INTECSEA
WorleyParsons Group

SMI Subsea R&D Workshop

A Life of Field Approach to Subsea Active Production Technologies

26th November 2012

EcoNomics

Key Presentation Elements

- Introduction
- What's meant by "Subsea Processing"?
- Why Apply Subsea Processing Technologies?
- Technology Status & Application Overview
- Can We Act Smarter?
- Conclusions

INTECSEA

- INTECSEA is a wholly owned global business within the WorleyParsons group
- Operates across a full project cycle of diverse and technological developments
- Comprehensive range of specialist skills and engineering disciplines in truly integrated teams
- Provides system solutions to subsea projects of all sizes – from a relatively simple tie-back to world-scale deepwater developments in the harshest environments – anywhere in the world.

Global Reach

With **40,800** people in**163** offices throughout **41** countries, we provide our customers with a unique combination of extensive global resources, world-recognized technical expertise and deep local knowledge.

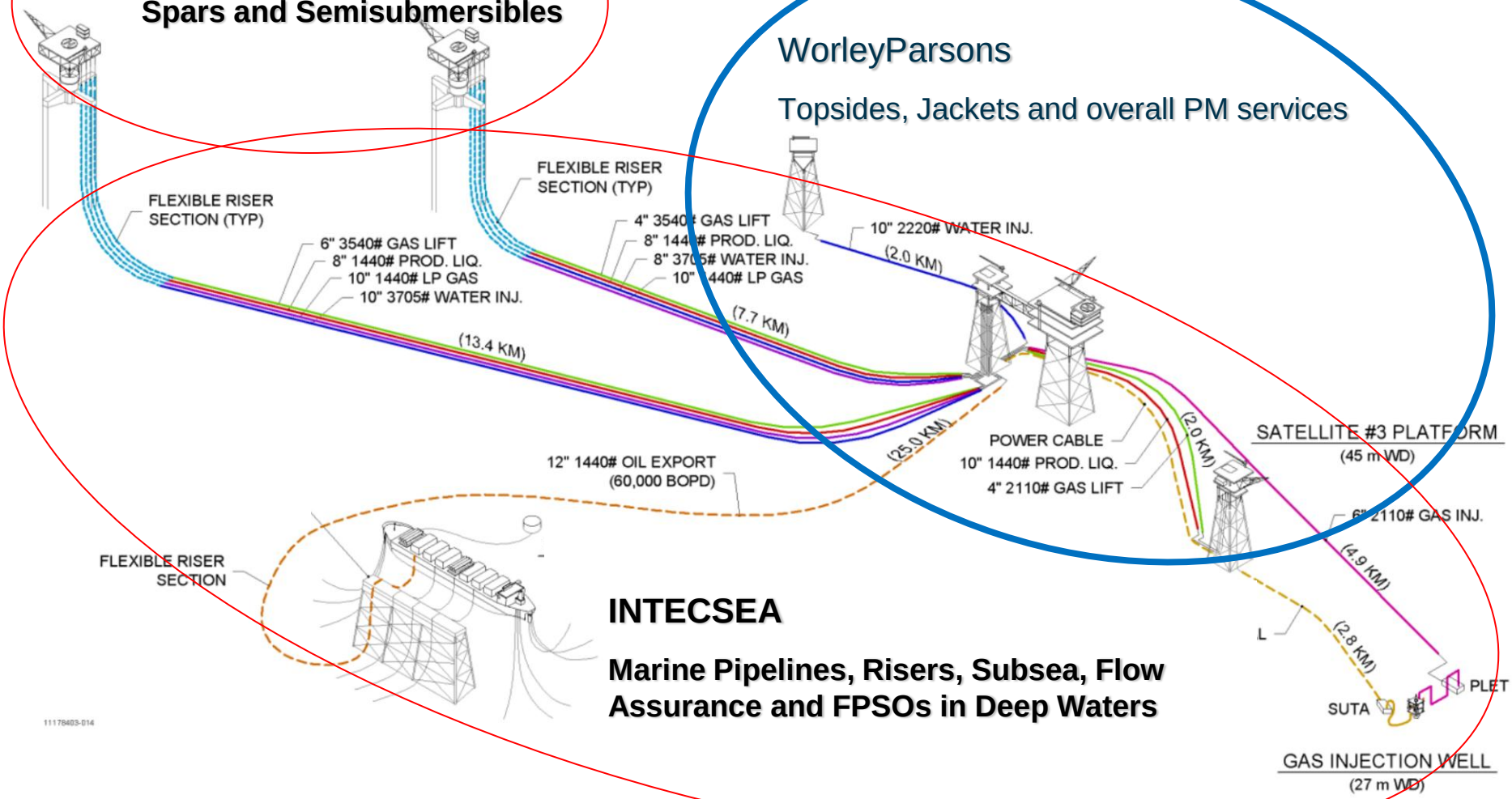
Group Offshore Expertise

INTECSEA

Hull and Moorings for TLPs, Spars and Semisubmersibles

WorleyParsons

Topsides, Jackets and overall PM services



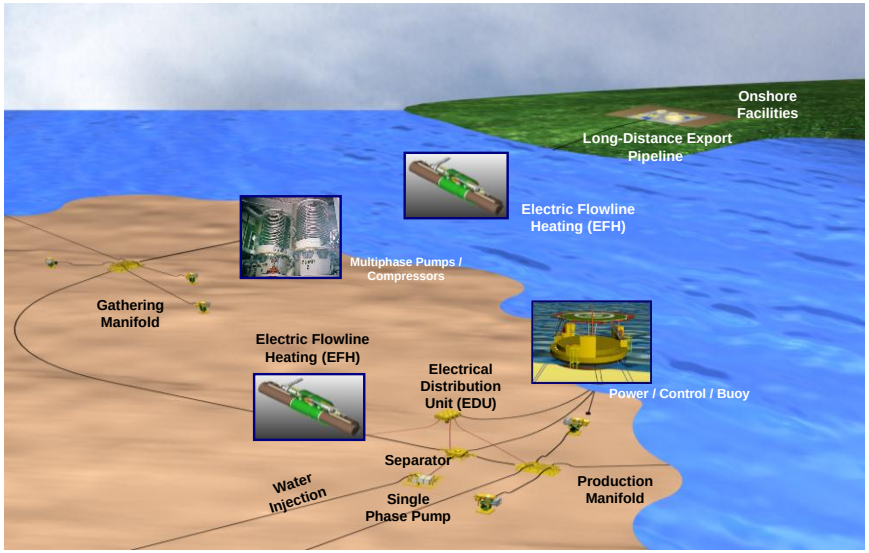
INTECSEA

Marine Pipelines, Risers, Subsea, Flow Assurance and FPSOs in Deep Waters

Long Distance Delivery Management

OBJECTIVE

- Assist Operators to:
  - Develop remote deepwater fields without local host facilities
  - Enhance the economic value of remote reserves
  - Allow smaller marginal reserves to be developed economically
  - Overcome production system constraints

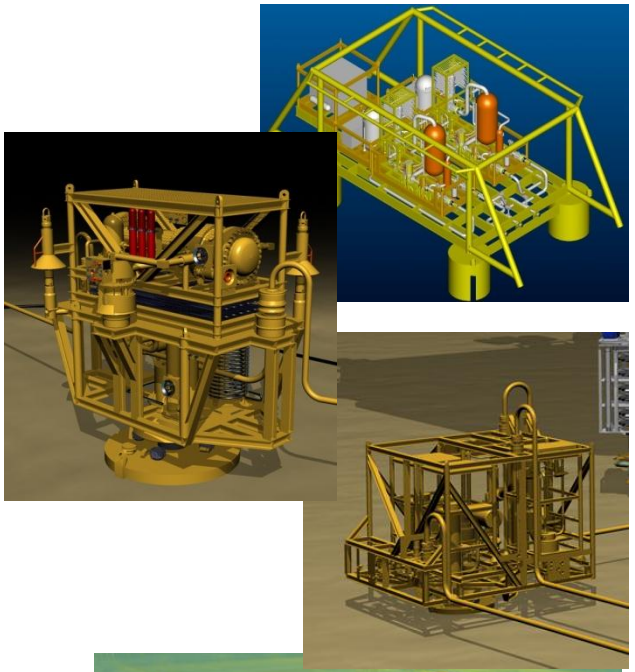


INTECSEA'S APPROACH

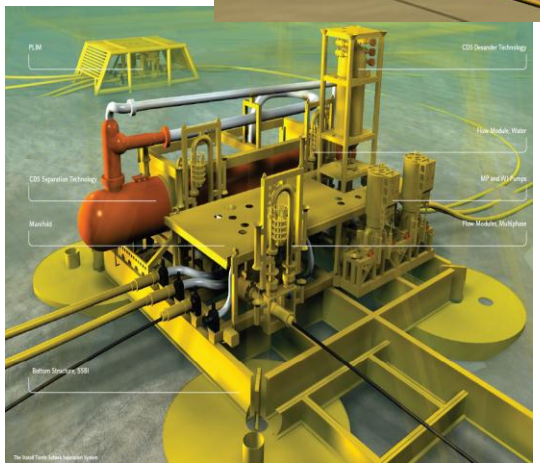
- Objective & impartial systems-based engineering analysis/design
- Identification & qualification of performance-enhancing new technologies
- Implementation of qualified emerging technologies, processes & equipment
- Push the boundaries of subsea tiebacks

The term "Subsea Processing"?

- Adding energy to wellstream fluids subsea, eg:
  - Pumping – liquids & multiphase
  - Compression – dry gas & multiphase
  - Separation – 2-phase & 3-phase + sand
  - Local Produced Water & Seawater Injection
  - Electrically Heated Flowlines
  - Plus associated Electrical Power Systems



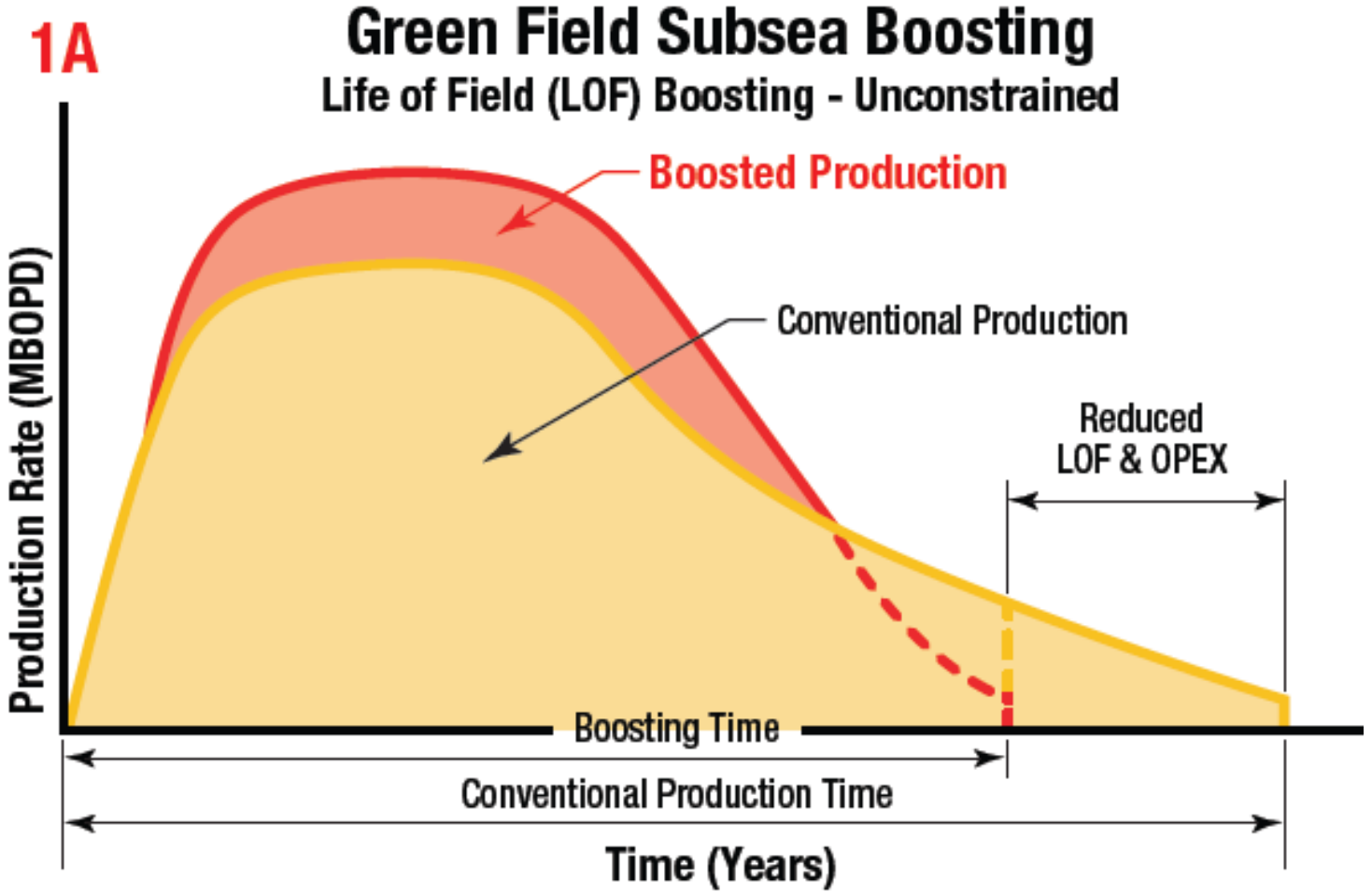
- INTECSEA uses the collective term SAPT:
  - **Subsea Active Production Technologies**



Drivers for SAPT

- Separation
  - Minimize topside water handling requirements
  - Separate liquid & gas streams, remove water from wellstream
  - Increase well and field overall recovery
  - Decrease pressure/flow boosting power requirements
- Pumping
  - Minimize topside water handling requirements
  - Increase & accelerate production by lowering flowing WH pressure
  - Increase overall recovery by reducing abandonment pressure
  - Enable recovery from lower pressure reservoirs
  - Reduce effects of hydrostatic head in deep-water
  - Enhanced transportation of separated liquids
- Compression
  - Enable longer subsea gas tiebacks
  - Eliminate need for surface structures in difficult environments
- Water Injection
  - Reduce weight, space & power loading on host facility
- Electrically Heated Flowlines
  - Manage production chemistry issues

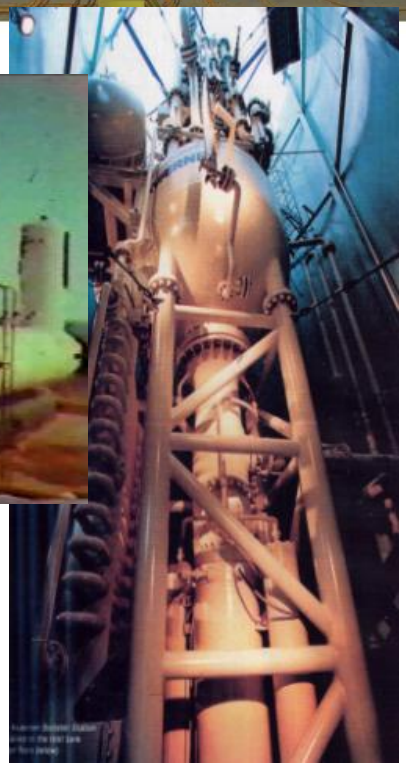
Drivers for SAPT



Industry Response to the Compelling Drivers

- **Regrettable under-investment for several decades (ca 1970 – 2000)**
  - Impressive pockets of technology development by Vendors
  - Isolated forays into offshore piloting by a few Operators
  - Relatively little visionary leadership, technology investment, challenge or practical encouragement pre-2000

Zakum Pilot 1972



Kvaerner Booster Station 1993

- **The new subsea era finally dawns – 30 years on**
  - Norway provides vision, challenge and orchestration
    - Norsk Hydro and Statoil commit to serious offshore pilot projects
    - Vendors provide the vision and resources to evolve the technology
  - Petrobras also provides leadership and challenge
    - PROCAP 3000 R&D initiative, in partnership with Vendors
  - Deepwater fields start to dominate the near-term prospects
    - Conventional (passive) subsea technologies no longer adequate
    - Heavy oil reservoirs compound the problem
  - **And then suddenly – Several Operators finally realize they can't actually develop some deepwater discoveries without applying enabling subsea processing technology!**

Life of Field Approach to SAPT

- A life-of-field approach to subsea active production technologies requires advanced, multi-disciplinary expertise; can be the difference between operational success and failure.
- INTECSEA's comprehensive global flow assurance capability provides expertise and solutions throughout the project life cycle.
- To help our customers understand and manage their flow assurance challenges, our team of experts have adopted Maximus™, a state-of-the-art design tool for steady state life-of-field simulation.

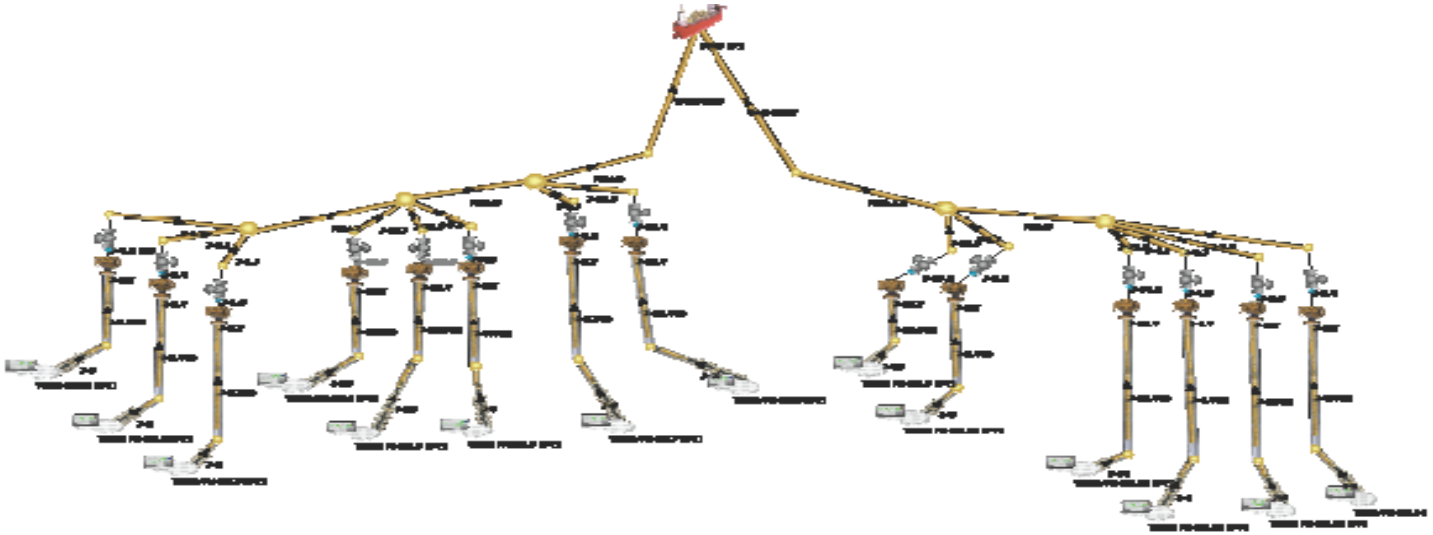
Life-of-Field Approach - Customer Benefits

- Full life of field analysis capability assists optimization of field design and performance considering each phase of field life;
  - Initial field layout and equipment sizing
  - Planning and execution of additional wells
  - Management of secondary recovery
- Rapid evaluation of a variety of subsea processing and artificial lift options
- Complete system analysis, from reservoir to facility – in a single model;
  - Ensures seamless, consistent and accurate performance predictions
- A high speed solver integral to the tool, along with an intuitive and flexible graphical user interface, allow for repetitive simulation of large and complex field developments, within reduced time frames as compared to conventional simulation tools

Traditional Simulator Tools

- Traditional integrated production modeling tools – trade-off between accuracy of the model and simulation speed
- Traditional steady state tools restrict user to multiple analytical simulations of single pipeline systems
- **Result – the breadth of the study or accuracy of the results could be compromised to complete a conceptual study in a reasonable timeframe.**

The Maximus™ Advantage



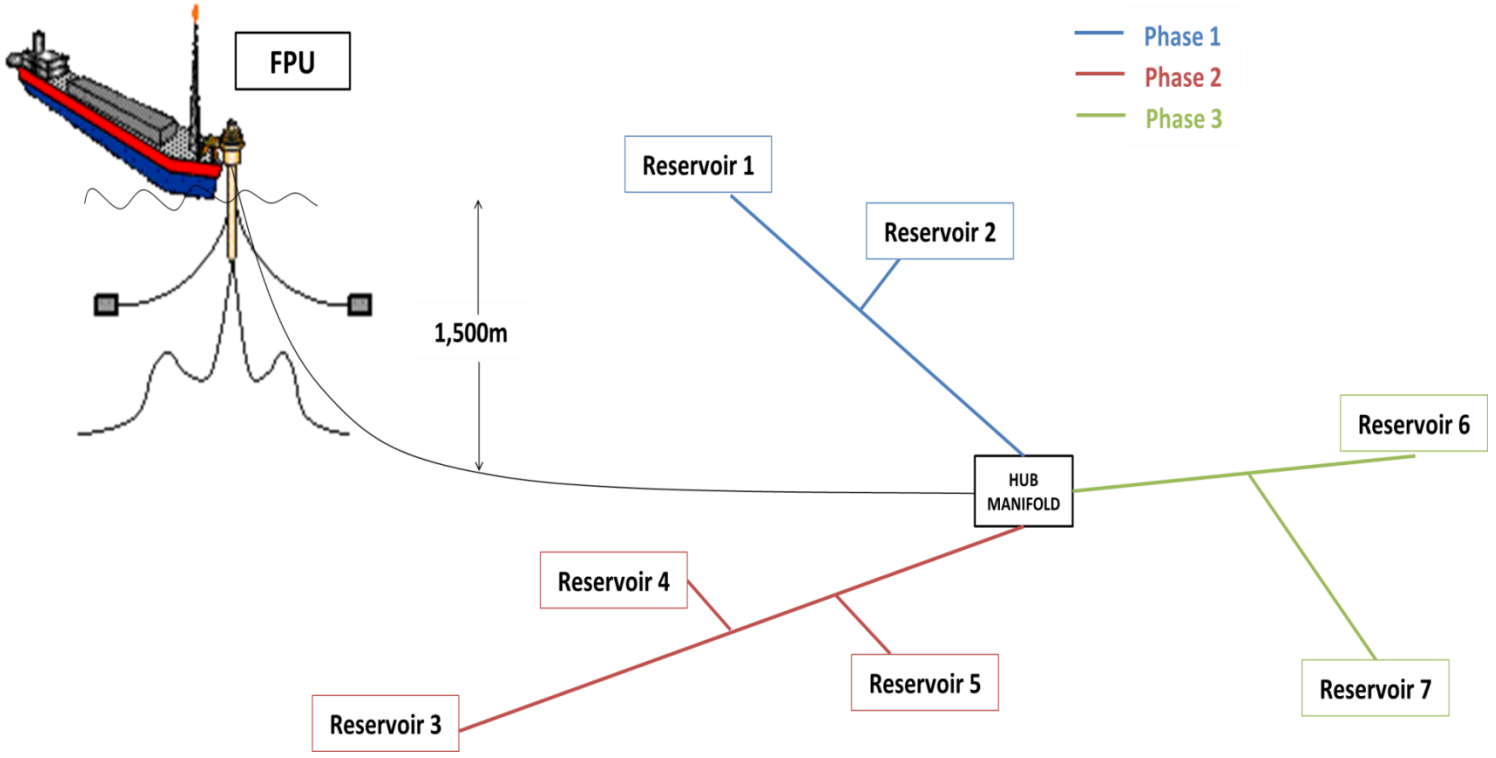
- **The MaximusTM advantage**
  - Higher computation speed, enabling multiple runs in reduced time
  - Network parametric studies (clear differentiator)
  - Single models for seamless analysis of entire field, regardless of complexity
  - Supporting features such as estimation of CO2 partial pressure data for corrosion analyses
  - Intuitive and flexible graphical user interface

Design Example

- Project Key Features
  - Deepwater gas development
  - 95 mol% + Methane
  - 20 year design life
  - Phased development 1, 2 & 3
  - Continuous hydrate inhibition assumed
  - Fully rated system (300 barg approx.)

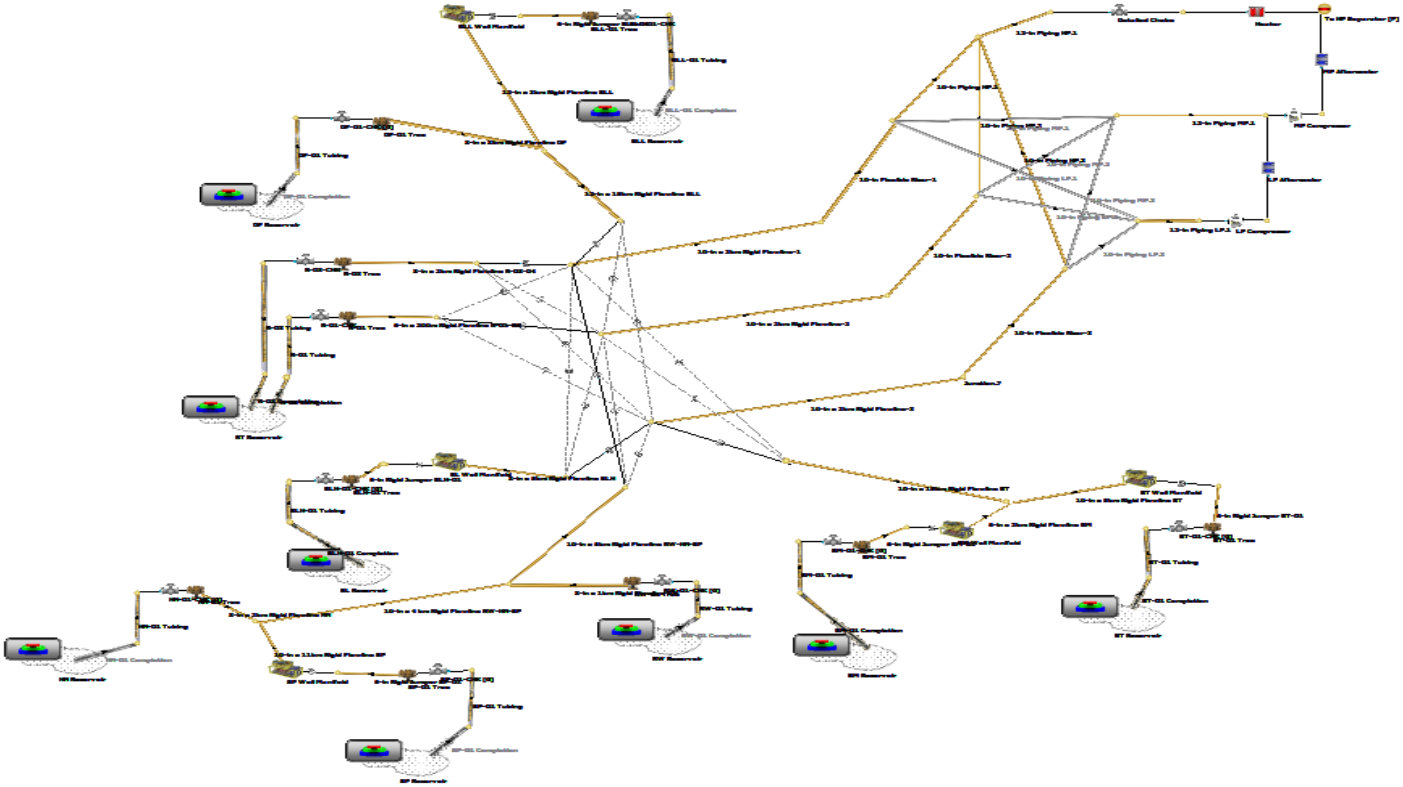
Design Example

- Field Development Key Drivers
  - To obtain maximum recovery from each phase
  - HP operation followed by MP compression
  - MP compression followed by LP compression
  - Topsides choking considered to minimise subsea choking

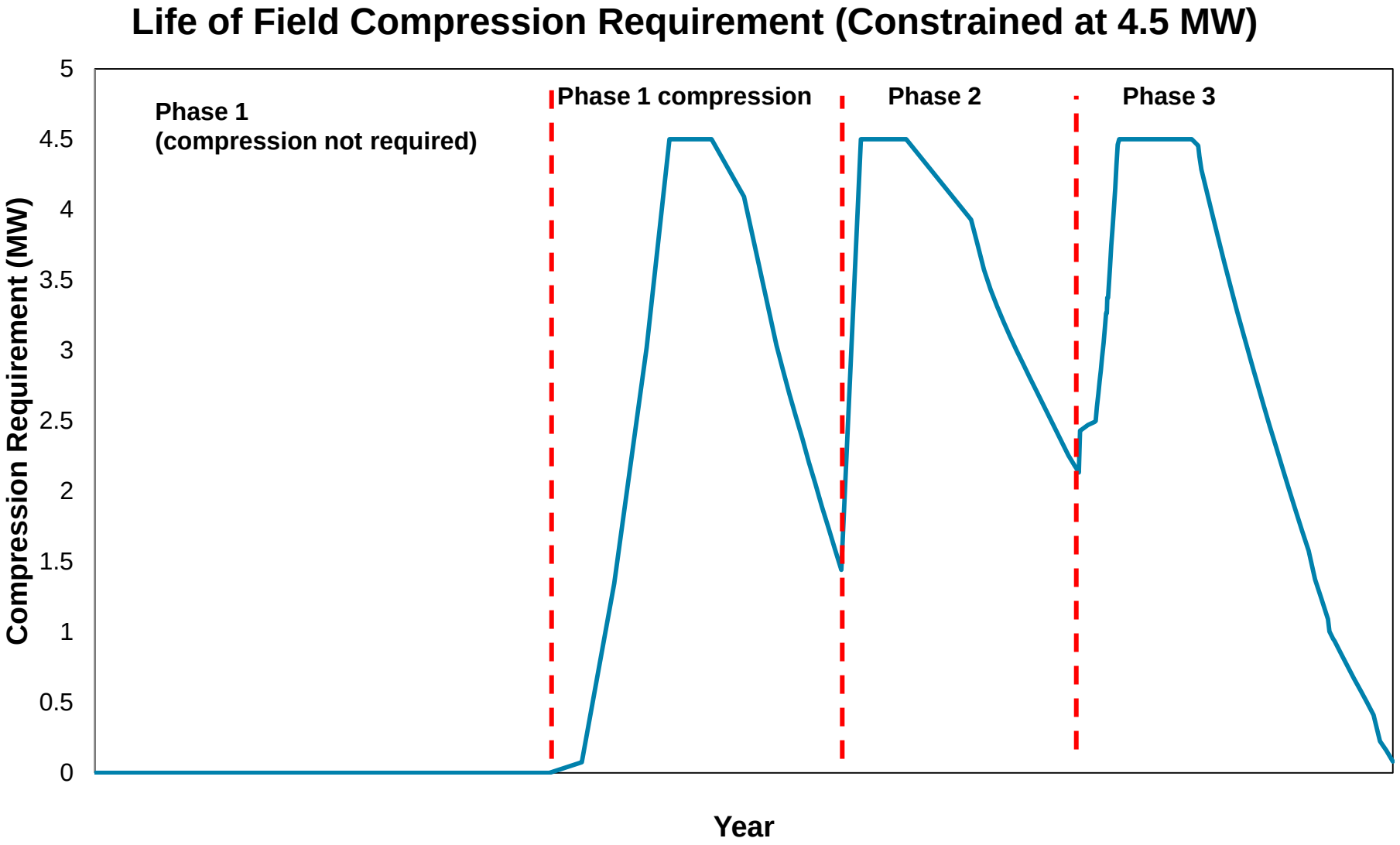


Design Example

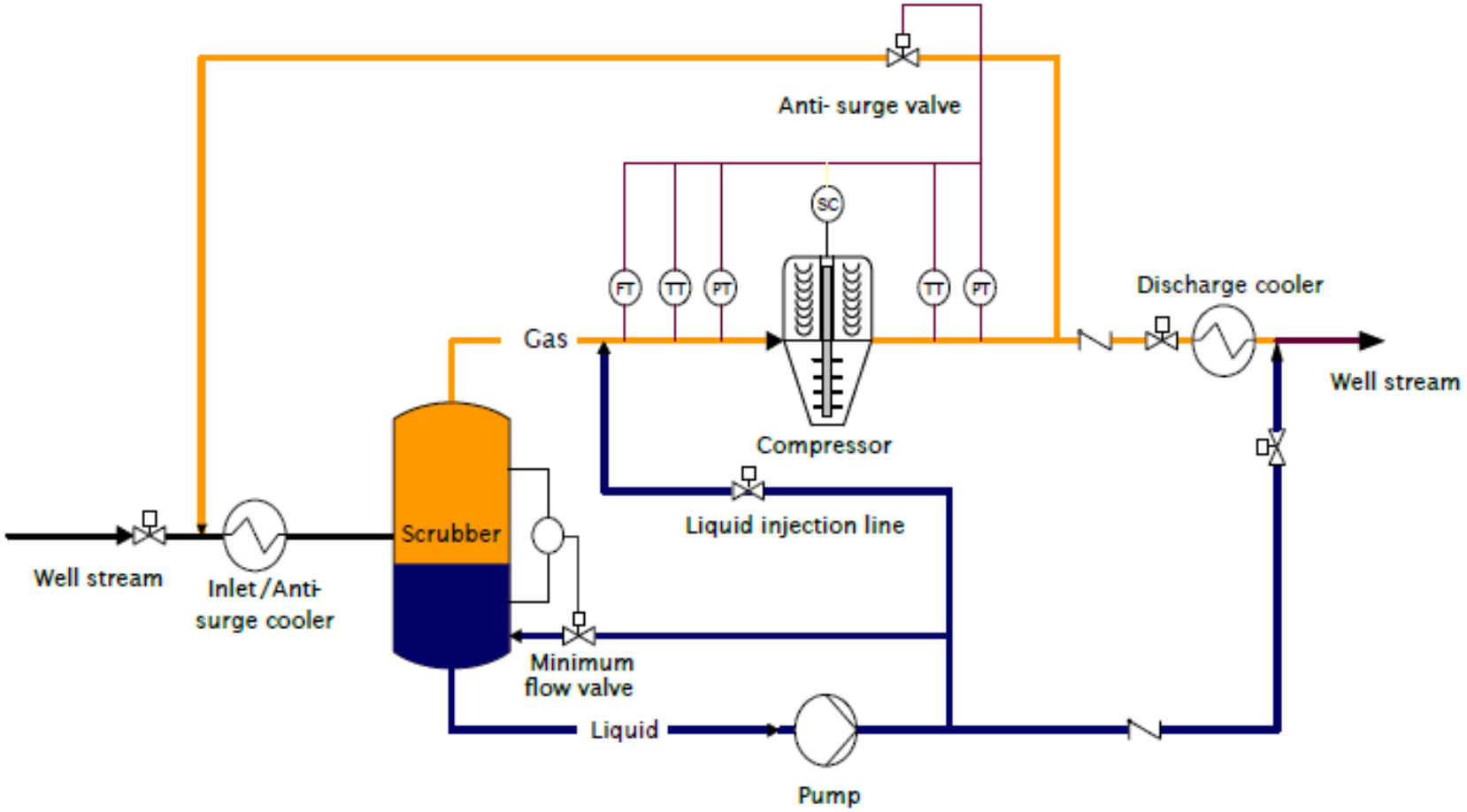
- Field Simulation Model
  - Life of field modelling for 20 years
  - Tank models for reservoirs
  - Develop phasing strategy and drilling program inputs
  - Identify optimum compression requirements



Design Example

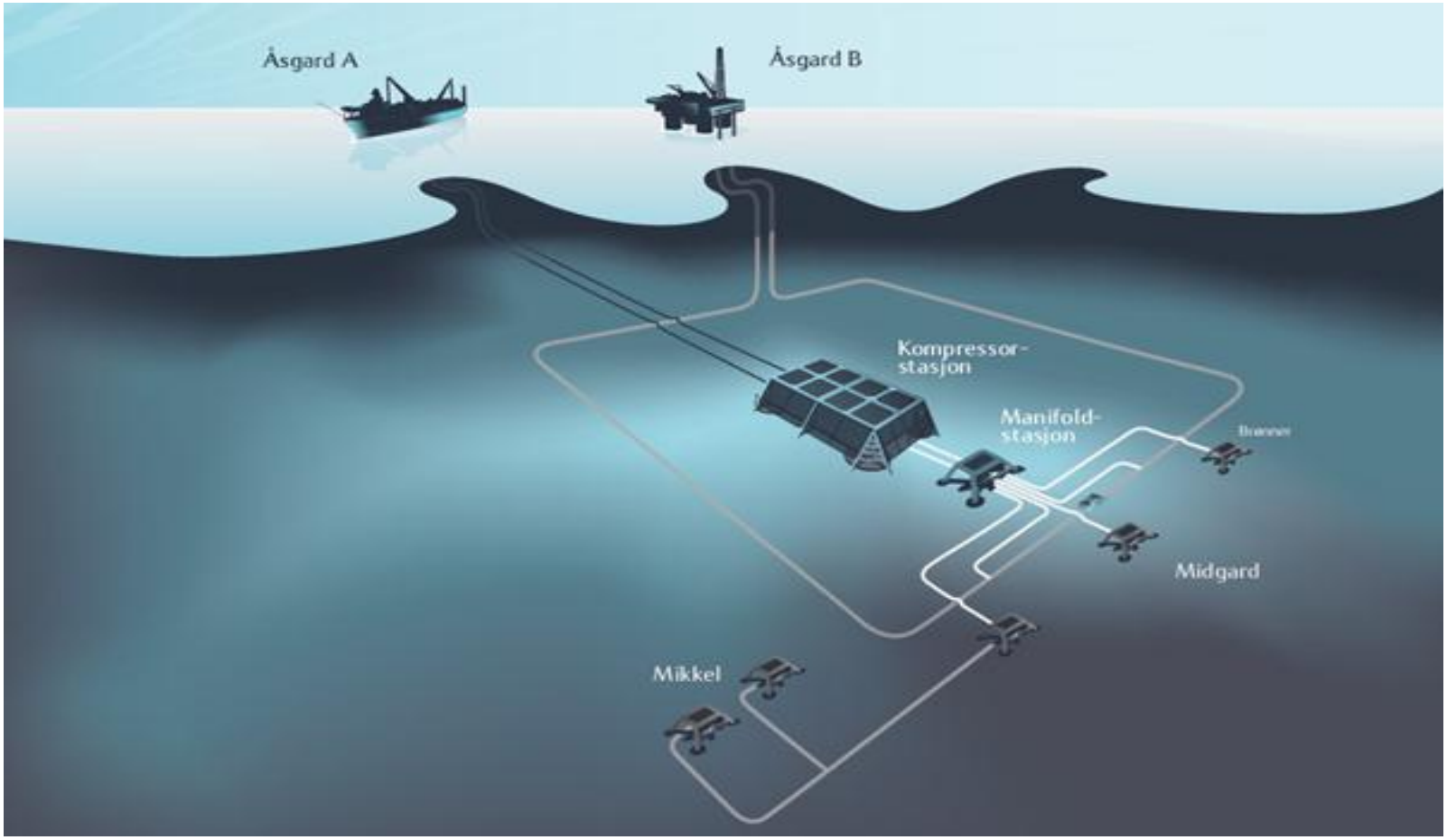


Typical Compression Schematic



Courtesy of Statoil

Typical Subsea Gas Compression

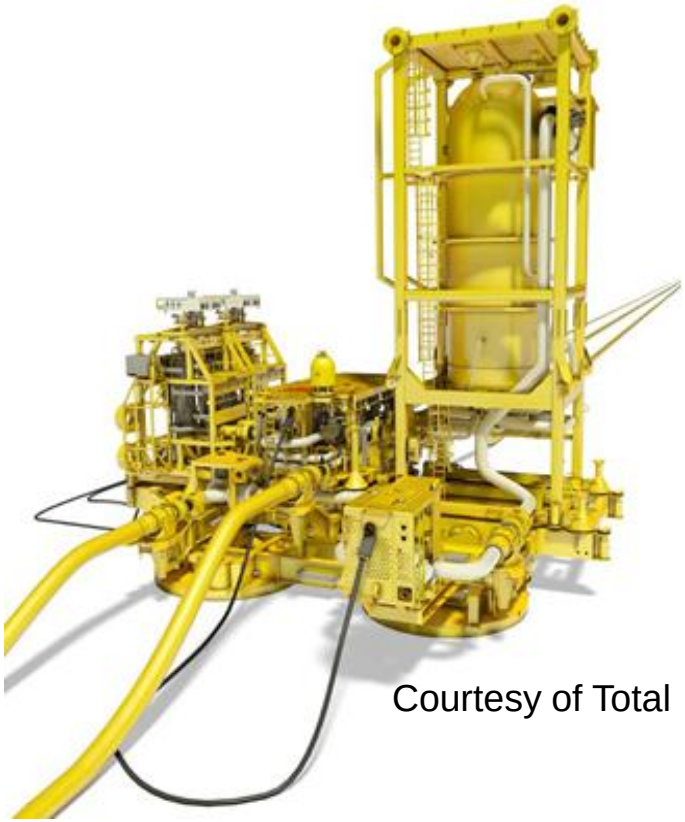


Åsgard Subsea Gas Compression

Other Subsea Processing Options

- Maximus™ can be used to evaluate other subsea processing options

- Subsea Separation



Courtesy of Total

- Subsea Water Treatment for Injection

Courtesy of SeaBox

Current INTECSEA Subsea JIPs

- Subsea Processing Concept Screening Application JIP
  - Centred on East Coast Canada
  - Enable better appreciation of benefits & practicality
  - Enhance understanding of evolving industry capability
  - Clarify technical readiness level & further qualification required

- Arctic Trenching JIP
  - Full-scale commercially ready burial/trenching system.
  - Burial depths >3m, with potential trench depths as much as 7m
  - Trenching in soil conditions that are difficult and highly variable
  - Trenching in water depths up to approximately 300m
  - Operating in harsh marine conditions.

Summarising Observations

- **The Development Agenda is changing:**
  - Subsea technology has long been essential enabler for deepwater
  - Energy adding technologies now emerging as game-changers
  - Often essential for deepwater feasibility
  - Inflated Oil price has created a major investment driver
  - Huge potential for recovery enhancement & production acceleration
- **But are we all aboard the change train?**
  - Often inadequate collaboration across silos
  - Reluctance to tackle root causes of risk perceptions
  - Reluctance to share meaningful operational experience
  - Resource constraints will continue to present risks

Concluding Comments

- So, can we act smarter to capture SAPT opportunities?
  - Better retention of staff with right exposure
  - Better collaboration across discipline silos
  - Better experience sharing between Operators and Vendors
  - Better collaboration & visibility on technology qualification
  - Better transparency by Vendors on performance data & costs
  - Better use of integrated production modelling tools
  - Better use of objective independent specialist resources

- Management challenge has tended to be "**Why SAPT**?"
  - **Likely soon to change into "Why Not SAPT?"**


INTECSEA
WorleyParsons Group