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Integrated Model Based Decision Analysis in Twelve Steps Applied to Petroleum Fields Development and Management

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Introduction

This text is based on the paper SPE174370 (Schiozer *et al*, 2015) and describes a methodology based on 12 steps for decision analysis related to petroleum fields development and management considering reservoir simulation, risk analysis, history matching, uncertainty reduction techniques, representative models and selection of production strategy. The main focus of the results is to show that the method can be used in practical applications, i.e., complex reservoirs in different field stages (development and management) because it allows the integration of static (geostatistical images generated by reservoir information) and dynamic data (well production and pressure) to reduce uncertainties allowing risk analysis integrating geological, economic and other uncertainties yielding a decision analysis based on risk-return techniques. In this methodology, no proxy model is used so reservoir simulation is used directly to reproduce field performance. We also show that the methodology is efficient and easy to use, even in complex cases where the computational time is an important concern and in real time operations.

Methodology

The methodology is based on the Closed Loop Reservoir Development and Management (Figure 1). The 12 steps of the methodology are structured as: (Step 1-2 in green, Steps 3-5 in red, Steps 6-11 in blue, Step 12 in black)

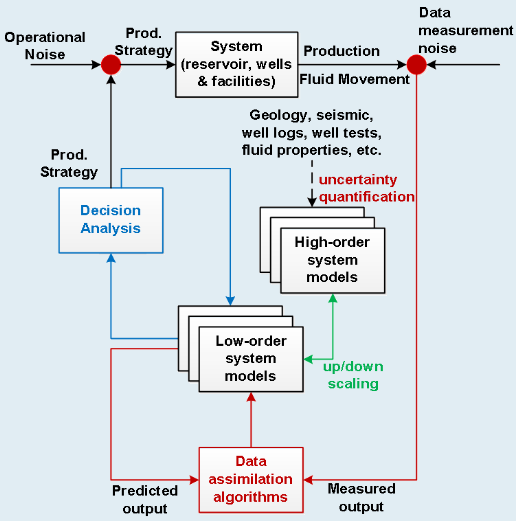

Figure 1: *Closed Loop Reservoir Development and Management (adapted from Jansen* et al, *2008)*

1. Reservoir characterization under uncertainties (to build models, develop scenarios and estimate probabilities). This is a crucial step and a multidisciplinary approach must be applied to consider all possible important uncertainties which for this problem are mainly: reservoir, fluid, economic and operational parameters.
2. Build and calibrate simulation model: in order to have accurate risk quantification, it is necessary to trust in the response of the model for each scenario created; therefore, it is necessary to calibrate the simulation model to have a fast response but robust enough to avoid bias evaluation. A high fidelity model is normally necessary because the interaction between the reservoir model and the production strategy so we have not use low fidelity models (proxies, emulators, for instance). The calibration is normally done with a Base Case (called Base0 in this work).
3. Verify inconsistencies of the Base Case with well dynamics data: scenarios correction and uncertainty. This step is normally simplified in the risk quantification methodologies but it is a very crucial step because, many times, it may avoid inconsistency between the model and the data from the fields. A typical history matching procedure can be used in this step.
4. Scenarios generation considering all possible scenarios (Schiozer *et al*, 2016).
5. Reduction of scenarios with dynamic data: the Base Case and uncertainties in reservoir and fluid properties are used to generate probabilistic scenarios. Several techniques can be used to reduce the number of possible scenarios that represent the case depending on the complexity of the case and amount of data. With the selected models, a base case must be selected to be used in the next step (Base1). The usual recommendation is to use a model that is close to P50 in all main indicators for the initial strategy. The step of selecting a new Base Case that represents an intermediate case (Base1) may be necessary if the Base0 does not honor the dynamic data or becomes an optimistic or pessimistic bias.
6. Selection of deterministic production strategy for Base Case. The decision (production strategy) and the risk quantification have mutual influence so it is important to use an iterative technique to select the production strategy. The first production strategy (called here S1) is selected using an optimization procedure and the Base1 Model.
7. First estimative of risk curve, considering S1 with all possible scenarios from Step 5, has to be done. In many cases presented in the literature, this risk curve is used in the projects but we show in this paper that the final risk curve can be very different from this option.
8. Selection of Representative Models (RM) based on all objective functions and input variables (Meira *et al*, 2016).
9. Selection of production strategy for each RM repeating Step 6 for each RM.
10. Selection of production strategy under uncertainty including economic and other uncertainties, using a risk-return analysis combining all possible strategies and all possible scenarios. If the number of scenarios combined with the simulation time of each scenario is too time consuming the RM can be used to represent the uncertainties.
11. Identification of potential for change in the production strategy to improve chance of suc-

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cess based on the value of information, value of flexibility and robustness of the production strategy, implying in possible modifications and final strategy. In this step, we recommend an integration with production facilities to check viability of the solution.

12. Final risk curve and decision analysis.

Application

The methodology is applied in the field UNISIM-I-D which is a benchmark case based on Namorado field, Campos Basin, in Brazil (http://www.unisim.cepetro.unicamp.br/benchmarks/br/unisim-i/unisim-i-d).

Results

The complete results are available in the original paper (Schiozer *et al*, 2015). Steps 1 through 5 were used to build and calibrate the model. These steps were not so difficult due to the low amount of historic data. At the end of the probabilistic process, 214 models were selected to the decision making process.

Steps 6 through 10 generated the risk curves shown in Figure 2. The production strategy select in this case was S9 (details are given in the paper).

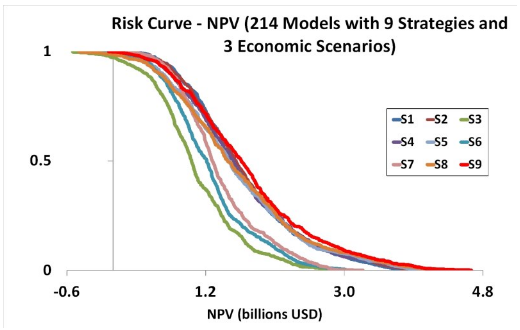

***Figure 2**: Risk curves for selection of best production strategy*

By analyzing each strategy applied to each representative model (Figure 3) it is possible to evaluate possibilities to change the strategy manually (Step 11 not shown here). S9 is now being studied in more detail to check potential improvements with information, flexibility, robustness, intelligent completion and integration with production facilities.

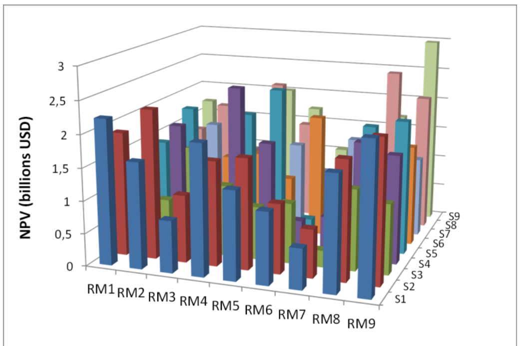

***Figure 3**: NPV of each strategy applied to each representative model*

Conclusions

We have presented a methodology based on 12 steps to be used in a model based decision analysis related to petroleum reservoir development and management under uncertainties.

Many times, several steps are not performed to speedup projects but we believe that, with the simplifications presented here, the methodology can be applicable to real cases even with complex models with long simulation time. Further simplification can yield suboptimal decisions.

The level of detail of each step is a function of the importance of the study and complexity of the case. The most time consuming part is the optimization of the production strategy and the results are a function of the quality of this process; therefore, it is important to use robust optimization processes.

The methodology is flexible enough to be applicable to reservoir in different life stages. We have presented a case in a development phase but it can be used in other stages.

Acknowledgments

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