Return to session directory

Floating Production System Deepwater Development Options

by

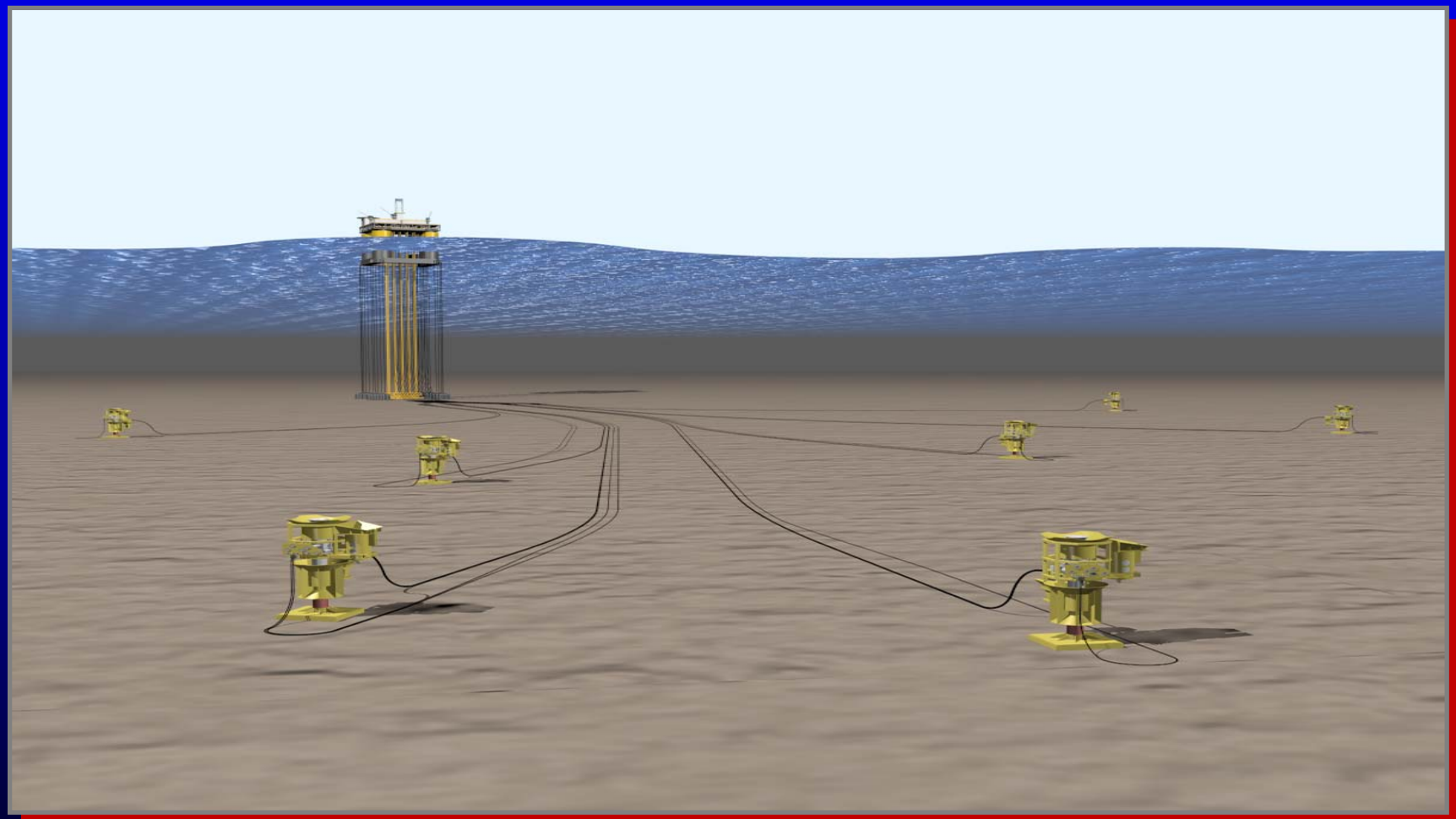
Pieter Wybro

Sea Engineering, Inc.

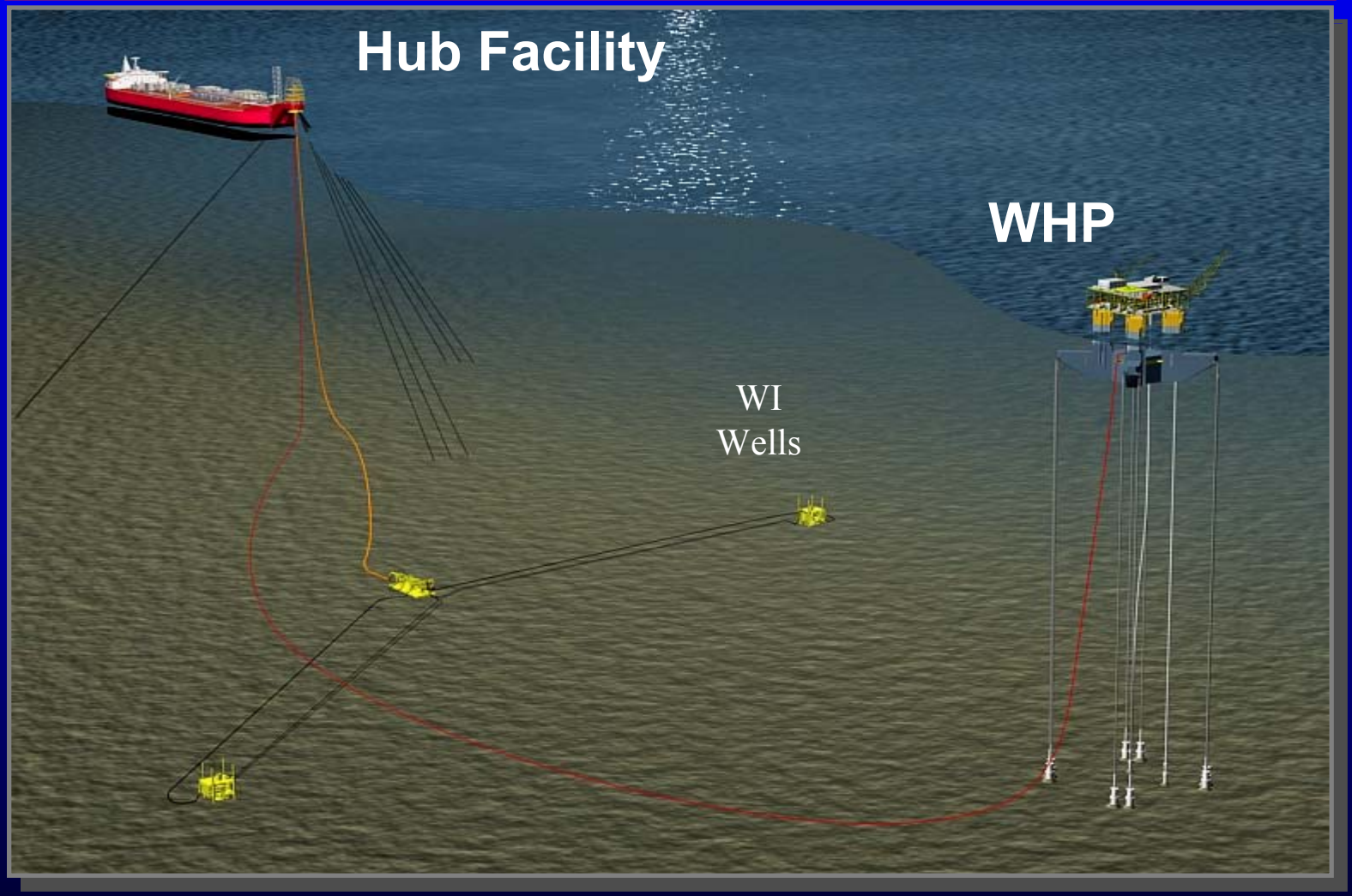
Presentation Topics

1. ***Deepwater Platform Options***
2. ***Market Trends***
3. ***Primary Drivers***
4. ***Technology Issues***
5. ***Future Trends***

Local Host Development Option



Satellite Wellhead Platforms to Central Hub



Production Floater Hull Types

- **Monohull**

FPSO - Production, Storage, and Shuttle Offtake
FSO - Storage and Shuttle Offtake
FPU - Production and Pipeline Offtake

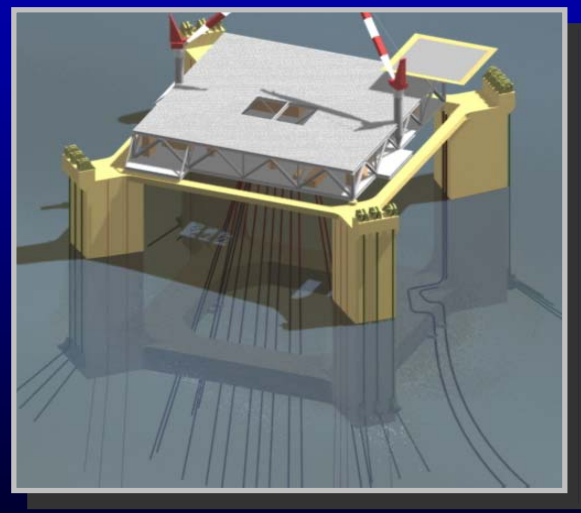
Production Floater Hull Types

- Monohull

- **Semi-Submersibles**

Conversions

New Generation New Build

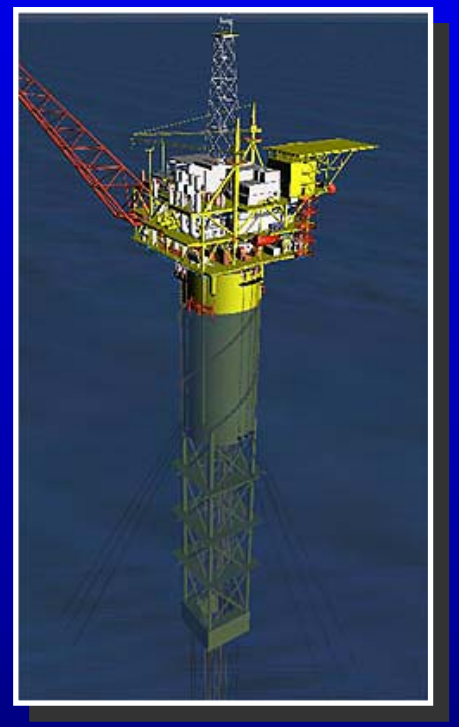


Deepwater Floater Hull Types

- Monohull
- Semi-Submersibles

- **Spars**

Classic Spar

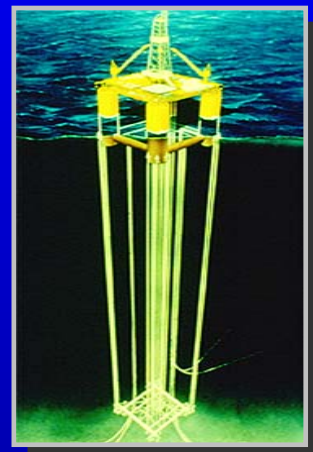


Truss Spar

Deepwater Floater Hull Types

- Monohull
- Semi-Submersibles

- Spars
- **Tension Leg Platforms (TLP)**

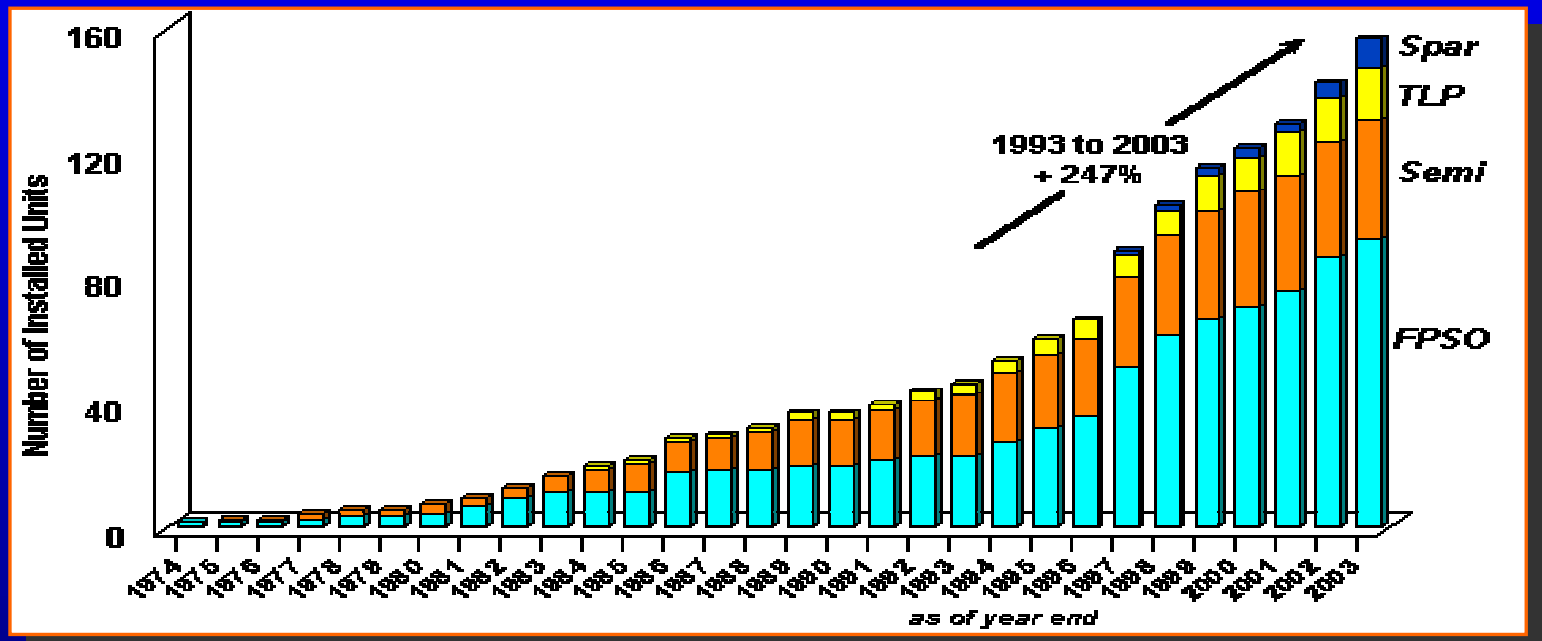


Classic TLP

Monocolumn TLP

Moses TLP

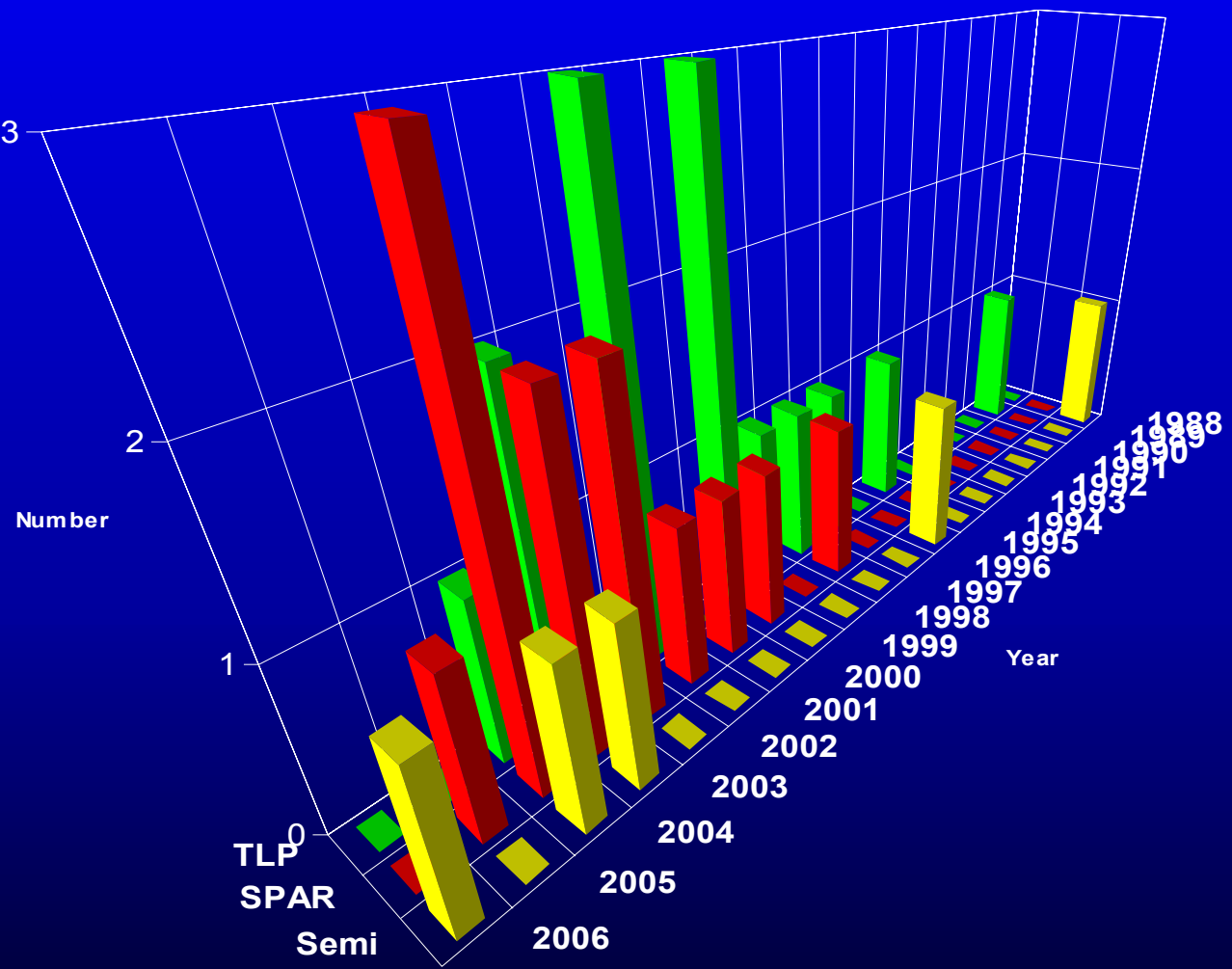
Floating Production Systems Growth



Reference: International Maritime Consultants 2004

- Mature Technology.
- Historically has been primarily conversions.
- Historically, FPS were used in medium water depth, early production, short field life, flexible risers.

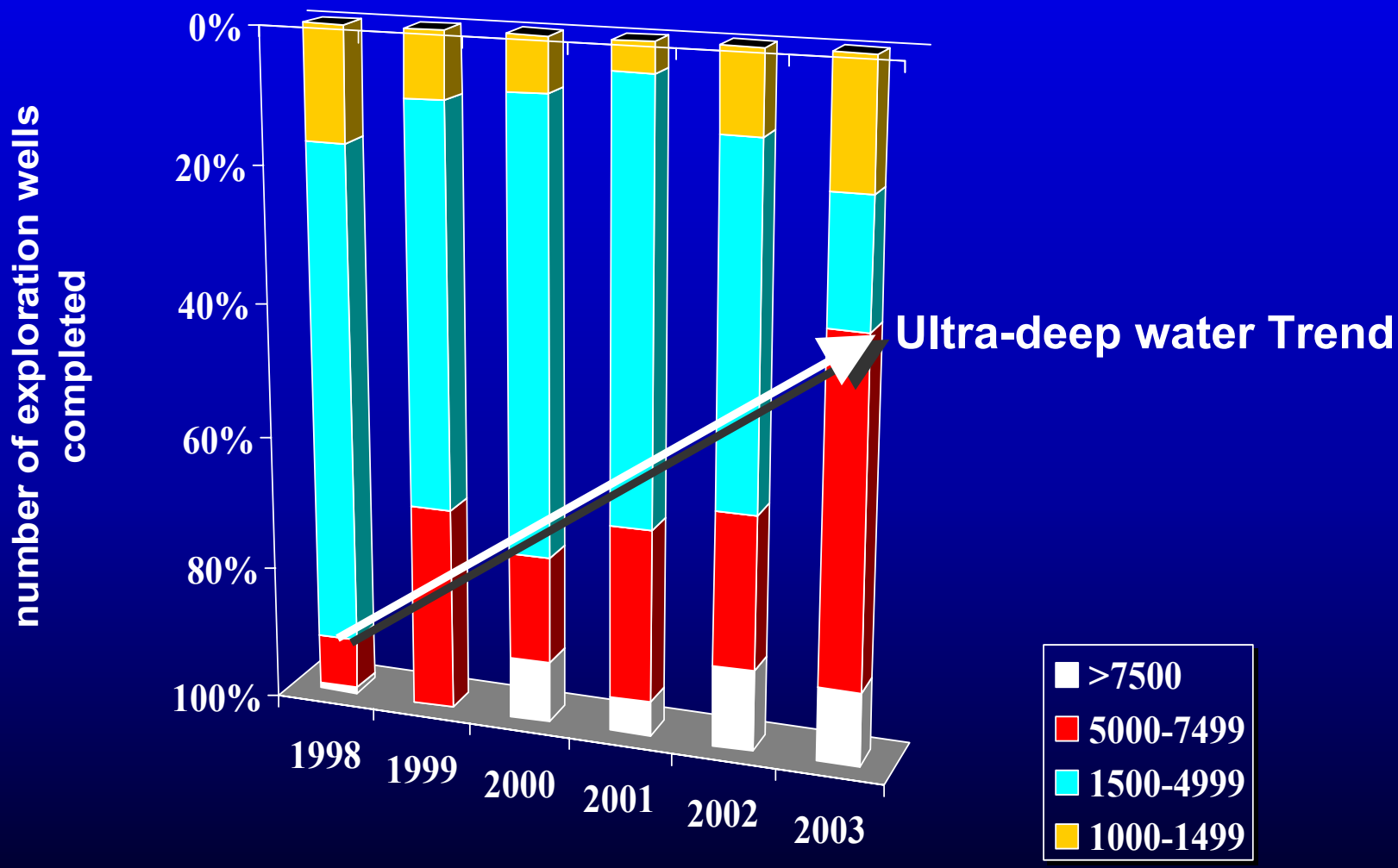
GOM Floating Systems



(Source: MMS Deepwater GOM Report 2004)

Recent Exploration Trends

(Source: MMS Deepwater GOM Report 2004)

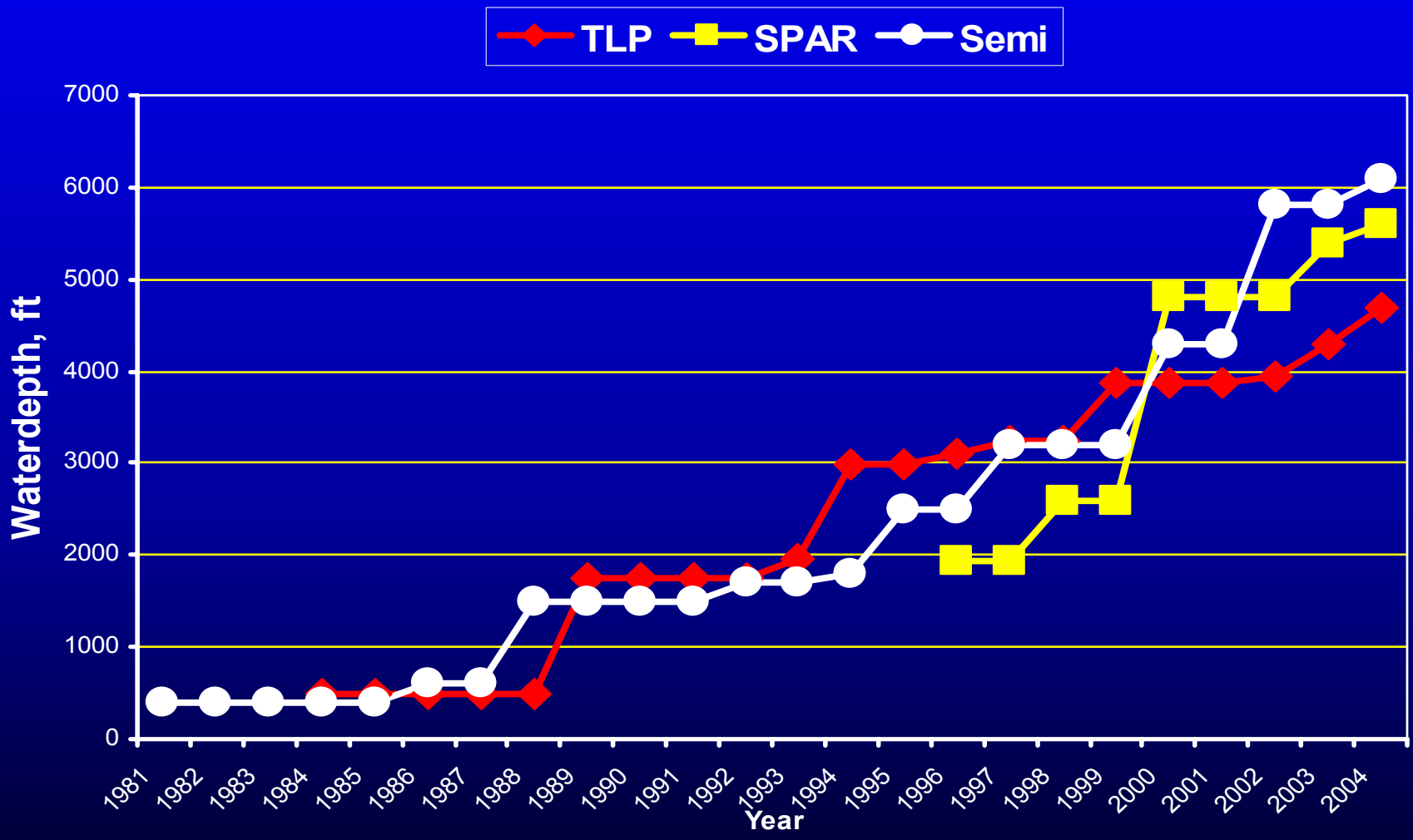


GOM Discoveries > 7000' WD

Project Name	Block	WD, ft	Year
Aconcagua	MC 305	7,379	1999
Camden Hills	MC 348	7,530	1999
Blind Faith	MC 696	7,116	2001
Merganser	AT 37	8,064	2001
St. Malo	WR 678	7,326	2001
Trident	AC 903	9,816	2001
Cascade	WR 206	8,143	2002
Great White	AC 857	7,425	2002
Vortex	AT 261	8,422	2002
Atlas	LL 50	9,180	2003
Chinook	WR 469	9,104	2003
Jubilee	AT 349	8,891	2003
Spiderman/Amazon	DC 621	8,100	2003

(Source: MMS Deepwater GOM Report 2004)

Waterdepth Records for FPU Types



Primary Drivers for Deepwater FPUs

- Waterdepth.
- Payload
- Production Characteristics – Well Access Requirements.
- Availability of Infrastructure & Market location.
- Platform drilling, predrilling vs postdrilling
- Gas Disposal Requirements.
- Local Content Requirements.
- Field Life.
- Metocean Conditions.

Wellbore Access: Direct vs Subsea?

Direct (Dry Tree)

- Single Drill Center
- Lower OPEX and Life Cycle Costs
- Simpler well Hardware
- Minimize well intervention Cost and downtime
- Less Flow Assurance Risk
- Higher recovery
- Strict motion requirements

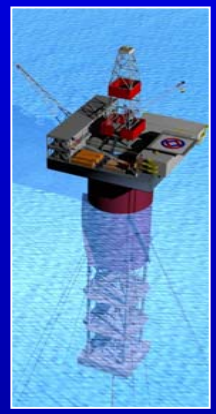
Indirect (Wet Tree)

- Multi Drill Centers
- Higher OPEX
- Minimize Drilling Costs and Risks for Large Areal Extent Reservoirs
- Maximize Development Plan Flexibility
- Capability for wide range of hull types
- More complex flow assurance issues
- Seafloor intervention, vessel availability

Proven Deepwater Technology

Dry Tree Solutions

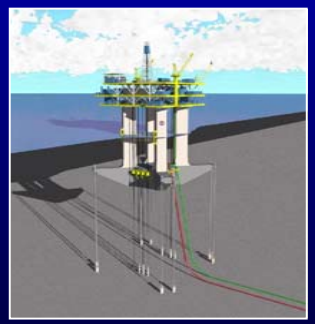
Classic Spar



Truss Spar

Compliant Tower

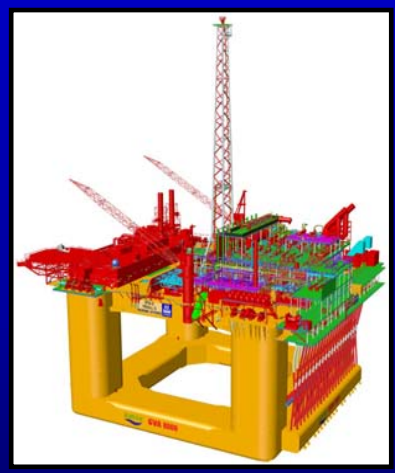
Conventional TLP



New Generation TLPs

Wet Tree Solutions

Shipshape FPSO



Semi FPS

Source: Offshore Magazine
Deepwater Production Solutions poster; Sept.,2000

Riser Options

Direct Vertical Access Options:

- **Direct Tensioned Riser**
- **Air Can Tensioned Riser** } TTR
- **Tubing Tie-back Riser**
- **Compliant Vertical Access Riser (CVAR)***
- **Near or At-Surface Completion***
- **Drilling/Completion/WO riser**

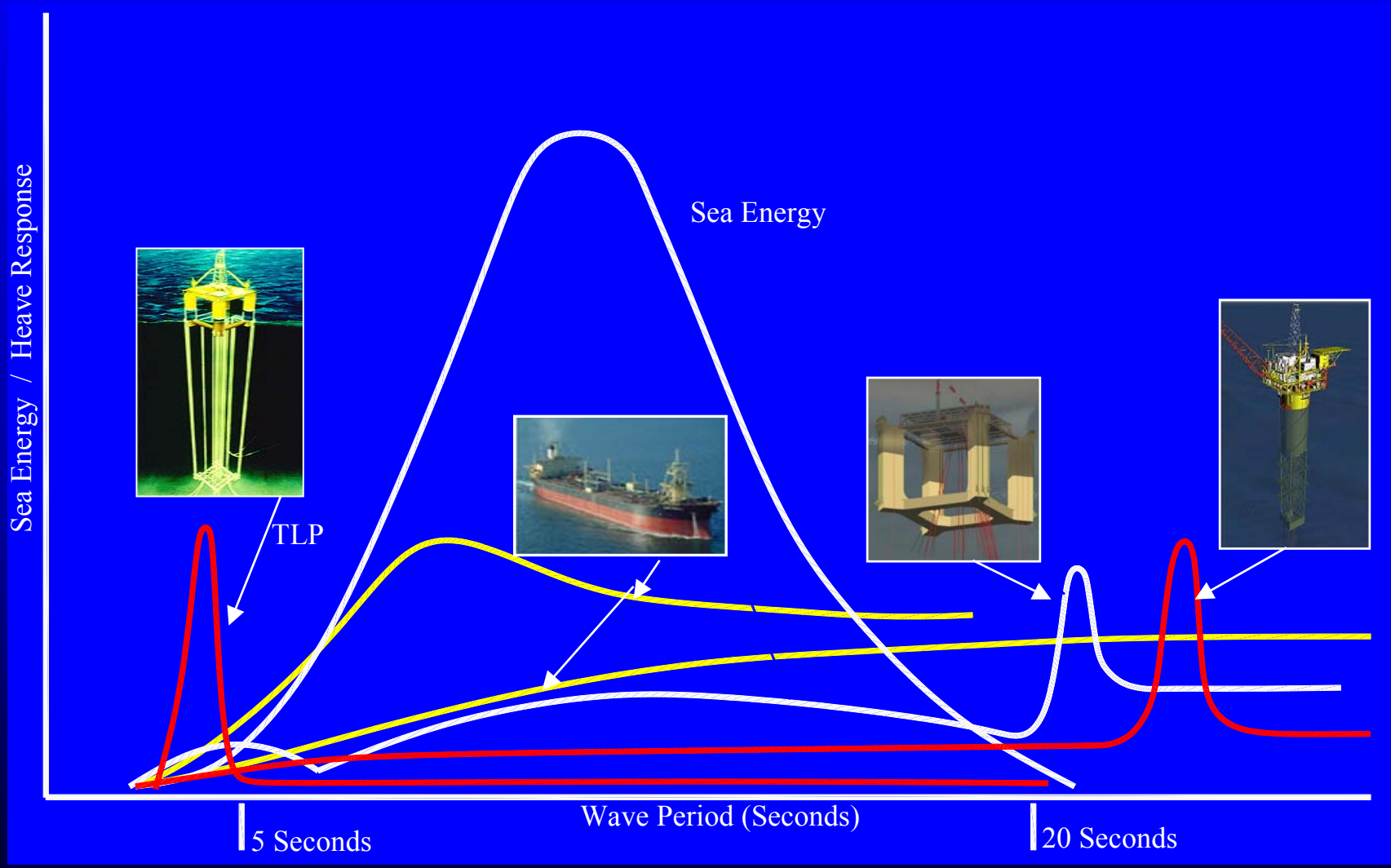
Wet Tree Options:

- **Steel Catenary Risers (SCR)**
- **Hybrid Risers**
- **Flexible Catenary Risers**

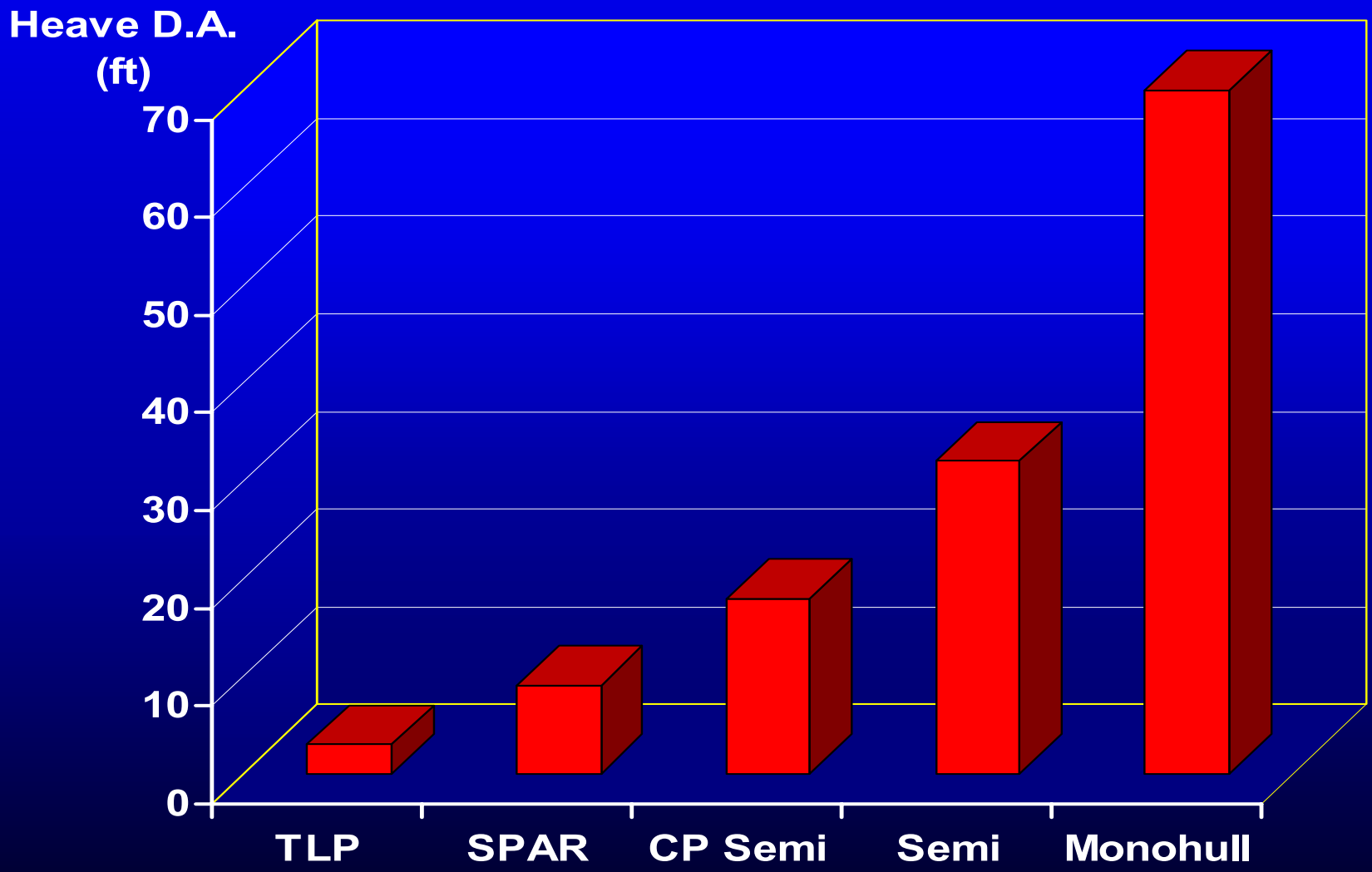
Stricter Hull Motion Requirements

Note: * **Option is unproven**

Motion Response Characteristics



GOM FPU Motion Comparison

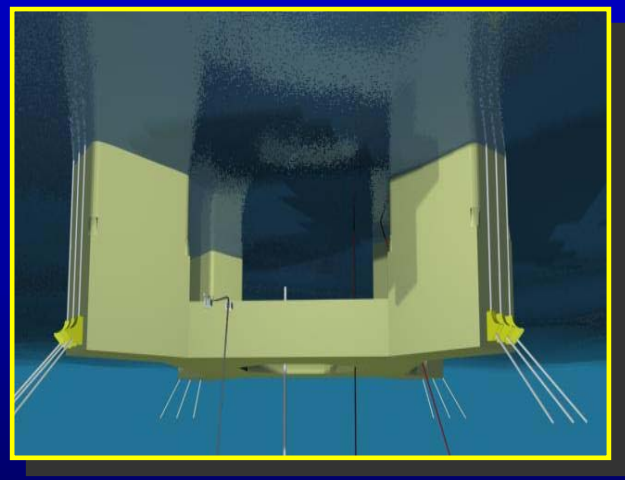


Mooring Options

Mooring Leg Options:

- Catenary leg moorings
- Semi-taut leg moorings
- Taut leg polyester mooring

Offsets Vert. Load



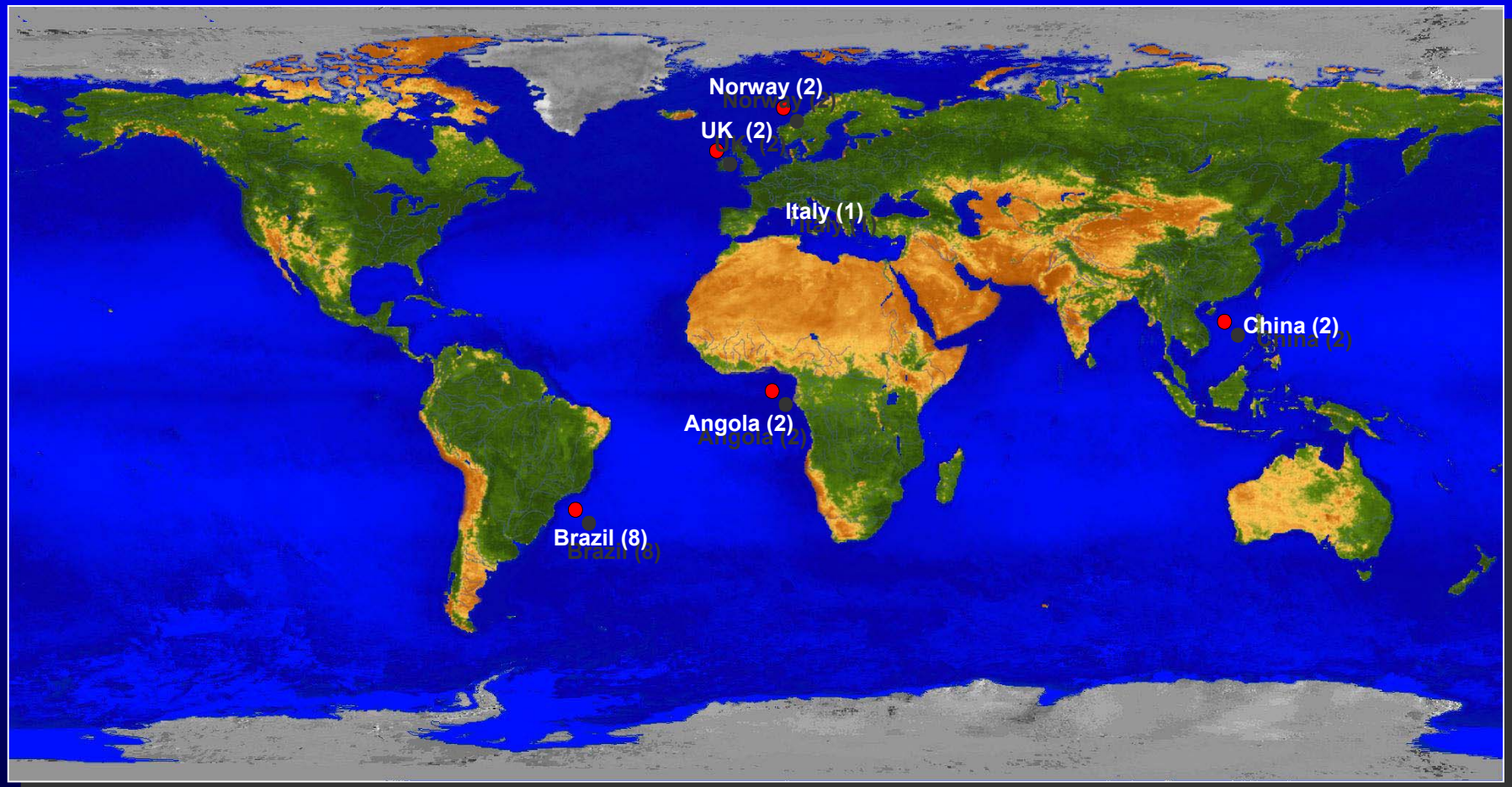
Foundation Options:

- Steel Driven Piles
- Suction Piles
- SEPLA
- VLA
- Drag Embedment

Uplift

Installed & Sanctioned FPSOs

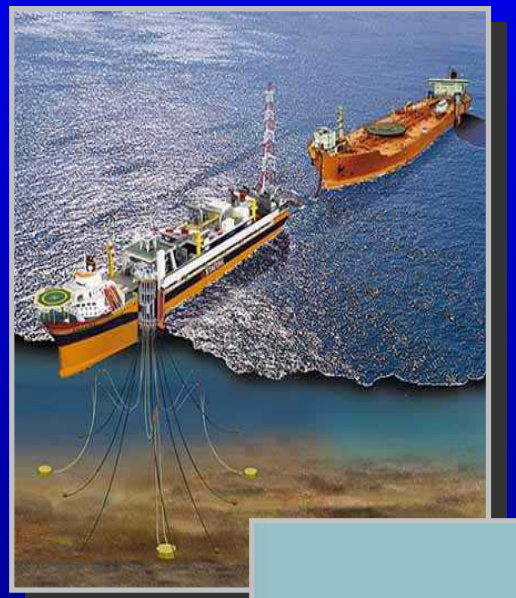
Water Depths > 300 m



Source: Aker Maritime's & Mustang Engineering 2001 Worldwide Survey of FPSOs; Aug, 2001 Issue of Offshore Magazine

Monohull Mooring Types

- **Internal Turret**
- External Turret
- Yoke System
- Spread moored



Monohull Mooring Types

- Internal Turret
- **External Turret**
- Yoke System
- Spread moored

Monohull Mooring Types

- Internal Turret
- External Turret
- **Yoke System**
- Spread moored

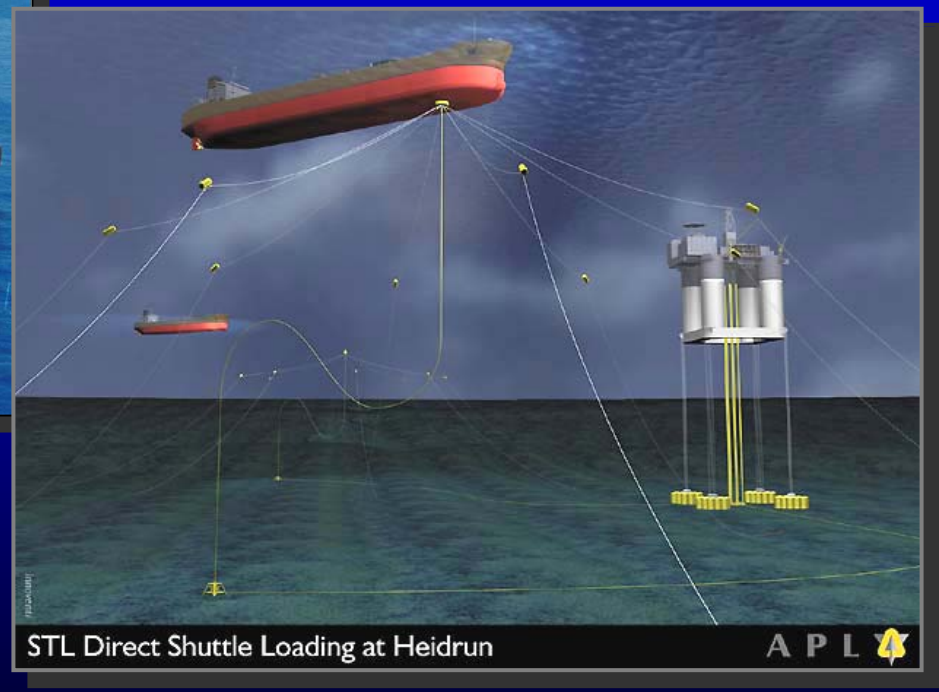
- Old style
- Not Applicable to deep water

Monohull Mooring Types

- Internal Turret
- External Turret
- Yoke System
- **Spread moored**

- Directional environment
- Offtake issues

Offtake



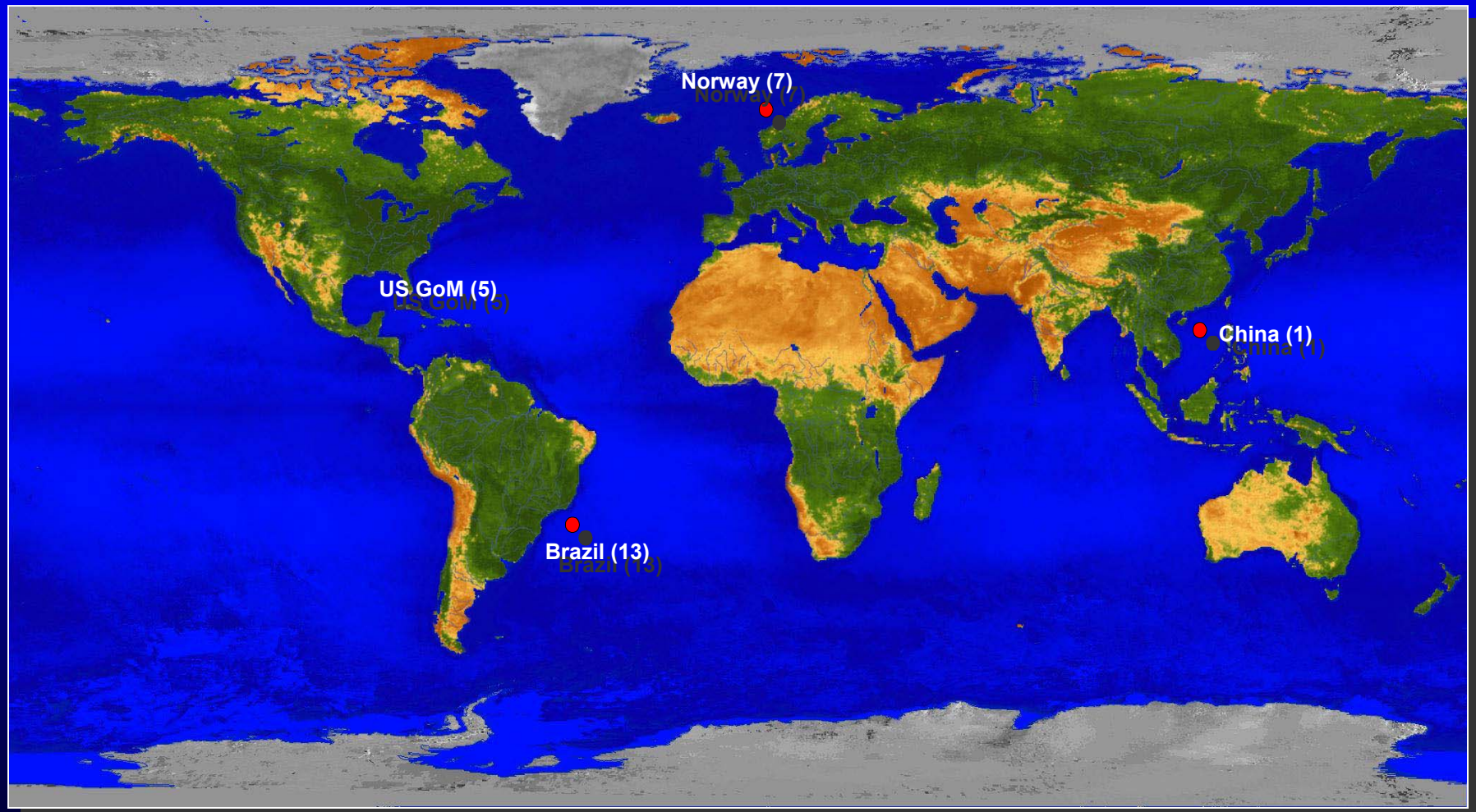
FPSO

- no oil export pipeline required
- Converted tankers, if used, can lower initial cost & schedule
- Available payload & deck area

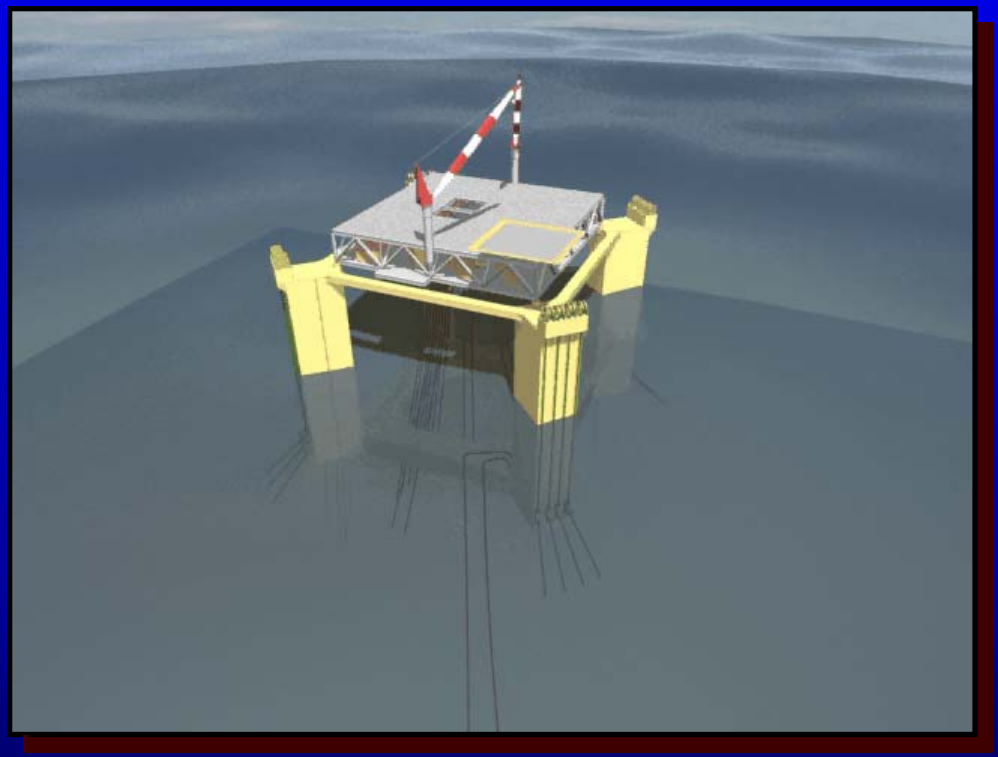
- Oil field use only (no advantage for gas field)
- Wet Tree – no direct well access
- Potentially high cost for well workover
- High turret/fluid swivel cost potential

Worldwide Installed & Sanctioned Semi - FPSs

Water Depths > 300 m



Semisubmersible FPU



- Hull steel weight equivalent to a TLP
- Deck can be pre-integrated inshore
- Installed with anchor handling vessels
- Hull motions generally acceptable for SCR risers.

CP Semi – New Generation Semi

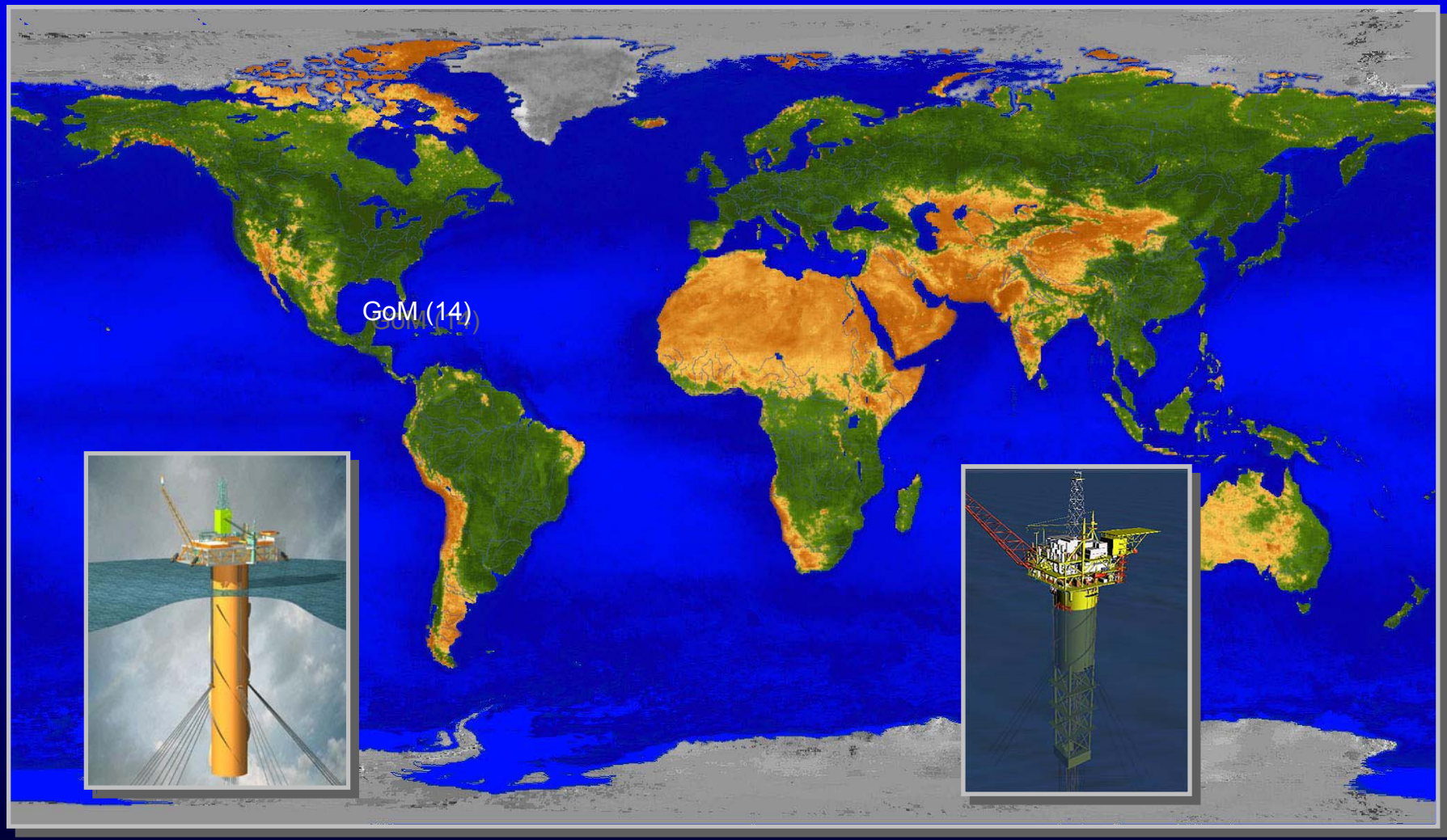
Semisubmersibles

- Low structure weight
- Catenary or Taut-Leg Spread moored
- Good motions, SCRs are possible
- Platform drilling or workover rig is possible
- Subsea trees with vertical access

- DVA risers w/dry trees unproven
- Large mooring footprint
- Pipeline offtake

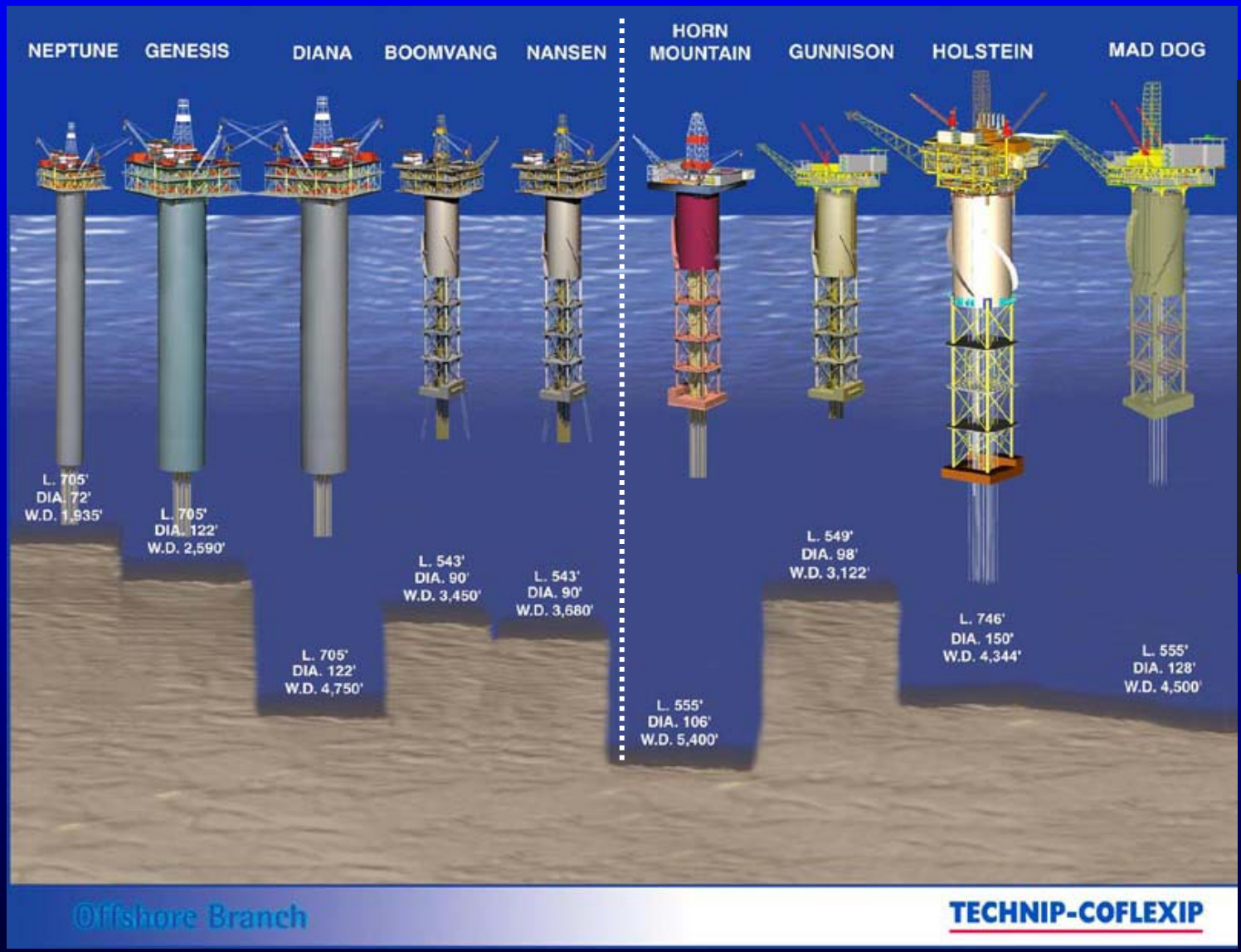
Installed & Sanctioned SPARs

Water Depths > 300 m

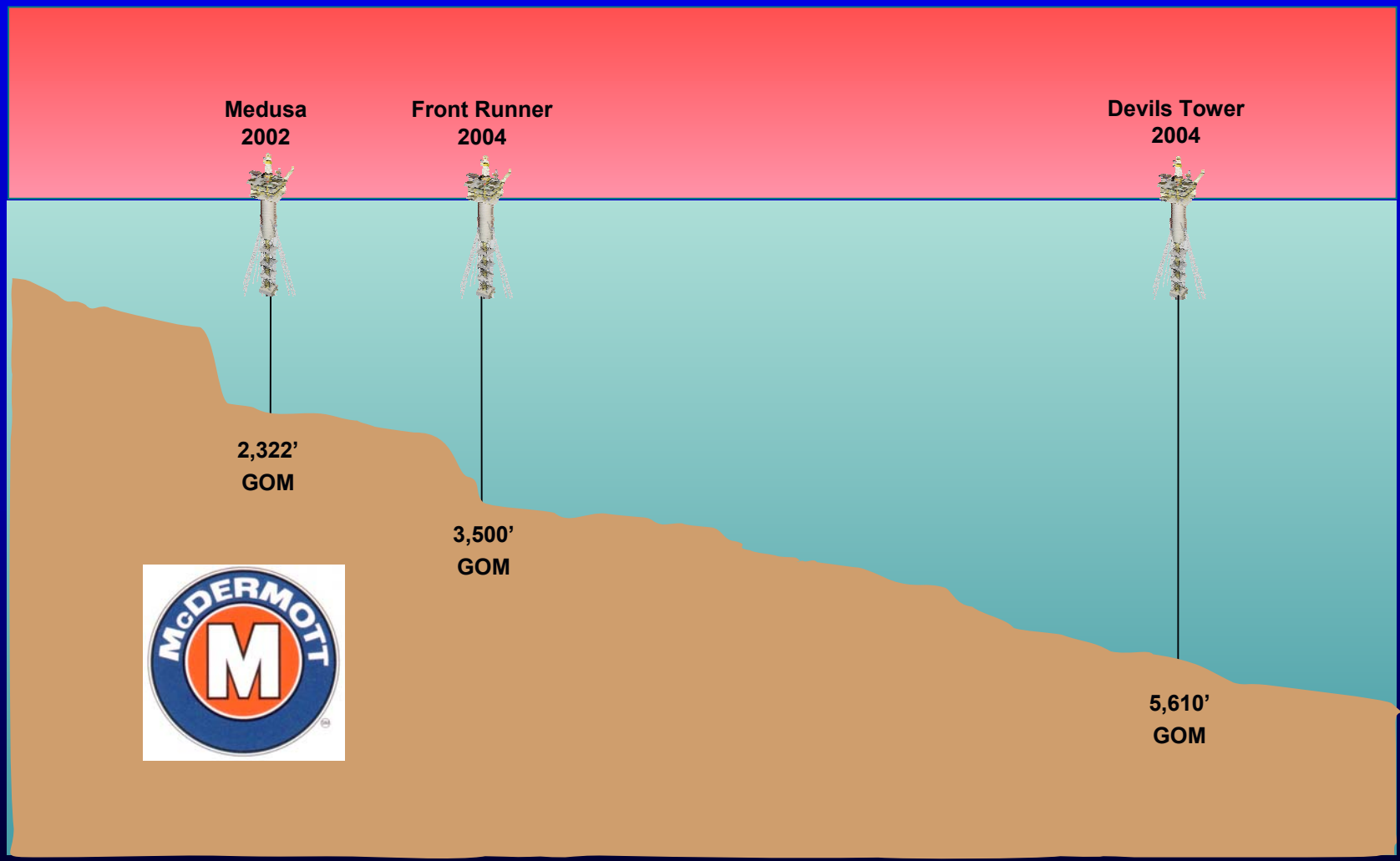


SPARS International

Technip

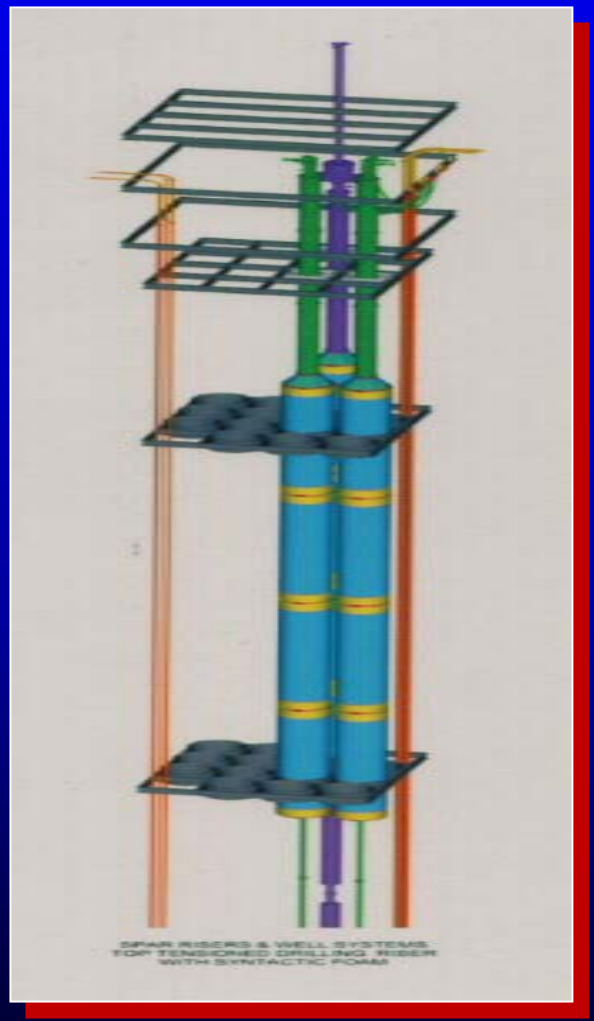


Spar Installations



Spar Installation

Air Can Risers



SPAR Production
Riser System

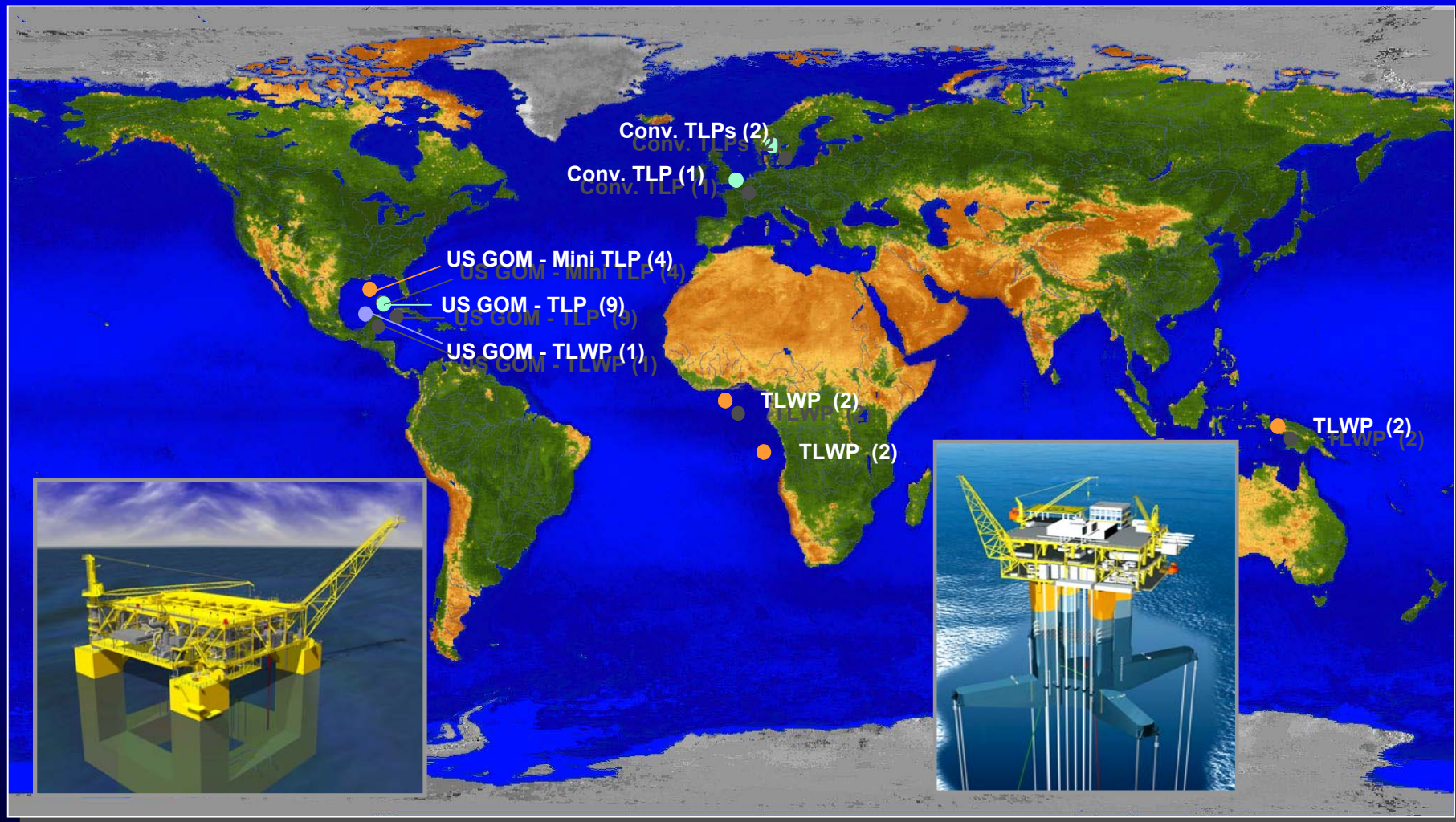
Spars

- Dry tree capable
- Low heave motions
- Catenary or taut leg moorings
- Low sensitivity to topsides weight

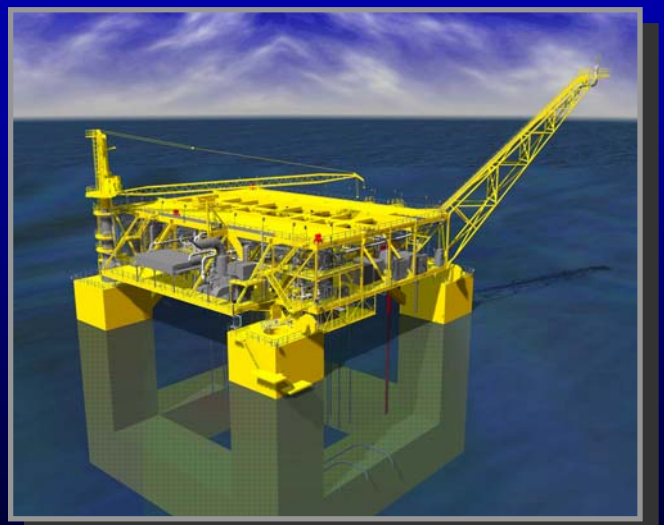
- Large structure weight
- Large seabed footprint
- Large lateral motions at deck and keel
- Hull VIM may cause fatigue of components (aircan, riser, mooring etc.)

Installed & Sanctioned TLPs

Water Depths > 300 m



Classic TLPs



Seno Field (1000m WD)

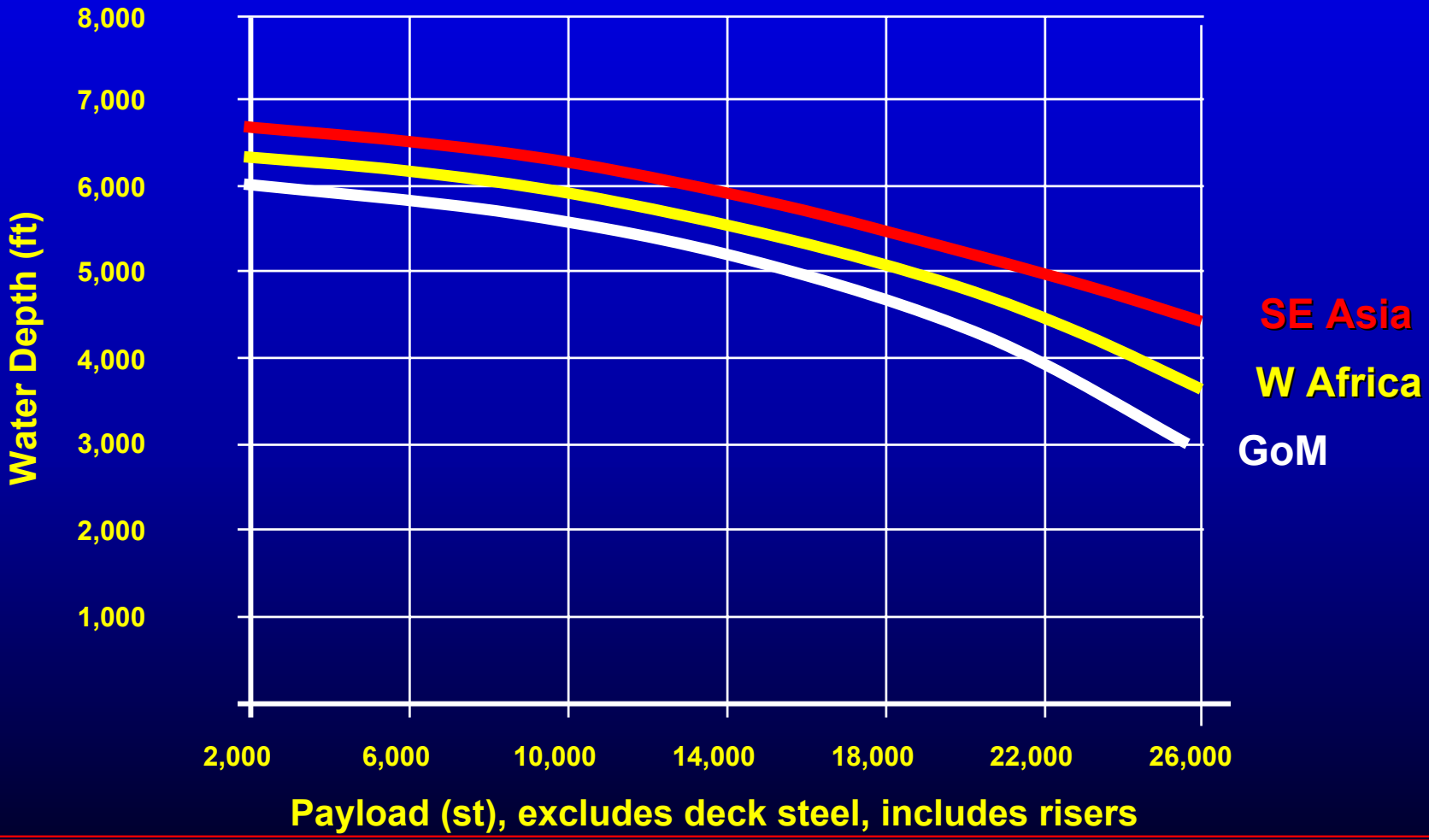
UNOCAL 76

MOSES New Generation TLP

Marco Polo TLP in 4300 ft Waterdepth

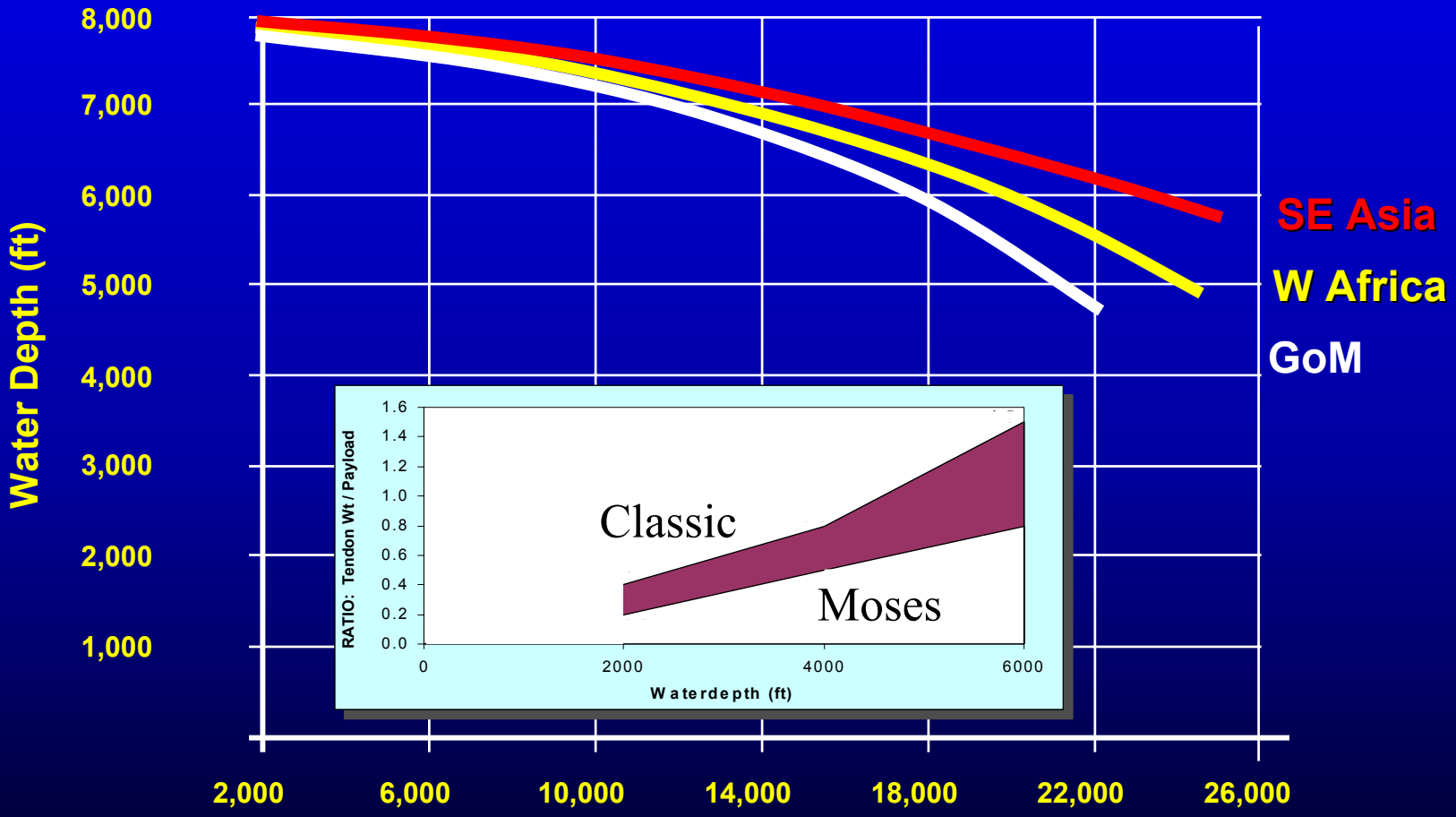
Steel Tendon Practical Depth Limits

Classic TLP



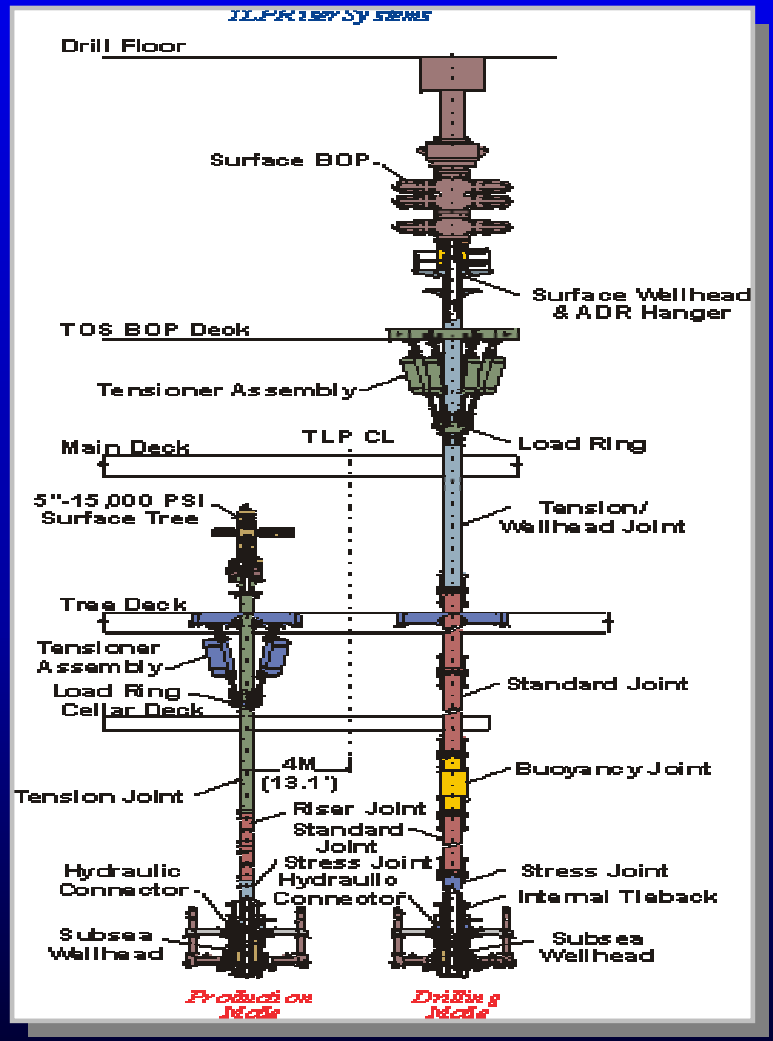
Steel Tendon Practical Depth Limits

New Generation TLP



Integrated TLP Tow out

Direct Tensioned Risers

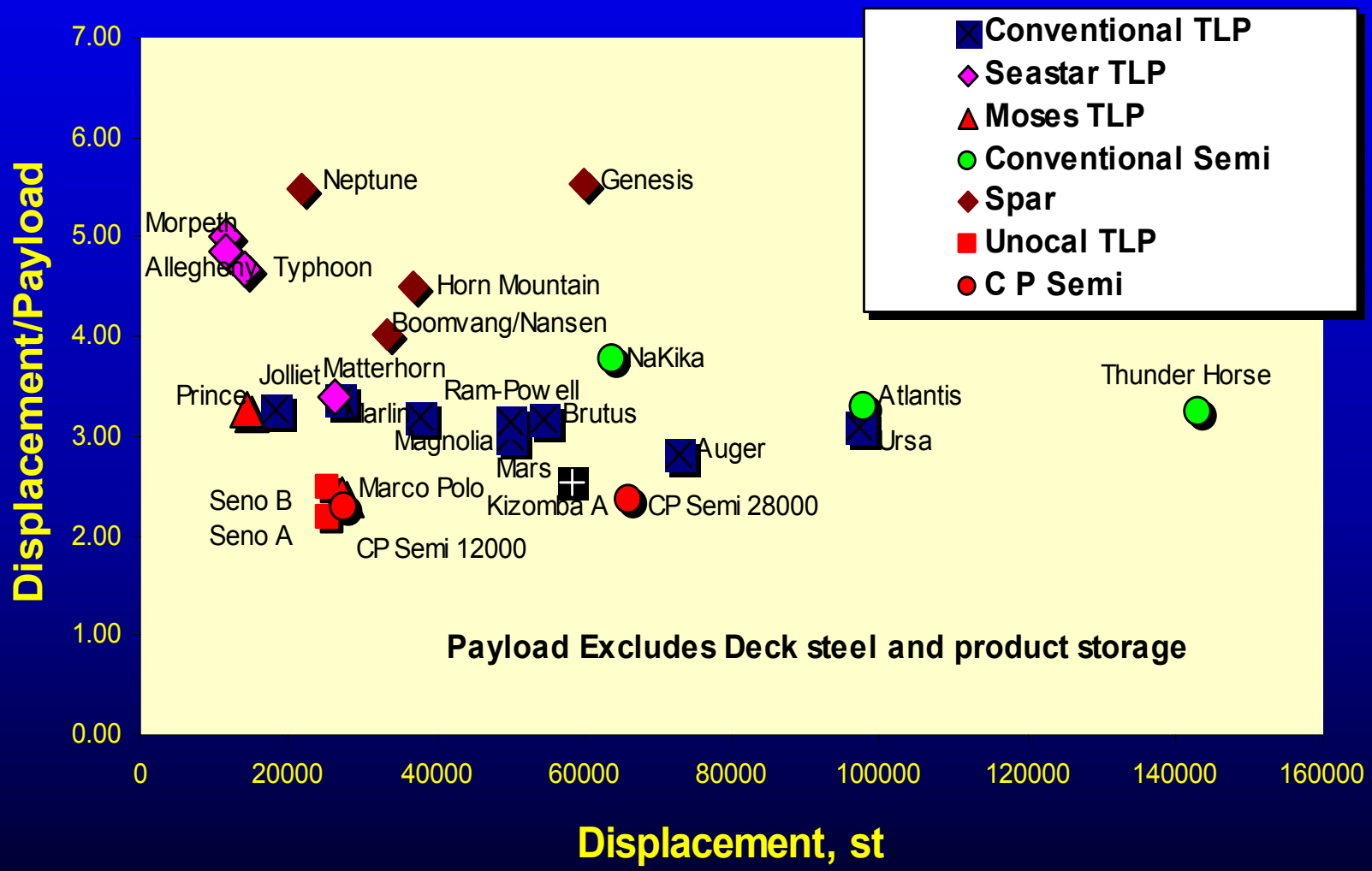


Tension Leg Platform

- Stable with minimal heave, roll and pitch motions
- Dry Tree capable
- Small seabed footprint
- Scalable to small fields
- Low structure weight
- Inshore integration

- No oil storage
- Sensitive to topsides weight
- Has water depth limit with steel tendons

Global Design Efficiency



Deepwater System Comparisons

SPAR

- Hull design less depth sensitive
- Riser aircans are weight sensitive
- Lower Payload Sensitivity of hull
- Simpler mooring system
- Simpler hull construction

TLP

- Simpler risers
- Less motions
- Lower Hull Weight
- Small seabed footprint
- Topsides can be integrated inshore

Deepwater System Comparisons

FPSO

- Used in area lacking pipeline infrastructure
- Oil storage and offtake capability
- Gas handling and offtake is an issue.
- SCR Risers are generally not feasible

Semi

- Used in areas with accessible infrastructure
- SCR Risers feasible
- Efficient hull weight
- Simpler Mooring system

Technical and Commercial Maturity

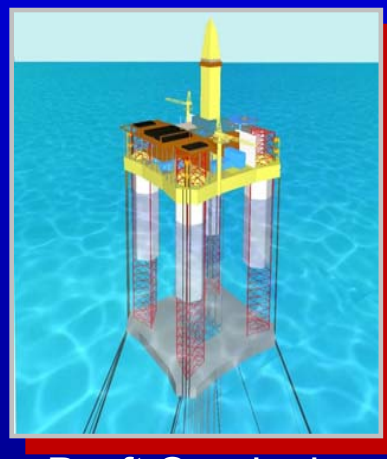
SYSTEM	TECHNICALLY MATURE	COMMERCIALLY MATURE
FPSO	Yes	Yes
Spar - Classic	Yes	No
Spar - Truss	Yes	No
Semi FPS	Yes	Yes
DD Semi	No	No
TLP	Yes	Yes

Deepwater FPU Design Challenges

- Efficient Hulls with good performance
- Reducing Installation costs & risks
- Deepwater mooring designs
- DVA riser designs
- Deep currents & VIV of risers and tendons
- Reduce drilling costs
- Non-linear hydrodynamics – VIM, run up, free surface effects, higher order loads
- Model Testing scale effects and mooring truncation effects

Emerging Deepwater Production Solutions

FDPSOs



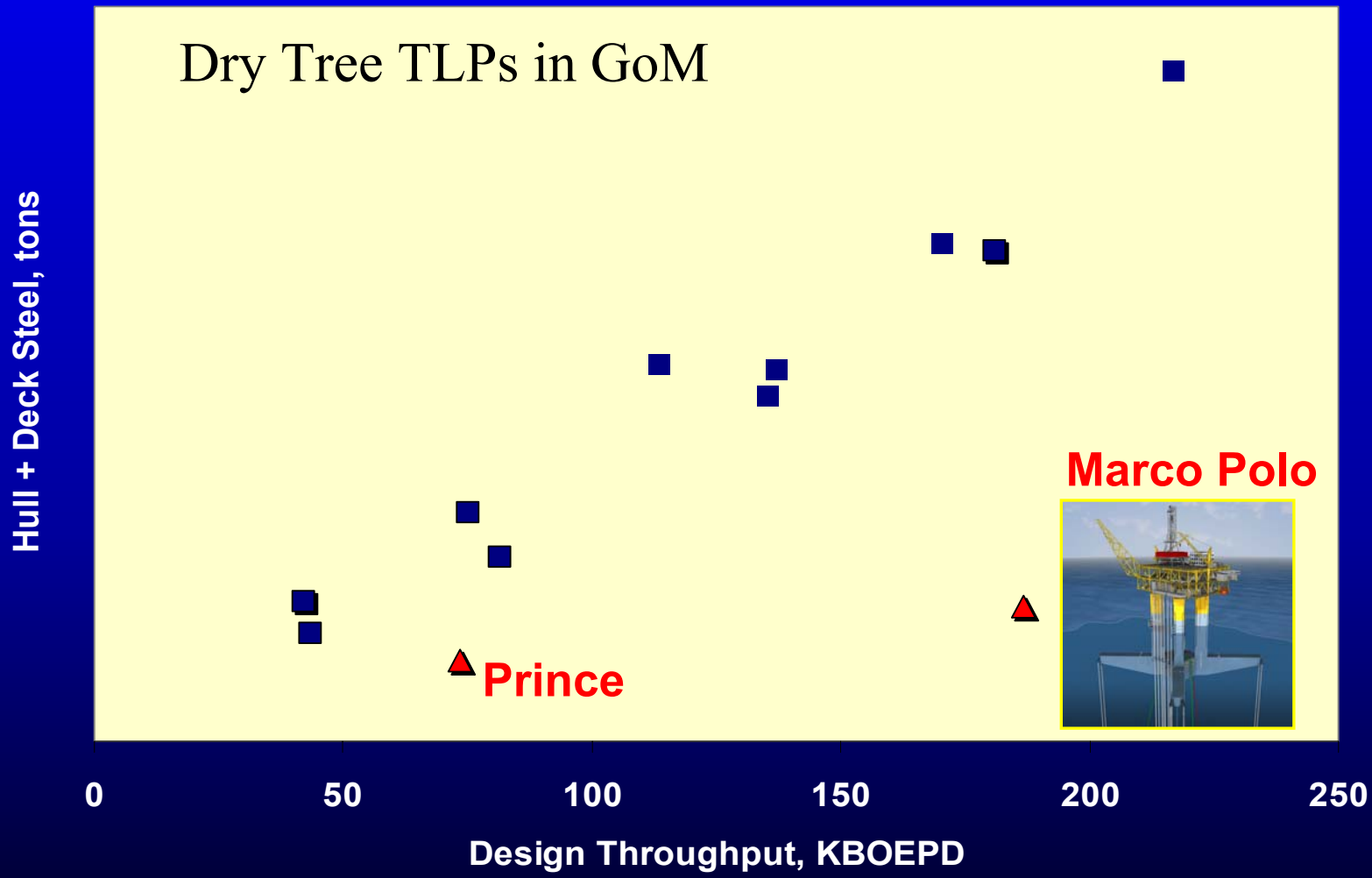
Deep Draft Semisubmersibles

Floating LNG

FPU Technology Direction

- Ultra-deep water
- New Generation efficient hulls
- Improved lightweight topsides
- Tender Assisted Drilling (TAD)
- Improved moorings and foundations
- Improved risers
- More efficient platform installation methods

New Generation Hulls + Lightweight Topsides



Summary

- SPARS, proven to 6000’ and TLPs, proven to 5000’ dominate deepwater in GOM.
- SPAR w/dry trees can be extended to 10,000 ft water depth; riser and mooring systems are a challenge.
- Semis and FPSO w/wet trees can be extended to 10,000 ft waterdepth; mooring system is a challenge.
- Development of emerging tendon technology is required to extend TLP beyond 7500 ft water depth.
- Costs and schedule for deepwater floating systems are market driven.
- “Best System” dependent on water depth, field size, existing infrastructure, market conditions, and reservoir characteristics