

Floating Weathervaning Platform for The LNG Receiving Terminal Using the Bishop Process™

2004 AIChE Spring National Meeting

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Paper 76d Rev 0



Speaker Bio

- James F. Davis, P.E. (Texas)
 - B.S. Mechanical Engineering, Ohio State University
 - 30 years in petrochemical, refining and gas processing design, procurement and construction
 - 10 years in gas processing, LNG, GTL and gas-to-methanol
 - Project Manager – Midstream projects
 - Paragon Engineering Services, Inc. Houston, Texas

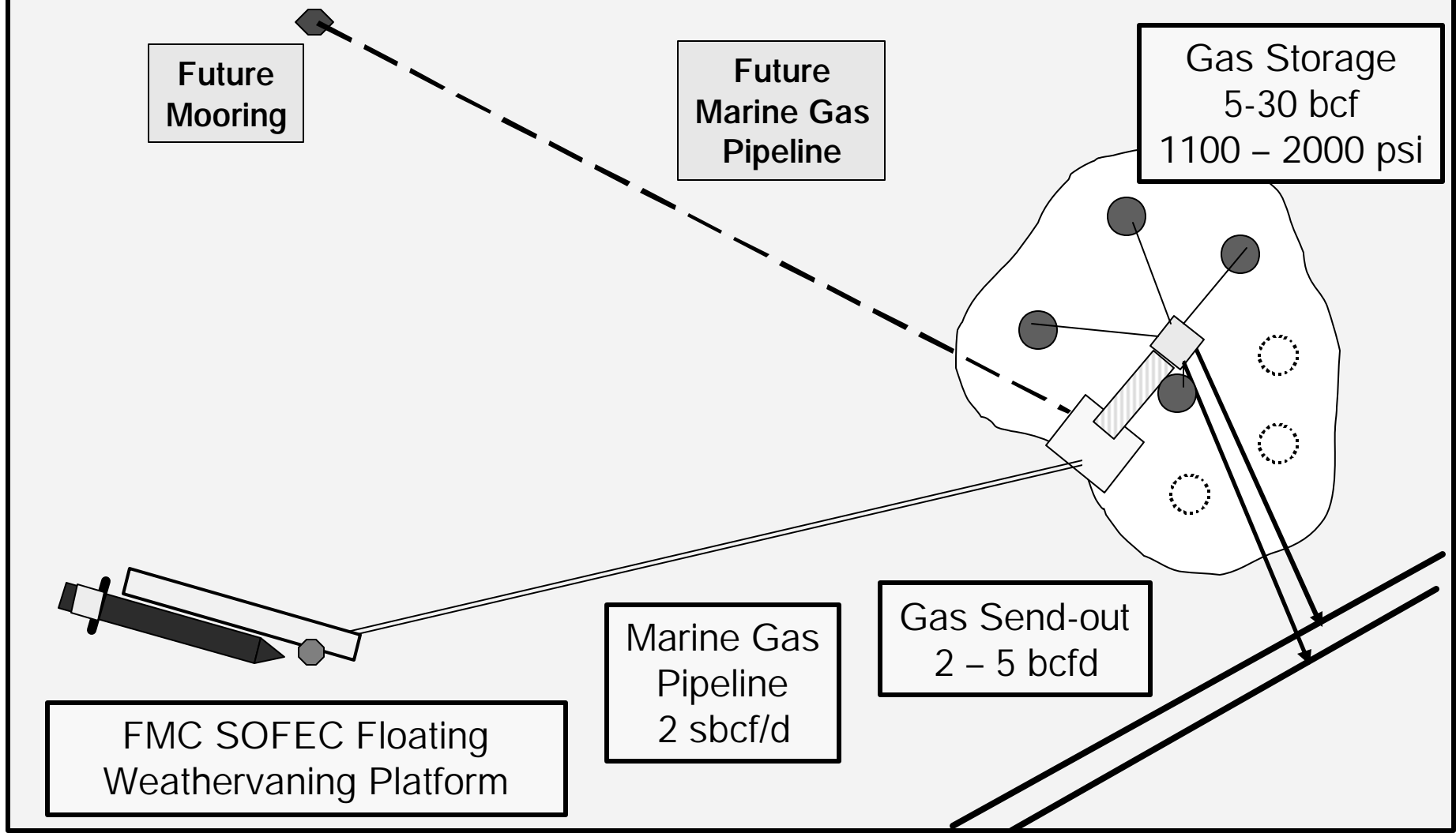
- L. Terry Boatman, P.E. (Texas)
 - B.S. Mechanical Engineering, University of Texas
 - 33 years marine equipment design & manufacturing
 - 18 years FPSO turret mooring systems & fluid swivels
 - Vice President, Product Development
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Presentation Overview

- **LNG Receiving Terminal Facility Concept for Salt Cavern Gas Storage & the Bishop Process TM**
- **Attributes of the “Ideal” Offshore LNG Receiving Terminal**
- **Enabling Technologies for the “Ideal” Terminal**
- **Concept for a Floating, Weathervaning, Column-stabilized Platform**
- **Achievement of the “ideal” terminal**

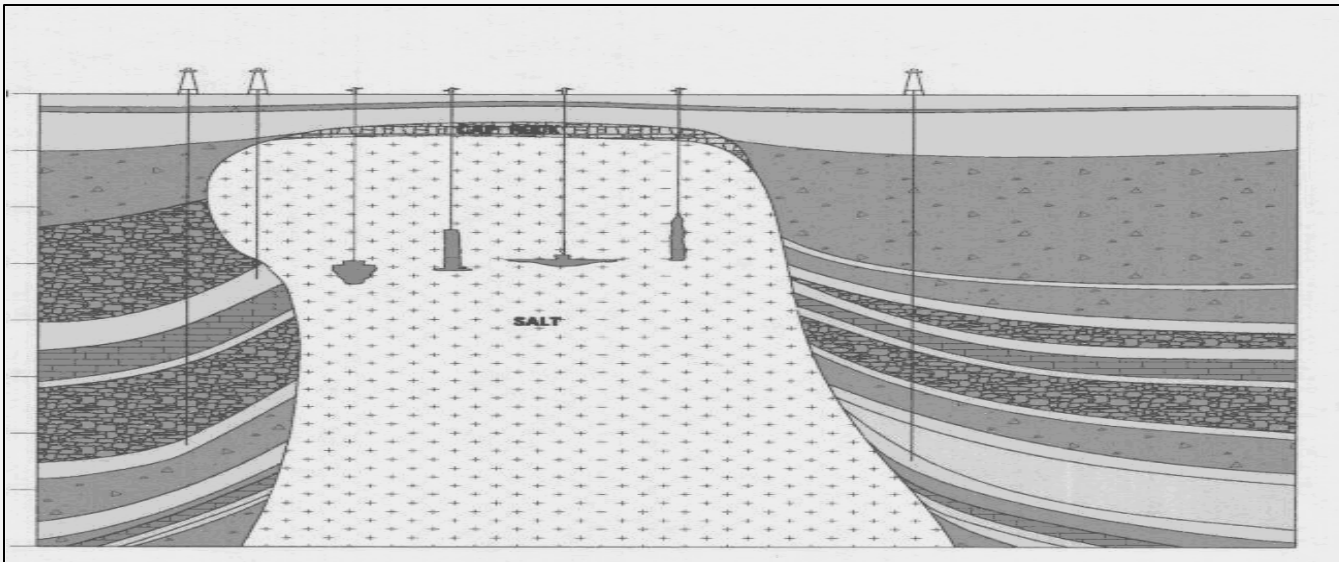
LNG Receiving Terminal Facility

Using a Floating Platform for Offloading & Process



Use Salt Caverns Because...

- 24 sites with salt domes in Gulf of Mexico near pipeline infrastructure
- Initial operation in 24 months
- Half the construction cost of cryogenic storage tanks
- Out of sight on land and water

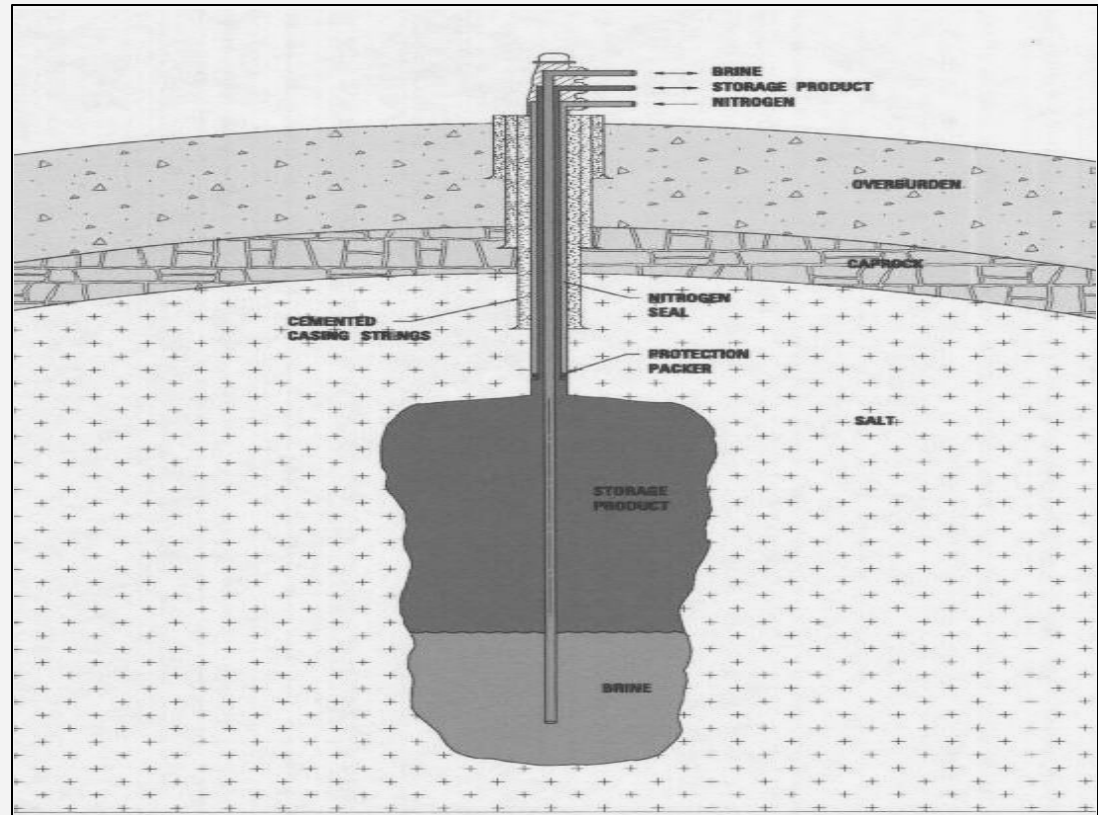


Gulf Coast Salt Dome

Courtesy of Conversion Gas Imports, Inc.

Salt Cavern Storage & Well

- High rate filling and discharge rate
- Quick response to variable send-out (low to high)
- Storage of any LNG cargo – rich or lean



Courtesy of Conversion Gas Imports, Inc.

- Extremely large storage volumes e, eg.17 bcf
- Expandable at low cost
- Inherently safe – below ground, long history of safe operations

Primary Attributes of an “Ideal” Offshore Terminal Using the Bishop Process TM

- Lowest overall risk (ALARP)
 - Least introduction of new technology
 - Safest berthing & offloading operation
 - Safest process & storage operation
- Quickest carrier turn-around
- Maximum “up-time” availability
- Lowest capital and operational expenditure
- Operational in less than 24 months

Enabling Technology: Cryogenic Pumps

Tested and now available from two major manufacturers:

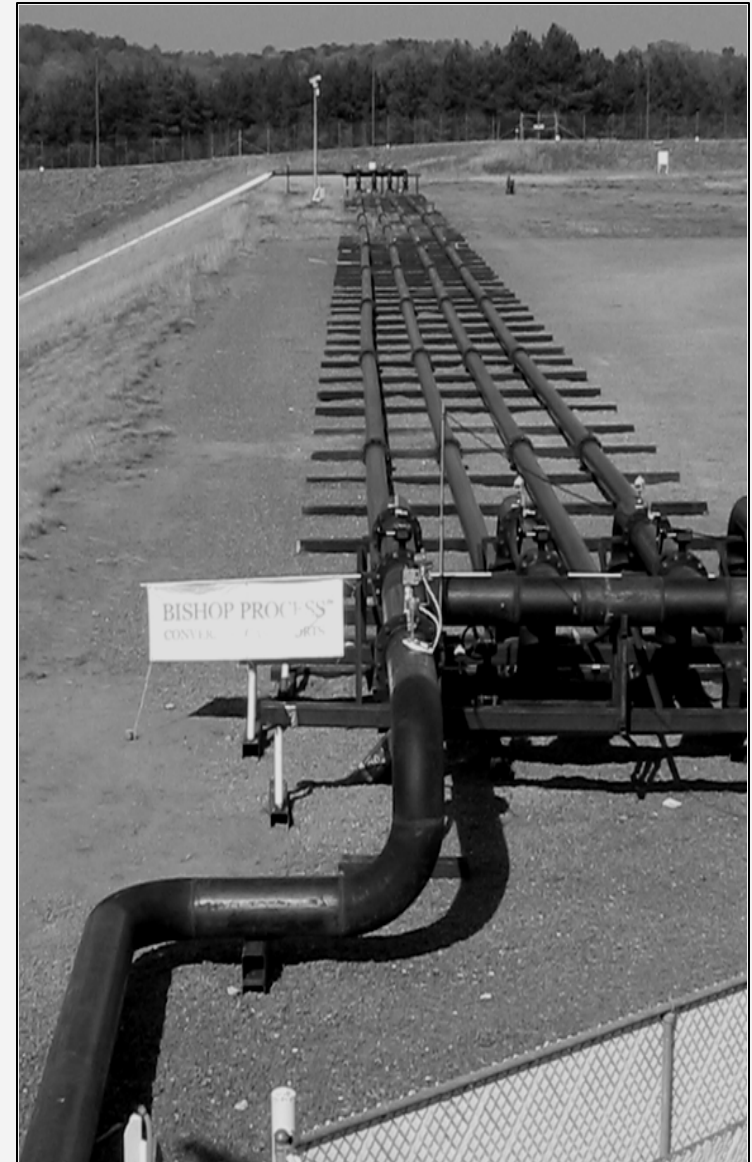
- Ebara
- Nikkiso



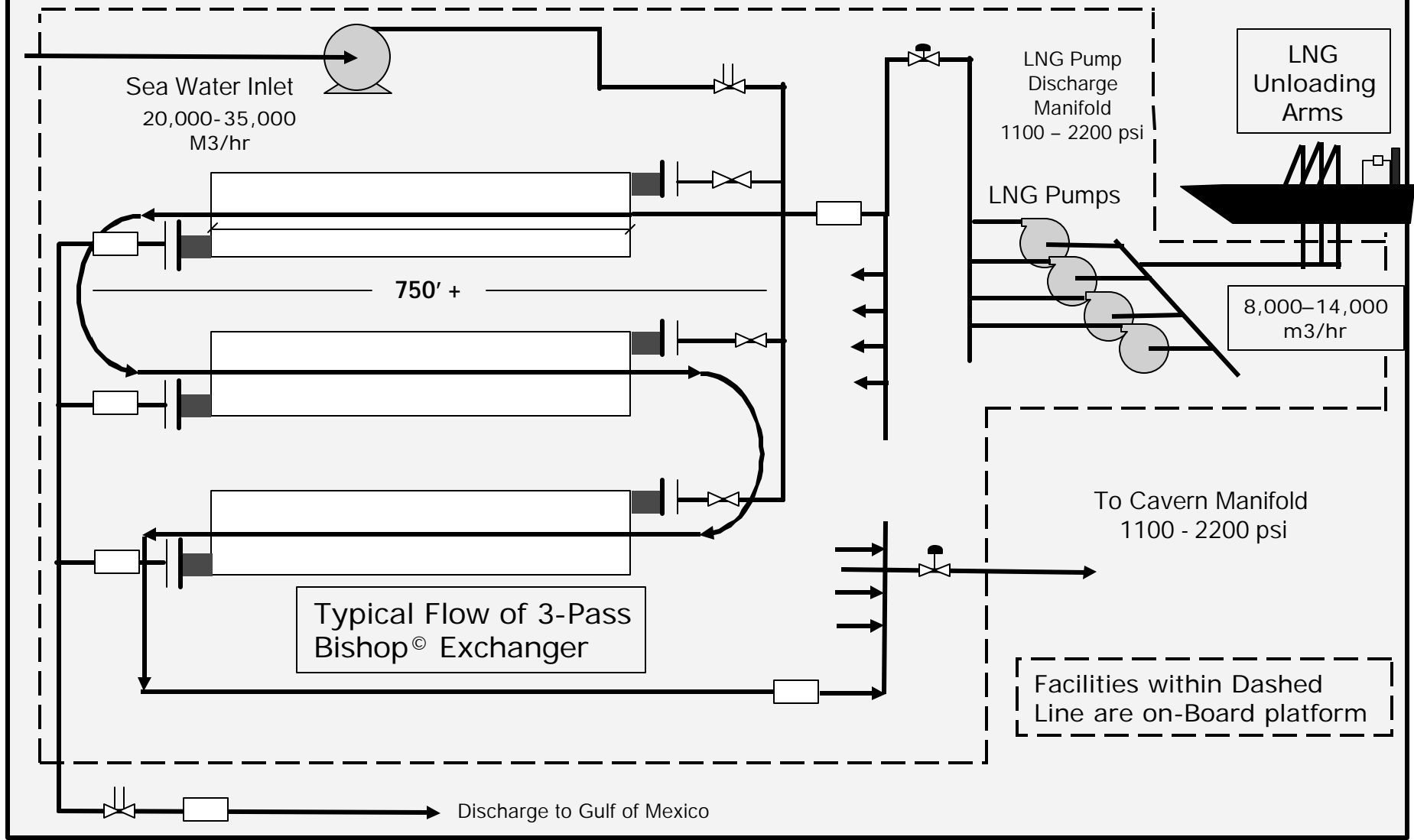
- Rated at either ANSI 600 (1480 psi) or 900 (2220 psi)
- LNG flow 300 m³/hr @ 2000 psig
- Operates efficiently across range from 1100 psig to 2000 psig working against variable cavern pressure
- No need for variable volume output (i.e., no variable frequency drives)

Enabling Technology: Bishop Process TM LNG Heat Exchanger

- Operation proven by full scale tests completed Apr-19-2004
- Warms a nominal 300 m³/hr at low capital cost & operational cost
- Simple pipe-in-pipe design using 316L SS as cryogenic pipe & polymer as outer shell.
- Multiple configurations to match project requirements – easily scalable
- Operates in dense phase at ANSI 600LB and 900LB ratings
- Minimizes pressurization cost by using pumps, not compressors



Bishop Process TM LNG Heat Exchanger 3-Pass Configuration

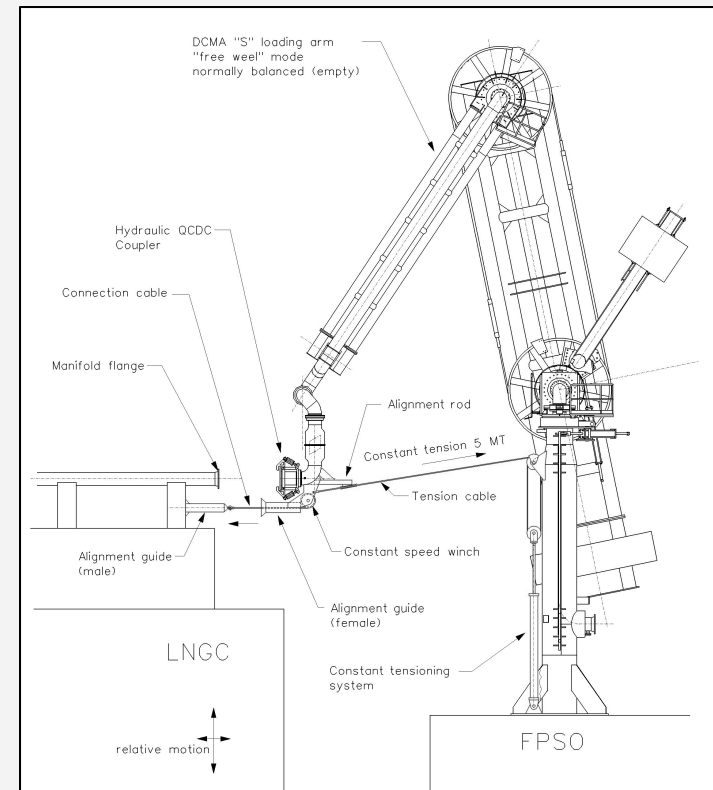


Enabling Technology: LNG Loading Arms

- No cryogenic hose
- No new LNG manifolds on LNG carrier



- Full scale connect testing of 16" arm in 2002 for **Shell Global Solutions** by **FMC**
- 4 m vertical motion range @ 0.85 m/s
- 5 m horizontal motion range @ 1.15 m/s
- 10 m surge fore-aft (design untested)



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

Enabling Technology: A Floating and Weathervaning Platform



FSO Ta' Kuntah
Pemex Cantarell Field
Gulf of Mexico

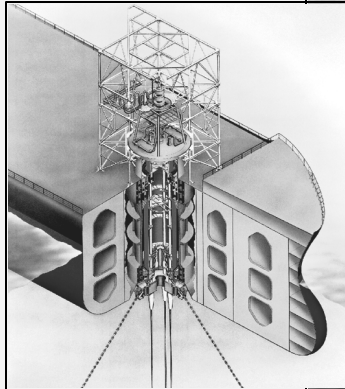
- 1st oil Aug-1998
- 246 ft (75m) water depth
- 352,000 dwt tanker conversion
- 2.3 million bbls storage



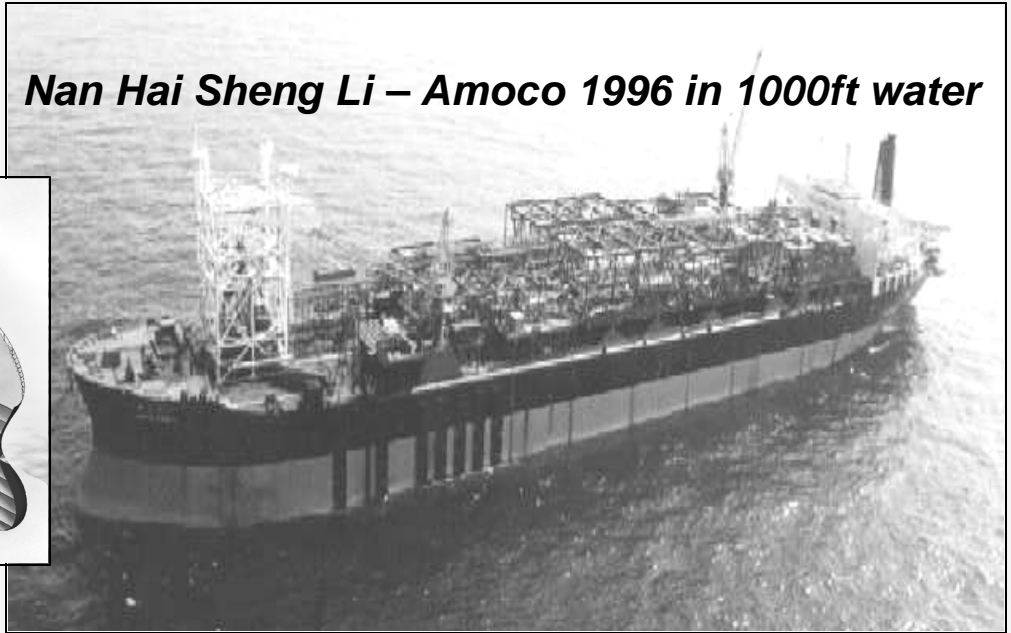
**Largest FSO in design
throughput: 800,000 BOPD
Offloading to 2 shuttle
tankers simultaneously
MODEC owned & operated
under 10+5 year lease**

Enabling Technology: Mooring Systems & Gas Swivel Systems

- Widely used deep water mooring turrets



Nan Hai Sheng Li – Amoco 1996 in 1000ft water



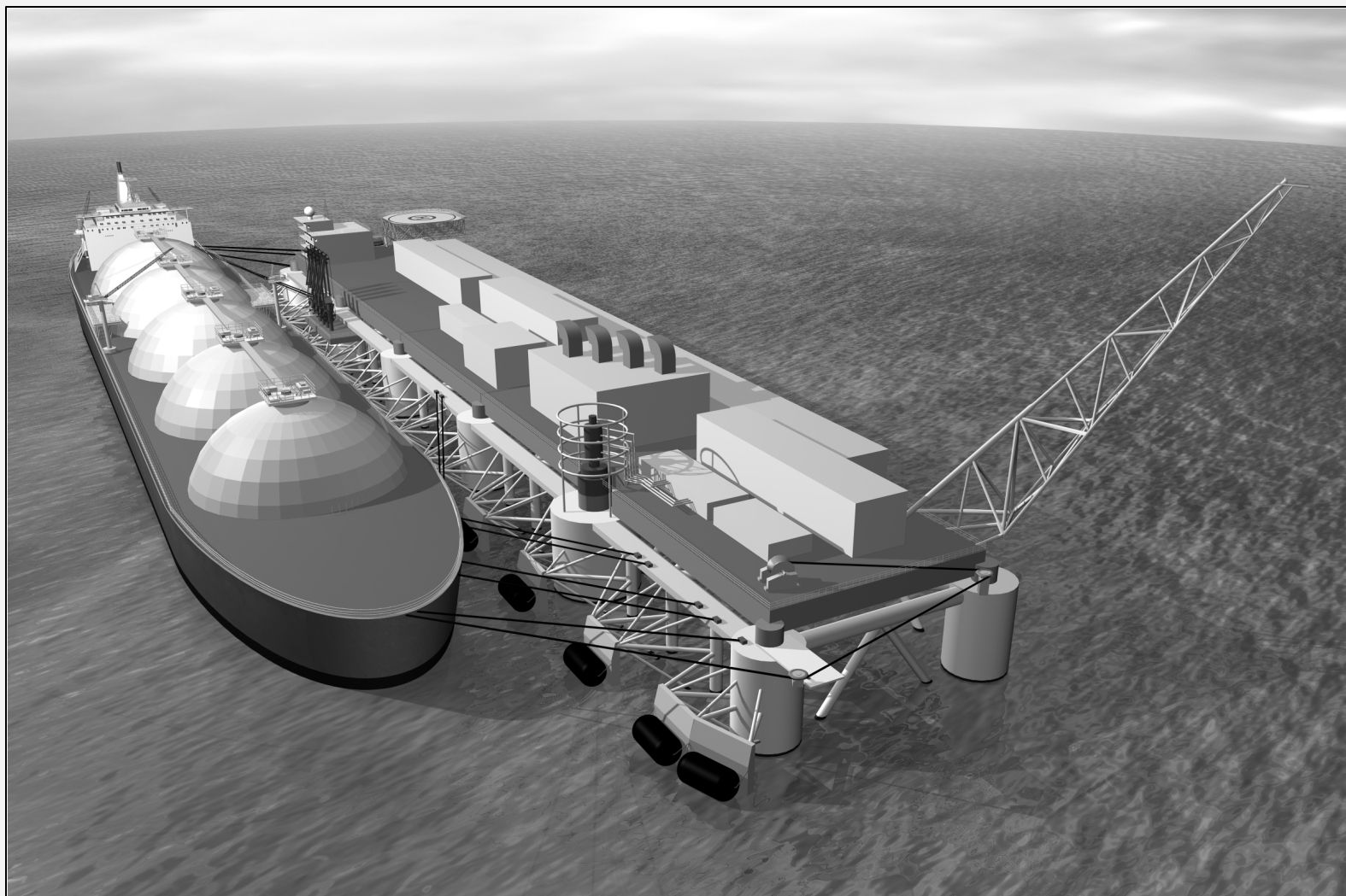
- Shallow water Tower Yoke Moorings
- Bohai Bay, CNOOC, China
- Chad FSO, Esso, West Africa

Enabling Technology: The Column Stabilized Platform

- Minimum relative motions
- Relatively low deck load ~ 6900t + 3100t LNG
- All process and power generation on board
- Length – based on:
 - Berthing considerations, LNG carrier size & motion optimization
 - Not dictated by process equipment
- Height – based on:
 - Air gap (1.8 m) above 100 year survival wave
 - 16.5 m (54 ft) air space under deck
- Draft:
 - As needed for displacement & Stability, & LNG carrier drafts, 15.2 m

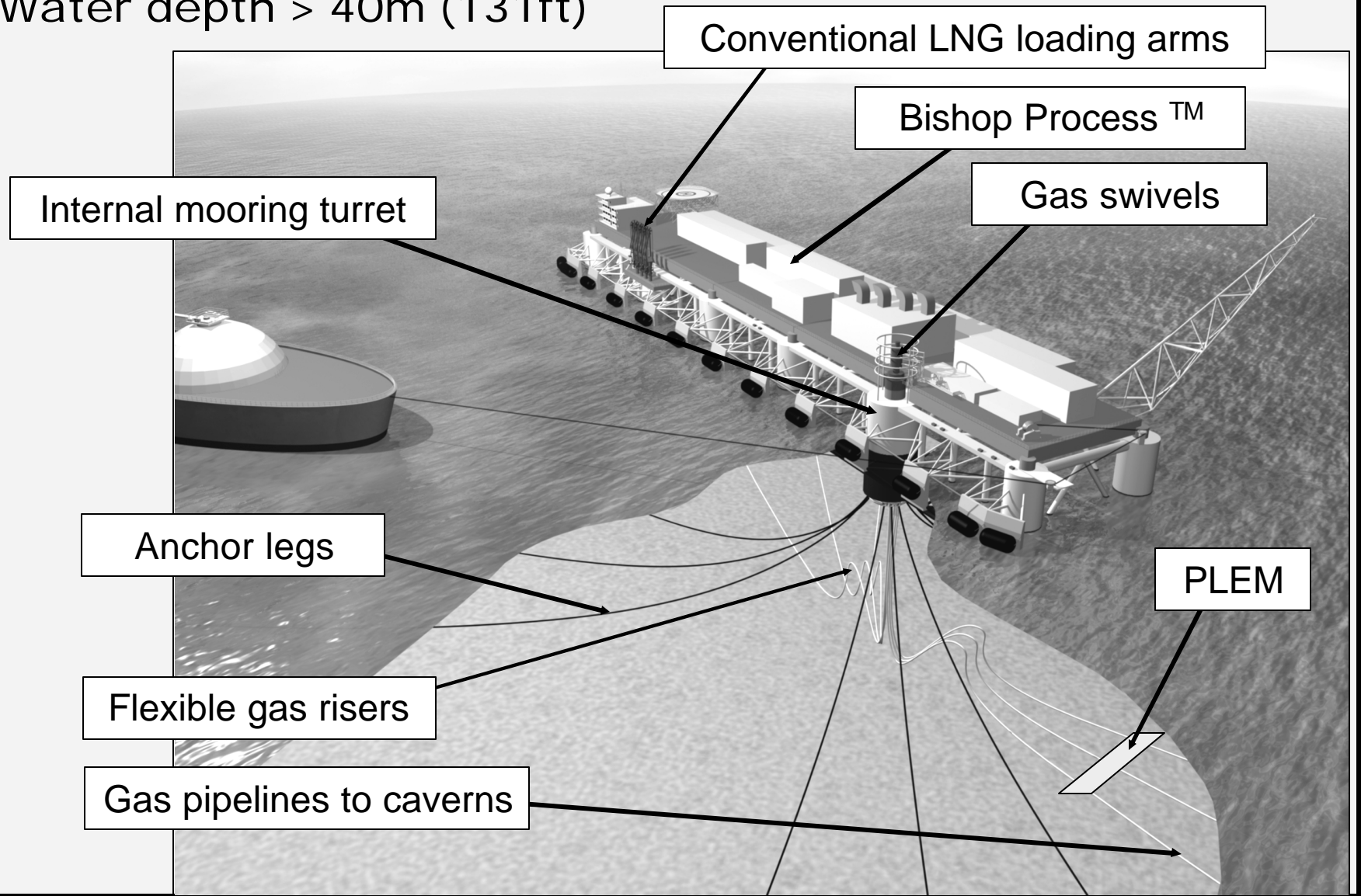


Column Stabilized Platform for an Floating LNG Receiving Terminal

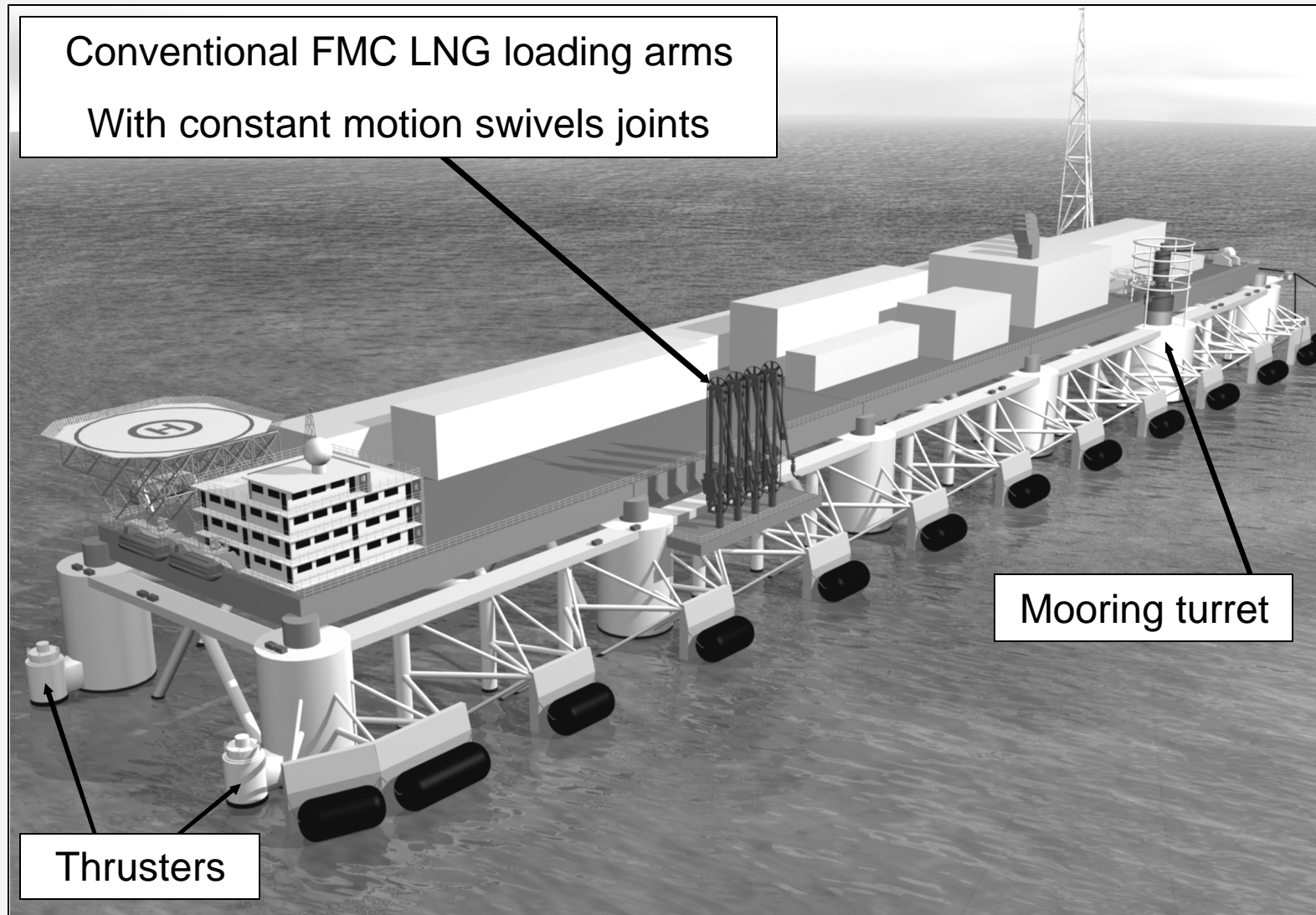


Floating LNG Terminal For Deep Water

Water depth > 40m (131ft)



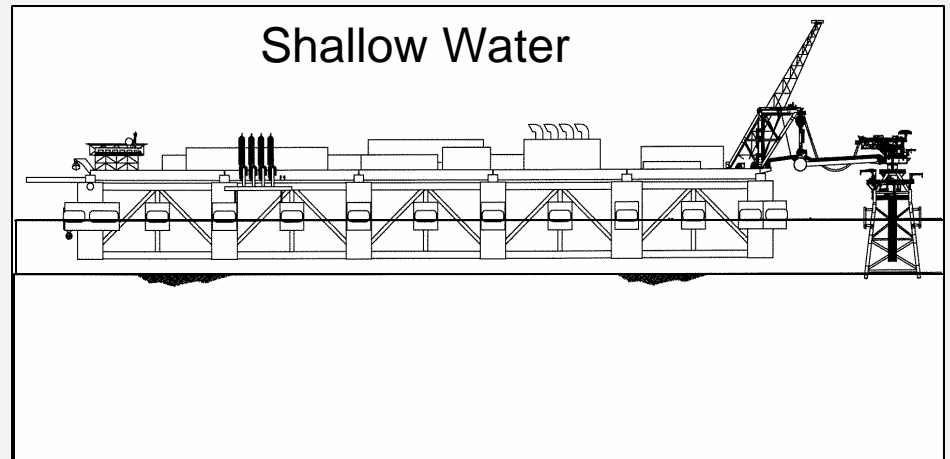
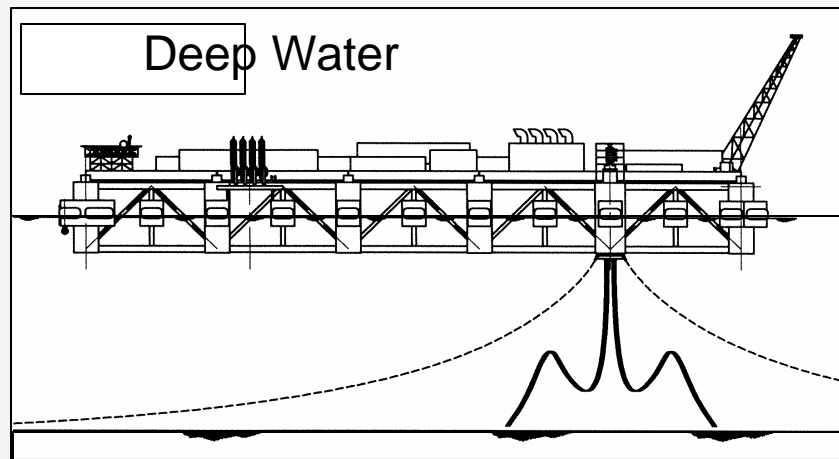
Floating LNG Receiving Terminal



FMC SOFEC LNG Floating Terminal

Deep or Shallow Water

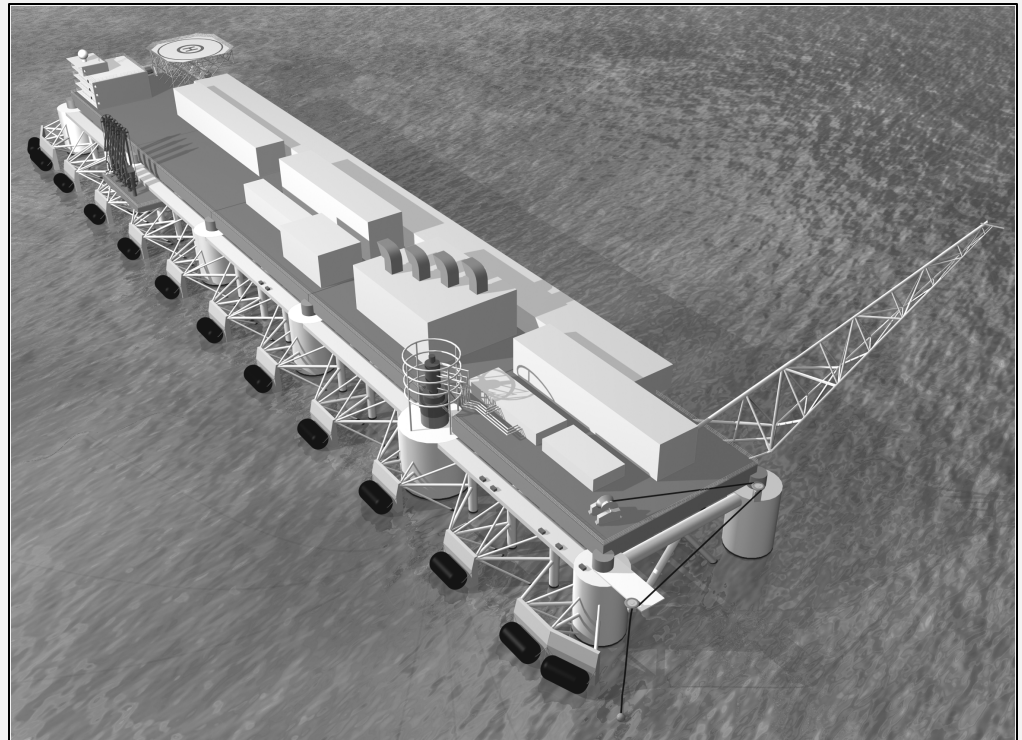
- Platform design suitable in any water depth (deep or shallow)
- Ample deck space for space separation of modules = safety
- Subsea cryogenic LNG pipeline is not required
- Achieves minimum relative motions between platform & ship = greater uptime availability
- Active position control using thrusters = higher operational safety for carrier mooring



FMC SOFEC LNG Floating Terminal

Deep or Shallow Water

- Large open flat deck space for process units
- Construction efficiency, float out completely tested system
- Construction in many fab yards – some on Gulf coast
- Modular construction – fast construction
- Accommodates LNG carriers of any size
- Low capital and operating costs
- Can be relocated to another site



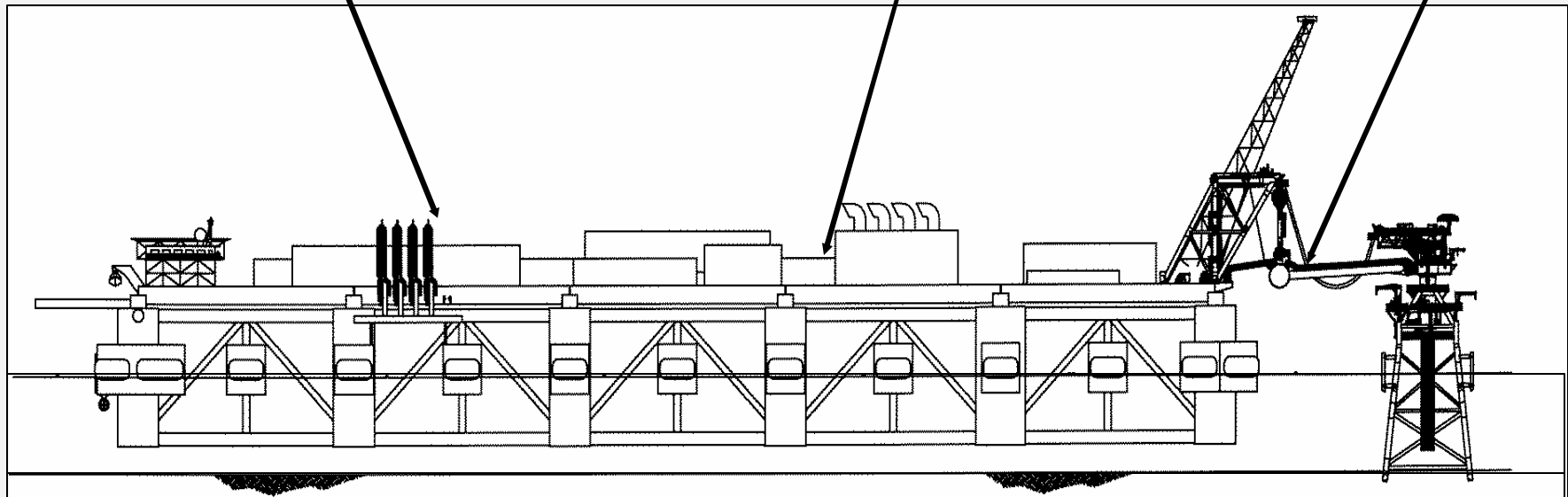
Shallow Water LNG Terminal

15 to 40m (49 to 130ft)

Conventional LNG loading arms

Bishop Process TM

Tower Yoke Mooring



Survives maximum storm load while moored in shallow water
due to minimum motions of column stabilized construction

Design Conditions - for 91 m (300 ft) Water

■ Carrier Berthing

2.5 meter significant wave > 90% berthing availability

■ Offloading – maximum conditions

3.5 meter significant wave > 99% offload availability

■ Relative motions @ Loading arms:

< 4 m heave, < 5m sway, < 10m surge



100 year storm survival load conditions

■ Vertical heave ± 9.4 m (30.8 ft)

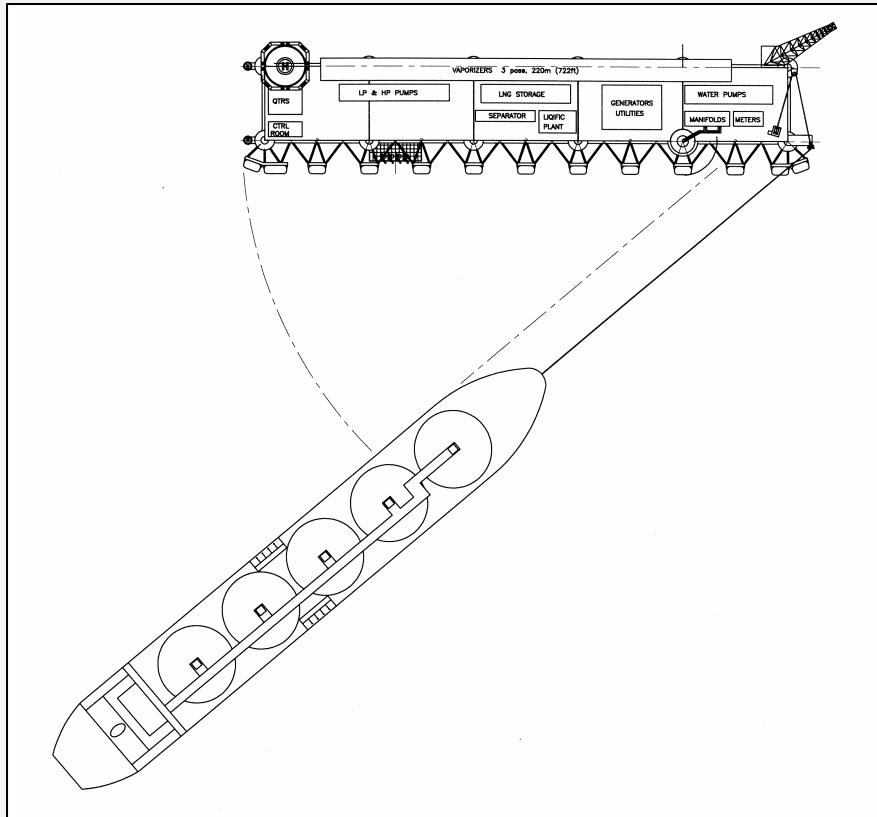
■ Roll motion ± 0.8 deg

■ Pitch motion ± 3.7 deg

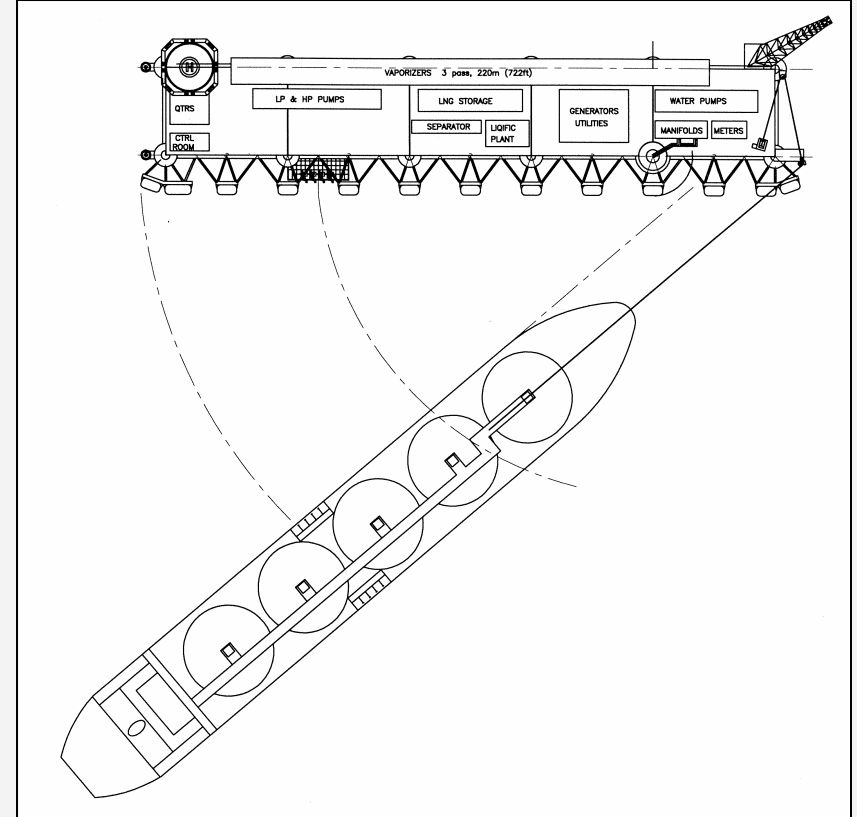


LNG Carrier Berthing Operations

1



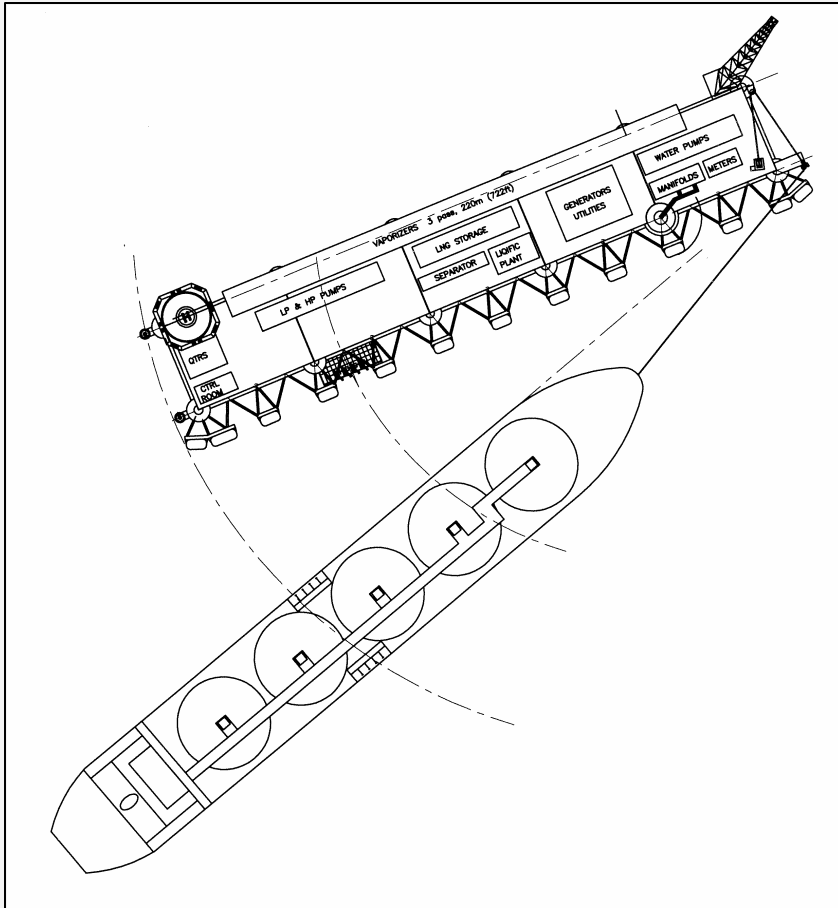
- Swing platform 30° to 40°
- Hawser tows carrier, aft thrust



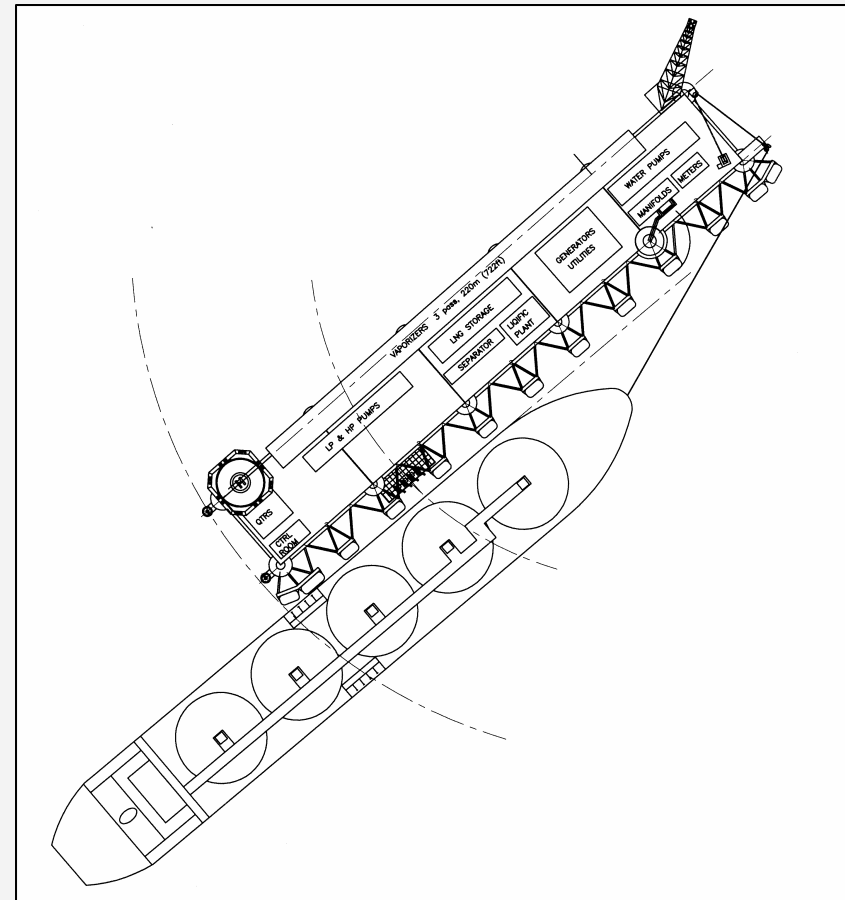
- Carrier slows to dead stop
- Engage thrusters (45t - 70t)

LNG Carrier Berthing Operations

2

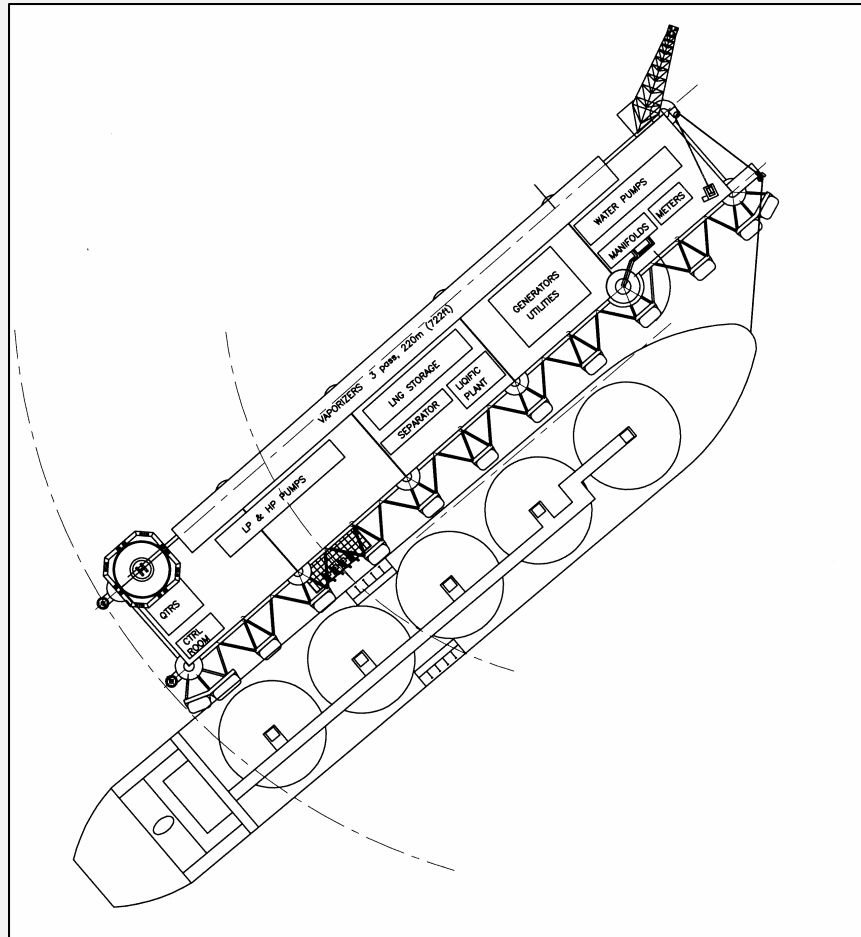


- Swing platform quickly to carrier
40°, 160 m arc @ 0.5 kt, 11 min

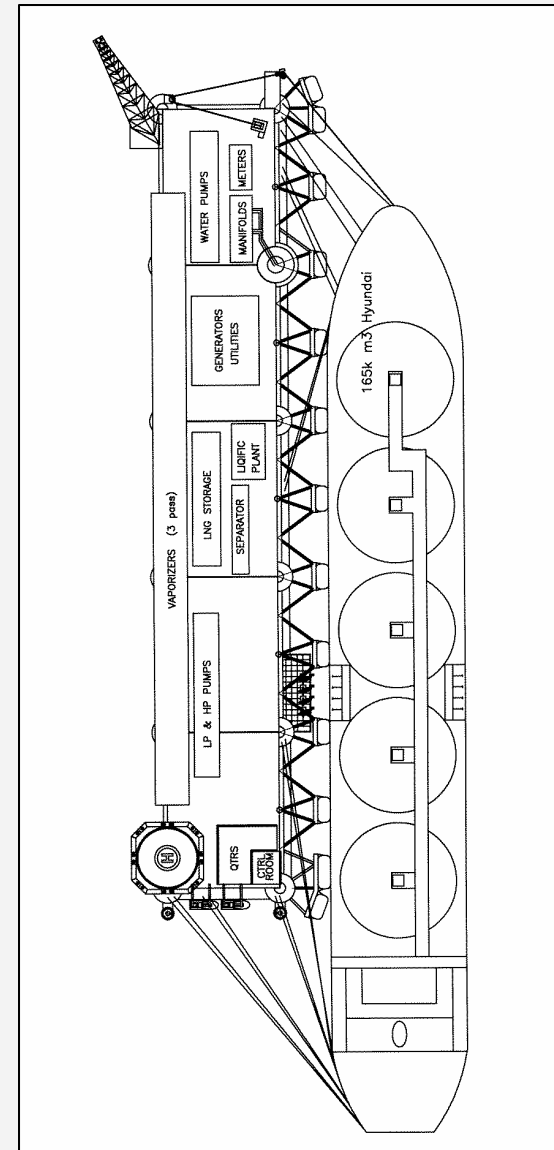


- Aft fenders contact
- Ready to align loading arms

LNG Carrier Berthing



Loading arms aligned & connected



3

Mooring lines run to platform

Comparison of Attributes to “Ideal” Terminal

	Bishop Heat Exchanger	LNG Pumps	Conventional Loading Arms	Weathervaning With Thruster Assist	Conventional Mooring System	Column Stabilized Low Motions
Least new technology	Yes	Yes	Yes	Yes	Yes	Yes
Safest Berthing of LNG Carrier	n.a.	n.a.	n.a.	Yes	Yes	Yes
Safest offload, process, & storage	Yes	Yes	Yes	Yes	Yes	Yes
Quickest LNG Carrier Offload	Yes	Yes	Yes	Yes	n.a.	Yes
Max Up-time Availability	n.a.	n.a.	Yes	Yes	Yes	Yes
Lowest Capex And Opex	Yes	Yes	Yes	Yes	Yes	Yes
Operational < 24 months	Yes	Yes	Yes	Yes	Yes	Yes

Conclusion

- The Bishop Process TM for natural gas storage in salt dome caverns can be combined with a self-contained floating platform designed for minimum relative motion and maximum operational safety while receiving and vaporizing LNG.
- This approach can provide a quickly built and cost efficient facility for expanding the import, storage, and distribution of natural gas