



Business benefit through the integration of GAP and HYSYS, via a CAPE-OPEN interface

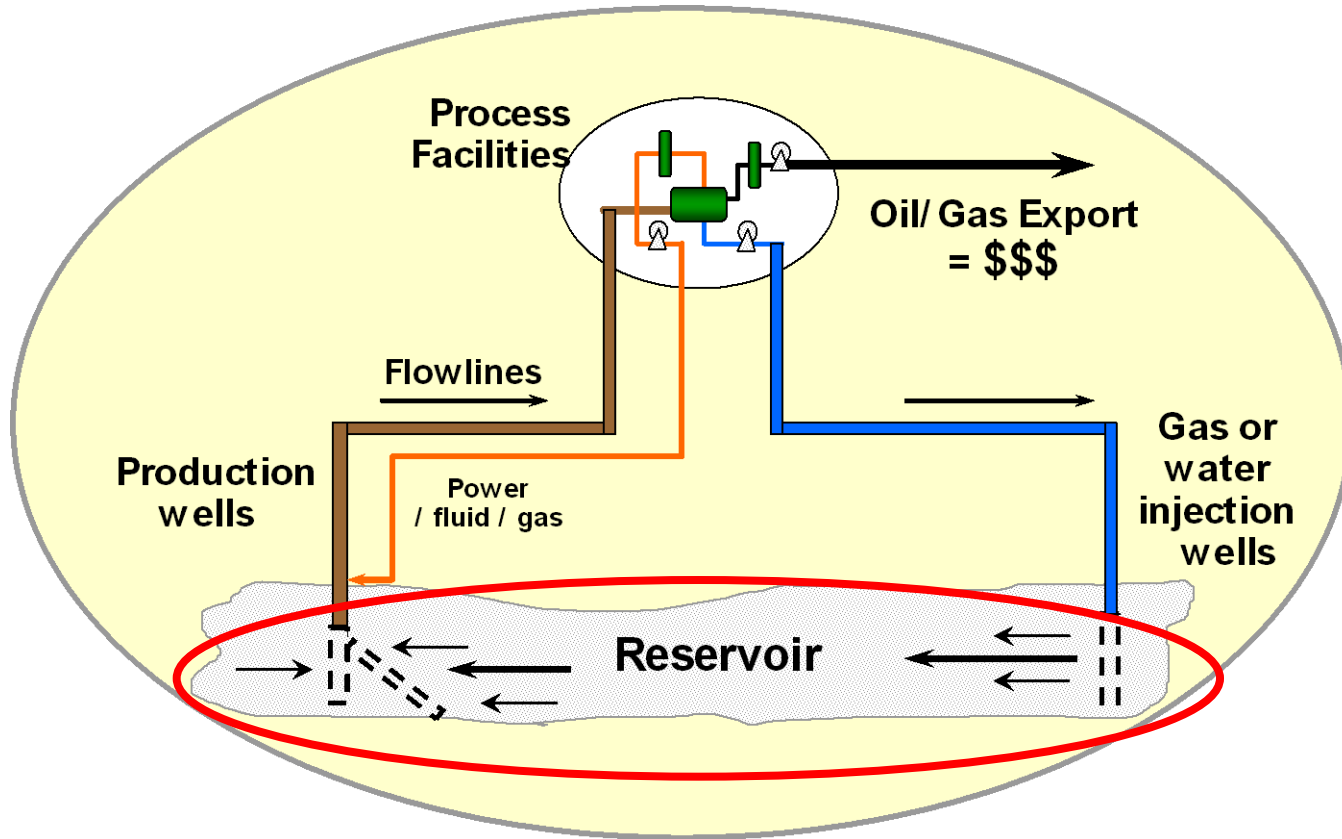
M.R. Woodman, B.J. Stenhouse, G.A. Goby &
K.J. Beanlands, BP Upstream

Overview

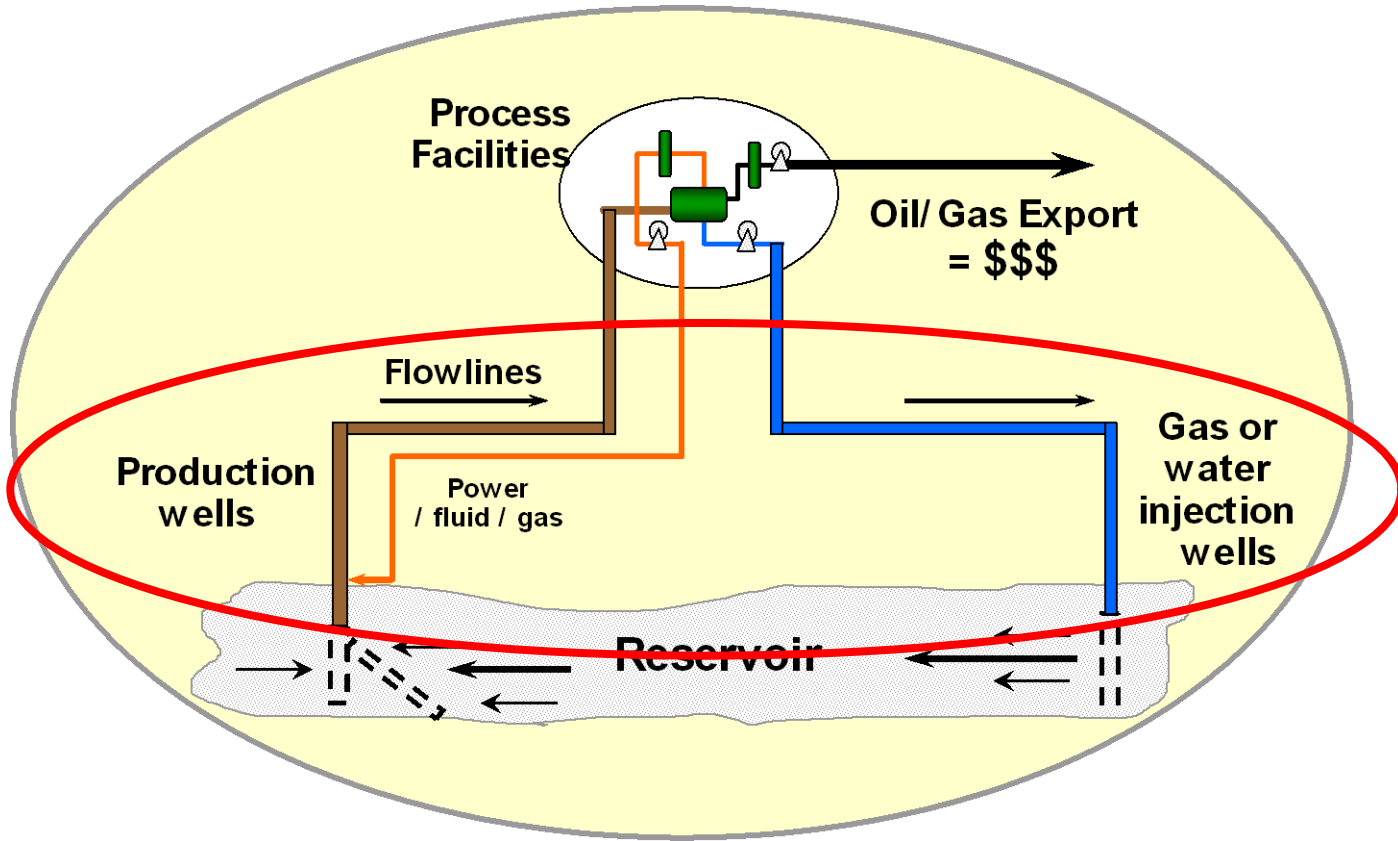


- Introduction
 - Current discipline modelling capabilities
- Business benefits of integrated modelling
 - Case study
- Integrated modelling
 - Commercially available integration environments
 - GAP as a CAPE-OPEN unit operation
 - Reconciling discipline descriptions of fluids
- Clair asset example

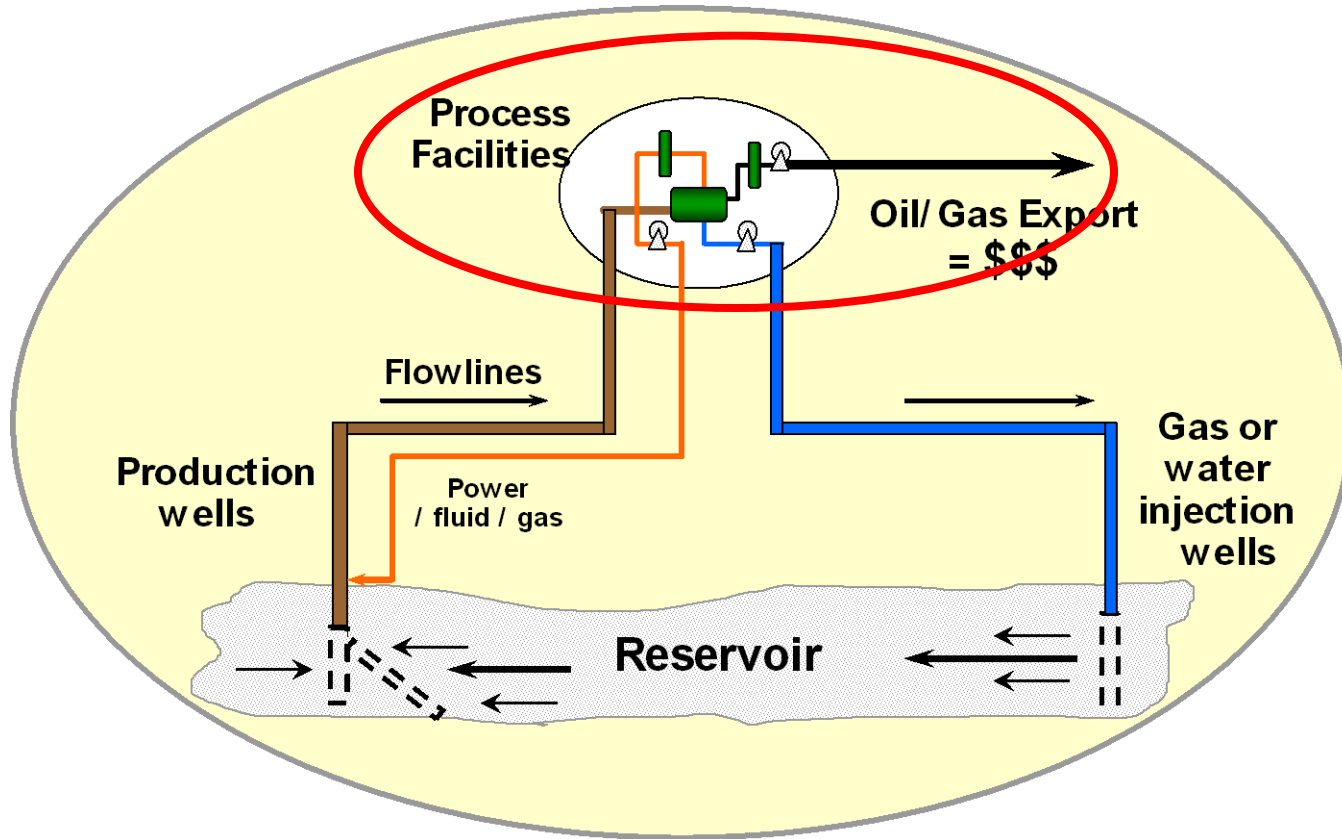
Introduction



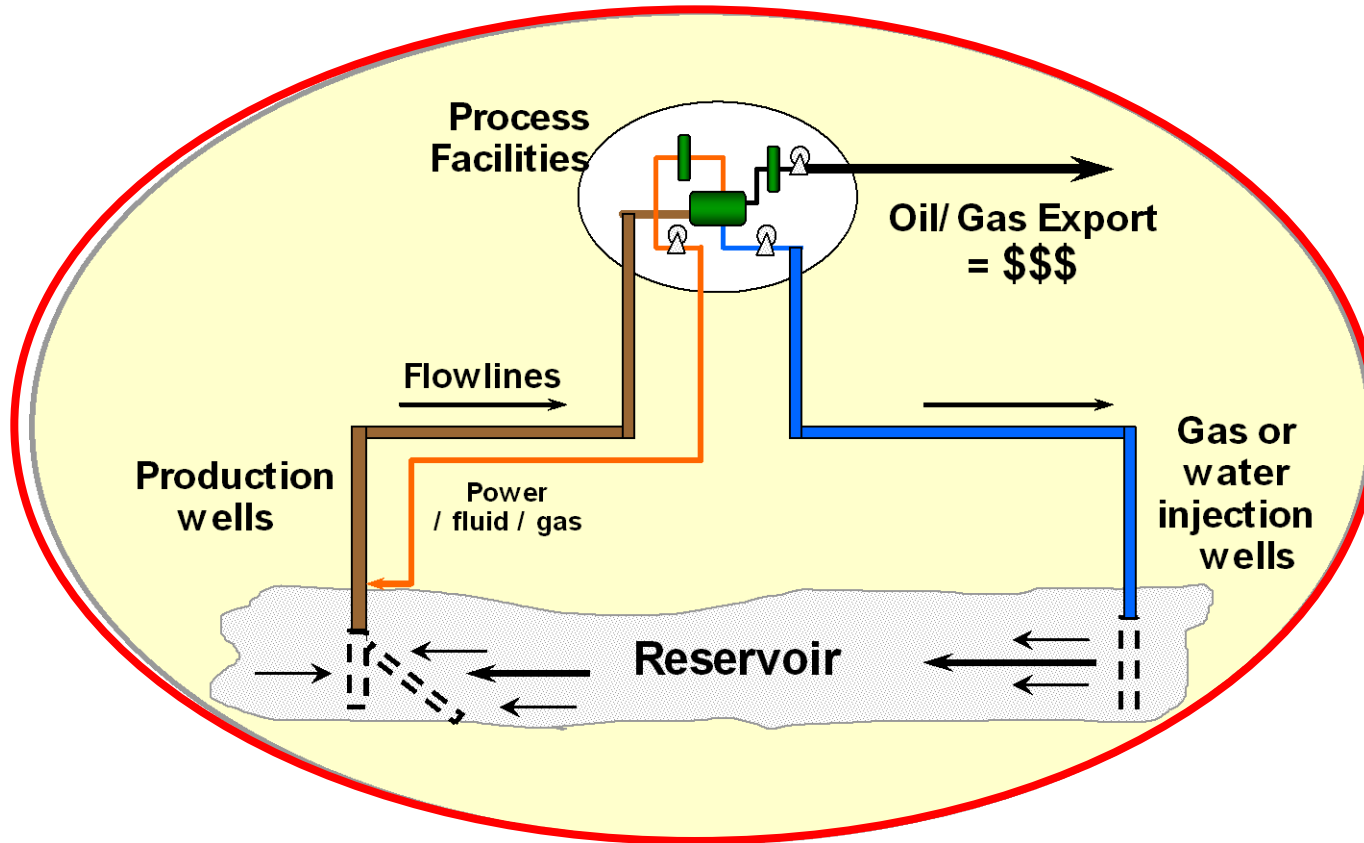
Introduction



Introduction



Introduction



- Integration will enhance business benefit
- Addressed within the BP Upstream System Optimisation programme (a fieldofthefuture® capability)
- Current focus is on operational support

Current Wells & Flowline Modelling

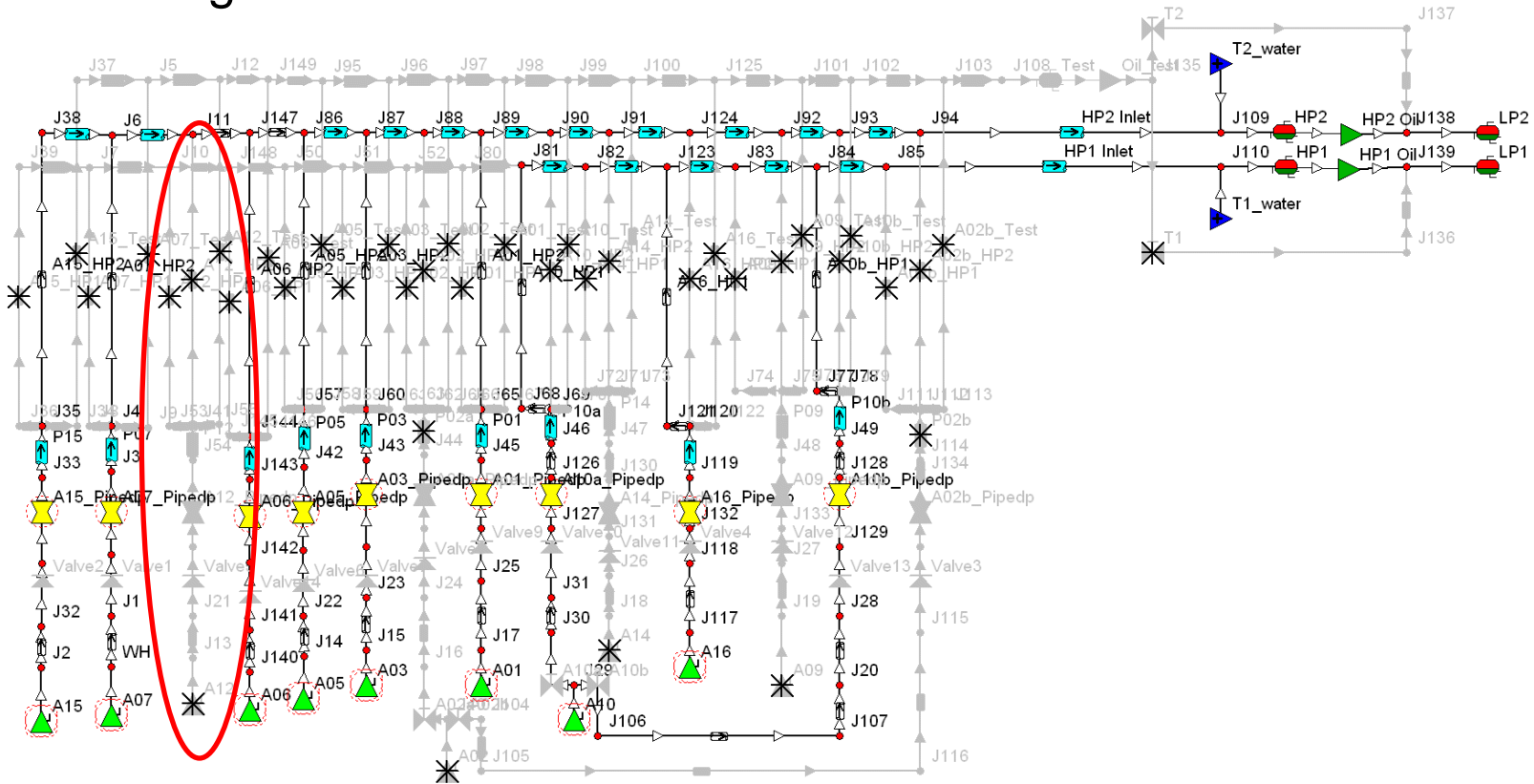


- For steady-state, BP uses Prosper (wells) / GAP (wells & flowlines)
 - From Petroleum Experts
- Scope
 - Sand face to Separator
 - Pressure driven
 - Specified separator pressure
- Business uses in operations include:
 - Understanding of well performance
 - Managing well and flowline interactions
 - Well to riser routings
 - Artificial lift optimisation

GAP model for a typical asset (Clair)



- An offshore oil and gas production facility in the UK North Sea region



- Offline well and alternative flowline routings are greyed-out

Current Facilities Modelling



- BP Upstream uses HYSYS
- Scope
 - Separator to Export
 - Flow driven
- Business uses of steady-state modelling in operations include:
 - Managing commercial constraints on export pipeline
 - Understanding interactions between multiple trains
 - Identifying equipment constraints
 - Assessing equipment performance against design

Business Benefits of Integrated Modelling



- Maximising production whilst ensuring the asset remains within the safe operating envelope
- Wells / Flowlines with facilities
 - Typically giving additional production increases of 1 – 4%
 - Lift Gas optimisation when facility is gas constrained
 - Separator pressures constrained by compression train and export pressure
 - NGL optimisation with variable well flowrates
 - Proven BP case-study gave significant commercial benefit, \$1 million+
 - Consistent fluid representation from reservoir to export
- Underpin a common understanding of the asset across disciplines

Integrated Modelling Case Study



Opportunity

- Steady state simulations of the well and gas processing facilities revealed an opportunity to raise production by dropping the pressure set point of the glycol contactor.

Action

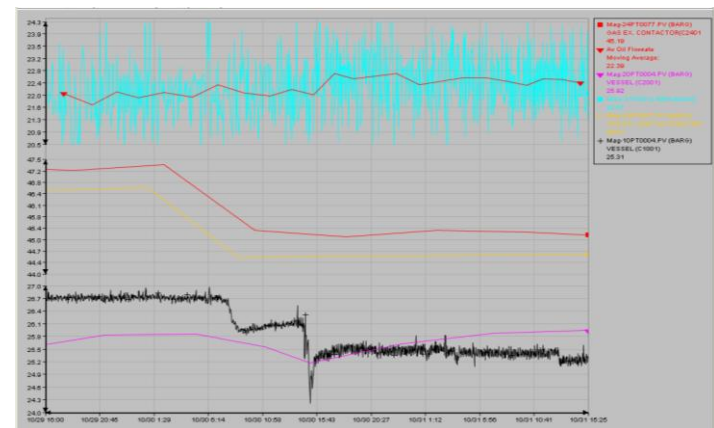
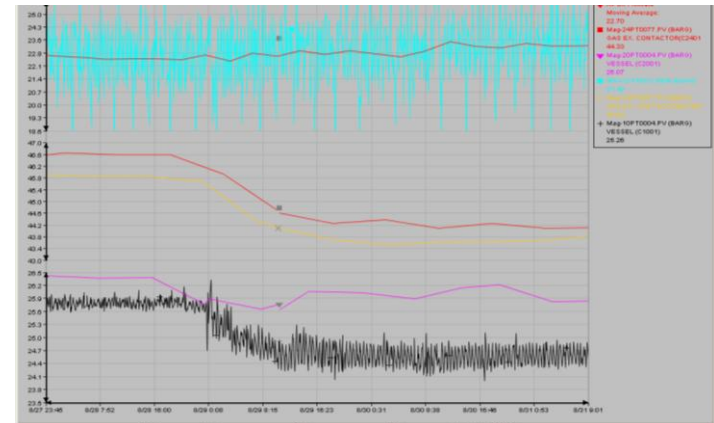
- The set point of the glycol contactor was lowered by 2.5 barg, leading to a 1.5 barg reduction in the pressure of the HP separator.
- The discharge pressure was dropped by 2 barg.

Result

- Modifications to the set point of the glycol contactor led to a production improvement of 400 bd. The lowering of the discharge pressure increased the gas handling capacity by 2 – 3 mmscfd.

Key to Delivery

- Integrated well and process modelling helped to quantify the value prior to implementation.



Possible Methods for Model Integration



- Extending model scope within a single modelling tool
 - Conceptually very simple
 - But extends model scope beyond core capability of tool
- Commercially available Model Integration environments
- CAPE-OPEN

Commercially Available Integration Environments



- Available from a number of suppliers
- Allow integration of modelling tools as “black boxes”
- Support optimisation of integrated models
- Need “drivers” for each modelling tool to be included
- Drawbacks
 - Need relevant drivers
 - User needs to be familiar with an extra tool
 - User may be required to develop the mapping(s) between the various fluid representations
 - E.g. black oil and compositional
 - Recycles (information and physical) often need to be converged as an optimisation problem

GAP as a CAPE-OPEN Unit Operation



- CAPE-OPEN defines rules and interfaces that allow CAPE (Computer-Aided Process Engineering) applications or components to interoperate
 - A freely available industry standard for interfaces
 - CAPE-OPEN is not software or a data model
 - CO-LaN is responsible for maintenance of the standards
- CAPE-OPEN wrapper for GAP
 - Using “OpenServer”
- Commissioned by CO-LaN
- Required no modifications to GAP
- Development took approximately 2 weeks
 - Plus subsequent debugging

Steam connections in HYSYS



The screenshot displays the Aspen HYSYS interface. The left pane shows a process flow diagram with two heat exchangers, HP1 and HP2, and associated streams. The right pane shows the PFD - Case (Main) view with a CO-100 unit highlighted. Below the PFD view is the CO-100 unit properties window, which includes a table of material connections.

Port ID	Port type	Direction	Material name
Test	Material	Outlet	test sep out
LP1	Material	Outlet	lp1 sep out
LP2	Material	Outlet	lp2 sep out
HP2	Material	Outlet	hp2 sep out
HP1	Material	Outlet	hp1 sep out

At the bottom of the CO-100 window, the status is **Not Solved** and there is a **Show Unit GUI** button.

GAP Inputs and Outputs in HYSYS



CO-100

Unit Specific Data and Public Variables

Name	Type	Mode	Lower bound	Upper bound	Value	Va
HP1 Pressure	Real	IN	94430.63296	6944125.39296	646430.599997621	
HP1 QGaslift StockTank	Real	OUT	14320352E+35	14320352E+35	1.80158730295754	
HP1 QGasReservoir StockTank	Real	OUT	14320352E+35	14320352E+35	2.70615778906715	
HP1 QOil StockTank	Real	OUT	.44444445E+29	.44444445E+29	428233195035E-02	
HP1 QWater StockTank	Real	OUT	.44444445E+29	.44444445E+29	920610414496E-02	
HP1 Upstream T	Real	OUT	.88888889E+35	.88888889E+35	323.979354832223	
HP2 Pressure	Real	IN	94430.63296	6944125.39296	644826.629445047	
HP2 QGaslift StockTank	Real	OUT	14320352E+35	14320352E+35	3.60085758584204	
HP2 QGasReservoir StockTank	Real	OUT	14320352E+35	14320352E+35	2.76970887000344	
HP2 QOil StockTank	Real	OUT	.44444445E+29	.44444445E+29	0.03940546657555	
HP2 QWater StockTank	Real	OUT	.44444445E+29	.44444445E+29	850627065926E-02	
HP2 Upstream T	Real	OUT	.88888889E+35	.88888889E+35	308.2035628444445	
LP1 Pressure	Real	IN	94430.63296	6944125.39296	163041.419810934	
LP1 QGaslift StockTank	Real	OUT	14320352E+35	14320352E+35	0	
LP1 QGasReservoir StockTank	Real	OUT	14320352E+35	14320352E+35	320650389576E-02	
LP1 QOil StockTank	Real	OUT	.44444445E+29	.44444445E+29	431418518167E-02	
LP1 QWater StockTank	Real	OUT	.44444445E+29	.44444445E+29	0	

Reset Parameters

Material Connections **Unit Variables** General Thermo

Not Solved Show Unit GUI

GAP Unit Operation:

General Equipment Parameters Ports

- ⊕ A16_HP2
- ⊕ A16_Pipedp
- ⊕ A16_Test
- ⊕ Error
- ⊕ Flow_Perturb
- ⊕ HP1
 - ⊕ Sub-type: PRODSEP
 - ⊕ HP1 Disabled
 - ⊕ HP1 GOR
 - ⊕ HP1 Masked
 - ⊕ HP1 Pressure
 - ⊕ HP1 QGaslift StockTank
 - ⊕ HP1 QGasReservoir StockTank
 - ⊕ HP1 QLiquid StockTank
 - ⊕ HP1 QOil StockTank
 - ⊕ HP1 QWater StockTank
 - ⊕ HP1 Upstream P
 - ⊕ HP1 Upstream T
 - ⊕ HP1 Watercut (Stock Tank Vol %)
- ⊕ HP1 Inlet
- ⊕ HP1 Oil
- ⊕ HP2
- ⊕ HP2 Inlet
- ⊕ HP2 Oil
- ⊕ Iterations

Disabled Masked Inactive

Add parameter

Black Oil to Compositional Mapping



GAP Unit Operation:

General | Equipment | Parameters | Ports

Port composition for separator: HP1

Composition mapping (mass based):

	Nitrogen	H2S	CO2	Methane	Ethane	Propane	i-Butane	n-Butane	m-Xylene	NBP 141*	NBP 260*	NBP 370*	NBP 463*	NBP 669*	TEGlycol	H2O	Total
Injected gas	0.0041		0.0004	0.5778	0.1278	0.1	0.0272	0.0498	0.0009	0.0031						0.0142	0.9999
Gas	0.0041		0.0004	0.5778	0.1278	0.1	0.0272	0.0498	0.0009	0.0031						0.0142	0.9999
Oil				0.0002	0.0002	0.0007	0.0006	0.0014	0.0048	0.0249	0.2609	0.1589	0.1795	0.3265			0.9999

Lift gas density calculated from host simulation

Lift gas specific gravity from OpenServer string:

User specified lift gas specific gravity:

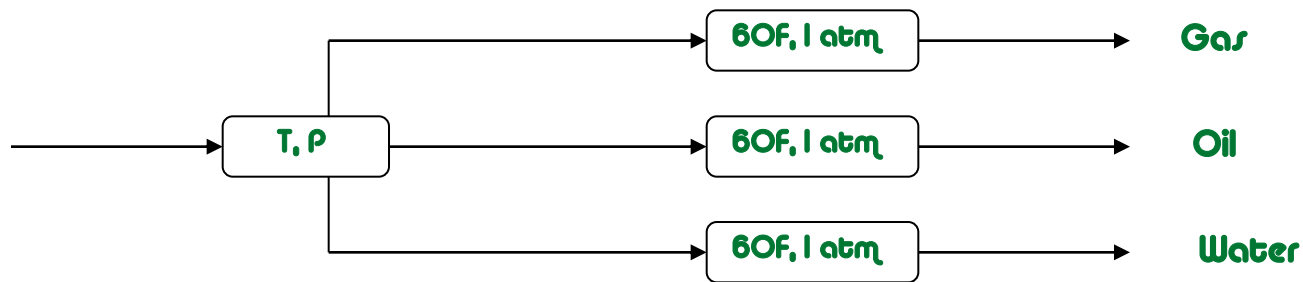
Reference density is 1.23187 kg/m3

Copy all... Same as... Store... Load

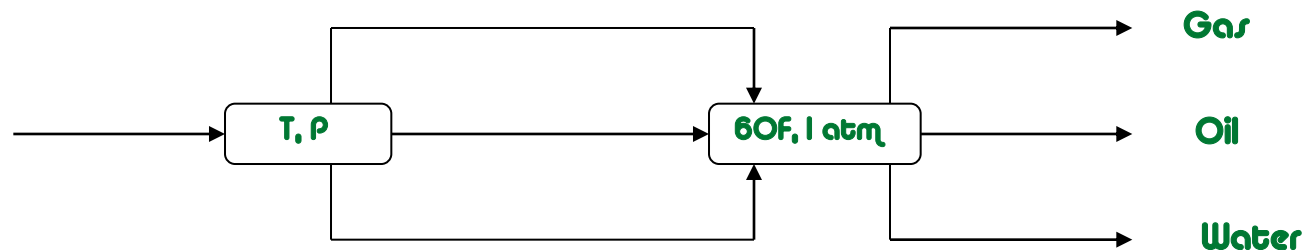
The Challenge: Reconciling Discipline Descriptions of Fluids



- Petroleum Engineers use concept of “Stock Tank” volumetric flows
- Process Engineer:



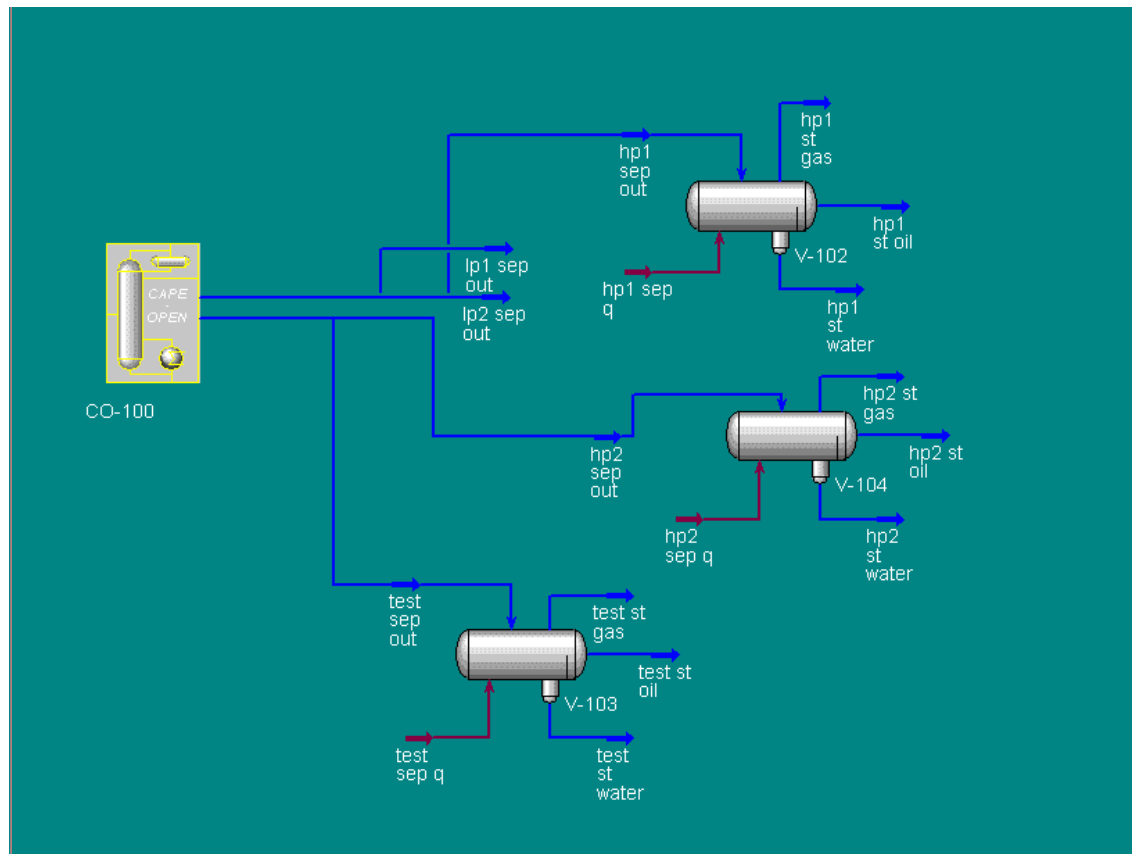
- Petroleum Engineer:



The Clair Asset example



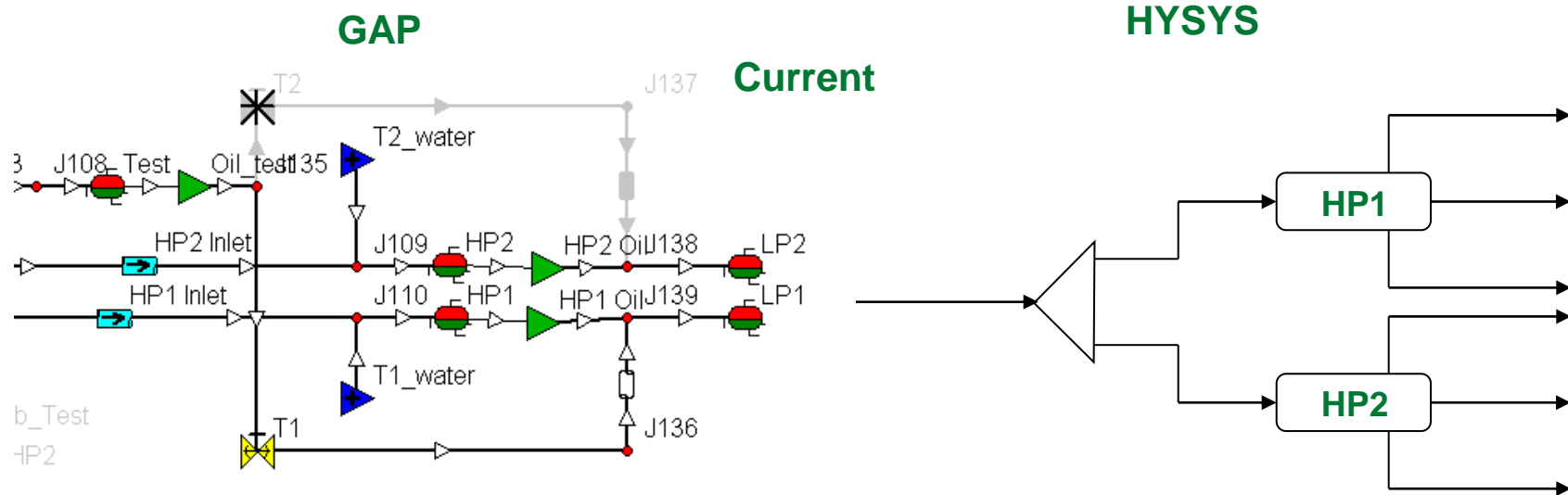
- A work in progress



The Clair Asset example (2)



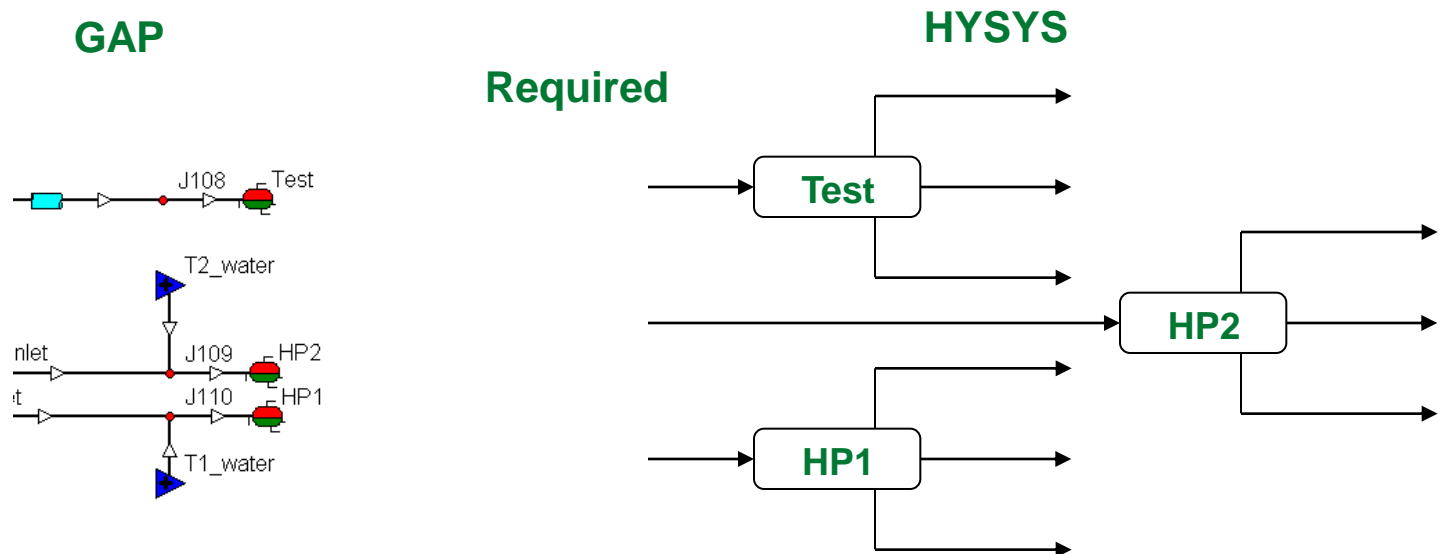
- Next steps:
 - Reconcile separator representation in GAP and HYSYS



The Clair Asset example (2)



- Next steps:
 - Reconcile separator representation in GAP and HYSYS



- Connect recycled gas lift from HYSYS to GAP gas lift input rates
 - Will require a HYSYS spreadsheet

Conclusions



- Benefits of integration include:
 - System optimisation within safe operating limits
 - Underpinning cross-discipline understanding
- CAPE-OPEN interface allows delivery of some of these benefits
 - Quick and easy to develop
 - Can be used in any CAPE-OPEN process simulator
 - Further work is required to prove that the interface will underpin the sustainable use of integrated models in Operations

Acknowledgements



- AspenTech for their support, especially Pradeep Polisetty
- CO-LaN for funding for interface development
- The Base Management and Operations teams at Clair