Finding Petroleum
24th Jan 2012

Technologies Addressing The Challenges Today and Tomorrow

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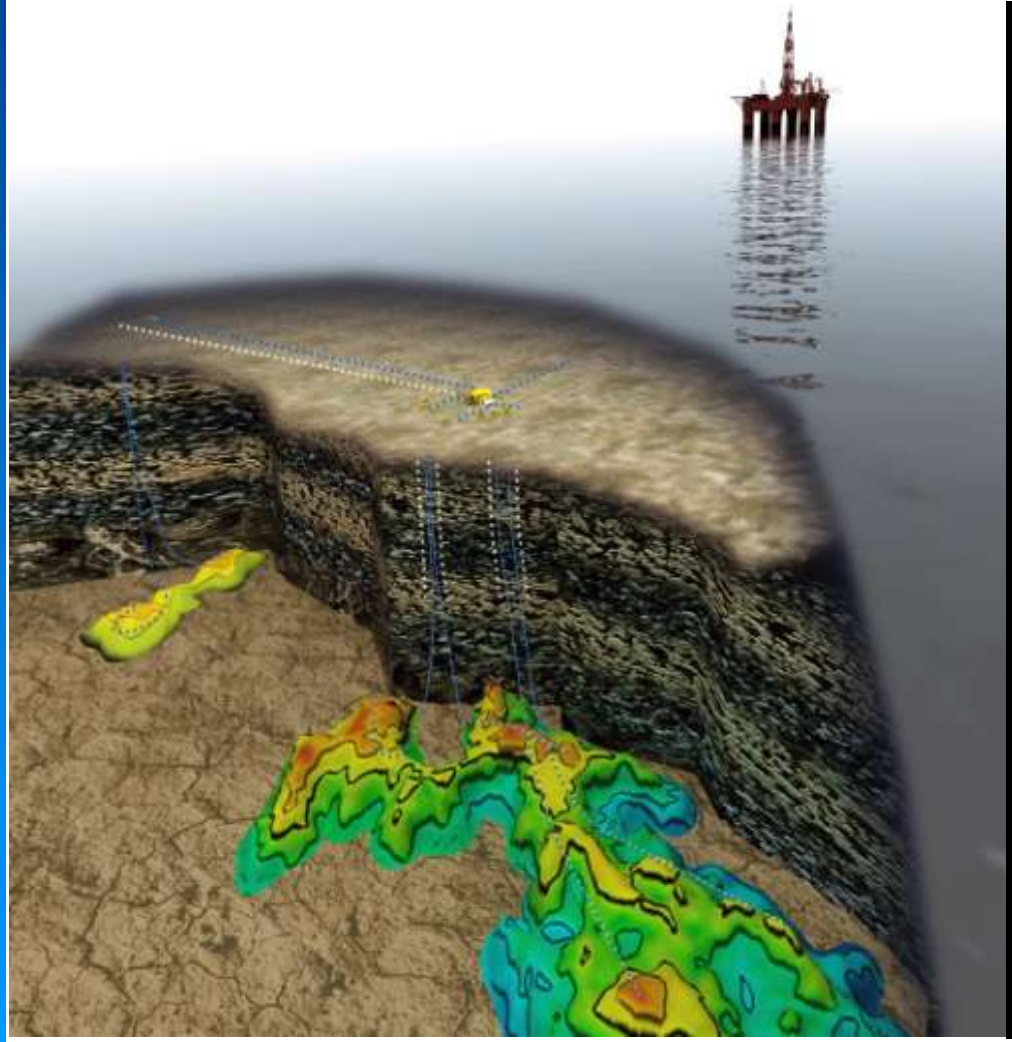
A Schlumberger Company

Content

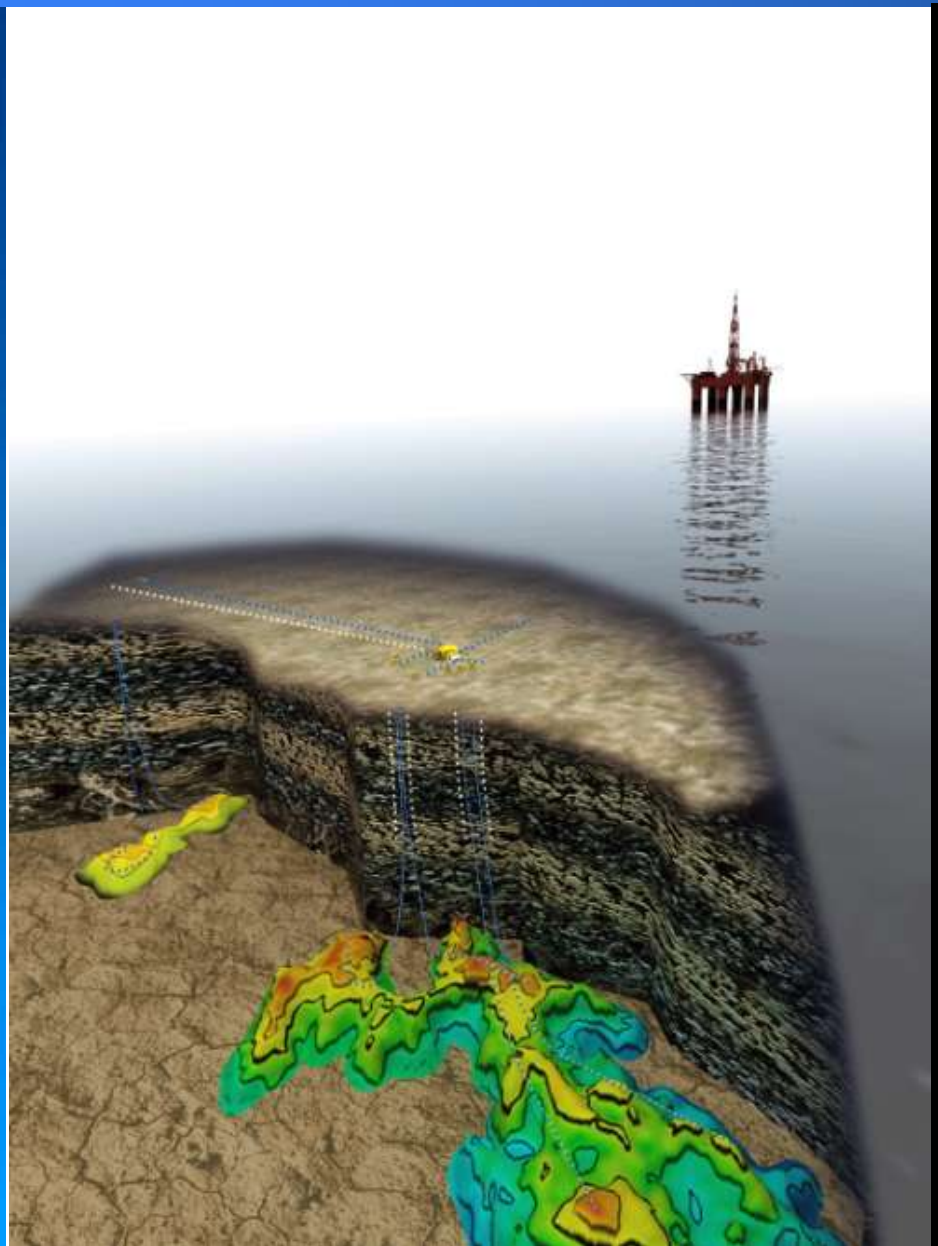
- Introduction
- Market drivers
- Technology Systems that are available
- Life of Field solutions
- Conclusions

Rising to the process challenge – “the ability to manage and enhance recovery”



- Aquifer Support
- Flow Regime
- Hydrate Formation
- Wax Formation
- Scale formation
- Asphaltine formation
- Pressure (15,000 psi)
- Temperatrure (200 deg C)

Subsea Enhanced Recovery - ‘Framo Systems’ “the ability to manage and enhance recovery”



Water Injection

Multiphase Boosting

Multi-Compressor (Wet Gas) -
(handling ‘true’ wet gas)

Separation

Multiphase / Wet Gas Metering

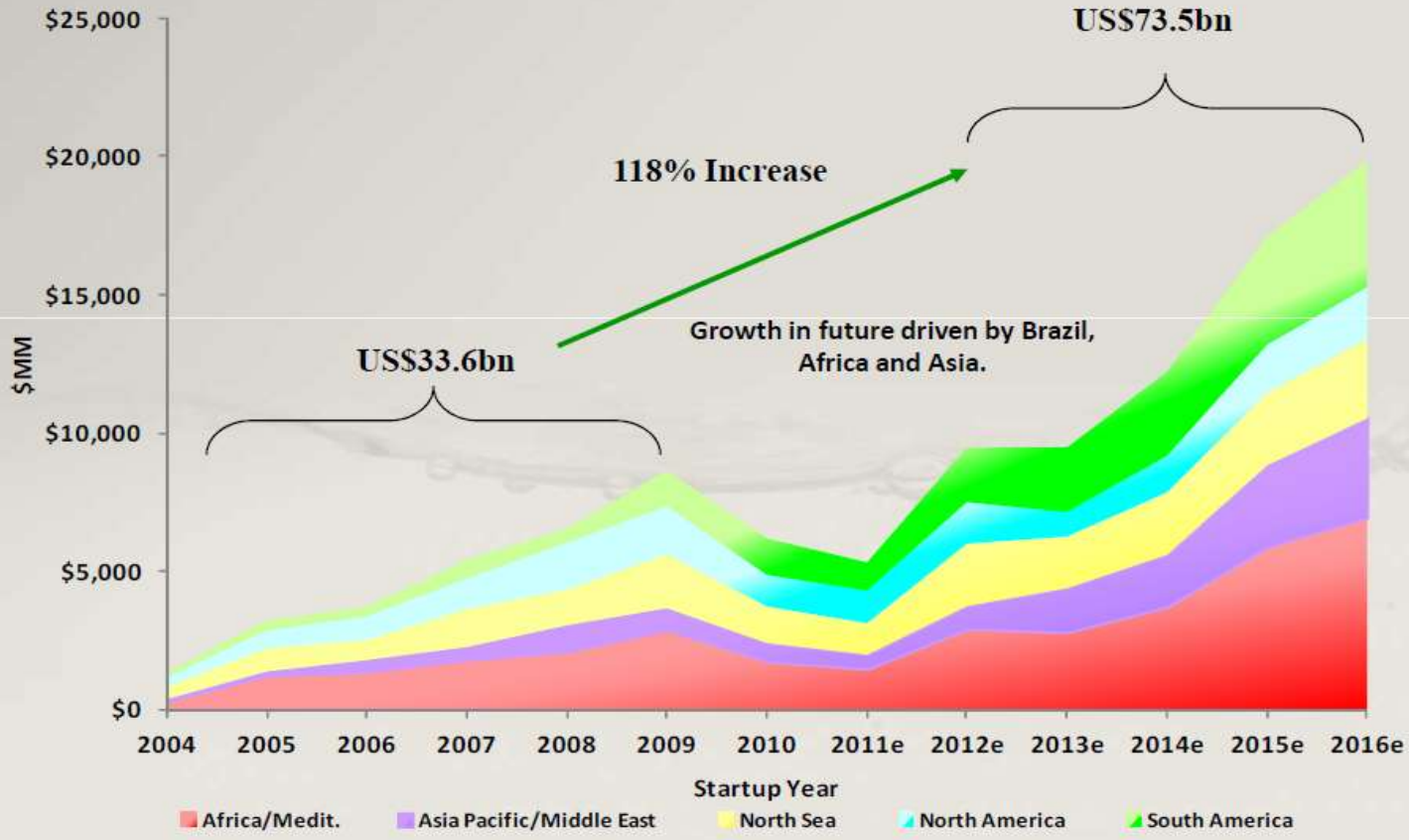
MultiManifold – compact cluster
(50% lighter in weight & size)

Content

Quest Offshore

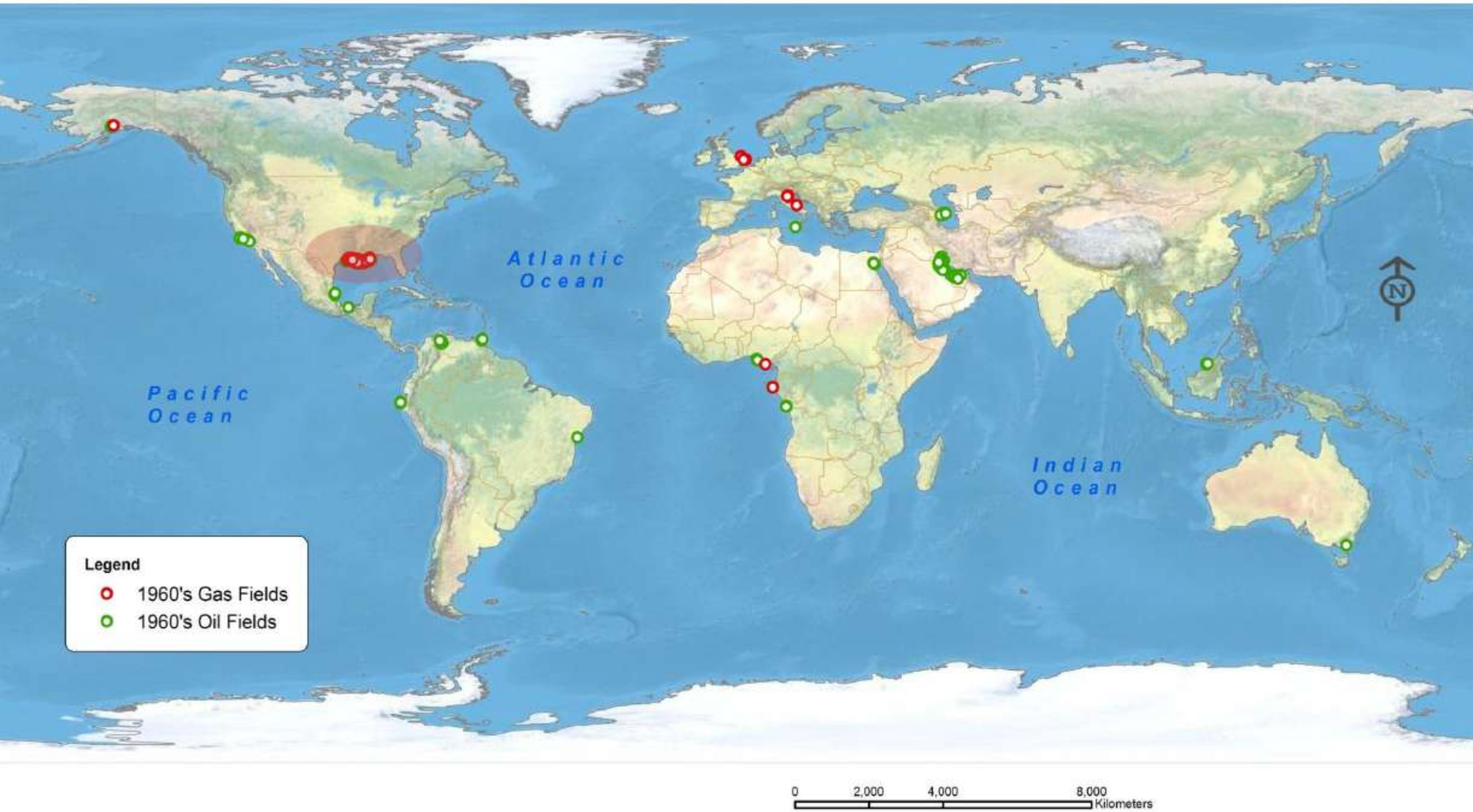
Global Subsea Capex

Forecast spending 2011-2016e $73.5bn

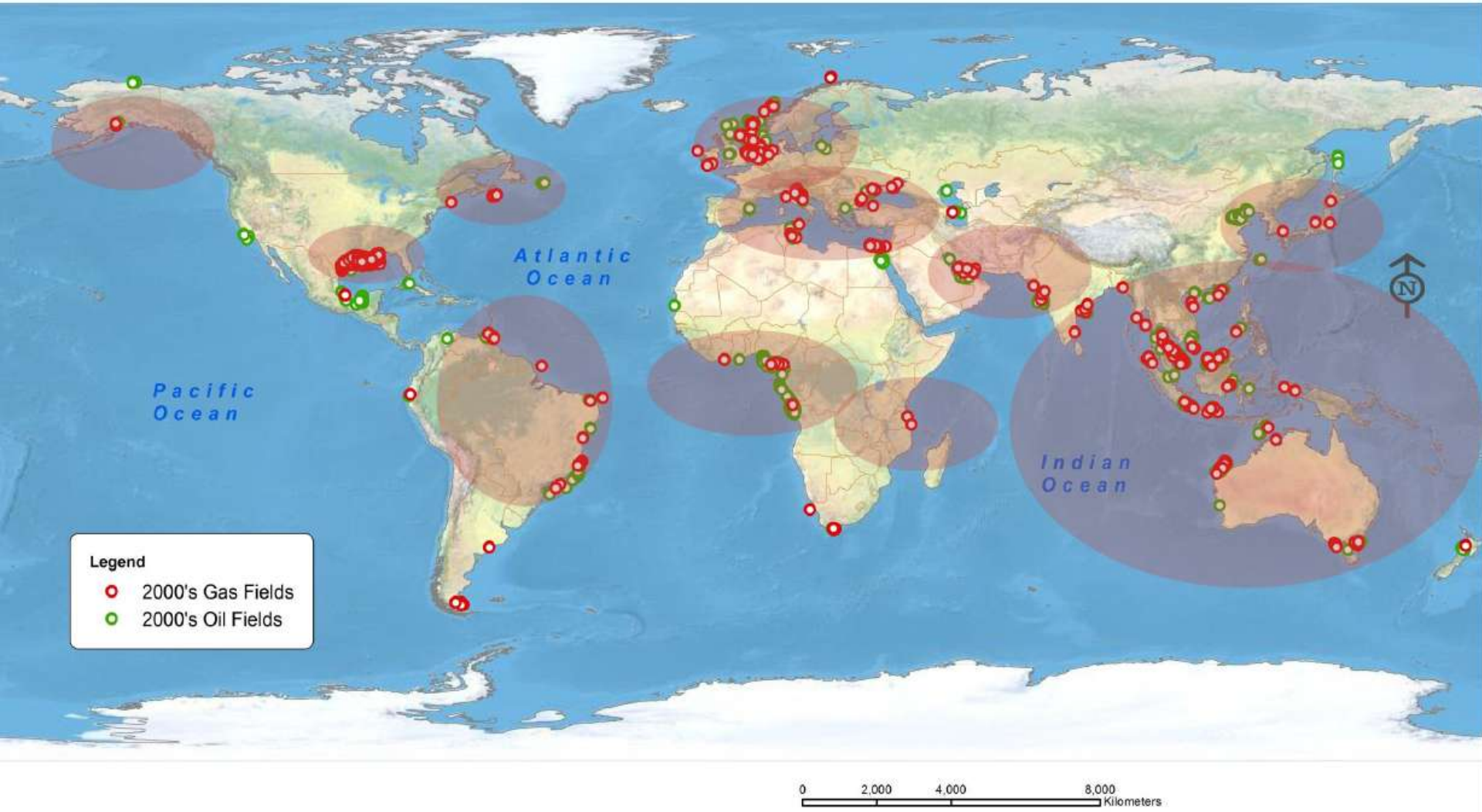


Source: HolyGrail_November2011.xls

Where Do We Find More? | Further, Deeper & Harsher 1960's



Where Do We Find More? | Further, Deeper & Harsher Fields 2000's



Company Overview –
founded in 1983, owned today by Schlumberger (June 2011)

Main Office

- Located in Bergen
- Project Management, Engineering, & Procurement
- all engineering and technology in-house

Horsøy

- Located just outside Bergen
- New Assembly and Test facility
- 20.000 m2
- Wet test dock

International Locations

- Regional offices in Americas, UK & Asia
- Bases in West Africa Brazil & Australia
- Plus Schlumberger network (over 80 countries)

Advanced test facilities

Horsøy, 2011 – the future ’today’

Increase Capacity

Enhance Lead Time

Maintain and Improve Quality

Increase Scope and Functionality Offering

Secure our Position as a World Leading System Supplier

- **2 subsea test docks**
- **Live hydrocarbon test loop**

Total System Solution – Flexibility to Field Developments

- Pumps Systems
- Process Manifolds
- Umbilical Systems
- Subsea Power & Controls
- Swivels and Marine Systems
- Multiphase / Wet Gas meters
- Intervention tooling
- Conditioning Monitoring

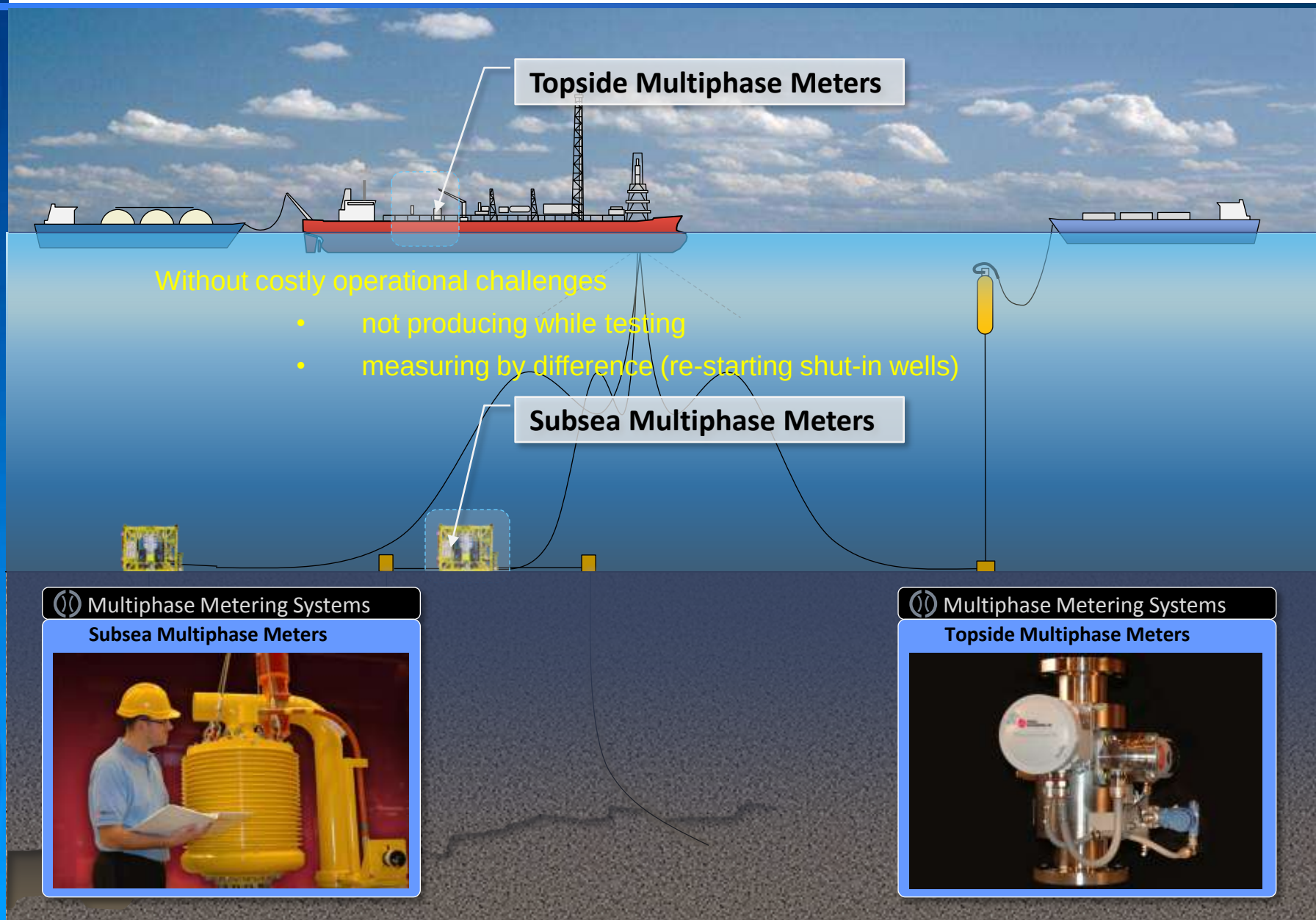
Total System Solutions – Subsea to Floater

Pumps & Subsea ProcessSystems

Multiphase Meters & Measurement Systems

Swivels & Marine Systems

Multiphase Metering & Measurement Systems



Multiphase Metering Systems

Subsea Multiphase Meters

Multiphase Metering Systems

Topside Multiphase Meters

PhaseWatcher Vx – 'Experience 'counts'

Meter for all process regimes

- The only single meter that can measure 0 to 100% gas.
- Measurement is not effected by emulsions or slugging

Experience

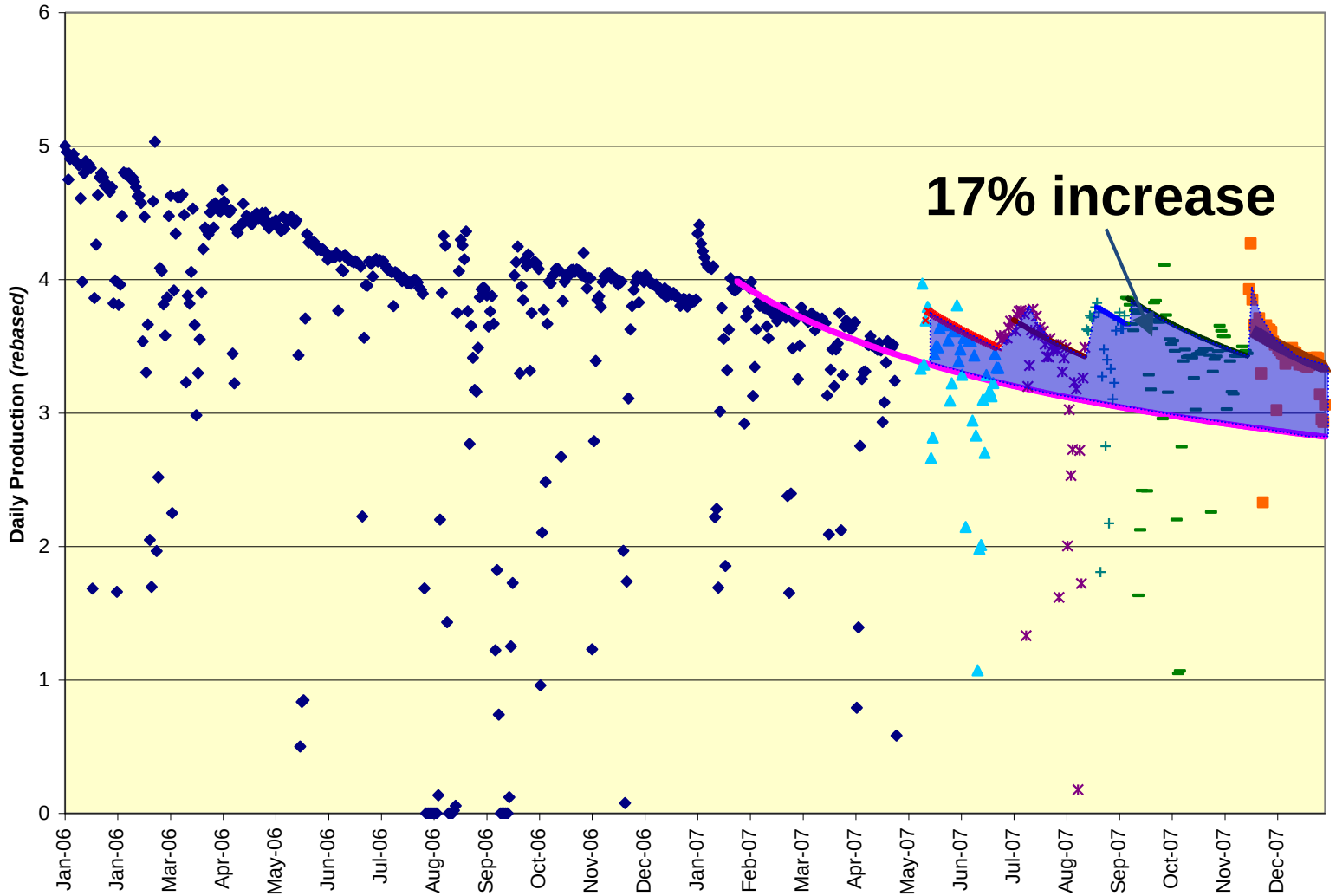
- Over 10 years in Operation (Vx established 1999)
- 1600 meter delivered in Dec 2011

Subsea package 'HP and HT qualified'

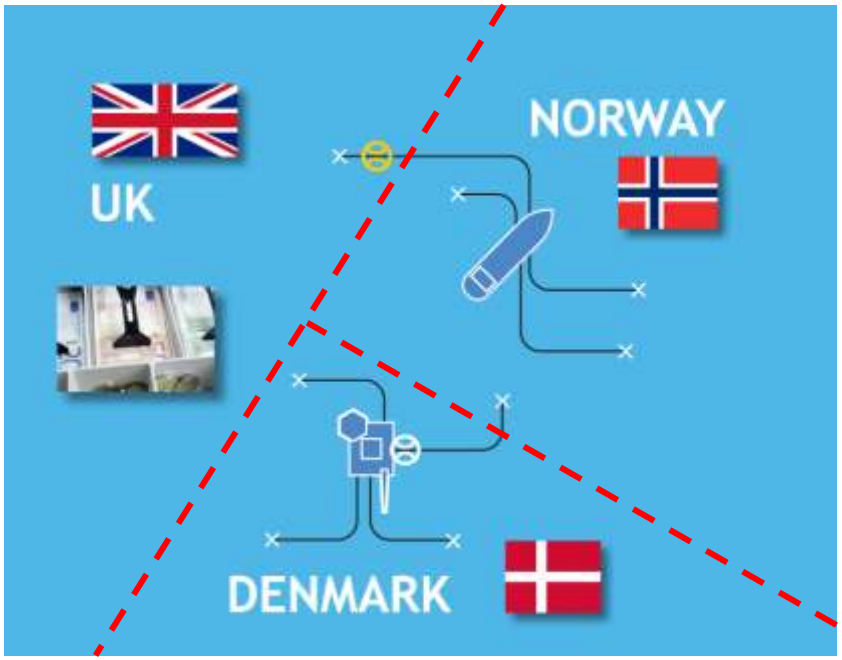
- 205 degrees C (400 F)
- 15K psi (qualified to industry standards – API6A and DNV 203)

Vx Production Optimisation at Marathon West Brae

SPE 124271 Paper; Offshore Europe 2009 – Mike Tharagonnet



Cross border measurement and management



PhaseWatcher Vx, the Multiphase and Wet Gas Fiscal "Cash Register" for the North Sea

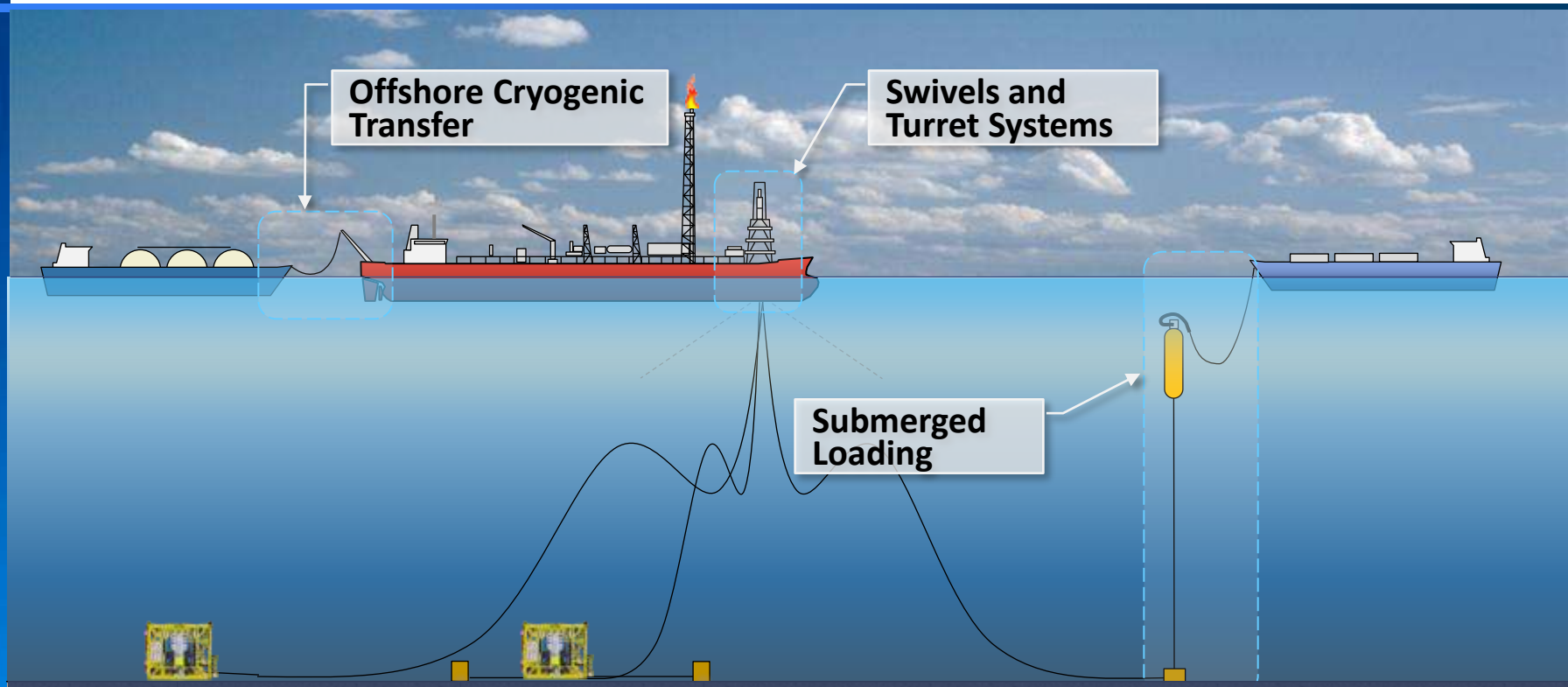
- **Accuracy**, the main evaluation criteria
- **Marathon Boa Field** – First World wide Multiphase "Cross Boarder" Fiscal Allocation application between UK and Norway, in operation since 2008
- **Dong Trym Field** - First World Wide Wet Gas "Cross Boarder" Fiscal Allocation application between Denmark and Norway, in operation since 2011

Knowing Your Reservoir - Subsea Sampling System and Services

Look deeper into your reservoir

- Representative sample of oil, water and gas
- True PVT quality sampling system
- Compact design for easy integration into the subsea hardware
- Integrated into the Phase Watcher Vx Multiphase Meter
- Field proven components and technology
- In-country Fluids Sampling and Analysis Services throughout the life of the field

Swivels & Marine Systems

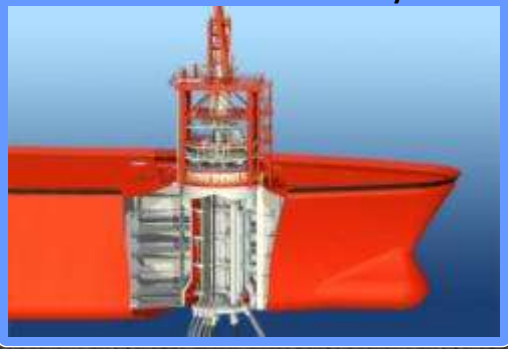


Swivels & Marine Systems

Framo Offshore Cryogenic Transfer

Swivels & Marine Systems

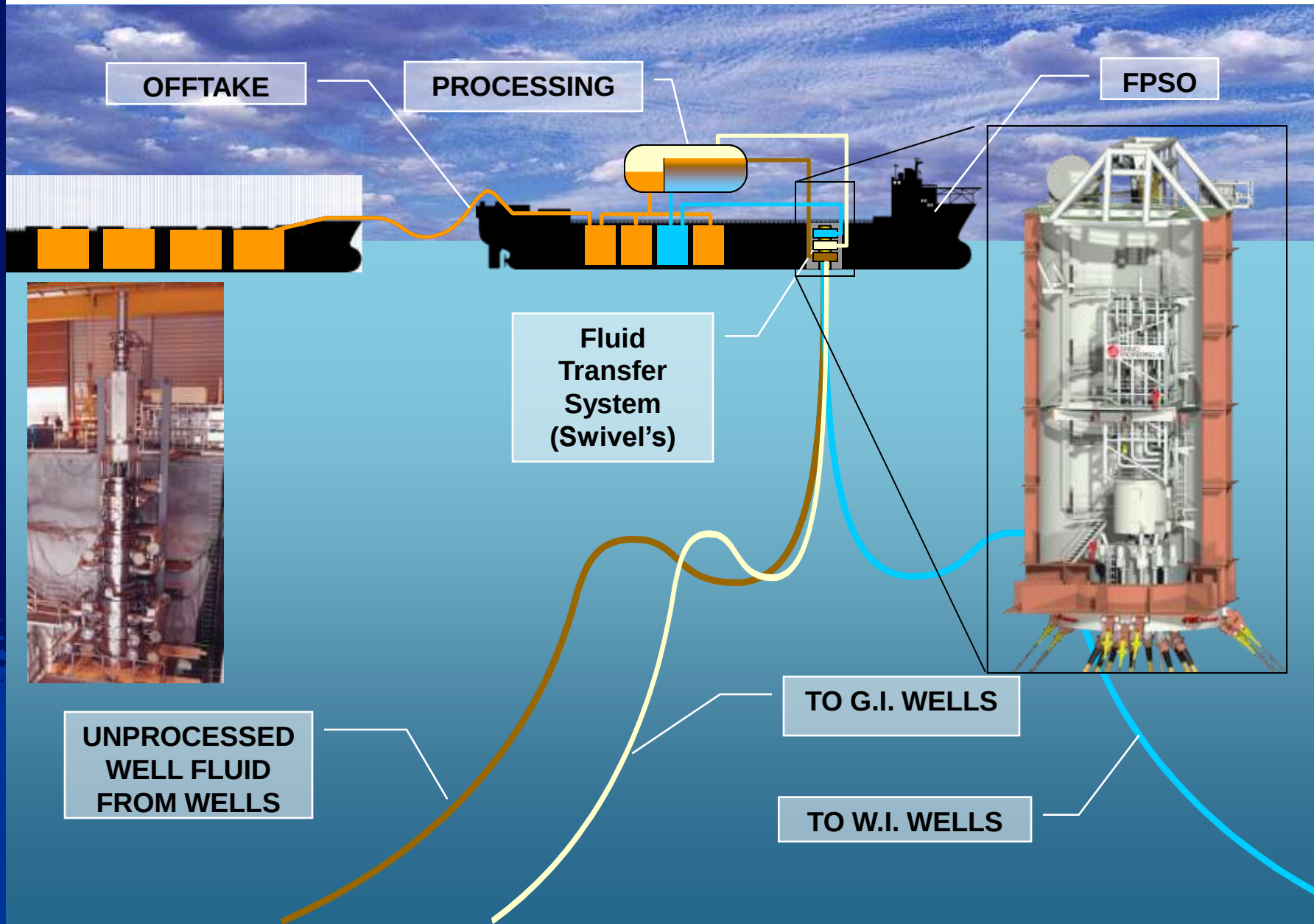
Framo Swivels and Turret Systems



Swivels & Marine Systems

Framo Submerged Loading

Fluid Transfer - Subsea Wells and FPSO – Swivels - The Heart of the FPSO



Swivels & Marine Systems - ‘Experience counts’

Reference Projects (by offshore Field name) - 2011

Pumps & Subsea Systems

Pumps & Subsea Systems

Framo Power Control Module

Power Control Module

Subsea Water Injection Pumps

Subsea Multiphase Pumps

Subsea MultiManifold

Pumps & Subsea Systems

Subsea Water Injection Pumps

Pumps & Subsea Systems

Framo Multiphase Pumps

Pumps & Subsea Systems

Framo MultiManifold

Benefits of Subsea Boosting

Increased Production and Recovery

- Accelerated and prolonged plateau production
- Increased Recovery

Production Enabling

- Well kick-off
- Extended reach of remote fields and wells

Flexibility wrt Subsea Integration

- Applicable for Green-fields as well as retrofit to Brown-fields
- De-bottlenecking in mature fields
- Deepwater applications

Commercially attractive solutions

- Relative short payback time
- Maintenance by ROV and light intervention vessel

IOR effect of Subsea Boosting

The well will flow at lower pressure

- Weak wells can be produced together with strong wells
- Weak wells can be produced for a longer period before dying
- Weak/dead wells can be started with the pumps
- More efficiently reservoir drainage when wells can flow at higher rate
- More controlled drainage

The liquid production rate will be higher

- Fields can be produced longer before critical low flow is present (slugging and cool-down problems)
- Economical cut-off will be at a higher water-cut

Statoil on IOR for Subsea Fields

- The ambition of the subsea improved oil recovery (SIOR) project in Statoil is to achieve an average recovery factor of **55 %** from subsea-completed fields

- New technology will be applied to raise the average recovery factor for mature fields while contributing to smart solutions for new projects.

- The project cover areas such as:
  - Reservoir management
  - Cost-effective drainage points
  - Light well intervention
  - Increased subsea handling of liquids – Subsea Processing
  - Reduced subsea wellhead pressure – Subsea Boosting
  - Integrated operations

Chevron on Subsea Boosting for Lower Tertiary

Strategic Overview & Evaluation

GoM Lower Tertiary

NGC DW Strategies

November 10, 2009

Mark Alden - NGC DW Theme Mgr.

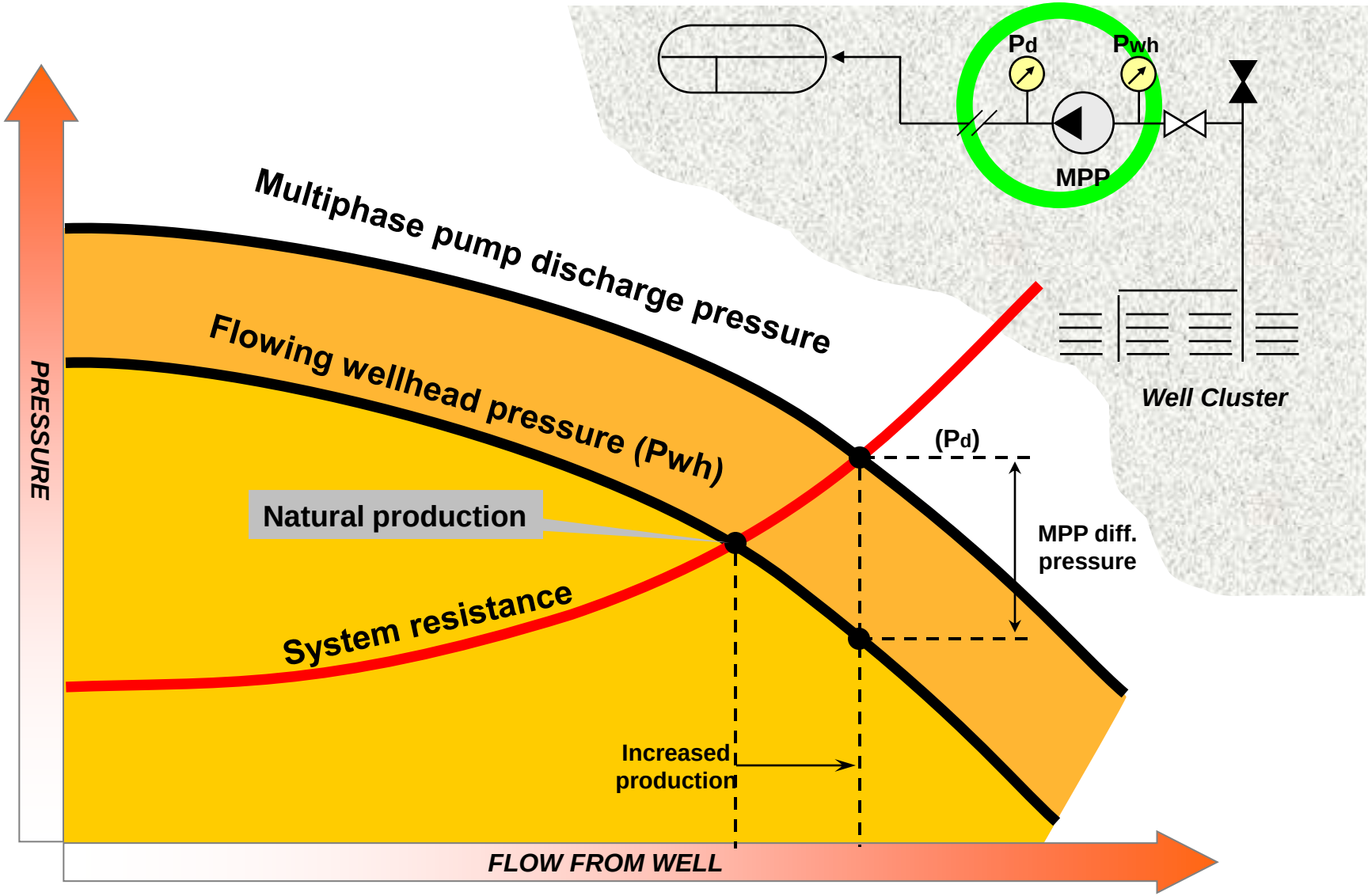
"Everyone involved with the trend agrees that increasing the Lower Tertiary Recovery Factors (RF) is the key to maximizing return.

Chevron studies have revealed the following:

With Natural Flow: RF = 1 Production enhancement with seafloor pumps: RF = 1.4 for single phase and 1.6 for multi phase."

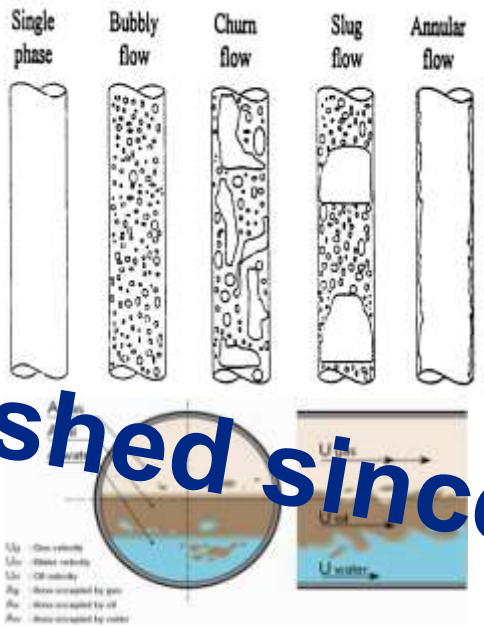
Framo Engineering – 'Experience counts'

Flowing wellhead pressure vs system resistance



Right Technology – to suit the process regime

Designed for handling gas, different flow regimes, viscous fluids, sand and other solids.

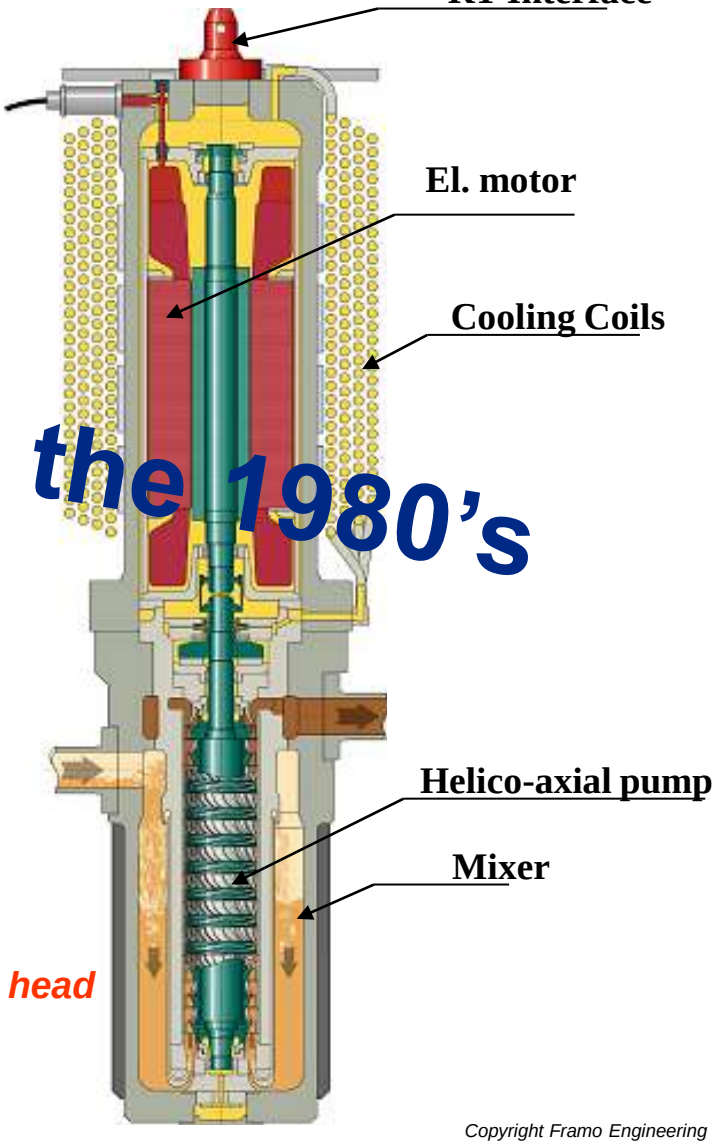


Established since the 1980's

Dynamic pump principle

Converts kinetic energy to multiphase head

$$\Delta P = C \cdot \rho_H \cdot Speed^2$$



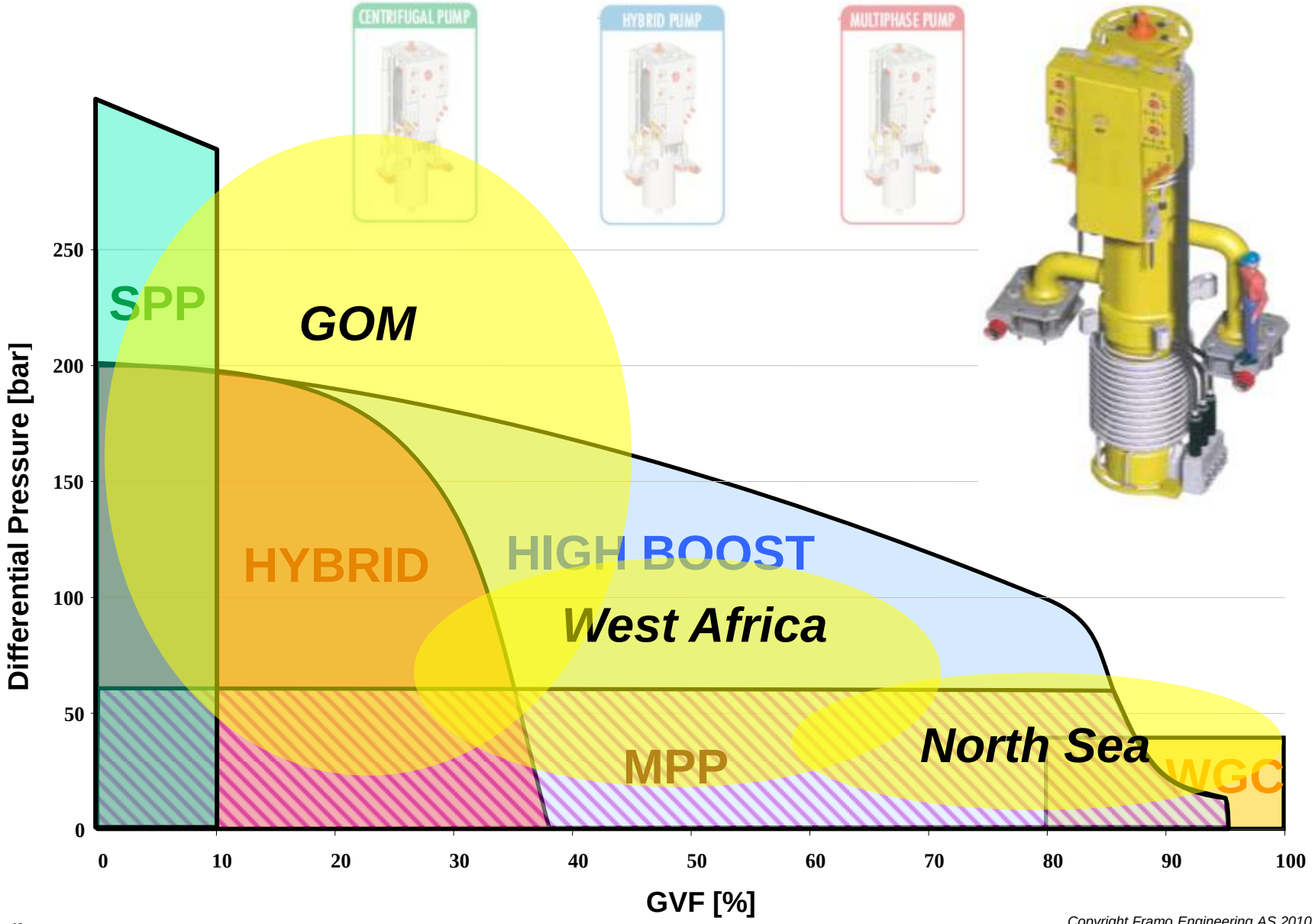
Commitment to a vision

Pioneer within Subsea Boosting!

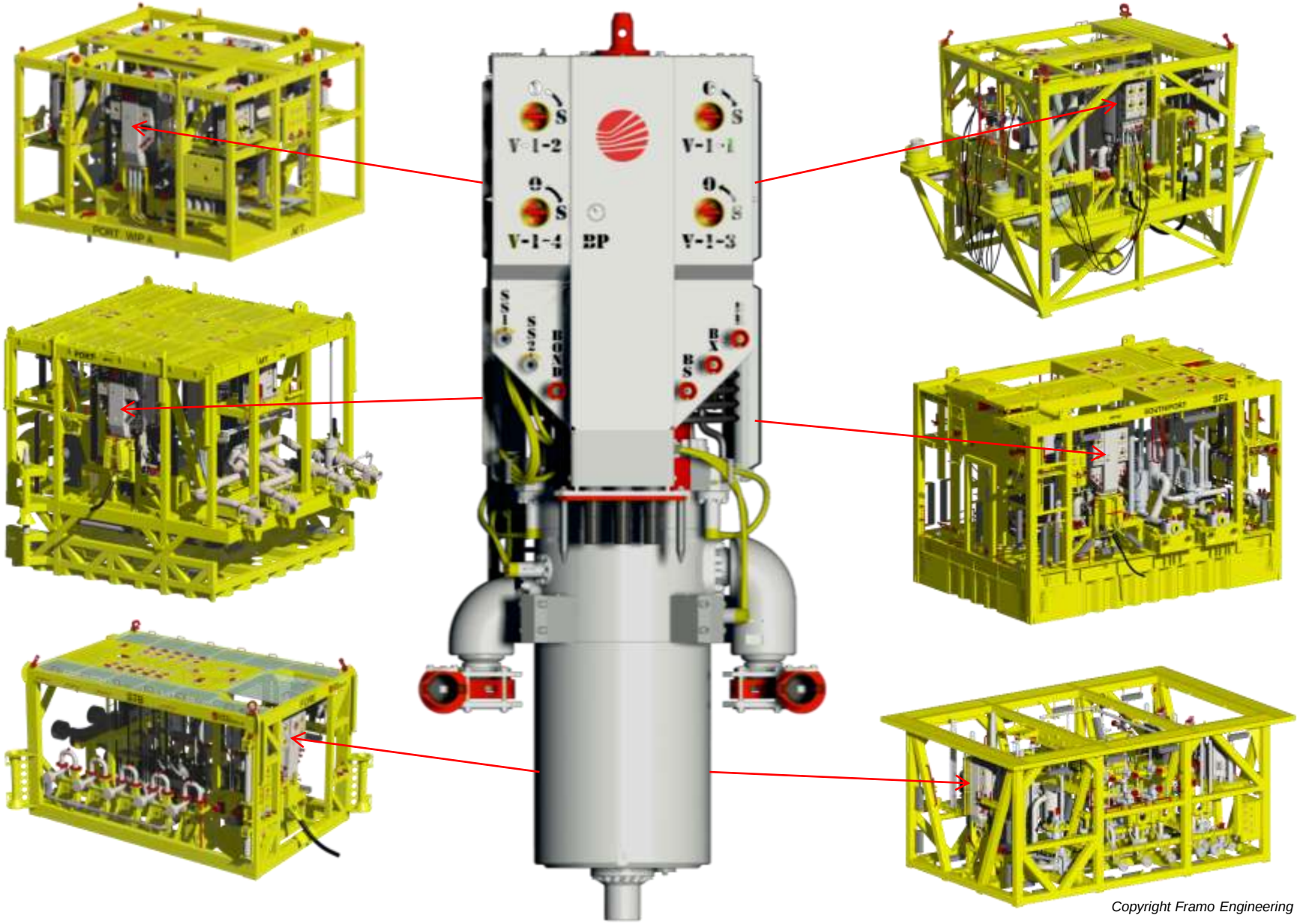
Track record second to none with more than 1 million operating hours .

1983	1984/5	1987	1994	1997
Framo Engineering established to develop products for the next decades	Screening boosting technologies First prototypes tested	Selected the Helico-Axial pump principle	Developed the electrical power and control system for subsea pumps	First commercial subsea multiphase pump installed at Lufeng field

Subsea boosting by Framo – Total flexibility



Modular approach - Seabed Pump Systems



Framo Subsea Pump Systems - Responsibility

Topside Power & Control Module

Running Too

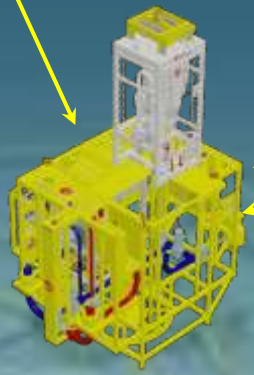
Power & Control Umbilical

Subsea Power Connections

Subsea Controls

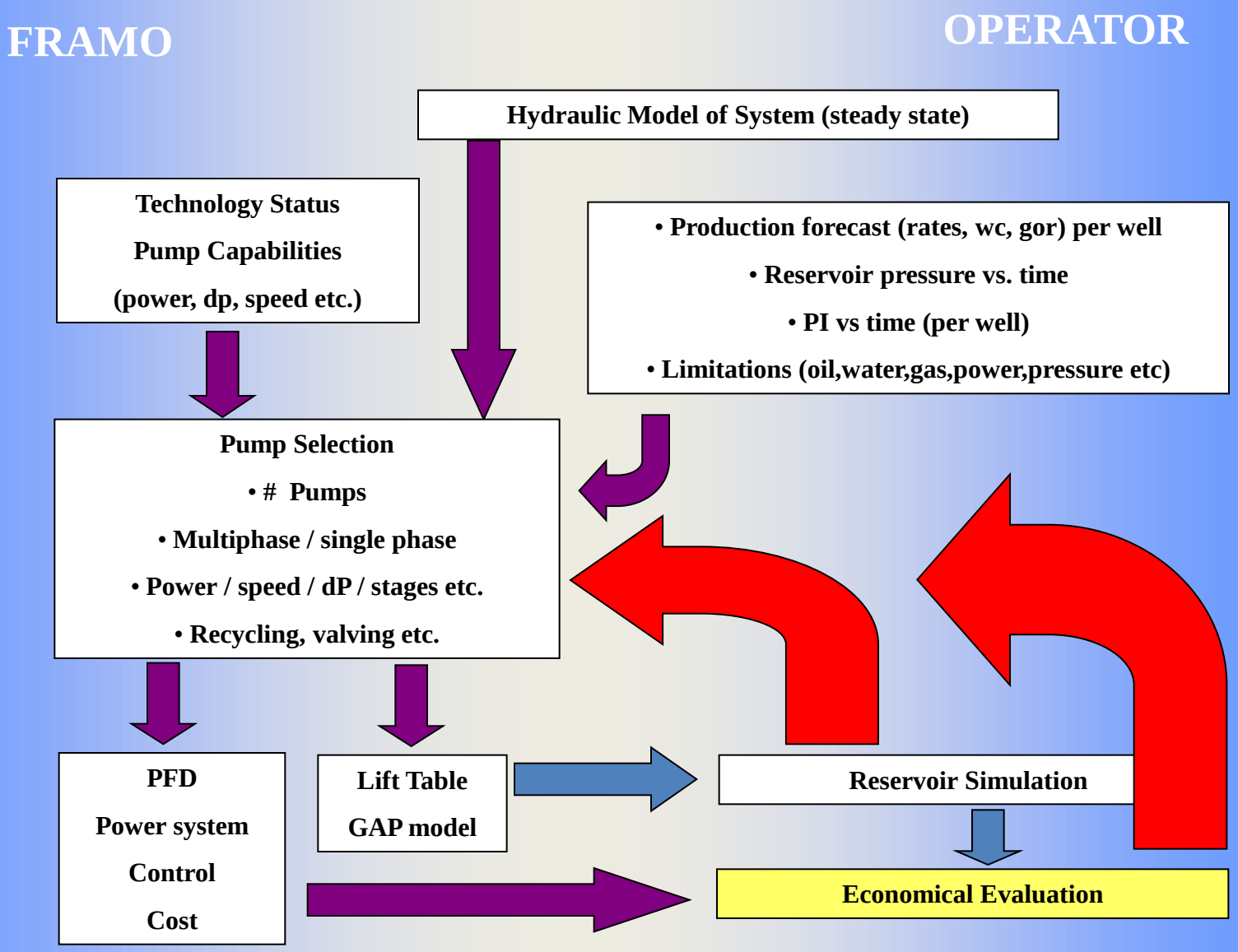
Subsea Distributio

Subsea Pump Station

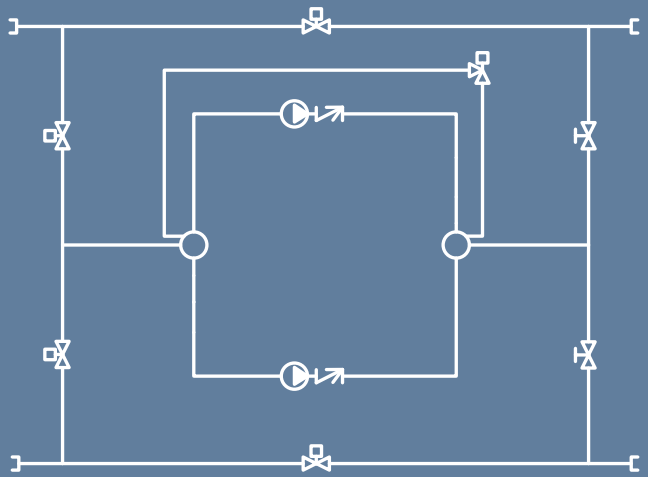


Subsea Transformer

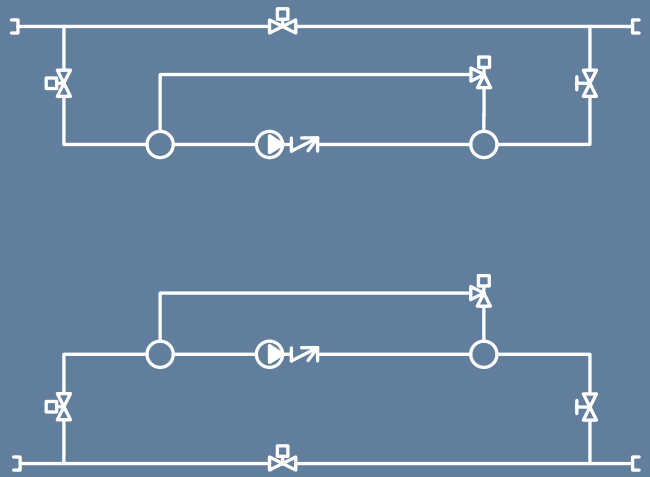
Pump Selection Process



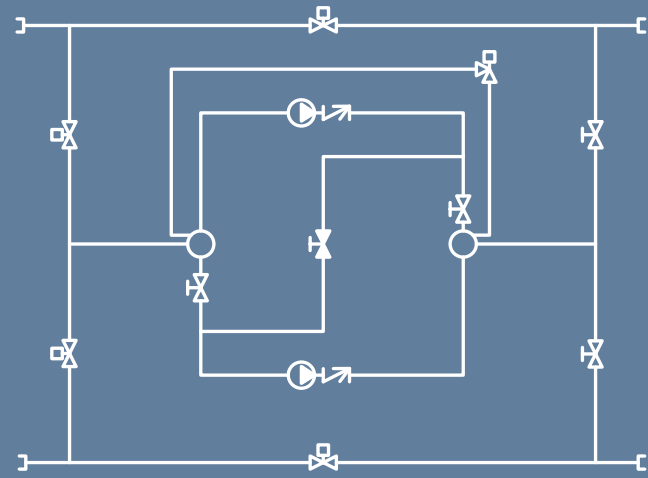
Configurations for the Field Development



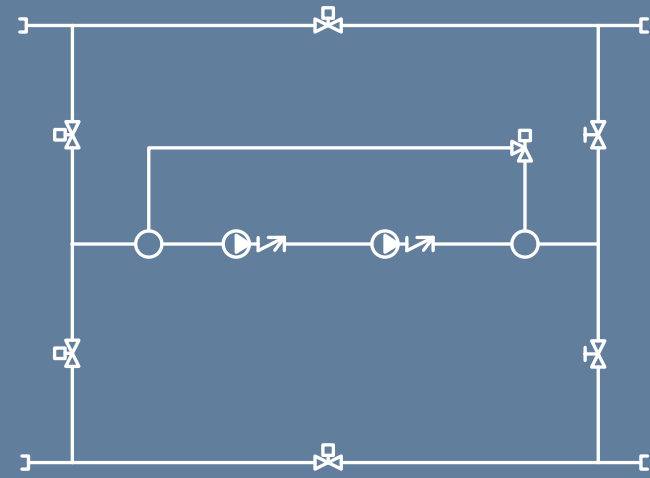
Parallel Boosting



Separate Line Boosting

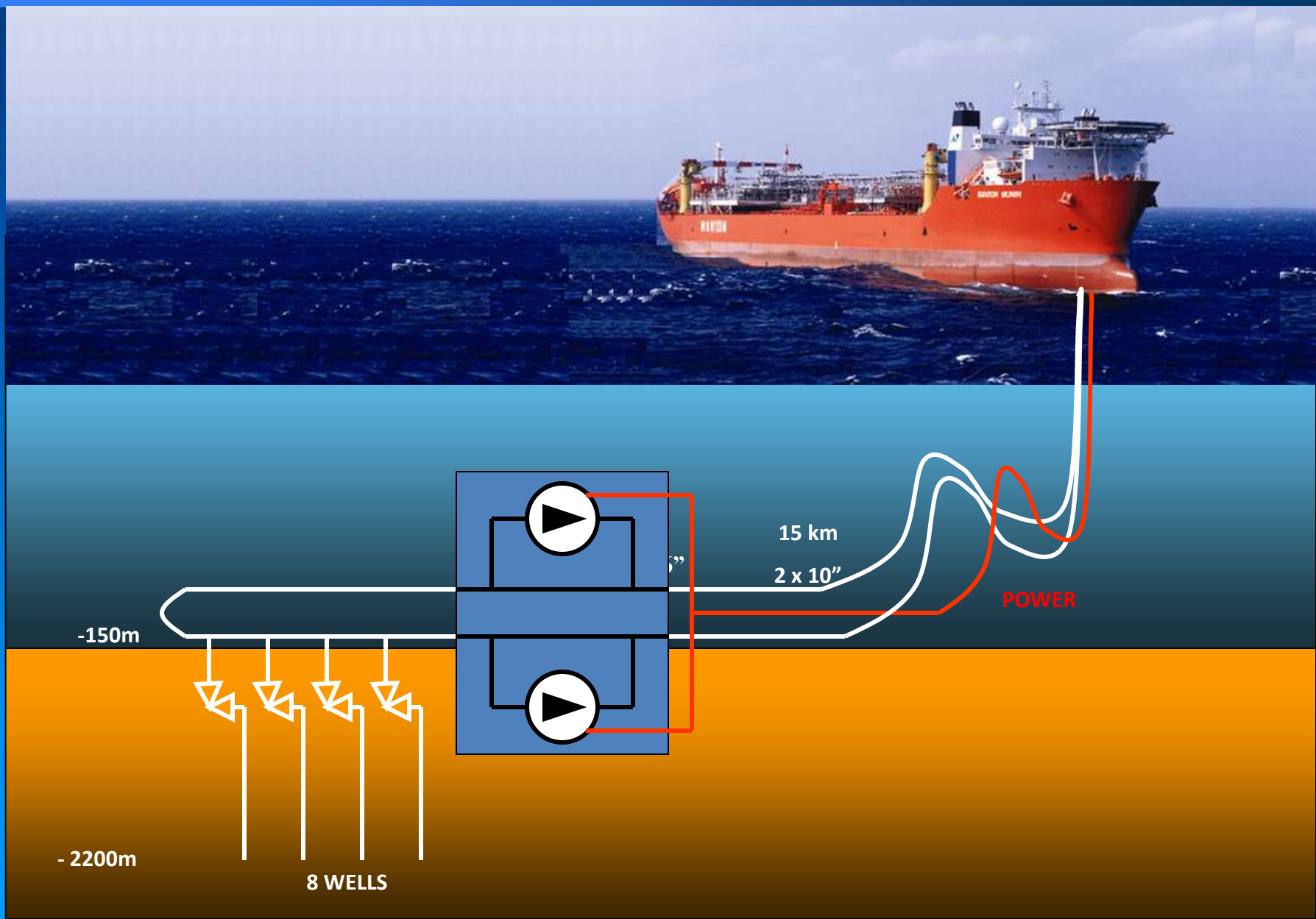


Parallel & Serial Boosting

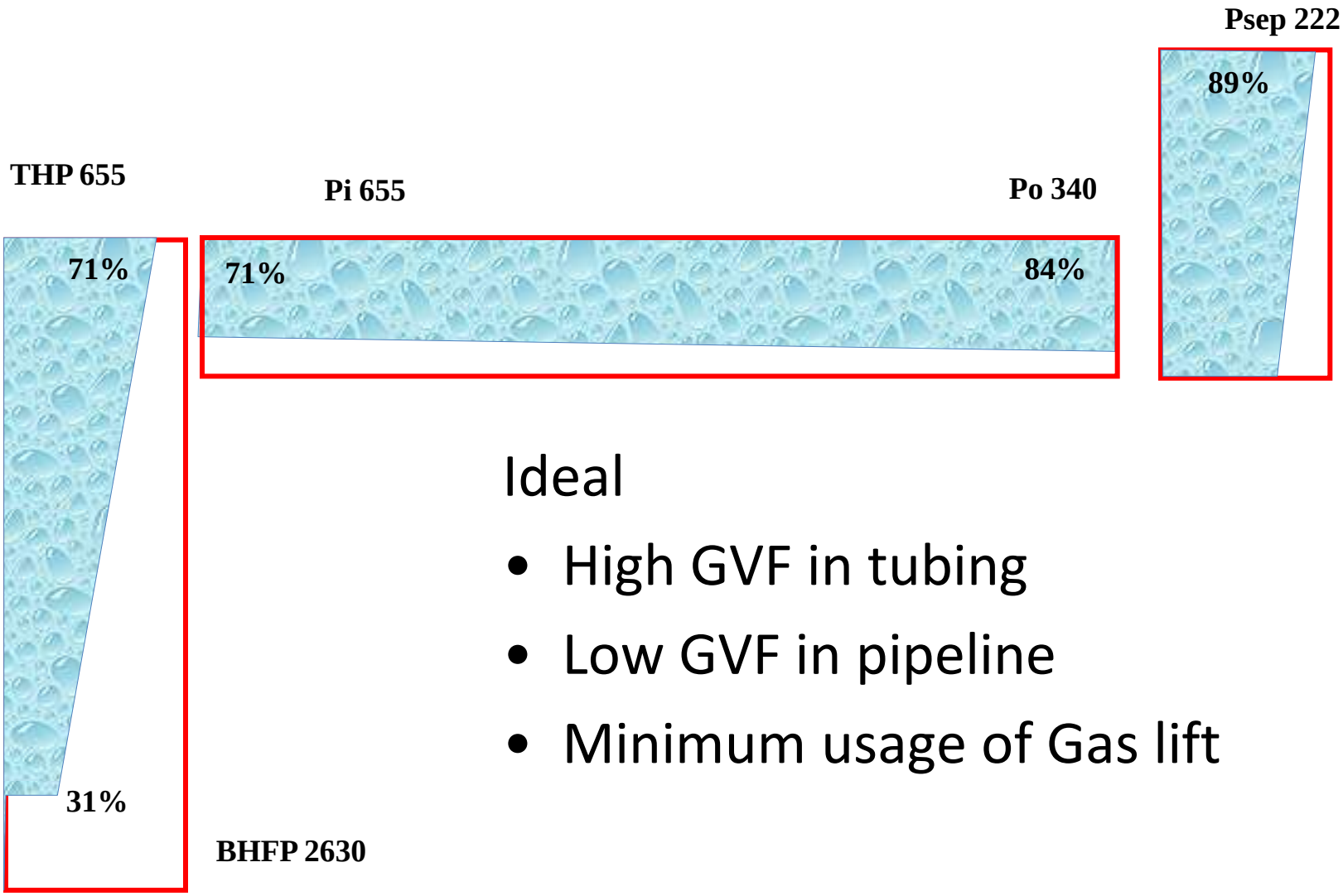


Serial Boosting

North Sea – Case Study Gas Lifting and Boosting



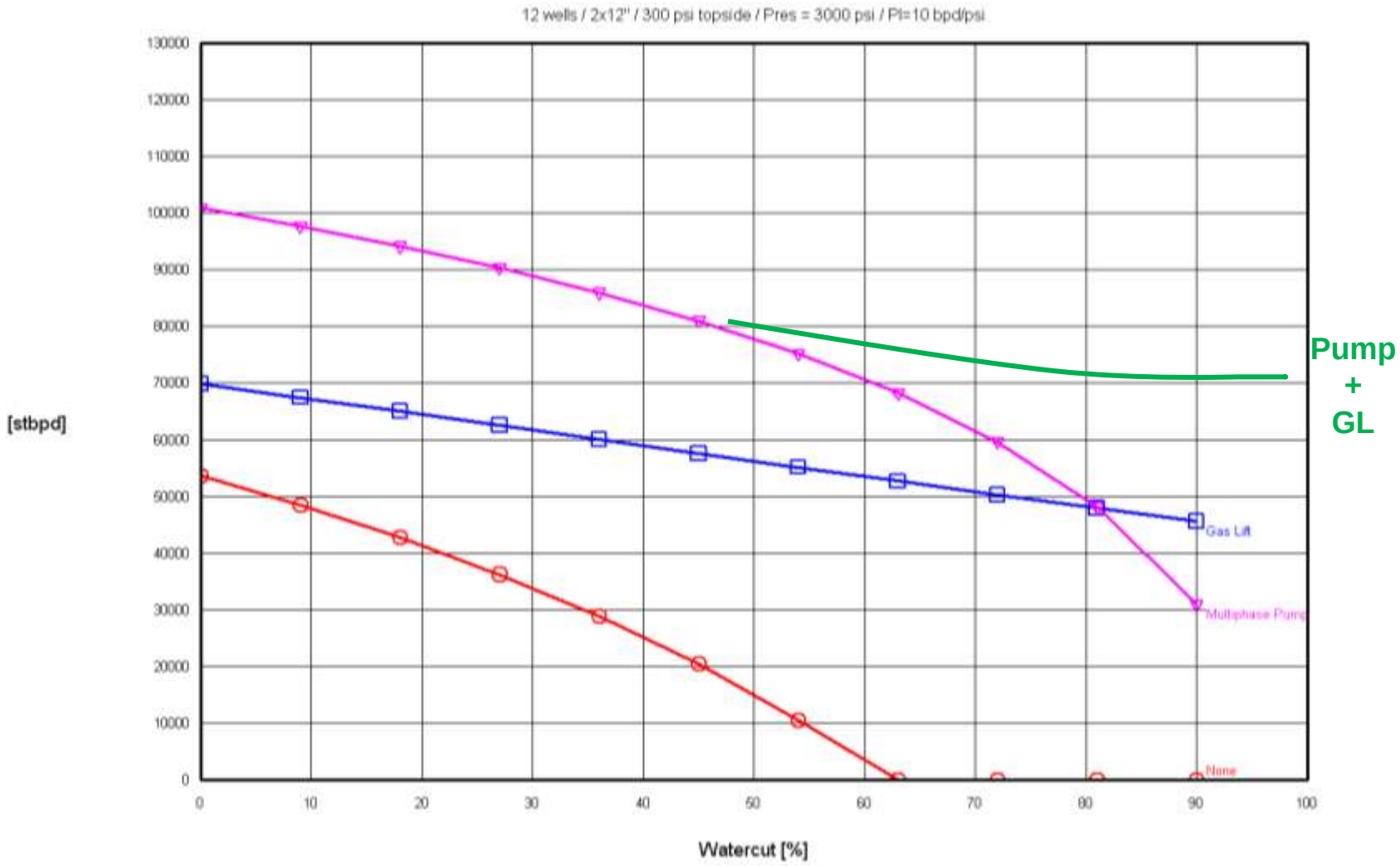
Gas volume fraction through system for gas lifted well



Ideal

- High GVF in tubing
- Low GVF in pipeline
- Minimum usage of Gas lift

Lift Alternatives (typical North Sea)

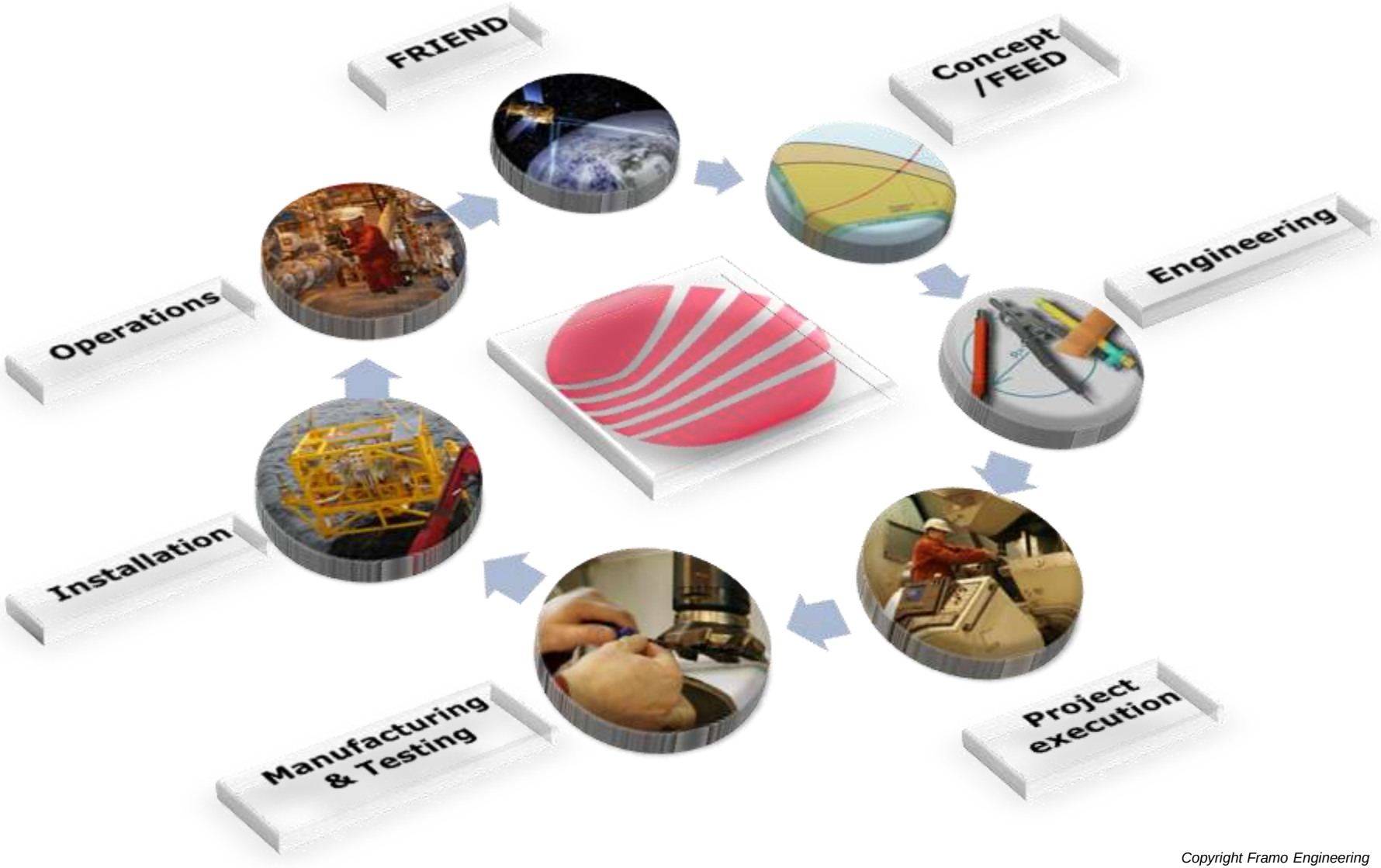


Life of Field Management

FRamo Interactive ENabling Diagnostics

- Increased equipment uptime
- Cost effective remote monitoring
- 24/7 specialized support

From Concept / FEED to Production Optimisation



Conclusions -

- There are many technologies; rising to the challenges (proven and being used)
- Complex process fluids drive technologies
- Complex / sophisticated infrastructure drive technologies
- Environments create new demands and requirements
- Life of Field solutions
- Improving business environment (value / cost / flexibility)

Operational Experience

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Framo Subsea Booster Pumps

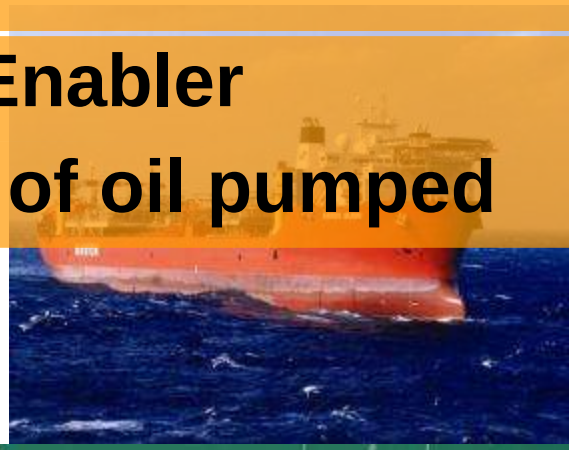
Statoil's Lufeng Field – South China Sea

1997

First commercial subsea electrical pumps

Production Enabler

42 mill barrels of oil pumped



91700 operation hrs of Pump BP009 prior to shut down on 2009, total 430000 hrs accumulated

Framo Subsea Booster Pumps
CNR's Columba E Field – UK

2006

SPE 109090 Paper; Offshore Europe 2007 – Neil Rogerson

First ever subsea seawater injection pump

- Treated Seawater via Framo Filtration System

- 2 x 2400 kW WIP's
- 2 pumps in series
- 430 bar diff press
- 140 m water depth
- 10 km tie-back

Combined Framo Control System for Pump Module, Manifold & Trees

Framo Subsea Booster Pumps
Premier Oil (Oilexco) Brenda Field – North Sea

2006

Multiphase Meter

Improved Reservoir Management

Multiphase Pump

Increased Production

Multiport Selector Manifold

Increased Flexibility

Subsea Control Modules

Increased Control Capacity

Framo Production & Boosting System

OTC – 17899 Paper; OTC 2006 - Mike Coulthard

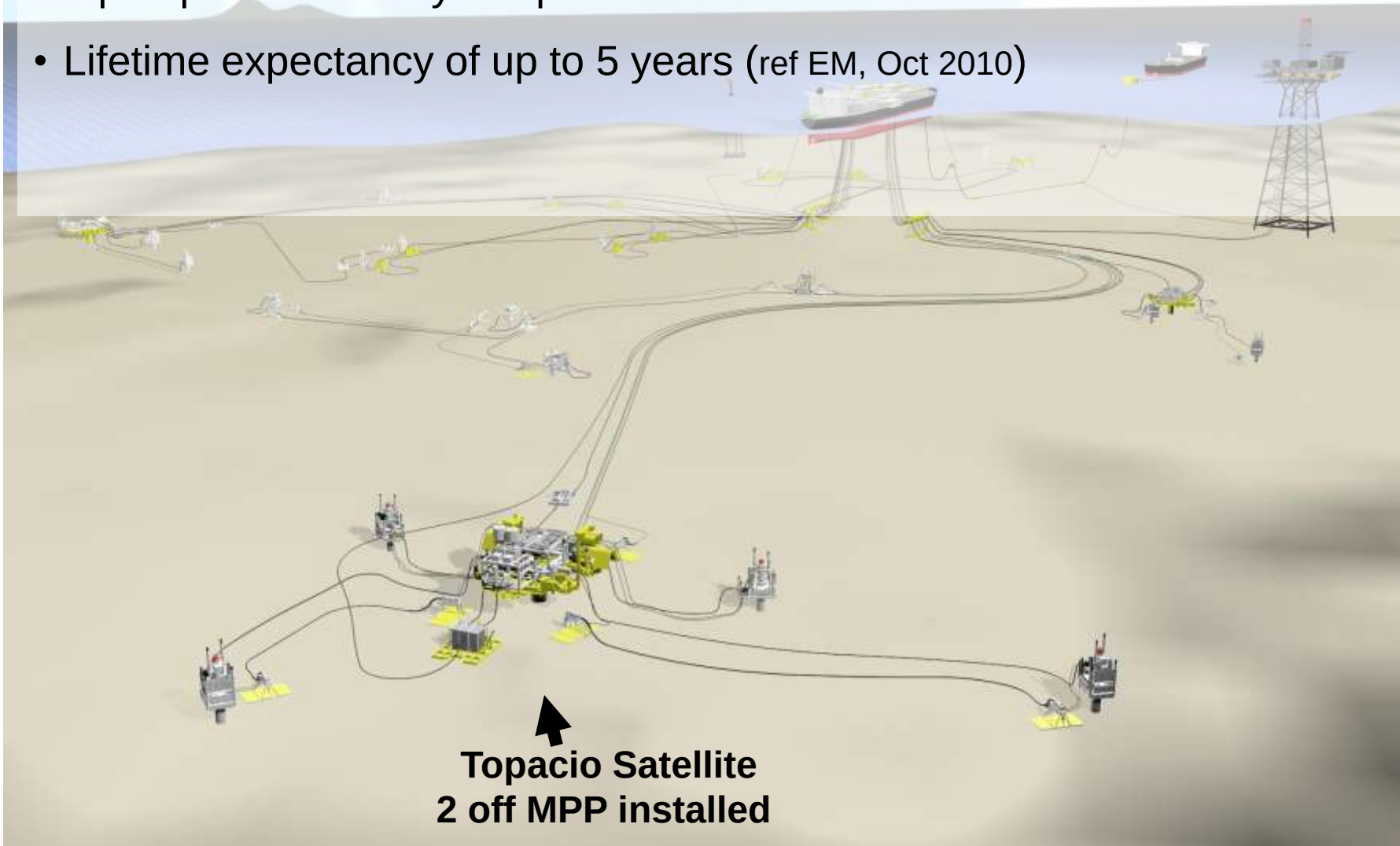
- 1100 kW MPP
- 150 m water depth
- 10 / 20 km tie-back

Framo Subsea Booster Pumps

ExxonMobil Topacio – Equatorial Guinea

2000

- Main Pump has been in operation more than 50000 hours Since 2000
- 1 pump covers todays required flow rates
- Lifetime expectancy of up to 5 years (ref EM, Oct 2010)

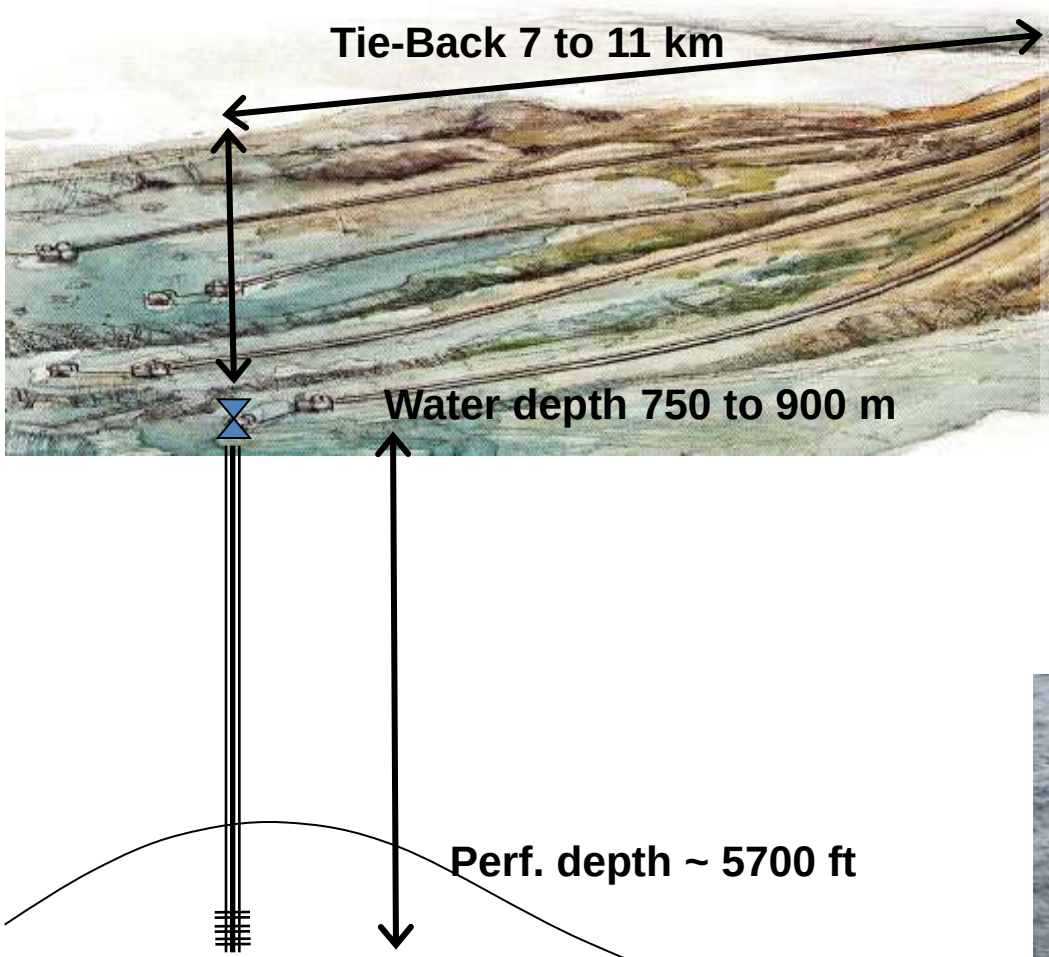


Topacio Satellite
2 off MPP installed

Framo Subsea Booster Pumps

Amerada Hess' Ceiba FFD –Equatorial Guinea

2003



Characteristics:

- Deep Water
- Medium tie-back
- Shallow reservoir
- No gas cap
- Medium GOR
- + 45000 hrs ops

Framo Subsea Booster Pumps

Woodside Vincent development - Australia

2008

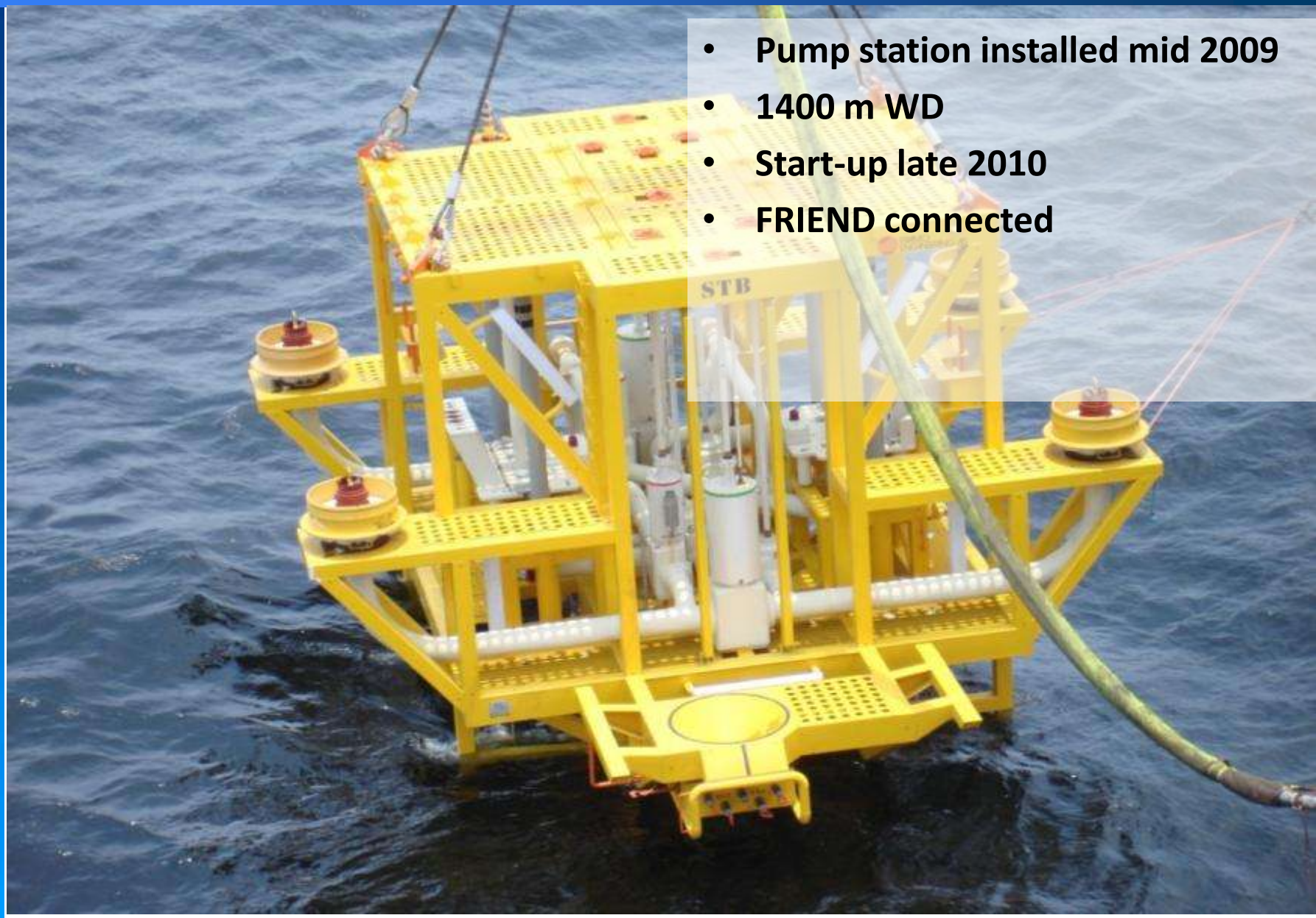
- Pumps installed & run May 2008
- Significant production increase reported
- FRIEND System connected

Example of Pump system supplied as EPC Independent of production system contract

Framo Subsea Booster Pumps

Murphy Oil Azurite Project – Congo

2009

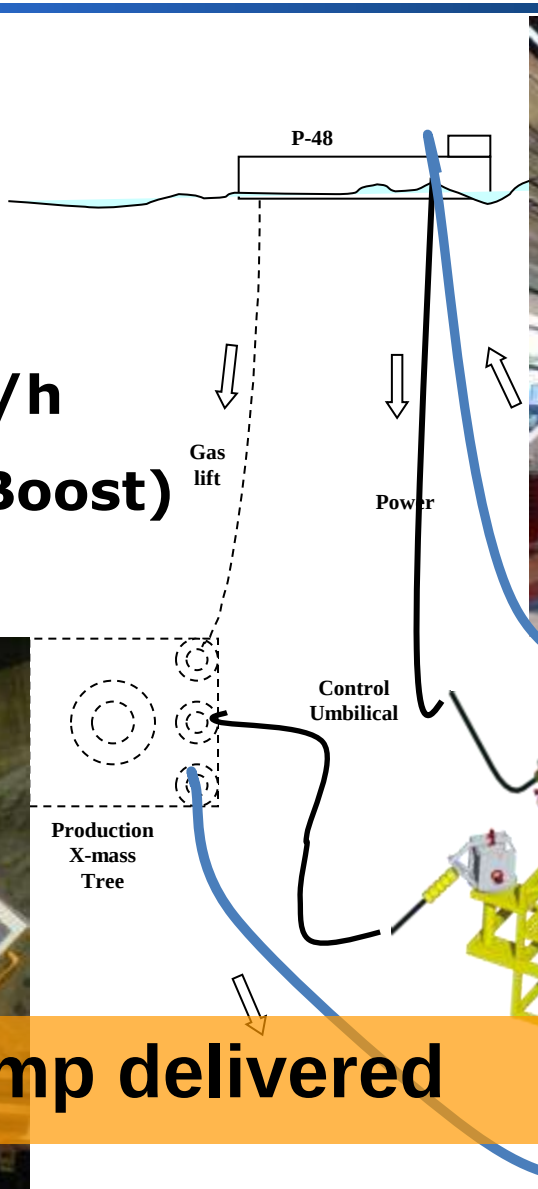


- Pump station installed mid 2009
- 1400 m WD
- Start-up late 2010
- FRIEND connected

Framo Subsea Booster Pumps

Petrobras' Barracuda Pumping System, Brasil 2011

- **FSS boosting one well**
- **Water Depth: 1040 m**
- **Tieback: 15.5 km**
- **Total flow: ~150 Am3/h**
- **DP: 60-80 bar (High Boost)**



First High Boost Pump delivered

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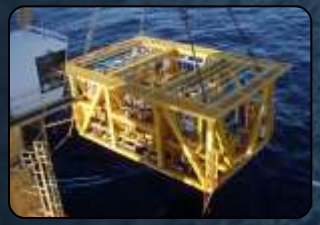
THANK YOU

CONFIDENCE THROUGH EXPERIENCE

Framo Dual Pump Station



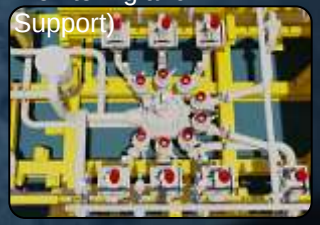
Framo MultiManifold

Framo Raw Seawater Injection System

Framo Multiphase Pumps

Framo Wet Gas Compressor

FRIEND Remote monitoring and Support)



Framo Multiport Selector Manifold

Framo Subsea Multiphase Flow Meter

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