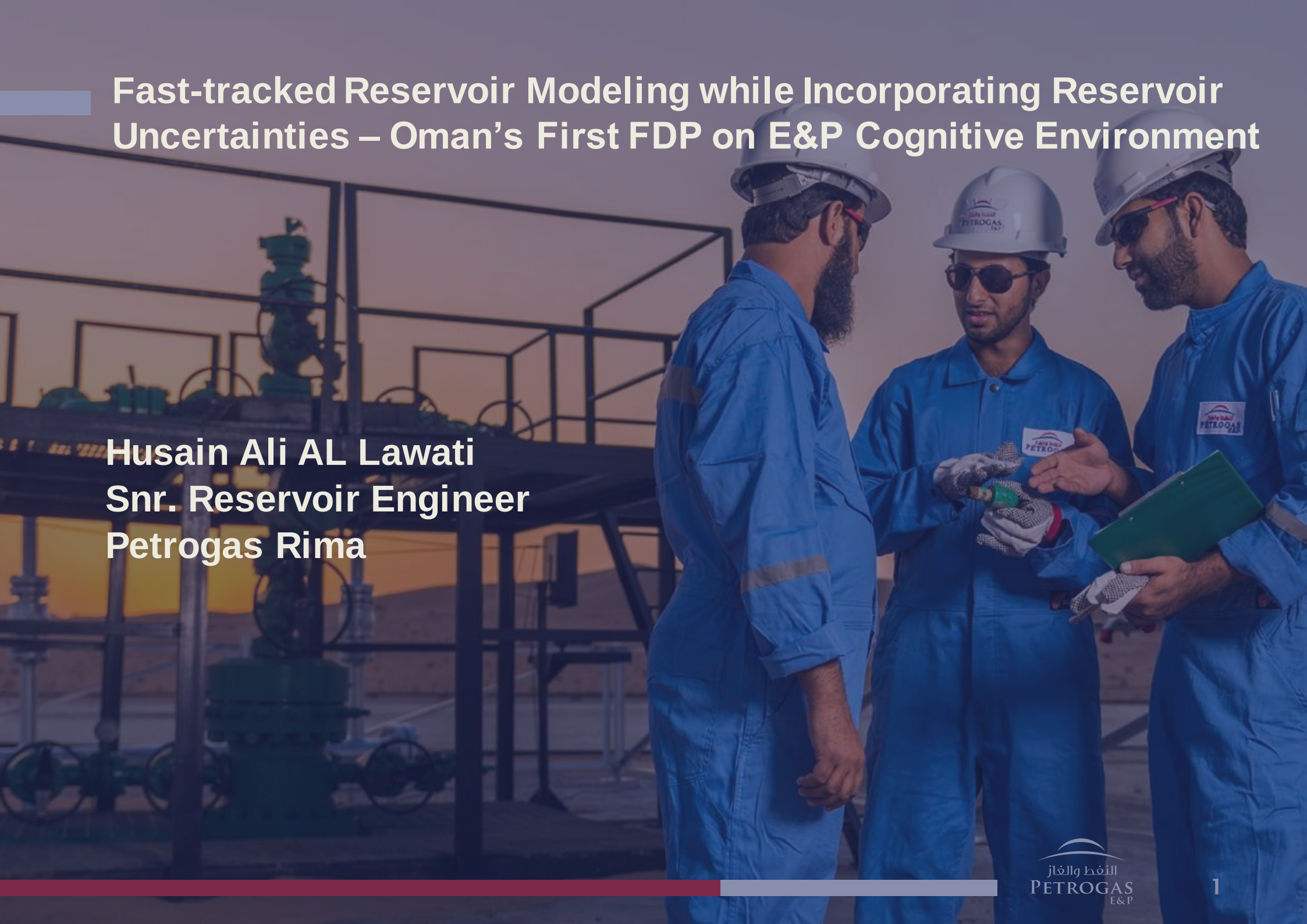
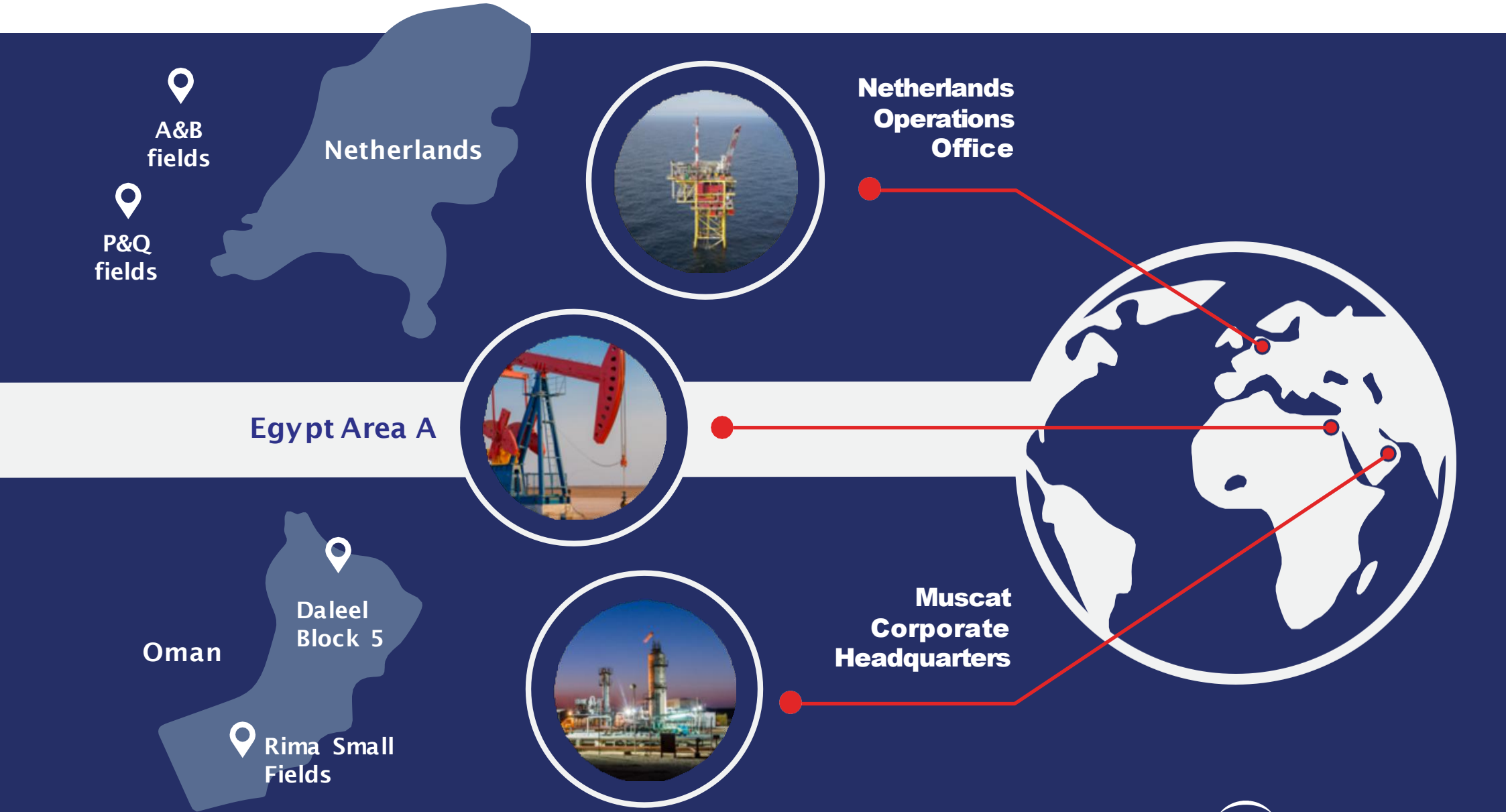
Fast-tracked Reservoir Modeling while Incorporating Reservoir Uncertainties – Oman's First FDP on E&P Cognitive Environment



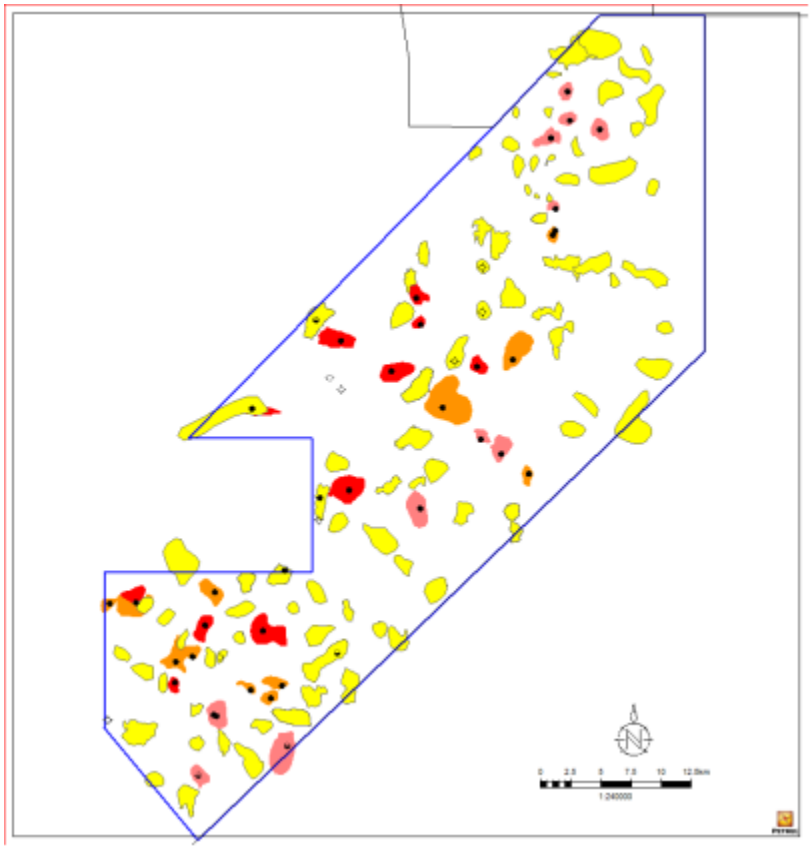
Husain Ali AL Lawati
Snr. Reservoir Engineer
Petrogas Rima

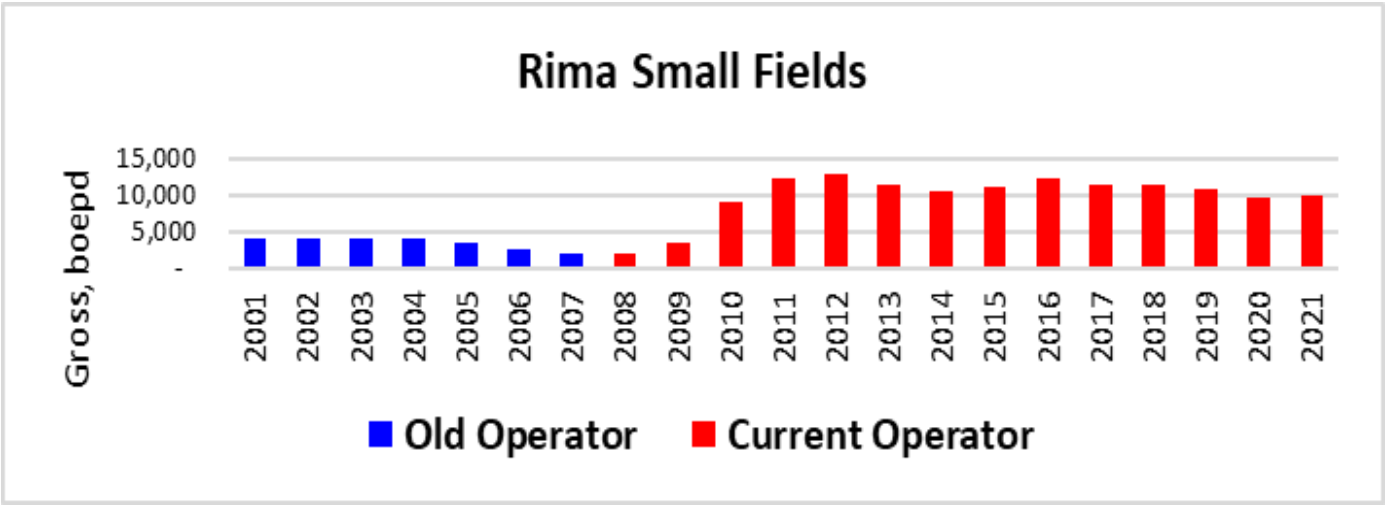
Where We Are


A&B fields
P&Q fields
Netherlands
Netherlands Operations Office
Egypt Area A
Daleel Block 5
Oman
Rima Small Fields
Muscat Corporate Headquarters

Petrogas Rima

- PETROGAS Rima Operates 26 small on shore heavy oil fields in the south of Oman
- The small fields are scattered over a large area
- The fields Produce from multiple Clastic Staked reservoirs
- Oil viscosity ranges between 15-2000cp.
- Most of the fields are produced using natural depletion
- Four fields are undergoing WF
- Three fields are developed with Cyclic steam stimulation
- One field is undergoing a polymer flood pilot





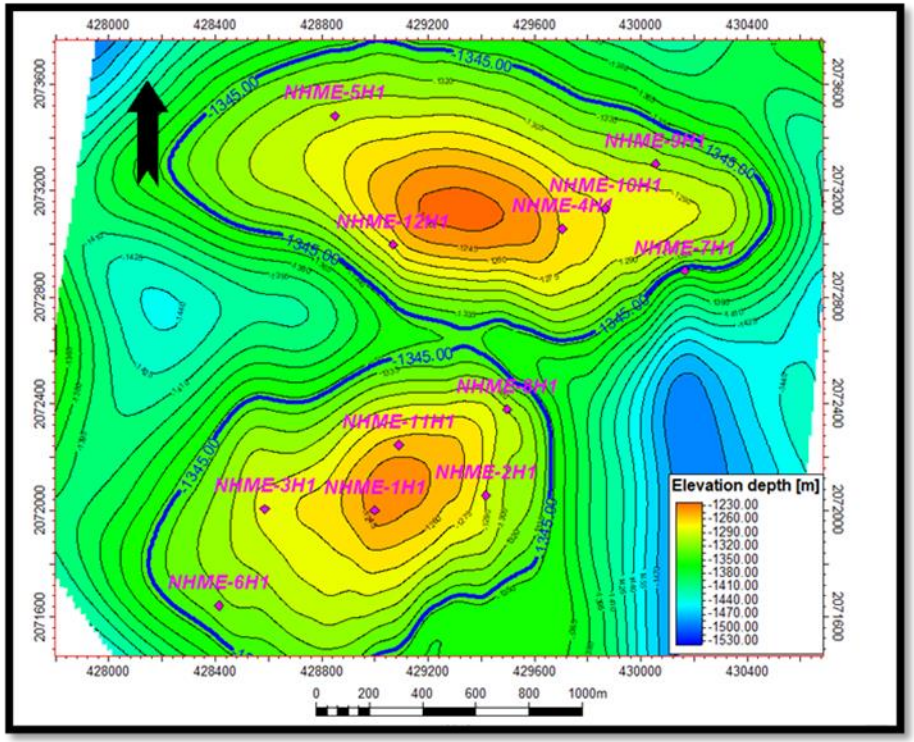
NHME Field

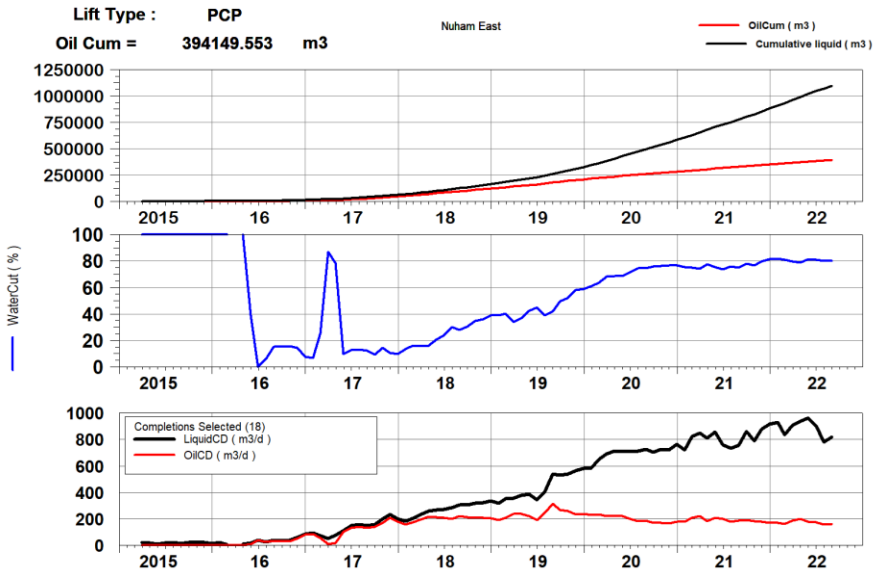
- Geologically seated in the Eastern flank of South Oman Salt basin.
- Two turtle-back Anticline structures producing from the clastic HSAK-P9 reservoir
- The two structures have different fluid properties with The northern structure being more viscous.
- Both structures are aquifer supported
- The fields are developed with Horizontal wells with laterals between 300-1000m long

- **Development Challenges:**

➢ ALL FMI's in the horizontal wells are showing an intensive fractured reservoir

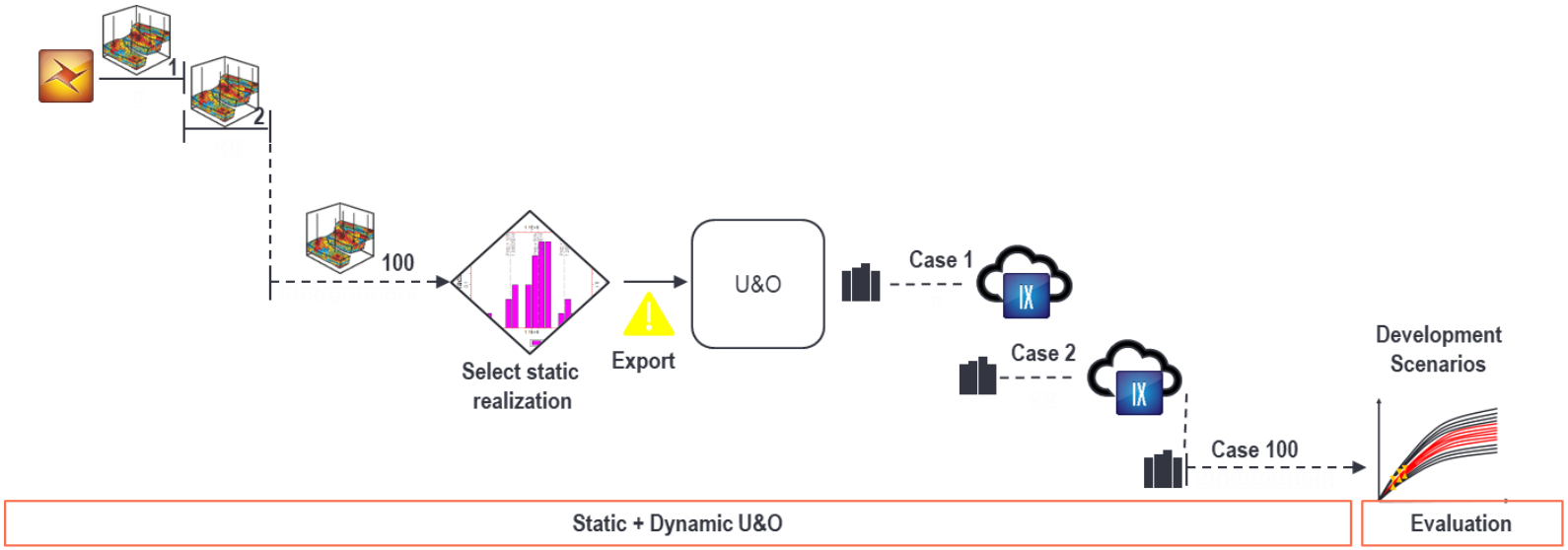
➢ Due to the lack of Core data and the short history there are a lot of uncertainties i.e. Permeability, Fractures Aquifer size and strength





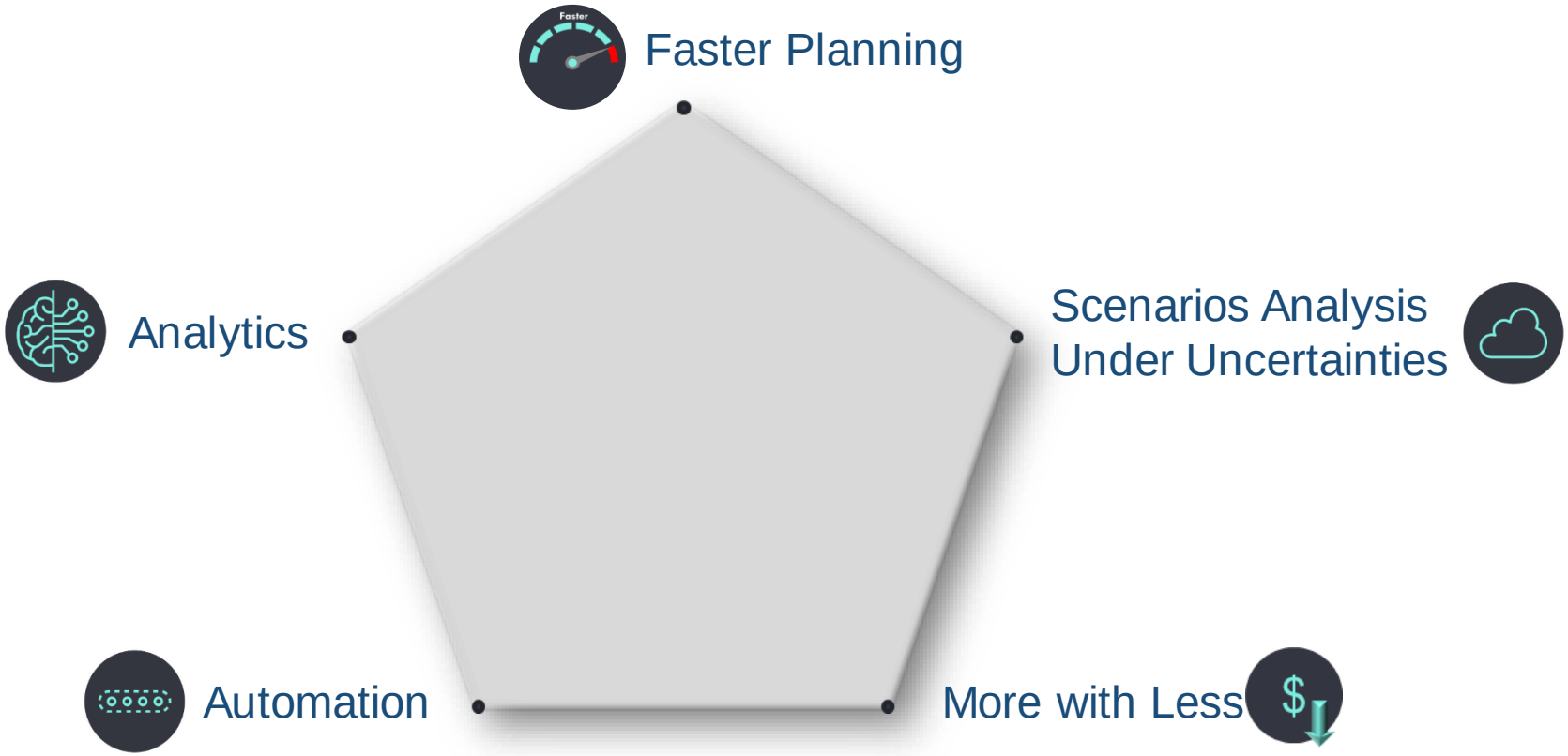
FDP workflowPetrogas Rima

- Petrogas Follows Conventional deterministic FDP Workflow with a very basic Hardware setup that produces one Constrained realization of development scenarios
  - Time Consuming process (~ 6- 8 Weeks spent on reservoir simulation task and economics evaluation)
  - Limited resources (Human, Hardware &Software)

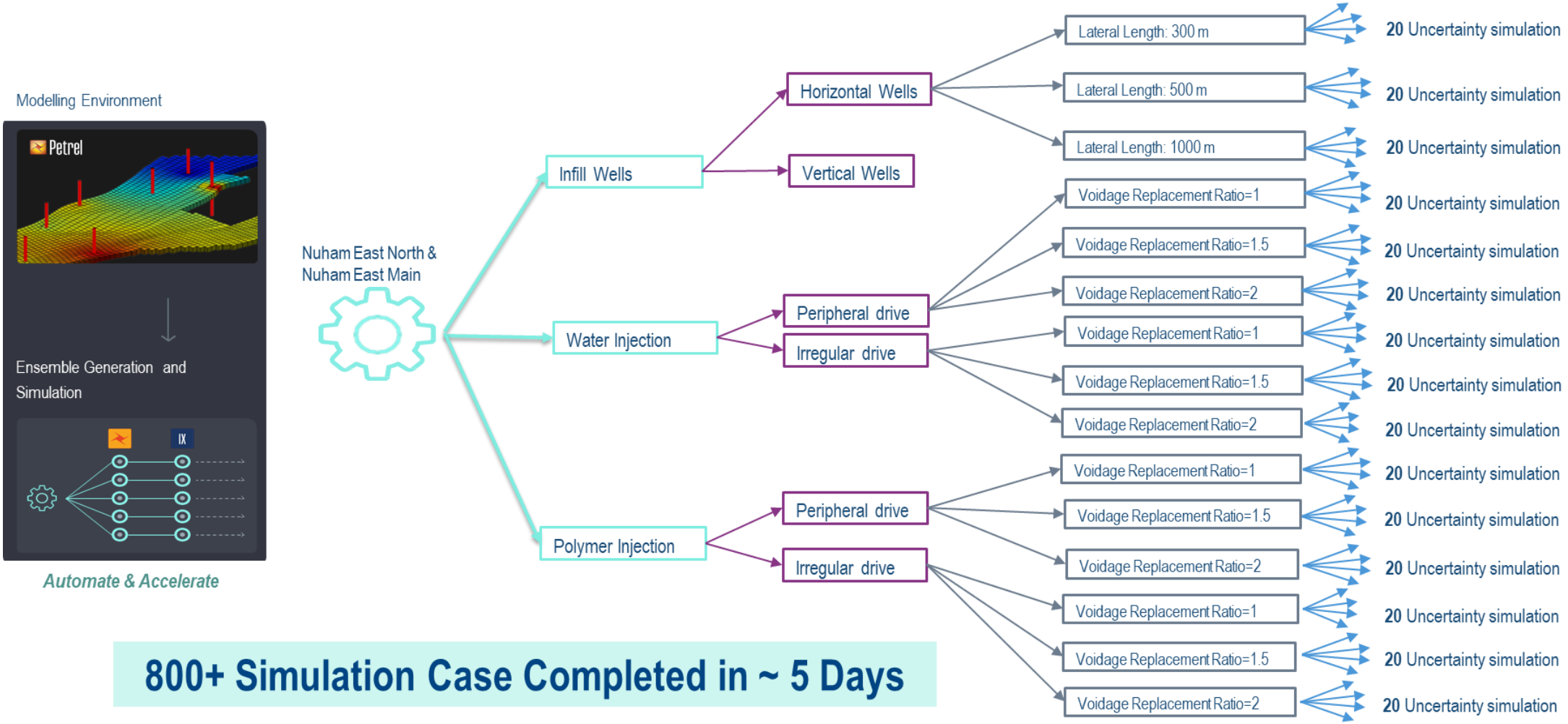


- For NHME field this approach is insufficient due to the high uncertainty associated with limited data and short productions history leading to High uncertainty in decision making.

Required Solution!!



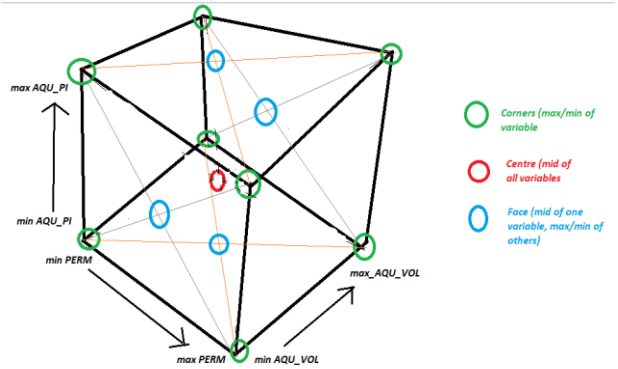
Implemented Solution
Agile Reservoir Modeling Integrated with FDPlan

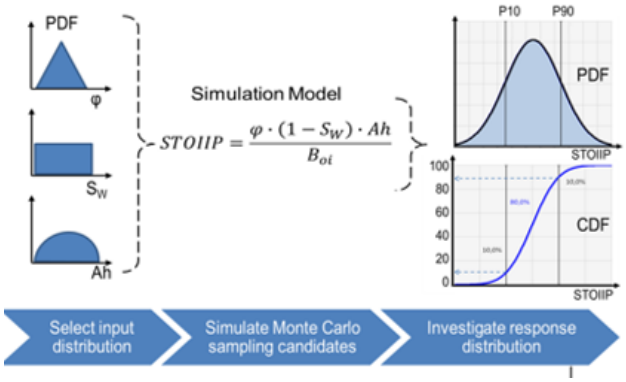


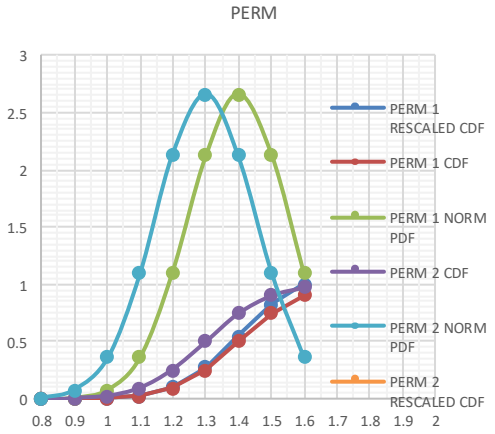
800+ Simulation Case Completed in ~ 5 Days

Subsurface Uncertainty matrix

Uncertain Parameter	Petrel Parameter
Permeability X	$PERM_MULT_S2
Permeability Y	$PERM_MULT_S1
Aquifer Volume	$Aq_Vol
Aquifer PI	$Aq_PI

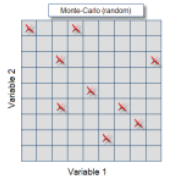






MONTE-CARLO SAMPLER

- Random Sampling Method

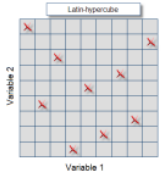


The variables are sampled randomly independent of each other.

Thus, there may be some parts of the range of the variable which might not be sampled at all.

LATIN HYPERCUBE SAMPLER

- Random Sampling Method

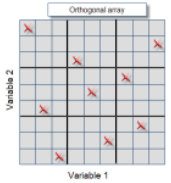


It is a smart sampling technique that divides the distribution into equiprobable bins. One value is then randomly sampled from each bin.

The number of bins is the same as the number of samples.

ORTHOGONAL ARRAY SAMPLER

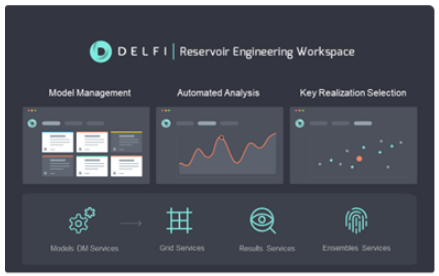
- Random Sampling Method



If we have more than one input variable and we subdivide each of them into equally probable bins, then we can use orthogonal sampling to make sure that values from all bins of all variables are combined with each other.

PETROGAS E&P

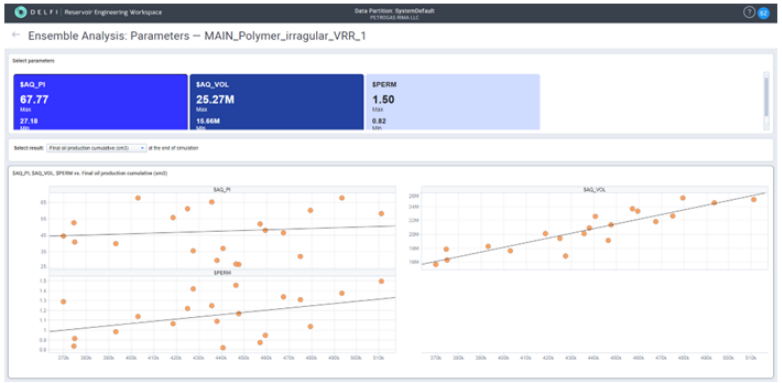
RE Workspace | Automated Analytics

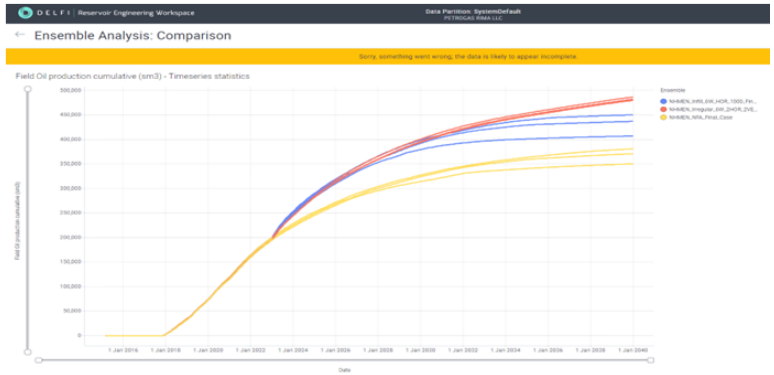


Assist decision making with analytics and insights

Model management & Auto uncertainty envelop

Auto correlation of uncertainties & responses

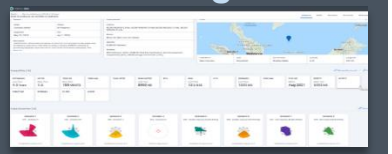




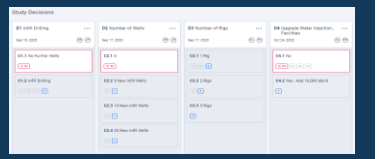
Developments Scenarios Decision Process

FDPlan

Manage

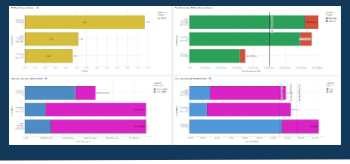


Frame



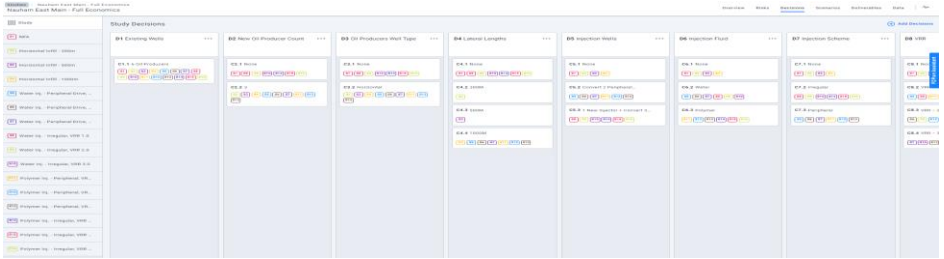
Evaluate

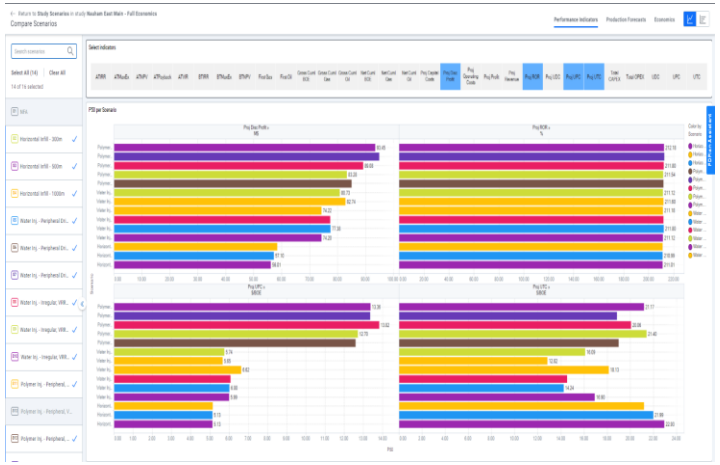
Decide

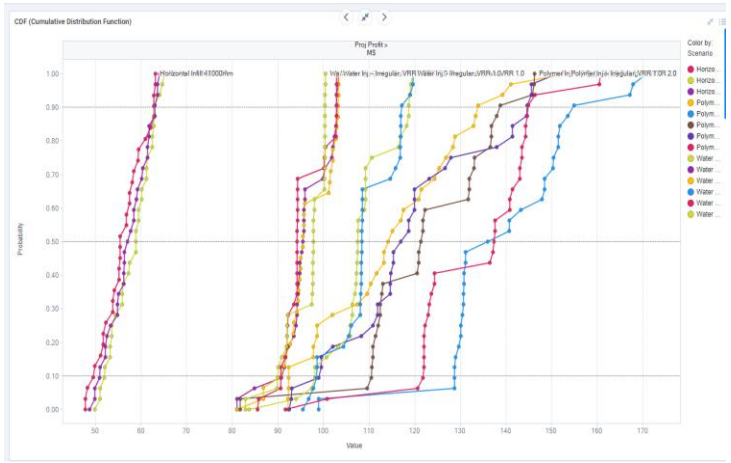


15 Nuham East Development Scenarios Represented in FDPlan

No	Development Scheme	Scenarios	Scenarios Name	New Oil Producers	New OP Well Type	Lateral Lengths	Injector	Injection Fluid	Injection Scheme	VRR	Polymer Concentration
		Decisions		3	Horizontal	300	2 new wells	None	None	1	None
					Vertical	500	Re-use 2 peripheral wells	Water	Pattern	1.5	None
						1000		Polymer	Line Drive	2	None
						0		Steam	Peripheral	None	None
											None
1		NFA		0	0	NA	0	None	None	None	None
2		Vertical			Vertical	NA	0	None	None	None	None
3	Infill Wells (Start of all other scenarios)	Horizontal - 300	Main_INFILL_3W_HORZ_300	3	Horizontal	300	0	None	None	None	None
4		Horizontal - 500	Main_INFILL_3W_HORZ_500	3	Horizontal	500	0	None	None	None	None
5		Horizontal - 1000	Main_INFILL_3W_HORZ_1000	3	Horizontal	1000	0	None	None	None	None
6		Peripheral Drive			Horizontal	Based on Scenario 3-5	Re-use 2 peripheral wells	Water	Peripheral	1	None
7		Peripheral Drive			Horizontal	Based on Scenario 3-5	Re-use 2 peripheral wells	Water	Peripheral	1.5	None
8	Water	Peripheral Drive			Horizontal	Based on Scenario 3-5	Re-use 2 peripheral wells	Water	Peripheral	2	None
9		Pattern (Irregular)			Horizontal	Based on Scenario 3-5	2 New Inj Wells + Re-use 2 peripheral	Water	Pattern (Irregular)	1	None
10		Pattern (Irregular)			Horizontal	Based on Scenario 3-5	2 New Inj Wells + Re-use 2 peripheral	Water	Pattern (Irregular)	1.5	None
11		Pattern (Irregular)			Horizontal	Based on Scenario 3-5	2 New Inj Wells + Re-use 2 peripheral	Water	Pattern (Irregular)	2	None
12		Peripheral Drive			Horizontal	Based on Scenario 3-5	Re-use 2 peripheral wells	Polymer	Peripheral	1	6
13		Peripheral Drive			Horizontal	Based on Scenario 3-5	Re-use 2 peripheral wells	Polymer	Peripheral	1.5	6
14	Polymer Injection	Peripheral Drive			Horizontal	Based on Scenario 3-5	Re-use 2 peripheral wells	Polymer	Peripheral	2	6
15		Pattern (Irregular)			Horizontal	Based on Scenario 3-5	2 New Inj Wells + Re-use 2 peripheral	Polymer	Pattern (Irregular)	1	6
16		Pattern (Irregular)			Horizontal	Based on Scenario 3-5	2 New Inj Wells + Re-use 2 peripheral	Polymer	Pattern (Irregular)	1.5	6
17		Pattern (Irregular)			Horizontal	Based on Scenario 3-5	2 New Inj Wells + Re-use 2 peripheral	Polymer	Pattern (Irregular)	2	6







Value Created to Petrogas

1. Quantified the uncertainty by providing a probalistic forecast taking into consideration most of the uncertainties
2. Fast tracked the FDP process while also Providing more insight into the recommended development (800 simulation runs over 5 days covering 28 development scenarios)
3. DELFI and cloud solutions will help reduce the time required from exploration till field development
4. Provided greater flexibility and scalability with high computational power
5. Automation of the data analysis process and Economic analysis leading to increasing the process efficiency
6. New FDP approach using the DELFI environment successfully enabling a small operator to do more (reservoir simulation and economic evaluation time reduced by more than 75%)