A smart LNG Offloading to Conventional LNG Carriers in Severe Open Sea Environments
FLNG offloading state of the art

Expected design features

- LNG loading of conventional/unmodified LNG carriers.
- High operability (up to at least Hs = 4 m).
- Large separation between units providing protection against risk of collision & process upsets.
- Minimize LNG transfer lines length (→ minimize pressure drop/BoG).
- Use of proven or qualified technologies.

Current side-by-side and tandem offloading systems do not satisfy all wishes...
# FLNG offloading state of the art

<table>
<thead>
<tr>
<th></th>
<th>Side-by-side Midship loading</th>
<th>Tandem Bow loading</th>
<th>HiLoad LNG Tandem Midship loading</th>
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</thead>
<tbody>
<tr>
<td><strong>LNGC Fleet</strong></td>
<td>Conventional (no DP, midship manifold)</td>
<td>Dedicated (w/ or w/o DP, Bow Loading System)</td>
<td>Conventional (w/o DP, midship manifold)</td>
</tr>
<tr>
<td><strong>Waves/Operability</strong></td>
<td>Up to Hs 2.5 m</td>
<td>Up to Hs 5.5 m</td>
<td>Up to Hs ≥ 4 m</td>
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<tr>
<td><strong>Separation Distance</strong></td>
<td>Close vicinity</td>
<td>Large distance</td>
<td>Large distance</td>
</tr>
<tr>
<td><strong>LNG Transfer Length/Efficiency</strong></td>
<td>≈ 30 m</td>
<td>≈ 150 m</td>
<td>≈ 350 m</td>
</tr>
<tr>
<td><strong>LNG Transfer Technology</strong></td>
<td>MLA Qualified</td>
<td>Aerial flexible pipe Qualified</td>
<td>Floating flexible pipe Under qualification</td>
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**Can we Take LNG Offloading Further?**
HiLoad LNG Parallel Loading System

A smart solution meetings all expectations

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<td>At least Hs 4 m</td>
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<tr>
<td>Separation distance (Collision &amp; Process upset)</td>
<td>Large distance</td>
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<tr>
<td>LNG Transfer Length/Efficiency</td>
<td>( \approx 100 \text{ m} )</td>
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HiLoad LNG Parallel Loading System

- **DP Support Vessel**
  - Constant ~30-40 tons pull

- **DP2 Station Keeping of LNG Carrier by HiLoad LNG**
  - 150 tons bollard pull

- **3 x 18" LNG Aerial Flexibles**

- **LNG Loading Arms**
  - No relative motion

- **FLNG w/ Heading Control**
  - FLNG to “lock” the heading based on given environmental conditions. When environment direction is changing, FLNG heading to be adjusted according to Mooring Master instruction

- **Reels**

- **100 m separation**

**Conventional LNG Carrier**
- No modification required

**Direction of resultant force**
- (Wind, wave and current)
Operational Envelope – LNGC Position Keeping

**Normal LNG Transfer Operation**
- Diameter: 20 m

**ESD 1**: Stop LNG Transfer and close valves
- Width: 2.5 m

**ESD 2**: Disconnect the LNG Flexibles and prepare to move LNGC away from the FLNG
- Width: 2.5 m

Direction of resultant force (wind, wave and current)

Operational Envelope for the DP Support Vessel (typical 30 m diameter)
Operational Envelope – LNGC Heading Control

Operational Envelope for the FLNG Support Vessel (typical 30 m diameter)
Change of FLNG Heading
LNG Fluid Transfer with Aerial Flexibles

- LNG Flow: 2 x 18” LNG Aerial Flexibles
- Vapour Return: 1 x 18” LNG Aerial Flexible
- Spare reel
Proven or qualified technologies

LNG transfer – Amplitude-LNG Loading System (ALLS)

Emergency Release System based on two field proven high performance butterfly valves by KSB Amri, double offset disc, metal to metal seat, fire safe, long tightness life and strong autoclave characteristics.
Proven or qualified technologies

DP station keeping by HiLoad DP

- 4 x 2800 kW diesel engines (CAT C175/60, MTU 20V4000P83, or similar).
- 4 x 2300 kW azimuth thrusters (4 x 50%)
  Compact Azipod or mechanical thruster.
Roll Damping by HiLoad keel = Reduced Sloshing

Main roll damping effect for waves with periods in [8s; 15s]

**UP to 50% ROLL REDUCTION**
(by passive damping from HiLoad only)

**UP to 80% ROLL REDUCTION**
(by active damping from HiLoad thrusters)
DEMO at MARIN Simulator – Sept 2015
DEMO at MARIN Simulator – Sept 2015

HiLoad Master at the Bridge of the HiLoad Vessel

Mooring Master at LNGC Bridge during Approach

Tug Master

Typ. LNGC Position Trace during Approach
LNGC Heading Control by Rudder

DP station keeping by HiLoad DP
Heading control by rudder

FLNG w/ Heading Control
FLNG Heading “locked” based on direction of environmental forces

LNGC Bow Thruster in Backup (if any)

100 m separation

LNGC Main Engine in constant “Dead Slow Ahead”
Typ. forward force: 40-50 tons

No Support Vessel Required

Direction - Sum of wind, wave and current forces

DP Station Keeping of LNG Carrier by HiLoad – Typ. 150 tons bollard pull

Heading Control by LNGC Rudder in Autopilot
Active & Passive Safety Barriers

Emergency Quick Release of LNG Flexible Pipes within 8 seconds

Technip Generic FLNG: $L_o = 395.6\, m$, $B = 65.0\, m$

Safety barriers in case of emergency escape:

A. HiLoad thrusters, 150 ton instant bollard pull in any direction
B. LNGC engine
C. FLNG AFT thrusters
D. LNGC bow thruster
E. Environmental Forces

HiLoad LNG PLS is a Fail Safe solution
Conclusion
HiLoad LNG PLS Combines the advantages of Side by Side and Tandem

SAFETY
Large separation distance: 100 m
No personnel transfer via crew boat
all travels safely to LNGC with HiLoad

EFFICIENCY
Operation in up to Hs 4.0 m
Increased offloading operability
Roll Reduction of LNGC
DP2 Station Keeping of LNGC by HiLoad

FLEXIBILITY
Enables use of any conventional LNGC
Even non-DP LNGC
Tug is not strictly required (efficient heading control with rudder)
Thank you

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