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Introduction to Subsea Technology

7 September 2023 | Technical Topic Webinar

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Introduction - Presenter

Engr. Dare Jeremiah

- Dare Jeremiah, a seasoned chartered engineer with over 20 years in the oil and gas sector, specializes in subsea system design.
- He has held leadership roles at top firms like INTECSEA, NETCO, Subsea 7, and WorleyParsons.
- Dare is the CEO of FEDDO GROUP and Global Leader of Subsea and Pipelines System.
- He also teaches at the Engineering Institute of Technology and serves as a Professional Keynote Speaker, mentoring engineers in subsea and pipeline design.

Agenda

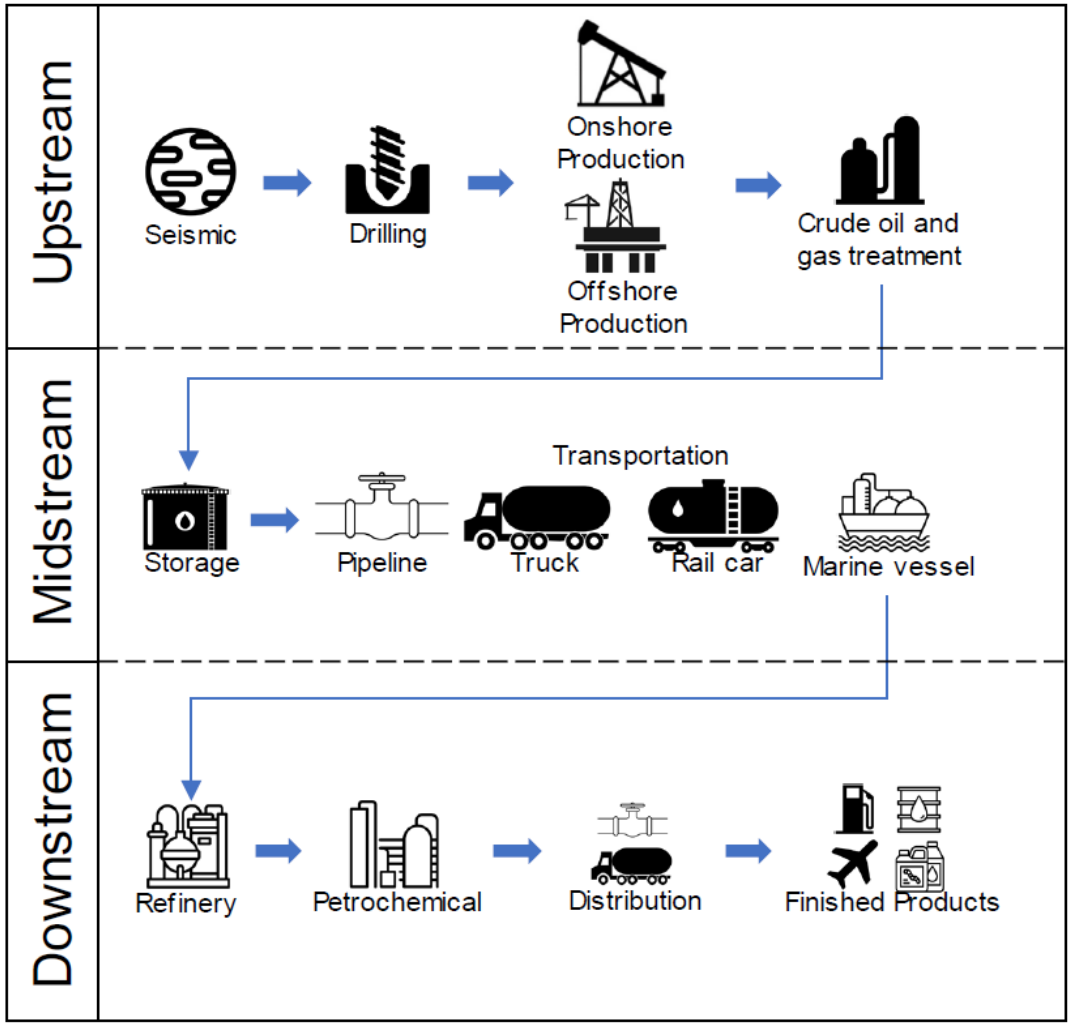
1	Brief Introduction to the Oil and Gas industry
2	Definition of Subsea system
3	Why Subsea development?
4	Drivers for subsea system
5	Subsea Field Development
6	Components of Subsea System

Expectation

- Gain a complete overview of subsea production equipment and systems.
- Understanding the drivers for the subsea system
- Understanding Deepwater and Shallow-Water Developments
- Learn about the structures and equipment involved in a subsea system.

Overview of Oil and Gas Industry

- *Upstream* is E&P (exploration and production).
- The *Midstream* sector is about oil and gas transportation, processing, and storage.
- *Downstream* refers to filtering raw materials obtained during the upstream phase.



Overview of Oil and Gas Industry

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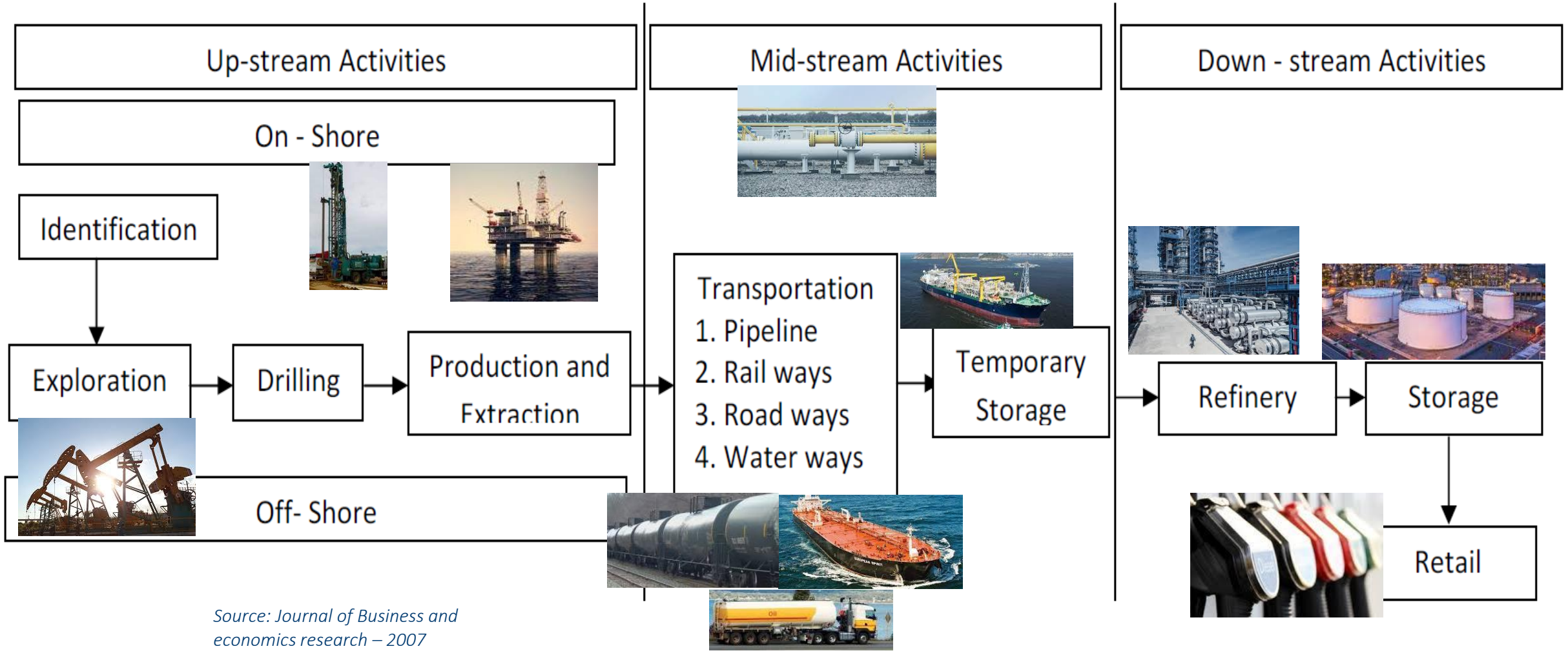


Source: Journal of Business and economics research – 2007

Upstream Activities

Definition of a Subsea System

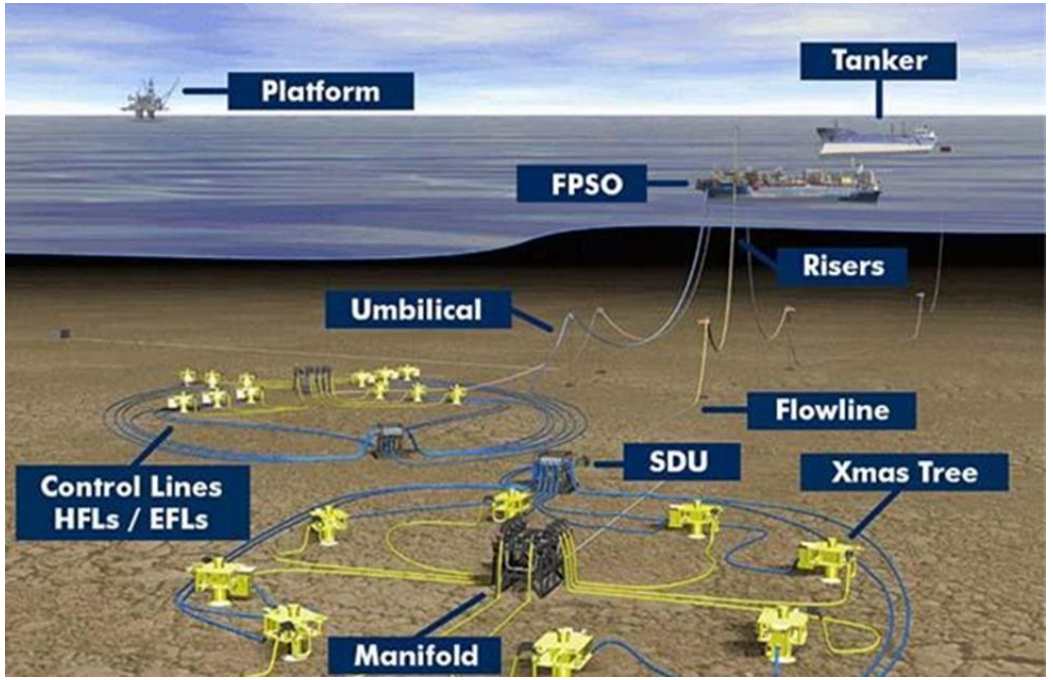
- Subsea Systems are production systems whose Christmas trees are located below the water's surface and tied back to a fixed, floating or onshore host facility.
- Examples include:
  - Subsea Satellite Tie-backs – many examples in N.Sea, GoM
  - Floating Production Storage Offloading (FPSO), e.g., Bonga
  - Floating Production Systems, e.g., Nakika
  - Subsea to Beach solutions, e.g., Ormen Lange, Corrib

Subsea Production System

- A subsea production system consists of a subsea completed well, seabed wellhead, subsea production tree, subsea tie-in to flowline system, and subsea equipment and control facilities to operate the well.
- It can range in complexity from a single satellite well with a flowline linked to a fixed platform, FPSO (Floating Production, Storage and Offloading), or onshore facilities, to several wells on a template or clustered around a manifold that transfer to a fixed or floating facility or directly to onshore facilities

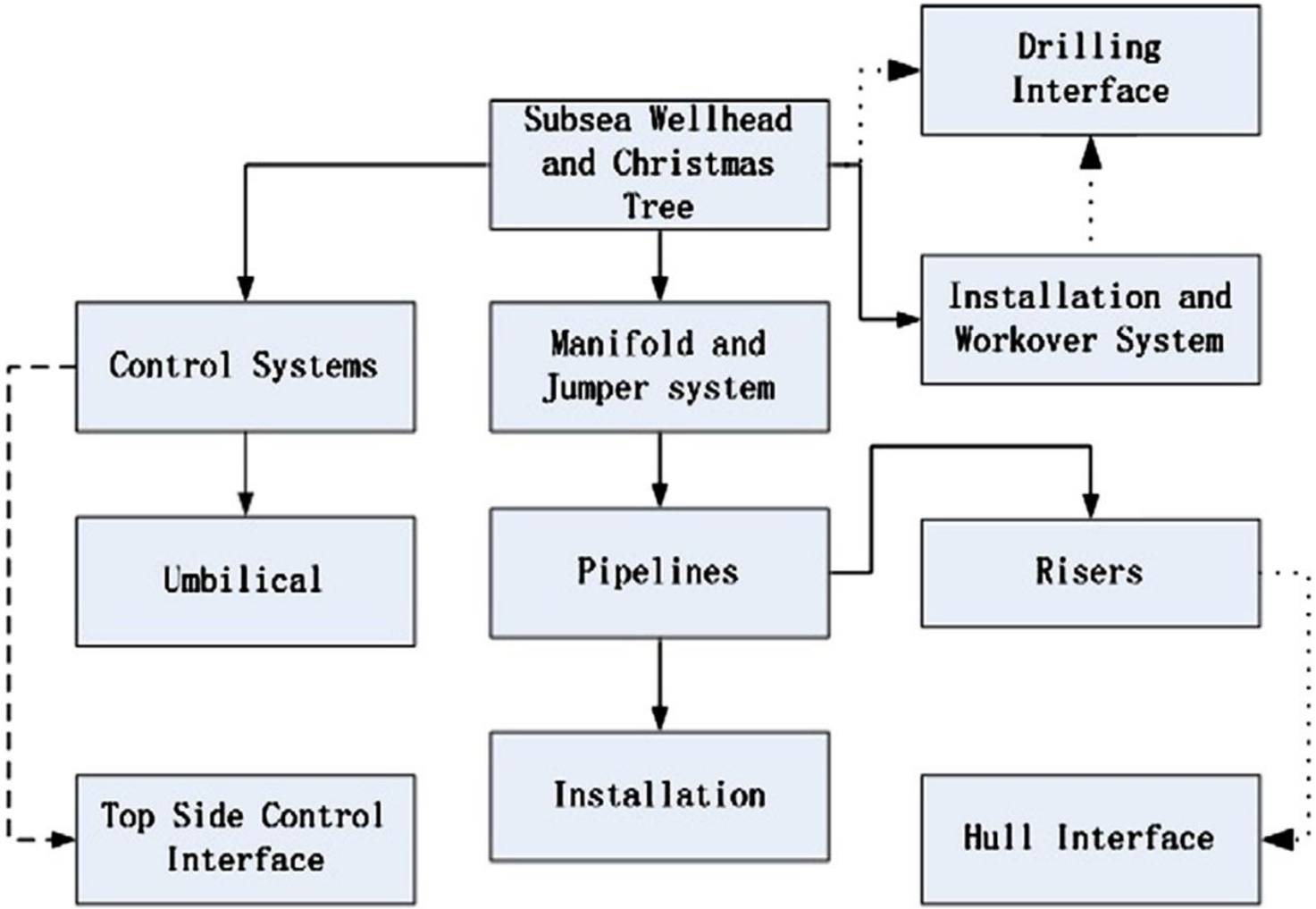
Subsea Production System

- The subsea production system consists of the following components:
  - Subsea drilling systems;
  - Subsea Christmas trees and wellhead systems;
  - Umbilical and riser systems;
  - Subsea manifolds and jumper systems;
  - Tie-in and flowline systems;
  - Control systems;
  - Subsea installation



Subsea Production System

- Relationship among the Major Components of a Subsea Production System



Why Subsea development?

- Economics
  - Production may not justify the CAPEX for a platform
  - Capex–subsea developments are generally less expensive than topside alternatives
  - OPEX–subsea developments do not require regular maintenance like topside structures
  - Early Production: fast-track development is required

Why Subsea development?

- Geography
  - Field reservoir areas may not be reached by deviated drilling from surface wells
  - The water depth may be too great to use a surface well platform
  - Well locations are spread out and not supported by dry trees
  - Lack of nearby processing/receiving facilities
  - Small field in close proximity to the existing platform

Why Subsea development?

- Safety
  - Personnel risk to man a platform or perform maintenance is eliminated with a subsea option

Why Subsea development?

- Advantages
  - No visual impact
  - Under ice in Arctic conditions
  - Eliminate CAPEX of platform
  - Cost burden transferred from CAPEX to OPEX
  - Construction cycle is conducive to fast-track projects
  - Suitable to phased projects – future expansion

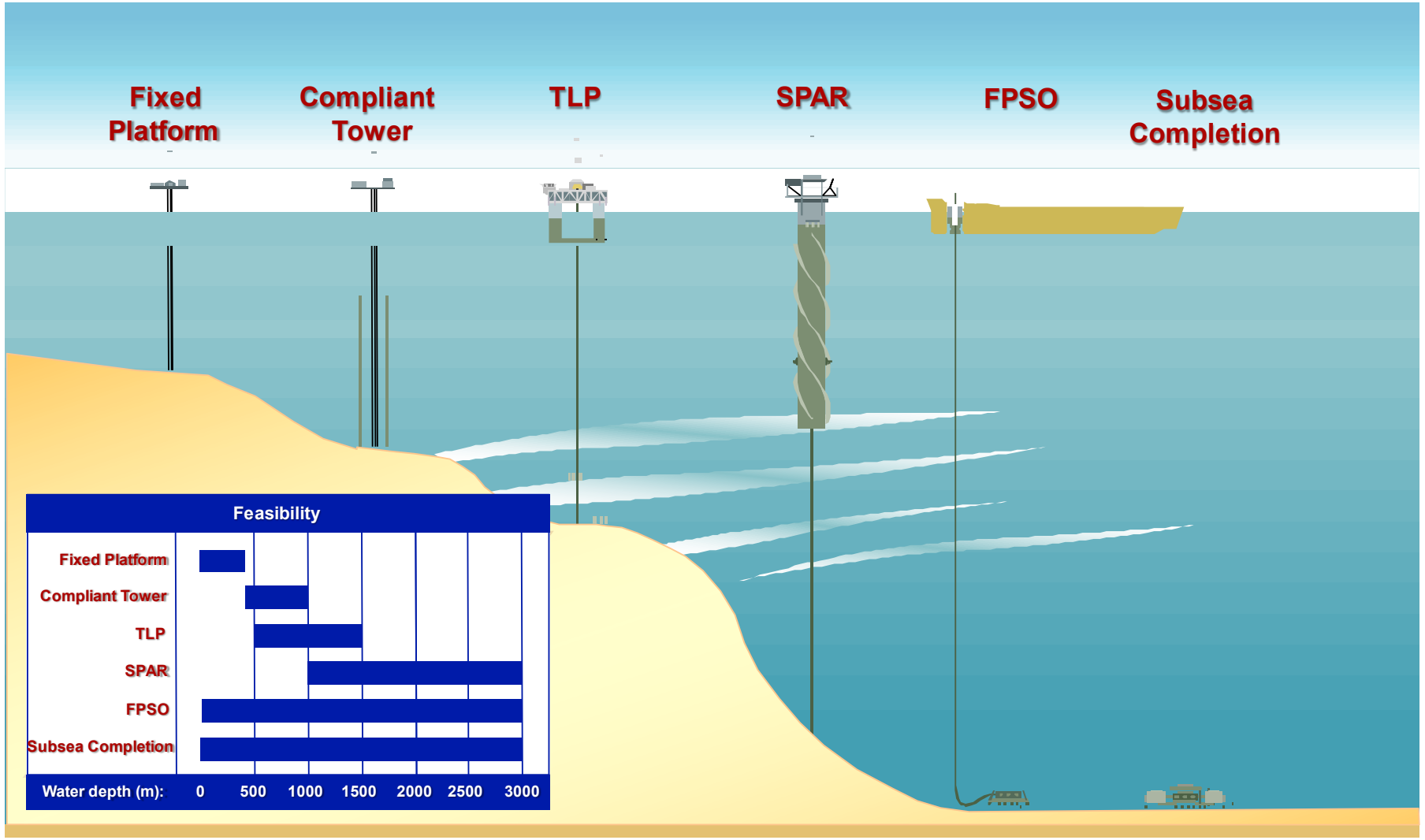
Why Subsea development?

- Disadvantages
  - Complex hardware
  - Inaccessible for maintenance and repair
  - Intervention is expensive and complex

Drivers for Subsea Systems

- Water Depth
  - It is not always technically and/or economically feasible to construct structure solutions beyond certain water depths
    - Fixed structures limit is approx. 400m
    - TLP limit is approx. 1500m
    - SPAR limit is approx. 3000m
  - Subsea systems with FPSO hosts are feasible up to approx. 3000m
  - Subsea systems provide the ability to locate the host in more technically or economically feasible water depths while still capturing deeper water reserves

Drivers for Subsea Systems



Drivers for Subsea Systems

- Subsurface Issues
  - Reservoir Drainage
    - Arial Extent – too far flung to reach from one drilling centre
    - Reservoir Depth – too shallow to reach from one drilling centre
    - Complexity – compartmentalisation, well count
    - Uncertainty - the need for a phased development
  - Drilling Hazards – e.g. shallow water flow, faults, shallow gas
  - Subsea systems provide flexibility concerning well locations and initial CAPEX
  - Subsea equipment is less “site-specific” and can be redeployed in the event of reservoir disappointment or short field life

Drivers for Subsea Systems

- Remote Product Markets
  - Limited Oil / Gas Export Facilities / Proximity to Market
  - No local market for oil e.g., West Africa (Nigeria, Angola)
  - Gas re-injected or local LNG facilities
  - FPSOs with Subsea Systems is a good fit where large oil storage and offloading capacity is required, utilizing the oil storage vessel as the host

Drivers for Subsea Systems

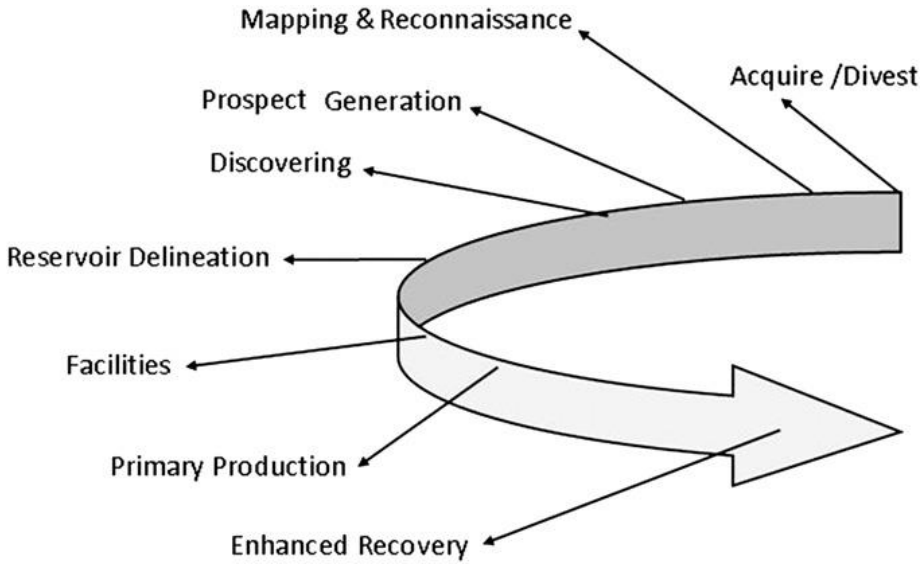
- Pre-Existing Infrastructure
  - Structures installed to exploit large fields develop ullage as field production functions decline
  - Utilizing ullage more economically than building new
  - Reserves too small to justify stand-alone development
  - Extending host life allows the capture of incremental oil
  - When ullage does not exist, expanding existing facilities to serve as hosts is often cheaper than building a second structure
  - Subsea satellites are frequently more cost-effective than alternative solutions e.g., GoM and North.Sea.

Drivers for Subsea Systems

- Other
  - Subsea Systems allow pre-drilling/completion of wells which can reduce time to the first production
  - Unique environmental issues such as icebergs
  - Subsea Systems are sometimes chosen for other “softer” reasons
    - Favorable fiscal environment to promote indigenous subsea industry and in-country content e.g. Snohvit, Ormen Lange
    - Safety and Sustainable development
      - Ormen Lange - Subsea System tie-in to an onshore facility
      - Avoids transporting personnel offshore
    - Aesthetic / Environmental
      - Avoid offshore platforms visible from onshore eg California

Subsea Field Development

- When defining a field architecture, the following issues should be considered:
    - Deepwater or shallow-water development;
    - Dry tree or wet tree;
    - Stand-alone or tie-back development;
    - Subsea processing;
    - Artificial lift methods;
    - Facility configurations (i.e., template, well cluster, satellite wells, manifolds).



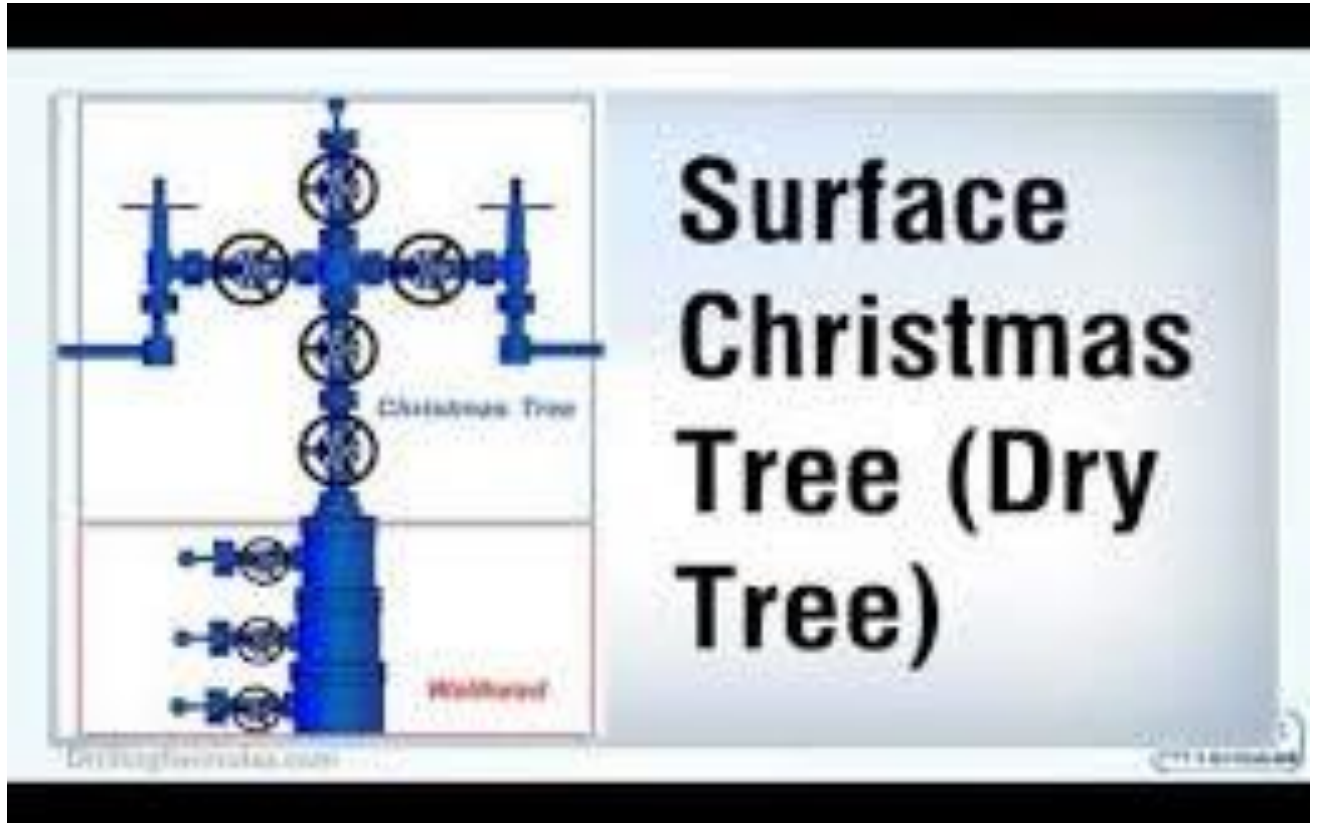
Subsea Field Development

- Deepwater or Shallow-water Development:
  - Subsea field development can be categorised according to the water depth:
    - A field is considered a shallow-water subsea development if the water depth at the location is less than 200 m (656 ft). In practice, shallow water is the depth of a diver's reach.
    - A field is considered a deepwater subsea development if the water depth ranges between 200 and 1500 m (656 and 5000 ft);
    - Ultra-deepwater subsea developments are those in which the water depths are greater than 1500 m (5000 ft).

Subsea Field Development

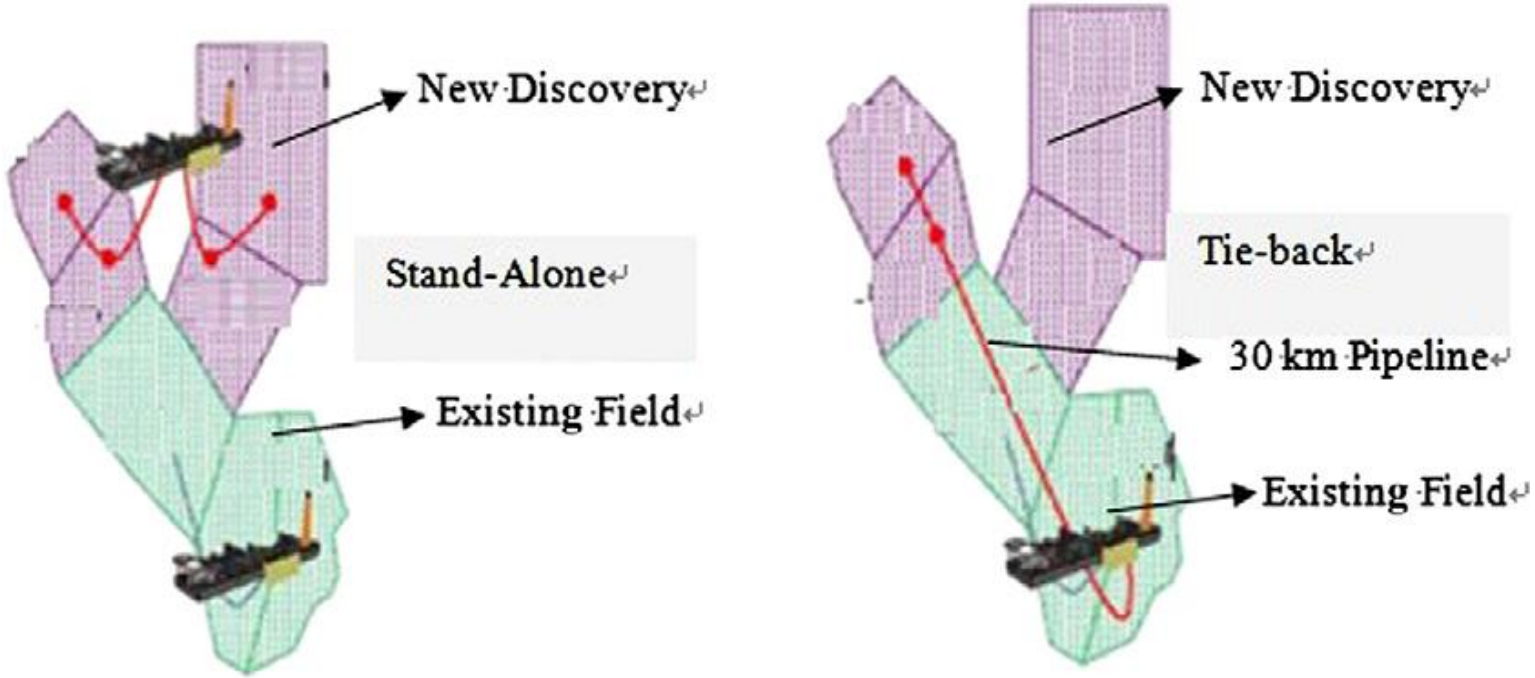
- Wet Tree and Dry Tree Systems:
  - Two kinds of subsea production systems are used in deepwater fields: dry tree systems and wet tree systems:
  - The dry tree system:
    - trees are located on or close to the platform
    - Tension leg platforms (TLPs) and spars are normally utilised in a dry tree system
  - The Wet Tree System
    - wet trees can be anywhere in a field in terms of the cluster, template, or tie-back methods.
    - the Christmas tree and its associated components are exposed to the ambient seabed conditions

Subsea Field Development



Subsea Field Development

- Subsea Tiebacks and Stand-Alone Development:
  - The development of new fields can either be initiated via long “tie-backs” to an existing facility or by installing a new “stand-alone” facility. Stand-alone facilities for the gas fields depend on the size of the gas reserves.



Subsea Field Development

Offshore installation Categorization:

Mobile Units

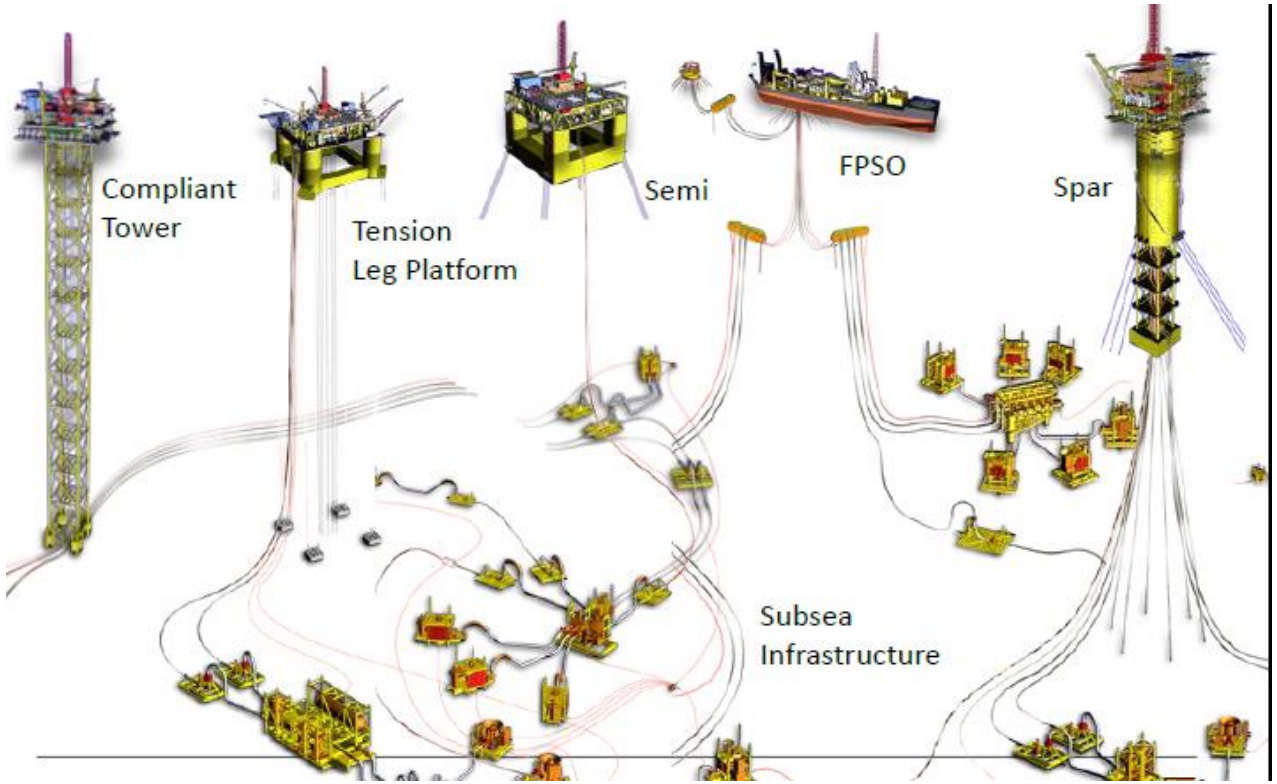
- Can be moved from one location to another either by towing or on their own.
- May be held in position using anchors or a dynamic positioning system
- Examples: Jack-up barges, semi-submersibles, drillships, FPSO vessel

Fixed Installation

- Incapable of movement on their own
- Designed to be moved for initial placement and post-production disposal.
- Example: Fixed Platform, X-trees

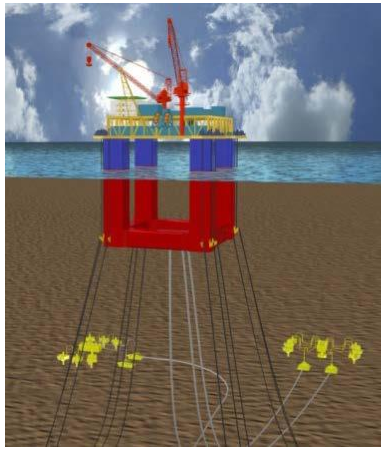
Subsea Field Development

- Type of Offshore Structures:
  - Fixed Platforms
  - Compliant Towers
  - Floating Production, Storage, and Offloading (FPSO) vessels
  - Tension Leg Platforms (TLP)
  - Semi-submersible Platforms (SEMI)
  - Spars

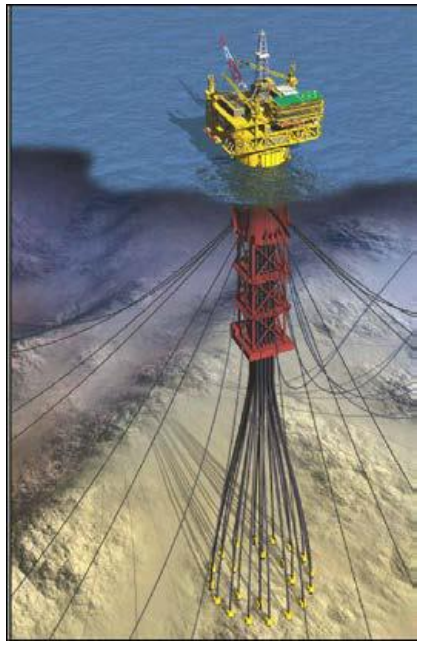


Subsea Field Development

Tension Leg Platform



Semi-submersible (Semi)



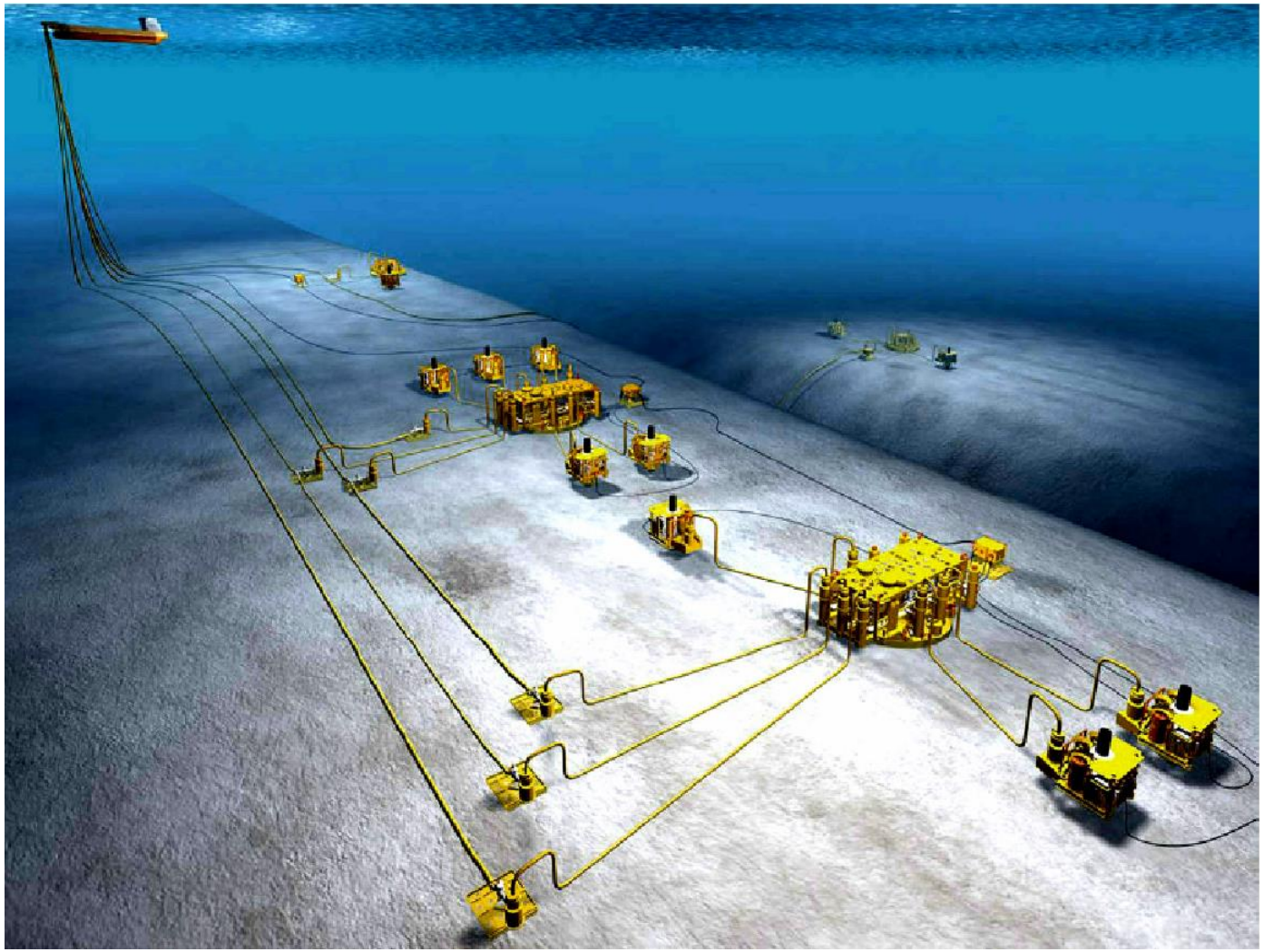
Spar

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

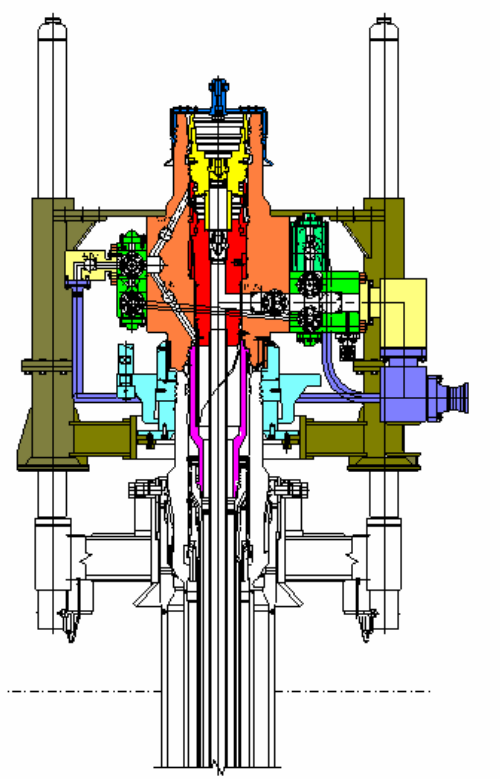
FPSO

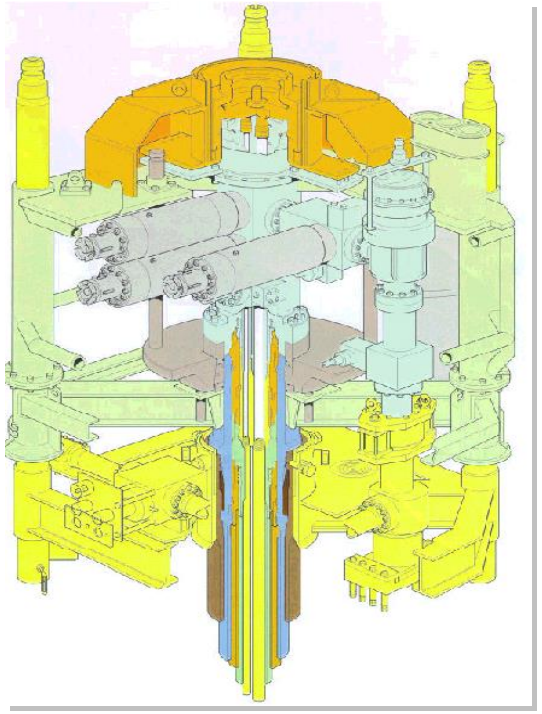
Components of Subsea System



Subsea Wellhead?

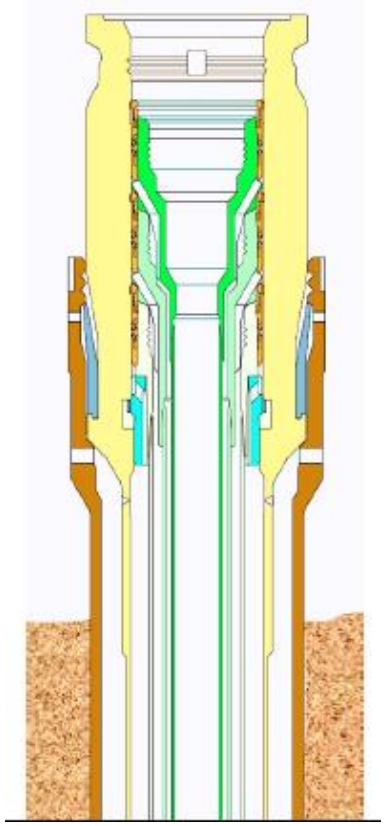
- What is a Subsea Wellhead?
  - The subsea wellhead is the interface between subsurface equipment (downhole) and the surface equipment (tree, BOP, flowlines, host, etc.).

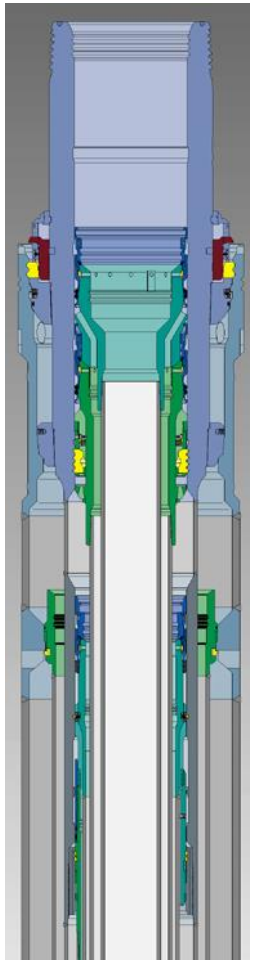




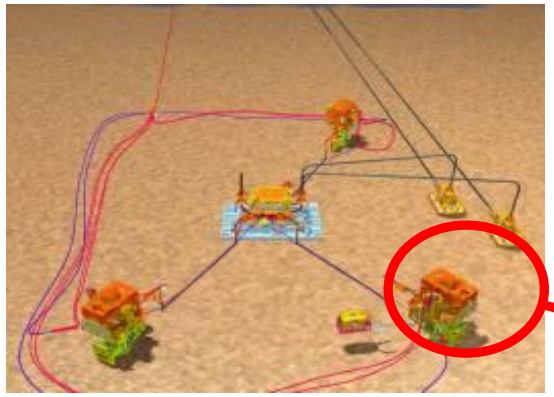
Subsea Wellhead

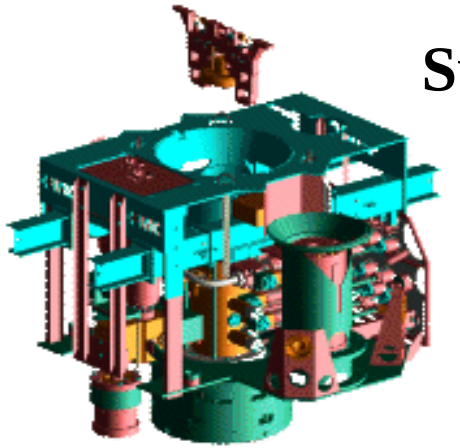
- What is the purpose of a Subsea Wellhead?:
  - Support the BOP (Blowout Preventer) and seal the well during drilling
  - Support and seal the subsea production tree
  - Support and seal the tubing hanger for conventional subsea trees
  - Act as a hanger for the casing strings in the well annulus



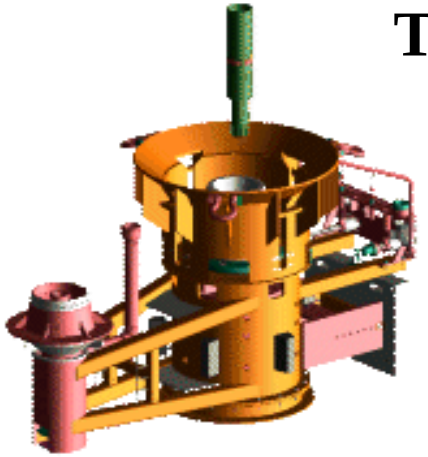


Subsea Wellhead Assembly & Xmas Tree





Subsea Tree

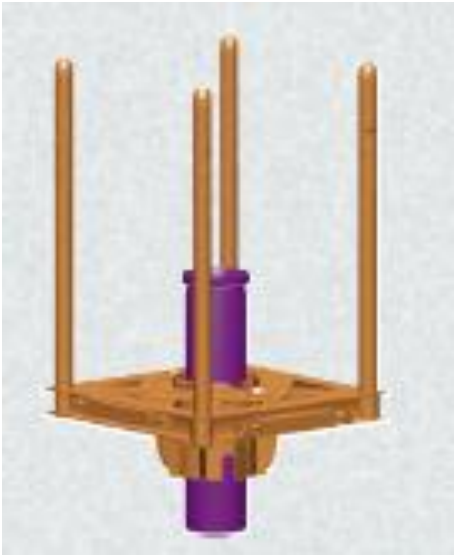


Tubing Hanger

Tubing Head Spool

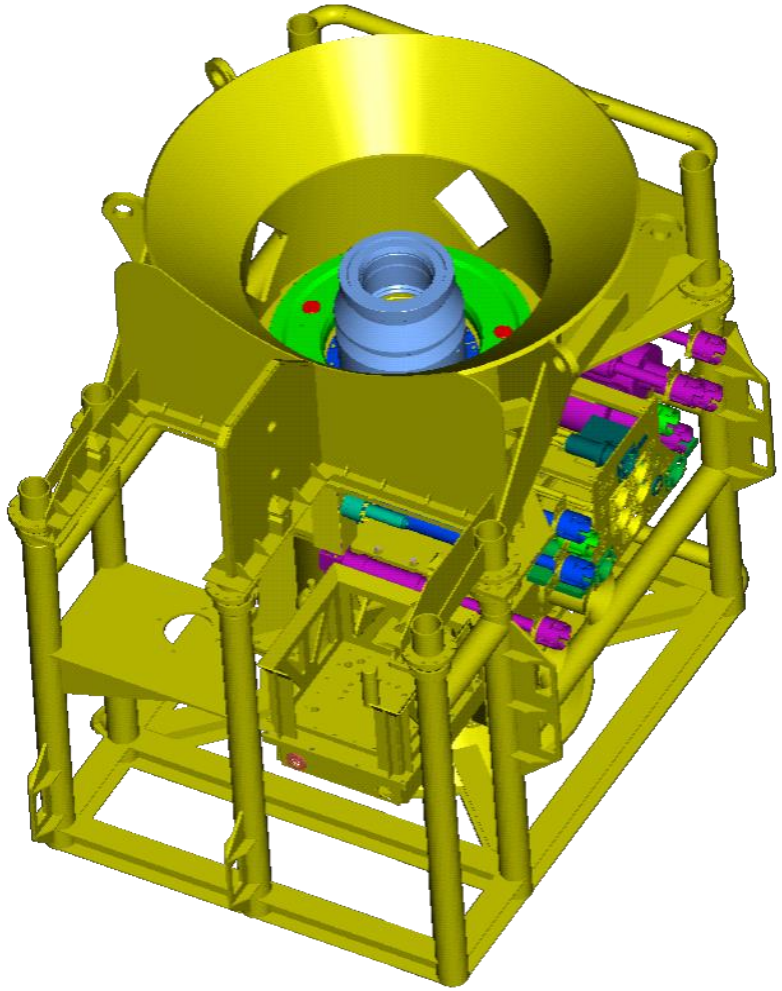
Wellhead Guidebase /Flowbase

- Most wellheads use a permanent guidebase (PGB) that often supports guideposts
- Guidelines attached to guideposts
- Completion guidebases (CGB) have piping and hubs to interface the tree and flowline



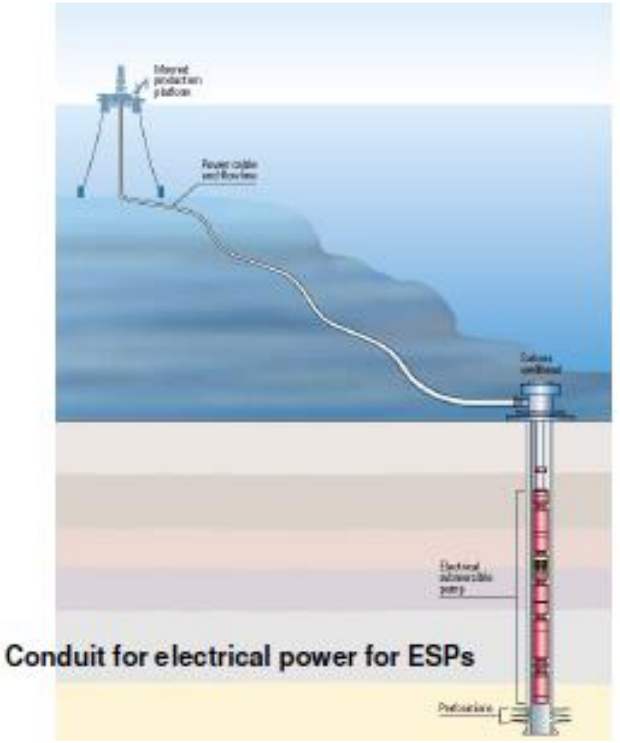
Wellhead Guidebase /Flowbase

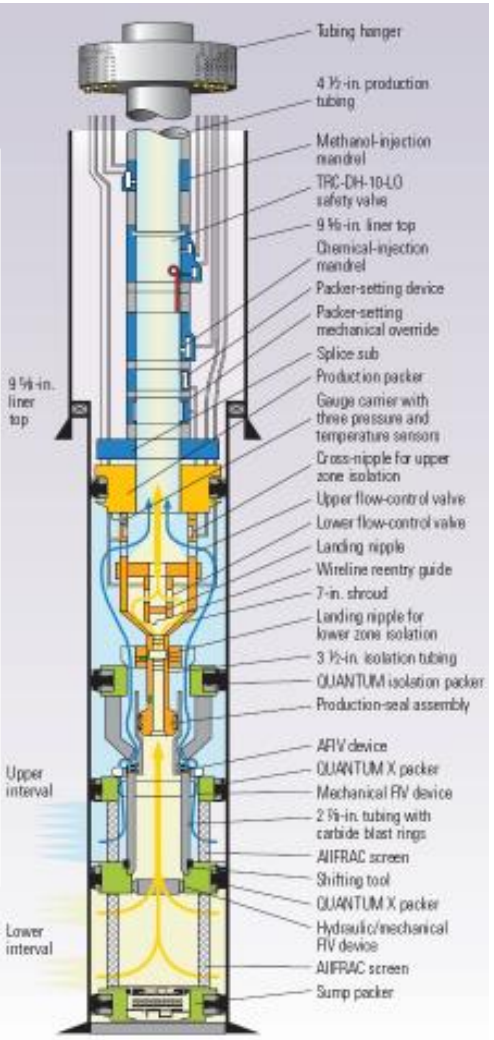
- Guidelineless (GLL) PGBs are used in deepwater (2000+ ft) where guidelines are cumbersome
- GLL PGBs are generally funnel-up but may be funnel-down



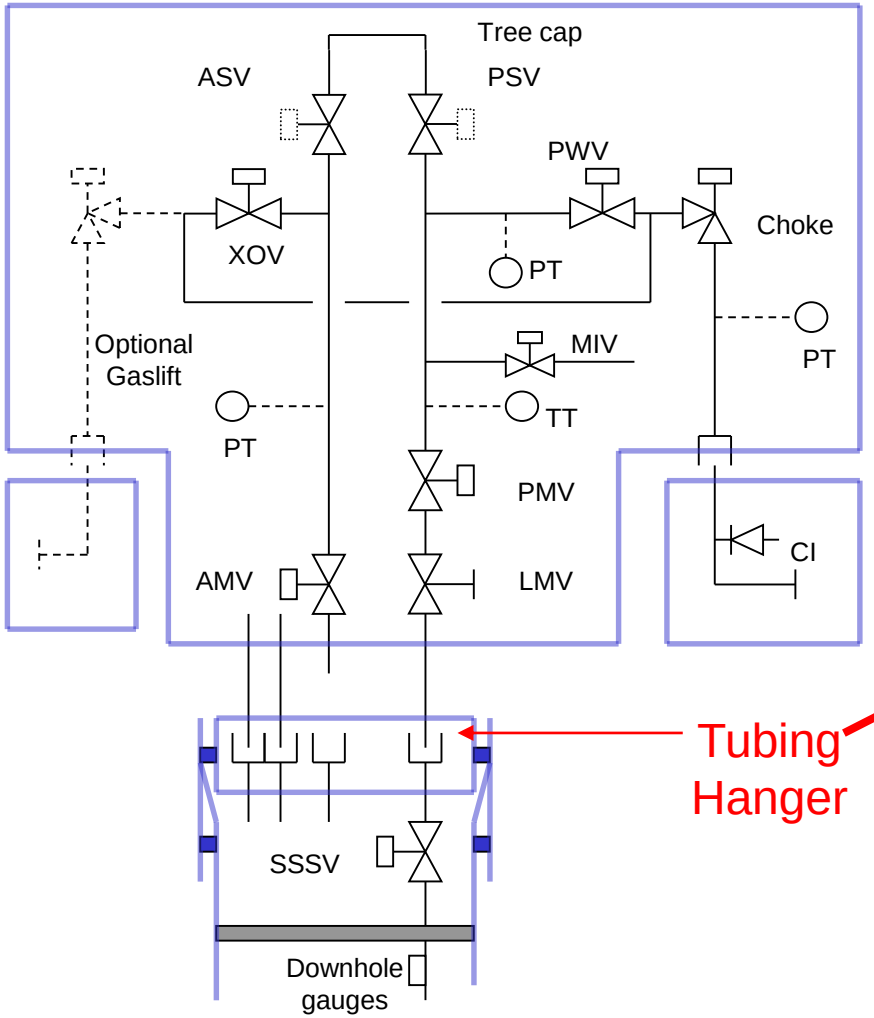
Subsea Tubing Hanger

- Supports the downhole tubing in the well
- Seals the annulus at the top of the well
- Provides access to the downhole equipment (jewellery)

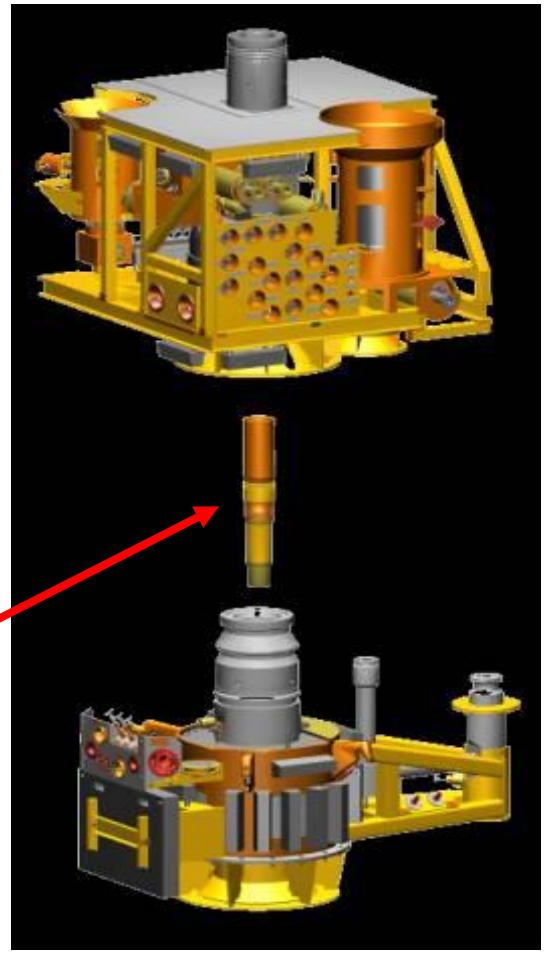




Subsea Tubing Hanger

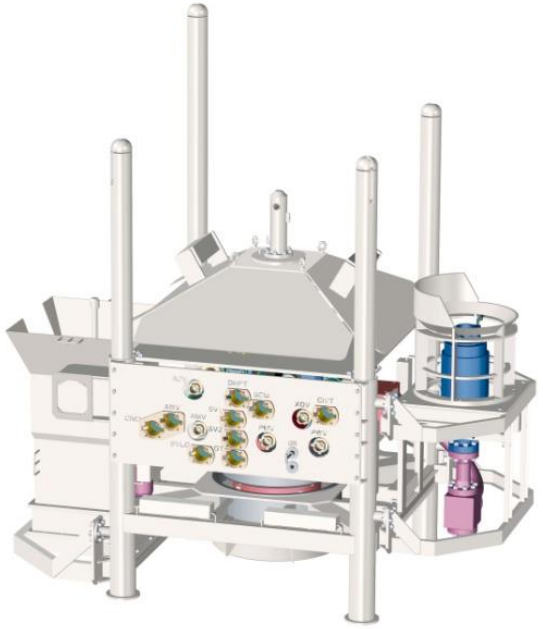


Tubing Hanger



Subsea Christmas Tree

- What is a Subsea Tree?
  - A set of valves and piping to allow the control of a well during production at the mudline and remote to the host facility.



Subsea Christmas Tree

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Types of Christmas Tree:

Onshore tree

Offshore tree

Subsea tree

Subsea Christmas Tree

Types of Subsea Tree:

Mudline Tree

Conventional Tree

Horizontal Tree

Subsea Christmas Tree

- What Makes Subsea Trees Different from Surface Trees?

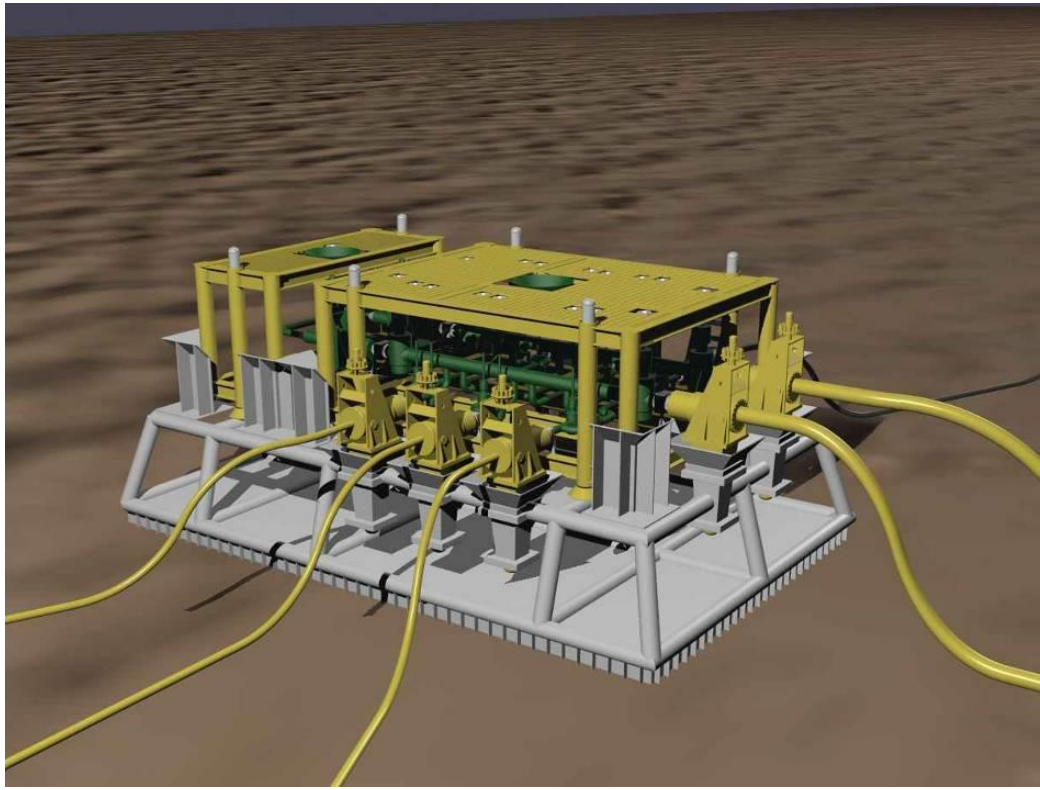
  Subsea Trees are:

  - More complex
  - Larger
  - More robust
  - More expensive
  - Inaccessible

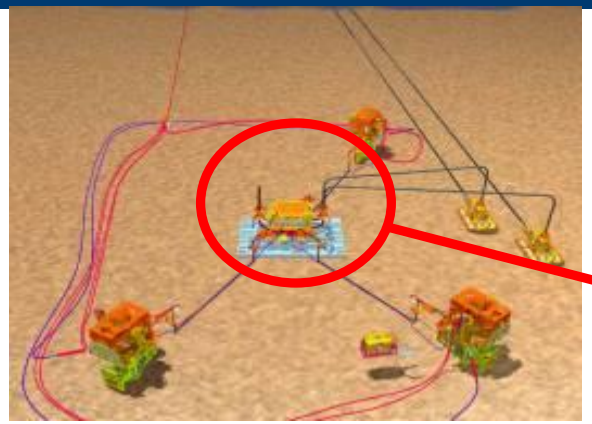
Subsea Manifolds

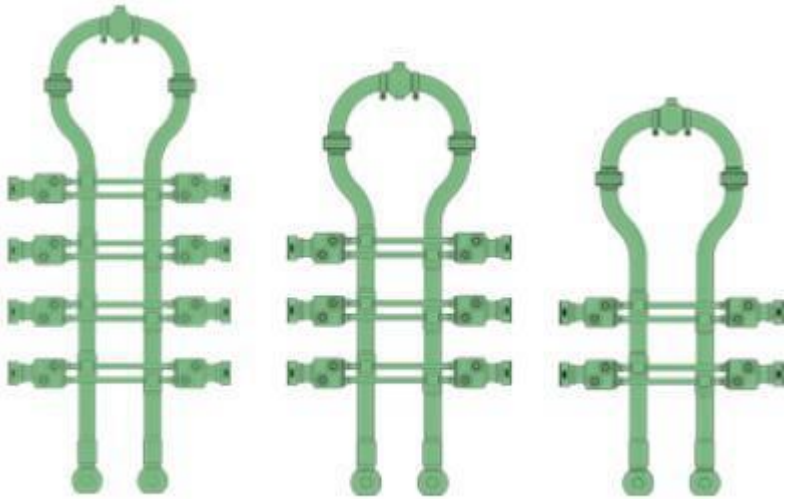
Why are subsea manifolds necessary?

- Collection of valves and piping
- Collects flow from multiple wells into a single transportation system
- Provides an economic alternative to individual flowlines
- Distribution point for chemicals, gas for gas lift etc. to Xmas Trees
- Allows for isolation of one Xmas Tree from others
- Allow pigging of flowline
- Designed to take expansion loads etc. from flowlines
- Provides protection from impacts (eg. dropped objects), snags (eg. fishing)



Subsea Manifolds



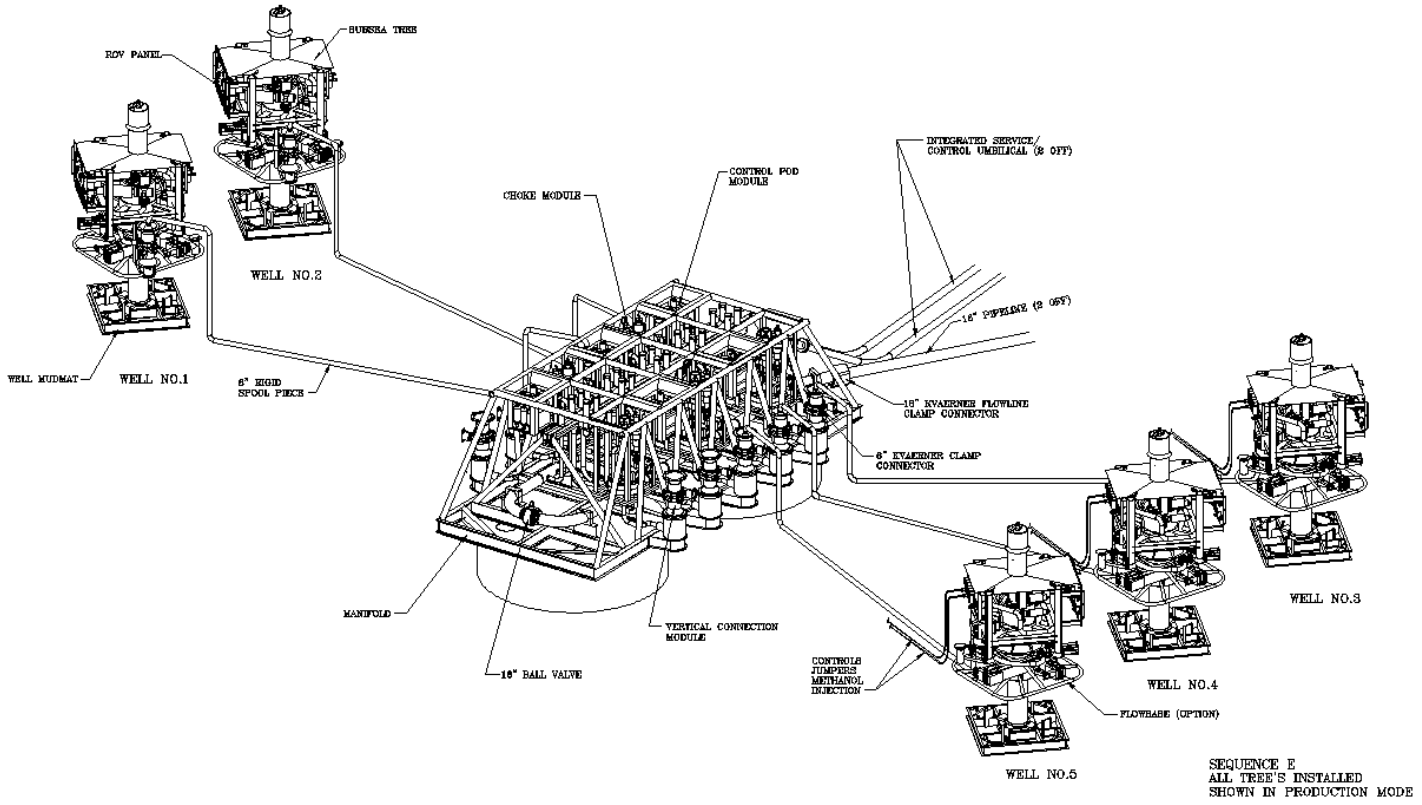


Manifold capacity can be increased by adding modular valve block assemblies

Deepwater Subsea Manifold

Subsea Manifolds

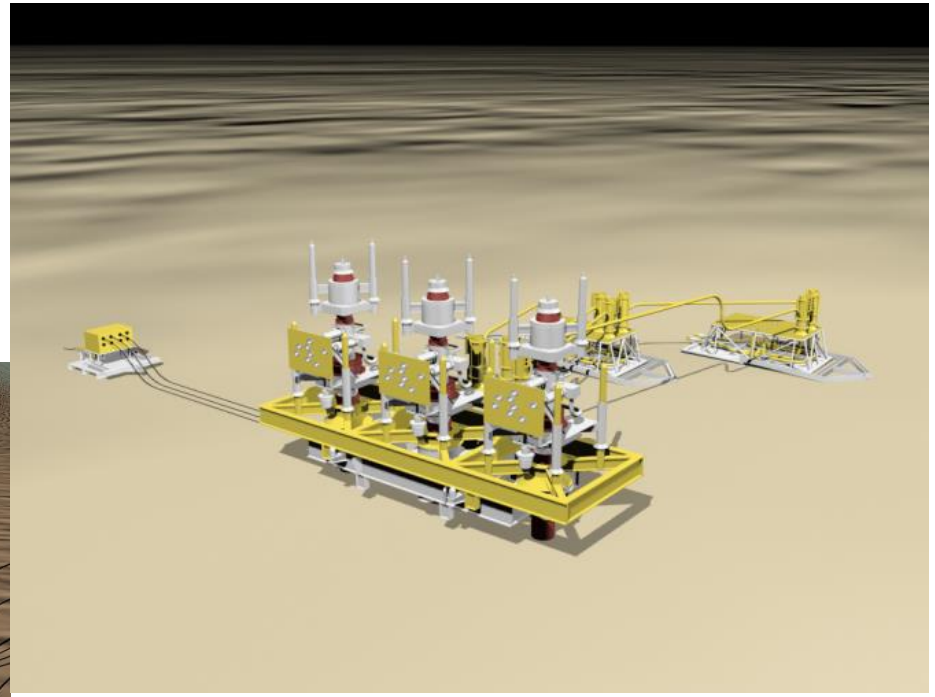
Typical Subsea Manifold and Subsea Field Equipment Arrangement:

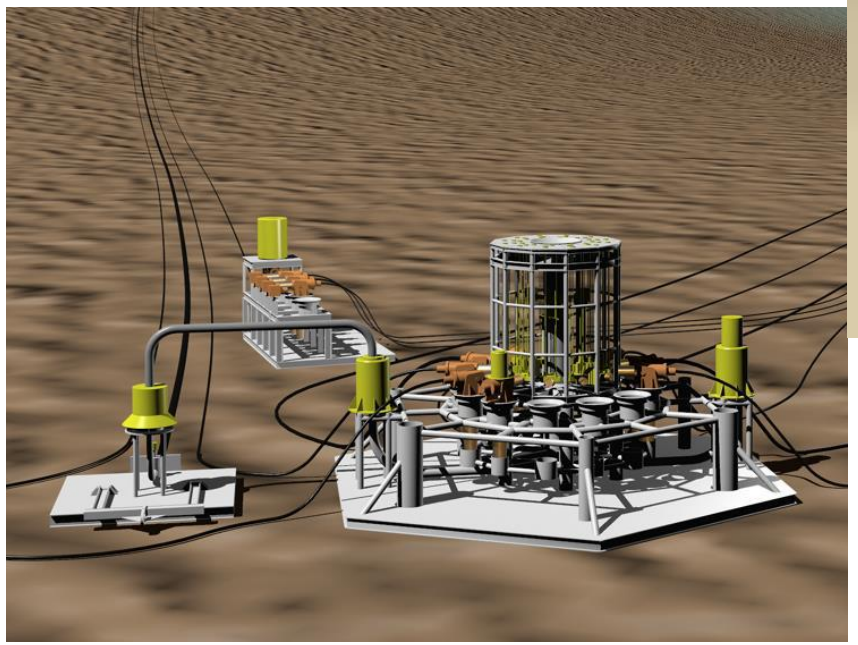


Subsea Manifolds

Manifolding Solutions – Types of Manifolds:

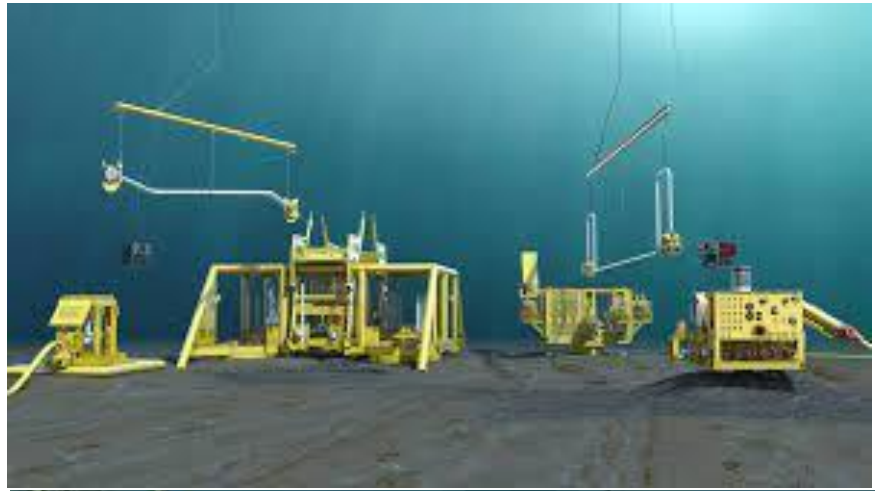
- Template Manifolds
- Cluster Manifold
- Large Gathering Manifolds
- Hybrid Manifolds





Well and Flowline Tie-In Systems

- We have looked at Manifolding solutions…..Now let's look at how we typically interconnect the wells and flowlines to our manifolds, or flowlines directly to wells…
- This it has typically done with the use of jumpers and/or spools and on the next several slides we will offer some description of these systems.



Well and Flowline Tie-In Systems

- In the simplest of terms…:
  - Tie-in systems are “purpose built” configurations of pipe and connectors
  - Typically these configurations combine Flexible or Rigid pipe, with Horizontally or Vertically configured connections, into jumpers or spools

Well and Flowline Tie-In Systems

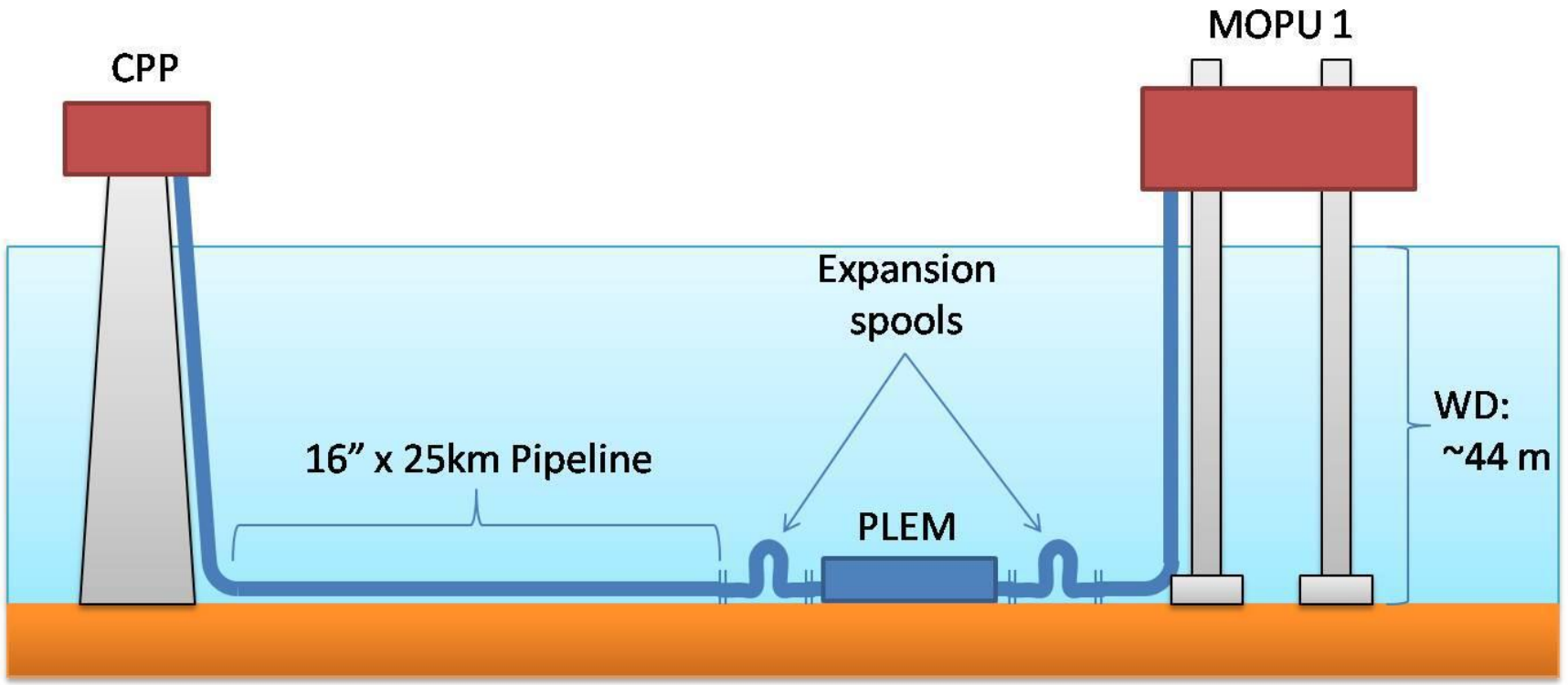
Flowline Jumper

Well Jumper

Subsea Flowlines and Risers

Components of the Flowline System Riser

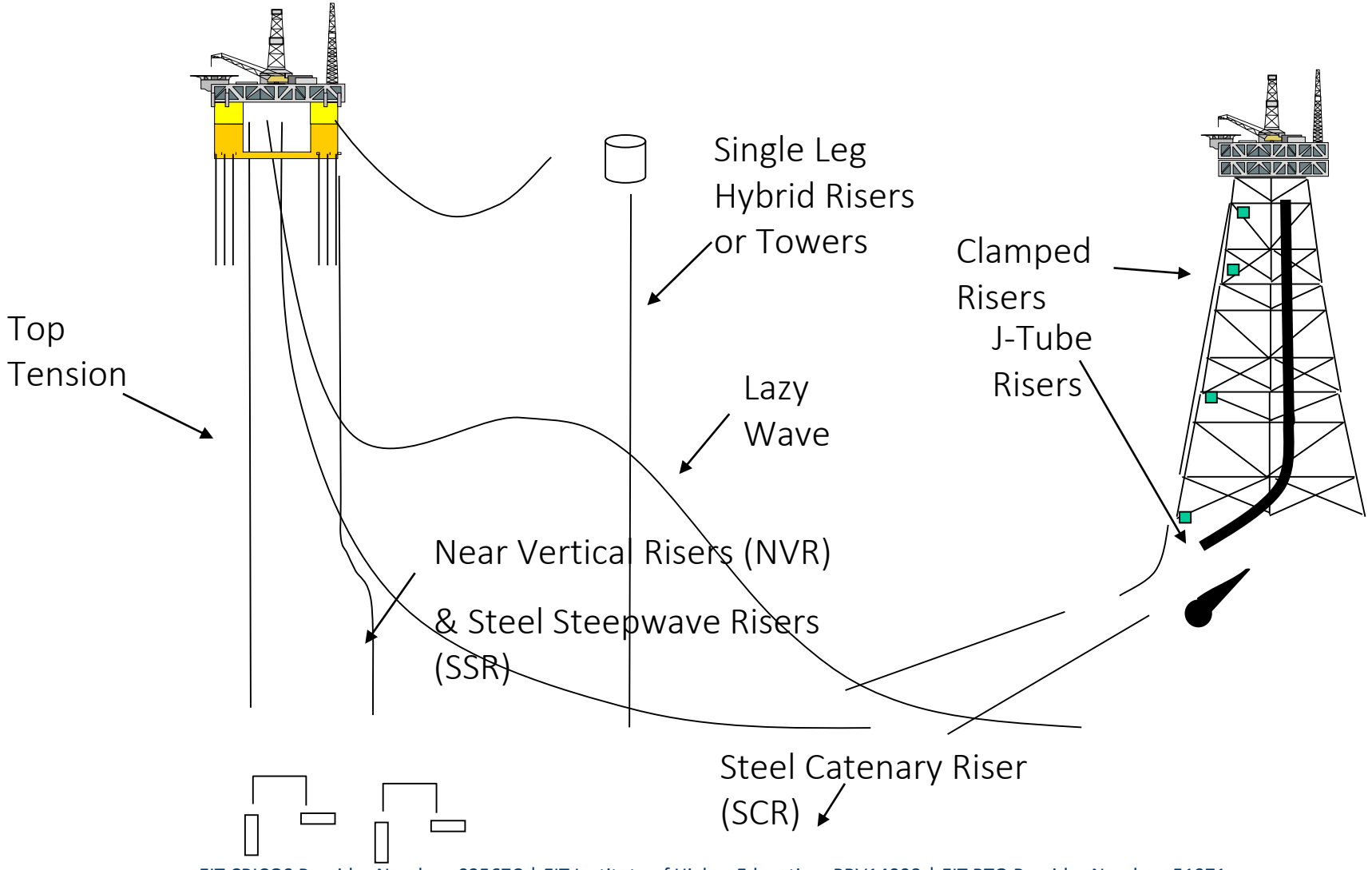
- Riser
- Flowline
- Terminations



Subsea Risers

- Riser system is a conduit between the subsea system on the seabed and the floating production units
- Riser Classifications
  - Based on function:
    - Drilling risers
    - Completion / Workover risers (CWOR)
    - Production / Injection risers
  - Export risers
    - Based on construction:
    - Compliant Risers
    - Top Tensioned Risers
    - Hybrid Risers
  - Based on material type:
    - Rigid
    - Flexible

Subsea Risers

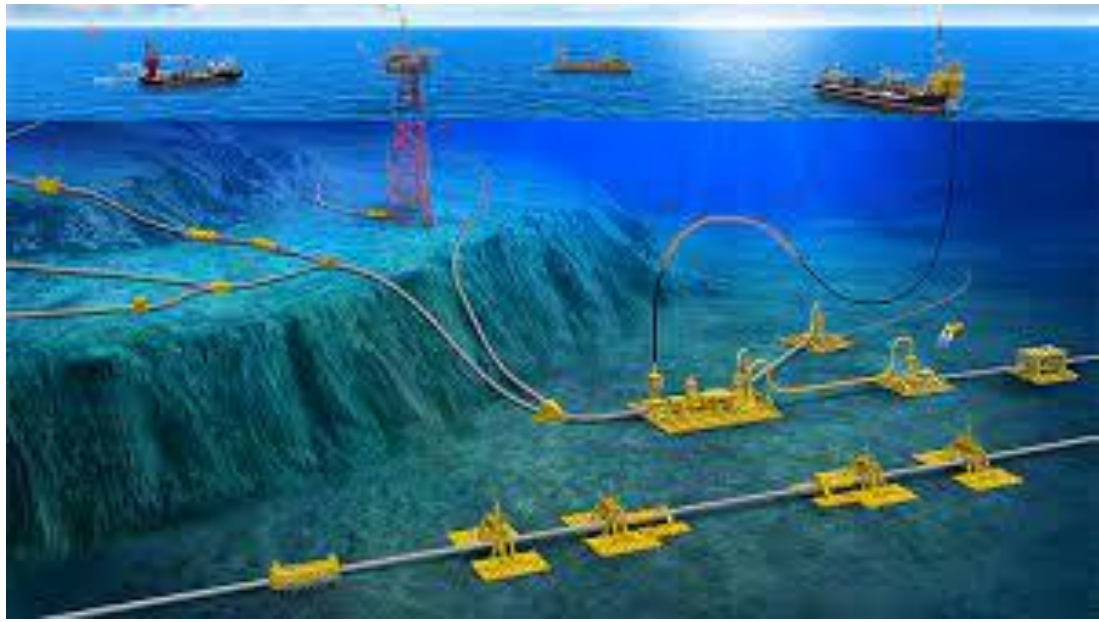


Subsea Pipelines

- A pipeline is a transport system for oil, gas, water or other fluids
- There are onshore pipelines —> on land
- There are offshore pipelines —> subsea
- are often divided into two categories:
  - In-field pipelines (flowlines)
  - Export pipelines (trunklines)

Subsea Pipelines

- In-Field Pipelines
  - In-field pipelines are limited in size
  - The diameter (size) typically ranges from 3 to 16 inches (80 to 400mm)
  - The length of in-field pipelines can be from a few 100 meters up to tens of kilometres
  - The size of the pipeline is determined by the volume rate and other operational characteristics of the fluid to be transported



Subsea Pipelines

- In-field pipelines can be:
  - Oil production lines
  - Gas production lines
  - Water injection lines
  - Gas injection lines
  - Service lines (Inhibitor, Glycol lines)

Subsea Pipelines

Export Pipelines

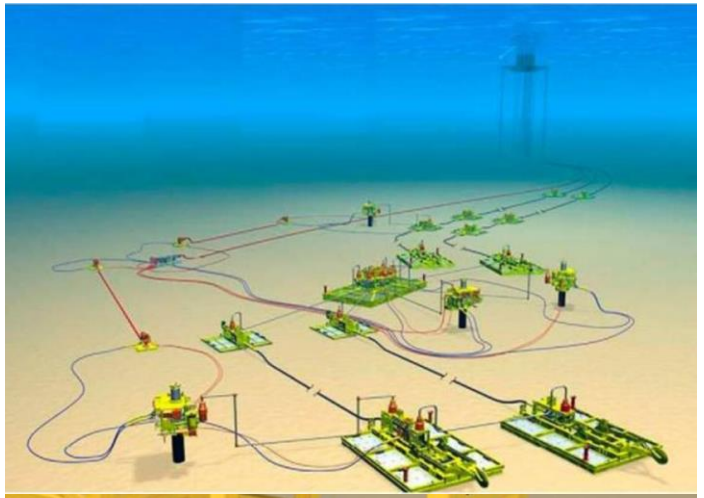
- Export pipelines transport fluid:
  - from platform to shore
  - or from shore to shore

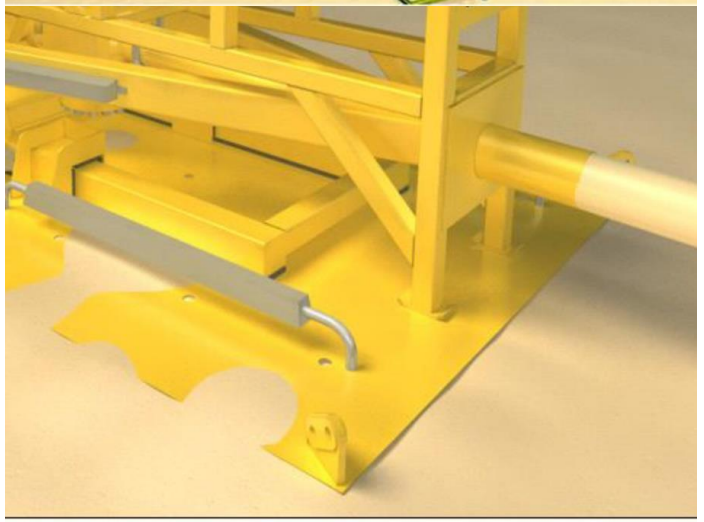
Subsea Pipelines

- Export Pipelines
  - Export pipelines transport fluid from platform / shore to shore
  - The diameter of these can be up to 60 inches (1500 mm)
  - Length of export lines can range from some kilometres up to several hundred
  - Most export lines transport gas, but also oil export lines are common

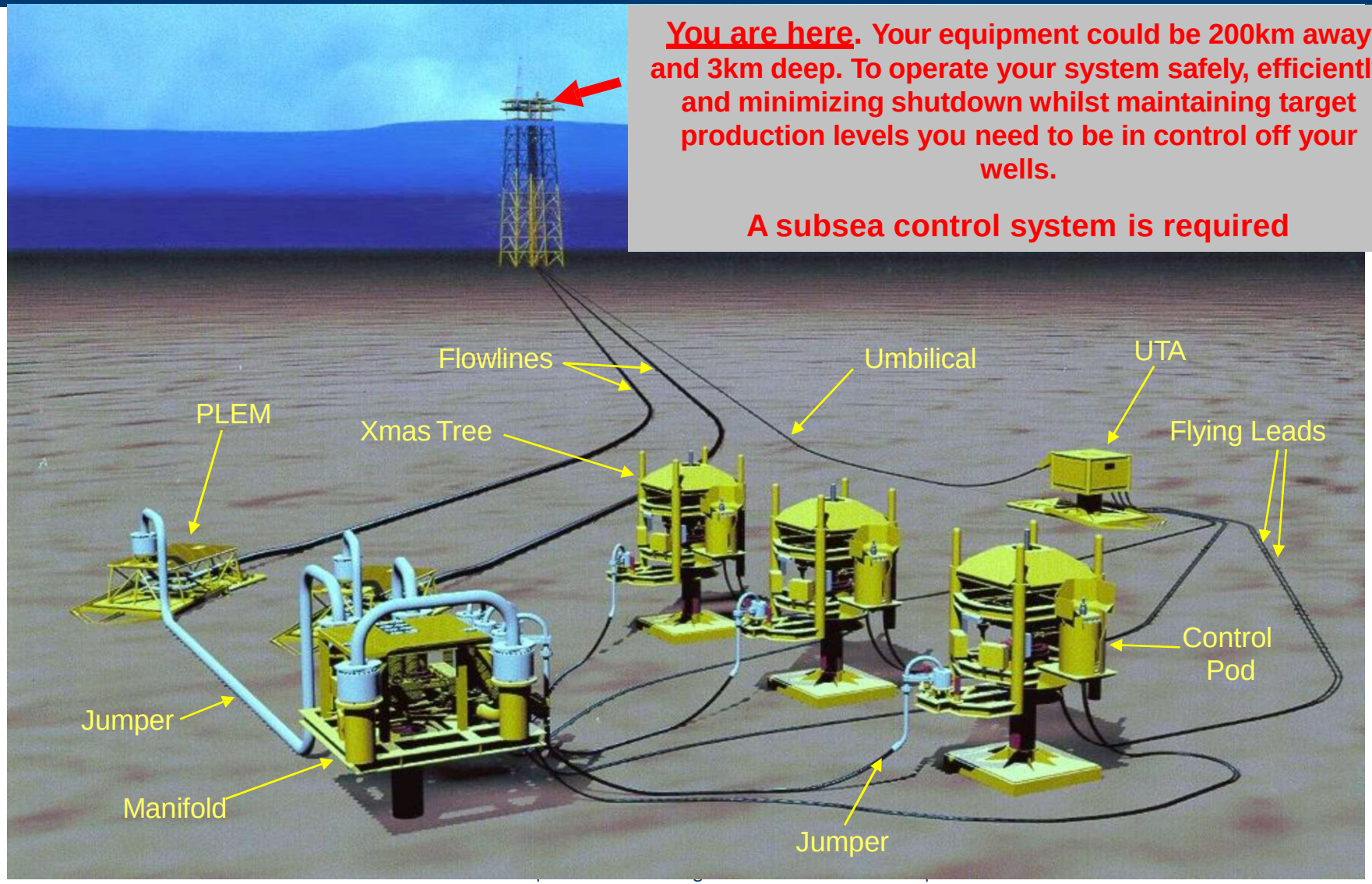
Subsea PLEM and PLET

- The PLET/PLEM is the required substructure for a pipe-to-pipe connection. It provides the support for the connection point
- The PLEM is a simple subsea structure set at the end of pipeline that is used to connect a rigid pipeline with other subsea structures, such as manifolds or trees, through a jumper
- It is called PLET when serving as a support for one pipeline valve and one connector, while the PLEM is supporting two or more pipeline connections.





Subsea Control Systems

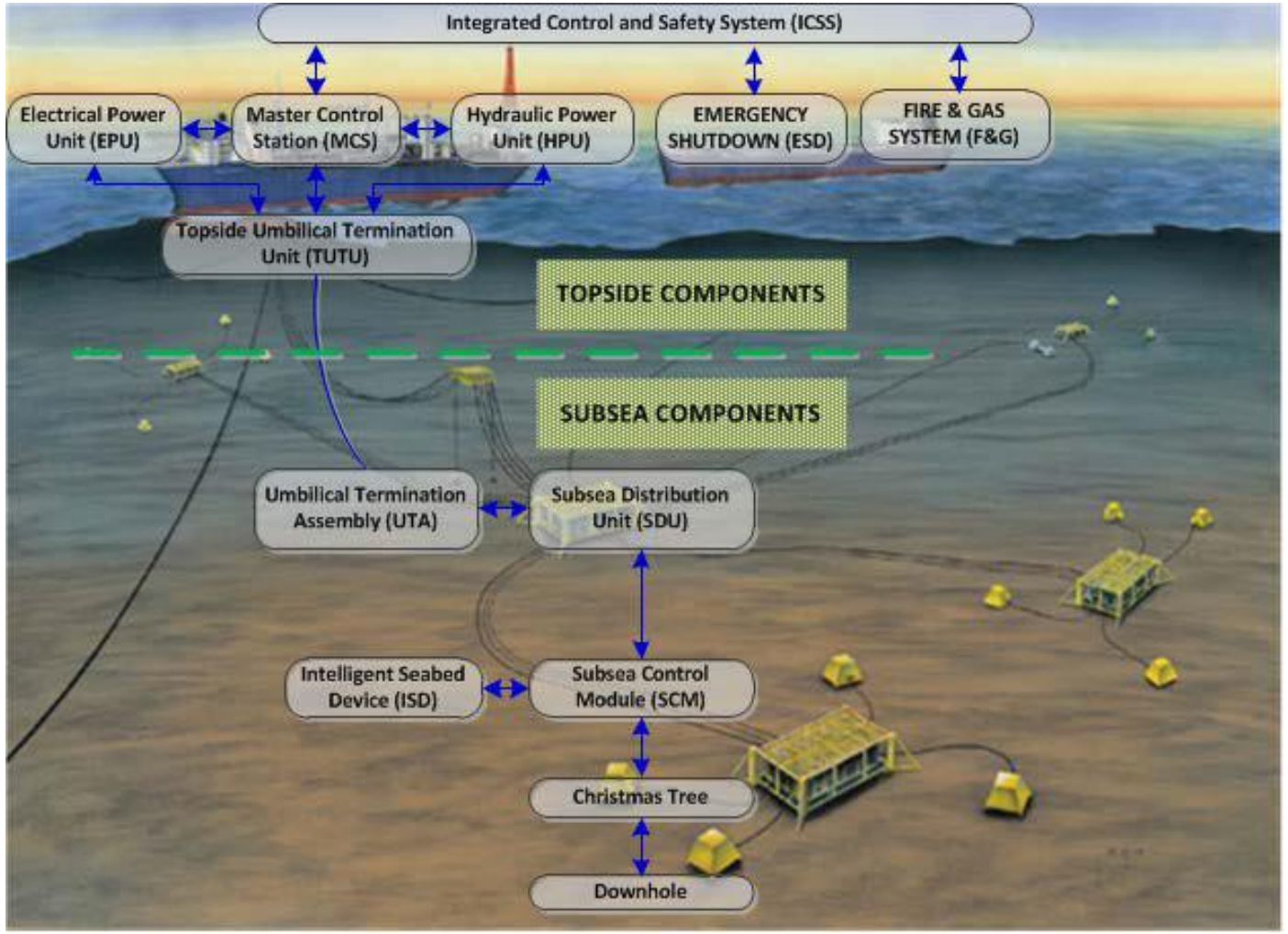


You are here. Your equipment could be 200km away and 3km deep. To operate your system safely, efficiently and minimizing shutdown whilst maintaining target production levels you need to be in control off your wells.

A subsea control system is required

Subsea Control Systems

- What is a Subsea Control System
  - The Subsea Production Control System performs the valve control and data monitoring required to operate the Subsea Facilities:
  - The Subsea Control System interfaces with topsides and subsea facilities and involve many different engineering disciplines



Subsea Control Systems

Subsea Controls and Umbilicals – Basic Functionality

CONTROLS

- Remotely operate subsea valves
  - Failsafe close isolating gate valves
  - Choke valves
  - Ball valves
- Monitor & collect data from subsea sensors
  - Electrical communications
  - Fibre-Optics

UMBILICALS

- Interface with Host facility
  - Platform
  - FPSO
  - Onshore
- Deliver Chemicals (or lubricant)
  - MeOH
  - Scale/Corrosion/Wax Inhibitor
  - H2S Scavenger
- Deliver power to subsea system
  - Hydraulic
  - Electrical

Subsea Control Systems

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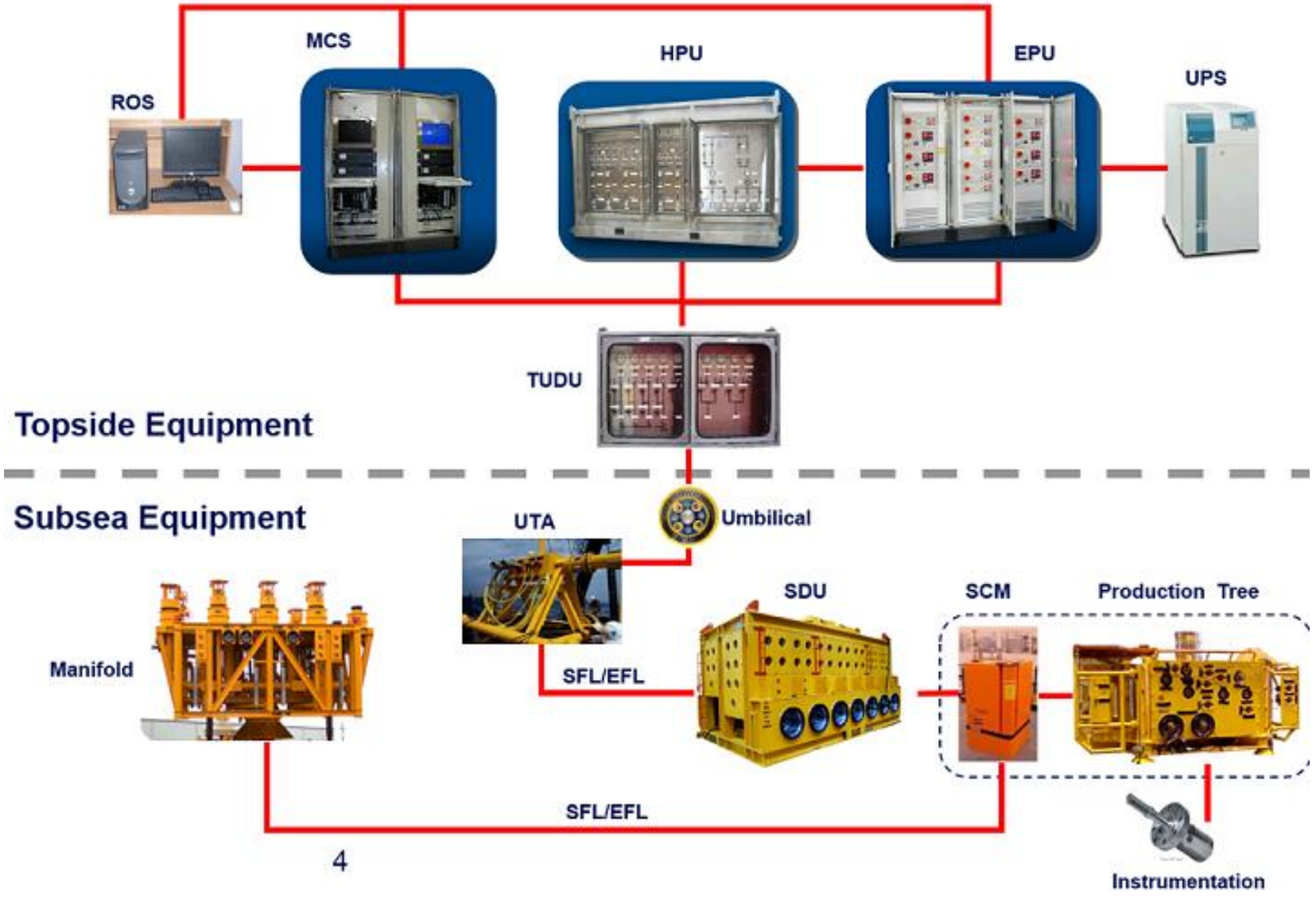
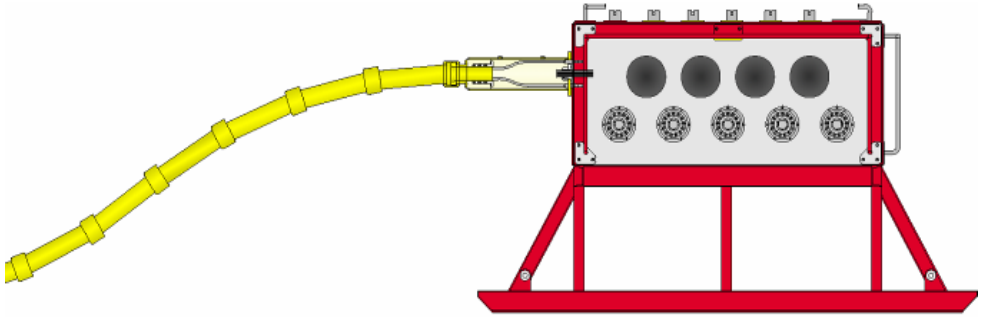
Subsea Controls Layout



Subsea Control Systems

Umbilical terminations and distribution units



Typical umbilical termination assemblies

UTA, STU, SUTU, UTU, etc. - All mean the same

Interface between umbilical and the Subsea control system

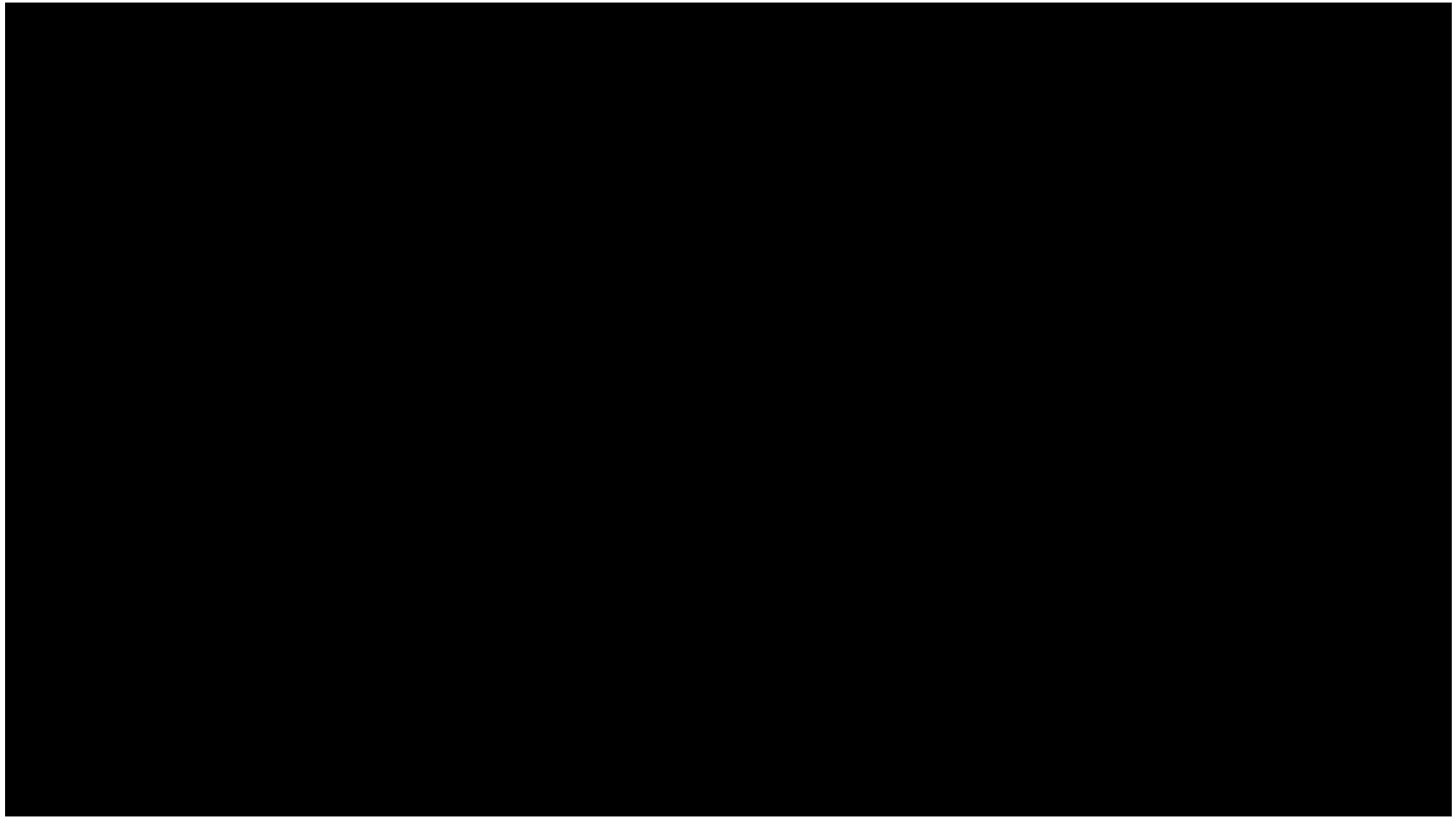
Splits up hydraulics and electrical supplies for distribution

Flying leads to Control modules

Re-configuration capabilities

Retrievable units

Subsea Project Documentary Video - Wheatstone



Thank You!

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52884WA Advanced Diploma of Mechanical Engineering Technology	2 October 2023
Graduate Diploma of Engineering (Mechanical)	2 January 2024
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