FLNG in Harsh Environment - Disconnectable and Relocatable Riser System

2H Offshore Engineering

Overview

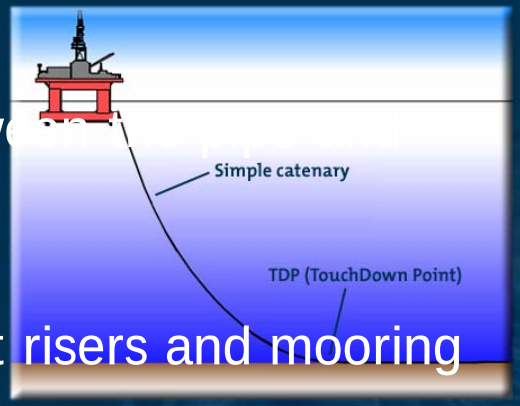
- Riser design requirements
- Flexible and steel riser system challenges
- Design features of Single Line Offset Risers (SLOR™)
  - Operating mode
  - Disconnected mode
- Track record
- Benefits and conclusions

Riser Design Requirement

- Large number of risers required
- Large diameter risers
- Upcoming FLNG field developments located in regions of hostile environment loading conditions
- Risers to share the real estate with the moorings at the vessel interface

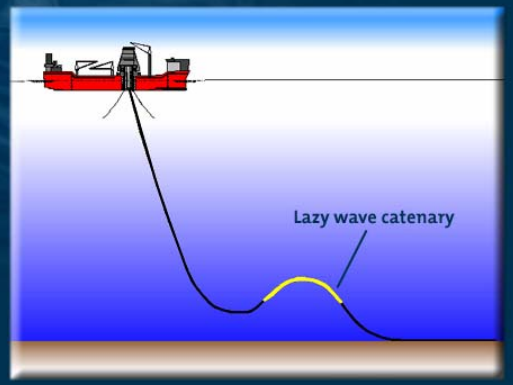
Steel Riser Design Challenges

- Potentially large vessel payloads due to large number of risers required
- Complex interactions between the pipeline and seabed
- Clashing with the adjacent risers and mooring lines



Motion sensitive
TDP fatigue vessel
offset limits

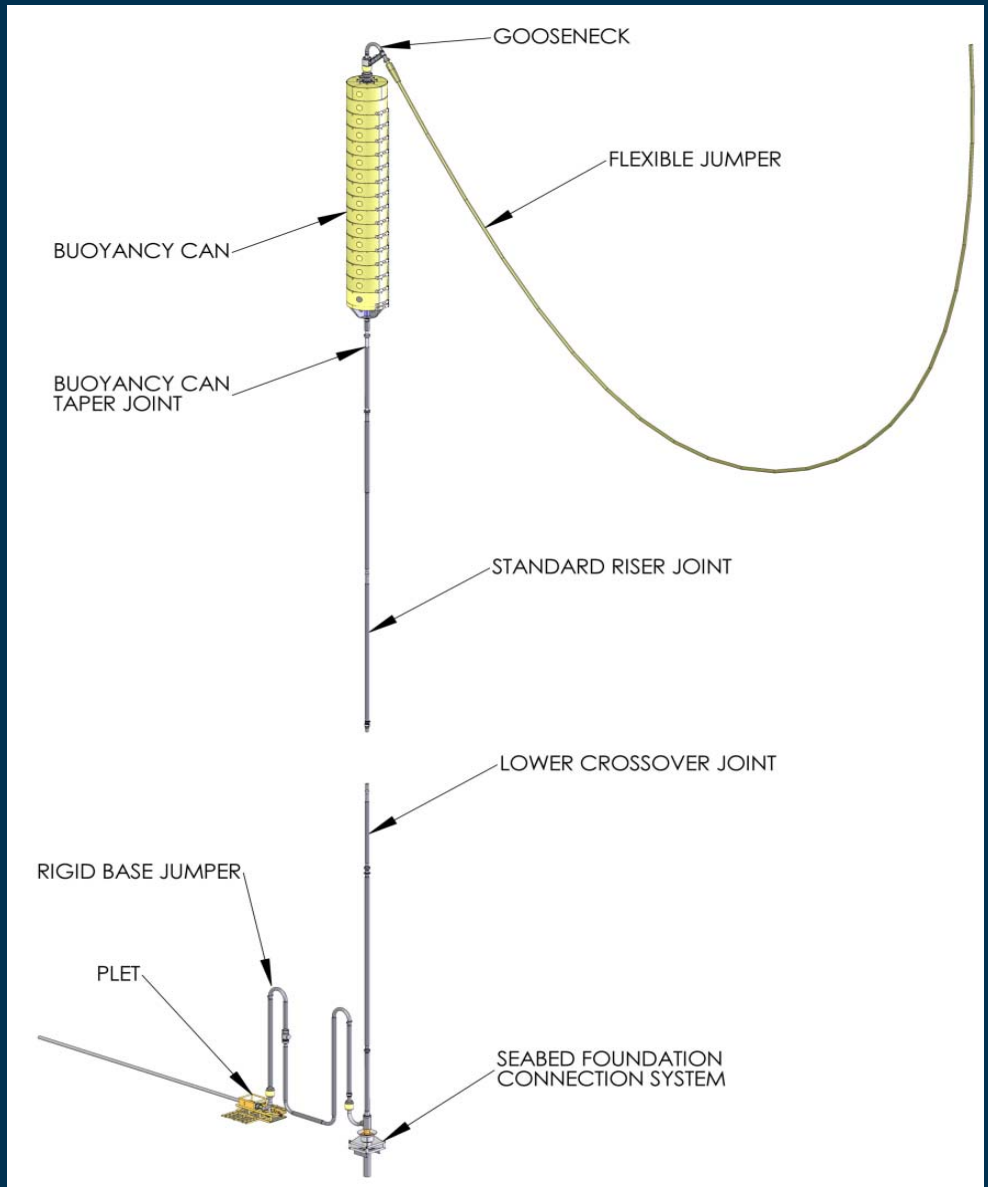
Buoyancy cost
Installation
slugging corridors



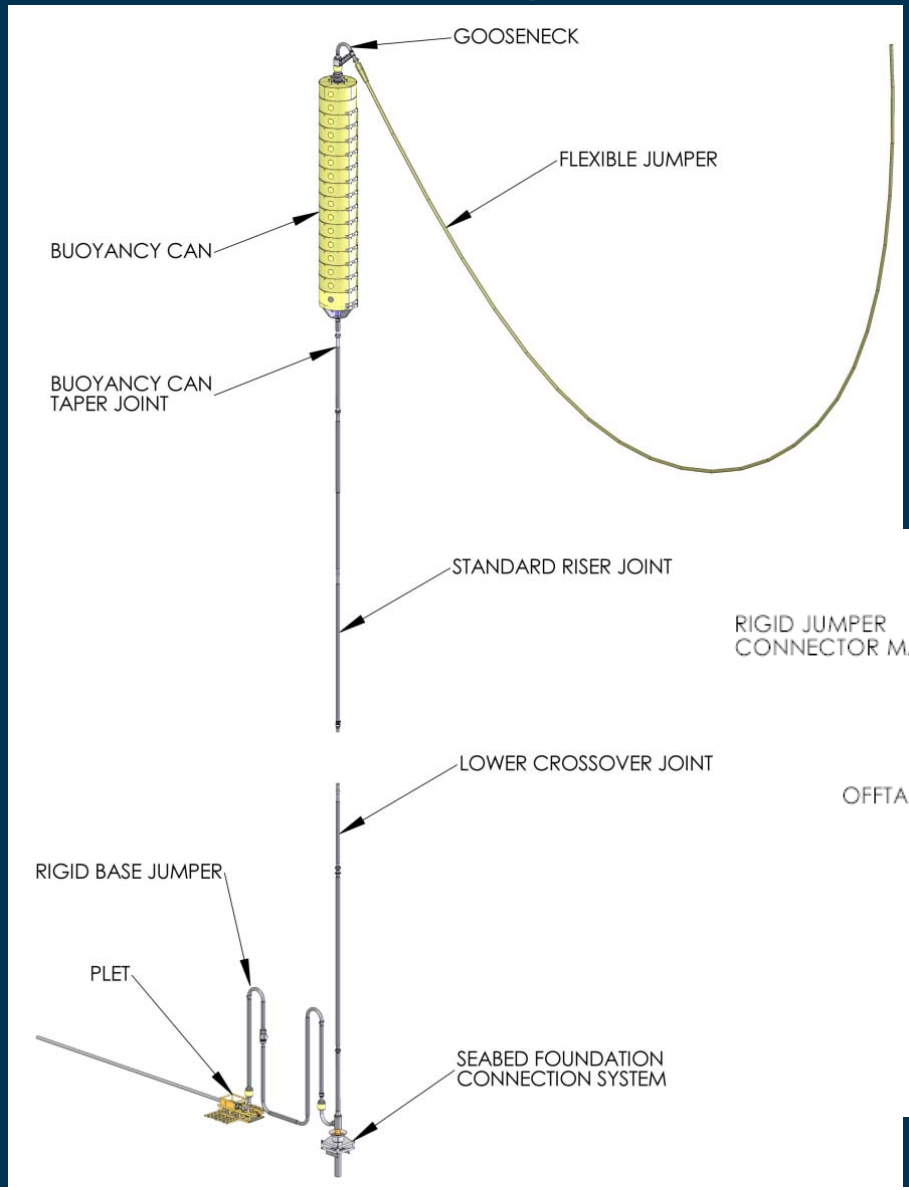
Flexible Riser Design Challenges

- Clashing issues due to highly dynamic nature of the risers
- Potentially large payloads for deepwater applications
- Pipe diameter limitations for deepwater
- Flexible risers are highly fatigue critical for deepwater

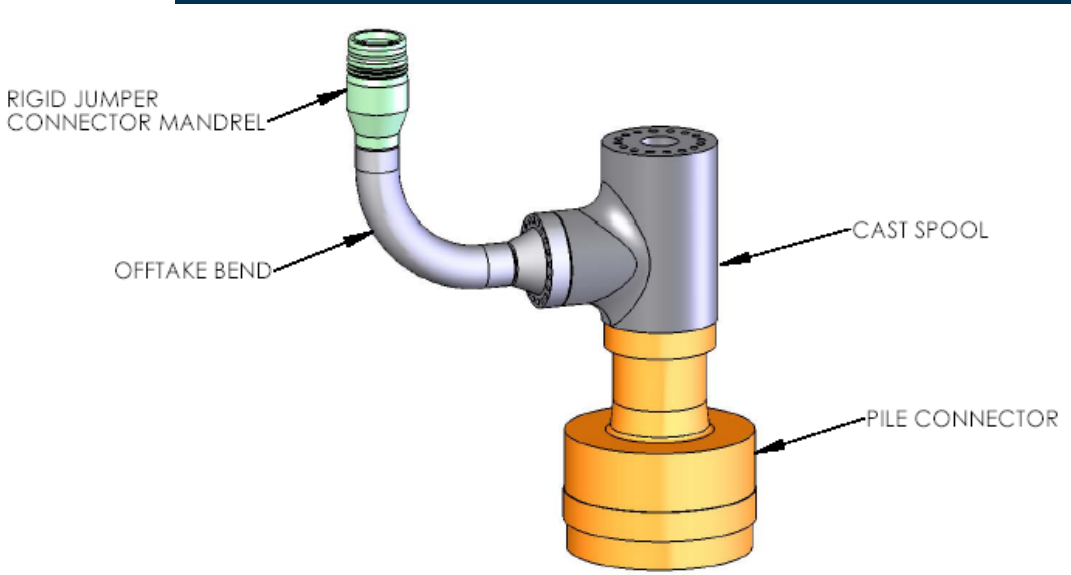
Single Line Offset Riser (SLOR™)



Single Line Offset Riser (SLOR™)



- Gravity base / pile foundation
- Offtake spool assembly links riser to rigid jumper



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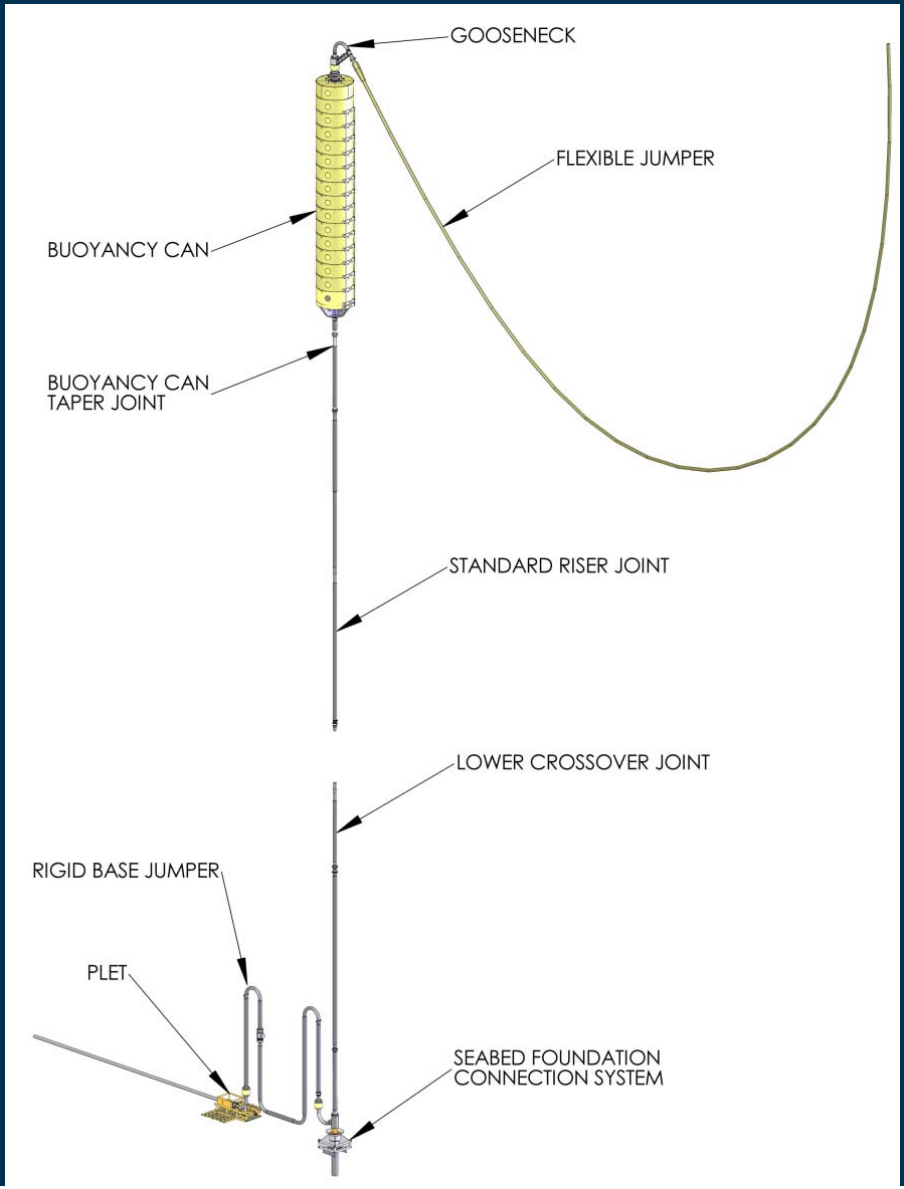
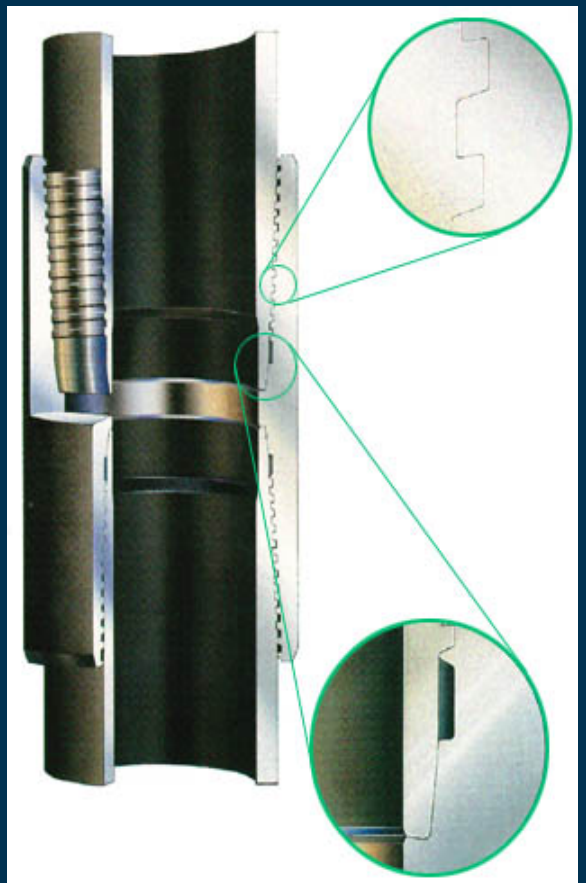


- Casing grade steel pipes with threaded connections or conventional offshore weld



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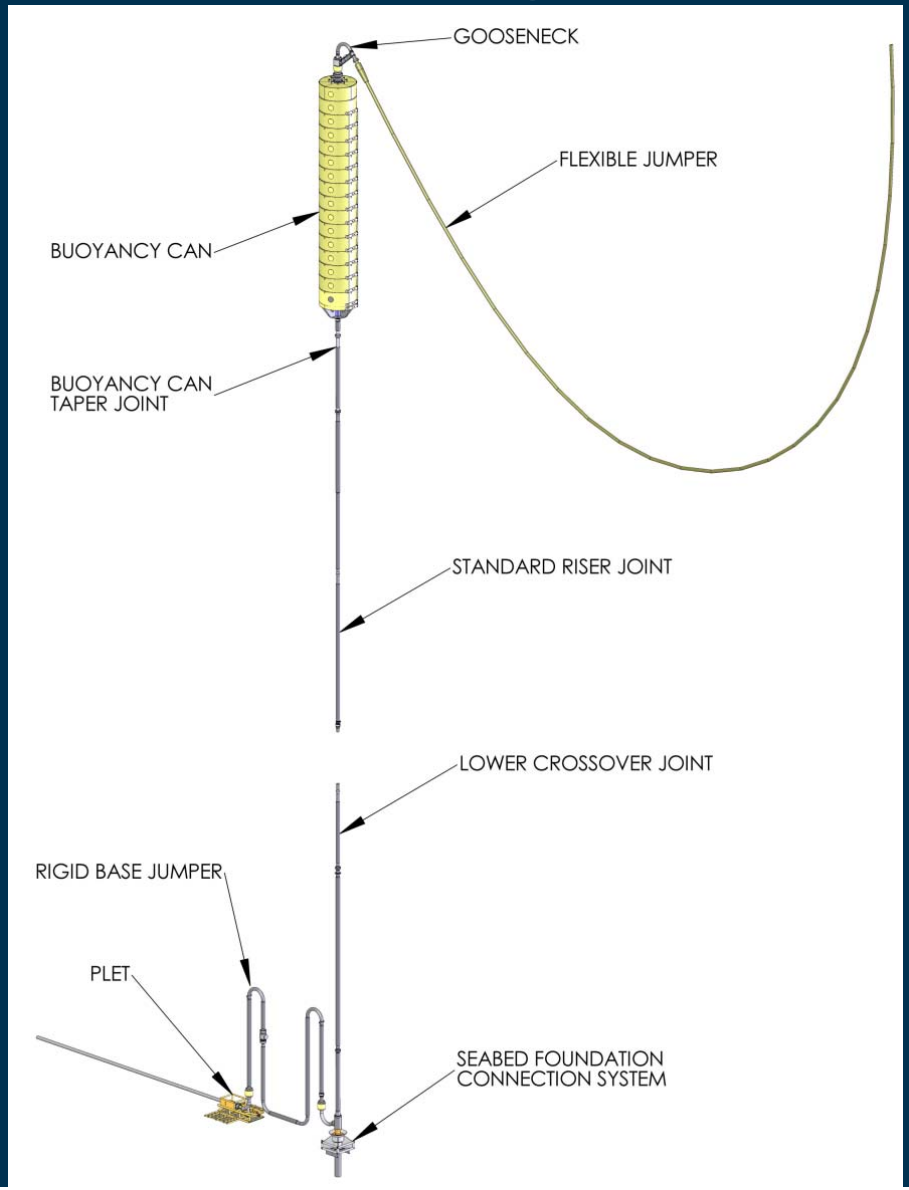
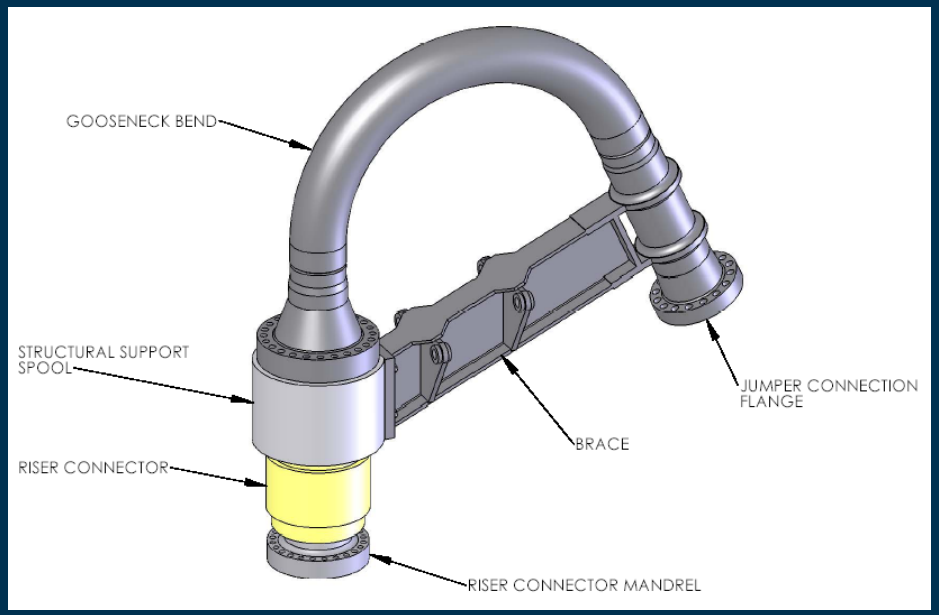
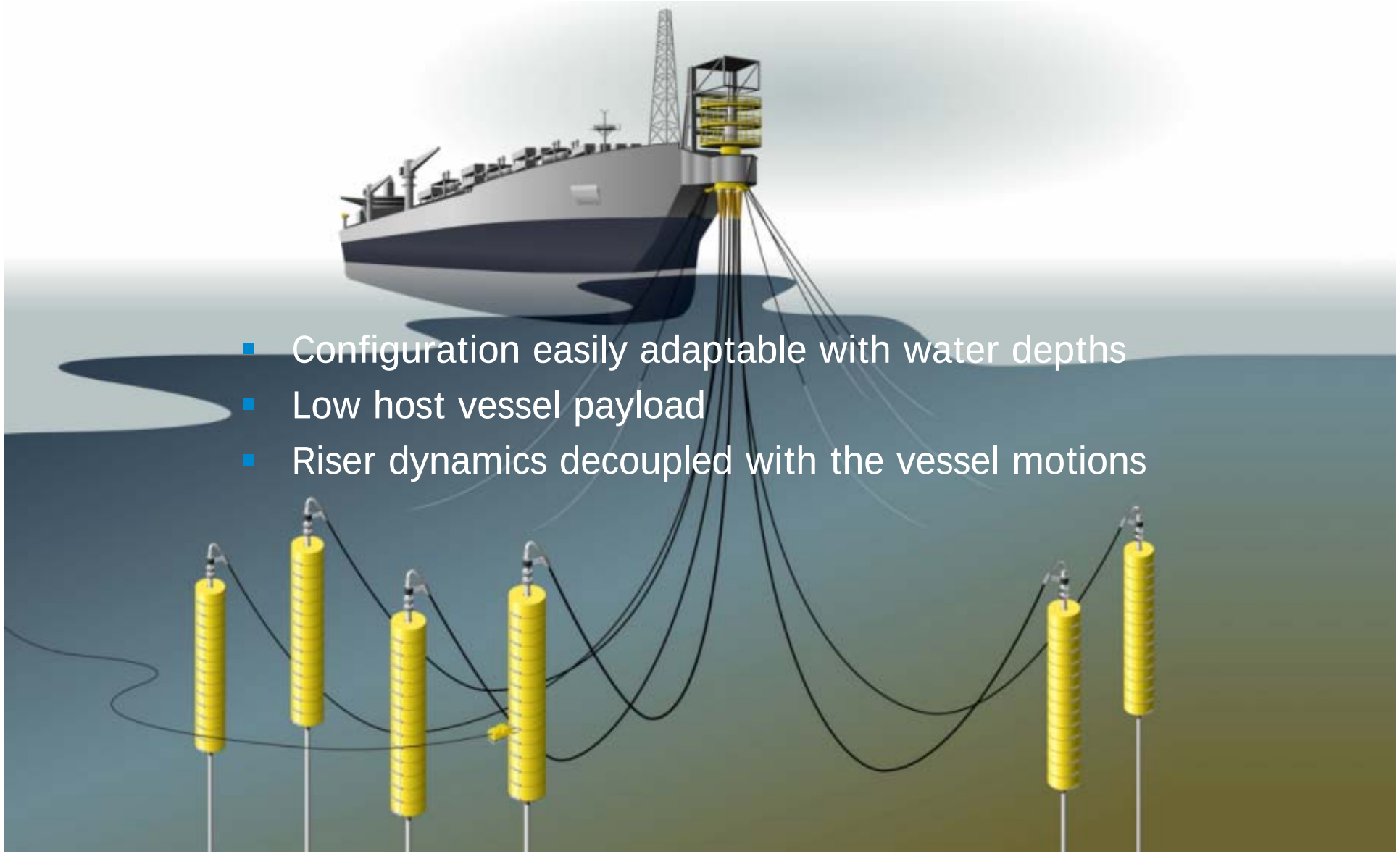


- Buoyancy can arrangement at the top to support the riser
- Gooseneck assembly for fluid offtake from riser to flexible jumper



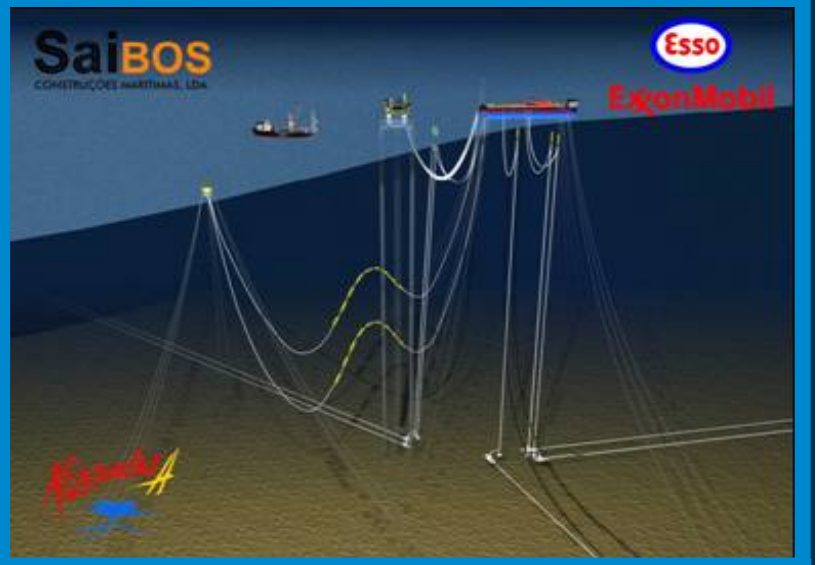
Single Line Offset Riser (SLOR™) – Host Vessel Interface



- Configuration easily adaptable with water depths
- Low host vessel payload
- Riser dynamics decoupled with the vessel motions

Track Record – SLOR's

- **Exxon Kizomba A (5 SLOR's)**
  - 3No. Water Inj. (12 inch)
  - 2No. Gas Inj. (8 inch)
- **Exxon Kizomba B (2 SLOR's, 3 COR's)**
  - 2No. Production (12 x 15 inch PIP)
  - 1No. Test (8 x 11 inch PIP)
  - 2No. Water Inj. (8inch & 12inch)
- **Petrobras P52 -18 inch export SLOR**
- **Petrobras Cascade EPS, GoM (5 SLOR'**
- BP Block 31 – 10 SLOR's
- Exxon – Kizomba Satellites (2-3 SLORs)
- Block 15 – Gas Export SLOR



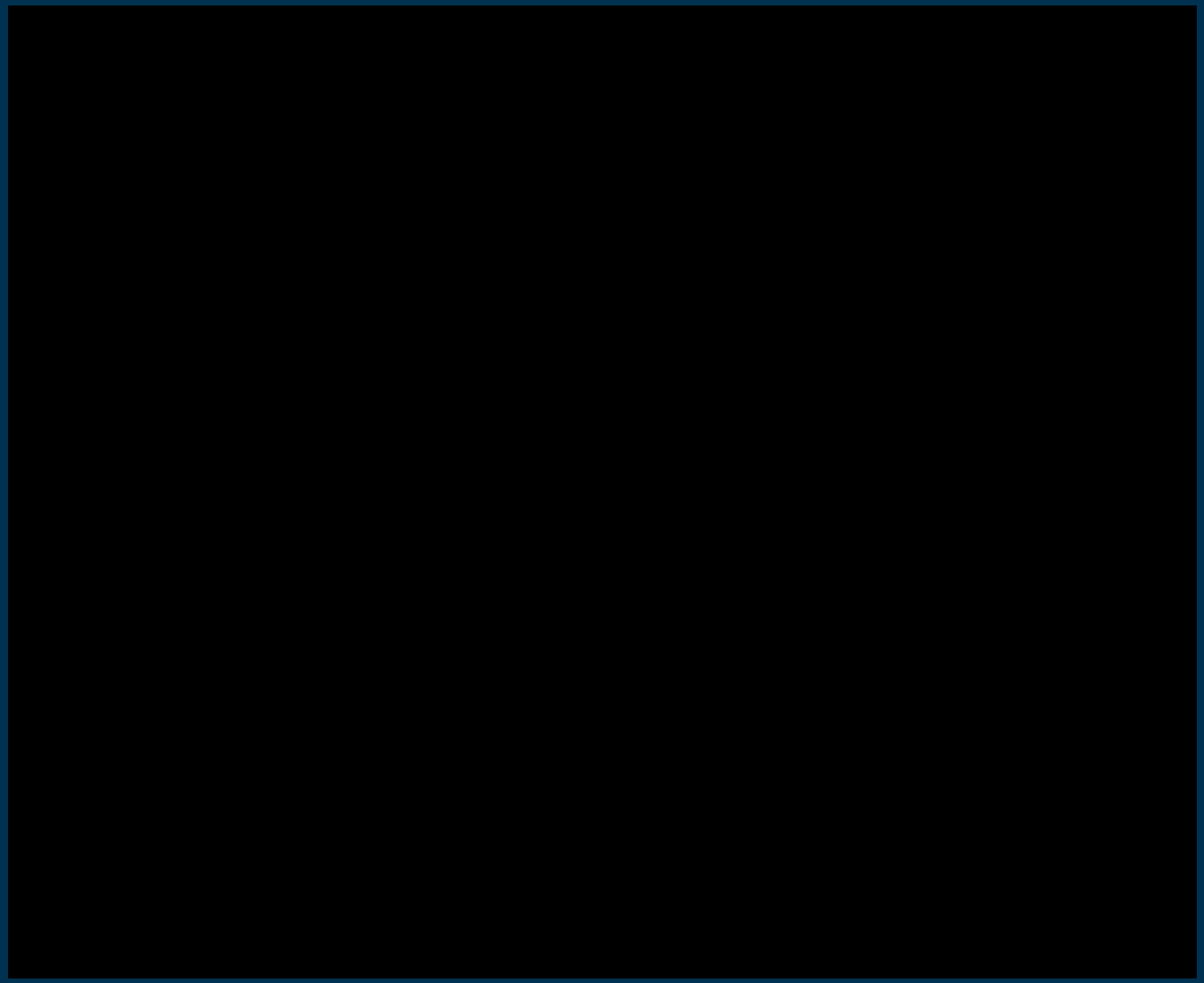
SLOR™ Benefits for an FLNG

- Excellent fatigue performance
- Large diameter risers reducing the number of risers
- Pre-installable
- Low vessel payload
- Wide range of installation options
- Adaptable for a large range of water depths (medium 1,500ft to ultra-deep >10,000 ft
- Re-locatable
- Field Proven WoA

SLOR™ Challenges for Large FLNG (> 2-2.5 mtpa)

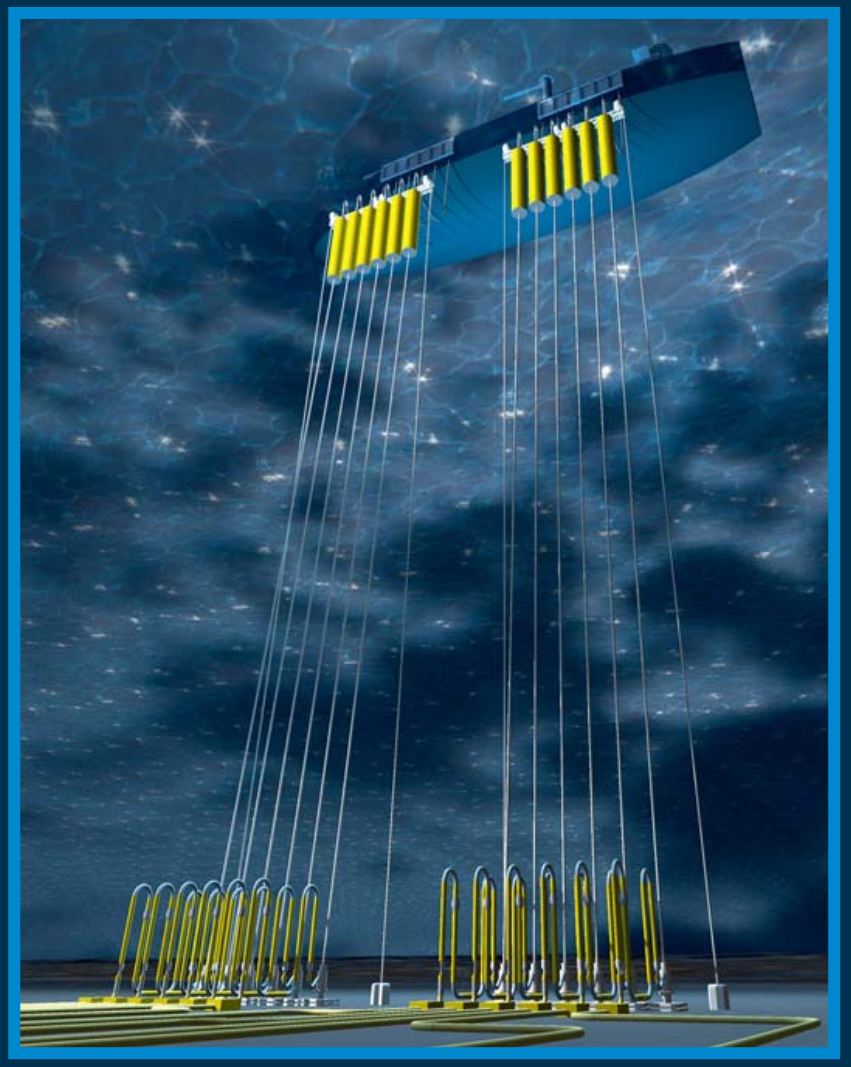
- Large spatial requirement
- Clearance issues
- Complex flowline routing for accessing scattered fields

Grouped SLOR™



Grouped SLOR™ Design

- Open bundled hybrid
- Designed for 4-SLOR or 6-SLOR arrangement
- Similar design features as SLOR
- Elongated riser wear stem through buoyancy can
- Guide frame at the top to group the individual SLORs



2H offshore

Installation

subsea 7

Installation

Suction Piles

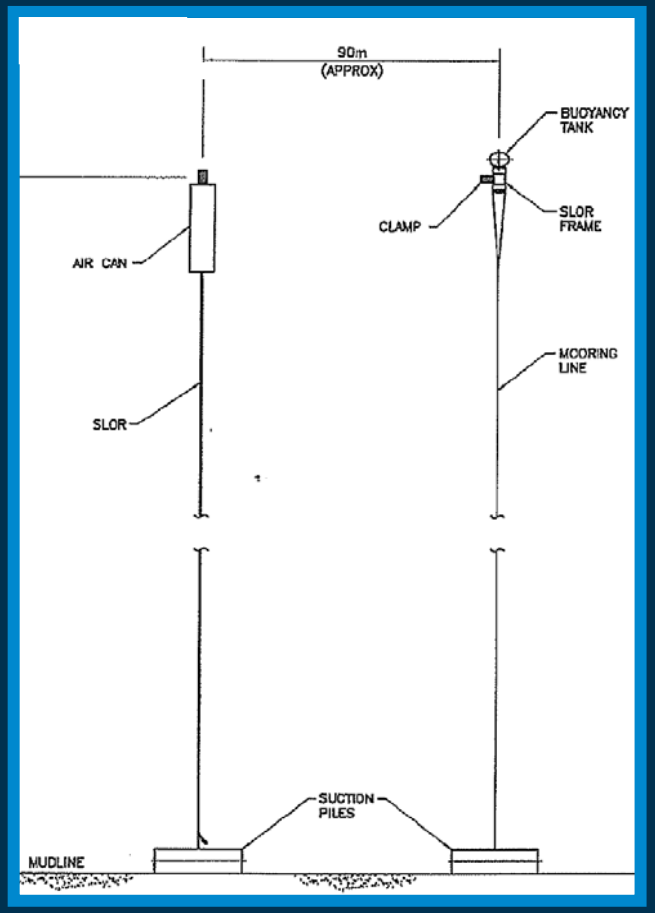
- Anchor handling vessel

SLORS

- Installable using J-Lay, Tow-out or Reeled
- Aircan controlled descent
- Freestands without gooseneck

Frame

- Tow-out or off barge
- Ballasted with chain to depth
- ROV connection to pile



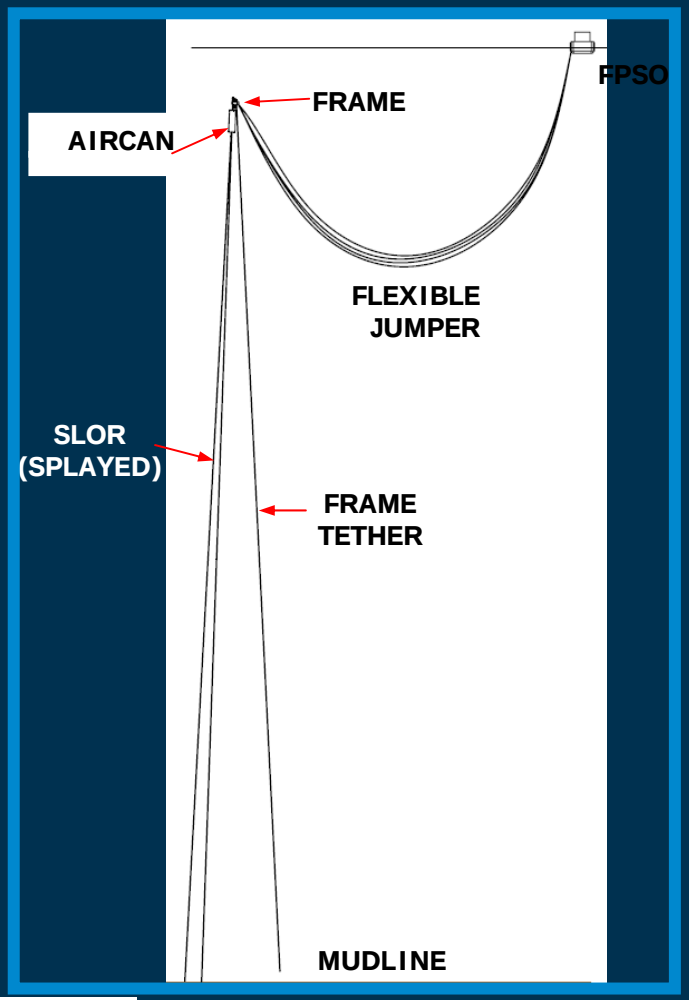
Installation

Grouping

- SLOR guided into frame
- ROV closes SLOR receptacle
- Risers freestand within frame awaiting FPSO

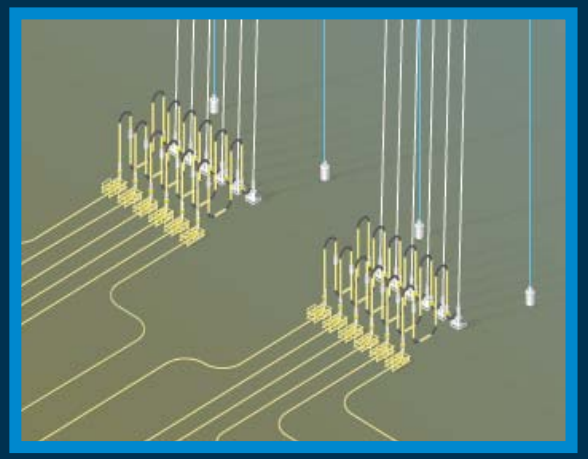
FPSO Arrival

- Goosenecks connected to riser stem
- Flexible jumper handed to FPSO & pulled in



Grouped SLOR™

- Scaleable
  - Capacity for 2-6+ SLORs
  - Mid to Ultra-deep water
- Flexible
  - Single Line
  - Pipe-in-pipe (gas lift)
- Maintainable
  - Removable risers
  - No need for redundant lines
  - Gooseneck offtake for intervention
- Stable
  - Splayed risers & tethers
  - Multi-riser stability
- Proven
  - Uses field proven elements
  - Design similarities with Spars



Field Proven Solution Dis-connectable Solutions

Petrobras Cascade-Chinook, 8000ft WD, GoM

- Disconnectable turret
- 5 x free-standing risers grouped to the buoyant turret
- BW Pioneer, large FPSO

Conclusion

- Well developed concept
- Spatially optimised
- Reduced subsea complexity
- Installation flexibility
- Disconnectable
- Relocateable
- Scalable for a range of water depths