Systems Approach to Subsea Projects Manufacturer´s Perspective

Presented by:
Denver Tsui

Author:
Corliss

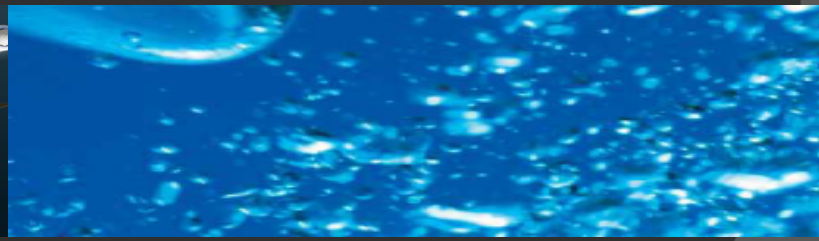
FMC Technologies

We put you first.
And keep you ahead.

Systems Approach

Manufacturer's Perspective






Introduction to Subsea Systems

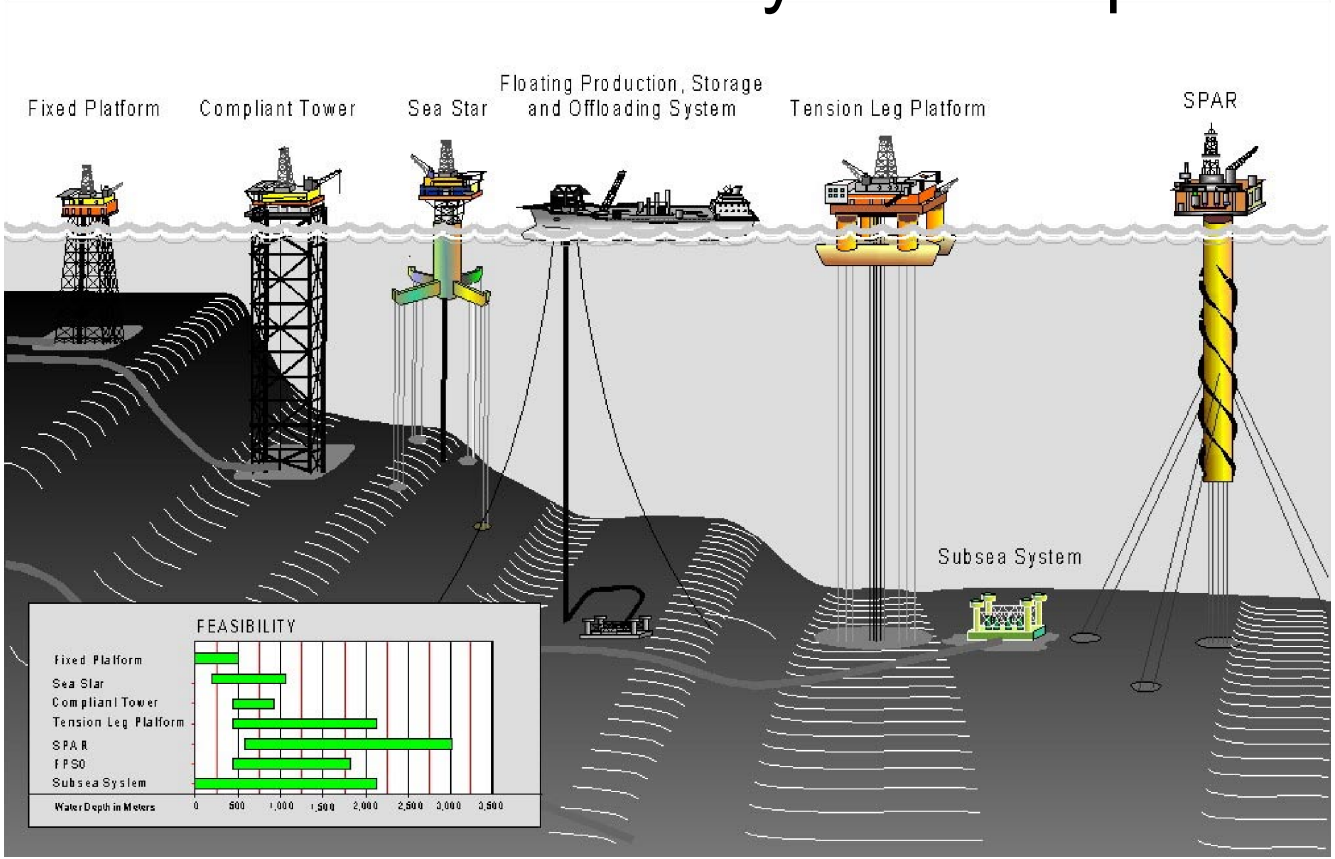
- Deepwater Discussion
- Trends in Equipment
- Flow Assurance-Deliverability
- Field Architecture
  - Subsea Layout Configurations
  - Economic Drivers
  - Scenario Planning
- Applications & Hardware Selection
- Project Execution

FMC Technologies

We put you first.
And keep you ahead.

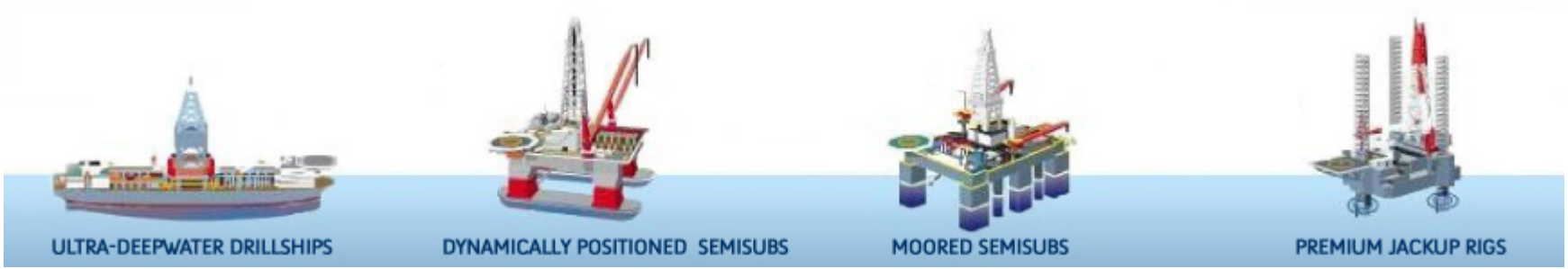
Deepwater Discussion

Production Platforms-by water depth



Source: www.rigzone.com

Drilling Vessels-by water depth



Water Depth (Feet)	Surface Vessel	Type of Mooring
< 400	Jack-up	Spud Can or Mudmat
400-4,000	Semi-Submersible	Mooring (Anchors)
> 4,000	Semi-Submersible	Dynamically Positioned (Thrusters)
> 2,000	Drill Ship	Dynamically Positioned (Thrusters)

Source: www.rigzone.com

Subsea Tree Equipment-by water depth

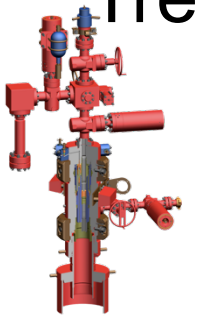
Water Depth (Feet)	Surface Vessel	Type of Tree
< 350	Jack-up	Mudline – Diver Assist
350-750	Floating Vessel	Diver Assist
750-2500	Floating Vessel	Diverless
> 2,500	Floating Vessel	Guidelineless

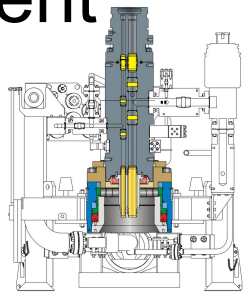
FMC Technologies

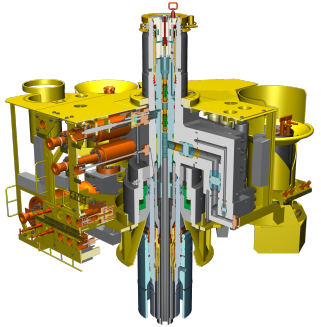
We put you first.
And keep you ahead.

Trends

Trends in Equipment





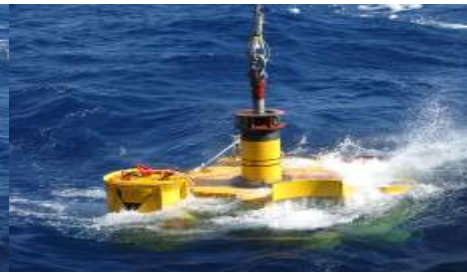


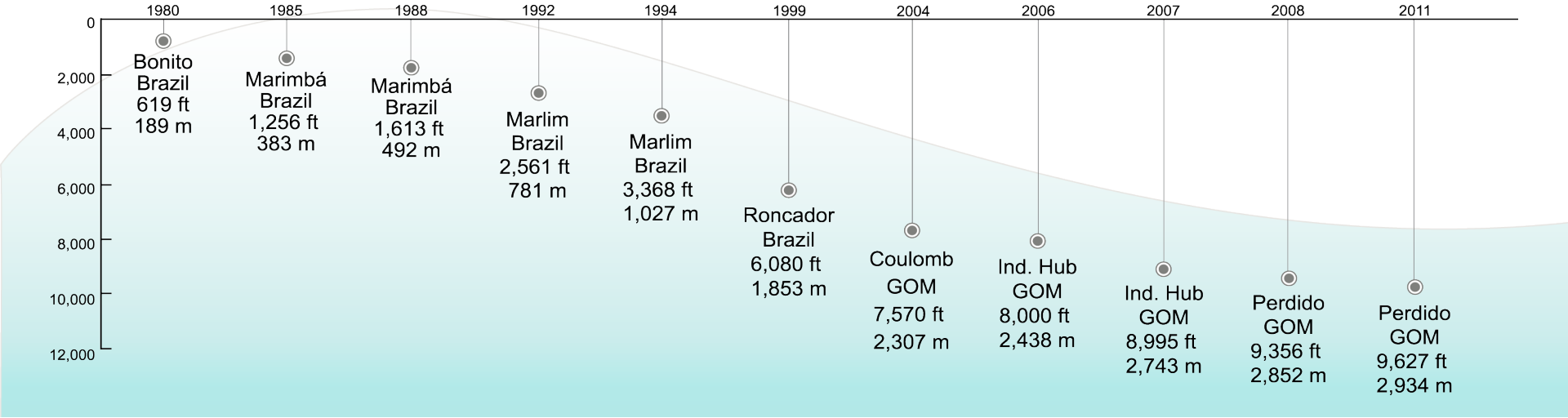
Time	Equipment Press/Prod Rate	Equipment Size/Location
1960s-1990	1,000 to 5,000 psi; 1,000 to 3,000 bbls/day	3” bore (GOM); 4” (Brazil) 5” (North Sea)
1990s	10,000psi; 5,000 to 6,000 bbls/day	4” bore (GOM); 5” (Brazil) 7” (North Sea)
2000s	15,000 psi; 10,000 to 50,000 bbls/day	5-7” bore (GOM); 5-7” (Brazil) 9” (North Sea)
2014+	20,000 psi; HPHT in development	?

Technology leadership

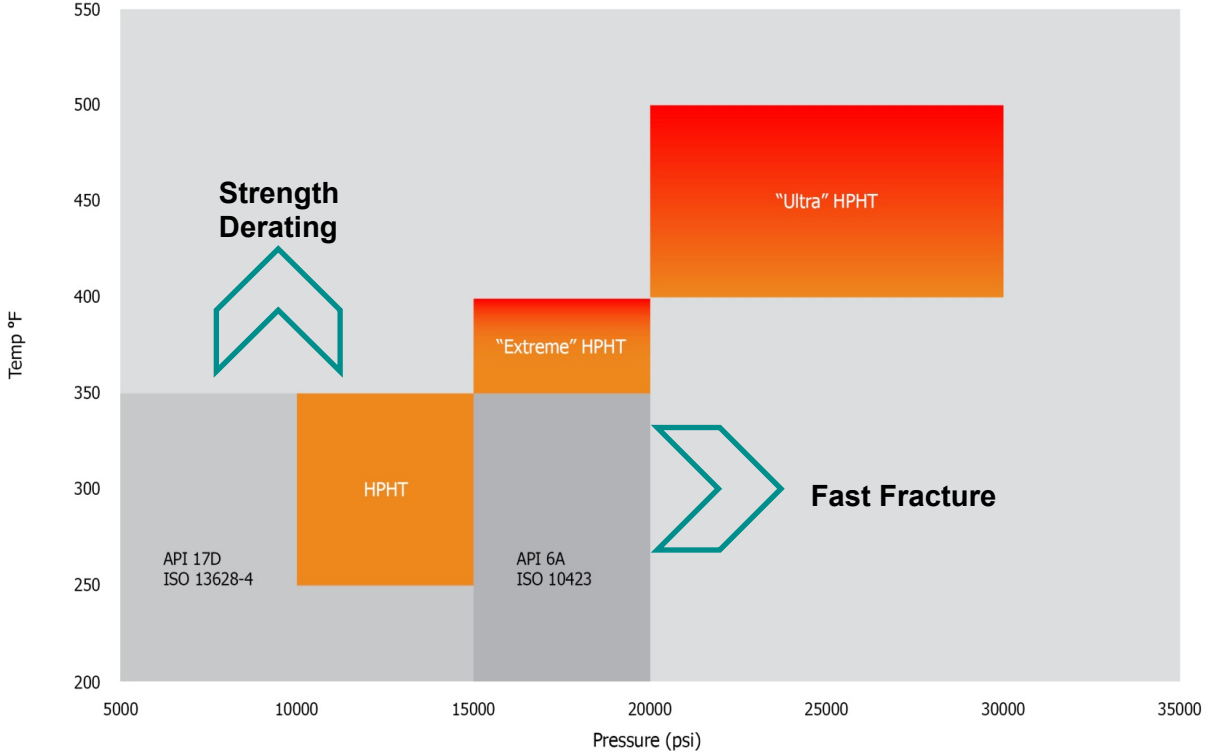
Subsea depth record is doubled every 5-7 years





How is HPHT Defined?



Subsea HPHT Range: 10-15Kpsi / 250-350F
Surface HPHT Range: 10-20Kpsi / 250-350F

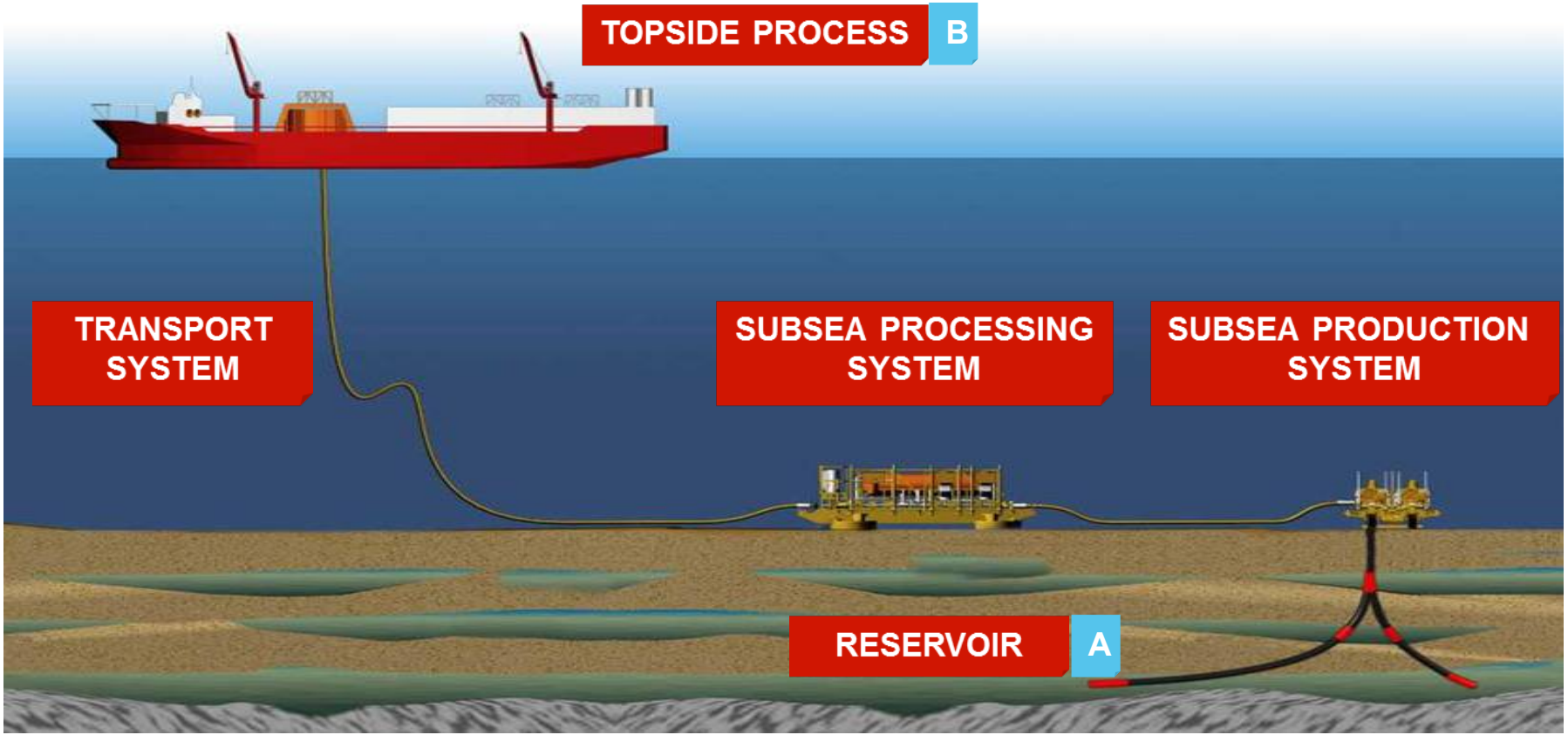
Source: OTC 17927

FMC Technologies

We put you first.
And keep you ahead.

Flow Assurance-Deliverability

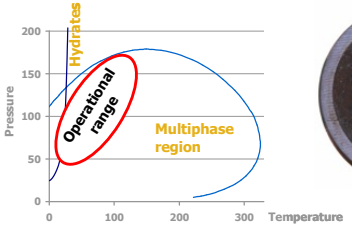
Overall Goal: getting hydrocarbons from A to B



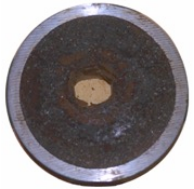
Flow Assurance-Deliverability

- System Deliverability
- Dynamic Flow Simulations
- Liquid Slugging
- Paraffin, Hydrates
- Corrosion, Erosion
- Flowline Design
- Flow Regimes
- Thermal Systems Design
- Operating Procedures
- Topside Impact Evaluation
- Chemical Injection System

Multiphase composition



Wax / Asphaltenes



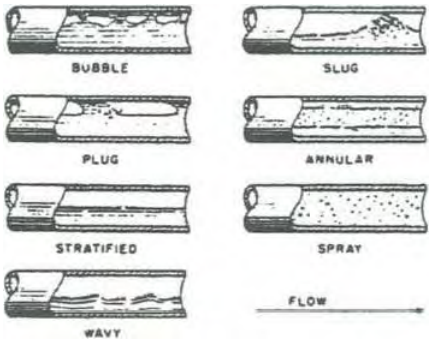
Emulsion / Foam

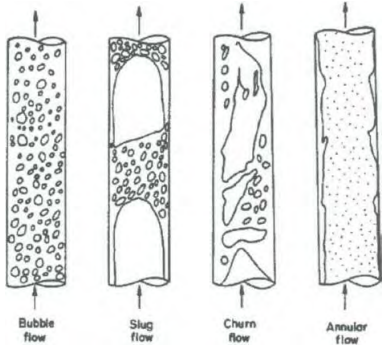
Sand / Erosion

Gas Hydrates

Corrosion

Scale (salts)

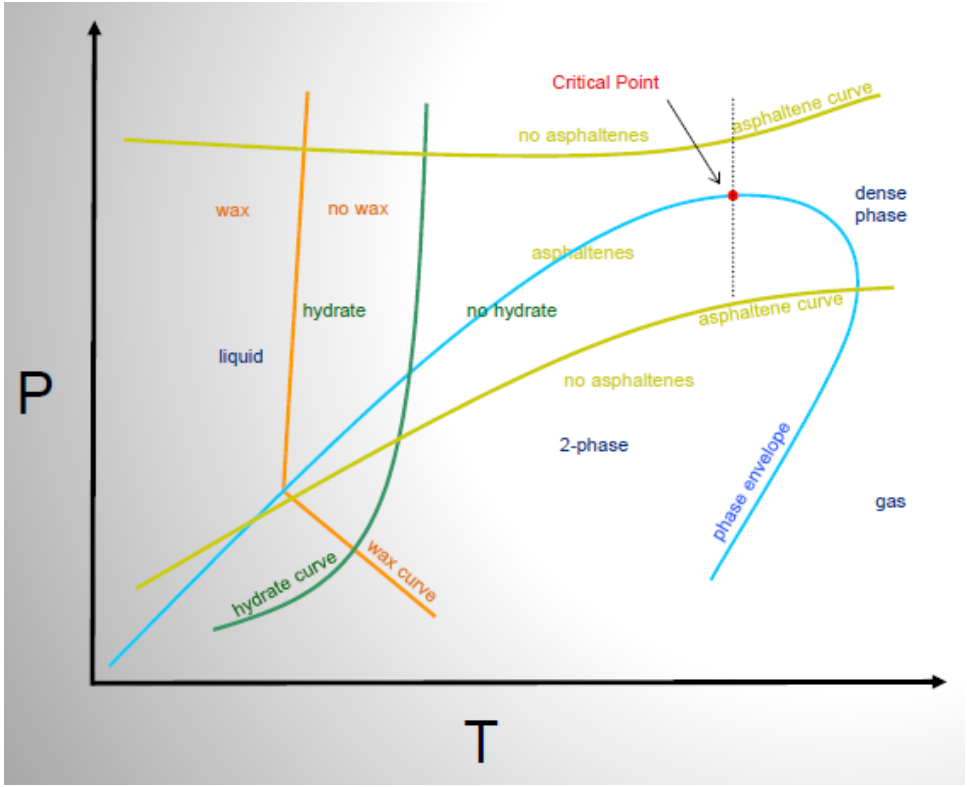




Source: Subsea Pipelines and Risers, Yong Bai and Qiang Bai

Flow Assurance-Deliverability

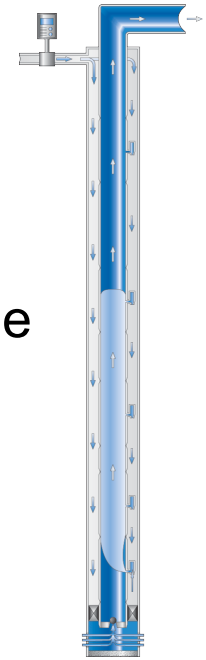
- Operating Envelope
  - Displays multiple curves on a pressure vs. temperature graph
  - Allows user to identify the ideal operating ranges to avoid flow assurance issues
  - Scale must be considered in analysis

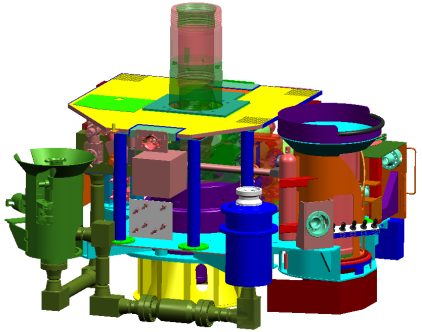


Source: Wood Group kenny, UH SUBS 6330, 2013,Lecture 3: Flow Assurance

Deliverability Enhancements

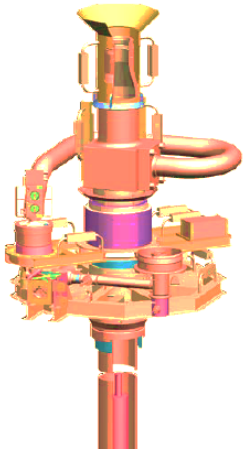
- Gas Lift
  - Downhole
  - Subsea Tree
  - Riser Base





- Injection Wells

- Pump
  - Seabed Multiphase
  - Downhole ESP

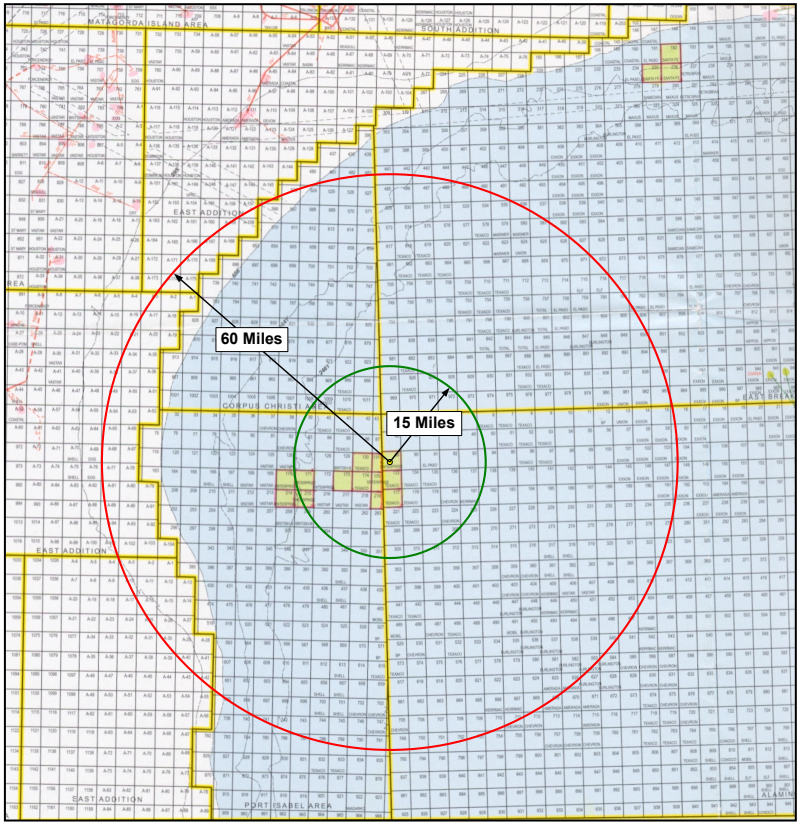


- Separation
  - Subsea
  - Downhole

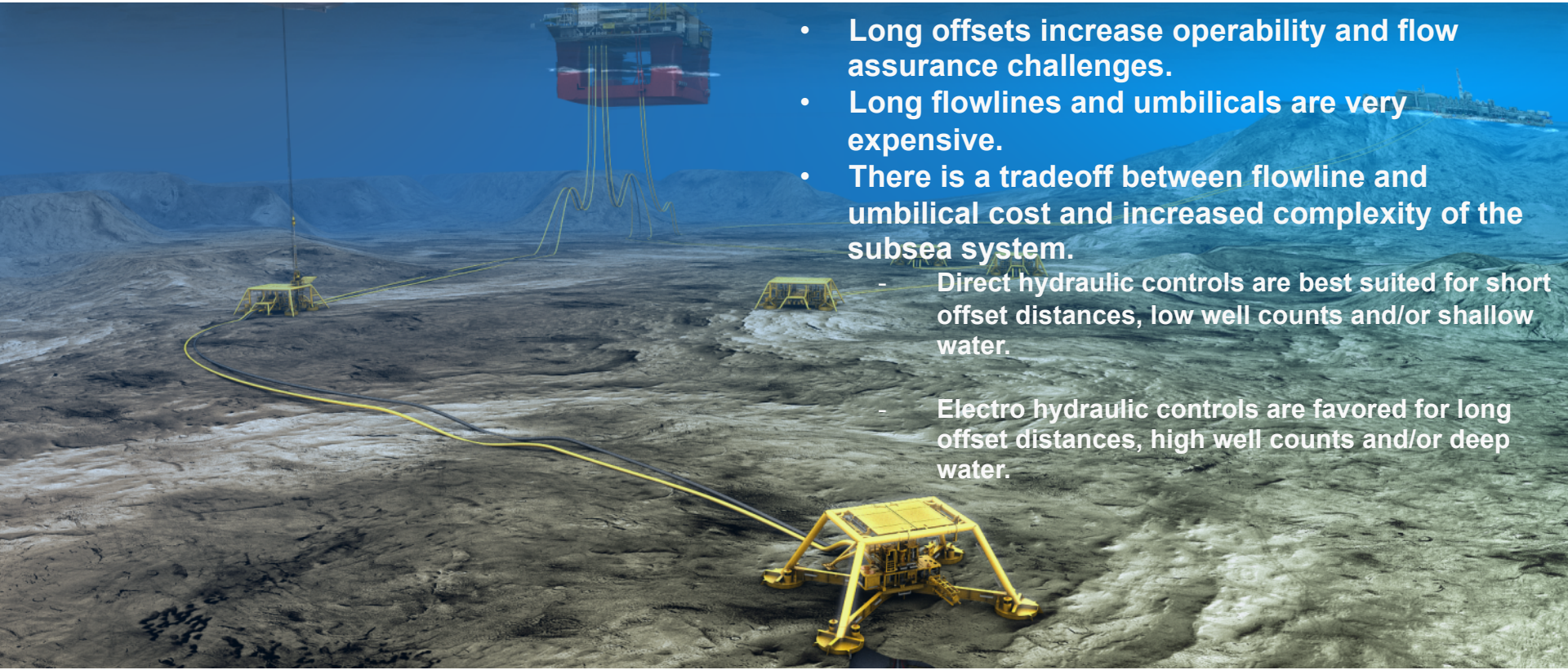
*Courtesy of Sulzer Pumps

General Rules for Subsea Tiebacks & Offsets

- If Oil: <15<30 miles
- If Gas: <60 miles
- Caveats
  - Oil
    - Energy to flow
    - Flow Assurance
  - Gas
    - Flow Assurance
    - Energy
    - Wet/Dry

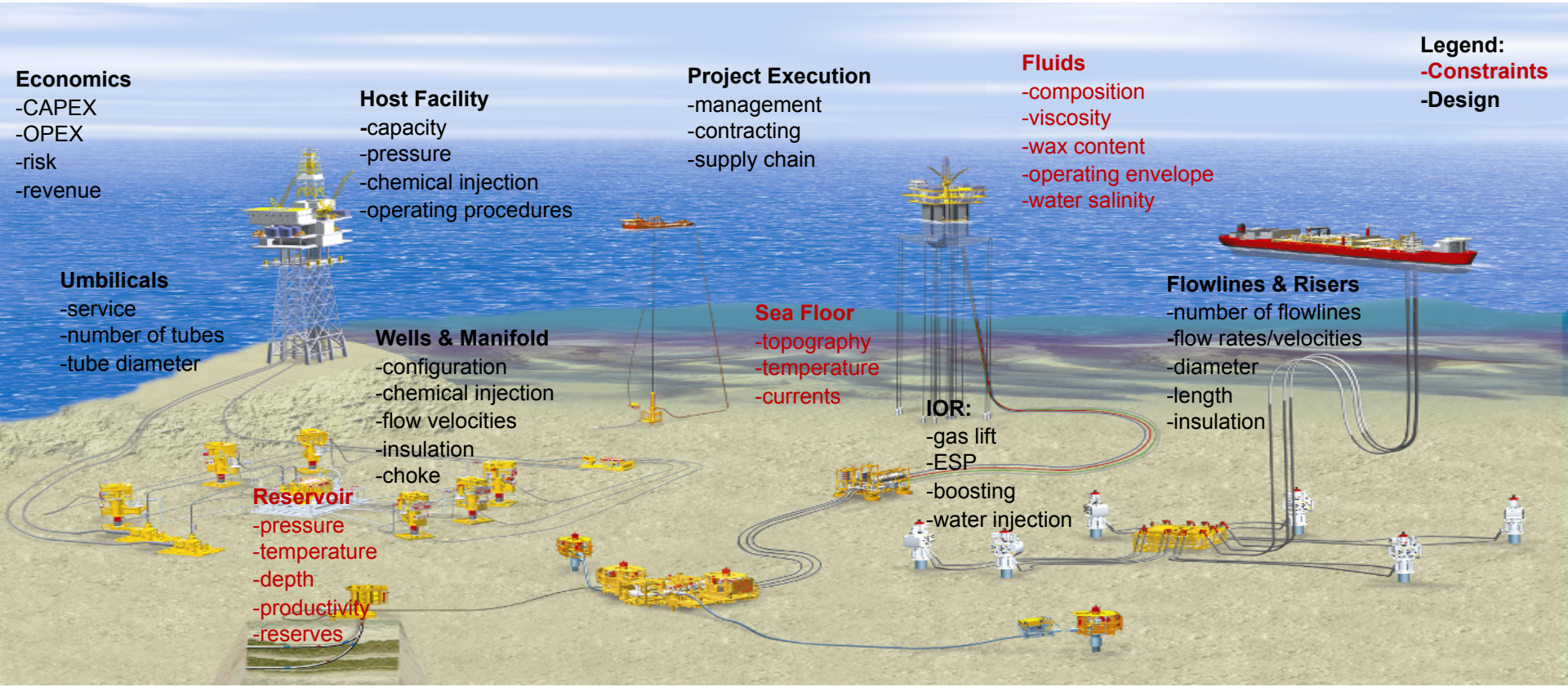


Importance of Offset Distance



- Long offsets increase operability and flow assurance challenges.
- Long flowlines and umbilicals are very expensive.
- There is a tradeoff between flowline and umbilical cost and increased complexity of the subsea system.
  - Direct hydraulic controls are best suited for short offset distances, low well counts and/or shallow water.
  - Electro hydraulic controls are favored for long offset distances, high well counts and/or deep water.

Operability Areas to be Addressed



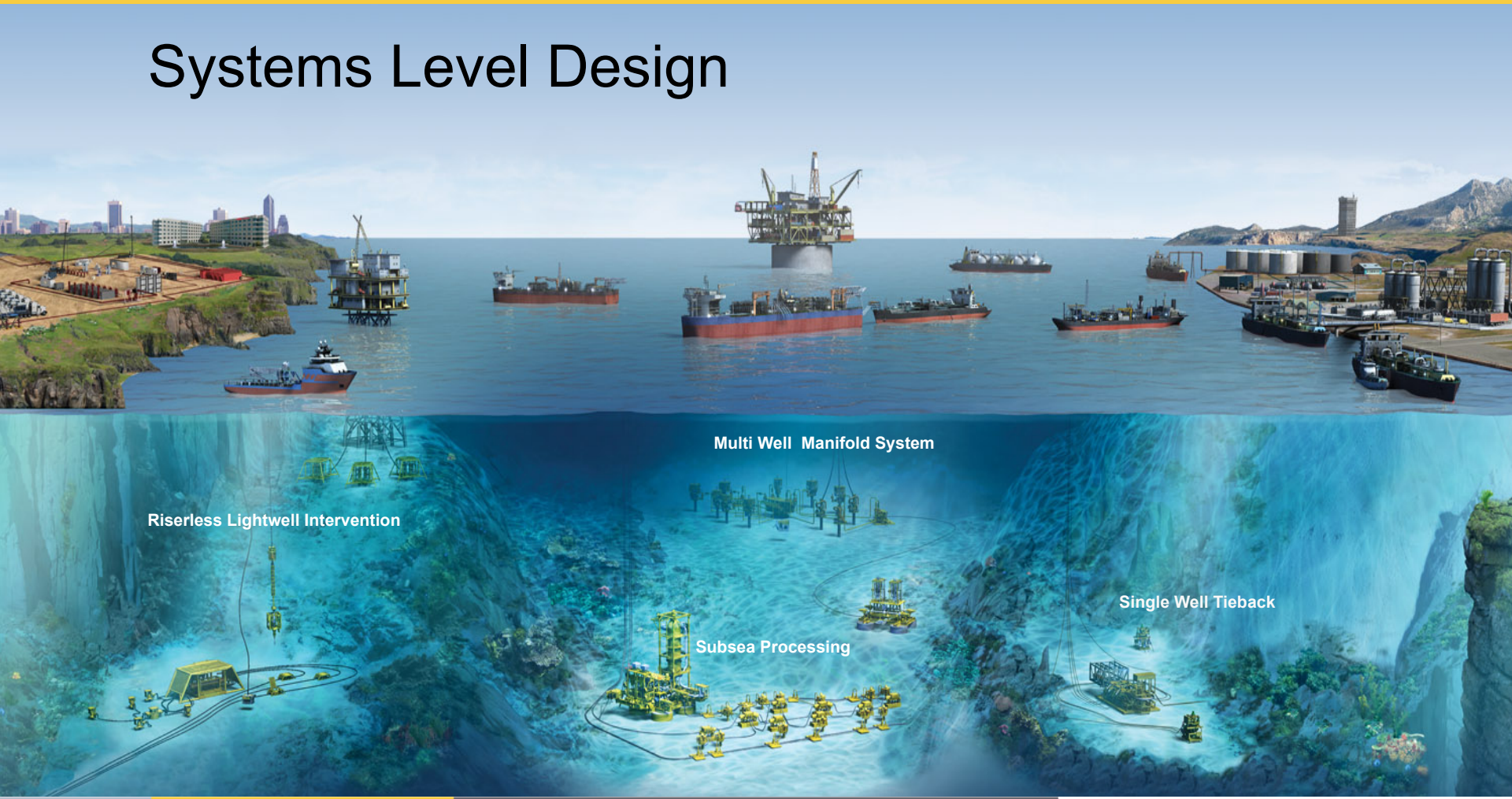
*Courtesy of IntecSea

FMC Technologies

We put you first.
And keep you ahead.

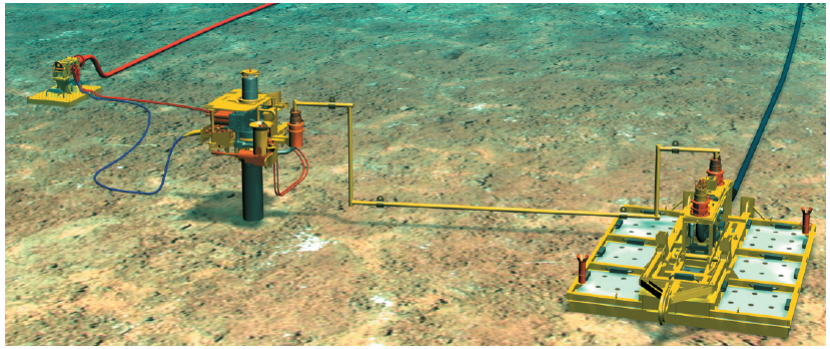
Field Architecture

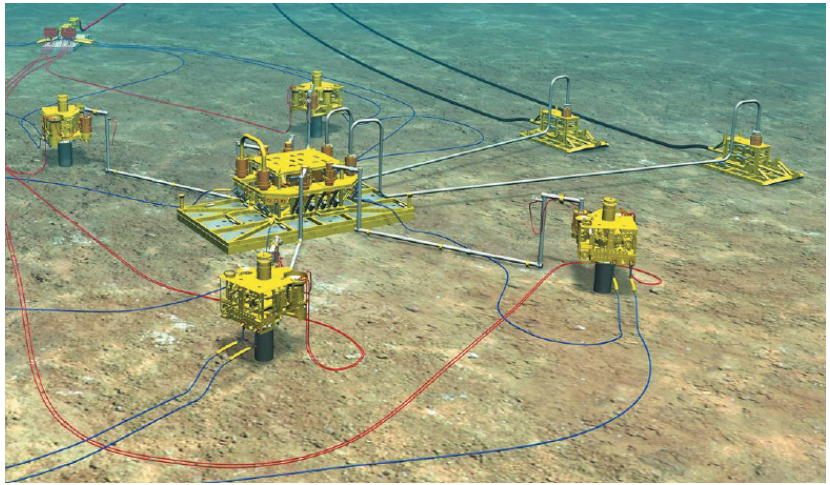
Systems Level Design



Field Architecture and Economic Drivers Subsea

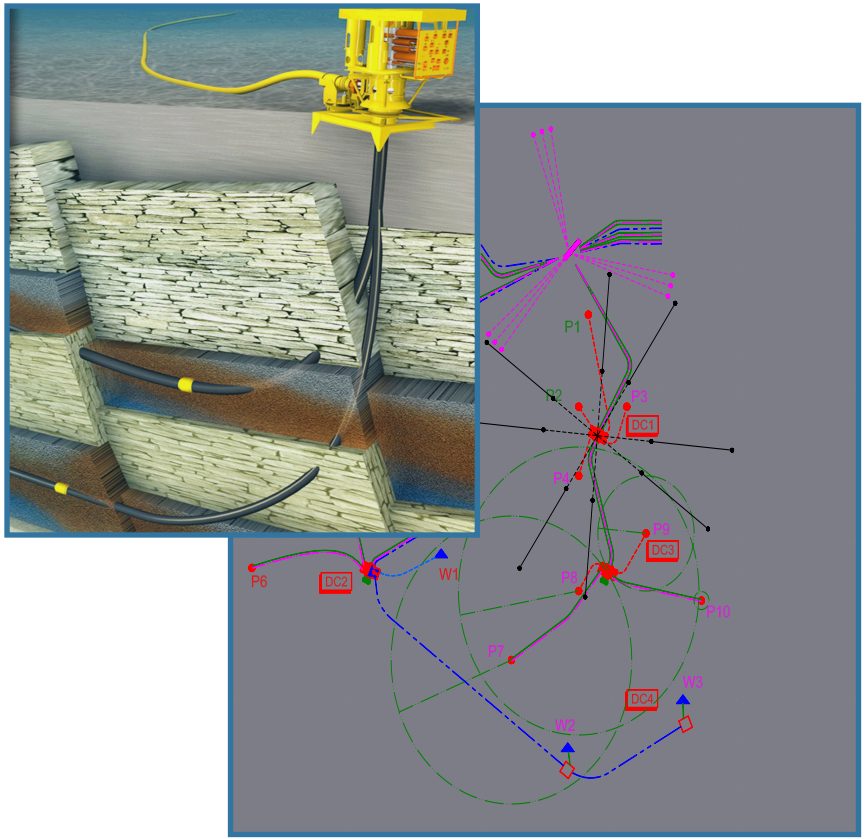
- Subsea equipment is “modularized” to accommodate a “building block” approach
  - Enabled by flowline jumpers and ROV flying leads
- Building blocks provide for:
  - Phased development
  - Adaptability to a variety of:
    - Field configurations
    - Host facilities
    - Logistics
    - Installation methods
  - Better control of “Risk Management”



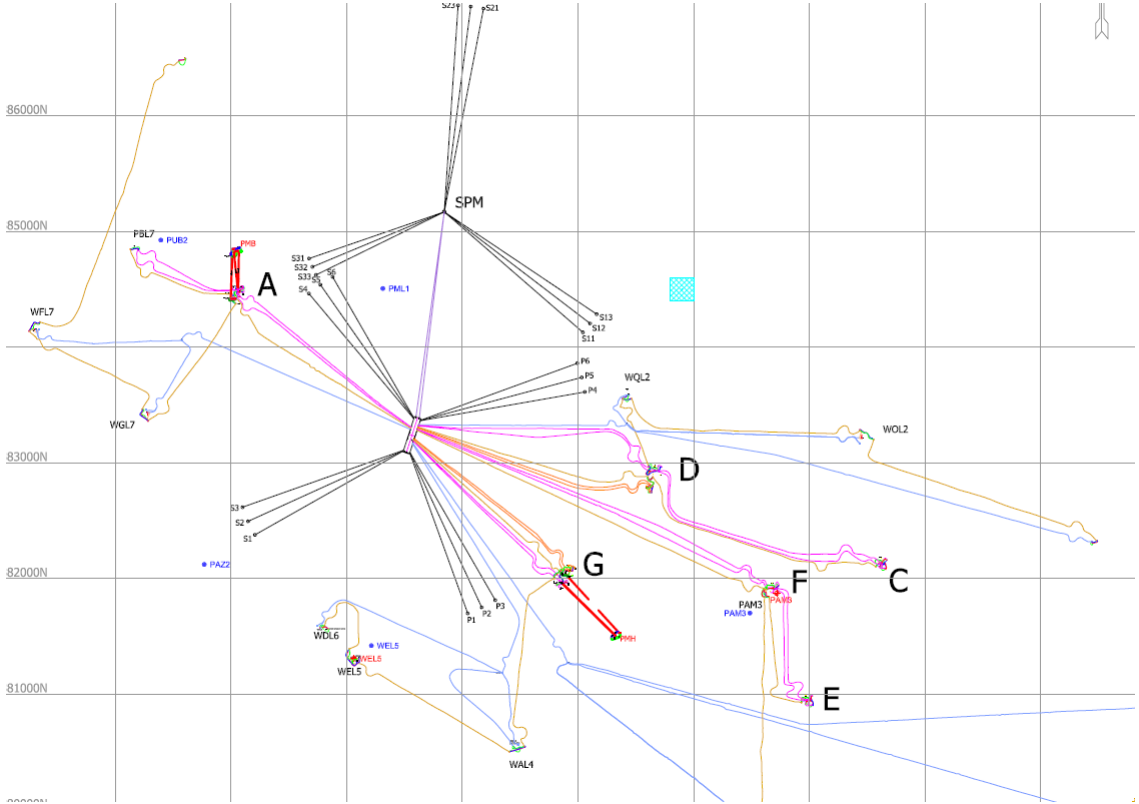


Trade Offs for Seabed Location of Wells

- Straight hole wells are typically the lowest cost to drill, but…
  - Deviated drilling allows wells to be located at drill centers
  - Drill centers minimize rig moves and simplify flowline and umbilical routing (saves cost)
  - Flowline and umbilical routing has to avoid interference with vessel moorings, well locations, seabed hazards, installation requirements, etc.
  - Well locations must satisfy drainage and injection requirements of reservoir



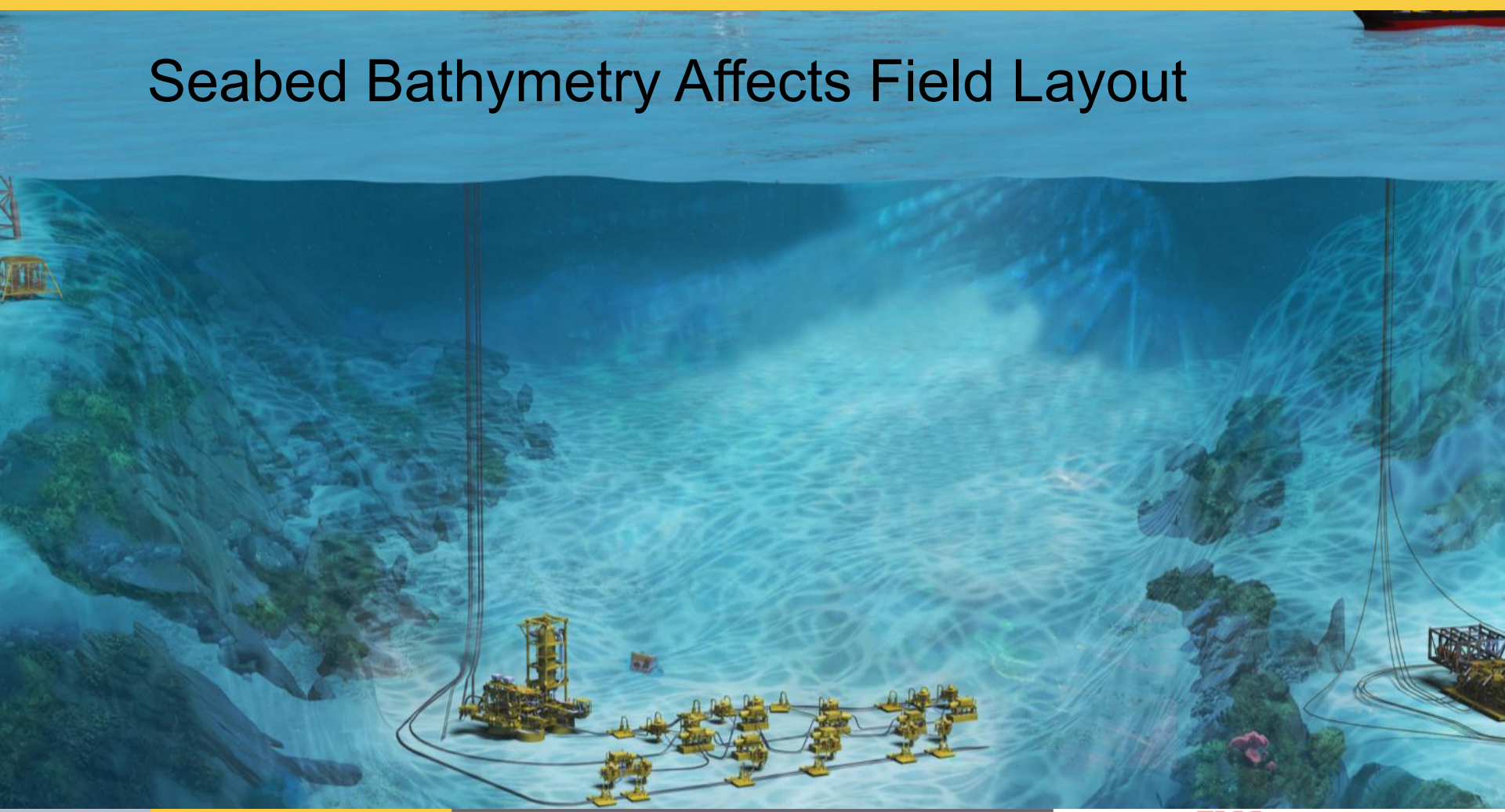
Example of Field Architecture



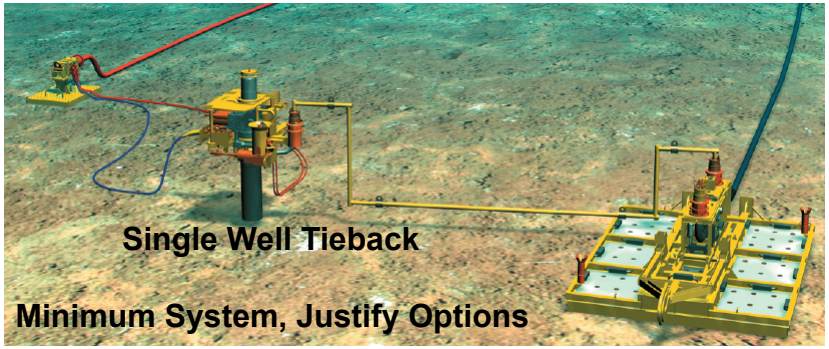
LEGEND	
	PRODUCTION FLOWLINE
	GAS INJECTION FLOWLINE
	WATER INJECTION FLOWLINE
	UMBILICAL
	SFL
	SFL
	EFL (EC1)
	EFL (EC2)
	SURFACE WELL LOCATION
	SUBSURFACE WELL TARGET

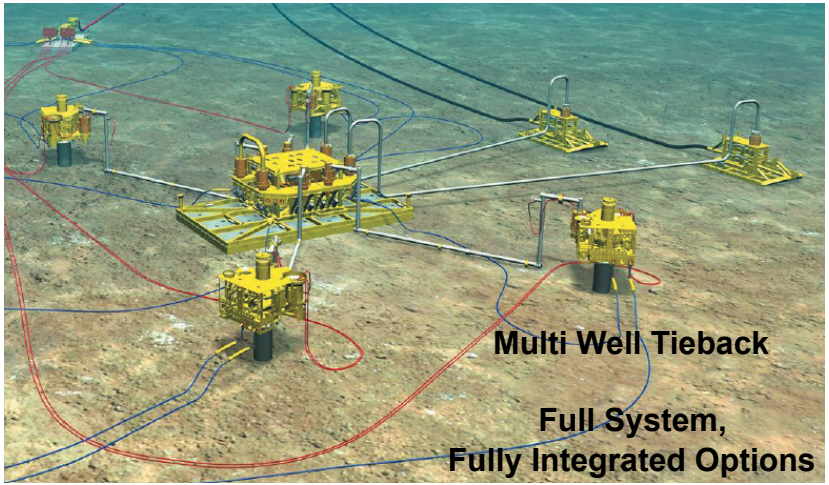
GEODESY	
ELLIPSOID	WGS84
PROJECTION	UNIVERSAL TRANSVERSE MERCATOR (UTM)
CENTRAL MERIDIAN	3° E
ZONE	31 NORTH
FALSE EASTING	50000m
FALSE NORTHING	0m

Seabed Bathymetry Affects Field Layout



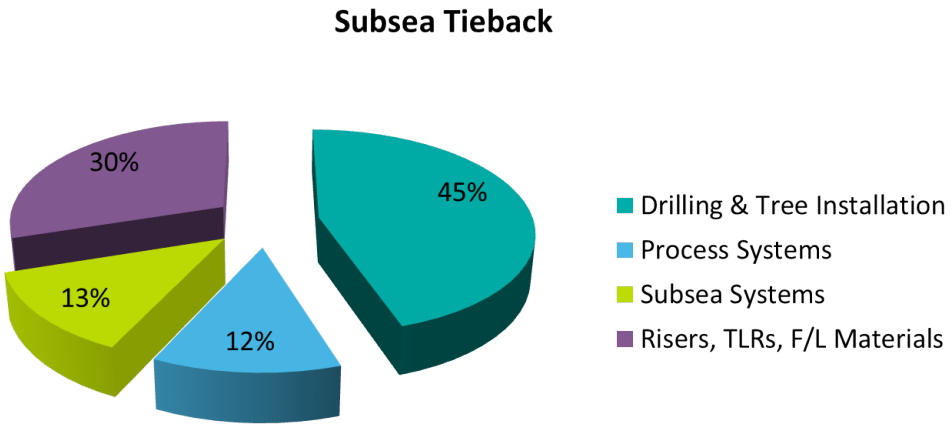
Scenario Planning-Range of Subsea Projects

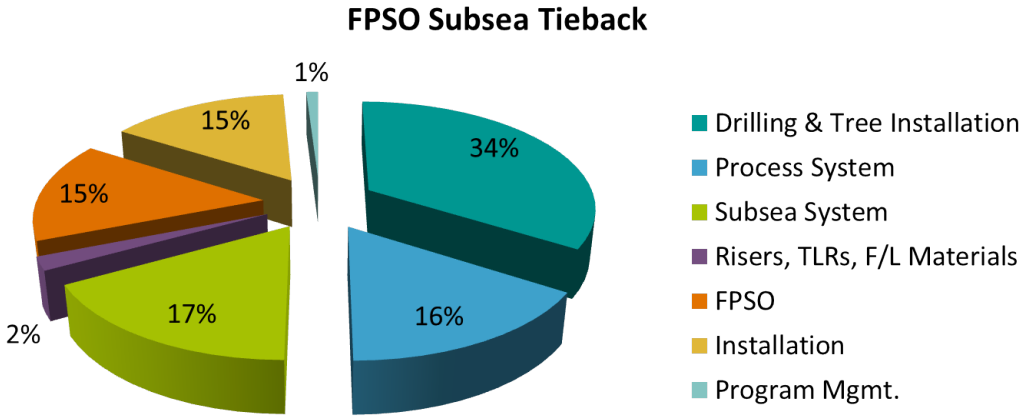




Case	Reserves (MMbbls)	Total Price CAPEX ($M)	Development Cost per Barrel
1	257	$1,192	$4.64
2	242	$1,169	$4.83
3	178	$1,015	$5.70
4	242	$1,217	$5.03
5	197	$ 952	$4.83
6	185	$ 949	$5.13
7	133	$ 818	$6.15

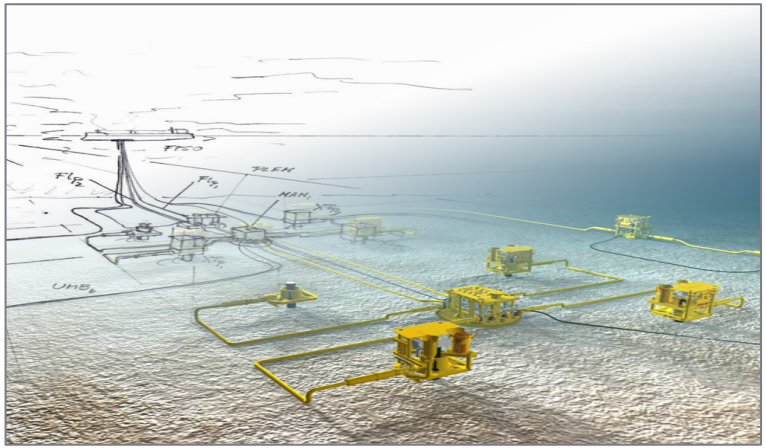
Cost Drivers-Total CAPEX Breakdown for Subsea





Field Architecture: an iterative process

- Participants
- Project Drivers
- Project Flow
  - Total Development Solution

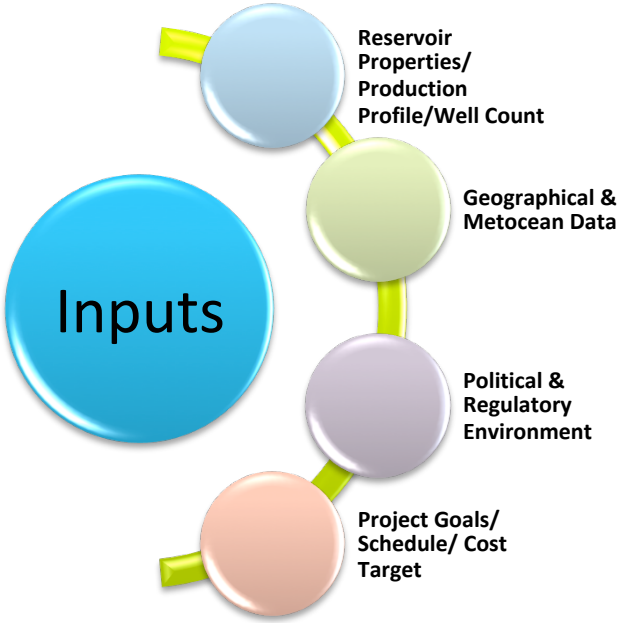


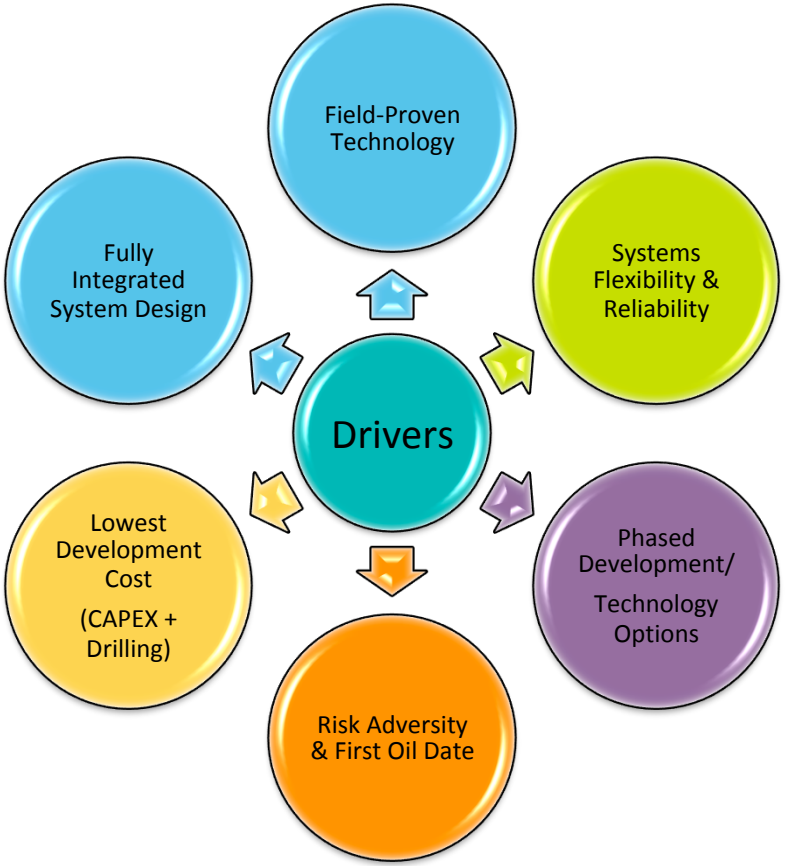
FMC Technologies

We put you first.
And keep you ahead.

Applications & Hardware Selection

Typical Project Inputs & Drivers

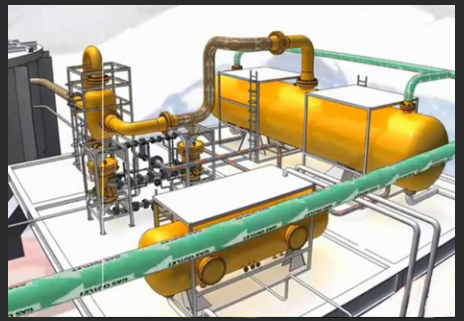




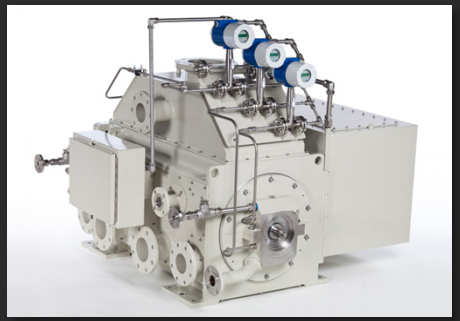
Systems, built from various combinations of these..

Loading Systems

Separation Systems



Direct Drive Systems

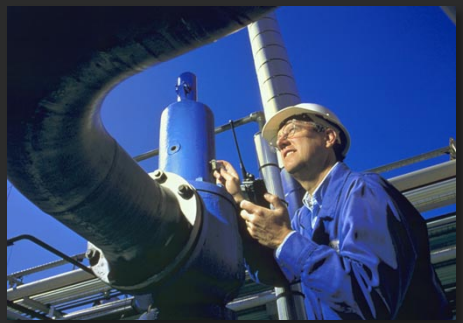


Multi Phase Meters

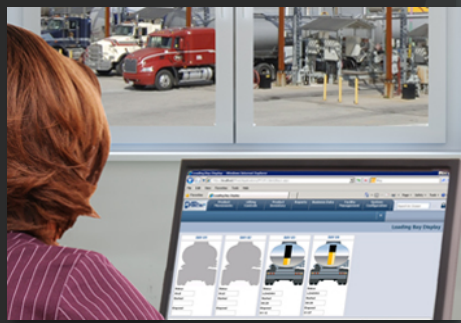
Measurement Solutions

Material Handling Solutions

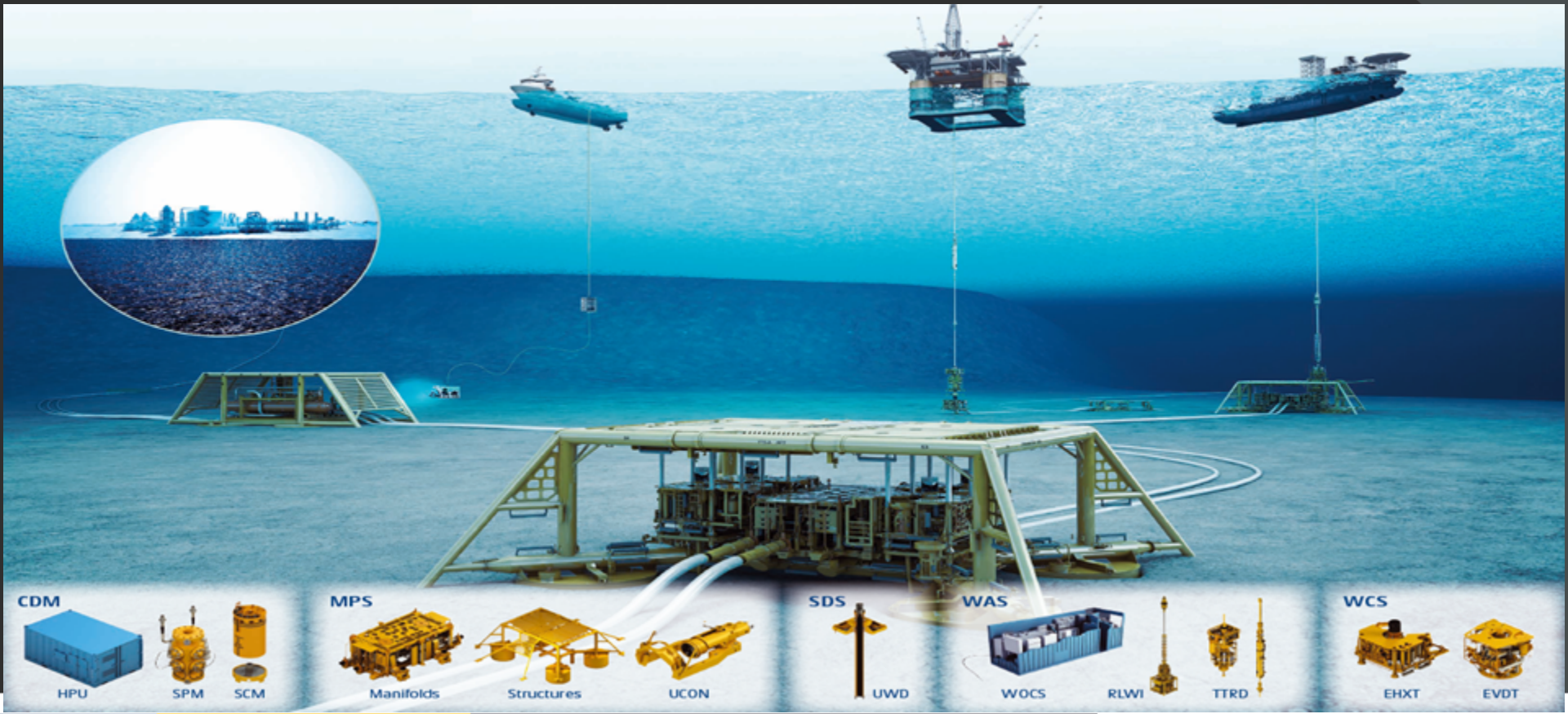
Blending and Transfer Systems



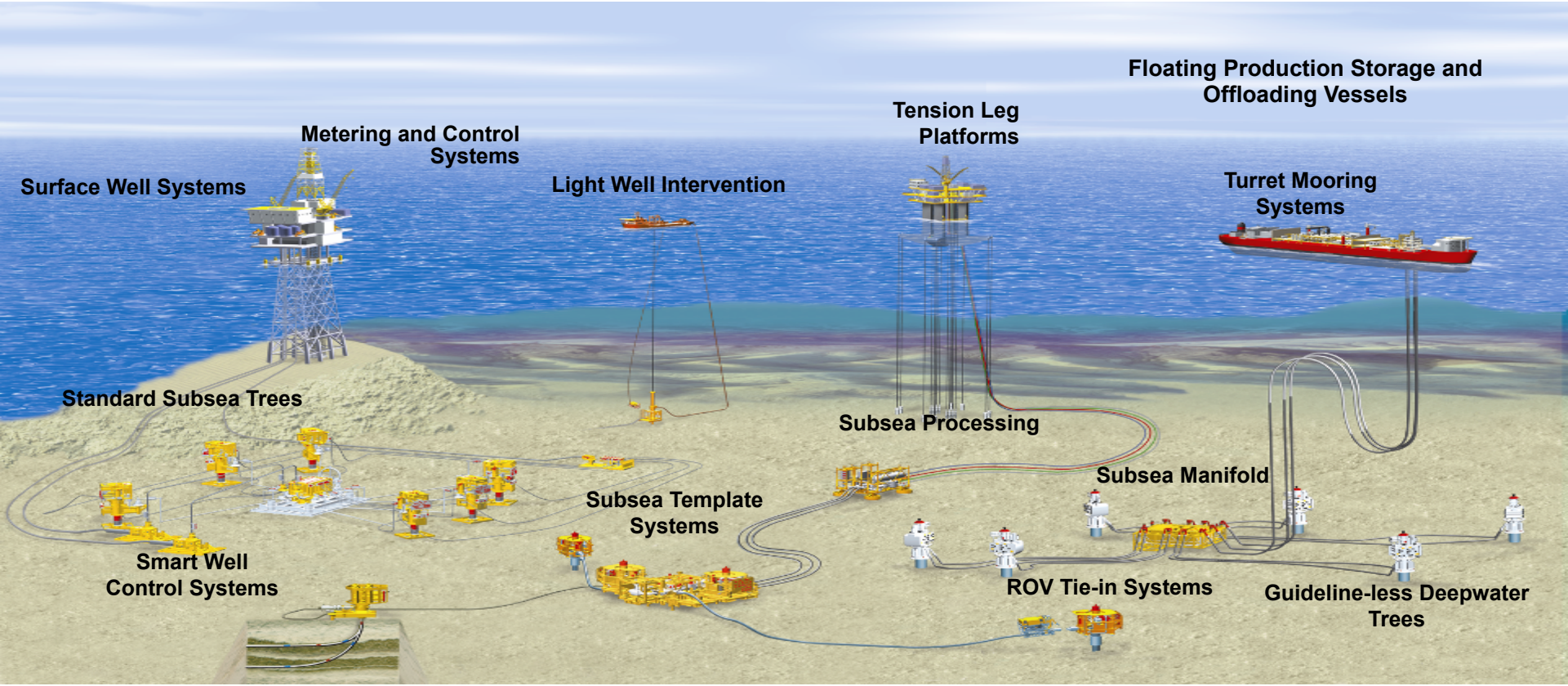
Automation and Control



Systems, built from various combinations of these..



Deepwater Systems-Tieback Options



FMC Technologies

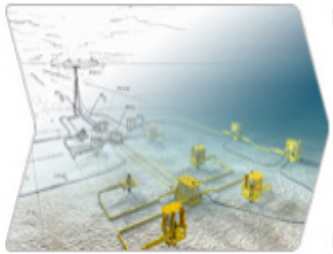
FMC Technologies

We put you first.
And keep you ahead.

Project Execution

Business Process Management System

Develop products & systems



Plan Sales and Operations

Acquire order

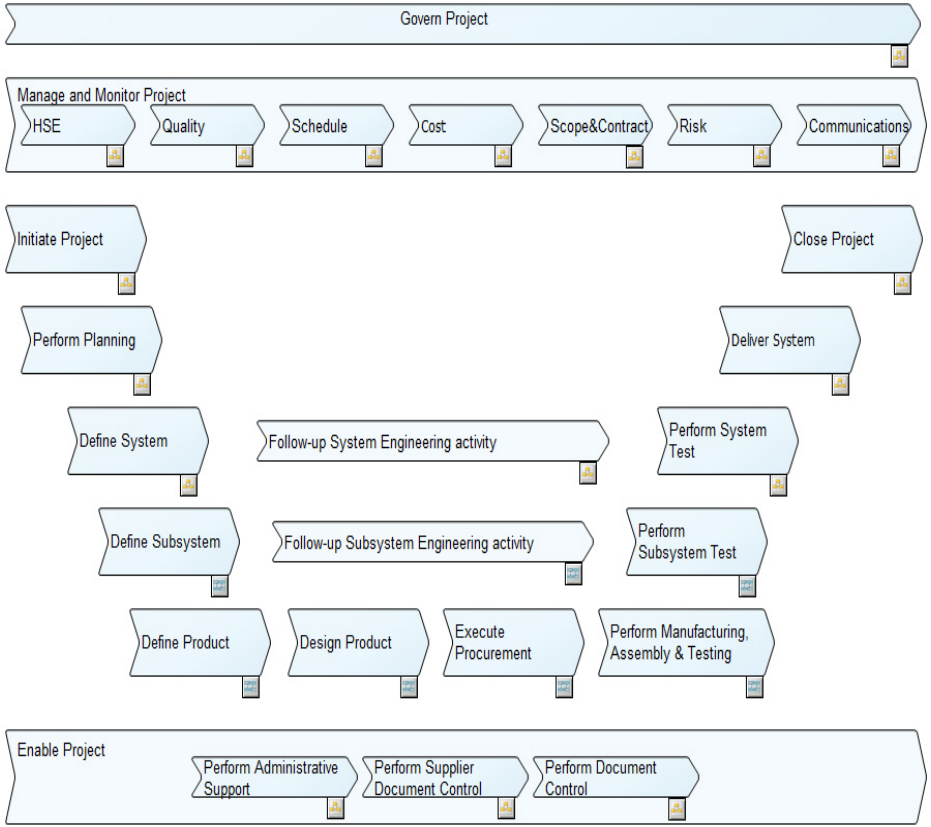
Execute project

Manage life of field

Systems Level Design

- Understanding Requirements
  - Design Basis Document (DBD)
- Defining Deliverables
  - Master Equipment List (MEL)
  - Contractor Master Document Register (CMDR)
  - Material Selection Matrix (MSM)
- Managing Interfaces
  - Interface Register
  - Systems Integration Test (SIT)
- Project Execution
  - Scheduling
  - Engineering
  - Risk Analysis
  - Lessons Learned

Execute System Project



Project Execution

System Challenges

- Every project/system is unique
- Projects involve multiple manufacturers
- Interface management
- Continuous improvement
- Triple Constraint
  - Time/Money/Resources

Engineering Challenges

- Higher reservoir pressures and temperatures
- Deeper water and longer offsets
- Flow assurance challenges
- Nastier produced fluids
- New technology demands

FMC Technologies

We put you first.
And keep you ahead.

Systems Approach to Subsea Projects

Manufacturer's Perspective