FDP Digital Ecosystem

Enhancing Cross Discipline Collaboration and Acceleration of FDP Projects

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Presentation Outline

FDP Digital Ecosystem in PETRONAS

BD Cluster: Field Background, Challenges and Solution

FDPlan Workflow Enhancement

Recommendation & Way Forward

From the lens of Program Coordinator
FDP insight from BD Cluster team
DELFI Technology to Enable Resource Acceleration and Robust Project Delivery

- Remote connectivity
  - Work from anywhere, anytime
  - Collaborating ‘live’ with team

- Packaged profiles
  - Economic of scale across EDP
  - Subscription vs perpetual license
  - High end Virtual Machine

- Processing & Storage
  - Information backed up and secured.
  - Storage and processing elastic capacity.
  - Parallel processing.

- Resources & Organization
  - Department Managers
    - track compute utilization
    - assign domain PTS profile

- Data Analytics, HPC, ML, AI
  - Faster compute times via HPC
  - Native cloud application, data analytics, Machine Learning and AI applications
How PETRONAS Manages High Risk Projects through Digital Technology

**Screening Evaluation and Criteria**

- **All CR1 Projects** as per ARPR database
- **Project cost** High CAPEX + OPEX
- **Incremental reserves** High Reserves
- **Current FDP stages** Feasibility, Concept ID
- **Multiple development scenarios** Integrated facility concept

**CAPEX, OPEX and Incremental Reserves**

- **Higher priority for resource acceleration**
  - Pilot (out of scale)
  - Scale Up
  - Enterprise

**Integrated facility concept**

- Pilot (out of scale)
- Scale Up
- Enterprise

**How PETRONAS Manages High Risk Projects through Digital Technology**

**FDP Digital Ecosystem**

- 2019
  - Asset 1a
  - Asset 1b
  - Asset 2
  - Asset 3
- 2020
  - Asset 4
  - Asset 5
  - Asset 6
  - Asset 7
- 2021
  - Asset 8
  - Asset 9
  - Asset 10
Case Study of BD Cluster: Development Challenges

BD Cluster: Field Overview

Data availability
- Poor to fair seismic imaging
- Sparse well coverage (5 wells)
- Very limited core data (1 well)
- Borehole Image logs (3 wells)
- LWD and MDW logs
- Pressure data
- Limited check shots data

Geological Complexity
- > 30 multi-stacked stratigraphic units
- Highly faulted, compartmentalized structure
- Multiple fluid contacts per zone
- High structural uncertainty due to limited well and check shot data
- Deep Water Turbidite reservoirs
- High lateral and vertical heterogeneity
- Poor understanding of reservoir connectivity

High resolution models required to capture heterogeneity

High uncertainties
3D grid construction criterion

- 3D Grids suitable for both Static and Dynamic modeling (no upscaling)
- Lateral I&J increments to capture lateral heterogeneity
- K layer thickness should capture vertical heterogeneity observed on the core and log data

Final resolution of the geocellular grids

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Number of zones</th>
<th>Grid dimension (m)</th>
<th>Number of cells (MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model E</td>
<td>27</td>
<td>25 x 25 x 0.3</td>
<td>91 MM</td>
</tr>
<tr>
<td>Model S</td>
<td>33</td>
<td>50 x 50 x 0.4</td>
<td>11 MM</td>
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<tr>
<td>Model M</td>
<td>10</td>
<td>50 x 50 x 0.3</td>
<td>28 MM</td>
</tr>
</tbody>
</table>

Comprehensive 3D static modelling and extensive uncertainty analysis studies to be performed within tight timelines.
Case Study Proof Point From *Geological Modeling* Perspective

**BD Cluster: Volumetric U&O Analysis on HPC**

**Run Time Improvement**

- Traditional approach: Runs sequentially one after another (R1, R2, R3, R4)
- HPC: Runs concurrently in the cloud, runs asynchronously

**High Performance Computing**

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Number of cells (MM)</th>
<th>One realisation run (min)</th>
<th>Total realizations</th>
<th>Time to complete conventional (days)</th>
<th>Time to complete on HPC (days)</th>
<th>Efficiency gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model E</td>
<td>91 MM</td>
<td>60</td>
<td>2700</td>
<td>112</td>
<td>2</td>
<td>56 times</td>
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<tr>
<td>Model S</td>
<td>11 MM</td>
<td>15</td>
<td>4050</td>
<td>42</td>
<td>0.5</td>
<td>84 times</td>
</tr>
<tr>
<td>Model M</td>
<td>28 MM</td>
<td>15</td>
<td>8100</td>
<td>84</td>
<td>1</td>
<td>84 times</td>
</tr>
</tbody>
</table>

**Value Creation**

- Interpretation & Model Building
- Uncertainty analysis
- Dynamic modeling & Development planning

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 mos.</td>
<td>Interpretation &amp; Model Building</td>
</tr>
<tr>
<td>1 mos.</td>
<td>Interpretation &amp; Model Building</td>
</tr>
<tr>
<td>2 days</td>
<td>Uncertainty analysis</td>
</tr>
<tr>
<td>5 mos.</td>
<td>Dynamic modeling &amp; Development planning</td>
</tr>
</tbody>
</table>

- ~90% reduction
- Prognosed timeline ~12-14 Months
- Shortened by ~2 months
- Subsurface Stage Gate Review
BD Cluster: Probabilistic Dynamic Simulation Studies

Challenges:
- **On-prem infra and license limitations** constraints large-scale ensemble-based probabilistic studies
- **Uncertainty management** via multi realization simulation of giant coupled reservoir model

Case for Change:
- Leveraging on **scalable cloud computing** power for ensemble-based reservoir simulation studies
- Empower team to **sample all possible development planning scenarios** - running dynamic simulations simultaneously
- High level **economics screening** for all reservoir realization for concept selection

### On-prem vs Cloud

<table>
<thead>
<tr>
<th>Field</th>
<th>Active cells</th>
<th>Simulation runtime (hours)</th>
<th>No. of concurrent simulations</th>
<th>No. of processors per simulation</th>
<th>Estimated simulation time to complete all concurrent simulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field B (M)</td>
<td>2.1 MM</td>
<td>5.1</td>
<td>500+</td>
<td>48</td>
<td>1 day</td>
</tr>
<tr>
<td>Field B (E)</td>
<td>1.3 MM</td>
<td>4.0</td>
<td>500+</td>
<td>32</td>
<td>1 day</td>
</tr>
<tr>
<td>Field B (S)</td>
<td>2.5 MM</td>
<td>6.3</td>
<td>500+</td>
<td>40</td>
<td>1 day</td>
</tr>
</tbody>
</table>
Case Study Proof Point From FDP Orchestration Perspective

Dynamic Simulation Outputs from Cloud Based Petrotechnical Tool & Simulation Engines

Manage the Plan
Integrated, coordinated team planning

Frame the Opportunity
Early stage planning with greater insight

Build and Evaluate
Live planning fueled with economic and technical rigor

Compare and Decide
Accelerated decision-making aligned with business needs

Production Forecast

Costing (CAPEX & OPEX)

Economic Framework

18 Development Scenarios Evaluation in 2 weeks’ time @ FEL 1 - ready with Live & Intuitive Platform to optimize for next FEL stages
Adopted Agile Methodology to Enhance User Experience via integration with other Corporate Digital Application

**FDPlan Workflow Evolution**
- Well Driven
- Field Driven (Single Prod)
- Field Driven (Multiple Prod) with RE Operators

**Expansion beyond Subsurface Domain**
- Front End Engineering & Costing Workflows
- Subsurface Workflows & Production Forecasts
- PlanningSpace

Ecosystem Components:
- Excel
- ECLIPSE / INTERSECT
- IPM Suite
- Other RE Simulator

Tech Apps:
- Tech App A
- Tech App B

Calculations:
- Standard Economics & Fiscal Regime Calculations
FDPlan – PETEX Integration
Eliminate manual export and upload data for seamless decision making

**Existing Workflow**
- Export production profile from PETEX
- Manually reformat to FDPlan template before upload into FDPlan.

**New Workflow**
- Integrate PETEX production engine and sensitize the parameters within FDPlan
- Simulation result consumed directly for seamless economic runs and analytics

**Enhancement**
- Automation with improved UI
- Allow dynamic linking to decision and optimization parameters in FDPlan
Process Cycle Efficiency Analysis
‘Conventional vs FDP Digital Ecosystem’

Key Value Delivery

• Improve FDP cycle time up to 6 months via cloud computing and high-level project economics screening
• Minimize iteration cycle time (FDP team, TA/TP reviews, Stage Gate reviews)
• Collaborative platform between Subsurface and Surface in delivering FDP

PCE = \frac{\text{Value Added Time}}{\text{Total Lead Time (VT + BVA + NVA)}}

Feasibility

FEL 1
-29 steps
81 steps
52 steps

FEL 2
30 steps
26.5 months
21.3 months

Concept Select

-8 steps
26.5
21.3

-5 months
21.3

Conventional = 5 Scenarios
Live FDP = 29 Scenarios

Gap analysis for FEL 1 – Conduct Feasibility Study

VALUE AREAS | AS IS | TO BE
--- | --- | ---
TOUCHPOINT REDUCTION | 81 STEPS | 52 STEPS
CYCLE TIME | IN MTHS | IN MTHS
MIN | 2 | 1
MAX | 5 | 2

OTHER VALUE GENERATION:
- Front ending of technical commercials for improved concept creation
- Increased quality and completeness of development scenarios
- Reduced cyclical involvement of resources

CONVENTIONAL

- Step 1
- Step 2
- Step 3
- Step 4

FDP DIGITAL ECOSYSTEM

- Step 1
- Step 2
- Step 3
- Step 4

AS-IS

TO-BE
Technology:
- Subsurface centric
- Operator centric (enhancement)
- Service provider centric
- API readiness for cross FDP platform integration (Front end concept, Economics)
- The industry (Operators and Technology Providers) must collaborate and be more open to integration

Business Model:
- Profile based subscription (named user) for PTS and FDPlan
- Limited scalability – the need for a fit for purpose access model
- Concurrent user subscription (Enterprise FDPlan access to FDP team rather than by engineer)

Competency:
- High dependency to Vendor for technical support and tech apps familiarity
- Not sustainable for digital adoption – require cross domain integration to deliver end-to-end workflow for users to be self sustainable
- Super user within disciplines fraternity on DELFI technology

Recommendation & Way Forward

Existing Solution
- Forward Plan
- Constraints
Thank you for your passion!