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# **LNG Tandem Offloading System**

**Authors: Terry Boatman**

**Stephen Jones, Ron Mack**

# **LNG Tandem Offloading System for Harsh Sea Conditions**

Combining two existing & proven FMC technologies:

- LNG Loading Arm technology (FMC Loading Systems)
- Mooring yoke & mooring connector technology (FMC SOFEC Floating Systems)



# Conventional LNG Import Terminal

Lake Charles , LA

- Land based
- Regasification
- Storage
- Conventional Marine Loading Arms (MLA)



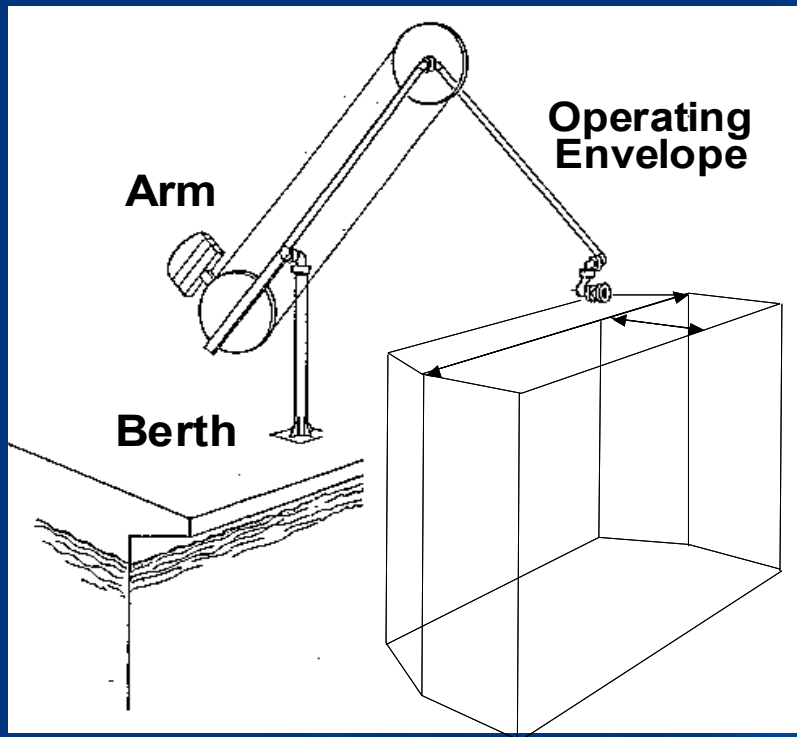


# Typical Marine Loading Arm Installations



# LNG Loading Arm Variables

## The Operating Envelope



- Location of terminal
- Wind, wave & currents
- Type of ship
- Mooring systems
- Water level, tidal variations



# Onshore – Protected from Weather (Conventional Terminal)



# Onshore – Protected from Weather (Conventional Terminal)

- **Typical Installation**
  - 3 Liquid / 1 Vapor Arm
  - 10,000 M3/Hr Flow
  - Typical Accessories
    - Emergency Release System
    - Manual Coupler
    - Position Monitoring System
- **Flange Connection Guidelines**
  - Vertical Displacement +/- 0.1 M
  - Horizontal Displacement +/- 0.1 M
  - Velocity +/- 0.05 M/Sec
  - Acceleration +/- 0.025 M/Sec<sup>2</sup>





# Onshore - Exposed

- **Typical Installation**

- 3 (2) Liquid / 1 Vapor Arm
- 10,000 M3/Hr Flow
- Typical Accessories
  - Emergency Release System
  - Hydraulic Coupler
  - Constant Motion Swivel Joints
  - Position Monitoring System

- **Flange Connection Guidelines**

- Vertical Displacement +/- 0.5 M
- Horizontal Displacement +/- 0.5 M
- Velocity +/- 0.25 M/Sec
- Acceleration +/- 0.125 M/Sec<sup>2</sup>





# Offshore - Ship to Ship

- **Typical Installation**

- 3 (2) Liquid / 1 Vapor Arm
- 10,000 M3/Hr Flow
- Typical Accessories
  - Emergency Release System
  - Hydraulic Coupler
  - Constant Motion Swivel Joints
  - Position Monitoring System
  - May Have Targeting System

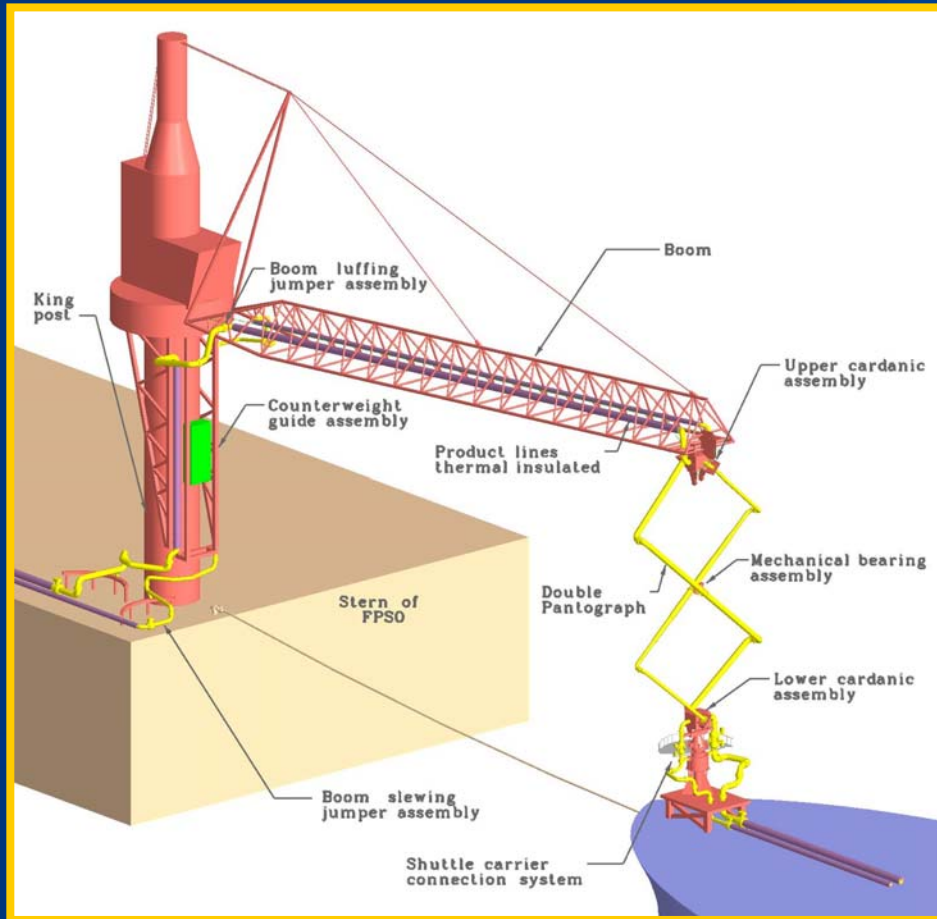
- **General Flange Connection Guidelines**

- Vertical movement +/- 2.5 M
- Horizontal movement +/- 1.7 M
- Velocity +/- 1.0 M/Sec
- Acceleration +/- 0.5 M/Sec<sup>2</sup>



# Offshore - Ship to Ship - Tandem Loading

## FMC Boom to Tanker (BTT)



Moderate sea conditions  
waves 2 to 4 m Hs  
Large & stable LNG FPSO

- JIP, 1997, BP, BHP, Shell, Texaco, Eni Agip, Gaz de France, Statoil, Woodside
- JIP - Model basin tests, tested relative motions
- Working model 1/5 scale now at FMC Sens France

# Tandem Loading (Boom to Tanker)

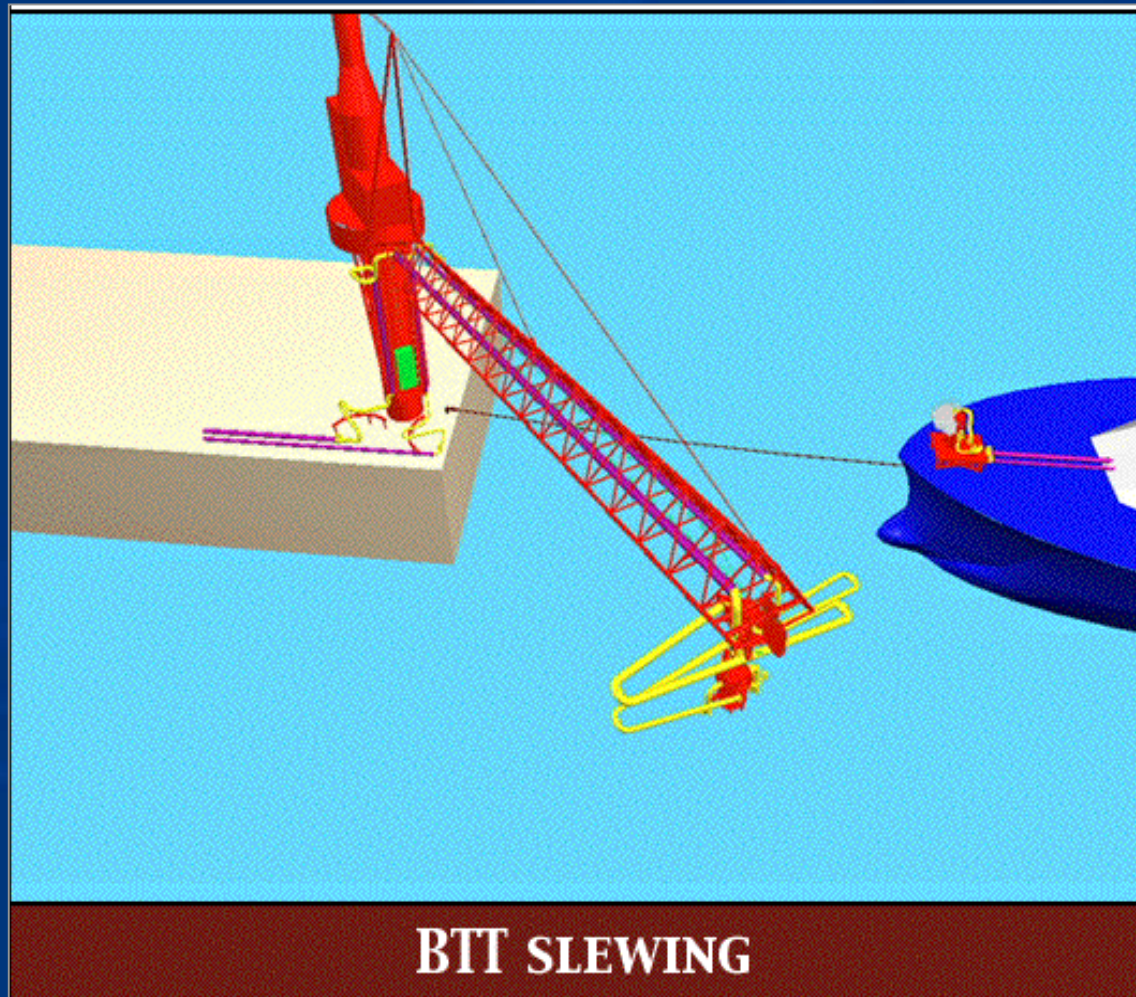
- **Typical Installation**
  - 1 (24 in.) Liquid / 1 (16 in.) Vapor Arm
  - 10,000 M3/Hr Flow
  - Typical Accessories
    - Emergency Release System
    - Hydraulic Coupler
    - Constant Motion Swivel Joints
    - Position Monitoring System
    - Targeting System
- **Connection Guidelines**
  - Heave +/- 5.0 M
  - Velocity +/- 2.5 M/Sec
  - Acceleration +/- 2.5 M/Sec<sup>2</sup>
  - 23.0 M Diameter Operating Envelope





# Ship to Ship - Tandem Loading

## FMC Boom to Tanker (BTT)



# Ship to Ship - Tandem Loading

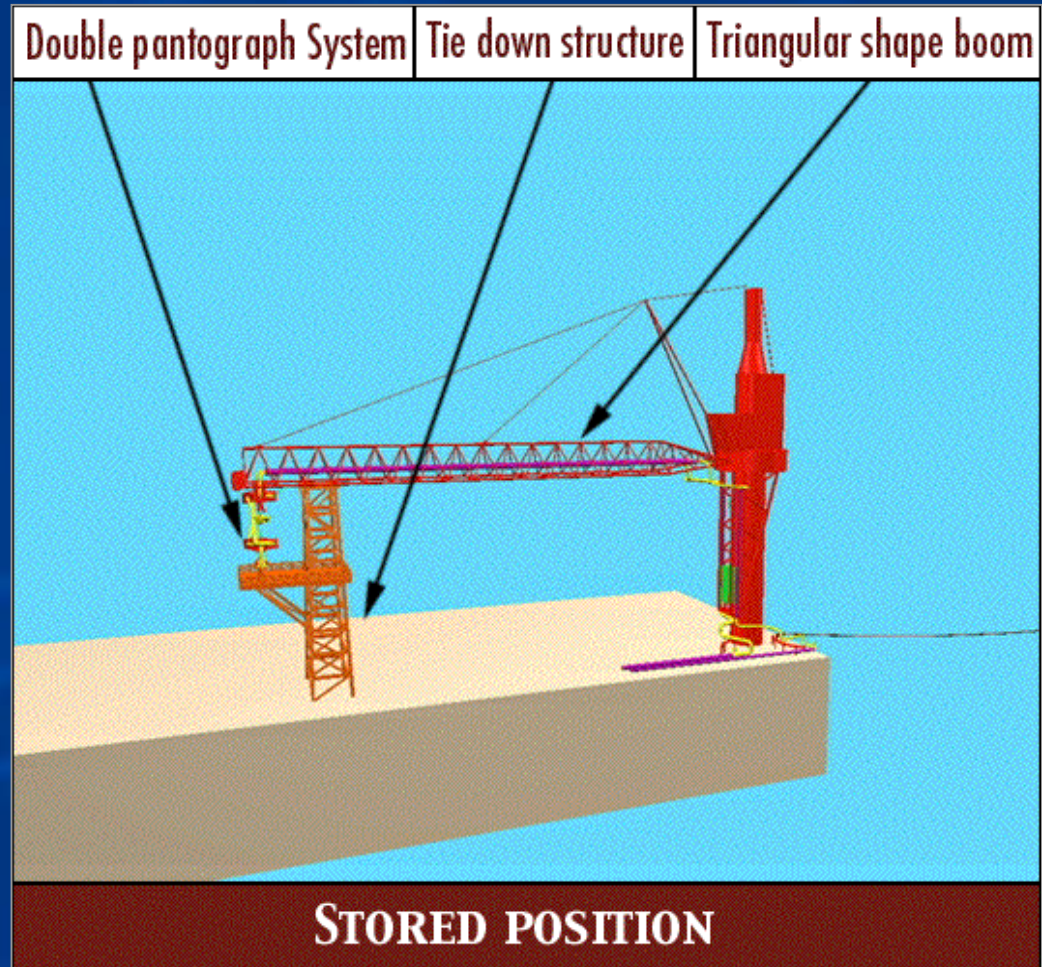
## FMC Boom to Tanker (BTT)

### Advantages

- Worse seas than allowed for side-by-side
- Relatively low cost for tandem loading
- Proven components

### Disadvantage:

- Dedicated LNG carriers with bow-mounted manifold





# FMC SOFEC Tower Yoke Mooring System

Constructed for CNOOC QHD32-6 FPSO, Bohai Bay



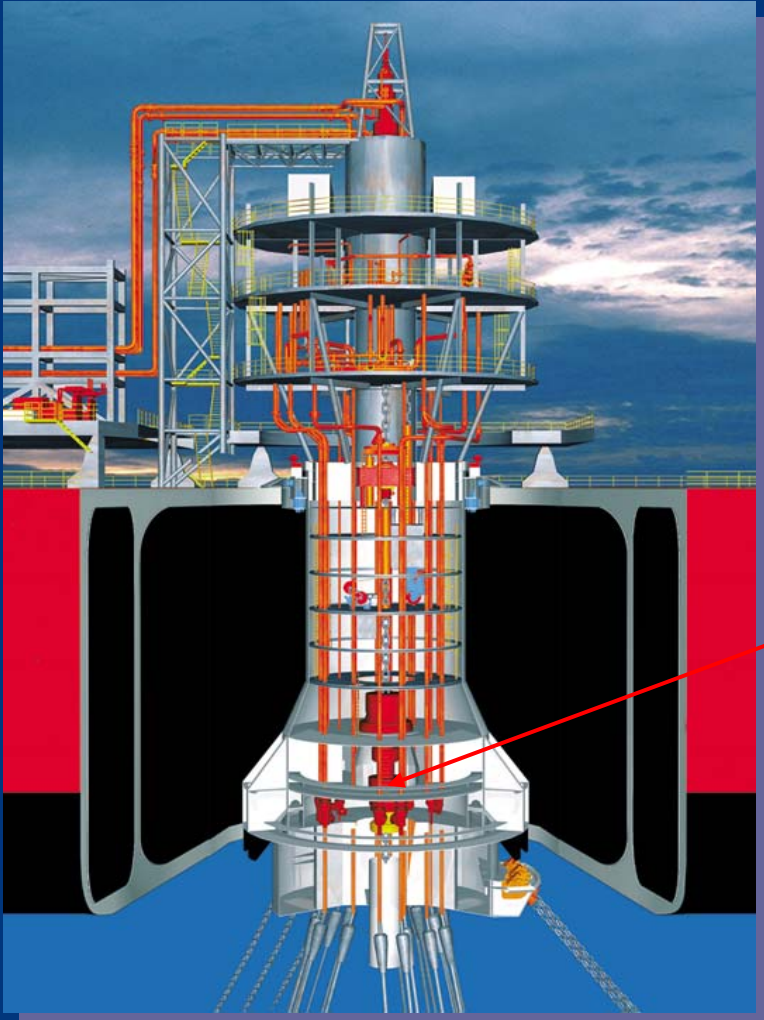


# FMC SOFEC Tower Yoke Mooring System

- CNOOC QHD32-6 FPSO



# Petro-Canada Terra Nova FPSO (Eastern Canada)



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

FMC 54" Hydraulic  
Connector

**World's first disconnectable  
turret system for icebergs**



# Combining Existing FMC Technologies



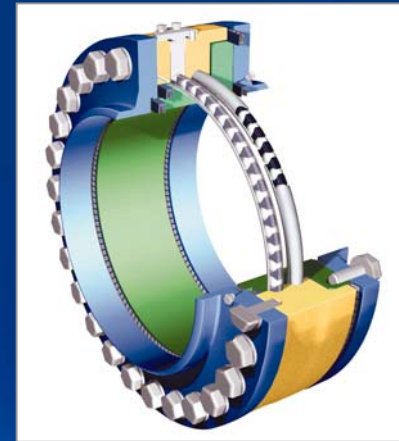
Shell Brunei LNG Terminal

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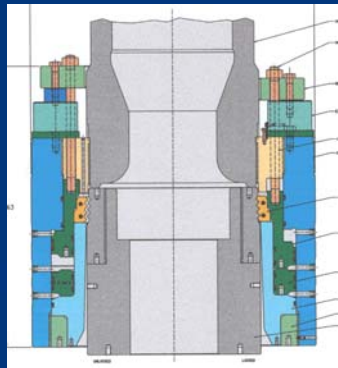
BTT

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Chiksan Marine LNG Swivel Joint

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FMC Connector

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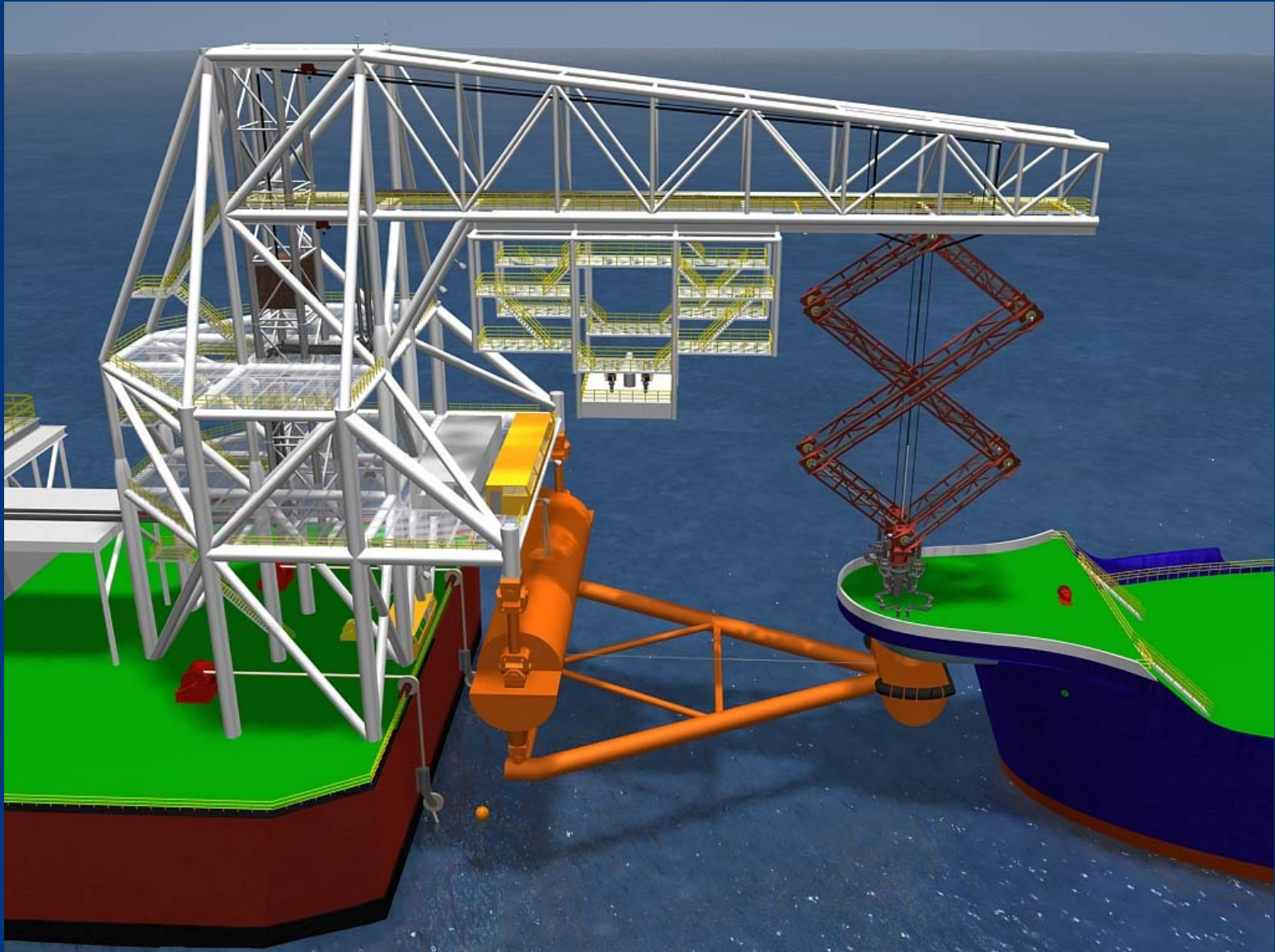
FMC SOFEC Yoke Mooring

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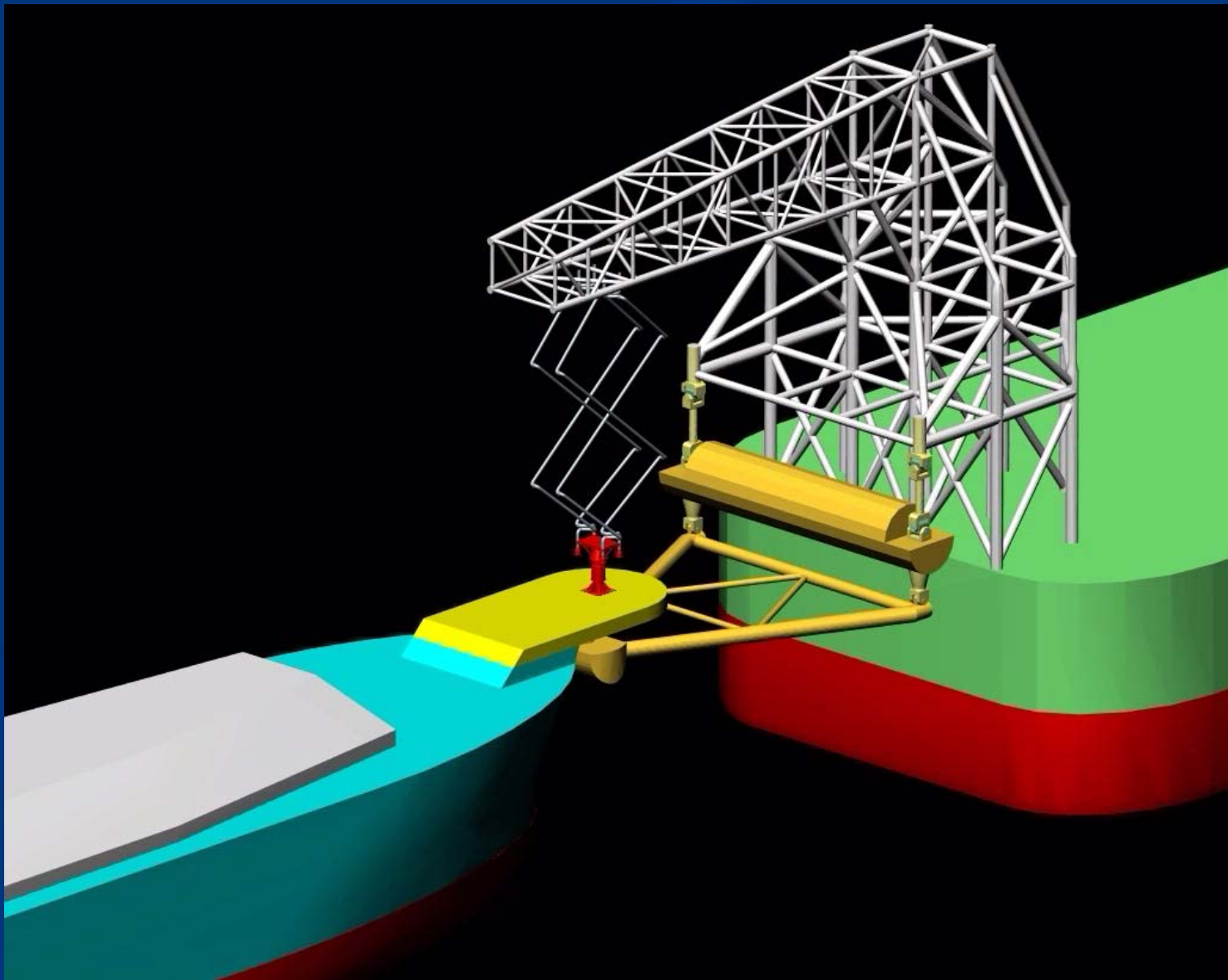




# Tandem LNG Offloading System

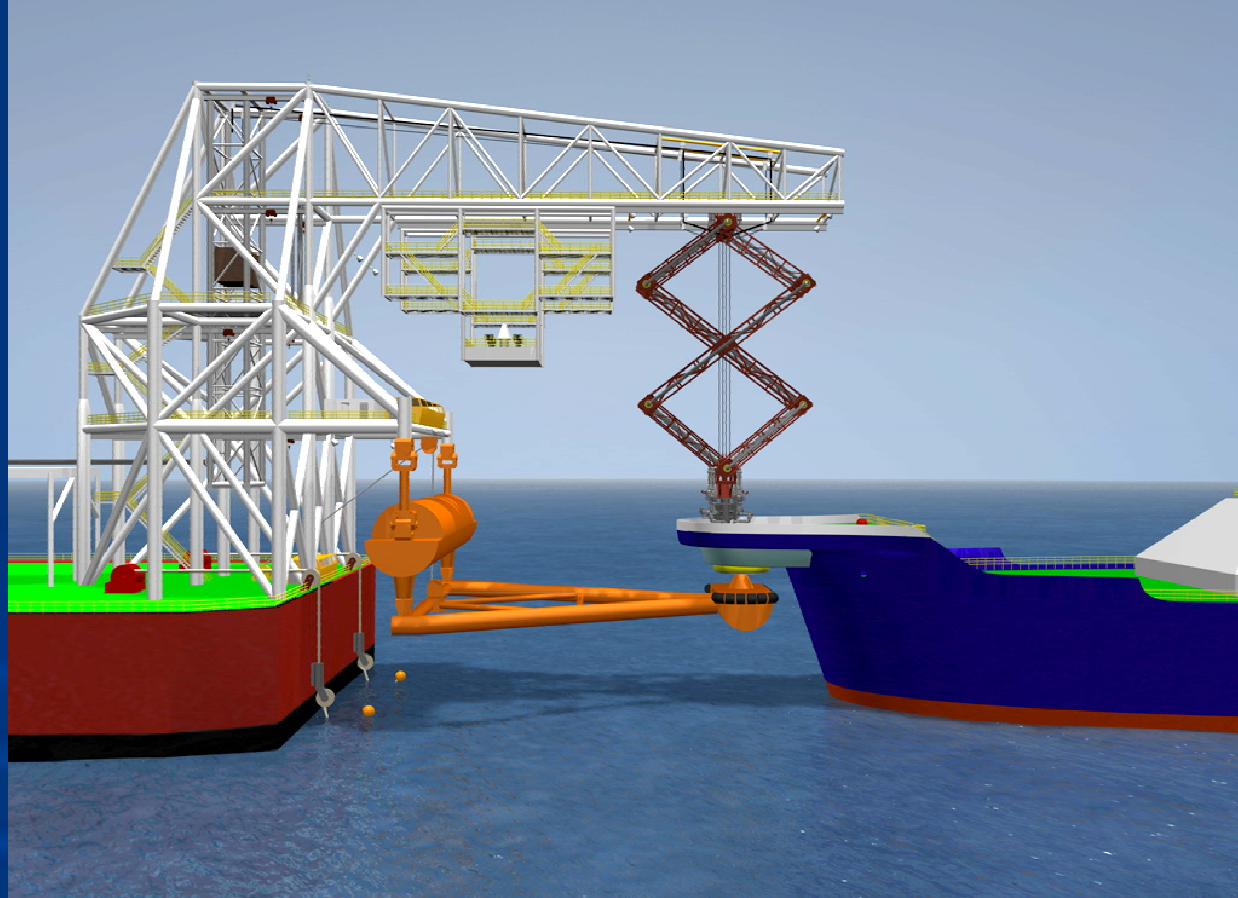


# Yoke & Pantograph – Relative Vessel Motion



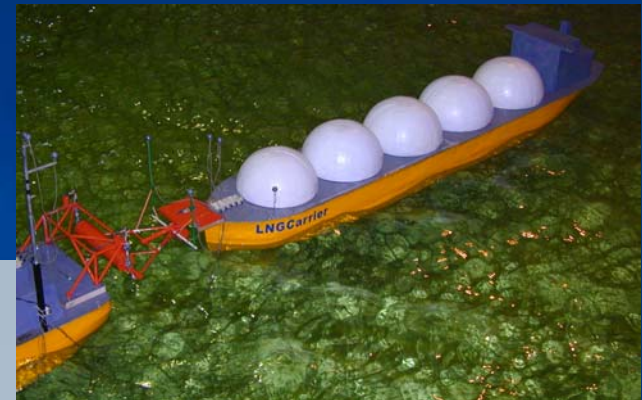
# Tandem LNG Offloading System For Harsh Sea Conditions

- **Mooring Connection**  
3.5 m Hs wave
- **Operation & Offloading**  
5.5 m Hs wave
- **Connected**  
> 5.5 m Hs wave





# Tandem Mooring - Model Testing Completed



## LNG Carrier and LNG FPSO Dimensions

	LNG Carrier	LNG FPSO	
<b>LNG Capacity</b>	<b>142,000</b>	<b>240,000</b>	<b>Cubic Meters</b>
Displacement .....	114,465	168,220	Metric Tons
Length of vessel at waterline .....	270.8	300.0	Meters
Beam of vessel at waterline .....	45.3	54.5	Meters
Vessel draft .....	11.3	12.5	Meters

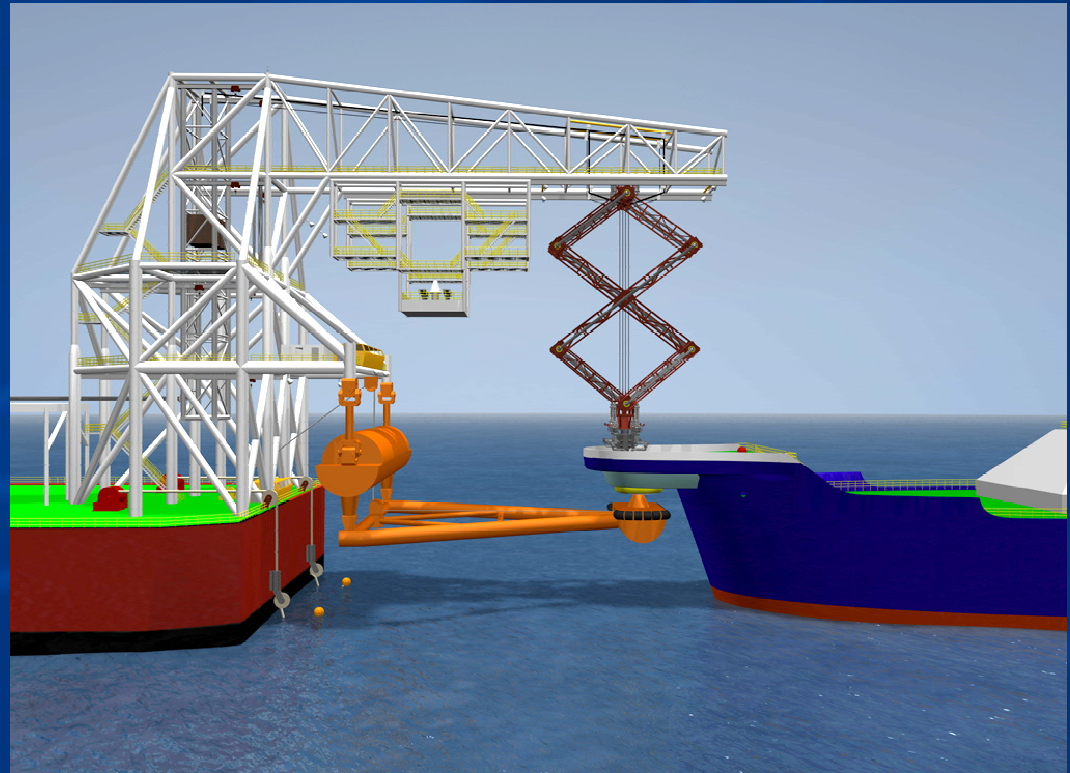
# LNG Offloading System Design Criteria

- 15,000 m<sup>3</sup>/hr LNG @ -162°C
- 3 lines, 16" LNG (5000 m<sup>3</sup>/hr each)
- 1 line, 16" Vapor (28,000 m<sup>3</sup>/hr vapor)



# Major Design Features of LNG System

- Provides **simple** LNG connection by vertically suspending the LNG loading arm (pantograph) from a stationary outboard boom
- Utilizes **industry proven** LNG transfer system components
- The LNG transfer system and mooring system are **separate and independent systems**
- Disconnection from LNG piping is totally **independent** from the mooring disconnection





# Major Design Features of the Mooring System

- Duplex mooring yoke **minimizes relative sway motions** between the vessels to maximize LNG loading availability
- Utilizes **industry proven** yoke and high load capacity FMC connector technology
- **Maximum safety** during mooring the LNG carrier
  - simple procedures
  - minimal assistance from auxiliary vessels



# **Sequence of Operations**

## **Connection of LNG Carrier Vessel**

# LNG Carrier is Pulled to FPSO by Winches & Hawsers

## Astern Thrust by LNG Carrier





# Hawsers Pull In, Reverse Stern Thrust



# Retrieval Yoke Messenger Line Onboard LNGC



# Yoke Pull-In Line Connected





# Yoke Retrieval Line Tightens Up



# Yoke Clears Water



# Yoke Cone Enters Connector Cone





# Yoke Connected, Service Platform Moves



# Pantograph Messenger Line Lowering



# Pantograph Pulling Down

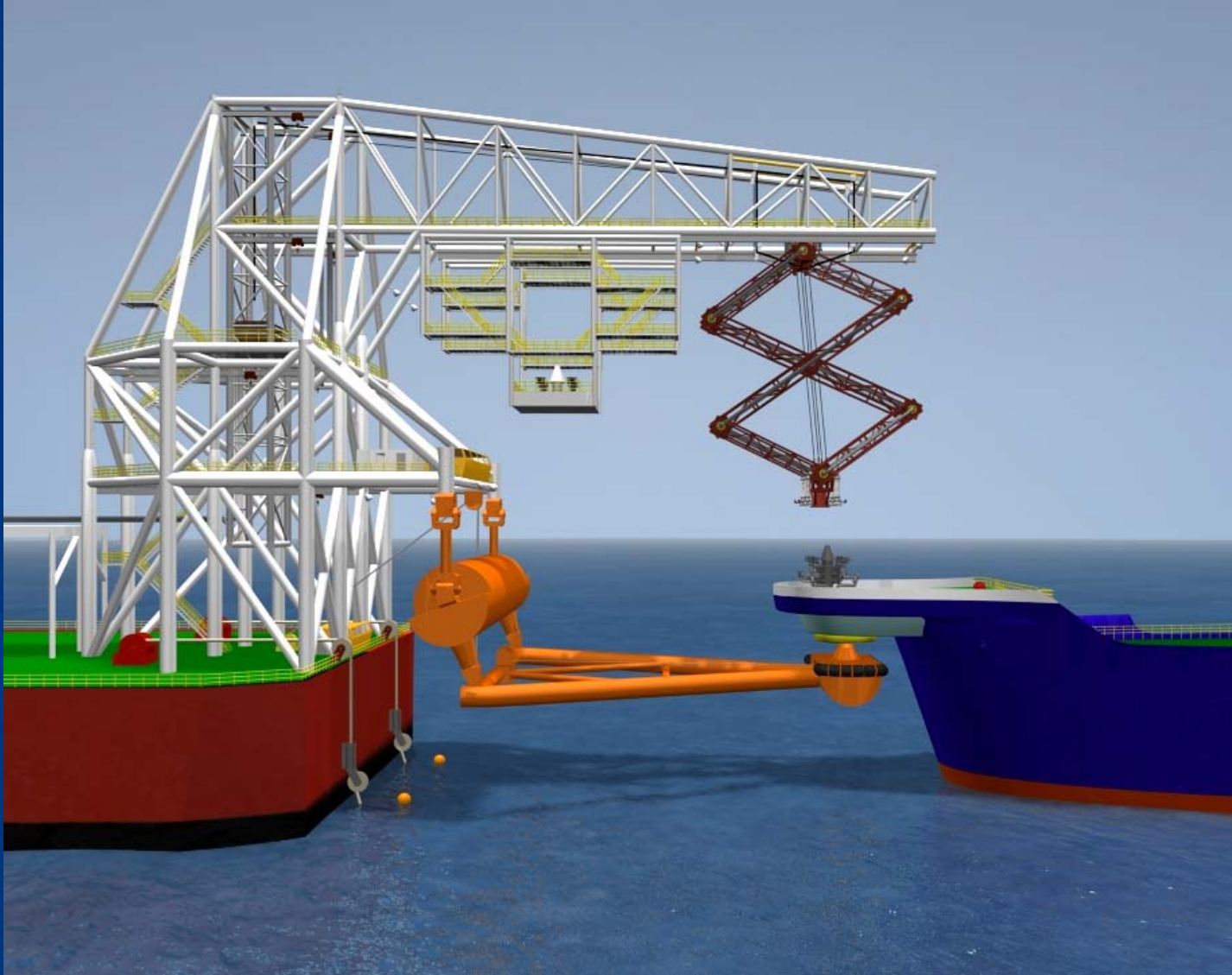




# LNG Piping Connected, Offloading LNG



# LNG Offloading Completed, Piping Pantograph Disconnects



# Lowering Yoke





# LNG Pantograph Parked, Wait for Next Carrier



# LNG Carrier Mooring & Loading



# Tandem LNG Offloading System



## Conclusion