



# Enhancing Waterflooding Performance On the Path to Autonomous Operations

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# Agenda



# Overview

## Summary

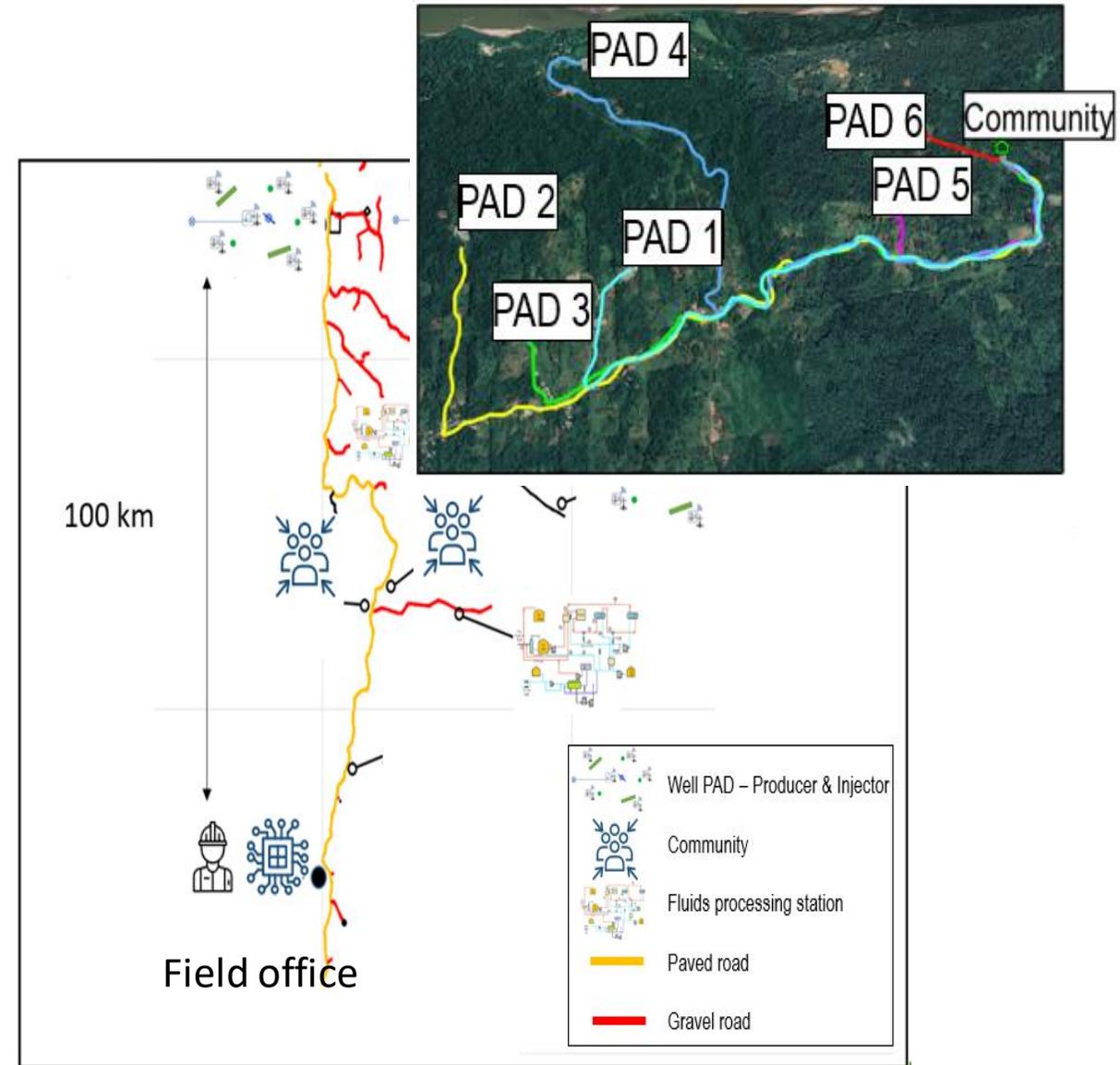
- Several fields scattered over ~800 Km<sup>2</sup> (NS)
- Reservoir management currently migrating from primary to secondary recovery

## Subsurface:

- Depleted reservoirs with limited active aquifer

## Facilities:

- Scattered in small clusters
- Power reliability one of main concerns



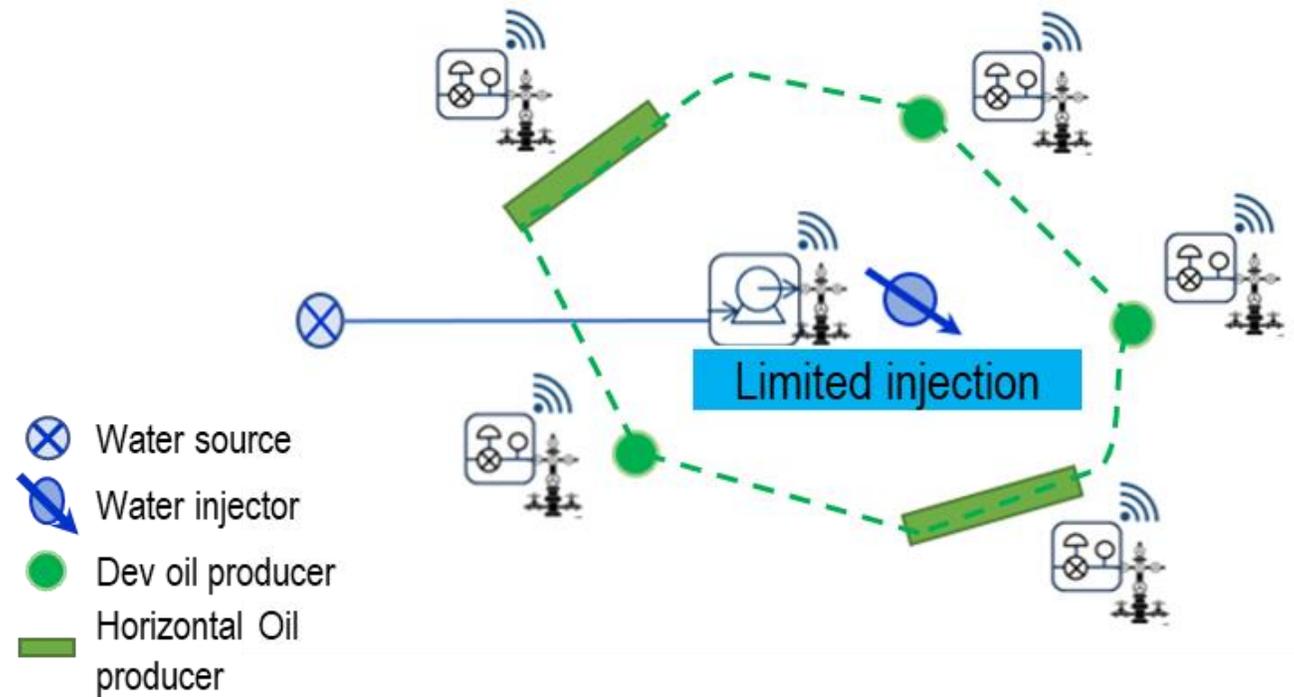
# Business Challenges

- Time to decision to meet production targets
- Inefficient optimization system.
- Generate actionable insights on waterflood management



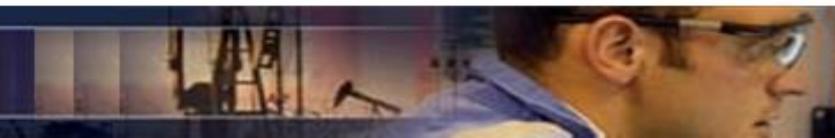
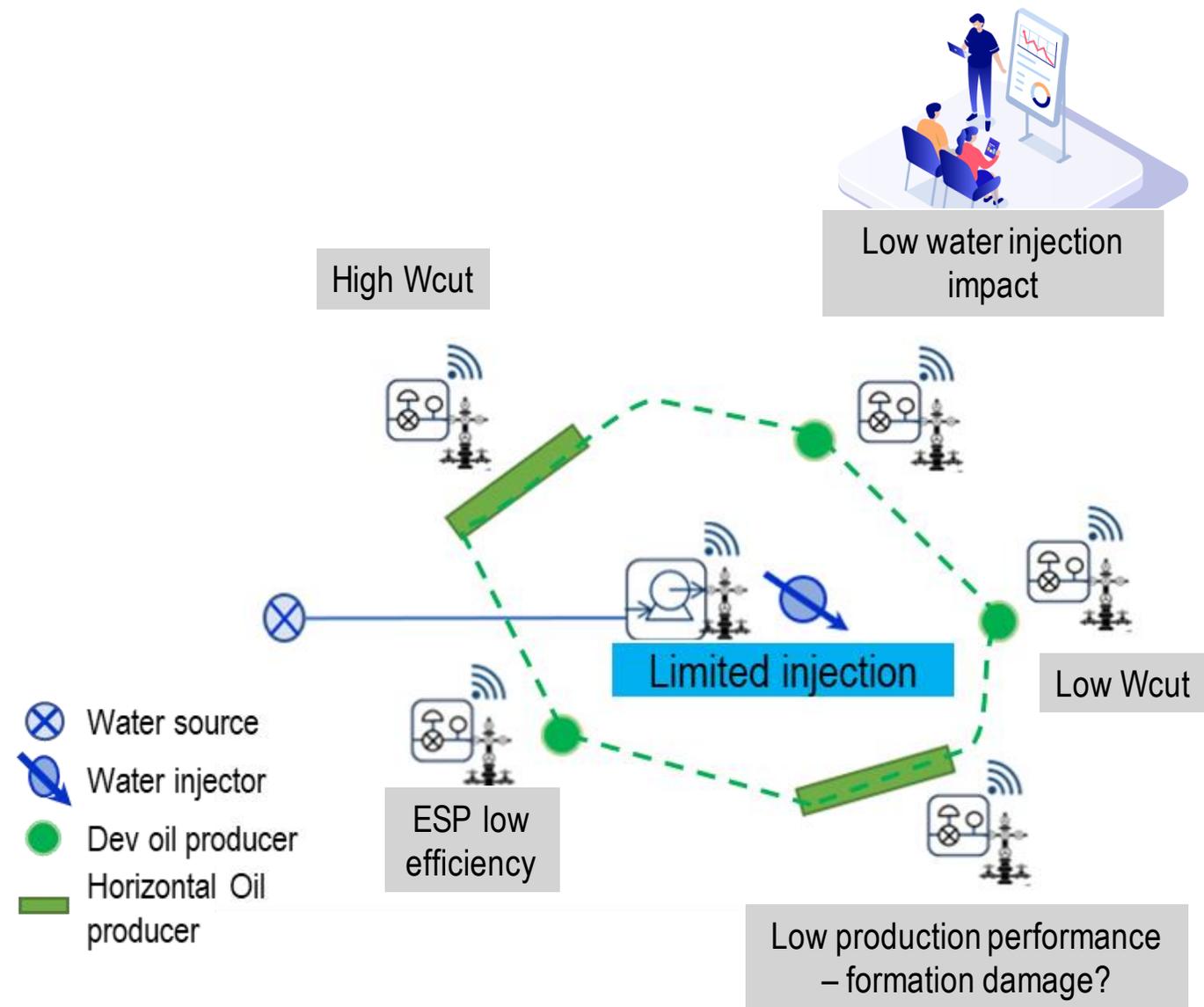
# Technical Challenges

- Primary recovery mindset and lack of previous experience in waterflooding



# Technical Challenges

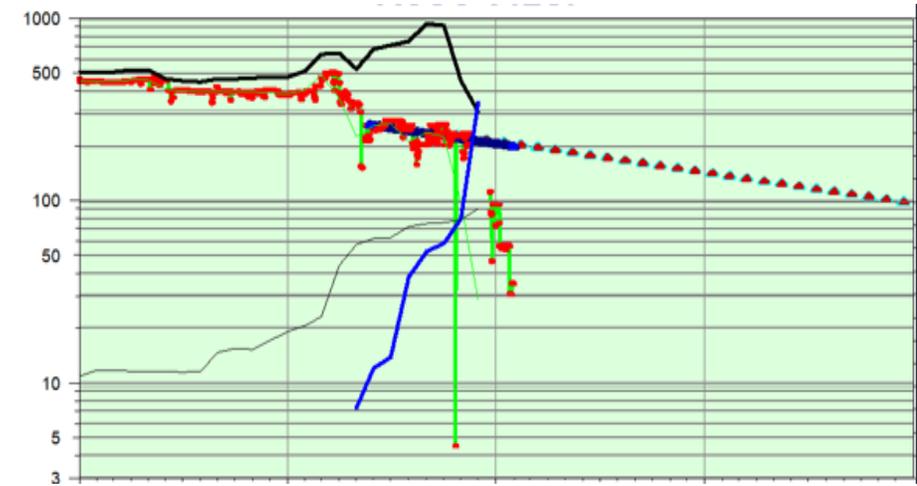
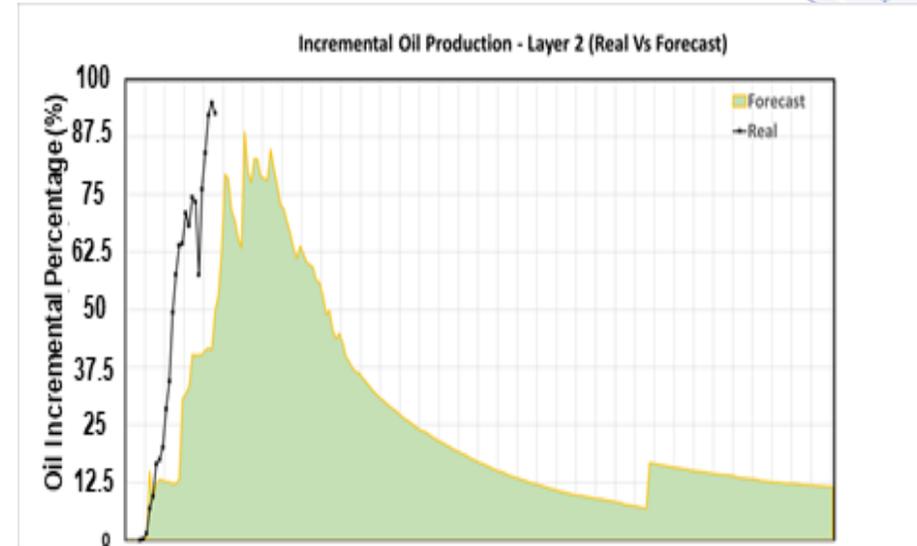
- Primary recovery mindset and lack of previous experience in waterflooding
- Combination of deviated injector wells and deviated/horizontal producer wells



# Technical Challenges



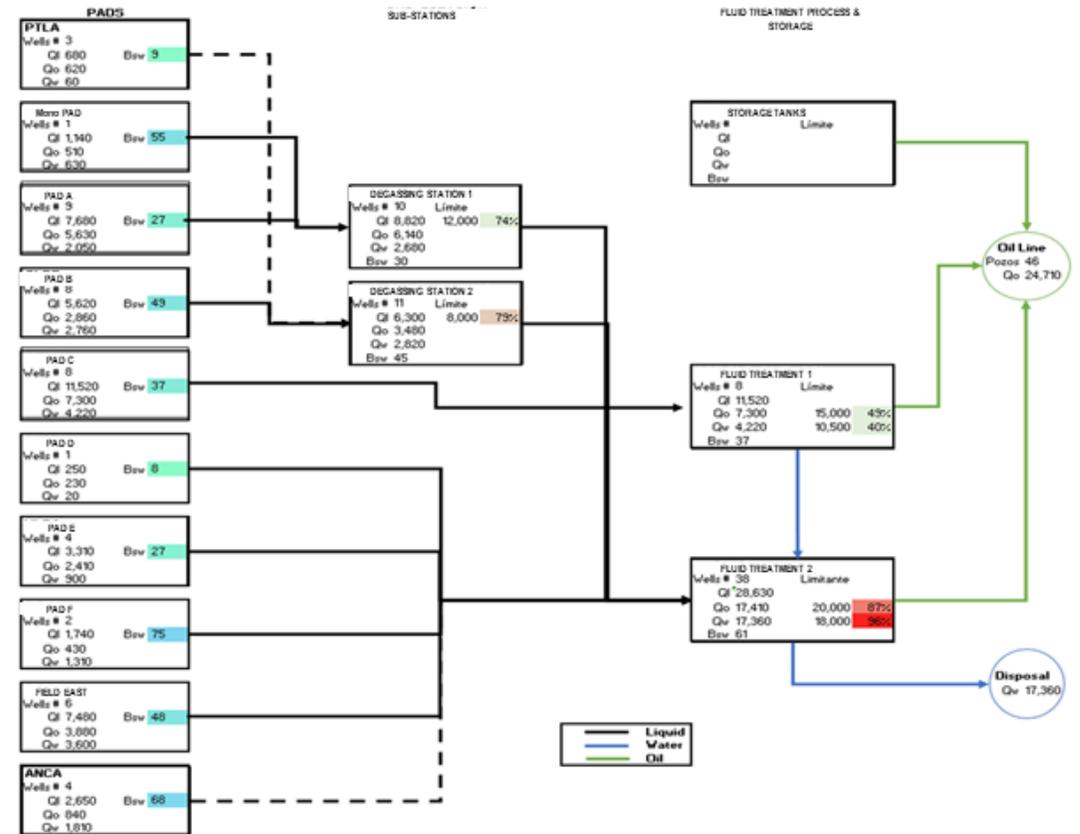
- Primary recovery mindset & lack of previous experience in waterflooding
- Combination of deviated injector wells and deviated/horizontal producer wells
- Steep decline with early water breakthrough



# Technical Challenges



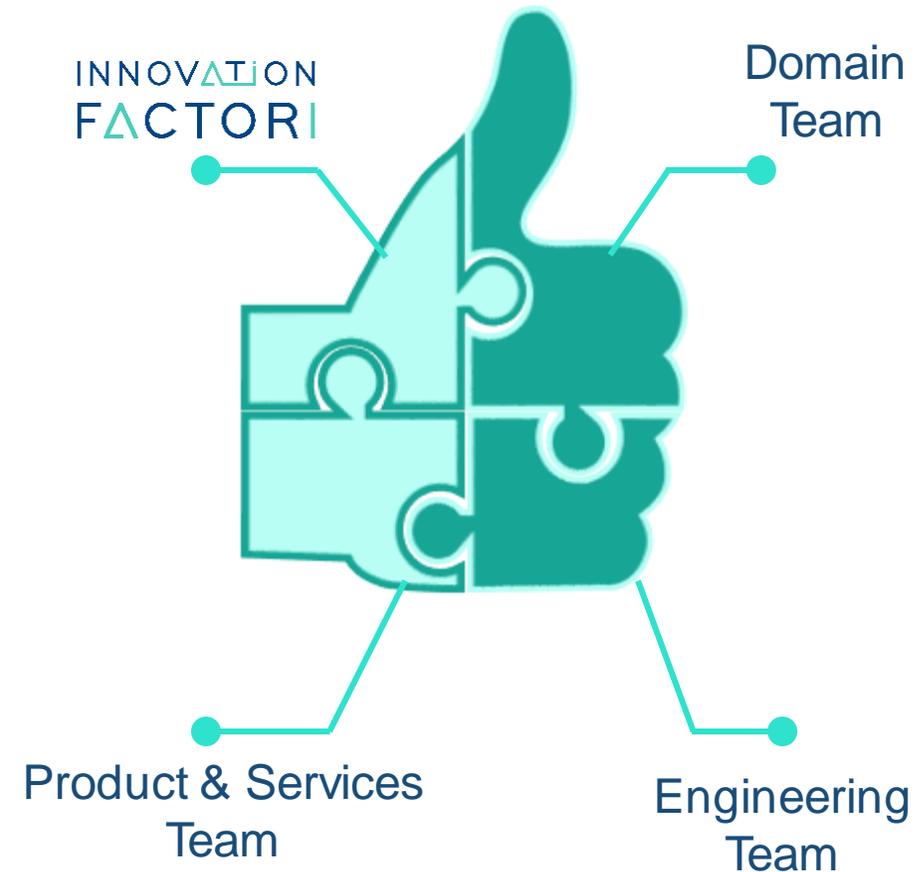
- Primary recovery mindset. No previous experience operating assets under water injection recovery
- Combination of deviated injector wells and deviated/horizontal producer wells
- Steep decline with early water breakthrough
- Fluid handling restrictions (fluid transfer process to processing station).



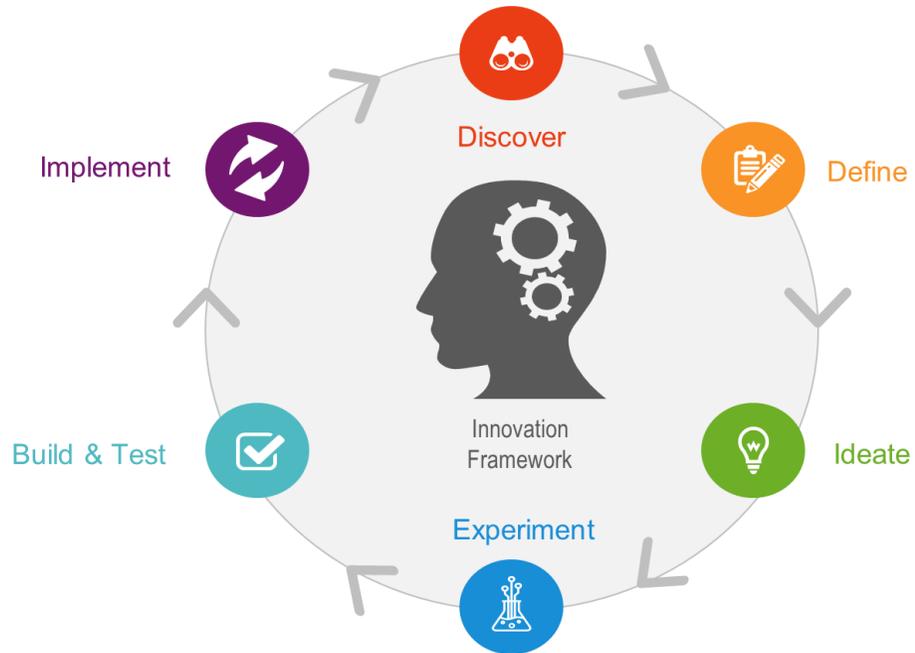
# The Solution: AI driven waterflood optimization

Customized decision support system for operational pattern flood optimization

- Physics based models
- AI driven workflows



# The Solution Development Approach – Design Thinking & Agile



**EXPERIMENTAL  
PROTOTYPE**



Prove and demonstrate  
that it can be done!

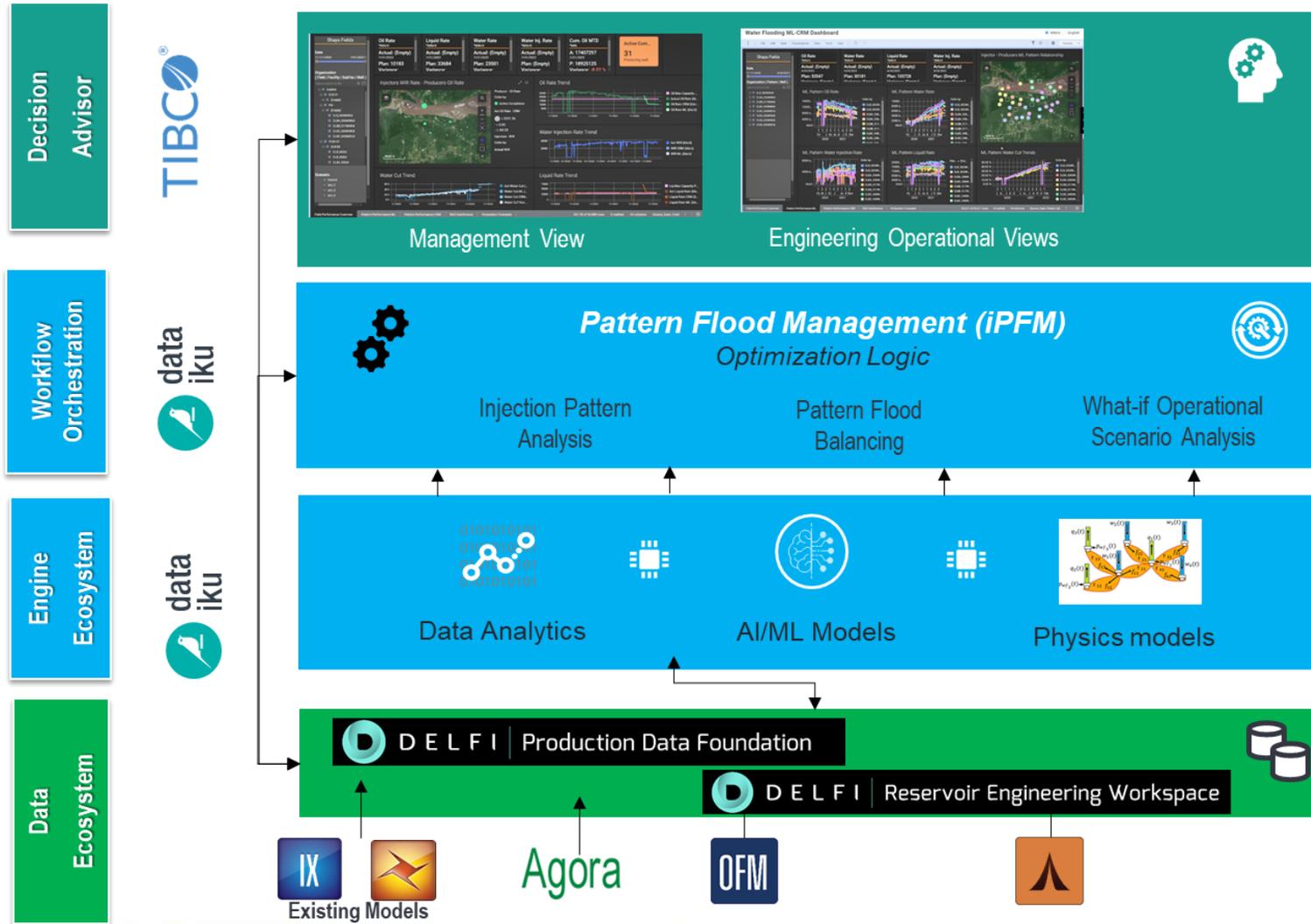
**DEPLOYABLE  
PROTOTYPE**



Validate and use in  
selected pilot project(s).

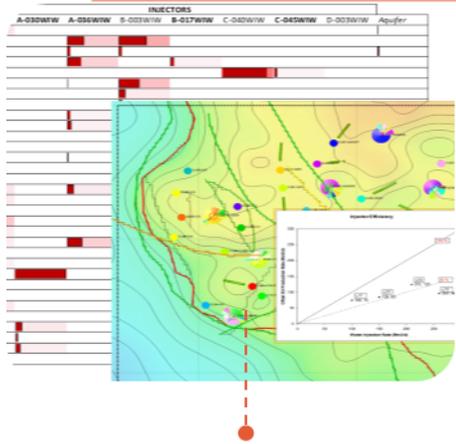
Intense collaboration, quick prototyping and field trial,  
Refine and mature for operational use

# Waterflood Optimization Framework



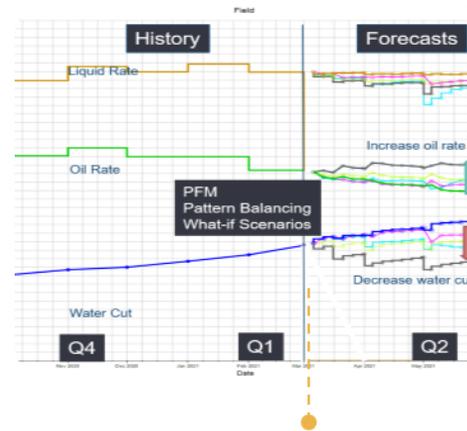
# Solution Overview

## Models & Pattern Analysis



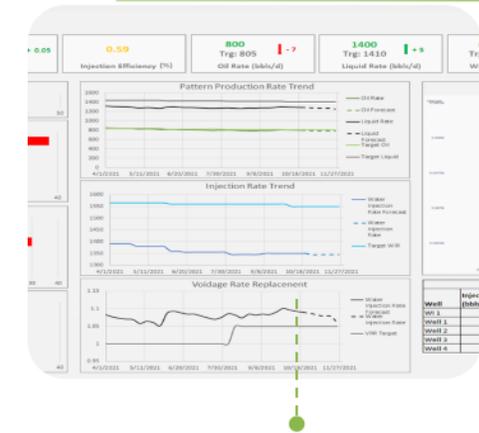
- Observed data
- Modelling (Physics, AI/ML)
- Pattern analysis

## Decision Analysis & Management



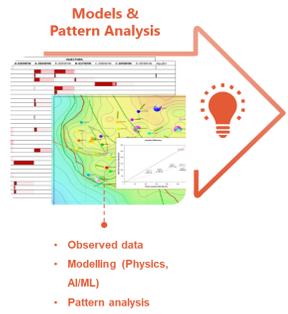
- Pattern balancing
- What-if scenarios
- General insights
- Short term and mid-term forecasts

## Actions



- Recommended production and injection
- Remedial operations
- Field implementation
- Monitoring & Surveillance

# ML Assisted Physics Model



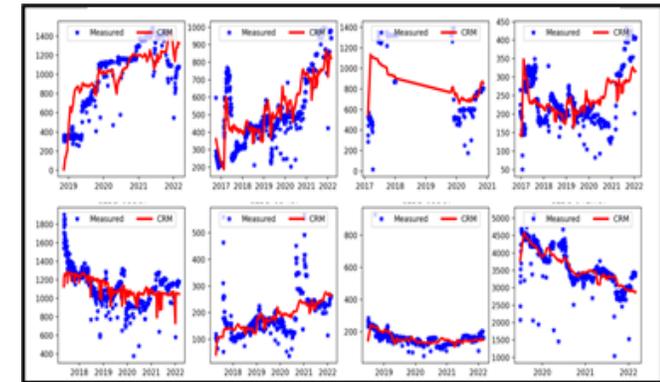
## STEP CHANGE IN PERFORMANCE

✓ Field pilot test reduced time to rebalance patterns from 23 hrs → 5 hrs

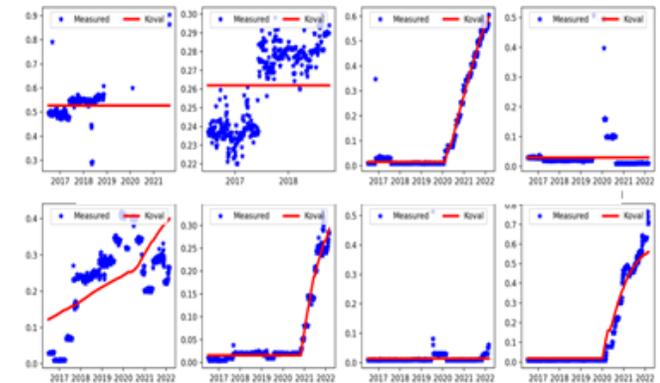


History match - Field level

## Liquid Rate – Well Level



## BSW – Well level

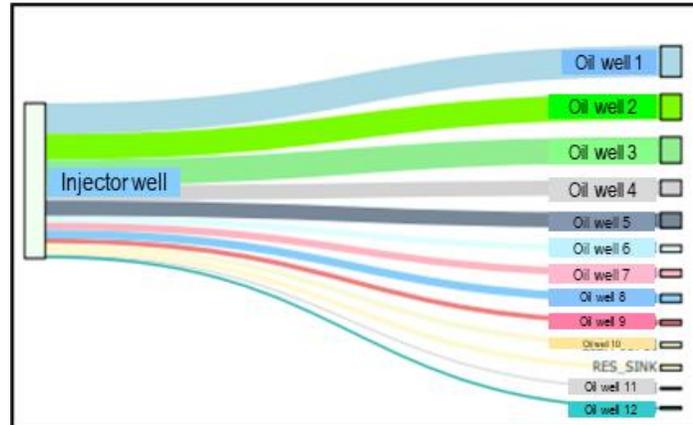


# Proven Pattern Balancing Algorithm (PFM)



## ROBUSTNESS PATTERN BALANCE ALGORITHM AND FORECASTING CAPABILITY

- ✓ Smart algorithm for allocation factors

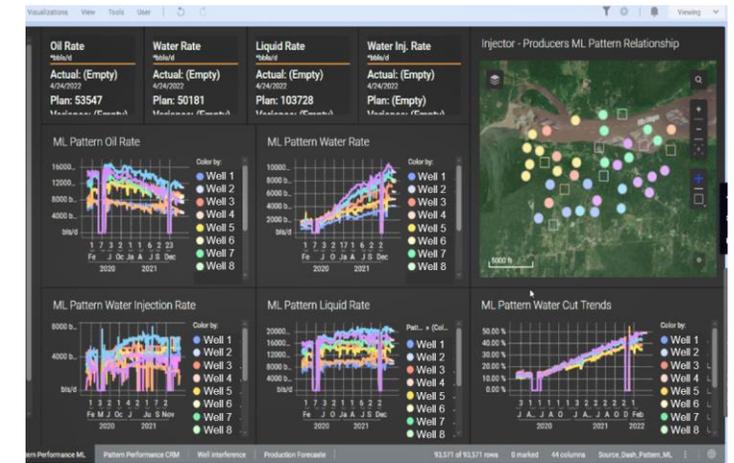
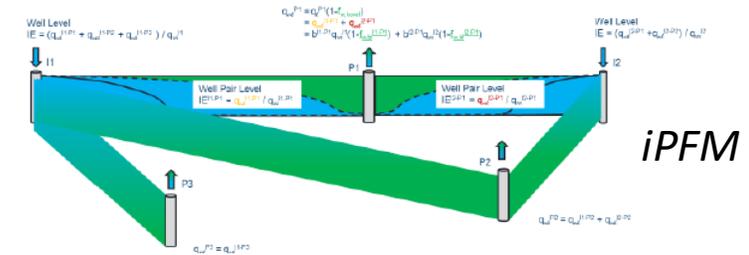


## WHAT-IF CAPABILITY

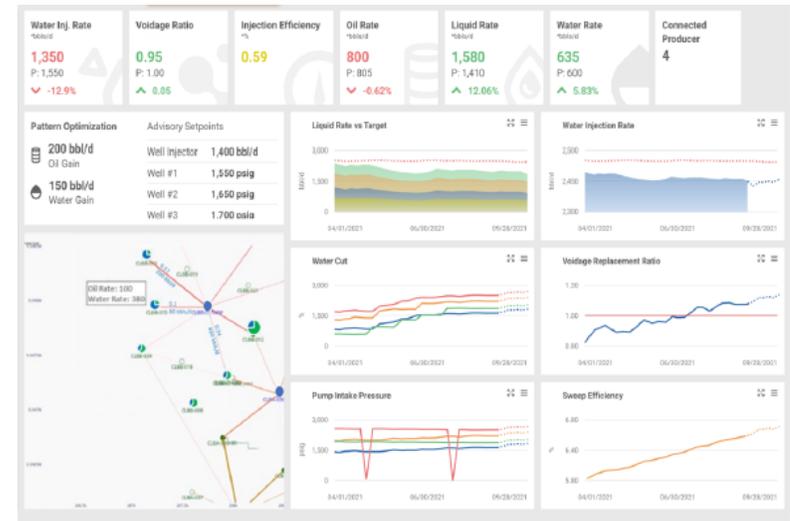
- ✓ What-If using operational parameters
- ✓ Unscheduled events

## Injection Allocation Optimization based on Injection Efficiency

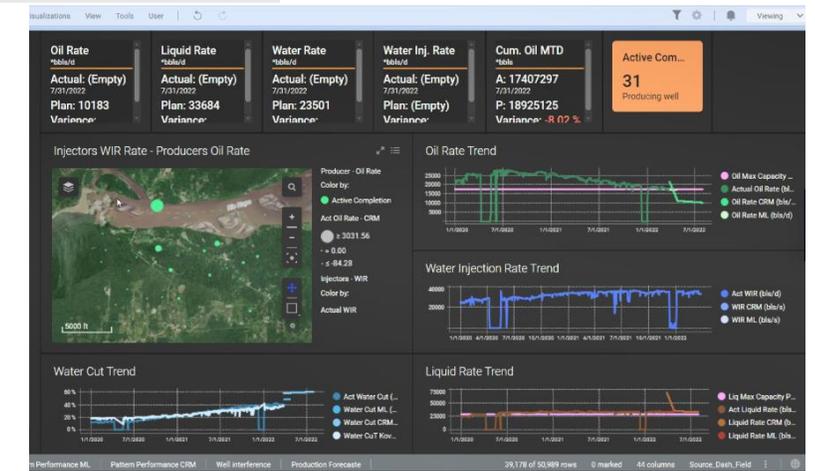
Maximize oil produced per barrel of water injected



# Waterflood Operations Surveillance Dashboards



**PRESERVE INTEGRATED RESERVOIR  
MANAGEMENT WITH OPTIMUM  
PATTERN BALANCE**



*Excellence in Execution*

# Value Delivered

## Time to decision



- Improved analysis efficiency by 80%
- Optimization time for 40 wells from 23 to 5 hrs

## Operational optimization



- Proactive response to operational upsets (What if with iPFM)
- Reducing field visits & HSE exposure

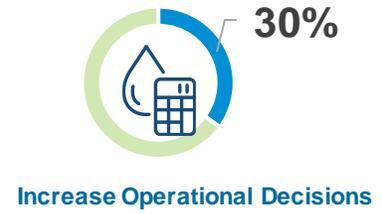
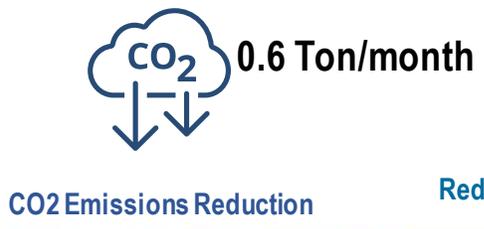
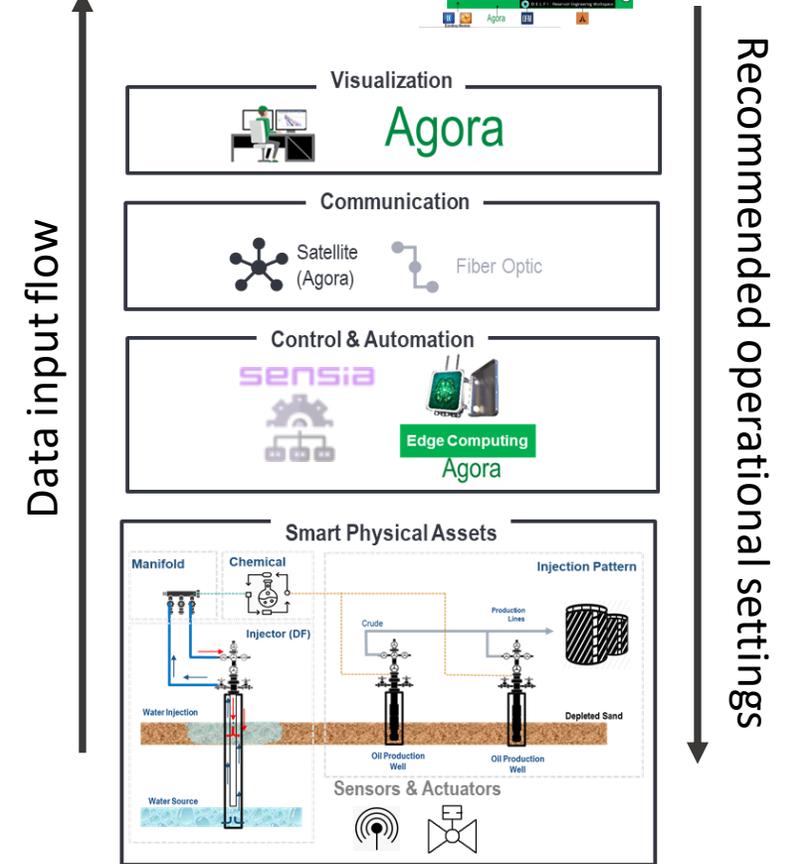
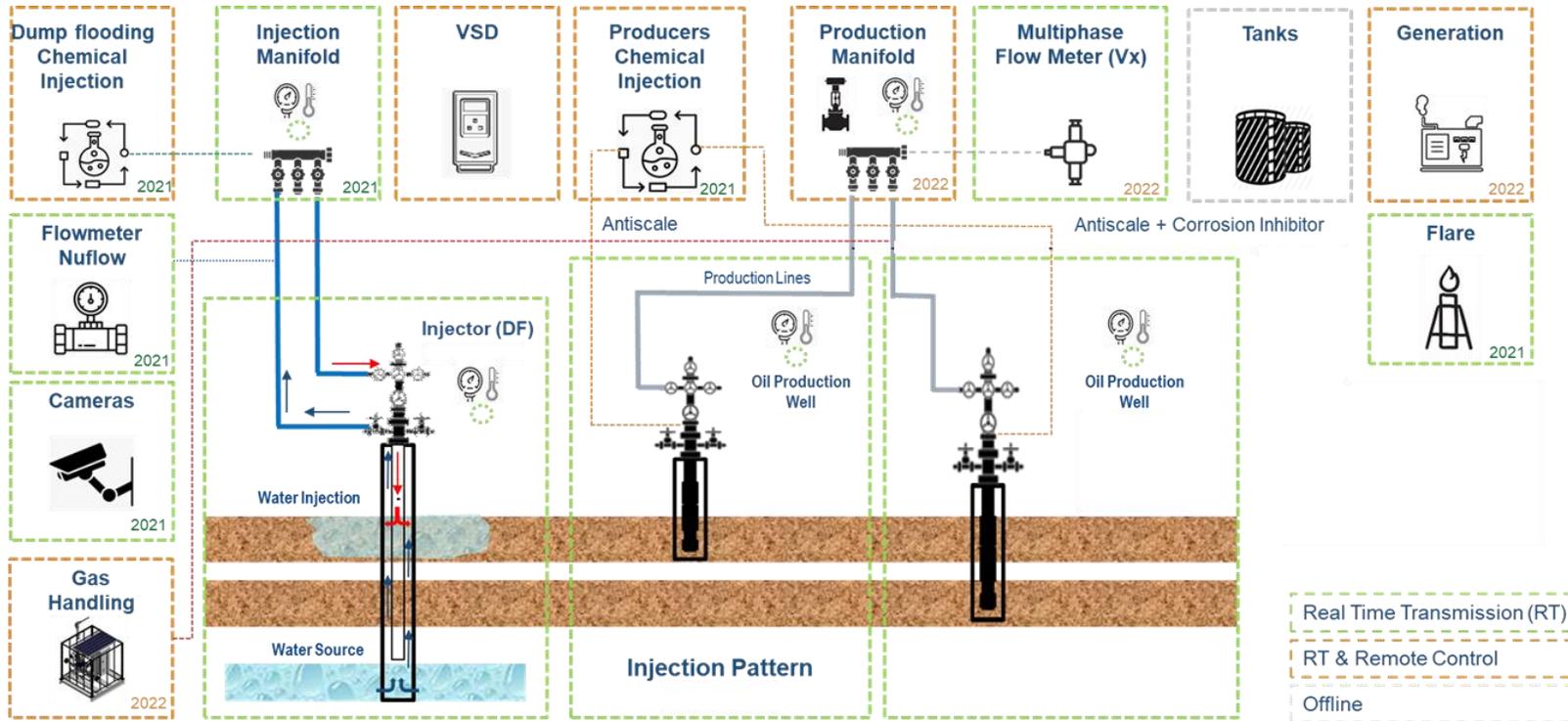
## Actionable insights



- Reliable 90 days forecast with uncertainty
- Better understanding of injection-production relationship



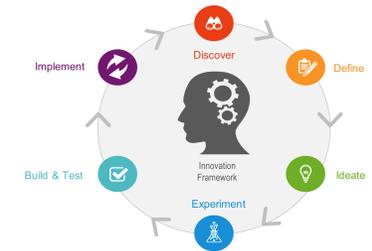
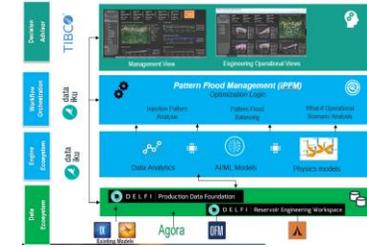
# Towards Autonomous Waterflood Operations



*Excellence in Execution*

# Conclusions

- ✓ Waterflood Optimization Framework that can support future Autonomous Digital Operations
- ✓ Injection pattern analysis and optimization tool for operational decision situations
- ✓ Design thinking approach: very effective to move from innovative idea into practical solution.



INNOVATION  
FACTORY

# Contributors - Teamwork



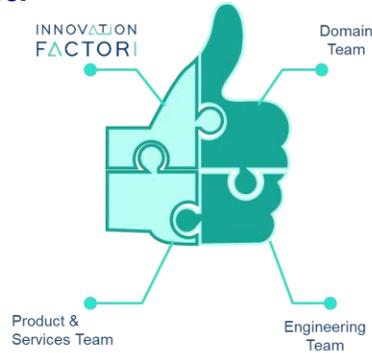
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