Deepwater Asset Optimization using Performance Forecasting

PETRONAS-PETRAD-INSTOK-CCOP Deepwater Workshop

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24th - 26th January 2011
PERFORMANCE FORECASTING
What is Performance Forecasting?

Reliability
- Equipment performance data i.e. Mean Time To Failure (MTTF), Mean Time To Repair (MTTR)
- System configuration & redundancy e.g. 2 x 50%, 2 x 100%

Maintainability
- No. of maintenance resources
- Shift constraints
- Mobilization delays
- Spares constraints

Availability
- Equipment / System Uptime e.g. 95%

Operability
- Ramp-Up / Restart times
- Flaring constraints
- Production / Sales demand
- Storage size
- Tanker Fleet and Operations

Production Efficiency
- Achieved production
- Production losses
- Criticality
- Contract shortfalls
- Flared volumes

Unit Costs/Revenue
- Product price
- Manhour / spares costs
- Transport costs
- Discount rates

Net Present Value
- Lost Profit Opportunity
What is Production Efficiency?

PRODUCTION EFFICIENCY = \frac{\text{Actual Production}}{\text{Potential Production}} \times 100\%
Why Performance Forecasting?

1. Predict achieved production and **deferment** over life

2. Predict **intervention requirements** and **maintenance utilisation** over life

**Optimum development option should not just be decided by CAPEX!**
Why use dynamic simulation for Performance Forecasting?

- Timing of failure may affect repair duration
- Explicit modelling of weather impacts depending on season
- Correctly reflect delayed production impact of certain failures
- Potential delay of repairs because of back-log
- Reflect system changes over time
- Use any type of failure distribution for equipment items
- Capture probability of multiple failures in 2x100% systems
- Reflect actual intervention strategy: when do you intervene?
- Track use & availability of spares – with potential delays
### When can it be applied?

<table>
<thead>
<tr>
<th>Concept</th>
<th>Design</th>
<th>Operations Optimisation</th>
</tr>
</thead>
</table>
| ▪ Compare performance of various development options  
  ▪ New technology (e.g. subsea separation vs. multiphase pumping)  
  ▪ Impact of spare wells  
  ▪ Subsea to beach vs. Subsea to shallow water platform | ▪ Define minimum availability targets for specific equipment to meet project target  
  ▪ OPEX forecasting for project economics  
  ▪ Intervention vessel workload for medium to long term planning | ▪ What is the optimum intervention strategy?  
  ▪ What is the impact of improving intervention response times?  
  ▪ How many capital spares should I keep?  
  ▪ What will be the impact of ageing facilities / wells on achieved performance? |
DEEPWATER CASE STUDY
Deepwater Case Study

Overview

Development located at 800 m water depth

Conventional subsea production wells

Production to host facility

Flowlines, risers and control umbilicals

Sand control subsea production wells
Deepwater Case Study

Objectives

- What questions need to be answered?
  - What is the expected production efficiency and associated revenue loss?
  - What are the major contributors to production deferment?
  - What are the expected intervention vessel requirements and associated OPEX throughout field life?
  - Should we drill an additional well to achieve N+1 configuration?
  - Should we install redundant control jumpers?

- What data do we need?
  - Equipment performance data i.e. failure and repair data
  - Well production forecast
  - Intervention vessel data e.g. response times, ad-hoc vs. contract
  - Economic parameters e.g. vessel day rates, oil price
  - Others e.g. weather impacts, operational philosophy, planned intrusive maintenance
Deepwater Case Study
Input: Subsea

Subsea Sand Control Well

Umbilical & Riser

Subsea Production Manifold & PLET

Dry Tree Unit
Deepwater Case Study

Input: Production Profile

- All wells are online and producing throughout field life
- Assume equal production from all wells – no spare capacity i.e. system is well constrained
- Assume that oil deferment results in plateau & field life extension

Oil production profile
Total recoverable reserves: 394 MMbbls
Deepwater Case Study
Input: Topsides

Dry Tree Unit Systems
Deepwater Case Study
Input: Intervention

Subsea Equipment
- Tubing
- SCSSV
- Sand Screen
- Tree Valves
- Choke Valves
- Jumpers
- Subsea Control Module
- Flying Leads
- etc.

Intervention Vessels
- Drilling Rig
- Remote-Operated Vessels (ROVs)
- Diving Support Vessel (DSV)
- Light Weight Intervention Vessel (LWIV)
- Multipurpose Support Vessel (MSV)
- etc.
Deepwater Case Study
Input: Reliability Data for Subsea Equipment

- Challenges exist in obtaining best-in-class reliability data:
  - Low failure rates (equipment designed to last field life / fault tolerant)
  - Not all failures require intervention – function of failure impact and intervention cost
  - Most detailed databases are not public domain

- Typical data sources:
  - Subsea subsurface – generic well data can be considered
    - Wellmaster (SINTEF / EXPROSOFT)
    - SINTEF reports (SSSV, completions, well valves)
    - In-house operator databases
  - Subsea surface facilities:
    - OREDA VII Subsea / OREDA 2009
    - Subsea Master
    - In-house operator databases
Deepwater Case Study
Deliverables: Production Efficiency

- Through-life performance: 96.3% (174.4MMbbls/year)
- As result of deferment, the decline profile is delayed and production must continue for further 1.5 years to recover all oil from base case profile
Deepwater Case Study
Deliverables: Equipment Criticality

- Equipment criticality: 3.7% absolute losses (6.7MMbbls/year)
- What are the causes of these losses?
Deepwater Case Study
Deliverables: Rig Utilization

- Number of drilling rig utilization days per year by equipment type translates into OPEX through vessel day rates.
- Rig utilization increases gradually up to 75 days per year as well equipment items wear-out.
Deepwater Case Study
Deliverables: ROV Utilization

### Predicted ROV Vessel Utilization

- **Average predicted annual OPEX for subsea interventions (ROV and drilling rig) is $11million.**
- **Increases gradually from $6million / year at start of life until $15million/year later in life.**

### Predicted Average Utilization per Annum

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Nr of Mobilisations</th>
<th>Nr of Activities</th>
<th>Annual Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rig</td>
<td>0.74</td>
<td>1.7</td>
<td>51.0</td>
</tr>
<tr>
<td>ROV</td>
<td>2.5</td>
<td>5.0</td>
<td>26.1</td>
</tr>
</tbody>
</table>
Deepwater Case Study
Sensitivity Case 1

- **Base Case:**
  - Non-redundant subsea control jumpers

- **Sensitivity Case:**
  - Dual redundant control jumpers. Control pods able to switch supplies automatically

  +0.2% in production efficiency (~ +0.04MMbbls/yr) due to reduced downtime associated with failed control jumper

  Reduction in the predicted number of ROV interventions

  **Savings far exceed the increase in CAPEX associated with installing new control jumpers.**
Deepwater Case Study
Sensitivity Case 2

- The base case assumes no spare well capacity
  - **Pro**: Minimum CAPEX
  - **Con**: Any production well outage results in immediate deferment i.e. system is well constrained

- What would be the impact on project economics if a spare production well could be included at a cost of $20 Million?

Define identical production well to achieve N + 1 configuration
Deepwater Case Study
Sensitivity Case 2

- Sensitivity model with spare well predicts:

<table>
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<th>Benefit</th>
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<tbody>
<tr>
<td>Initial CAPEX investment of $20 million</td>
<td>Average production efficiency increases by 3.3%, effectively</td>
</tr>
<tr>
<td>OPEX increases marginally by 8% due to increased intervention</td>
<td>mitigating for all single production well outages.</td>
</tr>
</tbody>
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- Overall project NPV improves by $35 Million (including impact of upfront $20million well cost).

- In conclusion, addition of spare well at $20 Million is a robust improvement option at given oil price:
  - Only with oil price less than $50/bbl can the spare well no longer be justified.
Summary

- Subsea performance forecasting using dynamic simulation (MAROS) is a proven technique.

- It has been successfully applied by DNV for more than 10 years:
  - BP (all UKCS and GoM subsea assets)
  - Shell (GoM, WoA, Malampaya)
  - ChevronTexaco (most WoA & GoM assets)
  - ExxonMobil (WoA assets, Bass Strait)

- Even with data uncertainty, methodology can still be applied successfully in comparative analysis

- Performance forecasting can provide operators with innovative, value added solutions to asset and risk management problems from concept selection through detailed design.
## DNV Subsea PF Experience

- BP - Thunder Horse Development
- BP - Atlantis Development
- BP - Mad Dog Development
- BP - Neptune Development
- BP - Mica Topsides
- BP - Marlin Area
- BP - King / Kings Peak
- BP - Shell Na Kika Development
- BP - Holstein Development
- BP - Horn Mountain Development
- BP - Foinaven
- BP - Schiehallion
- Chevron - Agbami Development
- Chevron - Tahiti
- Chevron - Benguela Belize
- Chevron - Lobito Tomboco
- Chevron - Jack/St Malo
- Chevron - Hebron Development
- Chevron - Frade Development
- Chevron - Kuito Development
- ConocoPhillips - Belanak Development
- ExxonMobil - Erha Development
- ExxonMobil - Yoho Development
- ExxonMobil - Kizomba A & B
- ExxonMobil - Pluto
- Shell - Bonga Main
- Shell - Bonga South West
- Shell - Malampaya
- Shell - Osprey
- Shell - Gannet
- Shell - Pelican
- Shell - BC10
- Shell - Gumusut
- Shell - Malikai
- Statoil / Hydro - Ormen Lange
- Statoil / Hydro - Asgard
- Statoil / Hydro - Gjoea
- Enterprise - Corrib
- Enterprise - Bijupira Salima
- Petrobras - Chinook/Cascade
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