Introducing the Very Large Turret (VLT)

Deepwater Risers, Moorings & Anchorings Conference
IBC 2002, Houston, Texas

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FMC SOFEC Floating Systems
18-19 March 2002

VLT Presentation Outline

- **Why a VLT?**
- **Features of the VLT**
- **VLT Design**
- **Riser Considerations for the VLT**
- **Conclusions**

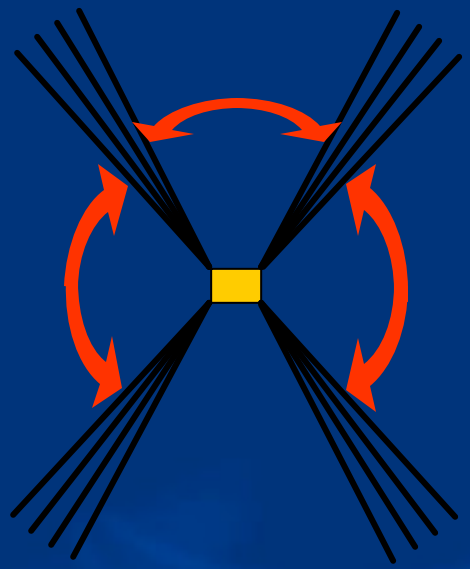
Why the VLT

- **Semi-Submersibles – General**
  - **Accommodates many risers**
  - **Congested deck layouts**
  - **No oil storage capacity – pipeline or FSO required**
  - **High CAPEX – limited availability of existing vessels**
- **FPSOs – General**
  - **High storage capacities**
  - **Generous deck space for topsides equipment layout**
  - **Accommodates many risers**
  - **Low CAPEX for new vessels and converted tankers**

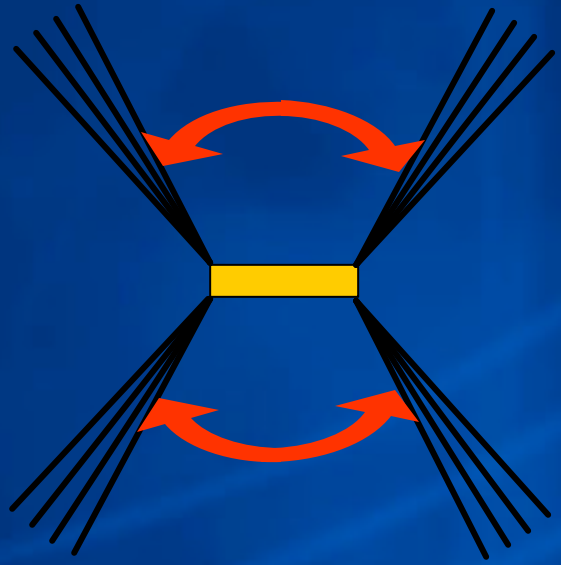
Why the VLT (cont.)

- **Spread Moored FPSOs**
  - **Suited for mild or moderate environments**
  - **High risks associated with side-by-side and tandem offloading**
  - **Satellite export system can be costly**
  - **Unfavorable response motions for beam seas or crossed conditions (particularly roll)**
- **Very Large Turret Moored FPSOs**
  - **Suited for extreme environments**
  - **Weathervanes and offers reduced motions**
  - **Tandem offloading eliminates need for satellite export system**
  - **Cost competitive with similar spread moored FPSOs**

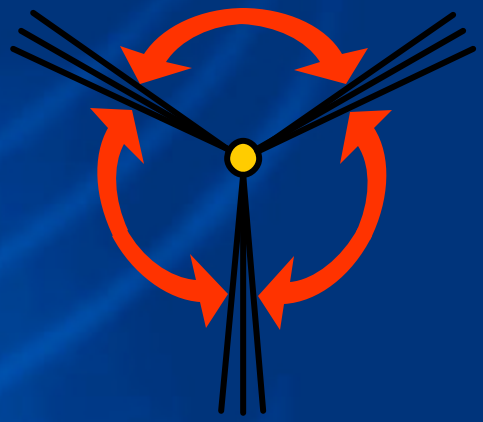
Seafloor Space Available at Riser Touchdown Point



Semi-Submersible



Spread Moored



Turret Moored

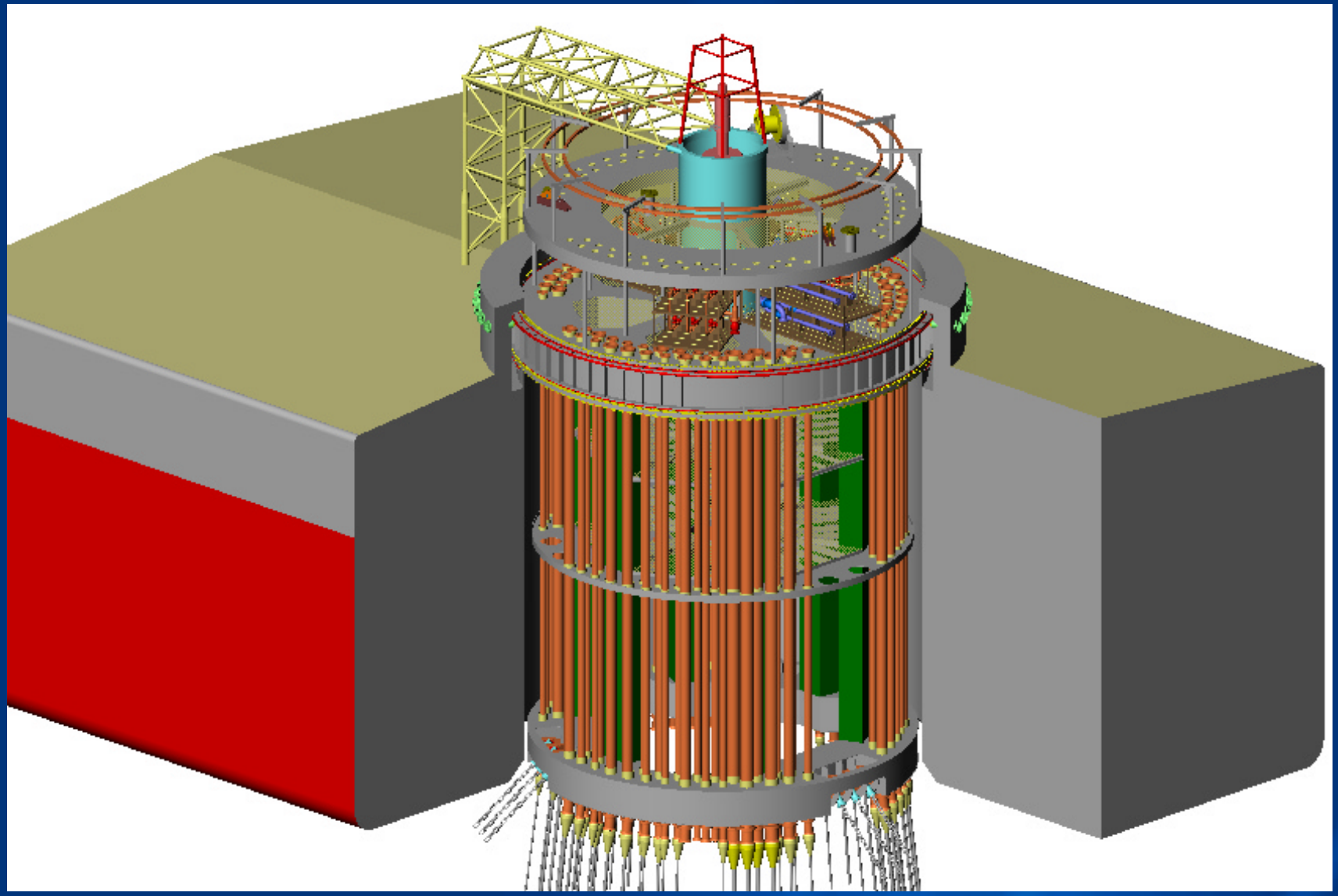
Features of the VLT

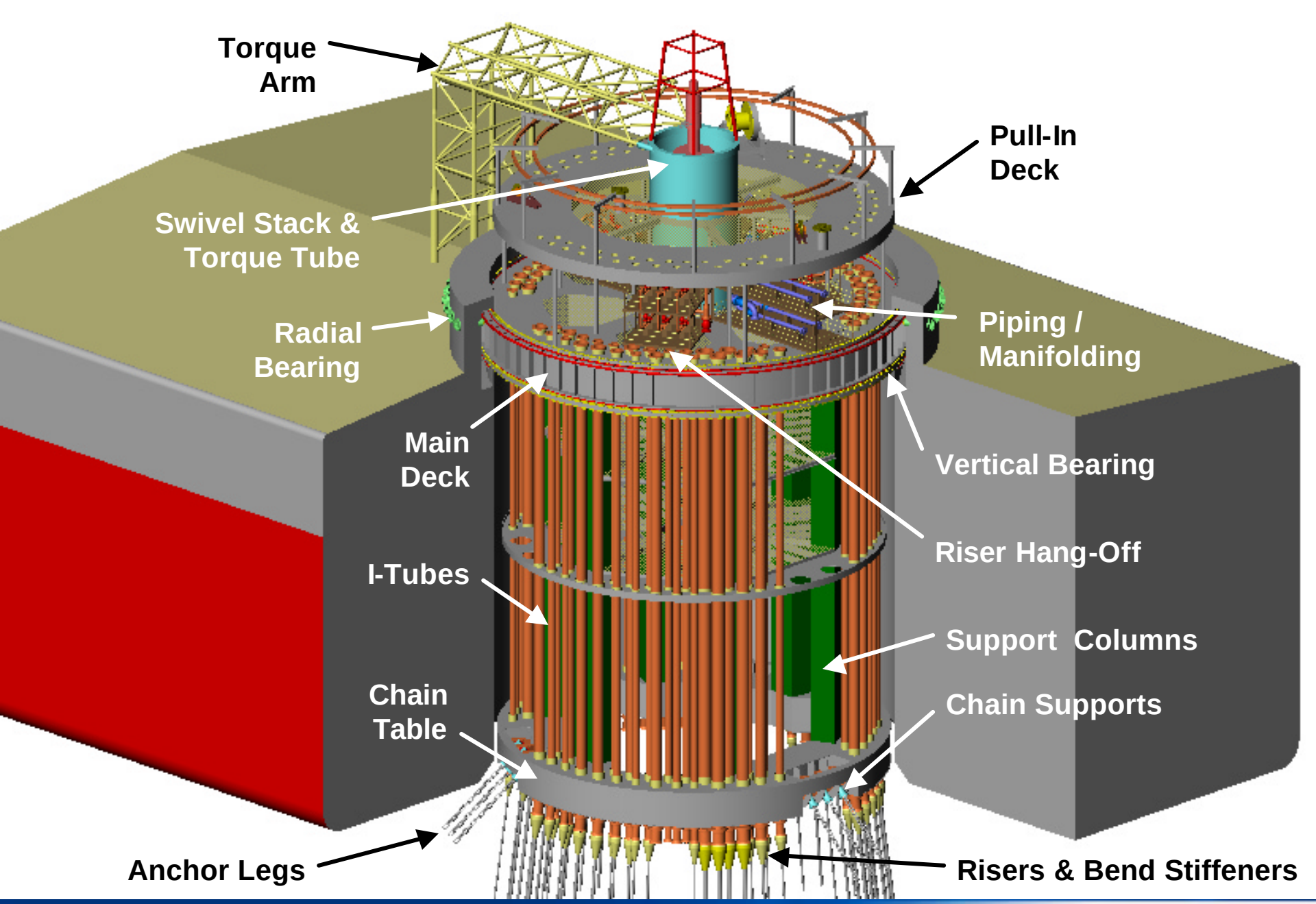
- **Supports 100+ risers**
- **Ultra deepwater FPSO applications**
  - **High loads from risers and mooring**
- **Simplified turret structure**
  - **Main deck, chain table and support columns**
- **Simplified bearing system**
  - **Proven AmClyde wheel roller bearing system**
  - **Lower bearing can be omitted**

Features of the VLT (cont.)

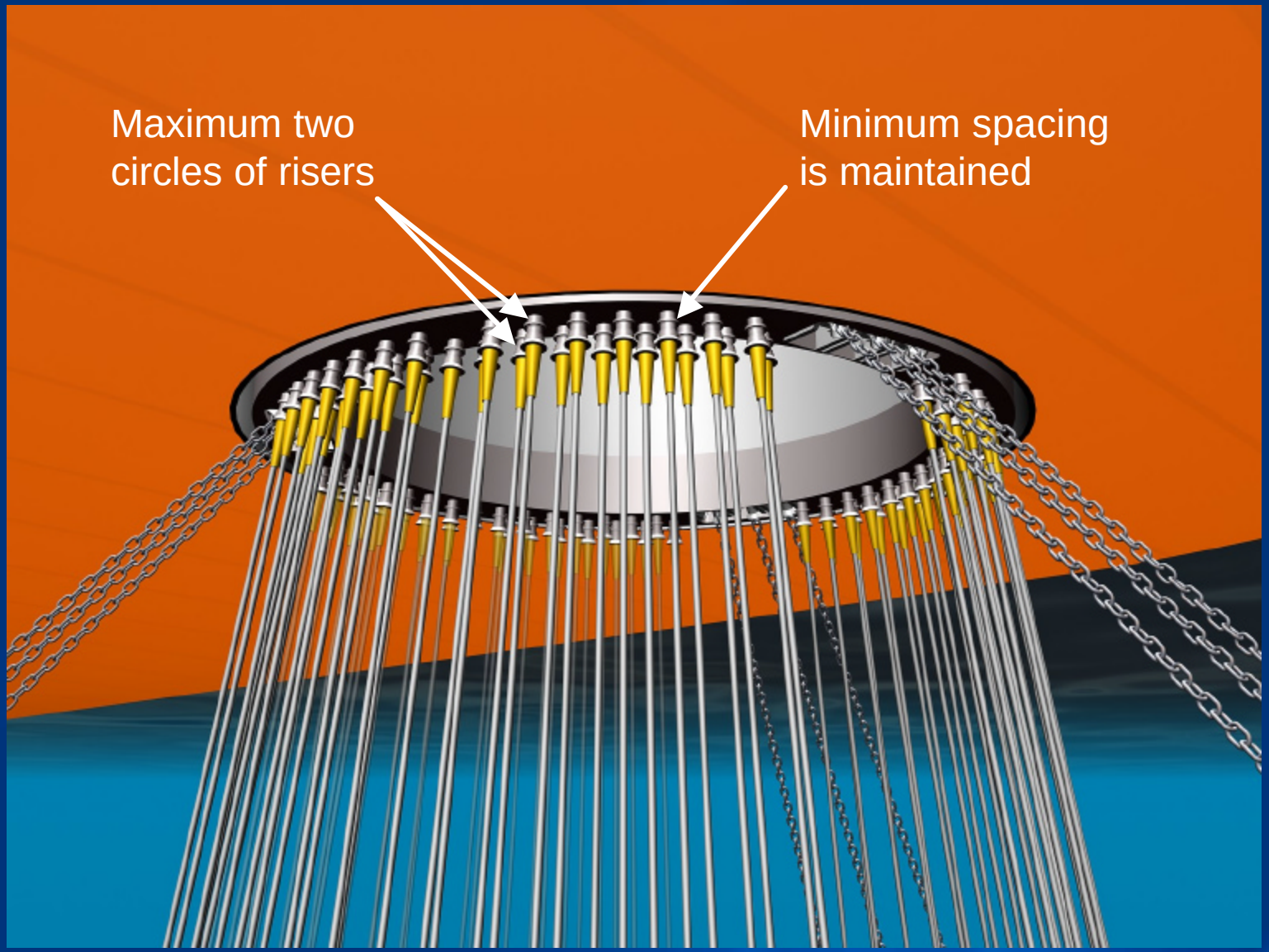
- **Generous open space throughout turret**
- **Riser slots interchangeable for riser sizes 6” ID and smaller**
- **Suitable for both flexible and steel risers**

FMC SOFEC's Very Large Turret




Torque Arm
Pull-In Deck
Swivel Stack & Torque Tube
Radial Bearing
Piping / Manifolding
Main Deck
Vertical Bearing
Riser Hang-Off
I-Tubes
Support Columns
Chain Table
Chain Supports
Anchor Legs
Risers & Bend Stiffeners

Riser Connection at VLT Chain Table



VLT Design Premise

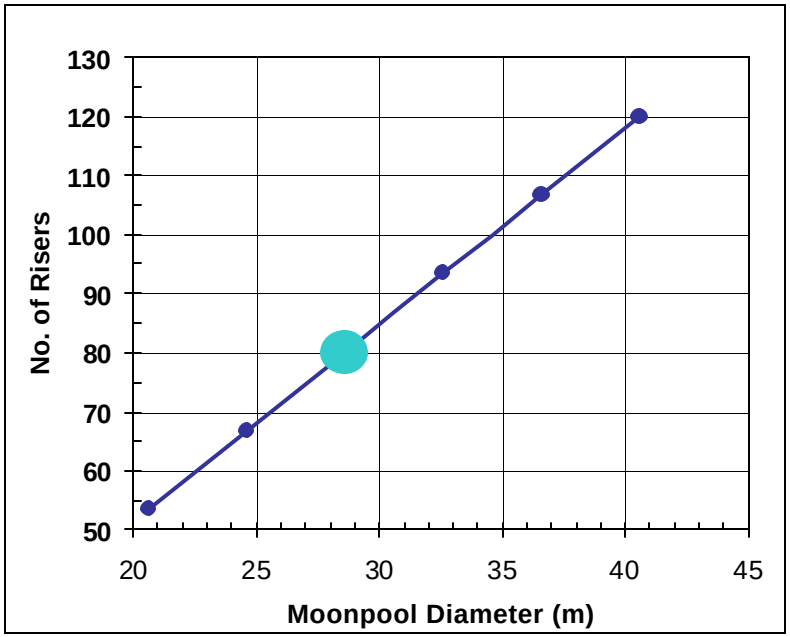
- **79 Flexible Pipe Catenary Risers**
  - **19 x 6” production**
  - **19 x 4” gas lift**
  - **7 x 6” water injection**
  - **4 x 10” & 1 x 6” ID export**
  - **29 umbilicals**
- **1 Large Steel Export Riser**
  - **1 x 16” OD Steel Pipe**
- **Water Depth: 1,300 meters**
- **Location: Brazil**

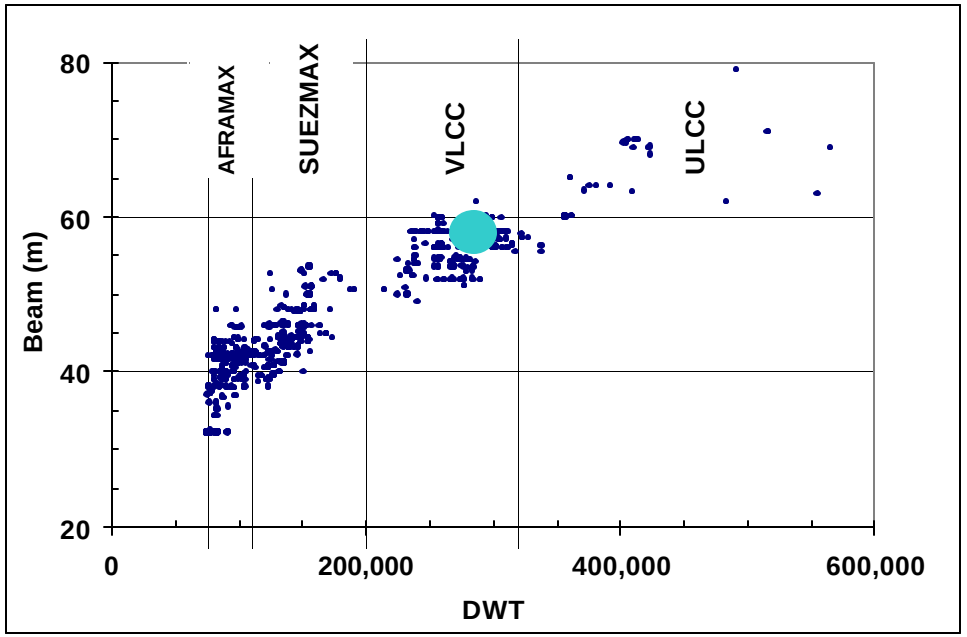
VLT Design Particulars

- **Vessel Size: VLCC (280,000 – 320,000 DWT)**
  - **Length: 325 meters (LBP)**
  - **Beam: 58 meters**
  - **Depth: 30 meters**
- **Mooring: 3x3 taut mooring**
  - **Chain/poly/chain**
  - **VLAs or suction embedded anchors**
- **Turret Location: 40 m aft of FP (12% LBP)**
- **Moonpool Diameter: 28.6 m (49% Beam)**
- **Moonpool Volume: 19,250 m^3 (6% Cargo Capacity)**

Vessel Size Selection for VLT

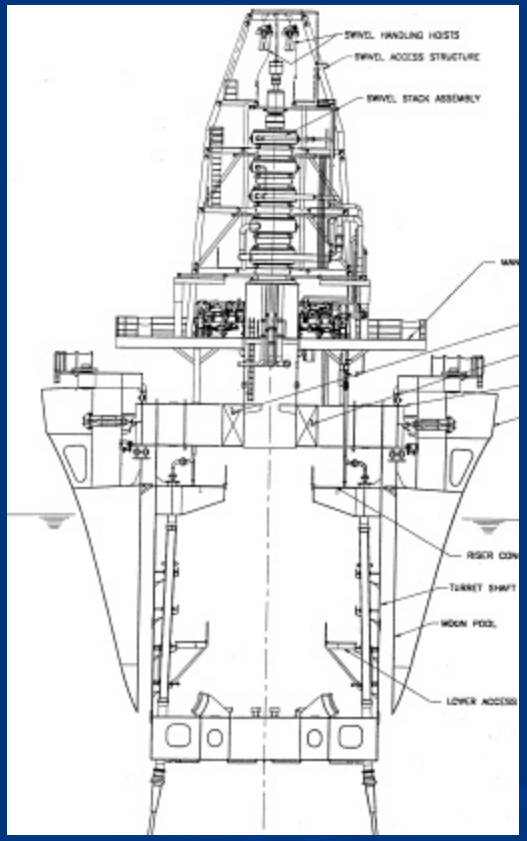
No. of Risers	Moonpool Diameter	Moonpool Diameter 50% Vessel Beam	Moonpool Diameter 57% Vessel Beam	Moonpool Diameter 67% Vessel Beam	Minimum Vessel Sized Required
53	20.6	41.2	33.3	30.9	Aframax
67	24.6	49.2	40.3	36.9	Suezmax
80	28.6	57.2	47.3	42.9	VLCC
93	32.6	65.2	54.3	48.9	VLCC
107	36.6	73.2	61.3	54.9	ULCC
120	40.6	81.2	68.3	60.9	ULCC

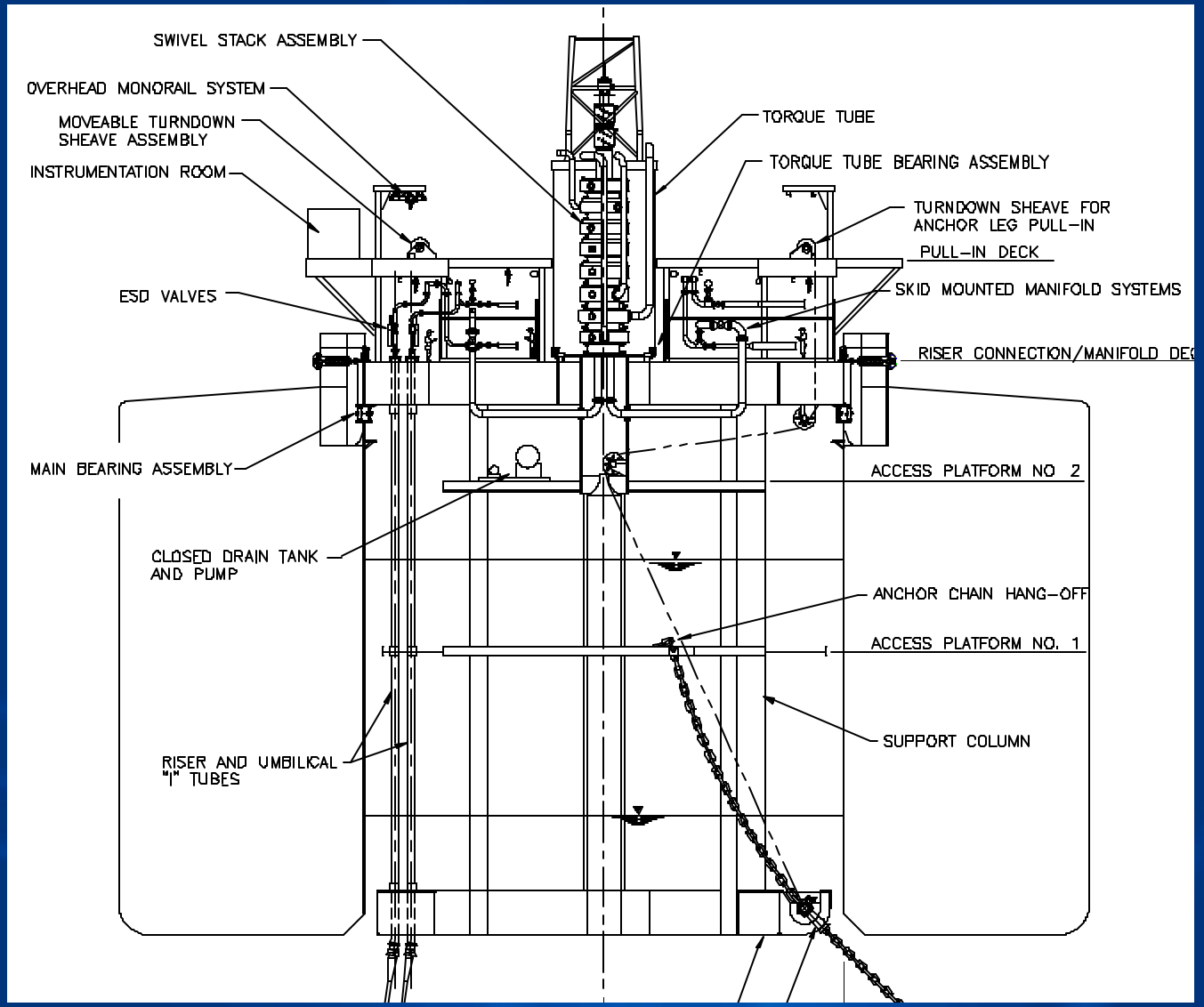




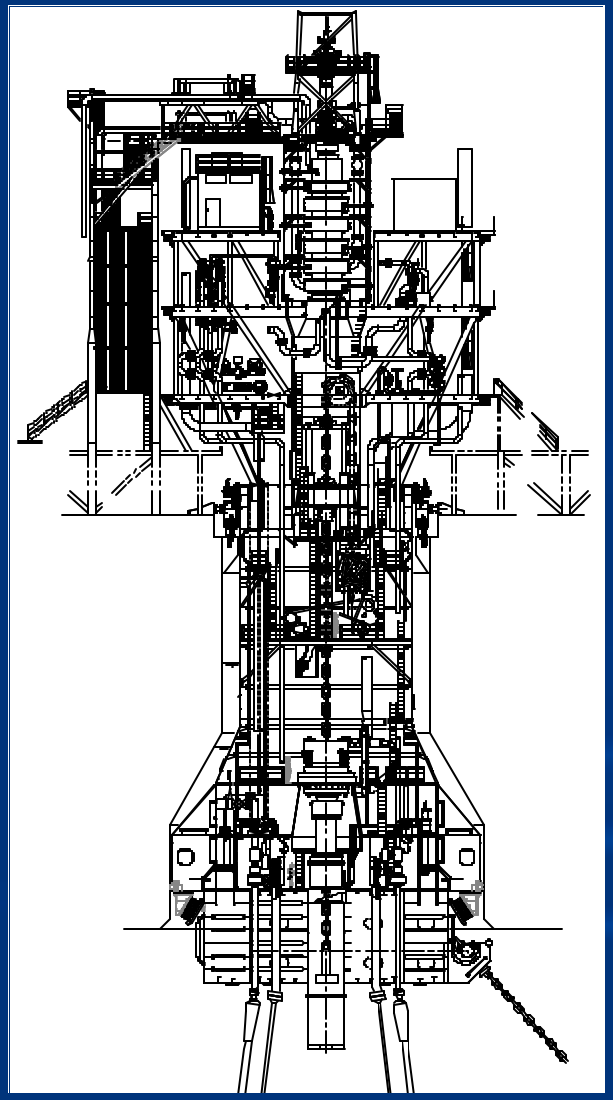
P-34 moonpool diameter is appoximately 67% of vessel beam
VLT moonpool diameter is appoximately 50% of vessel beam

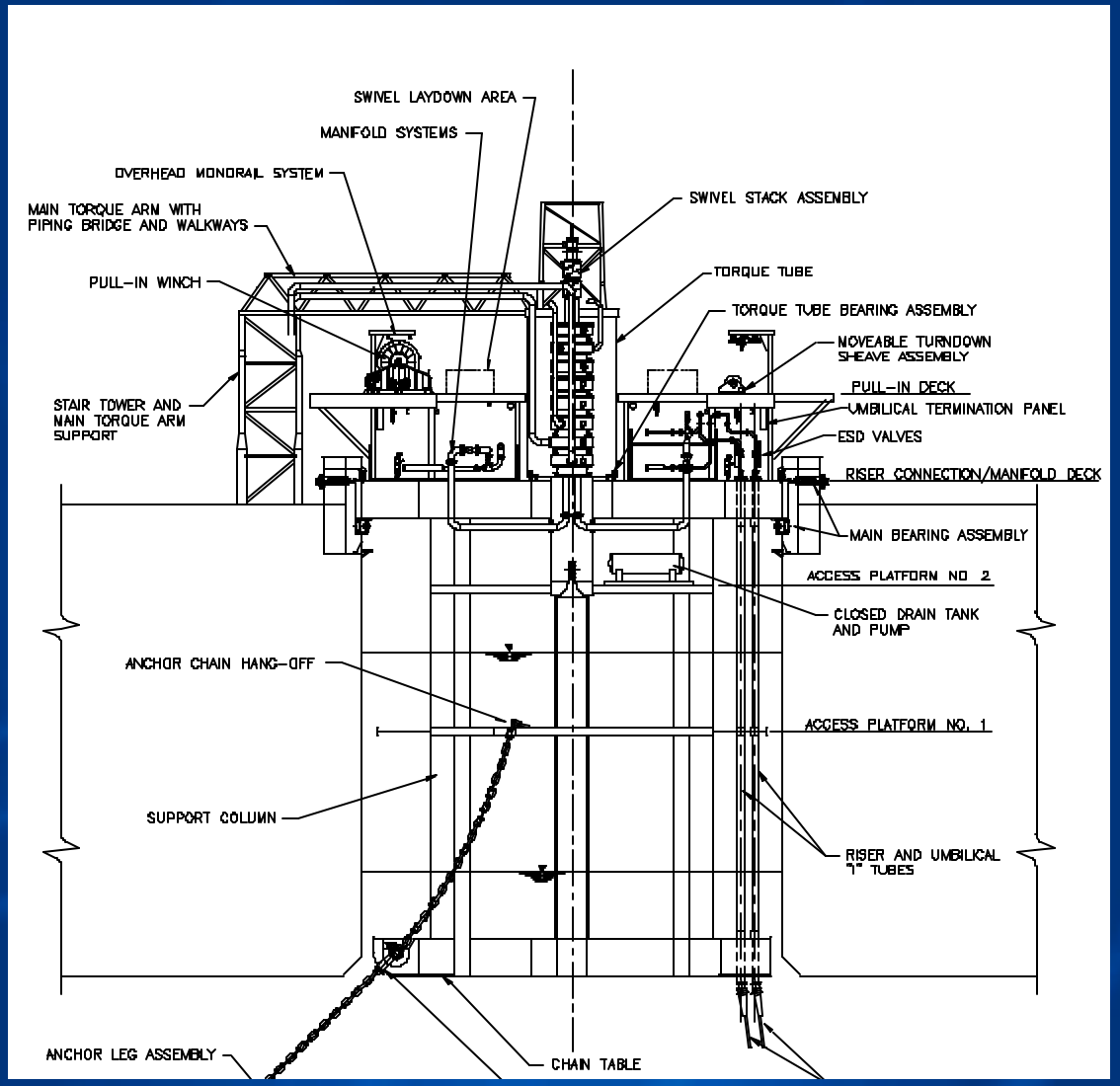
P-34 and the VLT





Terra Nova and the VLT





FMC SOFEC Turret Comparison

	P-34 Barracuda	P-31 Albacora	Terra Nova	VLT
Number of Risers	34	26	19	80
Moonpool Diameter (meters)	13.6	12	14.5 @ Main Deck 22 @ Keel	28.6
Moonpool Height [1] (meters)	17.2	28.6	29	30
Moonpool Volume (cubic meters)	2,500	3,250	6,900	19,250
Overall Turret Height (meters)	45.5	71.5	65	56
Turret Weight Est [2] (metric tons)	1,817	1,669	3,702	4,400
Turret Weight per Riser (metric tons / riser)	53	64	195	55

Notes:

[1] Main deck to keel.

[2] Excluding moonpool, anchor legs and swivel access structure.

Riser Considerations for the VLT

VLT Riser Systems for Deep water

- Challenges
  - Vessel motions
  - Weight
  - Collapse
  - Currents
  - Temperature

VLT Riser Systems for Deep water

- Riser Types
  - Flexibles
  - Steel
  - Hybrid
  - Composites

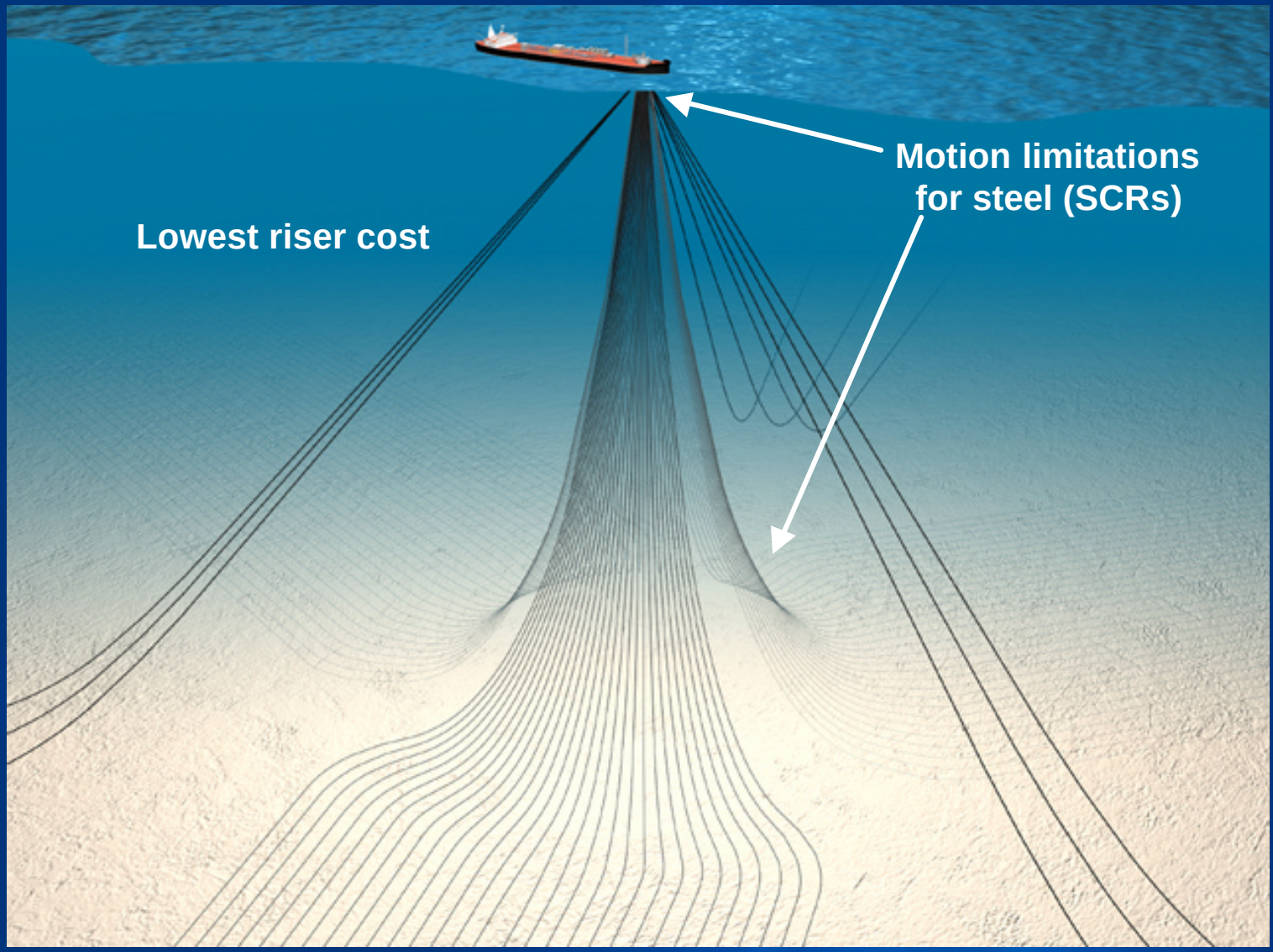
Flexible Risers

- Catenary
  - Benign/moderate environment
- Compliant configuration
  - Harsh environment
- Large turret loads compared to steel
- Higher cost than steel
- Development: larger diameters / deeper water

Flexible Pipe Qualified Ratings

	Currently Qualified	Future Qualified
Coflexip	**6” ID @ 2,575 m** **16” ID @ 1,300 m**	**6” ID @ 2,800 m (2005)** **16” ID @ 1,700 m (2005)**
Wellstream	**6” ID @ 2,000 m** **16” ID @ 700 m**	**6” ID @ 3,000 m (2005)** **16” ID @ 1,250 m (2005)**
NKT	**6” ID @ 1,500 m** **16” ID @ 700 m**	**8” ID @ 3,000 m (2005) Flextreme (Metal Core with Composite Outer)**

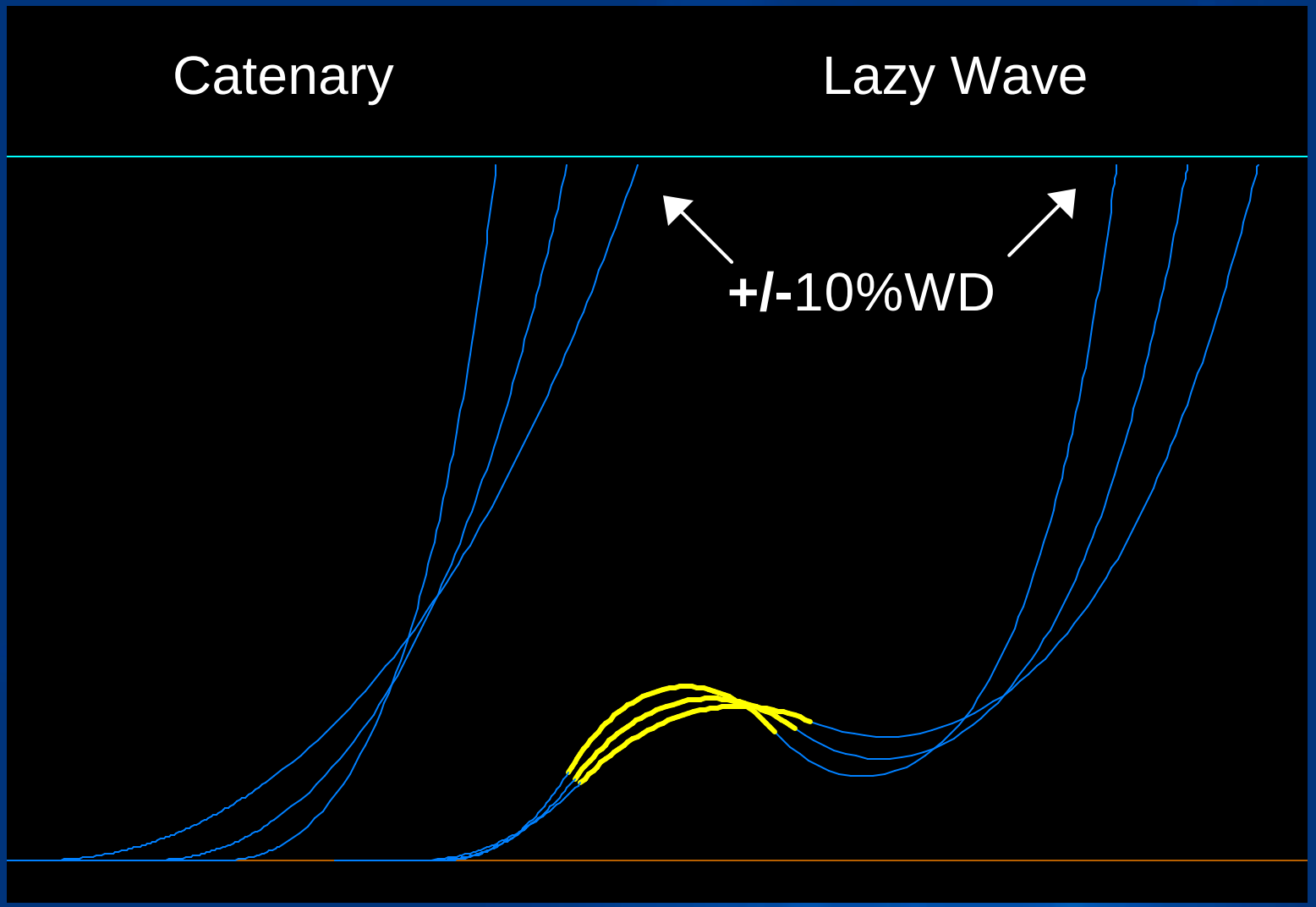
VLT with Simple Catenary Risers



Steel Risers

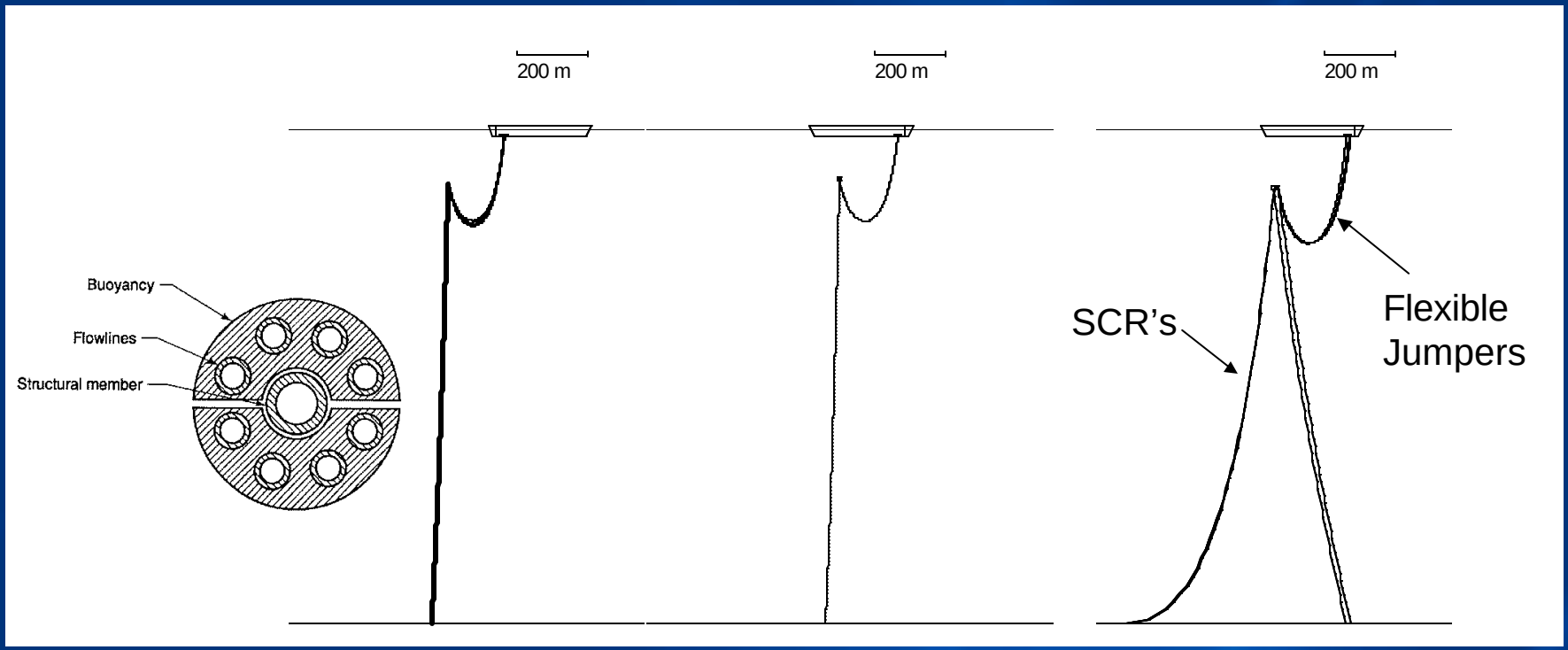
- Catenary
  - Limited vessel motions
  - Lowest riser cost
  - Simple installation
- Lazy Wave Riser
  - Large vessel motions
  - Higher cost
  - Increased installation time

Steel Risers



Hybrid Riser Systems

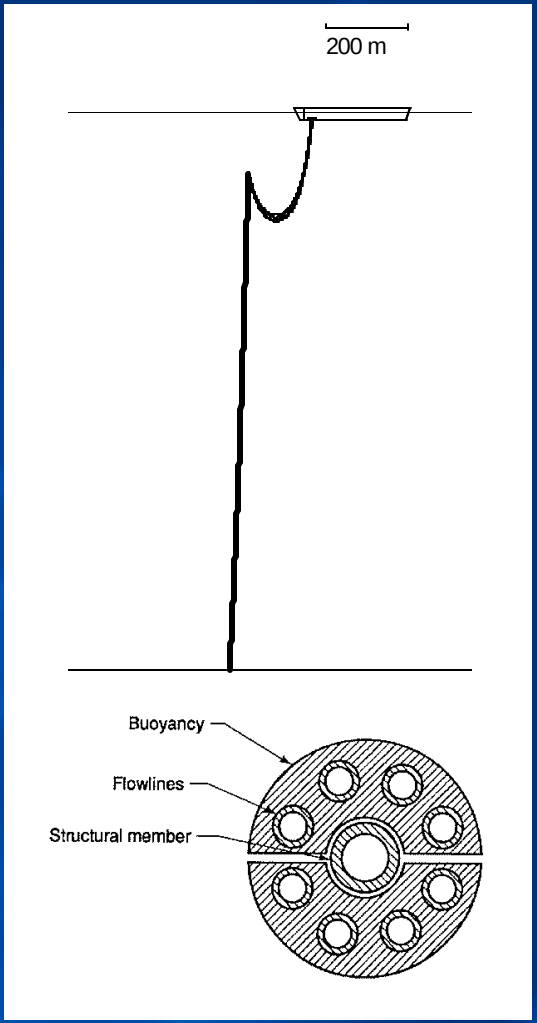
- Combination of steel and flexible pipe
- Decouple motions using self-standing risers or buoy
- Connection to the FPSO via flexibles



Multibore Hybrid Tower Single Leg Hybrid Tension Leg Riser

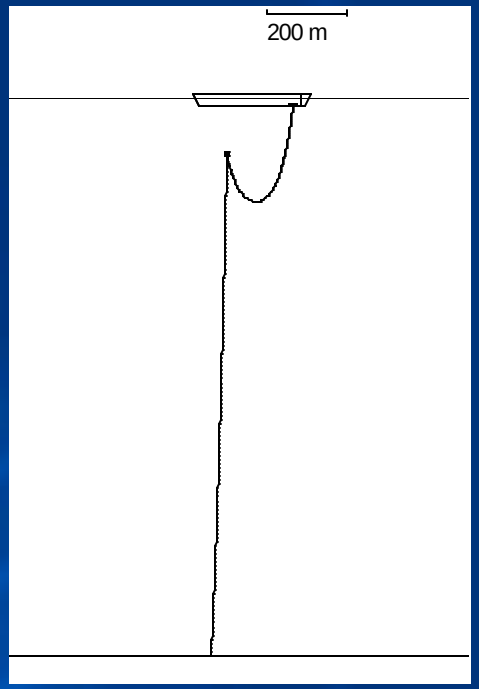
Bundled Riser Tower

- Decoupled vessel motions
- Suited for large number of risers
- Additional risers not easy
- Riser replacement not easy
- Tower can be pre-installed
- Used on Girassol field



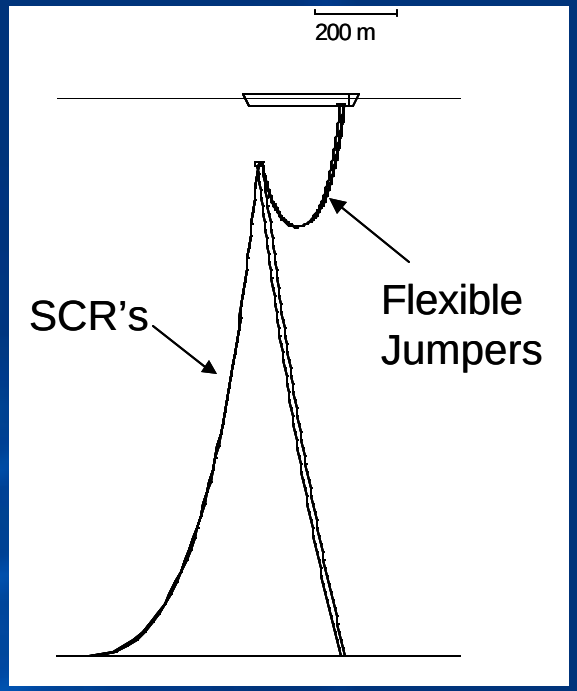
Single Leg Hybrid Riser

- Decoupled vessel motions
- Allows large bore pipe (export)
- Pre-installed riser
- Simpler installation
- Base case for Kizomba A field



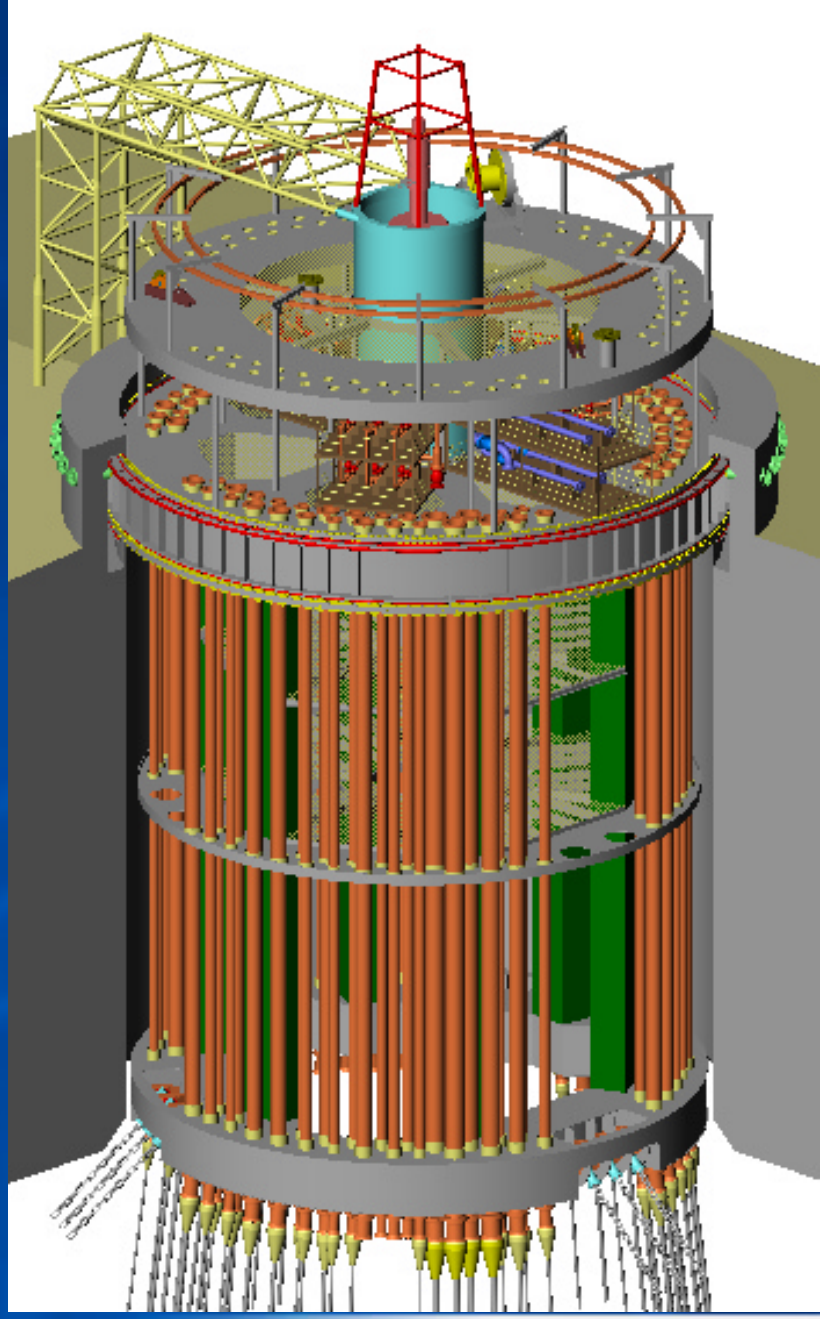
Tension Leg Riser Systems

- Decoupled vessel motions
- Economical for large number of risers
- Allows easy planning for future risers
- Steel catenaries can be pre-installed
- Subject of Deepstar study



Conclusions

- **Turret moored FPSO has cost and operational advantages**
- **VLT can support 100+ risers in ultra deep water**
- **VLT is a simple turret structure**
- **Generous space inside the turret**
- **Low cost / long life bearing**
- **Low turret weight-to-riser ratio**



Conclusions (cont.)

- VLT supports both flexible and steel risers
- Optimum riser configuration is a function of field development specifics
- VLT enables FPSO solutions for deepwater fields requiring a large number of risers