curve




EUR = 360,000 bbls

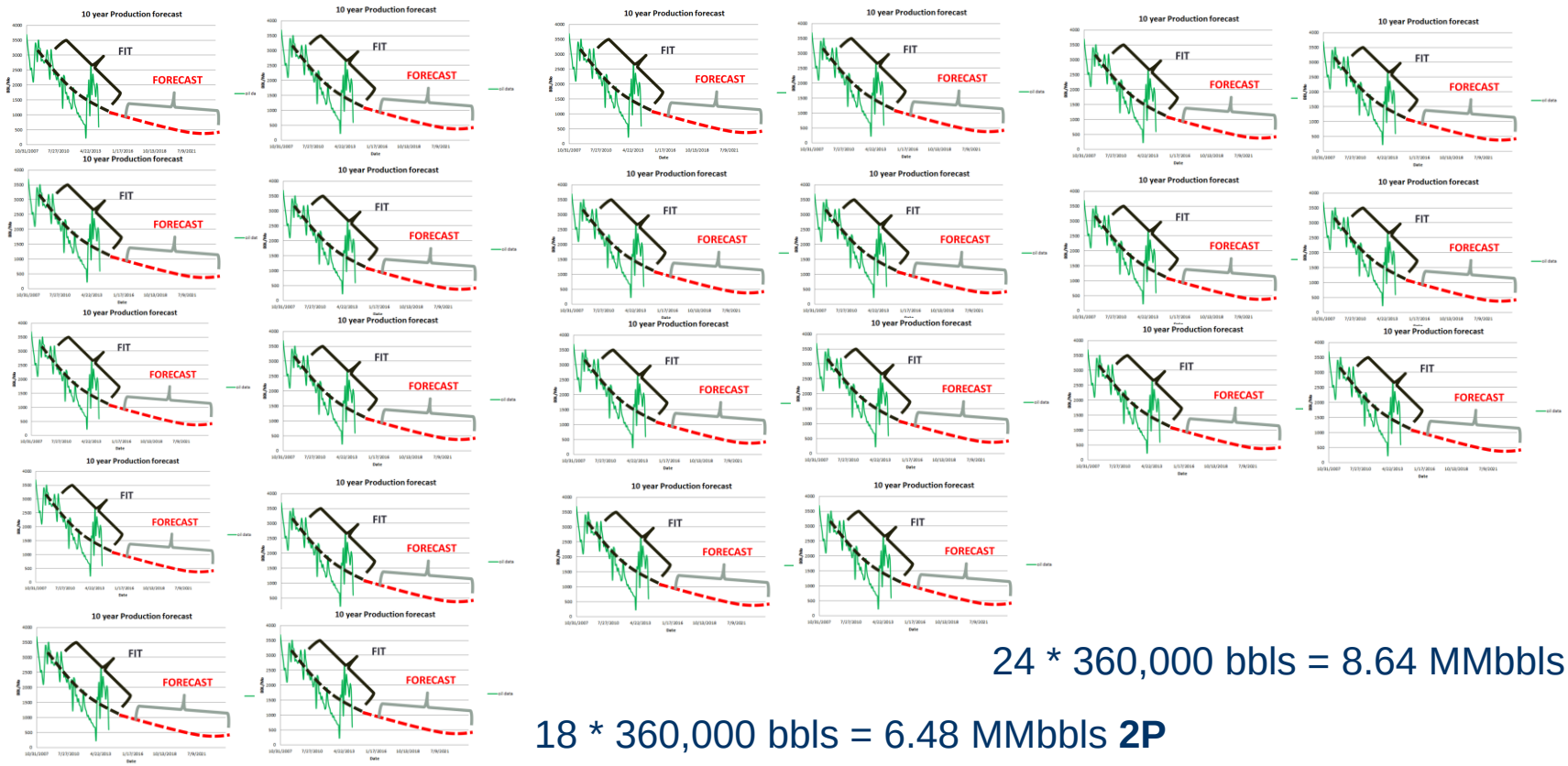
Remaining = 60,000 bbls

# Establishing an Uncertainty Range by ‘Distance Proxy’

10 ‘Proved’ Locations

Plus 8 ‘Probable’ Locations

Plus 6 ‘Possible’ Locations




24 * 360,000 bbls = 8.64 MMbbls **3P**

18 * 360,000 bbls = 6.48 MMbbls **2P**

10 * 360,000 bbls = 3.6 MMbbls **1P**

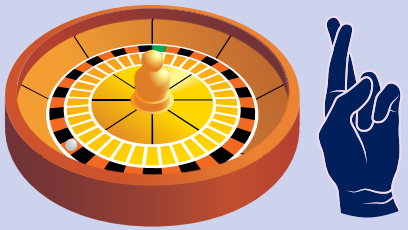
Uncertainty range is re-established but not based on performance uncertainty

# Establishing an Uncertainty Range by 'Distance Proxy'

- Uncertainty range is 're-established' but not based on performance uncertainty.
- 'Proved' volume is the sum of "P50" profiles most likely consisting of the wells that would have qualified as a **"project"** as per PRMS.
- Worse, the 'step-out' approach effectively incorporates GPoS into the Reserves – A Big No-no!
- So why is it done that way?
  - Mirrors typical development strategy for onshore Americas.
  - Generating true P90 – P10 cumulative exceedance forecasts per well and correctly aggregating at the field level is time consuming and has been historically difficult to do.

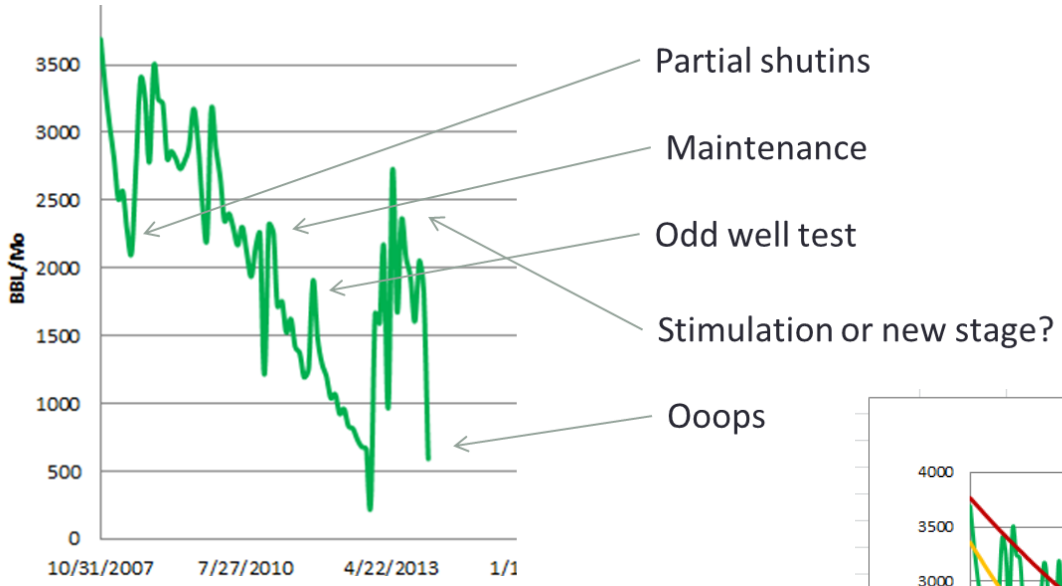
# Review of Incremental vs. PRMS approaches to Reserves Uncertainty

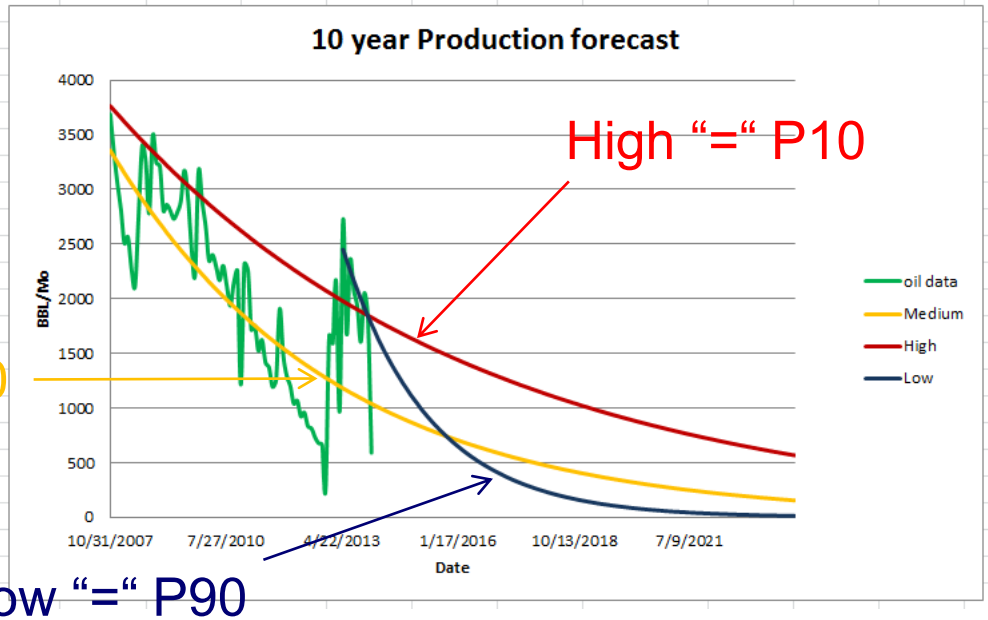
## Committed Wells (Development Plan)

| | P90 (1P) | P50 (2P) | P10 (3P) |
|---|---|---|---|
| Incremental | $$ |  |  |
| PRMS | $$ | $$ | $$$ |

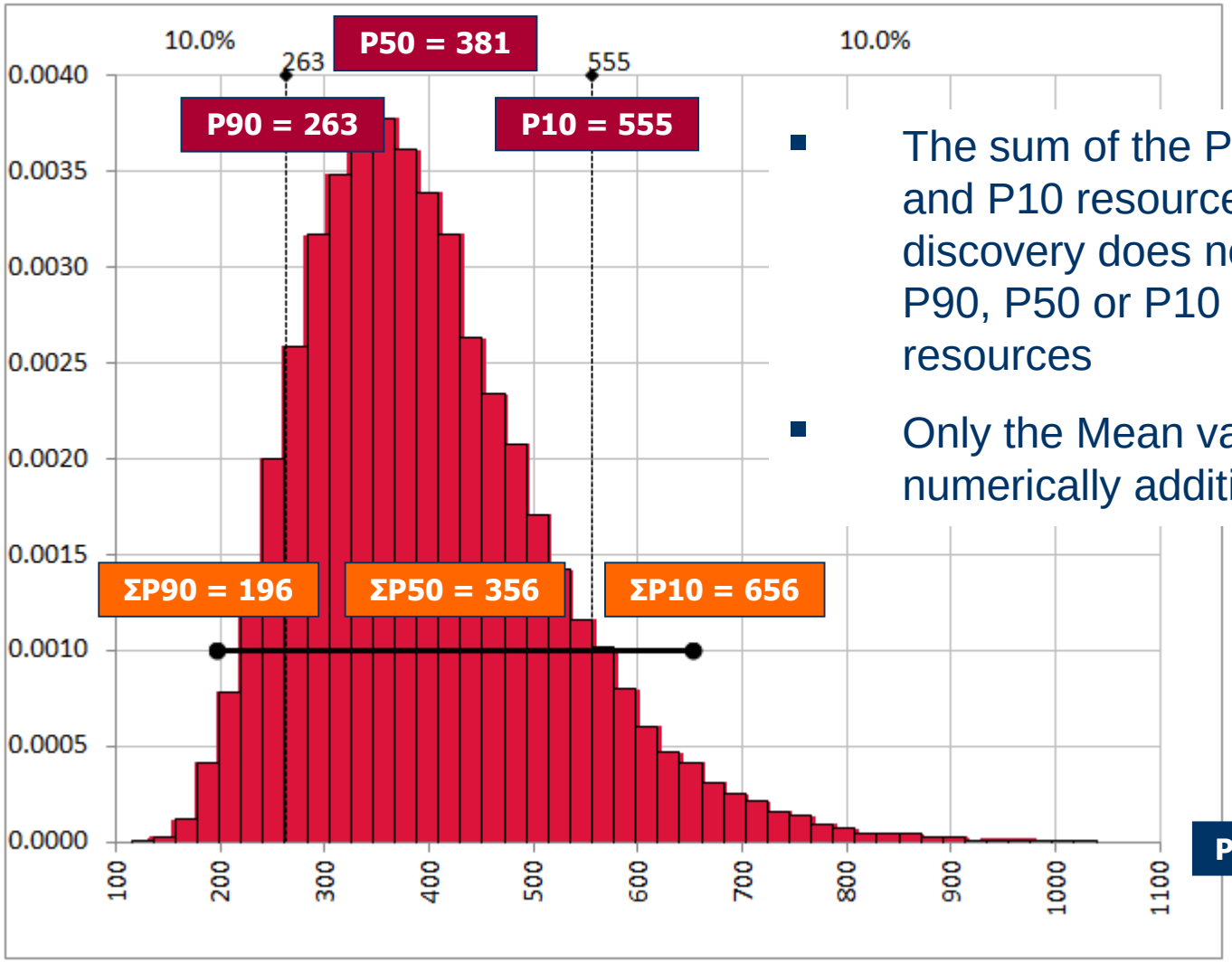
**“value driven by performance uncertainty”**

# Using Production Data to Capture Uncertainty



# Consolidation Effect (multiple wells)

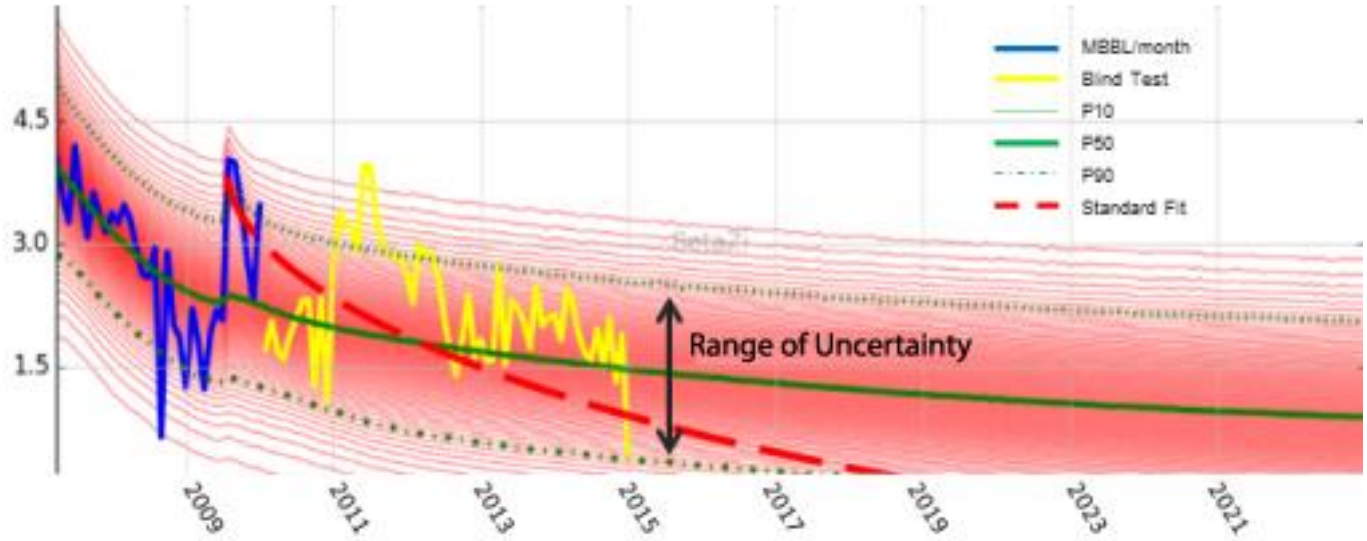



- The sum of the P90, P50 and P10 resources for each discovery does not equal the P90, P50 or P10 of the total resources
- Only the Mean values are numerically additive

**P0 = 80**

**P100 = 1600**

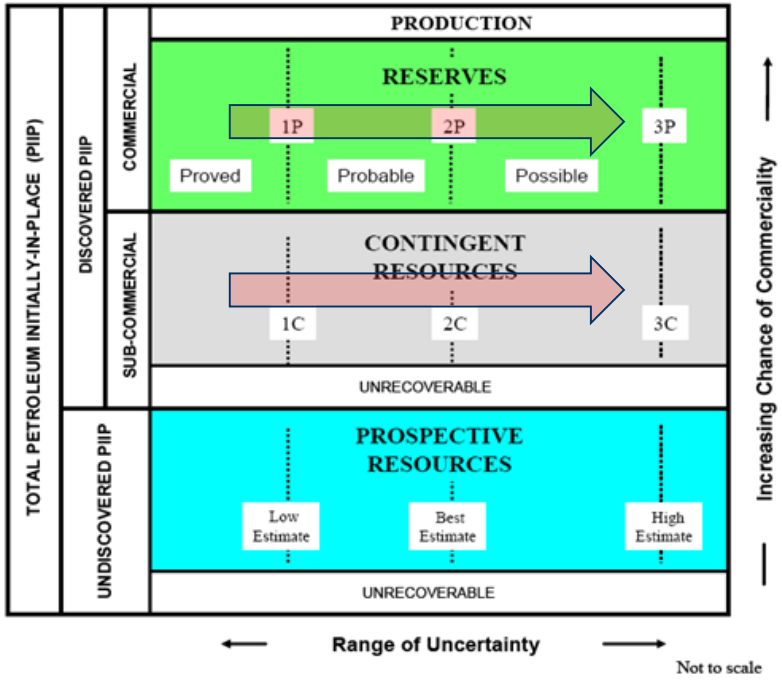
# A New Way to Look at Production History and Forecasts




'Big Data' predictive analytics techniques applied to forecasting and type curves allows genuine statistical aggregation. Probabilistic approach to production data! Eureka! We can model performance uncertainty and not rely on the central limit theory assumptions!

BetaZi™

# PRMS Principals can now be fully modelled – Value based on performance for ‘Reserves’ qualifying wells




- **Reserves**
- Those quantities anticipated to be commercially recoverable by application of a **defined development project(s)** to known accumulations from a given date forward under defined conditions
- They must satisfy 4 criteria:
  - Discovered
  - Recoverable
  - Commercial
  - Remaining

- Since we are now confident that we are not ‘blurring’ the distinction between Reserves and Contingent Resources, the International community is keenly interested in what they might be worth and when.
- A key subsidiary question to that interest is “What are they worth ‘now’?

# Classification of Contingent Resources

| Project Maturity Subclass | Additional Sub-Classification | Economic Status |
|---|---|---|
| Development Pending | Pending | Marginal Contingent Resources ✓ |
| Development Unclarified or On Hold | On Hold | |
| | Unclarified | Undetermined |
| Development Not Viable | Not Viable | Sub-marginal Contingent Resources ✗ |

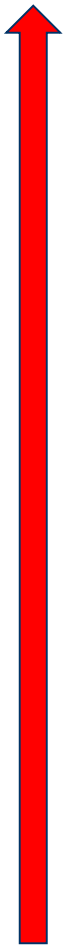
**Marginal Contingent Resources** are those quantities associated with technically feasible projects that are either currently economic or projected to be economic under reasonably forecasted improvements in commercial conditions but are not committed for development because of one or more contingencies.

**Sub-Marginal Contingent Resources** are those quantities associated with discoveries for which analysis indicates that technically feasible development projects would not be economic and/or other contingencies would not be satisfied under current or reasonably forecasted improvements in commercial conditions. These projects nonetheless should be retained in the inventory of discovered resources pending unforeseen major changes in commercial conditions.

Where evaluations are incomplete such that it is premature to clearly define ultimate chance of commerciality, it is acceptable to note that project economic status is "**undetermined**."

# RPS Chance of Development

- CoD ≥ 75%
- CoD ≥ 50% and ≤ 75%
- CoD ≥ 25% and ≤ 50%
- CoD ≤ 25%



**Contingent Resources – Development Pending**

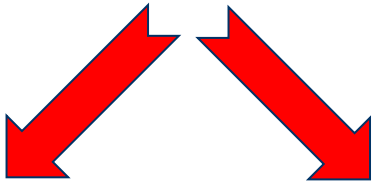
**Contingent Resources – Development Unclarified or On Hold**

**Contingent Resources – Development Not Viable**

Chance of Development = (Probability of exceeding commercial threshold * Remaining Probability)

# Step 1 – Initial Commercial Valuation

| | 1C (P90) | 2C (P50) | 3C (P10) | Mean |
|---|---|---|---|---|
| Contingent Resources (MMstb) | 49 | 89 | 164 | 100 |



**Scenario A**

| | 1C (P90) | 2C (P50) | 3C (P10) |
|---|---|---|---|
| NPV | +ve | +ve | +ve |

✓ ✓ ✓

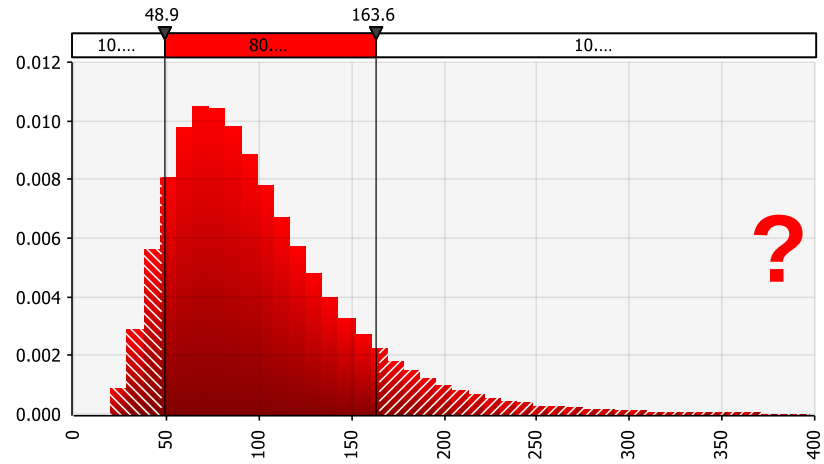
**Scenario B**

| | 1C (P90) | 2C (P50) | 3C (P10) |
|---|---|---|---|
| NPV | -ve | +ve | +ve |

✗ ✓ ✓

# Scenario A, Step 2 – Classify the economic volumes

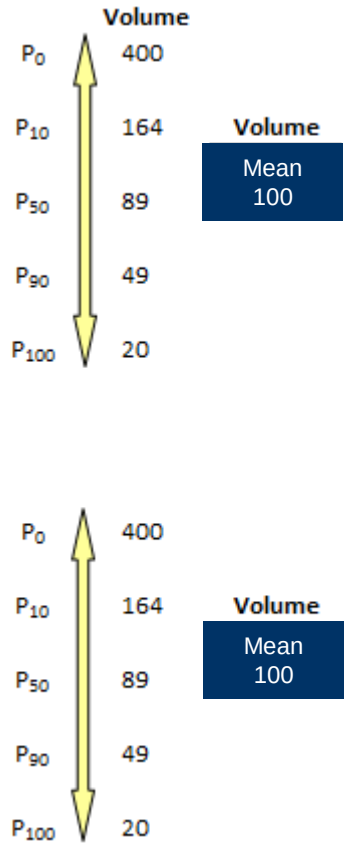
**Estimated Chance of Development =** **90%**




**Contingent Resources - Development Pending**

**90%**

**10%**

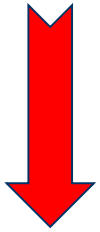



**Reserves**

**Contingent Resources - Development On Hold**

# Scenario A, Step 3 – Report the volumes

| MMstb | 1C (P90) | 2C (P50) | 3C (P10) | Mean |
|---|---|---|---|---|
| Contingent Resources | 49 | 89 | 164 | 100 |



| Unrisked (MMstb) | 1C (P90) | 2C (P50) | 3C (P10) | Mean | CoD |
|---|---|---|---|---|---|
| Contingent Resources (Development Pending) | 49 | 89 | 164 | 100 | 90% |

# Scenario A, Step 3 – Risked volumes

| Unrisked | 1C (P90) | 2C (P50) | 3C (P10) | Mean | CoD |
|---|---|---|---|---|---|
| Contingent Resources (Development Pending) | 49 | 89 | 164 | 100 | 90% |

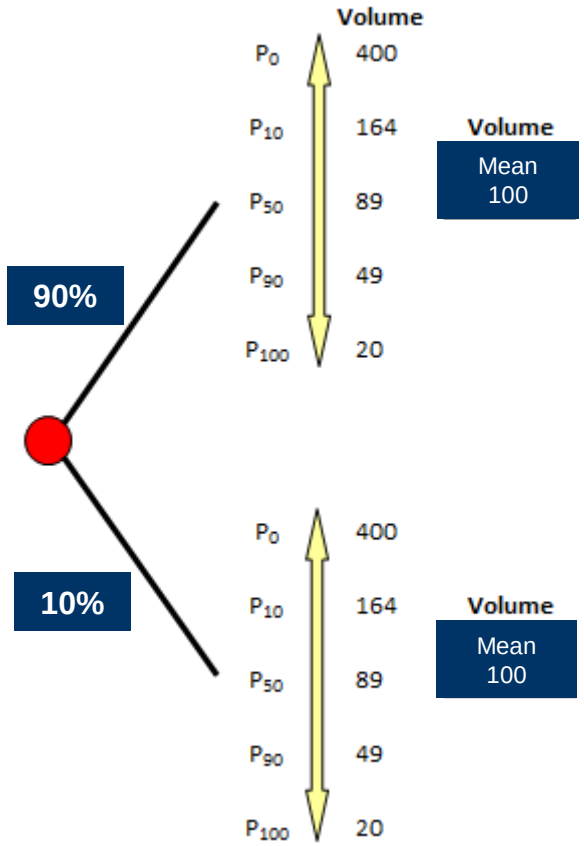
| Risked | 1C (P90) | 2C (P50) | 3C (P10) | Mean | CoD |
|---|---|---|---|---|---|
| Contingent Resources (Development Pending) | 44 | 80 | 148 | 90 | 90% |

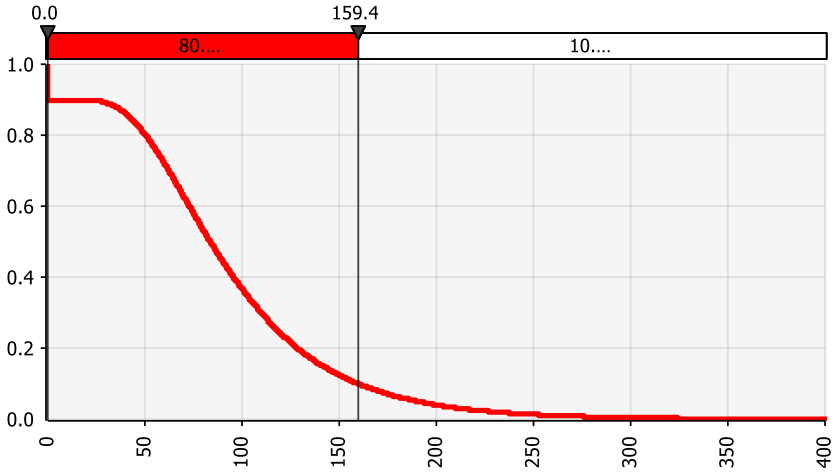
| Risked | 1C (P90) | 2C (P50) | 3C (P10) | Mean | CoD |
|---|---|---|---|---|---|
| Contingent Resources (Development Pending) | 0 | 84 | 159 | 90 | 90% |

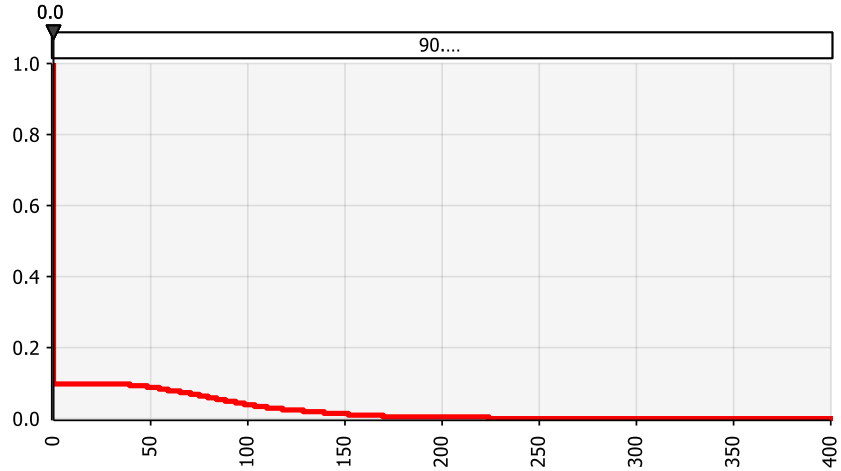
| P81 | P45 | P9 |
|---|---|---|
| 49 | 89 | 164 |

# Risked volumes

**Estimated Chance of Development =** **90%**

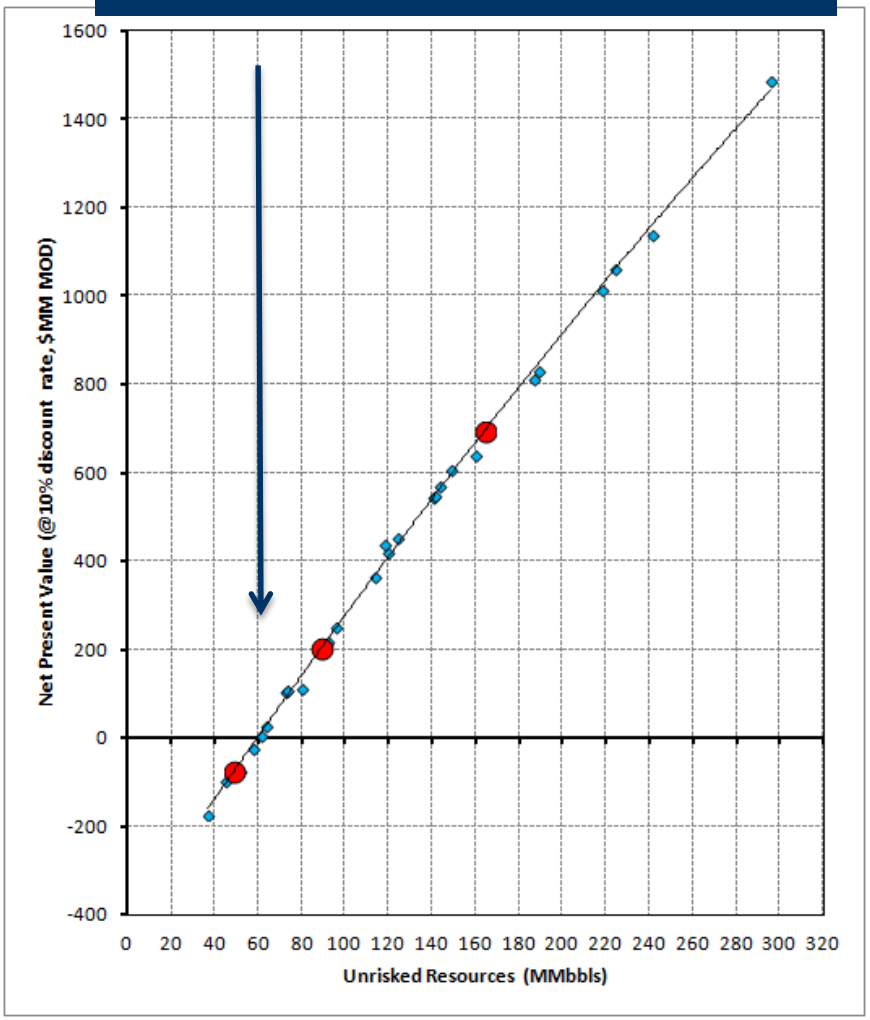


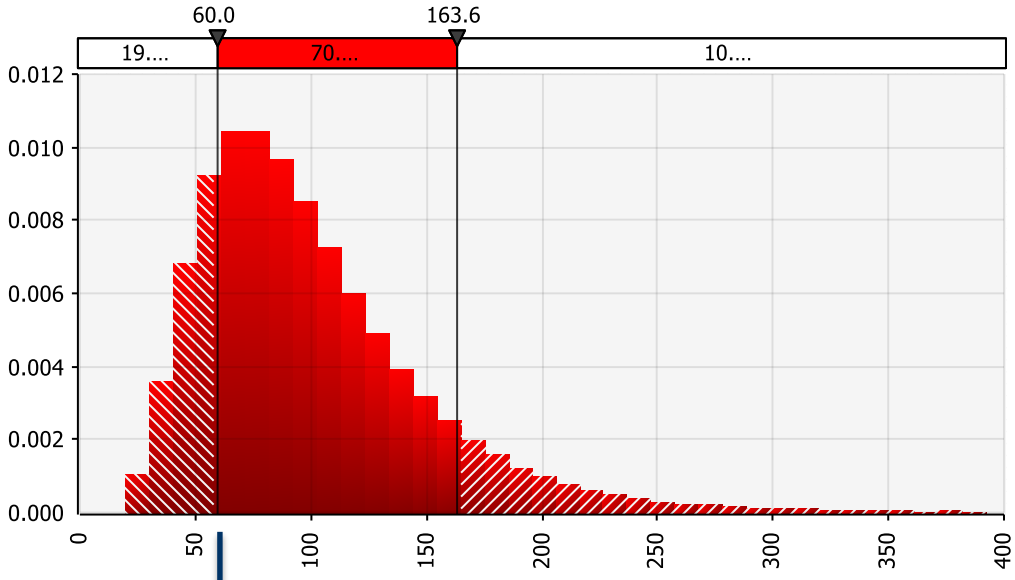



# Scenario B, Step 1- Establish Economic Status

**Commercial Threshold = 60 MMstb**



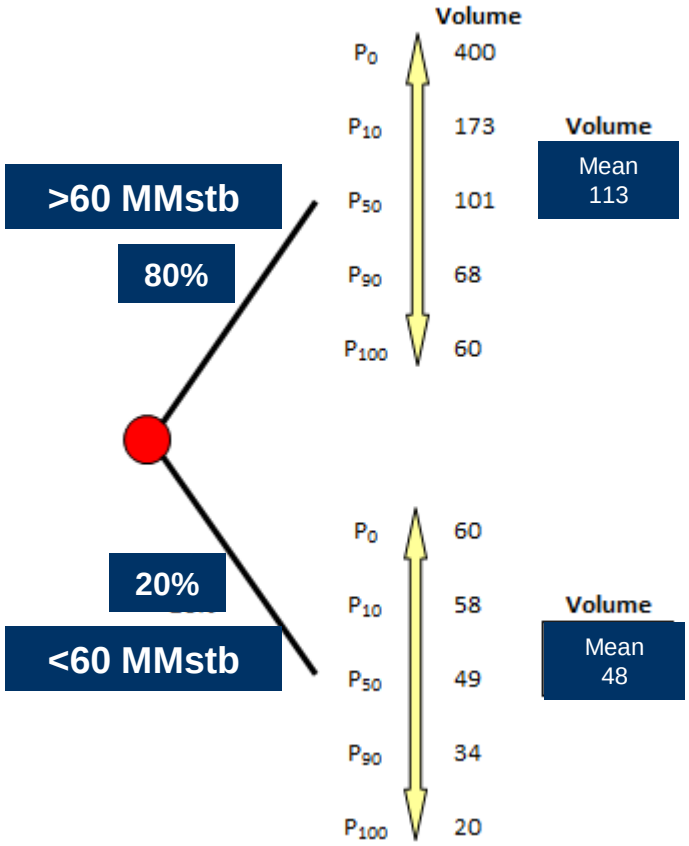

**60 MMstb = P80**

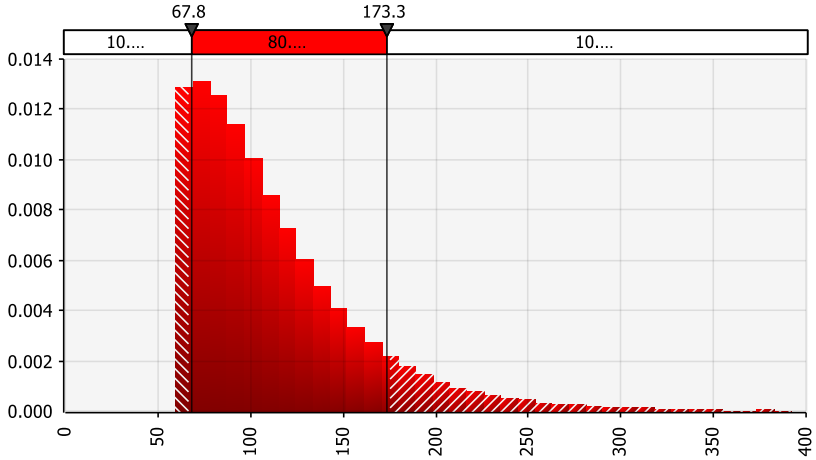


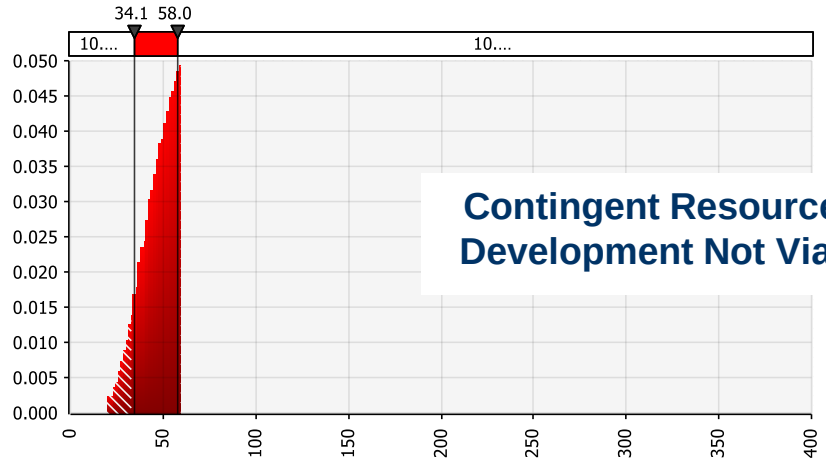

**Sub Marginal Economic Status**

**Marginal Economic Status**

# Scenario B, Step 2 – exclude the uneconomic volumes



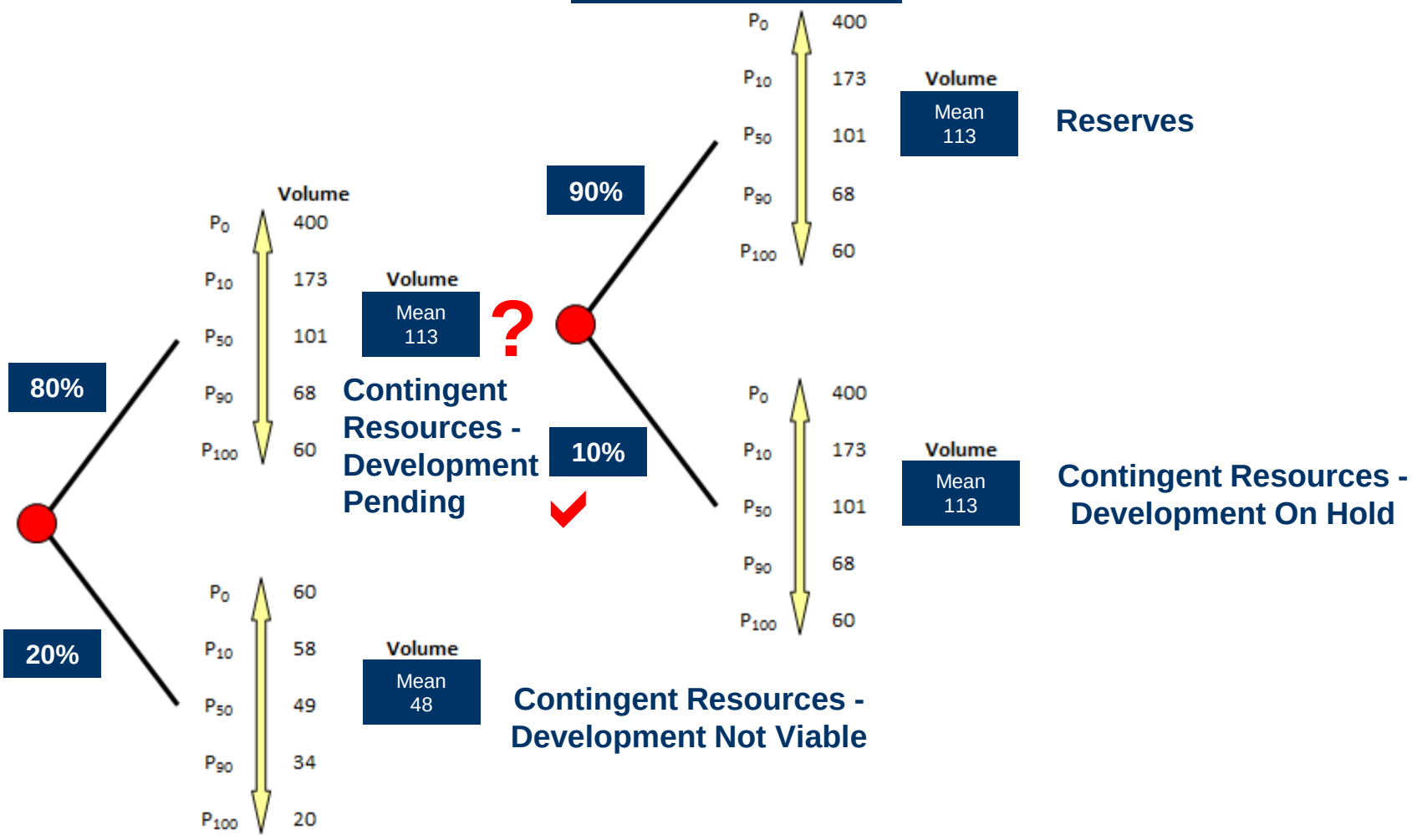




**Contingent Resources - Development Not Viable**

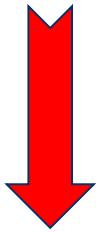
# Scenario B, Step 3 – Classify the economic volumes

**Estimated Chance of Development =** **80% * 90% = 72%**



# Scenario B, Step 4 – Report the volumes

| Unrisked MMstb | 1C (P90) | 2C (P50) | 3C (P10) | Mean |
|---|---|---|---|---|
| Contingent Resources | 49 | 89 | 164 | 100 |



| Risked MMstb | 1C (P90) | 2C (P50) | 3C (P10) | Mean | CoD |
|---|---|---|---|---|---|
| Contingent Resources (Development Pending) | 68 | 101 | 173 | 113 | 72% |

# Conclusions (i)

- The International community does not routinely deal with very high well-count developments. It is more concerned therefore with establishing the distribution of uncertainty due to performance than relying on the 'average' within a "statistical play".
- They have a different view of what Proved, Probable and Possible means when compared to both the traditional and post 2010 SEC approach.
- PRMS, and therefore the International community, is very clear on the criteria that differentiates Reserves from either Contingent or Prospective Resources and requires an uncertainty distribution to be stated per Class of Resource/Reserve
- To be fair, strict reading of the SEC, post 2010, has similar criteria which it has largely adopted as a result of the introduction of PRMS in 2007. However, common application of the modernized rules has clung to the traditional interpretation of 'step-out' locations "in the immediate area" to mean "Proved".
- All Reserves locations from a PRMS perspective are proven and the Proved category is simply a point (90% exceedance confidence or 'P90') in the potential distribution of performance expectation of those wells that are committed within a sanctioned development plan. No geological or development risk remains.

# Conclusions (ii)

- Previous time and date manipulation constraints on creating meaningful estimates of uncertainty distributions based on performance variation in high well-count developments has resulted in a simplified methodology relying on central limit theory assumptions and a well-count proxy to establish 1P, 2P & 3P estimates.
- However, this practice has gone beyond “statistical plays” and is seen in conventional and low well-count developments.
- Modern big data, predictive analytic, computer science has now been applied to the complex field of production forecasting and truly captures performance uncertainty which can be aggregated at the field level.
- Opens up new possibilities for the correct implementation of PRMS and opportunity evaluation and optimization, particularly for large well-count fields such as commonly found in US and LA.
- Clear distinction of Reserves and Contingent Resources allows the correct level of economic modelling and risking to be applied in assessing the value of Contingent Resources which are of keen interest to the International community.

# Thank you for your kind attention

Any Questions? –

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