IMPROVING EFFICIENCY THROUGH DELFI ENABLED ON DEMAND RESERVOIR SIMULATION: A SEPLAT CASE STUDY

SCHLUMBERGER DIGITAL FORUM 2022

UDEME JOHN & CHUKS E. KALU

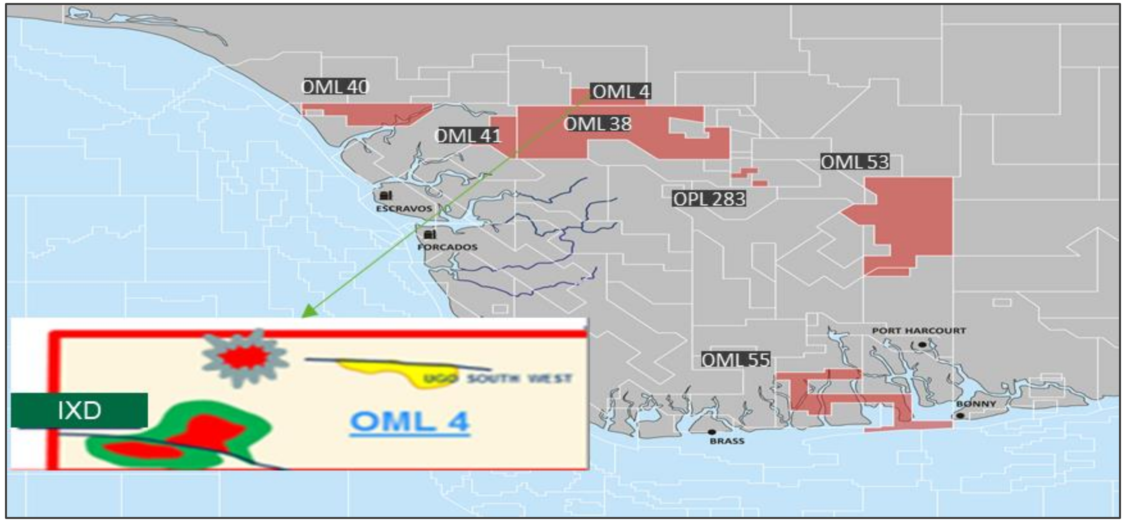
SEPTEMBER 20 -22, 2022

OUTLINE

- Field Overview
- Technical and Business Drivers
- Key Challenges (Project Highlights)
- Workflows
- Results & Insight Gained
- Closing remarks & recommendations

Schlumberger-Private

ASSET OVERVIEW



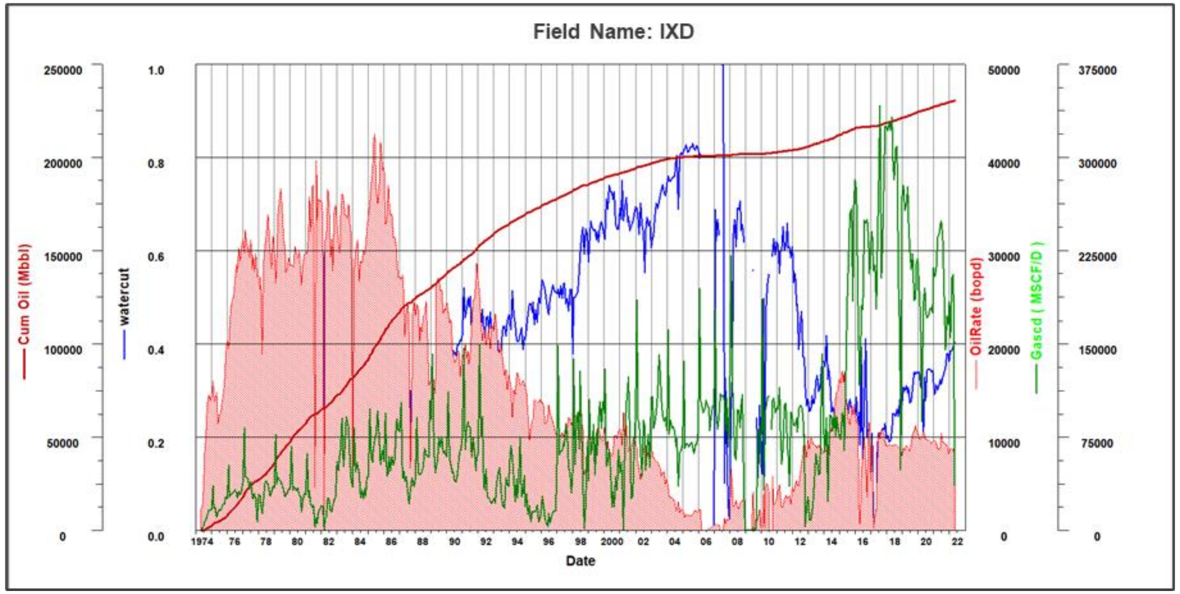
*Source: YE 2021 TRR

	Oil (MMbbls)	NAG (Tscf)	Gas Cap Gas (Bscf)	Condensate (MMbbls)
*STOIIP/GIIP	576.71	2,436	471.20	98.67
*UR	287.91	1,814	329.96	65.94
Cum Prod.	228.90	1,048	20.68	17.40

- 75 reservoirs – 33 oil, 42 gas; Production start date - 1974
- 51 wells – 38 oil; 90 drainage points – 77 oil
- Oil: 21 active oil drainage points; 56 shut-in drainage points.
- Production rate (Mar 2021) – circa 8500 bbls/d oil, 36mmscfd gas
- Two Phase studies: Phase 1 (33 Reservoirs including oil and gas – 70% of Undev) to be completed within 16 months
- Phase 2 (42 reservoirs): To be completed within the next one year

Key Project Objectives

- Provide a consistent field structural framework. .
- Demonstrate value driver for commingled production & Gas-cap blowdown feasibility.
- Provide notional development plan to underpin long-term gas supply obligations and asset life cycle development.



Source: Seplat OFM Database

Schlumberger-Private

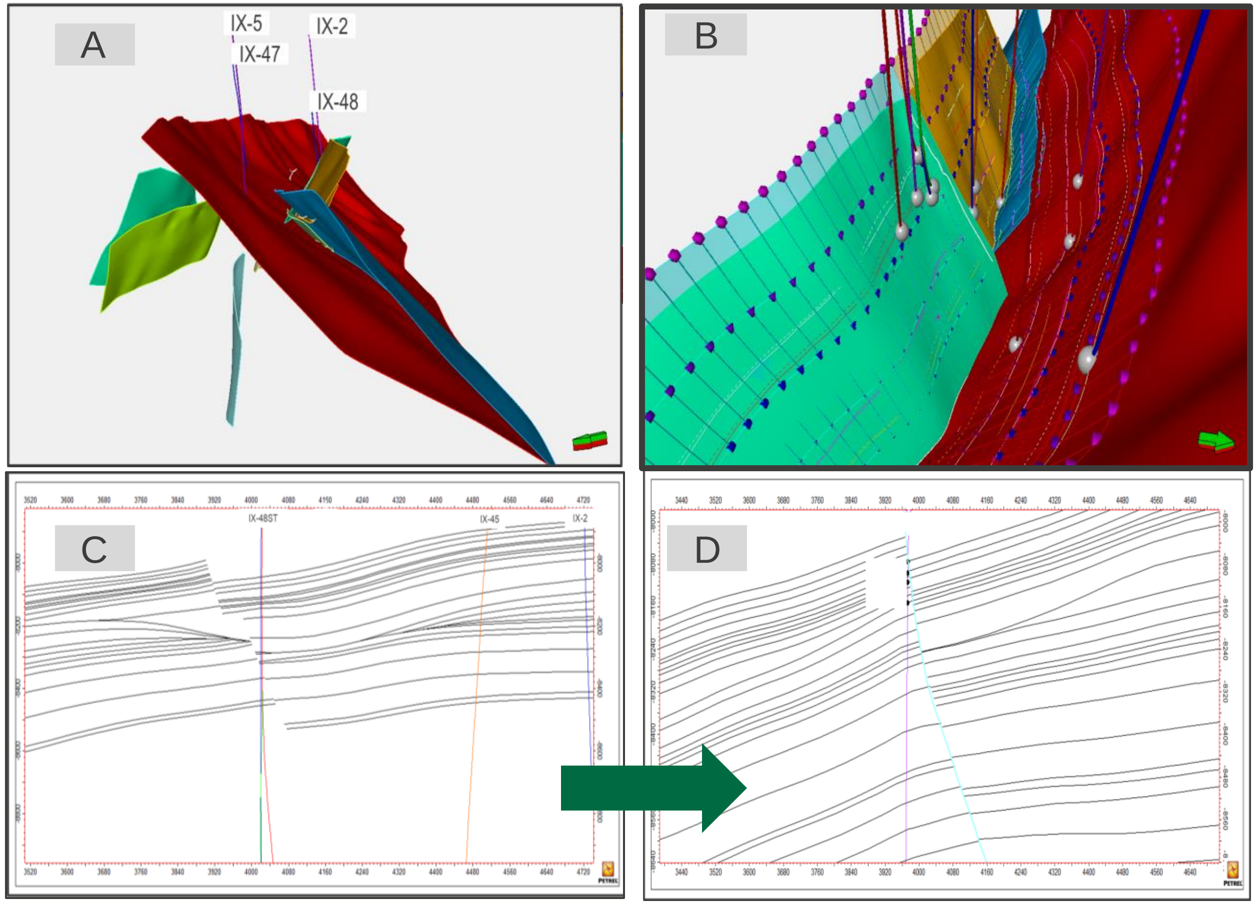
PROJECT CHALLENGES HIGHLIGHTS

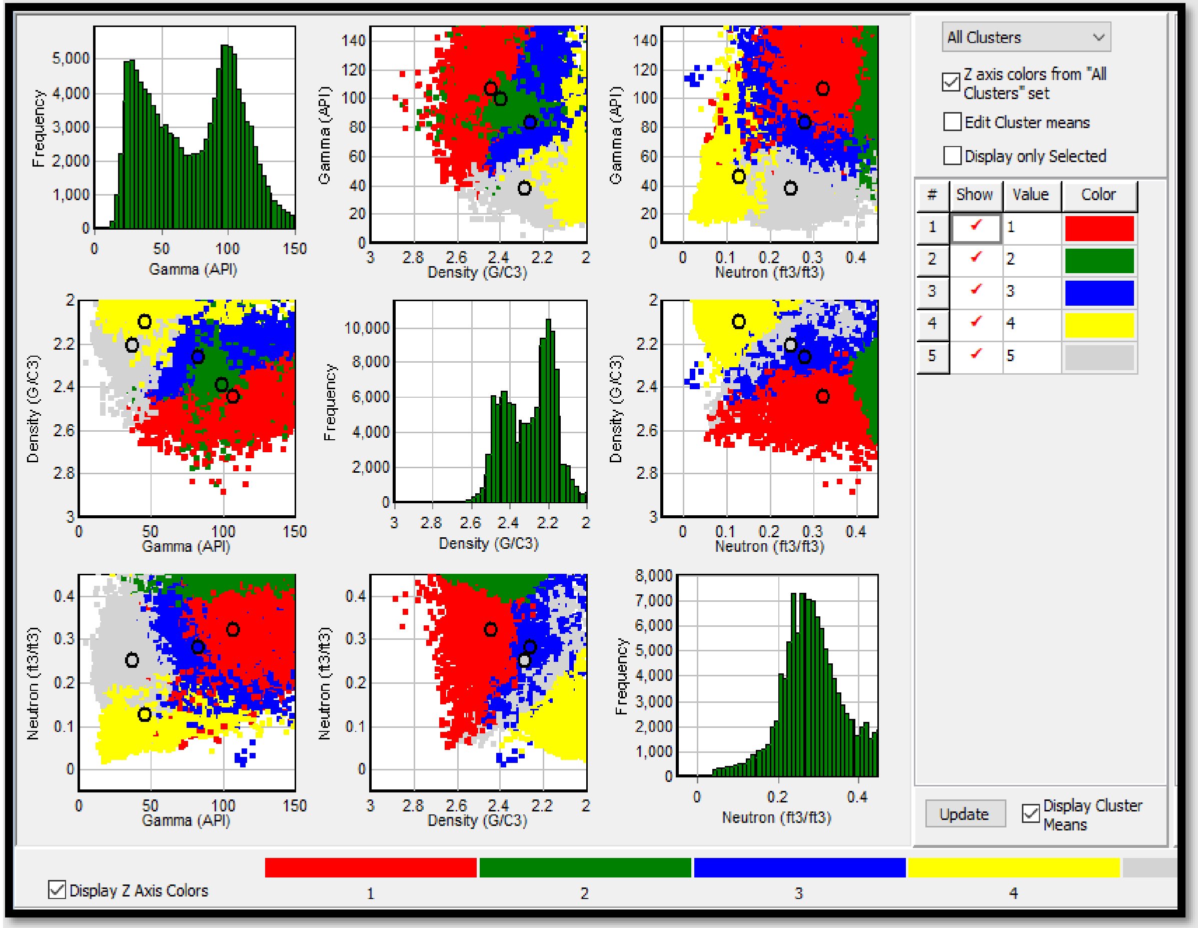
Key Challenges	Adaptation Strategy
Structural Framework complexity -Horizon Pinch-out, orthogonality issues	Building a consistent structural framework for IXD Field -All fault cuts were calibrated at fault-well intersections
Reservoir compartmentalization in some reservoirs	Detailed Environment of Deposition (EOD) Modelling
Sand Connectivity Uncertainties	• Application of Cluster Analysis for Lithofacies Classification • Use of EOD and Lithofacies based property distribution
High water Saturation estimates due to suppressed resistivity logs (LRP/ LCP) in some wells/ reservoirs.	Porosity-based Sw estimate from SHF, and exclusion of wells with LRP in reservoir sums/ averages (supported by well production performance (e.g IX-07,08, 09, 10, 25 in A3000)
Thin oil rim, early water break-through (observed in previous models) and reservoir heterogeneity	High resolution gridding system (50m x 50m x 1ft) and LGR in some cases (E.g A2000, A3000, A4000/B4100)
High model run-time	• Use of Block-Parallel and Parallel/MR computing system • Implementation of DELFI Enabled On Demand Reservoir Simulation

- *These challenges led to complex simulation models with runtime running to days on single processor 50 x 50 grid models*
- *Responsible for the choice of project reservoir (A3000M) for DELFI enabled ODRS*

Schlumberger-Private

PROJECT CHALLENGES HIGHLIGHTS CONTD.

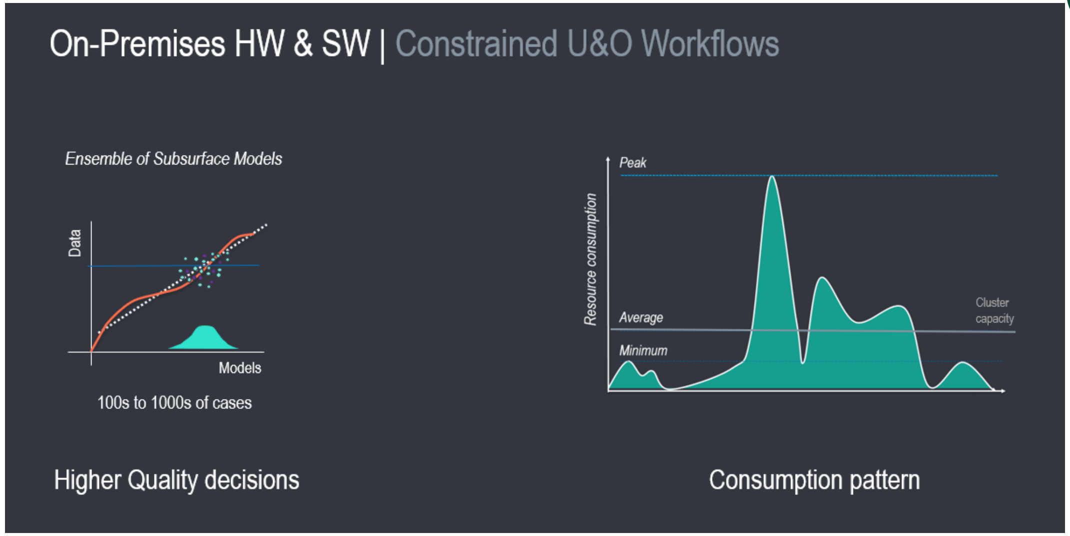


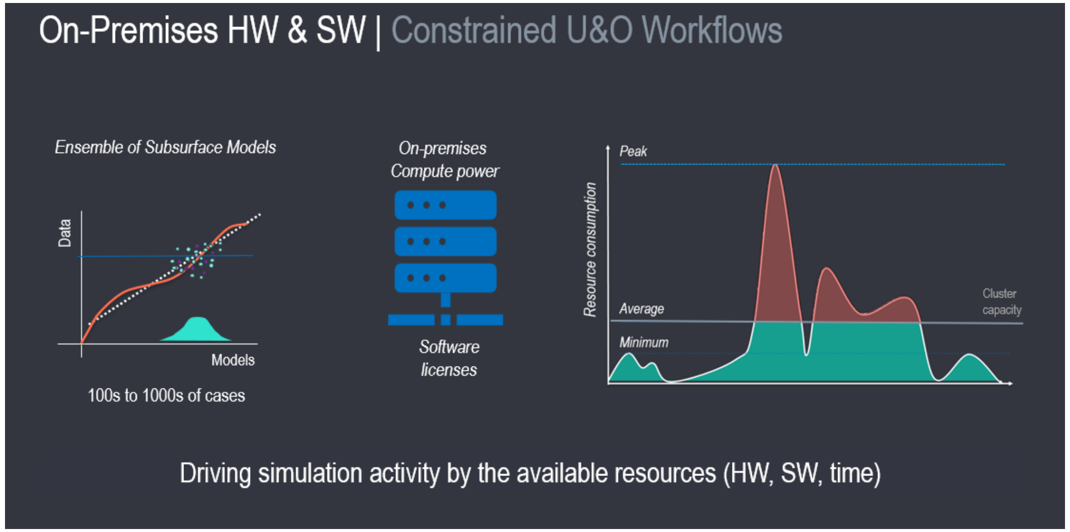


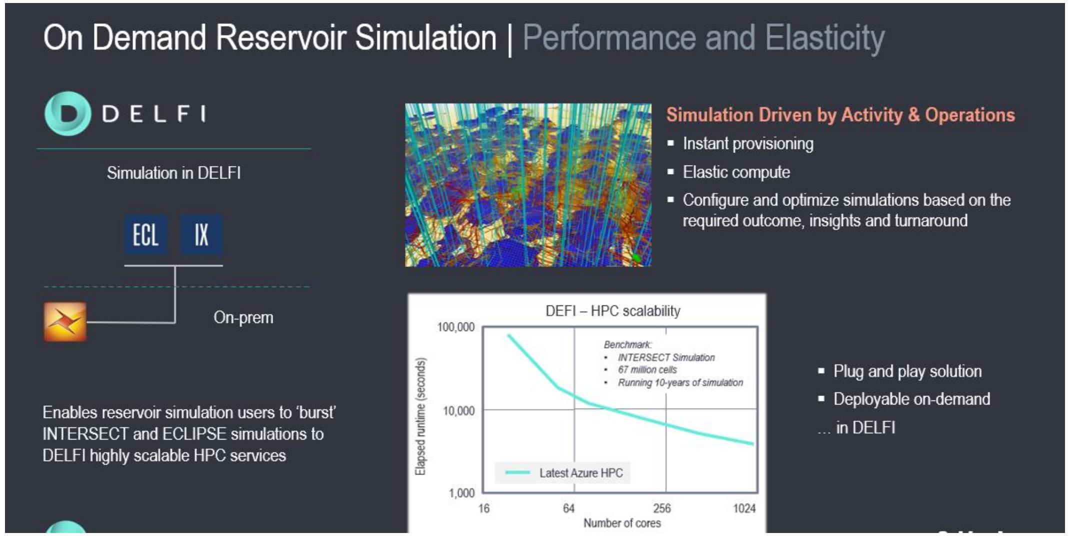
- *A & B: Horizon pinch-outs, crossing horizons and horizon juxtaposition across faults due to fault complexity and well-fault cuts (Missing section)*
- *C & D: Depth issues identified in some wells*
- *Fault Truncations, twisted Cells, high orthogonal cells leading to complex simulation models*

- *Cluster Analysis across wells identified 5 electro-facies/clusters, which are indicative of rock types/reservoir quality.*
- *Defined rock types are tied to relative permeability to better capture fluid movement within the reservoir*

DELFI ENABLED ODRS



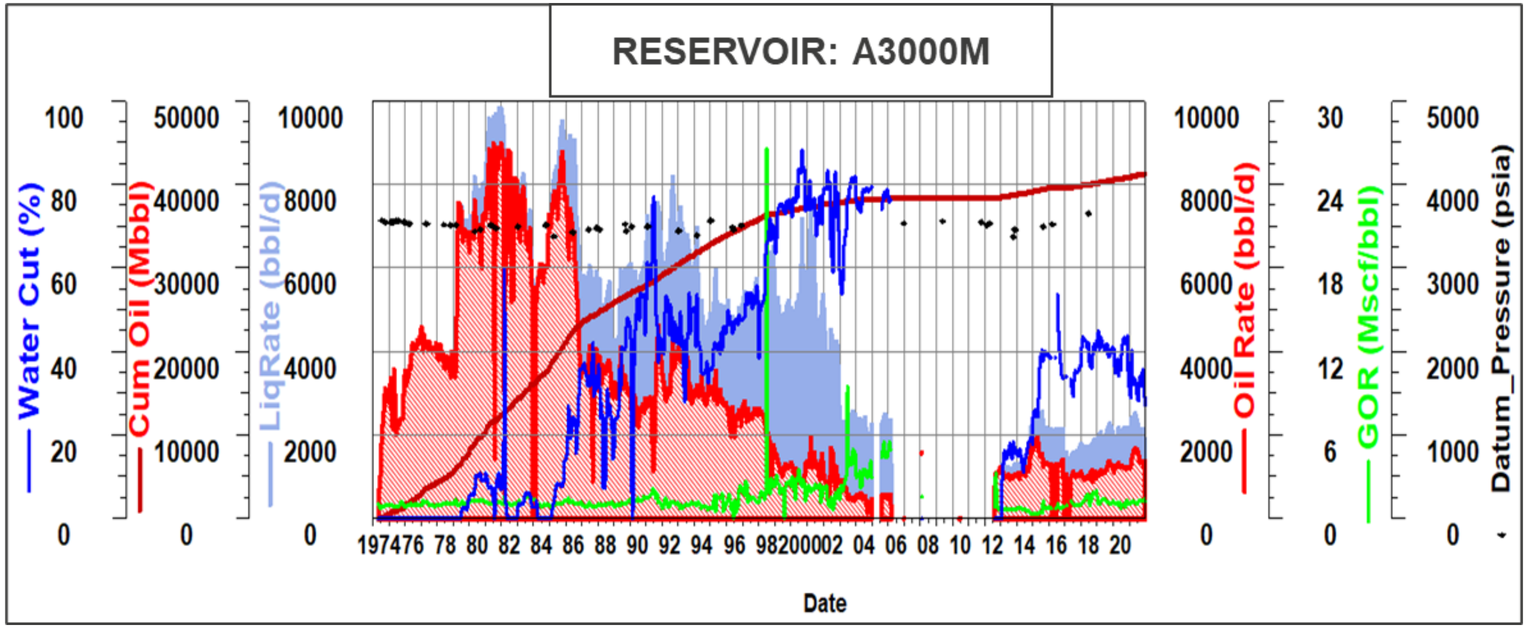




Source: Schlumberger

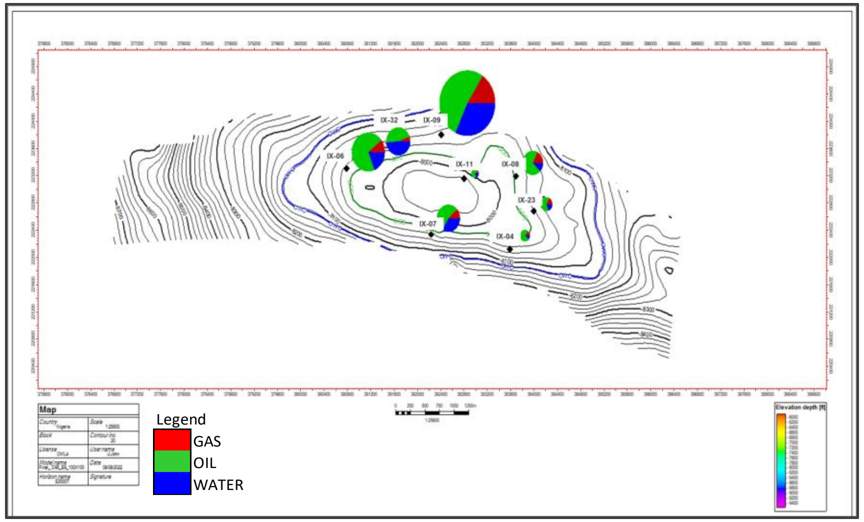
- Identifying remaining oil in matured fields with complex stratigraphy and non-uniform contact movement requires appropriately calibrated models
- On-Premises Hardware and Software (HW & SW), including personnel support can be enormous for major re-development projects
- On Demand Reservoir Simulation provides optimized access to cloud-based resources that could reduce or eliminate need for onsite IT infrastructure and IT/simulation engineers

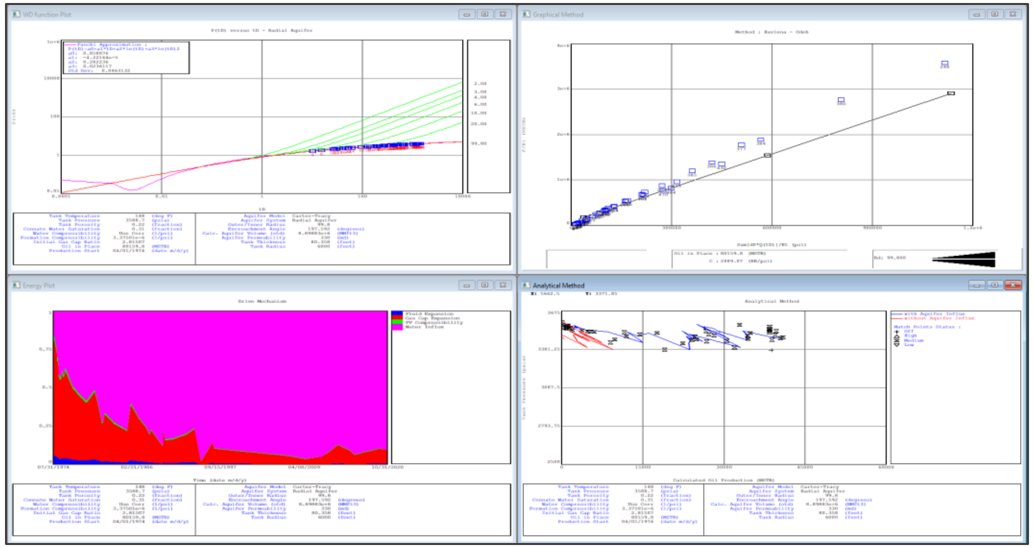
A3000M RESERVOIR PERFORMANCE SUMMARY



*DUR (MMstb)	Np (MMstb) 08/21	Dev. Res (MMstb)
43.95	41.4	2.53

Drainage Point	DUR (MMstb)	Np (MMstb)	Dev. Res (MMstb)	Status
IX-04L	2.84	2.84	0.00	FCG
IX-06L	8.68	8.68	0.00	FCW
IX-07L	4.75	4.75	0.00	FCW
IX-08L	6.00	5.36	0.63	FTL-246bopd
IX-09L	6.27	10.82	0.00	FCW
IX-11L	4.03	2.12	1.91	FTL-1148bopd
IX-23L		2.81		FCW
IX-32L	9.61	3.53	0.00	FCW





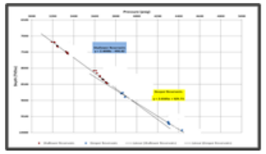
A3000M Reservoir Properties (Oil)	
Avg Phi	0.22
Avg K	1101 mD
NTG	0.89
Avg Sw	0.35
Boi	1.43
Pi/Pcurr (psi)	3547/3470
Oil Viscosity (cp)	0.45
Bubble Point, Pb	3547
Rsi(scf/stb)	930
**STOIIP/UR	77.5/41.9 MMstb
**Np/RF	41.4 MMstb/ 53.4%
**Reserves	0.5 MMstb

› **YE 2021 TRR

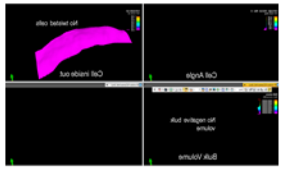
reliable energy, limitless potential

Schlumberger-Private

GENERAL WORKFLOW ADOPTED

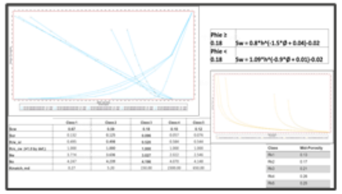


Pressure & Temperature Gradient



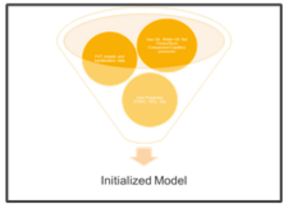
Static model QA/QC

Establish property trend & orthogonality check



PVT model from EOS tuned experimental data & correlation for reservoirs without valid sample

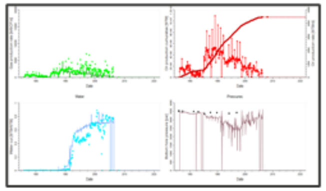
SCAL model biased to lithofacies model



Static model initialized at reference conditions

History Matching Strategy

- Grid size optimization
- Aquifer Sensitivities
- Assisted History Matching (AHM)
- Reservoir Level History Match optimization
- Well-by-Well History Matching



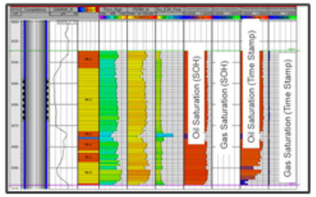
Initialized model history matched

-Aquifer modelling

Transmissibility

Kv/Kh

LGR



History-matched models further calibrated with Open Hole, CO and RFT data

General Production Forecast Constraints

- Minimum THP (oil): 100 psia
- Minimum THP (gas): 1323 psia/90 bars
- Maximum WCT: 90%/VLP
- Abandonment oil rate of 50 stb/d
- Abandonment Gas Cap blowdown rate of 1 mmscfd
- Forecast Start: 01/01/2022
- Forecast End: end of life

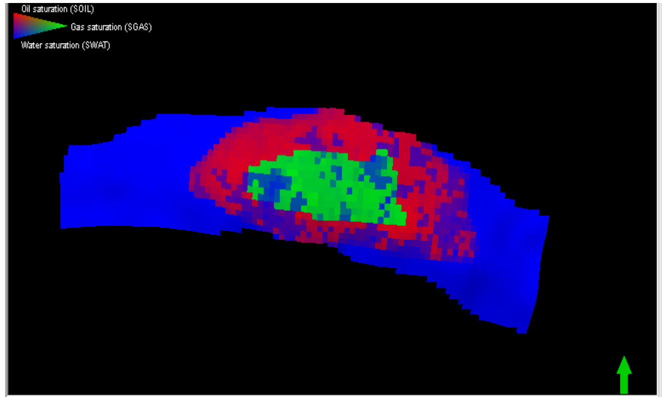
STOG, Side-track, New infill opportunities identified based on well availability & potential reward

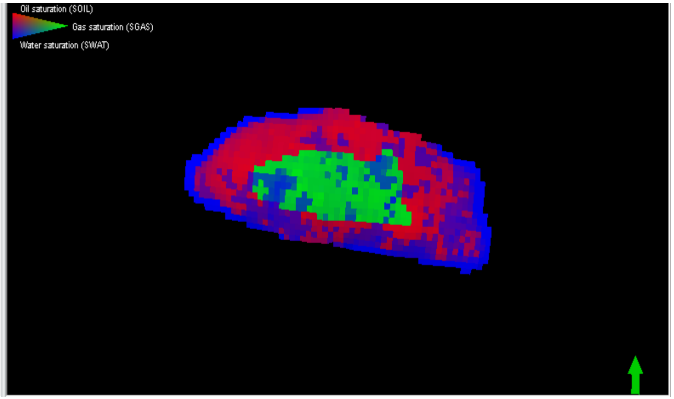
Schlumberger-Private

A3000M MODEL INITIALIZATION SUMMARY

	STATIC MODEL	DYNAMIC
STOIIP (MMSTB)	80.42	79.68
FGIIP (BSCF)	28.83	28.07
DIFFERENCES WITH STATIC MODEL (STOIIP)		**1.0%**

Description	Value
Number of properties:	
In this folder:	16
Includes sub folders:	16
Grid cells (nI x nJ x nK)	97 x 34 x 70
Total number of grid cells:	230860
Total number of cells in filtered area:	57537
Unit:	





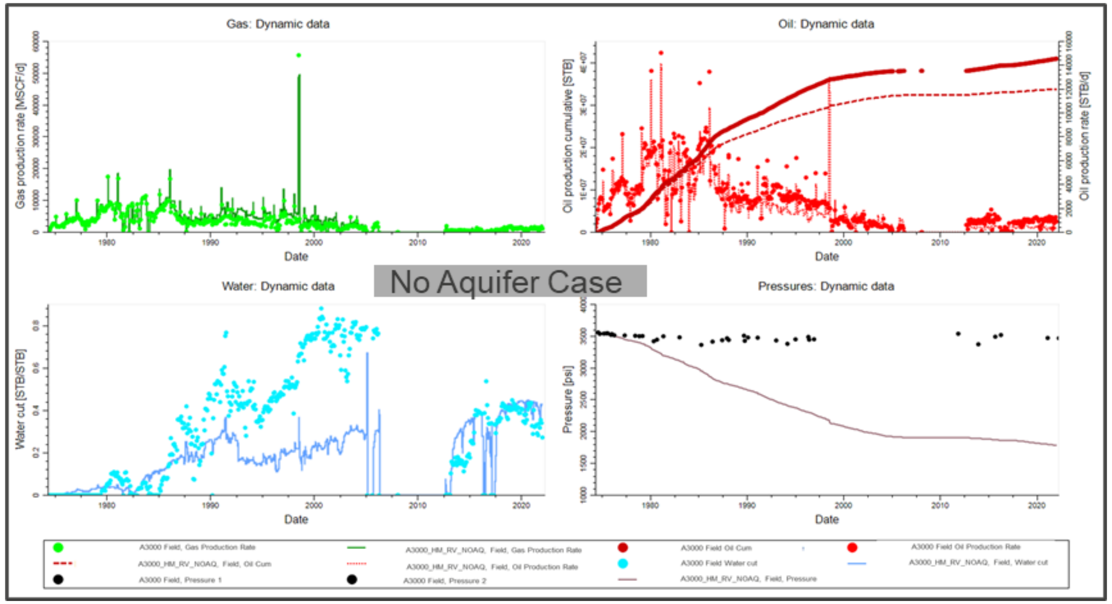
- A3000_INIT_NOACTNUM: 79.68 MMSTB
- A3000_INIT_ACTNUM: 79.68 MMSTB
  DIFFERENCE: **0%**

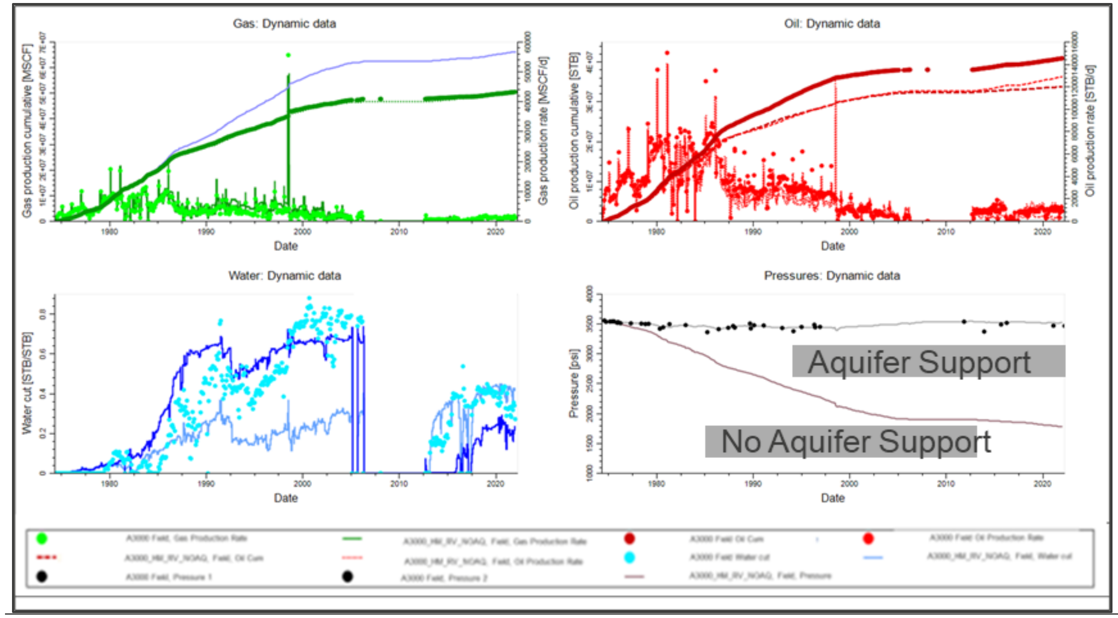
Runtime optimized by more than 40% by clipping the aquifer using ACTNUM keyword

A3000 STOIIP Realization	STOIIP (mmstb)	Np (mmstb)	Current RF.	Remarks
P90	53.74	41.4	77.0	
P50	67.92	41.4	61.0	66% RF with DUR of 44mmstb
P10	81.98	41.4	50.5	Consistent with reservoir performance and potential. Selected as base case for static model

BASE CASE HISTORY MATCHING (RESERVOIR VOLUME)

Seplat Energy

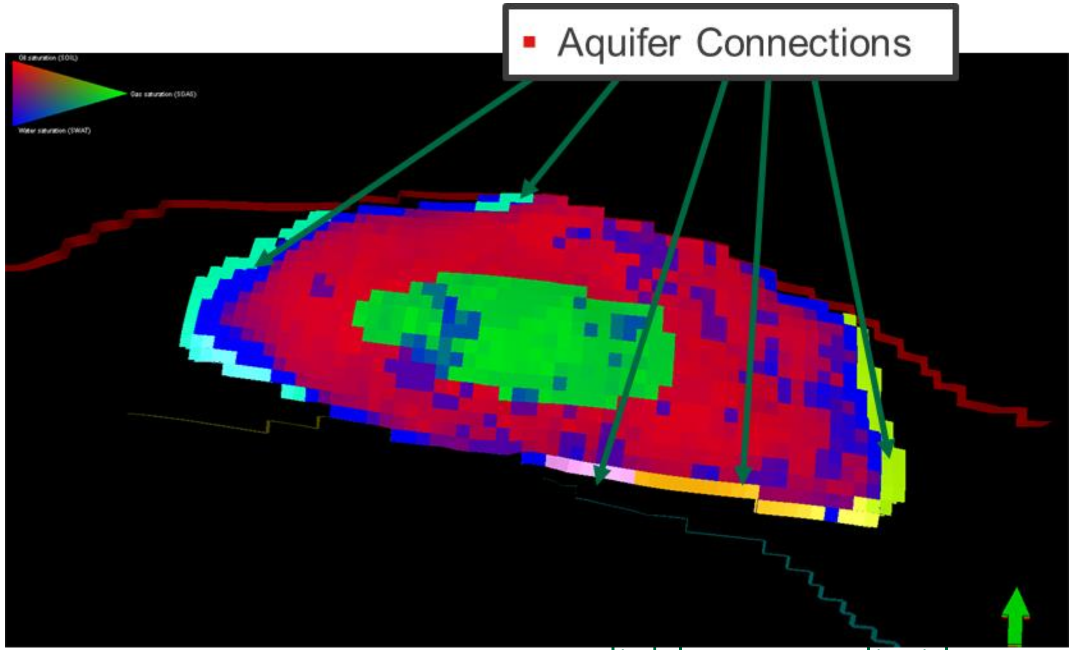




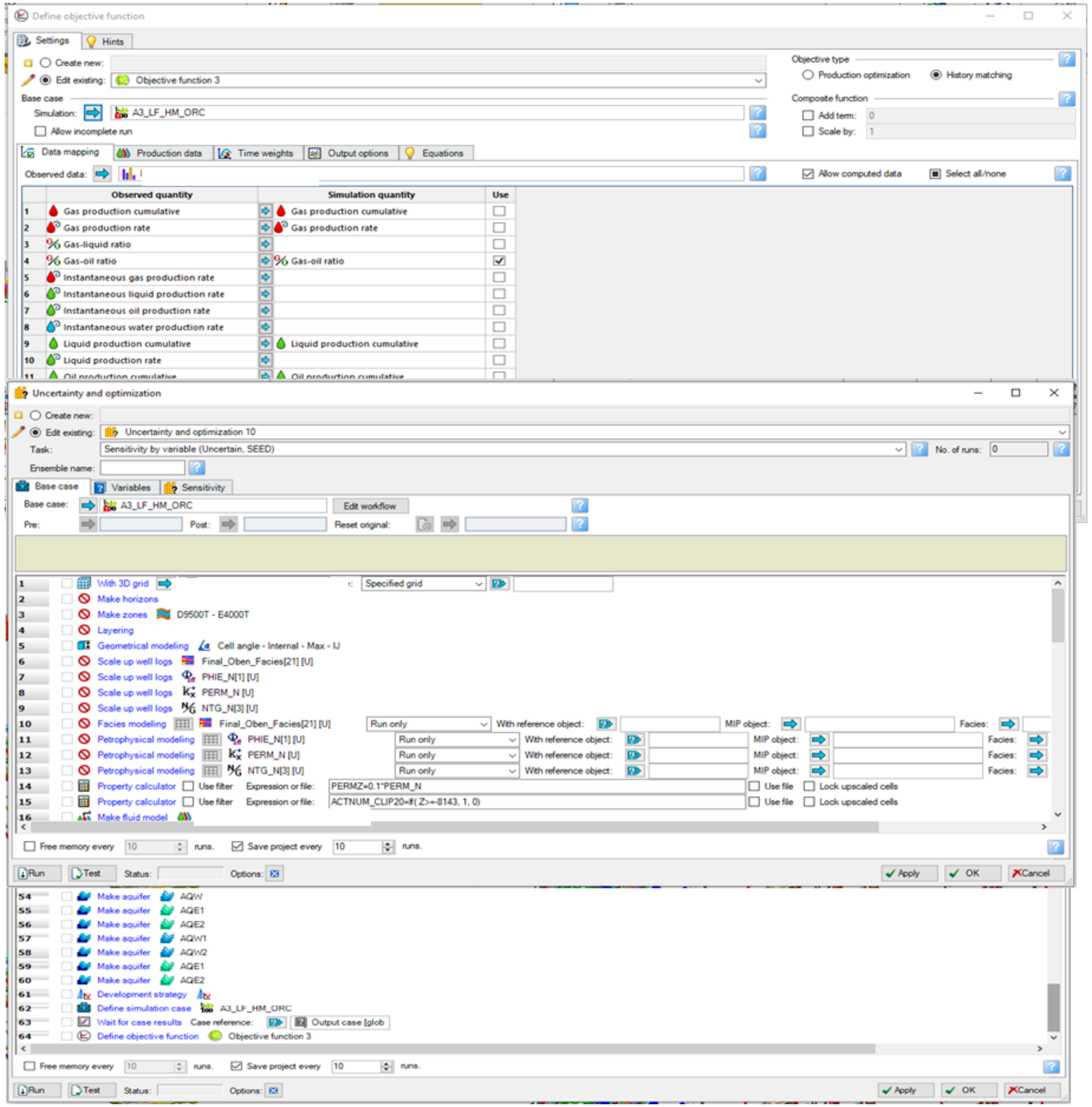
- History Matching Strategy

- **Pressure**
- Control: Reservoir Volume
- Key History Matching Parameters:
- Aquifer Properties: Fetkovitch, aquifer volume/permeability
- Kv/Kh = 0.1
- Reservoir energy provided by gas pre-1980 and then external aquifer influence from post-1980.

- **Saturation (Next page)**
- Control: Oil Rate
- Key History Matching Parameters-Transmissibility, Rel Permeability endpoints-initial sensitivities done on Assisted History Matching (AHM)

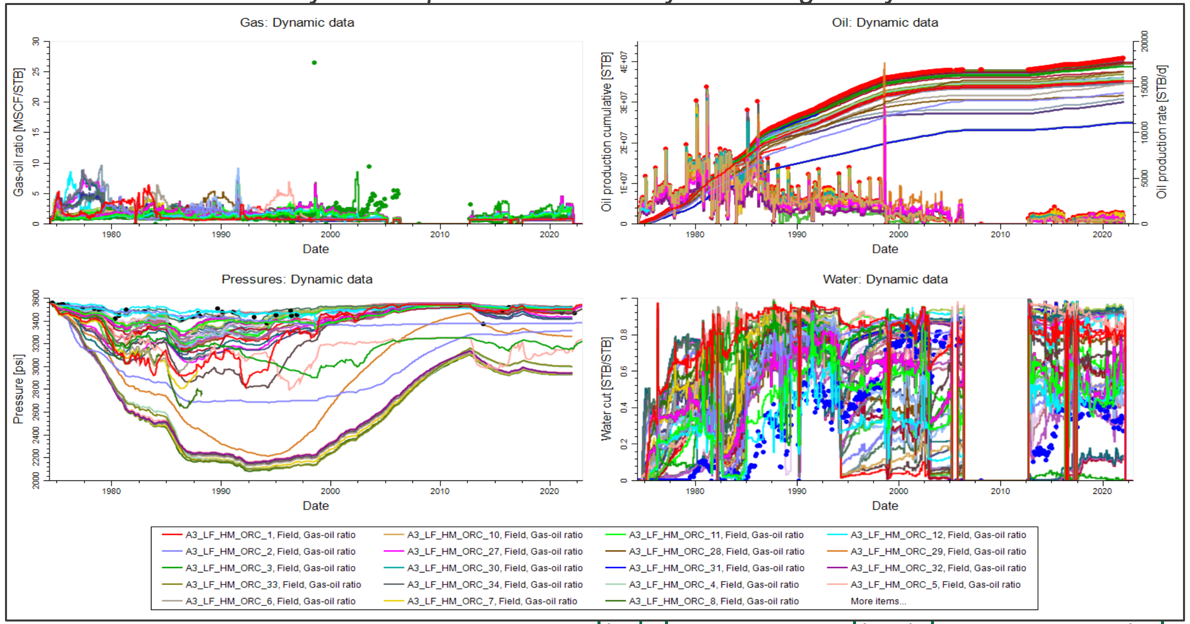


ASSISTED HISTORY MATCH & SCALABILITY SENSITIVITIES

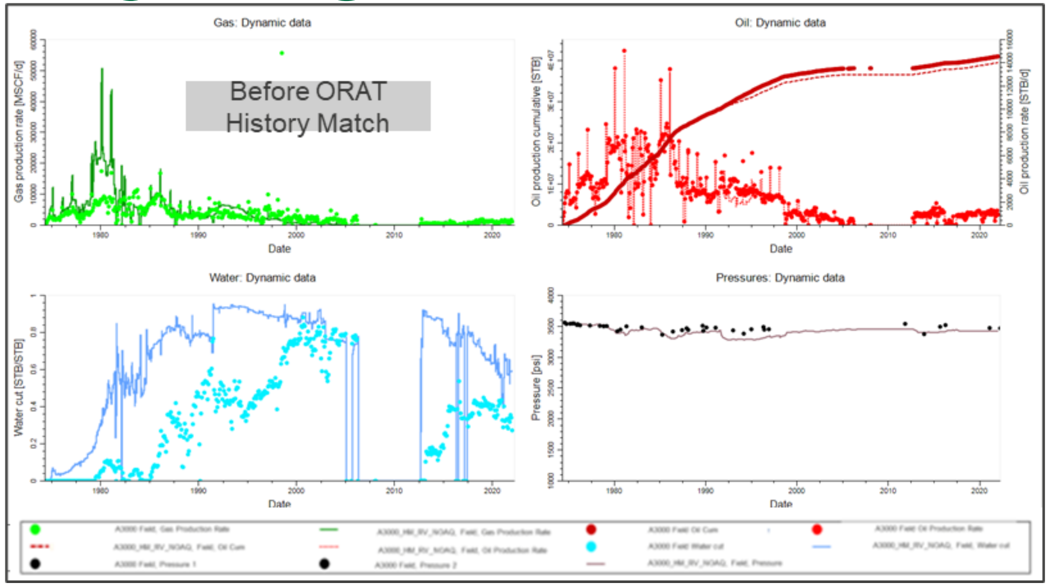


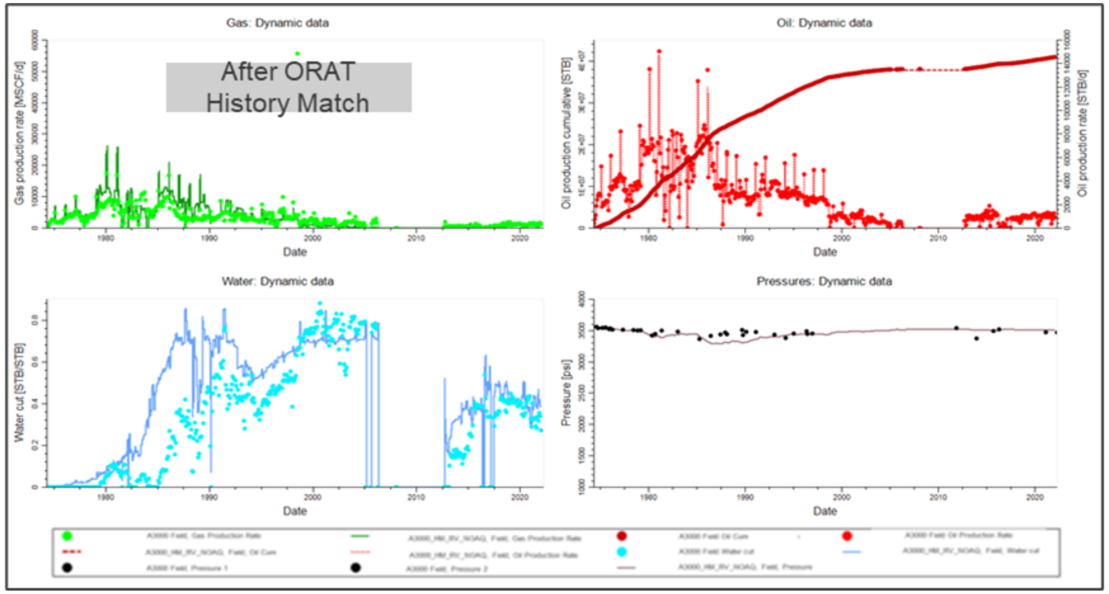
	Simulation Runtime (50 x 50 Grid) (mins)				
	On-Premises		DELFI Enabled ODRS		
No of Processors	1	16	64	32	16
A3000	1080	159	30	20	174

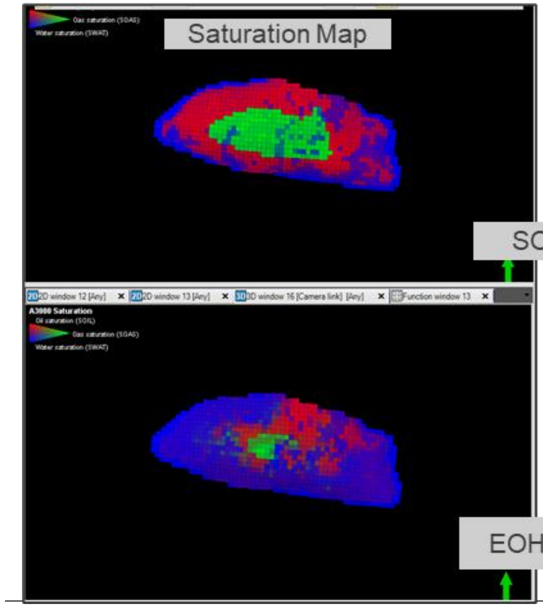
- *75 sensitivity runs within 24 hours*
- *Provided sensitivity envelop for further history matching analysis*

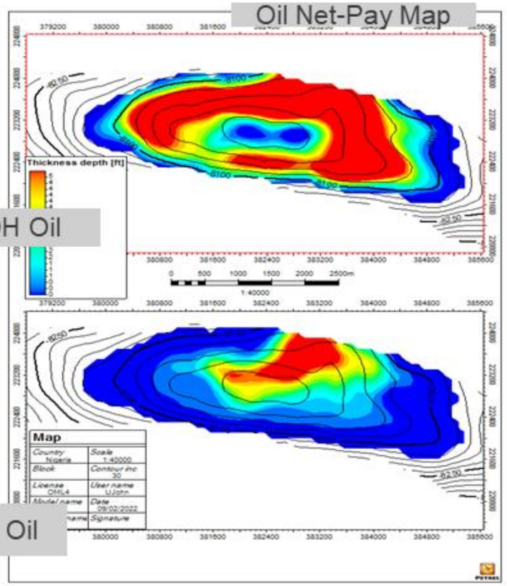


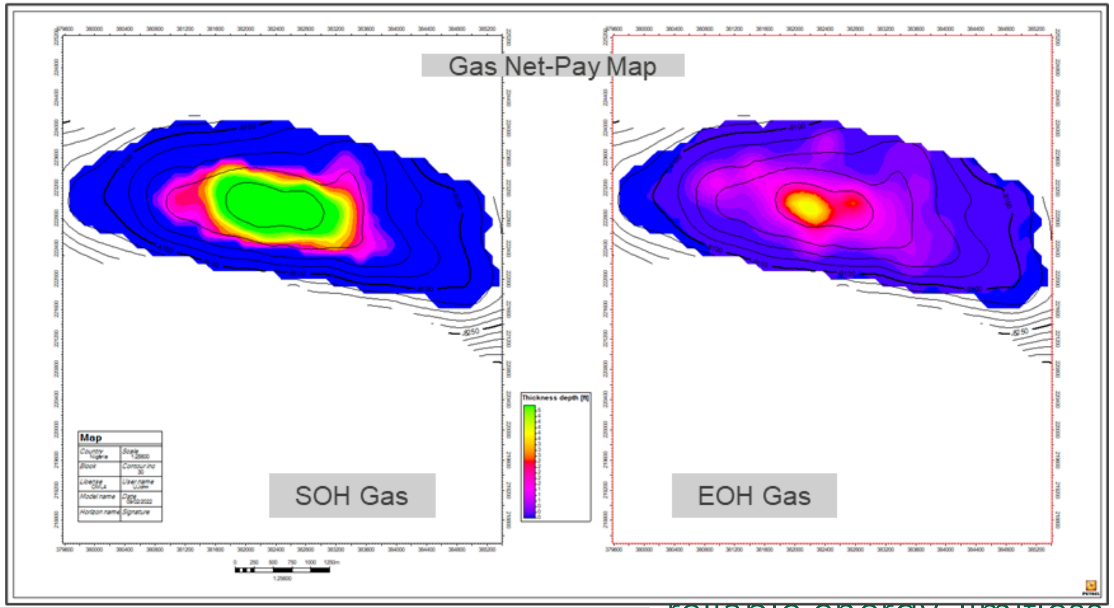
BASE CASE HISTORY MATCHING (OIL RATE CONTROL) RESERVOIR LEVEL





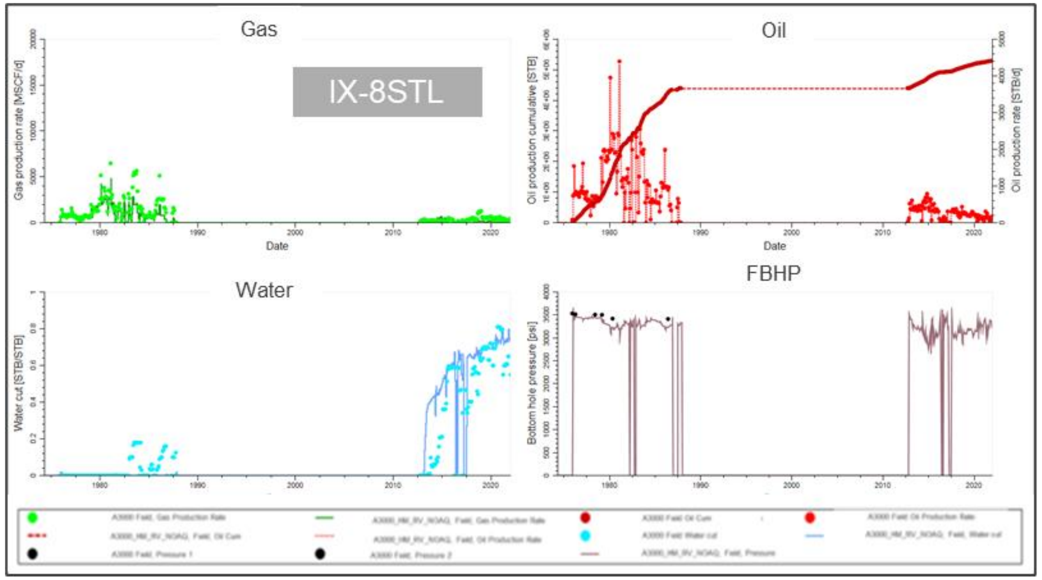


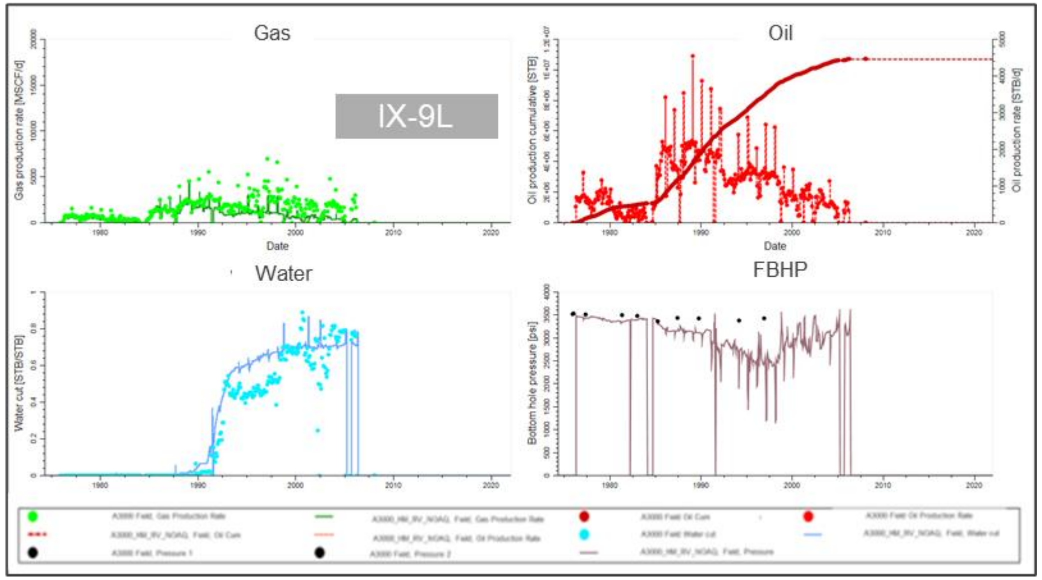


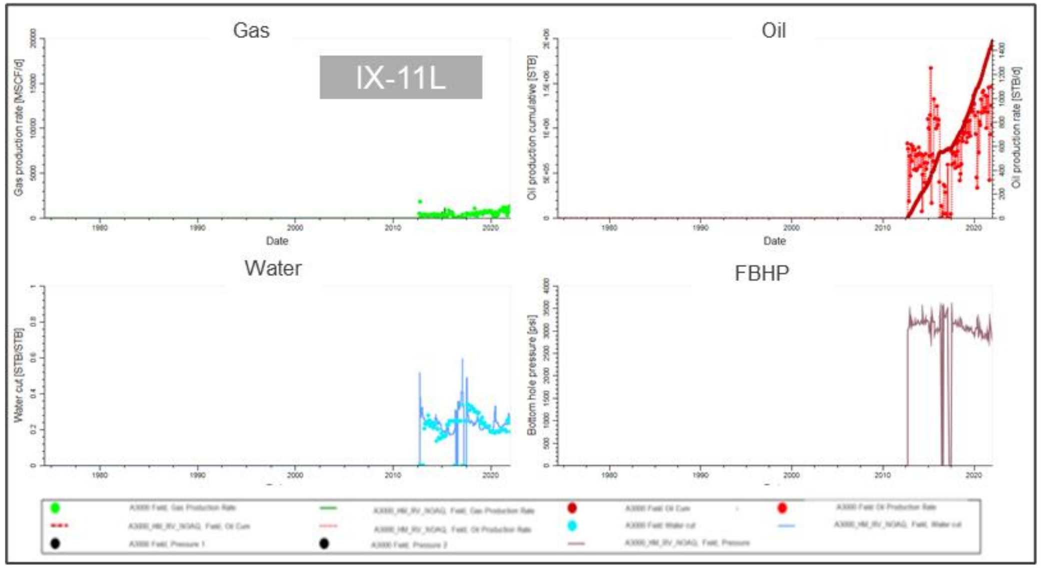


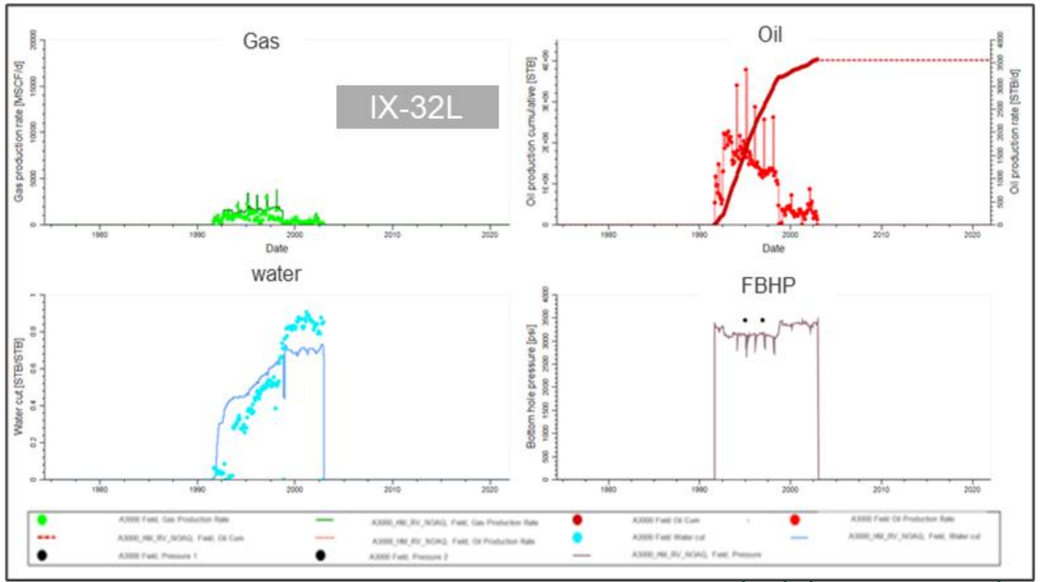
Schlumberger-Private

BASE CASE HISTORY MATCHING (OIL RATE CONTROL) WELL LEVEL CONTD

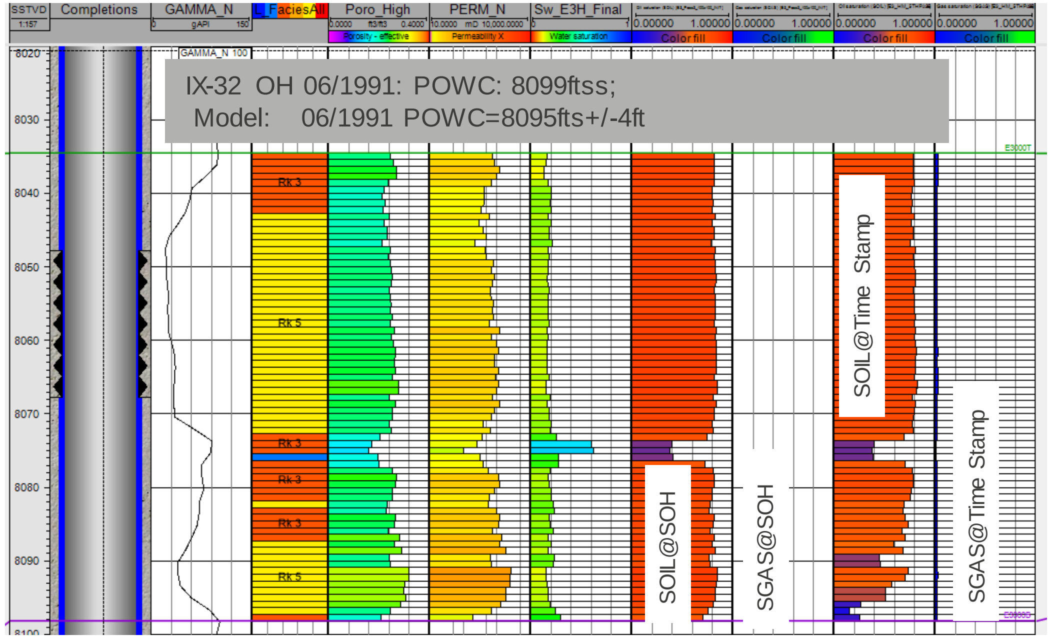


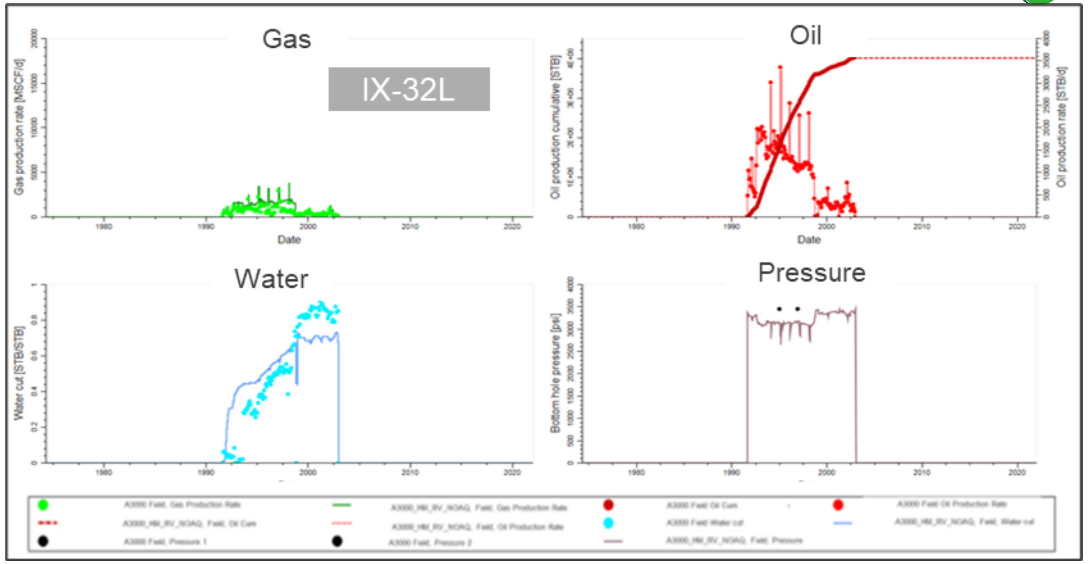


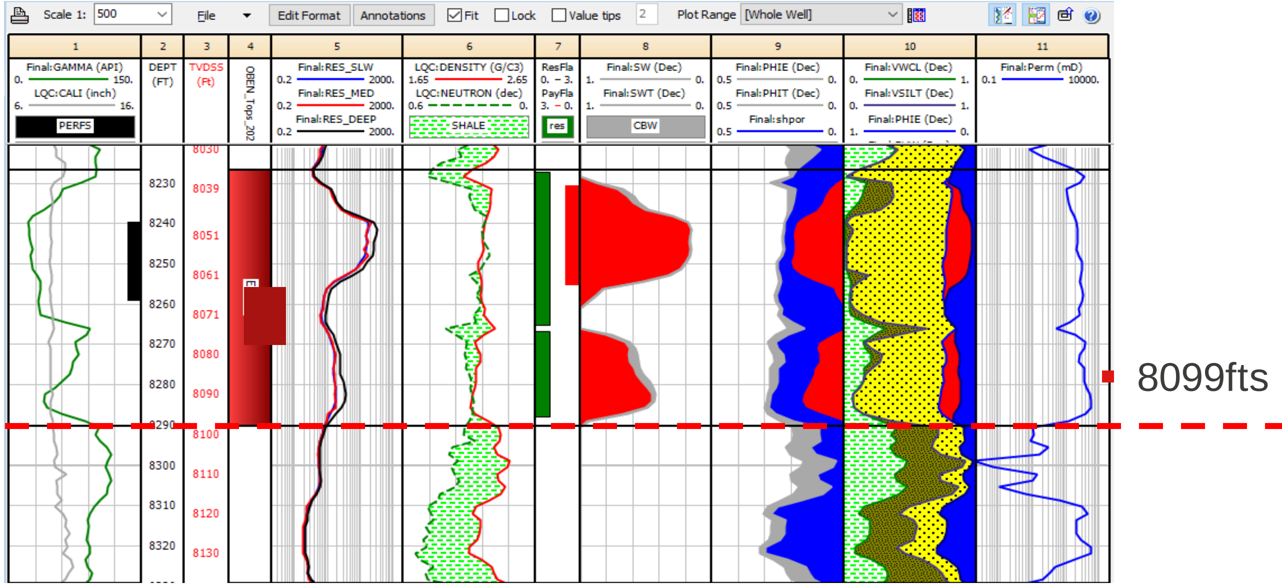




HISTORY MATCH CALIBRATION (OH AND CO LOGS)







Well	Reference Date	Model Contact	Reference System		Variance
			Open Hole	Carbon Oxygen log	
		ftss	ftss	ftss	ftss
IX-20	08/1977	PGOC(8018)	8021	-	3
IX-32	06/1991	POWC(8095)	8099	-	4
IX-23	11/2009	POWC(8038)	-	8041	3
IX-6	12/2009	POWC(8041)	-	8045	4
IX-8	07/2012	POWC(8047)	-	8048	1
IX-45	11/2014	POWC(Flushed)	Flushed	-	-
IX-46	09/2021	PGOC(7975)	-	7970	5

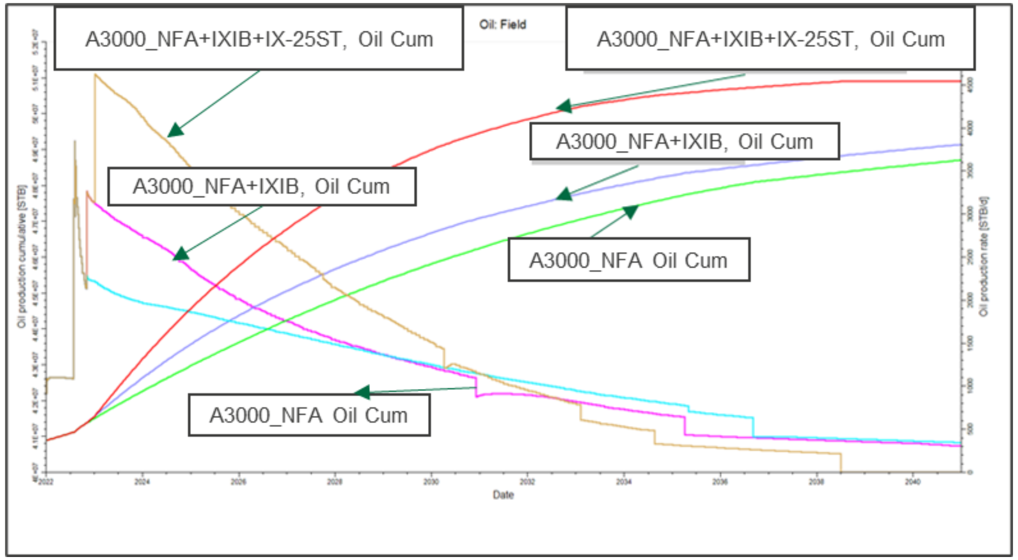
Schlumberger-Private

SUMMARY OF A3000M OPPORTUNITIES & RISK MITIGATION

Summary

- Fairly good model calibration obtained (using Open Hole and CO logs, 2022 Gas Well test data)
- Potential to reduce simulation runtime by about 98% and 80% relative to single processor and 14-processor respectively
- Reserves addition of about 8.6mmstb over previous studies
- 2 Years reserves and production acceleration and incremental recovery of about 1.75 mmstb over NFA.

RESERVOIR	STOIIP (MMSTB)	Np @31.12.21 (MMstb)	Current Np/STOIIP	ACTIVITY	Well	OFFTAKE RATE	Activity Rewards	*EUR (mmstb)	Incremental on NFA+IXIB-02	RF (%)
A3000	79.70	40.09	50%	NFA	NFA_IX-8STL	250 BOPD	0.1			
					NFA_IX-11L	1000 BOPD	2.39			
					NFA_IX-44L	5MMSCFD/1000BOPD	1.48			
				NFA+IXIB-02	IXIB-02	1500 BOPD	1.94			
				NFA+IXIB+ IX-25ST	IX-25ST	1500 BOPD	4.02			
							9.93	50.02	0.59	63%



Opportunity	Risk & Uncertainty	Proposed Mitigation
IX-44L_NFA	GOC, risk of fouling of gas facility.	Blowdown gas at low rate and switch to oil line when rate drops
IXIB-02 New Well	IX-6L and IX-32L water-cut calibrations. Uncertainty in recovery estimates	Use history match realizations based on quality of IX-6L water-cut calibration
IX-25 Sidetrack	Reservoir stratigraphy. Low saturation, Poor incremental recovery	Use pilot well to test area between IX-11 and IX-8.

MERITS, DEMERITS & RECOMMENDATIONS

MERITS

- The quick turnaround time for ODRS speeds up decision making and enhances the business portfolio
- It minimizes or eliminates on-site IT infrastructure and attendant problems leading to significant cost savings
- Reduces need for specialist IT staff, with a resultant optimal staff management and cost-efficiency
- Shortens study duration which implies that several projects can be undertaken by the same team over a shorter period
- Robustness of results due to ability to perform uncertainty modelling in reasonable time. A robust low, base and high case realizations covering the uncertainties are generated
- Scalable solution - suitable for small consultancy and middle to large operating company
- Reduces the waiting time for simulation results to be out before taking the next steps. Therefore, eliminates staff redundancy-less resources required to conduct reservoir studies
- Overall, lower cost and lower in-house, onsite resources per project

DEMERITS

- Misalignment of pay-per-use business model with annual budgeting and cash call from IOC and Independents
- Exorbitant initial cost outlay

RECOMMENDATIONS

- Project based and/or annual cost model at agreed processor numbers (not hourly timing)
- Consider bundling ODRS with AHM (Production optimization) at a cost-efficient pricing
- Provide assurance for confidentiality of data
- There is a potential to integrate the solution into SEPLAT's field reservoir simulation workflow especially for complex reservoirs

Schlumber

THANK YOU ???

ACKNOWLEDGEMENT

1. Management & Colleagues at SEPLAT ENERGY PLC
2. Schlumberger Seplat Account Managers & Technical support team

reliable energy, limitless potential