galp.com

Digitalization of Production Systems

A Catalyst for Early Detection and Mitigation of Future Risks

Presenting authors:

Peter Nuñez

Co-authors :

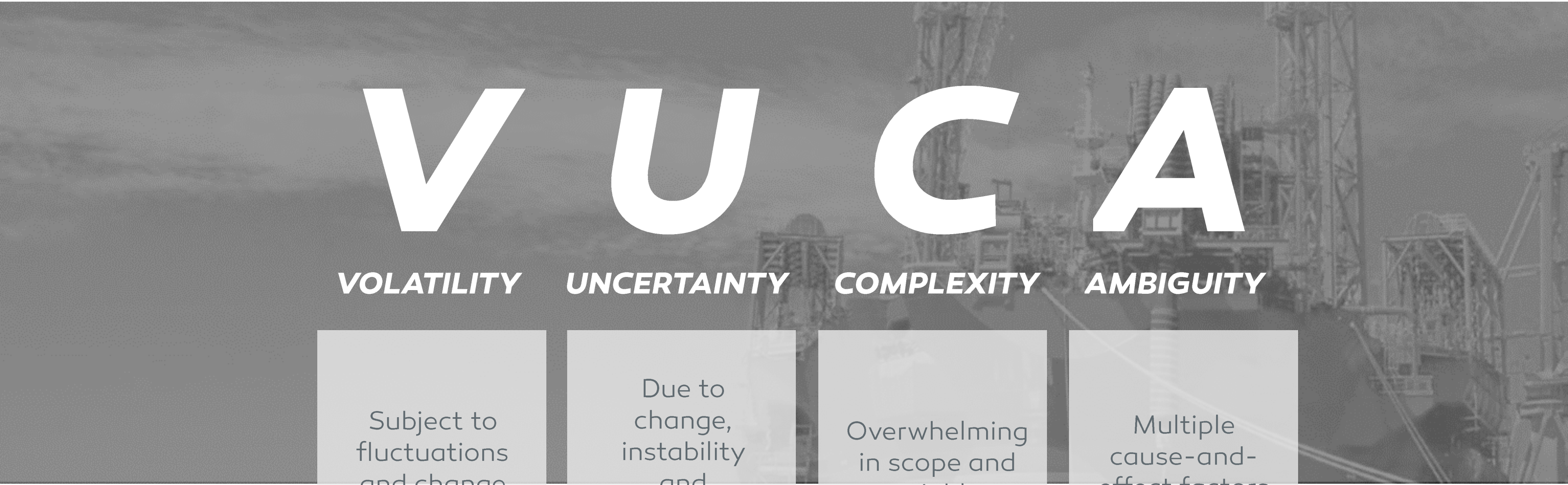
Jorge Trujillo
Daniel Elias

galp

SIS Global Forum 2019
September 17th–19th
Grimaldi Forum, Monaco

Introduction

World and Industry facing a VUCA environment on a daily basis



VOLATILITY	UNCERTAINTY	COMPLEXITY	AMBIGUITY
Subject to fluctuations and change	Due to change, instability and unavailable information	Overwhelming in scope and variables	Multiple cause-and-effect factors

galp

How to live under a VUCA environment?

Continuous evolution and change the paradigm of simulation

HOW?

Online monitoring
Predictive Analysis
AI applications
Continuous follow up

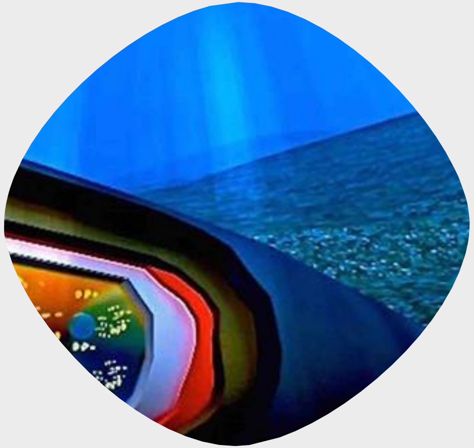
NEEDS

Increase of Computational Power

Continuous Sofware Development

Understanding the Uncertainty in Flow Assurance

Complex scenarios require digitalization of the production systems



Complex scenarios with several uncertainties in key parameters

- Complex multiphase flow problem, only possible to deal with adequate software;
- Frequent necessity to run sensitivity analysis in Flow Assurance models;
- Preparation and post processing of cases and sensitivities is very time consuming;
- Difficult to identify robust/firm deterministic value for the required inputs - specially for projects in early stages if development;

Schlumberger
PIPESIM

Automation of workflows

Python toolkit as a robust solution for scripting and implement personalized tools

*Create an user-friendly in-house tool that allows a time efficient **setup of multiple cases** on PIPESIM Flow Assurance Models;*

VBA

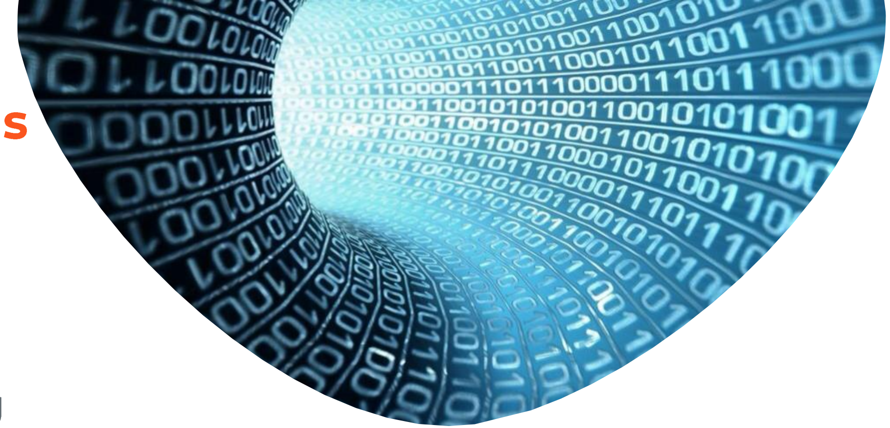
***Python toolkit** as a solution to automate procedures and empower PIPESIM.*

User interface made with Excel

galp

Digitalization of Production Systems

Python toolkit unlocking development of tools



Better understanding of uncertainty and continuous monitor of well productivity achieved by two tools developed in-house using Python Toolkit from Schlumberger

OpEn Tool

Operational Envelope Stochastic Analysis
Pre-development and Development

Sensitivity tool with implementation of Monte Carlo method for stochastic analysis of operational envelopes

ProMo Tool

Well Productivity Monitoring Tool
Production

Well PI continuous monitoring with all the uncertainty associated to reservoir properties / behaviour with time

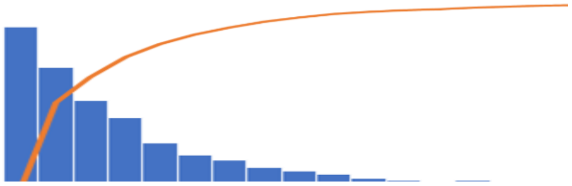
OpEn Tool – Stochastic Analysis

Monte Carlo method implemented to better understand and assess uncertainties

UNCERTAINTY

HOW TO DEAL WITH IT?

- Extensive sensitivity analysis on multiple parameters;
- Imposing probabilistic distributions to each parameter rather than deterministic values;
- Associate probability of occurrence of certain outcome scenarios.



Monte Carlo Simulation for Flow Assurance

OpEn Tool Workflow

User friendly generation of stochastic case matrix with customizable set of primary parameters

→ Create PIPESIM Model → Import Model → Define how variables change → Run Script → ***Analyze Results***

A1	
Model:	C:\Users\851434\Desktop\MC BM-S-8 part2\Simulations\WI_1DC_4W.pips
Pipesim Version	2017.2
Unit System	PIPESIM_METRIC
Number of Cases/Simulations	6000

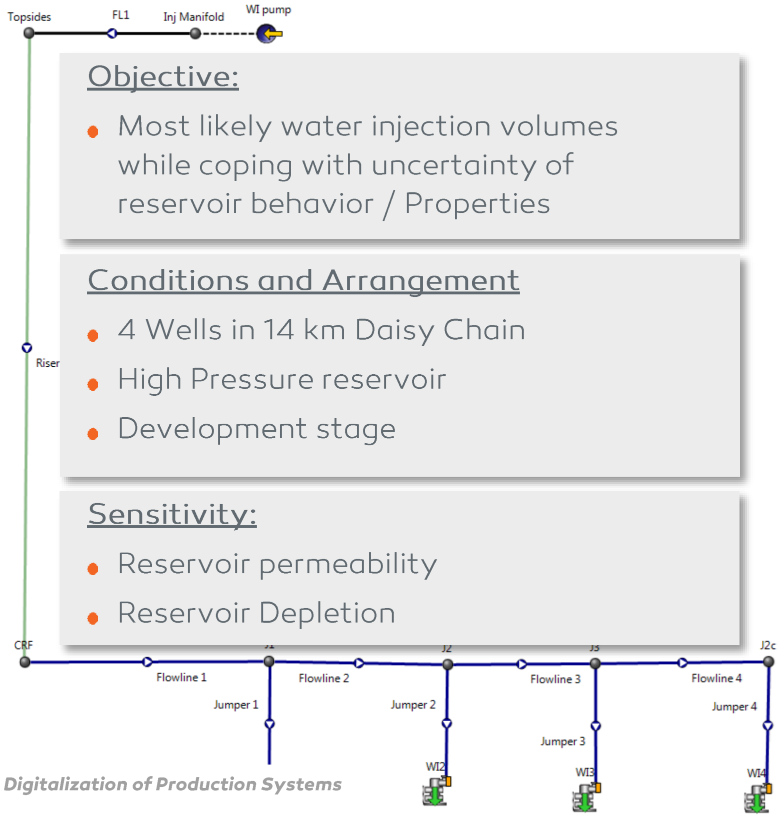
Step 1 - Import

Variable Description

Object Type	Object Name	Variable	Original Valu	Units	Change	Distribution	Param1	Param2	Param3
Completions	WI1:WI_comp1	Reservoir Static Pressure	700.000	bara	Yes	Uniform	400	100	
Completions	WI1:WI_comp1	Reservoir Temperature	96.000	degC					
Completions	WI1:WI_comp1	Reservoir Thickness	100.000	m					
Completions	WI1:WI_comp1	Reservoir Permeability	5.000	mD	Yes	Histogram	Permeabilities		
Completions	WI1:WI_comp1	Mechanical Skin	0.000	-					
Completions	WI1:WI_comp1	Fluid GOR		sm3/sm	Yes	Normal	300	50	
Completions	WI1:WI_comp1	Fluid Water Cut		%					
Completions	WI2:WI_comp2	Reservoir Static Pressure	700.000	bara	Yes	Uniform	400	100	
Completions	WI2:WI_comp2	Reservoir Temperature	96.000	degC					
Completions	WI2:WI_comp2	Reservoir Thickness	100.000	m					
Completions	WI2:WI_comp2	Reservoir Permeability	5.000	mD	Yes	Same as Variable	Reservoir Permeability		
Completions	WI2:WI_comp2	Mechanical Skin	0.000	-					
Completions	WI2:WI_comp2	Fluid GOR		sm3/sm	Yes	Normal	300	50	
Completions	WI2:WI_comp2	Fluid Water Cut		%					
Completions	WI3:WI_comp3	Reservoir Static Pressure	700.000	bara	Yes	Uniform	400	100	
Completions	WI3:WI_comp3	Reservoir Temperature	96.000	degC					
Completions	WI3:WI_comp3	Reservoir Thickness	100.000	m					
Completions	WI3:WI_comp3	Reservoir Permeability	5.000	mD	Yes	Same as Variable	Reservoir Permeability		

Case study: WI system deliverability capturing reservoir uncertainty

Stochastic results available to have better understand most likely operational envelope



Objective:

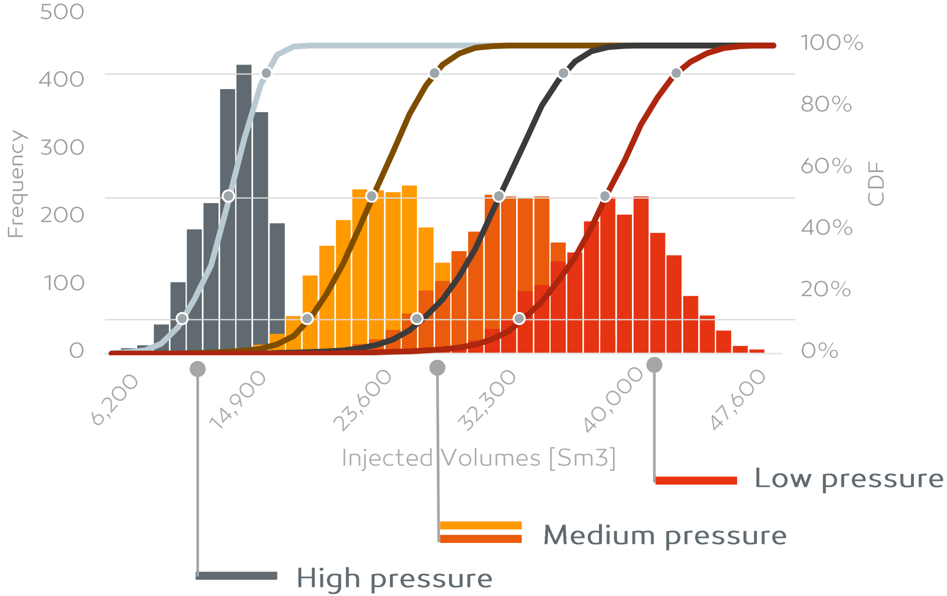
- Most likely water injection volumes while coping with uncertainty of reservoir behavior / Properties

Conditions and Arrangement

- 4 Wells in 14 km Daisy Chain
- High Pressure reservoir
- Development stage

Sensitivity:

- Reservoir permeability
- Reservoir Depletion



8000 Cases

14.5 h

galp

ProMo tool for PI monitoring

Continuous monitoring of well PI for early detection of potential well impairment

$$PI = \frac{Q}{P_{res} - P_{BHFP}}$$

Q

For satellite wells, flowrate is usually known with good precision.

P_{BHFP}

Flowing bottom hole pressure usually known through usage of PDG on the well.

Available on a daily basis

P_{res}

Reservoir pressure only possible to estimate after long pressure build-up periods or with reservoir model.

PI

Original PI possible to be estimated based on reservoir properties and early production.

Requires good understanding on key reservoir parameters (permeability, fluid properties, static pressure, etc.)

Uncertainty on value throughout field life

ProMo tool workflow

Simple methodology used to estimate Reservoir Pressure

User Environment

Create well model from PDG upwards → Field data matching → Run Script → ***Analyze Results***

Ran in Background

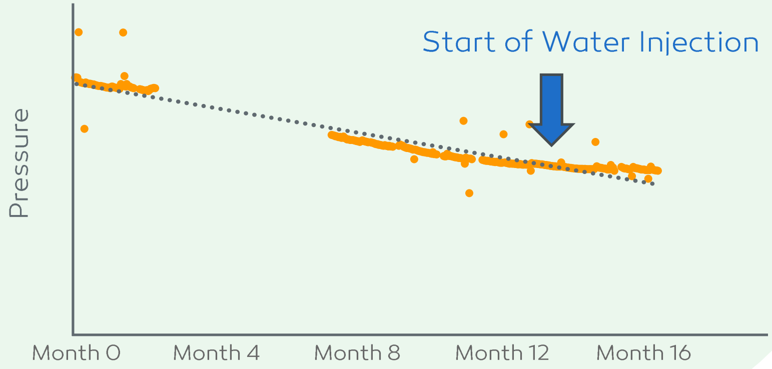
Run for each daily production report:

1. Impose reported flow rate and PDG value
2. Run to calculate Inlet Pressure / Reservoir pressure
3. Register Inlet Pressure / Reservoir pressure

galp

Case study: UDW well with no impairment

ProMo confirmed no impairment on the well and pressure support after start of water injection



Reservoir Pressure
in Well X

Satellite Well

Little influence from nearby wells

Period without information due to lack of PDG data

Pressure profile that can be compared with other reservoir models

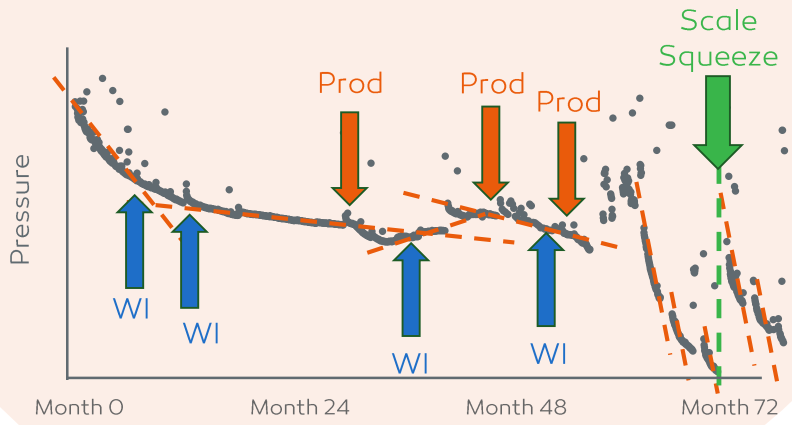
Change of decline rate explained by start of water injection

Early life of well and field

galp

UDW well with formation damage due to scaling

Detection of productivity impairment allowed partners to push for an intervention



Reservoir Pressure in Well Y

Engagement with Operator to push for Well Intervention

Decline rate decrease after entrance of Water Injector (WI)

Decline rate acceleration after entrance of new Producer (Prod)

Excessive decline rate with no justification from the reservoir point of view: Possible well impairment

PI clearly recovered after well acidification and scale squeeze

Analysis performed together with scale assessment and reservoir expected behavior

galp

Conclusions

Python Toolkit for PIPESIM proved to be a catalyst for developing tools that improve flexibility and agility

- Enabler of Stochastic Flow Assurance analysis;
- Expander of PIPESIM native sensitivity capabilities;
- Better understanding on impacts from uncertainties associated to the project;
- User friendly and powerful tool to monitor well productivity index on a continuous basis;
- Additional tool for follow up of well behavior throughout field life.

OpEn Tool **ProMo Tool**

We are committed to continue to develop knowledge and application of state of the art tools, to generate value to the world class partnerships where we participate

the future is open

galp

galp.com

galp