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UNISIM-I-M: Benchmark Case Proposal for Oil Reservoir Management Decision-Making

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"UNISIM-I-M takes on special importance due to the lack of benchmark cases with known answers and complete reservoir models comprising geological, operational and economic scenarios."

Introduction

This edition presents the development of the UNISIM-I-M benchmark case, a set of simulation models representing the field and the information required for decision-making analysis in the oil field management phase, giving continuity to UNISIM-I benchmark studies. Using the feedback from previous benchmark cases - UNISIM-I-D (Gaspar et al, 2015) and UNISIM-I-R (Avansi and Schiozer, 2015a) - we present a proposal specifically for the management phase, the period after strategy implementation.

UNISIM-I-M is designed for research activities on decision analysis to select exploitation strategies in the reservoir management phase. This work presents the results of the construction of this benchmark and how it can be used.

UNISIM-I-M considers an exploitation strategy (Avansi and Schiozer, 2015a) already in place in the initial stage of the field development and waterflooding project with 25 wells (14 producers and 11 injectors) with history production data for the first 7 years.

Figure 1 presents a map of intermediate layer oil per unit area with the implanted strategy aiming to show the disposition of wells.

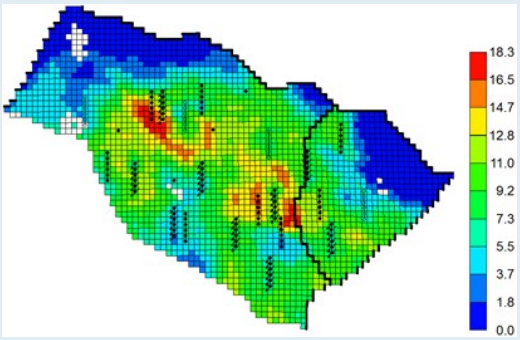


Figure 1: *Implanted strategy - Map in intermediate layer oil per unit area.*

Uncertainties

Uncertainties include: PVT data; oil-water contact; water relative permeability; vertical permeability multiplier; rock compressibility; 500 images with petrophysical characteristics related to facies, net-to-gross ratio, porosity, horizontal and vertical permeabilities; systems availability information; and economic scenarios. The simulation model, with affordable simulation time, is based on a reference model reflecting the characteristics of Namorado Field, Campos Basin in Brazil comprising real and synthetic data from the appraisal phase.

Construction of UNISIM-I-M

Based on a geological model, we used Discretized Latin Hypercube with geostatistical realizations - DLHG (Schiozer et al, 2015) to sample and combine with other uncertainties to generate 2000 possible scenarios. We obtained 1985 possible scenarios because some simulations were duplicated.

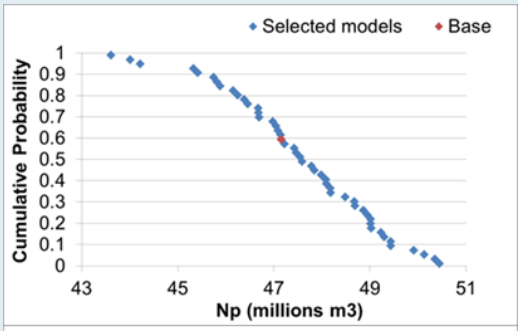
We applied a probabilistic history-matching process to reduce the number of scenarios according to the methodology proposed by Almeida et al (2014) and Avansi and Schiozer (2015b). The misfit between the models and the production history data were evaluated by quantification and diagnostic procedures considering acceptance levels and 78 objective functions simultaneously. The number of objective functions derived from 4.

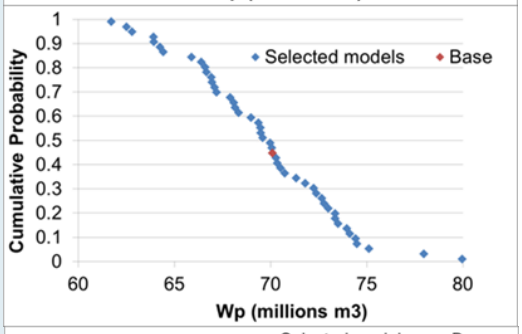
objective functions for each producer and 2 for each injector, considering oil production rates, water production rates, gas production rates, producer bottom-hole pressures, water injection rates and injector bottom-hole pressures.

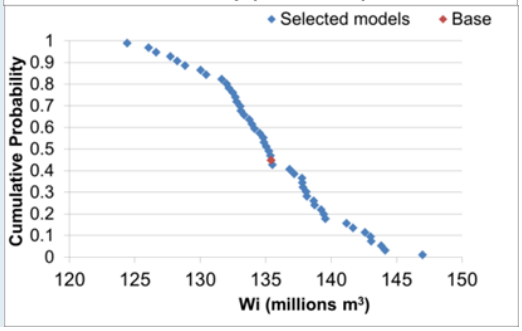
This yielded a set of 48 scenarios honoring the dynamic data with local modifications. Then, we added the technical uncertainties concerning availability of systems and considered the economic scenario. The technical uncertainties were also combined using DLHG.

Therefore, a set of 48 scenarios honoring the history data and considering all uncertainties compose the probabilistic case.

A model close to P50 in all main indicators (net present value - NPV, cumulative oil, water and gas productions - Np, Wp and Gp, cumulative water injection - Wi and oil recovery factor -







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"UNISIM-I-M provides challenges to test techniques for decision analysis in the management phase due to the uncertainties and complexity involved, constraints and the design and control variables to be optimized."

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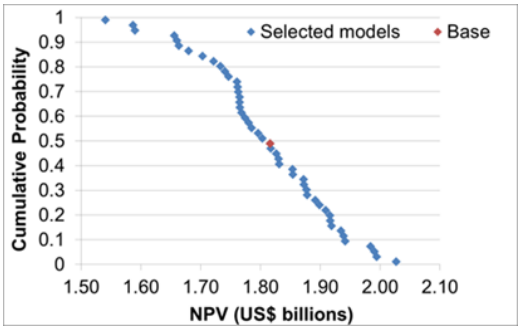

***Figure 2**: Risk curve of 48 scenarios for Np, Wp, Wi and NPV objective functions highlighting the selected base case.*

RFo) for the given exploitation strategy was selected as base case. Figure 2 presents the risk curve for some objective functions (Np, Wp, Wi and NPV).

Proposal of the benchmark case

This benchmark proposes the optimization of future design and/or control variables of the exploitation strategy for the remaining 23 years, such as infill drilling, recompletion, well conversion, conditions for shutting wells, and intelligent valves. To develop the benchmark, the studies should consider deterministic and probabilistic approaches using reservoir simulation, economic and risk analysis. All main probabilistic parameters are specified to allow a complete evaluation.

Deterministic and Probabilistic Approaches

The objectives of the UNISIM-I-M deterministic and probabilistic approaches are to optimize the design and control variables of the provided exploitation strategy between t_M (after the strategy implantation in development phase) until the maximum final time t_F.

This project considers the management phase, the period after the strategy implantation. In this phase, design and/or control variables should be optimized, such as infill drilling, recompletion, well conversion and conditions for wells shut-in, use of intelligent valves, among others.

Some important dates, assumptions, information and data should be considered. The dataset is publicly available at UNISIM-I webpage: http://www.unisim.cepetro.unicamp.br/benchmarks/br/unisim-i/unisim-i-m.

Conclusions

To conclude, UNISIM-I-M enables tests, application, validation of existing and new methodologies; and comparison of the results of research institutes, universities and oil companies regarding control exploitation strategy optimization and risk analysis techniques. It provides challenges to test techniques for decision analysis in the management phase due to the uncertainties and complexity involved, constraints and the design and control variables to be optimized.

UNISIM-I-M takes on special importance due to the lack of benchmark cases with known answers and complete reservoir models comprising geological, operational and economic scenarios.

Participants are encouraged to discuss methods, results and challenges to validate different procedures to select the management strategy. To enable a fair comparison a set of results data with complete documentation of assumptions should be reported.

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About author:
Ana Teresa Gaspar holds a chemical engineering degree from the State University of Maringá, a M.A. in chemical engineering and a Ph.D. in petroleum engineering both from UNICAMP. She is a researcher at UNISIM since 2007 working on decision analysis in E&P projects, reservoir simulation and optimization of petroleum exploitation strategies.

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