The Very Large Turret

A Single Point Mooring for 100+ Risers

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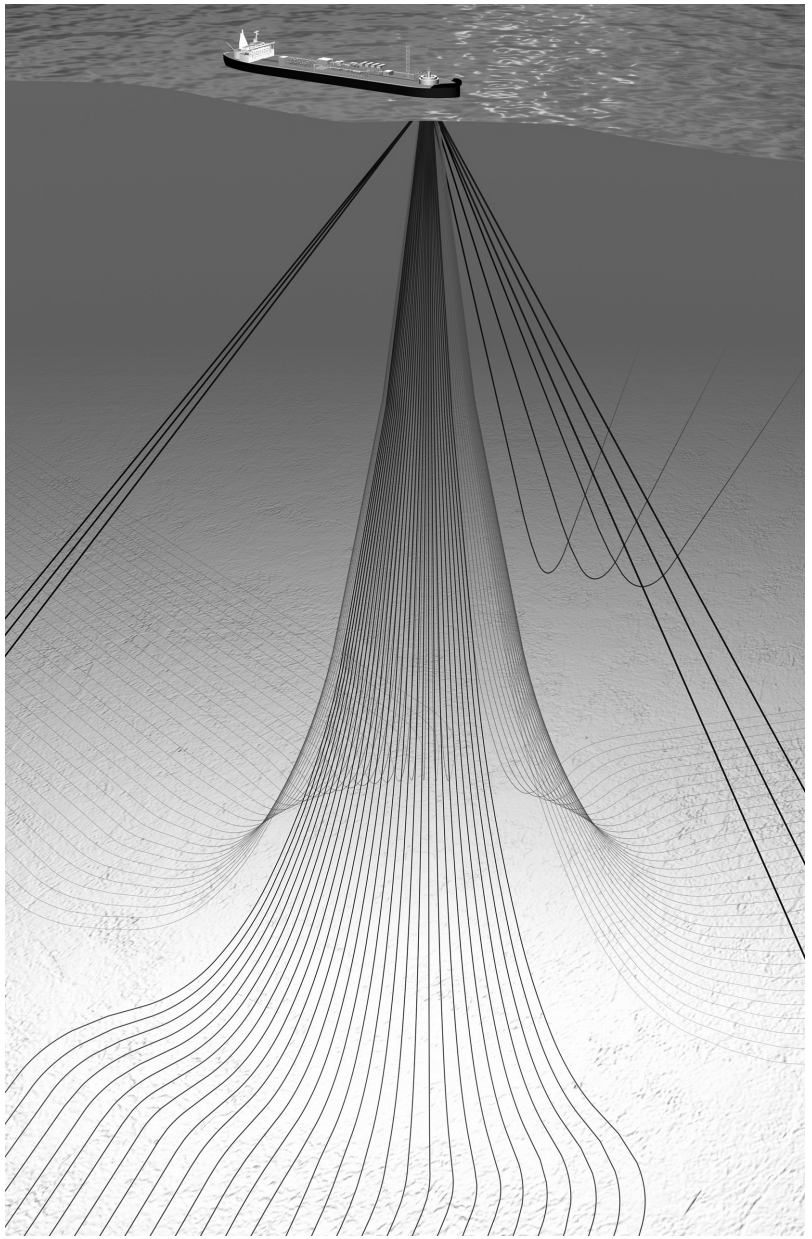
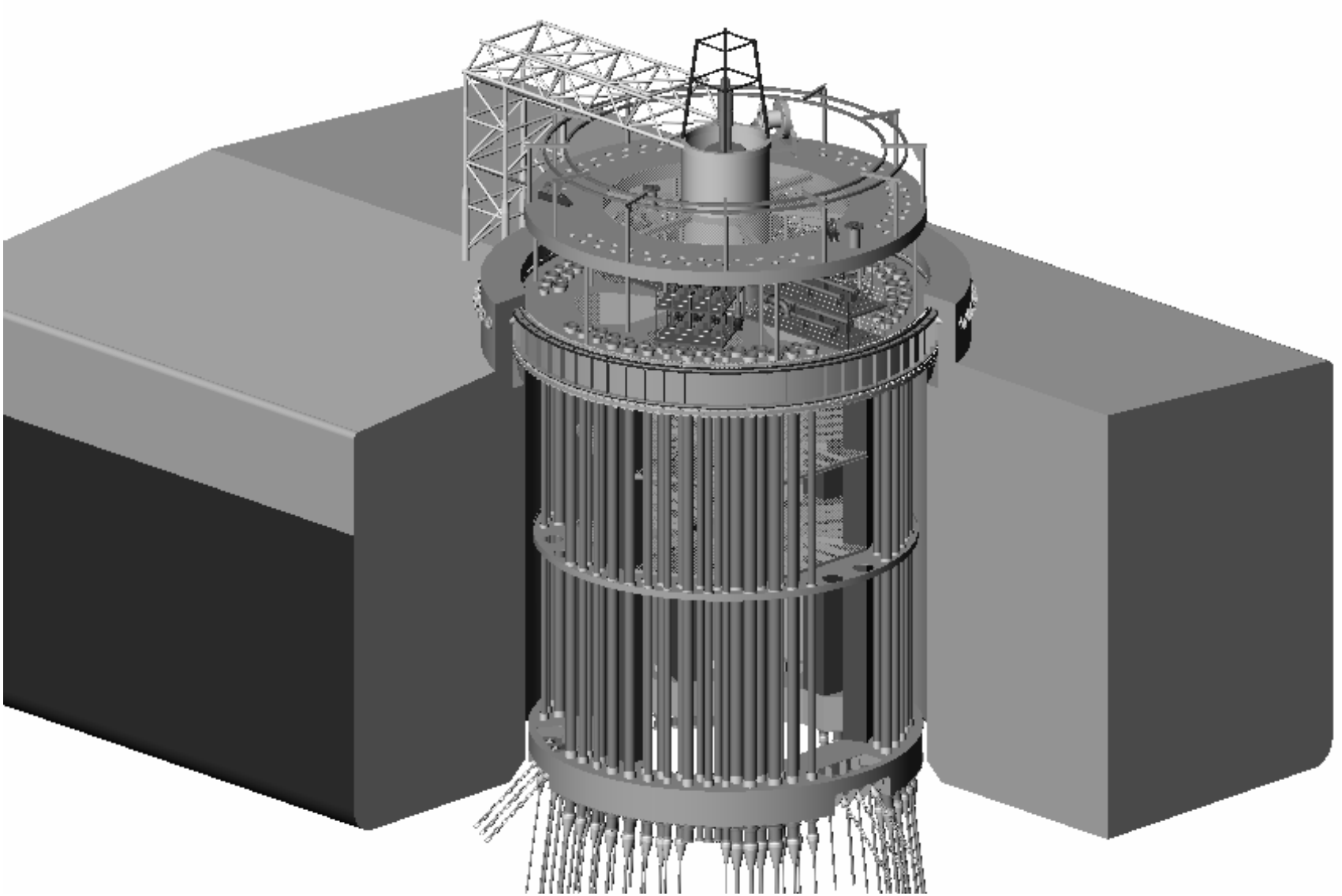
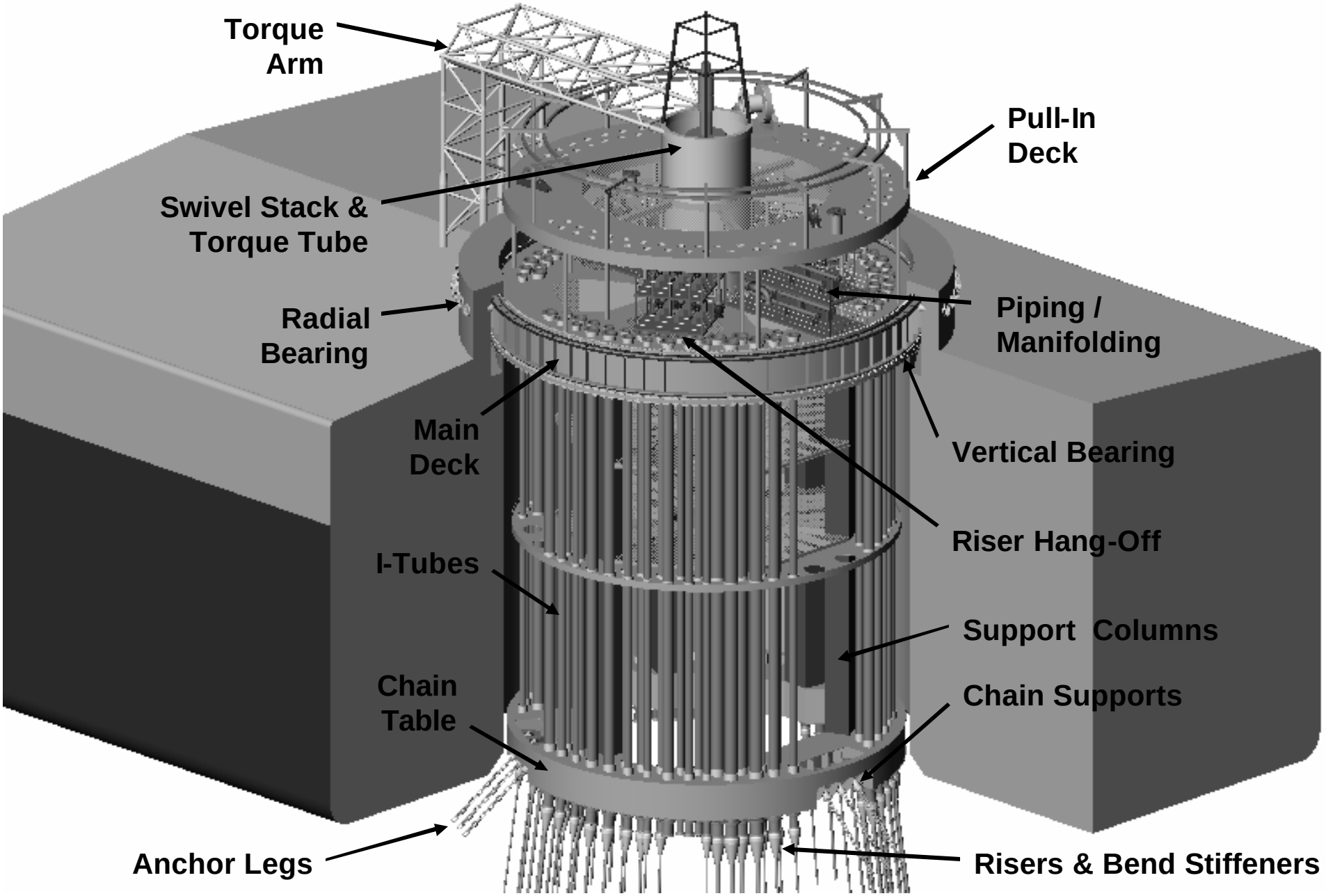
Very Large Turret

- **Application**
  - **FPSO weathervaning SPM**
  - **Large field (>100,000 bbld)**
  - **50 to 100+ risers**
  - **Deep to ultra deep water**
  - **Worldwide**
- **Weathervaning advantages**
  - **Mooring tensions**
  - **Tandem offloading**
- **Simplified turret structure**
- **Robust bearing system**



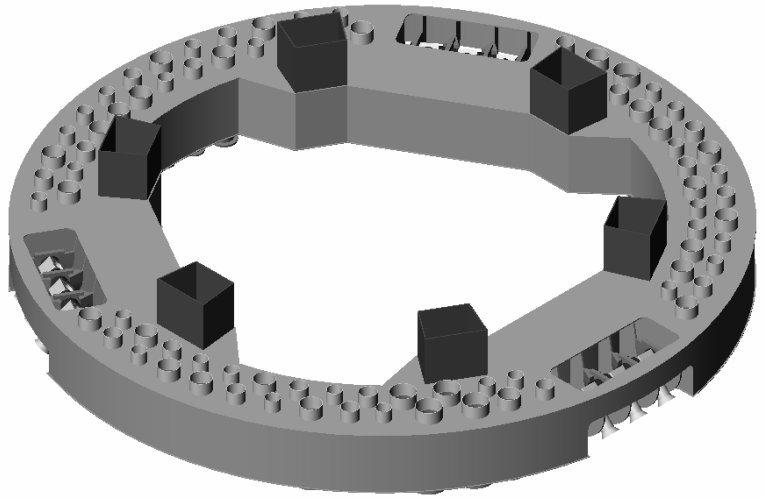
Very Large Turret

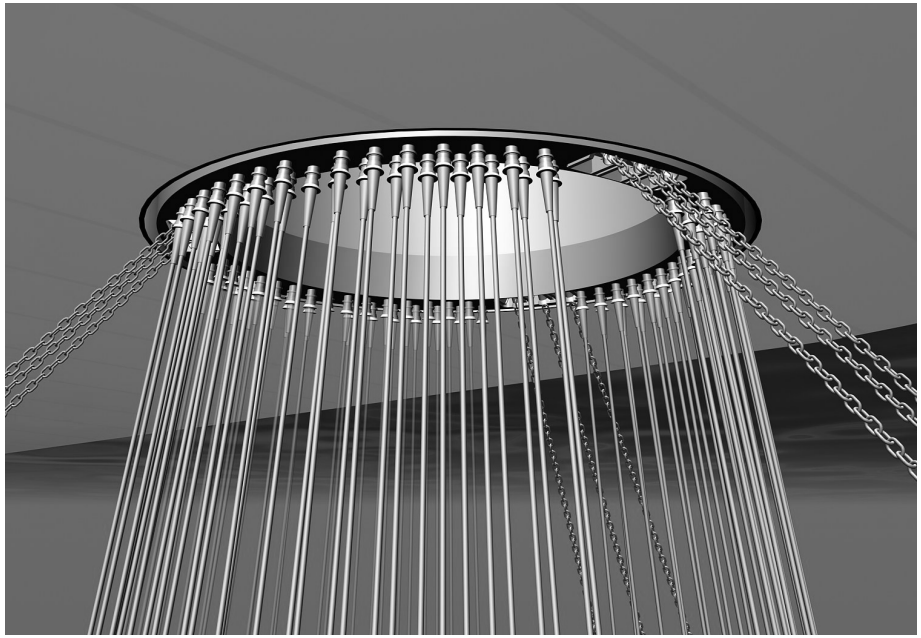



Torque Arm
Pull-In Deck
Swivel Stack & Torque Tube
Radial Bearing
Piping / Manifolding
Main Deck
Vertical Bearing
Riser Hang-Off
I-Tubes
Support Columns
Chain Table
Chain Supports
Anchor Legs
Risers & Bend Stiffeners

VLT Chain Table

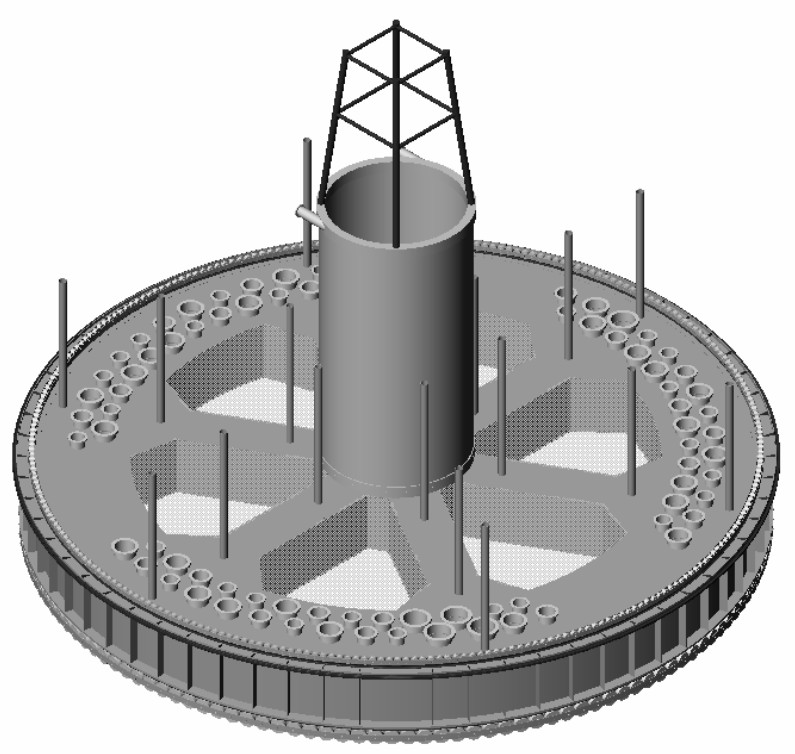
- **3x3 mooring provides 3 riser corridors**
- **Riser quantity defines chain table (and turret) diameter**
  - **60 risers - 22 m dia**
  - **90 risers - 31 m dia**
  - **120 risers - 40 m dia**
- **2 riser rows maximum**
- **No shadowing to allow inner row installation and replacement**





VLT Main Deck

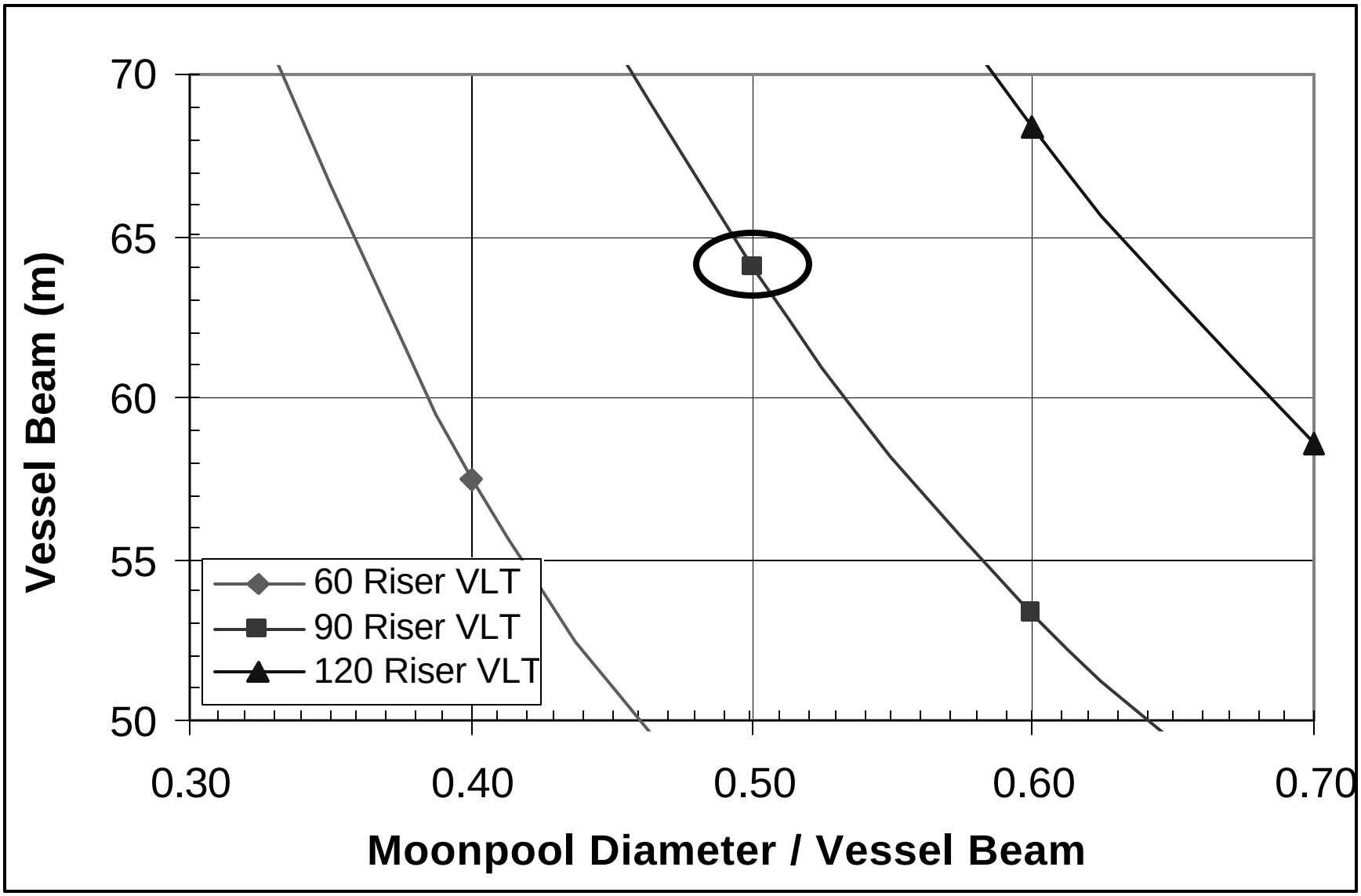
- **Supports all loads, including:**
  - **Riser hang-off loads**
  - **Mooring loads through chain table and support columns**
  - **Turret self weight**
- **Depth-to-diameter ratio is a key design parameter**
  - **Flexibility to move with vessel**
  - **Strength to support risers, mooring and turret weight loads**
  - **2.5 m depth / 32 m diameter for a 90 riser VLT**



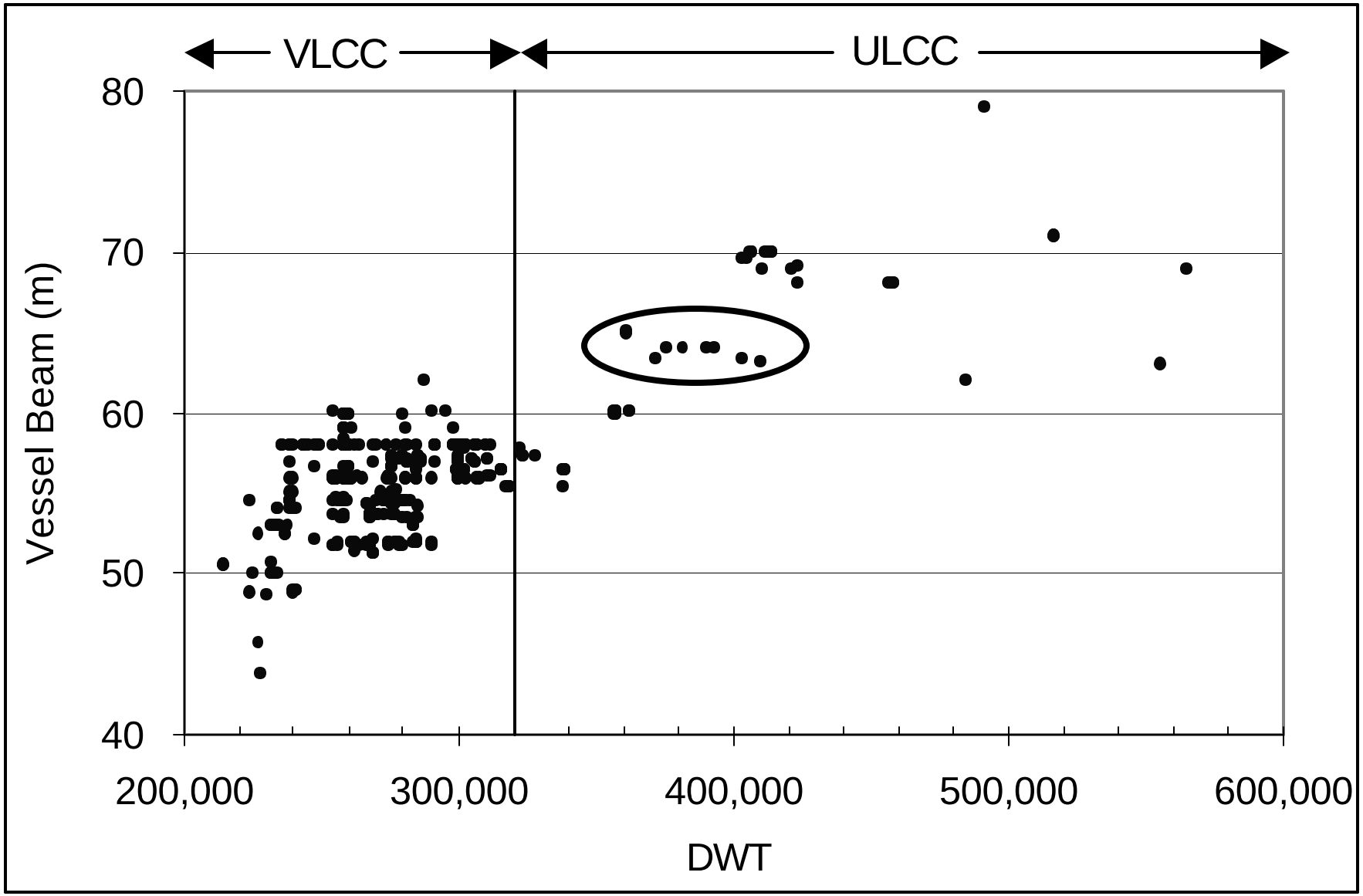
VLT Main Bearing Roller Arrangement

Wheels are replaceable during operation

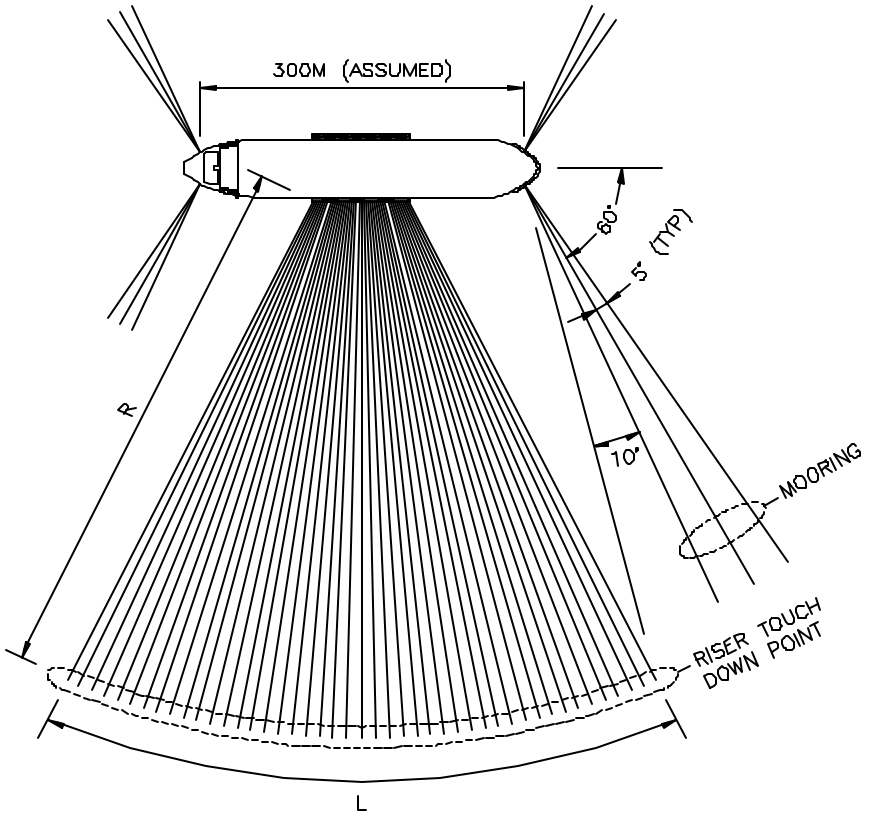
Vessel Beam vs Moonpool Size

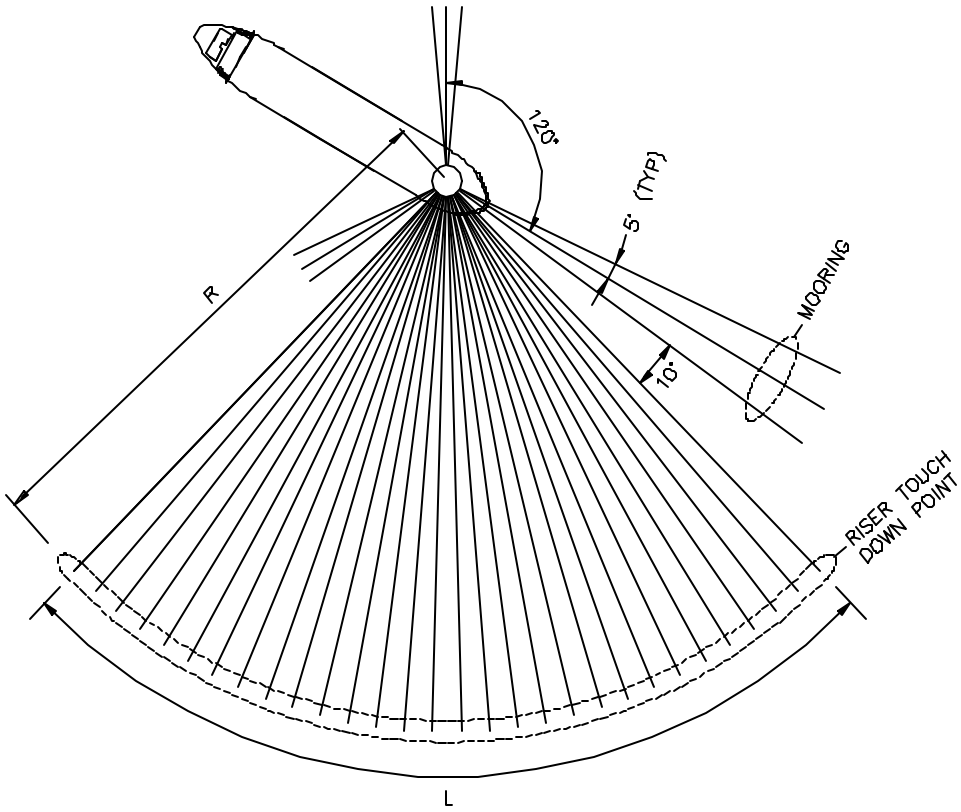


Large Vessel Availability



90 Riser FPSO
Spread vs Turret Mooring





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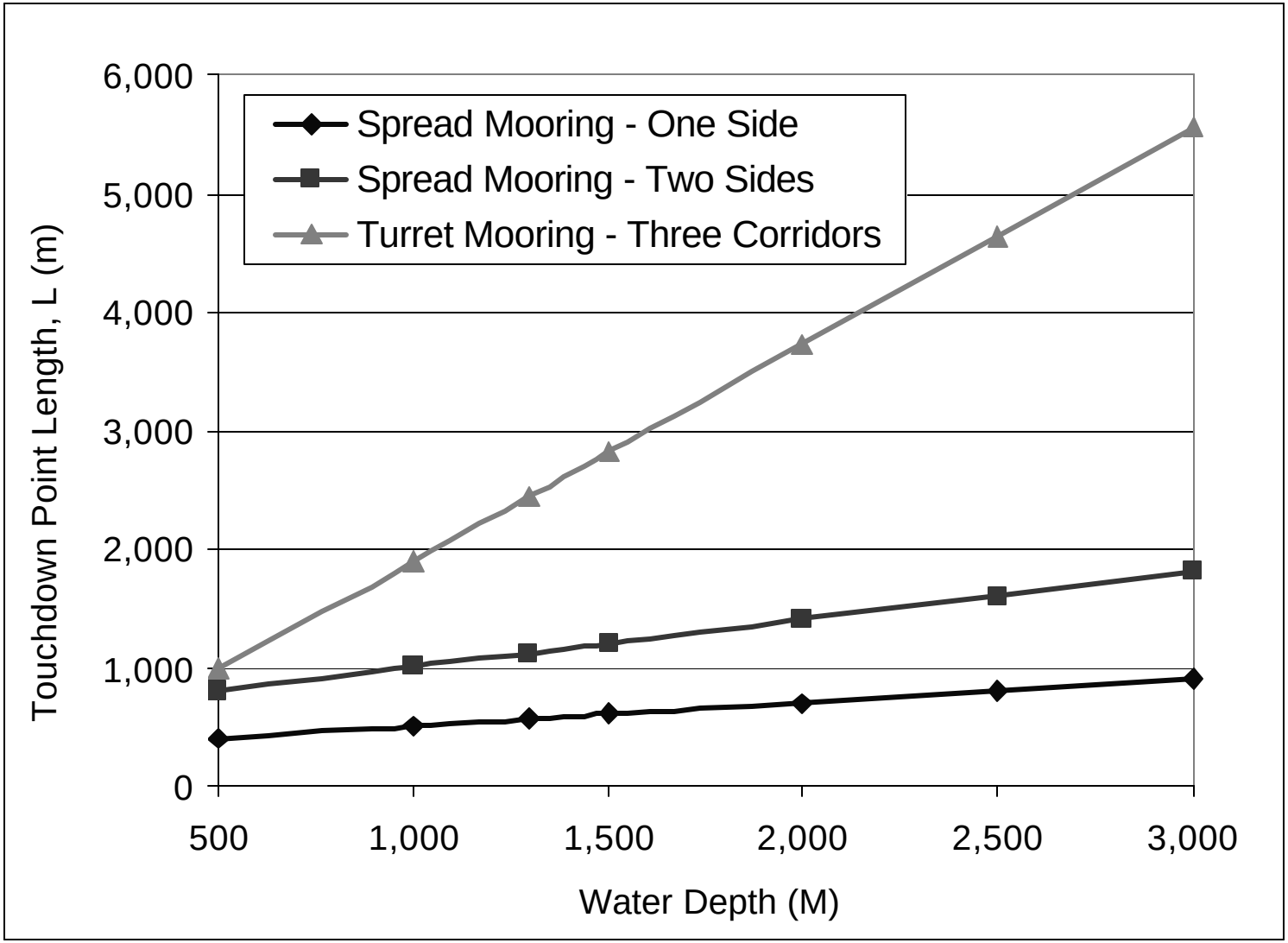
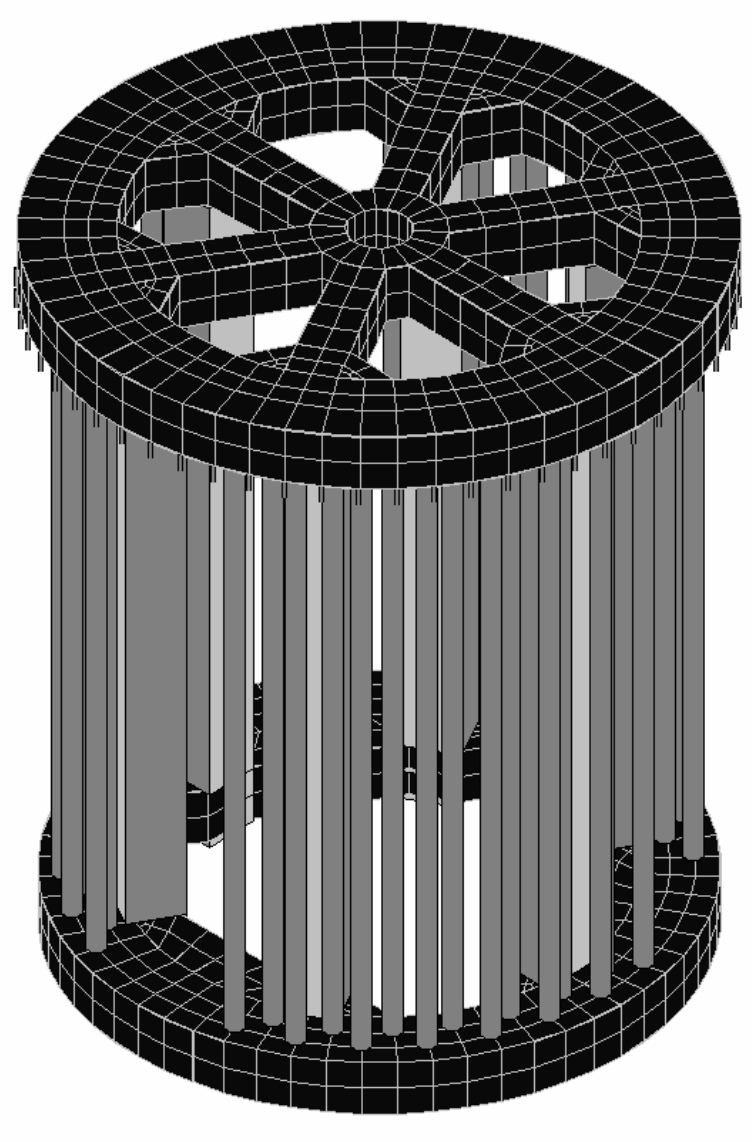


VLT Comparison with other Turrets

Turret	Number Risers	Water Depth	Turret Weight	Turret Weight per Riser
Albacora P31	**28**	**330 m**	**1,669 mt**	**60 mt/riser**
Barracuda P34	**34**	**840 m**	**1,817 mt**	**56 mt/riser**
60 riser VLT	**60**	**1,300 m**	**1,953 mt**	**34 mt/riser**
90 riser VLT	**90**	**1,300 m**	**2,803 mt**	**31 mt/riser**
120 riser VLT	**120**	**1,300 m**	**3,740 mt**	**31 mt/riser**

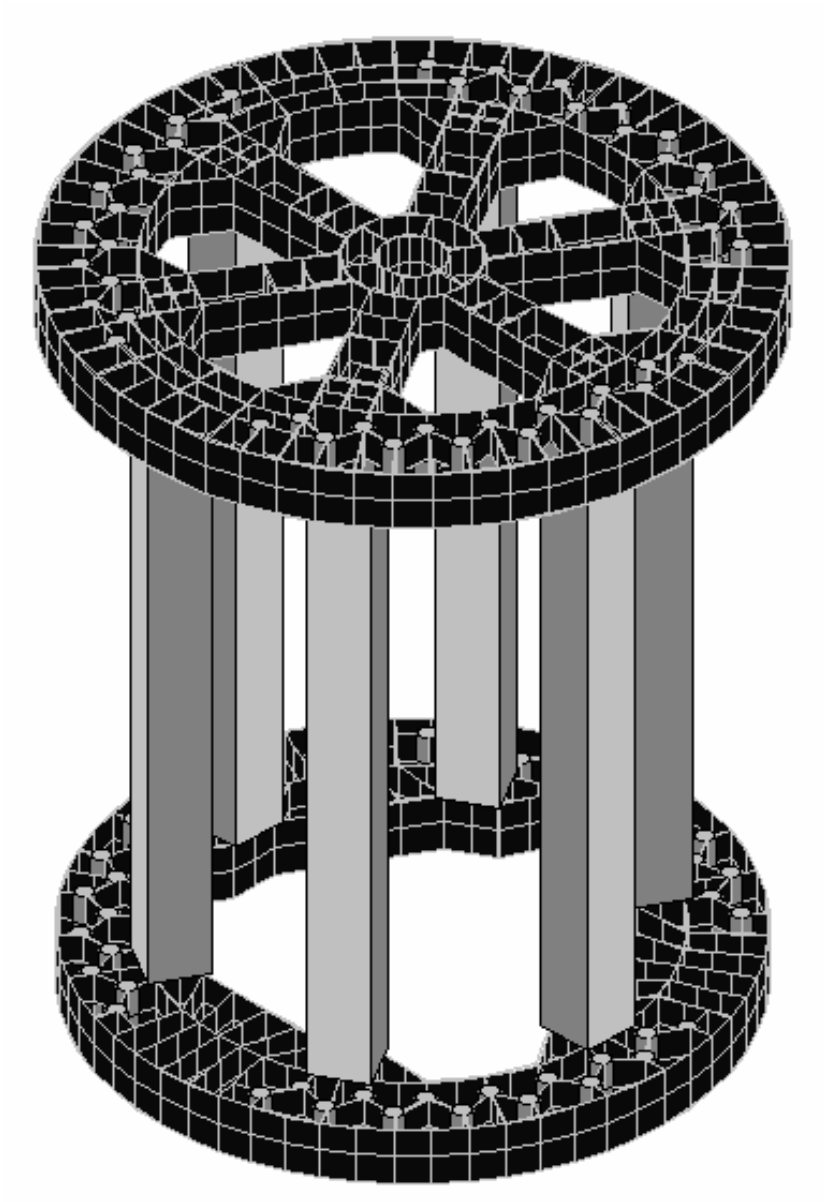
VLT Analysis

- **Goal of FEA to predict**
  - **Global stresses**
  - **Global deflections**
  - **Bearing load distribution**
- **Global structural model**
  - **Main deck**
  - **Support columns**
  - **Chain table**
  - **Bearing wheels**
  - **I-tubes**

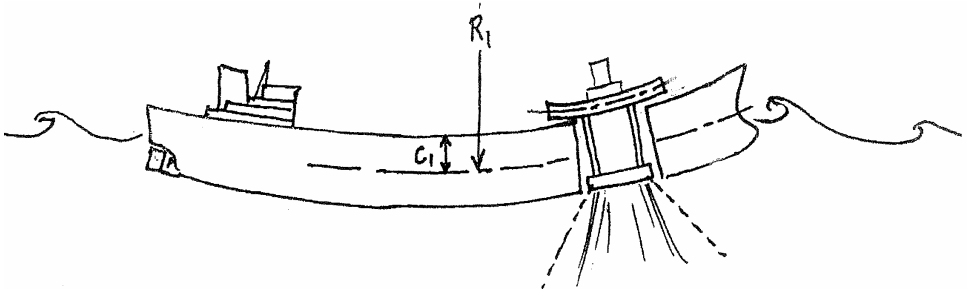


VLT Analysis (cont.)

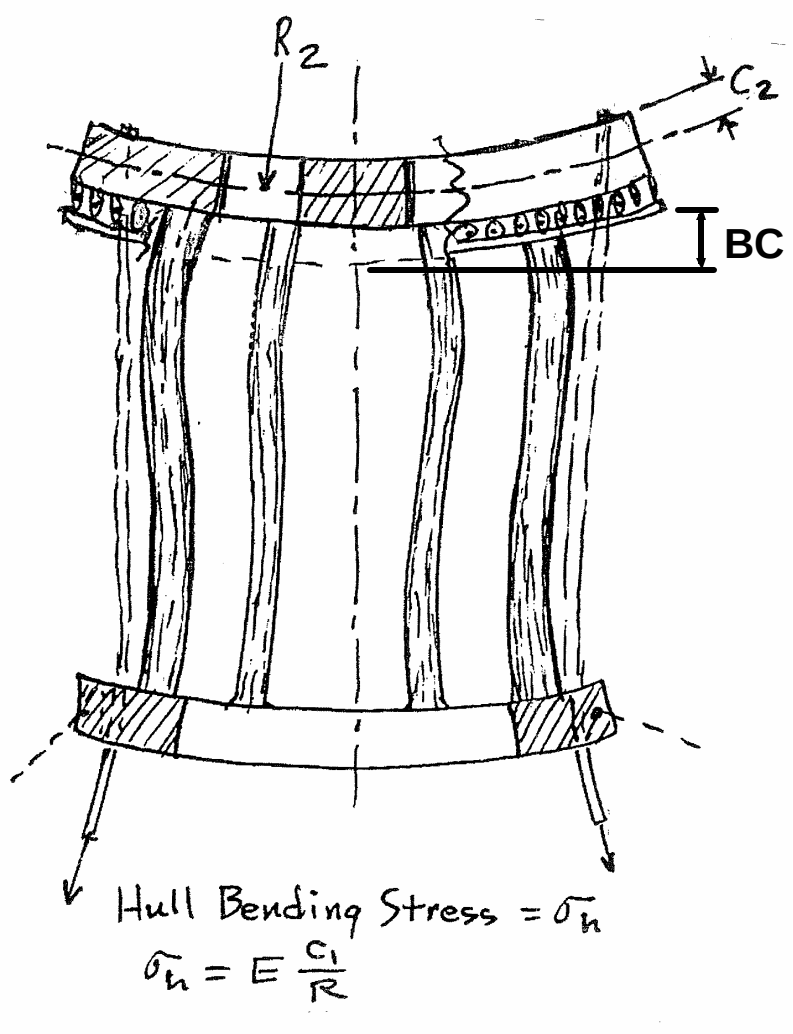
- **10 load combinations**
  - **With and without risers**
  - **Static and 100-yr storm**
  - **Flat deck, hog and sag**



VLT Analysis

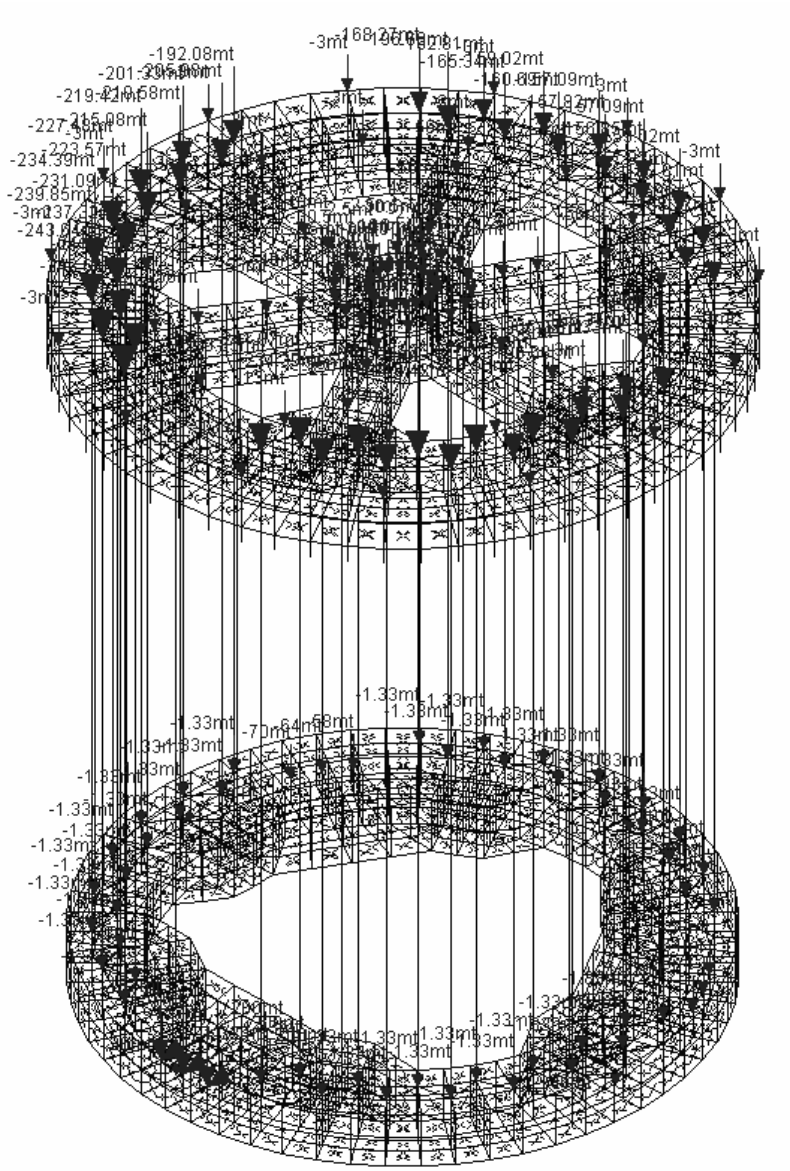


- **Boundary conditions**
  - **Max vessel hog and sag**
  - **Machining tolerance of bearing surfaces**
  - **50% contingency applied**
  - **BC applied**
    - **+/- 10 mm for 60 riser VLT**
    - **+/- 15 mm for 90 riser VLT**
    - **+/- 20 mm for 120 riser VLT**



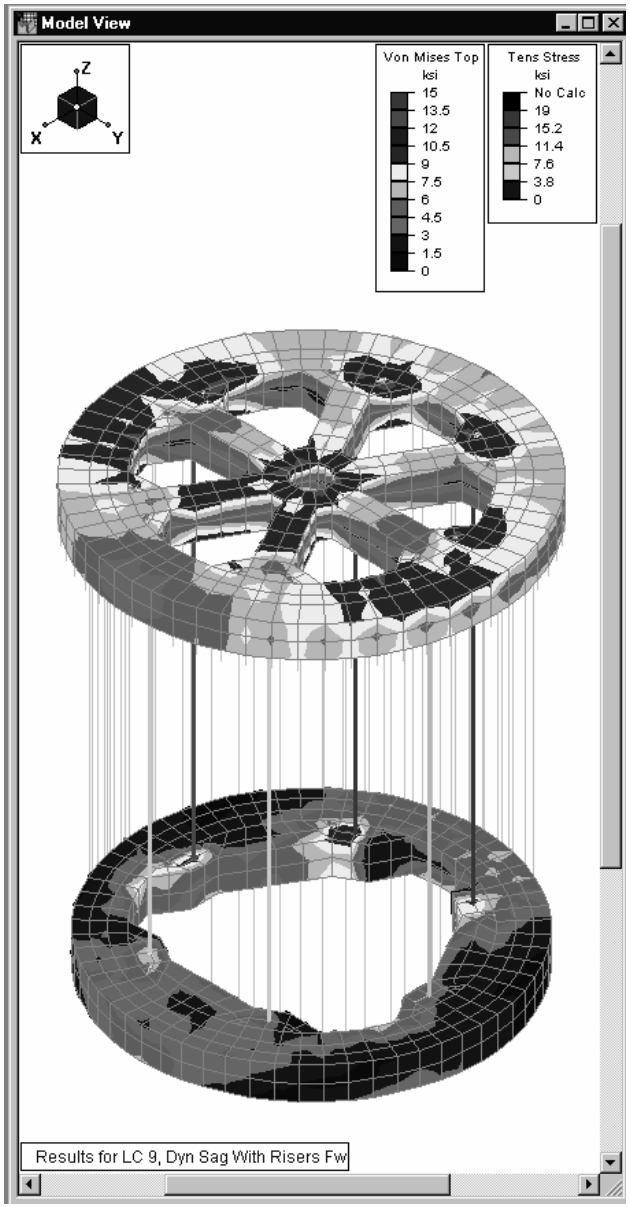
VLT Analysis (cont.)

- **Input loading**
  - **Turret weight**
  - **Riser loads**
  - **Mooring loads**
  - **Breakout torque**



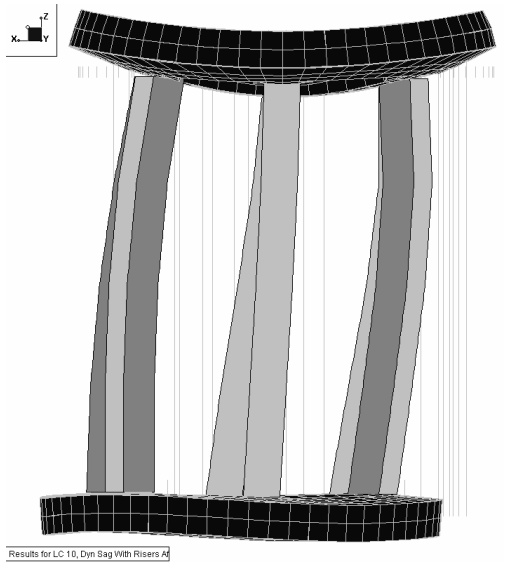
VLT Analysis (cont.)

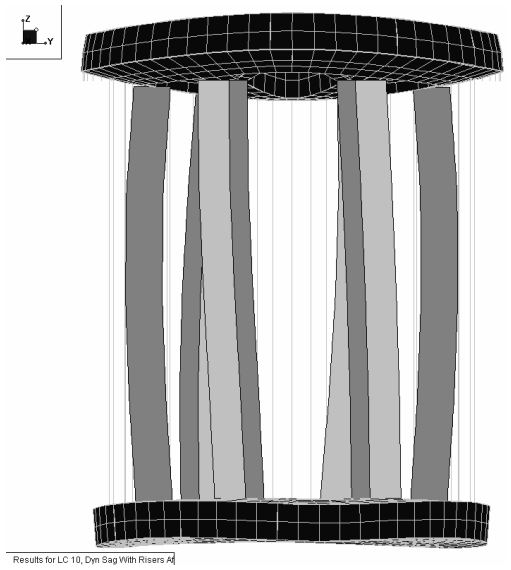
- **FEA stress results**
  - **Maximum stress values are well below allowables**
  - **Maximum stress ranges are below acceptable values for preliminary fatigue requirements**
  - **Design optimization is expected to improve results**



VLT Analysis (cont.)

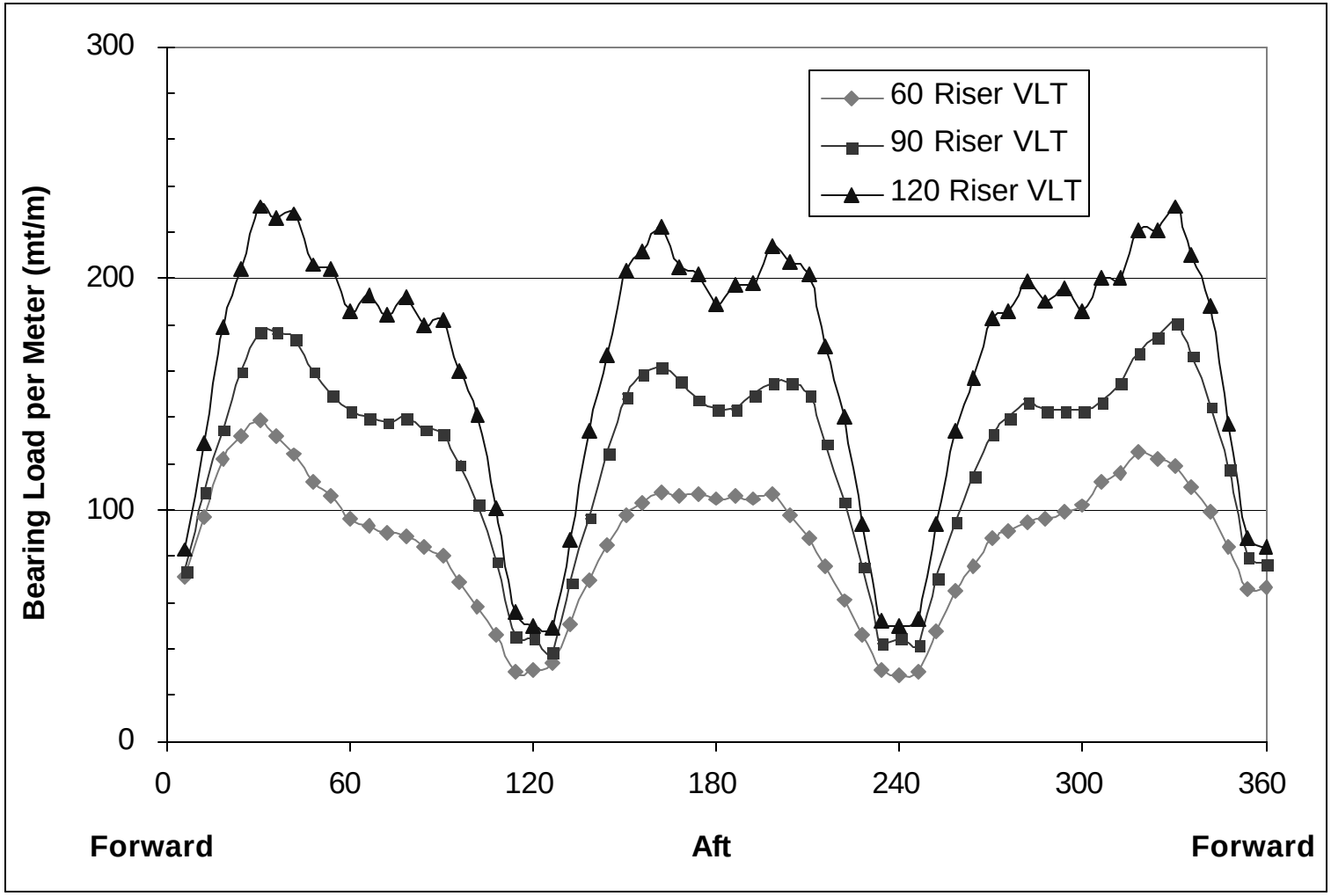
- **FEA deflection results (90 riser VLT)**
  - **Max horizontal deflection at chain table is approximately 50 mm**
  - **Max rotational deflection at chain table perimeter is approximately 47 mm**
  - **Max vertical deflection at the main deck center is approximately 23 mm**





VLT Analysis (cont.)

- **Bearing load distribution**



Conclusions

- **Turret moored FPSOs have advantages resulting from their weathervaning capability**
- **VLT can support 100+ risers in ultra deep water**
- **VLT is a simple turret structure**
- **VLT incorporates a robust / long life bearing**
- **VLT provides more riser space than spread mooring**
- **VLT has low turret steel weight-to-riser ratio**
- **Flexibility of the VLT main deck results in a well distributed bearing load**
- **FEA has confirmed the VLT design**