Technology

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SBM OFFSHORE

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Contents

Industry Trends

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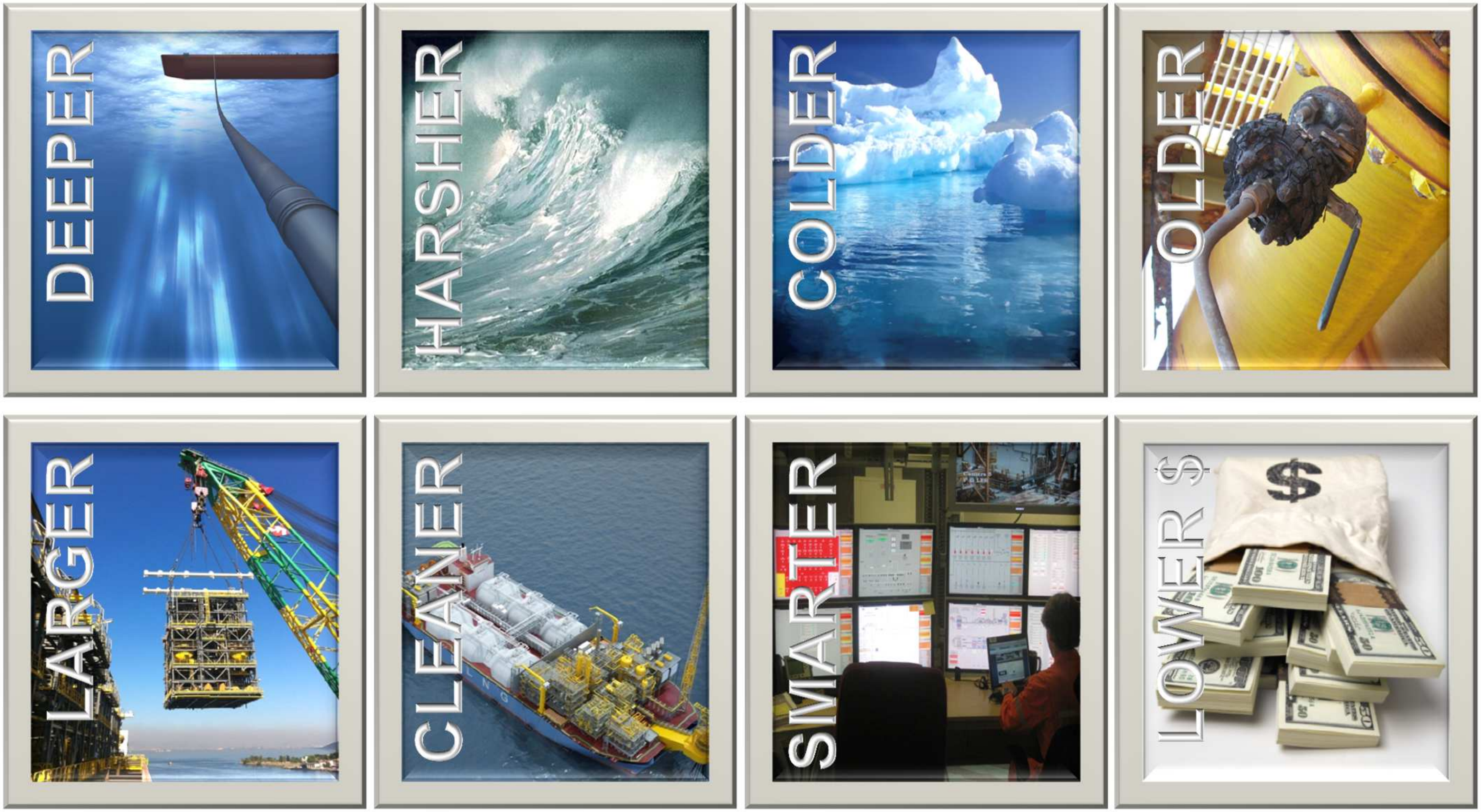
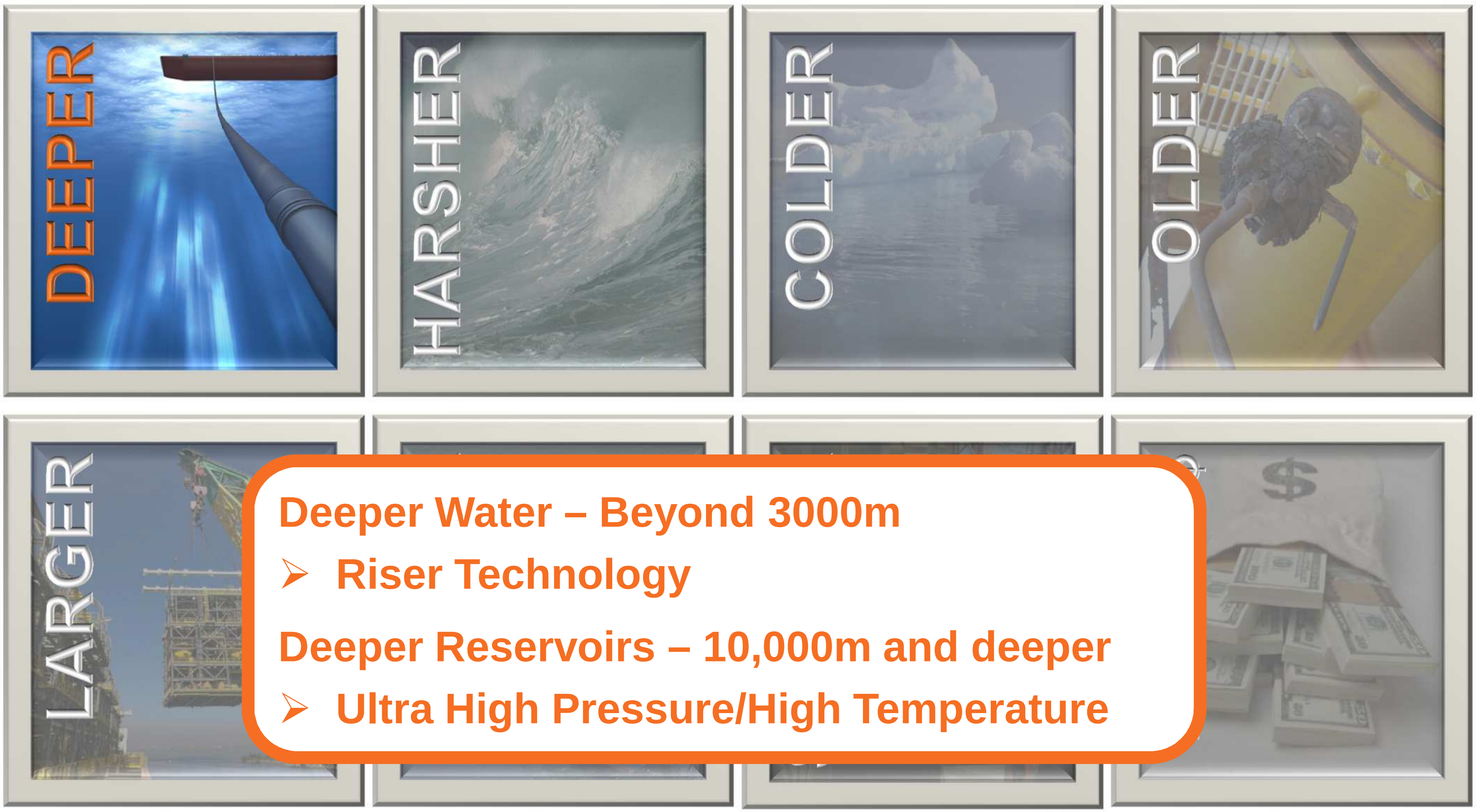
What We Are Hearing From Our Clients as Key Trends in the Industry

Key Industry Trends



Key Industry Trends



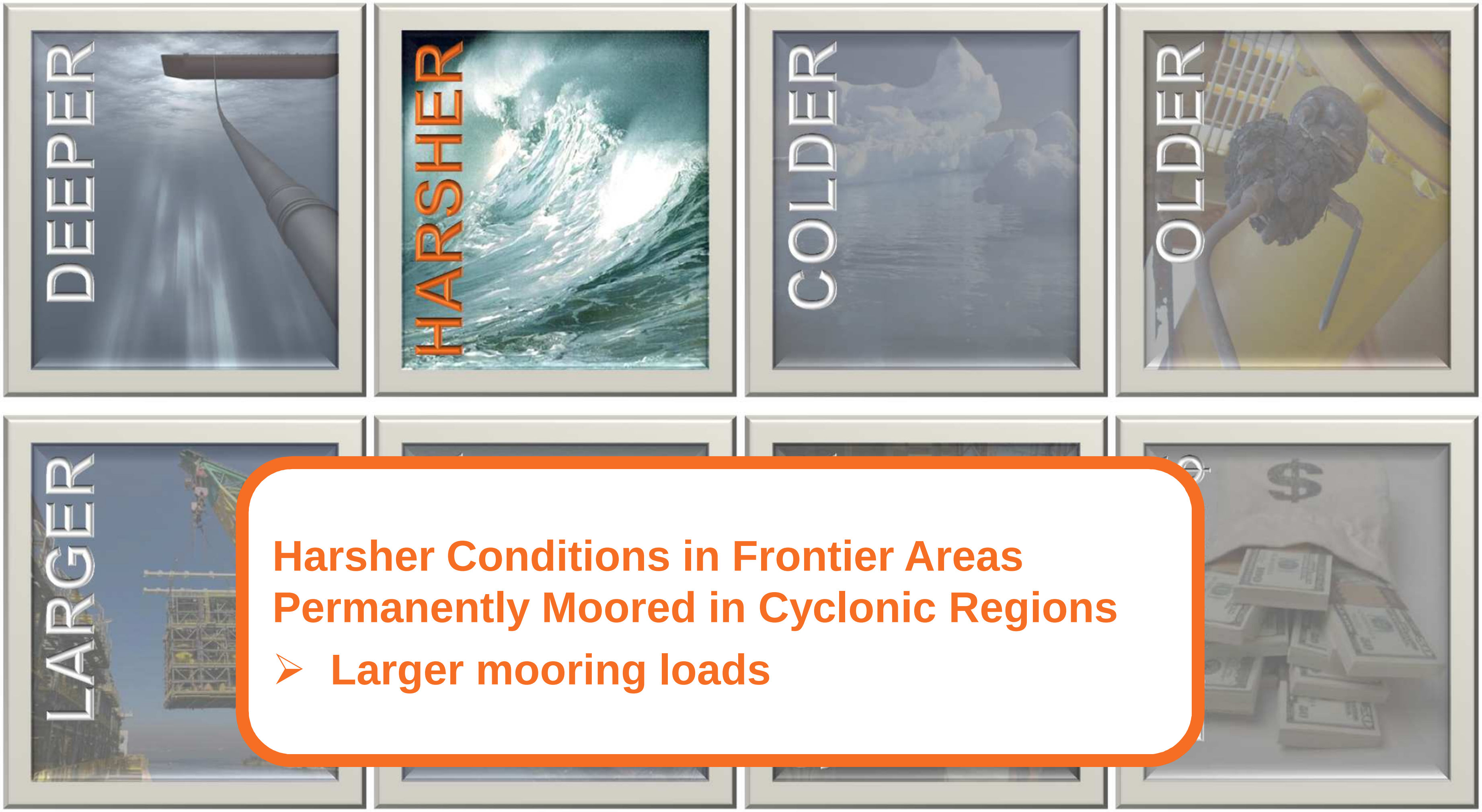
Deeper Water – Beyond 3000m

- ➢ **Riser Technology**

Deeper Reservoirs – 10,000m and deeper

- ➢ **Ultra High Pressure/High Temperature**

Key Industry Trends



Harsher Conditions in Frontier Areas
Permanently Moored in Cyclonic Regions

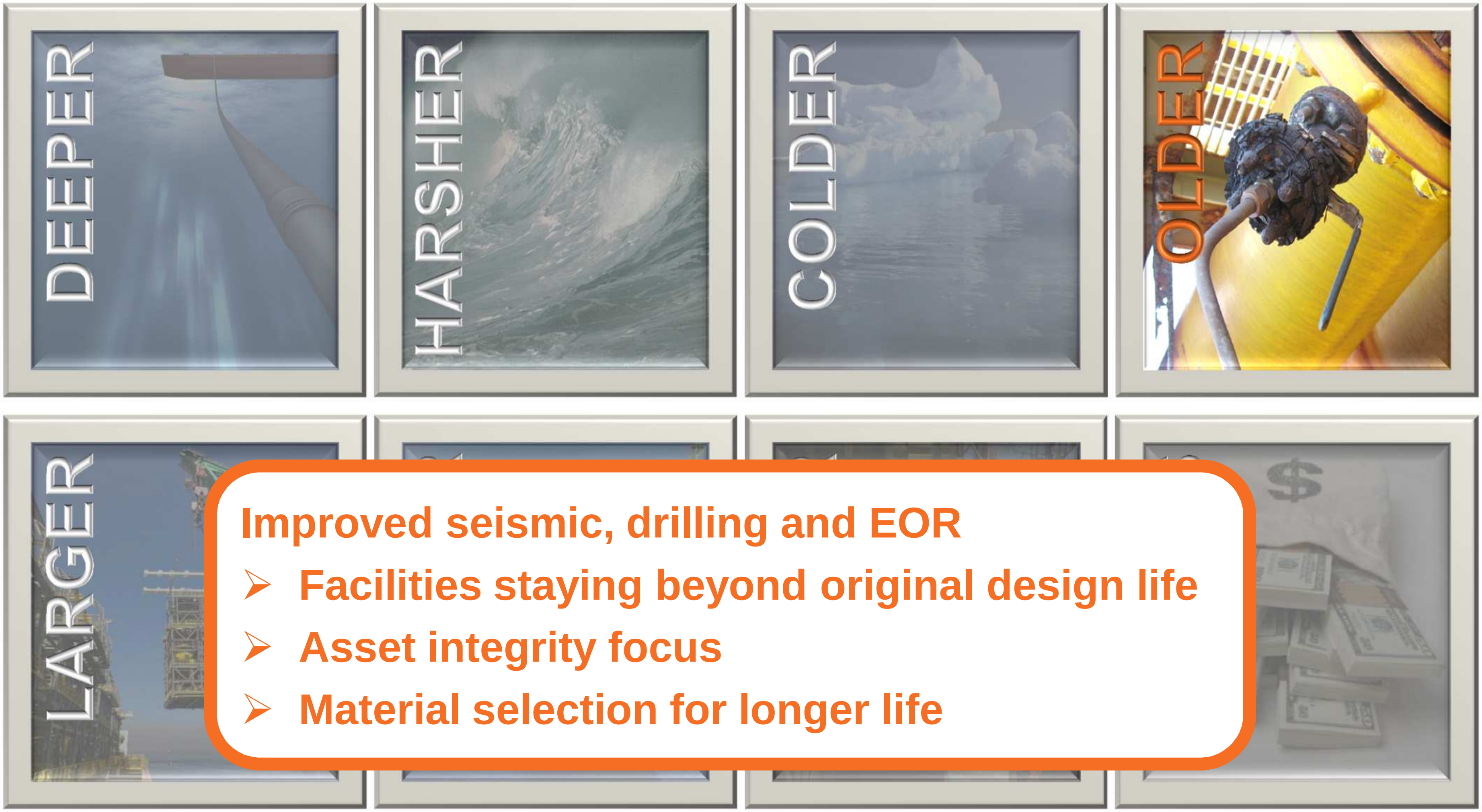
- **Larger mooring loads**

Key Industry Trends

Field developments moving further North into Arctic waters

- **Disconnectable under ice loads**
- **Operability in severe ambient conditions**

Key Industry Trends



Improved seismic, drilling and EOR

- **Facilities staying beyond original design life**
- **Asset integrity focus**
- **Material selection for longer life**

Key Industry Trends

Increased capacity, higher pressures and more complex processing

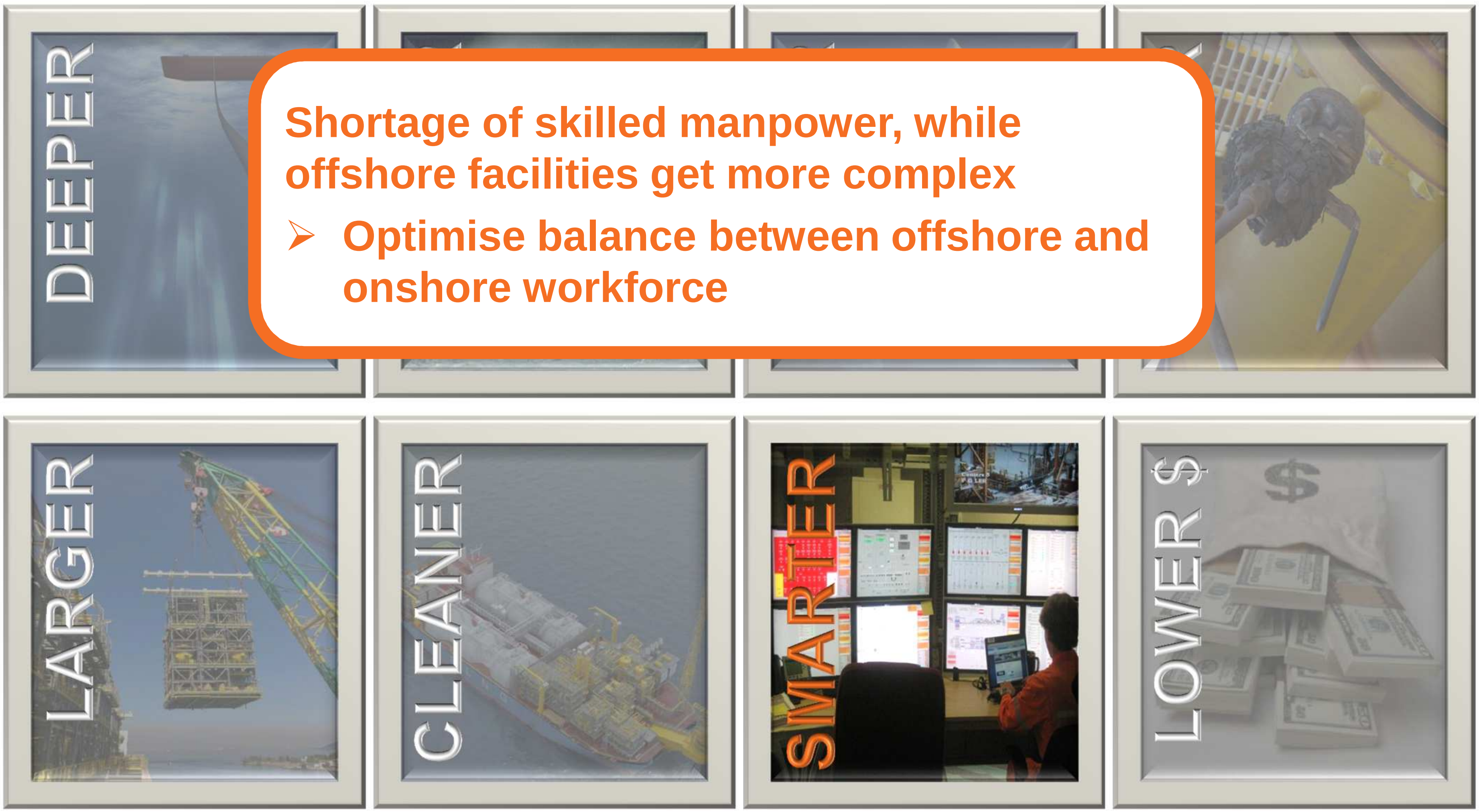
- **Larger topsides modules**
- **Hull size, strength, stability**

Key Industry Trends

Increasing demand for cleaner fuels such as LNG

- **Floating LNG now becoming accepted**
- **Need to find lower cost FLNG solutions**

Key Industry Trends



Shortage of skilled manpower, while offshore facilities get more complex

- **Optimise balance between offshore and onshore workforce**

Key Industry Trends

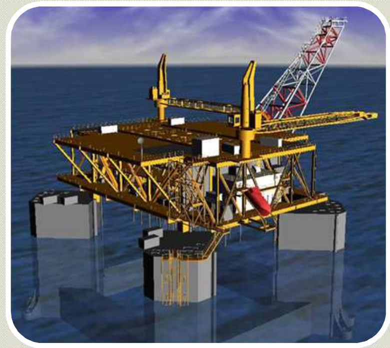
Increasingly hard to sanction deepwater projects – Capex vs. oil price trends

- **Urgent need to reduce cost & schedule**

Industry Trends Mainly Working Against Cost Reduction Objective

Technology Development in SBM Offshore

Four Technology Leadership Centres



Monaco

Mooring Systems

Schiedam

Gas,
Hulls

Houston

Semis,
TLP's,
Risers

KL

Topsides

Technology Readiness Level (TRL)

Status	TRL
Proven in service for >3 years	7
System installed and operating.	6
Execution of full scale project	5
System prototype / FEED	4
Component prototype / pre-FEED	3
Concept validation by testing	2
Concept proving by theory	1
Idea definition	0

Technology developed in SBM is now matured through a stage-gate process to ensure robustness prior to first sale.

FPSO Technology

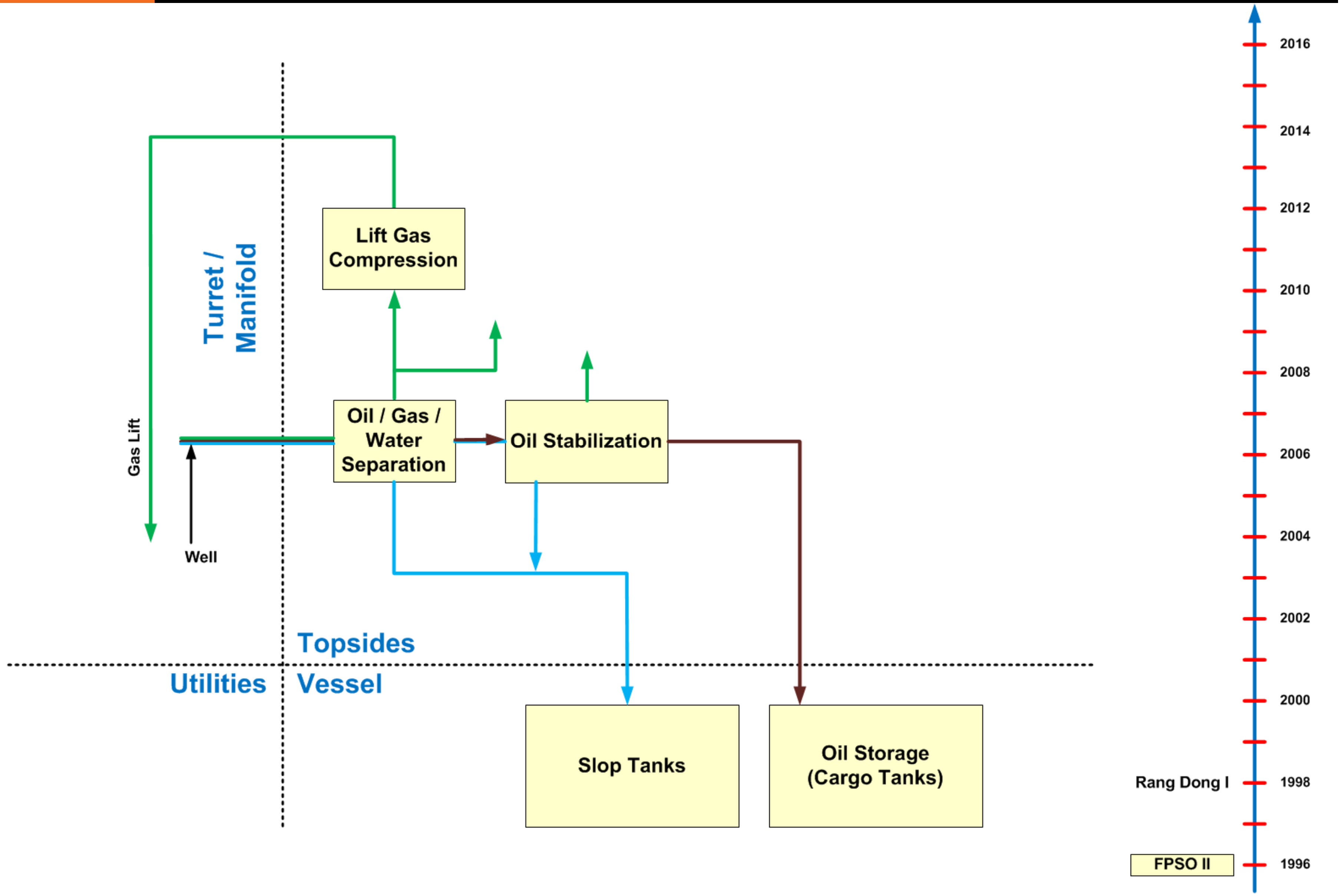
Generation 1
Simple Oil Processing FPSOs

FPSO IV **1986 to 1998**

FPSO II
1981 to 1996

Rang Dong I
1998 to 2008

Generation 1
Rang Dong & Pre-1998 FPSOs

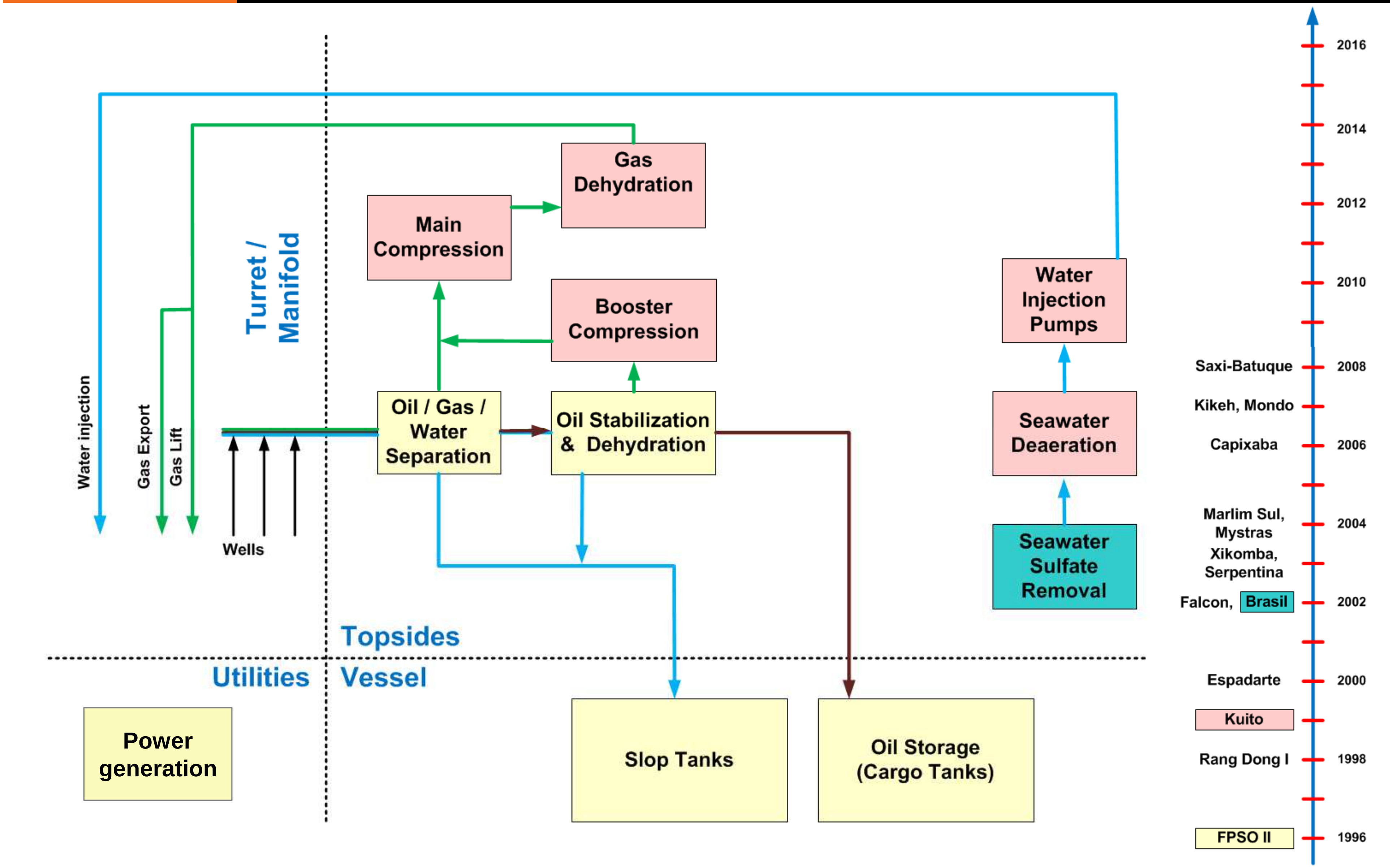


Generation 2
FPSO *Brasil* and *Marlim Sul*

Marlim Sul

FPSO Brasil

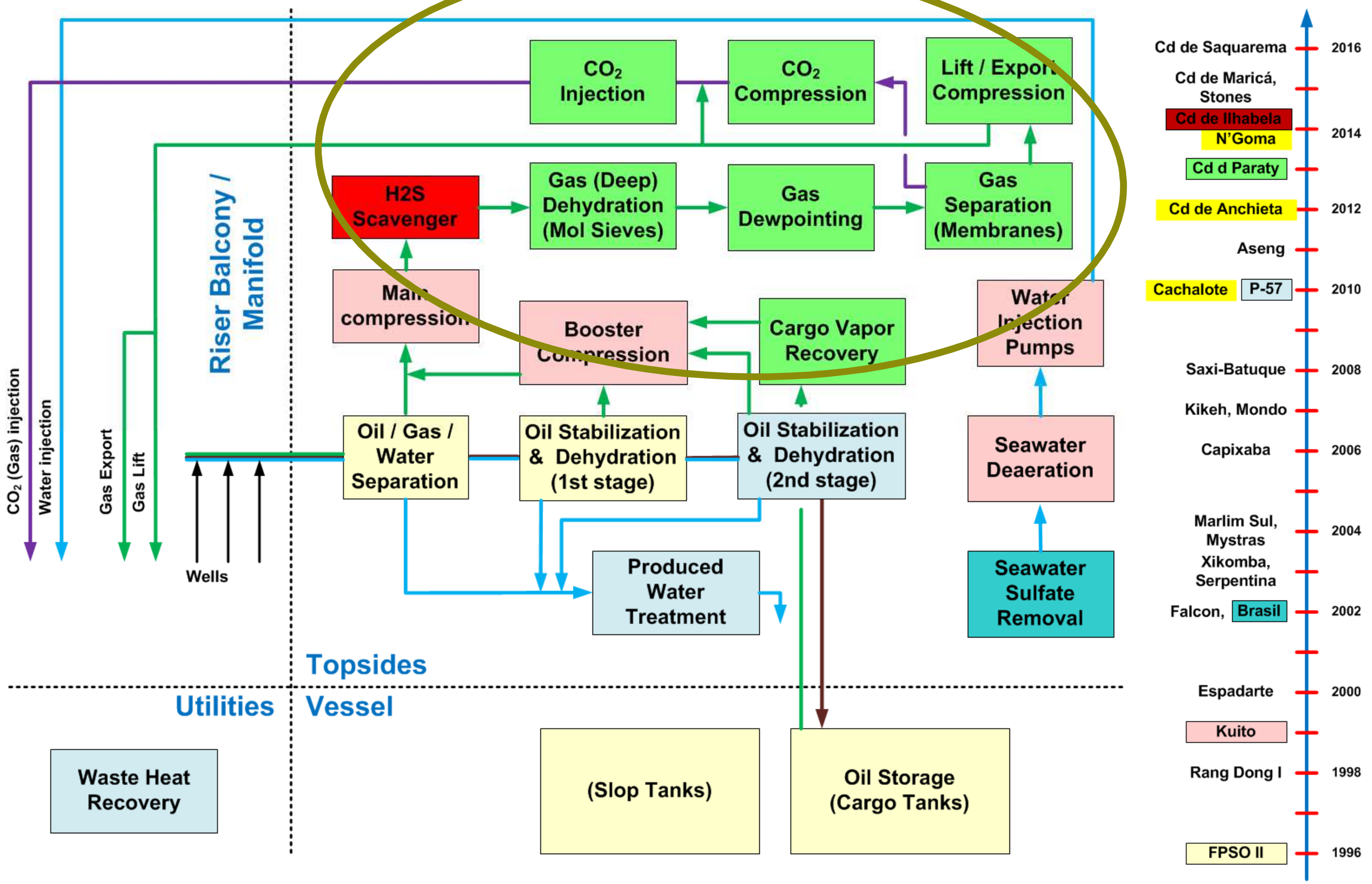
Generation 2
FPSO *Brasil & Marlim Sul*



Generation 3
Cidade de Paraty and Beyond…

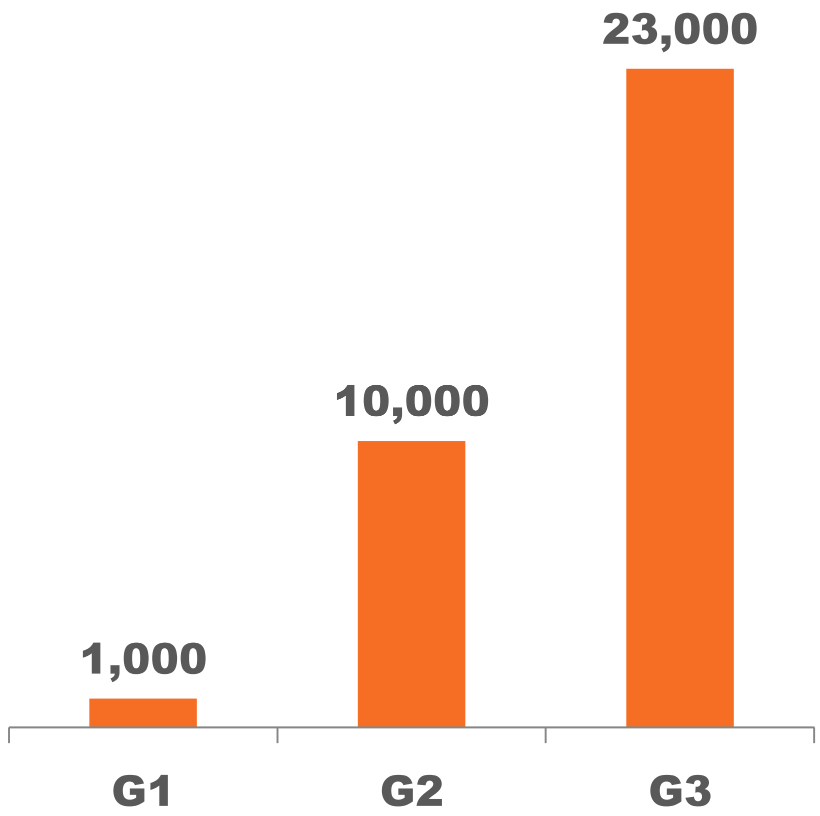
Cidade de Ilhabela	**2014**
Cidade de Saquarema	**2015**
Cidade de Maricá	**2016**

Generation 3
Cidade de Paraty and Beyond

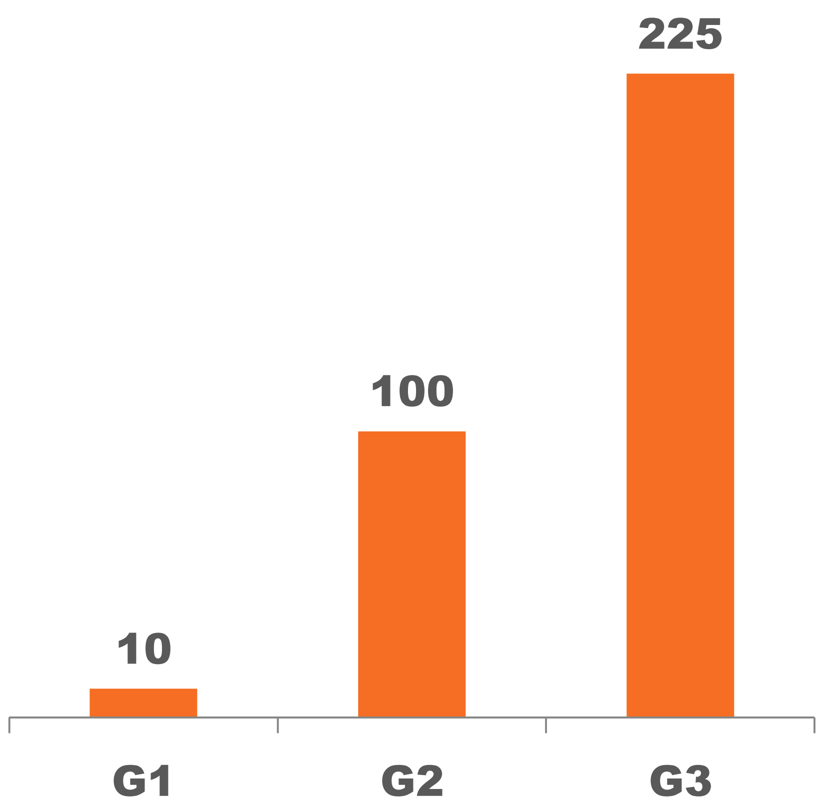


Generation 3 FPSO's Measure of Complexity

Topsides Weight (mt)



Shaft Power (MW)



Cidade de Ilhabela – Sailaway

Process Intensification (PI)

Subject

Compact topsides technologies

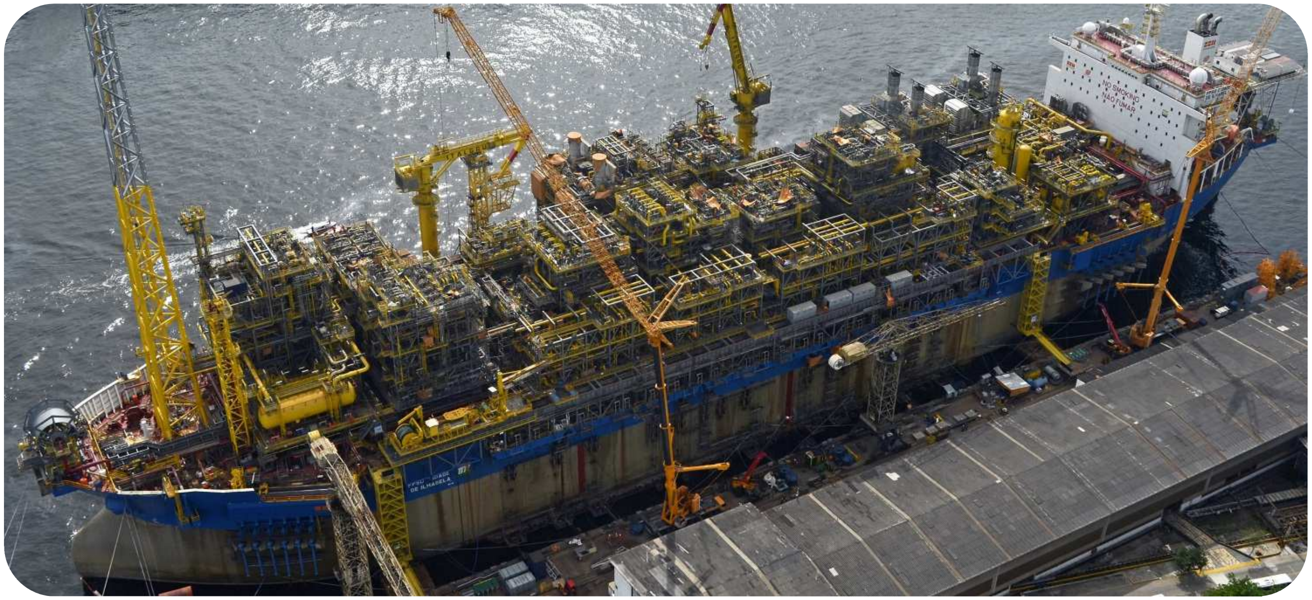
Objective

Process Intensification:

- ➔ Reduce topsides weight
- ➔ Increase capacity
- ➔ Reduce HC inventories
- ➔ Reduce fabric maintenance

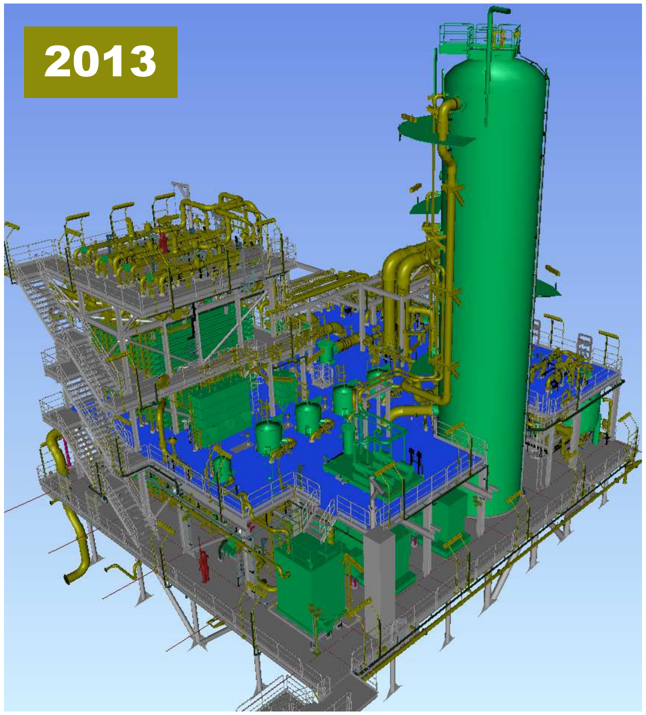
Value Proposition

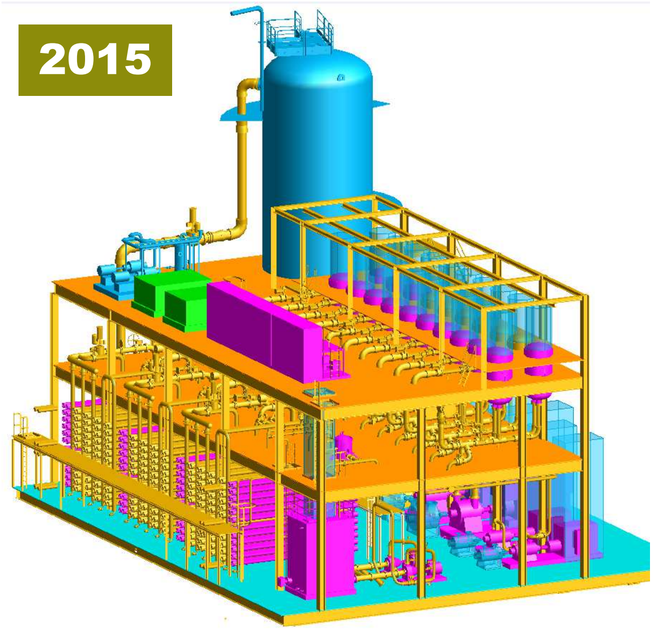
- Greater capacity
- Cost reduction
- Improved & Inherent Safety
- Improved Performance



New Technology with PI Ultrafiltration of Seawater

Note: Pictures to approx. same scale





C.de Ilhabela sea water treatment:

MMF → vac DA → SRP

180,000 bwpd

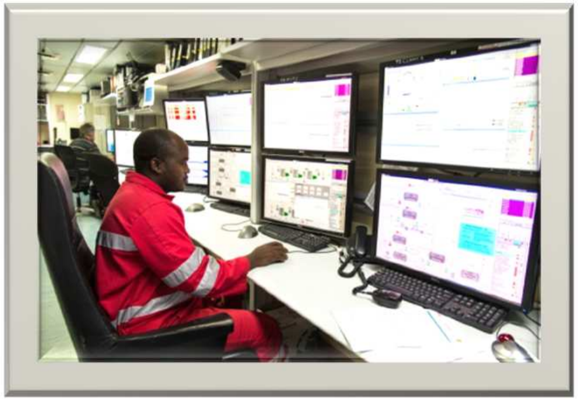
Standardised, scalable SW treatment:

UF → SRP → vac DA

270,000 bwpd

New Ways of Working Offshore

Offshore

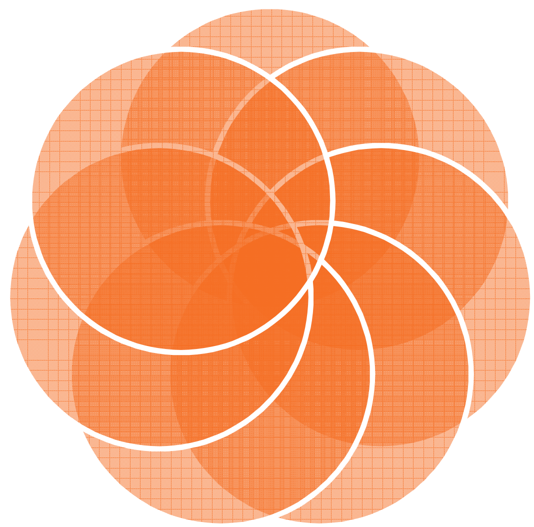


Onshore

Full data transmission to shore

Improved performance

Onshore Support Center (OSC)



Optimized offshore manning

Real Time Support to Crew

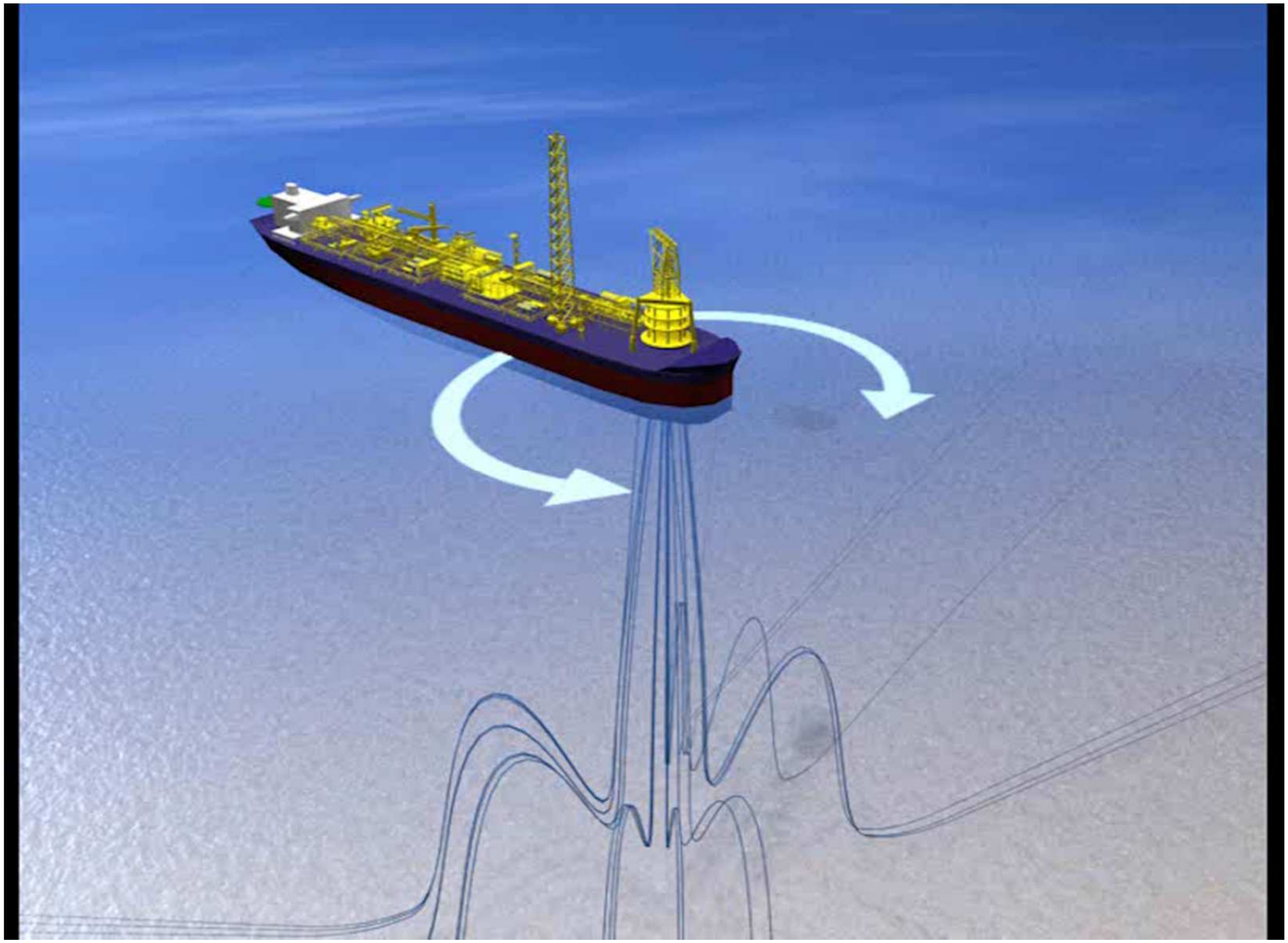
Lower maintenance equipment

More plant automation

Mooring Technology

Andrew Newport

Turret Moored FPSO



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Spread Moored FPSO

Past Mooring Systems











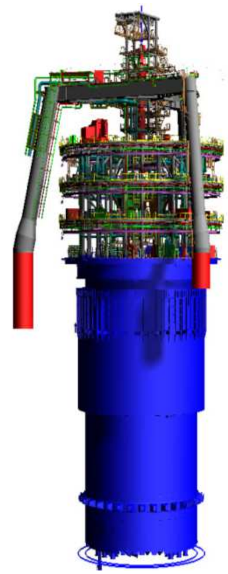

Current Range of Internal Turrets

Petrobras P-53

Shell Espirito Santo

BP Skarv

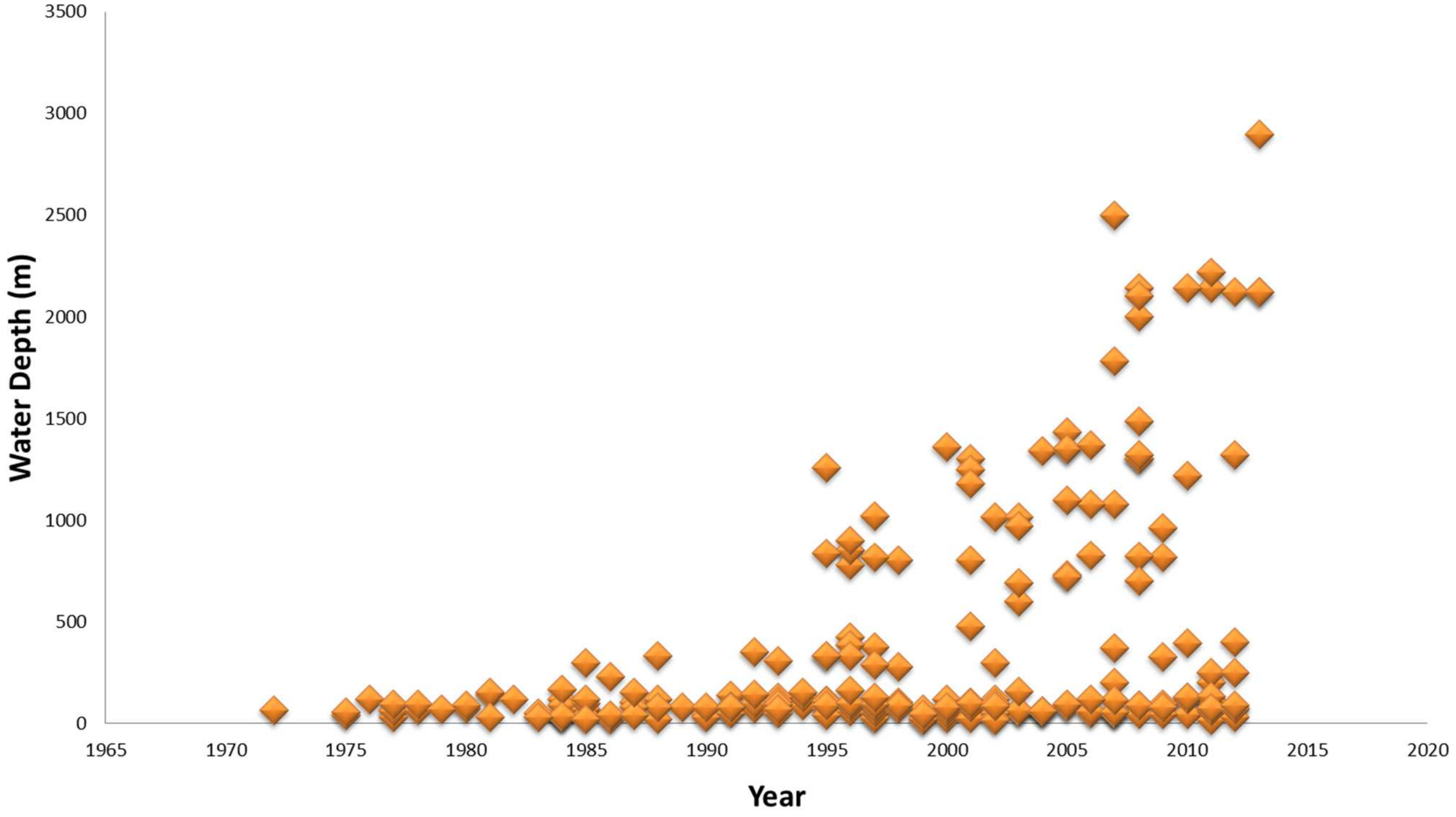
Petrobras Marlim Sul



Shell Prelude

BP Quad 204

Water Depth Trend For FPSO and FSO Moorings



Top Mounted Internal Turret (TMIT)

Virtually no limit on riser number – scalable

Virtually no limit on mooring loads

Bogies and radial wheels are inspectable and replaceable

Top Mounted Internal Turret (TMIT)

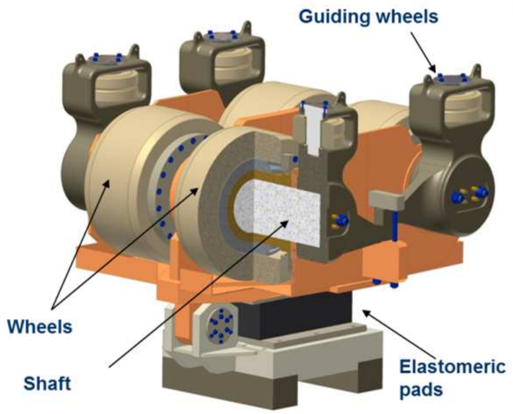
Bogies support axial loads

Radial wheels support radial loads

Dry access in turret for inspection and maintenance

The bogie design is standard

The number of bogies is selected to accommodate the design loads (N+1)



TMIT with Steel Risers

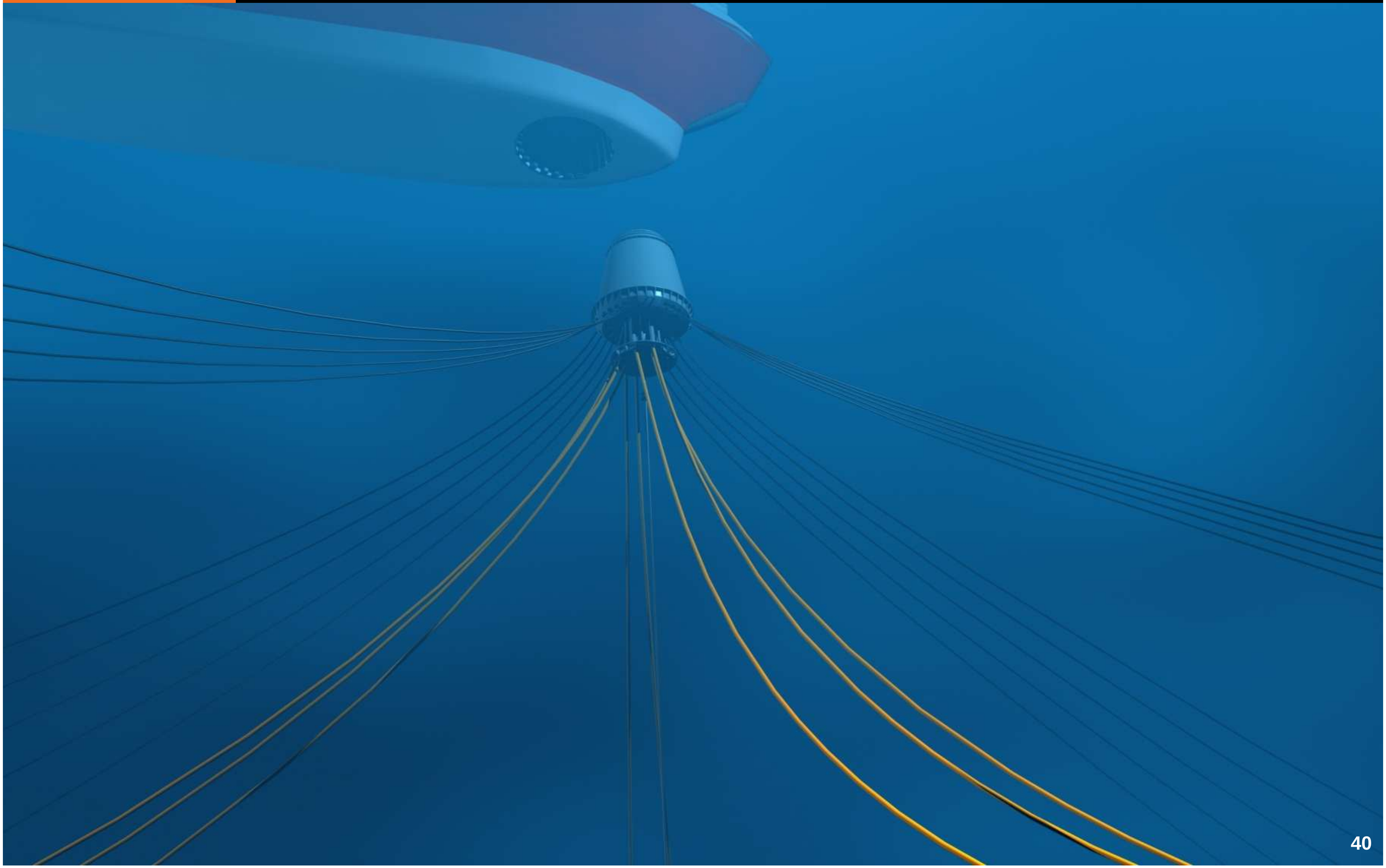
Espirito Santo **employs steel lazy wave risers**

Steel Lazy Wave Risers terminate at lower cylinder deck

Umbilicals terminate at upper cylinder deck

Weathervaning system unaffected

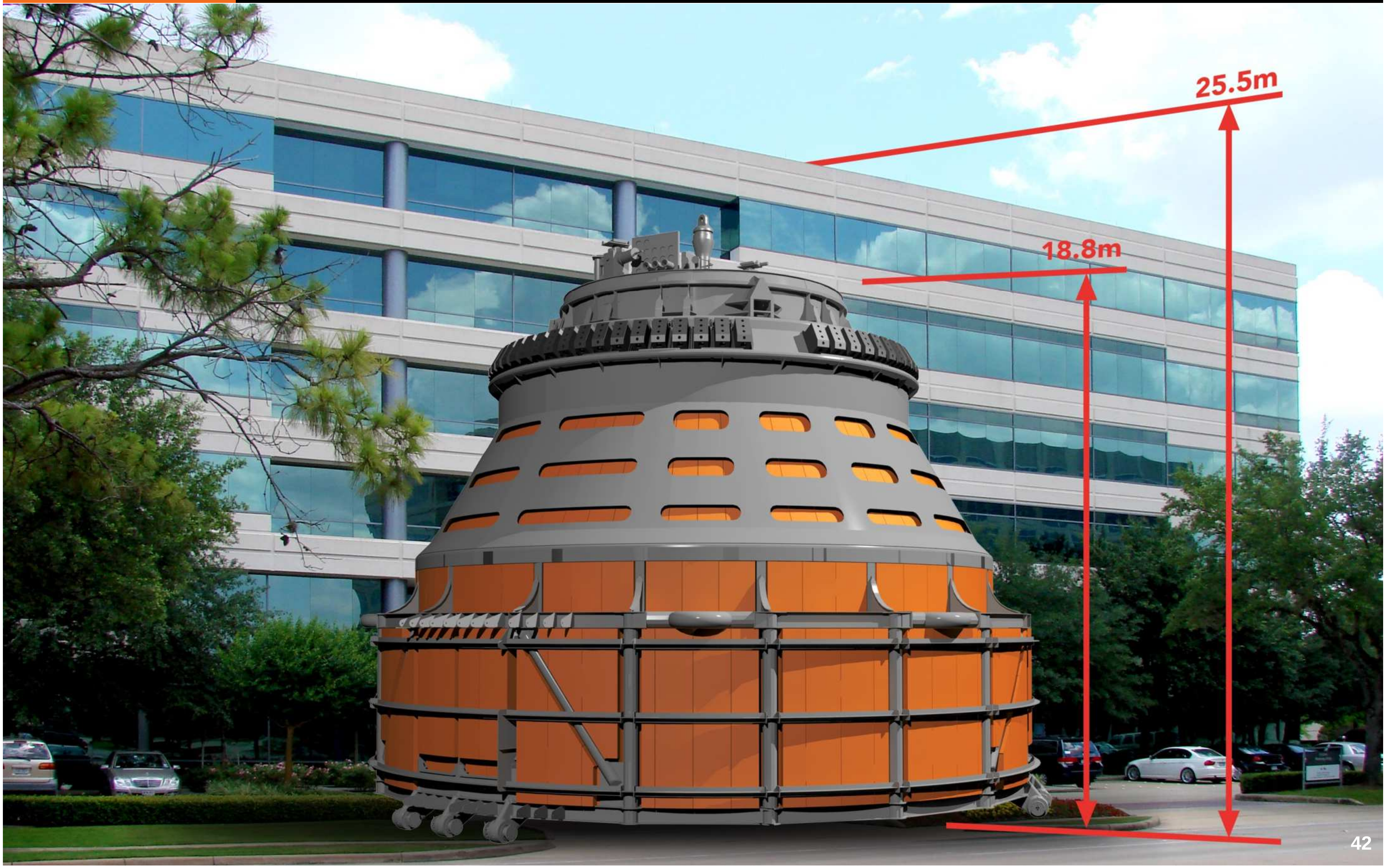
Disconnectable Turrets



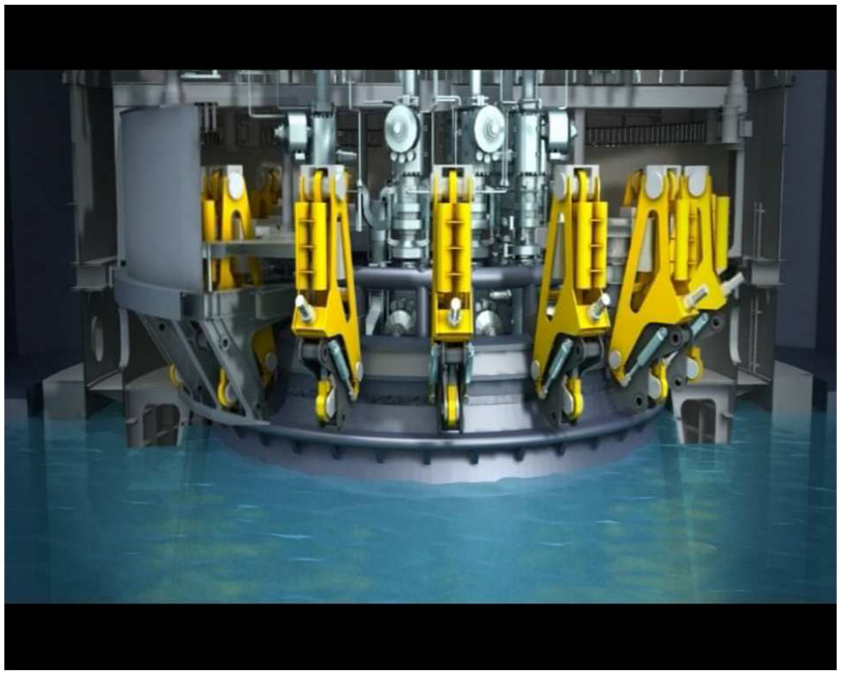
FPSO *Turritella*

- **Disconnectable FPSO in 2,900 meters**
- **Steel lazy wave risers**
- **Worlds deepest production unit**

Turritella Mooring System



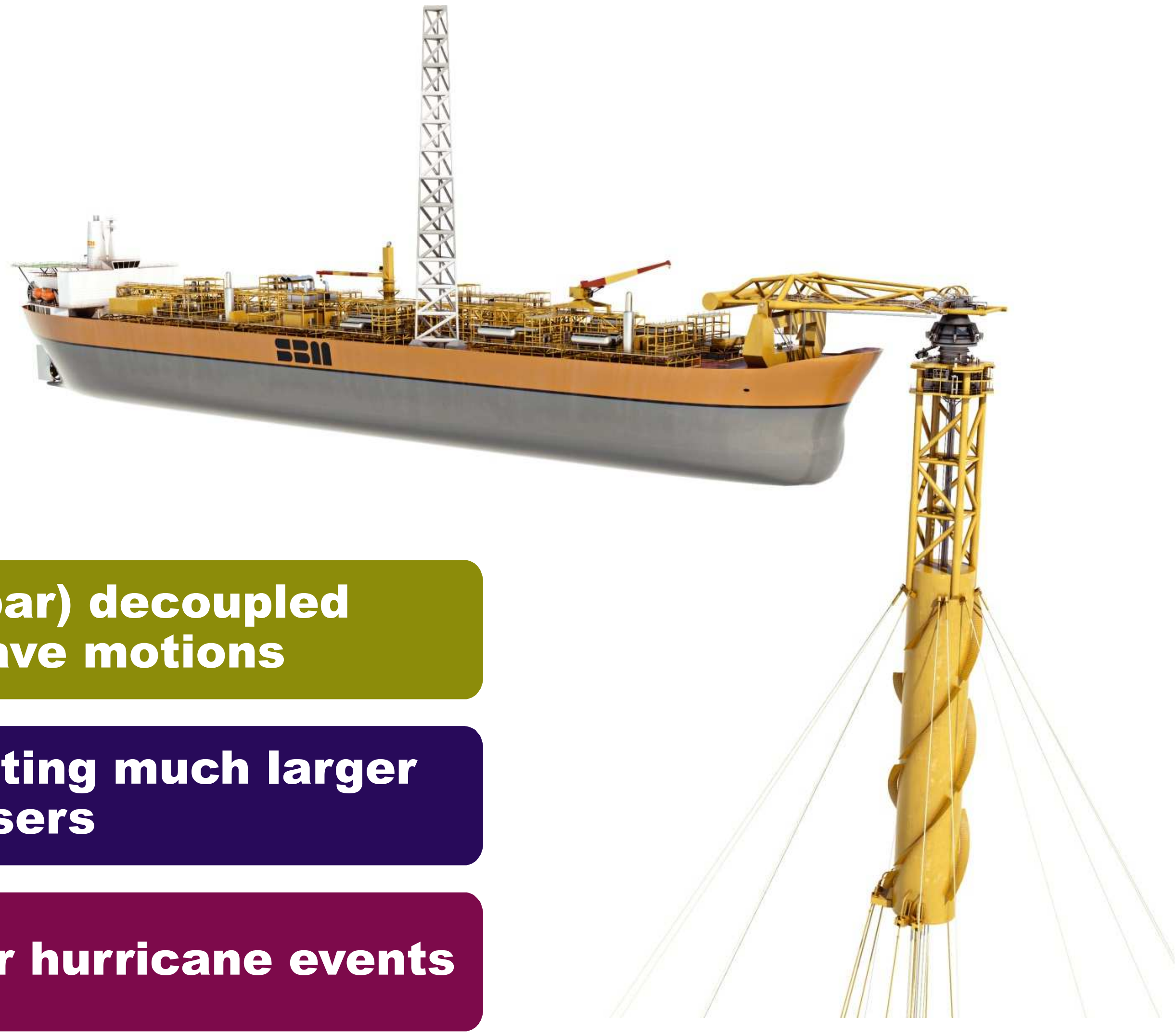
Disconnectable Mooring Systems



Able to disconnect under loads (600 tons per locking device)

Able to transfer up to 900 tons per locking device when connected

MoorSpar™



A slender buoy (spar) decoupled from the FPSO heave motions

Capable of supporting much larger number of steel risers

Disconnectable for hurricane events

MoorSpar™

Arctic Moorings

Icebergs

- 100 yr return condition
- Disconnect under low loads

Ice fields

- Ice vaning
- Disconnect under high loads

Ice Class FPSOs

Key Mooring Challenges

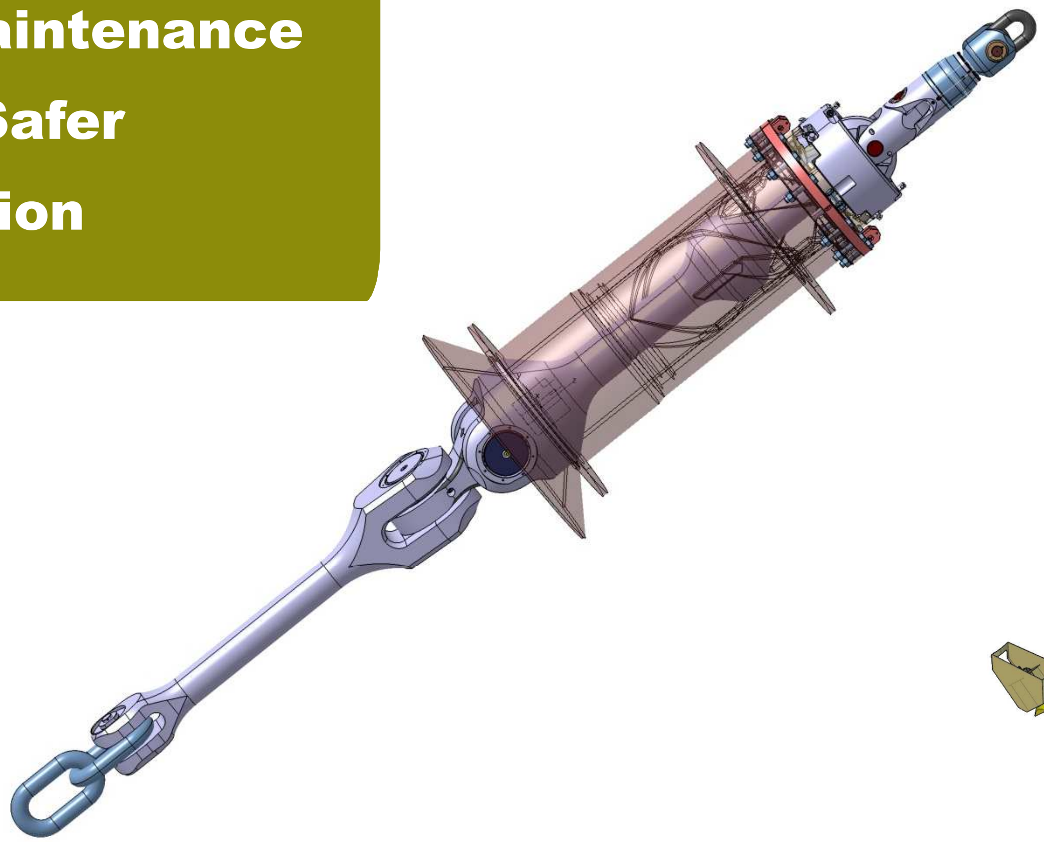
- **Sheet ice – “Ice Vaning” required**
- **Mooring system disconnectable under ice loads**

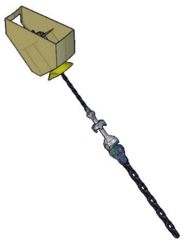
Ice Vaning Tests in Arctic Model Test Basin

Ice model test campaign in Arctic conditions

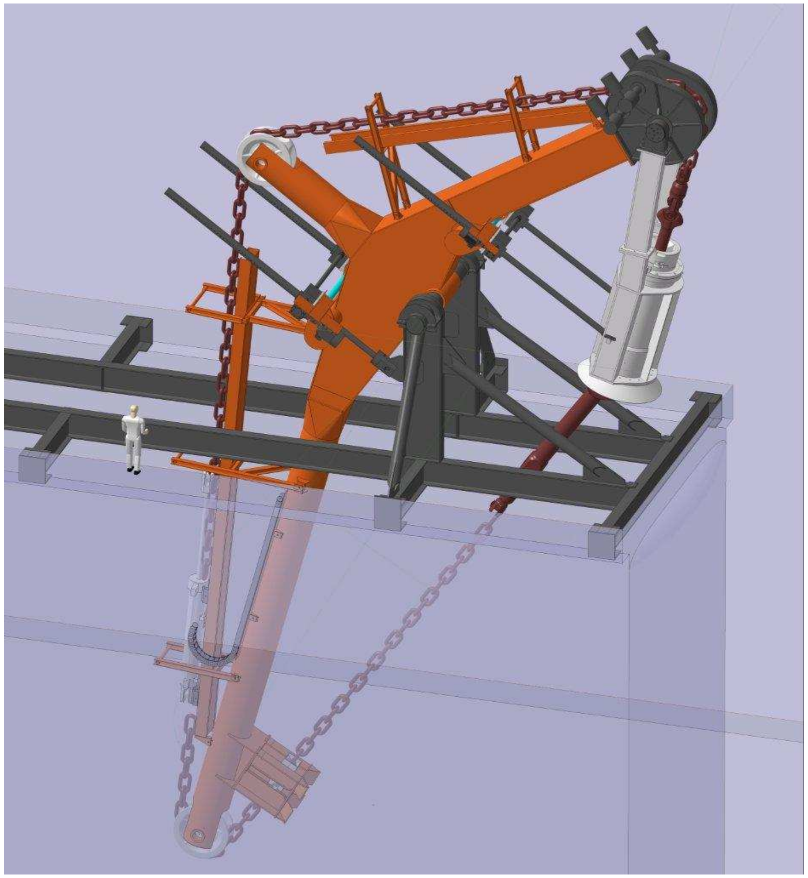
Articulated Rod Connecting Arm (ARCA)

- **Improved Maintenance**
- **Diverless – Safer**
- **Cost Reduction**





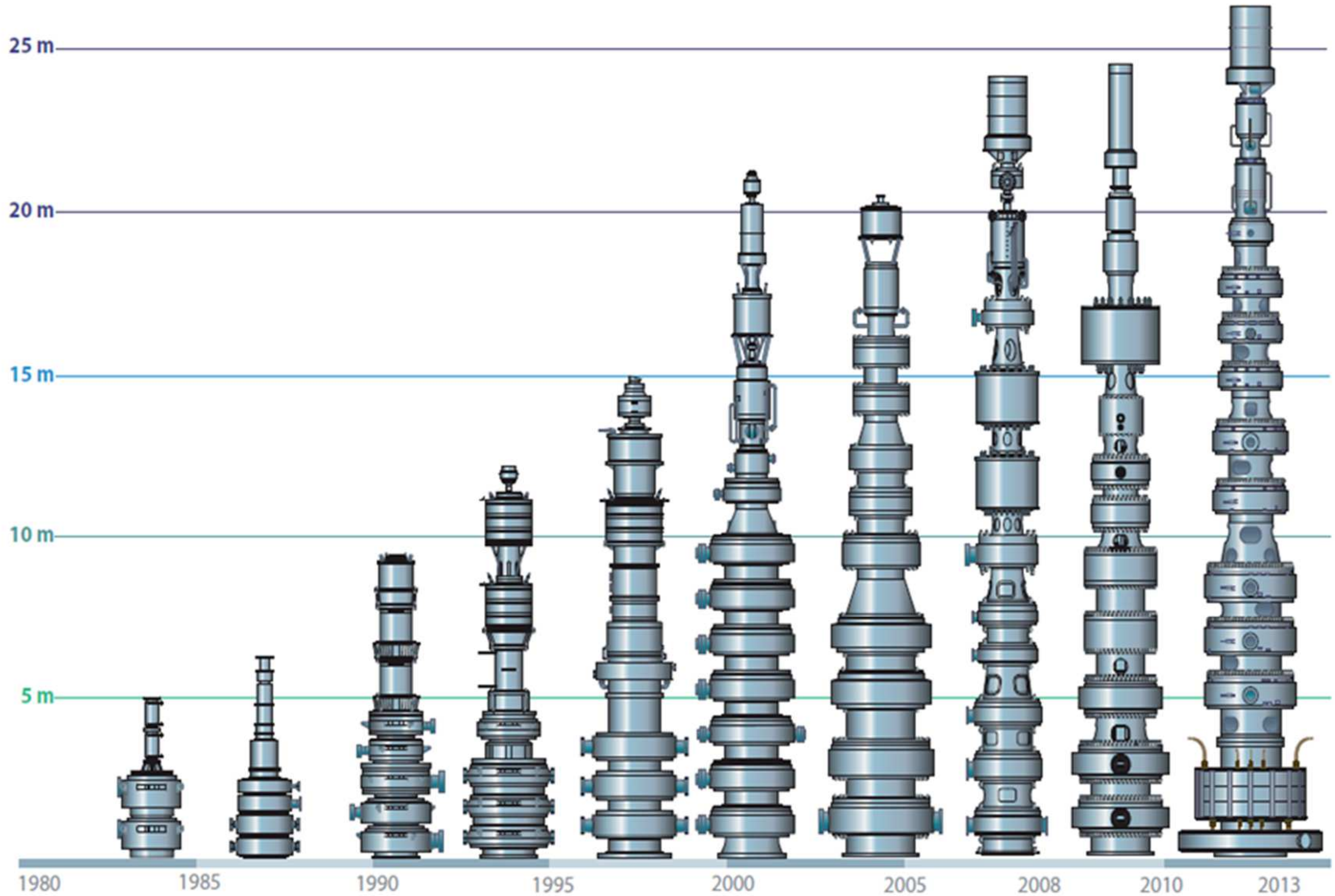
ARAC Prototype



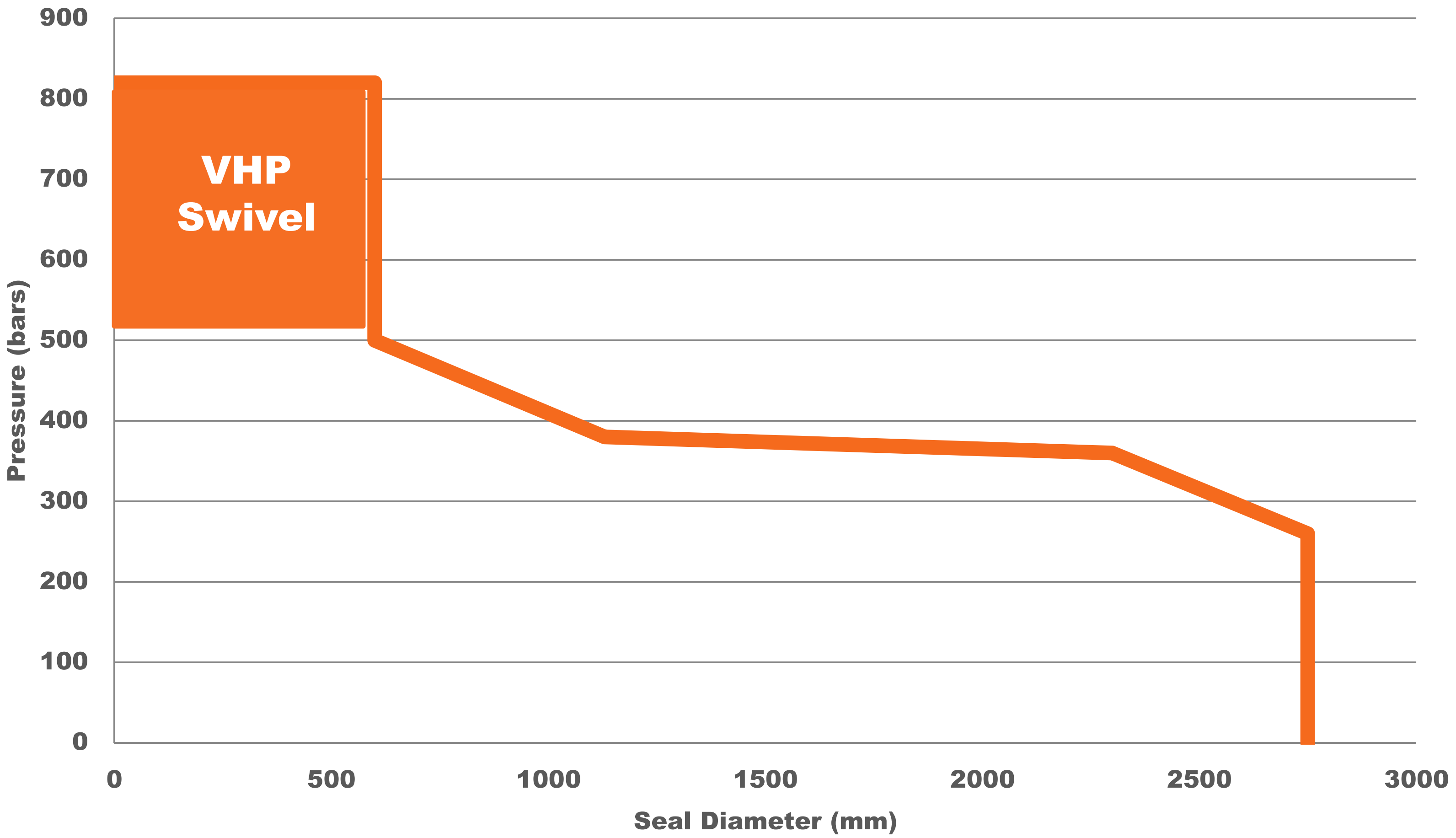
Swivel Overview

Swivels transfer fluids, utilities, power and signals between the geostationary turret and the weathervaning vessel.

Growing in Size of Swivel Stacks

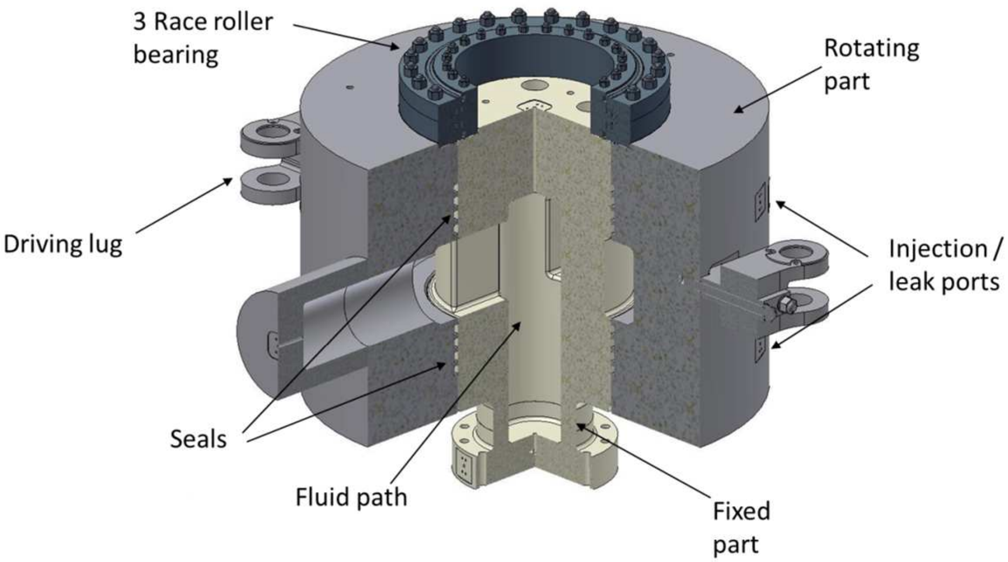


Present Fluid Swivel Operating Envelope



Very High Pressure Swivels Introduced in 2014

2014 Spotlight on new TECHNOLOGY



Core Swivel Technology

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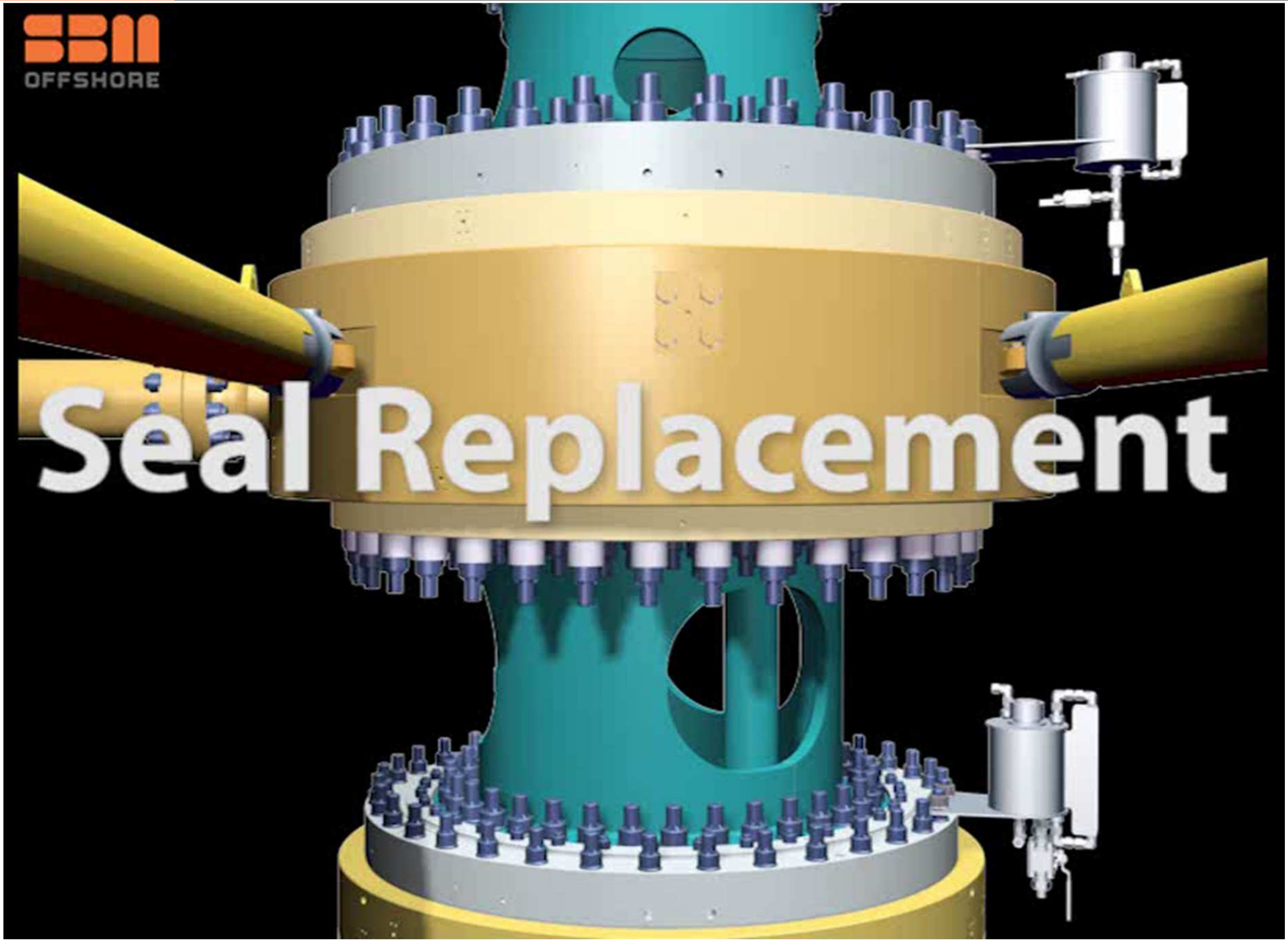
Lower Seal Replacement



Large Scale Power Import or Export

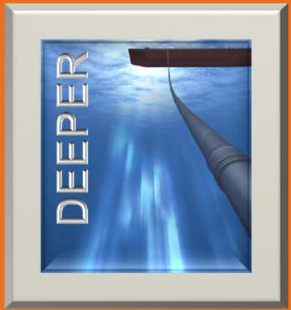
2011 Spotlight on new TECHNOLOGY

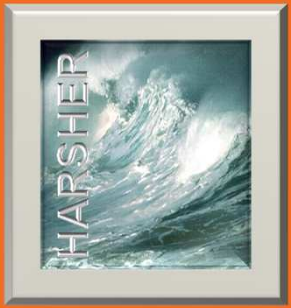
HVAC swivel rated at 65 kV and 150 MW

Mooring Systems – Summary

Deeper	• VPH Swivels for deeper reservoirs
Harsher	• Increased mooring loads using bogie bearings
Colder	• Disconnectable turrets for Arctic
Larger	• Higher capacity swivels, optimised manifolds
Lower Cost	• ARCA, higher capacity external turrets

Semi Sub & TLP Technology





Proven Deepwater Semi-Submersibles and Tension Leg Platforms

Beyond ~1500m water depth

DeepDraft Semi Submersible

- 2 Units installed in US GoM
- Operating in 2450m water depth
- Optimised for wet trees and steel risers
- Also available for dry trees in moderate Hs

Below ~1500m water depth

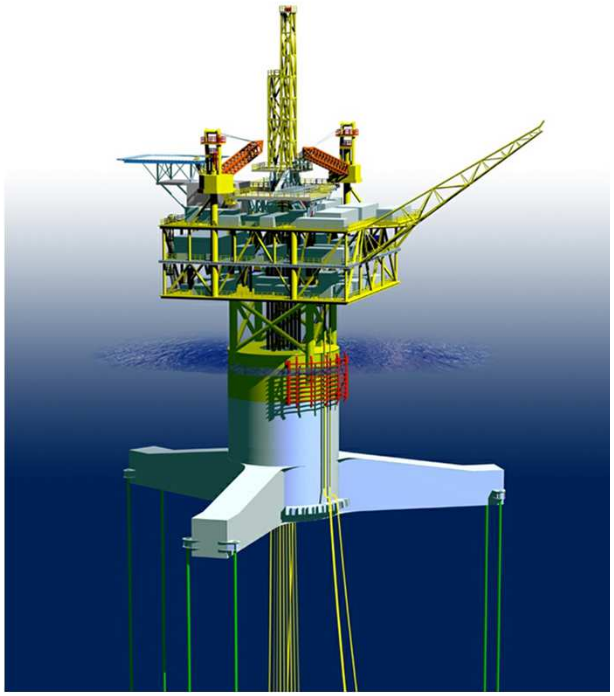
Tension Leg Platform (TLP)

- 5 SeaStar units installed, marginal field solution
- FourStar TLP design for larger fields
- Both available for dry or wet trees





Alternatives to FPSOs



Production units in areas of developed infrastructure do not need storage

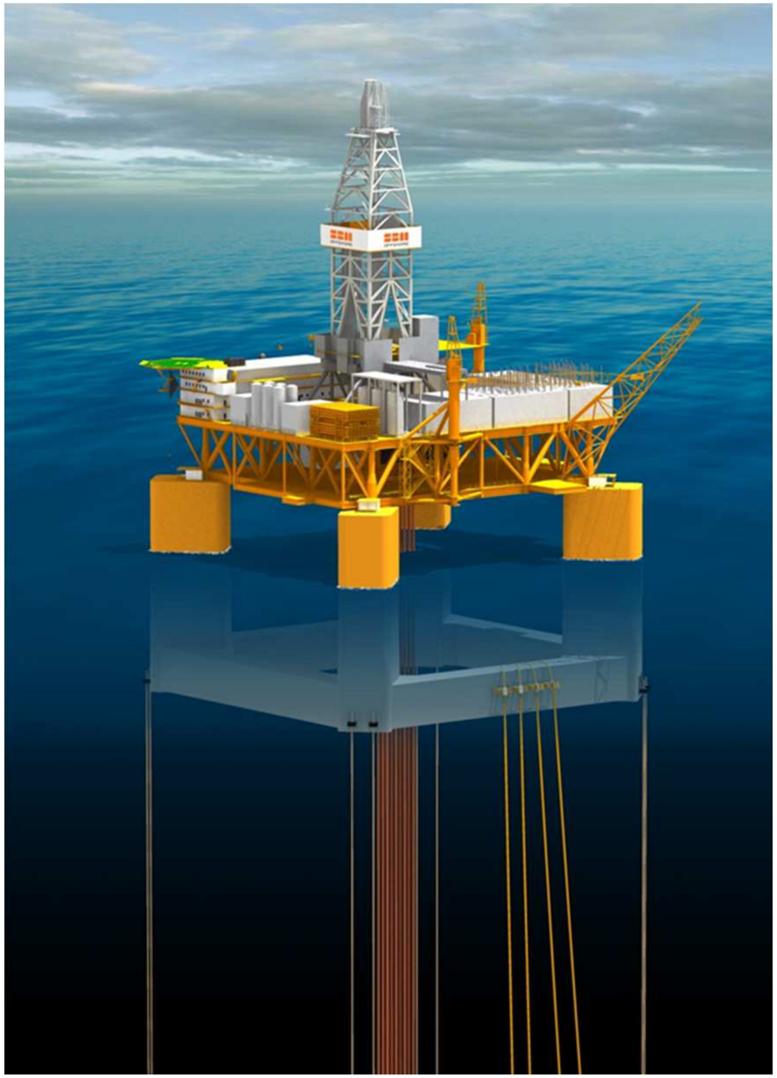
FourStar^{TM} TLP

Builds on SeaStar experience

Higher payload than SeaStar

Suitable for Wet or Dry Trees

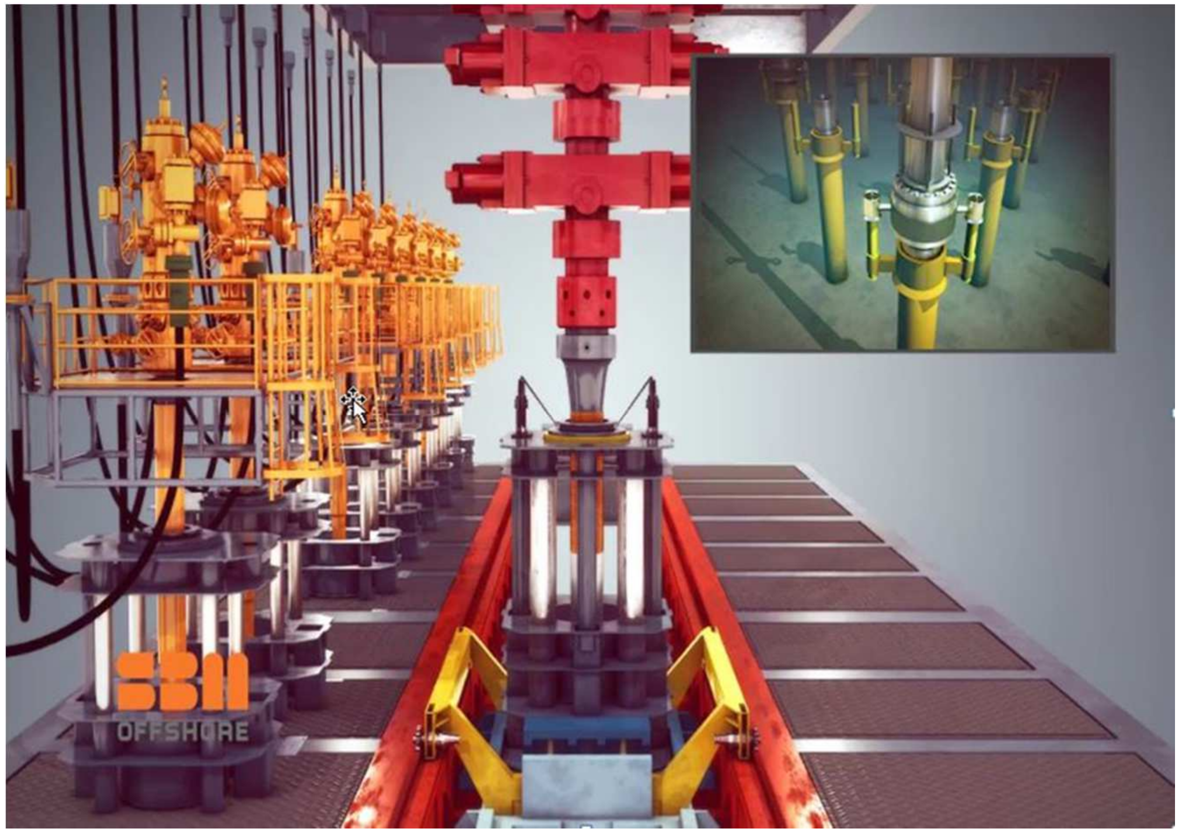
Topsides integrated at Quayside



Drilling Riser *TRIP-SAVER*™

Allows all wells to be drilled consecutively without recovering and redeploying the Drilling Riser

Significant Drillex saving



2013 Spotlight on new TECHNOLOGY

Horizontal Tendon Assembly

Horizontal Tendon Assembly

Significant Installation saving

SBM Deep Draft Semi™ with Dry Trees

Builds on production semi experience

Lower cost and more flexible than a Spar

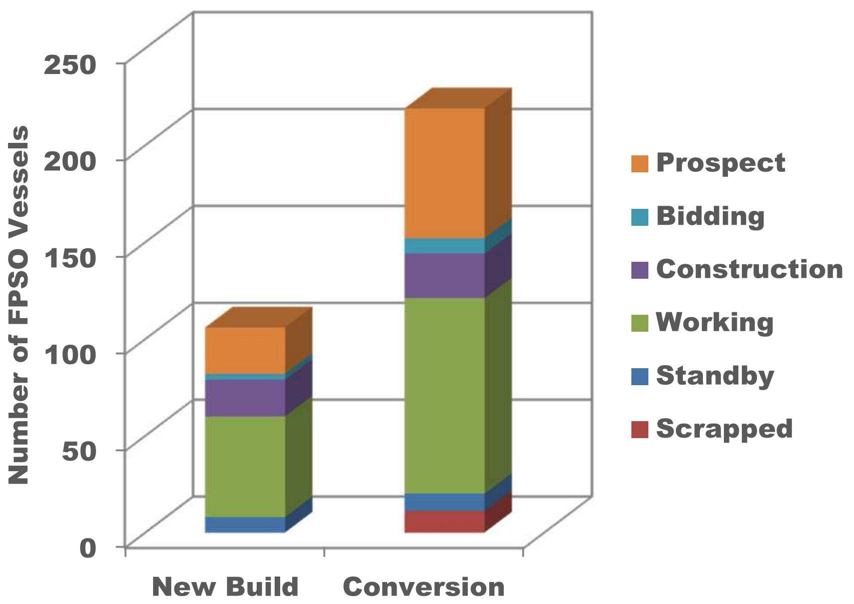
Quayside topsides integration

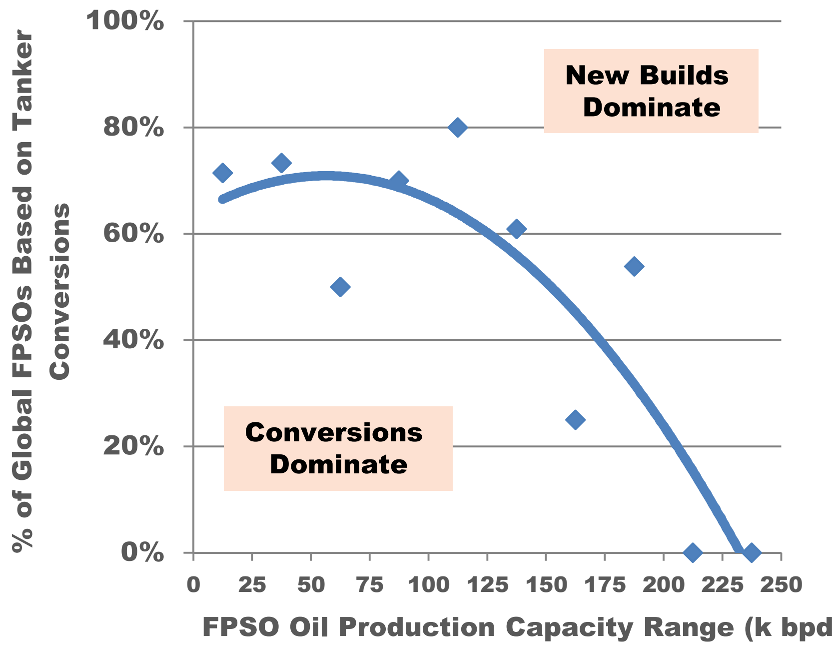
Beyond 1500 m, more cost effective than a TLP

FLNG Technology

Conversion or New Build? Analogy with FPSO

Tanker Conversions Dominate the Global FPSO Fleet





- 2/3 of global FPSO fleet are based on tanker conversions
- Conversions dominate in small to mid-scale FPSO oil capacity

Analogy to FPSO Market

New Build FPSO
150,000+ bpd

New Build FLNG
2+ mtpa

Converted FPSO
<150,000 bpd

Converted FLNG
<2 mtpa

FLNG vessels based on LNG tanker conversions can replicate the success of converted FPSOs, drawing on experience from the global FPSO fleet

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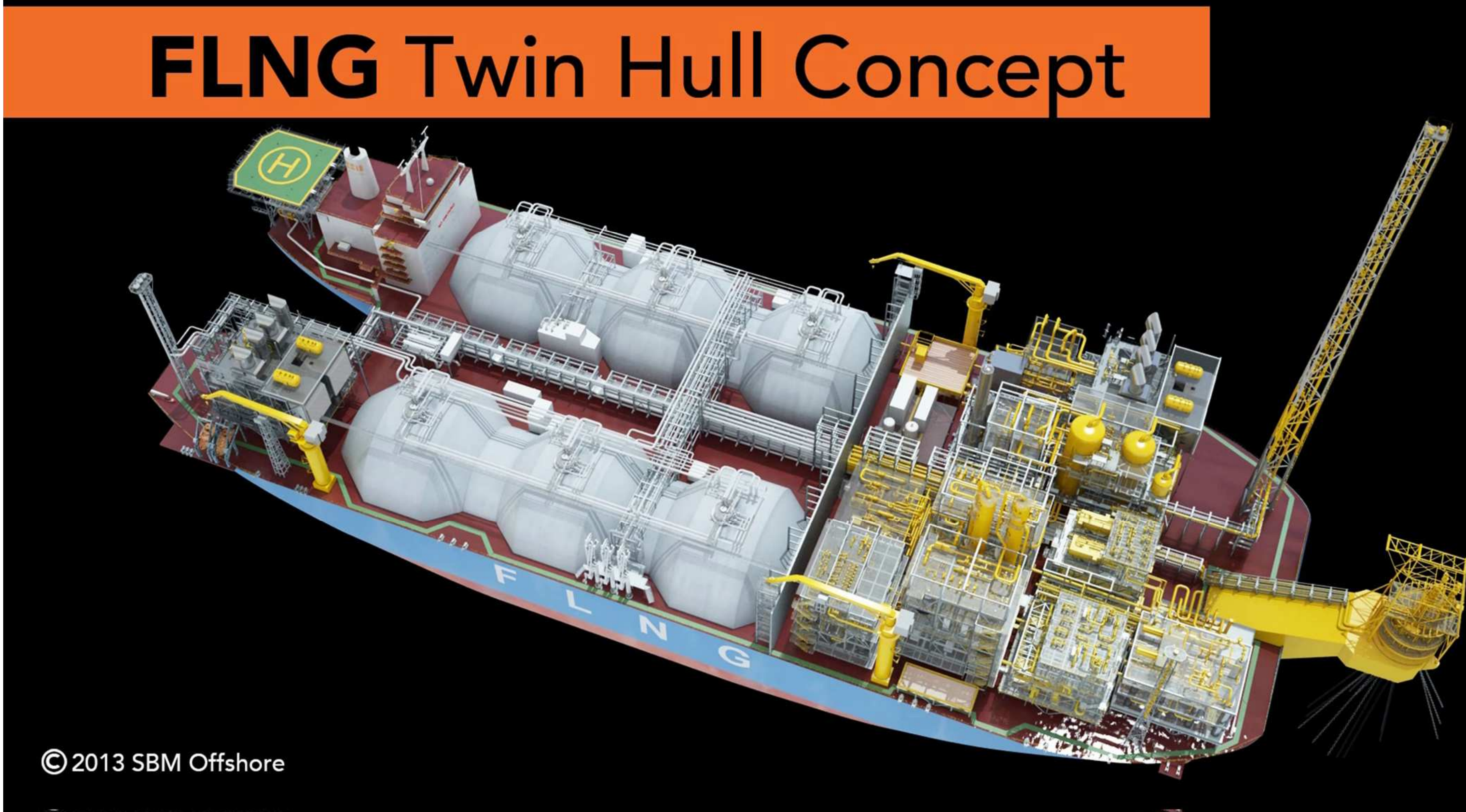
Mid Scale Floating LNG



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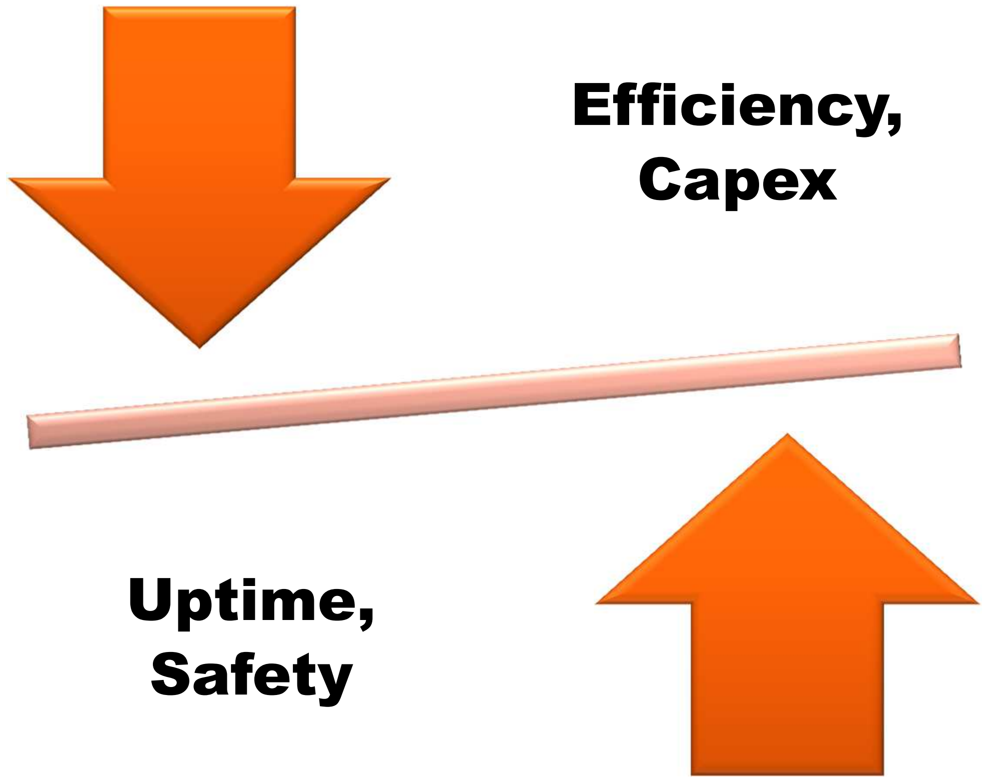
Topsides Process Selection



NPV = fn (Capex, Opex, Efficiency, Uptime, Risk)

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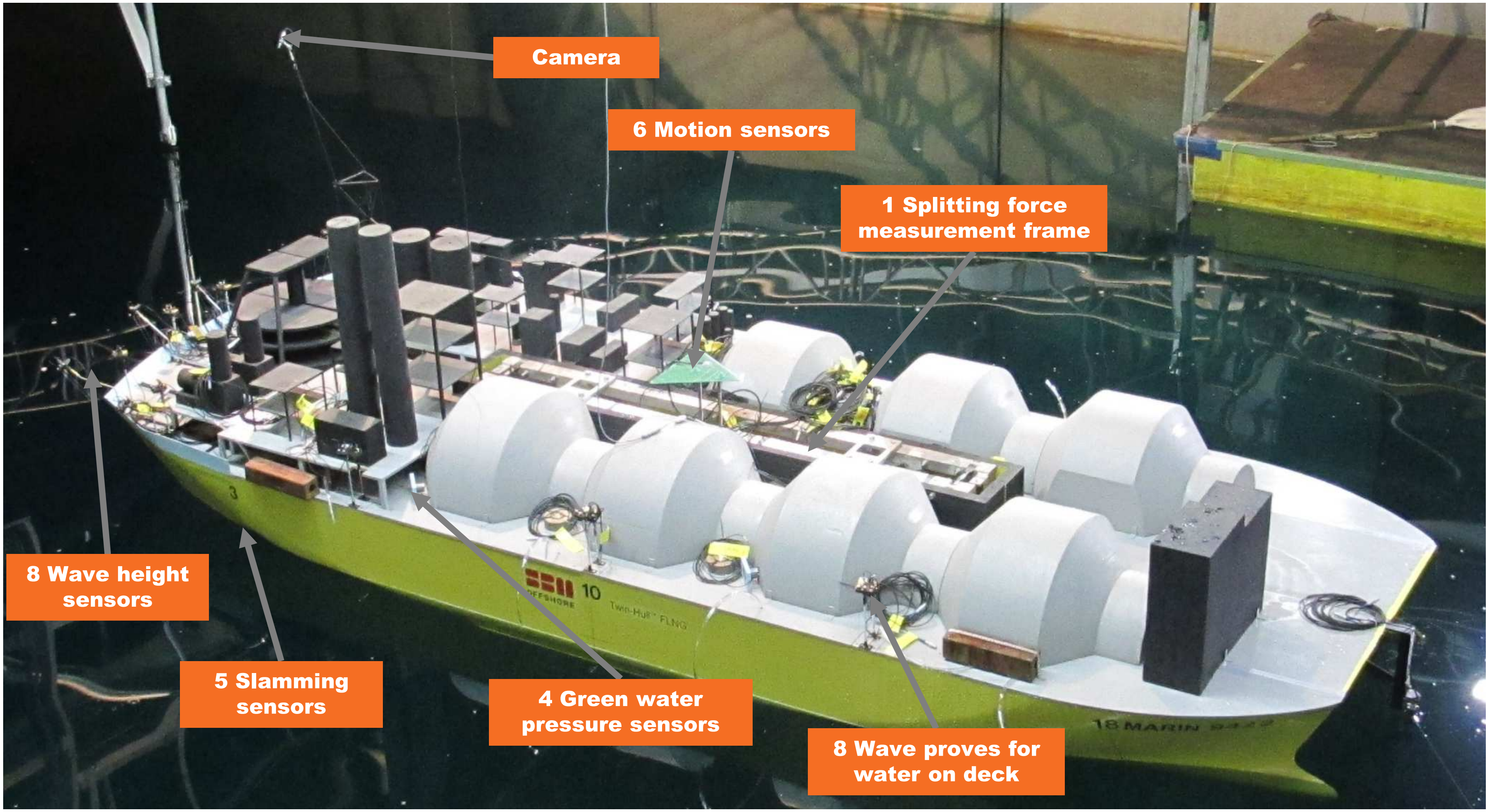
Comparison of Liquefaction Process Options

	Dual Mixed Refrigerant	Single Mixed Refrigerant	Dual Nitrogen Expansion
Proven technology	Yes	Yes	Yes
Overall space required	High	High/Moderate	Moderate
Hazardous Refrigerant	Yes	Yes	No
HC Refrigerant make-up	Yes	Yes	No
Explosion Hazards	High	High	Low
Complexity of operation	High	Moderate	Low
Process Efficiency	High	Moderate	Moderate
Expected Availability	Moderate	Moderate	High
Total Capital Cost	High	High/Moderate	Moderate
Operating Cost	High	High	Moderate

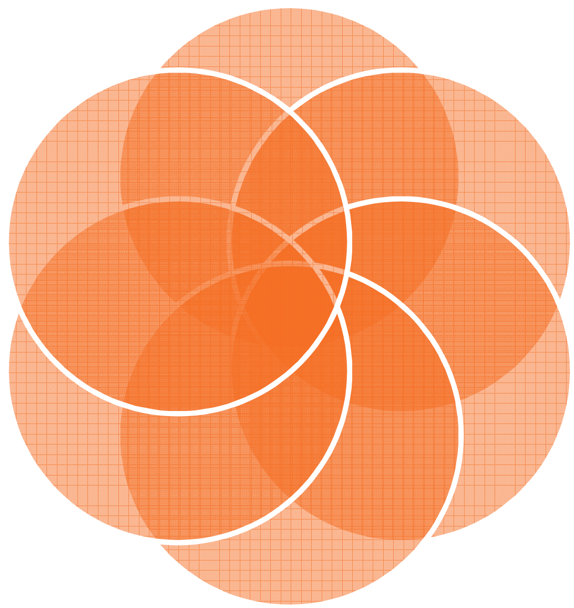
1/60 Scale Model Test in MARIN Basin



Comparison Between Converted FPSO and Converted FLNG

- **Similar Topsides weight**
- **Similar Capex**
- **Similar Schedule**

Competitive Advantage Through Technology – Twin Hull FLNG



Other Technology

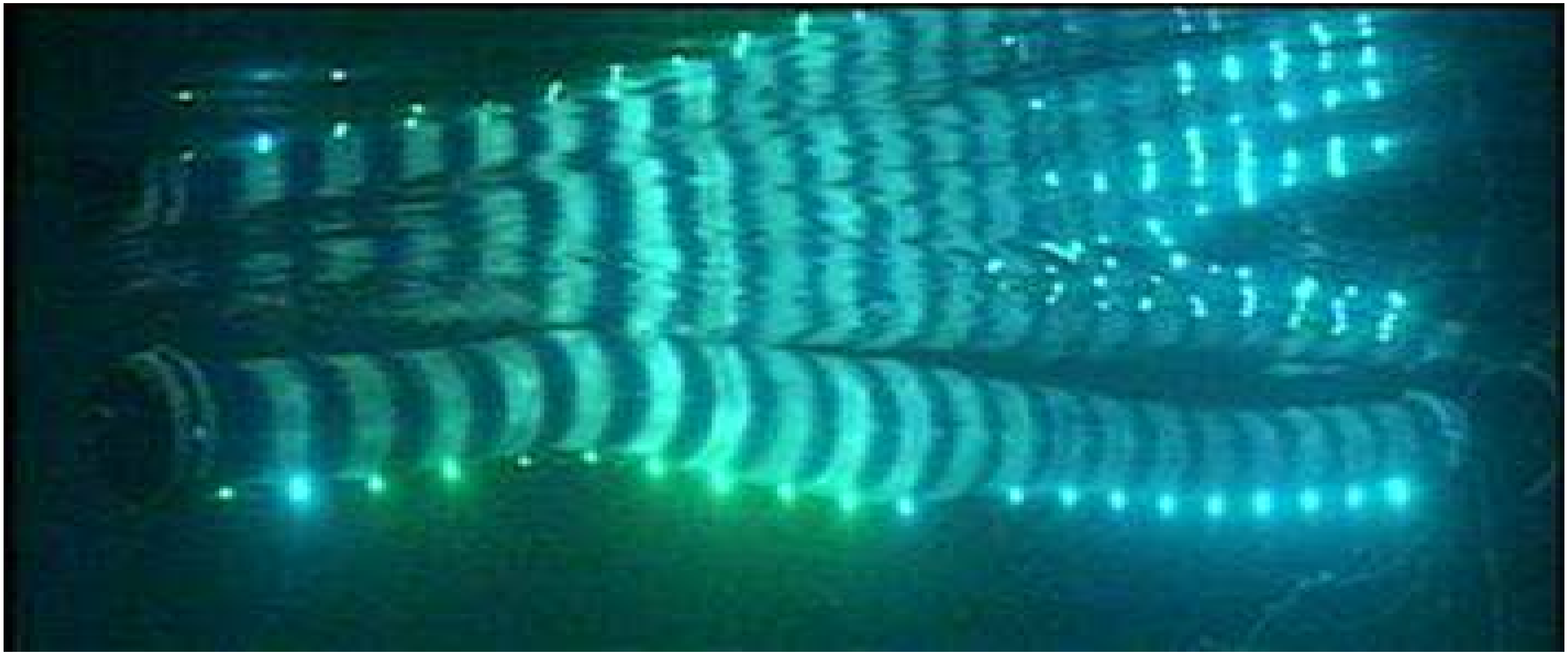
Extended Well Test with GTL

30,000 bpd + 40 MMscfd 33,000 bpd blended crude

FPUSO Main Components

50,000 bpd of 9º API → 45,000 bpd 20º API

S3 Wave Energy Converter (WEC)



Electro Active Polymer (artificial muscle) converts mechanical energy into electrical energy

No mechanical moving parts, Excellent Efficiency

SBM Offshore Group Technical Standards

Continuous Feedback Loop

ENGINEERING

PROCUREMENT

RELOCATION

CONSTRUCTION

OPERATIONS

INSTALLATION

SBM OFFSHORE	CLIENT: SBM OPERATIONS		
	PROJECT: GROUP TECHNICAL STANDARDS		
	ES45000	PECEMETS999005	A 3
DOCUMENT TITLE: MECHANICAL UNFIRED PRESSURE VESSEL STANDARD SPECIFICATION			

Technical Lessons Learnt

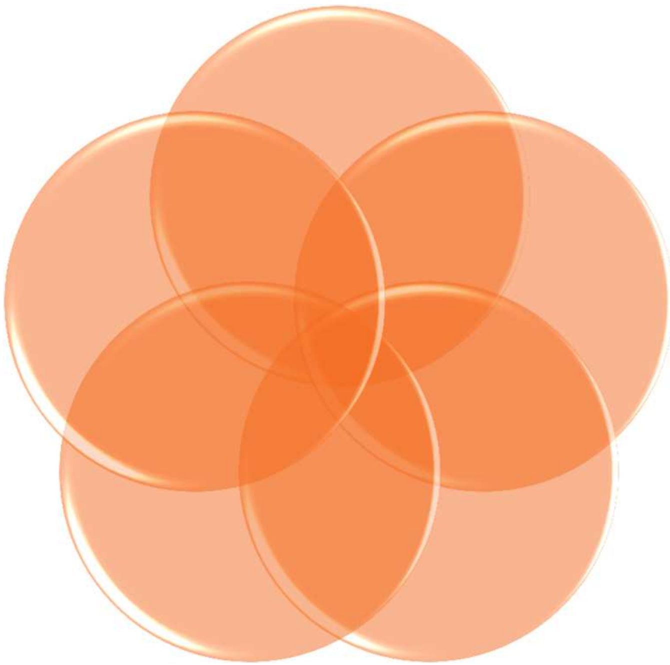
- Established 2003
- 150 Standards and Specifications
- Pre Approved by ABS
- Updated annually
- Default standards for SBM leased FPSOs
- Now also applied to 4 EPC Sale FPSOs

Conclusions

SBM Technology – Conclusions

Exciting Portfolio of new Products and components

Strong Technical Partners



Aligned to needs of clients and Industry Trends

Major Cost & Schedule reduction initiative

Stage Gate process for TRL

Q&A