



LNT A-BOX[®]

Introduction & assessment
Marintec China, December 2017

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- **LNT Marine**
- **LNT A-BOX[®] containment system**
- **Benchmark assessment**
 - *Building cost drivers (CAPEX)*
 - *Operational cost drivers (OPEX)*
 - *Operational features*
- **Summary**

Introduction to LNT Marine

Who we are...

- LNT Marine is a player in the emerging small and mid-scale LNG market, as well as marine LNG fuel and services for other types of gas carriers.
- The company is a result of the recent merger between LNG New Technologies and MGI Thermo.
- Multinational team with offices in Singapore, Norway, China and Poland.



What we do...

- We invent and develop new technologies within the LNG sector and marine insulation systems.
- We provide design and engineering for marine solutions based on our proprietary technologies
- We offer system supply as well as technical support, training and installation services.



Where we are going...

- LNT Marine aims to become the leading technology provider for containment systems in the small and mid-scale LNG segment.
- Further, we plan to establish ourselves as a turn-key supplier in the emerging LNG fuel market.
- Capitalizing on our unique experience with all kinds of marine insulation systems, we will provide tailormade insulation systems for our client's needs.



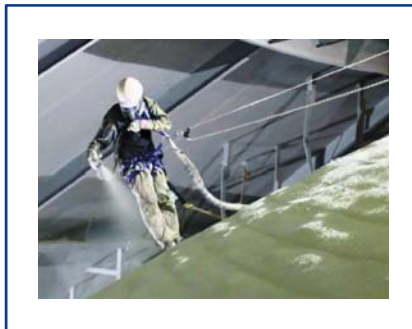
LNT Marine is engaged in different business segments with complementing competence creating synergies

1. LNG containment systems



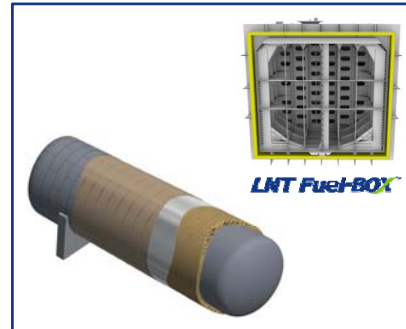
- LNT A-BOX is a containment system for LNG and other gases at temperatures below -55°C.
- LNT Marine offer system engineering and supervision as well as supply of insulation and secondary barrier system.

3. Gas carrier insulation systems



- Liquified gases are predominantly transported at temperatures below ambient temperatures and need thermal insulation systems.
- LNT Marine offers insulation systems for essentially all types of gas carriers.

2. LNG Fuel tank systems



- LNG is an increasingly popular alternative as marine fuel.
- LNT Marine offers LNG fuel tank solutions as well as fuel gas supply systems. We do both small type C tanks as well as our own LNT Fuel-BOX system.

4. Reefers and other cold cargo insulation systems

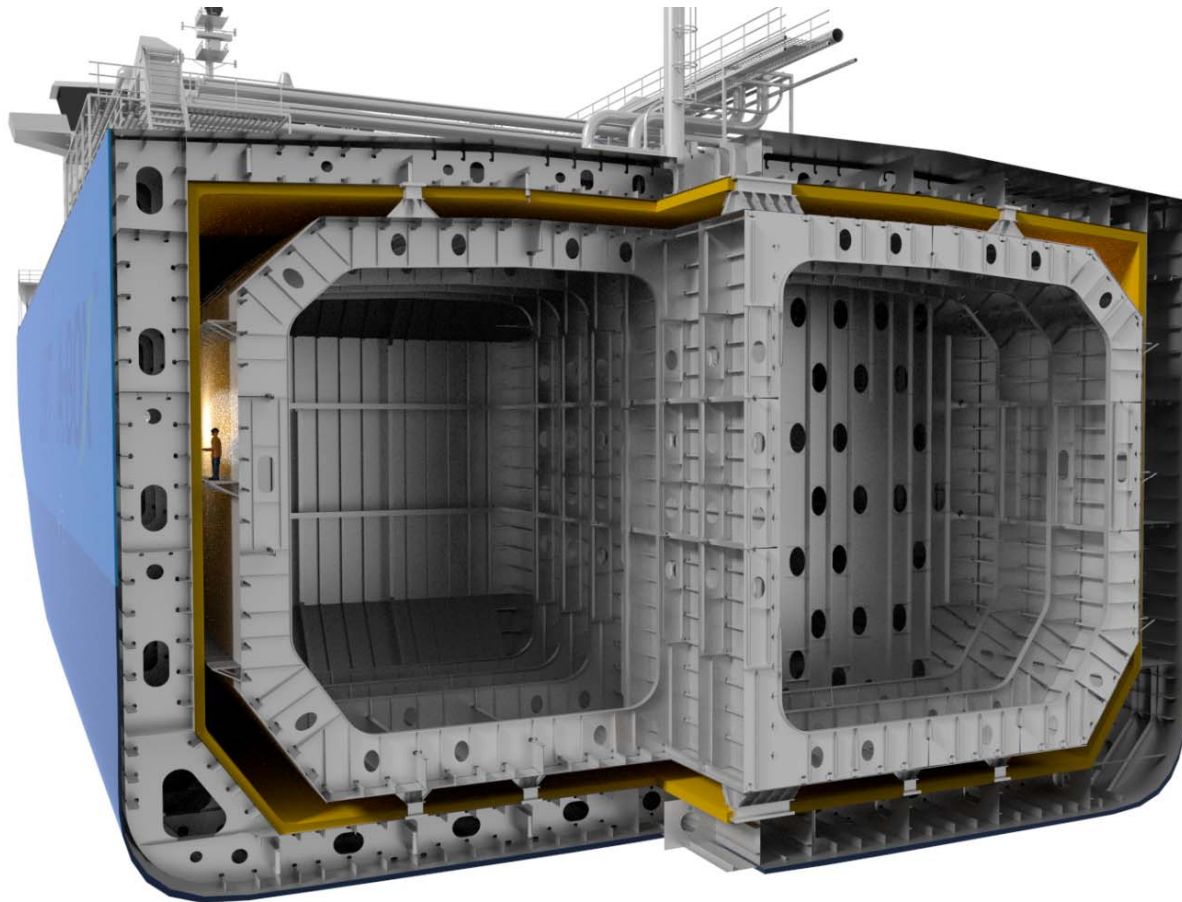


- Reefers are ships used to carry refrigerated cargoes, such as fruit, vegetables and fish.
- LNT Marine offers tailor-made insulation systems for such ships as well as supervision services during the installation.

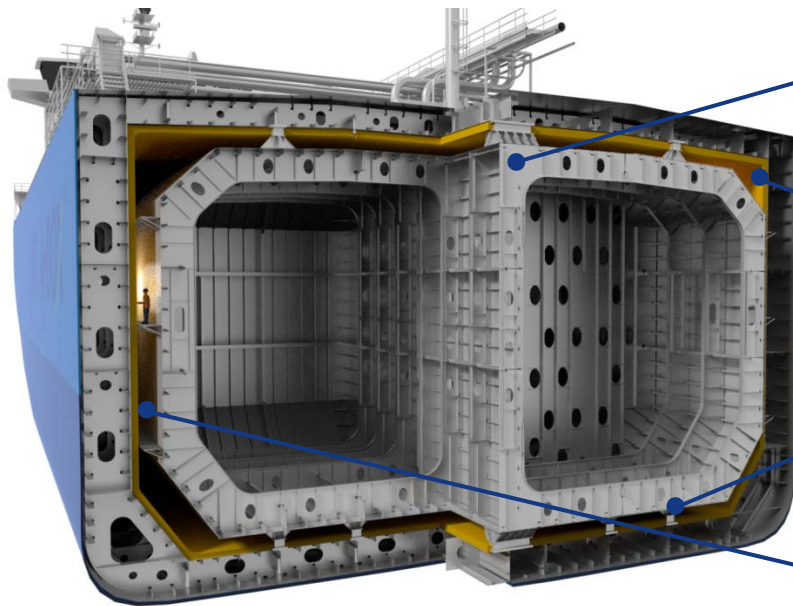
LNT A-BOX[®]



An un-insulated IMO independent tank type A in an insulated hold space.



LNT A-BOX[®] - characteristics



Primary barrier: *Self-supporting IMO independent tank type A*

Secondary barrier: *Liquid tight insulation acting as full secondary barrier in accordance with IGC 4.6*

Cargo tank support: *Laminated compressed wood supports preventing bodily movement of the tank*

Interbarrier space: *Accessible interbarrier space between tank and insulation*



A novel system based on proven technologies in a new configuration

LNG containment systems



IMO



LNG Containment Systems

MEMBRANES

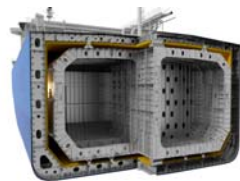
Non-self-supporting tanks that consist of a thin layer for liquid and gastight (membrane) **supported through insulation by the adjacent hull structures**



INDEPENDENT TANKS

Type A

Primarily designed using **classical ship structural analysis** procedures in accordance with recognized standards



Type B

Designed using model tests, **refined analytical tools and analysis methods** to determine stress levels, fatigue life and crack propagation characteristics

Prismatic



Spherical



Type C

Based on **pressure vessel criteria** modified to include fracture mechanics and crack propagation criteria

Cylindrical



Bi-lobes





Benchmark

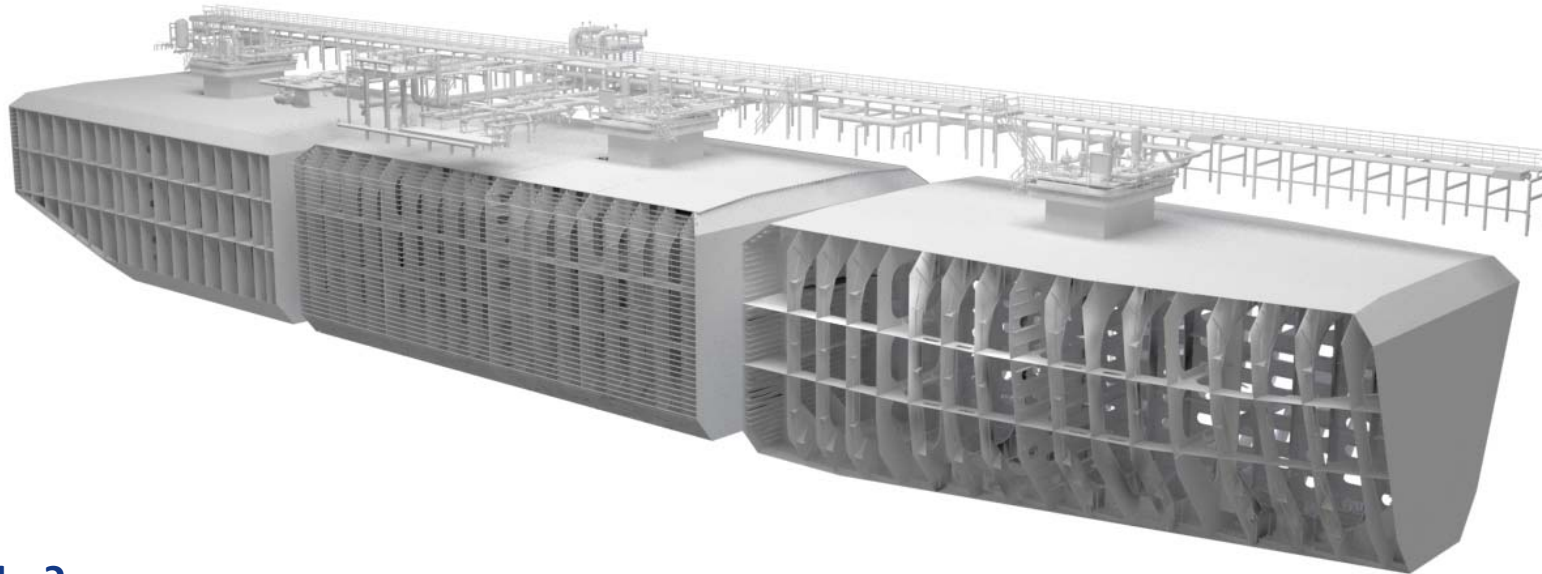
CAPEX drivers

OPEX drivers

Operational features

CAPEX drivers, primary barrier

INDEPENDENT SELF-SUPPORTING TANKS

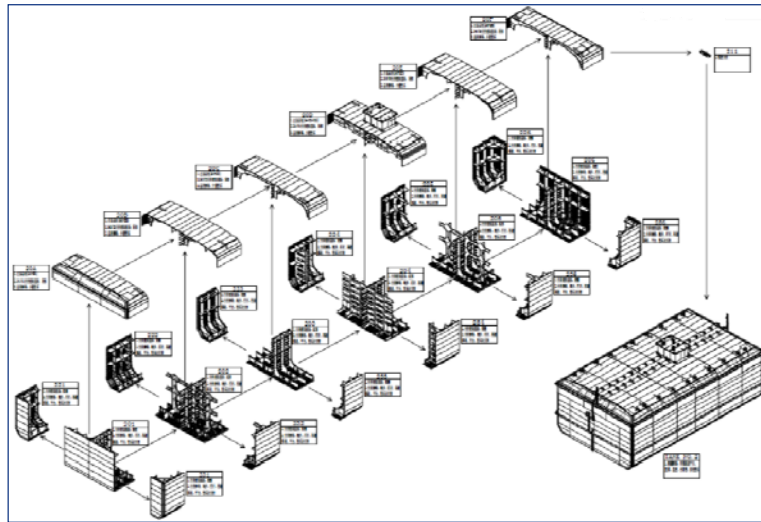


Why?

- Are built separately from the ship's hull → *enables parallel activities in the building schedule and allows for outsourcing*
- Supported and aligned on a limited number of supports in the hull structure → *eases the requirements for hull construction and building tolerances, and soften the requirements to the insulation system*

CAPEX drivers, primary barrier

INDEPENDENT TANK TYPE A



**Building
friendly**

**Qualified
workers**

**Qualified
yards**

Flexible

- Type A tanks are constructed primarily of flat surfaces and designed according to classical ship structural procedures
- Reasonable welding and construction requirements
- Limited infrastructure requirements at building yard
- Type A tanks can be designed and built for various densities, design pressure and material grades

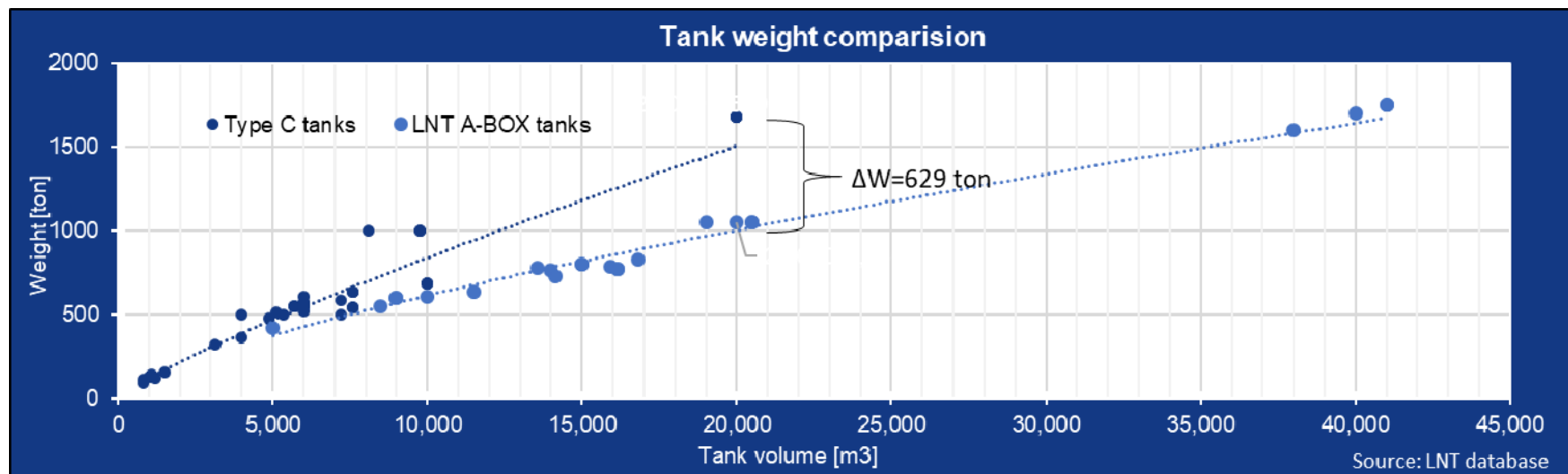
CAPEX drivers, primary barrier

LNT A-BOX vs. Type C

WEIGHT

IMO Type C tanks are designed according to pressure vessel criteria. As per IGC code Ch. 4.2.4.4, design pressure (P_0) of a pressure vessel has to be established from the following formula: $P_0 = 2 + AC(\rho_r)^{1.5}$

- Cargo density
- **Characteristic tank dimension (the greatest of h , $0.75b$ or $0.45l$)**
- Function of stress and material properties



*Minimum design pressure for a large type C tank will have to be relatively high.
High pressure means thick steel plates and high weight.*

CAPEX drivers, primary barrier

LNT A-BOX vs. Type B

Design requirements as per IMO IGC code

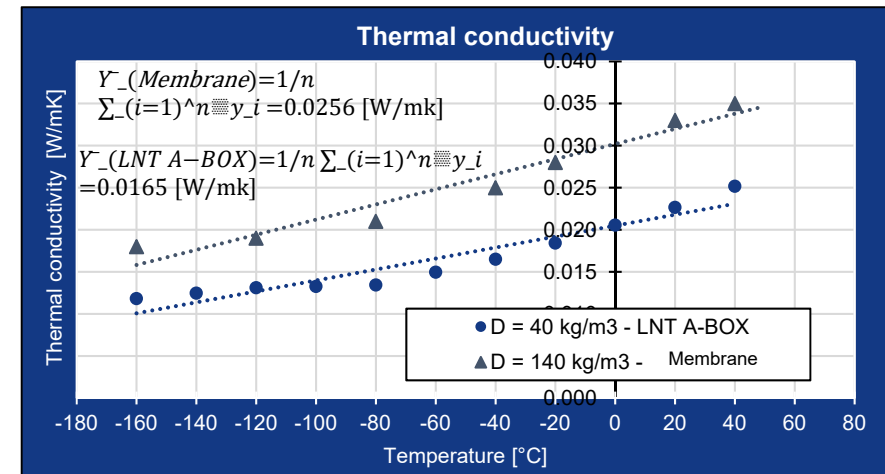
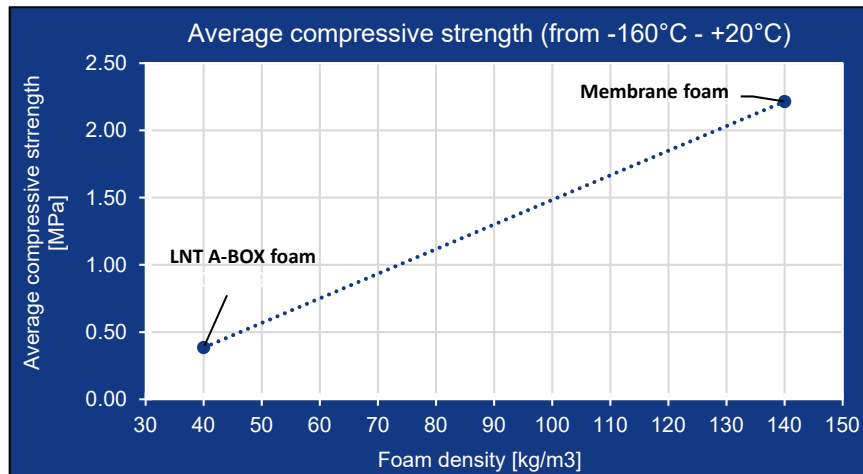
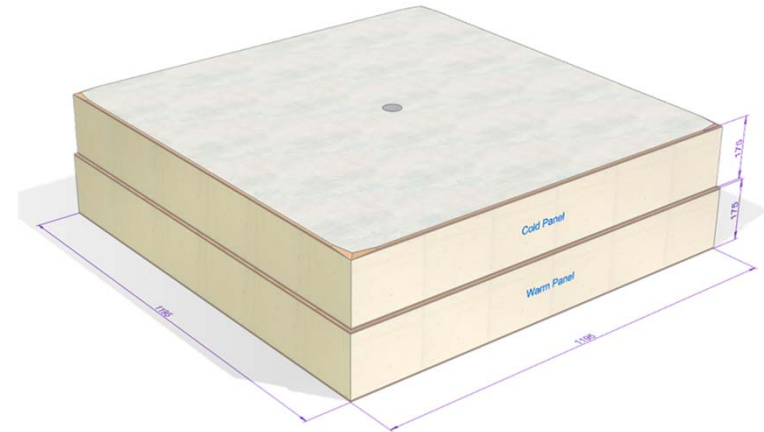
- **Type A** – designed using classical ship structural analysis and procedures in accordance with recognized standards → ***ordinary strength calculation based on allowable stress***
- **Type B** – designed using models tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics → ***advanced and precise engineering studies, including strength analysis and laboratory tests***

Production & workmanship

- **Type A** – A standard in accordance with a hull standard (IACS R47). Normal requirement to workmanship. Limits for imperfections for quality levels: B (ISO 5817) → ***ordinary shipbuilding standards and requirements***
- **Type B** – Very strict requirements to workmanship in order to justify adequacy of fatigue inputs in analysis. Limits for imperfections for quality levels: B (ISO 5817) including additional requirements for welds subjected to fatigue, such as weld bead toe radius and flange angle → ***very demanding requirements, beyond what most yards can manage***

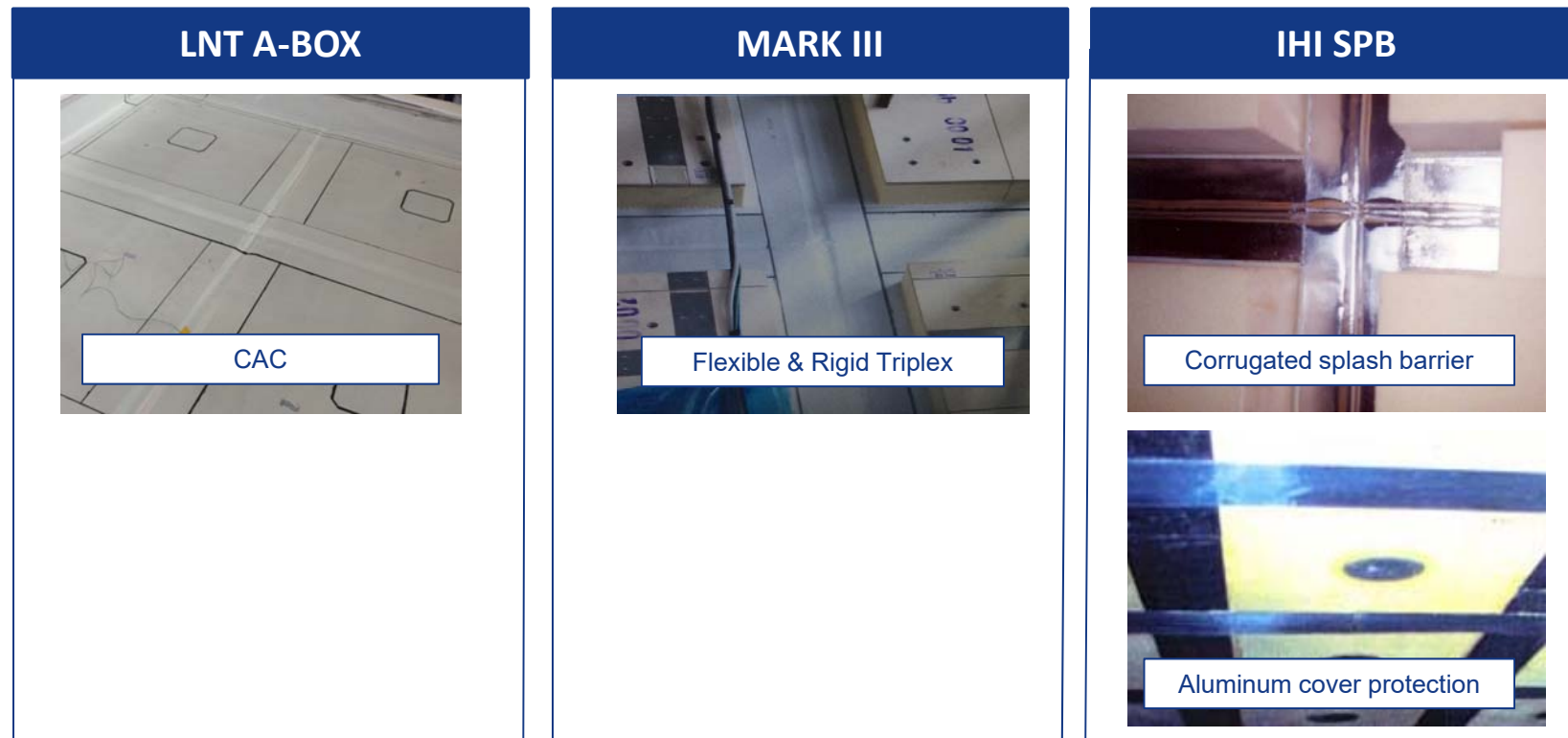
CAPEX drivers, thermal insulation

- For LNT A-BOX® and other independent tank types, the insulation system does **not** need to be designed for **static nor dynamic load from the cargo**.
- Thus, the insulation system can be **optimized for best possible thermal performance**.
- This means **lower density foam** which offers **lower thermal conductivity** as well as **low weight – and cost**.



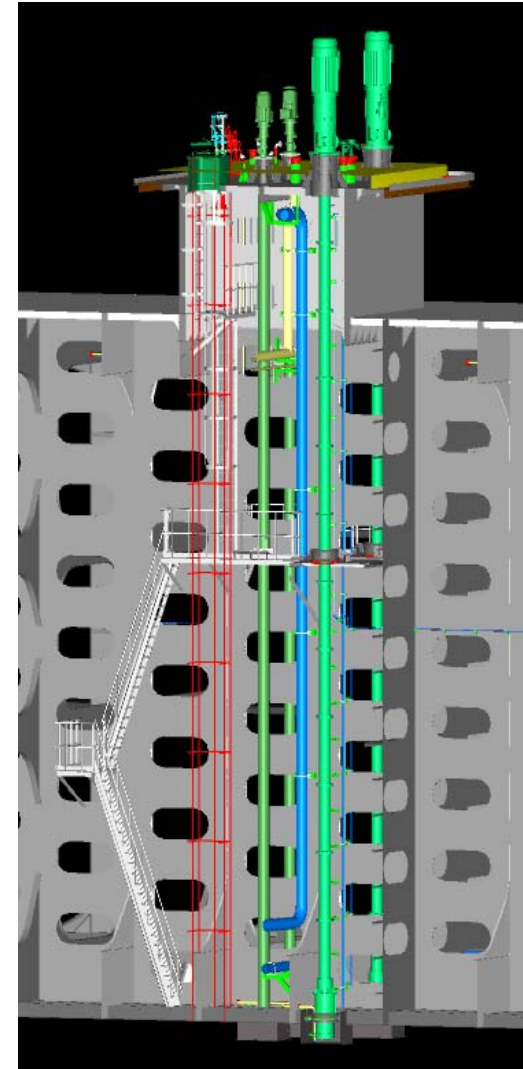
CAPEX drivers, secondary barrier

- LNT A-BOX® and membrane systems has a full secondary barrier
- Type B tanks have a partial secondary barrier (splash barrier) and drip tray(s) to collect any leak from the tank.
- Such secondary barriers and partial secondary barriers are well proven in the industry, and there are in principle not too big differences between the solutions.



CAPEX drivers, auxiliary systems

- The LNT A-BOX system offers a simple set of auxiliary systems to control the containment:
 - *Instrumentation and monitoring*
 - *Gas detections system in CIS*
 - *Bilge, leak and level alarm system for CIS and IS*
 - *Pressure and atmosphere control system in CIS and IS*
 - *Cofferdam heating system*
- The pressure and atmosphere control system comprise a P/V relief valve in cold interbarrier space (CIS) inerted by N₂. No complicated pressure differential control.
- Since the tank has internal structure and bulkheads where pumps can be supported, no pump tower is needed.

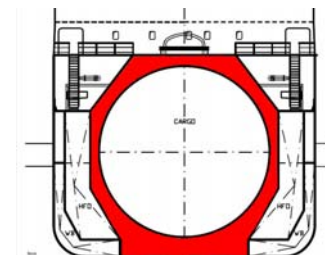
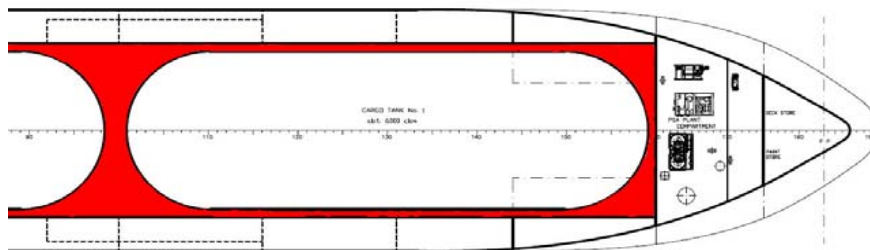
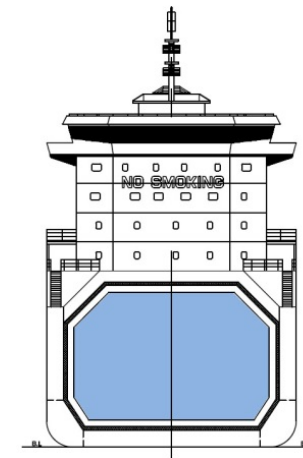
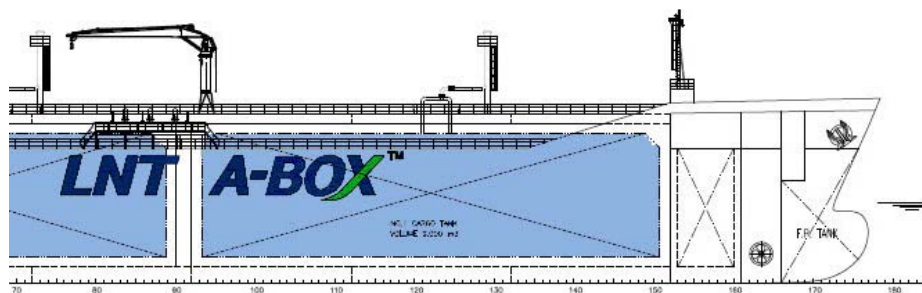


OPEX drivers, volume utilization & fuel consumption

Volume efficiency is important to optimize the vessel design and minimize fuel consumption. LNT A-BOX® offers market leading volume efficiency.

Prismatic tank shape

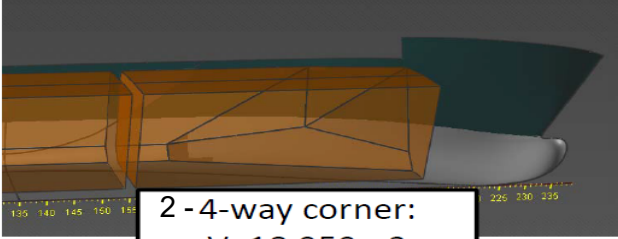
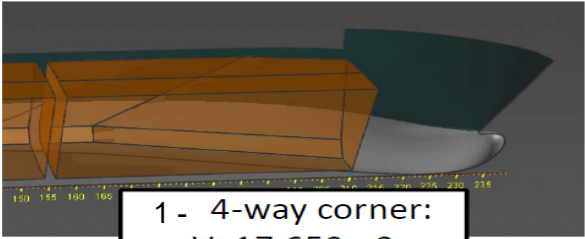
- minimizing the void spaces in the hull



OPEX drivers, volume utilization & fuel consumption

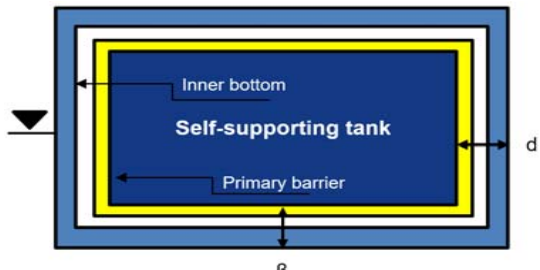
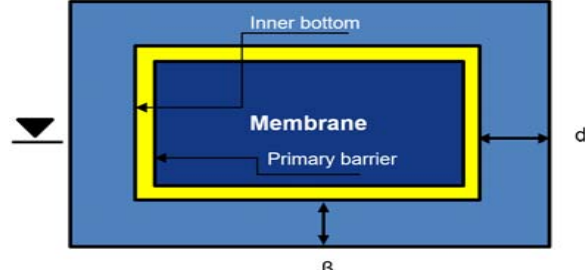
Flexible geometry

- allowing the ship designer to optimize the hull lines

LNT A-BOX with two (2) 4 way knuckle point	LNT A-BOX with one (1) 4 way knuckle point
 <p>2 - 4-way corner: $V=18,050\text{m}^3$</p>	 <p>1 - 4-way corner: $V=17,650\text{m}^3$</p>

Regulatory advantage

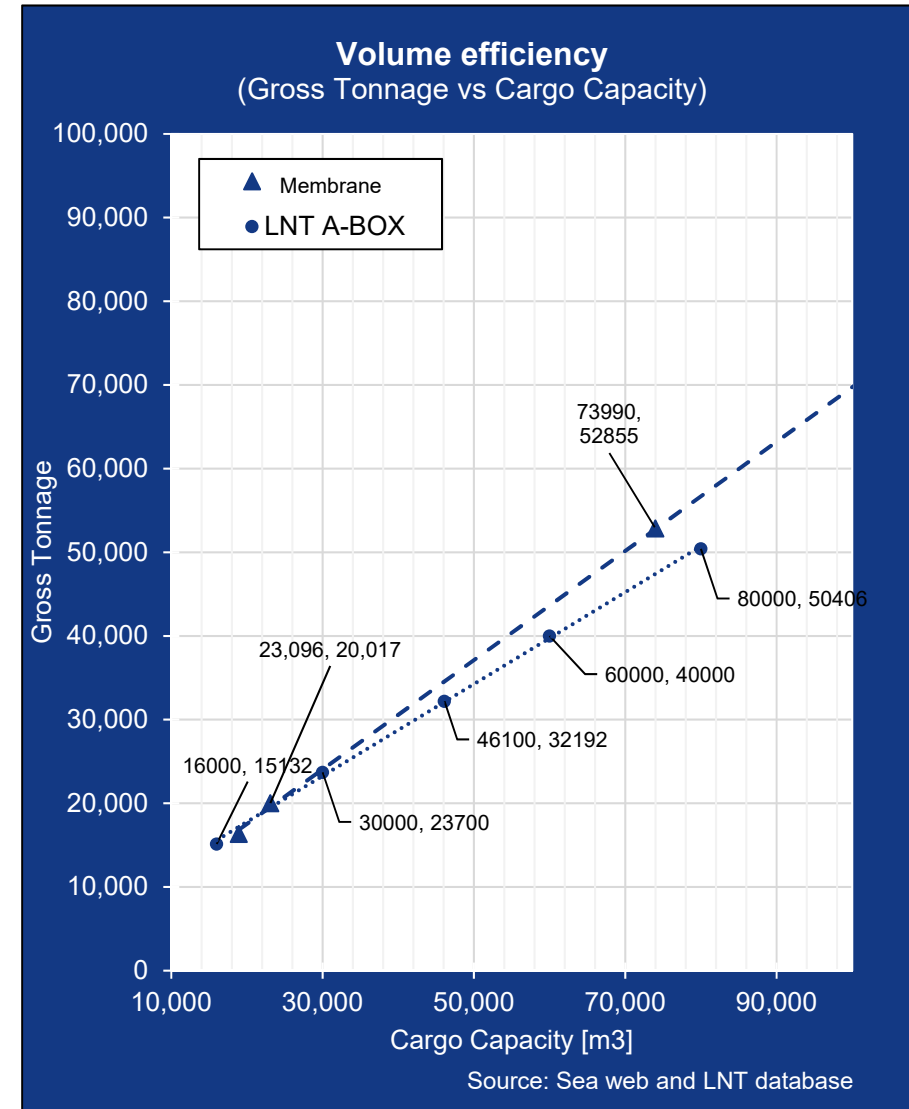
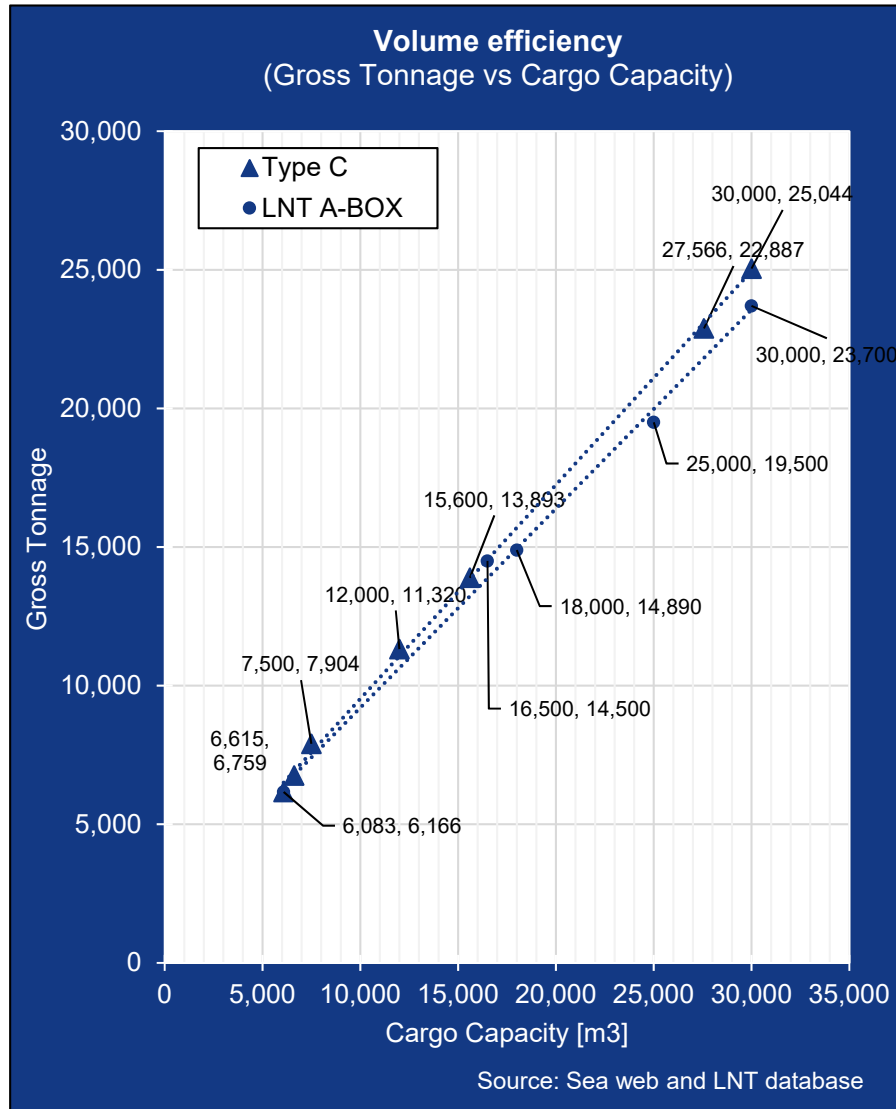
- location of the cargo tanks in the hull

Definition of tank position as per IGC code Ch. 2.4.1.2	
Prismatic independent tanks	Membrane
	



Distance to outer shell, β , whichever is less of: d , $B/15$ or 2 m

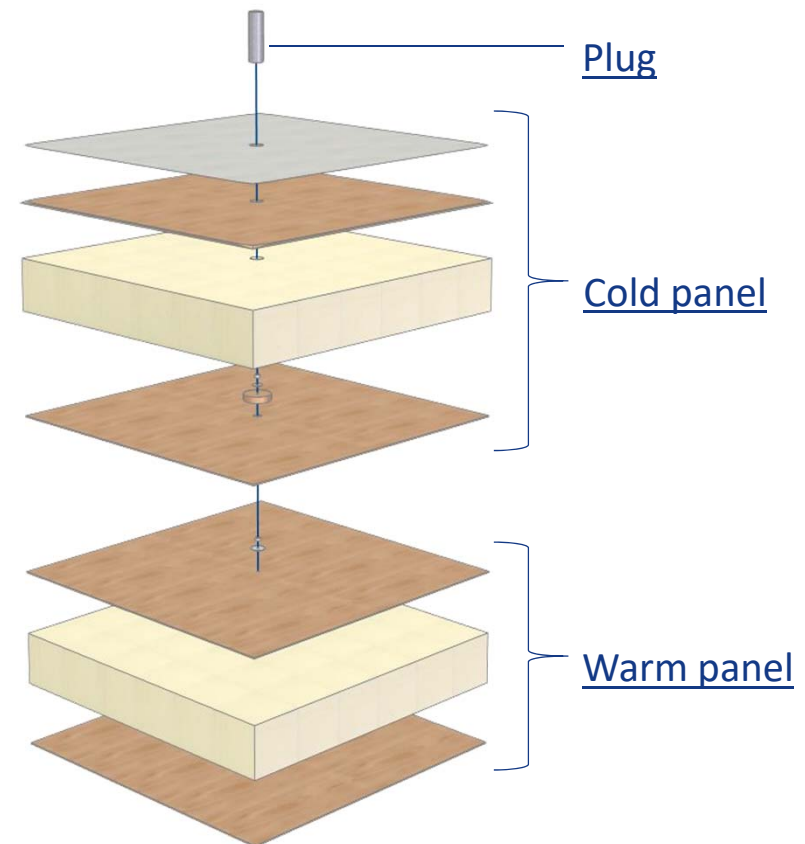
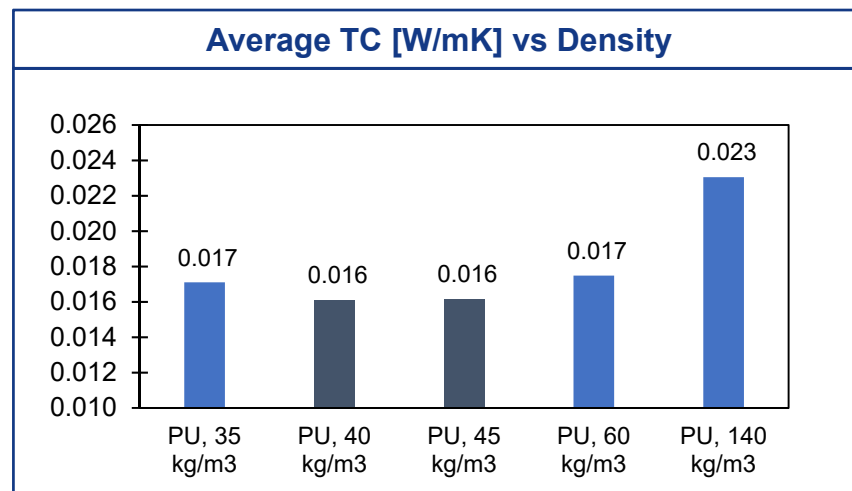
OPEX drivers, volume utilization & fuel consumption



OPEX drivers, thermal insulation & BOR

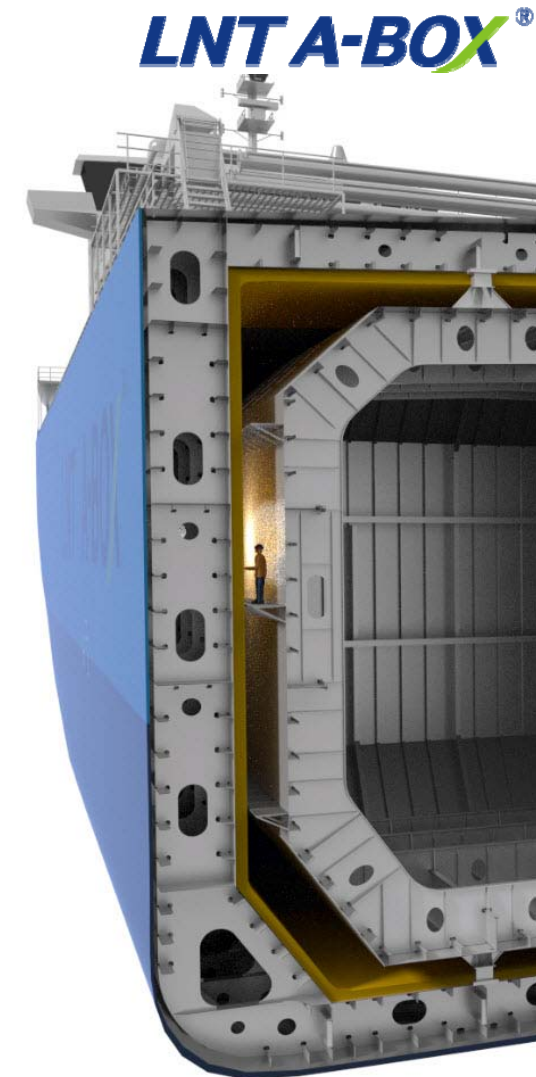
Thermal insulation and lowest possible boil-off rate (BOR) is important to minimize energy consumption and offer maximum operational flexibility.

- LNT A-BOX® insulation system is optimized for best possible thermal performance
- The insulation system thickness is flexible and can be adjusted to meet the BOR requirements.

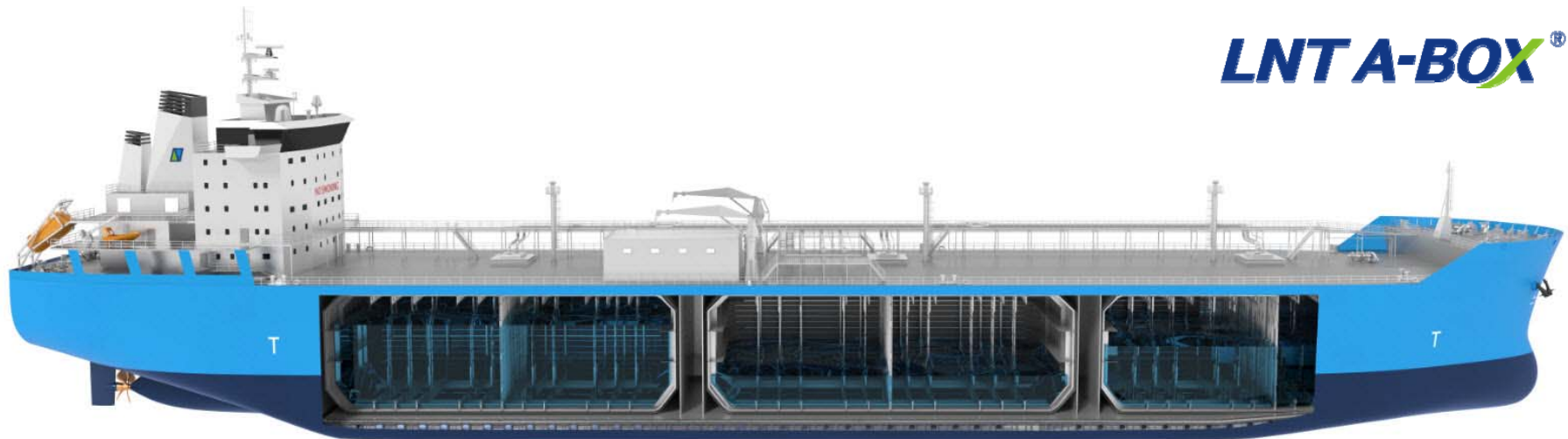


Operational features

- The LNT A-BOX® system is uniquely accessible for close-up inspections and repairs:
 - **Primary barrier** – accessible from both sides for inspections, repairs and vacuum test without removal of insulation and without staging.
 - **Secondary barrier** – accessible in the cold interbarrier space without gas freeing of the cargo tank. Enabling visual condition monitoring and easy access for repair of any damaged areas of secondary barrier.
 - **Wooden supports** – accessible from CIS for inspections and repairs.
 - **Inner hull** – accessible for inspection from cofferdams, void space and ballast tanks. Cold spots may be detected during such inspections with cargo loaded. Bracket toe condition for support steel keys can be checked with NDT without insulation removal.

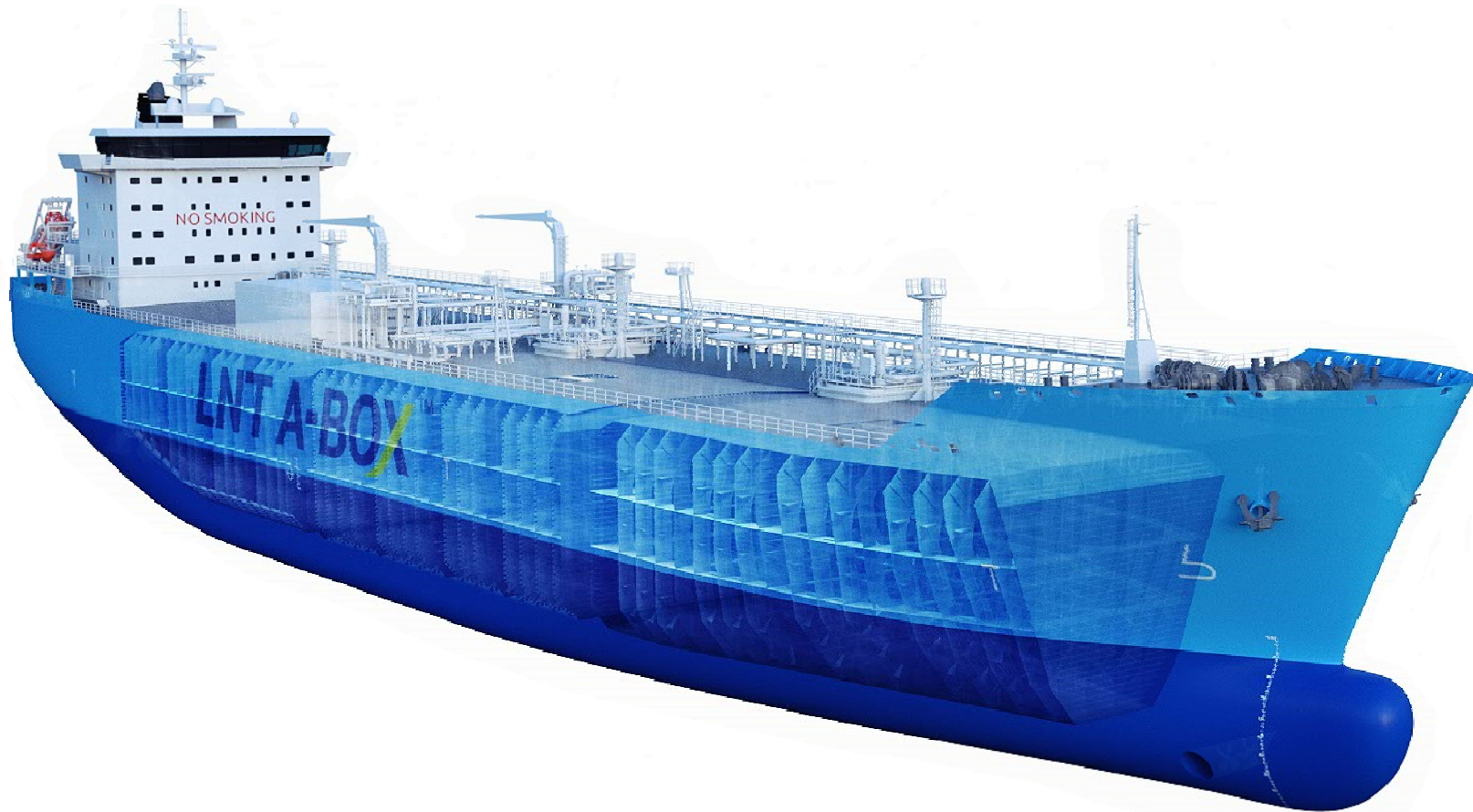


Operational features



- **Partial loading** – LNT A-BOX offers operations at all liquid levels. No cargo limitations due to sloshing that is minimized by the internal tank structures. Multiport service possibility.
- **Cargo stripping** – IMO independent tank type A allows for pumps sumps and benefit the cargo stripping capability.
- **Cool down** – as most other cargo tanks, the LNT A-BOX is design for 10°C per hour cool down.
- **Flat deck** – enables good navigation visibility, minium windage and flexibility for arrangement on deck as well as major topside structures (FSRU etc.)

Case study: LNT45



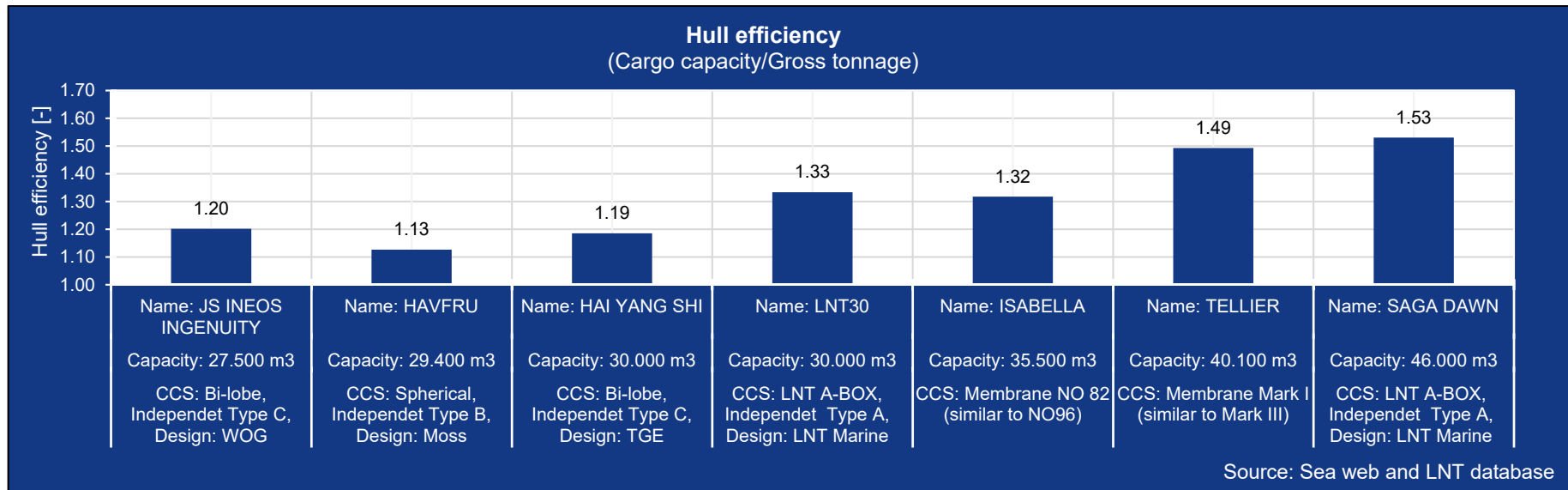
Case study: LNT45 – 45,000 m3 LNG carrier

- LNT45 is designed with the purpose to achieve market leading efficiency in all aspects of the design. This have been emphasized from concept design throughout detail design.
- Central KPIs throughout design phases have been to (1) exceed all applicable environmental regulations and (2) to achieve market leading IMO index EEDI and EEOI.

Name		SAGA DAWN
Cargo containment system		LNT A-BOX® Design: LNT Marine
Cargo capacity (100%)	[m3]	Abt. 46,000
Length overall	[m]	195.2
Length between pp	[m]	184.8
Beam	[m]	30.0
Depth	[m]	20.0
Design Draft	[m]	9.0
Deadweight (LNG)	[ton]	22,400
Lightweight	[ton]	14,100
Gross tonnage	[-]	30,060



Case study: LNT45 – 45,000 m3 LNG carrier



- Comparison with relevant reference ships underpins LNT A-BOX®' excellent volume efficiency
- The LNT45 design was model tested by MARIN in Holland, and concluded with the following:
“Compared with the MARIN statistical records of resistance and propulsion tests for similar vessels, the results of the present vessel at the tested draughts are qualified as very good¹⁾”

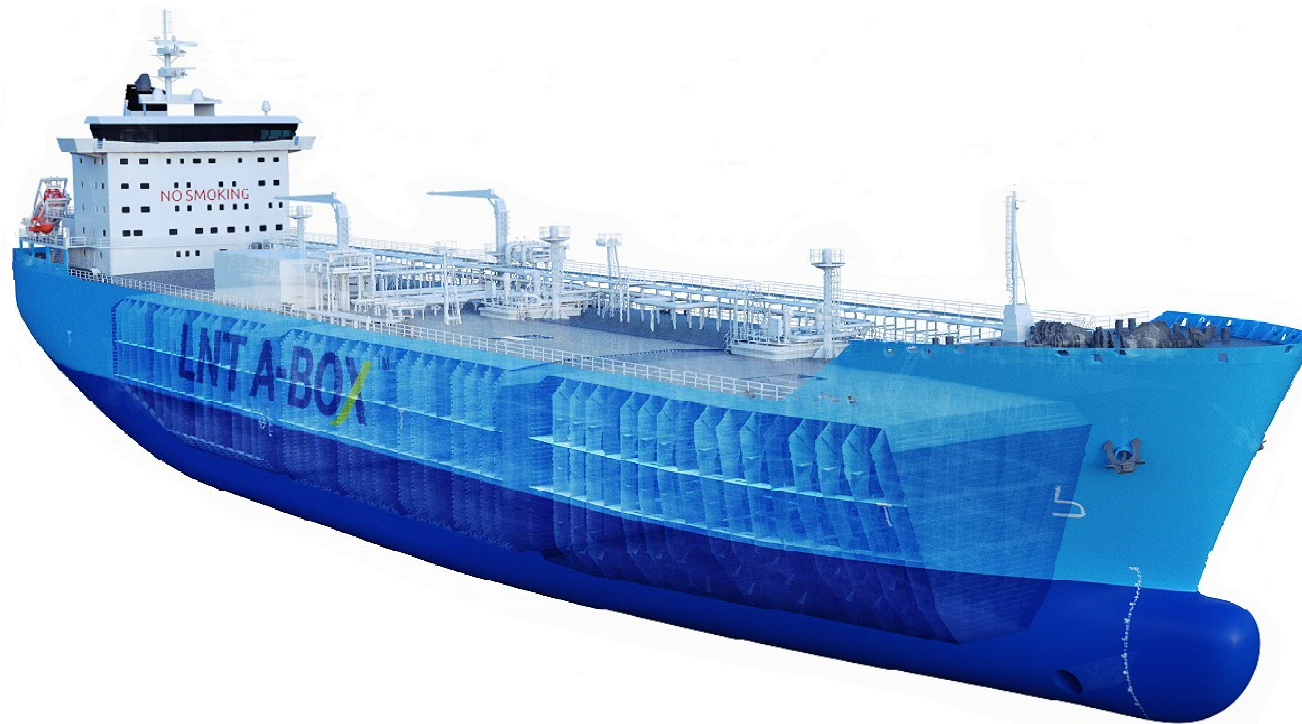


Summary



Summary

- LNT A-BOX® is a containment system for LNG and other gases at temperatures below -55°C. The system is based on proven technologies, and is a robust and cost effective alternative.
- The system is well suited for a wide range of applications including LNG and ethane carriers of various sizes as well as floaters, such as FSRU and FLNG.



Flexible

Efficient

Robust

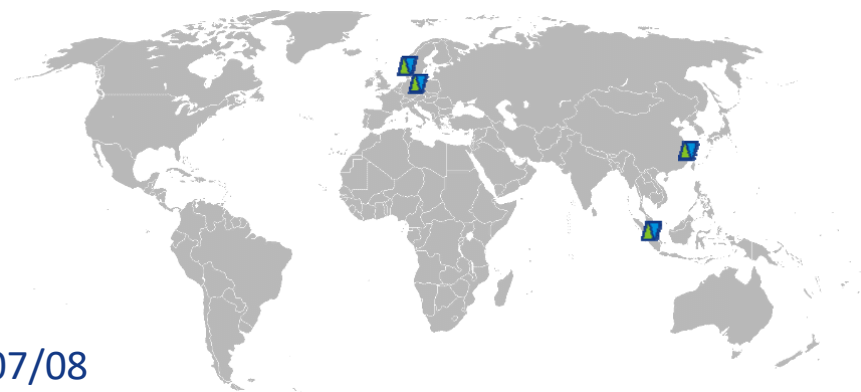
Accessible



THANK YOU

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