Floating Offshore LNG Receiving and Regasification Facility

For the Gulf of Mexico

Presented to

OMAE 2005

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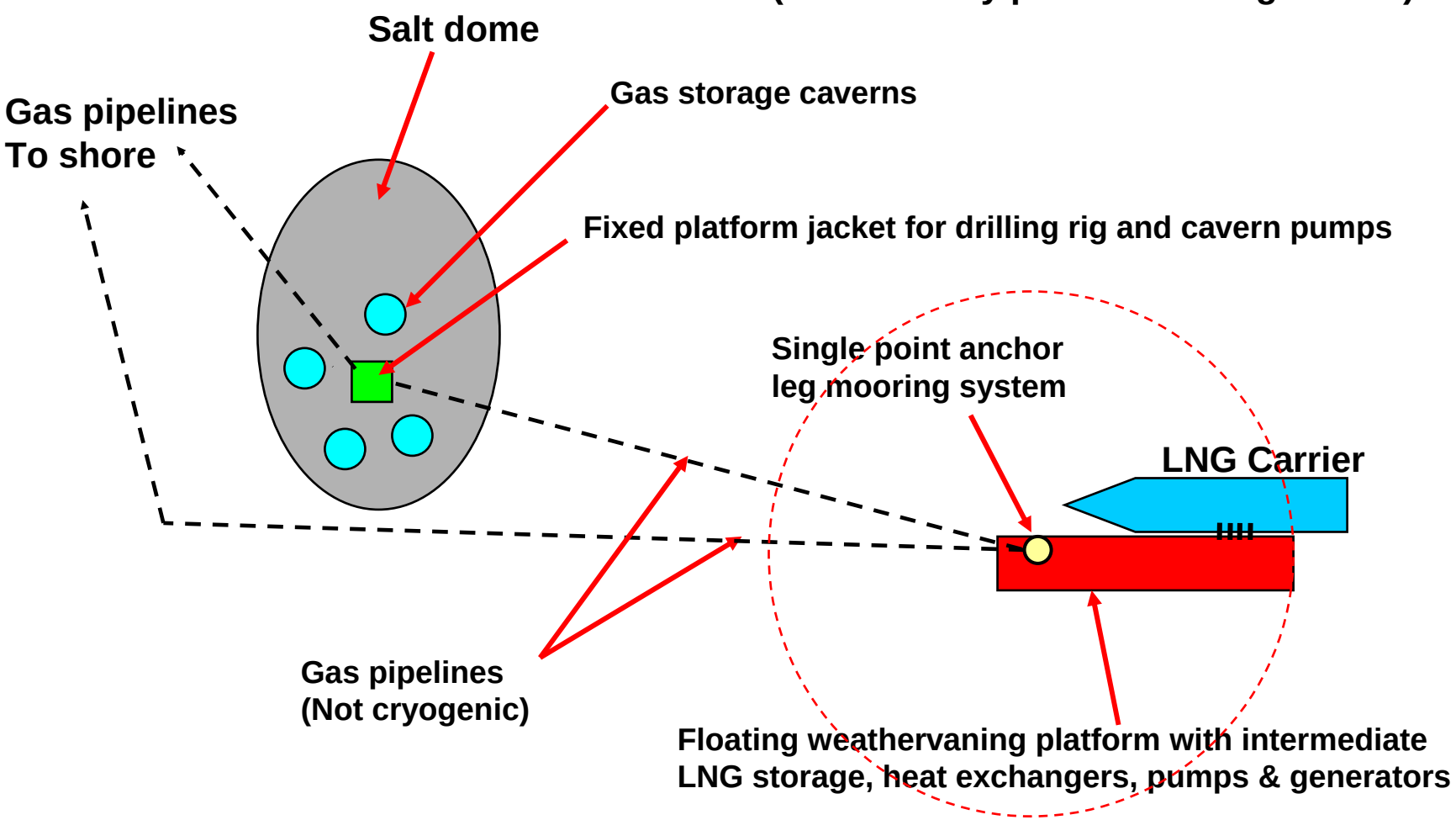
FMC EnergySystems

FMC SOFEC Floating Systems

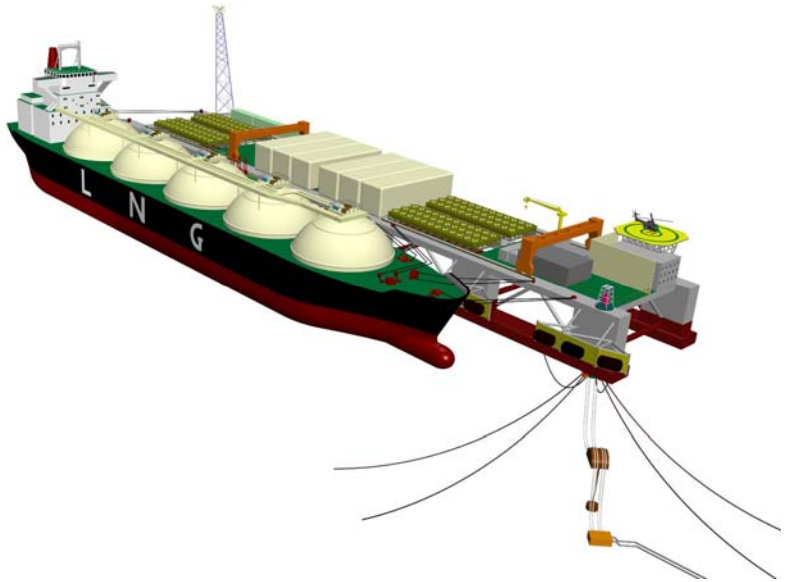
Floating Offshore LNG Terminal - Gulf of Mexico With Gas Storage in Salt Caverns

(One of many possible arrangements)



Operational LNG Offloading Objective for a Floating & Weathervaning LNG Regas Facility

- **Safely berth/unberth carriers 99% of time in Gulf of Mexico**
- **Design Conditions:**
  - **Berth Carriers in 2.5m Hs (8.2 ft)**
  - **Offload in up to 3.5m Hs (11.5 ft)**



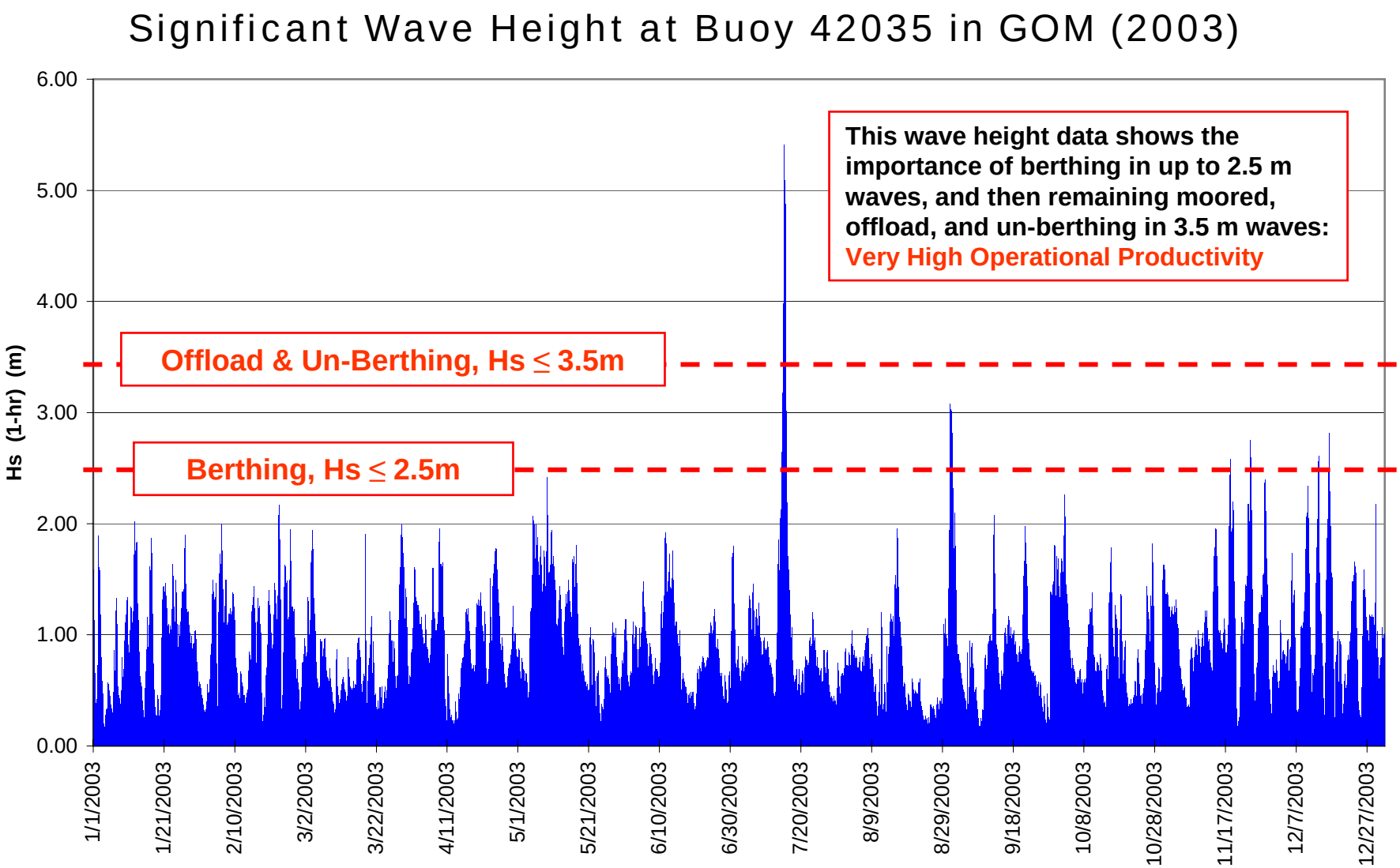
LNG Ship Berthing at a Shore Facility

Gaztransport & Technigaz GT No 96 Membrane Containment

Seagoing Tug Operations

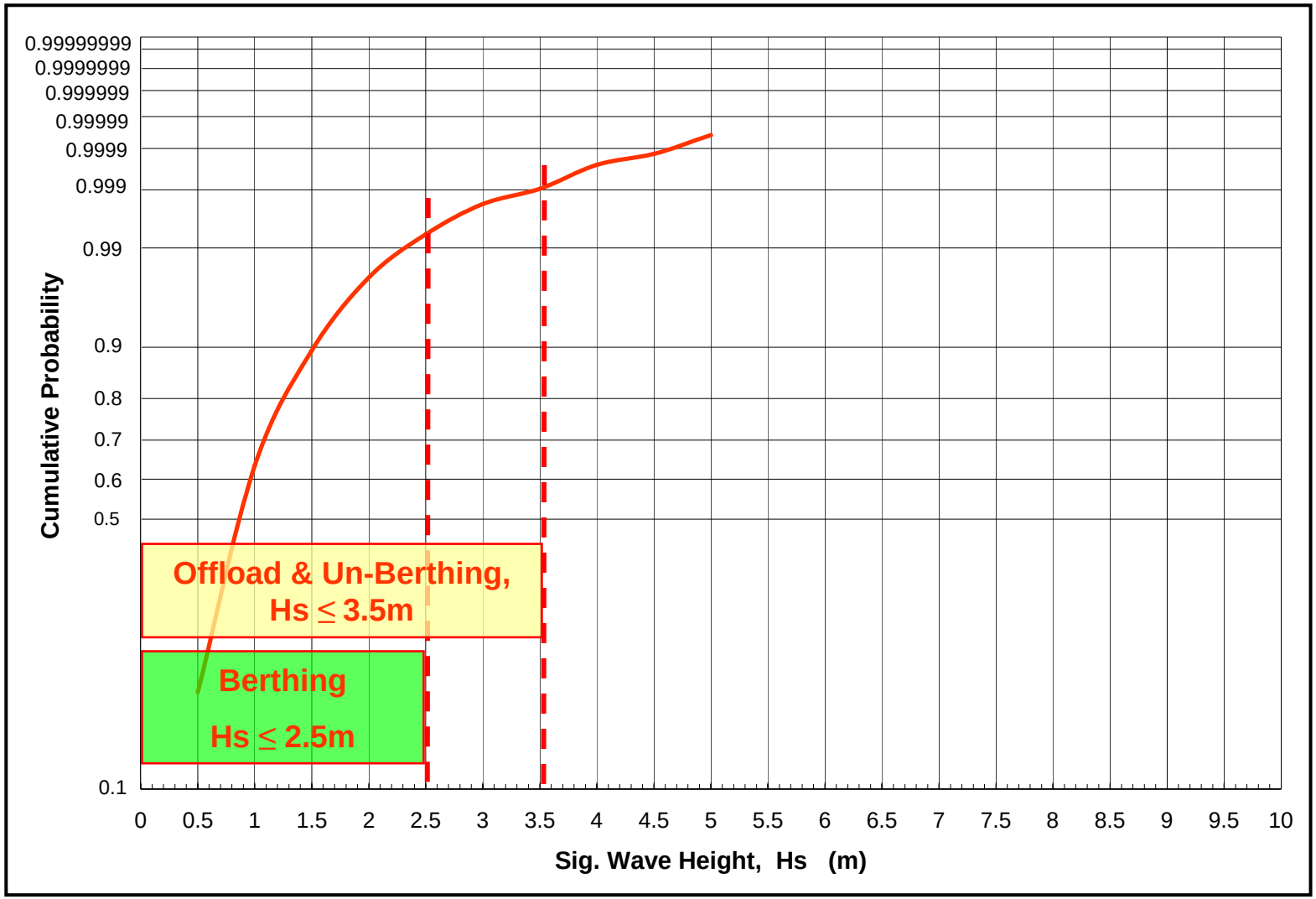
- Limitations of large seagoing tugs:
  [Ref: OCIMF Mooring Equipment Guidelines, p.18, Oil Companies International Marine Forum**]**
  - Limited to 1.5 m waves in conventional push handling on hull sides of ships due to tug motions, especially with the tug broadside to the waves
  - Excessive power of tugs can result in over compression of fenders and damage to the ship's side
- Advantages of tug operations with the FMC Floating Offshore Re-Gas Facility
  - Eliminates need for tug pushing on ship sides while rolling in heavy seas, berthing accomplished in **2.5 m waves**, use hawsers only
  - Seagoing tugs can safely tow ship in over **3.5 m waves** when tugs not broadside to the waves (2.5 m = 8.2 ft, 3.5 m = 11.5 ft)
  - Platform **moves to** the stationary ship while held by tugs fore and aft while berthing
  - Platform **moves away** from ship when un-berthing

Wave Height Data (Hs) vs Date – Shallow Water Location

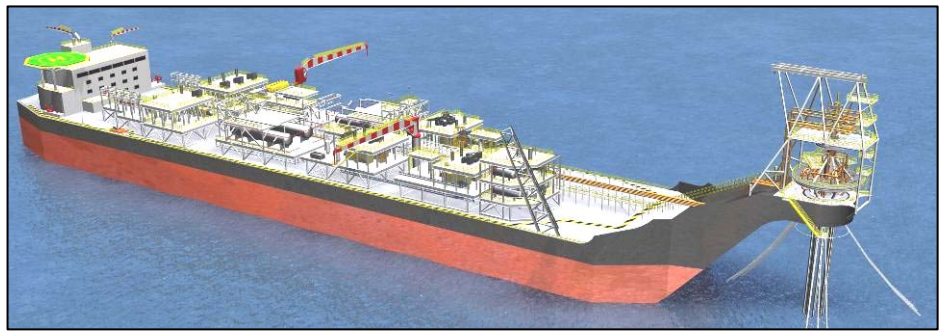


Wave Height Data (Hs) – Shallow Water Location

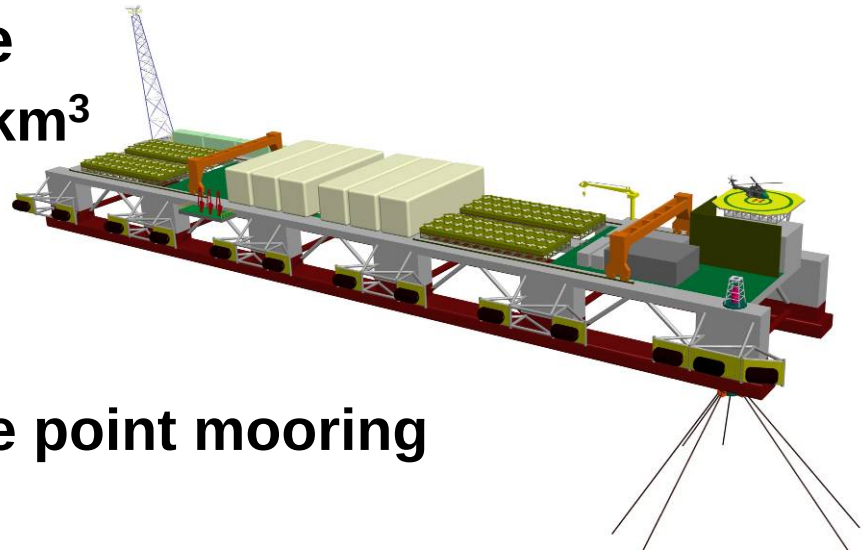
Cumulative Probability Distributions of Waves at Buoy 42035 in GoM



Hull Structures for Weathervaning Terminals



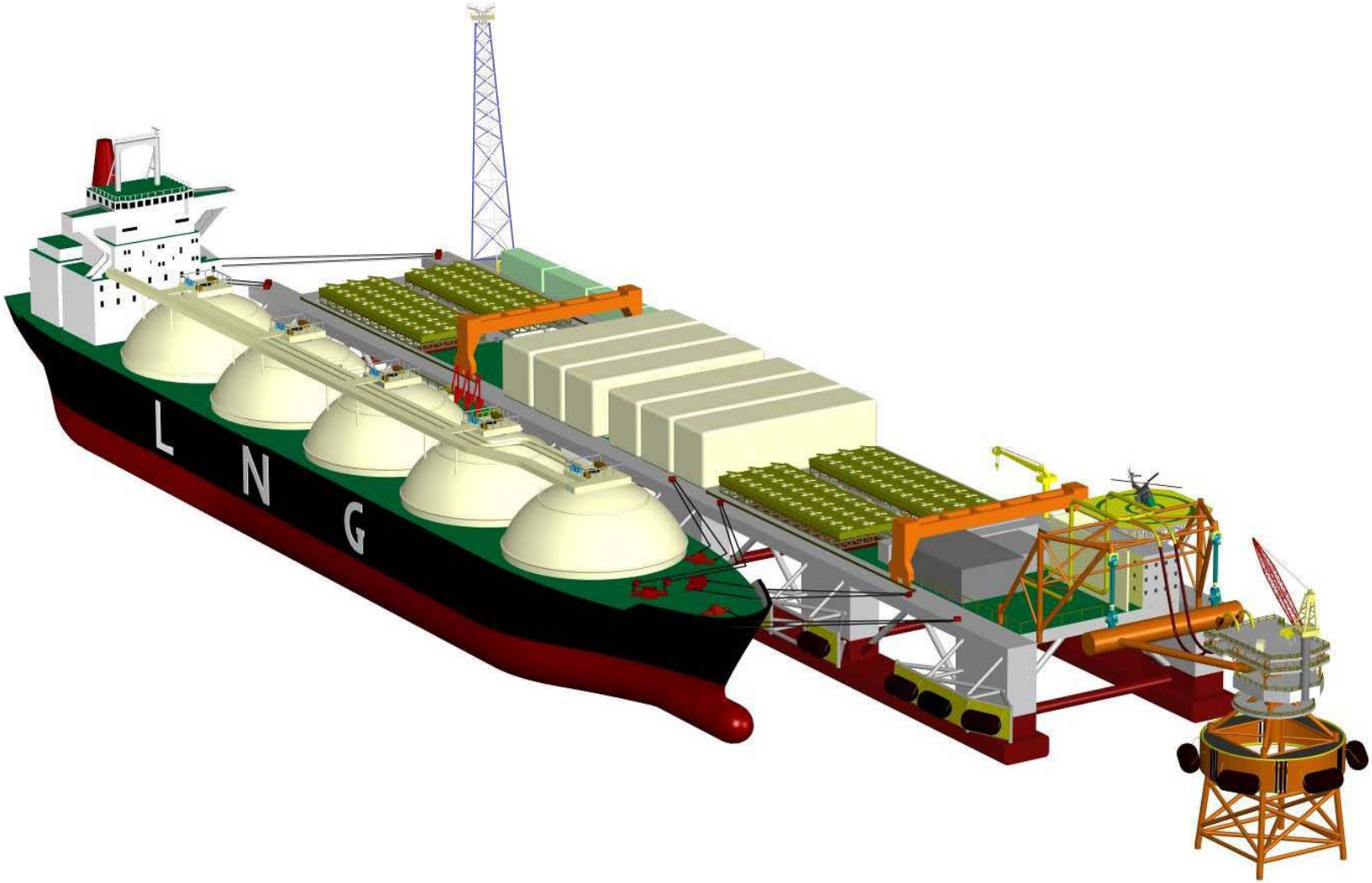
- **Monohull (ship type)**
  - **Large LNG storage**
  - **Long shipyard delivery**
  - **Motions larger**
  - **Slower to swing around single point mooring (SPM)**



- **Column stabilized structure**
  - **LNG storage 25 km^3 to 38 km^3**
  - **Fab-yard construction**
  - **Delivery time faster**
  - **Vessel motions smaller**
  - **Faster swing around single point mooring**

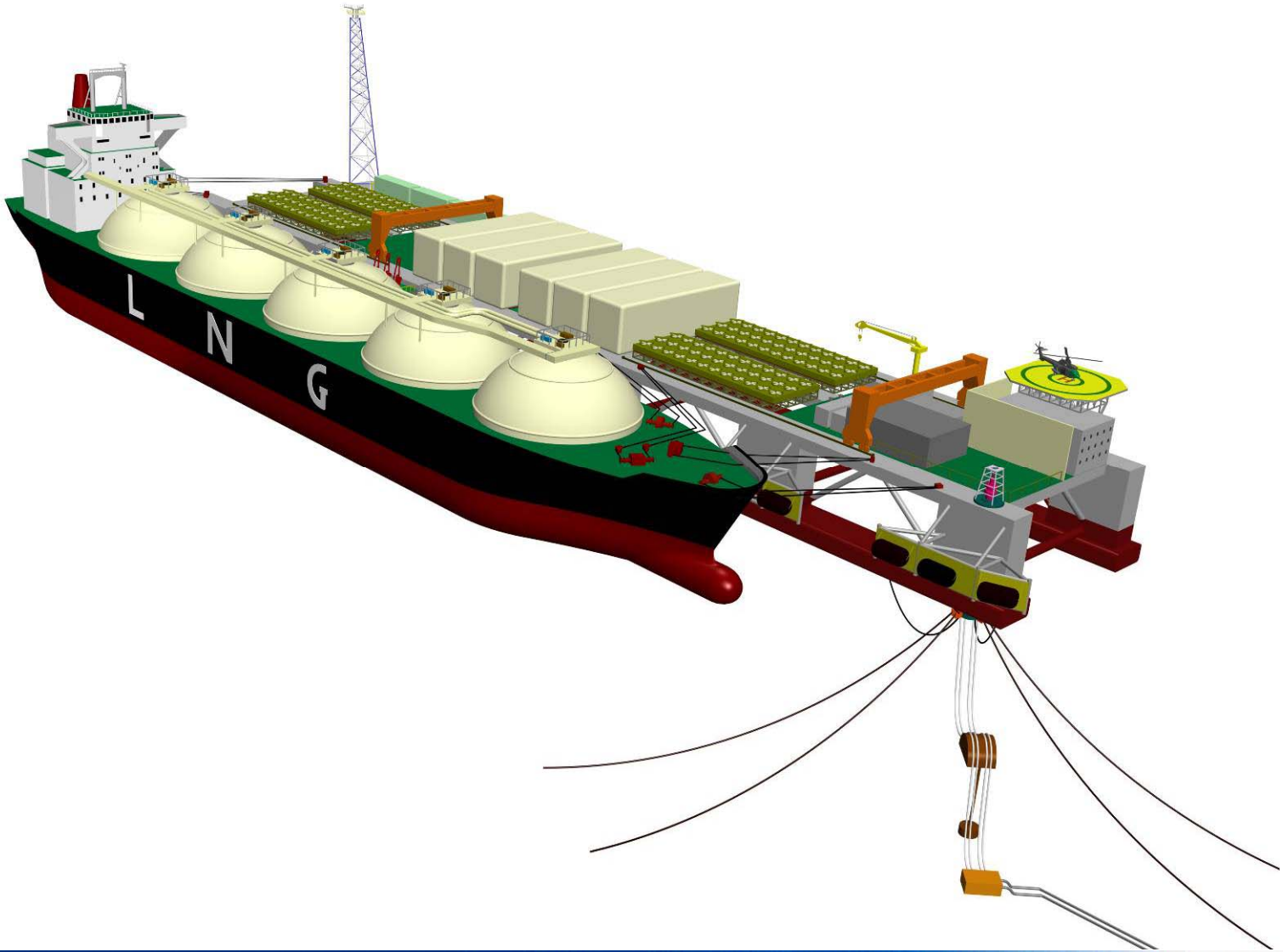
FMC SOFEC LNG Floating Platform

Column Stabilized Platform for Shallow Water, under 40 m (131 ft)



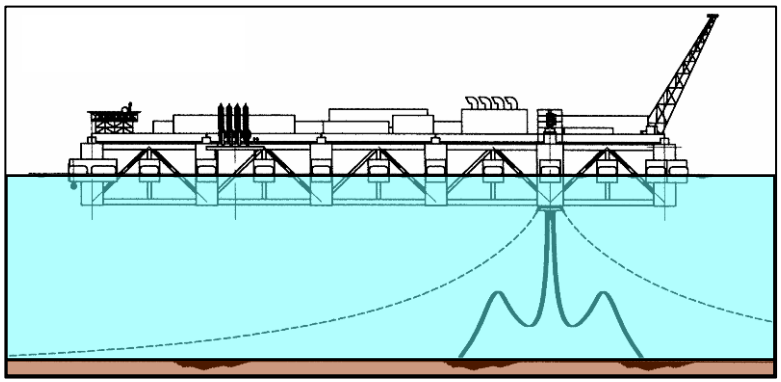
FMC SOFEC LNG Floating Platform

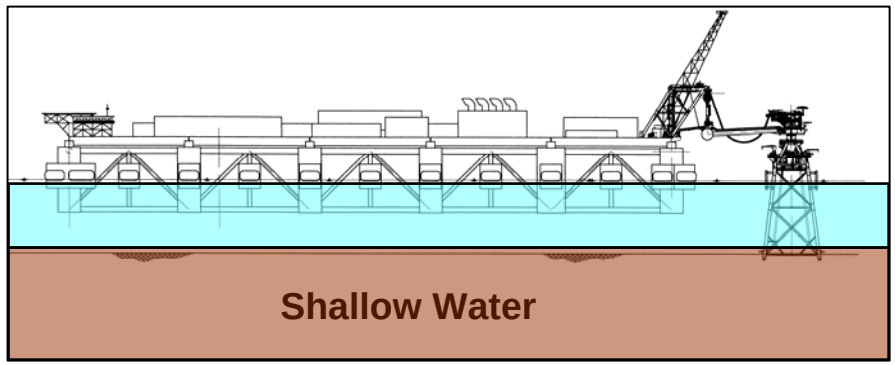
Column Stabilized Platform for Deep Water, over 40 m (131 ft)



FMC SOFEC LNG Floating Platform
Concept Advantages

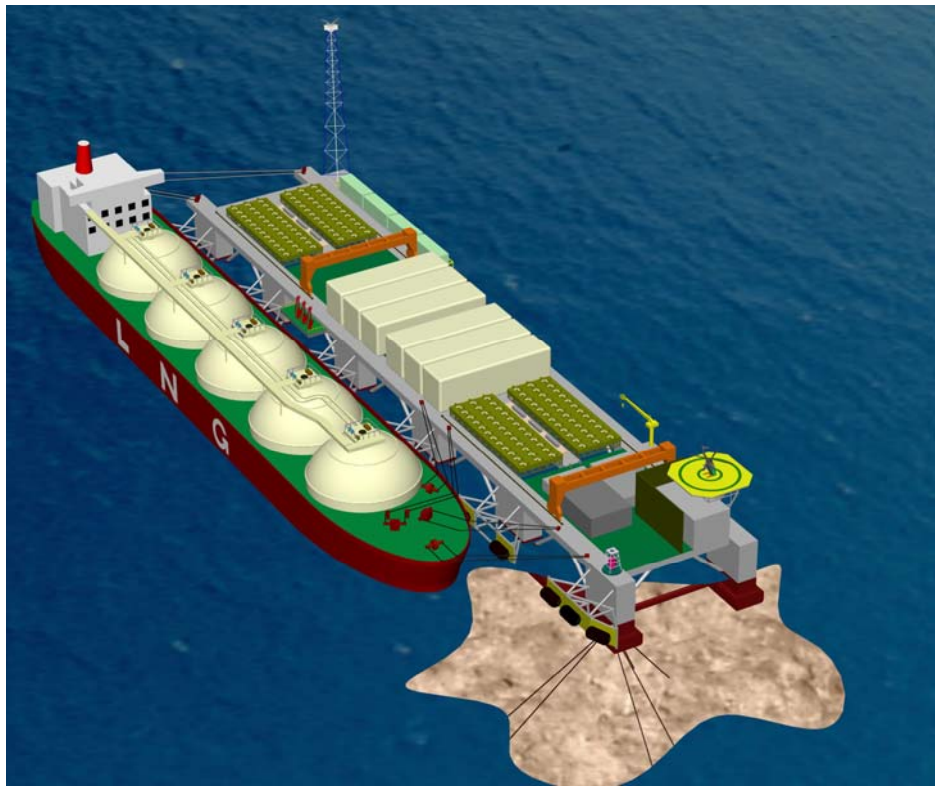
- Platform design suitable in <u>any</u> water depth (deep or shallow)
- Ample deck space for space separation of modules = safety
- Achieves minimum relative motions between platform & ship = improved operational availability
- Active position control using thrusters = higher operational safety for carrier mooring
- Construction efficiency, float out completely tested system
- Least introduction of new technologies
- Size scalable as needed for increased gas throughput





Weights & Dimensions – LNG Storage 25,000 m^3
Column Stabilized Platform for Deep Water over 40 m (131 ft)

- Deck Load 10,000 t
- LNG & storage tanks 18,000 t
- Structure 26,000 t
- Displacement 54,000 t
- Dimensions
  - L = 334 m (1096 ft)
  - B = 62.8 m (206 ft)
  - Depth = 26 m (85 ft)
  - Draft = 11 m (36 ft)



- **Compare displacement with loaded 250k m^3 LNG carrier:**
  - **Carrier displacement approx. 175,000 ton**
  - **Platform weight (displacement) = 31% of LNG carrier wt.**

Vaporization Process,

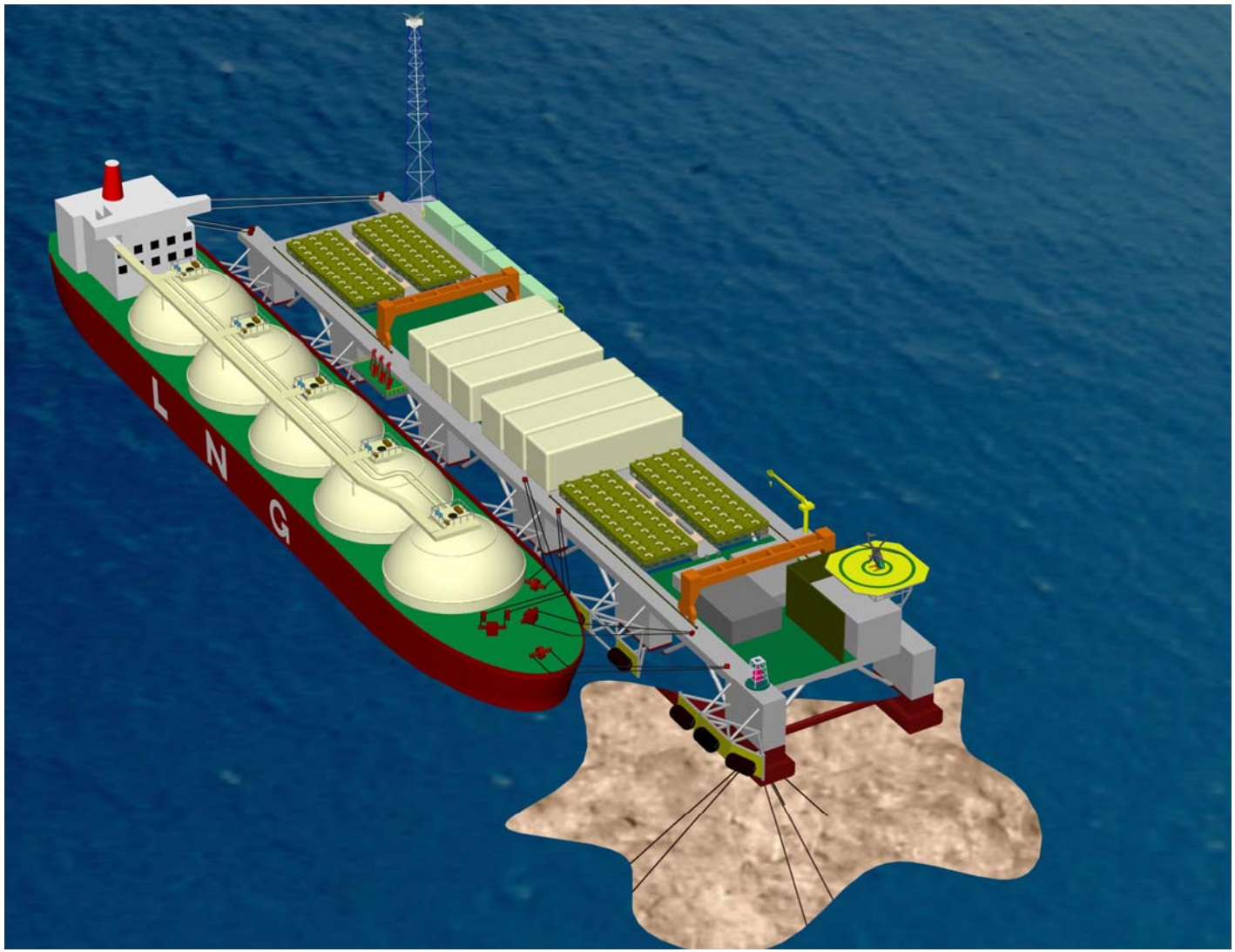
Marine Equipment & Components

Many Vaporization Processes Are Suitable for FMC SOFEC Floating Terminal

- Submerged combustion vaporizers (SCV's)
- Seawater vaporization
  - Shell & tube heat exchangers
  - Closed loop or open loop
- Ambient air vaporization
  - Mustang Smart™ Regasification System
  - Supplementary SCV's
- The choice of vaporization equipment depends on location site, economics, and circumstances

FMC SOFEC Floating Platform

with Mustang Smart™ Ambient Air Vaporizer System



Tandem FPSO & FSO Oil Offloading to Tankers

The Future for LNG?

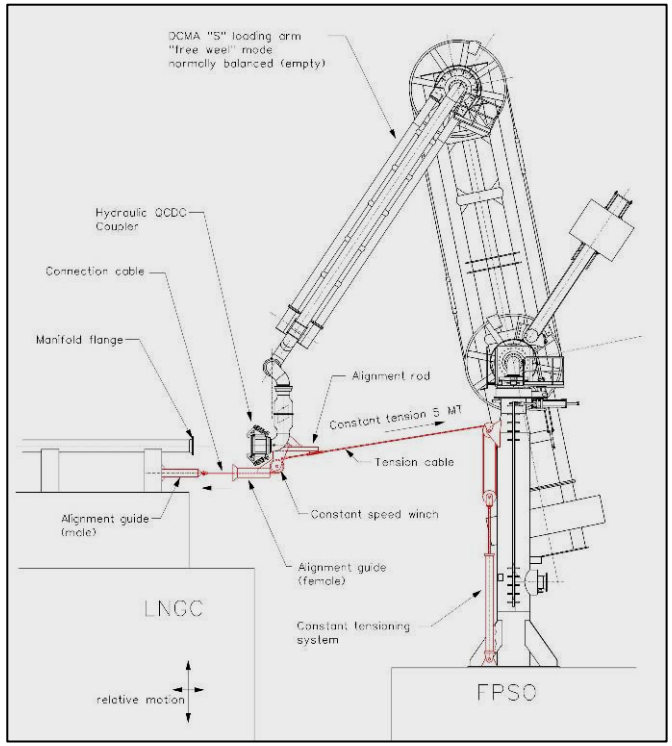
LNG Cryogenic Hose

- **Floating Hose - Not commercially available yet**
- **In-Air Cryogenic Hose – Maybe soon**

But until then……..

LNG Loading Arms Tested for SBS (Side by Side) Loading

- Cryogenic hose motion envelope?
- No new LNG manifolds on LNG carrier

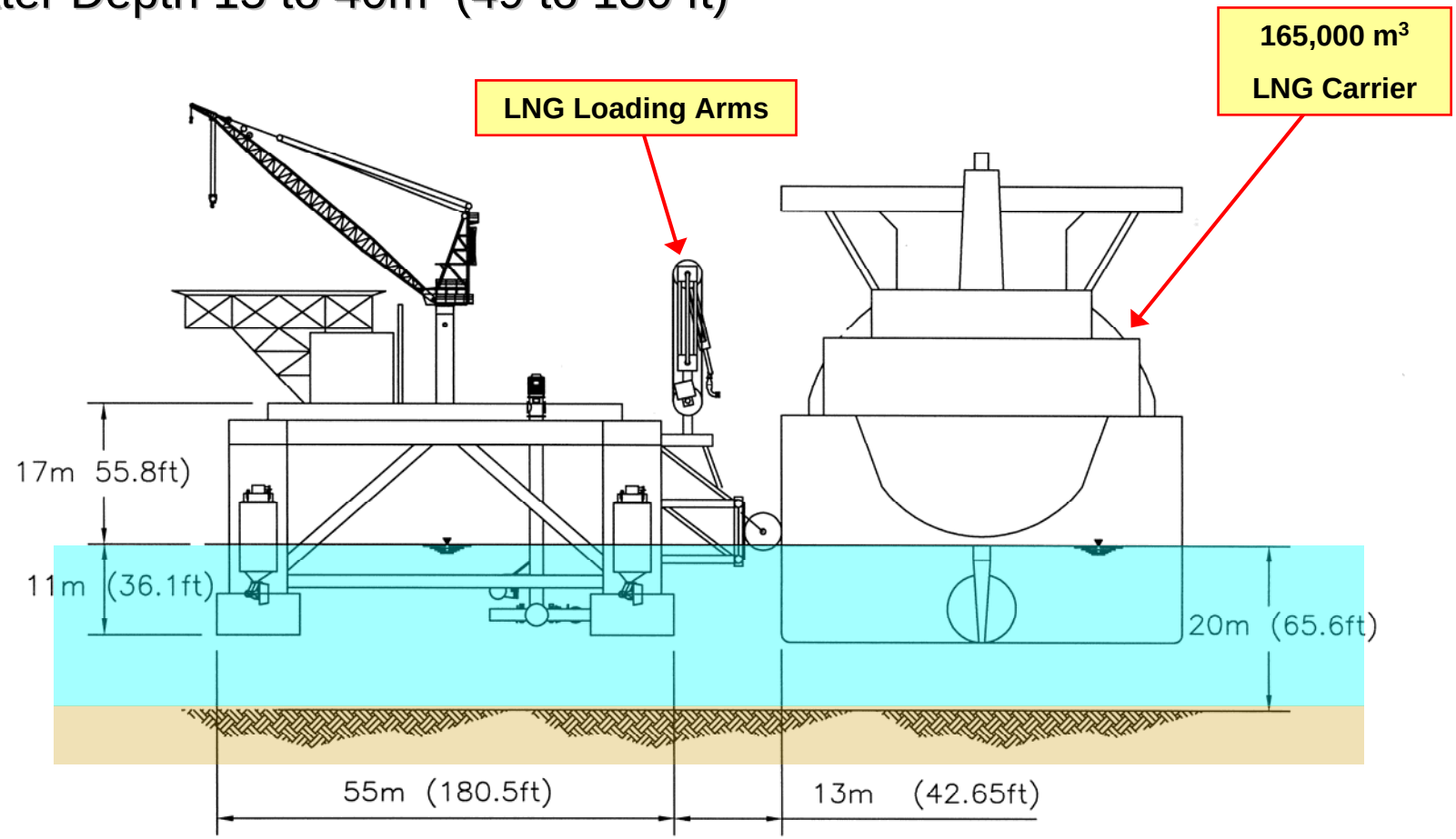


- Full scale connect testing of 16” arm in 2003 for Shell Global Solutions by FMC
- Flange Connection Motion
  - 4 m vertical motion range @ 0.85 m/s
  - 5 m horizontal motion range @ 1.15 m/s
  - 10 m surge fore-aft (design)

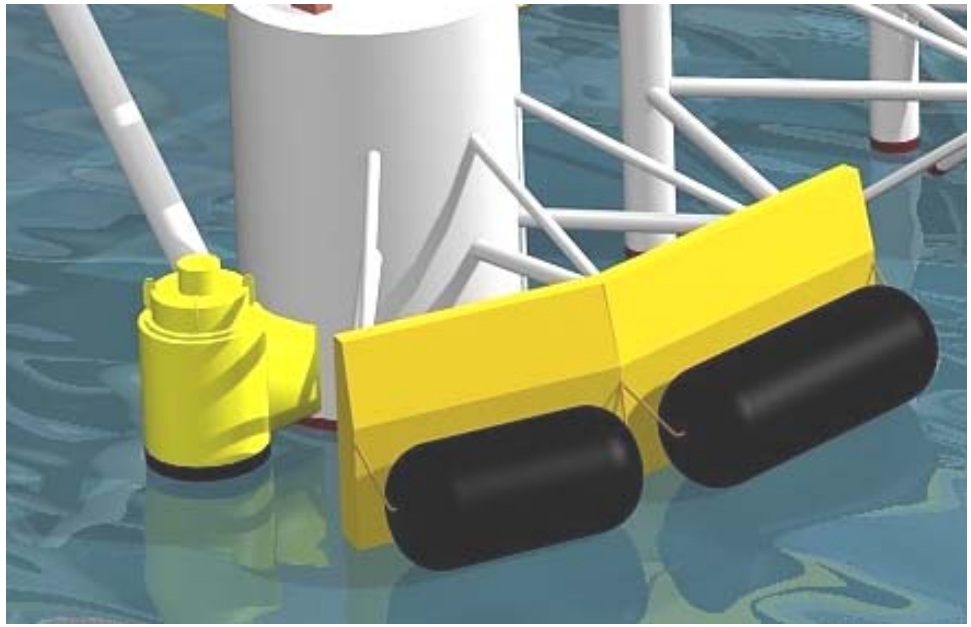
- FMC Targeting system assistance for flange connection in very severe dynamic conditions.
- Simple mechanical system.
- Connects to conventional mid-ship manifolds

FMC Marine Loading Arms for LNG

Shown on Shallow Water Weathervaning Platform
Water Depth 15 to 40m (49 to 130 ft)



Marine Fenders



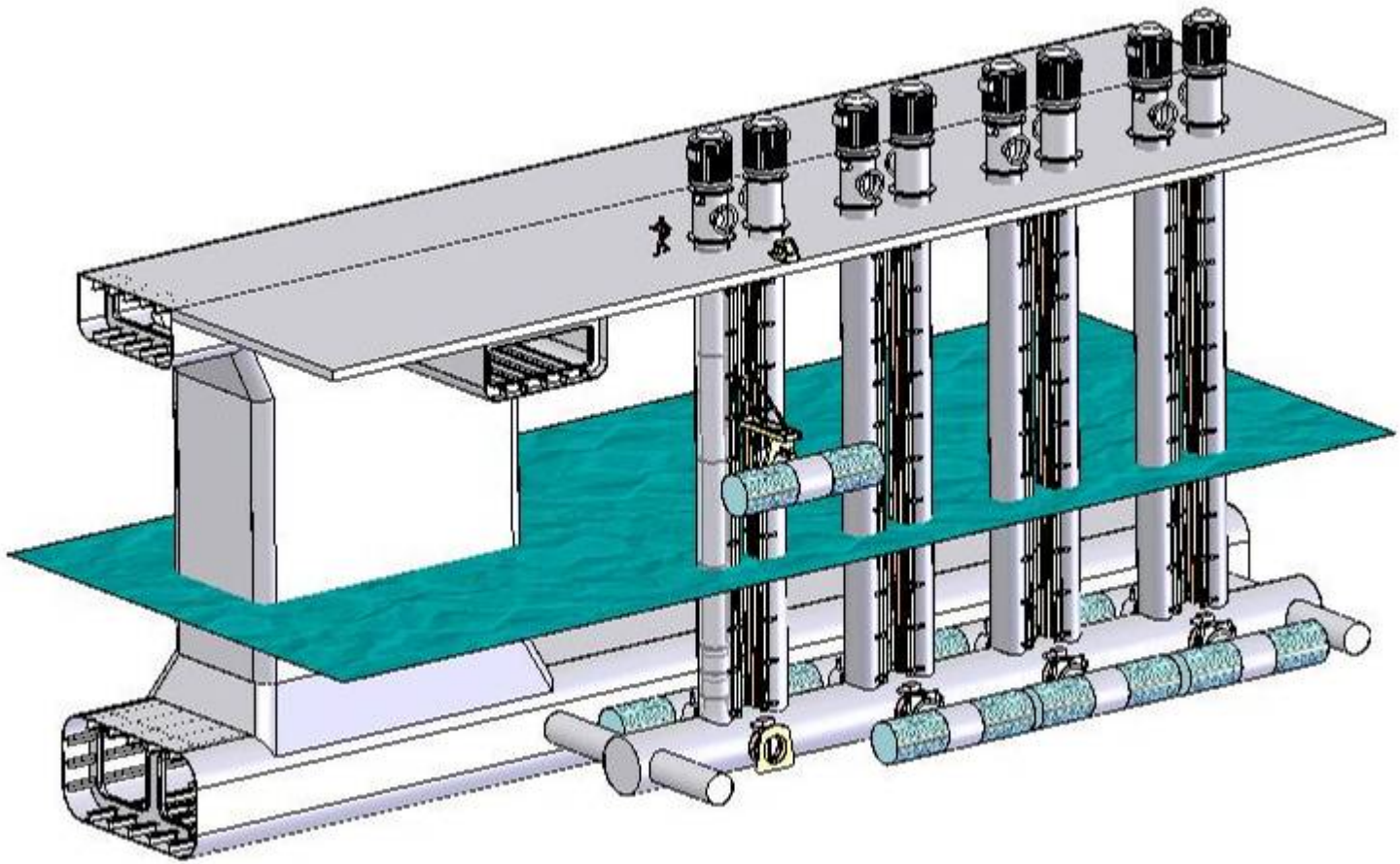
- **Desired Characteristics**
  - Commercially Available
  - Proven Applications / Passive
- **Design Basis**
  - 165,000 m^3 LNG Carrier / 0.8 knots / 15 deg. Berthing angle
  - Berthing, Sway and Yaw Kinetic Energies considered
  - Mooring Line Effects
- **Marine Fender Selection**
  - Yokohama Pneumatic Fender 4500x9000 P50 - normal operation
- **Catastrophic Event**
  - Defined as a collision energy of 14,000 kJ by DNV & LRS.
  - Further study/definition required based on marine operations, site specifics and risk analysis.

Platform Pelican Hooks for Mooring Lines

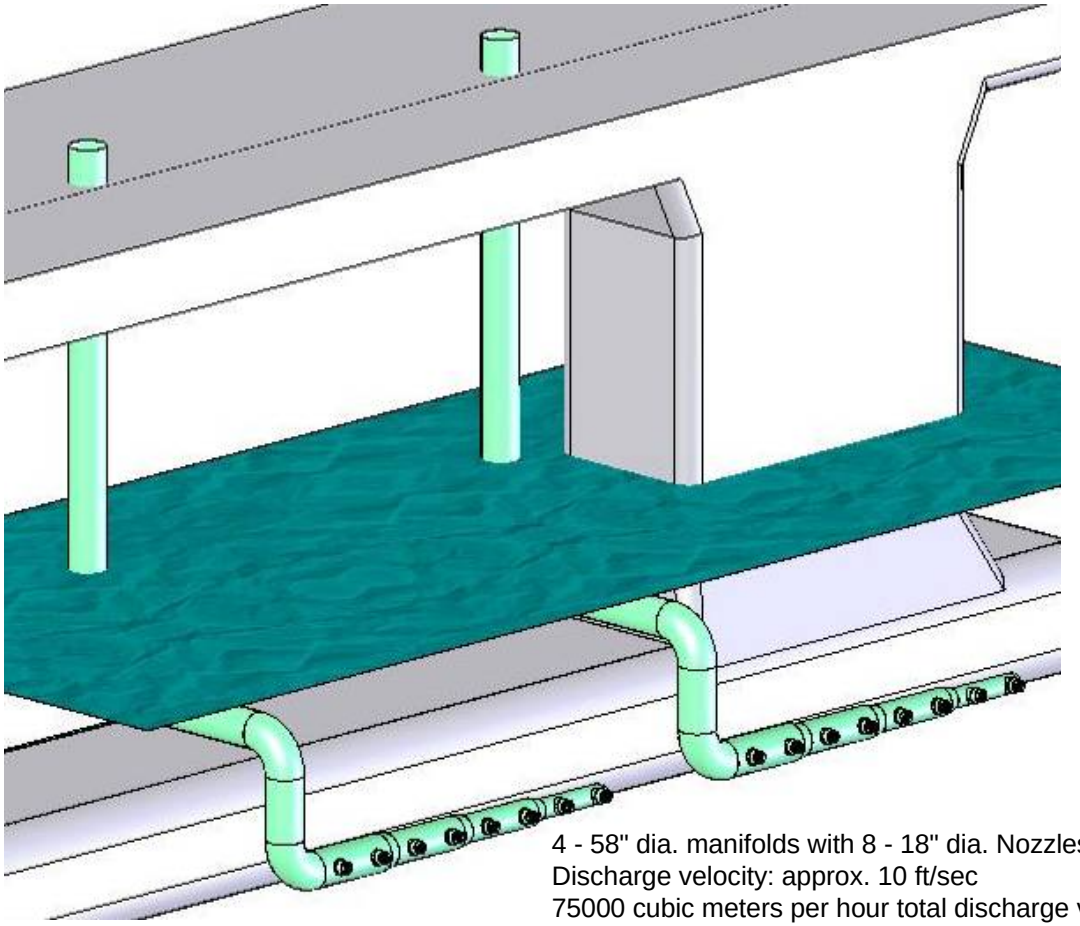
Remote Release, Load Monitoring System

Seawater Lift System for 3.9 Bcf/d Vaporization (7500 m^3/hr LNG)

Eight Pumps, 42” 3000 HP each, 33,000 GPM each



Seawater Discharge System 3.9 Bcf/d Vaporization

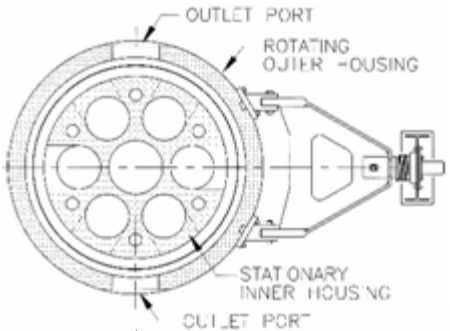


4 - 58" dia. manifolds with 8 - 18" dia. Nozzles each
Discharge velocity: approx. 10 ft/sec
75000 cubic meters per hour total discharge volumetric flow rate (330,000 gpm)
Discharge Water Temp. : 50F (10C)
Ambient Seawater Temp. : 70F (21C) data from buoy shows this is average temp. for 8 months excluding winter.
Current Speed: 0.25 ft/s

Zone of cool water influence approx. 3 meters from nozzle (defined by a deltaT of 3F or greater)

High Pressure Gas Swivel

900 Lb (2200 Psi) Dry Gas Rating
1.8 Bcf/d @ 1900 Psi & 40F
1.8 Bcf/d @ 1200 Psi & 35 F



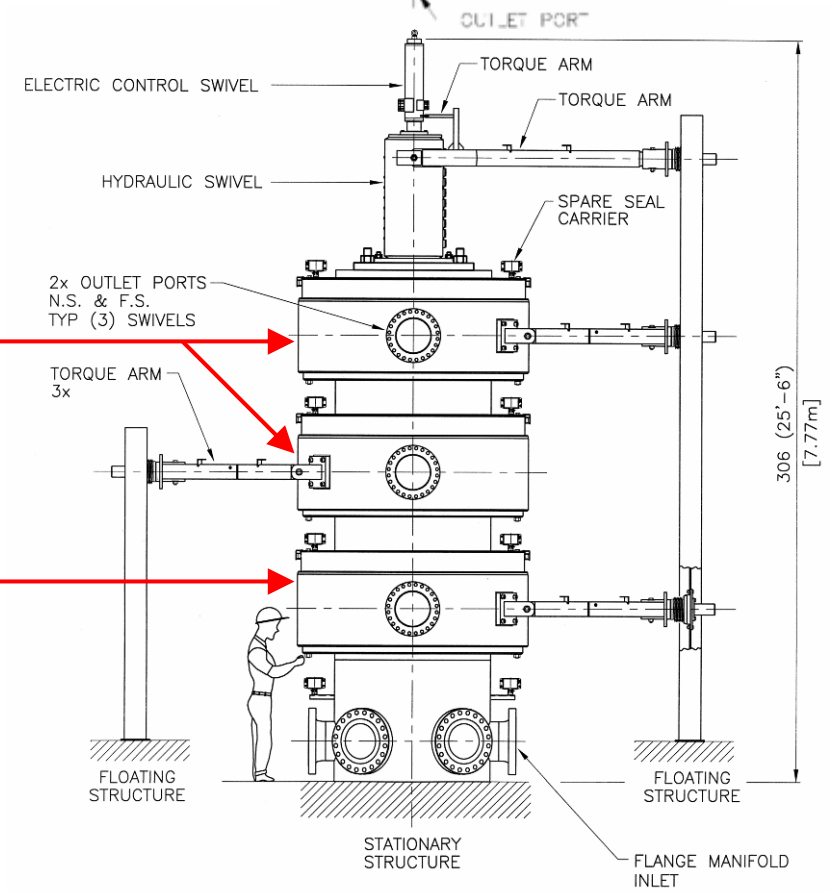
Two (2) separate swivels

For two separate flow paths

- **2 ports per swivel**
- **Each port: 14” (12.12” ID)**
- **Total of 4 ports, 14”**

One spare swivel

- **One separate flow path**
- **2 ports, 14”**

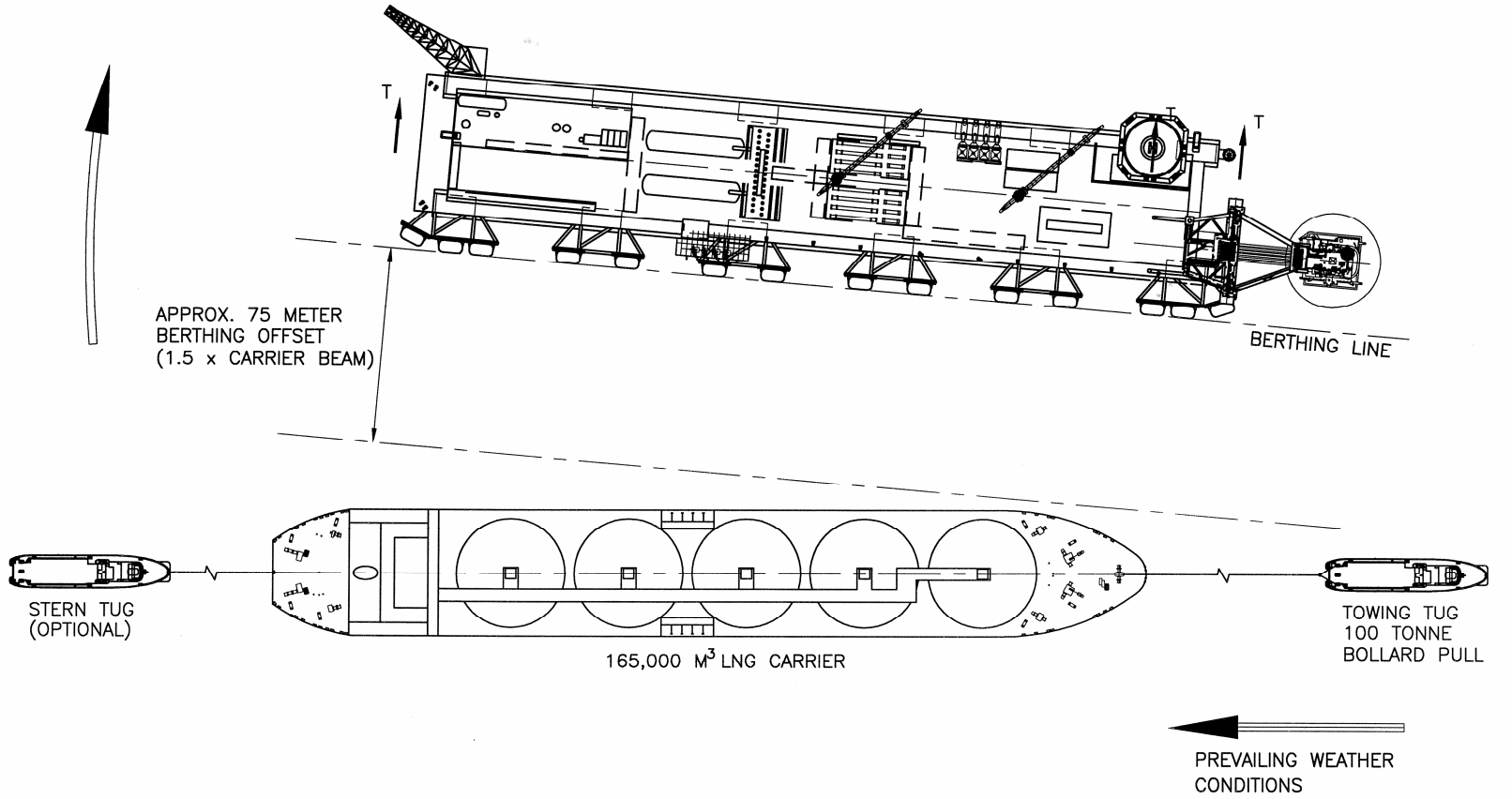


Est. Wt. 131 Ton (289,000 Lb)

Marine Operations & Ship Docking

Carrier Berthing Operations

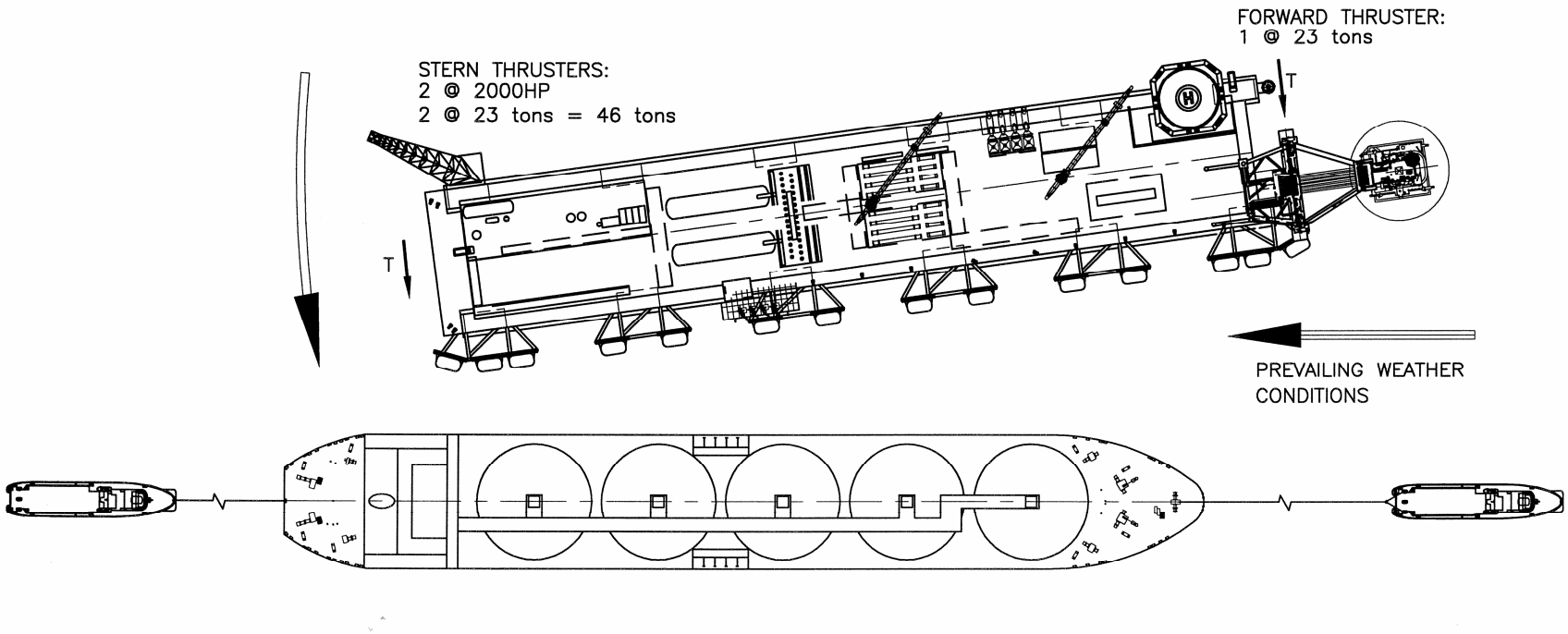
Berthing Hs ≤ 2.5 m (8.2 ft) Offload Hs ≤ 3.5m (11.5 ft)



1.1 SWING PLATFORM AWAY FROM SHIP BERTHING LOCATION
1.2 WITH MOORING MASTER ABOARD, TOW SHIP TO BERTHING POSITION WITH TUGS HEADING INTO SEAS
1.3 USING TUGS, STOP SHIP'S HEADWAY & HOLD AS STATIONARY AS PRACTICAL NEAR BERTH POSITION

Carrier Berthing Operations

Berthing Hs ≤ 2.5 m (8.2 ft) Offload Hs ≤ 3.5m (11.5 ft)



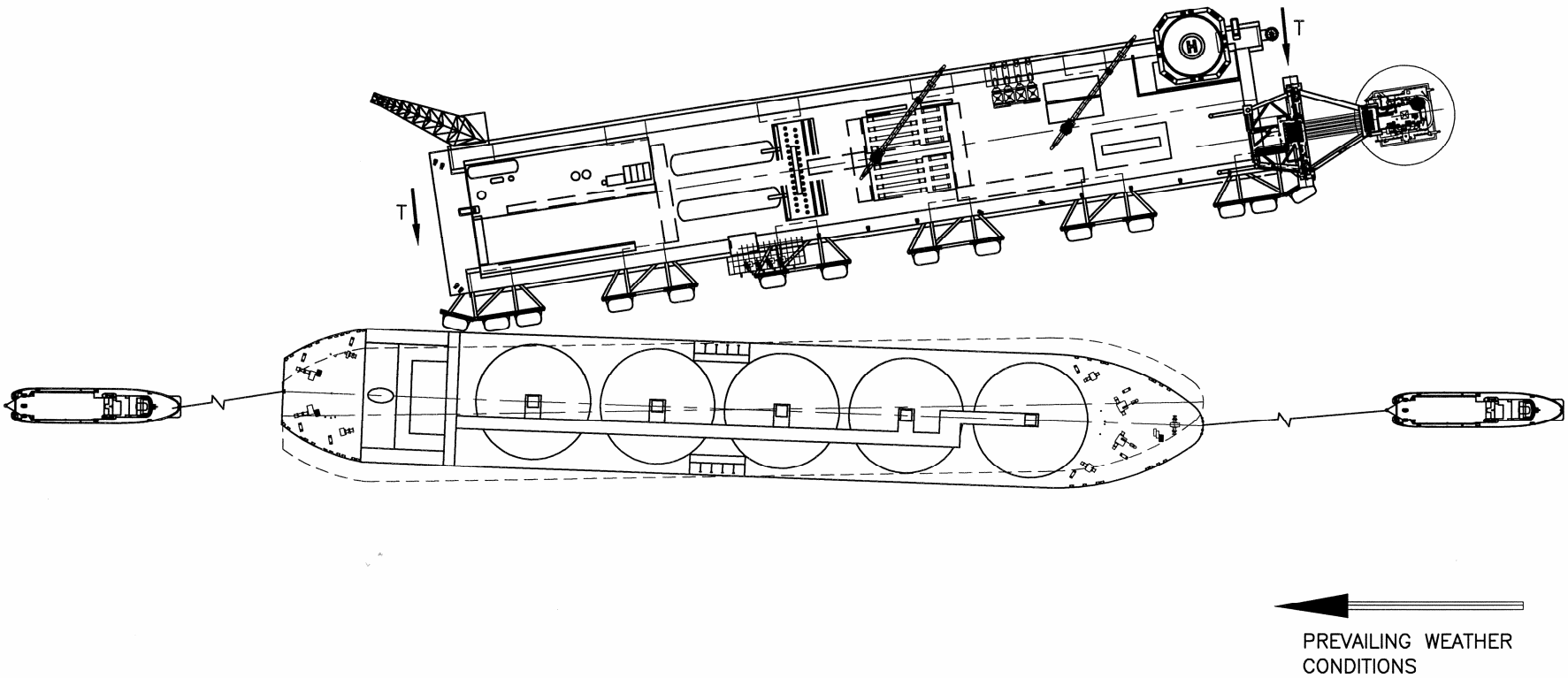
2.1 CONTINUE HOLDING SHIP NEAR BERTH LOCATION WITH TUGS HEADING INTO SEAS

2.2 SWING PLATFORM TOWARD SHIP USING PLATFORM THRUSTERS

T = THRUST

Carrier Berthing Operations

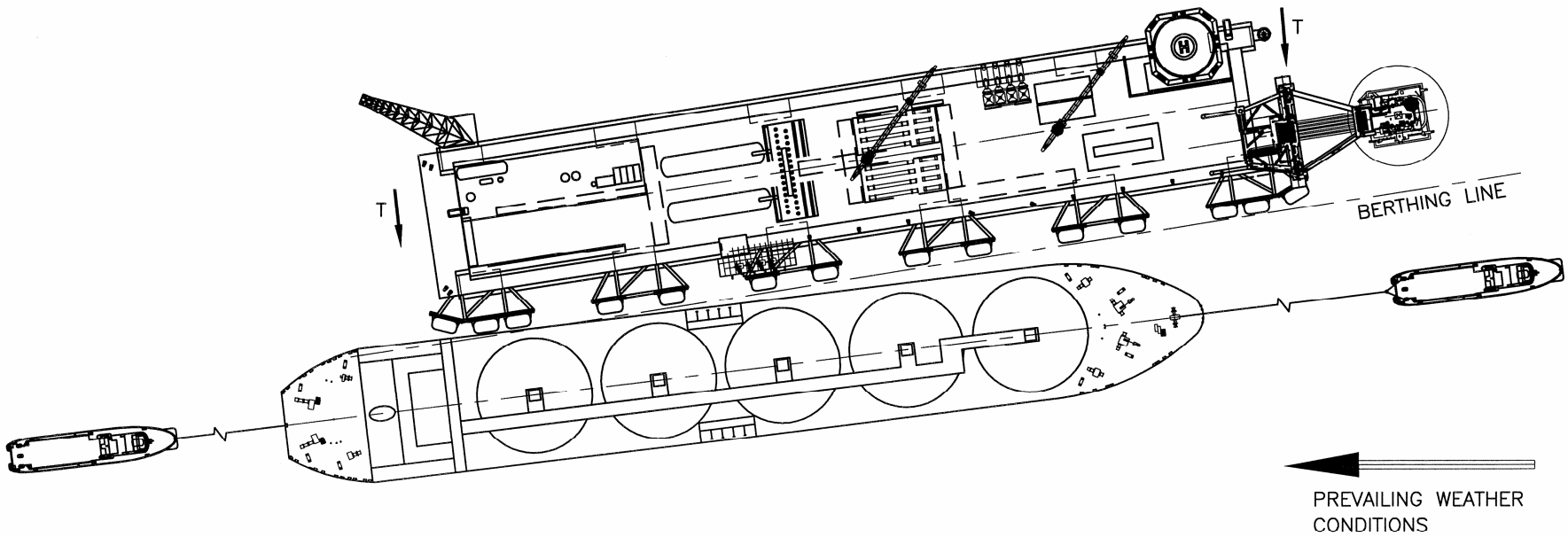
Berthing Hs ≤ 2.5 m (8.2 ft) Offload Hs ≤ 3.5m (11.5 ft)



3.1 CONTINUE HOLDING SHIP NEAR BERTH LOCATION WITH TUGS HEADING INTO SEAS
3.2 USING PLATFORM THRUSTERS, BRING PLATFORM AFT FENDERS TO BEAR ON SHIP
3.3 COORDINATE THE PLATFORM SWING WITH SHIP YAW MOTION

Carrier Berthing Operations

Berthing Hs ≤ 2.5 m (8.2 ft) Offload Hs ≤ 3.5m (11.5 ft)

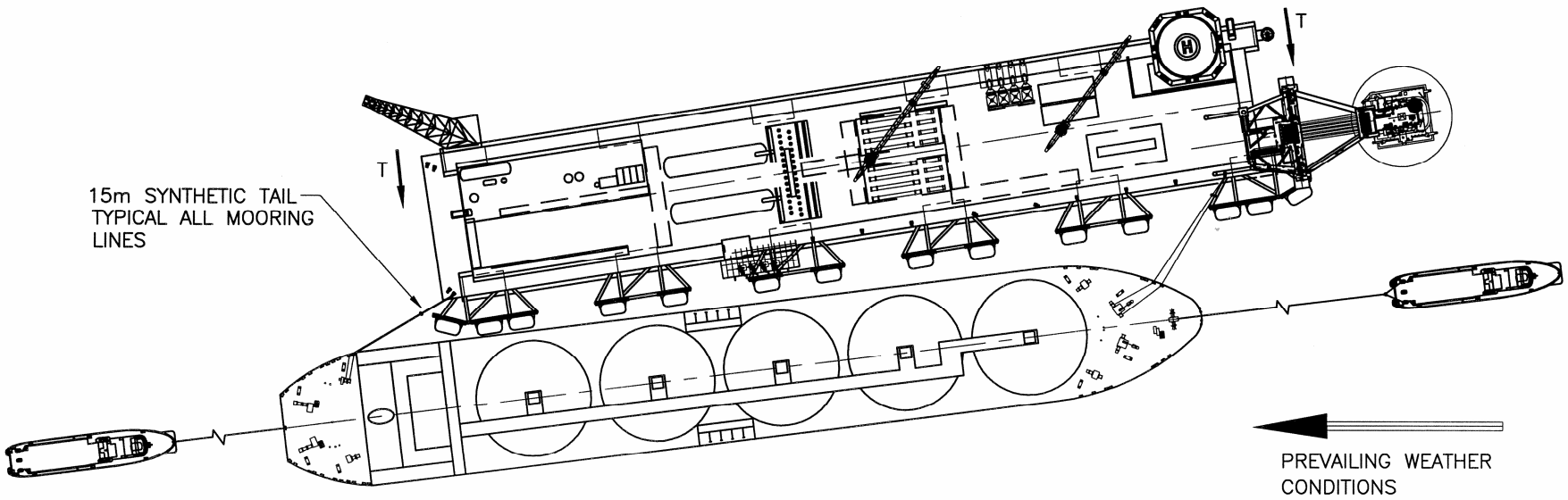


4.1 CONTINUE PLATFORM PUSHING ON SHIP TO BRING SHIP HEADING AROUND TOWARD PLATFORM BERTHING LINE

4.2 TUGS CONTINUE HOLDING SHIP STATIONARY FORE & AFT AS IS PRACTICAL

Carrier Berthing Operations

Berthing Hs ≤ 2.5 m (8.2 ft) Offload Hs ≤ 3.5m (11.5 ft)

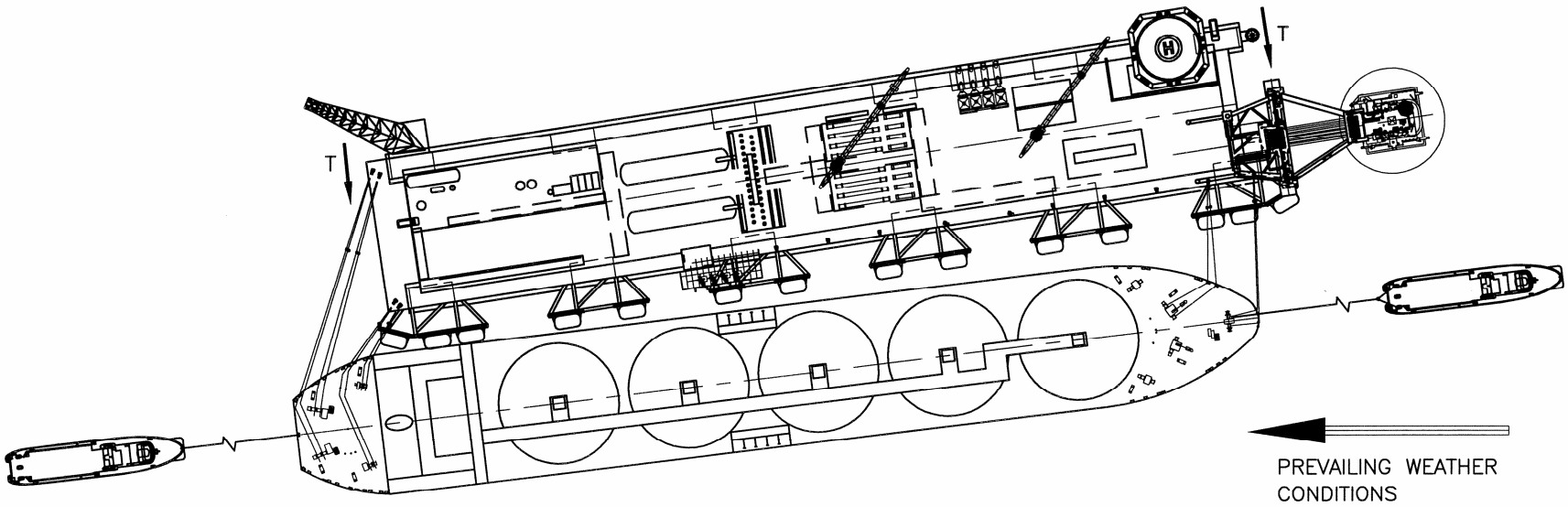


5.1 TRANSFER SHIP'S MOORING LINES TO PLATFORM PELICAN HOOKS

5.2 MAINTAIN SHIP POSITION AGAINST PLATFORM FENDERS USING TUGS FORE & AFT AND BY PLATFORM PUSHING SHIP PARTLY BEAM–ON TO THE WIND

Carrier Berthing Operations

Berthing Hs ≤ 2.5 m (8.2 ft) Offload Hs ≤ 3.5m (11.5 ft)



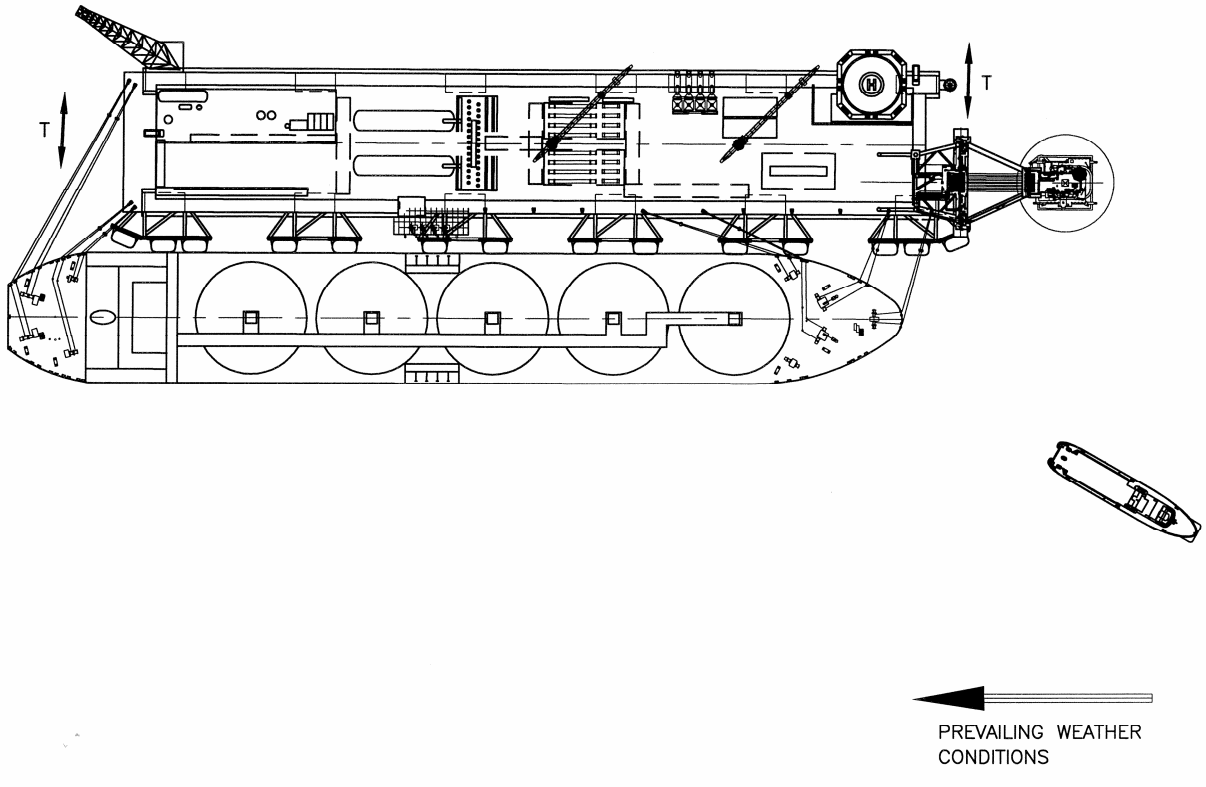
6.1 USING MOORING LINES AND TUGS FORE & AFT, MOVE SHIP FORWARD TO ALIGN MIDSHIP MANIFOLD WITH LNG LOADING ARMS

6.2 FINISH ALL MOORING LINE PRETENSIONING

6.3 CONNECT LNG LOADING ARMS

Carrier Berthing & Offloading Operations 7

Berthing Hs ≤ 2.5 m (8.2 ft) Offload Hs ≤ 3.5m (11.5 ft)



7.1 WITH ALL MOORING LINES SECURE, TUGS CAN MOVE TO STANDBY LOCATION

7.2 STARTUP REGAS PROCESS, BEGIN LNG COOL–DOWN AND OFFLOADING

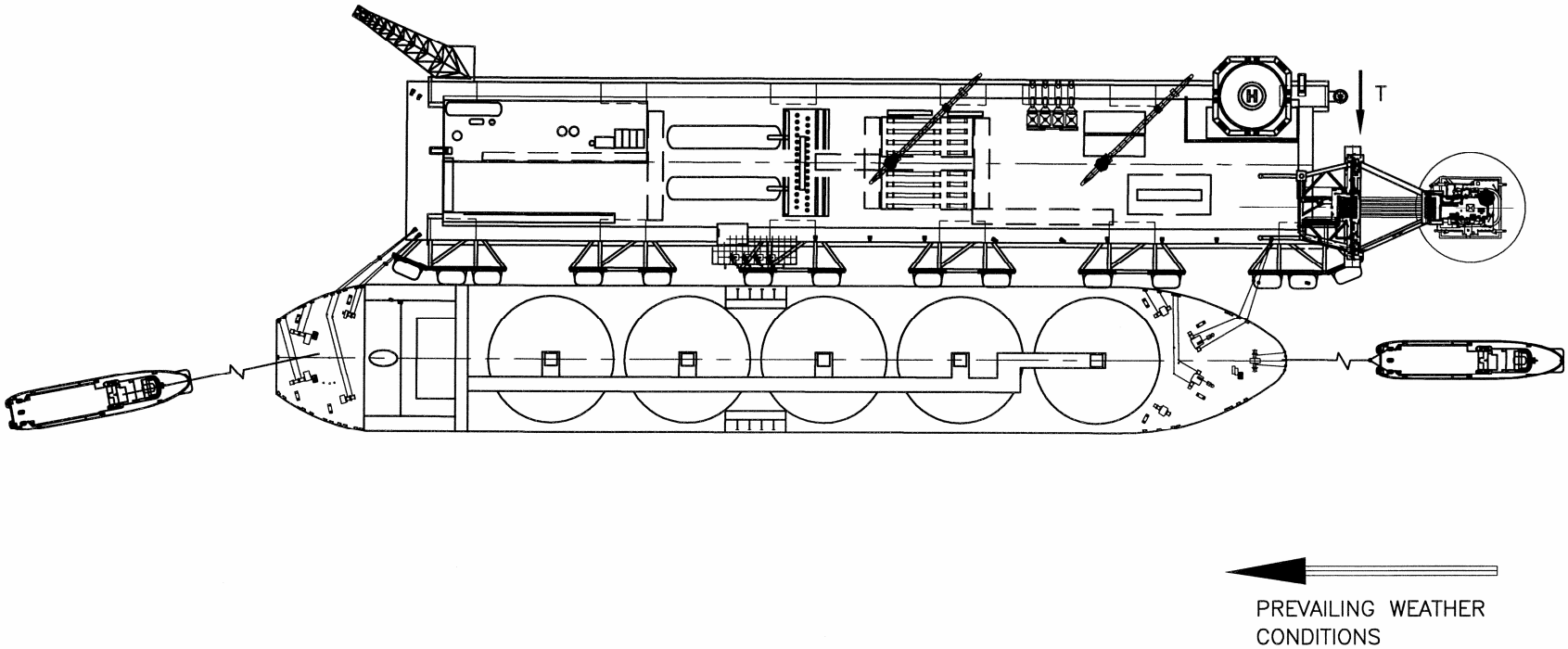
7.3 PLATFORM AND SHIP CAN FREELY WEATHER–VANE IF SHIP MOTIONS REMAIN SATISFACTORY

7.4 IF NEEDED, USE PLATFORM THRUSTERS TO ADJUST PLATFORM AND SHIP HEADING TO MOST FAVORABLE DIRECTION TO WEATHER DURING LNG OFFLOADING TO MINIMIZE SHIP ROLL MOTION

7.5 MONITOR LOADS IN ALL MOORING LINES CONSTANTLY DURING OFFLOAD, AND ADJUST PRETENSION IF NECESSARY

Carrier Un-Berthing Operations

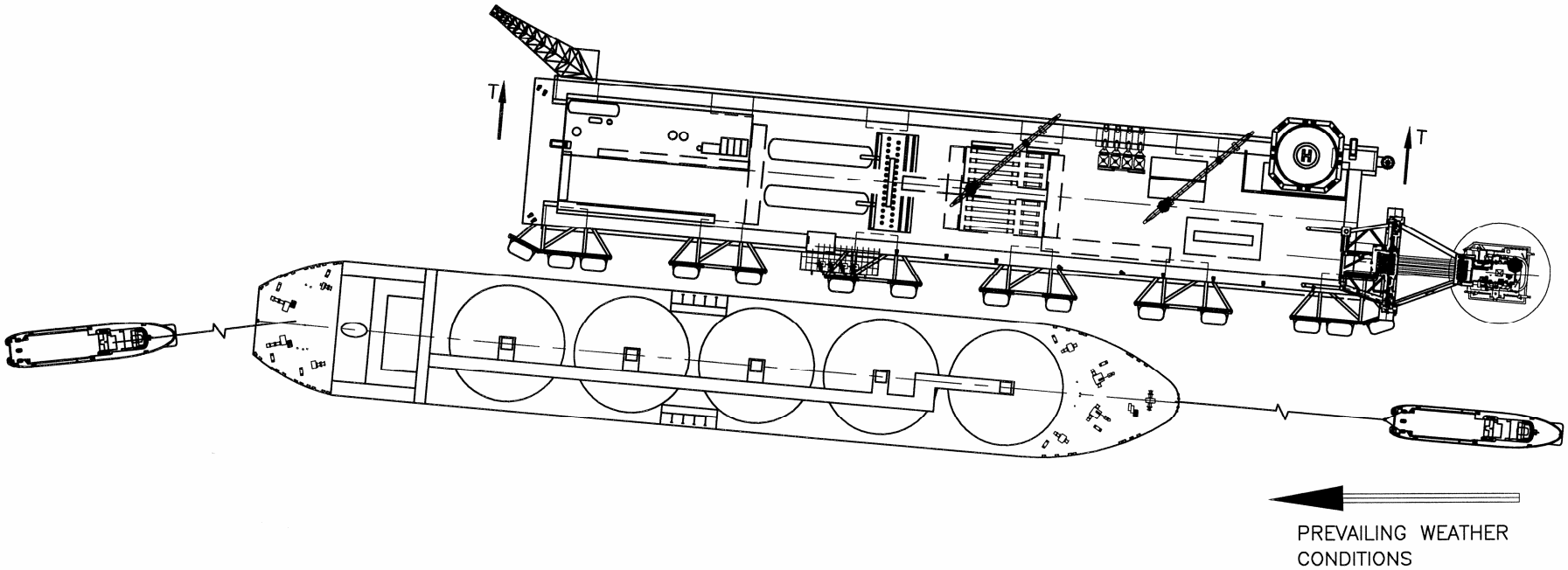
Offload & Un-Berth in Wave Height Hs ≤ 3.5m (11.5 ft)



8.1 UPON COMPLETION OF OFFLOADING AND SHUTDOWN SEQUENCE, DISCONNECT LNG LOADING ARMS
8.2 RECONNECT TOWING LINES TO TUGS (IF DISCONNECTED)
8.3 POSITION TUGS FORE & AFT FOR SHIP DEPARTURE

Carrier Un-Berthing Operations

Offload & Un-Berth in Wave Height Hs ≤ 3.5m (11.5 ft)



9.1 USING THRUSTERS, SWING PLATFORM AND SHIP TO CREATE A LEE ON THE PLATFORM FENDER SIDE

9.2 RELEASE PELICAN HOOKS AND RECOVER MOORING LINES TO SHIP

9.3 AS MOORING LINES ARE RELEASED, BEGIN RAPID PLATFORM SWING AWAY FROM SHIP USING THRUSTERS

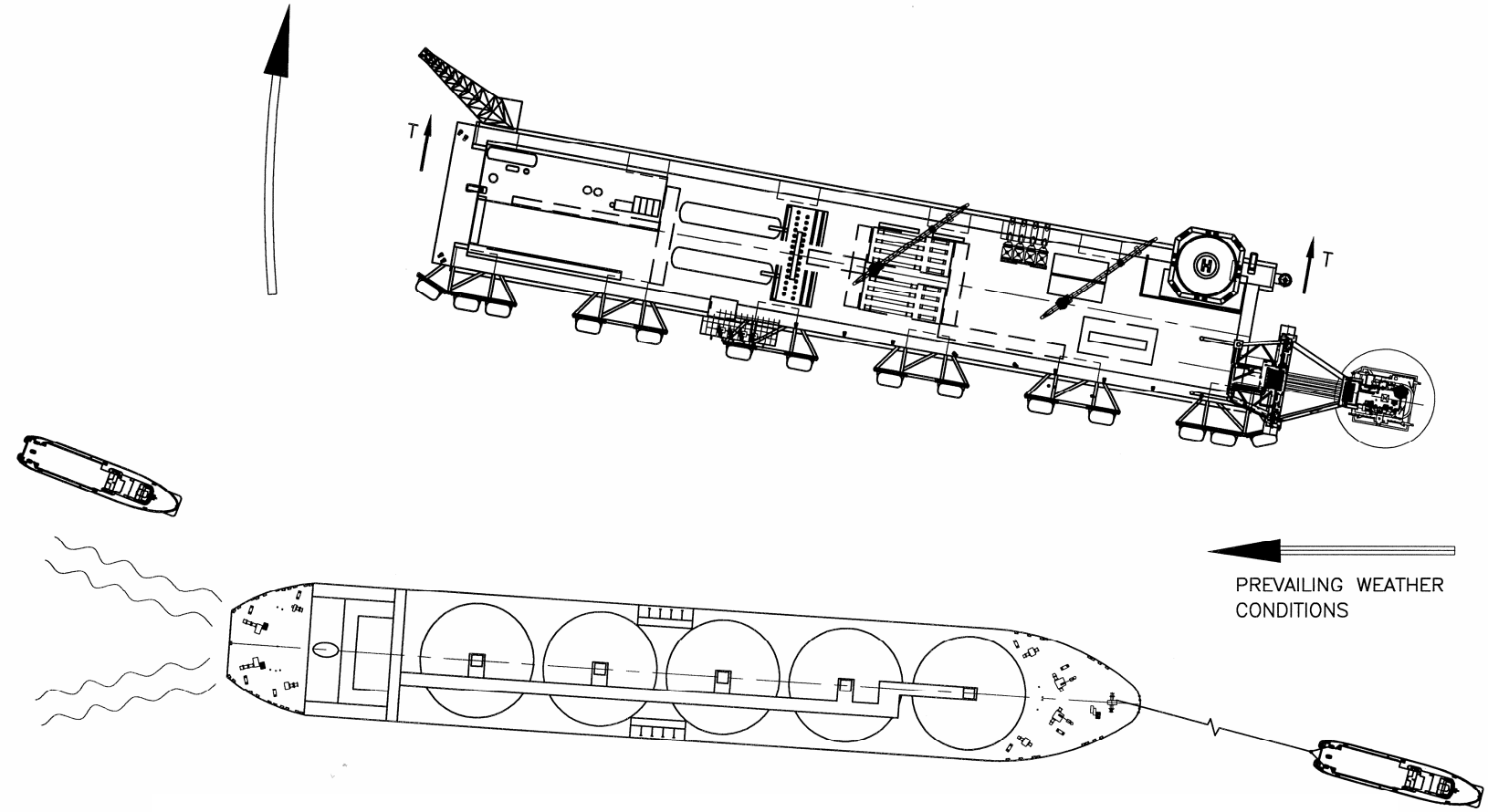
9.4 TUGS BEGIN MOVING SHIP ASTERN AND SWINGING BOW AWAY FROM PLATFORM USING WIND DIRECTION TO ASSIST

9.5 TUGS CONTROL SHIP HEADING FOR DEPARTURE AND TOW SHIP TO CLEAR PLATFORM

T = THRUST

Carrier Un-Berthing Operations

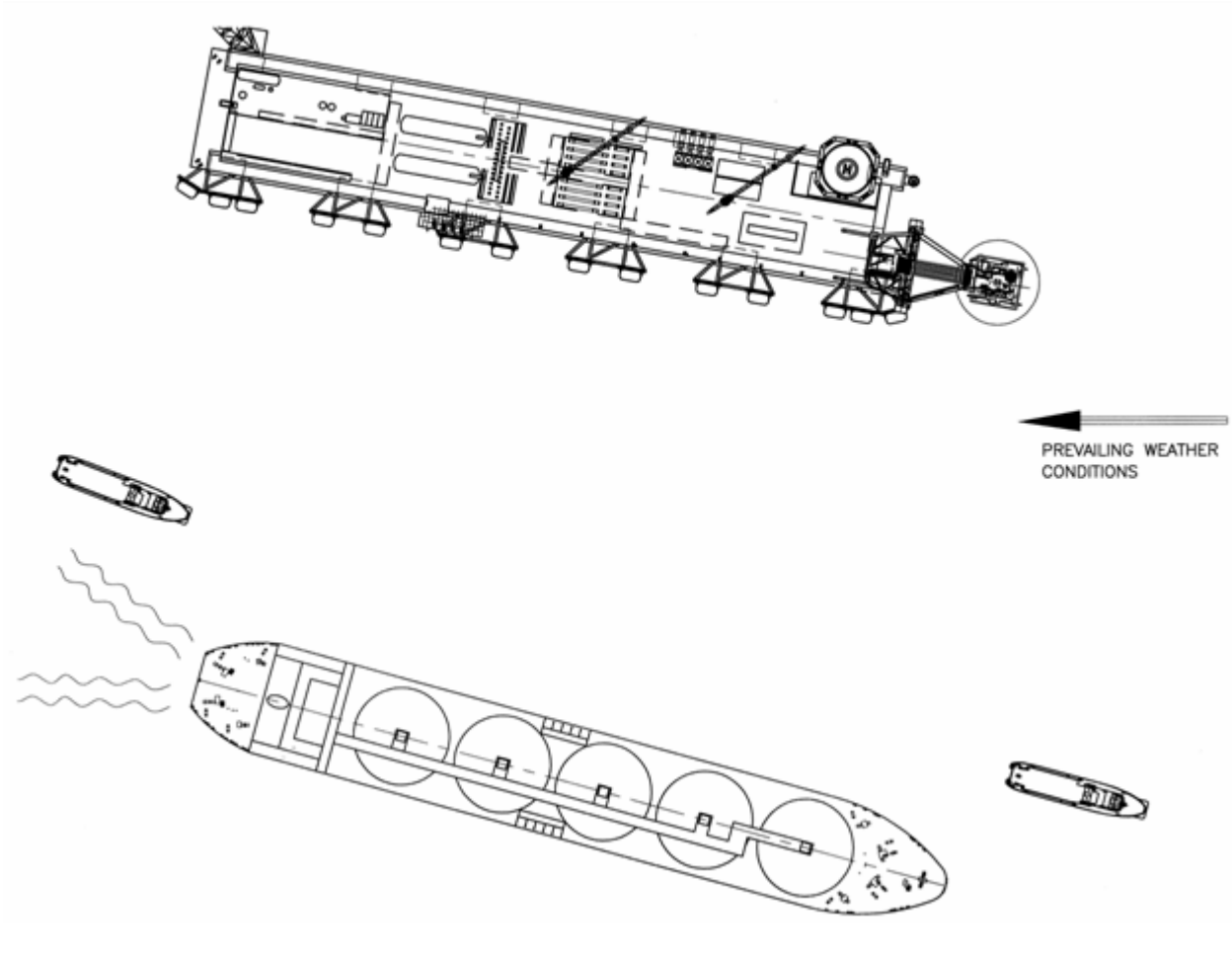
Offload & Un-Berth in Wave Height Hs ≤ 3.5m (11.5 ft)



10.1 TUGS AND SHIP CONTINUE MOVING AWAY FROM PLATFORM
10.2 WITH SHIP UNDER POWER, RELEASE TOWING LINES

Carrier Un-Berthing Operations

Offload & Un-Berth in Wave Height Hs ≤ 3.5m (11.5 ft)



11.1 TUG ESCORTS SHIP UNDERWAY TO SAFE ZONE BOUNDARY

11.2 MOORING MASTER RE–BOARDS TUG FOR TRIP TO NEXT WAITING SHIP

LNG Terminal Loads & Motions – Shallow Water

Comparison of Tower-Yoke Loads & Motions - 20m Water Depth

Parameter	QHD 32-6 FPSO	LNG Terminal	Unit
Storm Conditions			
Significant Wave Height, Hs	5.2	9.2	meters
Wind Speed	26.6	41.2	m/s
Current Speed	2.05	1.1	m/s
Vessel Displacement	201,380	39,000	m. tons
Vessel Motions (@ FP)			
Surge, Max	5.4	2.1	meters
Surge, Min	-9.8	-8.8	meters
Sway, Max	10.96	7.8	meters
Sway, Min	-15.42	-3.9	meters
Yaw, Max	38.5	29.1	degrees
Yaw, Min	15.1	20.9	degrees
Tower Forces			
Fx- Longitudinal Force	-861	-724	m. tons
Fy - Transverse Force	-320	166	m. tons
Fz - Vertical Force	-367	-209	m. tons
Fxy - Resultant Force	871	724	m. tons
Fxyz - Resultant Force	908	750	m. tons
Max Tension	742	695	m. ton

LNG Terminal Loads & Motions – Shallow Water

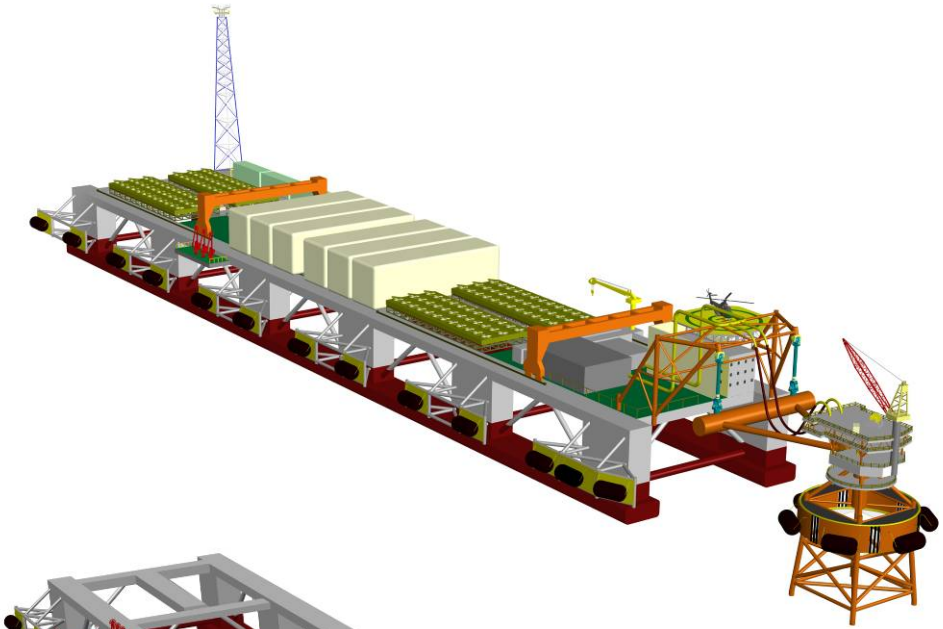
Side-by-Side Offloading Loads & Motions - 20m Water Depth

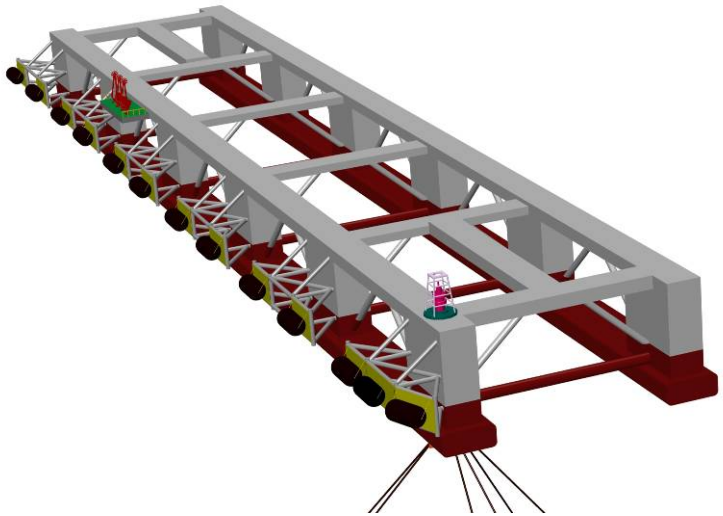
Parameter	Offloading	Berthing	Unit
Storm Conditions			
Significant Wave Height, Hs	3.5	2.5	meters
Wind Speed	32	28	m/s
Current Speed	0.40	0.35	m/s
LNG Carrier	165,000	165,000	m^3
Relative Motions (@ Loading Arms)			
Surge, Max/Allowable	82%		
Sway, Max/Allowable	76%		
Heave, Max/Allowable	50%		
Max Mooring Lines Tension	53		MT
Safety Factor	2.0		
Max Pull-in Wire Tension		71	MT

Platform Construction & Schedule

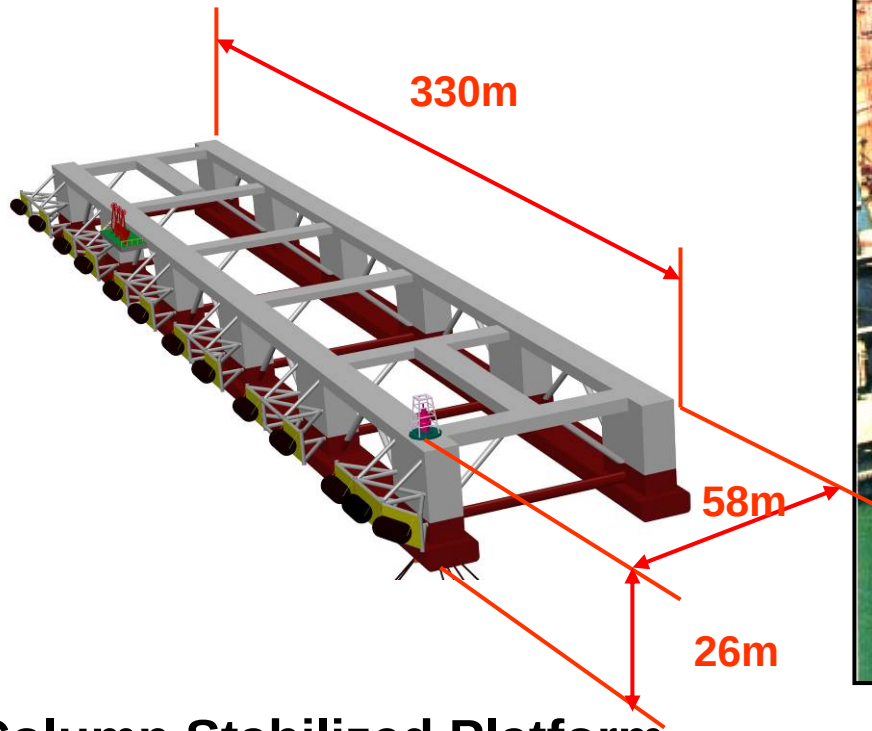
Platform Construction Advantages

- Shipyard drydock not required
- Tubular and flat plate construction, fabricate in domestic or foreign fab yards
- Lends itself to modular construction
- Dockside testing of all onboard process & power generation units
- Offshore construction spread is minimal
- Install offshore & commission in a few weeks time



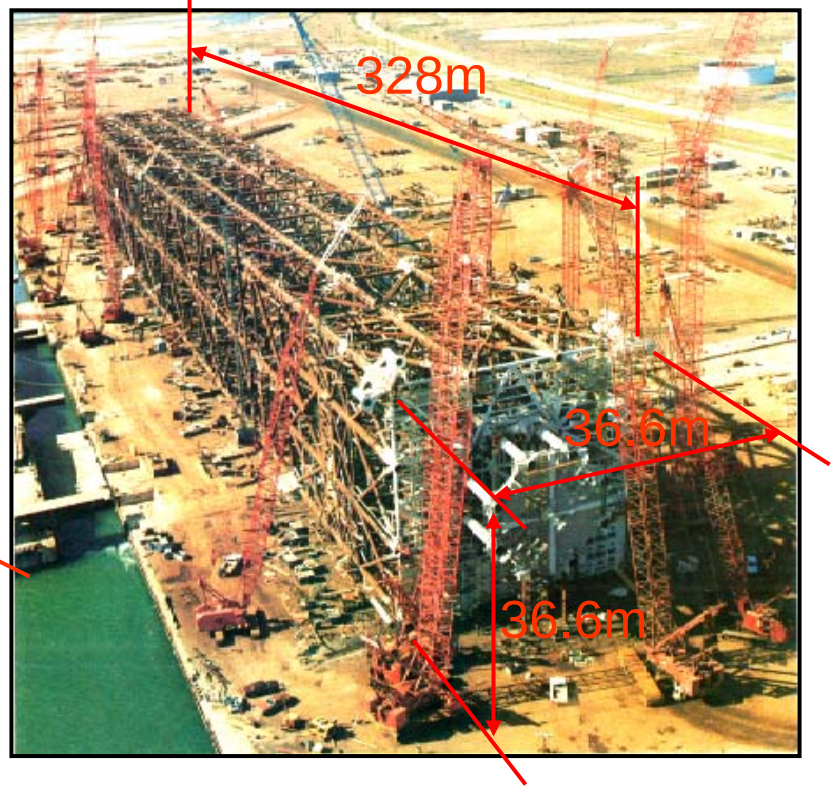


Floating Platform Size



- Column Stabilized Platform
- 58m W x 26m H x 330m L
- 26,000 ton steel w/o payload
- Fab yard: GoM or SE Asia

OCEAN INDUSTRY, April 1983



- Exxon Lena Guyed Tower
- 36.6m x 36.6m x 328m
- 24,000 ton trussed tower
- Brown & Root Harbor Island Yard, 1983

Schedule for Floating Platform
Design, Fabrication, Installation

Total Elapsed Time: 26 months

Conclusion

- No technology gaps to hinder permitting, design, & construction completion of a floating LNG receiving terminal within 28 months
- FMC Energy Systems can fully support the import facility construction requirements for this project by
  - participating in the port permit application process
  - by supplying hardware systems including:

    - LNG loading arms
    - Platform, gas swivel, risers, & mooring
    - Cavern wellheads, subsea or dry trees
    - Gas metering