Annual Report
2017

UNISIM Group

Research in
Reservoir Simulation and Management

Center for Petroleum Studies
School of Mechanical Engineering
Department of Energy
Division of Petroleum Engineering
University of Campinas
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1. INTRODUCTION

UNISIM is a research group created in 1996, dedicated to numerical simulation and management of petroleum fields. The group is part of the Energy Department, Division of Petroleum Engineering (Scholl of Mechanical Engineering) and Center for Petroleum Studies (CEPETRO), University of Campinas (UNICAMP). More information about the group is available at: http://www.unisim.cepetro.unicamp.br.

1.1. Mission
The mission of UNISIM is to promote innovative research, development and training of human resources in the area of numerical simulation and management of petroleum reservoirs.

1.2. Objectives
The main technical objectives of the group are:

- Increase the reliability of studies and methodologies that employ the numerical simulation of reservoirs;
- Improve the decision making process in oil exploration and production;
- Develop techniques to increase research’s efficiency by the management of multiple simulations;
- Integrate reservoir simulation with reservoir engineering, geosciences, production engineering, economics, among others; and
- Develop research on subjects related to the needs of the E&P industry.

1.3. Research Lines
The research developed by the group includes the main activities related to the decision analysis process, focused on the development and management of oil fields using reservoir simulation.

The main research lines of the group are:

- Integration with reservoir characterization
  The objective of this line is the representation of rock and fluid properties in simulators, including the treatment of uncertainties, estimation of the value of information, the integration with 4D seismic and benchmark cases construction.
- Simulation techniques
  This line is dedicated to the construction of simulation models aiming their reliability for the study of oil production process, including techniques to speed up the process such as proxies and emulators.
• History matching

The main focus is the development of model calibration techniques through dynamic data. Assisted history matching processes, probabilistic approaches and real time matching are included in this line.

• Decision analysis

The key objectives of this line are the decision-making process for development and management of oil fields, addressing optimization of exploitation, selection of strategies under uncertainty, risk analysis, smart fields, flexibility and robustness value and integration with production systems.

• Applications

The methodologies developed by the group are tested mainly in pre-salt carbonate reservoirs, heavy oil reservoirs, naturally and hydraulically fractured reservoirs, mature fields, multi-reservoir simulations and WAG processes.

• Auxiliary techniques

This line includes optimization methods, parallel computing, integration with economic evaluation (including different tax schemes in Brazil) and modeling of production systems.

1.4. Knowledge Transfer

UNISIM aims to transfer to the society and to the oil industry the knowledge obtained from its research in the form of publications such as articles, theses, dissertations, UNISIM ON-LINE (periodical publication with the research results), and computational software in which the methodological solutions generated by the group are available.

In 2013, the UNISIM-I project was launched, which has some benchmark projects for comparative studies (http://www.unisim.cepetro.unicamp.br/unisim-i). In the original version, we generated a reference case (UNISIM-I-R), a comparative case for reservoir development (UNISIM-I-D) and a case to test history matching procedures (UNISIM-I-H). UNISIM-I-M was created in 2016 to represent a reservoir in a management phase.

The first part of the UNISIM-II project, representing a benchmark case of a carbonate reservoir, was created in 2017.

The group also develops tools integrated to the main current commercial simulators.
2. ORGANIZATION AND STRUCTURE

In 2017, UNISIM had the following staff:

2.1. Coordination and Administration
- Prof. PhD. Denis José Schiozer – General coordination
- Guilherme Roberto Tonin – Administrative support
- Administrative support: CEPETRO – Center for Petroleum Studies

2.2. Faculty
- Prof. PhD. André Ricardo Fioravanti – School of Mechanical Engineering (FEM)
- Prof. PhD. Celmar Guimarães da Silva – School of Technology (FT)
- Prof. PhD. Guilherme Palermo Coelho – School of Technology (FT)
- Prof. PhD. Luís Augusto Angelotti Meira – School of Technology (FT)
- Prof. PhD. Marcelo Souza de Castro – School of Mechanical Engineering (FEM)

2.3. Collaborative research
- Prof. PhD. Alexandre Campane Vidal – Geosciences Institute (IG)
- Prof. PhD. Emilson Pereira Leite – Geosciences Institute (IG)
- Prof. M.S. Euclides José Bonet – Center for Petroleum Studies (CEPETRO)
- Prof. PhD. Osvair Vidal Trevisan – School of Mechanical Engineering (FEM)
- Prof. PhD. Rosângela B. Zanoni L. Moreno – School of Mechanical Engineering (FEM)
- Prof. M.S. Sérgio de Pádua Iatchuk – Center for Petroleum Studies (CEPETRO)

2.4. Research
- Antonio Alberto S. Santos
- PhD. Alessandra Davolio Gomes
- PhD. Ana Teresa F. S. Gaspar
- PhD. Carla Janaina Ferreira
- PhD. Carlos Eduardo A. G. Barreto
- PhD. Célio Maschio
- PhD. Eduin Orlando Muñoz Mazo
- PhD. Gil Fernando Gomes Correia
- PhD. Guilherme Daniel Avansi
- PhD. Helena Finardi A. Scanavini
- PhD. Igor Ricardo de S. Victorino
- M.S. João C. v. Hohendorff
- PhD. Luciana Maria da Silva
- PhD. Manuel Gomes Correia
- PhD. Samuel Ferreira de Mello
- PhD. Vinicius Eduardo Botechia

2.5. Technology
- M.S. Cristina C. B. Cavalcante
- Daniel Lopes de Carvalho
- Derek Brito Vasconcelos
- João Lucas Augusto Abreu
- Marcos Pinheiro da Rocha
- Miguel Mechi Naves Rocha
- Paulo Soares Drumond
- Rafael Jurado Neto
- Raphael Veronesi Bastos
- Sérgio Ferreira Batista Filho
- Talita Cristina Tomaz Alves
2.6. Students

PhD Students

- Ashish Kumar Loomba
- Bruno Albiero Pazetti
- Cinthia Kelly Quispe Cerna
- Cristina Célia Barros Cavalcante
- Evângela Patricia A. da Silva
- Forlan La Rosa Almeida
- Gil Fernando Gomes Correia
- Gilson Moura Silva Neto
- Gonçalo Soares de Oliveira
- Helena Nandi Formentin
- Luís Augusto N. Costa
- Luís Fernando L. de Oliveira
- Masoud Maleki
- Pablo Julián Rodríguez
- Ricardo Alfonso H. Moreno
- Robison Quintana Saalfeld
- Rodrigo Gonçalves Vaz
- Seyed Kourosh Mahjour
- Susana Margarida da G. Santos
- Victor de Souza Rios

Master Students

- Daniel Rodrigues dos Santos
- Fernanda Gramorelli
- Forlan La Rosa Almeida
- João Henrique L. Nascimento
- João Victor Rosa
- Josué Maurício Plata Chaves
- Juliana Maia C. dos Santos
- Kildare George Ramos Gurjão
- Leticia Siqueira dos Santos
- Luís Otávio M. da Silva
- Luz Diana Torres Camacho
- Nathaly Alice Moreno Ayala
- Oscar Julián Peña Piraneque
- Otávio Freitas Neves
- Ricardo Vasconcellos Soares
- Romulo Messias Silva Souza
- Santiago Pérez Toledo
- Vinicius Luiz R. S. Morais

Undergraduate Students

- Gabriel Marchiori
- Guilherme de Abreu Polizel
- Igor Rocha Vingrys
- Lucas Perez Osório

Other Students

- Henrique Treptow Weinberger – Undergraduate Internship
  Federal University of Pelotas
- Rafael Medeiros de Souza – PhD Student
  The University of Western Australia
3. PROJECTS - FINANCIAL SUPPORT

The 2017 projects with external funding are presented below:

3.1. Industry Projects


4. Methodologies to increase the reliability in reservoir simulation models - Focus on Carbonate Reservoirs and Offshore Mature Fields, Effective: 02/2016 – 02/2020, Sponsor: Petrobras

5. Methodologies for Oilfield Development and Management through Reservoir Simulation, Effective: 02/2016 – 01/2020, Sponsor: Petrobras


8. Integration of Reservoir Simulation and 4D Seismic Data - Phase 2, Effective: 12/2017 – 12/2021, Sponsor: Shell
3.2. Scholarships

1. Comparação entre Número e Posição de Poços para projetos de Injeção de Água e Polímeros. 
   Effective: 03/2014 - 02/2018
   Sponsor: CAPES – PhD Scholarship (Luís Fernando Lamas de Oliveira)

2. Metodologia para Seleção de Métodos de Gerenciamento de Risco Aplicada à Fase de Desenvolvimento de Campos de Petróleo.
   Effective: 03/2014 - 04/2017
   Sponsor: CAPES – PhD Scholarship (Susana Margarida da Graça Santos)

3. Aplicação da Regionalização do Reservatório Petrolífero para o uso de Métodos Geoestatísticos com o Objetivo de Optimização do Ajuste de Histórico
   Effective: 08/2014 - 04/2017
   Sponsor: CNPq – PhD Scholarship (Gonçalo Soares de Oliveira)

   Effective: 08/2014 - 07/2018
   Sponsor: CAPES – PhD Scholarship (Pablo Julian Rodriguez)

5. Integração da Simulação de Reservatórios com Sistemas de Produção Aplicado em Reservatórios de Pré-Sal.
   Effective: 03/2015 - 02/2017
   Sponsor: CAPES – Masters Scholarship (João Victor Rosa)

   Effective: 03/2015 - 02/2017
   Sponsor: CAPES – PhD Scholarship (Bruno Albiero Pazetti)

7. Análise de Incertezas e Decisão usando Simulação de Reservatórios.
   Effective: 04/2015 - 07/2017
   Sponsor: CAPES – PhD Scholarship (Ricardo Alfonso Hernandez Moreno)

   Effective: 08/2015 - 07/2017
   Sponsor: CNPq – Masters Scholarship (Ricardo Vasconcellos Soares)

9. Metodologias de Otimização da Estratégia de Produção Sob Incertezas Geológicas e Econômicas.
   Effective: 03/2016 - 02/2018
   Sponsor: CAPES – Masters Scholarship (Luís Otávio Mendes da Silva)

10. Investigação de Métodos para Redução Gradual de Incertezas de Atributos de Reservatórios usando Dados Observados.
    Effective: 03/2016 - 02/2018
    Sponsor: CAPES – Masters Scholarship (William Chalub Cruz)

11. Um Estudo Comparativo de Modelagem para a Simulação Eficiente de Reservatórios Carbonáticos.
    Effective: 03/2016 - 02/2017
    Sponsor: CAPES – PhD Scholarship (Robison Quintana Saalfeld)
12. Avaliação do Impacto da Modelagem Integrada de Produção no Desenvolvimento de Campos de Petróleo.
   Effective: 08/2016 - 07/2018
   Sponsor: CAPES – Masters Scholarship (Kildare George Ramos Gurjão)

   Effective: 08/2016 - 07/2018
   Sponsor: CAPES – Masters Scholarship (Oscar Julian Peña Piraneque)

   Effective: 03/2017 - 02/2019
   Sponsor: CAPES – Masters Scholarship (Leticia Siqueira dos Santos)

15. Integração do Sistema de Produção com Reservatório no Campo de Libra.
   Effective: 07/2018 - 07/2018
   Sponsor: CAPES – PhD Scholarship (Rodrigo Gonçalves Vaz)

16. Aplicação de Alternativas de Controle e Otimização na Integração de Sistemas de Produção no Gerenciamento de Campos de Petróleo.
   Effective: 08/2017 - 07/2019
   Sponsor: CAPES – Masters Scholarship (Otávio Freitas Neves)

17. Impacto da Modelagem Composicional de Misturas de Fluidos no Gerenciamento e Desenvolvimento de Sistemas Integrados de Produção e Reservatórios.
   Effective: 08/2017 - 07/2018
   Sponsor: CAPES – Post Doctoral Scholarship (Samuel Ferreira de Mello)
4. LECTURES AND PUBLICATIONS

4.1. Lectures

1. Uso de Modelos de Simulação para Estimativa de Fator de Recuperação
   Date: 24/Mar/2017
   Location: Seminar on Increasing the Recovery Factor in Brazil – ANP
   Lecturer: Denis José Schiozer

2. CEPETRO and Research Areas in Reservoir Development and Management
   Date: 29/Mar/2017
   Location: International Workshop on Robotics – UNICAMP
   Lecturer: Denis José Schiozer

4.2. Articles – Journals


4.3. Articles – Congress


UNISIM ON-LINE


2. SCHIOZER, D. J. UNISIM reached the mark of 100 graduate students, year 12, number 3, 111th Edition, March, 2017.


5. COMPLETED ACADEMIC WORKS AND AWARDS

5.1. Ph.D.

1. CORREIA, Gil Fernando Gomes. Integration of Reservoir Characterization with History Matching Guided by Pilot Wells: Application to the Norne Field, SHELL (Advisor: Denis José Schiozer).

2. LAMAS, Luís Fernando. Influence of Polymer Properties on Selection of Production Strategy for Heavy Oil Fields, CAPES (Advisor: Denis José Schiozer).


5.1.1. Other PhD students – Collaborative work with other Universities

1. SOUZA, Rafael Medeiros de. Quantitative Analysis of 4D Seismic and Production Data for Saturation Estimation and Fluid-flow Model Assessment, Cooperation with UWA (The University of Western Australia) (Advisors: David Lumley and Denis José Schiozer).

5.2. Master

1. SANTOS, Daniel Rodrigues dos. Influência das Variáveis de Controle de Poços durante o Desenvolvimento de Campo de Petróleo sob Incertezas, CNPq (Advisor: Denis José Schiozer).

2. SANTOS, Juliana Maia Carvalho dos. Semi-quantitative 4D Seismic Interpretation Integrated with Reservoir Simulation: Application to the Norne Field, SHELL (Advisors: Denis José Schiozer and Alessandra Davolio).

3. TOLEDO, Santiago Pérez. Atualização de Modelos de Reservatório com Informações de Testes de Formação e Perfilagens de Produção no Desenvolvimento de Campos de Petróleo, PETROBRAS (Advisor: Denis José Schiozer).


5.3. Undergraduate


5.3.1. Other Undergraduate students – Collaborative work with other Universities


5.4. Awards

1. CORREIA, Manuel Gomes. *First place in CEPETRO AWARD 2016 – Category PhD*. CEPETRO, UNICAMP.

2. REGO, Fabio Bordeaux. *First place in CEPETRO AWARD 2016 – Category Master*. CEPETRO, UNICAMP.


6. PUBLICATIONS AND PROJECTS

The figures below show the evolution of UNISIM publications over the years and external funding considering all projects initiated from 1996 to 2017.

6.1. Publications

6.2. External Funding (including projects signed up to 2017)

UNISIM - 1996 to 2022
(Total - US$ 24 millions)
7. PRODUCTS

Computational applications are also developed in UNISIM aiming to help professionals involved with reservoir engineering activities. The main applications are listed below:

Software composed by modules:
- Risk and Uncertainty Analysis (MAI)
- Economic Analysis (MEC)
- Distribution of Simulation (MPS)
- Reduction of Uncertainty (MRI)

A framework built with plug-ins designed to assist the users in some key reservoir areas such as: exploitation strategy, risk and uncertainty analysis, history matching, optimization, representative models, economic analysis, among others.

The PSGR (Reservoir Simulation and Management Portal) was developed aiming to create a repository with up-to-date information on oil reservoir simulation and related subjects.

The UNISIM web page was developed aiming to share information about the UNISIM group, such as research lines, publications, software applications, among others.
8. ADDRESS, OPPORTUNITIES AND PARTNERSHIPS

8.1. Address
UNISIM/CEPETRO/UNICAMP
Cora Coralina Street, 350, Campinas, São Paulo, Zip Code 13083-970
PO Box 6052 – Phone: +55 19 3521-1220 – http://www.unisim.cepetro.unicamp.br/

8.2. Opportunities

*Academic: information about graduate courses at the Petroleum Science and Engineering program:*

- Phone: +55 19 3521-3344
  - http://www.cep.depm.fem.unicamp.br

*• Information about undergraduate course in Mechanical Engineering:*
  - Phone: +55 19 3521-3161
  - http://www.fem.unicamp.br/

*Research: opportunities for researchers:*

*• If you are interested in developing research in any of the UNISIM action fields, send your updated CV to: rh-unisim@cepetro.unicamp.br*
8.3. Partners during 2017

- **UNICAMP (Project Partnership)**
  - Laboratory of Methods Miscible Recovery – LMMR/UNICAMP – CO₂ Injection
  - Laboratory Oil Reservoirs – LABORE/UNICAMP – Polymer Flooding
  - Laboratory of Computational Mechanics – LABMEC/UNICAMP – Optimization

- **Brazilian Universities (Petrobras Research Networks SIGER)**
  - Federal University of Pernambuco – UFPE
  - State University of Northern of Rio de Janeiro – UENF
  - Federal University of Rio de Janeiro – UFRJ
  - Rio de Janeiro State University – UERJ
  - Federal University of Santa Catarina – UFSC
  - Pontifical Catholic University of Rio de Janeiro – PUC-RJ

- **Brazilian Universities (Project Partnership)**
  - São Paulo University – USP

- **Brazilian Universities (Exchange Undergraduate Students)**
  - Federal University of Pelotas – UFPel – Reservoir Simulation

- **International Partners (Dual PhD Degree and Project Partnership)**
  - Durham University – UK – Simulation techniques to speedup optimization processes (Emulators)

- **International Partners (Exchange Graduate Students)**
  - Texas A&M University – USA – Production optimization
  - University of Western Australia (UWA) – Australia – Integration with 4D seismic

- **International Partners (Dual PhD Degree and Project Partnership)**
  - Durham University – UK – Simulation techniques to speedup optimization processes (Emulators)
9. SPONSORS

BR Petrobras

Shell

energi simulation

CAPES

Programa de Recursos Humanos da ANP

ANP

CNPq

FAPESP