Expert in LNG

# How to comply with the specificities of LNG market

## Floating LNG Global Conference


Amsterdam, 14th May 2019

Safety | Excellence | Innovation | Teamwork | Transparency

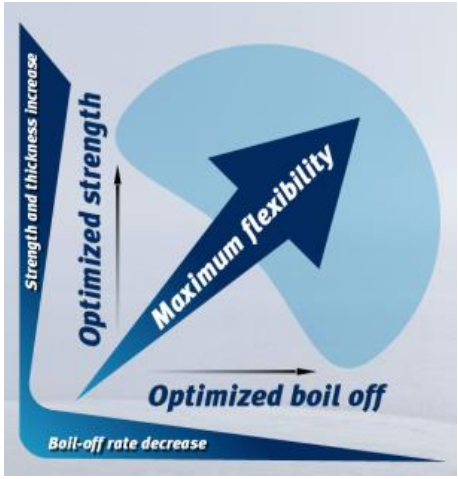
# Agenda

- LNG Shipping Market : increase the thermal efficiency of the containment system
- LNG Offshore Market : adapting the tank design to the FLNG and FSRU operations
- Innovative solutions from small sizes to large capacities : the case of GBS with membrane tanks

# LNG Shipping Market

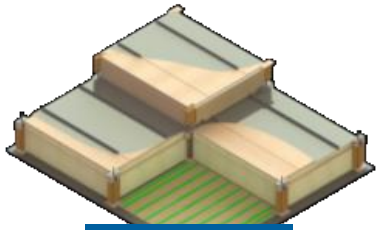
# Standard LNGC specification is evolving

- The new size of “conventional” LNGCs is increasing, today around 170,000 $m^3$ to 180,000 $m^3$
- Technological advances :
  - ME-GI and XDF propulsion efficiency
- Demand for lower BOR (≤0.1%V/day)
- Demand for higher strength of containment systems for increased flexibility in filling levels

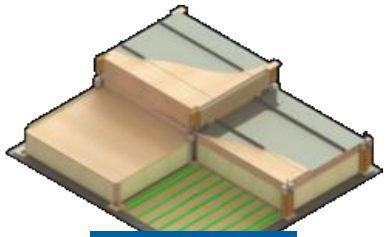


# GTT innovation activities for lower BOR

- **Introduction of new systems since 2010**



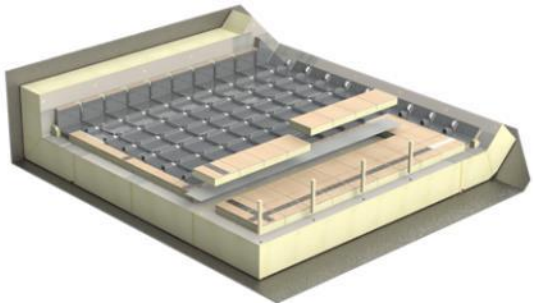
NO96 L03



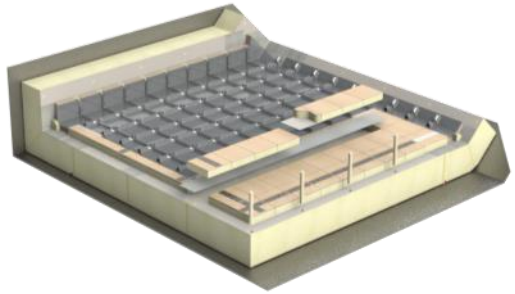
NO96 L03+

NO96 Flex

**GTT Innovations for lower BOR since 2010**



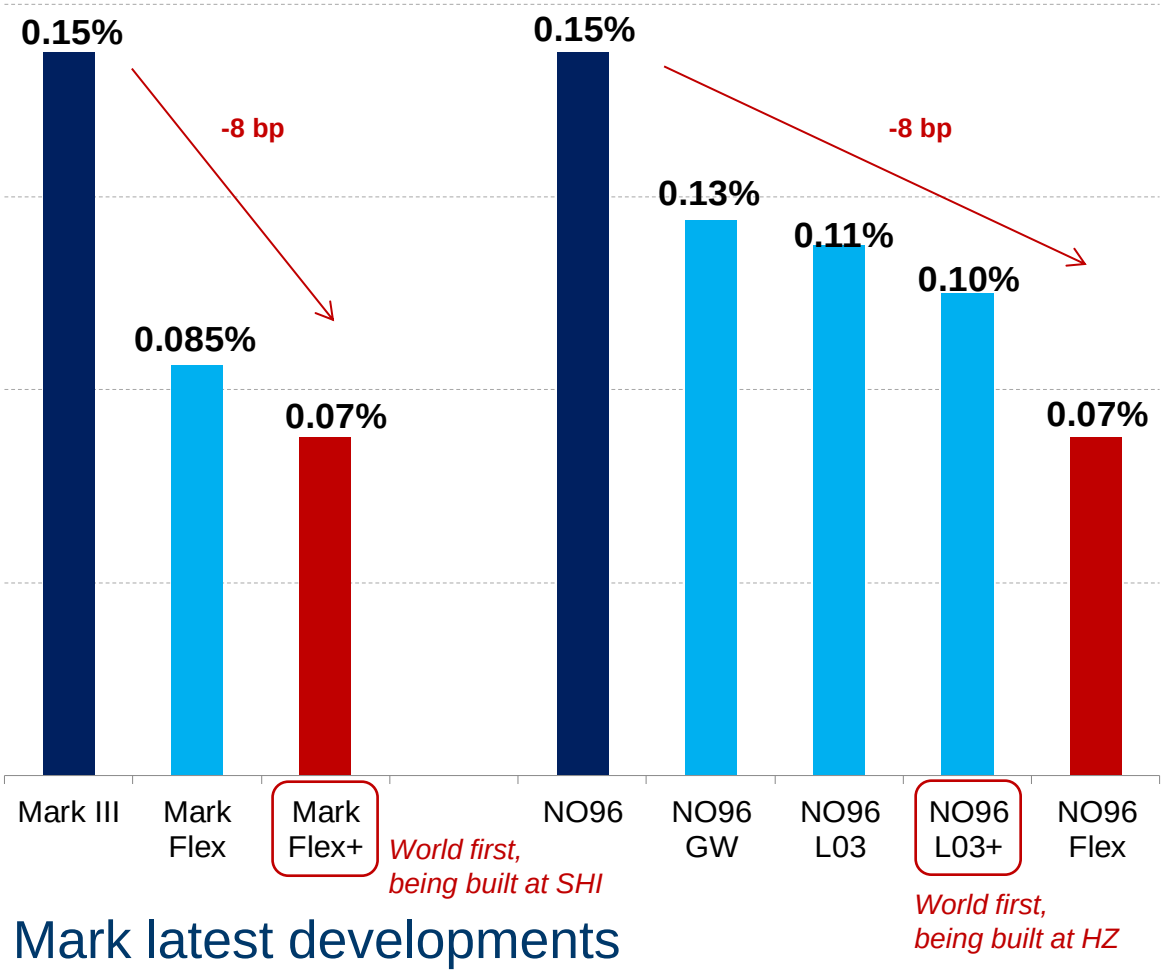
Mark III Flex



Mark III Flex+

# GTT innovation activities for lower BOR

- **Thermal performance of GTT technologies developed since 2010**



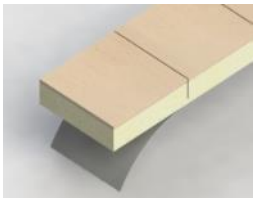

- NO96 and Mark latest developments

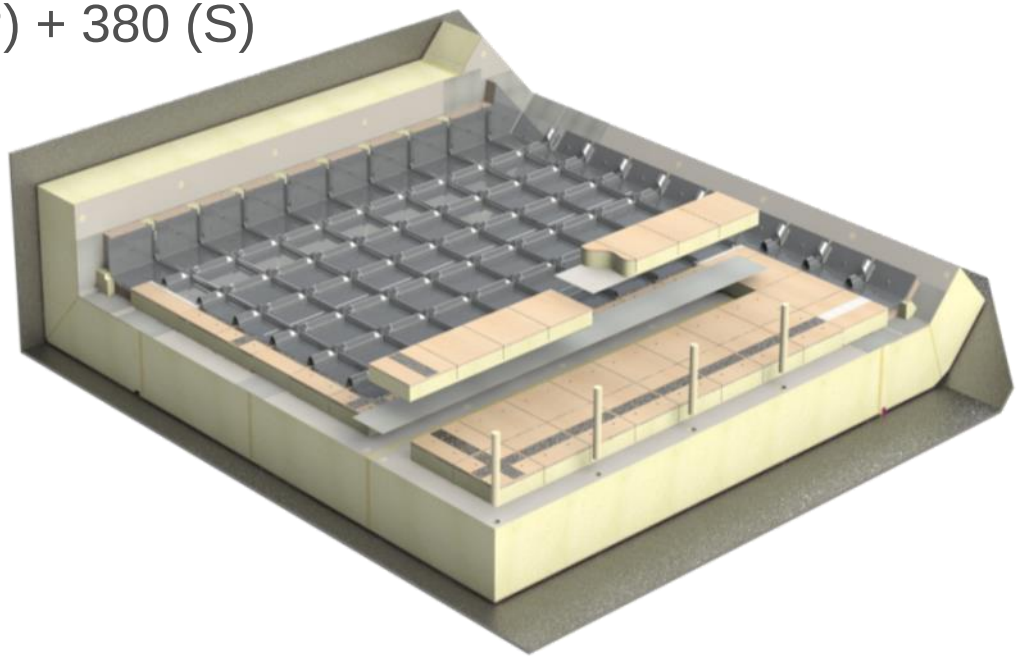
*Design BOR for a 174,000m³ vessel*
*Optimised HFC 245-fa foams exhibiting improved thermal conductivity, with repeatable production process*

# Mark III Flex+

## Design & Characteristics

- Primary membrane: 1.2mm corrugated stainless steel
- Secondary membrane: **Reinforced Triplex**
  - Additional RSB under Top Bridge Pads (glued at prefabrication stage)
- Thickness: **480mm** = 100 (P) + 380 (S)
- Strength: **130kg/m$^3$** R-PUF



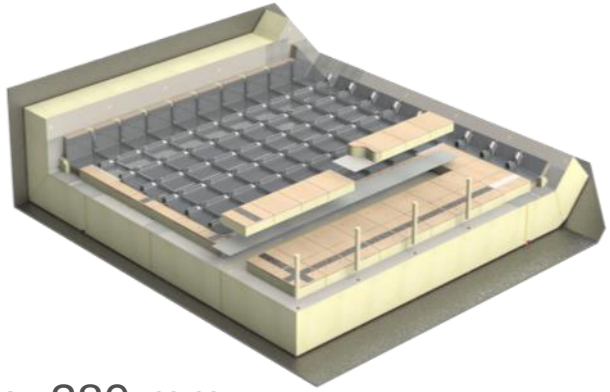


## Performances(1)

- BOR: **0.07%V/d**

*(1) - Design BOR for a 174,000m$^3$ vessel*
*- Optimized HFC 245-fa foams exhibiting improved thermal conductivity, with repeatable production process*

# Mark III Flex+

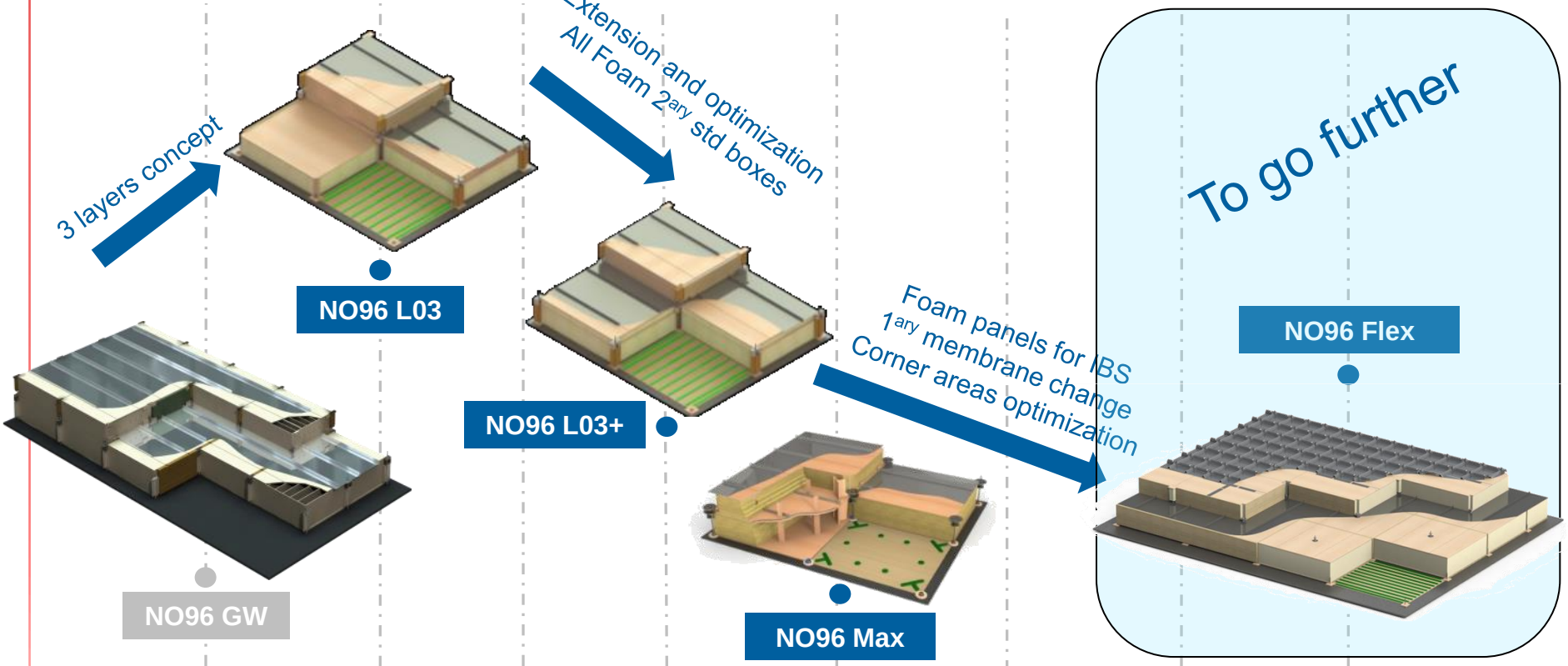


## Conclusions

- Guaranteed BOR: 0.07%V / day
  - 480 mm thick insulation panels
  - Primary space: 100 mm, and secondary space: 380 mm
- Benefits from latest secondary barrier improvement
  - Reinforcement of 2$^{ary}$ barrier by means of additional triplex under the TBP
  - Already fitted on 6 vessels ordered
  - Fatigue behavior of the bonded joints is significantly enhanced
  - Safety coefficients are increased in flexible secondary barrier
- Mark III Flex+ is relying on shipyard best practices and standards for erection with full GTT support

- 1st ship with SHI shipyard – delivery third quarter 2019
  - Positive feedback regarding this first application in terms of construction

# NO96 Technical Roadmap




- NO96 Max: a new philosophy based on pillar geometry associated to densified plywood
  - Industrialization of this system requires investments and change of erection procedures
  - Extra-cost considered as not acceptable
- NO96 L03 and NO96 L03+: a progressive introduction of foam panels, only for 2ary insulation space, without changing erection procedures

# NO96 Flex System

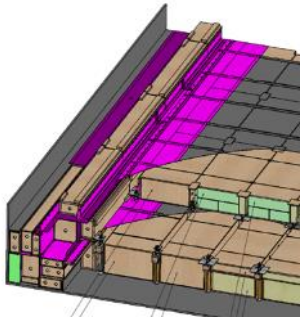
## Design challenges based on experience regarding last projects

- Identification of the **design levers** in order to optimize the performance and the mechanical behavior

**Supporting of the tubes with plywood boxes**

**Anchoring to the inner hull with tubes**

**Transition areas to manage "steps"**



**NO96 Invar membranes**

# NO96 Flex System

## Design challenges based on experience regarding last projects

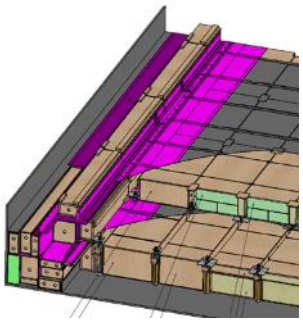
- Identification of the **design levers** in order to optimize the performance and the mechanical behavior

**Supporting of the tubes with plywood boxes**

**Anchoring to the inner hull with tubes**

**Management of Transition Areas**

**Three main items which imply:**
- **Heat Flux**
- **Potential Extra-cost**
- **Complex Mechanical Behaviour**

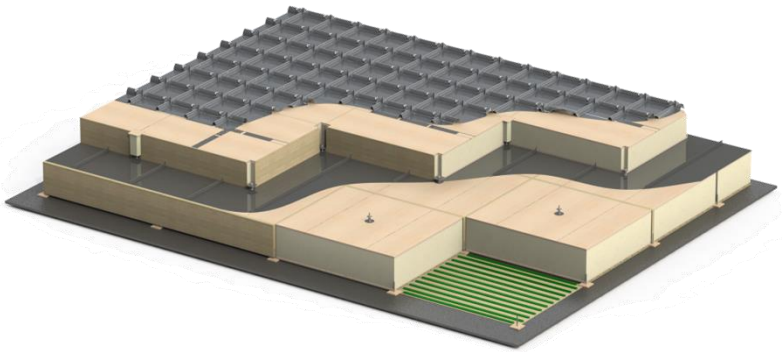


Using a **flexible primary membrane** and a **new design for transverse corners** is required to attain low BO performance

# NO96 Flex System

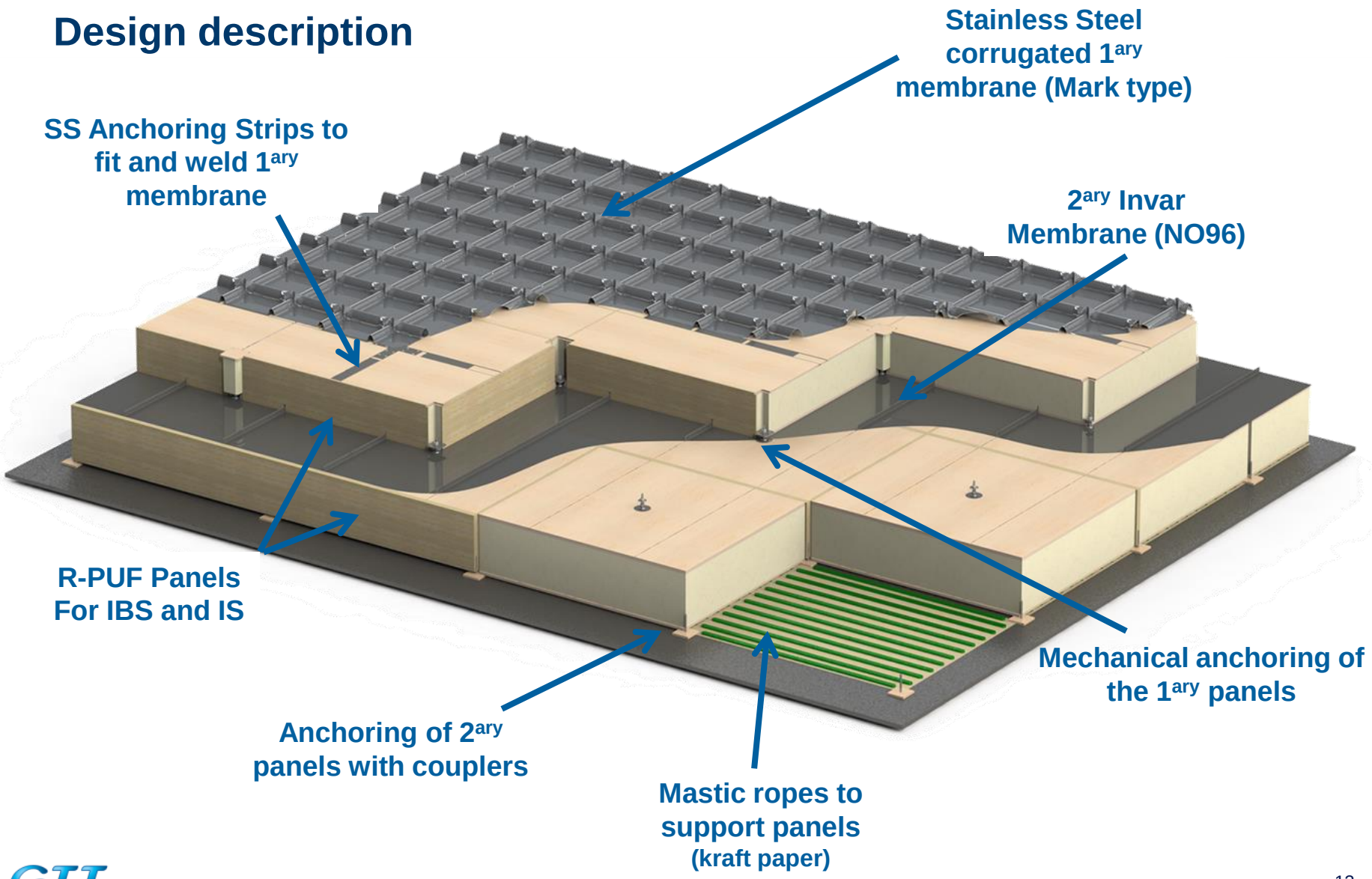
## Objectives of the project

- Improved thermal performances …
  - BOR = 0.07%V/d
- … by using the following design levers:
  - **1ary membrane** sufficiently **flexible** to avoid any strong anchoring to the inner hull
  - Optimized design for the **corner areas** (Longitudinal and Transverse corners)
  - Prefabricated **R-PUF panels** for IS and IBS
  - Unchanged **2ary Invar membrane**
  - Mechanical anchoring of the panels to the inner hull (**couplers** type)



# NO96 Flex System

## Design description



# LNG Offshore Market

# Newbuilding FSRUs in service

- 10 in service GTT NO96 membrane LNG-RV/FSRU
  - Excelerate, Exmar, MOL
  - Classed by BV
  - Offshore partial filling operations initially intended in the Gulf of Mexico and Massachusetts Bay
  - First unit delivered in 2005
- 15 in service GTT Mark III membrane SRV/FSRU
  - Höegh, Golar, BW
  - Classed by DNV GL
  - Offshore partial filling operations initially intended in Massachusetts Bay
  - First unit delivered in 2009
- More than 1,500 STS performed
- About 10 more FSRUs under discussion



NO96 LNG-RV (top),
Mark III SRV (bottom)

# FLNG orders:
## *Four first large offshore units with membrane*

- Shell Prelude FLNG
  - EPCIC awarded to Technip-SHI
  - Storage tanks:
    - Two-row MkIII (220,000 m3 LNG)
    - Two-row MkIII (90,000 m3 LPG)

Dimensions
- Length 488m
- Wide 74m
- Draught 17-20m
- Weight 600,000 ton fully ballasted; 260,000 ton dead weight

**MAJOR AWARDS SO FAR**
**SBM Offshore:**
Turret mooring system
**Kawasaki Heavy Industries:**
Marine boilers
**GE Oil & Gas:**
Steam turbine-driven compressors
**Air Products:**
Cryogenic coil-wound LNG heat exchanger
**GTT:**
Tank containment system
**FMC:**
Main subsea hardware

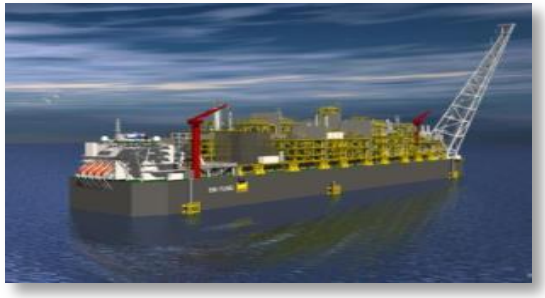
*LNG Unlimited, 14/10/2011*

- Petronas FLNG 1 (Kanowit)
  - EPCIC awarded to Technip-DSME
  - Production capacity: 1.2 mtpa of LNG
  - Storage tanks:
    - Two-row NO 96 (177,000 $m^3$ LNG)


PETRONAS

- Petronas FLNG 2 (Rotan – Sabah)
  - EPCIC awarded to JGC-SHI
  - Production capacity: 1.5 mtpa of LNG
  - Storage tanks:
    - Two-row Mark III (~180,000 $m^3$LNG)

- ENI CORAL South FLNG
  - EPCIC awarded to TechnipFMC-JGC-SHI
  - Production capacity: 3.4 mtpa of LNG
  - Storage tanks:
    - Two-row Mark III (~239, 000 $m^3$LNG)



Eni

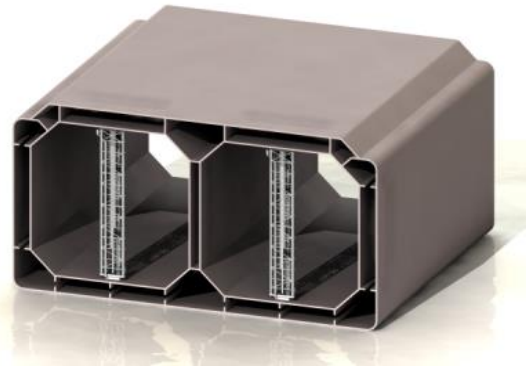
GTT

# Requirement to operate without filling limits

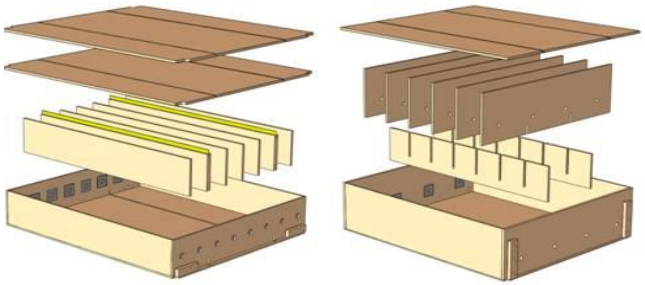
Sheltered site or exposed to open seas?

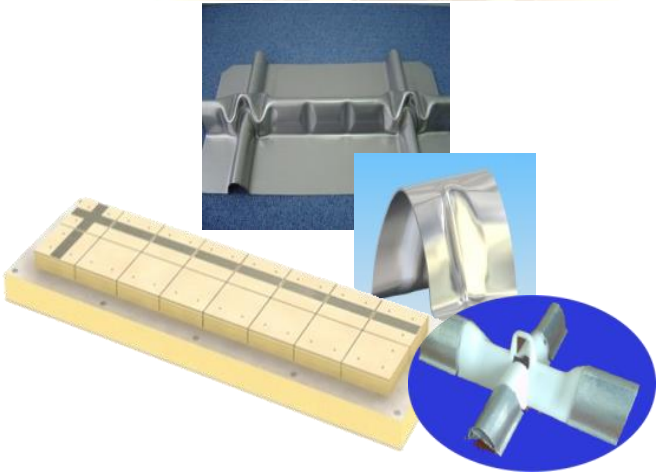
How to make sure the sloshing loads are acceptable?

With dedicated sloshing assessment leading to new tank design or appropriate CCS design reinforcement

**Primary box** **Secondary box**





# Specific operations for FSRUs

Regas operations

Seasonal gas demand

Ship-to-Ship Operations


How to manage BOG ?

⇒ Increase the maximum tank pressure

⇒ Perform simulations to modelize the new CHS operations

# FLNG versus LNGC

| | LNGCs | FLNGs |
|---|---|---|
| **DESIGN** | -Fillings <10%H or >70%H<br><br>-"Mobile" Unit, designed for worldwide navigation<br><br>-Loading/Unloading operations at Onshore Terminal (calm environmental conditions) | -Fillings mostly between 15%H and 75%H<br><br>-"Fixed" Unit, site-specific design<br><br>-Offloading in offshore environment |
| **MAINTENANCE** | -Dry dock every 5 years<br><br>-All Tanks entry every 5 years<br><br>-~10-20 subcontractors overall<br><br>⟹<br><br>- 4-5 subcontractors for cargo tanks | -No dry dock during FLNG life (up to 40 years)<br><br>-Minimize tank entry (impact on production) ➔ **RBI approach**<br><br>-++ 100 subcontractors involved; ➔ **"Package" approach** to minimize interfaces<br><br>-**1 single subcontractor** for cargo tanks |
| **« ENVIRONMENT »** | -Cargo functionality; atmospheric pressure, -163°C | -Process units environment (pressures up to 500/700 barg, temperatures from – 160°C to 500°C) |
| **HSSE** | -As per LNG shipping industry | - « Oil & Gas » E&P standard; much more stringent compared LNG shipping industry |

# Requirement to keep the FSRU on site

- FSRU = very flexible energy provider
- Dedicated on site contract :

duration can exceed 5 years

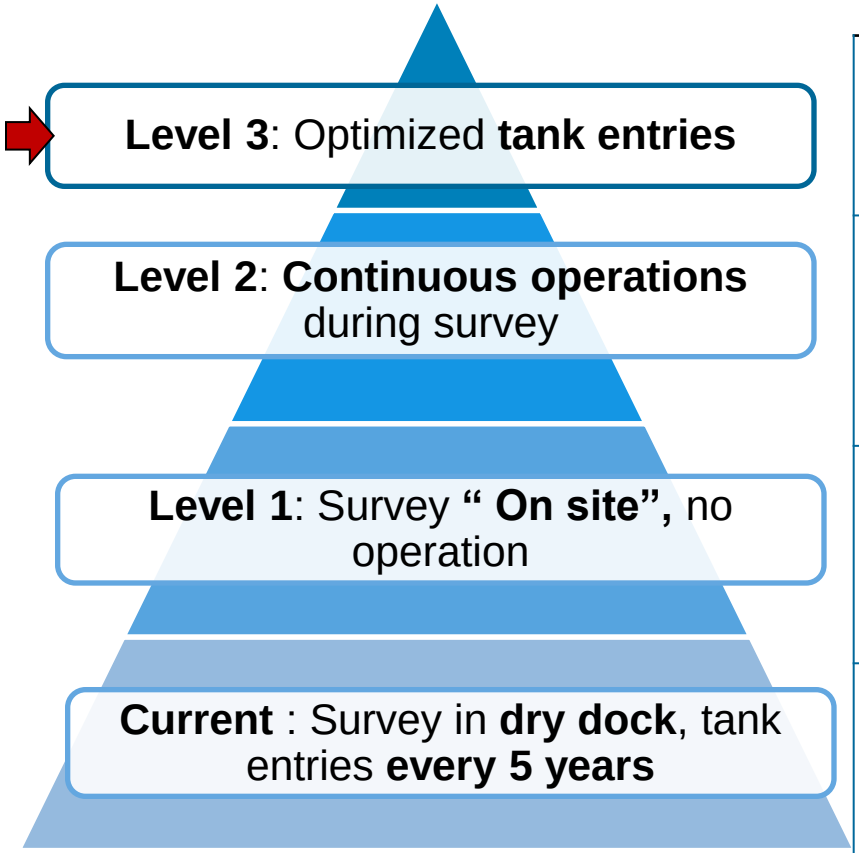
- Specific environment

- Current Renewal Certificate
  - Standard LNGC regime
  - Tank inspection <u>every 5 years in dry-dock</u>

How to accommodate the existing standards to FSRU requirements ?

Develop a dedicated FSRU maintenance plan to minimize the downtime of FSRU operations

# A dedicated solution for each FSRU




| Same Procedure as for level 2 | Same Procedure as for level 2 | To be developed |
|---|---|---|
| To be adapted for "On Site" constraints and continuous operation | To be adapted to perform safe aerating with segregation | N/A |
| To be adapted for "On Site" constraints | Current procedure for all tanks aerating | N/A |
| Current procedure | Current procedure for all tanks aerating | N/A |
| **Inspection procedure** | **Decommissioning & recommissioning procedure** | **Risk Based Inspection Plan** |

# GBS : an innovative solution from small to large storage capacities

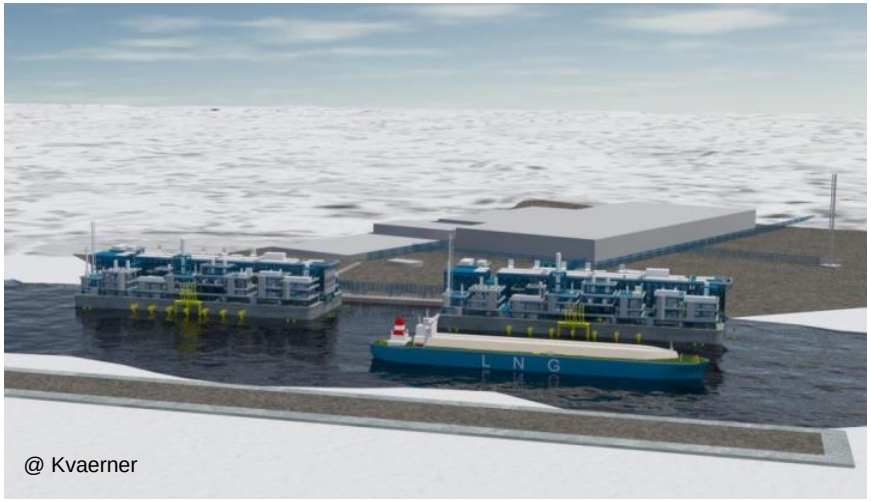
# Gravity Based Structure

- Gravity Based Terminals opportunities:
  - LNG projects require flexibility on construction site & schedule
  - Solutions adapted to nearshore conditions

## GTT Membrane contributes to all caisson solutions

- GTT Membrane benefits from the combined experience of LNG Carriers and Onshore Tanks.

@ GTT - Acciona

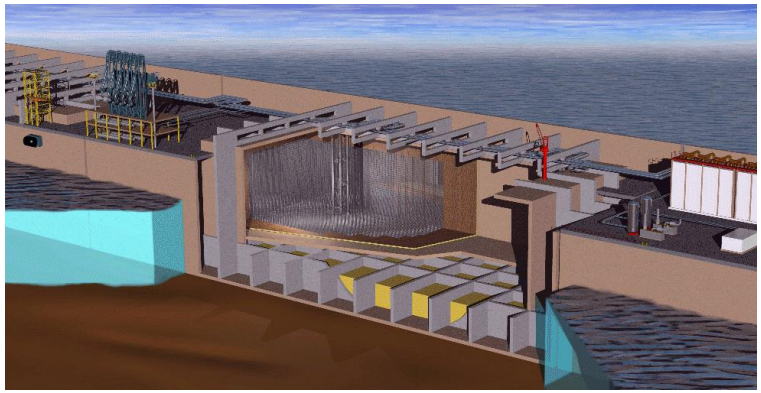



@ Kvaerner


@ SemCorp

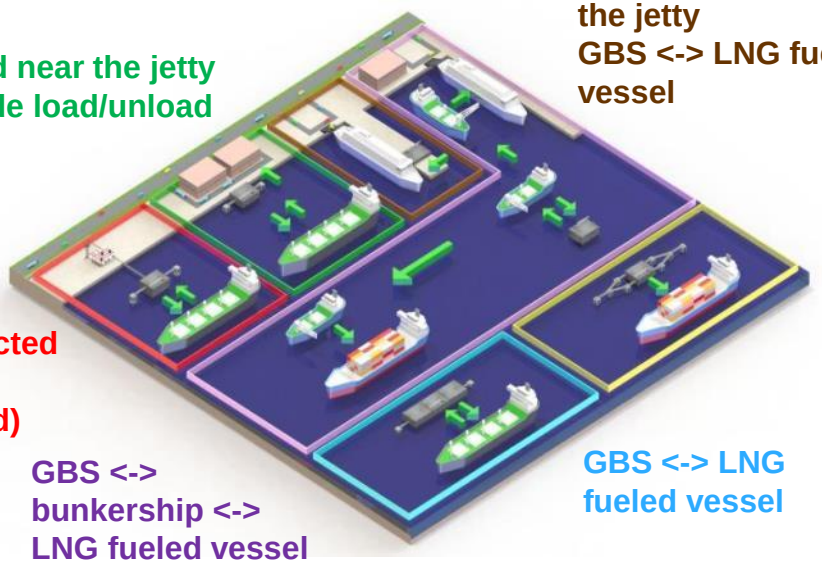
# Well adapted for large capacities…

- GTT Membrane is an industrial system whose installation has a reduced impact on the overall schedule;
- GTT Membrane is a light system that optimizes the weight to size ratio;
- Many studies demonstrating the interest of the solution;
- Several FEED carried out with GTT technologies.



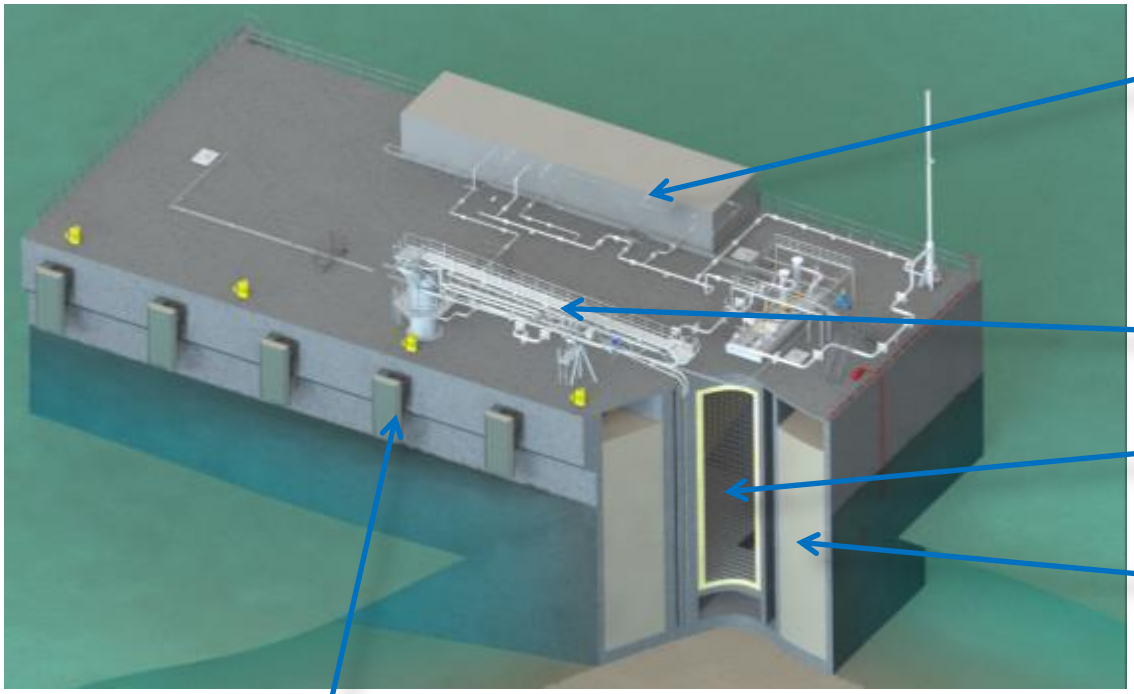
# … and also for small sizes

- Modular concept, can be adapted to projects in several phases;
- Caisson implantation can adapt to many of coastal profiles, at quay location or nearshore;
- The caisson can be equipped with bunkering facilities, equipment for electricity production etc…
- A Plug and Play concept.





# All functions in a box



Process on top side

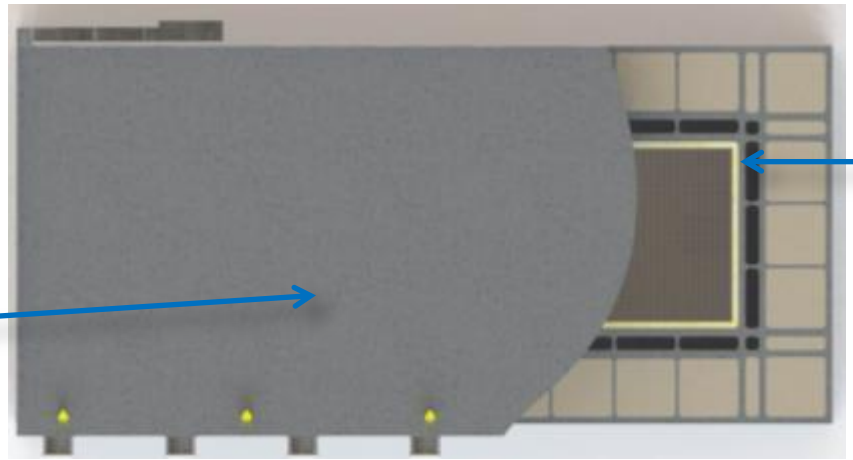
Can be fitted with a regas unit on topside

Loading arm

Containment system

Solid Ballast for stability

Berthing fenders



Free space all around the tank for inspection and water management

Concrete structure

# Concrete construction external to ports in floating docks

Construction in floating dock

Towing

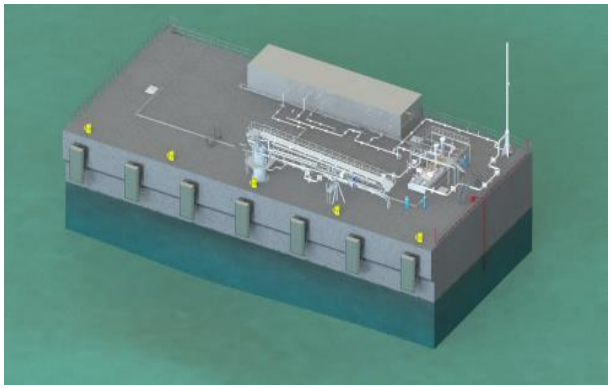
Installation by ballasting and completion

Commissioning

With the Courtesy of Acciona

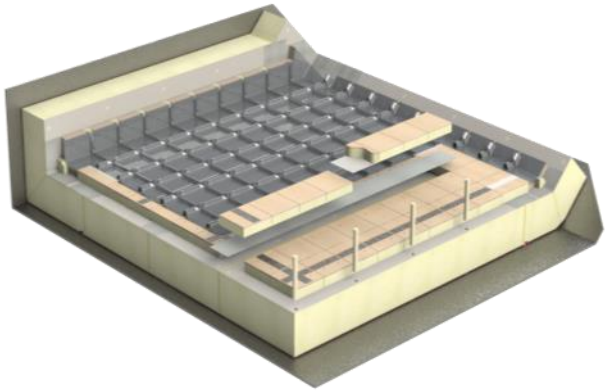
# Main advantages of GBS

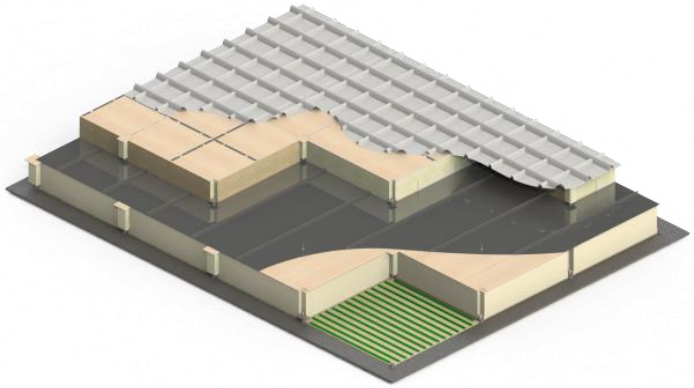
- No land requirement / Reduced visual impact;
- Construction in controlled environment securing cost and schedule;
- Strong resistance to extreme environmental conditions;
- Remote industrial risk, far from inhabited areas (safety area);
- Easy access for vessels;
- Modular concept;
- Cost competitive.



# Conclusions

- Innovations on GTT containment systems are bringing significant savings and flexibility to the LNG industry
- Specificities of offshore LNG market may lead to some tank and cargo handling system design adaptations to make the life easier for the FLNG & FSRU operators
- GBS : an innovative solution taking benefit of a proven technology together with cost competitiveness








# Thank you for your attention

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