THE DIGITAL OIL FIELD IN PRACTICE

How the DoF can be used in high uncertainty and low RT measurement contexts

INTRODUCTION

Many fields experience significant data quality and availability issues. Real-time, digital oilfield (DOF) systems are often viewed as the exclusive preserve of fields with high levels of data availability and frequency. The DOF can also provide a significant amount of value to systems that have significant data issues.

This field case details how the Petroleum Experts DOF system was used to address some significant technical challenges experienced by the field. In particular the serving to reduce the uncertainty present in the system and address some of the data availability and quality issues.

CHALLENGES

One of the main challenges that was experienced by the field was the significant uncertainty in current operating conditions; this stems from a historical lack of adequate allocation data and the inability to test many of the wells on their own.

In many systems the ‘test-by-difference’ principle is used to infer producing conditions from wells that cannot be tested individually. In this field, this technique does not allow for a complete understanding in the system since there is very little real-time information available for many of these wells also (e.g. ≈50% of WHP and/or FLP gauges are currently not working…). These complications mean that there has been a great deal of uncertainty in the current operating conditions and consequently production allocation for some time.

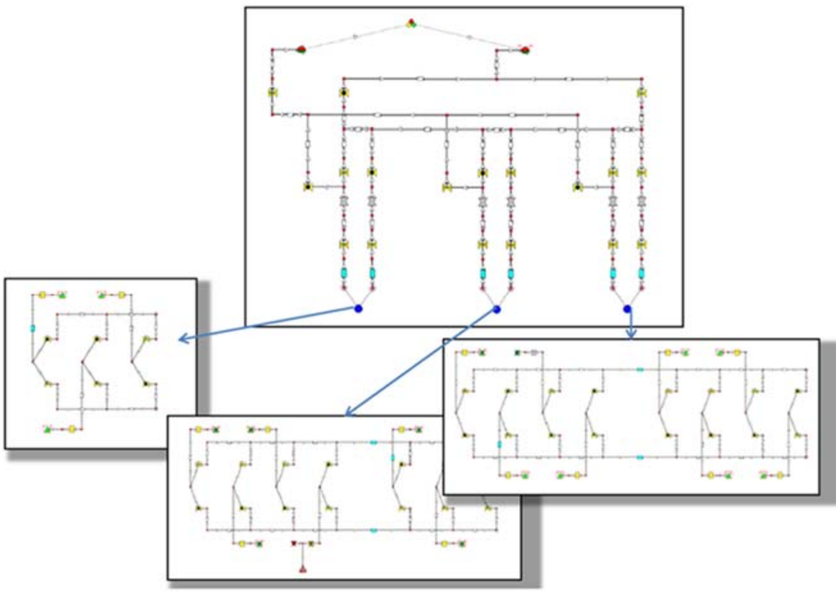
FIELD DESCRIPTION

The field consists of 5 subsea templates produced through 6 risers. There are a total of 22 Gas lifted wells and one gas injector. The field has 2 separators, one production, and one test separator.

Perhaps one of the most significant uncertainties in the system is the gas-lift gas injection rate provided to each well.

This creates a substantial issue when attempting to generate an understanding of the current water cut and gas oil ratio being produced through each well.

Compounding this issue is the fact that the gas lift injection system is also being used to provide gas to the gas injector for the field.



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OBJECTIVE OF THE SOLUTION

The main objective of the solution is to provide a system that can be used to optimise the production system. To achieve this it is first necessary to create a valid physics-based model tuned to the current production conditions.

SOLUTION FORMULATION

- Enable field surveillance through real-time production monitoring
  - ⇒ Considering the data availability issues
- Implement standard workflows:
  - ⇒ AWS – well surveillance
  - ⇒ GLA – Gas-Lift allocation
  - ⇒ SQC – System Quality Control
  - ⇒ MWA – test separator multi-well allocation
  - ⇒ MWA – field wide multi-well allocation
  - ⇒ OPT – Optimisation
    - ⇒ Production system optimisation {Gas lift allocation, well control optimisation}
    - ⇒ GIRO {well/riser routing optimisation}
- Create a platform within which any custom field surveillance workflows can be leveraged

The high level solution: Petroleum Experts Digital Oilfield

To be able to achieve the stated objectives (and overcoming the issues), a production optimisation surveillance system is necessary that combines the physical models of the field with real time data. The petroleum Experts Digital Oilfield was chosen to do this.

The premise was to capture the entire system from wellbore to the production and test separators, whilst being connected to a high frequency real-time data. This was achieved using the following Petroleum Experts tools: PROSPER, GAP, RESOLVE, IFM and IVM.

A Detailed Description of the Solution

The Digital Oilfield (DoF) is made up of three key layers (under which we may sub categorise tasks/software):

- Physical Models (IPM)
- Integrated Field Management (IFM)
- Data Management and Integrated Visualisation of the system and its associated sub components (IVM)

CASE STUDIES

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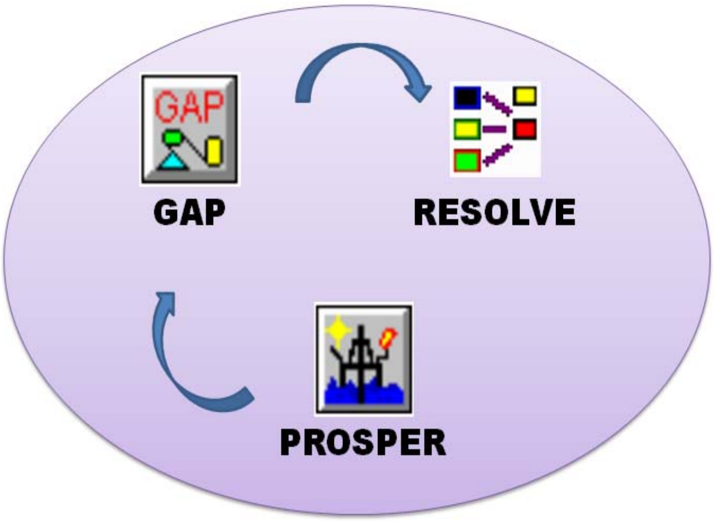
Integrated Production Modelling (IPM)

The Integrated Production Modelling (IPM) tool kit was used to build models which captures the physics, these were built using PROSPER, GAP and RESOLVE.

These physical calculators (physical models) are at the core of all of the engineering calculations.

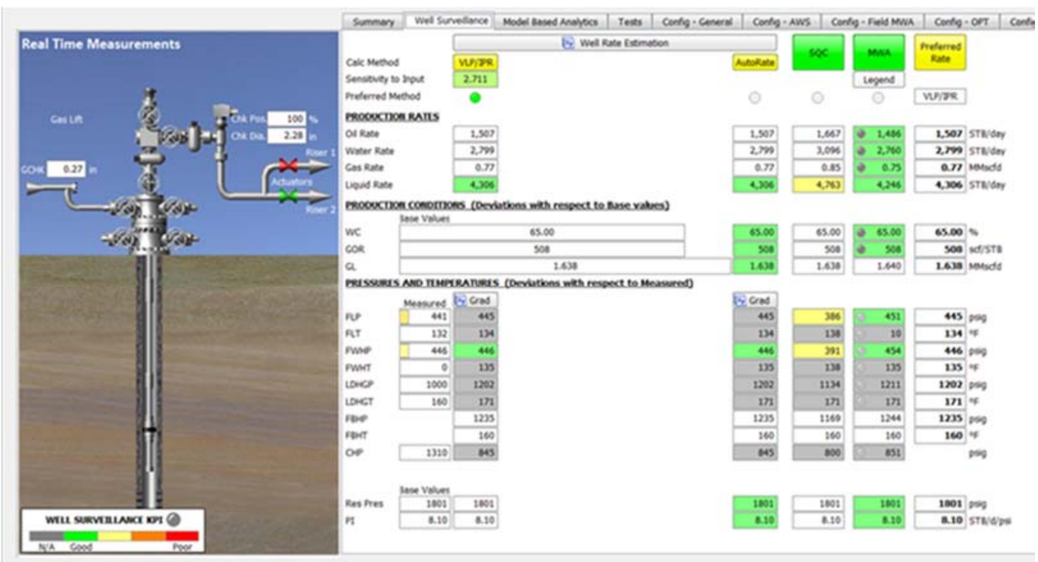
Integrated Field Management (IFM)



These models are intended for use by engineers to represent field reality and as such a system is required which can identify and remedy any deviations from reality. This meant that a system needed to be provided which could help in identifying the causes for any divergence between model and reality. IFM is composed of two sub systems: Model Catalogue and the Workflow manager. The IFM workflow manager automates the calculations carried out with the physical models; one example would be the Network Pressure Estimator.

Data availability issues

One significant challenge that presents itself in this field is the significant lack of available real-time field measurements. Around 50% of the wellhead pressure gauges (FWHP) and flow line pressure gauges (FLP) are not currently functioning. Many downhole gauges are also not functioning. (Fig. 5)



CASE STUDIES

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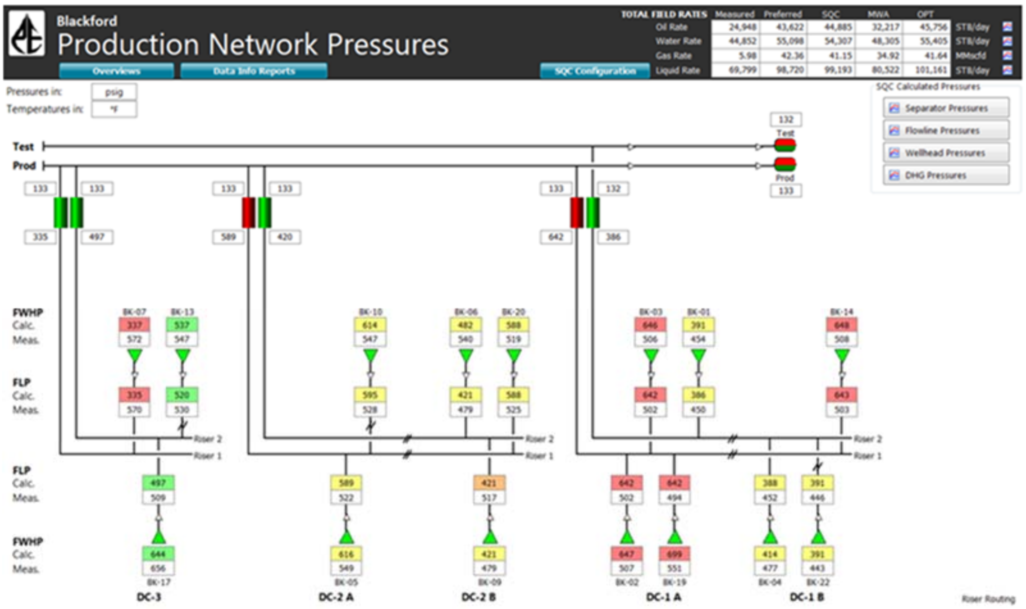
Many of the wells in the system however were produced through sub-sea templates that were shared with wells that did have pressure gauges. A custom workflow was therefore developed that could infer pressures for the missing data using gauges that were close-by.

The workflow encapsulates a logical set of steps that is used to select the most appropriate gauge to use to calculate flow line and wellhead pressure. The workflow is run in real-time, selecting a proximal well if possible, then if none is found finding a well that is producing through the same riser and applying a pressure correction to the measured pressure.

Since each well on the template can be produced through two risers this workflow is run at high frequency in order to capture the correct FWHP and FLP for each well in as close to real-time as possible.

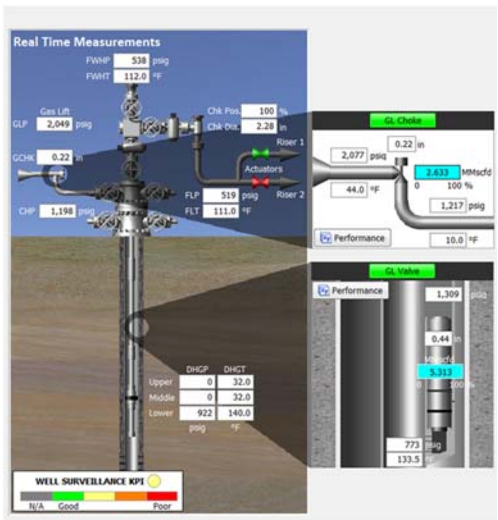
Another example of such is the GLA workflow that pulls the available gas lift injection data in order to accurately capture the response of the gas lift gas provided to the wells.



The GLA workflow leverages all the available information to calculate the gas lift rates being provided to the wells. These calculated rates rely on different boundary conditions, the concept of redundancy that is utilised in many of the workflows allows the GLA workflow to monitor and validate the allocated gas lift rates as well as the performance of the individual gas lift chokes and gas lift valves in the wells. (Fig. 4)

In addition to balancing the rate calculations using the different methods the GLA workflow performs sensitivities which are designed to calculate the systems required to match the calculated rates.

These values can be used to match the performance of the wells and provide valuable information to the surveillance engineers that can be used to calibrate the well models. (Fig. 5)



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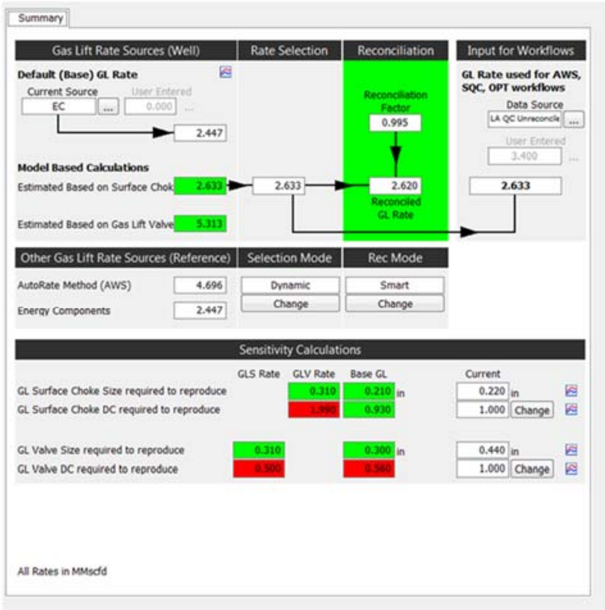
An additional validation point that can be exploited in the system is that the total gas lift gas allocated to each well must equal the total injected into the system; a quantity that can be more easily measured at the facilities. (Fig. 6) In fact it is critical to ensure that the calculated rates for the gas lift can be reconciled to the total measured for the field. This provides another validation that the physical models reproduce reality.

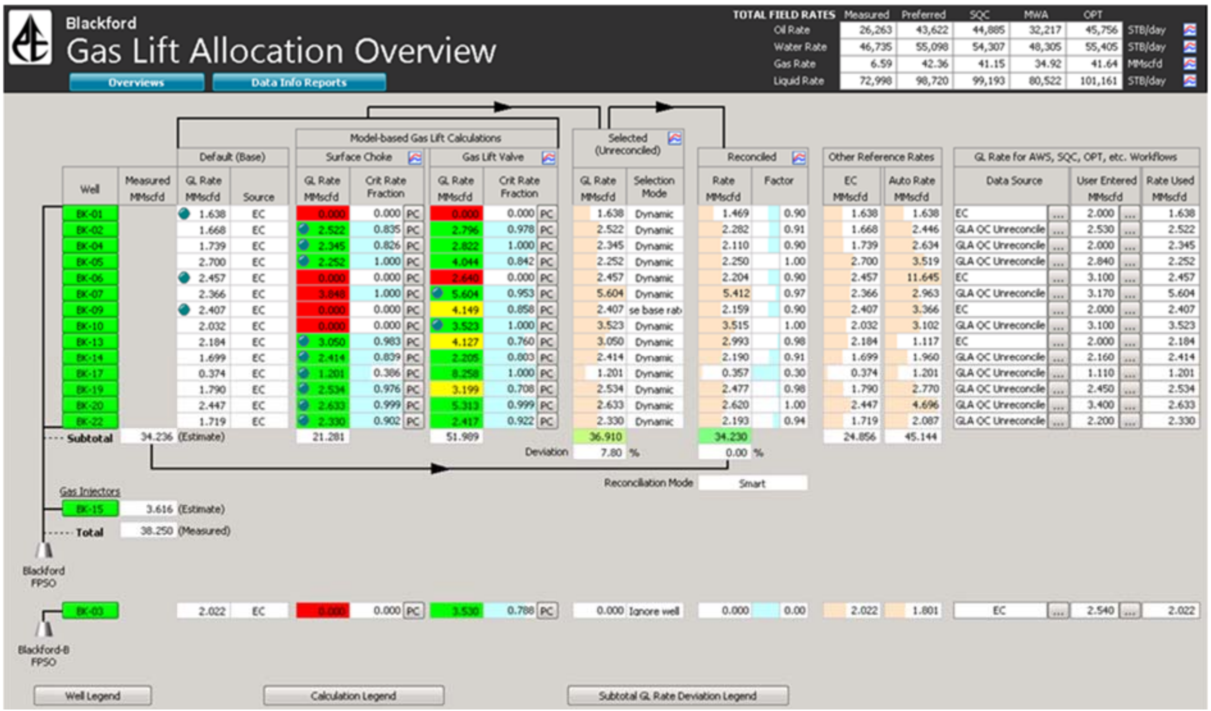


The GLA workflow contains a number of methods that can perform this reconciliation.

The AWS workflow is then used to compliment the GLA workflow in that it can exploit any data redundancy by performing as many well performance calculations (e.g. rate estimations) as possible using different methods (and subsets of data), challenging our understanding of the reality of the well from as many 'angles' as possible.

Each method attempts to isolate one element of the well so that it results focuses primarily on one clearly defined aspect of the well (e.g. Inflow Performance, ESP, Wellbore, Choke, etc.).

As each method is affected differently by the input data used (many of which are uncertain values such as current production conditions), the results of the various methods can be used to validate not only the physical models but the real-time data from the field.



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Multi-well allocation

The AWS and GLA workflows are then complimented by the use to the Multi-well allocation workflow (MWA). This workflow is used to allow the system to extract the necessary information to generate well test information for the wells that currently have the greatest uncertainty.

The MWA workflow monitors both the test separator and the field as a whole. The DOF system automatically detects which wells are in test and uses the MWA to test the wells in real-time continuously through production. It is therefore possible to implement a testing regiment that aims to combine wells that have the largest quantity of available data (also wells that can still be tested individually) and wells that still have significant uncertainty to generate useful production test data.

Summary

In the well metered and high frequency data available contexts, the Digital Oil Field system are continually proving themselves as an invaluable resource to all serious operators looking to maximise production, and minimise production loses through better understanding of the field response.

The above case is a very good example of how the very same approach could be (and is currently) being applied to fields with data frequency and quality issues. In this context, using multiple workflows (to create redundancy in calculations) and deductive reasoning the engineer can gain a much clearer understanding of what is happening in the system, and thus make higher quality decisions.