Desenvolvimento do Campo (Field Development)

Escolha do Sistema Oceânico

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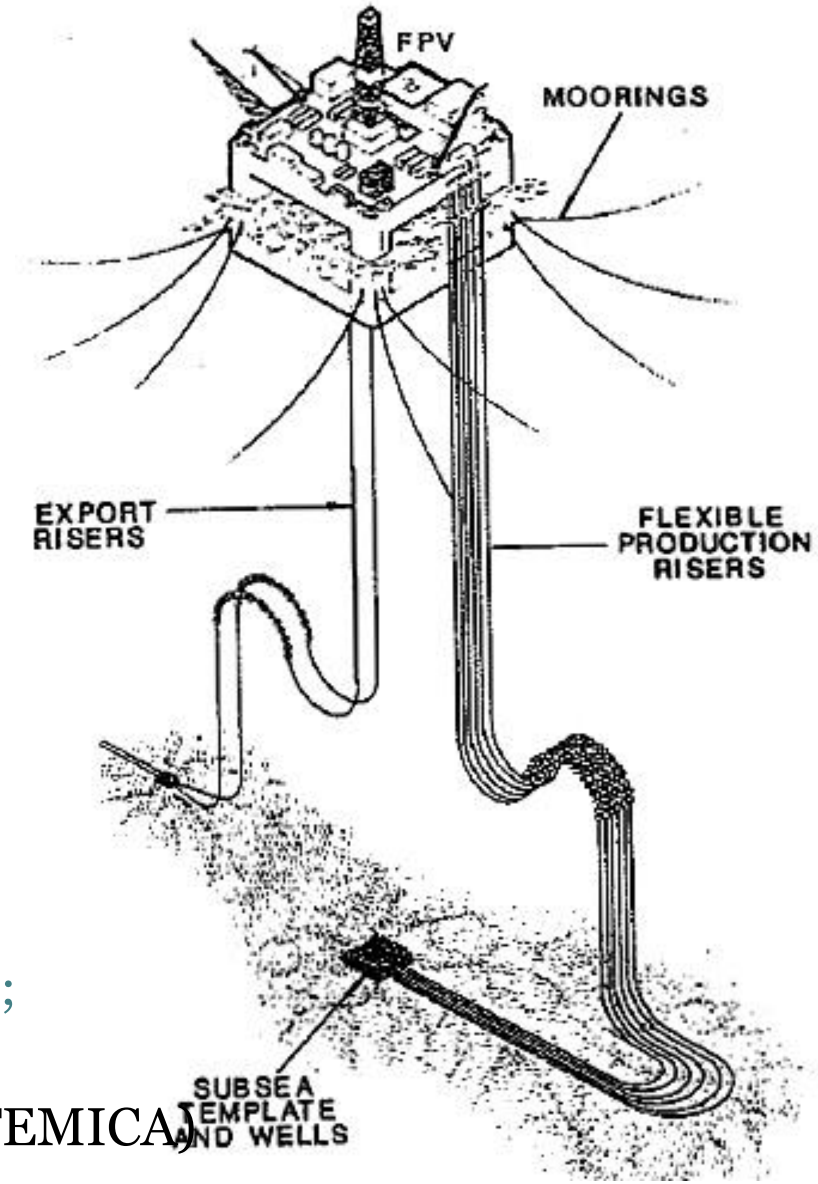
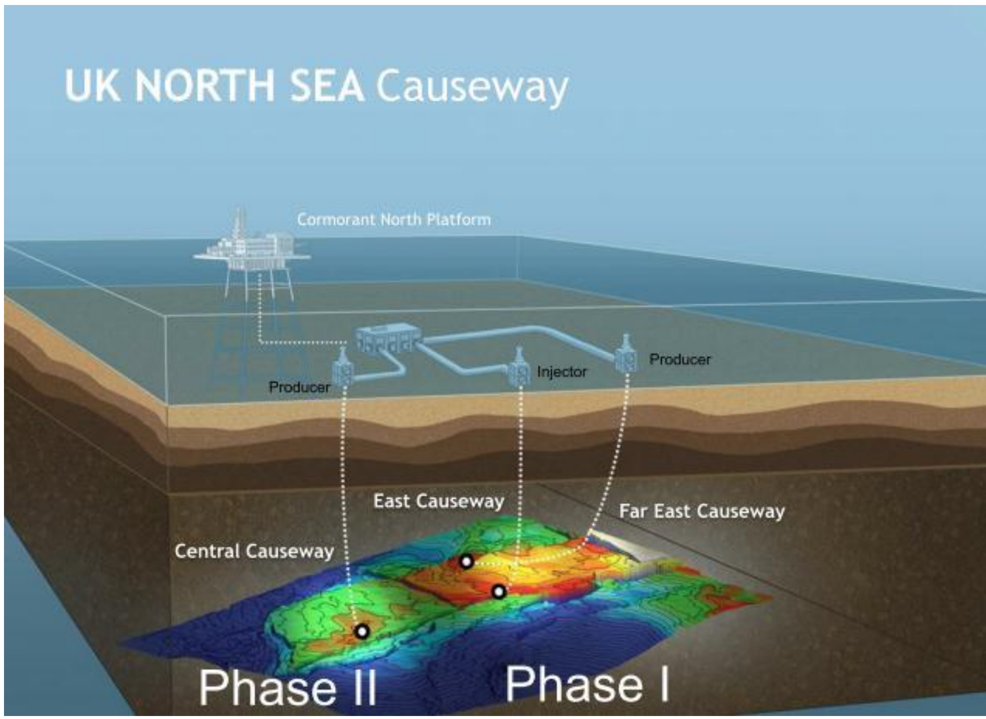
Espiral de Projeto – Sistemas Oceânicos

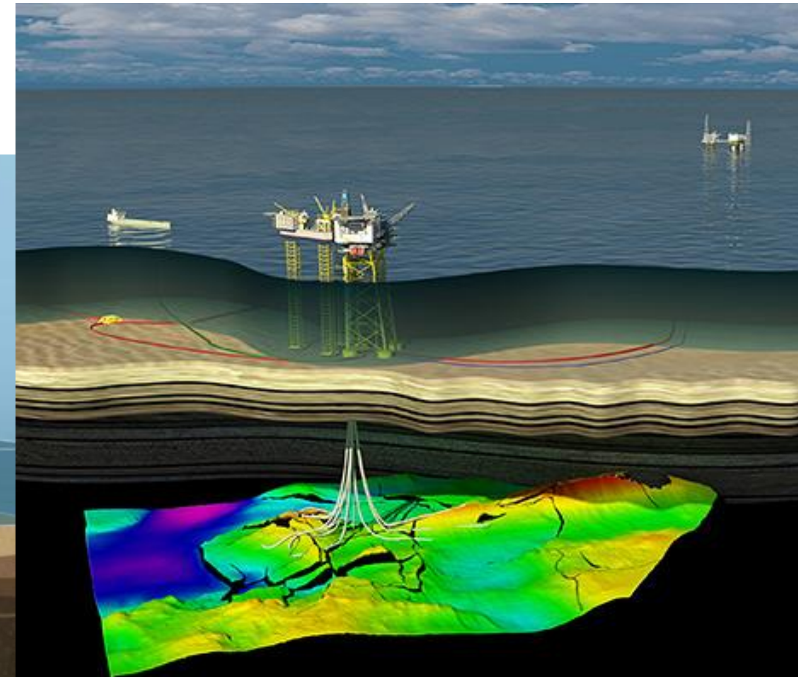
- Complexidade > navios & plataformas fixas;
- Grande variedade soluções;
- Interdependência subsistemas;
- Equipe multidisciplinar ⇒ Obter solução ótima;

- Primeira análise, problema ⇒ tópicos específicos, exemplo:
  - Planta de produção;
  - Plataforma (Estrutura Suporte);
  - Equipamentos & arranjo submerso;
  - Riser;
  - Armazenamento & transporte de óleo;
  - Amarração;
- Otimização do conjunto; (VISAO SISTEMICA)

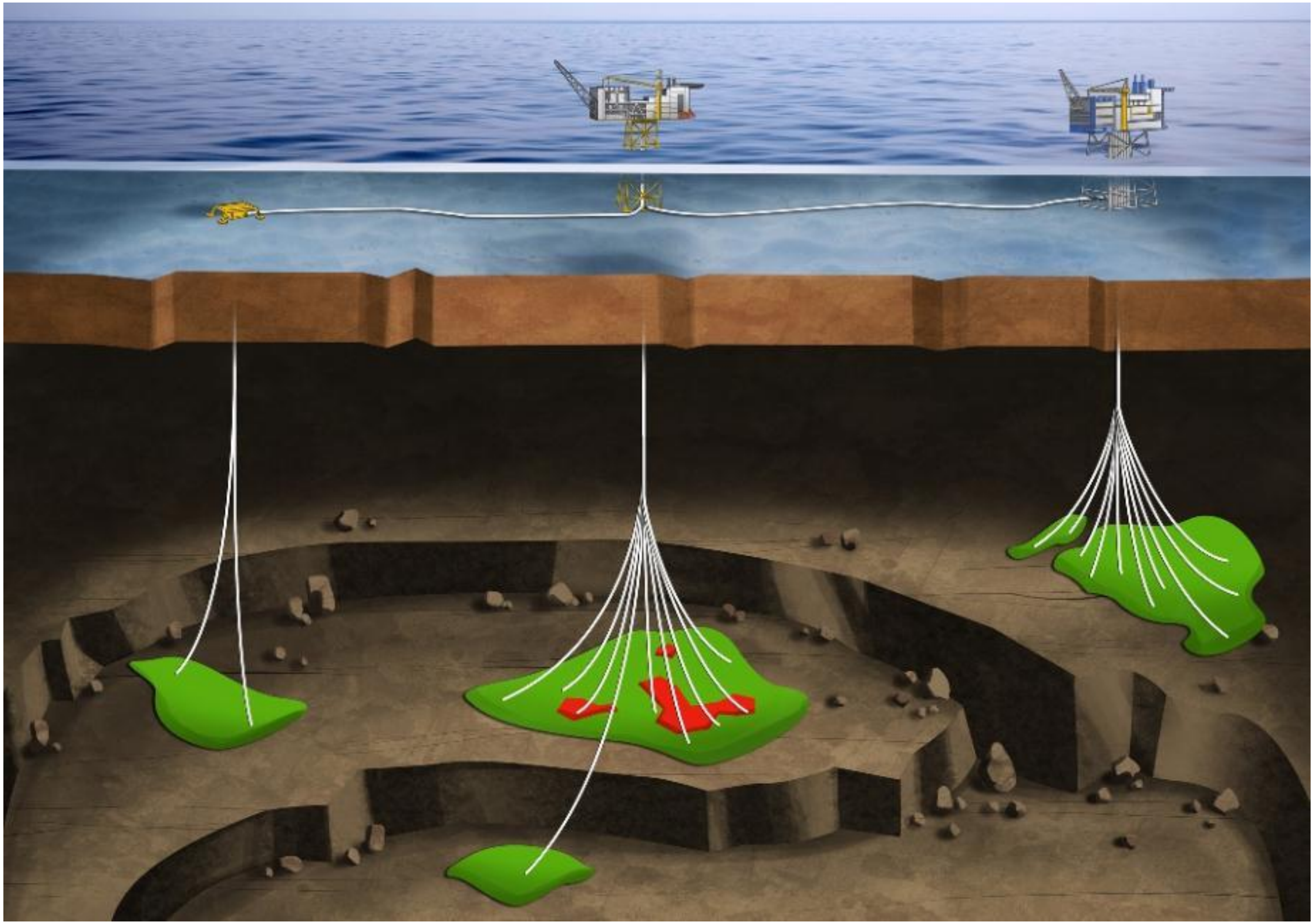


Field Development





Field Development

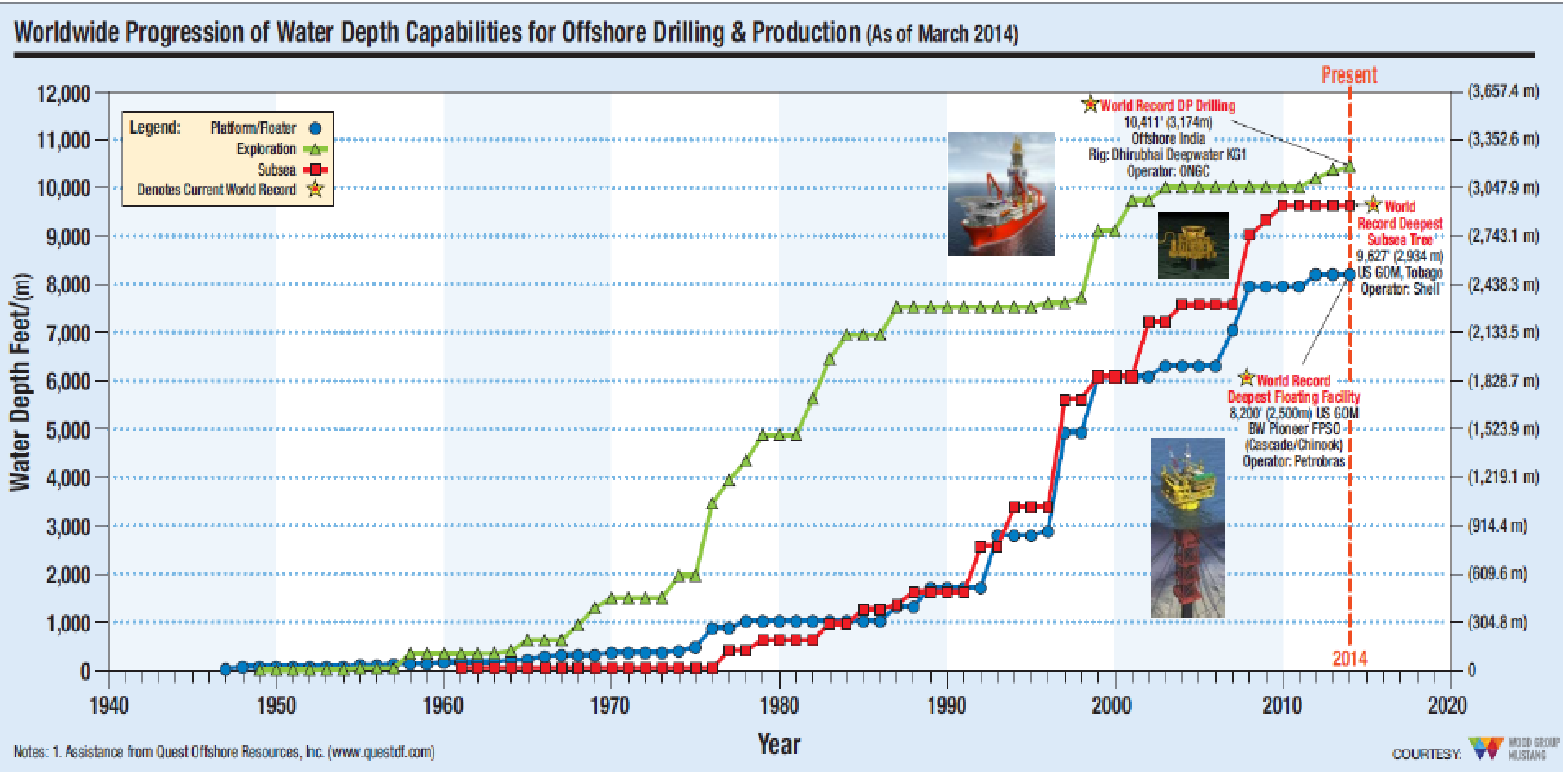


Topics

- Introduction to Field Development
- Design Requirements – Owner needs and regulations limits
  - Production field – size, oil quality, reservoir size, etc.
  - Environmental Conditions – wave, wind & current
  - Number of wells – dry or wet tree, etc.
  - Production rate – number of barrel per day (bpd)
  - Local water depth and location from coast
  - Infrastructure needs – pipe lines – oil & gas

Ocean Systems for Oil & Gas Exploration

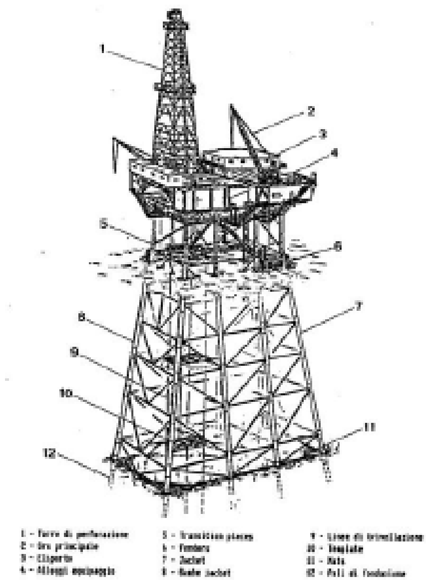
The 50 Year March to Deepwater



1. The drillers were drilling in deepwater long before we had the production capability.
2. The time and depth gap between drilling and production is closing fast.
3. 10,000’ has been the water depth threshold for almost 10 years.

Available Offshore Platform Technologies

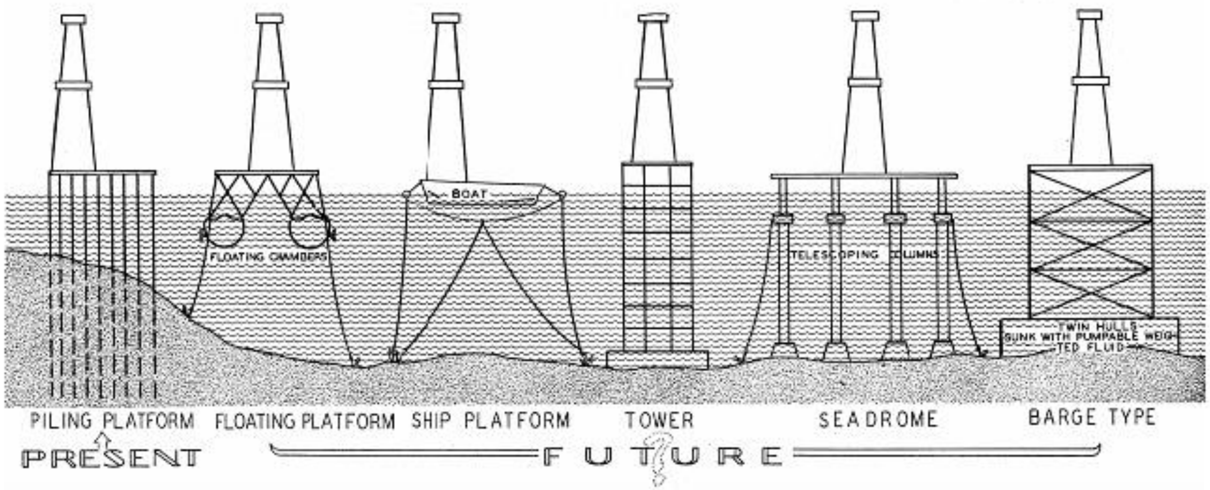
- Fixed Platform
  - ✓ Jacket Structure
  - ✓ Gravity based
  - ✓ Compliant Structures
  - ✓ Guyed towers



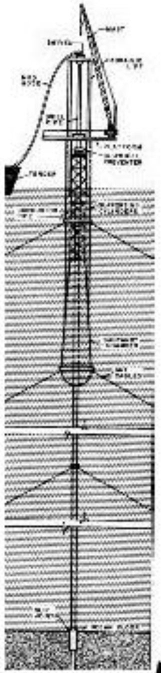
- Floating Platform
  - ✓ Semi-sub
  - ✓ Tension Leg
  - ✓ SPAR
  - ✓ FPSO

The Deepwater Vision – Then and Now

June 1947 - Oil & Gas Journal



Feb 1959 - Offshore Magazine



Spar

Semi

FPSO

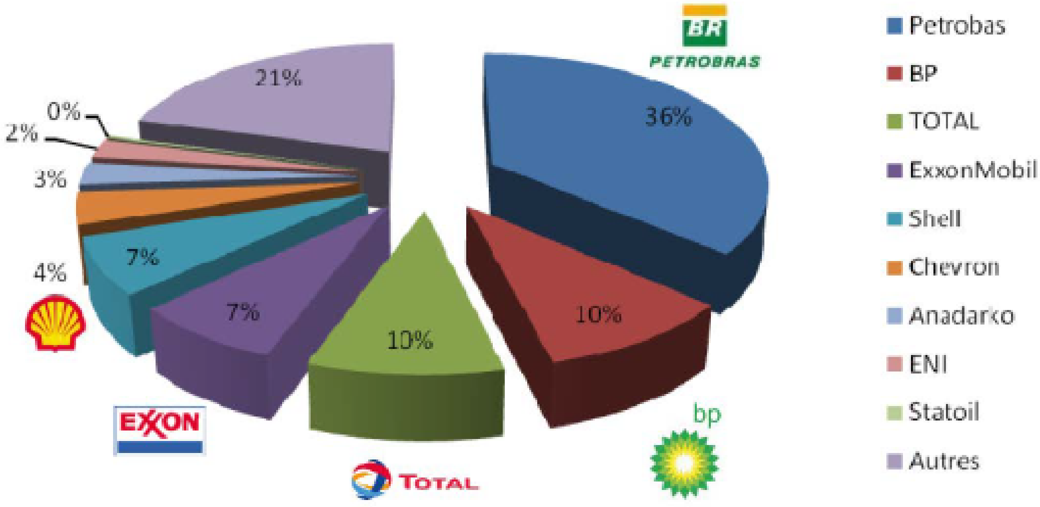
Compliant Tower

TLP

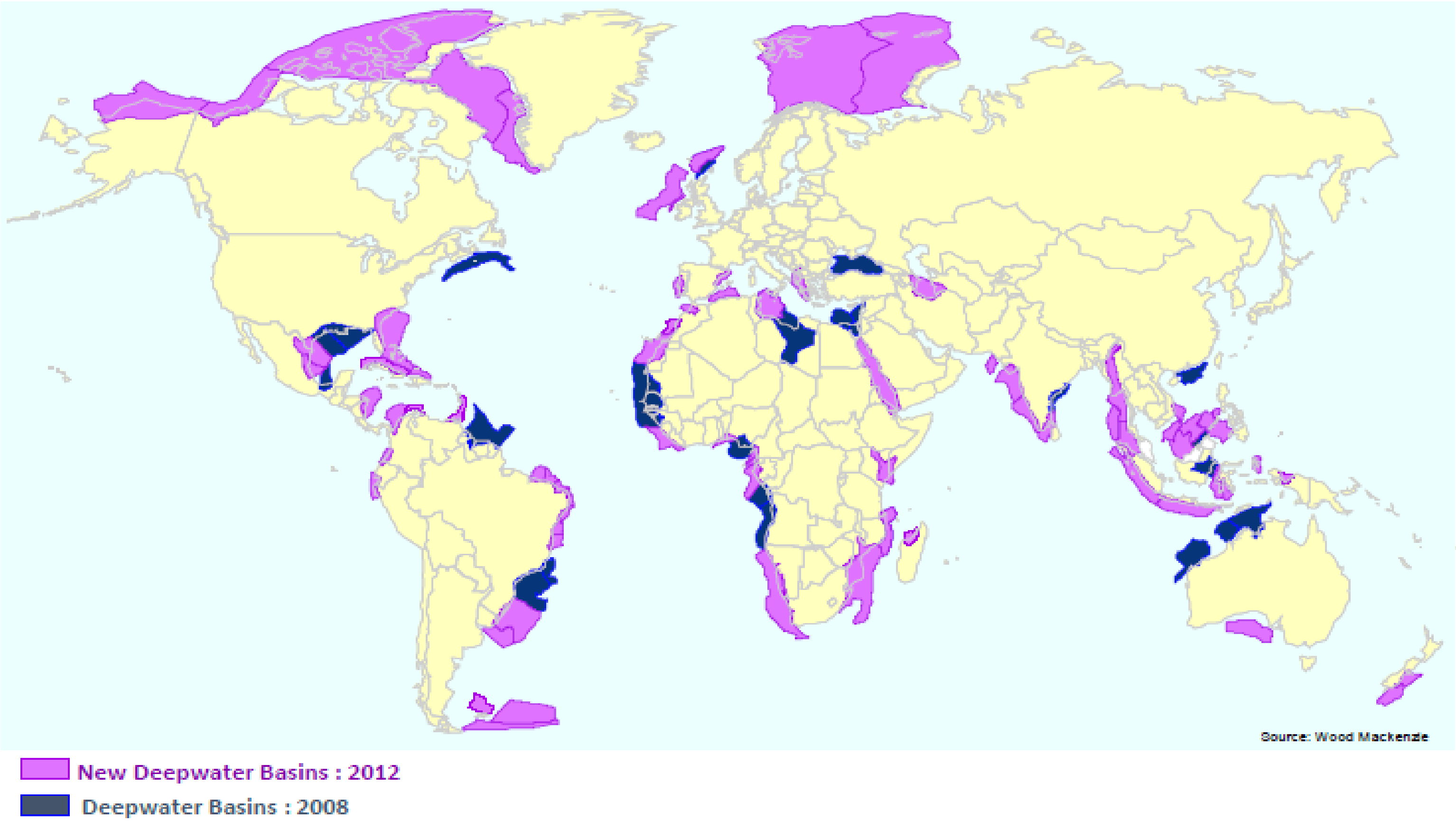
Why Deepwater?

- Future oil demand will remain strong
- Deepwater is where the remaining big reserves are located
- Deepwater will account for 25% of global offshore production by 2015, compared to just 9% now
- Innovative technologies will allow economic developments in deep and ultra-deepwater

Relative Deepwater Well Activity in 2013

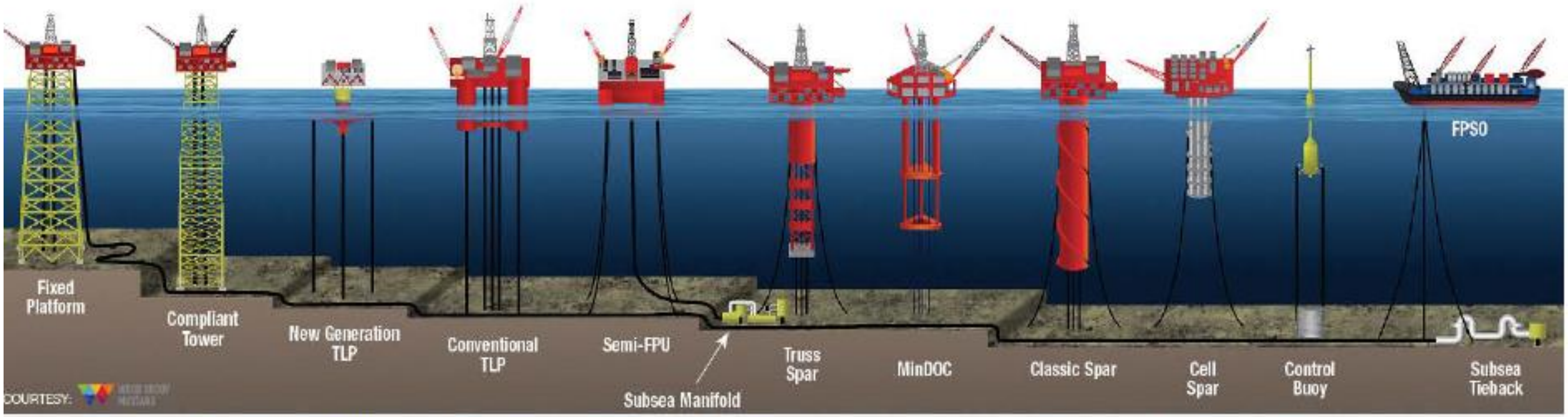


Deepwater Drilling is Rapidly Expanding



- New deepwater basins are being identified at a rapid pace
  - Expansion will be further enabled by the significant additions to the floating rig fleet over the next several years

Deepwater System Types Currently in Use

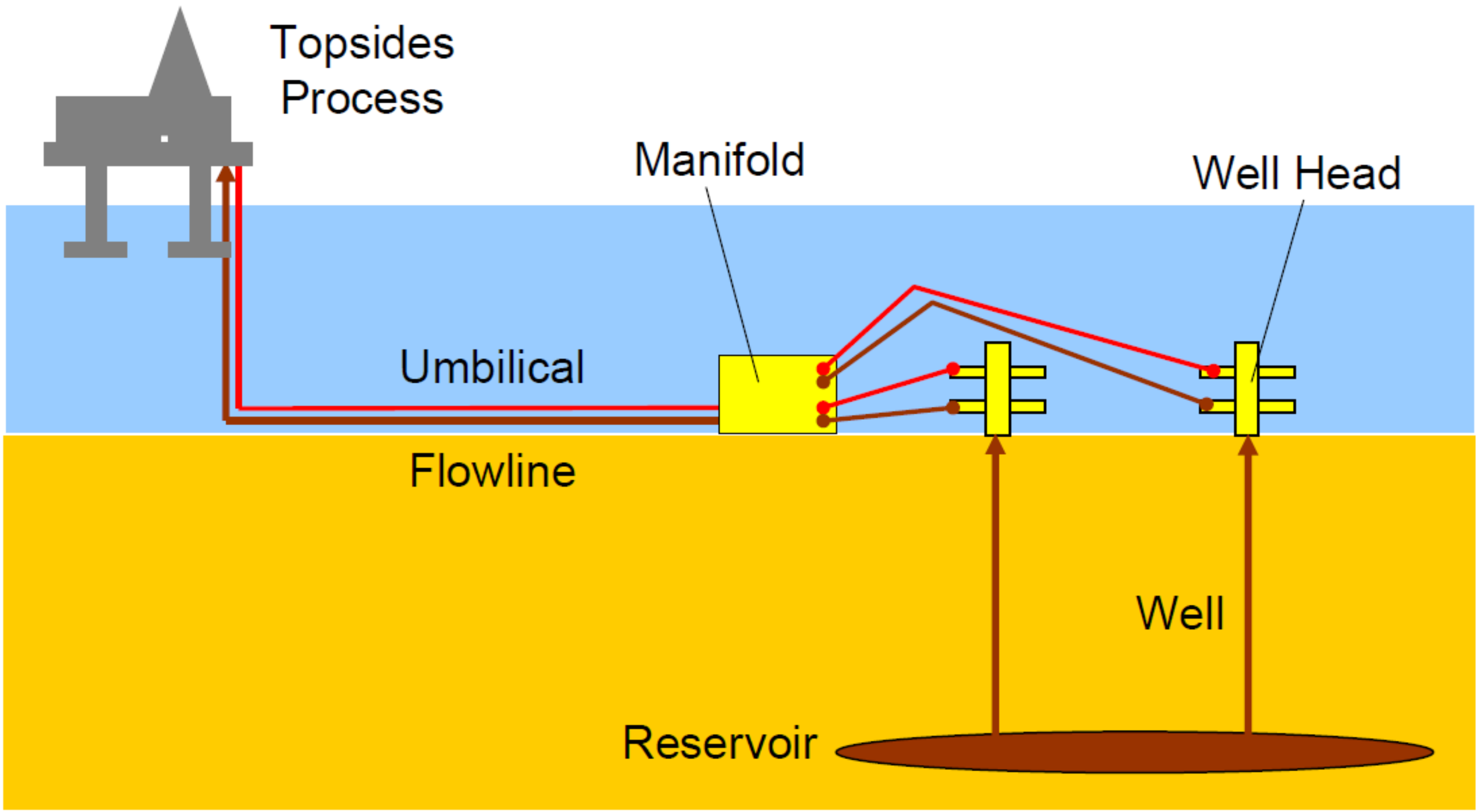


Source: *Mustang Engineering & Offshore Magazine Deepwater Poster – May, 2013; Go to www.offshore-magazine.com/maps-posters.html*

Three Deepwater System Groups:

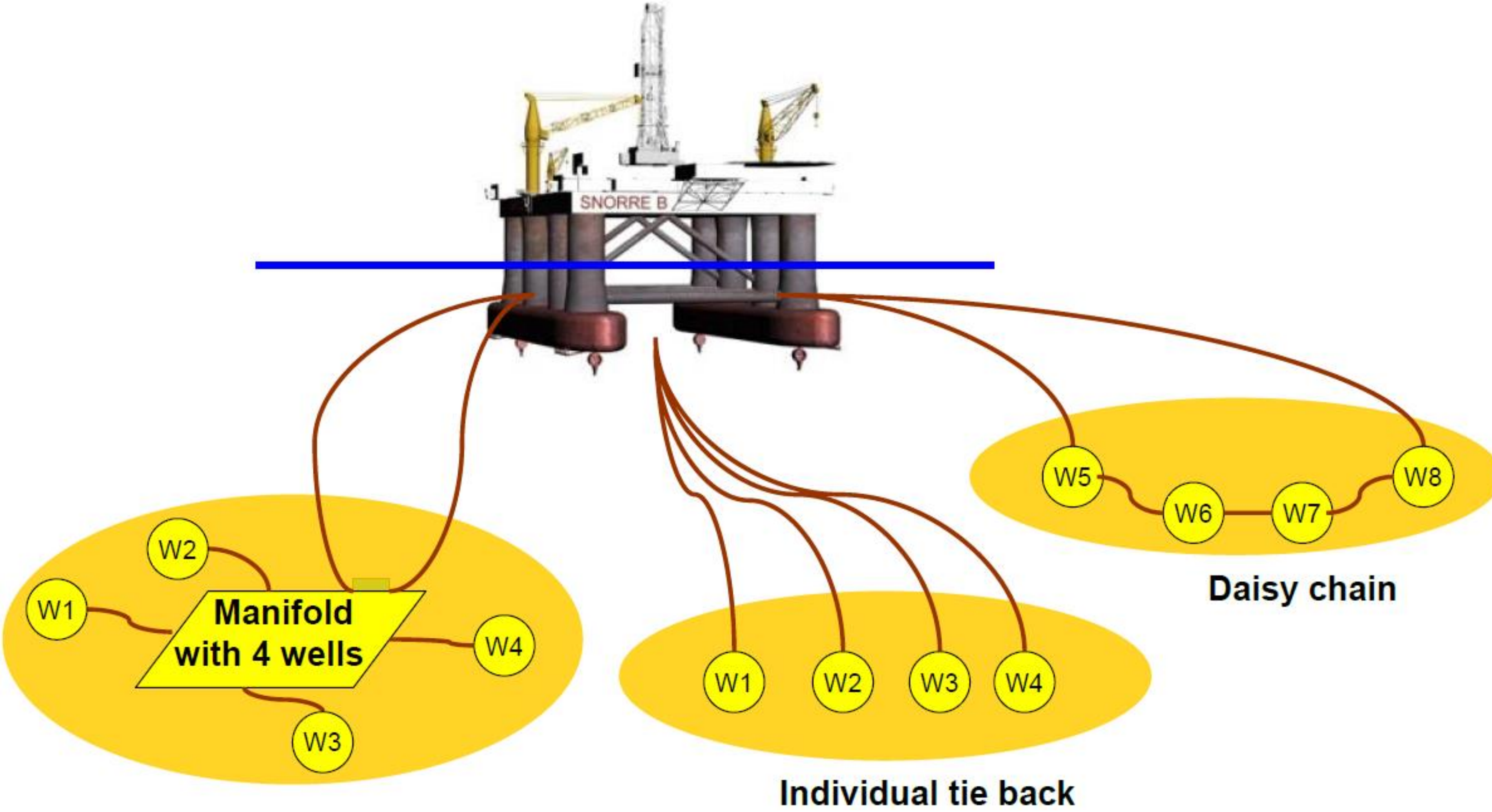
1. Dry Tree Systems – Fixed Platform, Compliant Tower, TLP, Spar
2. Wet Tree Systems – New Gen. TLPs, Conventional TLPS, FPSOs, Cell Spar, Control Buoy, SS Tiebacks, Semi-FPS
3. Mixed Dry / Wet Tree Systems – Fixed Platforms, New Gen. TLP, Conventional TLP, Spar

Components in a Subsea Production System

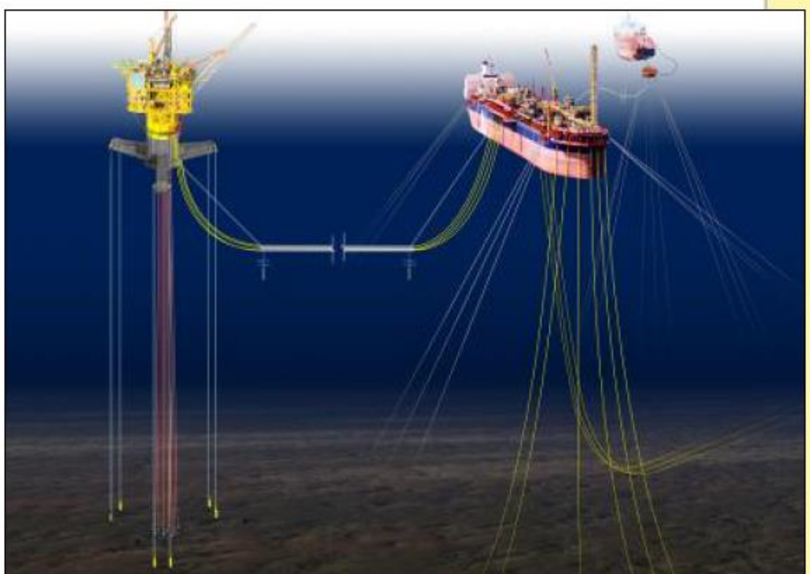


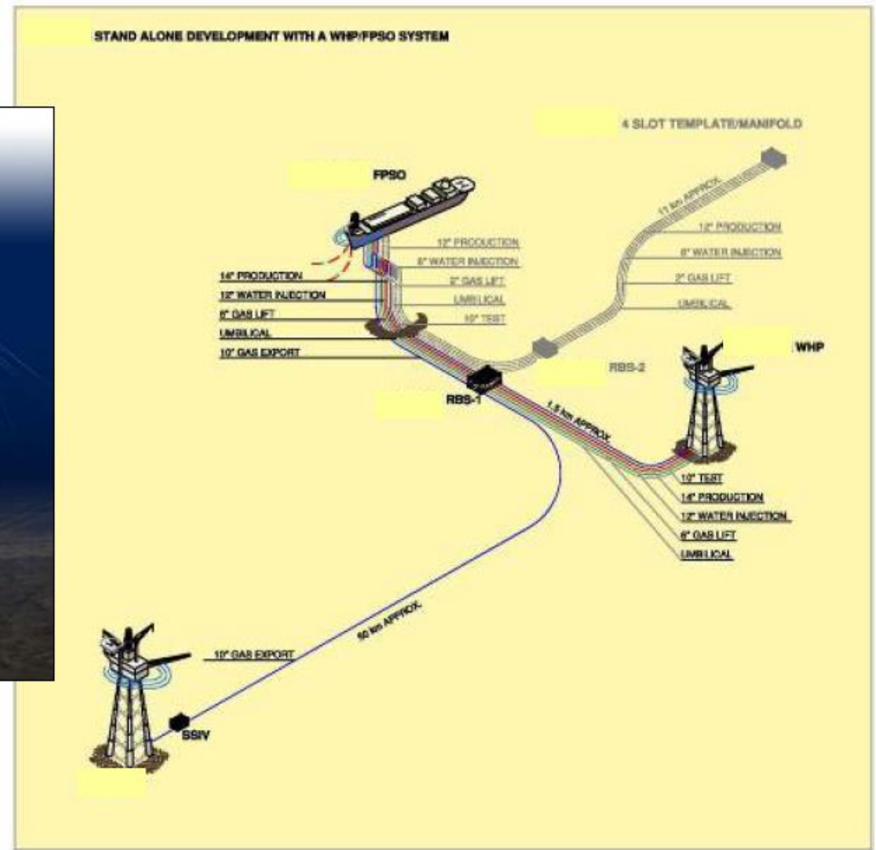
Field development architectures:

Manifold, individual wells or daisy chained well; tied back to a production facility



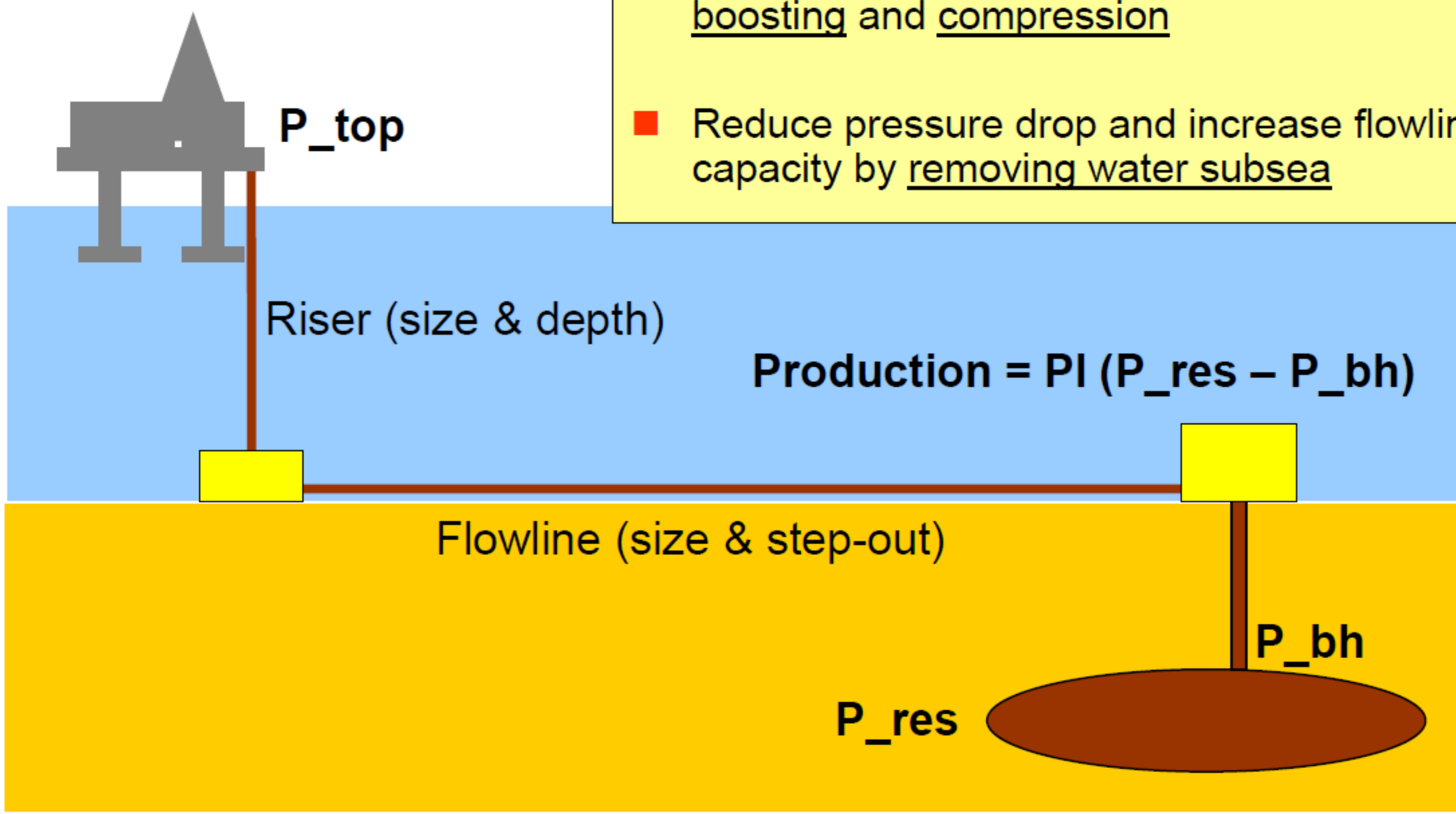
Start with a Study to Establish the Concept





Possible "Tools"

- Inject water to maintain reservoir pressure
- Reduce wellhead pressure by subsea boosting and compression
- Reduce pressure drop and increase flowline capacity by removing water subsea



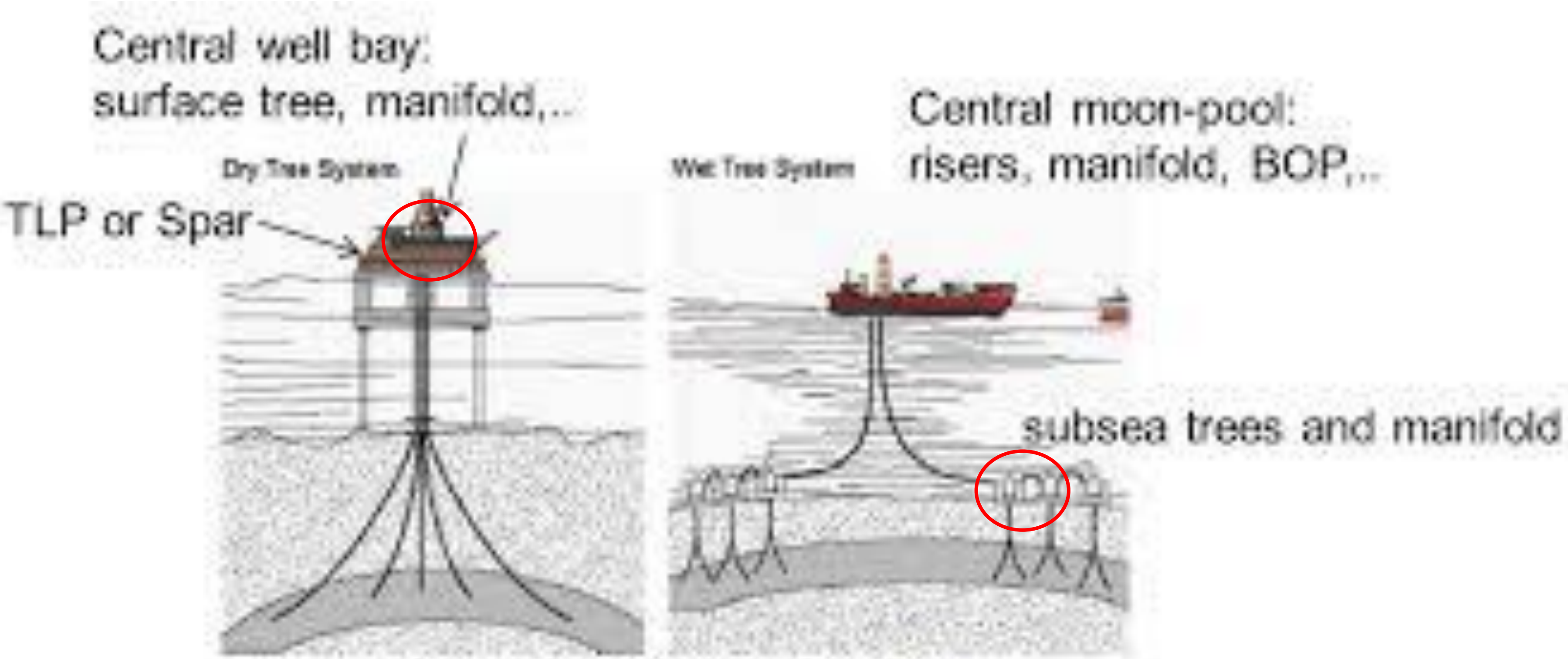
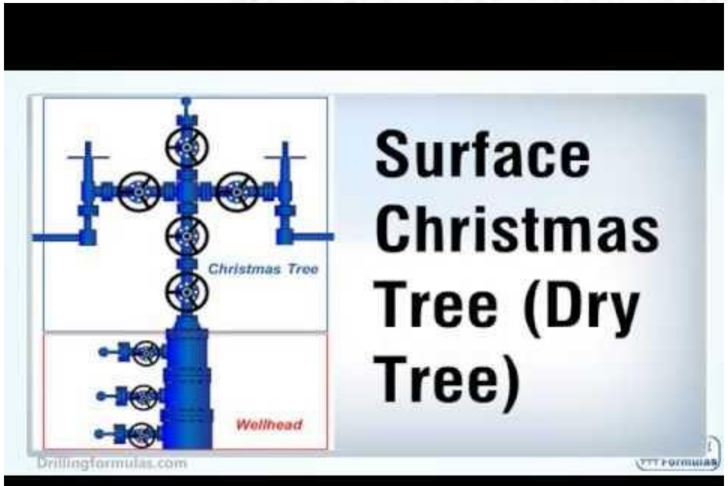
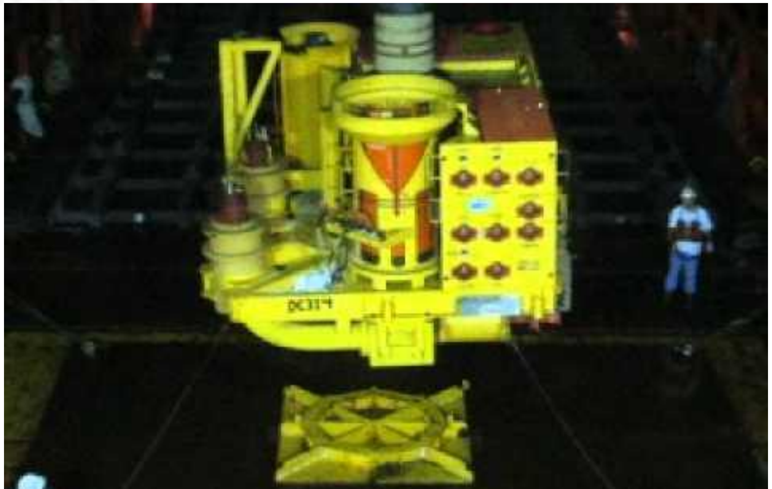
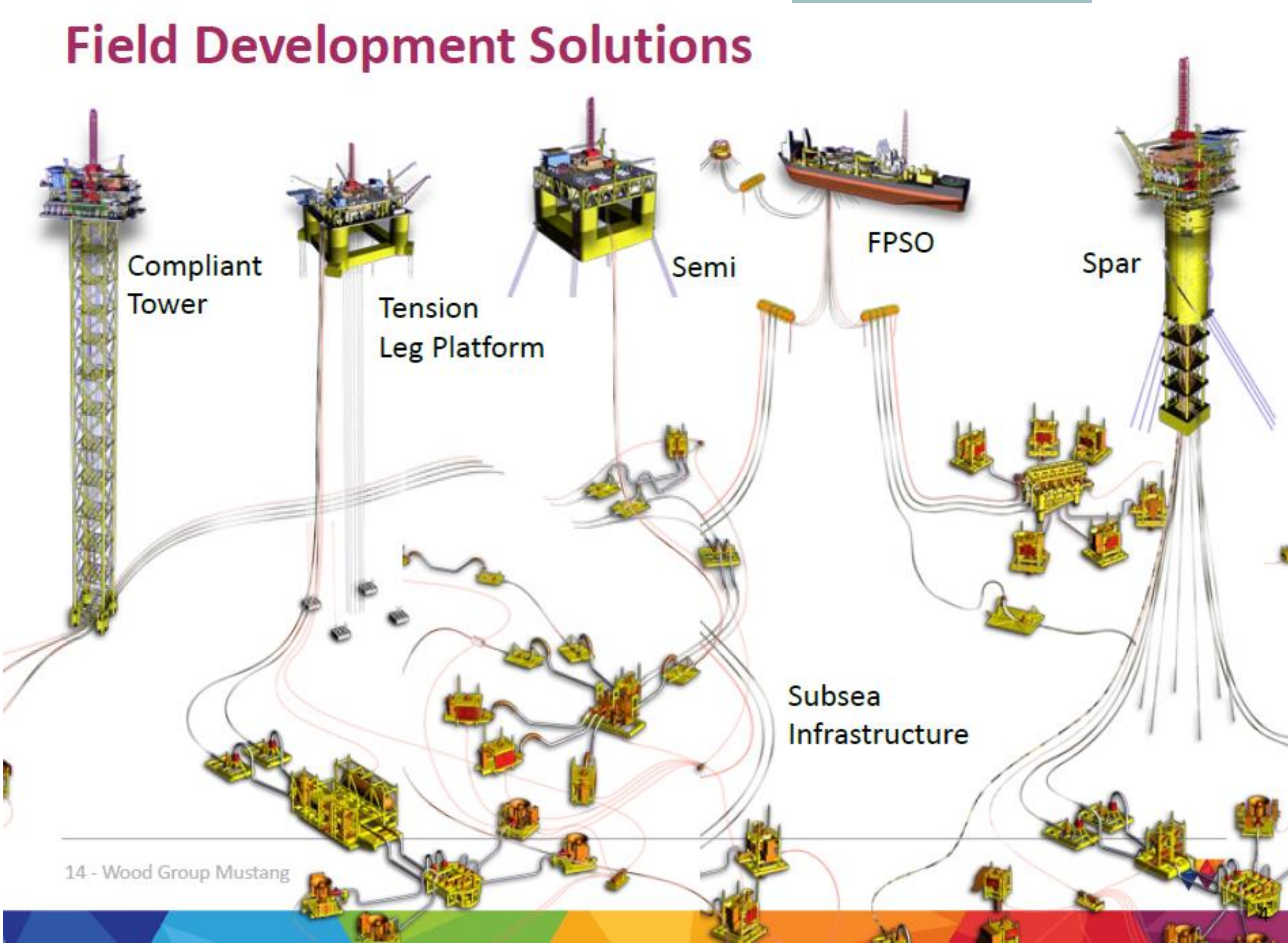


Figure 2-2 Dry Tree and Wet Tree Systems [1]





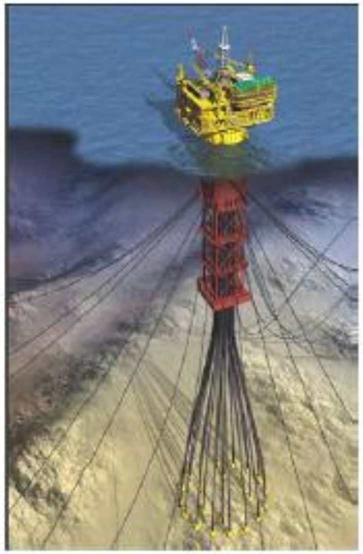

Field Development Solutions
Compliant Tower
Tension Leg Platform
Semi
FPSO
Spar
Subsea Infrastructure
14 - Wood Group Mustang

Predominant Floater Types

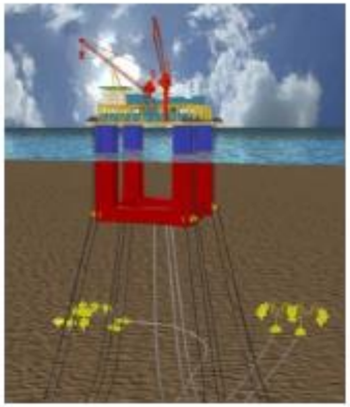
There are four primary industry recognized floating production solutions, accepted because:

- ***Proven*** - Many years of Operating history
- ***Functional*** - Used for a large variety of functions, wet or dry tree
- ***Scalable*** – Wide range of topsides payloads
- ***Adaptable*** – Applications worldwide

Tension Leg Platform

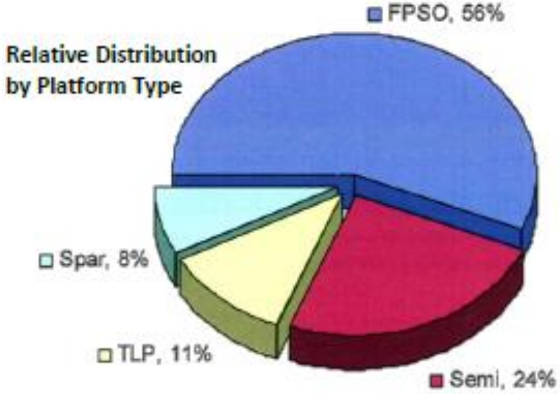


Spar



Semi-submersible (Semi)

FPSO

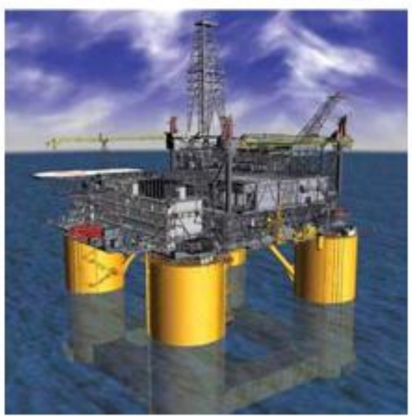


Fundamental Concept Differentiators

- Functionality
- Scalability
- Integration
- Installation
- Flexibility

Semisub (Wet trees)


Spar (Dry or Wet trees)


TLP (Dry or Wet trees)


FPSO (Wet trees)

Semisubmersible Platform – Variants and Differentiators

- **Functionality**
  - Wet trees
  - Subsea BOP drilling, completion, intervention
- **Scalability Constraints**
  - Limited envelope of SCR applicability
- **Installation, Integration**
  - Quayside integration
  - Relatively simple installation
- **Flexibility**
  - Ease of decommissioning, relocation and future expansion

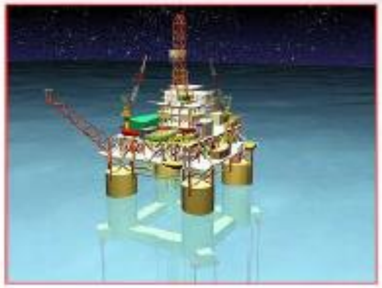
Conventional Draft

Deep Draft

Tension Leg Platform – Variants and Differentiators

- **Functionality**
  - Dry or Wet trees
  - Subsea BOP drilling, completion, intervention
- **Scalability Constraints**
  - Tendons limit w.d. to about 5,000 ft
- **Installation, Integration**
  - Quayside or offshore integration
  - Installation relatively complex
- **Flexibility**
  - Limited flexibility for decommissioning, relocation

Classic (Aker)



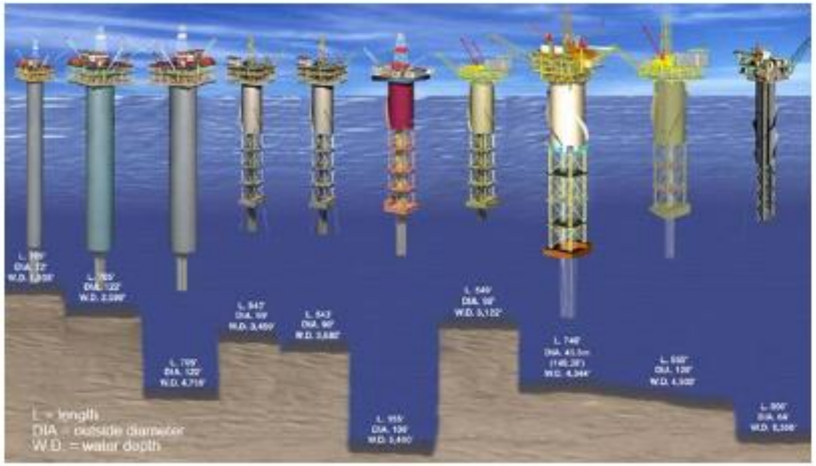
ETLP (FloaTEC)

MOSES (Modec)

SeaStar (Atlantia)

Spar Platform – Variants and Differentiators

- **Functionality**
  - Dry or Wet trees
  - Subsea BOP drilling, completion
- **Scalability Constraints**
  - Dual barrier production riser with increasing depth and pressure
  - Very large payloads (>25,000 tons)
- **Installation, Integration**
  - Offshore deck installation
- **Flexibility**
  - Limited flexibility for decommissioning, relocation, expansion



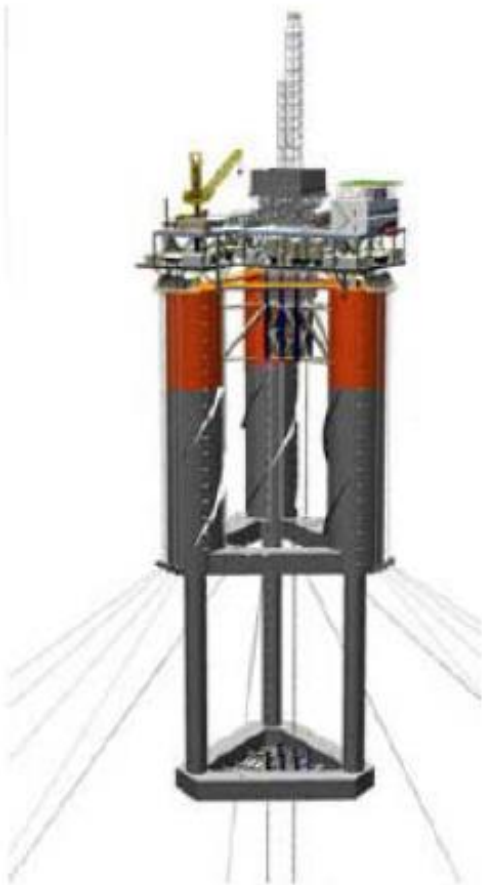
Classic, Truss and Cell Spars

Floating Production, Storage & Offloading – Variants and Differentiators

- **Functionality**
  - Wet trees
  - Subsea BOP drilling, completion, intervention
- **Scalability Constraints**
  - No water depth constraints
  - Riser constraints in deeper waters
  - Very large payloads (>25,000 tons)

- **Installation, Integration**
  - Shipyard integration
  - Suitable for harsh and remote locations
- **Flexibility**
  - Good flexibility for decommissioning, relocation, expansion

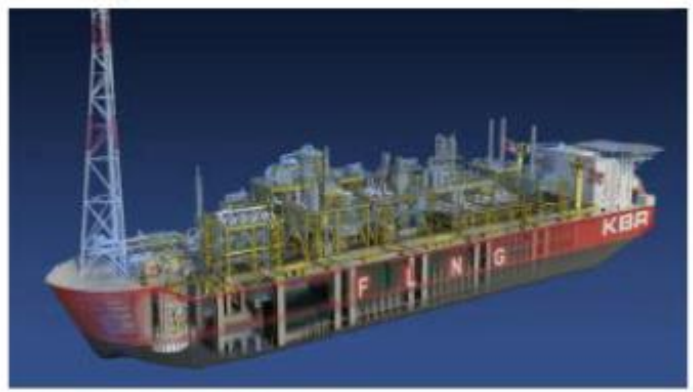
Emerging Deepwater Floating Platforms



MinDOC 3™
(dry tree, worldwide)

Sevan, MonoBR
Circular FPSO
(wet tree, worldwide)

FPSO with drilling
(mild, directional seas)

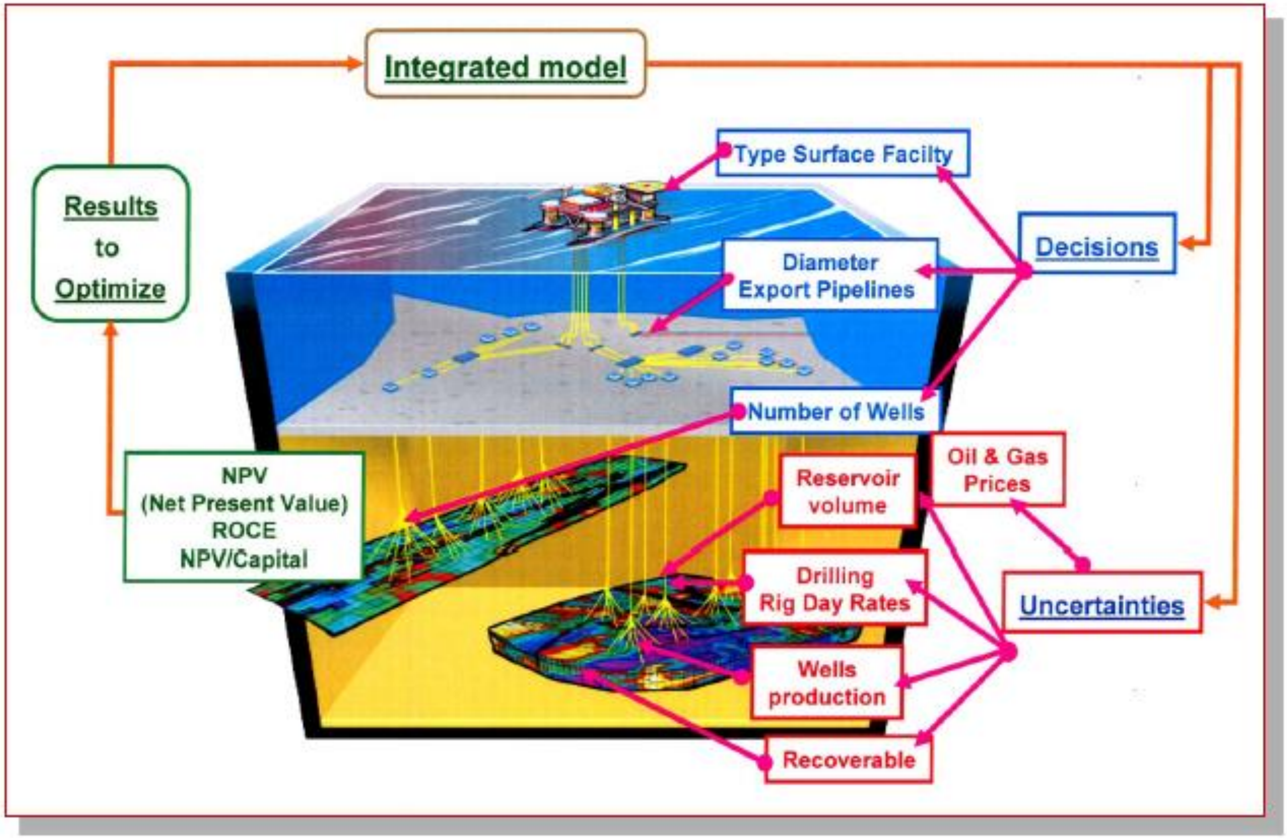


Floating LNG
(wet tree, worldwide)

Field Development Planning Process

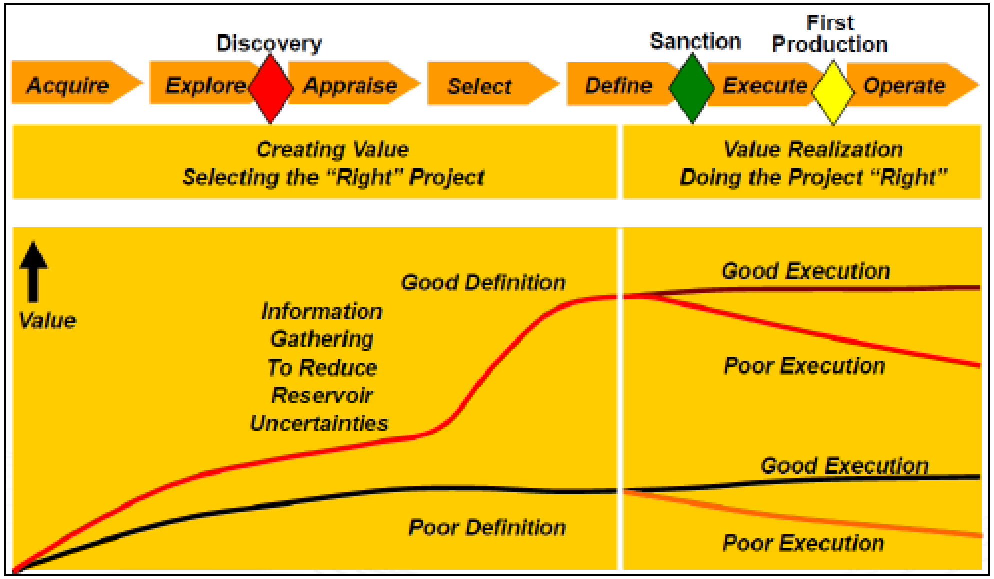
- To define an **optimum reservoir depletion** and **compatible facilities development plan** that has a high probability of meeting an Operator's major business drivers

- **It occurs in early project phases** when reservoir information is limited and uncertainty of key decision variables is high



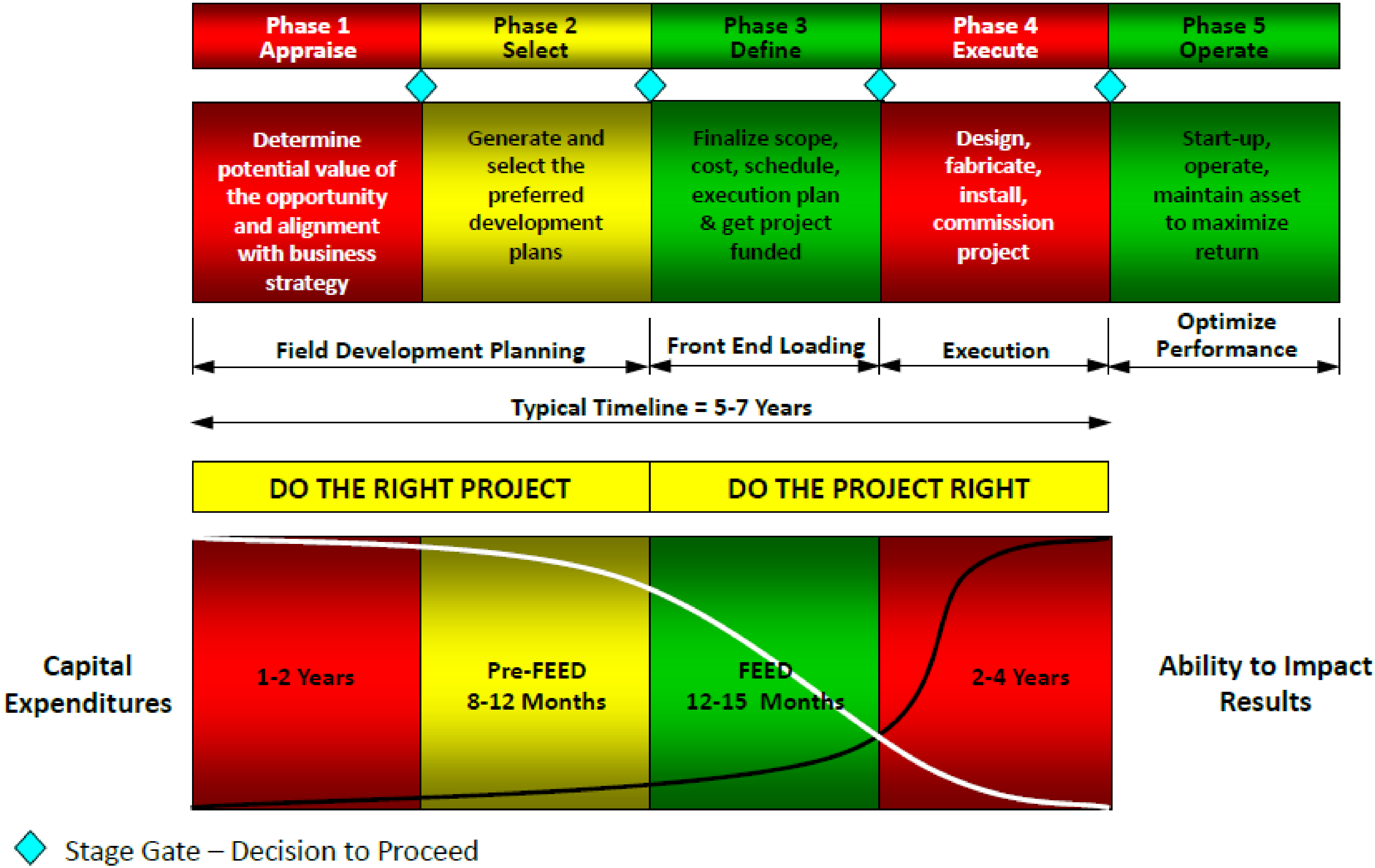
Early Planning Creates the Greatest Value

- The **greatest value to a project is created in the Appraise and Select phases** which involve:
  - Developing a robust **reservoir model** and depletion plan
  - Optimizing the **drilling program** (greatest recovery with fewest wells)
  - Minimizing **well performance** uncertainty
  - Selecting the right **surface facility** plan



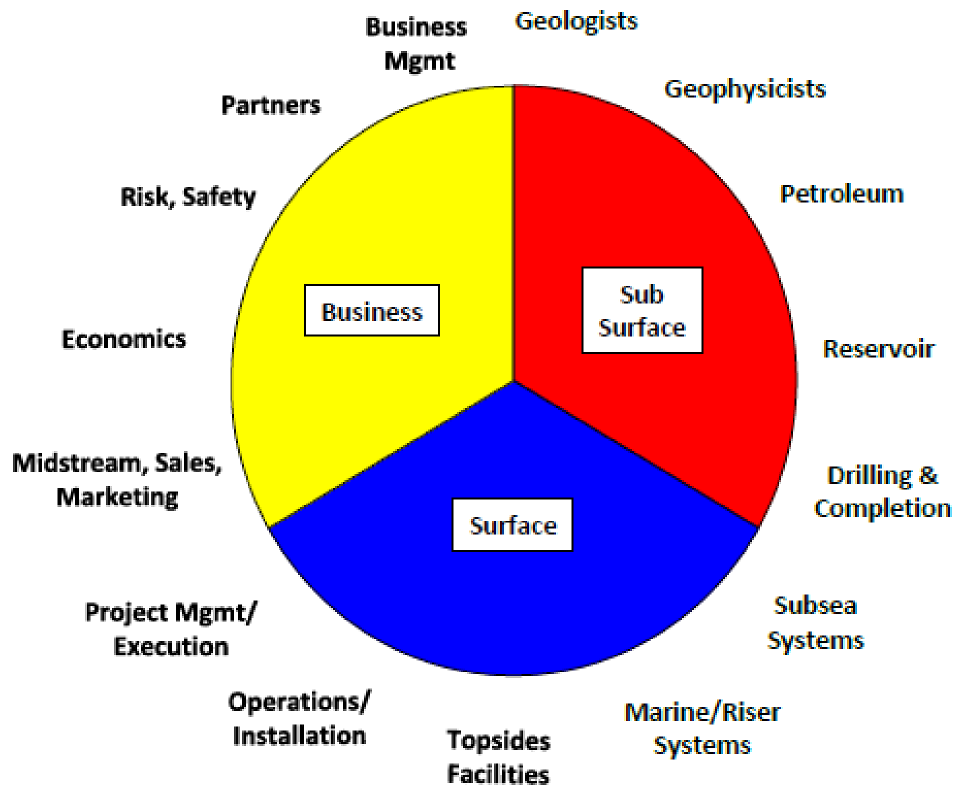
- The **spend in these phases is generally a small percentage of total development spend** but provides substantial added value to the project

Project Phases Have Distinct Objectives

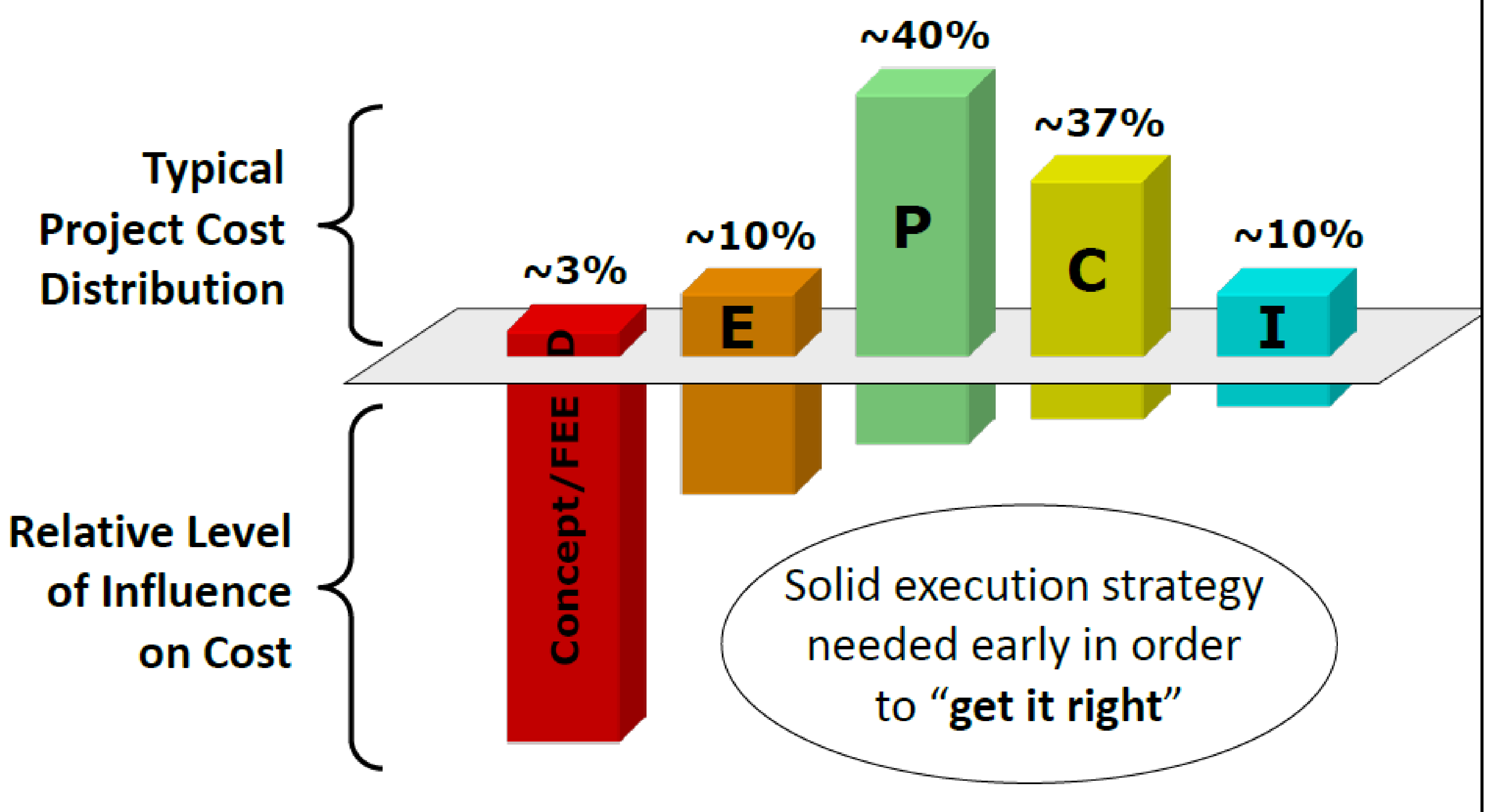


Planning is a Collaborative Process

- Objective is to **select a development plan that satisfies** an Operator's commercial, strategic and risk objectives
- It involves a **continuous interaction** between key elements:
  - Subsurface
  - Surface
  - Business
- The process **requires continuous and effective collaboration and alignment** between reservoir, well construction, surface facilities and commercial teams



Relative Influence on Cost



Proper Planning is Critical to Success

Assess – Feasibility Study

Select – Concept Selection

Define – Project Specifications

Execute – Design & Construction

Feasibility Studies

- Identify alternatives
- Determine technical feasibility
- Determine Commercial Viability


Concept Studies

- Screen alternatives
- Select development concept

FEED

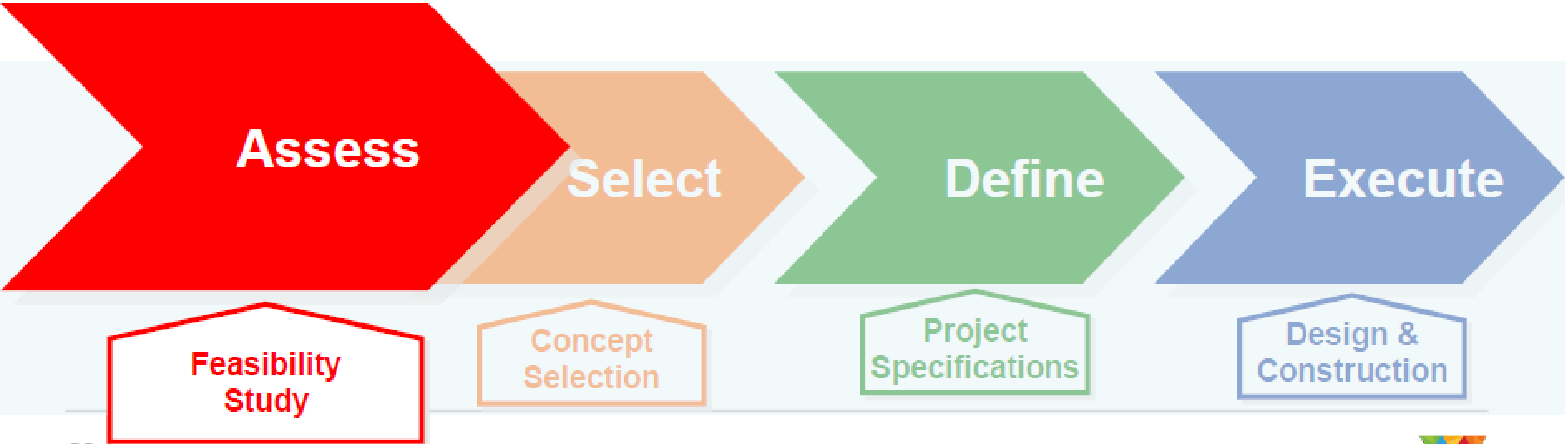
- Define development concept
- Design basis
- Cost
- Schedule
- Execution Plan

Execute EPCI

- Detail design
- Construction
- Installation
- HUC

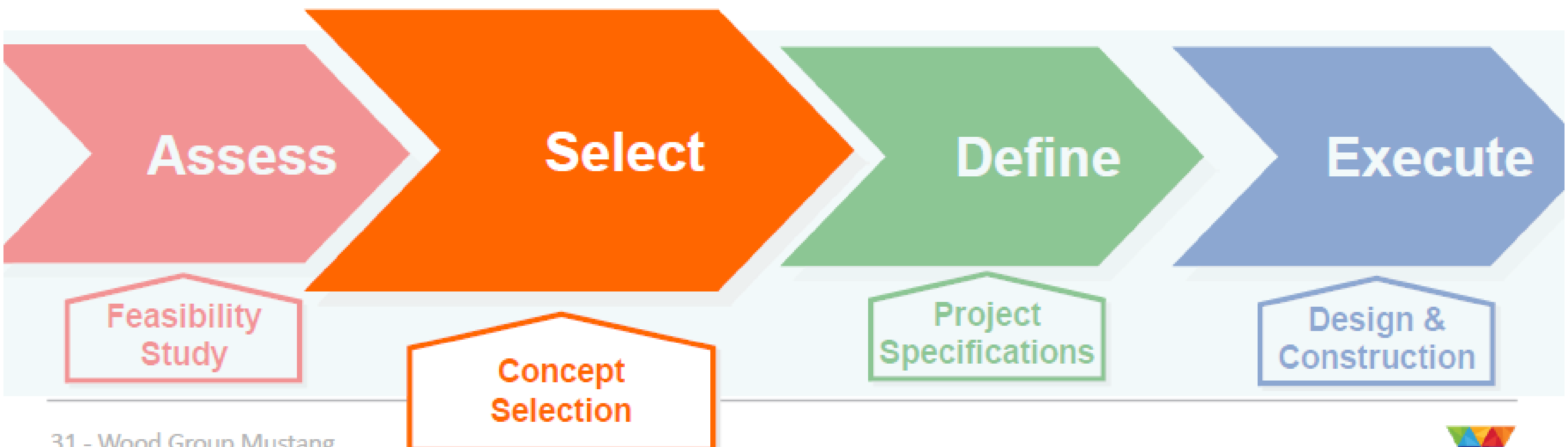
Planning for Success – Feasibility Phase

- Does the technology exist?
- Is it technically feasible?
- Can it be built to the required size?
- Can it be installed?
- Do the risks appear manageable?



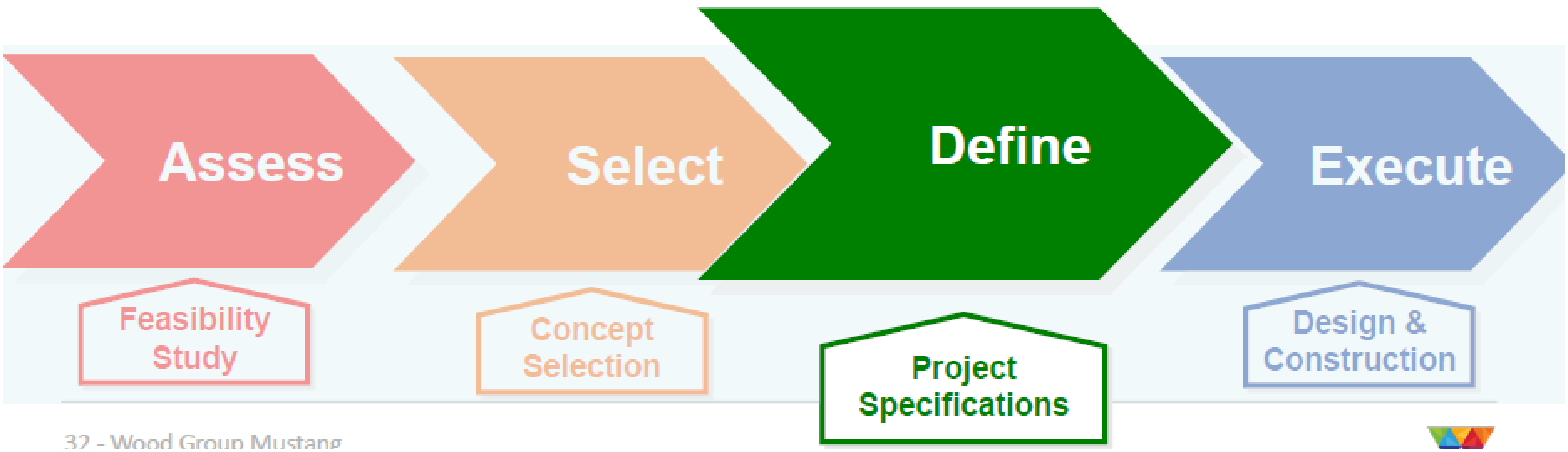
Planning for Success – Concept Selection

- Which concept will have the highest NPV?
- Constructability and install ability issues
- First-of-a-kind issues
- Site conditions
- Potential contracting constraints
- Risk analysis



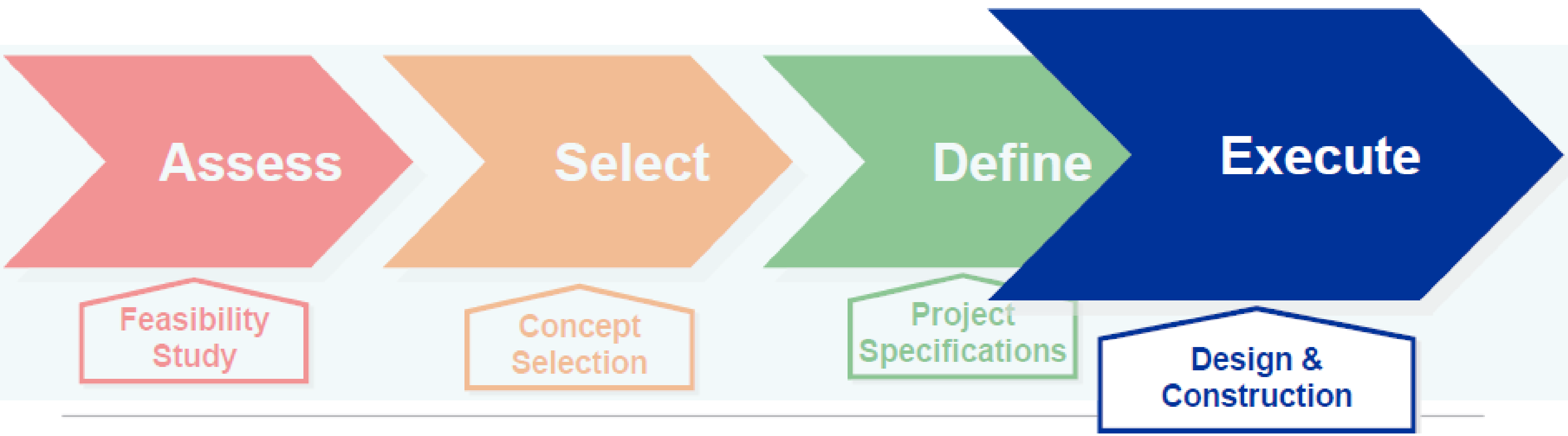
Planning for Success – FEED Phase

- Strive for a fabrication friendly design
- Strive for an installation friendly design
- Identify risks and develop mitigation plans
- Develop a manageable contracting strategy
- Develop a realistic cost estimate and schedule



Planning for Success – EPCI Phase

- Reflects pre-sanction planning
- Focus becomes ‘work the plan’
- Inadequate planning leads to serious problems
- Recovery is expensive

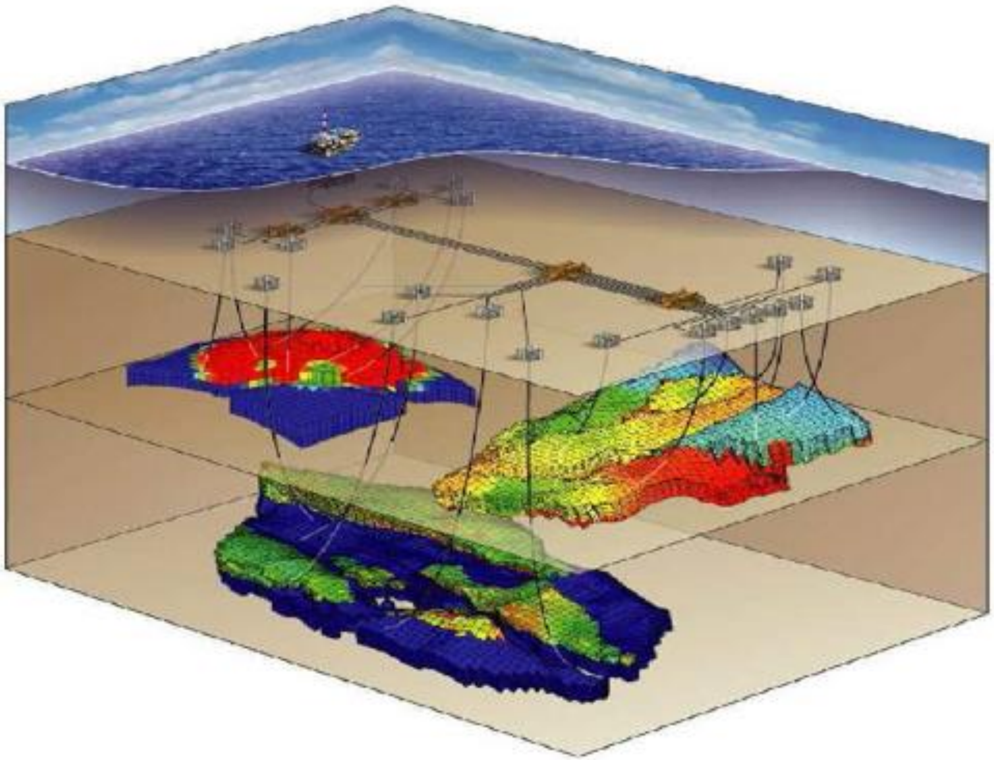


Floating System Selection Factors

- **Functional**
  - Dry/Wet trees; drilling, workover
- **Technical**
  - Water depth; Metocean; Shut-in pressure; risers
- **Execution**
  - Topsides integration, installation and commissioning
- **Operations**
  - Safety; reliability; availability
- **Flexibility**
  - Contracting; future expansion; relocation
- **Commercial**
  - Capex, Opex and schedule

Key Drivers for Floating System Selection

- **Reservoir** characteristics drive everything
- **Field architecture** and layout / future expandability
- **Riser** options / platform motions
- **Metocean** criteria
- **Topsides** requirements
- **Local content** requirements
- **Drilling & completion** strategy
- **Risk** issues & mitigating measures
- **Execution** plan and delivery model



Completion Strategy Drives Floater Selection

Criteria	**Total Subsea** (wet-tree)	**Surface** (dry-tree)
CAPEX Cost	Lower	Higher
DRILEX Cost	Higher	Lower
OPEX Cost	Higher	Lower
Production Reliability	Lower	Higher
Reservoir Mgmt and Productivity	Lower	Higher

Deepwater Concept Qualification Matrix

Deepwater Field Development Concept Selection Matrix

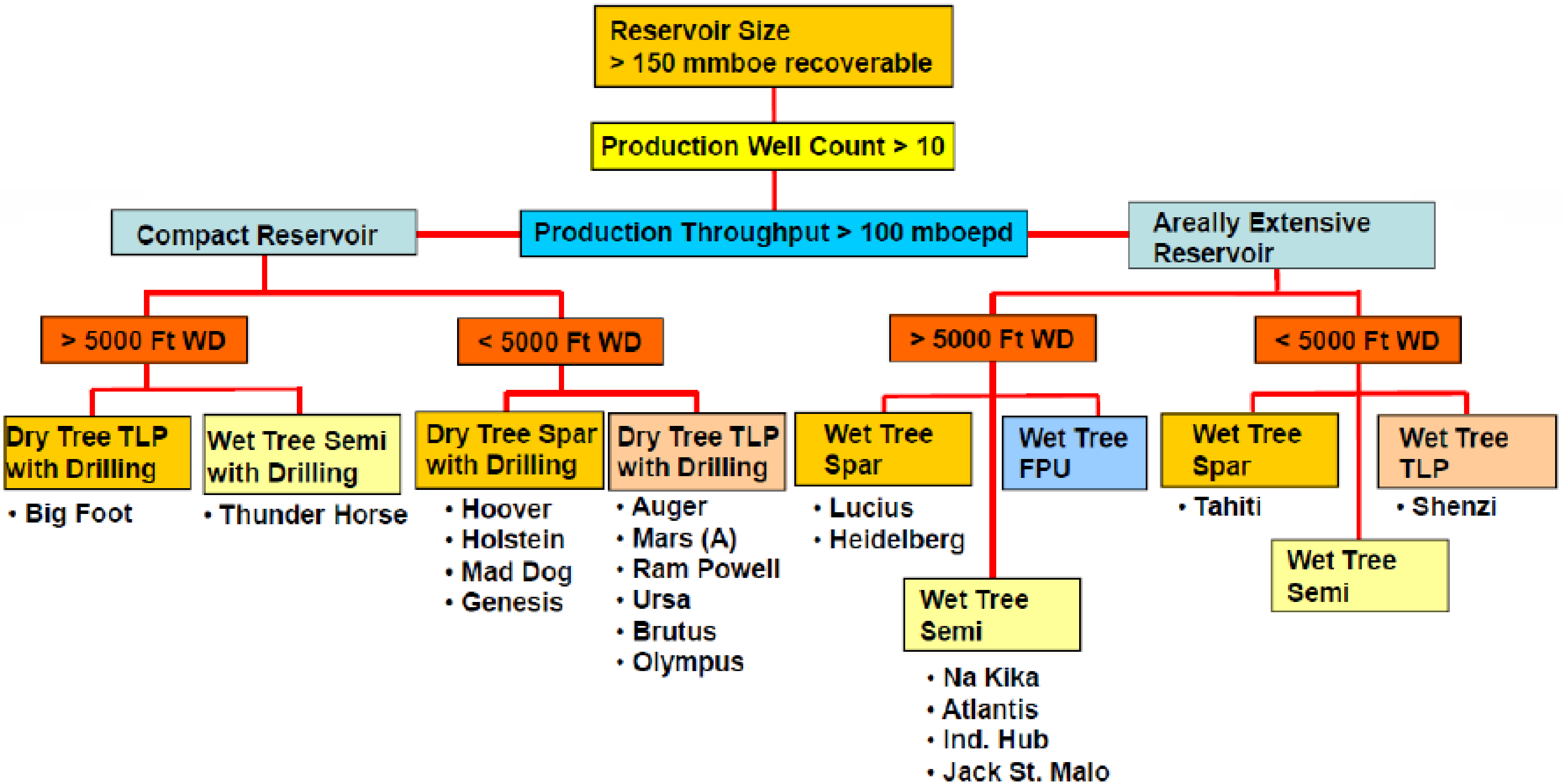
COURTESY: WOOD GROUP MUSTANG

Legend:
- Field Proven 🟢
- Qualified 🟡

* "Unconventional" FPSOs include Sevan SSP, Petrobras MonoBR, Global SSP SSP320 & SSP PLUS.

		MAJOR CAPABILITY					INSTALL		RESERVOIR INFO. – ARIAL EXTENT		TREE TYPE			LOCATION APPLICATION			ENVIR. CONDITIONS			RISERS			EXPORT			
	FIELD APPLICATION EXPERIENCE	PRODUCTION	DRILLING	STORAGE	WATER DEPTH RATING	PAYLOAD SENSITIVE	DECK/HULL MATING OFFSHORE	DECK/HULL MATING @ FABRICATION YARD	SMALL AREA	LARGE AREA	WET TREE	DRY TREE	WELL COUNT	NEARBY INFRASTRUCTURE	REMOTE	SMALL FOOTPRINT (Mooring System)	CALM	AREA WITH HURRICANES/TYPHOONS	HARSH	STEEL CATENARY RISER (SCR) CAPABLE	FLEXIBLE PIPE CAPABLE	TOP TENSIONED RISER	OIL PIPELINE EXPORT APPLICATION	SHUTTLING APPLICATION	GAS PIPELINE	GAS REINJECTION
Conventional Fixed Platform (>1,000')	🟢	🟢	🟢		See Water Depth Range Comparison Graph		🟢		🟢	🟢		🟢	See Well Capability by Deepwater Production Type Graph	🟢		🟢	🟢	🟢	🟡	🟢	🟡		🟢	🟡	🟢	🟢
Compliant Towers	🟢	🟢	🟢				🟢		🟢	🟡		🟢		🟢		🟢	🟢	🟢	🟡	🟢	🟡		🟢		🟡	🟡
FDPSOs	🟢	🟢	🟢	🟢			🟡	🟢			🟢	🟡		🟡	🟡		🟢	🟡		🟡	🟢	🟡		🟢	🟡	🟡
FPSOs																										
Spread Moored	🟢	🟢		🟢			🟡	🟢	🟢	🟢	🟢				🟢		🟢			🟢	🟢			🟢	🟢	🟢
Turret Moored	🟢	🟢		🟢			🟡	🟢	🟢	🟢	🟢				🟢			🟢	🟢	🟢	🟢			🟢	🟢	🟢
Unconventional*	🟢	🟢	🟡	🟢			🟡	🟡	🟡	🟡	🟡	🟡			🟡	🟡	🟡	🟡	🟡	🟢	🟢	🟡	🟡	🟡	🟡	🟡
Conventional TLPs	🟢	🟢	🟢					🟢	🟢		🟢	🟢		🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡
Proprietary TLPs	🟢	🟢	🟢			🟢	🟢	🟢	🟢	🟢	🟢	🟢		🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟡	🟢	🟡
Spars																										
Dry Tree	🟢	🟢	🟢			🟢	🟢	🟡	🟢			🟢		🟢	🟡	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟡
Wet Tree	🟢	🟢	🟢			🟡	🟢	🟡	🟡		🟢			🟢	🟡	🟢	🟡	🟢	🟡	🟢	🟡	🟡	🟢	🟡	🟡	🟡
Semi-FPUs																										
Conventional	🟢	🟢	🟡					🟢	🟡	🟢	🟢	🟡		🟢			🟢	🟢	🟢		🟢		🟢		🟢	🟡
Deep Draft Wet Tree	🟢	🟢	🟡			🟡	🟡	🟢	🟢	🟡	🟢			🟢	🟡	🟡	🟢	🟢	🟡	🟢	🟢	🟡	🟢	🟡	🟢	🟡
Deep Draft Dry Tree	🟡	🟡	🟡			🟡	🟡	🟡	🟡	🟡		🟡		🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡
Subsea Tiebacks	🟢								🟢	🟢	🟢			🟢			🟢	🟢	🟢							

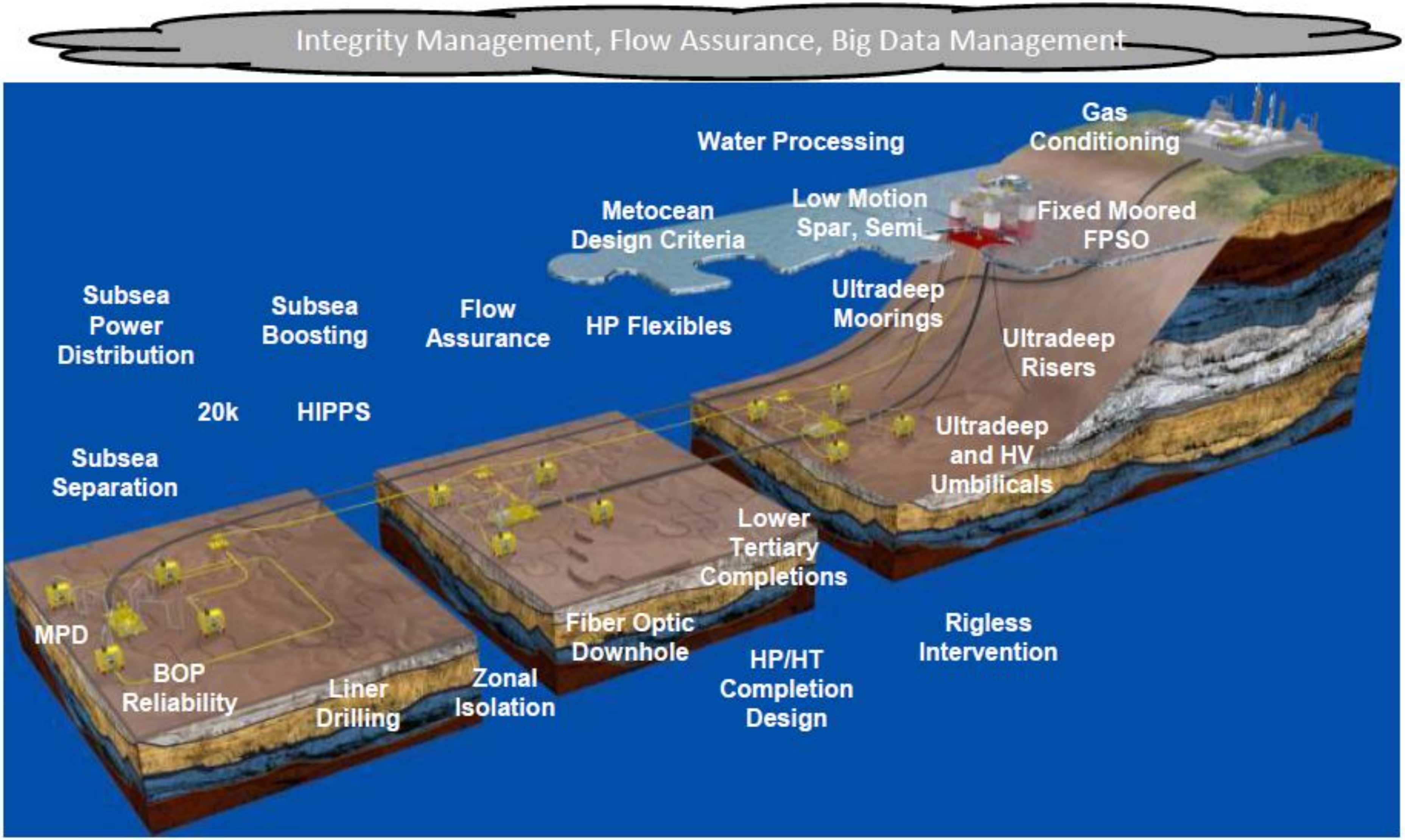
Typical Decision Tree for Screening Floating Platforms – Large Multiple Reservoirs



Platform Configuration	JU	CGS	Jacket	CT	MF	FPSO	Semi**	Semi	Subsea	TLP	Spar
Water Depth (m)*	109	303	412	535	1615	1853	1890	2438	2740	1450	1710
	S***	S/M		M	V					D	UD
DVWA	Y				N		Y	N		Y	
Well Pattern	Clustered				Distributed		Clustered	Distributed		Clustered	
Tieback Length	V	L	V			L	V	M		V	
Well Count	M	M /H		H	Low	V	M / H	V	Low	M /H	M
Steel Catenary Riser	No Constraint				Needs Evaluation					No Constraint	
Top Tension Riser[3]					N						
Service Life	V	M / L			M	V				M / L	
Derrick	Platform / Jack up			Platform	MODU					Platform	
Tree	Dry/Wet				Wet		Dry/Wet	Wet		Dry/Wet	
Structure Weight Sensitivity To Topside	SW				Least		SW		Least	More	SW
Export Mode	P / T	T	P / T			T	P / T		P	P / T	
Drilling	C			Y	N		C	N		C	
Just MODU Drilling				N	Y		N	Y			
Unmanned	C	N	C	N					Y	N	
Inshore Integration	Y	N				Y			-	C	N
Reuse / Conversion	C					C			N		
Early Production System	C								C	N	
Contracting Flexibility	Good				Better	Best	Better		-	Good	
Storage	N				-	Y	N				

C	Common	JU	Jack up	S	Shallow	*Data is valid for the maximum water depth (meter) in which facility have been employed till the year 2003[2].
CGS	concrete gravity structures	L	Long	SW	Somewhat	
CT	Compliant tower	M	Moderate	T	Tanker	** Semi-submersibles are categorized into tow groups; with and without direct vertical well access[2].
D	Deep	MF	Mini floater	TLP	Tension leg platform	
DVWA	Direct vertical well access	MODU	Mobile offshore drilling unit	UD	Ultra deep	***Production facility types have been categorized into shallow and deep water with the division at 300 m here.
FPSO	floating production, storage, off-loading vessel	N	No	V	Various	
H	High	P	Pipeline	Y	Yes	

Deepwater Technology Needs



Putting Field Development Costs in Perspective

GoM – Exxon Hoover - $1.2bn
Installed 2000

GoM – BP Horn Mountain $650M
Installed 2002

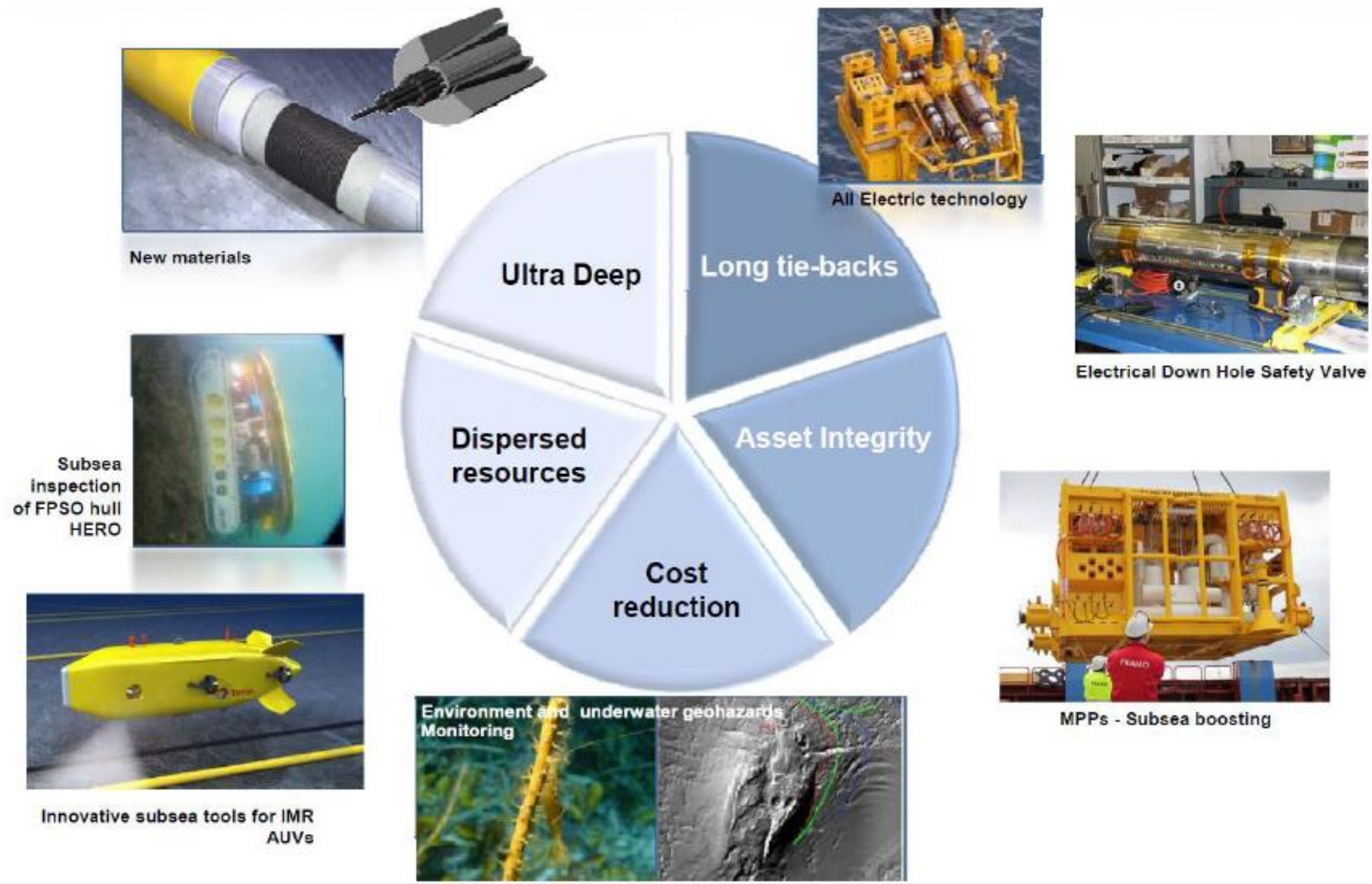
GoM – BP – Thunderhorse - $5bn
Installed 2005

GoM – Anadarko I-Hub - $2bn
Installed 2007

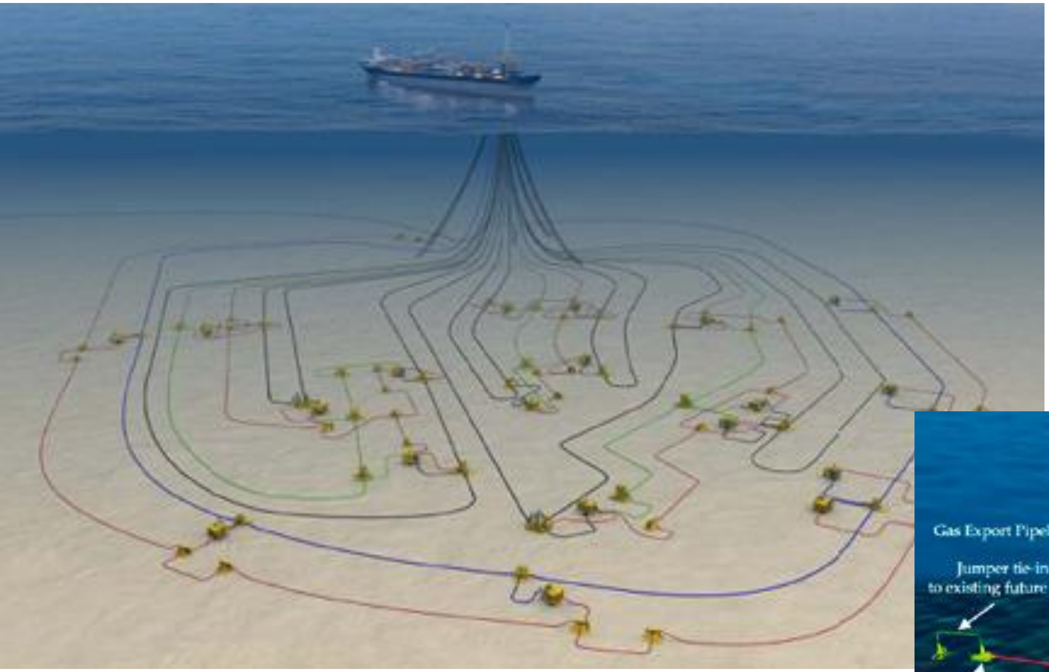
GoM – Chevron Tahiti - $2.7bn
Installed 2009

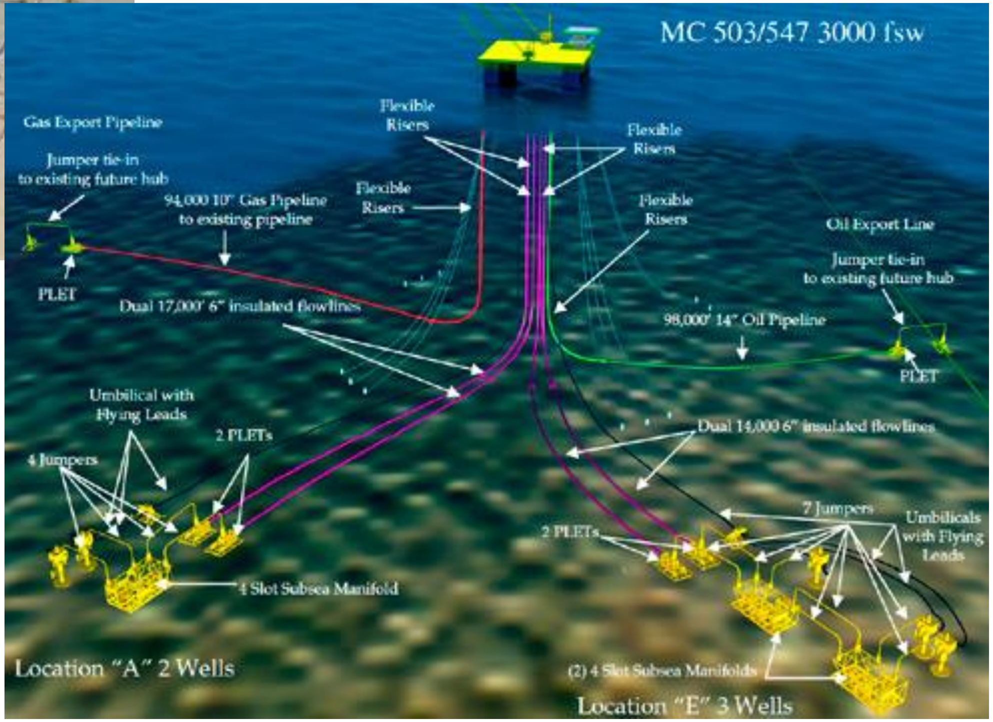
GoM – Chevron JSM - $7.5bn
Installed 2014

Some Deep Offshore R&D Challenges

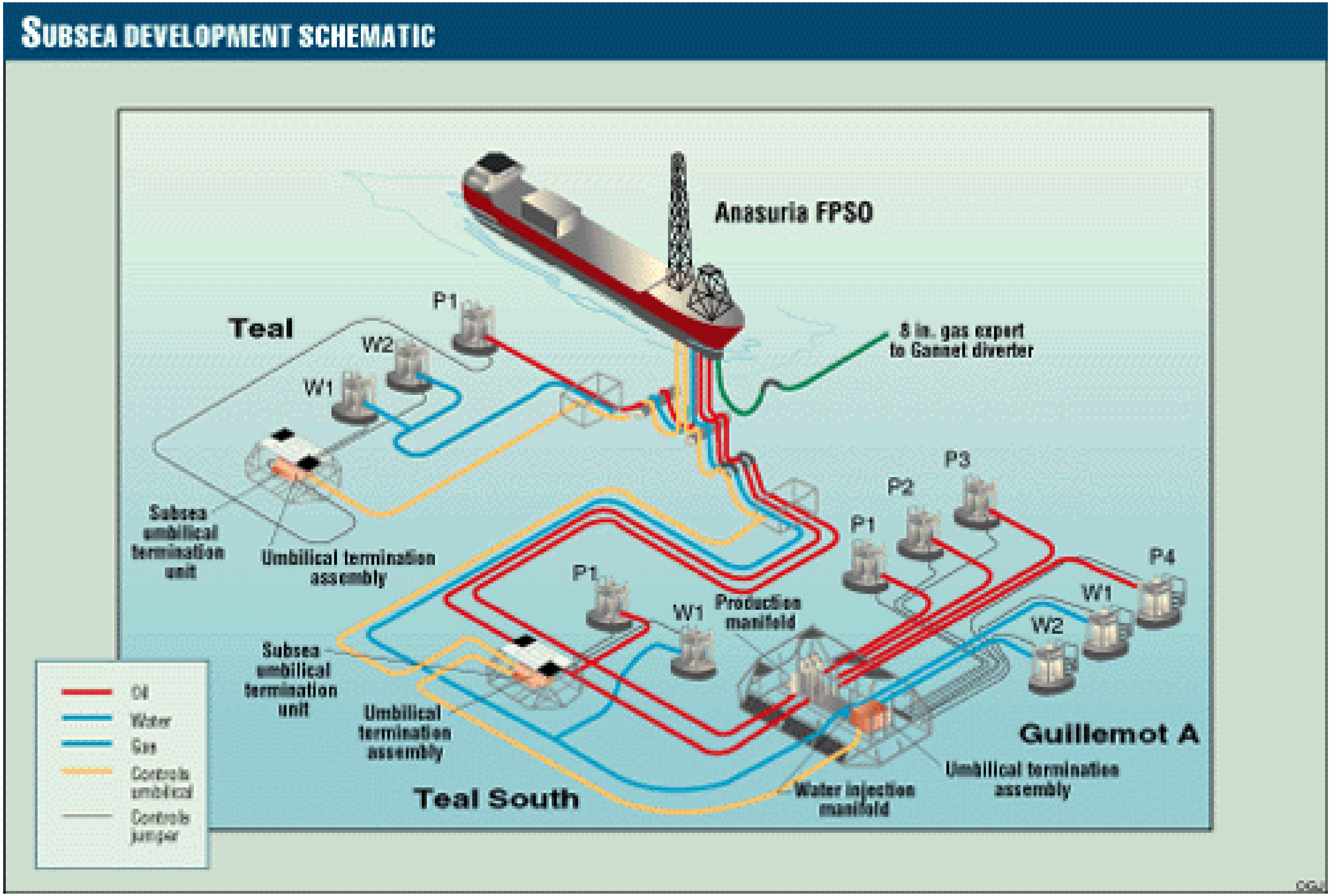


Field Development





Field Development



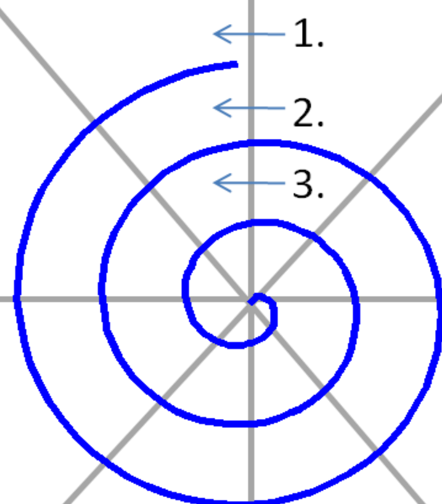
Espiral de Projeto – Sistemas Oceânicos

1. Estudo de Viabilidade
2. Projeto Preliminar
3. Projeto Final

Fatores Externos Limitantes do Projeto
- Requisitos da empresa - Política e as metas da empresa
- Restrições governamentais
- Legislação Internacional - MARPOL, SOLAS,etc.
- Regras e restrições industriais

Caracterização da Reserva Encontrada
- Mapeamento e estimativa da reserva
- Teste do poço e propriedades do fluido
- Modelagem da reserva
- Localização dos poços

Análise Econômica
- Planejamento de execução
- Estimativa do custo
- Estratégia para execução
- Plano de Operação



Critérios Ambientais.
- Natureza física e geotécnica da região do reservatório:
  - Aspectos Meteorológicos
  - Aspectos Oceanográficos
- Estabilidade e declividade do solo
- Levantamento das propriedades da água:
  - Temperatura
  - Salinidade
  - Condutividade
- Distribuição de velocidade e pressão da água

Transporte de Óleo e Gás
- Transporte via tubulação
- Transporte via navio tanque
- Armazenamento Local

Escolha do Sistema Oceânico de Produção
- Plataforma:
  - Jaqueta convencional
  - Plataforma do tipo gravidade
  - Plataforma do tipo Complacente (TLP, Torres, etc.)
  - Sistema de produção Flutuante (Semisub, FPSO,etc.)
  - Template, Manifold, Riser, etc.
- Equipamentos de produção

Planejamento dos poços e de perfuração
- Sequência de perfuração e dimensões das tubulações
- Perfuração direcional ou vertical
- Escolha do tipo de plataforma de perfuração
- Completação e “Workover”

Definição dos equipamentos de processos
- Equipamentos de processamento de óleo e gás
- Equipamentos de injeção
- Logística e acomodação
- Segurança

Referências

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Thank You!!