

Turret-Mooring System:

Design of the Terra Nova Turret-Mooring System

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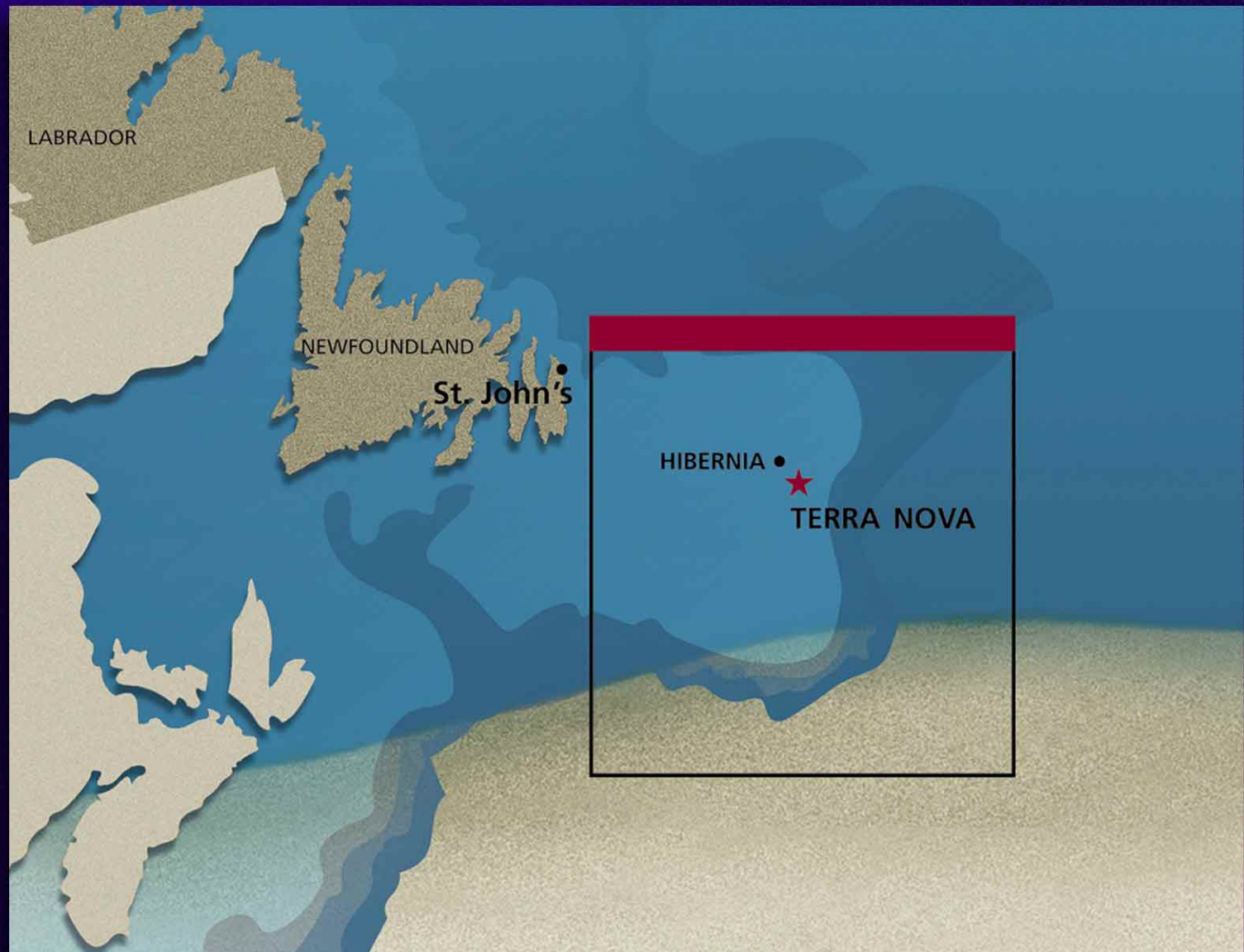
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2001 Offshore Technology Conference

April 30, Houston, Texas

The Grand Banks



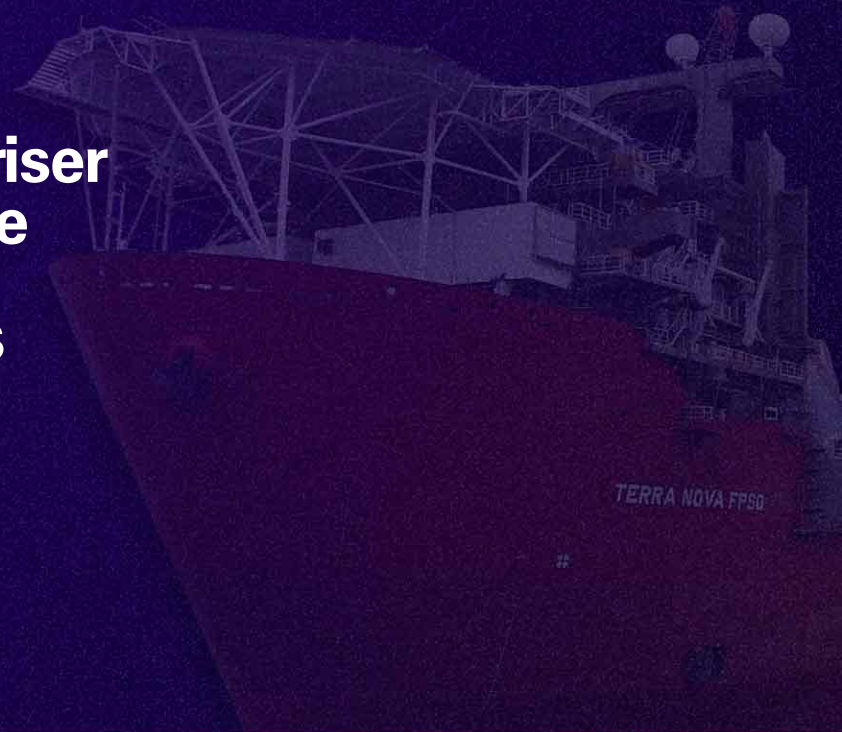
Terra Nova FPSO



- **Vessel: ice-strengthened, 960,000 bbl storage**
 - **L=292 m, B=45.5 m, D=28.2 m**
 - **5 azimuthing thrusters @ 5 MW each**
- **Disconnectible turret system**
- **Thruster assisted 3X3 mooring system[#]**
- **19 risers & umbilicals**

Turret Design Basis

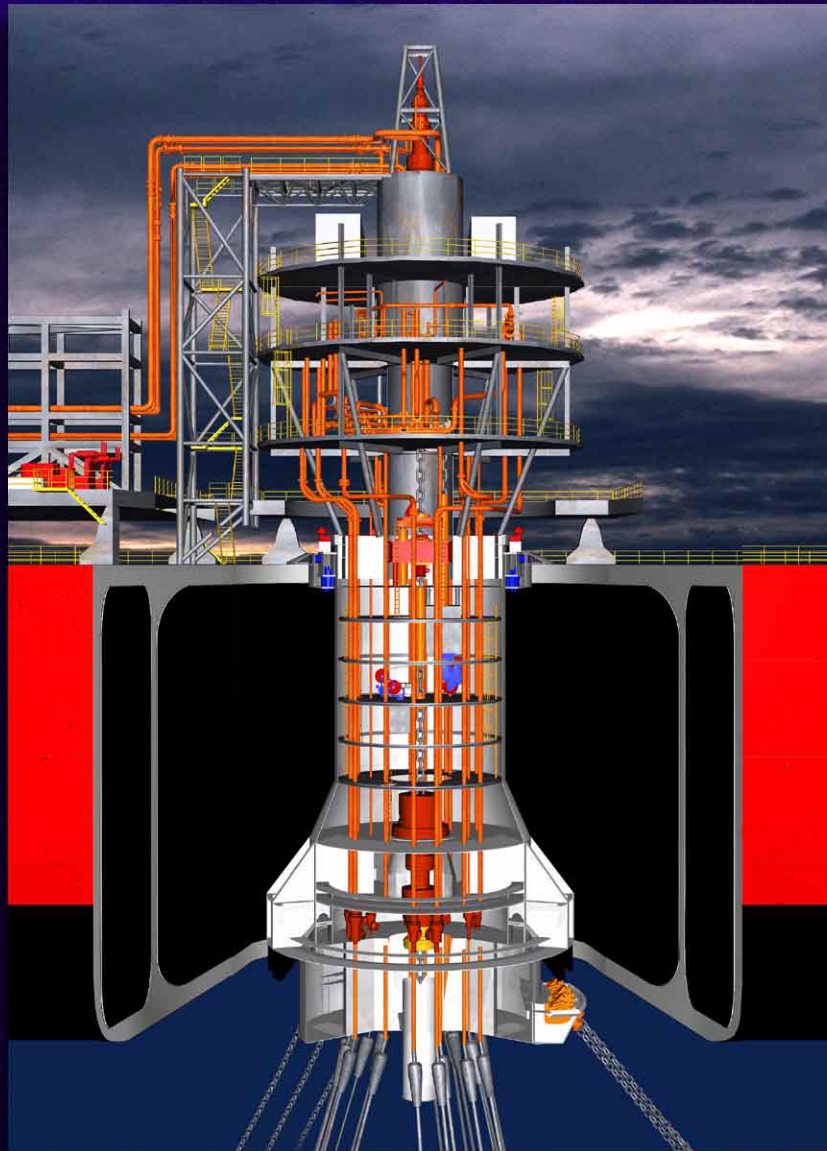
- FPSO to stay on station during the 100-year storm
- FPSO to disconnect from mooring and risers to avoid icebergs (>100,000 MT) and pack-ice
 - controlled disconnect in approximately 6 – 8 hours
 - reversibility of procedure up to final disconnect
 - re-connect to mooring & riser system without assistance
- 19 risers and umbilicals
- 25 year design life



Turret System Functions

- **Allow Vessel to Weathervane and serve as a Load Transfer Mechanism between Vessel and Mooring System**
- **Provide Quick Disconnection and Reconnection between FPSO and its Mooring and Risers**
- **Provide an Efficient Fluid-Transfer System from the Risers to the Vessel Production Systems**
- **Provide an Interface for Control Systems and Utilities between Vessel and Subsea Systems**

Terra Nova Turret



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Design Environment

	1-Year	100-Year
Waves	Hs = 10.9 m Tp: 12.9 – 16.0 sec	Hs = 16.0 m Tp: 15.7 – 20.2 sec
Wind	Vw = 28.8 m/s	Vw = 39.6 m/s
Current	Vc = 1.0 m/s	Vc = 1.3 m/s
Pack Ice	0 – 30%	> 50 – 70%
Icebergs	< 100,000 MT	> 100,000 MT

Model Test Program

- Wind tunnel tests
- Survival environment tests
- Resistance and propulsion tests
- Pack ice and iceberg impact tests
- Buoy disconnect & reconnect tests
- Installation tests



100-Year Storm



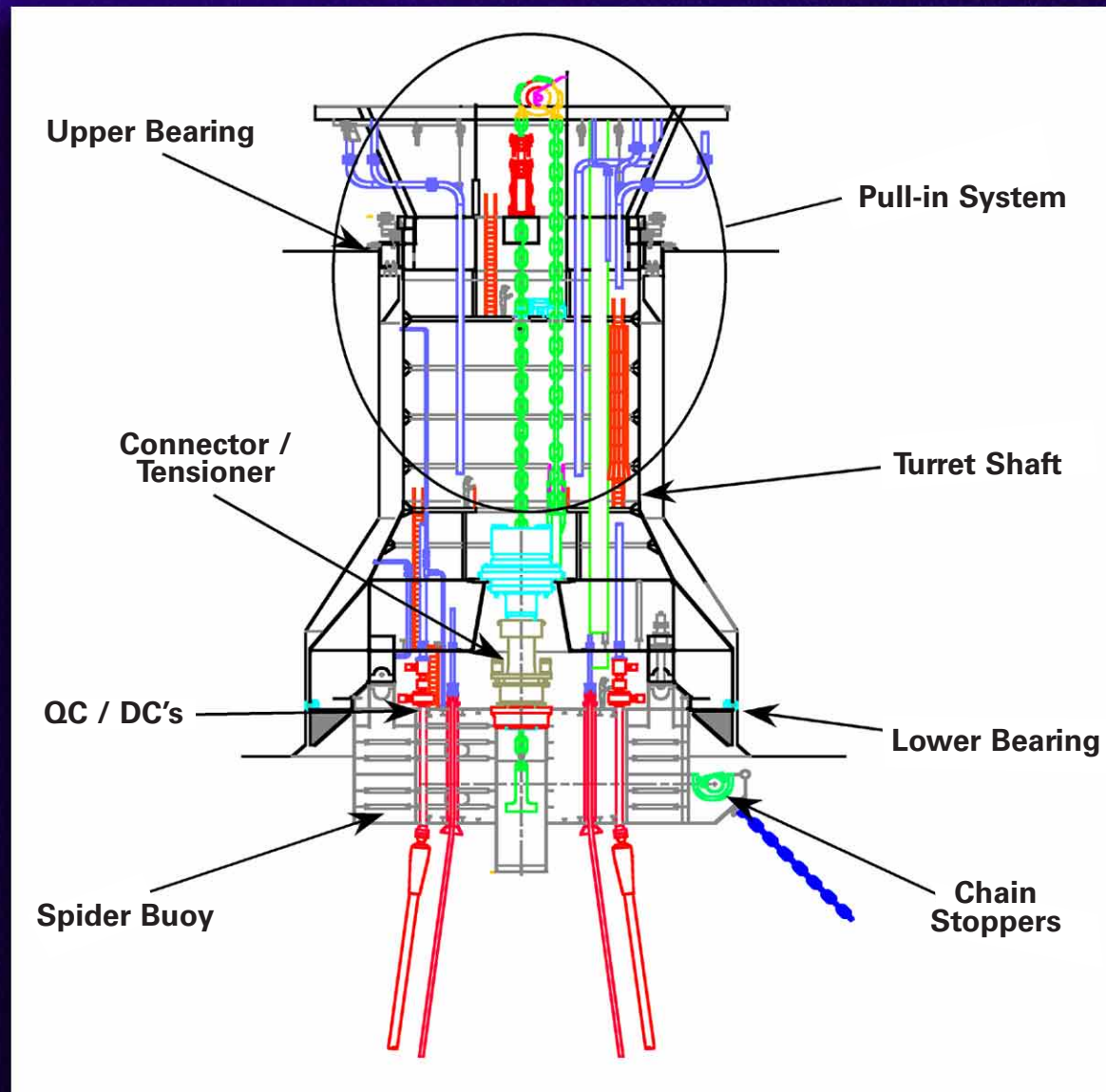
Pack Ice Tests



Towing an Iceberg (22 May 2000)

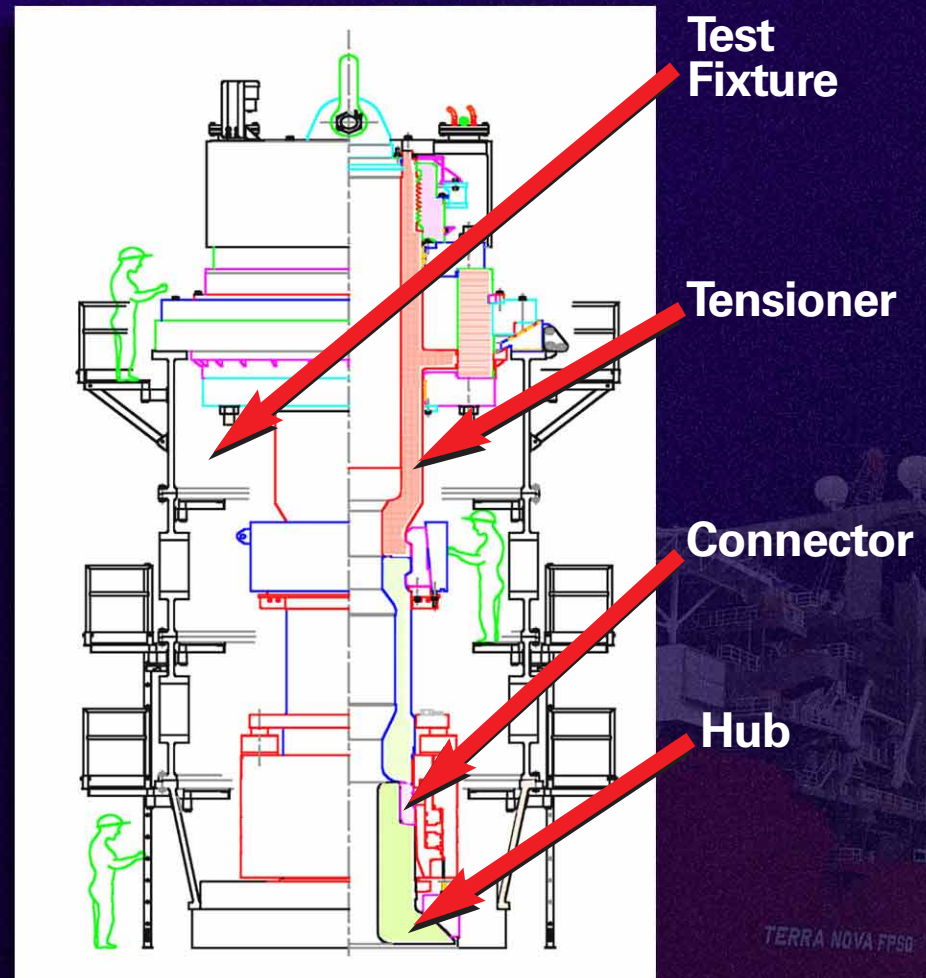


Lower Turret & Pull-in Equipment



Connector Tensioner-Test Fixture Configuration

- Tensioner Connector capable of pulling & locking in a test load of 11,600 tonnes
- Connector design operating load capacity 7,700 tonnes
- Height approx. 11.5 m



Trial Fit Set-Up

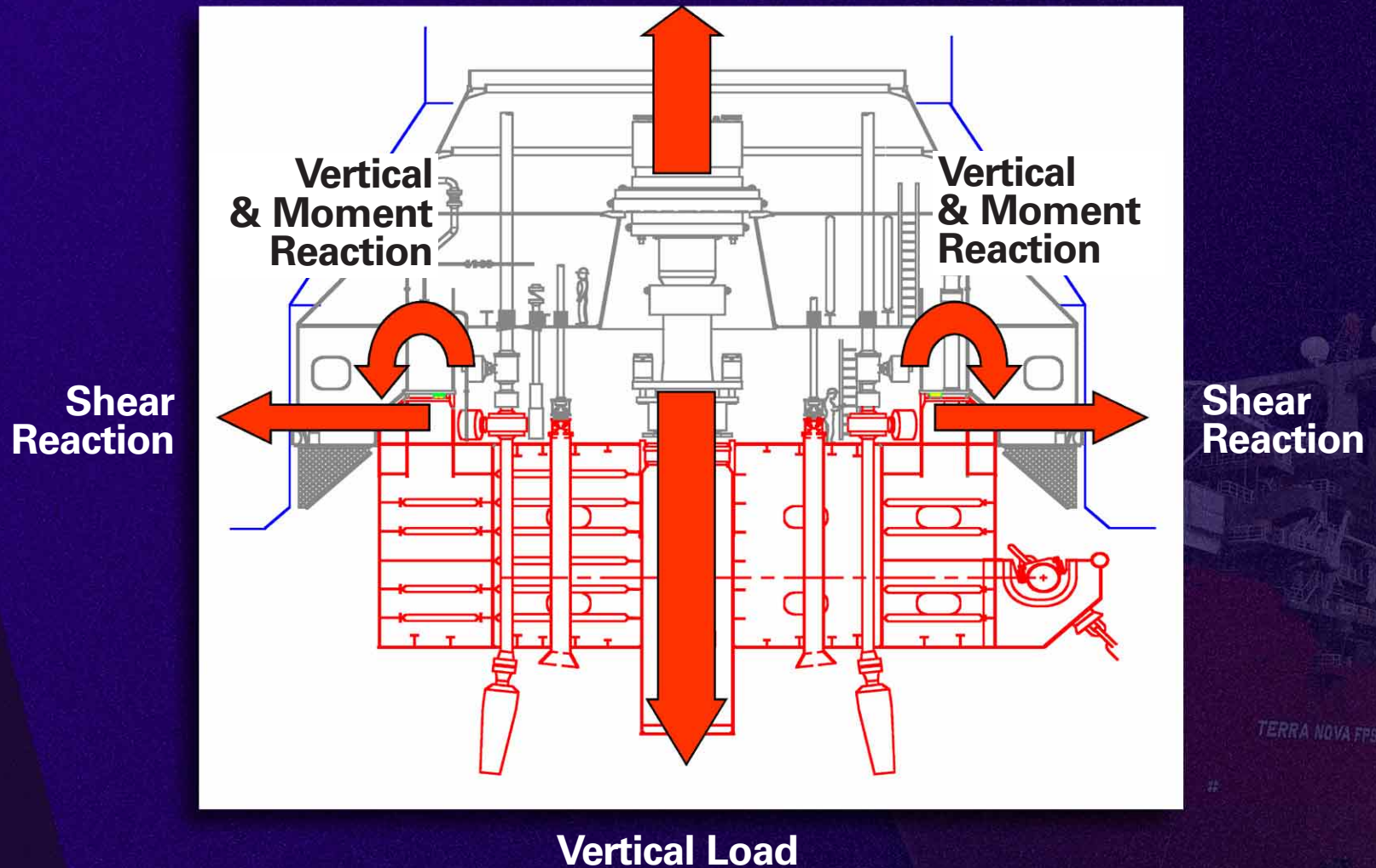


Trial Fit Set-Up



Turret/Buoy Interface & Isolation of Loads

Preload eliminates fatigue loading



Offloading at Daewoo Shipyard – Korea

**Lower turret module
(TS1) inserted in ships
moon pool keel block**

**SOFEC equipment
offloaded to
Daewoo Drydock**



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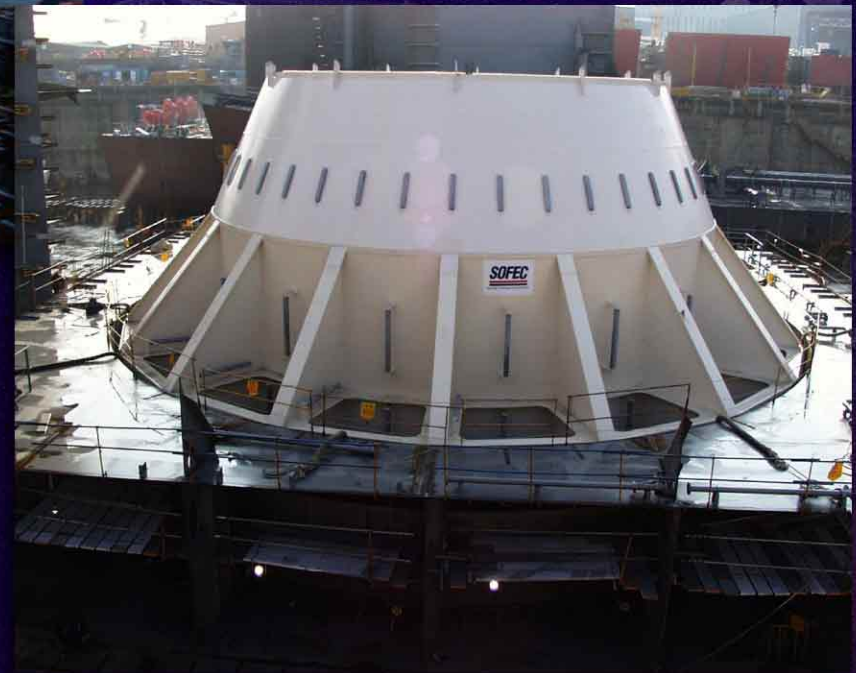


Offloading at Daewoo Shipyard – Korea



**Lower turret module
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moon pool keel block**

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Turret & Vessel in Dry Dock



Pile & Anchor Chain



Spider Buoy



Spider Buoy Installation



QC / DC Room

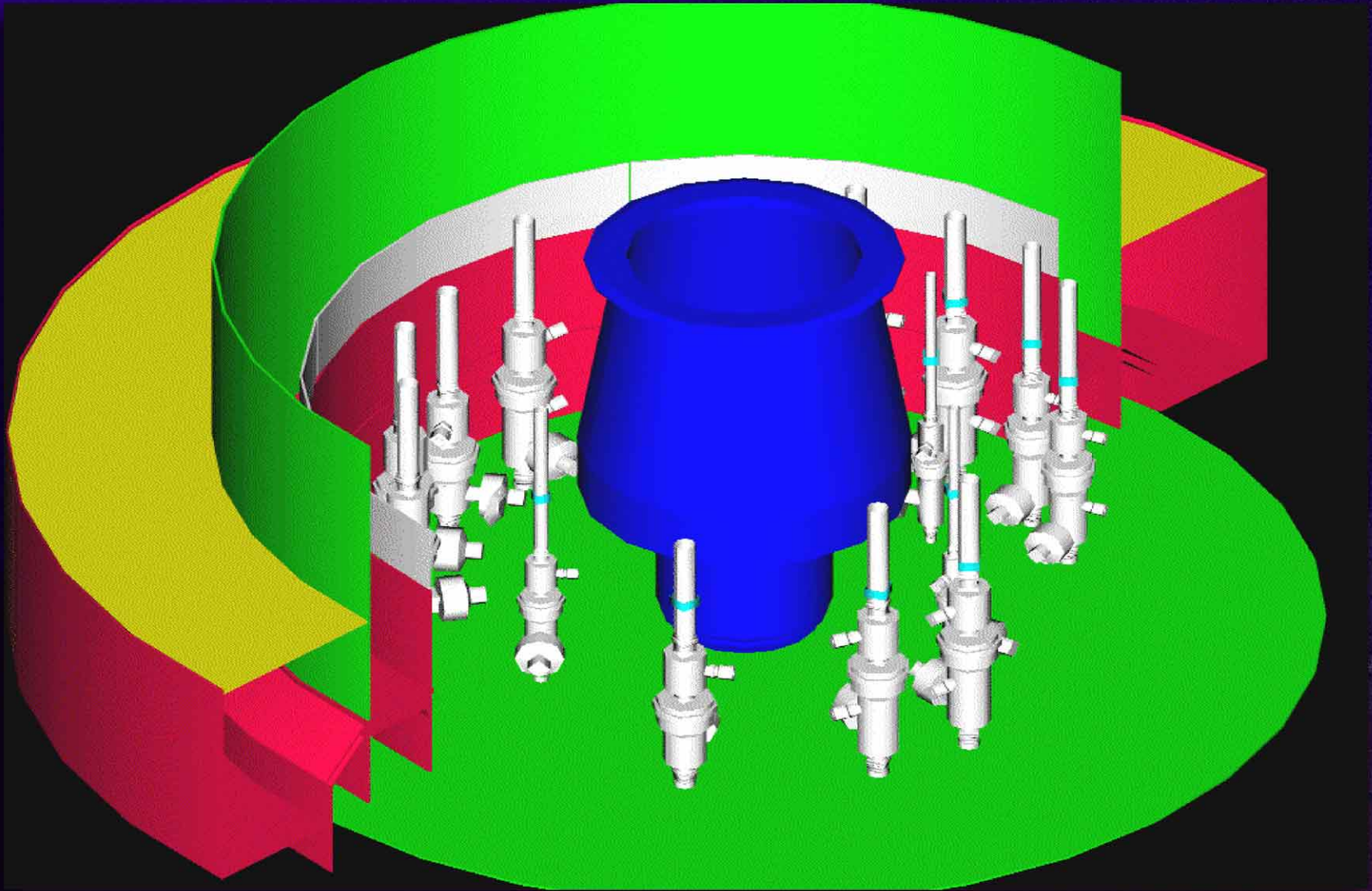


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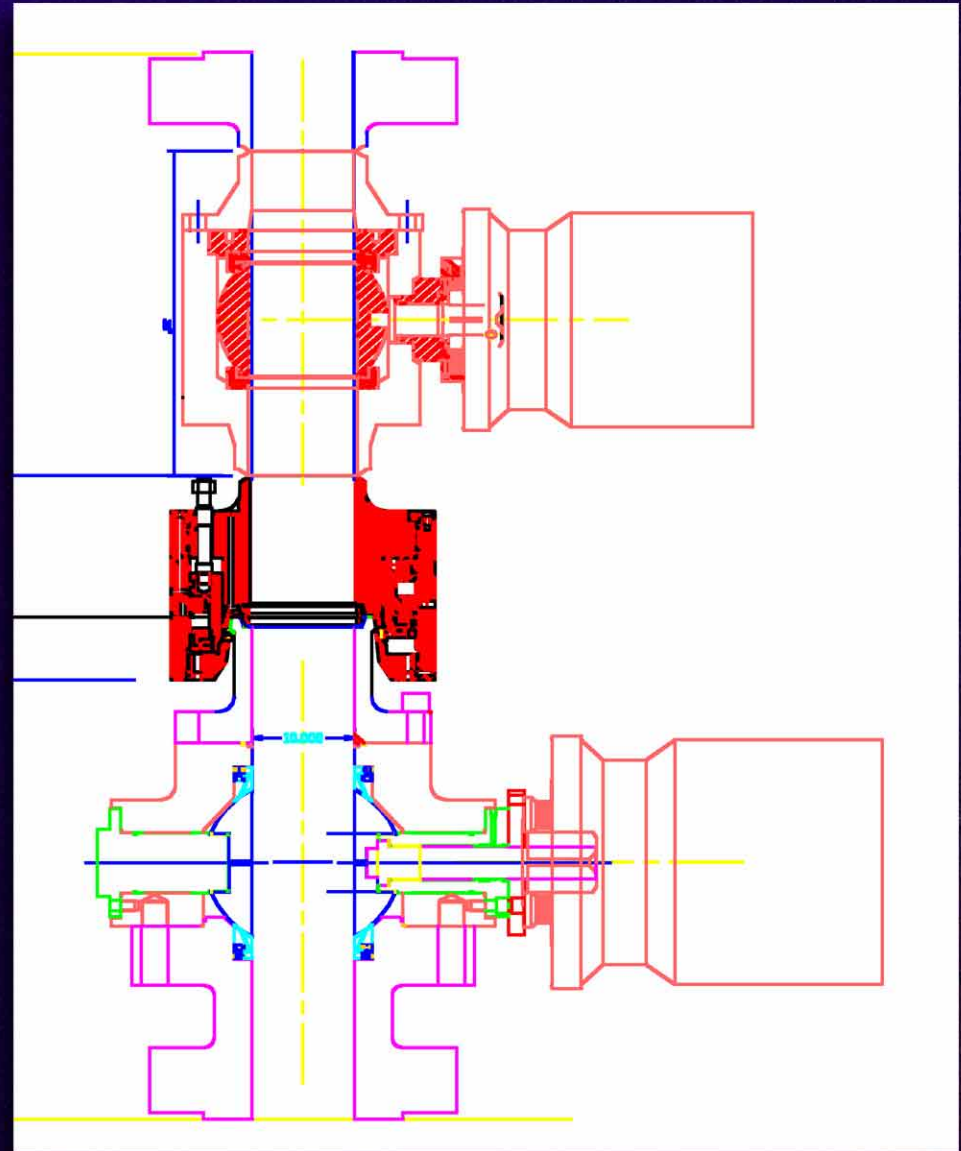
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QC / DC Room

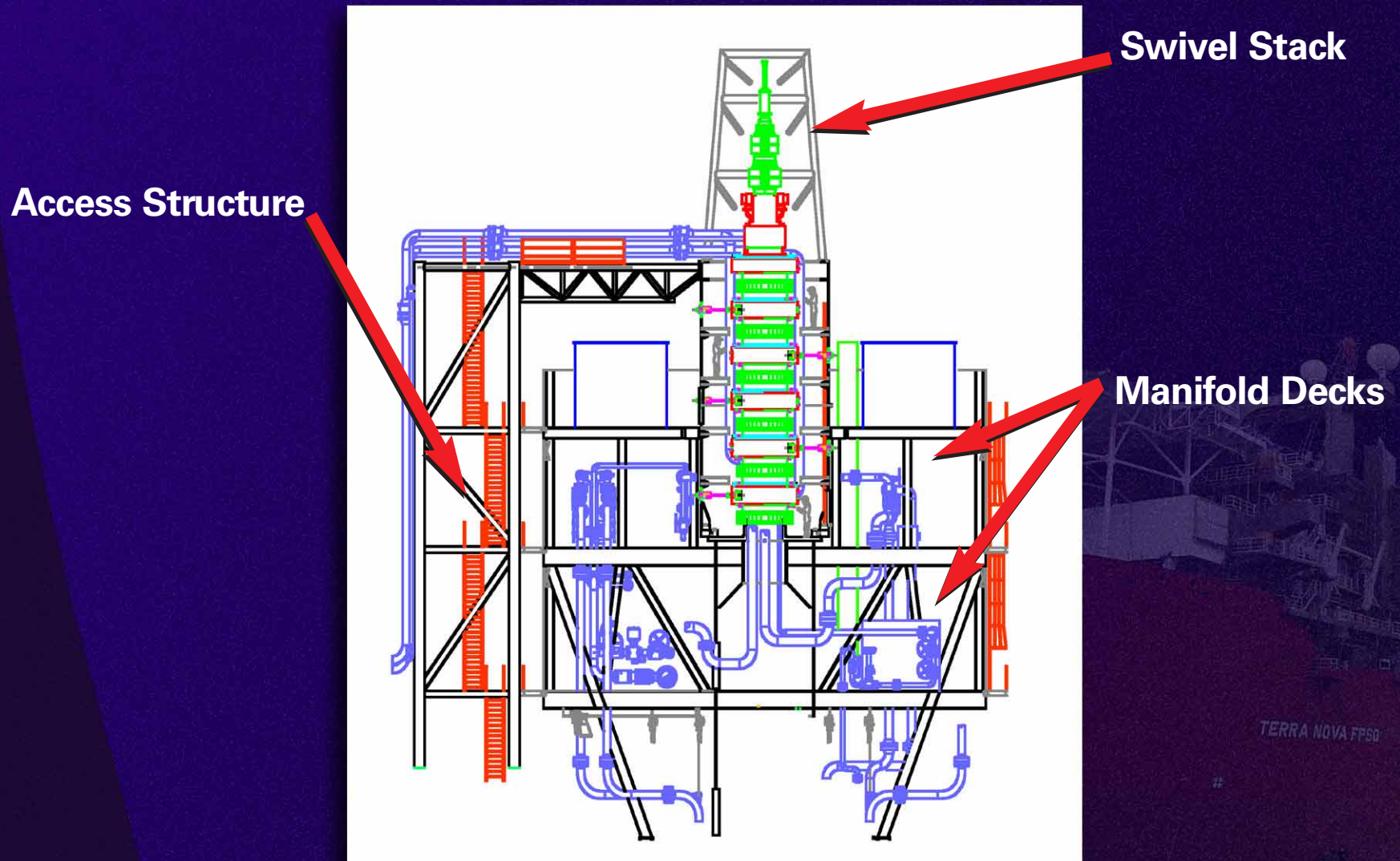


QC/DC Assemblies

- Lower QC/DC valve assemblies
 - two standard ball valves in a single body
 - Torus connectors



Upper Turret System



Upper Turret Module



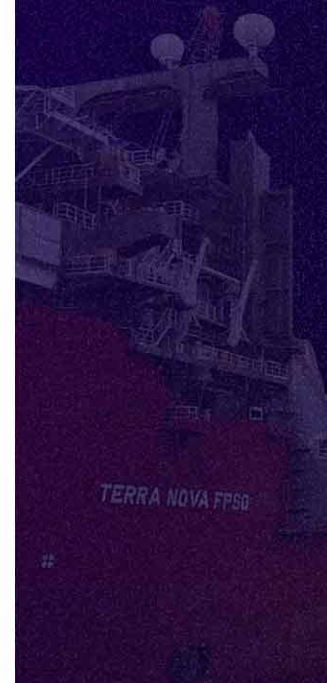
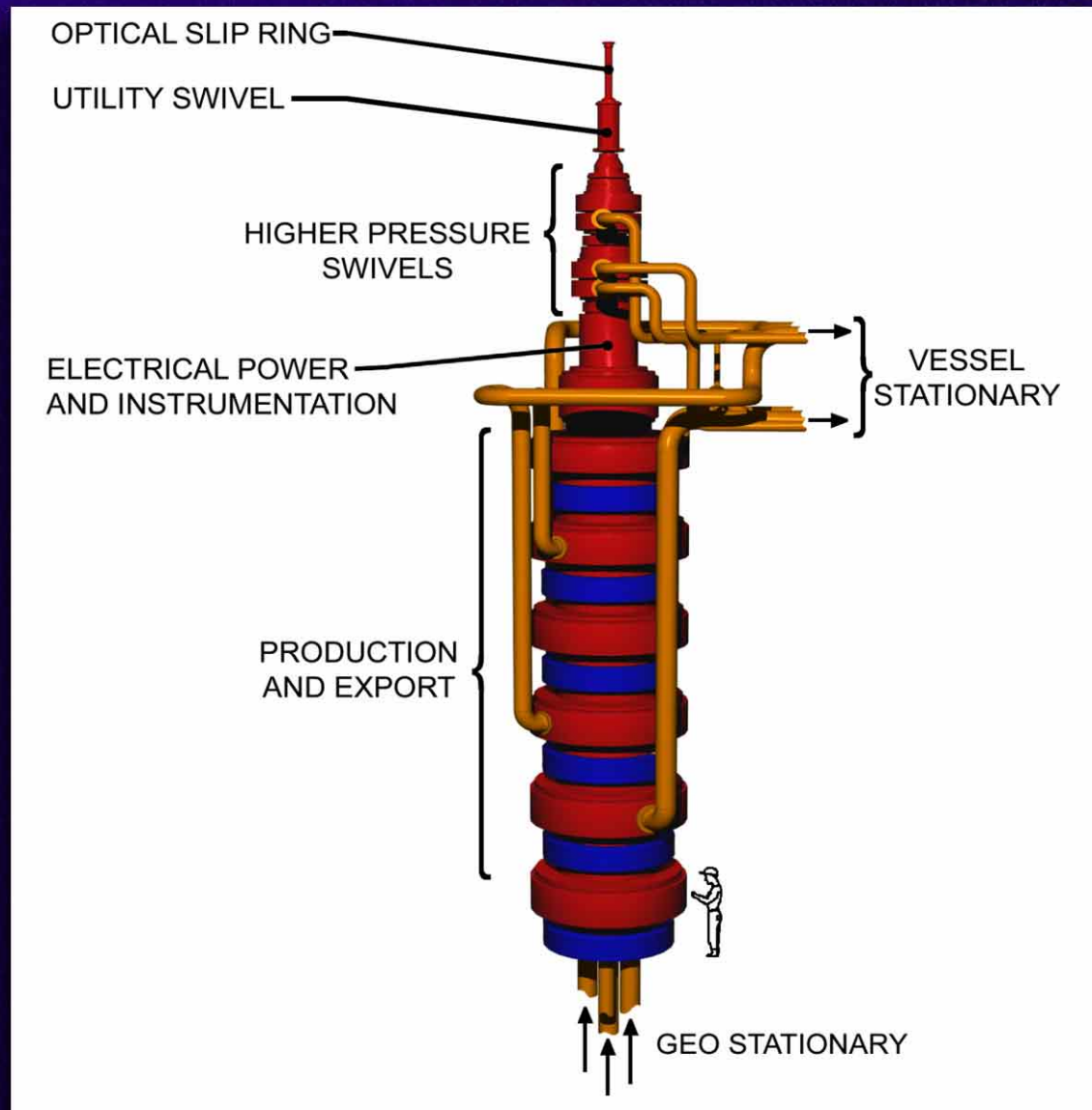
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Upper Turret on FPSO

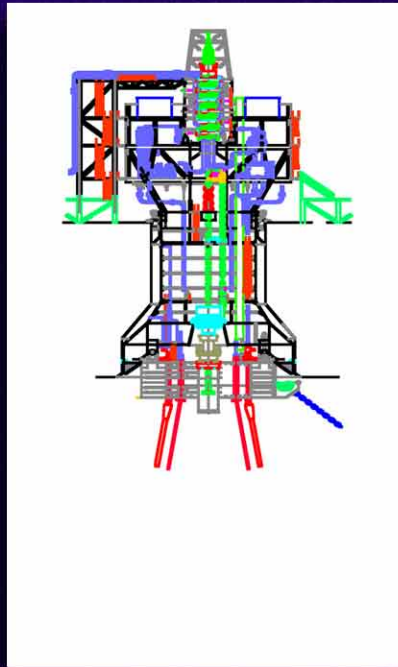


Terra Nova: Swivel Stack



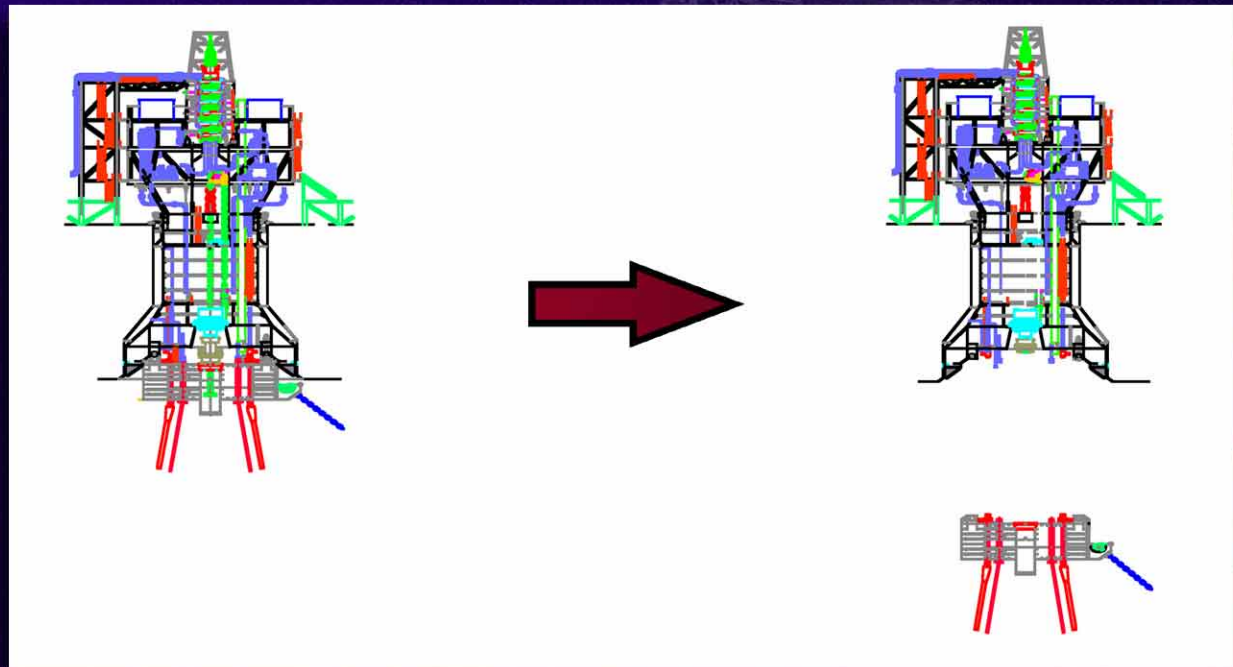
Disconnect Sequence

- Blowdown and flush lines (planned disconnect only)
- Disconnect riser quick connect disconnect couplings
- Flood turret interior
- Disconnect main connector

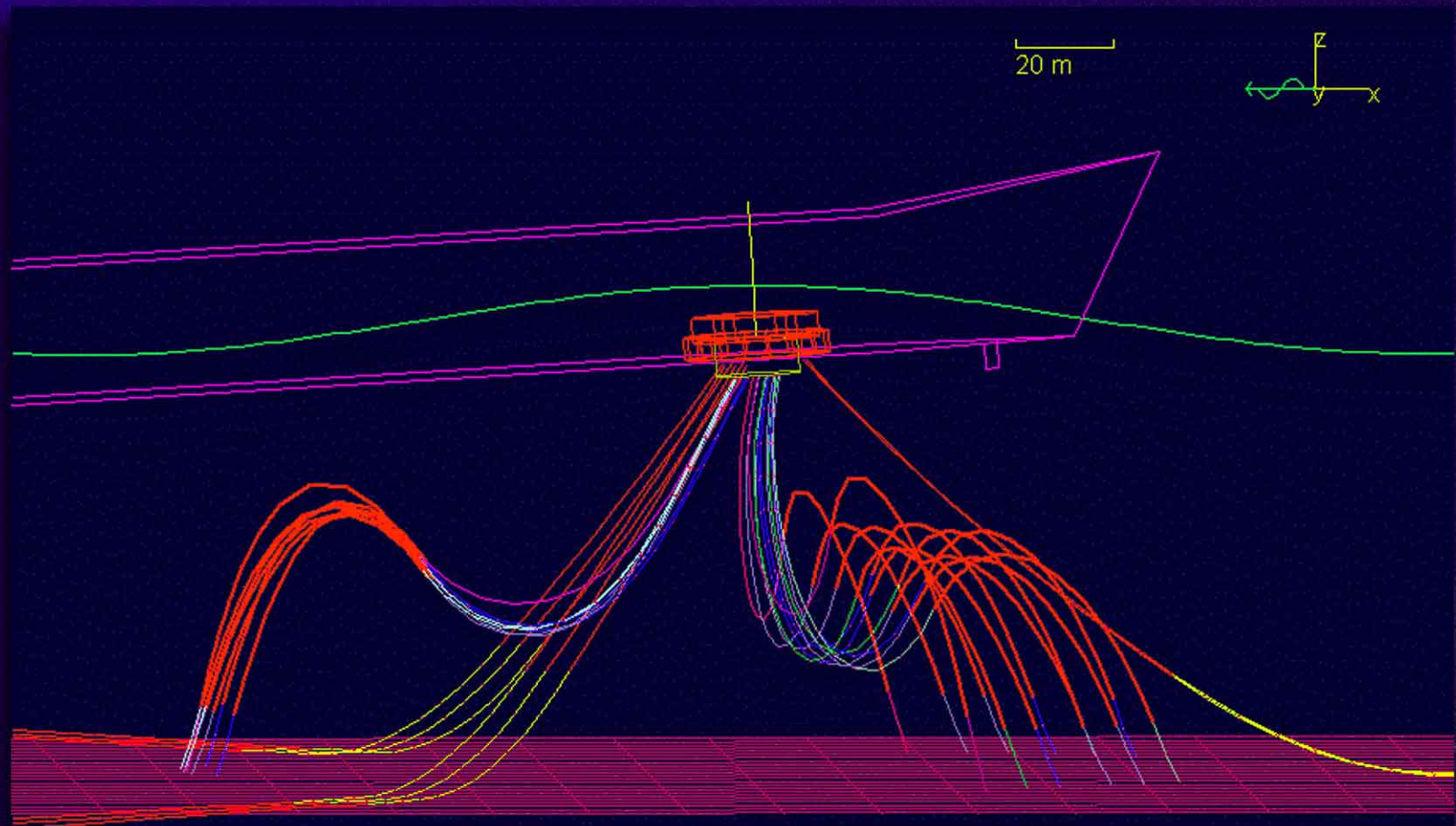


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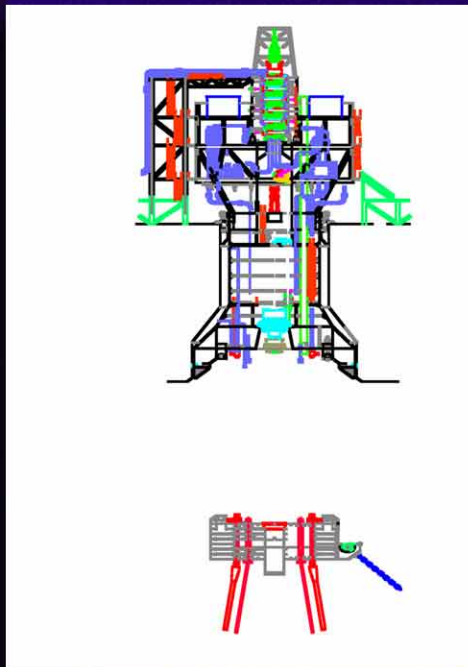


Spider Buoy Disconnect



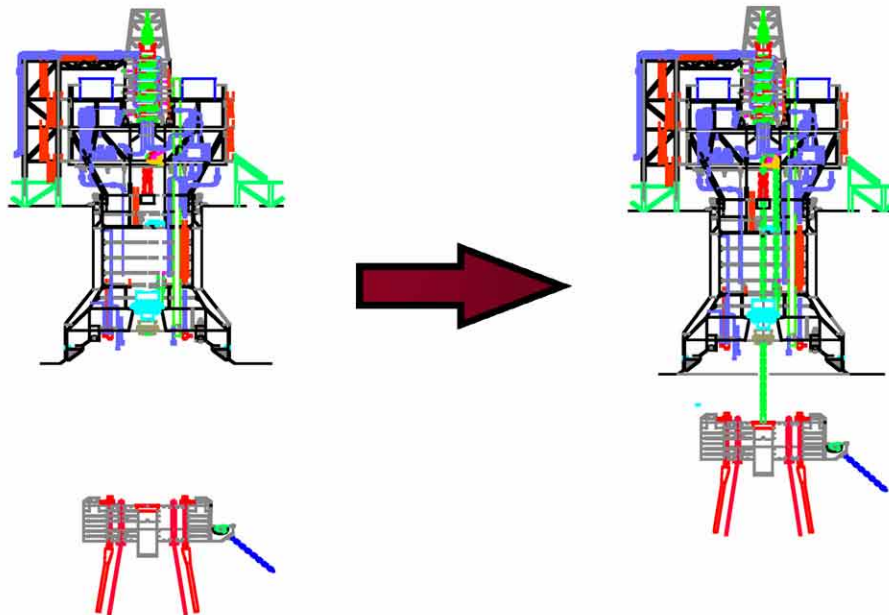
Reconnect Sequence

- Engage retrieval line
- Pull-in buoy
- Make up main connector
- De-water turret
- Make-up quick connect disconnect couplings
- Start process



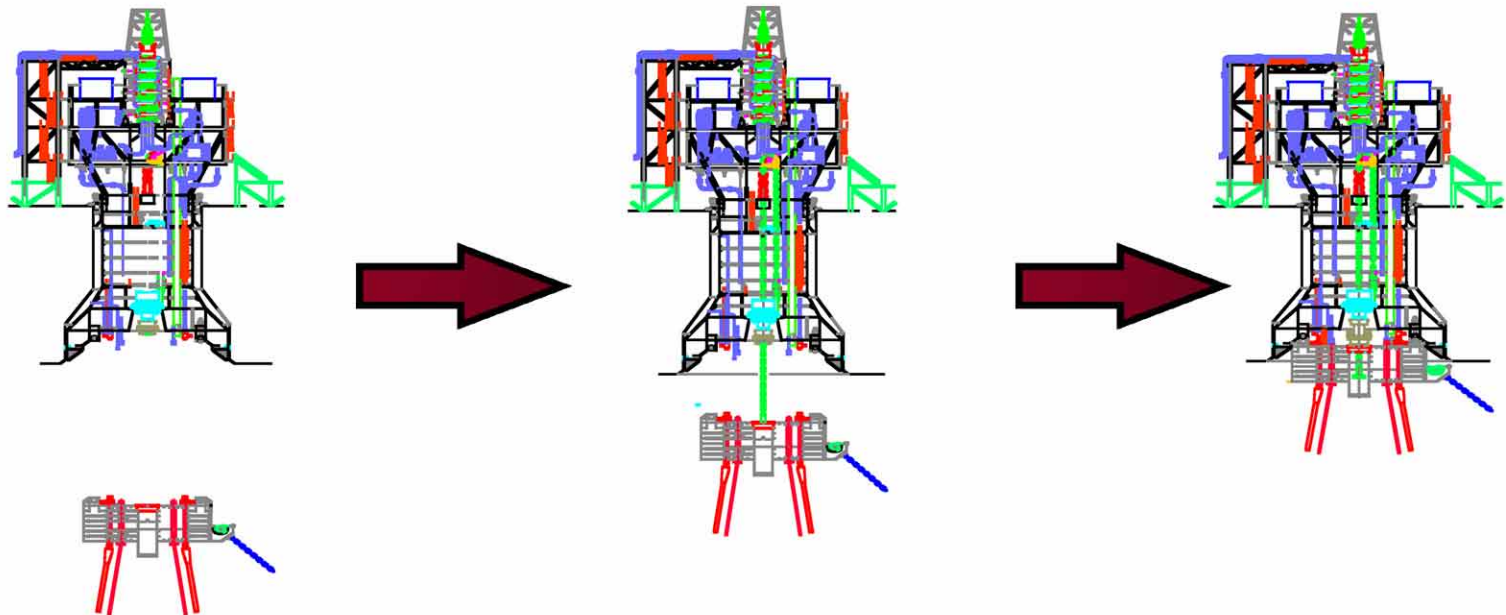
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Terra Nova FPSO



Thank You

