CASE STUDIES

RESOLVE Case Study:

Stochastic Scenarios in Field Planning

INTRODUCTION

Production from oil or gas fields is associated with various events and associated field activities that are performed throughout field life. These are performed usually with the aim of repair/maintenance of equipment to ensure long term stable production, with a view to maximising production and recovery. These events and activities sometimes have adverse effect on the instantaneous field production.

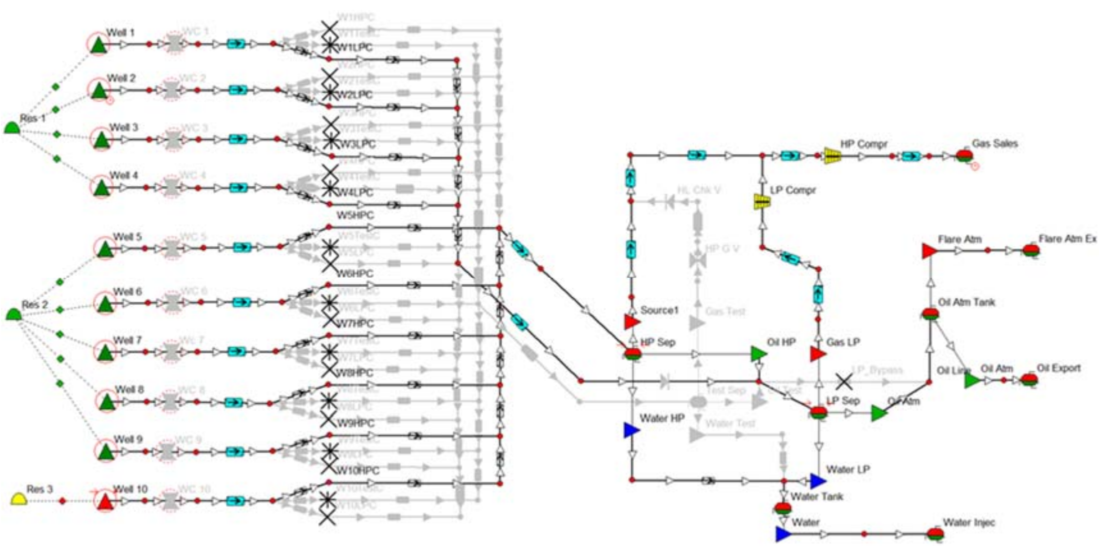
There are two types of interventions in this context: (i) Planned and (ii) unplanned. In the latter, unplanned well shut down or ESP wear will result in production losses. In the former, increasing well productivity through well work over activity (e.g. acid stimulation of the completion) will improve production. However, in both contexts a temporary stop of production is required: the described fluctuations in production need to be carefully planned and mitigated. This becomes particularly important when production commitments (e.g. daily contractual quantity constraints) are in in place with legal and financial implications for not honouring the agreed production rate.

To plan and mitigate unnecessary production downtimes, the industry is now tending towards field activities being simulated in physical models to understand the overall impact – for instance numerical representation of the field and the scheduled downtimes can be used to understand the implications of these production fluctuation on the reservoir. Provided that models are calibrated and up to date, they can be used to generate field production profiles. Implementation of production stoppage in the physical model is usually straight forward and achieved through various mechanisms in whichever tool is being used (e.g. schedules, DCQ tables, workflows, macros, etc.). The difficulty lies in predicting when and how long the production stoppage will occur, and this is usually left to the discretion of the engineer and their knowledge of the field (as it is an input to the simulations).

As always whenever engineering judgment needs to be exercised, it hinges upon the engineer applying it. The uncertainty that is carried by the scheduled downtimes will significantly change the production profiles, and as such an alternative to engineering judgment is to use statistics and parameterise the downtime value. The following case study demonstrates a method to use statistics which parameterises these downtimes, and subsequently runs multiple scenarios to understand the impact of the downtimes.

FIELD DESCRIPTION

The production system consists of three (3) reservoirs: two (2) oil and one (1) condensate producing interval (see below GAP schematic). The surface network includes 10 production wells, two (2) main pipeline systems leading to two separators (LP and HP) with gas compressors on each system. The high pressure separator is constrained by maximum liquid rate and gas rate it can pass. It is also possible to route wells between the HP or LP systems. The system layout is shown in the figure below.



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The field has been in production for a number of years, allowing the operating company to accumulate information regarding the field behaviour and its equipment. Field control and maintenance are driven by the model, and as such the model is regularly kept up to date and is representative of reality.

OVERALL ENGINEERING OBJECTIVES

The objective of the project is to generate production profiles and estimate cumulative production for the field over the next year taking into account various plausible field events. The following set of events should be included in the forecast:

- Planned
  - ⇒ Separator corrosion maintenance – there is planned corrosion maintenance for the low pressure separator. During this period production will flow to the HP system.
  - ⇒ Well stimulation – this is planned in the middle of the year for two wells that have a low productivity index;
- Unplanned
  - ⇒ Separators shutdown – separators in the system are subjected to unplanned shutdowns for around 6% of the total production time (Historical Trend);
  - ⇒ Wells are shutdown for workover – all wells in the system are subjected to unplanned shut downs for workover and maintenance;
  - ⇒

To incorporate the above objectives into a physical model and run scenarios, the following overall steps will be required:

- Step 1: Generate a set of assumptions with regards to the field future events.
- Step 2: Implement assumptions in the model.
- Step 3: Generate production forecast within those assumptions.

STEP 1: THE STATISTICAL APPROACH IN IPM

The above events can be accounted for in the GAP model using ***Downtime factors*** for wells shutdowns, ***Unscheduled Production Deferment*** for separators shutdowns and ***Equipment Schedule*** for planned events such as well stimulation and corrosion maintenance.

In other words, if downtimes values, dates and resulting productivity indexes are known a priori they can be implemented in the model. Implicit in this approach is a confidence in the unplanned events frequency: if this changes over time with no real consistency, then this could lead to violation of contractual obligations due to imprecise assumptions.

It is therefore required to develop a more holistic approach towards short term forecasting and planning using existing experience (including possible uncertainties that are implicit in all planned events). Uncertainties in the events can be taken into account using statistical approaches. In this case each parameter that should be taken into account should be assigned with a ***probable value*** and a ***distribution***.

For example, the planned well stimulation job can be set for a particular date and it is planned to have a certain resulting PI. Based on previous field experience planned acid jobs can be shifted earlier or postponed for 2 weeks depending on other events in the field. The resulting PI of the well in question may also vary in the range of 1.5 units (STB/day/psi).

Once assumptions like the above are set for all parameters, it is possible to run multiple realisations of the model and analyse the resulting values.

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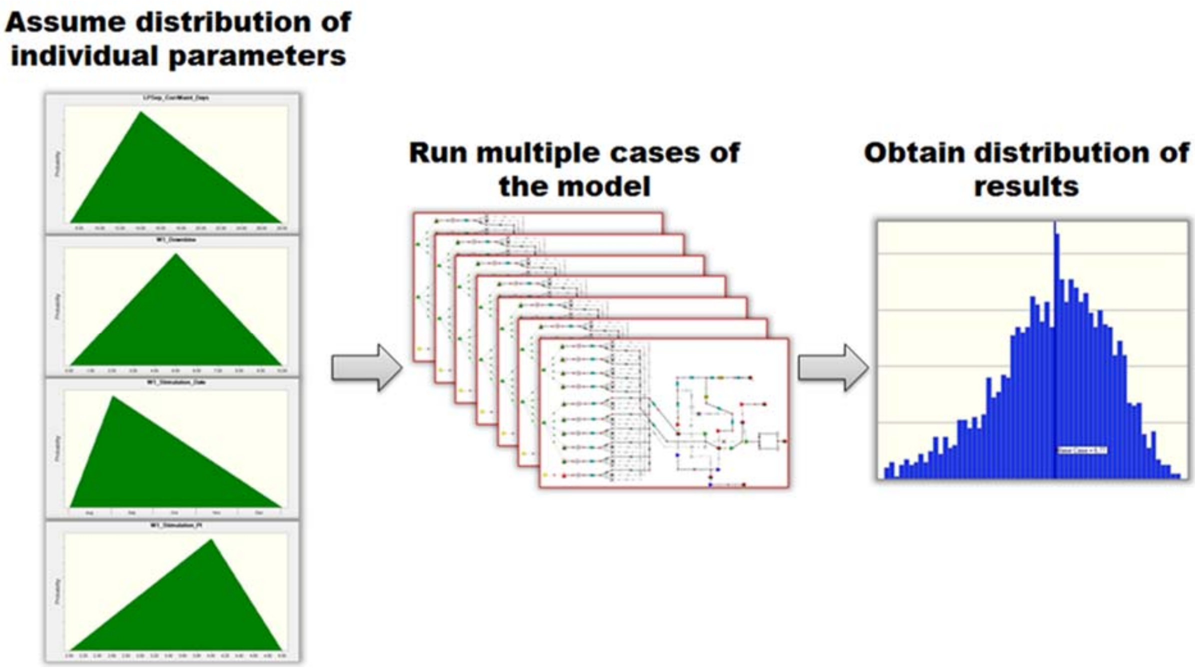

STEP 2: MODEL ARCHITECTURE AND SETUP

To define assumptions and generate a set of input values a statistical analysis tool, such as Crystal Ball can be used. It is then required to pass data to GAP for calculations. This is run multiple times to obtain distribution of cumulative production, which can of course be saved and later analysed for decision making. It is therefore required to establish a dynamic integration between Crystal Ball and GAP: this will be achieved using RESOLVE.

The RESOLVE model setup consists of the following elements:

1. GAP model. GAP, the multiphase network optimiser is the platform in which the reservoir, well and surface network is integrated and then optimised.
2. Controlling workflow. This workflow is used to control the GAP run externally and essentially sets the input parameters into GAP, runs the calculations and finally extracts the results.
3. Crystal Ball analysis tool. This analysis tool in Excel will be used to generate input data for GAP and analyse results returned after the calculation.

The last two elements – *Crystal Ball* tool and *Controlling Workflow* are pre -packaged together in the *Crystal Ball data object*. The overall system architecture and corresponding RESOLVE model layout are shown in the figures below.

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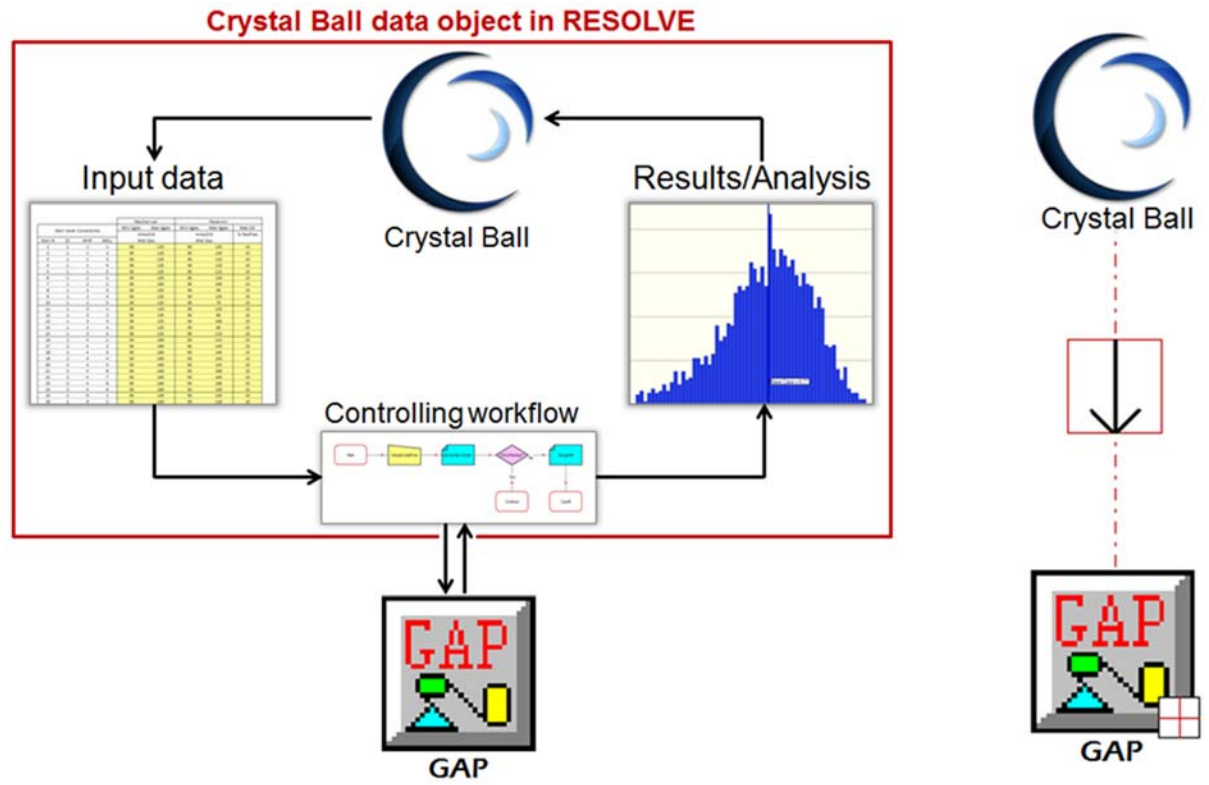
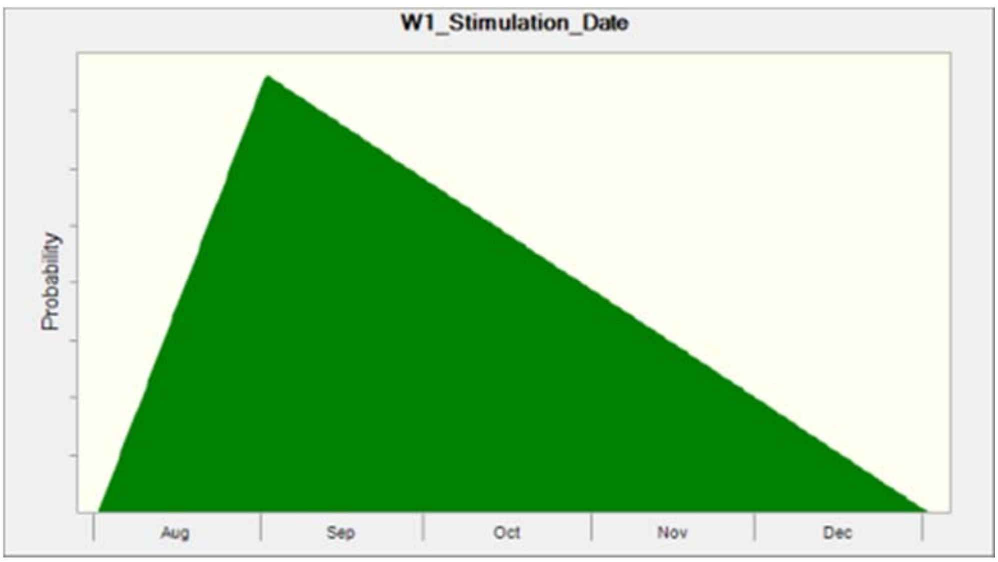


Following the above logic the Crystal Ball object was setup with assumptions for uncertain parameters, number of cases to run and resulting variables that should be generated by GAP. Examples of distributions for well stimulations date and PI are shown in figures below. Resulting variables were provided to Crystal Ball to utilise its functionality in terms of analysis, such as building distributions for specific parameters and correlations.



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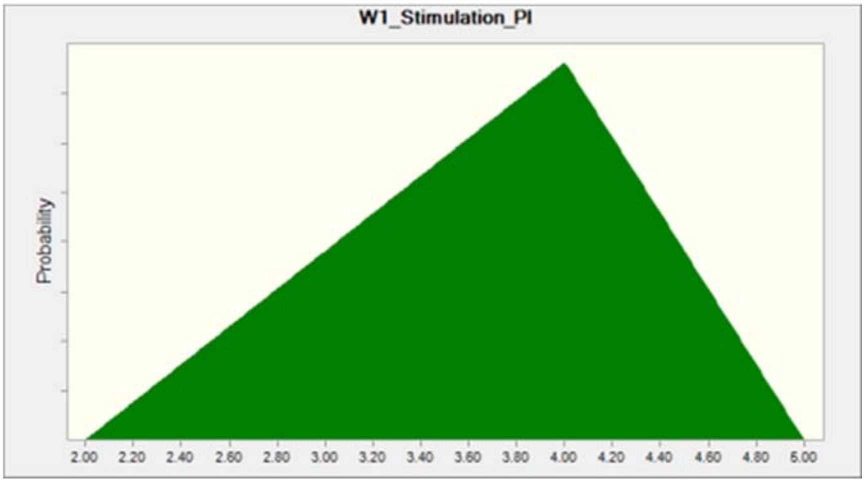
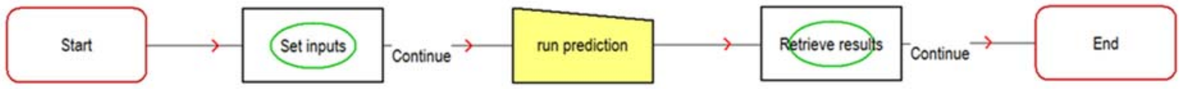
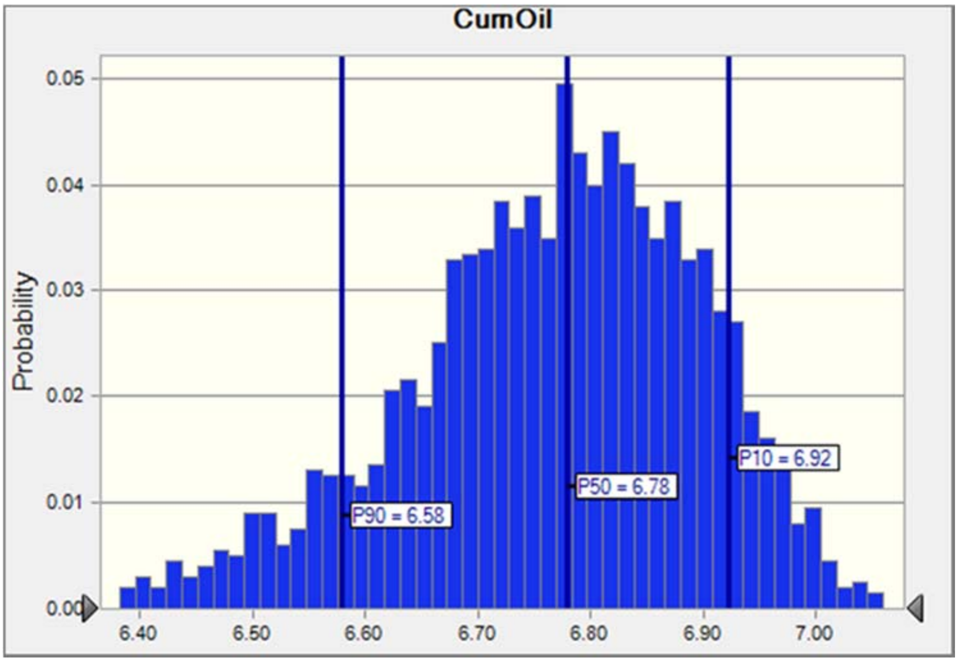


Controlling workflow was defined to run a full year forecast of the GAP model.



STEP 3: RESULTS AND ANALYSIS

Running 1000 cases of the model allowed the construction of a cumulative Gas and cumulative Oil Production profile for the year ahead: the results are shown below.



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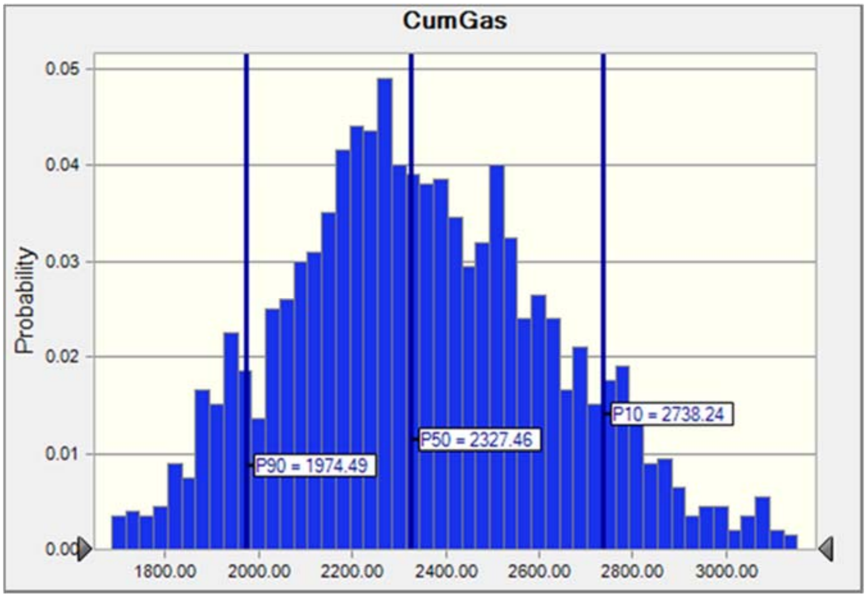

Combining the above results, and demarking the section of the distribution where contractual obligations are not met highlights the probability of these events becoming true. Following on from this, an analysis can be performed to look at what series of events led to these results, and subsequently what mitigation actions (e.g. preventative maintenance) can be performed. The net result of this process is to create a more refined planning process for planned field events, and how to respond to unplanned scenarios.

All individual cases are stored in the Crystal Ball data object, hence allowing the above analysis ad post rationalisation of the scenario failure modes. The results were also used to generate the most probable version of the model to be used for other studies during the year.

SUMMARY

This approach considers the stochastic nature of reactive maintenance and also considers the planned operations, both of which are an operation reality in the field. This approach also demonstrates how statistical methodologies can be used in planning and decision making processes to narrow down uncertainty associated with field activities.

The described approach covers a full range of various field events starting from equipment maintenance to full field shutdown. Flexibility in implementation is provided through the controlling workflow that utilises the full power of both Crystal Ball (a statistical tool) and any underlying physical model. To achieve all of the above, three simple steps were followed:

Step 1: Generate a set of assumptions with regards to the field future events.
Step 2: Implement assumptions in the model.
Step 3: Generate production forecast within those assumptions and analyse the response.