Magnus Field
Opportunity Identification and
Uncertainty Management in a Mature
Asset

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Magnus – A Giant

- Start-up date: Aug 1983
- 100% EnQuest (Op)
- Block 211/12a, 211/7a
- STOIIP ~1,700 MMbbls
- 700 scf/stb GOR (38° API)
- 933 MMbbls produced Feb’19 (c.52% RF)
- 3 Reservoirs:
  - Magnus Sandstone Member (MSM)
  - Lower Kimmeridge Clay Formation (LKCF)
  - Brent
- 10 MSM + 4 LKCF Producers
- 8 MSM + 1 LKCF Injectors
- NW Magnus Brent 1 producer + 1 Injector
The Challenge

Uncertainty
- Interpretation Complexities
- Data Assimilation
- Multiple Models
- Forecast Uncertainty

Time
- Skills
- Resources
- IT & Software
- Model Run Times
- Project Timelines

Data
- Uncertainty & Error
- Alternative Interpretation
- Accuracy
- Precision
- Non-Uniqueness

Strategy
- Budgets
- Options
- Plans
- Decisions
- Forecasts

Magnus DEVEX 2019
Types of Uncertainty – How Wrong Could We Be?

- Detection
  - Sampling
  - Measurement
  - Partial Temporal Local
- Conceptual Interpretative
  - Correlation Analytical
- Statistical Empirical
  - Extrapolation
  - Propagation Correlation
- PVT Logs
- Data Uncertainty
- Horizons Faults Isochores Facies
  - Interpretation Uncertainty
- NtG Perms Fault Trans. Sat-Ht STOIIP
- Reservoir Model Uncertainty
- Averaged Smoothed Conditioned Constrained
- Statistical Empirical Extrapolation Propagation Correlation
- Inexact Inaccurate Analytical Uncertain Unique
- Relperms Aquifer Allocation
  - Simulation Uncertainty
  - Prediction Uncertainty
  - Output
- Production Forecast Reserves
- Experts
- Modelling
- Data
**Conventional Linear Workflow**

- **Data & Interpretation**
  - Limited integration with linear workflow

- **Static Model**
  - Single Deterministic Base Case Model
  - Local non-geological fixes

- **Dynamic Model**
  - Error & Uncertainty generally not included

- **Simulation & History Match**
  - Iteration typically manual & slow
  - Match quality typically not quantified (only single model)

- **Results & Forecast**
  - Prediction cases based on single model
  - Uncertainty only assessed by perturbation of base case model

- **Match quality typically not quantified (only single model)**

- **Results & Forecast**

**Ensemble Modelling Workflow**

- **Data & Interpretation**

- **Objective Function**
  - Information on model errors
  - Assisted History Match
  - Assimilation
  - Kalman Filter
  - Iterative Workflow
  - Ensemble (100x) of models

- **Reservoir Model Ensemble**
  - Uncertainty & Prediction Ranges

- **Results & Forecast**

**Limited Integration with linear workflow**

**Error & Uncertainty generally not included**

**Iteration typically manual & slow**

**Match quality typically not quantified (only single model)**

**Uncertainty only assessed by perturbation of base case model**

**Results & Forecast**

**Magnus DEVEX 2019**
ResX Ensemble Modelling
Uncertainty Analysis & Assisted History Matching

Property Workflow

NTG CONCEPT  NTG  FACIES PROBABILITY
FACIES  PHIT  PERM

Posterior Perm Realizations
ResX Ensemble Modelling
Uncertainty Analysis & Assisted History Matching

Faults

MSM/LKCF
Fault Transmissibility Split

Fault Transmissibility Modification

Prior & Posterior Fault Transmissibility
ResX Ensemble Modelling Results and Implementation

**Prior & Posterior Ensemble Results QC**

- **RFT Data Match**
- **Sw Data Match**

**Model Ranking on Profile Comparison & Error Score**

- **M26z Oil Rates & Cumulative**
- **M26z Water Rate**
- **M26z Water Cut**
- **M26z BHP**
ResX Ensemble Modelling Results and Implementation

Opportunity Identification

Target Prediction Cases

Hydrocarbon Thickness Remaining Oil

Target Cumulative Oil Range

Target Incremental Oil Range
## Summary

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Conventional Modelling (Manual History Matching)</th>
<th>Ensemble Modelling Approach (Assisted History Matching)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>Linear build &amp; often limited cross-functional integration (“over-the-fence”)</td>
<td>Cross-Discipline &amp; Integrated</td>
</tr>
<tr>
<td>Repeatability Auditability</td>
<td>Often difficult to fully repeat or audit due to manual steps</td>
<td>Fully defined in workflows (complete repeatability)</td>
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<tr>
<td>Uncertainty Management</td>
<td>Uncertainties typically evaluated post-history match as sensitivities</td>
<td>Uncertainties explicitly handled upfront in workflows</td>
</tr>
<tr>
<td>Geological Model Update</td>
<td>Often only Dynamic Model modified during HM</td>
<td>Geomodel updated during history match through workflows</td>
</tr>
<tr>
<td>Dynamic History Matching</td>
<td>Generally only Single Deterministic Case with iterative manual adjustments to match production history</td>
<td>Full Model Ensemble with automated updates of model during history match</td>
</tr>
<tr>
<td>HM Quality</td>
<td>Often only single model so difficult to assess quality (range)</td>
<td>Match quality easily measured against objective function targets</td>
</tr>
<tr>
<td>Forecast Prediction</td>
<td>Base Case = Mid Case (+/- Low/High) – range often artificial (e.g. 3&gt;2&gt;1)</td>
<td>Full Range for forecast generation</td>
</tr>
<tr>
<td>Opportunity Identification</td>
<td>Limited range of models to evaluate target robustness/uncertainty</td>
<td>Options quickly and easily ranked/quantified – test robustness against full model ensemble or subset</td>
</tr>
<tr>
<td>Model Sustainability</td>
<td>Difficult to update or handover to new user(s)</td>
<td>Easily modified/updated or rebuilt</td>
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</tbody>
</table>
“The first principle is that you must not fool yourself — and you are the easiest person to fool.”

RICHARD P. FEYNMAN