4th INTERNATIONAL SHIP DESIGN AND NAVAL ENGINEERING CONGRESS

Naval technologies for the development of Offshore Industries

Jorge E Trujillo

Gerente de Perforación

Anadarko Colombia Company

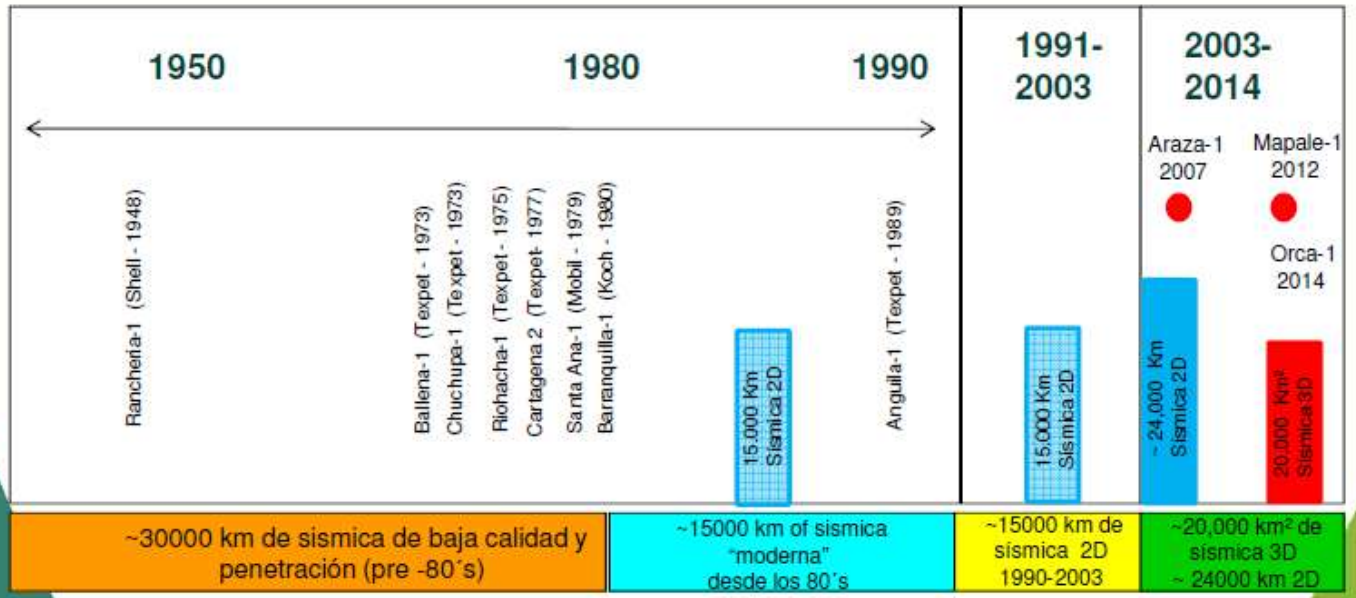
13 de Marzo del 2015

Introduction - Anadarko International Deepwater Drilling

Offshore Colombia

Offshore Colombia como Cuenca Frontera

- ~ 40 pozos A3
- 3 descubrimientos comerciales de los 70´s (Chuchupa, Ballena y Riohacha onshore)
- 2 Descubrimientos no comerciales (Santa Ana, Cartagena)

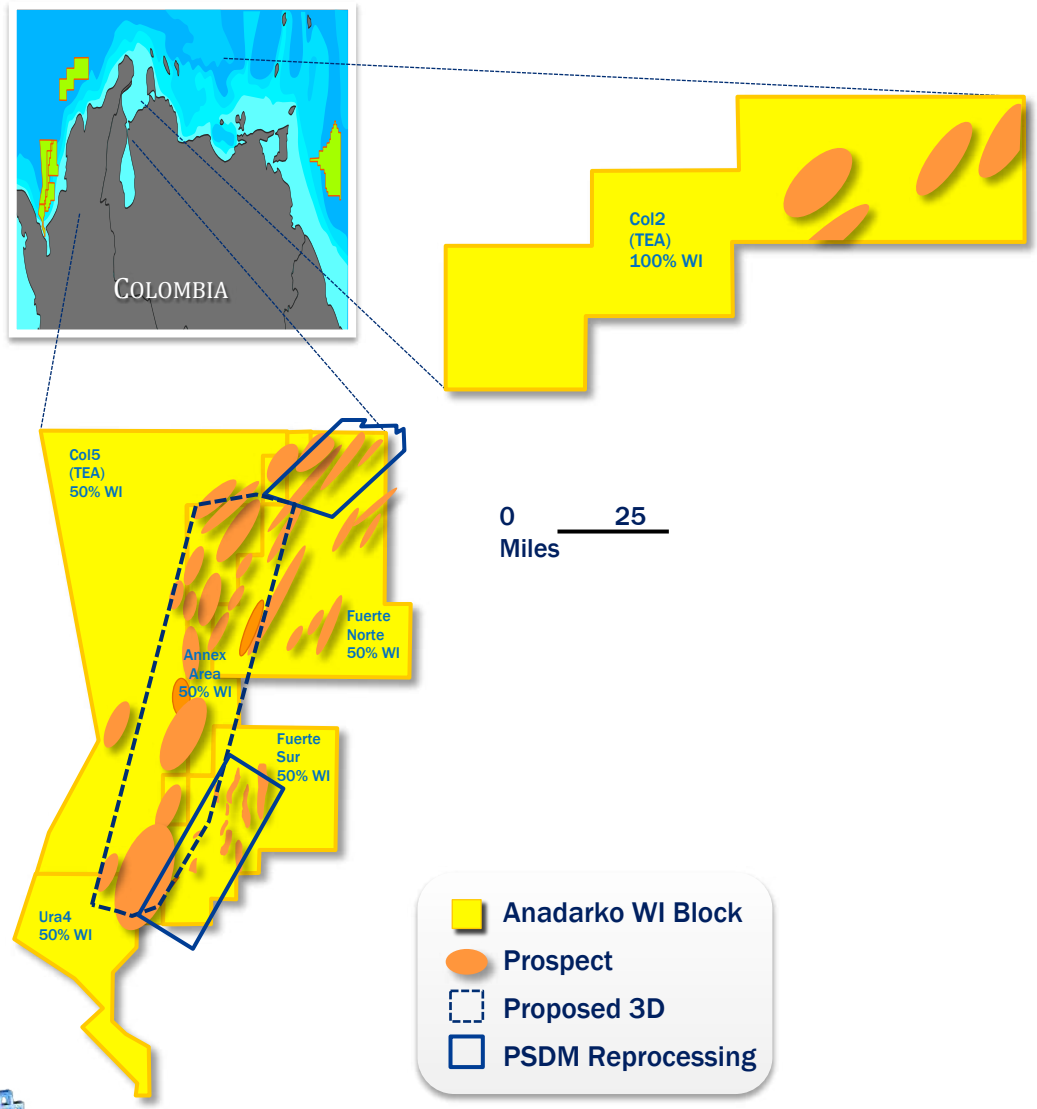


Ecopetrol

Colombia Offshore

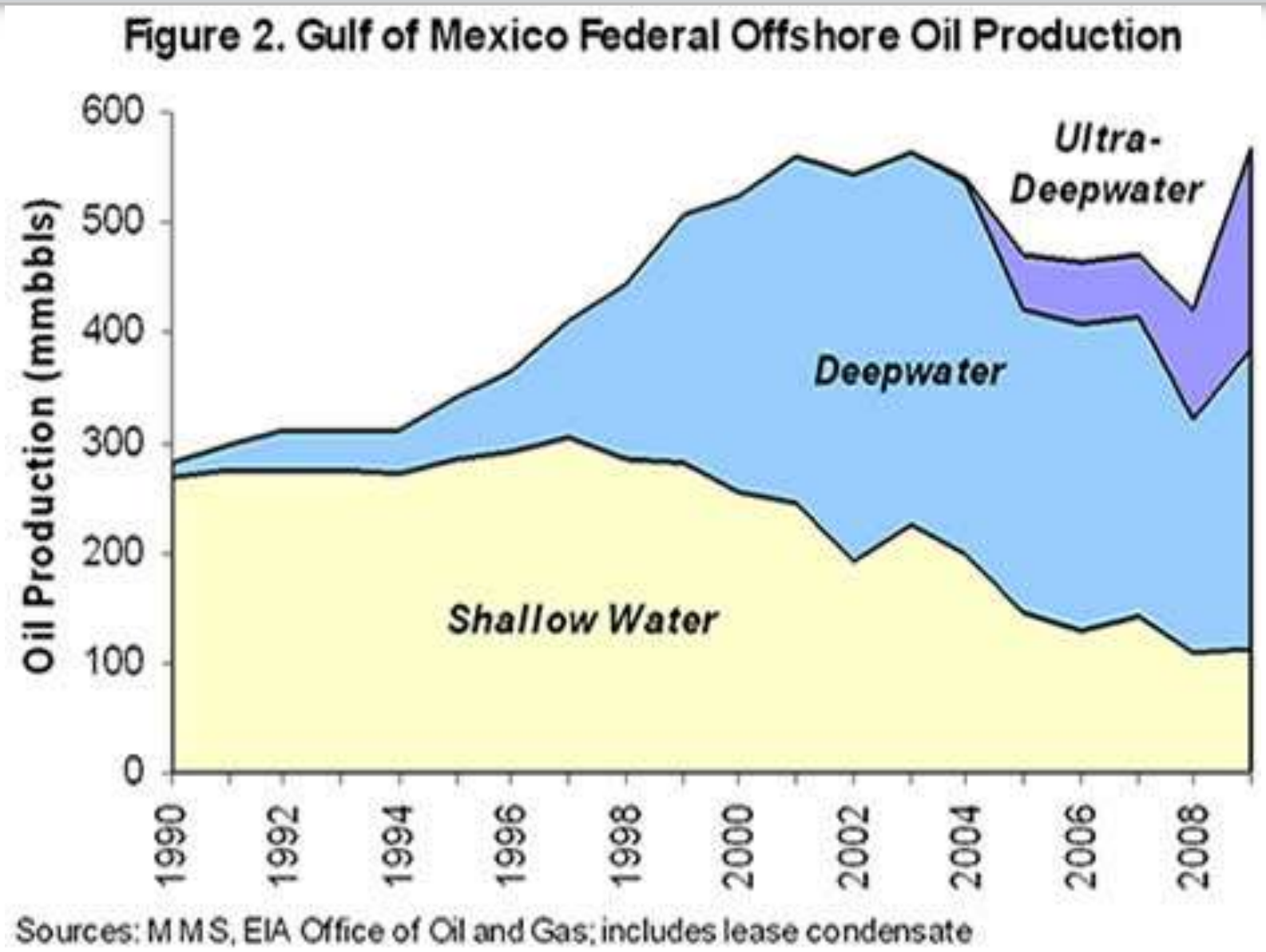
Colombia : New Entry, Exciting New Opportunity Set

~7.5 MM Gross Acres



- Large, Untested Basin with Known Oil-Prone Source Rock
- Basin-Floor Fans Similar to Mozambique
- Captured Entire Play Concept
- Numerous Targets Identified on Existing Seismic Data
- Acquiring 3D Seismic to Solidify 2014 Drilling Plans

Deepwater Market – Building on Success



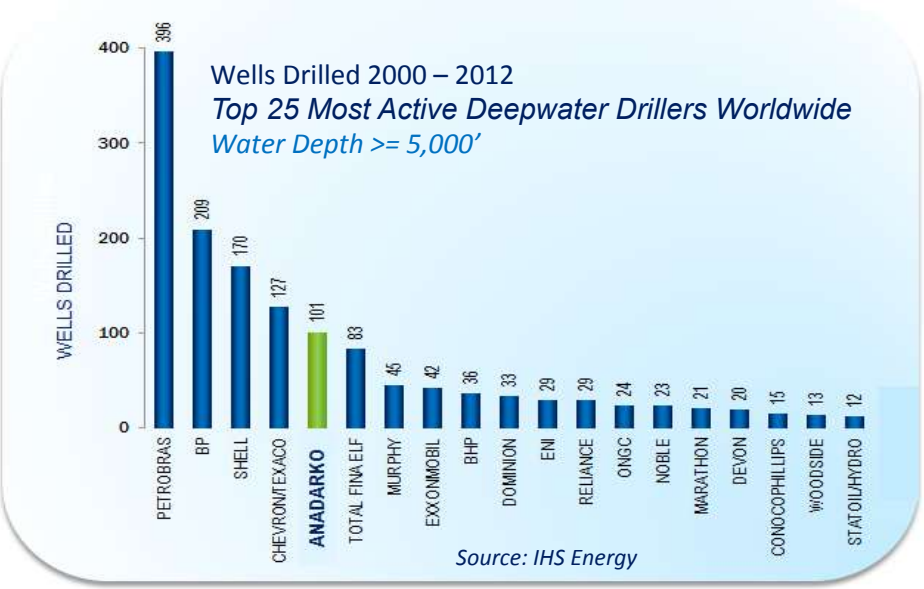
Global Deepwater Drilling

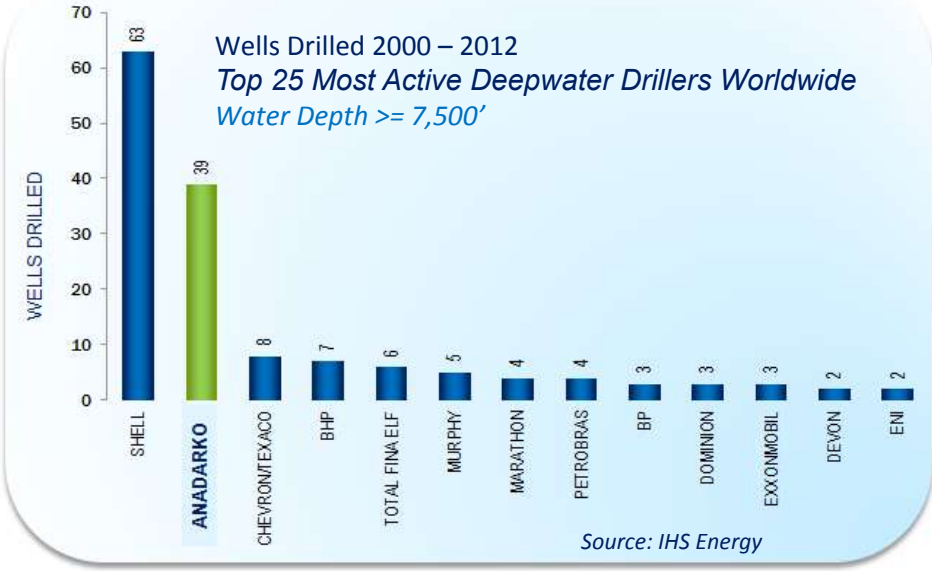
Anadarko Experience

- 29 Total Years of Ultra Deepwater Rig Time Under Contract
- Top Two Ultra Deepwater Drillers Worldwide
- Top Five Deepwater Drillers Worldwide

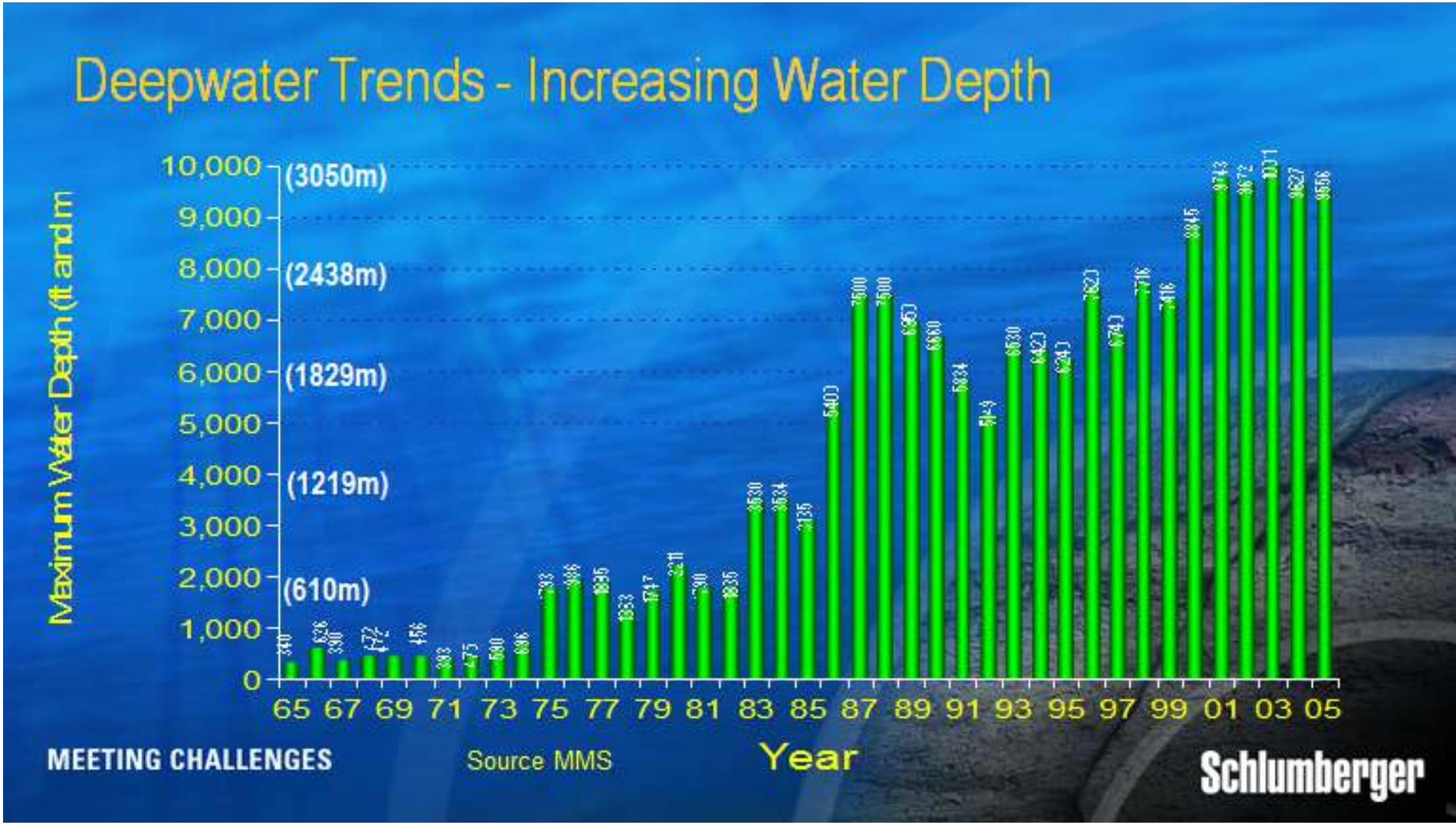
Anadarko Investment

- 11 Long-Term Contracts for DW and UDW Rigs
- Five Newbuild UDW Drillships Slated for Delivery Thru 2014
- Industry Average Int'l Spread Cost is ~U.S. $1.0 – $1.3 Million/Day





Deepwater Trends - Increasing Water Depth

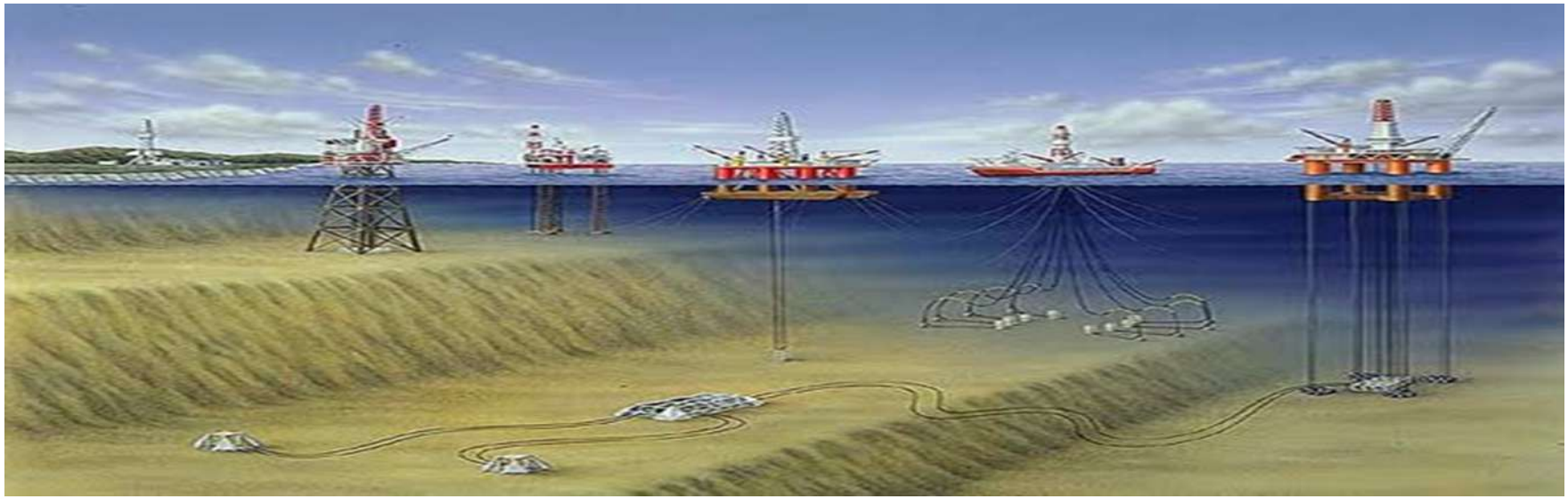


What does the Offshore Industry do?

- Search for and recover crude oil and natural gas.
- Separate, treat and transport oil and gas to onshore for further processing
- Processing is done:
  - Subsea,
  - Fixed platforms
  - Floating platforms - Spars, Semi-Submersibles, Tension Leg Platforms (TLP) or Floating, Production, Storage and Offloading facilities (FPSO)

TYPES OF Mobile Offshore Drilling Units (MODU)

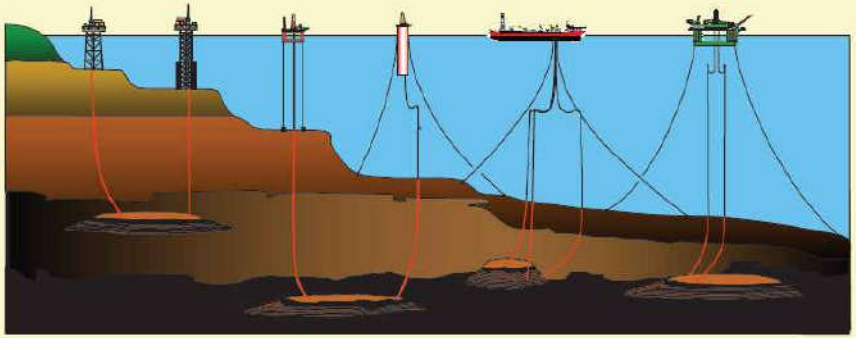
Rig Type	Water Depth Rating	Drilled Depth Rating	Drawworks HorsePower	Accomodations	Variable Deck Load	Dimensions
Drill Ship	3650m	12190m	≤5750	≤210	≤25000t	≤255m length
SemiSub	3000m	11430m	≤7000	≤180	≤7716t	≤107mx92m
Jackup	190m	10668m	≤3000	≤150	≤5590t	≤107mx49m
Land		12190m	≤3000			



What is deepwater?

Evolving Deepwater Definition

- MMS Definition
  - 1,000 feet to 5,000 feet is Deepwater
  - Above 5,000 feet is Ultra-Deepwater
- Other Definition
  - 500 meters to 1500 meters is Deepwater
  - 1500 meters and above is Ultra-Deepwater



Focused on Platforms

- Drillers Definition- above 3,000 feet

OTC 2005 Sandeep Khurana, P.E. 5

MODU evolution for deepwater

1000’

5000’

300 m
(980 ft)

1000 m
(3280 ft)

2100 m
(6880 ft)

3052 m
(10011 ft)

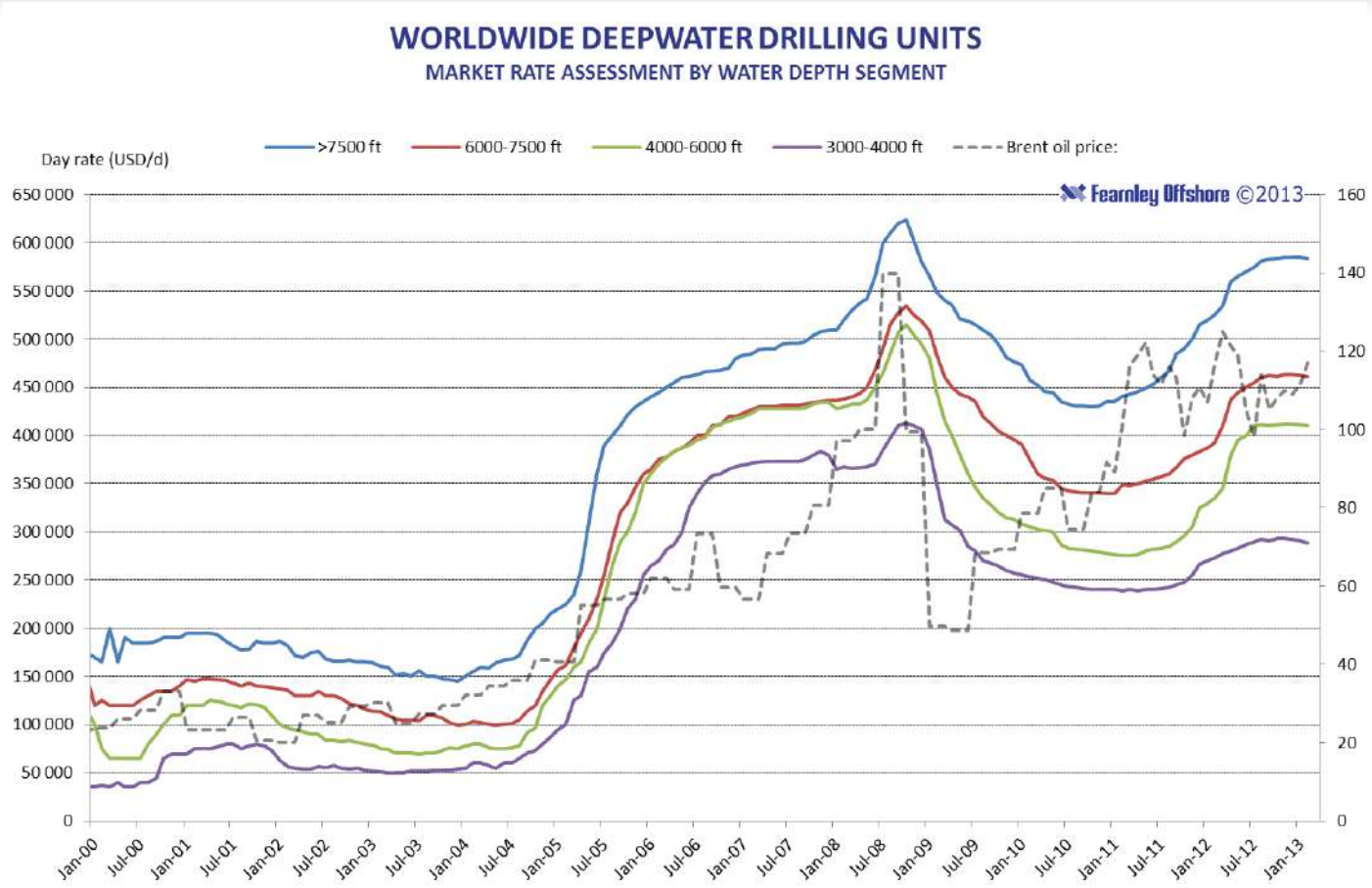
2nd. Gen
3rd. Gen
4th. Gen Semi
4th. Gen BP
5th. Gen Semi
5th. Gen DP
6th. Gen DP

Transocean Richardson
Transocean Seven Seas
Deepwater Nautilus
Enterprise Class
Drillships and semi’s

$$$$

Courtesy of Transocean

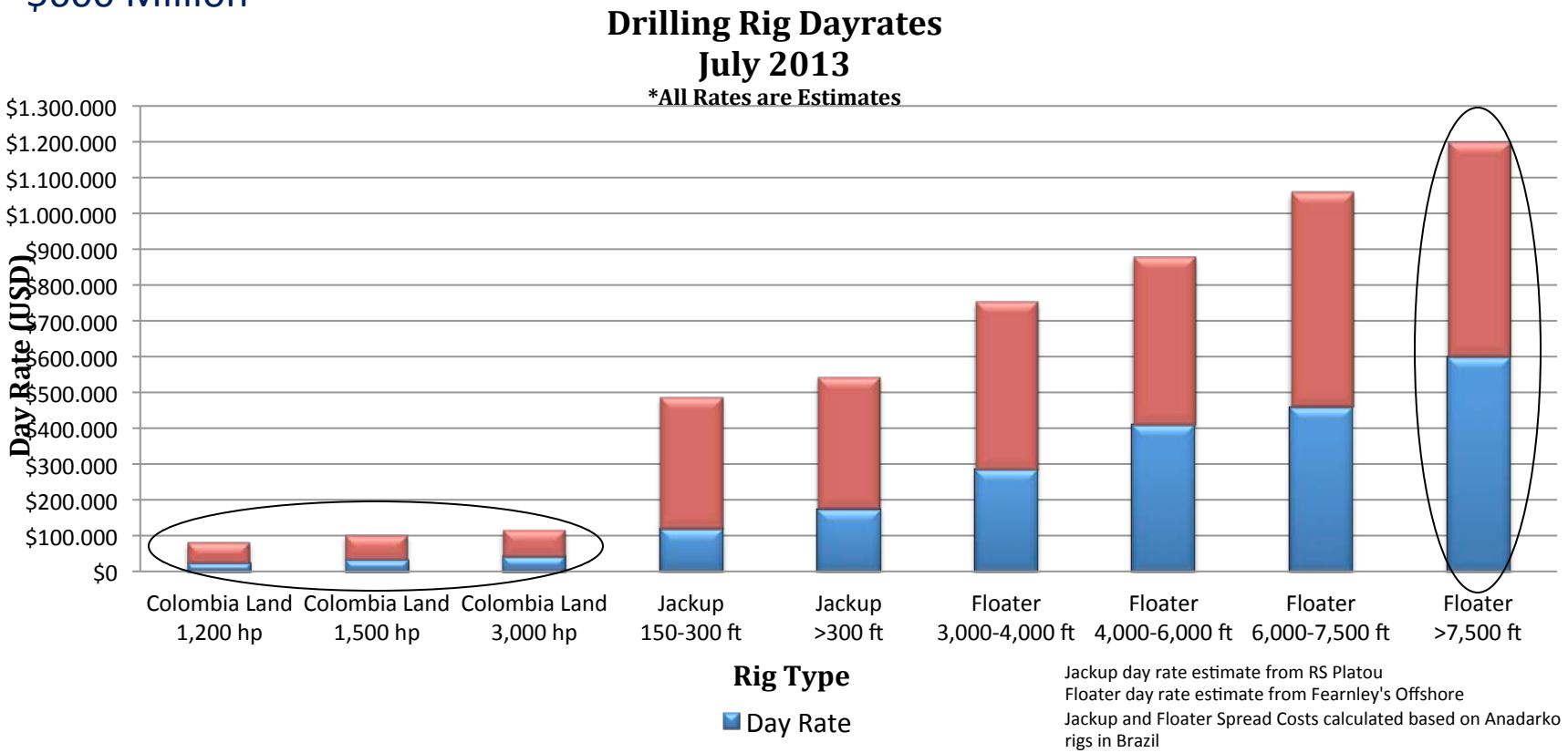
Ultra Deepwater Market



- Short term flattening of dayrates (~ $575MM - $625MM) location specific
- Increasing gap between standard DW and Ultra DW rigs
- Most drilling contractors looking for minimum 3-year term

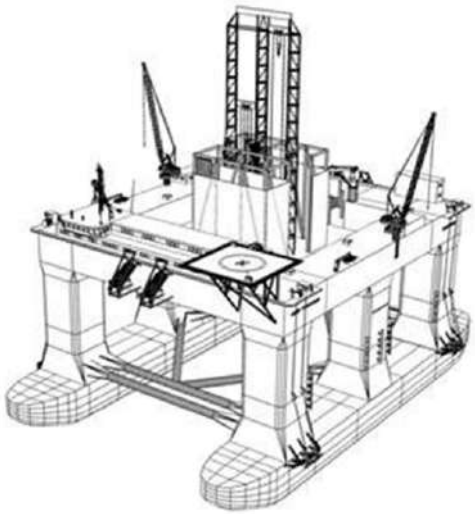
Ultra Deepwater Market

- UDW Market Spread Cost (per day) is ~10 times greater than Onshore Market
- Commitment time for UDW drilling vessel is usually over 18 months in advance
- Minimum term for UDW drilling vessel is usually 3 years (rig farmouts occur in certain markets for short programs – Note: 3 year term commitment is likely to be over US $600 Million



TYPES OF Mobile Offshore Drilling Units (MODU)

- **Bottom Supported MODU**
  - *Jack-up*
  - *Submersible*
  - *Maximum water depth ±190m for Ultra-Premium Jackups*
- **Floating MODU**
  - *Semi-submersible*
  - *Drill ship*
  - *Either can be moored (anchored) or dynamically positioned (DP)*
  - *Water depths to 4,000m*



Key Elements

- **Self-contained for extended periods**
- **Includes drilling package, cranes, material storage, crew accommodations, heliport, power generation**
- **Requires Vessel Support to Supply**

TYPES OF MODU - JACKUP

Bottom Supported MODU - Jackup

- Towed to location with barge afloat
- Movable legs lowered to seafloor
- Pre-load required prior to "jacking up" into position
  - *Reduce the risk of "punch through"*
- Barge is raised out of water by jacking against the legs
- Provides very stable platform
  - *No Movement in Work Platform*
- Drilling depths to 12,000m
- Maximum water depth ±190m

TYPES OF MODU – Floating Rigs

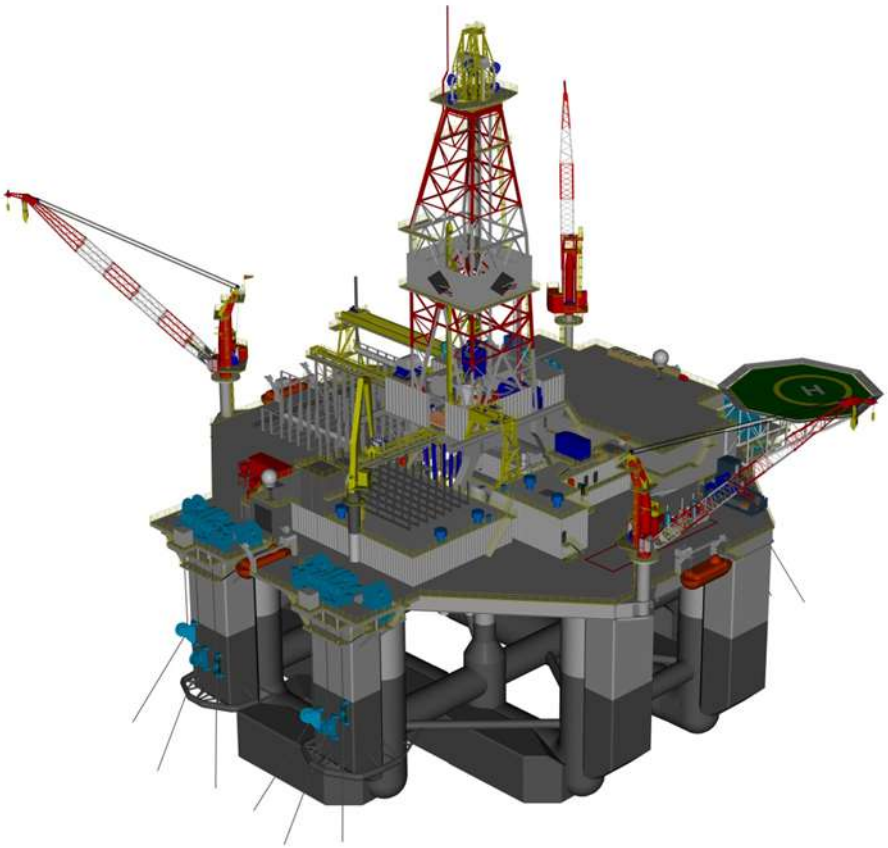
- **In water depths >190m, bottom supported rigs become impractical for exploration wells**
- **Floating MODU types**
  - *Semi-submersible barge*
  - *Drill ship*
- **Either Floating type can be moored (anchored) or dynamically positioned (DP)**
- **Additional equipment is required to accommodate vessel movement (heave, pitch, roll)**
  - *Motion compensation system*
  - *Subsea blowout preventers (BOP) & Controls*
  - *Marine riser system*
  - *Remotely operated vehicle (ROV)*

TYPES OF MODU – Moored vs. DP

- **Moored - practical water depth limit ±1,500m**
  - *Material storage typically limited by buoyancy & deck space – circa 4,000 MT*
  - *Weight & storage volume of mooring wire/chain consume increasing amount of rig's available capacity*
- **DP - practical water depth limit ±3,658m**
  - *Ship shape designs have much more deck/hold area than semisubmersibles*
  - *Load capacity often exceeds 20,000 MT for late generation drill ships*
  - *Limiting factor is ability to hold top tension on marine riser*
  - *Seafloor transponders & GPS used to maintain position*
  - *Higher fuel usage due to significant power required to operate thrusters 24hr/day*

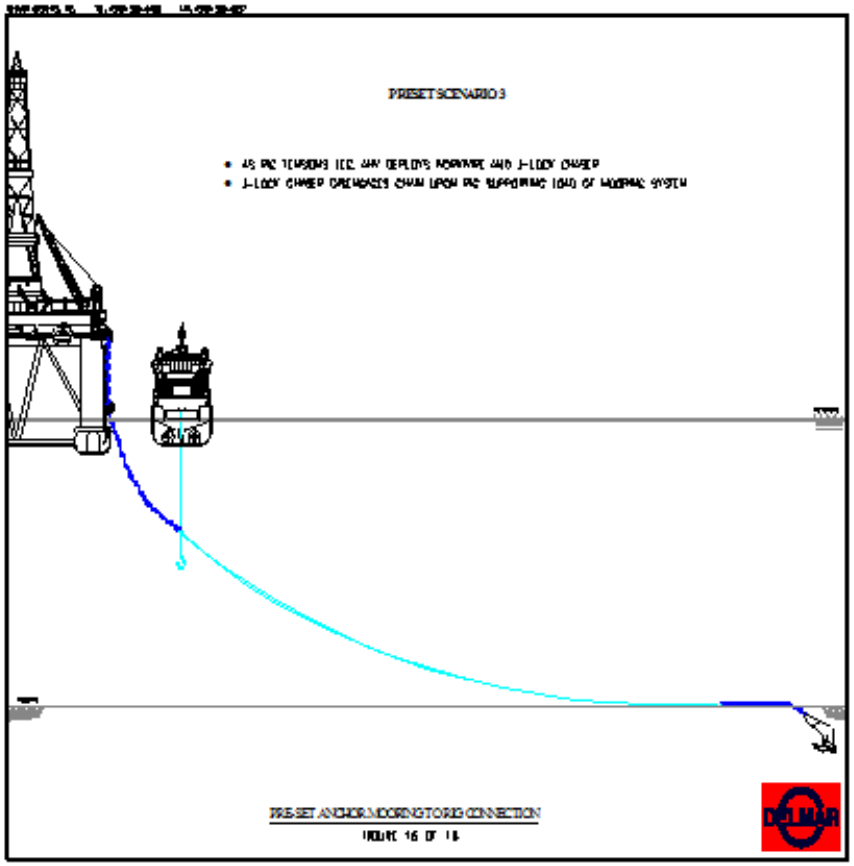
TYPES OF MODU - Moored Semi-submersible

- **Towed to drill site at shallow draft**
- **At drill site, mooring system is deployed (utilizing AHV), and the MODU held in place w/ anchor & chain**
- **After mooring, hull is ballasted down to provide stability (lower COG)**
- **Better motion characteristics than early drill ship**
  - *Smaller water plane profile & lower center of gravity minimizes vessel motion*



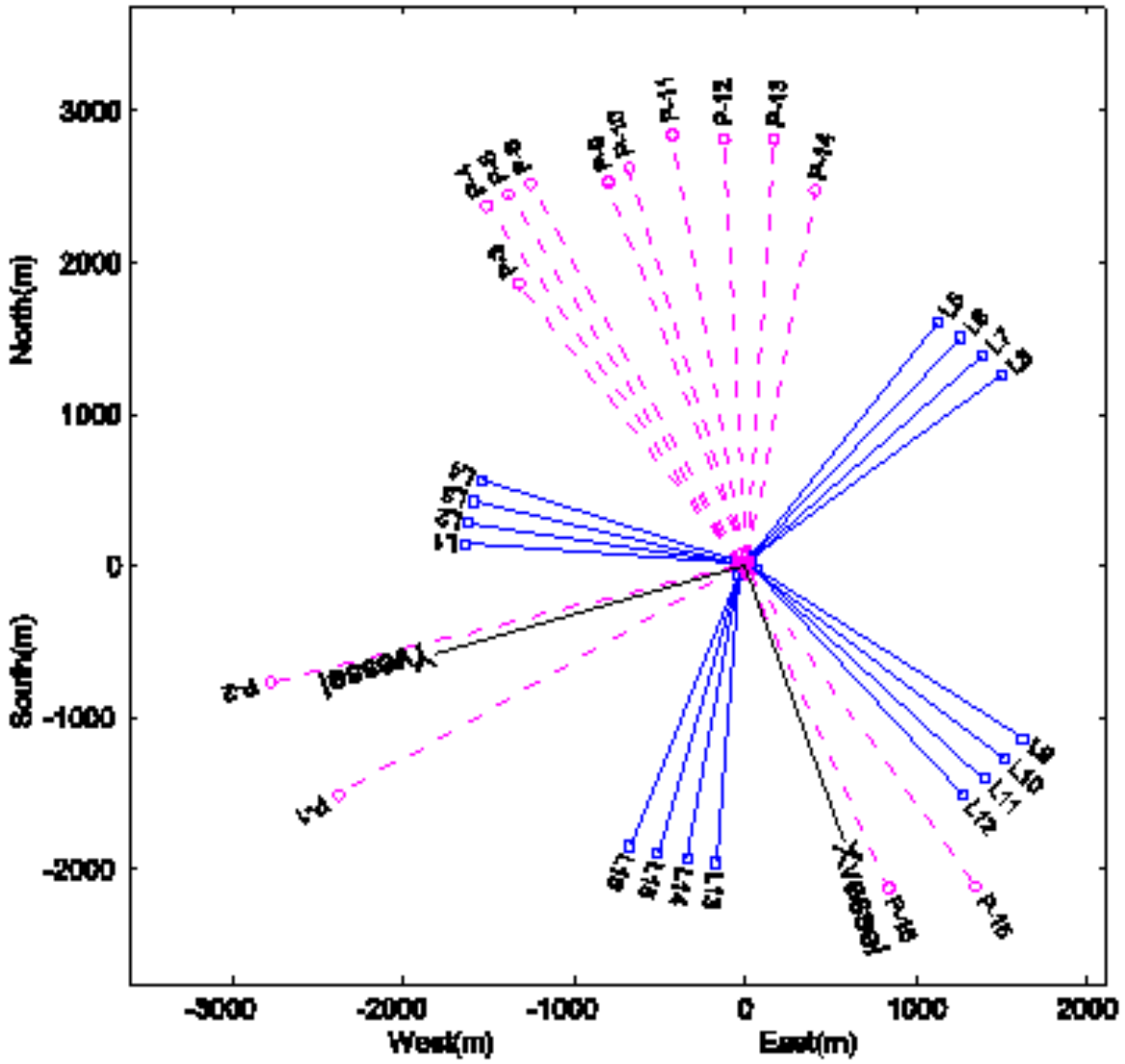
TYPES OF MODU - Mooring Operations

- Mooring/de-mooring can occupy 6-8 days
- Anchor setting complicated by too soft, too hard, or uneven seafloor
- Requires very specialized, high HP vessels, winches & crews to safely place anchors in desired pattern



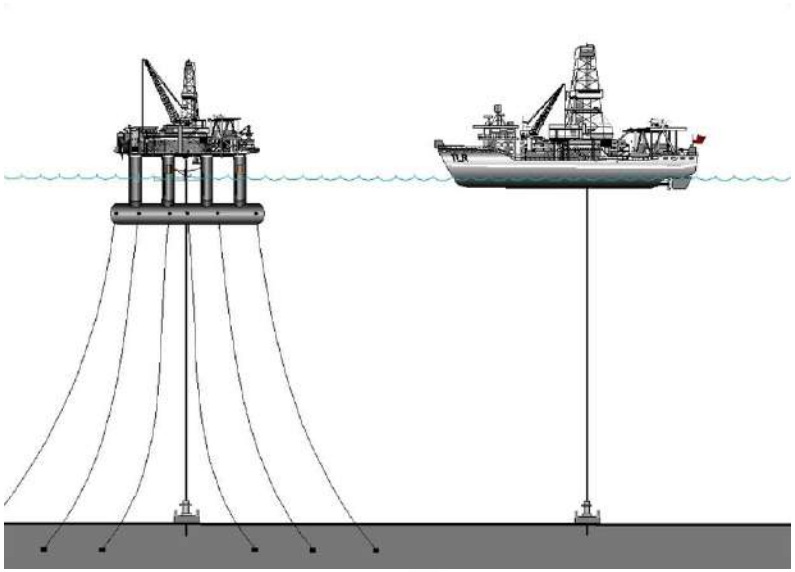
Anchor Handling Boat

Taut Mooring Patter Example – lines are 35° off vertical

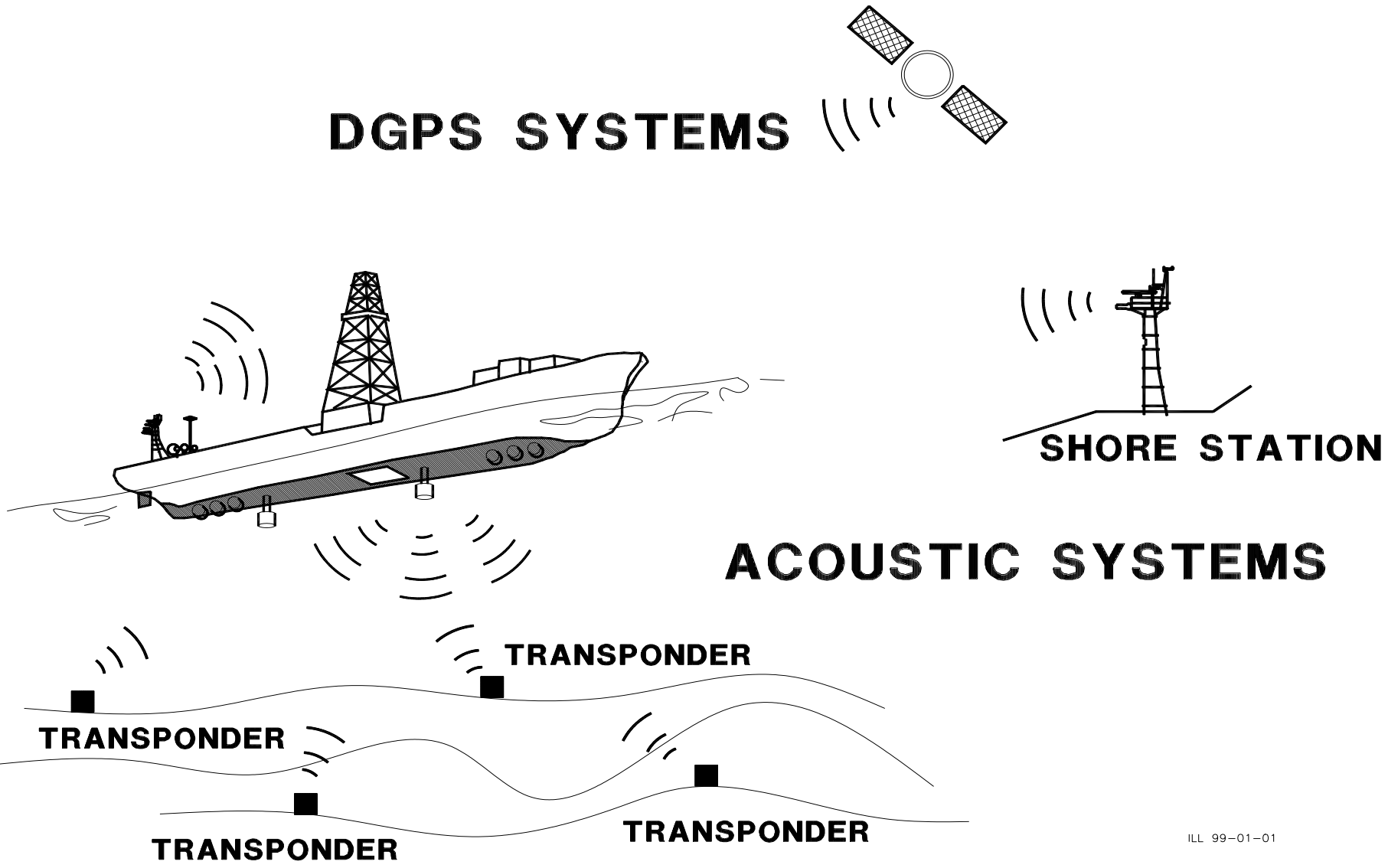


TYPES OF MODU - Dynamically Positioned Drill Ship

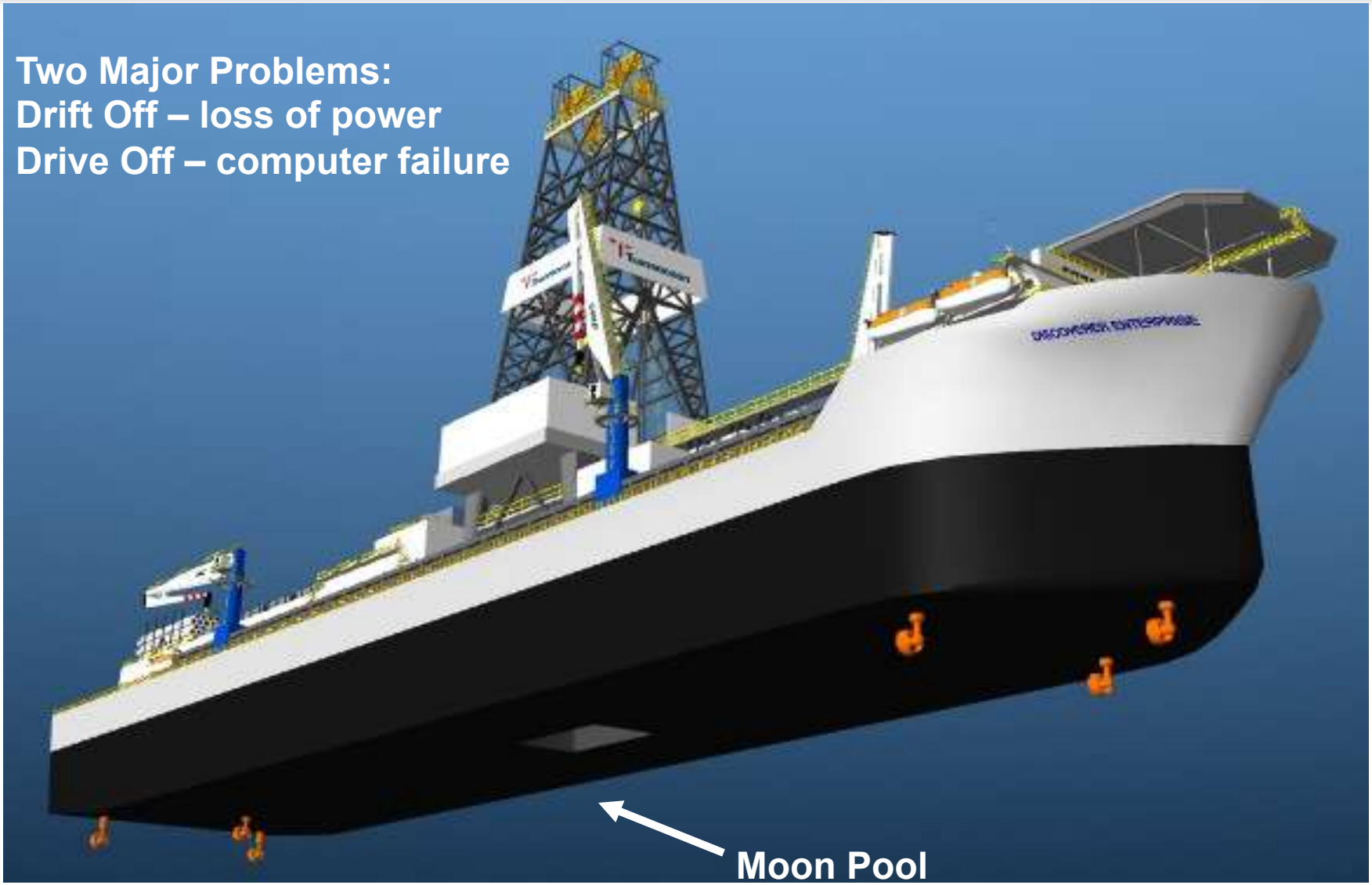
- Vessel sails to site under its own power
- Vessel remains on station using 'dynamic positioning' (DP)
- DP set up much faster than mooring (6-18hr vs 6 days)
- DP set up much faster to retrieve transponders than mooring (24 hrs vs 6 days)
- Higher fuel usage due to significant power required to operate thrusters 24hr/day



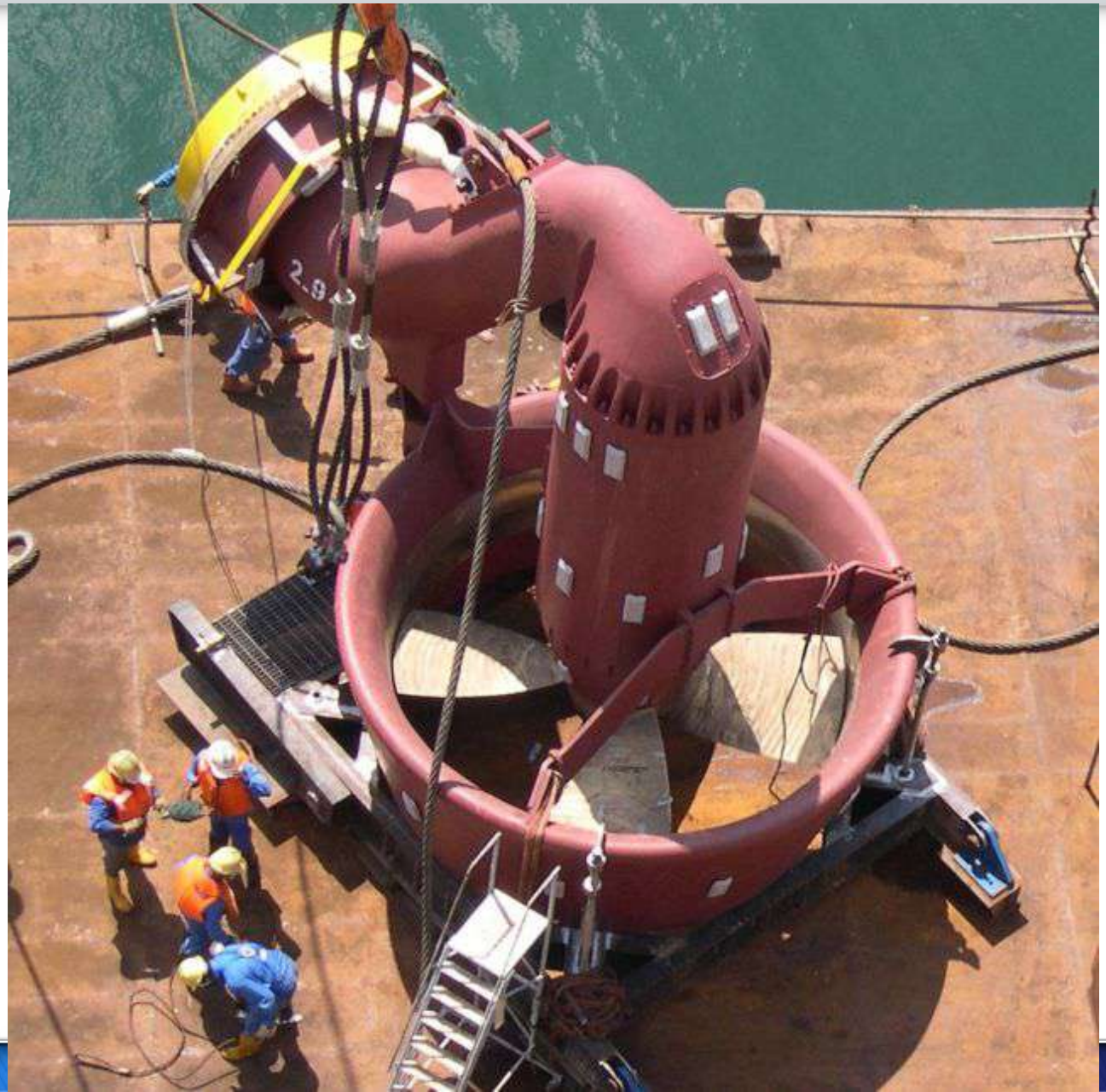
TYPES OF MODU - Dynamically Positioned Drill Ship



Computers drive thrusters to hold/keep the rig over the well



Thruster from DD2 (DP semi)



TYPES OF MODU - Dynamic Positioning

- Initial position established by global positioning system (GPS)
- Seabed transponders (4 to 5) deployed in predetermined pattern w/ ROV
- Absolute position continuously received from vessel's GPS system
- Vessel's acoustic transceiver regularly queries seabed transponders to determine relative position
- Computer processes inputs and adjusts power & azimuth of thrusters to hold position

Bolette Dolphin (Video)

- Construction: HHI at Ulsan S. Korea
- Design: MSC P10000 Drillship
- Dimensions-752’ x 118’/229 mtrs x 36 mtrs
- Dual Derrick (NOV)
- Water Depth-12,000’/3658 mtrs
- Drilling Depth-40,000’/12,192 mtrs
- Variable Deck Load-20,000 tonnes
- Quarters-210 persons
- Thrusters-6 x 5500 kw x 1.35 (44,500 hp)
- Power Generation-6 x 8000 kw x 1.35 (64,800 hp)
- 2 BOP / LMRP Stacks

Remotely Operated Vehicle (ROV)

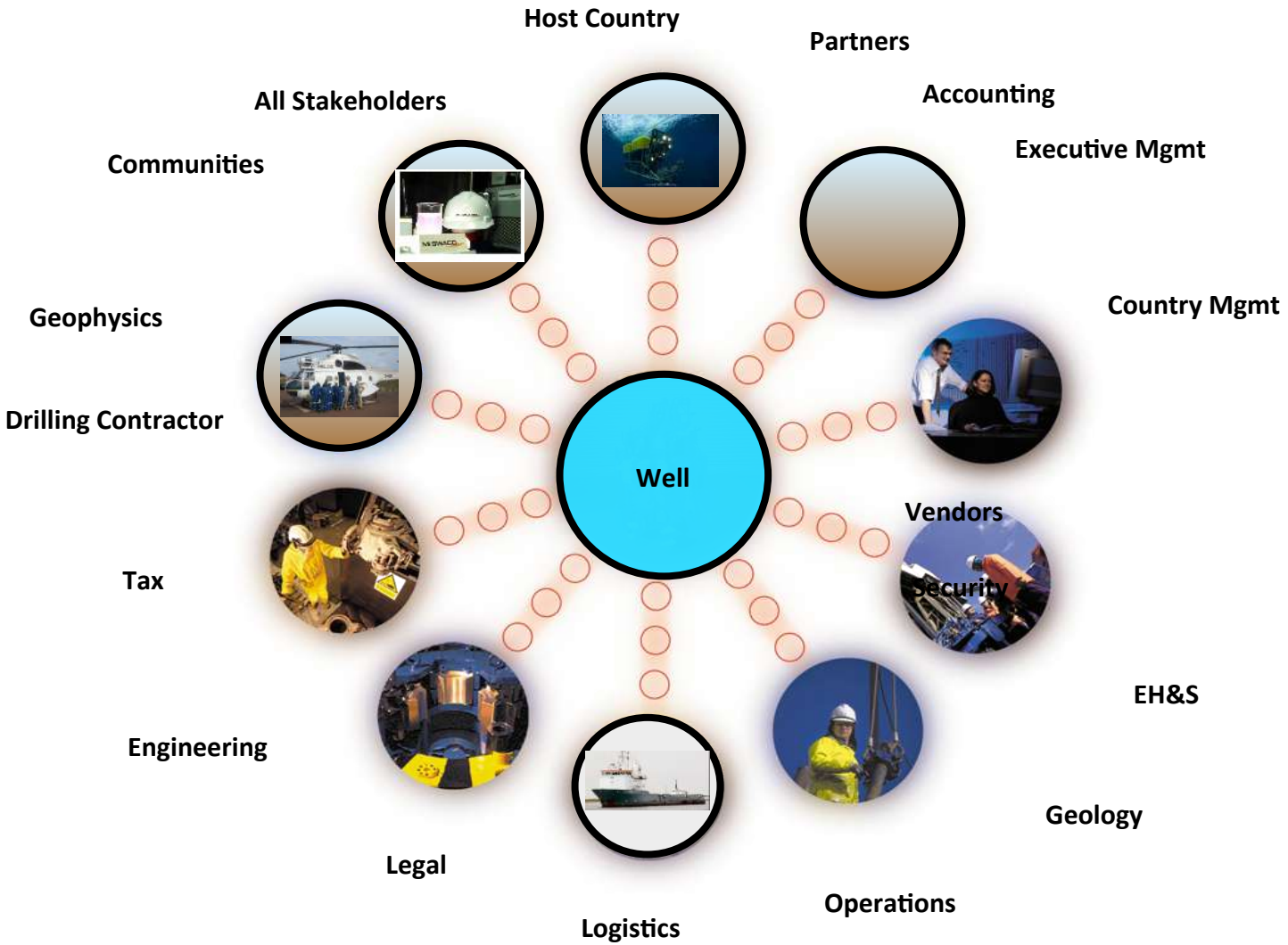
- Provides subsea monitoring & intervention capability
  - High resolution video
  - Manipulation of simple tools &/or BOP controls
- Visual operation of riserless operations
- Seafloor surveys
- Placement of seabed transponders
- Inspection of riser, BOP and wellhead

Planning and Preparation – Plan for the Unknowns

International Drilling Campaigns – Deep Water

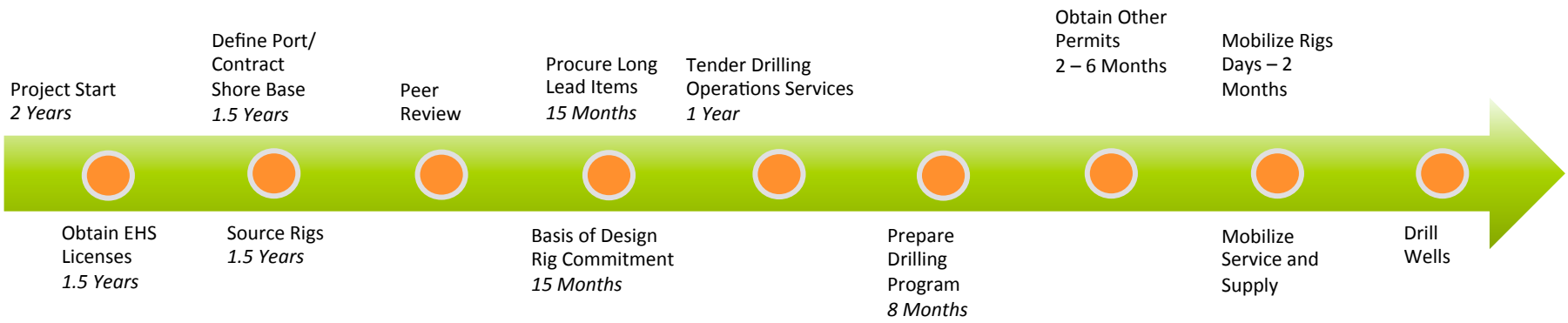
- Early Commitment to Drilling Schedule
- Work Scope / Cost Creep
- Rig & Equipment Importation/Exportation
- Managing FCPA
- Staffing from Exploration to Development
- Managing Expectations
- Managing the Unknowns
- Performance on first attempt
- Security Protection
  - Law Enforcement/Military Relations
  - Establish Rules of Engagement
  - Piracy Plan

Planning and Preparation



Flexibility is Essential in All Exploration Programs

- Manage Expectations
- Obtain Early Commitment of Licenses and Permits
- Coordinate Exploration and Appraisal Drilling Timeline
- Secure Resources 12 – 18 Months Before Drillship Arrival



Ciclo de vida de un proyecto E&P en el mar

Fuente: Empresa afiliada ACP. Diagrama basado en proyecto realizado en Ghana

Types of Developments

Fixed (Shallow Water/Shelf/Jacket)

Noble Tamar Platform – 800' WD

Floating (Spar, Semi-submersible, TLP, FPSO)

Shell Perdido Spar– 8000' WD

Types of Developments (2)

Direct Vertical Access (Drilling or Workover/Completions Rig)

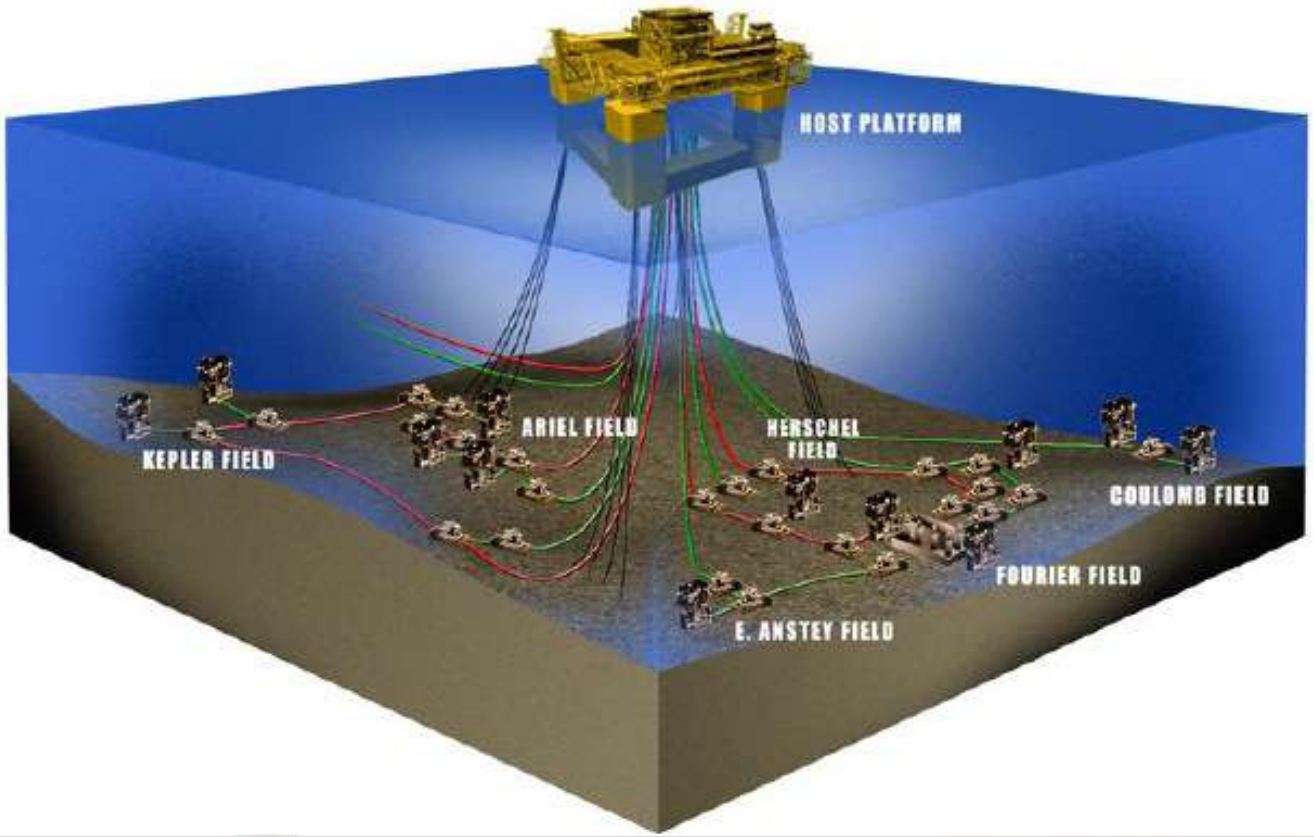
Vastar Horn Mountain Spar – Workover/Completions Rig

Subsea Tieback

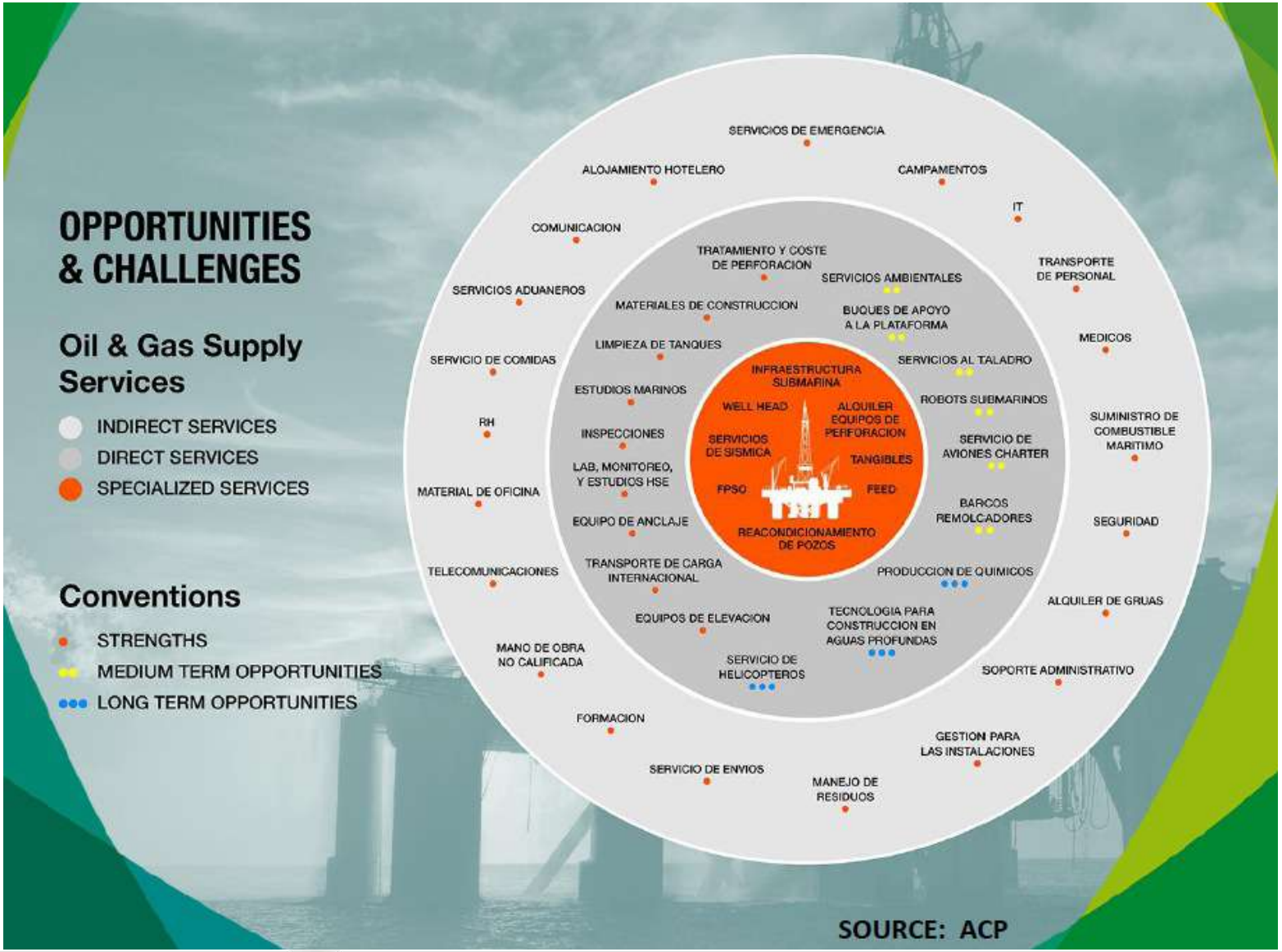
British-Borneo Morpeth TLP – Subsea Tieback

Subsea Tie-back

Subsea Well Production Combined and Routed to a Central Host



Offshore Supply Services



What Does International Project Success Look Like?

Identify Challenges and Work with Stakeholders to Develop Solutions

- ✓ Relationships
  - Establishing Good Working Relationships is Essential
- ✓ Regulatory
  - Laws and Regulations Unique to Each Country
  - Work with Agencies to Develop Best Practices
  - Government Commitment to develop offshore industry
- ✓ Logistics
  - Local Resources – development of local content policy
  - Proximity to Port
  - Access to Services and Supplies
- ✓ Changing Gears
  - Transitioning to Long-Term Operations Upon Success