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## Pressure-driven Steady-State Simulation of Oilfield Infrastructure

Pascal Floquet, Xavier Joulia, Alain Vacher, Martin Gainville, Michel Pons

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Pressure-Driven  
Steady-State  
Simulation of  
Oilfield  
Infrastructure

Pascal Floquet<sup>1</sup>,  
Xavier Joulia<sup>1</sup>,  
Alain Vacher<sup>2</sup>,  
Martin  
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Michel Pons<sup>4</sup>

# Pressure-Driven Steady-State Simulation of Oilfield Infrastructure

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Martin Gainville<sup>3</sup>, Michel Pons<sup>4</sup>

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- (3) IFP Direction Mécanique Appliquée, Rueil-Malmaison, France
- (4) Michel Pons Technologie, Lyon, France

ESCAPE 17 - Bucharest - 27-30 May 2007





# OUTLINE

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- Part I : Introduction and Problem Statement
- Part II : Pressure-Driven Steady-State Simulation
- Part III : Case Studies
- Part IV : CAPE-OPEN Integration
- Part V : Conclusions and Future Work



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TINA

Problem  
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# Part I

## Introduction and Problem Statement





# TINA Project

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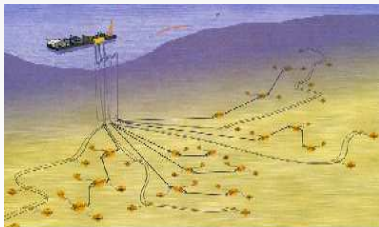
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- A TOTAL-IFP research collaborative project
- A platform for integrated multiphase flow simulations

• with INDISS as reference simulator

- TINA Application Domain





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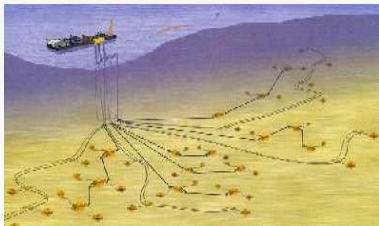
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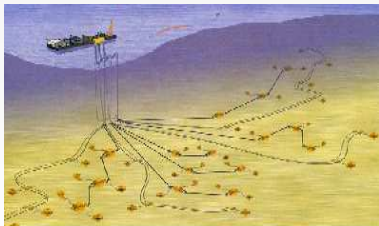
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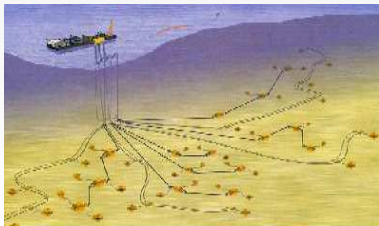
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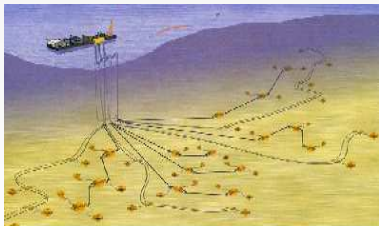
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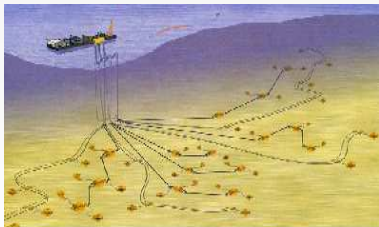
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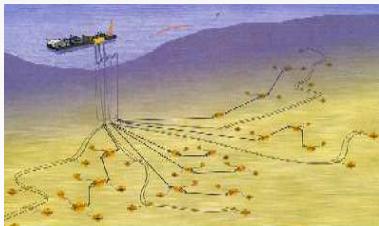
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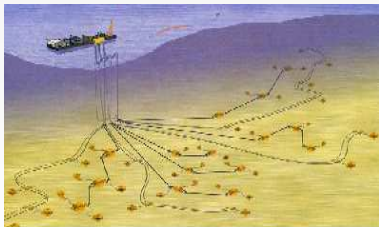
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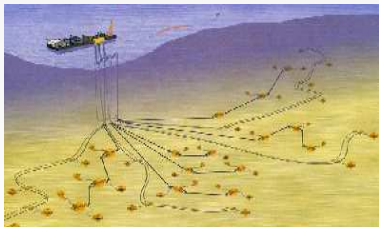
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## Extend simultaneous modular strategy

- for solving steady-state pressure-driven simulation and design problems
- in Oil and Gas production networks

## Interoperate *via* CAPE-OPEN

- Extend INDISS simulator capabilities by integration of ProSim CO SPEC module
- Extend INDISS simulator capabilities by integration of IFP TOTAL pipeline multiphase flow module



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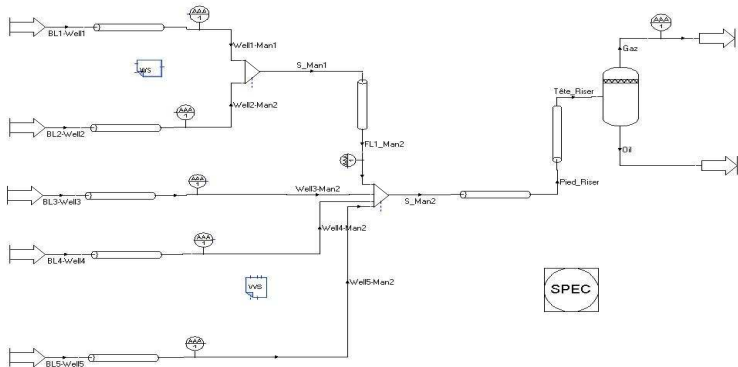
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## Base case description

Two subsea production clusters,  
Two and three subsea wells  
controlled by choking wellhead valves,  
Two flowlines connected to a riser and a basic surface process





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## Part II

# Pressure-Driven Steady-State Simulation



# Pressure-driven vs classical simulation

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## Sequential Modular Simulation

$X^0$  : Temperature T, Pressure P, Composition z and total flowrate Q

$d$  : operating and design parameters of the modules are the standard input of a pure simulation case

## Pressure-driven Simulation

Characterize Oil and Gas upstream operations

For example, pipes connected to the same manifold must operate at the same pressure

$n_w$  Pressure Equality Constraints



# Pressure-driven vs classical simulation

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# Numerical strategy in Pressure-driven simulation

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Pressure-driven problem is a particular case of design problem

Variables associated to pressure constraints are

- the well flowrates
- other variables

Two types of problem are treated :

- **Flowrates/Pressure problems**
  - Well flowrates and riser top pressure are known
  - Action variables are chokes openings or well pressures
- **Pressures/Pressure problems**
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Simulation of  
Oilfield  
Infrastructure

Pascal Floquet<sup>1</sup>,  
Xavier Joulia<sup>1</sup>,  
Alain Vacher<sup>2</sup>,  
Martin  
Gainville<sup>3</sup>,  
Michel Pons<sup>4</sup>

Pressure-driven problem is a particular case of design problem  
Variables associated to pressure constraints are

- the well flowrates
- other variables

Two types of problem are treated :

- **Flowrates/Pressure problems**
  - Well flowrates and riser top pressure are known
  - **Action variables are chokes openings or well pressures**
- **Pressures/Pressure problems**
  - Well pressures and riser top pressure are known
  - Action variables are well flowrates



# Numerical strategy in Pressure-driven simulation

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Without recycle

With recycle

## Part III

### Case Studies





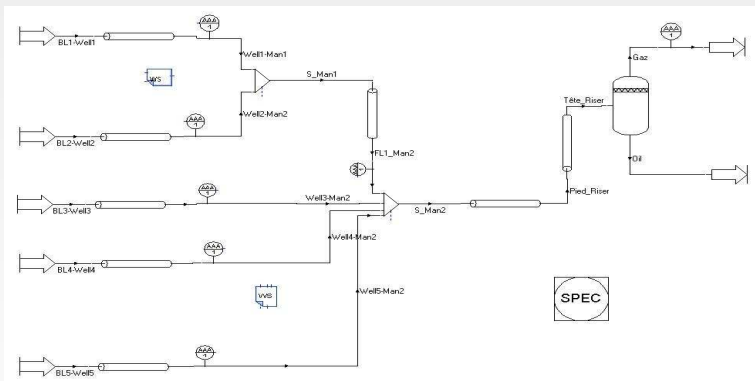
# Flowsheet without recycle

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We are interested to examine the ability of convergence of Sequential Modular Simulator in Pressure Driven Problem



# Flowrates/Pressure problem

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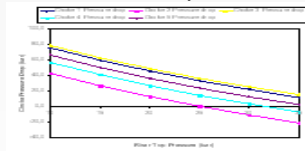
Without recycle

With recycle

## FP Problem :

- Specification on the pressure at riser top
- Well pressures, flowrates and temperature are fixed (base case)
- Action variables : 5 pressure drops of the 5 chokes
- *Quasi-Newton* Strategy used
- Results obtained in 4 iterations and 11 flowsheet simulations, for 15 bar

## 5 Pressure Drops *versus* Riser top pressure specification





# Flowrates/Pressure problem

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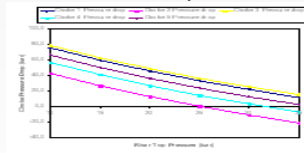
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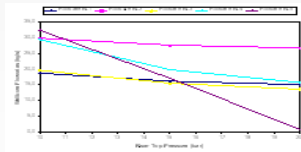
Without recycle

With recycle

## PP Problem :

- Specification on the pressure at riser top
- Pressures drops of the 5 chokes, well pressures and temperature are fixed
- Action variables : 5 well flowrates
- Results obtained in 5 iterations and 12 flowsheet simulations, for 15 bar
- ...but it depends on initialization !

## 5 Flowrates *versus* Riser top pressure specification





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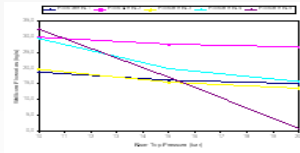
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# FP or PP Problem with recycle

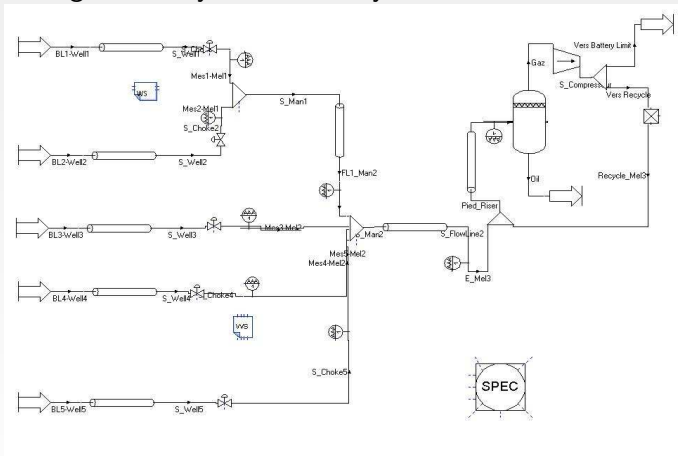
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Without recycle

With recycle

Here gas-lift may be mandatory.





# Flowrates/Pressure Problem

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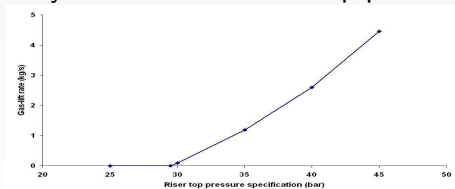
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Without recycle

With recycle

- Specification on the pressure at riser top
- Action variables : pressure drops of 4 chokes and flowrate of gas-lift
- Tear stream : compressor output ( $15 + 2(T, P)$  iterative variables)
- Less eruptive choke completely open
- Results obtained in 5 iterations and 12 flowsheet simulations, for 30 bar

Recycle rate *versus* Riser top pressure specification





# Flowrates/Pressure Problem

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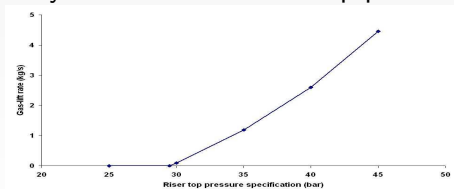
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CO Results

## Part IV

# CAPE-OPEN Integration



# Interoperability

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CO Results

- ProSimPlus is reference simulator chosen to adjust the approach
- IFP TOTAL pipeline multiphase flow modules are specialized upstream Oil and Gas modules
- ProSim CO-SPEC (CAPE-OPEN Unit Operation 1.0)
- and IFP TOTAL pipeline multiphase flow modules

integrated in INDISS-TINA environment



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## Part V

### Conclusion and future work



To conclude...

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CAPE tools such as ProSimPlus are able to solve  
pressure-driven simulation  
CAPE-OPEN standards are the best way to plug-and-play  
CAPE software components

## Future Works

Multi period optimization in an Oil and Gas context



# To conclude...

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*THANK YOU FOR YOUR ATTENTION!*