



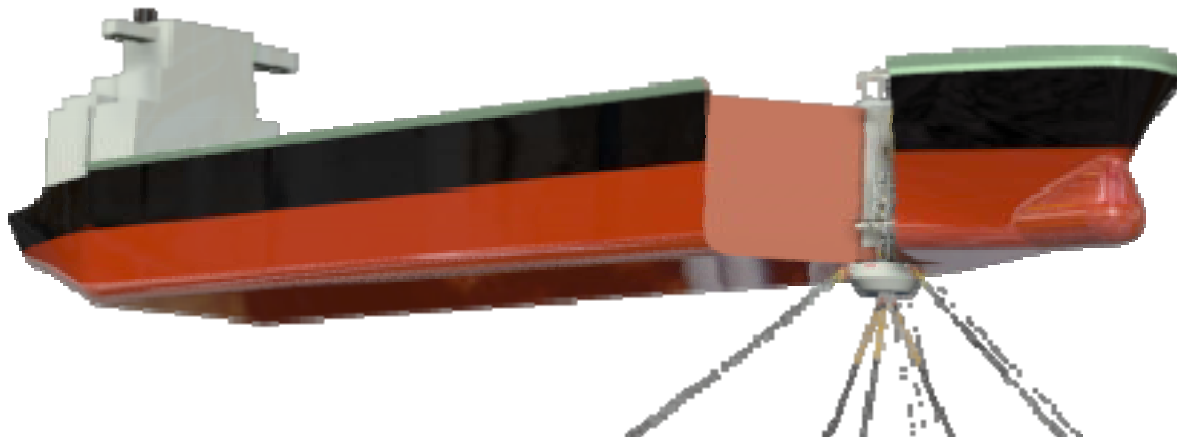
Keel Integrated Transfer System – Smart, Compact and the Next Generation Mooring and Fluid Transfer System

Ron Mack (SOFEC)

Global Floating Production Systems 2006 Conference
December 6, 2006



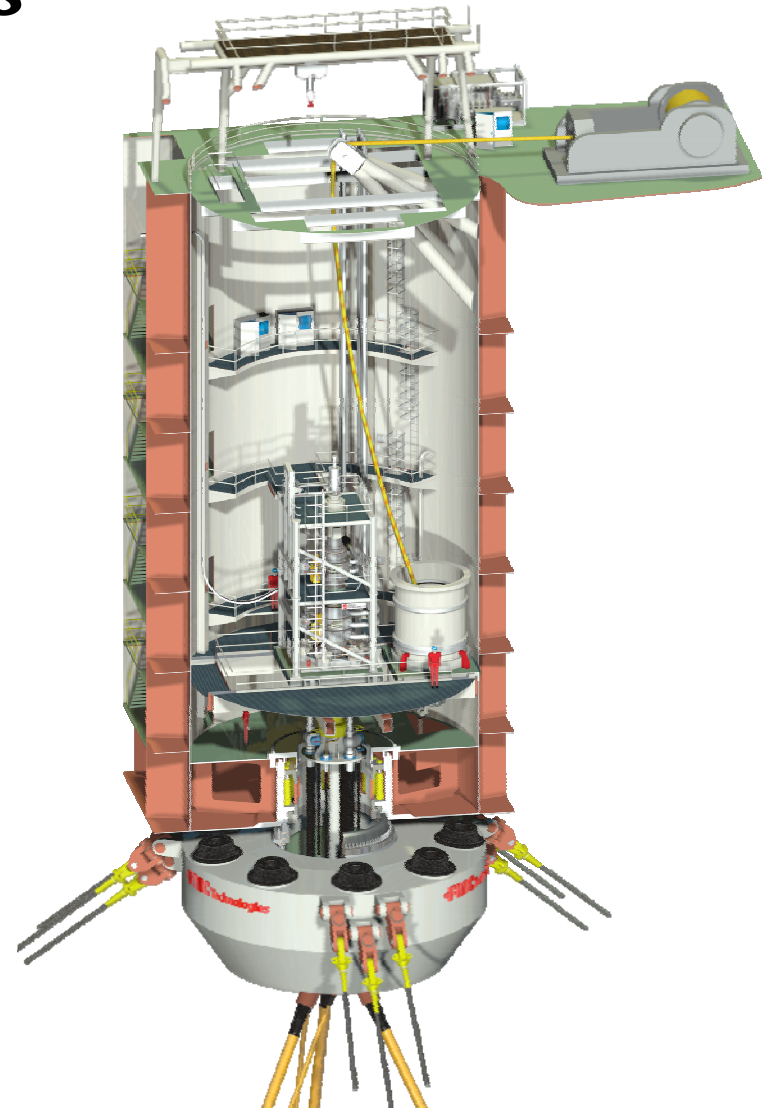
What is a KIT System?



- A weathervaning single point mooring system
- The next generation compact (turretless) “turret” system that uses fully proven technology
- A system that meets or exceeds the capabilities of existing submerged or compact turret systems

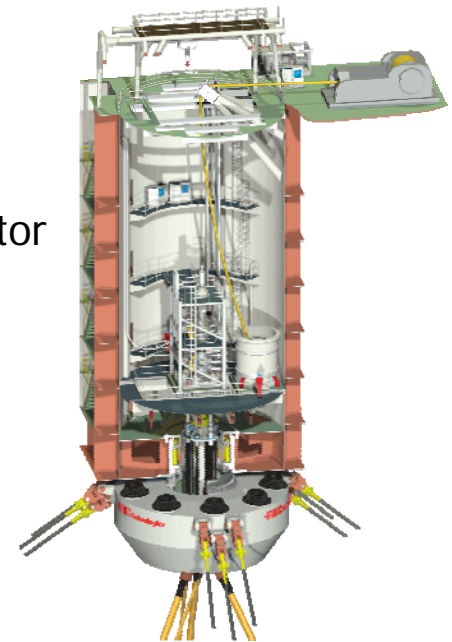
KIT – Range of Applications

- Loading Systems
- Production Systems
- LNG Regas Offloading Systems
- Early Production Systems
- Permanent, Connectable or Disconnectable
- DP Applications
- Other Unique Applications



What distinguishes the KIT System?

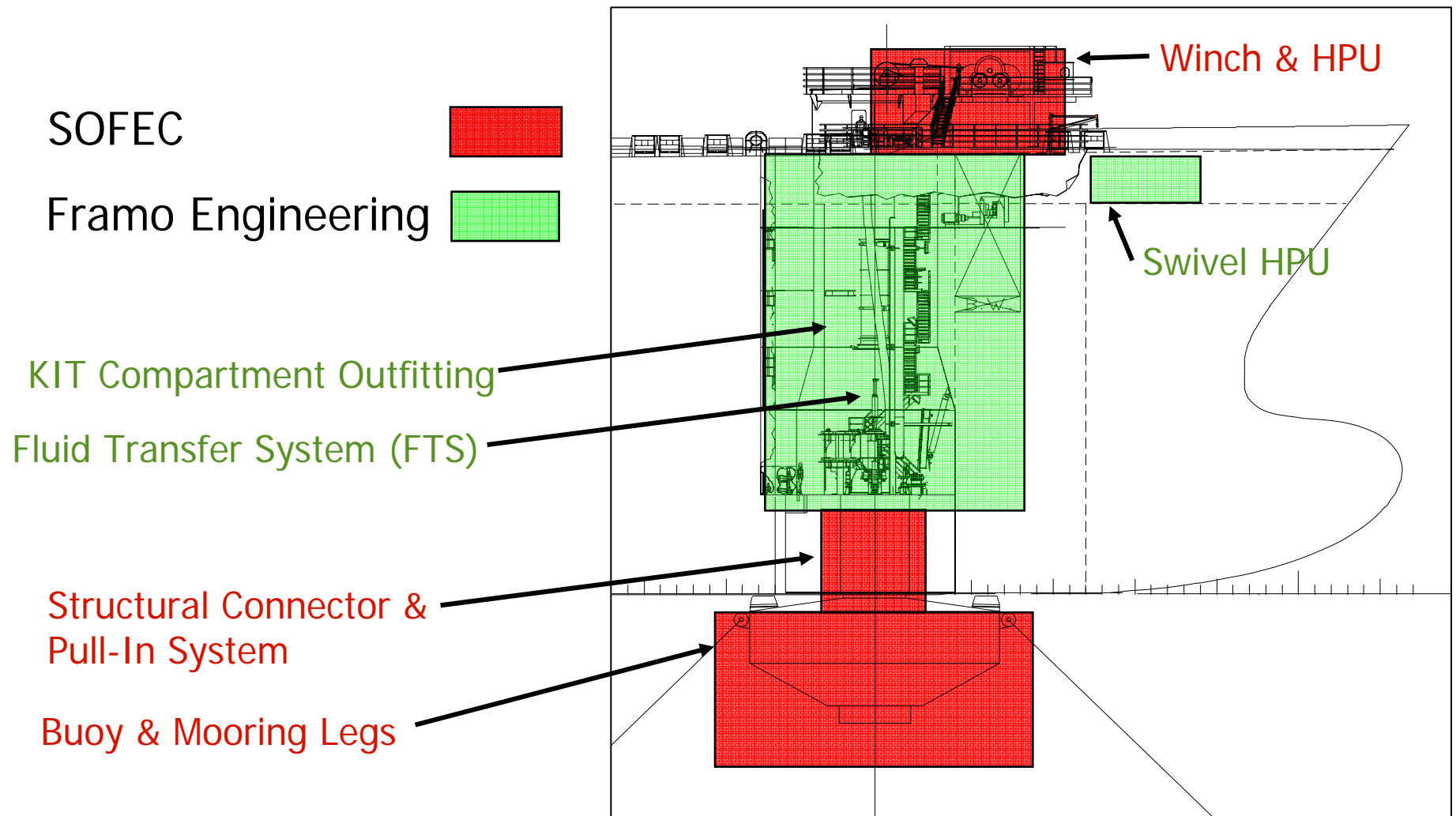
- A keel integrated system that is fully integrated into and beneath the keel of the vessel
- A disconnectable (or permanent) mooring load transfer system, including:
 - a mooring buoy (or chain table)
 - a submerged sliding bearing
 - a large diameter, high capacity structural (or bolted) connector
- A compact fluid transfer system, including:
 - a compact manifold system with riser load transfer
 - a submersible, high pressure, movable swivel stack
 - integration within the KIT compartment



Cooperation Agreement for KIT Supply

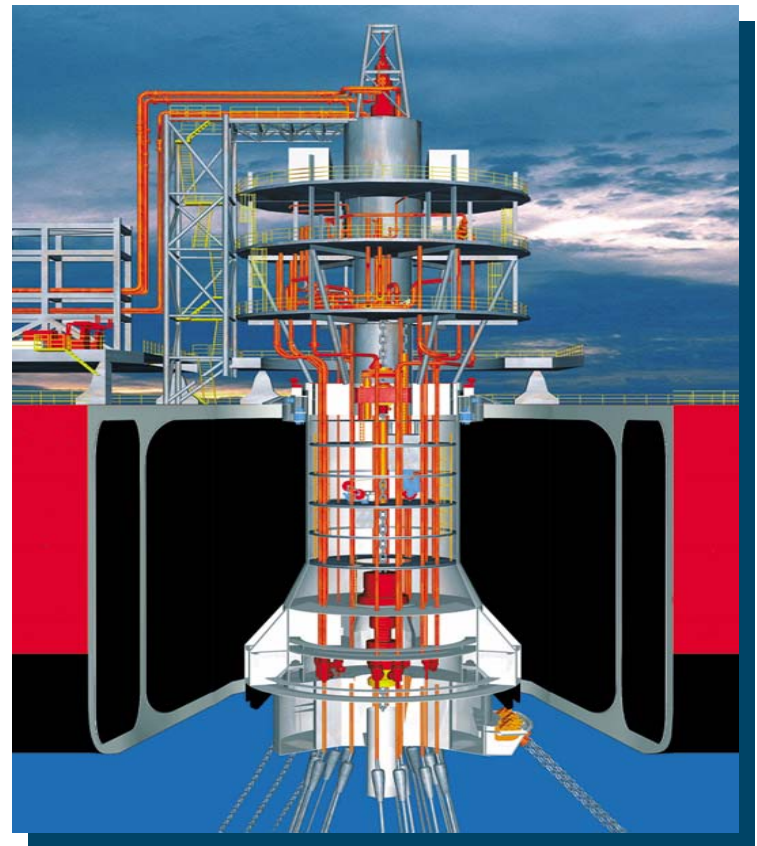
- Combines existing technologies from SOFEC and Framo
- Based on successful long term, preferred customer/vendor relationship
- Incorporates best in class mooring and fluid transfer technology
- Mutual commitment towards marketing, sales, product development, and supply of KIT systems
- Committed to success!

SOFEC/Framo Responsibilities for KIT Supply



SOFEC Inc.

- Engineering and construction company based in Houston, TX
- Founded in 1972, acquired by FMC Corporation in June 1993, acquired by MODEC Inc. in Dec. 2006
- Approximately 150 employees
- Major Project Experience
 - 51 SALM/CALM terminals
 - 20 major FPSO/FSO projects
 - 3 spread moorings
 - 9 external turrets
 - 3 permanent internal turrets
 - 3 disconnectable turrets
 - 2 tower yoke moorings
 - 4 FPSO/FSO projects underway



SOFEC Mooring Systems

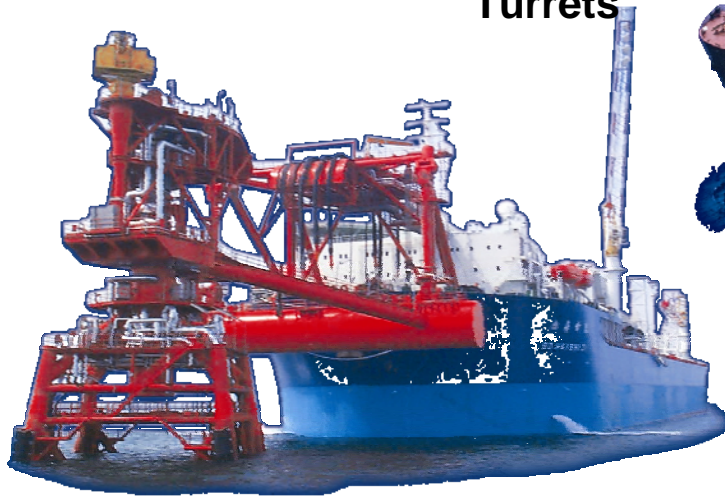


**Internal
Disconnectable
Turrets**



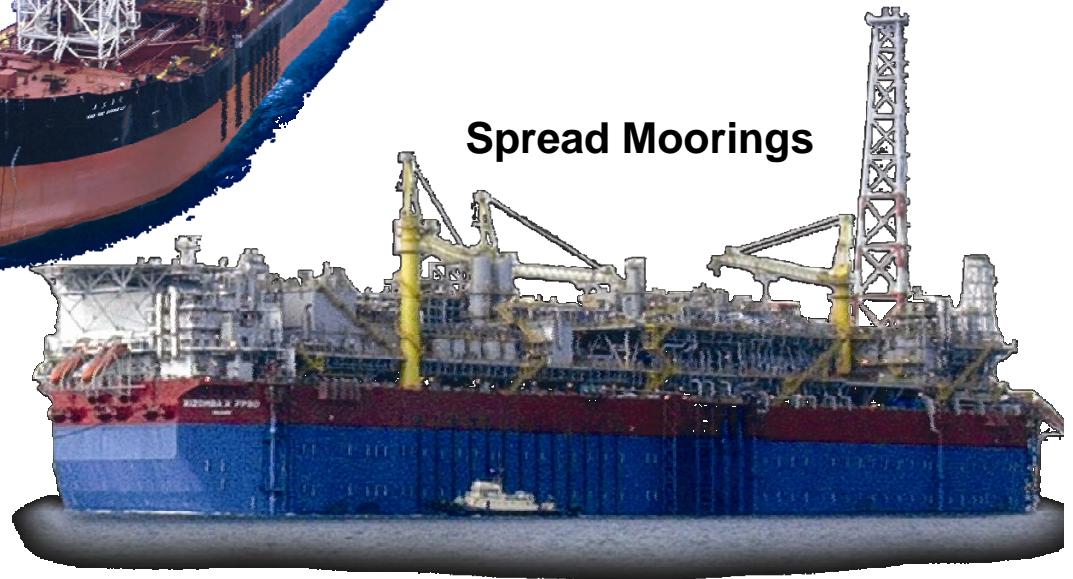
**External
Turrets**

**Internal Permanent
Turrets**



Tower Yoke Moorings

Spread Moorings



Relevant (Transferable) Technology



**Disconnectable
Buoy Systems**

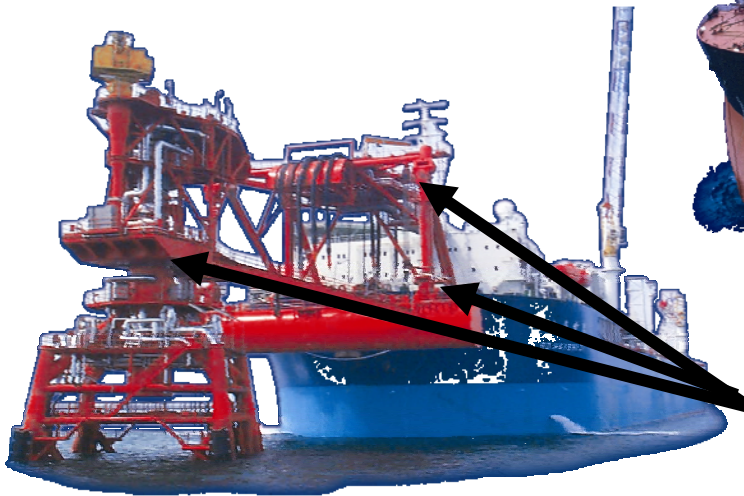
**High Capacity
Collet Connectors**



**Single Bearing
Chain Tables**



**Submerged Sliding
Bearings**



**Large Diameter, Highly Loaded
Sliding Bearings**

Petro-Canada Terra Nova FPSO (Eastern Canada)



- Awarded 1/98
- Installed 10/01
- 90 m water depth
- New-build vessel
- 193,000 mt displacement
- 950,000 bbls storage

World's first disconnectable turret system for icebergs

Turret Access
Structure

Upper Turret

Lower Turret

Spider Buoy

Fluid Swivel

Manifold System

Upper Bearing

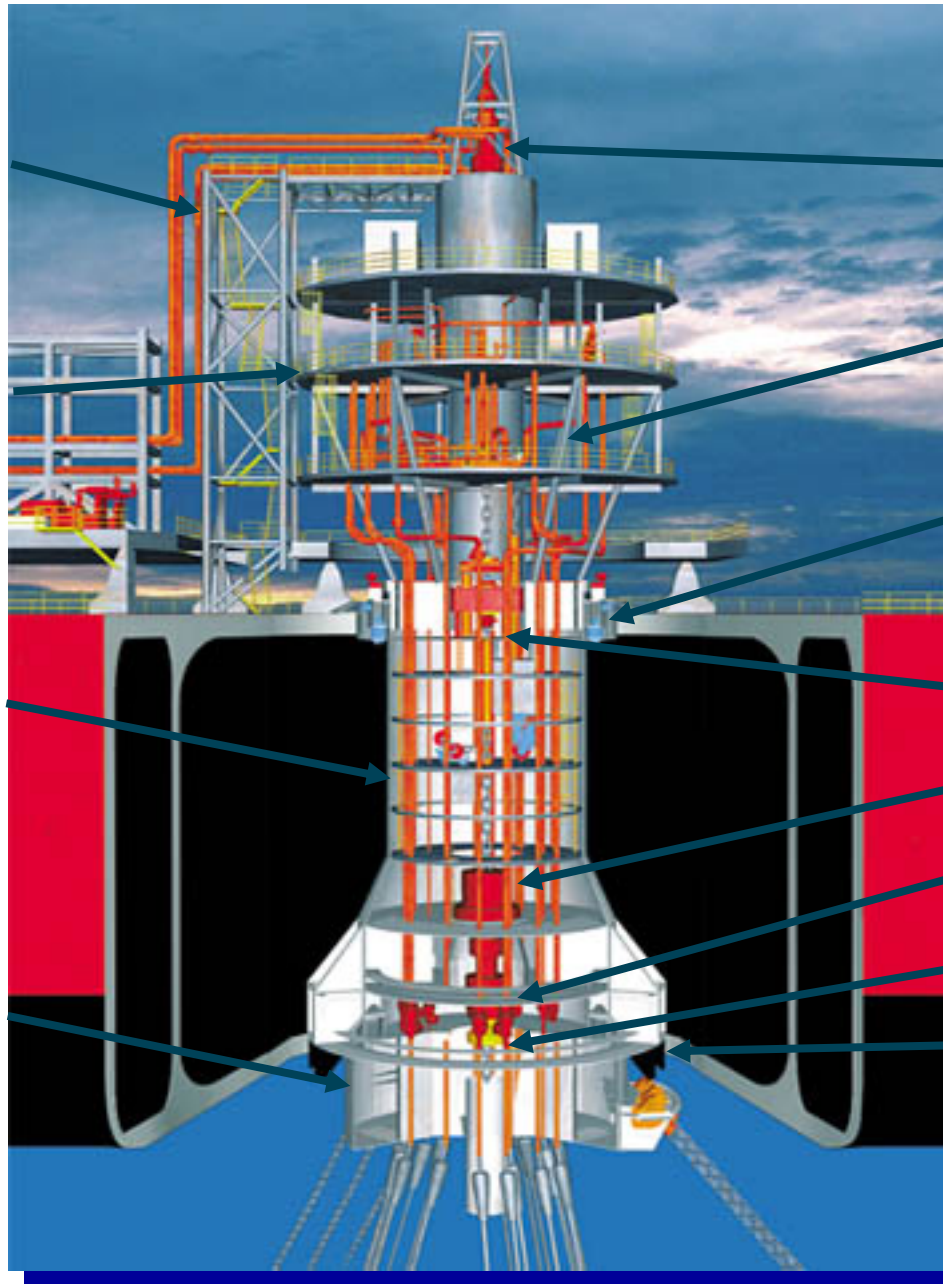
Chain Jack

Tensioner System

Connector System

QC/DC Connectors

Lower Bearing



The “Original” KIT System

Disconnectable KIT System Description

- Mooring System / Buoy
- Sliding Bearing / Structural Connector
- Pull-In System

KIT System Overview

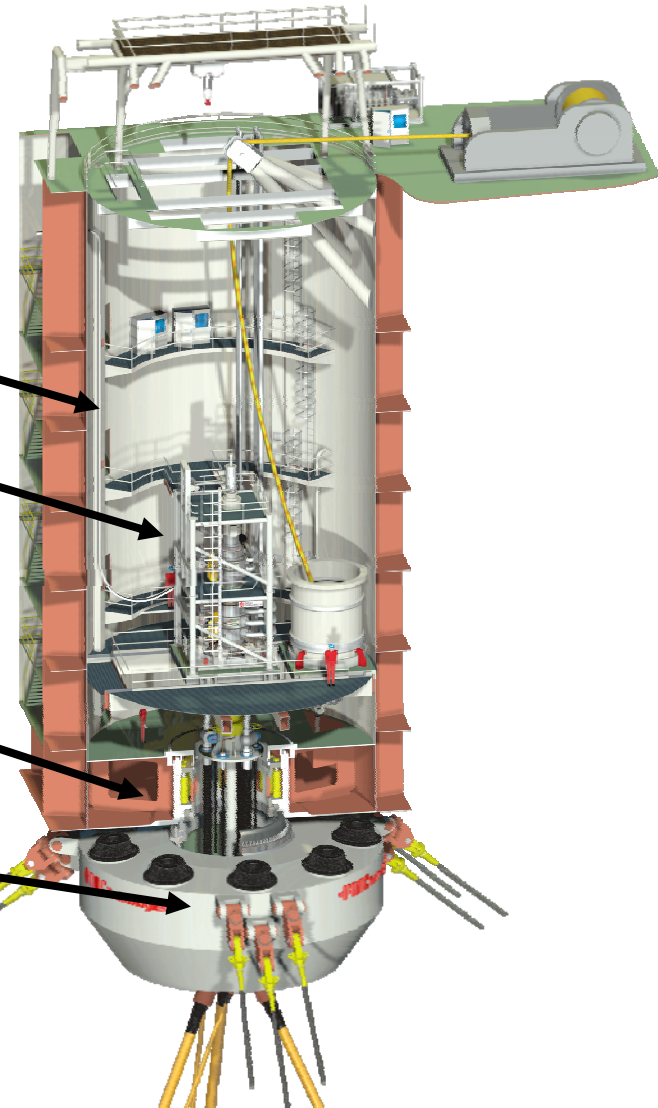
KIT Compartment

Fluid Transfer System (FTS)

Structural Connector

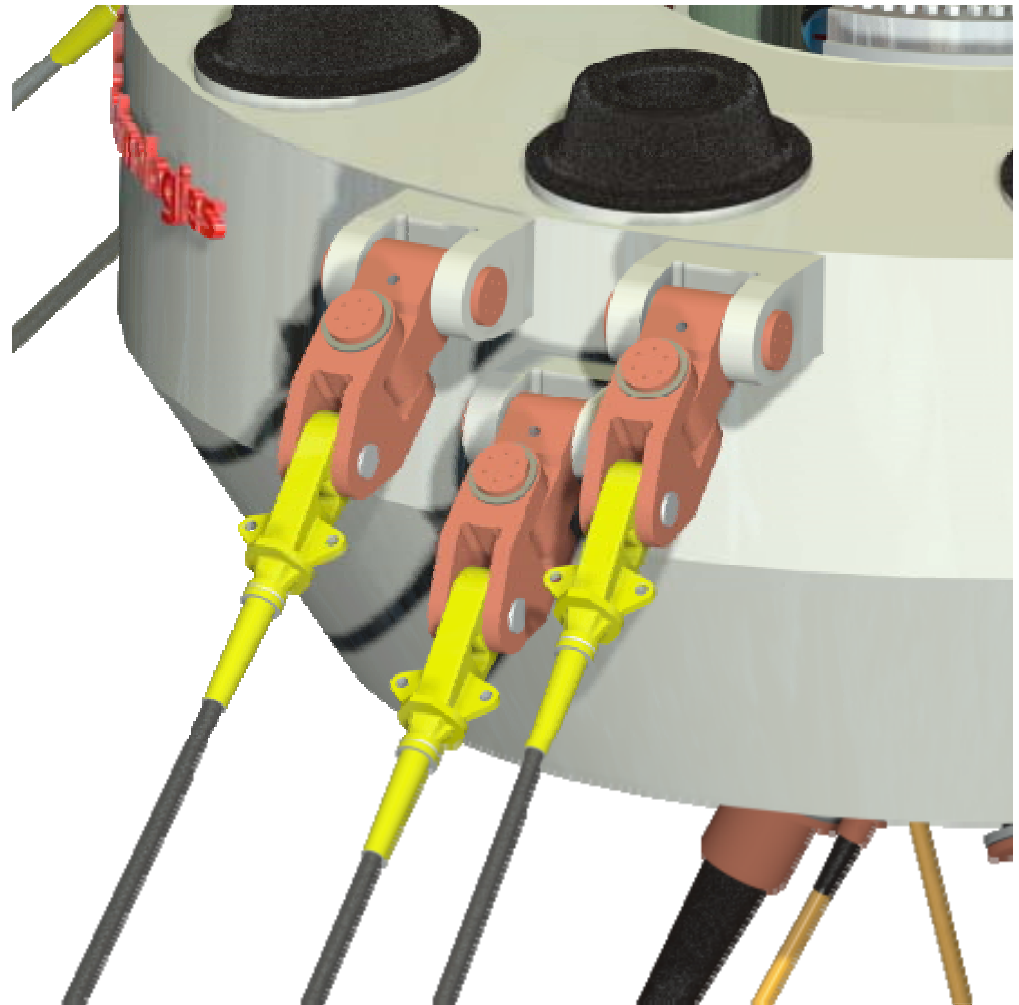
Buoy & Sliding Bearing

Anchor Legs



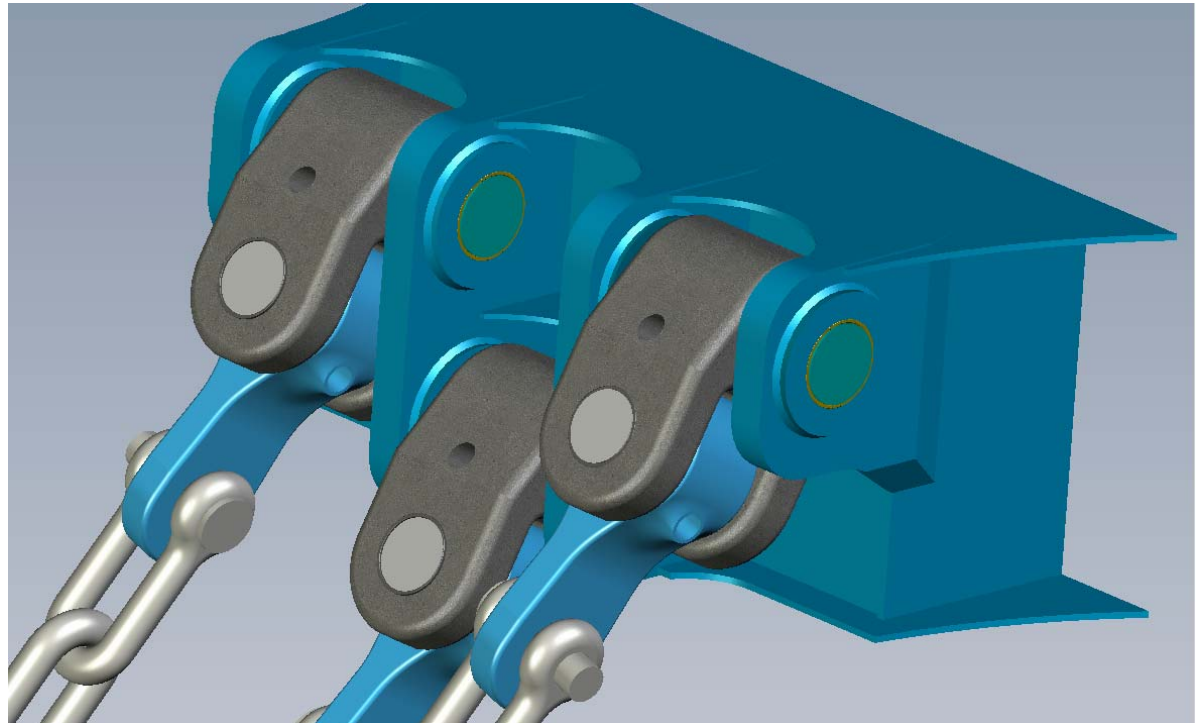
KIT Mooring System

- 3 x 3 configuration
- Direct anchor leg connection to buoy (without chain stoppers)
- Dual axis universal joint connections



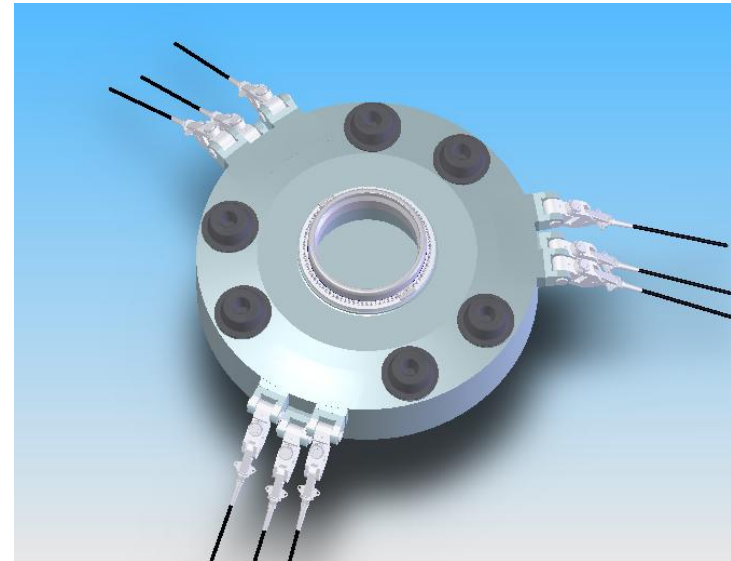
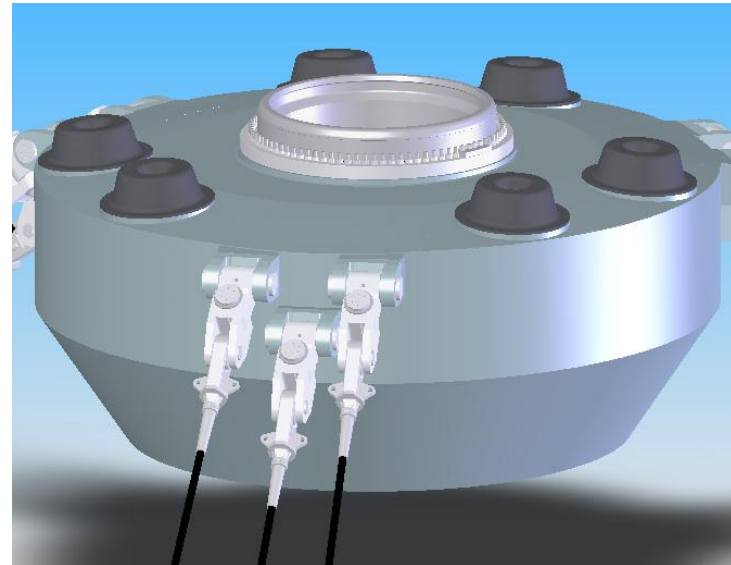
Mooring Connection U-Joints

- Lightweight anchor leg connection
- Designed to reduce chain wear and fatigue due to rotational friction



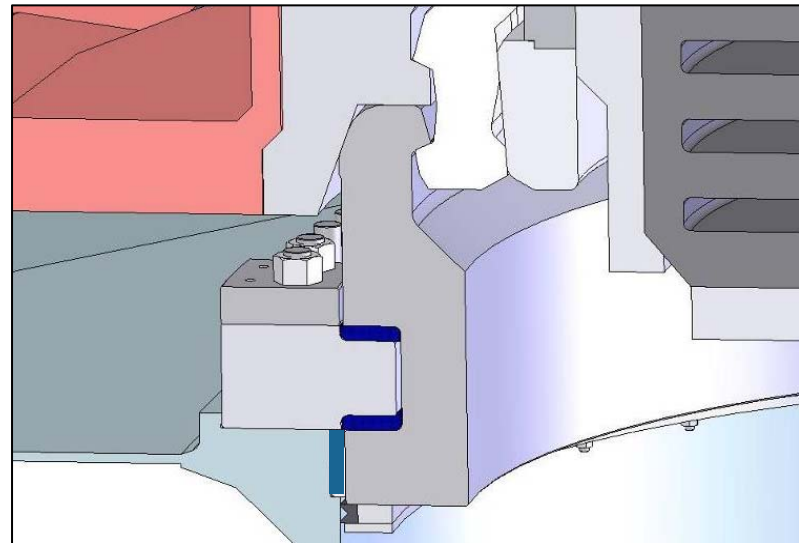
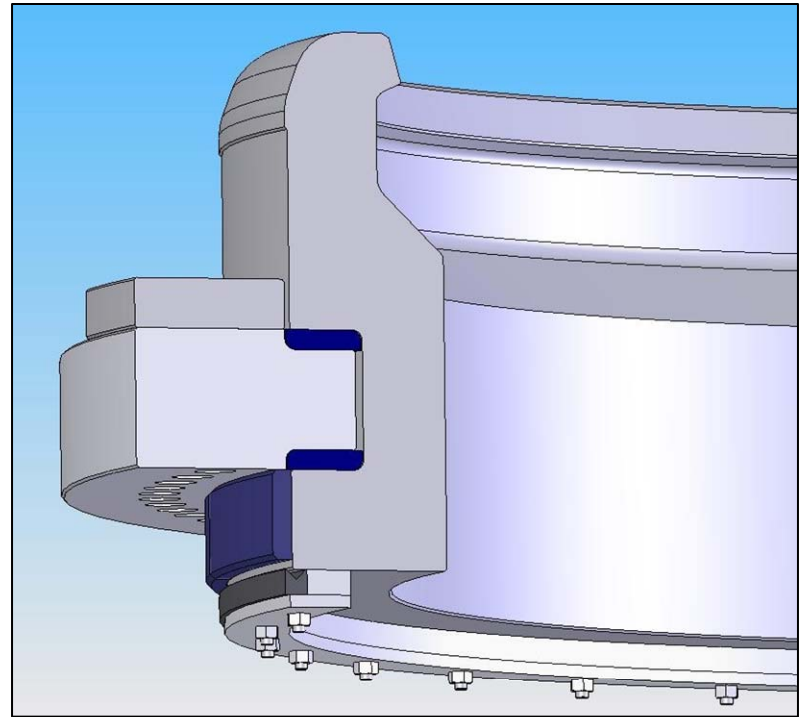
KIT Buoy

- Cylindrical conical plate construction
- Displacement sized to safely support risers and mooring in disconnected condition
- Conventional circular marine fenders
- Submerged sliding bearing



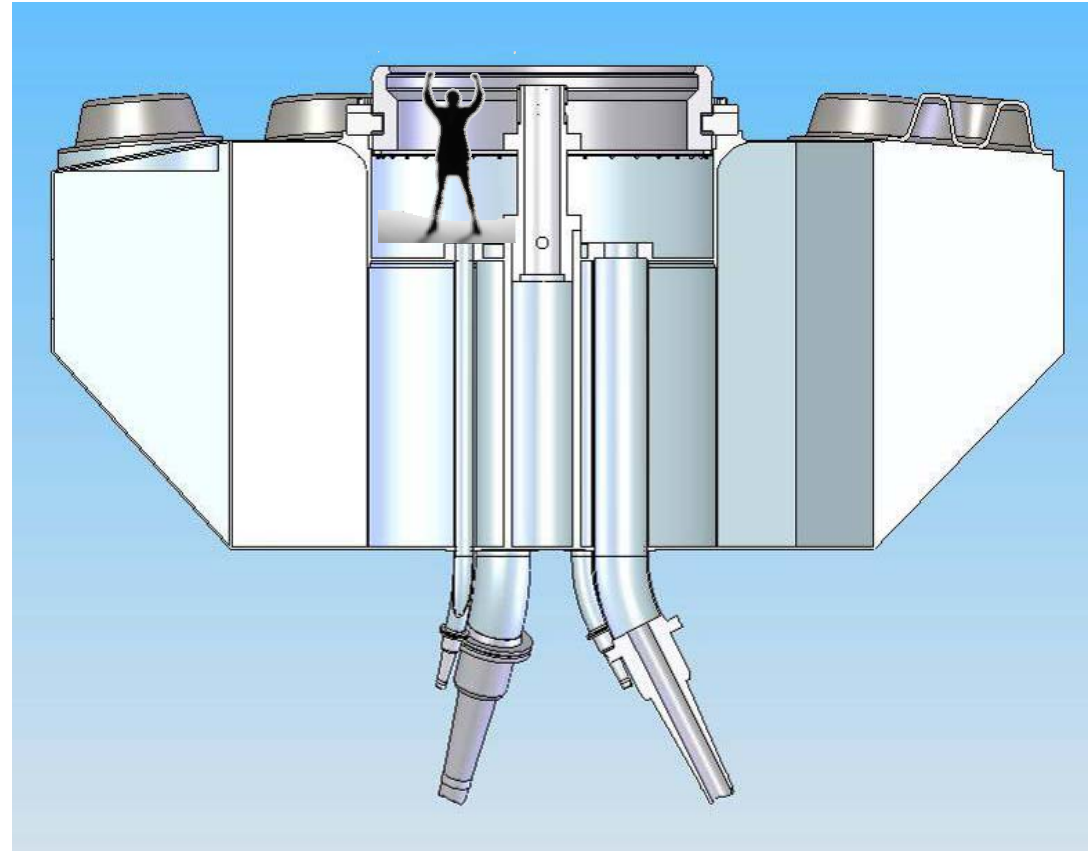
Integrated Connector/Bearing Assembly

- Bearing and connector hub integrated into single manufactured assembly
- Single submerged sliding element (Orkot material) design



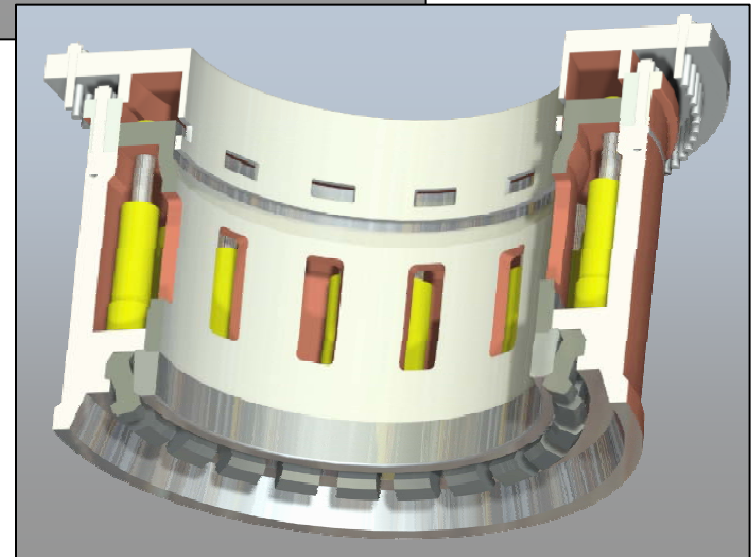
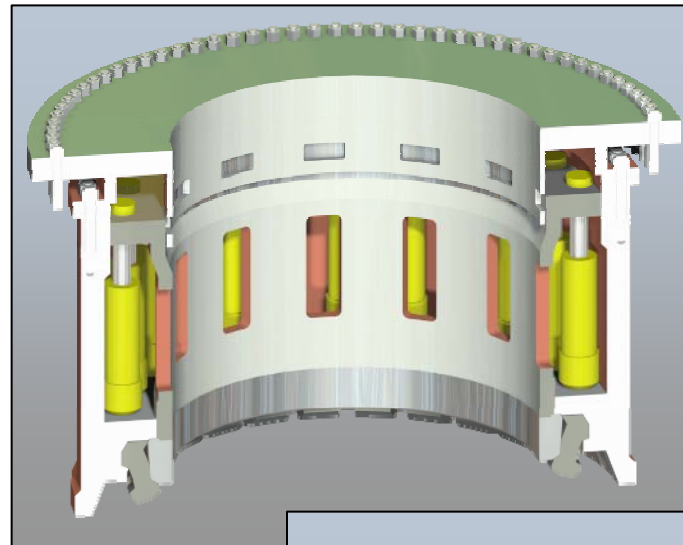
KIT Bearing Inspection/Replacement

- Bearing is readily inspectable in a dry environment (while connected)
- Bearing is fully replaceable in-situ (while disconnected)

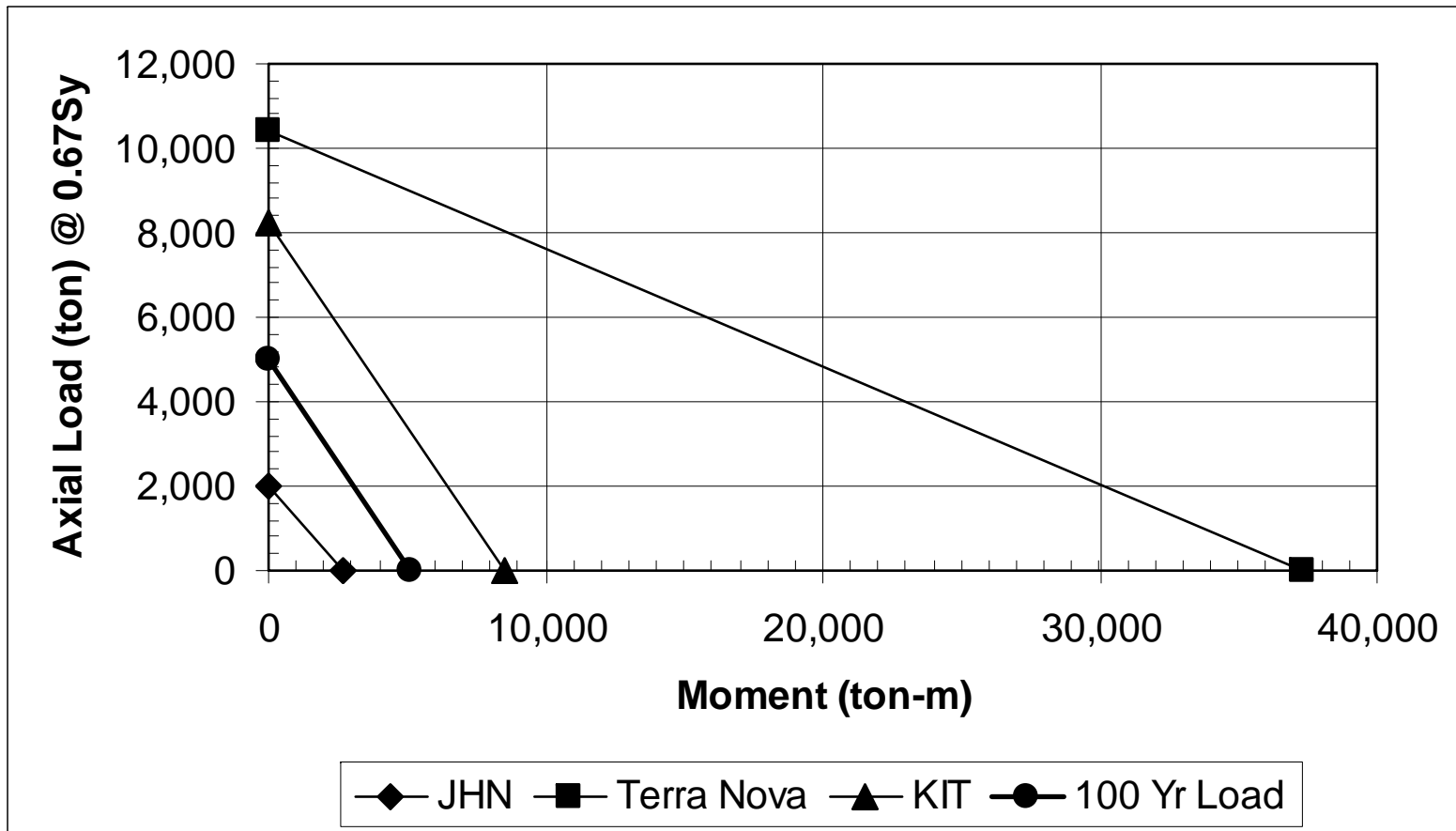


KIT Structural Connector Assembly

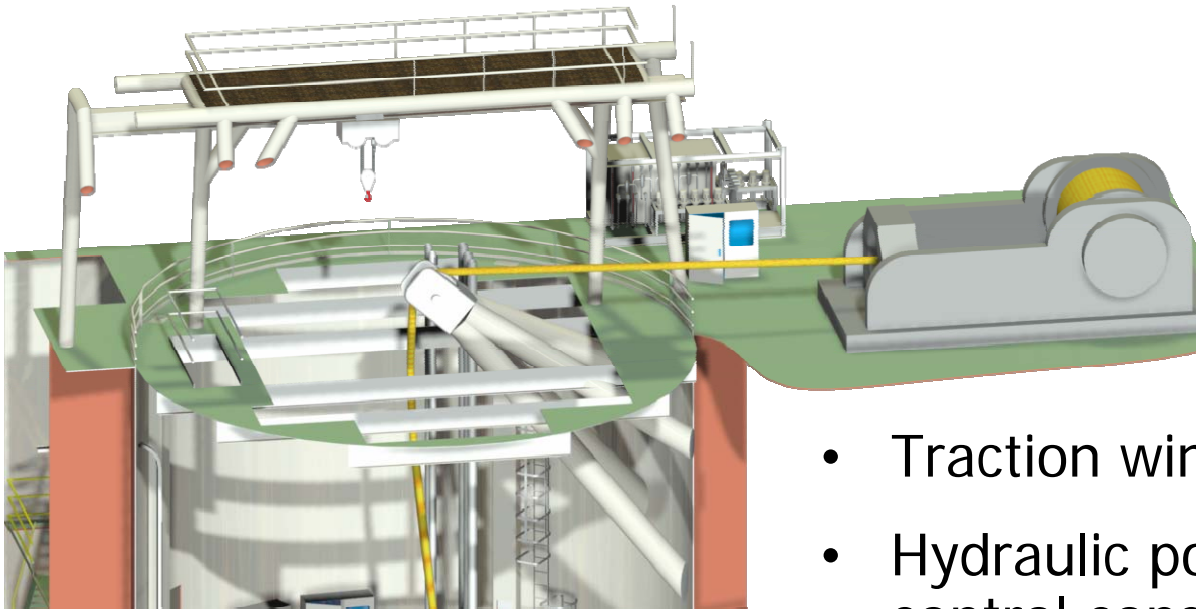
- Bolted into keel structure, in-situ replacement
- Collet connector with internal collets
- Hydraulic actuation for connect and disconnect



KIT Structural Connector Assembly Capacity



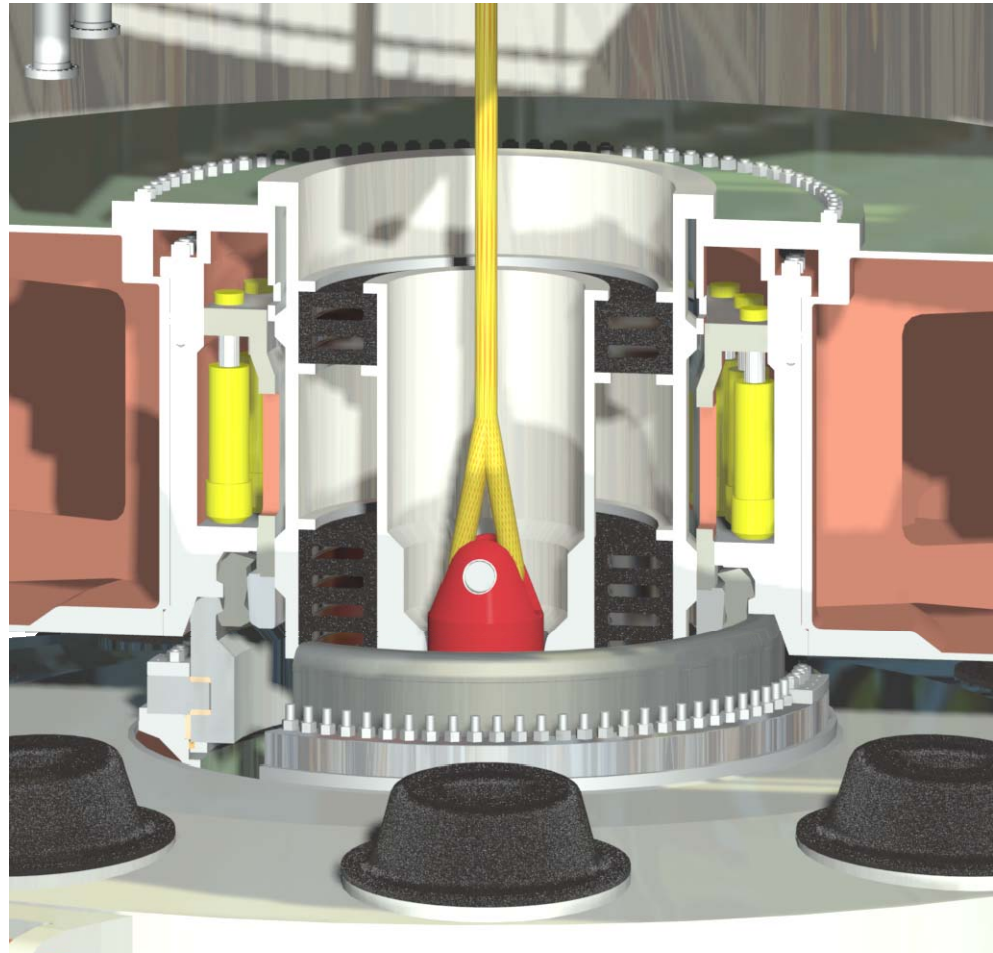
KIT Pull-In Equipment (on vessel deck)



- Traction winch
- Hydraulic power unit (with pull-in control console)
- Compensator (need determined by reconnection sea state)
- Turndown sheave
- Pelican hook and rope handling gear on bow

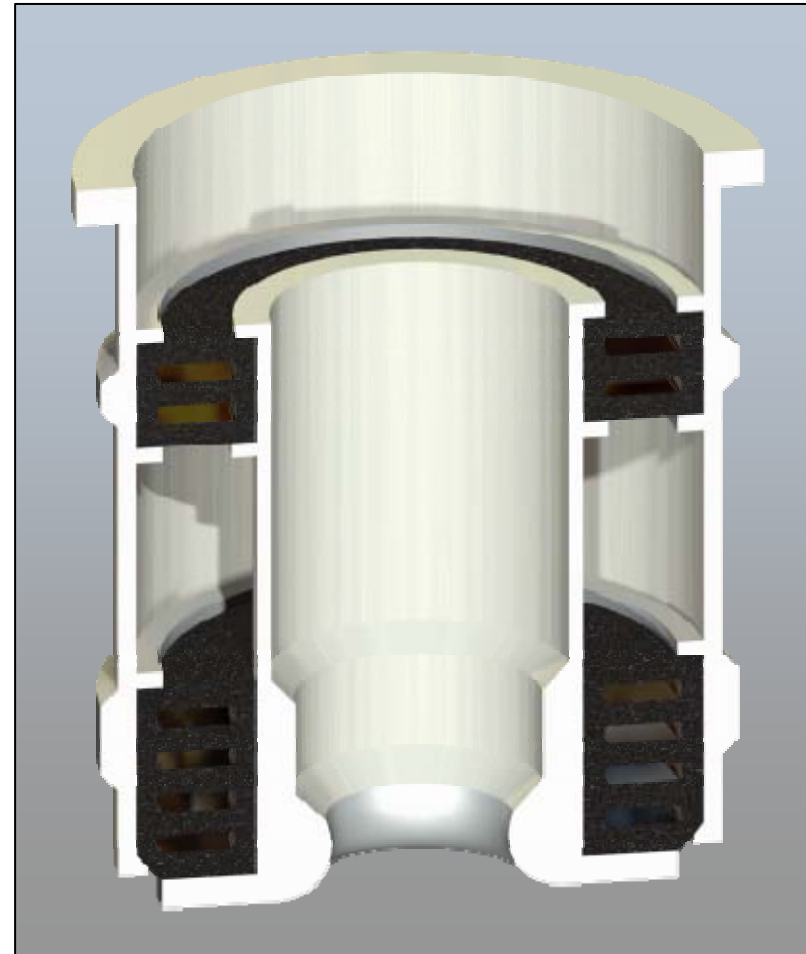
KIT Pull-In Equipment (in vessel keel)

- Pull-in tools
 - Pull-in rope
 - Pull-in head
 - Pull-in guide



KIT Pull-In Guide

- Inserted into connector opening for connection operations
- Radiused bull nose at rope entry (bottom)
- Elastomeric shock absorber
- Sized for specified connection seastate conditions

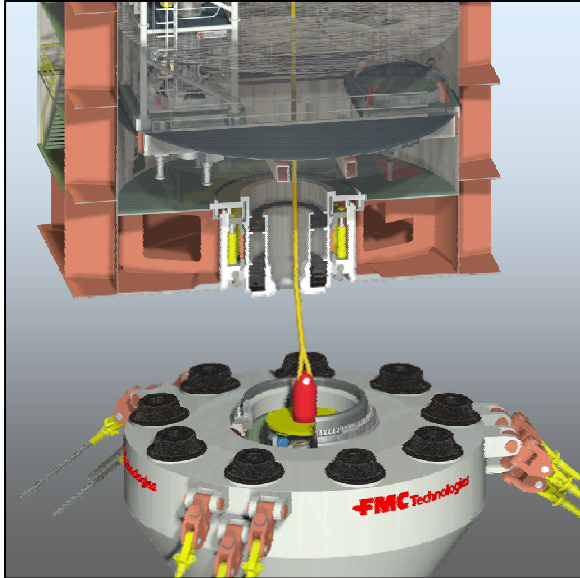


KIT Pull-In Equipment (in buoy)

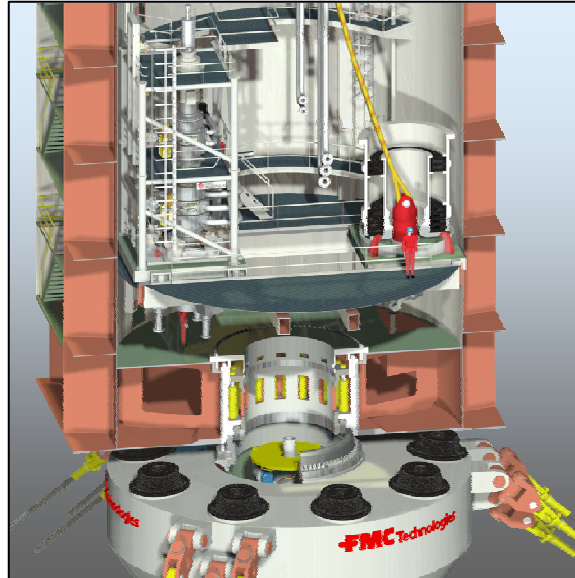
- Center post
 - Pull head attachment
 - Swivel torque tube
 - Pull-in guidance



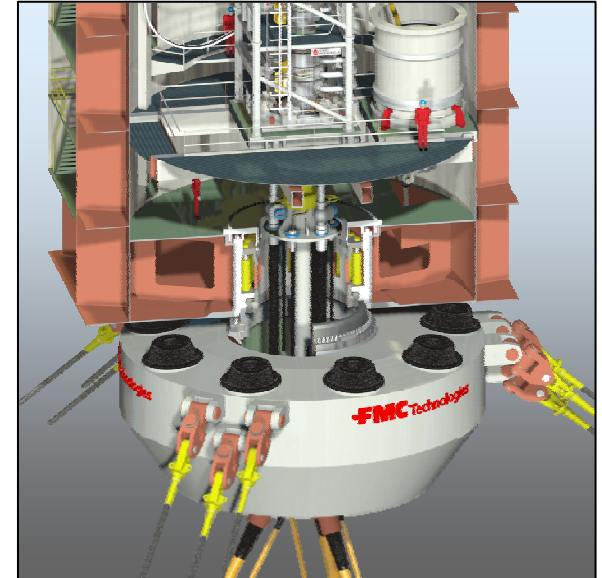
KIT Reconnection Summary



**Buoy / Mooring
Pull-In**



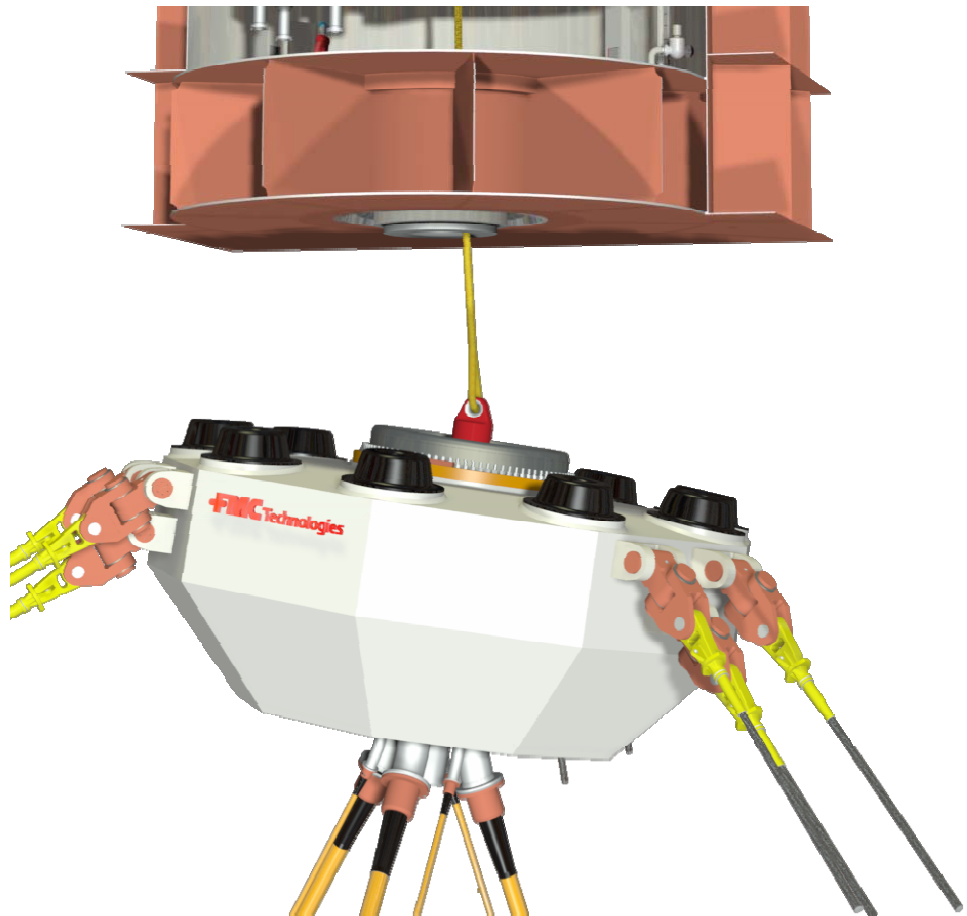
**Structural
Connection
(Vessel Moored)**



**Fluid Transfer
Connection
(Vessel Producing)**

KIT Buoy Disconnect / Reconnect

- Buoy drops clear of keel under all conditions. No problem with disconnect under load with vessel offset.
- Buoy reconnects in level orientation. Does not “pry” into cone with vessel offset.



Advantages of KIT Solution

- Cost effective compact solution
- Complete turnkey delivery by SOFEC and/or Framo
 - through shipyard integration, commissioning and testing
 - during offshore installation
- Simplified and less expensive shipyard integration
 - minimal impact on vessel hull construction or conversion
 - reduced construction work at keel / no in-situ machining
 - ship owner and conversion yard friendly
 - reduced shipyard and drydock schedule

Advantages of KIT Configuration (cont.)

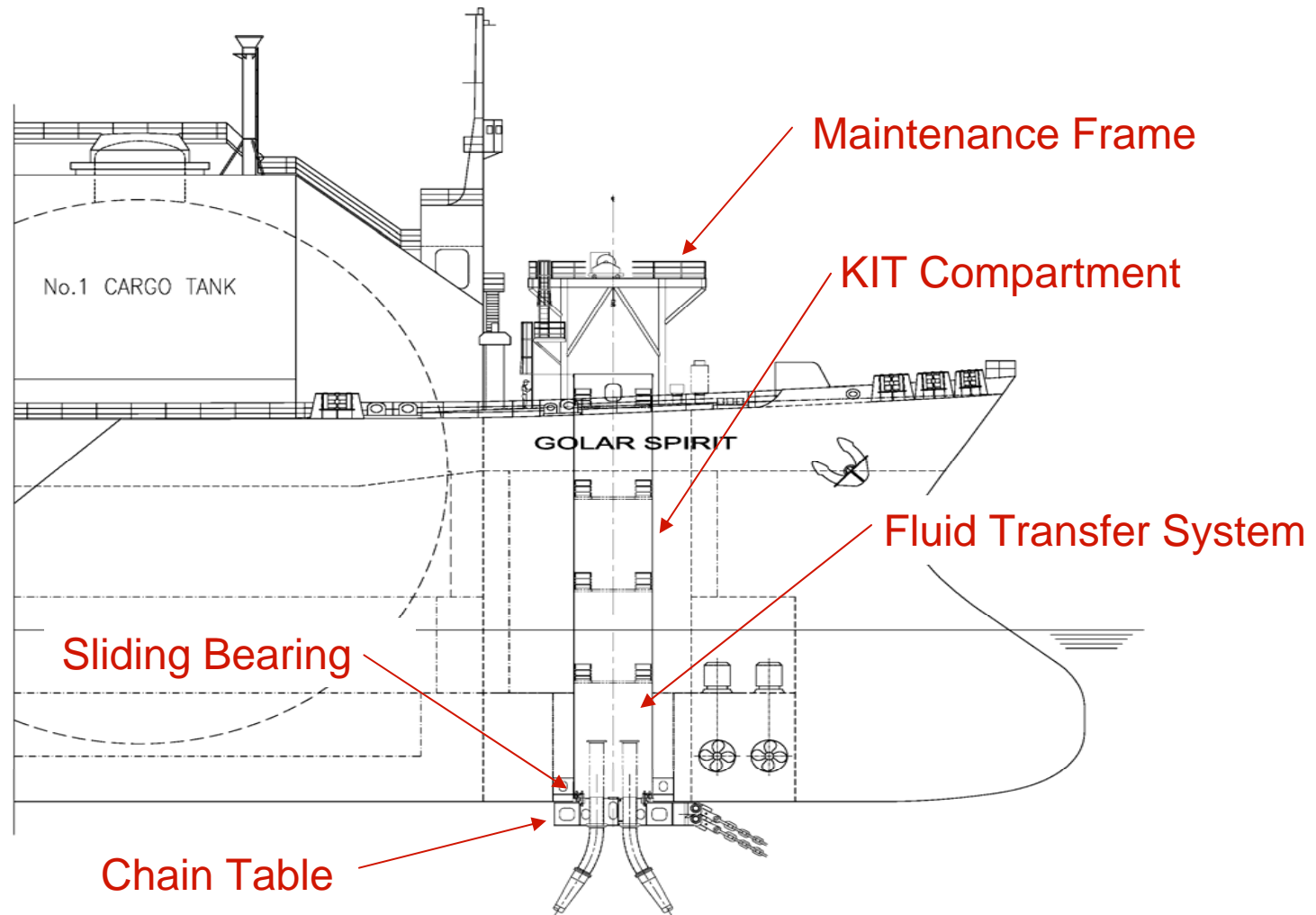
- Buoy pulled flush to vessel keel – not up into vessel hull
 - Reduces buoy / vessel collision exposure time during connect and disconnect
- Small opening in vessel keel
 - Permits installation in flat bottom, even in vessels with a fine bow (e.g. LNG carriers)
 - No ovaling of opening during vessel hog and sag conditions
 - Reduced propulsion drag during transit
 - Opening can be plugged allowing for dry compartment when disconnected
 - Opening can be covered with flush fitting cover

The “First” KIT System

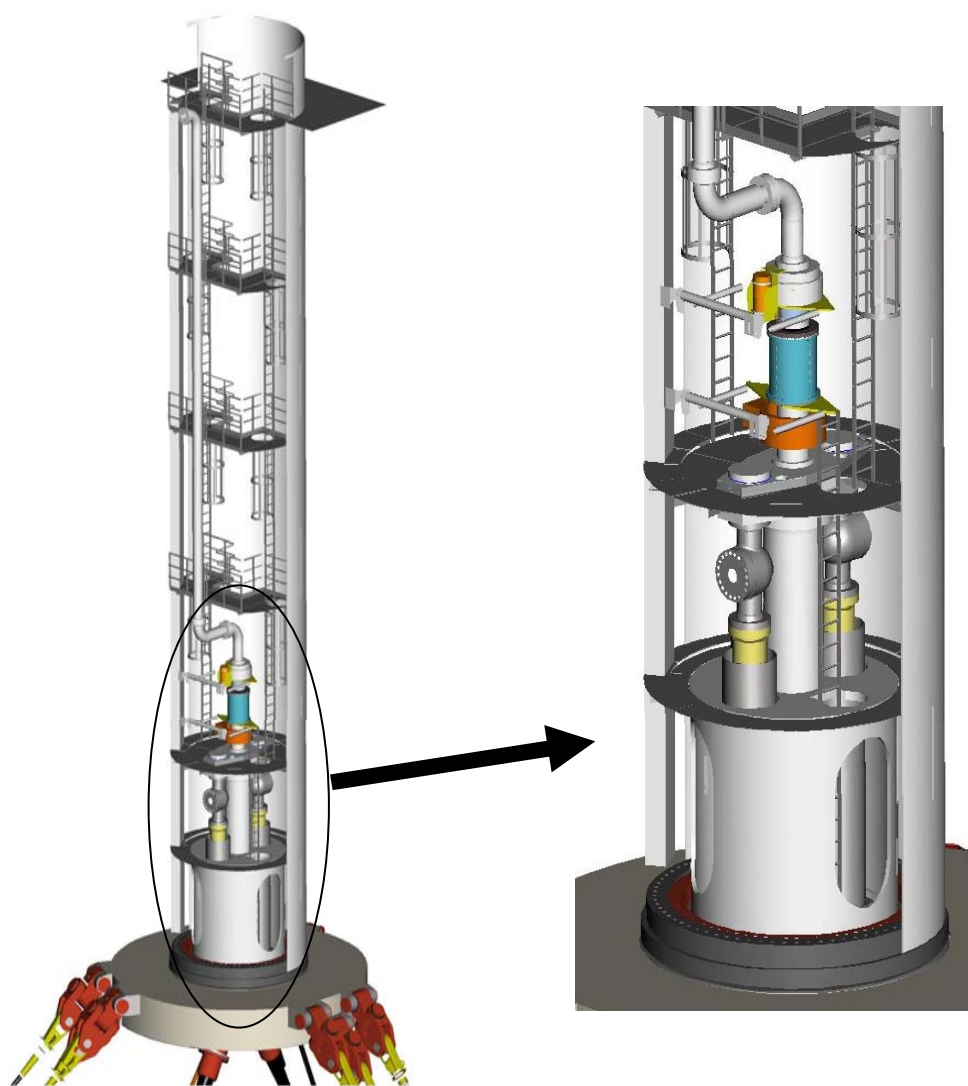
Permanent KIT System Description

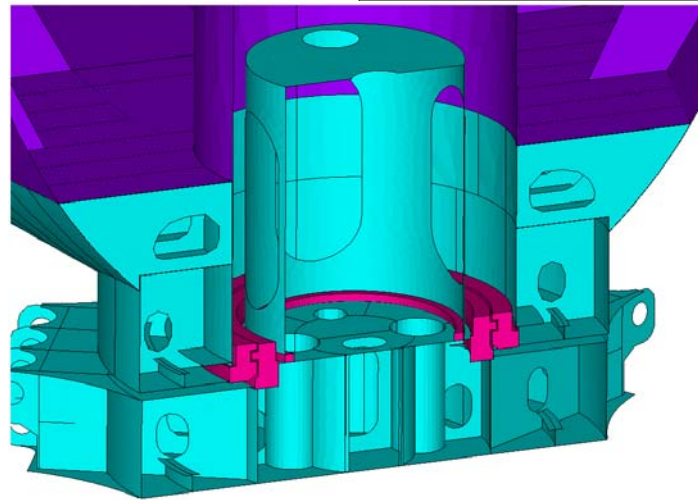
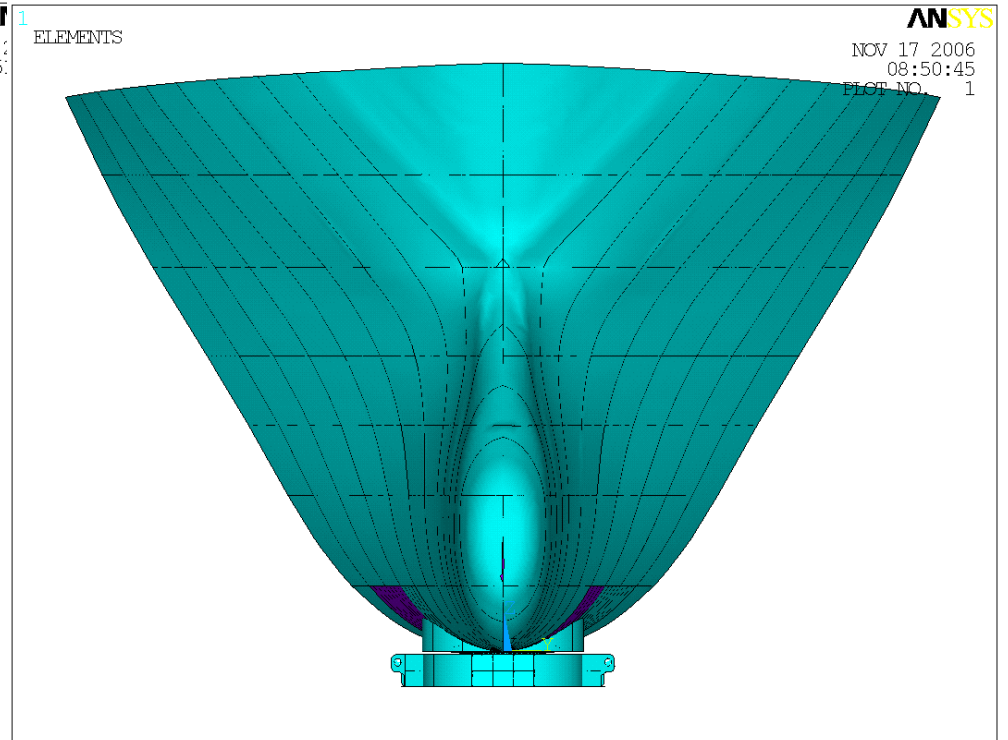
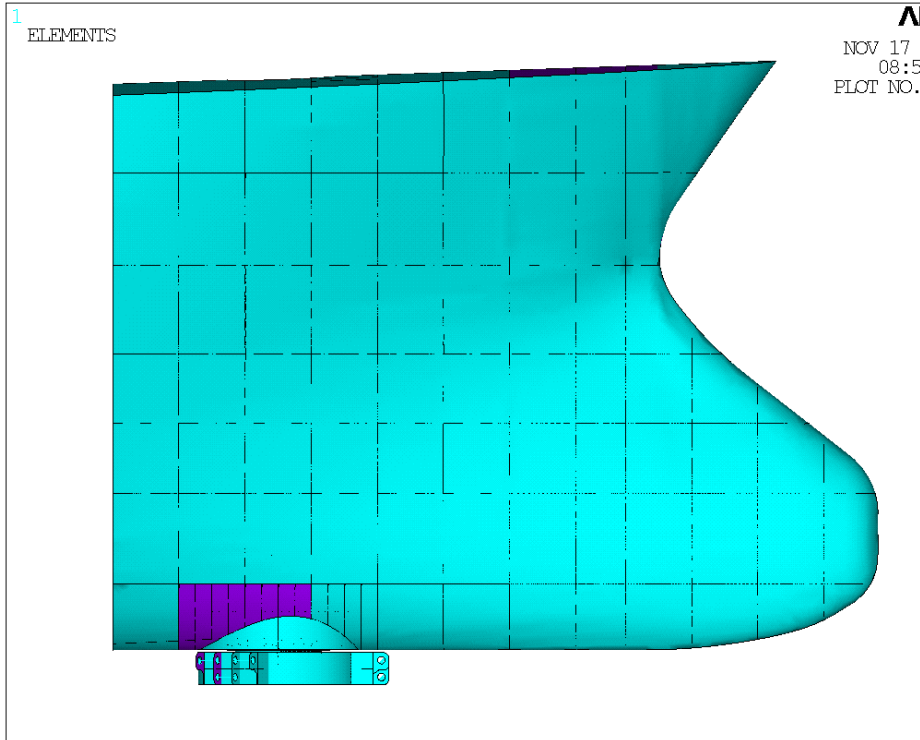
- Golar Speculative LNG FSRU

Golar FSRU Permanent KIT System

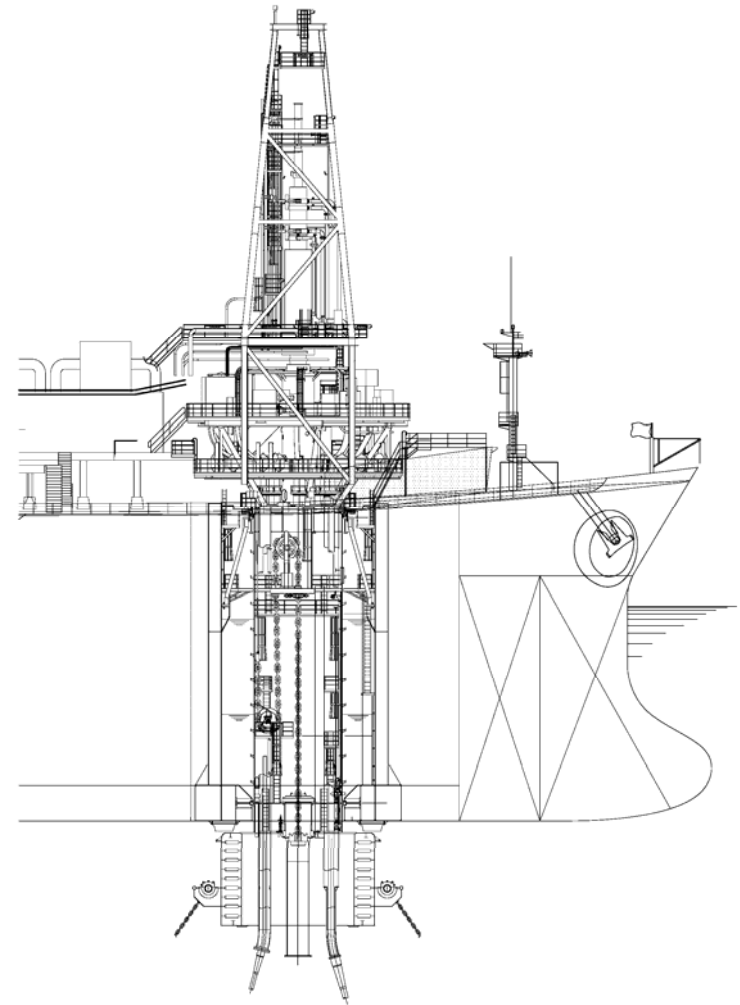
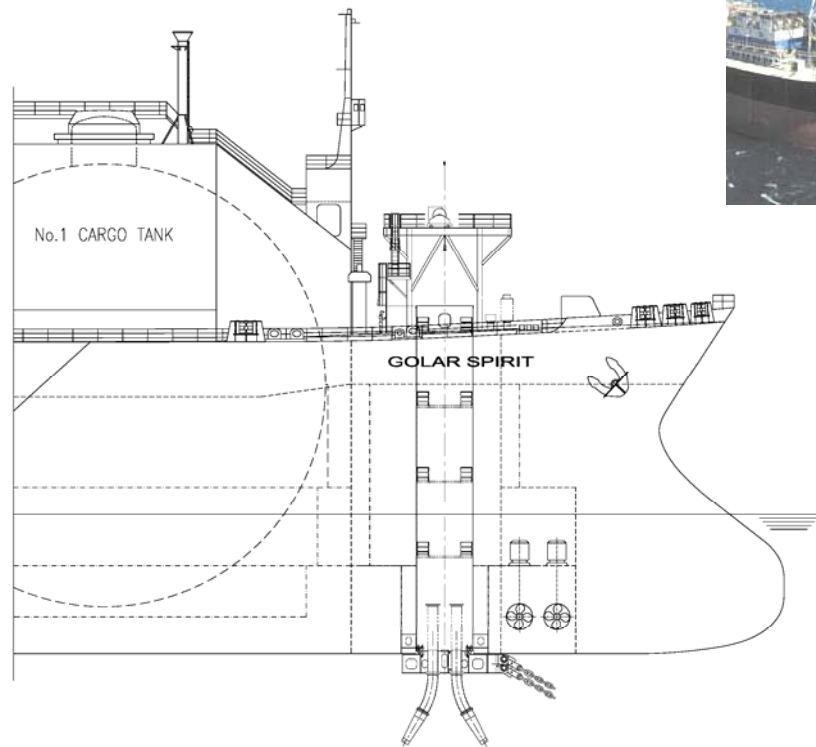


Golar FSRU Permanent KIT System



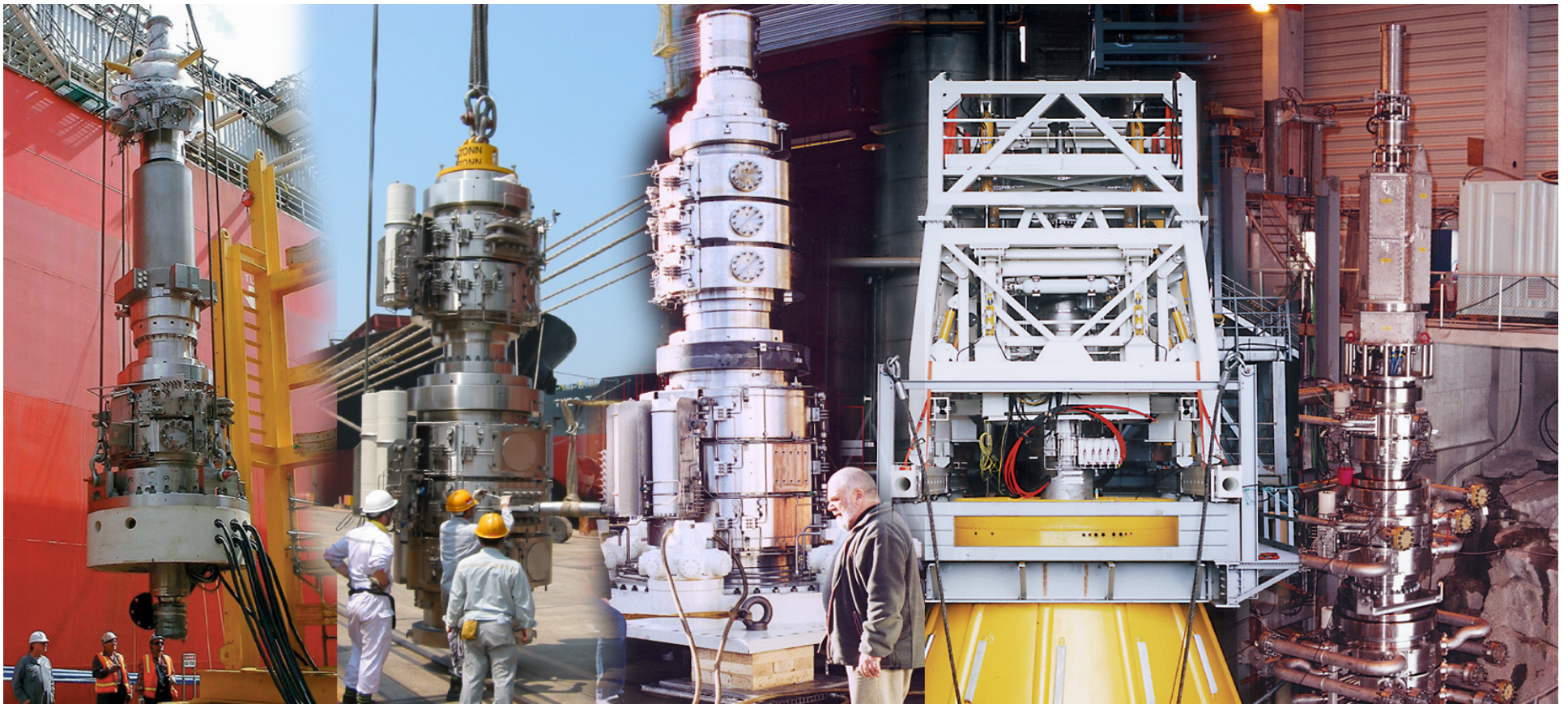


Golar FSRU KIT vs. Santos Mutineer/Exeter Disconnectable Turret



Framo Engineering - Swivel Stack & Fluid Transfer Systems

Framo Engineering AS can offer a range of Swivel Stack Systems and Fluid Transfer Systems for FPSO/FSO's used in oil and gas production.



Fluid Transfer Systems (FTS) and Swivel Stack Systems (per August '06)

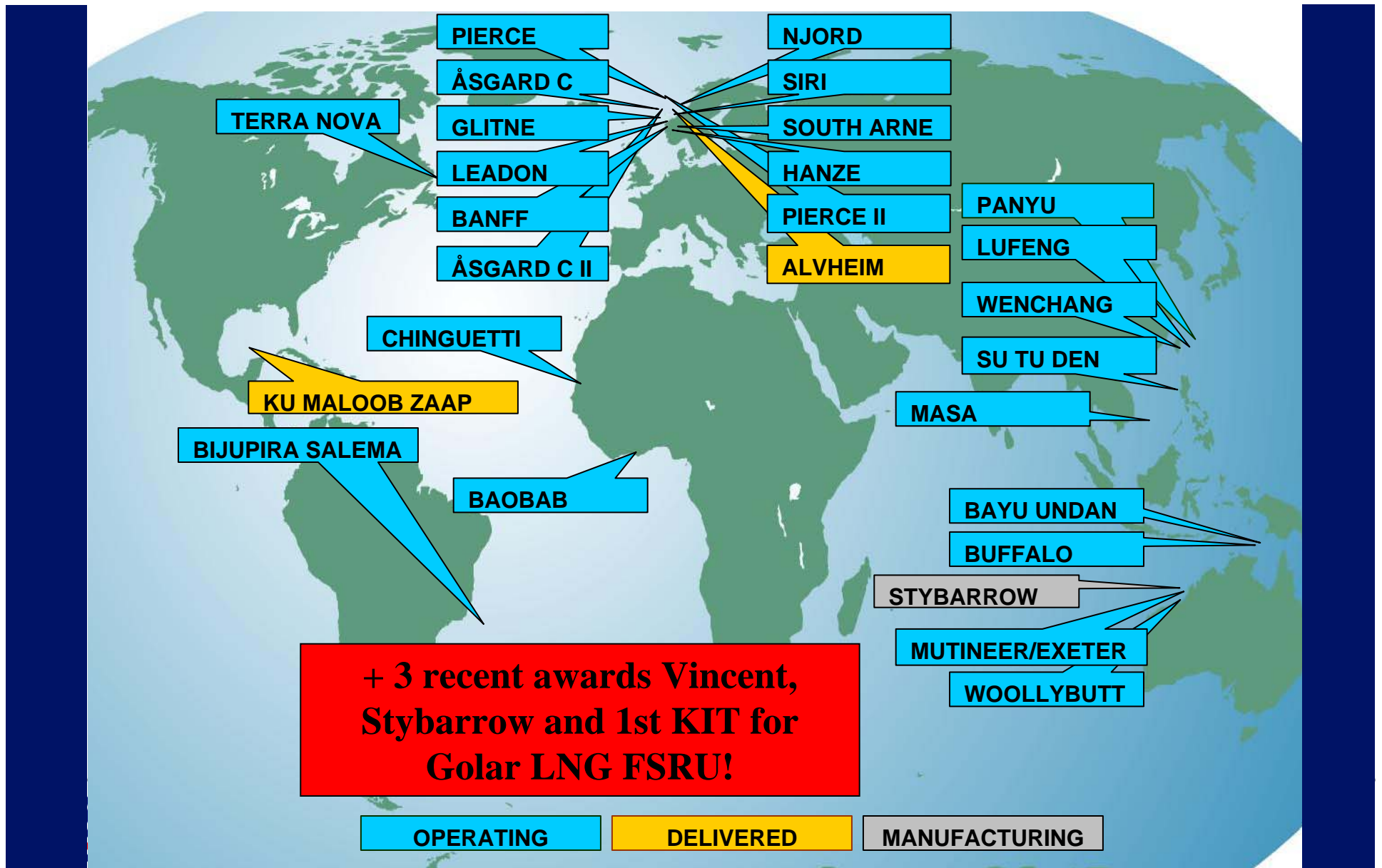


FTS & Swivel Stack Systems

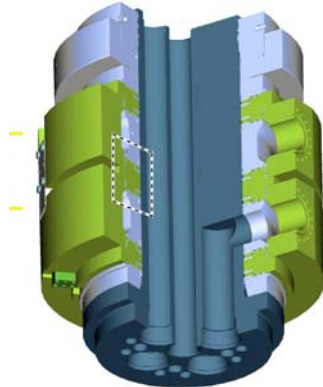
- 30 swivel stack systems worldwide
- 132 fluid swivels (all types)
- 12 fluid transfer systems
- Over 110 yrs operational experience accumulated (per Aug '06)
- Operating pressures - 414 bar



Framo Engineering - Reference Projects



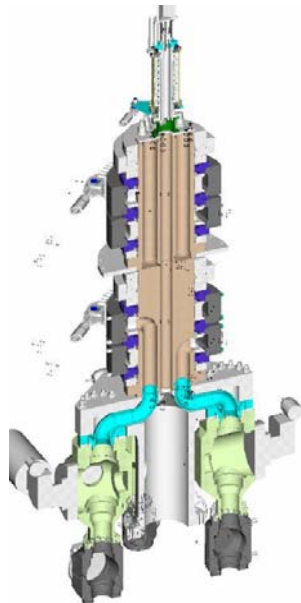
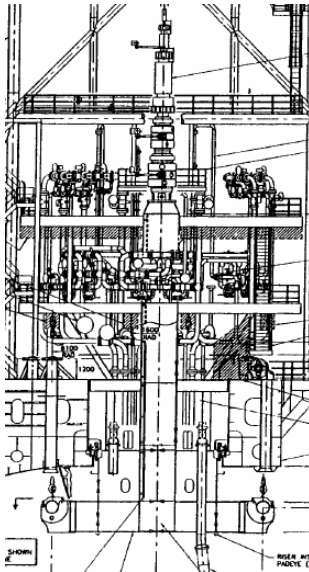
What is the purpose of a swivel and fluid transfer system?



Fluid Swivels

enables continuous transfer of fluids and utilities from a geostationary part (subsea, turret) to the process plant (vessel part) during any environmental condition

unlimited free weathervaning is achieved by using swivels. There are process activated and barrier activated swivels.



Fluid Transfer System

includes all swivels, slip rings and utilities, and all piping, valves, manifolds, & pigging systems. May involve transfer of riser loads and also various equipment for the turret and subsea, related to the production, injection and controls.

Fluid Transfer Systems: from top of risers to topside!

Framo Engineering - Recently Completed Projects

Bayu Undan – test at Framo facilities



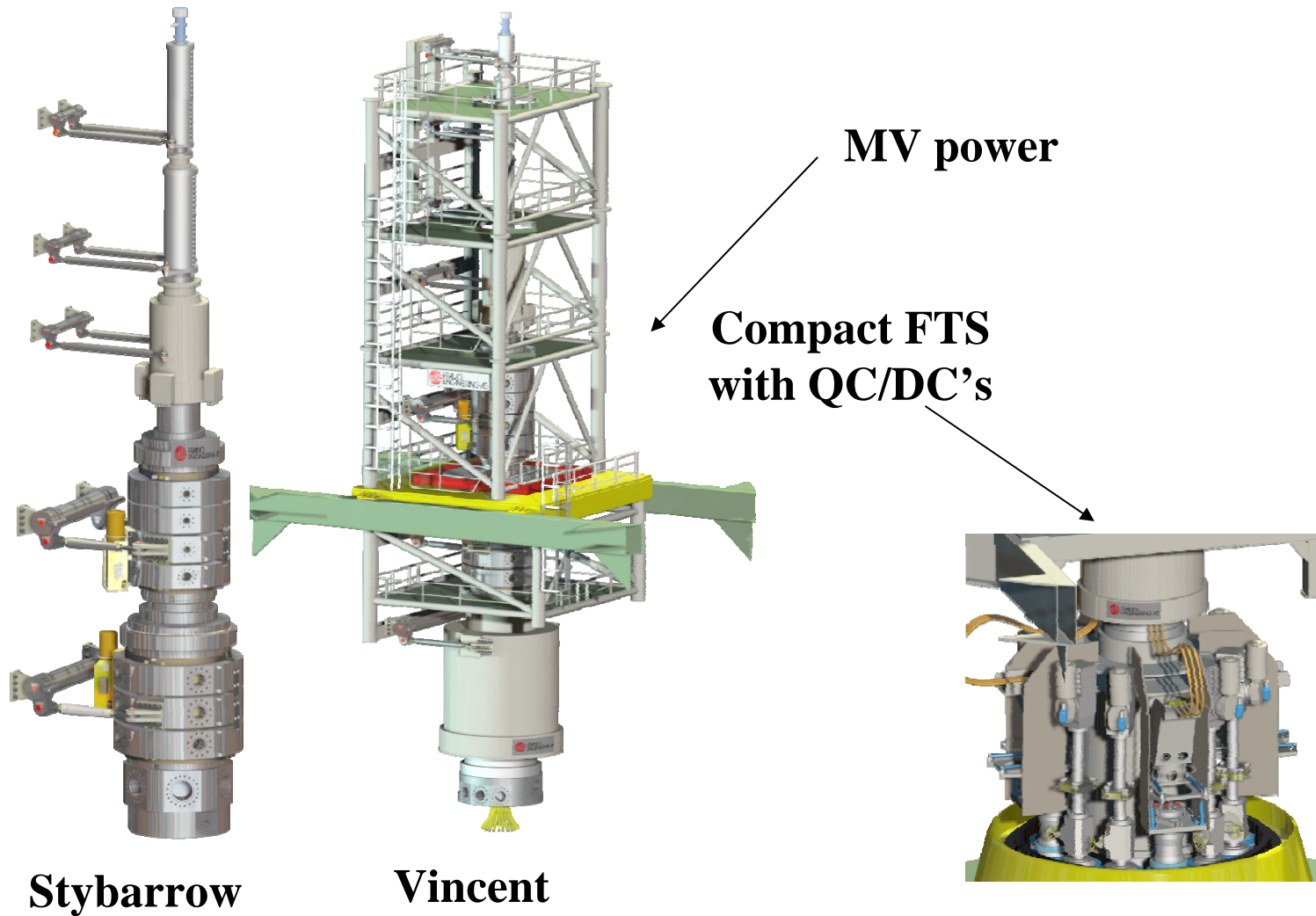
Pemex KMZ – installation in S'pore



Marathon Alvheim – ready to be installed in FPSO



Framo Engineering - Latest Awards



KIT Vessel Compartment

- Deck hatches, stairway, ladders, gateway and access deck
- Blast relief panel
- Open and closed drain
- Flooding / dewatering piping
- Deluge system
- F&G system
- PA and CCTV system
- Electrical and Instrumentation systems
- Ventilation system
- Fluid Transfer System with trolley arrangement including valves, piping, cabling both at turret and shipboard side



KIT Fluid Transfer System

- Swivel stack assembly and surround structure
- Hard piping/manifolding
- Flexible piping (if used)
- Valves (ESD, service, choke, isolation)
- Cabling
- Instrumentation
- Riser hang-offs
- QC/DC's
- Piping Connections
- Umbilical Connections

