ADVANCED PROCESS MODELLING FORUM
LONDON
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Oil & Gas

Optimising Oil & Gas production and processes

James Marriott – Head of PSE Oil & Gas

gPROMS

Optimising Oil & Gas production and processes

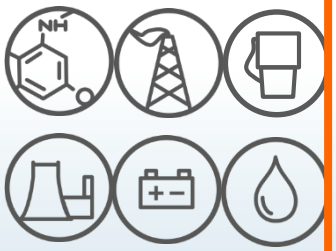
1) Process: Natural Gas Processing facilities

2) Production: Oil & gas well and well network systems
    1) Case Study 1: Optimisation Onshore
    2) Case Study 2: Optimisation Offshore

gPROMS product family

A family of advanced process modelling environments built on the gPROMS platform

"Vapour-liquid process world"



g|PROCESS
gPROMS ProcessBuilder
Process gMLs, AMLs

g|WATER	Water MLs
g|UTILITIES	Utilities MLs
g|CCS	CCS MLs
g|POWER	Power MLs
g|OILFIELD	Oilfield MLs

"Formulated products world"

g|FORMULATE
gPROMS FormulatedProducts

Crystallization MLs	g|CRYSTAL
Solids MLs	g|SOLIDS
Oral absorption MLs	g|COAS
g|FLARE *	Flare & depressurisation MLs
g|FUELCELL	Fuel cell AMLs

General mathematical modelling

g|MODEL

gPROMS ModelBuilder provides essentially the full platform functionality

The gPROMS platform

Equation-oriented modelling & solution engine

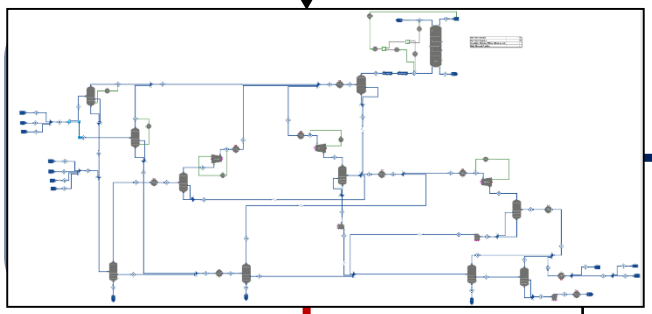
* Primarily used internally by PSE for delivery of services

Optimising Oil & Gas production and processes

Modelling natural gas processes

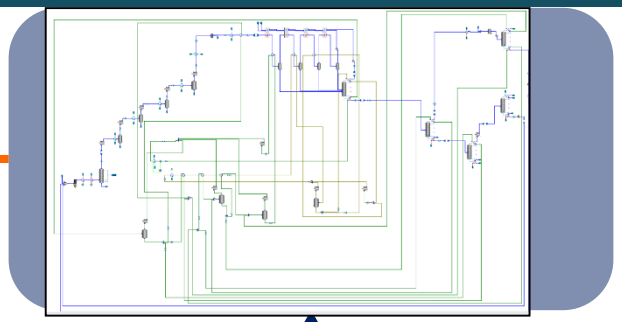
Overview

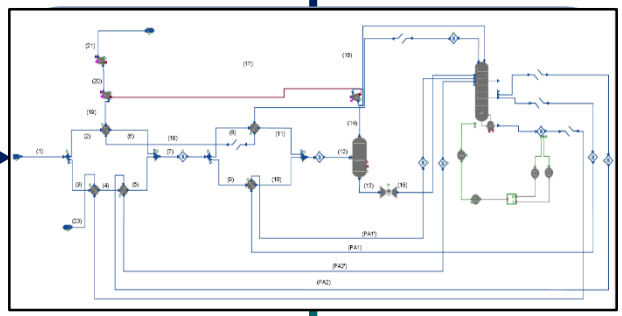
Reservoir and production system



Gas treatment
Amine treatment
Dehydration
Mercury removal
.....

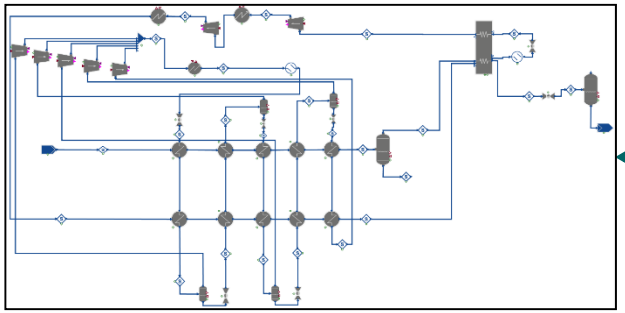
Ethane, Propane, Butanes, Pentanes+





Wastewater
Water treatment

Condensate / Oil
to refinery



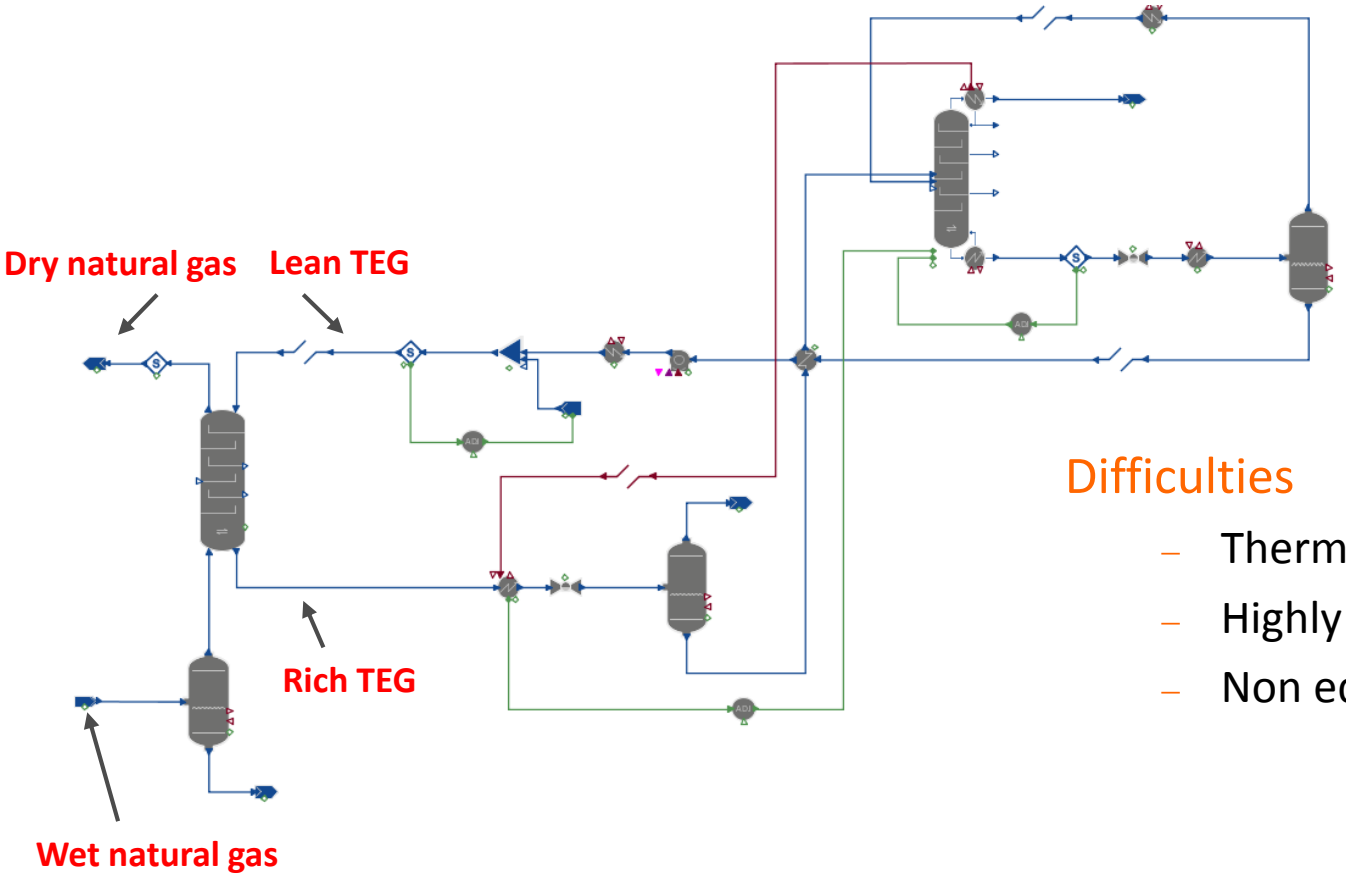
Sales Gas
to Pipeline

g|PROCESS

Natural gas treatment

Natural gas treatment

- Dehydration example (with TEG)



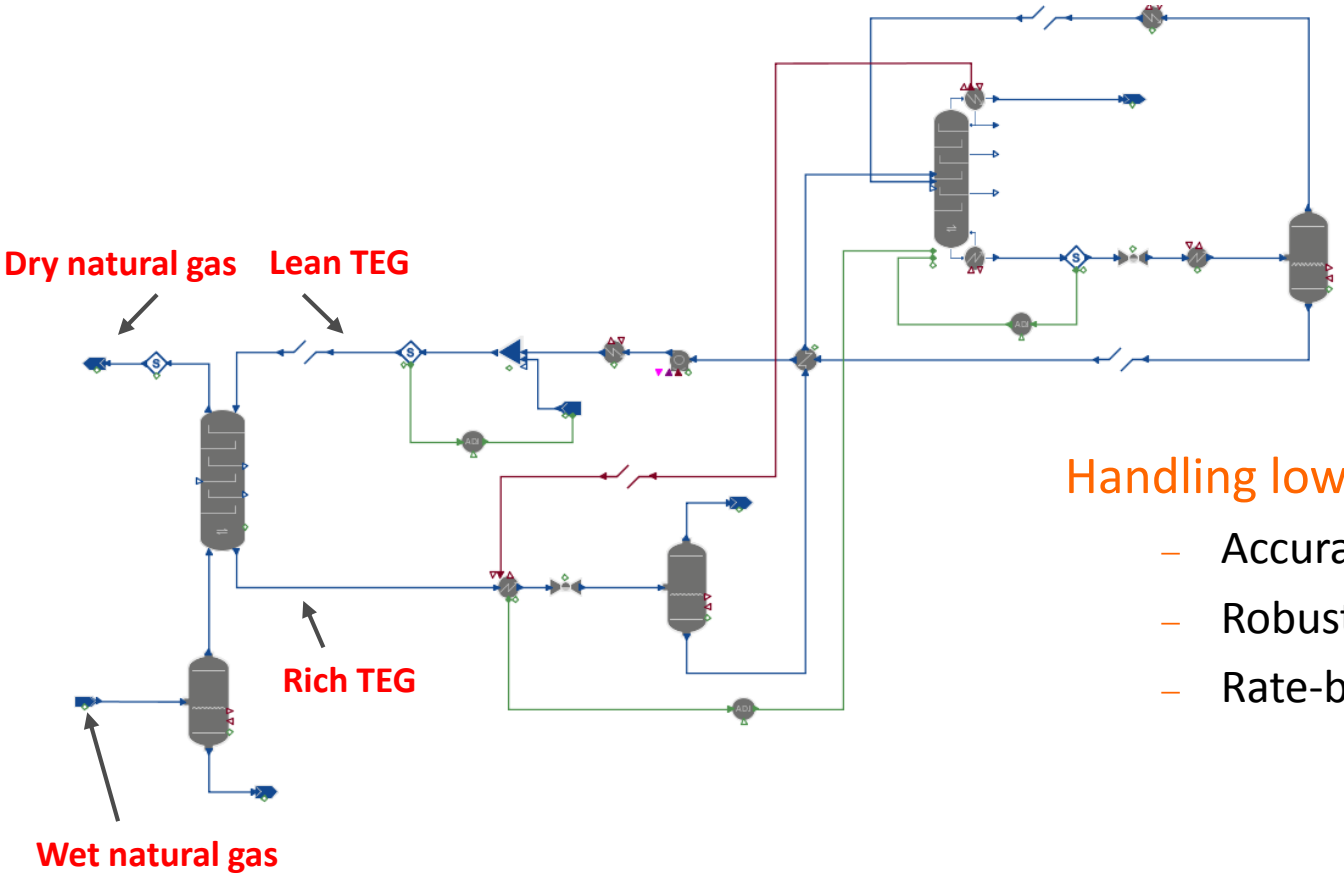
Difficulties

- Thermodynamics
- Highly integrated
- Non equilibrium

Natural gas treatment

Natural gas treatment

- Dehydration example (with TEG)



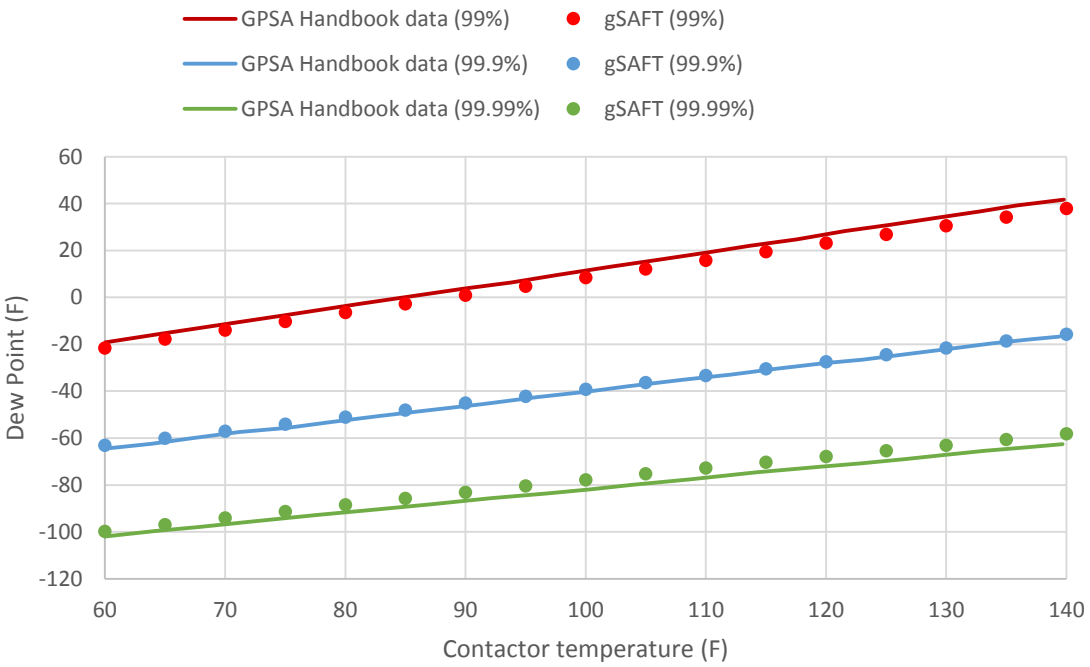
Handling low concentrations => dry gas

- Accurate gSAFT thermodynamics
- Robust numerics
- Rate-based contactors

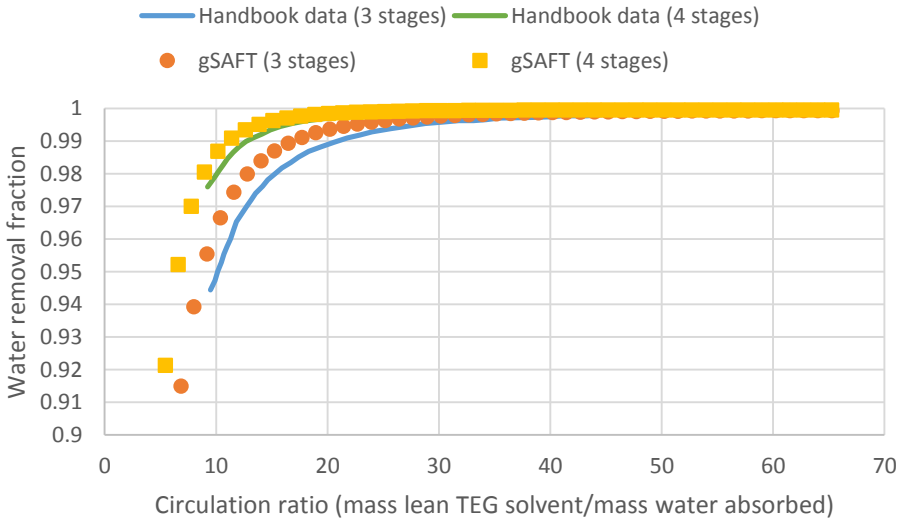
Natural gas treatment – TEG dehydration

gPROCESS

gSAFT dew point predictions for different concentrations of TEG solutions



gSAFT absorber performance predictions for a 99.99% TEG solution



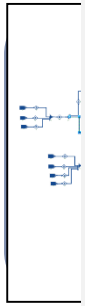
Challenges

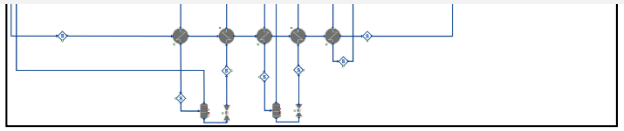
- Three significant modelling challenges

Dynamic system behaviour	Interconnected facilities	Optimisation

Dynamic modelling of natural gas processing facilities

Optimisation of an entire regional gas production network





Condensate / Oil
to refinery

Optimising Oil & Gas production and processes

gPROMS Oilfield: an introduction

gPROMS product family

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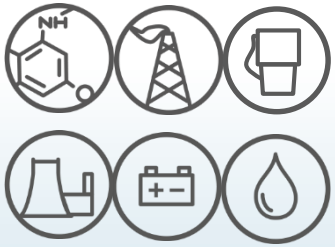

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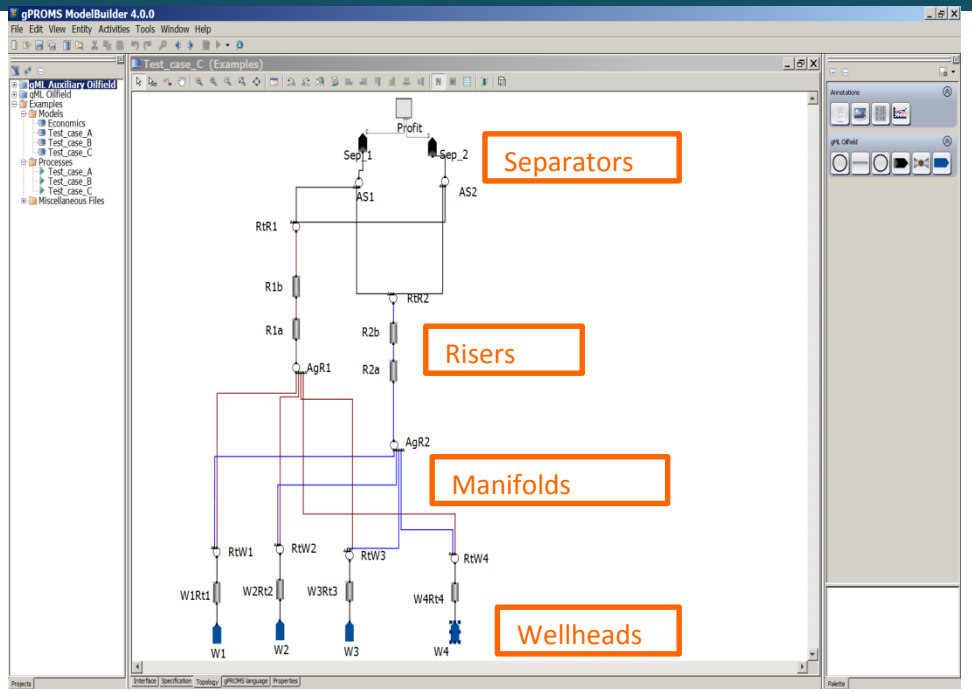
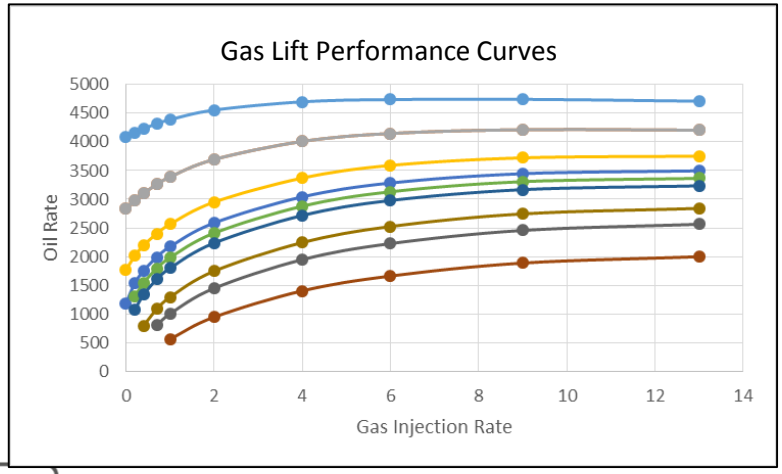
gPROMS Oilfield Model Library

- Scope
  - Models for: Wellhead, pipe, gas injection point, router, aggregator, sink, valve, separator, rate multiplier
  - Connected to topside models (gPROMS ProcessBuilder)
  - Well Performance Curve import

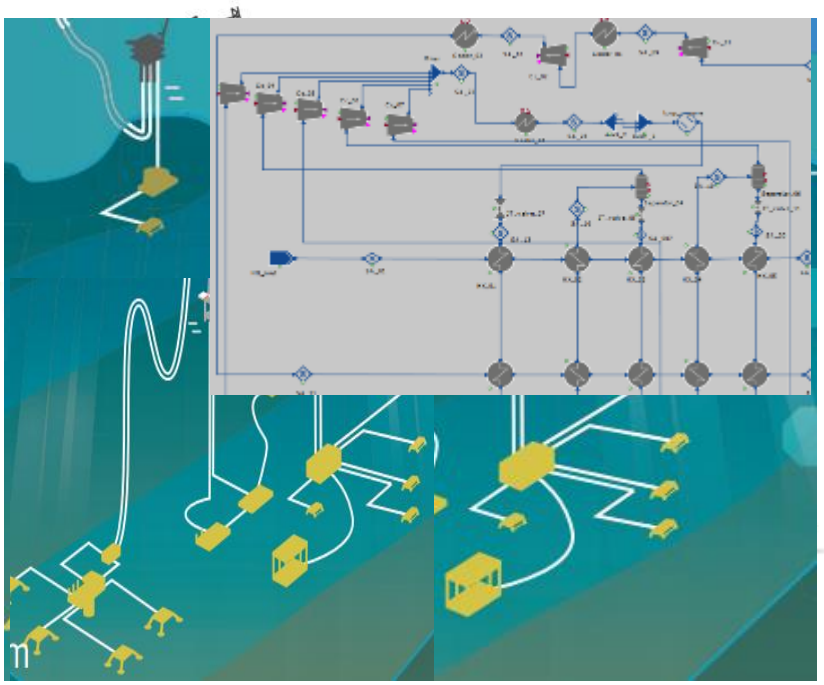
- Key features [v1.0]
  - Balances: steady state & dynamic [v 1.2]
  - Physical properties: black oil & compositional
  - Pressure drop:
    - Pseudo-homogeneous & multi-phase
    - OLGA-S Two Phase
  - Heat transfer: adiabatic & with environment
  - Customisable by user (e.g. objective function, erosional constraints)





Typical Application Areas

- Production system modelling
  - Well modelling
  - Pipeline & riser modelling
  - Equipment modelling
  - Field modelling
- **Optimisation of Production Systems**
  - Continuous and discrete variable optimisation
  - Constraint Management
  - Field configuration
- Full Asset modelling and optimisation
  - Linked production and process model
- Pipeline Monitoring
- Enhanced oil recovery



Optimising Oil & Gas production and processes

gPROMS Oilfield Optimisation

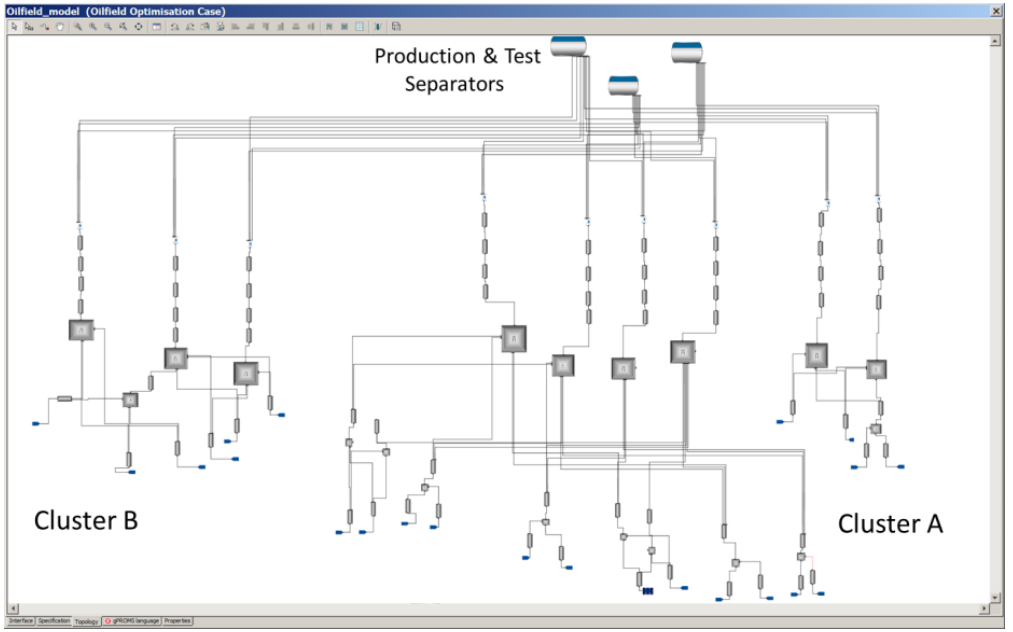
Scope

Oilfield Production Optimisation

- Maximize production value from an oilfield by adjusting process and well behaviour
- Decide
  - which wells to use
  - which routing to take to the surface
  - how much gas-lift to apply to each well
  - ……
- …within operational envelope

Scope

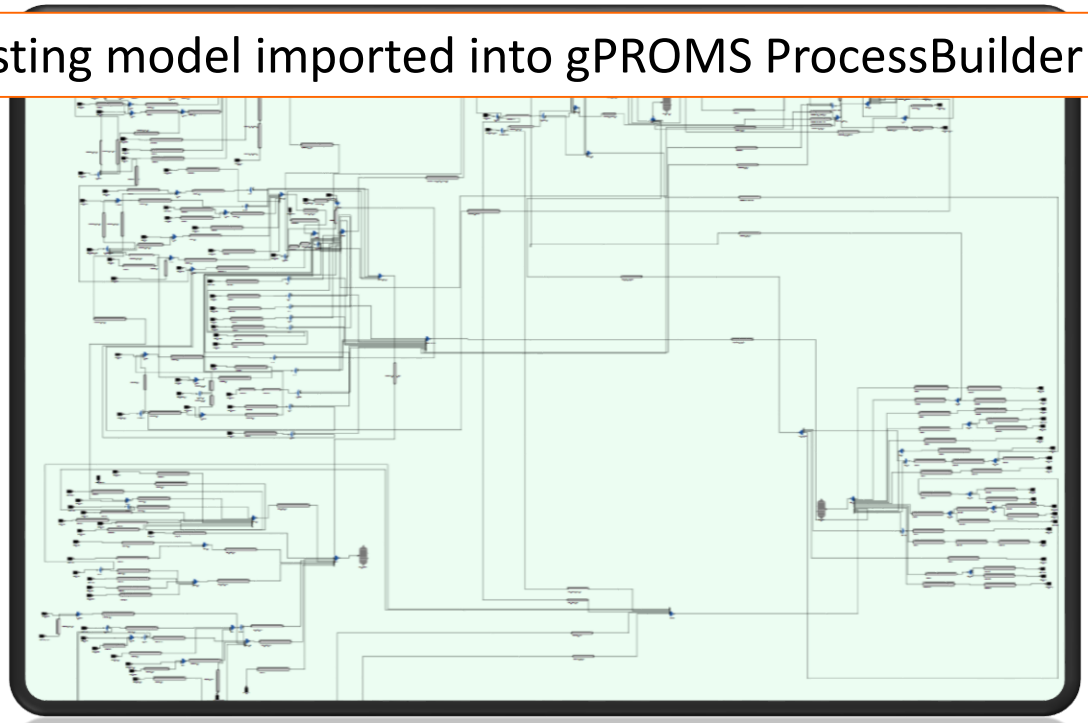
- Well and well-network systems:
  - *From:* Sandface
  - *To:* Topside Separator



Case Study 1: Optimisation Onshore

- Client: Confidential
- Field type:
  - Gas Condensate
- Well count > 120
- Pipeline count > 200
- Separator count: 3
- Routing combinations: >1 Million

Existing model imported into gPROMS ProcessBuilder



- Challenge
  - Optimize revenue (from both oil & gas)
  - Separator: maximum gas rate constraints
  - Well: Maximum liquid rate & maximum drawdown

Current Technology vs gPROMS results

		Gas rate [MMScf/day] / separator			Oil rate [bbl/day]	Revenue [MM$/day]
		A (max 1030)	B (max 571)	C (max 161)		
Simulation	Current Technology	973	610	155	221,615	$ 24.08
	gPROMS	974	608	161	222,235	$ 24.15

- Matched simulation results of leading production modelling tool to within 0.3%.
- Constraints violated

Current Technology vs gPROMS results

		Gas rate [MMScf/day] / separator			Oil rate [bbl/day]	Revenue [MM$/day]
		A (max 1030)	B (max 571)	C (max 161)		
Simulation	Current Technology	973	610	155	221,615	$ 24.08
	gPROMS	974	608	161	222,235	$ 24.15
Optimisation (Continuous + Well Status)	Current Technology	974	555	157	215,380	$ 23.4
	gPROMS	991	571	161	224,924	$ 24.37
gPROMS solution into current technology		991	567	154	223,880	$24.25

- Increase in production of 4.4% with gPROMS, ~ $1M/d!

Current Technology vs gPROMS results

		Gas rate [MMScf/day] / separator			Oil rate [bbl/day]	Revenue [MM$/day]
		A (max 1030)	B (max 571)	C (max 161)		
Simulation	Current Technology	973	610	155	221,615	$ 24.08
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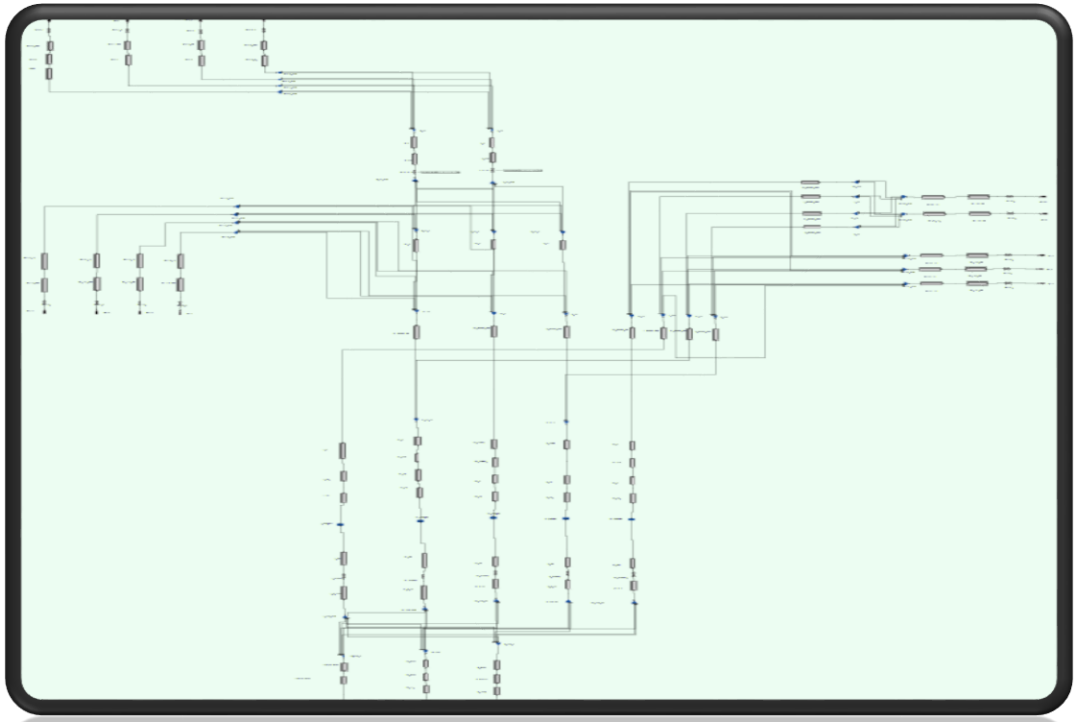
Optimisation (Continuous + Well Status)	Current Technology	974	555	157	215,380	$ 23.4
	gPROMS	991	571	1601	224,924	$ 24.37
Optimisation (Field Configuration)	Current Technology	974	555	157.2	215,380	$ 23.4
	gPROMS	1030	571	161	239,570	$ 25.83

- Increase in production of 11.0% with gPROMS, ~ $2.5M/d!
- Better utilisation of separators

Case Study 2: Optimisation Offshore

- Client: Confidential
- Field type:
  - Gas Lifted Oil Field
- Well count: 13
- Riser count: 5
- Separator count: 3
- Routing combinations: > 300,000



- Challenge
  - Optimize Oil Production
  - Riser: maximum fluid velocity speed & limited gas lift injection gas
  - Well: Maximum liquid rate & maximum drawdown

Current Technology vs gPROMS results

		Oil rate [bbl/day]	Revenue [MM$/day]
Simulation	Current Technology	85,254	$ 9.26
	gPROMS	86,107	$ 9.36

- Matched simulation results of leading production modelling tool to within 1.1%.

Current Technology vs gPROMS results

		Oil rate [bbl/day]	Revenue [MM$/day]
Simulation	Current Technology	85,254	$ 9.26
	gPROMS	86,107	$ 9.36
Optimisation (Continuous + Well Status)	Current Technology	90,404	$ 9.82
	gPROMS	95,464	$ 10.34

- Increase in production of 5.6% with gPROMS, ~ $ 0.5M/d!

Current Technology vs gPROMS results

		Oil rate [bbl/day]	Revenue [MM$/day]
Simulation	Current Technology	85,254	$ 9.26
	gPROMS	86,107	$ 9.36
Optimisation (Continuous + Well Status)	Current Technology	90,404	$ 9.82
	gPROMS	95,464	$ 10.34
Optimisation (Field Configuration)	Current Technology	90,404	$ 9.82
	gPROMS	105,432	$ 11.37

- Increase in production of 16% with gPROMS, ~ $1.5M / d!

Conclusions

- Modelling
  - gPROMS technology can demonstrably model the field as accurately as established production modelling tools
  - Existing production system models can easily be imported
  - The process and production system can be modelled in the same environment

Best practice multiphase flow approaches + validation

- Optimisation
  - Standard gas lift / choked well (continuous optimisation)
    - gPROMS Oilfield Optimisation => Reliably better solutions that established production modelling tools
  - Discrete Optimisation (well status and routing)
    - gPROMS Oilfield Optimisation => Significant increase in production and/or revenue

Equation-based modelling and Optimisation

Thank you