Challenges for Oil & Gas Operators: An industry perspective

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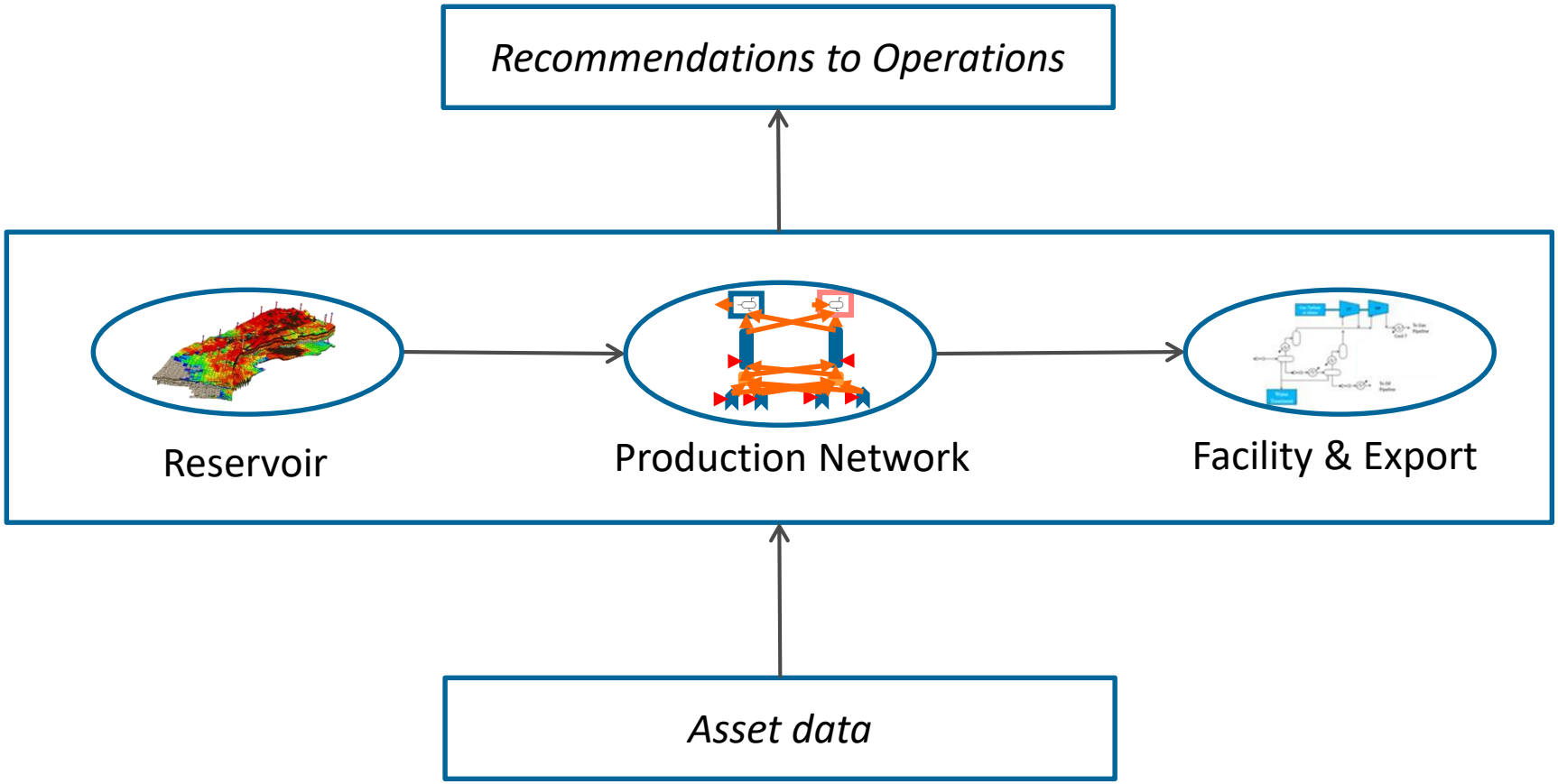
Introduction

Challenges *in the use of physics-based models for operations & planning* for Oil & Gas Operators: An industry perspective

- Physics-based models range from
  - Correlations with the correct behaviour, but coefficients fitted to data
    - Flow correlations
    - Compressor curves
    - etc.
  - First principles models with no fitted coefficients at all
- All have a predictive capability
  - Can be used (with care) to model regimes where an asset has not been operated before
- Pure data-driven models are only valid in the regime for which the data was obtained

Scope

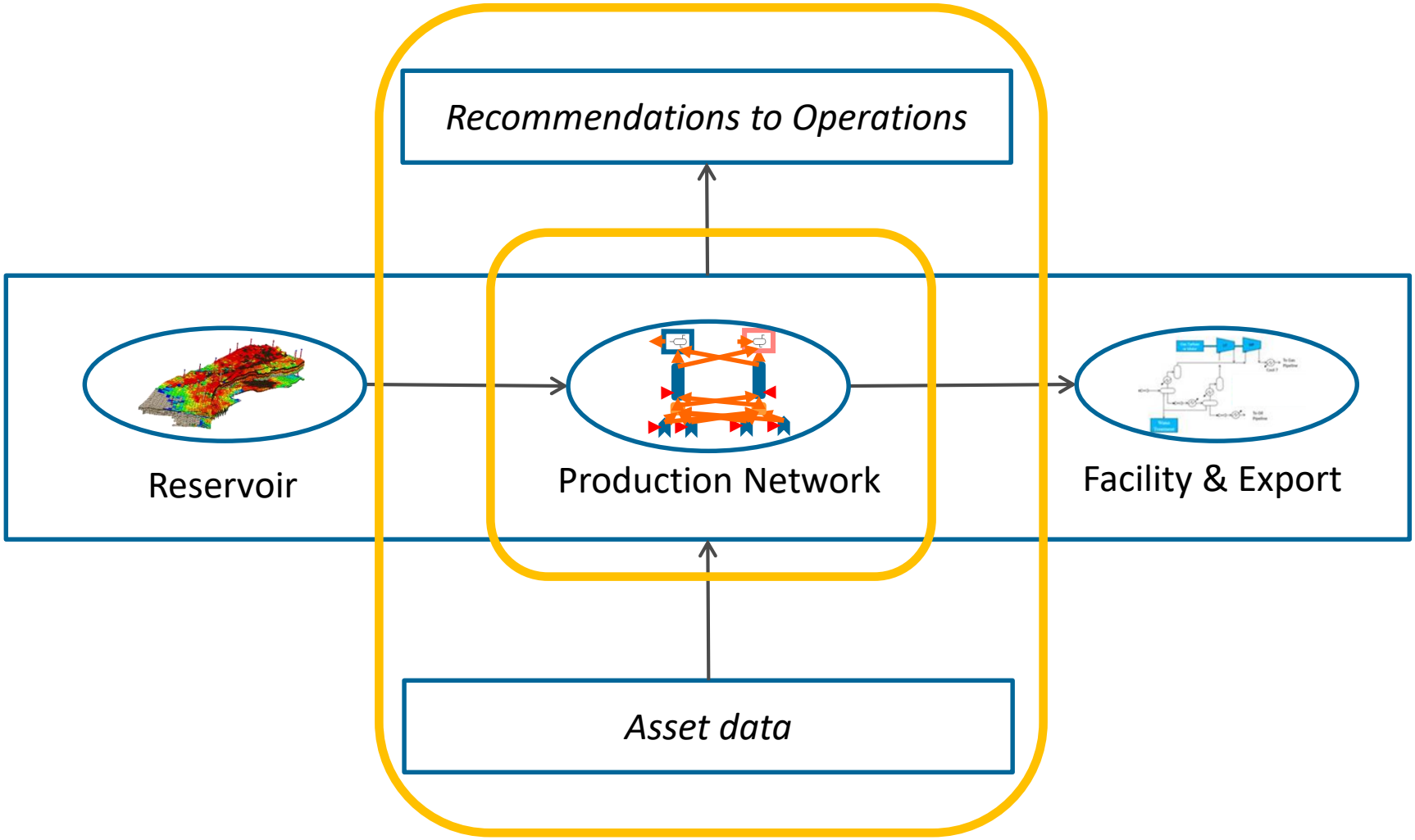


Overview

- Description of technology
- Potential benefits
- Challenges

- … but NOT solutions

Production Network Optimisation

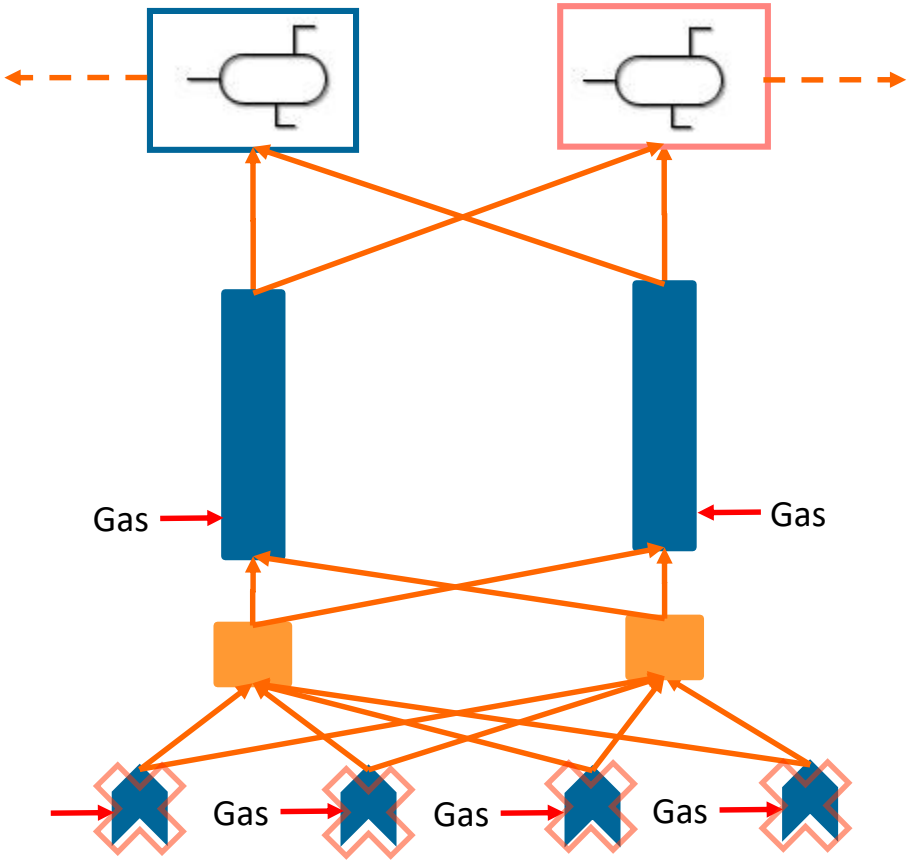


Definition

- Wells, flowlines & network through to separator
- Identification of increased daily production
  - Through the use of optimisation technology
- Through operational changes on the asset
  - Open-loop, so all changes made by operators
- Benefits:
  - Is your asset optimised?
  - How do you know?
  - 2 – 20% production increases

Production Network Optimisation

Example



Gas

- Control Decisions
  - "Continuous variables"
    - Well Choke Valves
    - Gas Lift rates
    - Separator Pressures
  - "Discrete variables"
    - Well routings
    - Riser routings
    - Well status
- Constraints
  - Well Drawdown (DHGP)
  - Riser velocity constraints
  - Total gas lift
  - Gas lift pressures
  - Gas & water handling

Challenges – Optimisation Technology

- Highly constrained non-linear problem
  - Needs a fast and reliable optimiser
  - Current standard industry tools
    - Not fully flexible
    - Become less reliable with increasing scale
- Continuous + discrete decision variables
  - MINLP optimisation technology is required
  - Not currently available in single optimiser
- Multiple optima
  - Current tools normally find the (same) optimum all the time

Challenges – Model fidelity (1)

- Model fidelity relies on availability of accurate asset data
- Many potential issues:
  - Instrumentation may not be available, especially on older assets
    - Potentially expensive to retrofit
  - Instrumentation may be inaccurate or have failed
    - Often not a priority on an operating asset, especially if in decline
    - How do we know if there is instrument drift?
    - Can be expensive to fix
  - Well test data unreliable or inaccurate
    - Well tests not possible or carried out infrequently
    - Multi-phase flow meters often unreliable (and expensive)
    - How to well test if many low-rate wells?

Challenges – Model fidelity (2)

- Are the physics based models sufficiently accurate?
- Example – choice & tuning of flow correlation
  - Use Beggs & Brill
  - Tune gravity and friction coefficients to asset data
  - Model matches across range of data
  - But Beggs & Brill incapable of matching qualitative flow behaviour in some circumstances
    - NO predictive capability!
- Can we address data inaccuracy & model tuning simultaneously?
  - Has been done in other industries
  - But need redundant data?

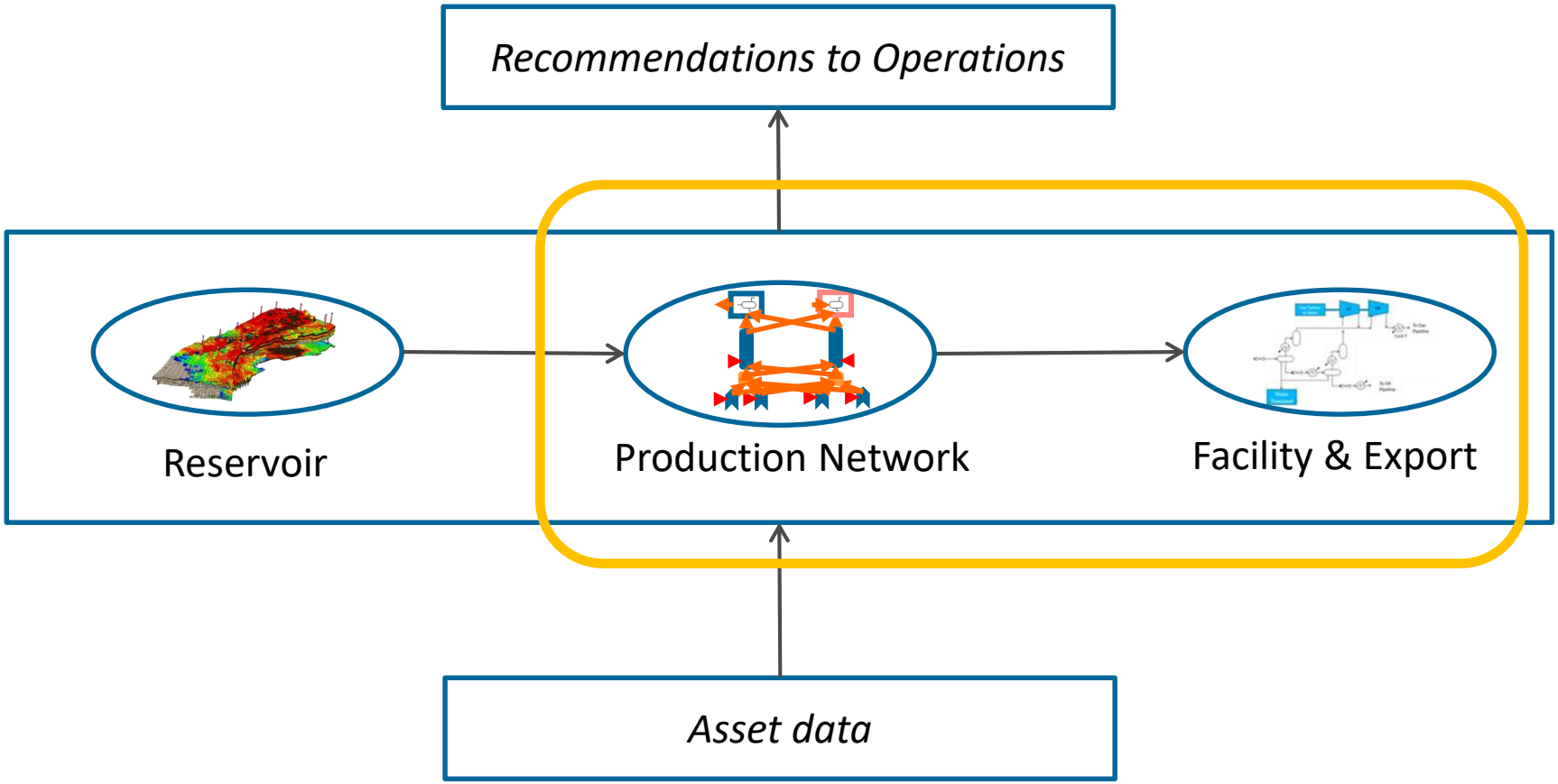
Challenges – Model fidelity example

- Multi-well production system
  - Common flowlines and risers
  - Back pressure effects
    - Open choke valve on one well
    - Production from that well increases
    - Production from all other wells routed to same riser decreases
- Model tuned to best available well test and asset data
- Optimisation recommends set of choke valve positions to maximise production
- … well test data was out of date
  - When recommendations implemented, total production rate decreased!

Challenges – Implementation of recommendations

- Potentially large number of decision variables
  - Well choke position and gas lift rates
  - Riser gas lift rates
  - Separator pressures
  - Well & Riser routings
  - Well status
- Operators can only implement in a sequence
  - Could we shut-in the asset if the sequence is wrong?
  - How long will it take to implement all the changes?
  - Will the operators even be willing to consider making so many changes?
- Can we identify a (much) smaller sub-set of decision variables?
- How do we track whether the changes worked?

Production Network + Facility Optimisation



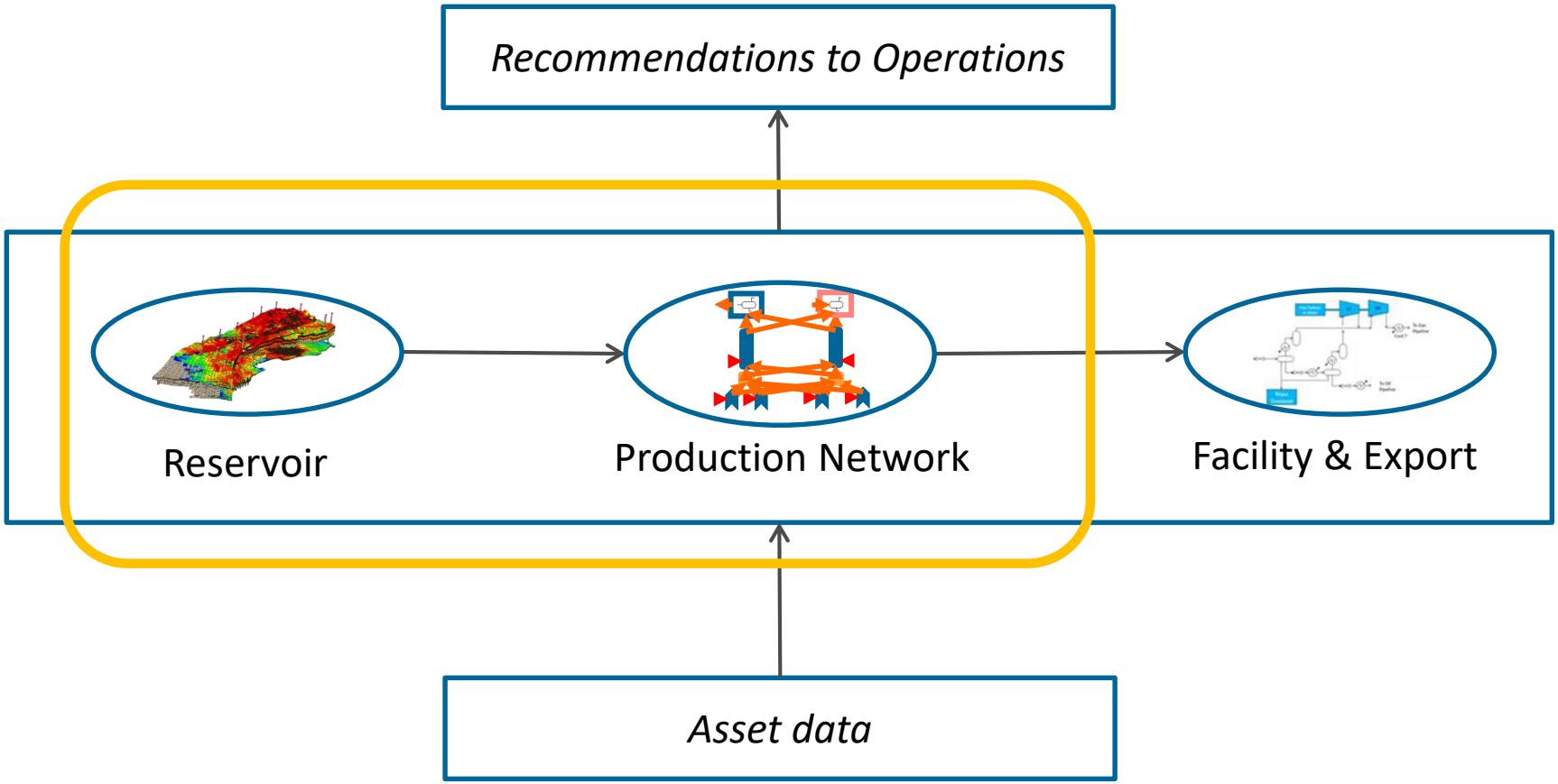
Definition

- Wells, flowlines, separators and facility through to export
  - Or beyond?
  - Export pipelines and terminal may be significant
- Replaces simple facility constraints with complex model
  - e.g. Facility gas constraint with detailed model of compression train
  - Increases accuracy of constraint modelling
- Identification of increased daily production
  - Same aim as Production Network optimisation
- Additional benefits:
  - Accurate constraint model may lead to higher production
  - Or, may identify scenarios where simple constraint too optimistic
  - Allows production optimisation when facility in upset condition
    - E.g. loss of one of multiple compressor trains

Challenges

- Increased scope of model
  - Longer run-times
  - Higher non-linearity leads to poorer convergence stability
- Thermodynamic modelling
  - Production network typically uses black oil model for speed
  - Facility model needs compositional modelling for accuracy
  - Switching production network to compositional may be too slow
  - How to manage the boundary between the two models?
  - Do we actually know the current reservoir fluid characterisation?
  - Multiple reservoirs feeding a single facility
    - Different fluid characterisation for each reservoir
- Implementation requires communication between discipline “silos”

Reservoir + Production Network Optimisation



Definition

- Simultaneous optimisation of Reservoir to Separator
- Benefits
  - Improved forecasts for planning
    - Short term (up to 1 year)
    - Long term (5+ years)
  - Planning of well work, e.g. new infill well
    - Considering reservoir only predicts increase in total production
    - Modelling both reservoir and production network simultaneously can demonstrate no overall increase in production
    - Avoids drilling of very expensive well
  - Traditional production optimisation focuses on short-term production increases
    - Reservoir limitations modelled via drawdown constraint
    - Inclusion of reservoir in scope also maximises long term reserves recovery
  - Integrated model can be used in design optimisation over lifetime of field to improve facility design

Challenges

- May not be realistic to re-implement reservoir model in a single model with production network
  - Need to optimise two separate models?
- Long calculation times
  - Reservoir models are typically complex
  - Iterative convergence strategy at each time period
- Different timescales for reservoir and production networks
  - Months / years vs. seconds / minutes
- Uncertainty in future reservoir production profiles
  - Do we therefore need detailed production network model?
- Communication between discipline “silos”

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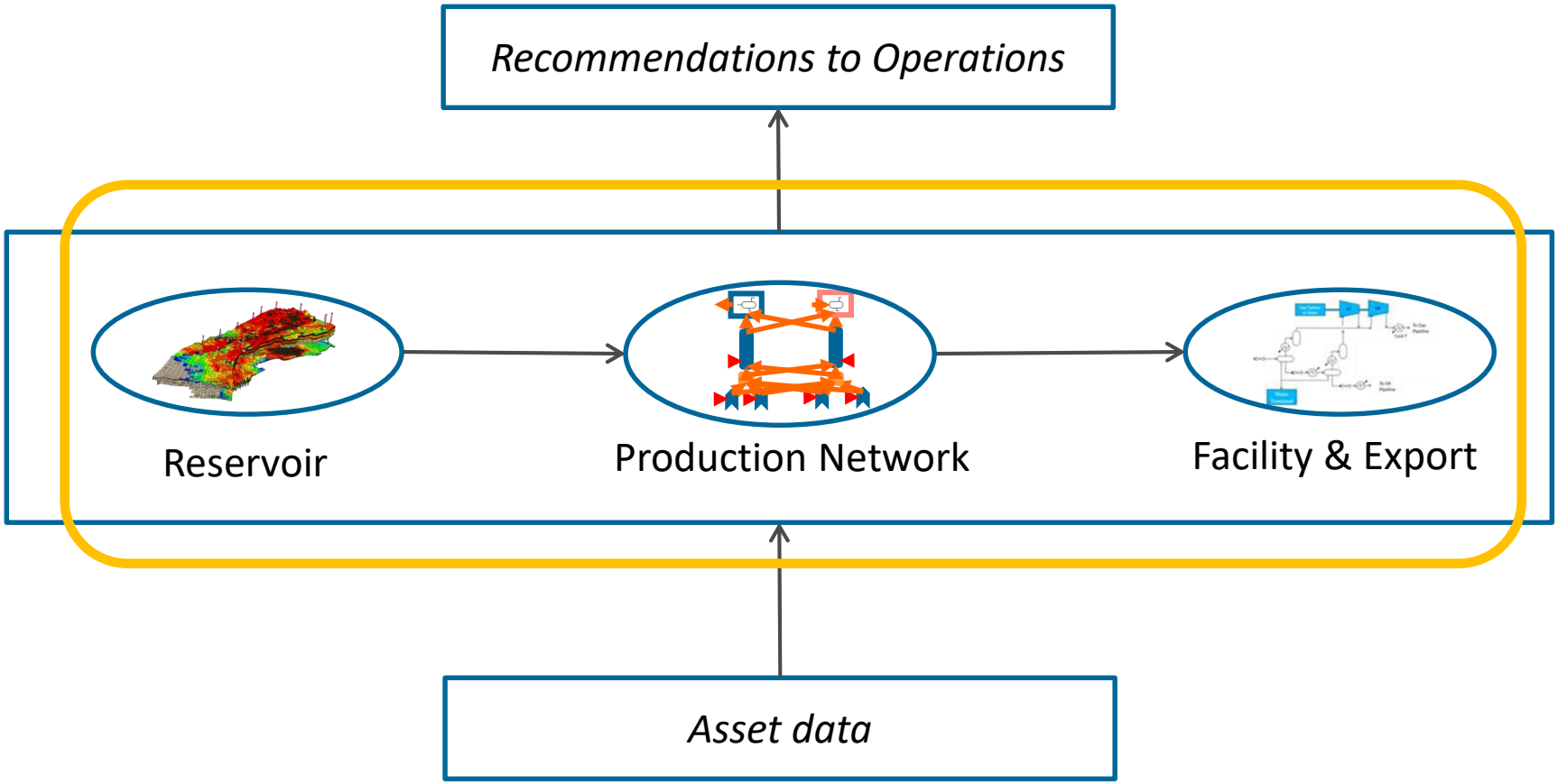
Reservoir + Production Network + Facility Optimisation



Definition & Challenges

- Simultaneous optimisation of Reservoir to Export
- Need a justification for this scope
  - Don’t assume full asset model is required
- Benefits
  - Combination of all those already presented
- Challenges
  - Everything already presented!

Other model-based technologies

- Real time optimisation
  - On-line closed loop
- Advanced control
- Benefits
  - Continuous optimisation without operator intervention
  - More stable operation
  - Constraint pushing
- Challenges
  - Reservoir is inherently unsteady
    - Slugging
    - Water breakthough etc.
  - Reservoir decline gives continuous change
  - Basic automated regulatory control may not exist

Summary

- Significant benefits. Highlights:
  - 2 – 20% production increases
  - Avoidance of $multi-million well work
  - Production optimisation during upset conditions
  - Improved forecasts and planning
- Challenge highlights:
  - Optimisation technology
  - Asset data & model fidelity
  - Implementation of optimisation results
  - Long run times for integrated asset models
  - Thermodynamic models
  - Communication between discipline “silos”

Questions?