



# A new containment system for LNG from concept to reality

*Kjetil Sjølie Strand, CEO, LNT Marine*

**Gastech 2019**

# Disclaimer

---

This presentation (the "Presentation") has been prepared by LNT Marine ("the Company").

This Presentation has been compiled by LNT Marine in good faith from sources believed to be reliable and includes and is based, inter alia, on forward-looking information and statements that are subject to risks and uncertainties that could cause actual results to differ. These statements and this Presentation are based on current expectations, estimates and projections about global economic conditions, the economic conditions of the regions and industries that are major markets for LNT Marine. These expectations, estimates and projections are generally identifiable by statements containing words such as "expects", "believes", "estimates", "plans", "anticipates" or similar expressions. Important factors that could cause actual results to differ materially from those expectations include, among others, macro economic fluctuations, inflation, interest rates, rent levels and such other factors as may be discussed from time to time in the Presentation. All forecasts and forward looking statements are entirely those of LNT Marine, and should not be relied upon as having been authorized by any other person. While all reasonable care has been taken to ensure that the facts herein are accurate and that the forecasts, opinions, expectations and other forward looking statements stated herein are reasonable, there can be no assurance that the assumptions and expectations on which they are based are correct. Should one or more of these risks or uncertainties materialise, or should underlying assumptions prove incorrect, actual results may vary materially from those described in this document. LNT Marine does not intend, and does not assume any obligation, to update or correct the information included in this Presentation. There may have been changes in matters which affect LNT Marine subsequent to the date of this presentation. Neither the issue nor delivery of this Presentation shall under any circumstance create any implication that the information contained herein is correct as of any time subsequent to the date hereof or that the affairs of LNT Marine has not since changed, and LNT Marine does not intend, and does not assume any obligation, to update or correct any information included in this presentation.

Neither LNT Marine nor any of its respective directors, officers or employees is making any representation or warranty, expressed or implied, as to the accuracy, reliability or completeness of the Presentation. No person accepts any liability whatsoever for any loss howsoever arising from the use of this Presentation or its contents or otherwise arising in connection therewith. Any investment or acquisition which you make should be based on such investigations as you consider necessary.

The content of this Presentation are not to be construed as legal, business, investment or tax advice. Each recipient should consult with its own legal, business, investment and tax advisor as to legal, business, investment and tax advice. The presentation is subject to Singapore law, and any dispute arising in respect of this Presentation is subject to the exclusive jurisdiction of the Singapore courts.

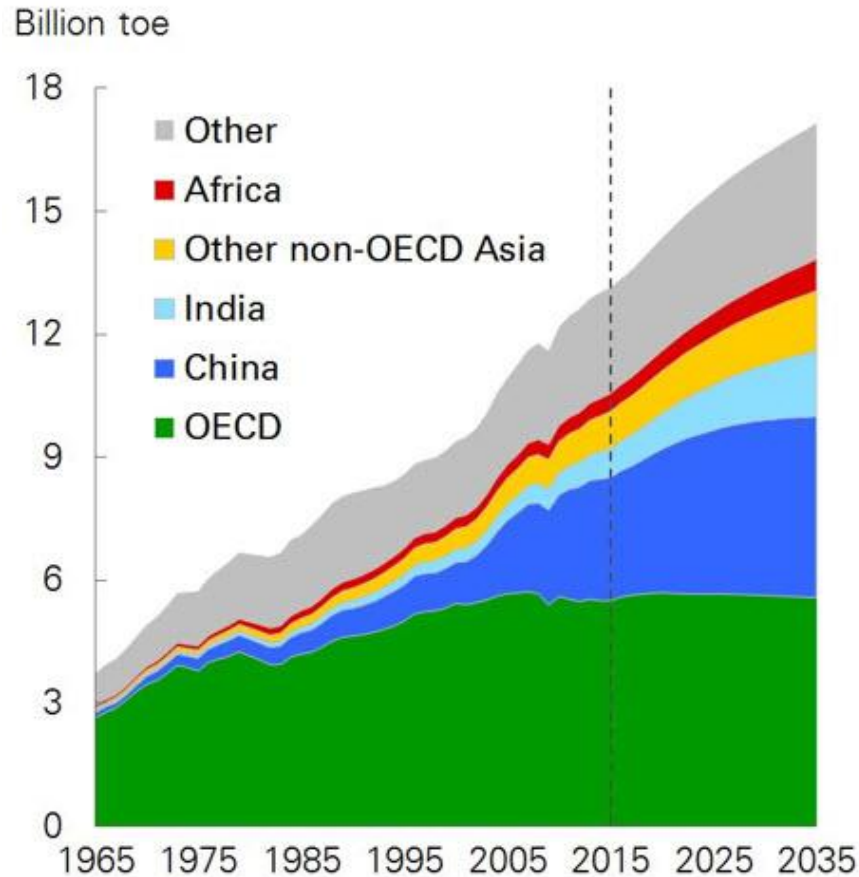


# Agenda

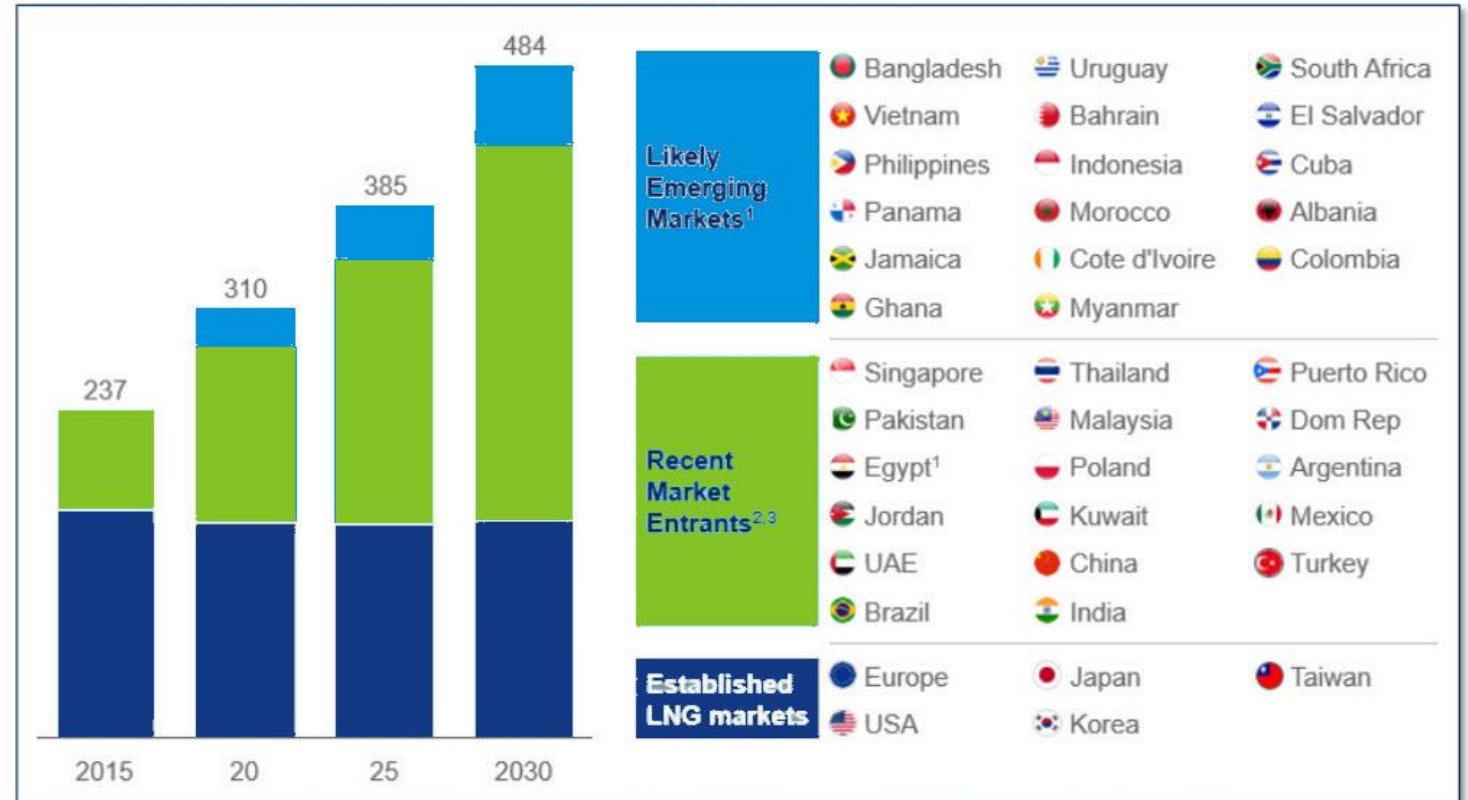
---

- Introduction & background
- Development process
  - *Intellectual Property Rights*
  - *Partnerships*
  - *Class approvals*
  - *Testing*
- Ship project development
  - *Market entry*
  - *Specifications & contract*
  - *LNT45 – Saga Dawn*
  - *Construction process*
  - *Testing & trials*
- Summary

# Population growth and urbanization, especially in emerging markets, are driving LNG market growth



NG demand by country for established, recent and likely market entrants, Mtpa



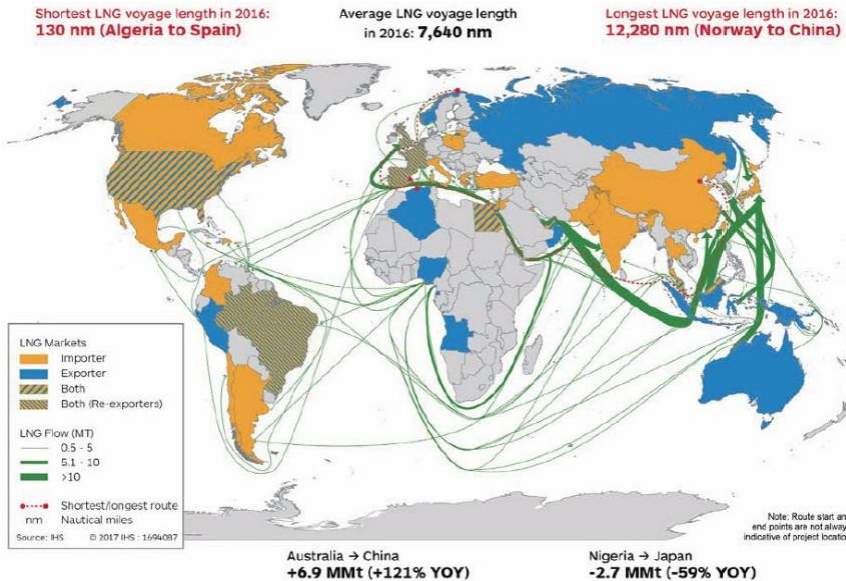
<sup>1</sup> Including South East Europe ; <sup>2</sup> Egypt (Zohr) and Argentina (unconventional gas), both of which currently import LNG but are not forecast to do so in 2030 due to recovering domestic production ; <sup>3</sup> Including Other Latin America & Baltics

- Smaller importers, together with India and China, will accelerate the shift from coal to natural gas.
- Smaller import nations are projected to account for 31% of the global consumption by 2030.

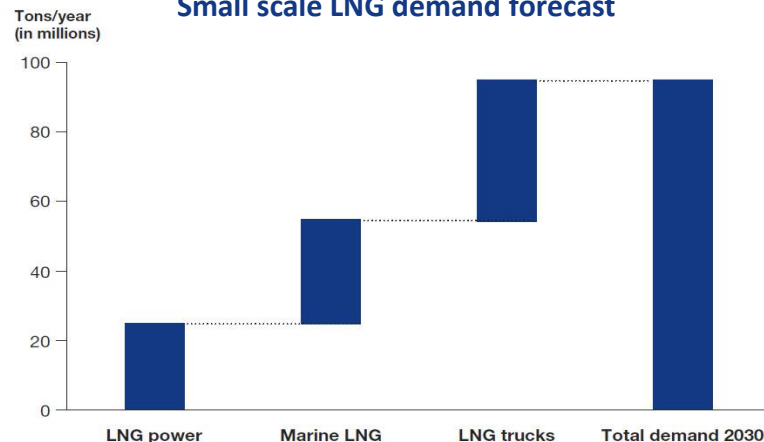


# A demand for more diverse and flexible fleet of LNG carriers is evolving

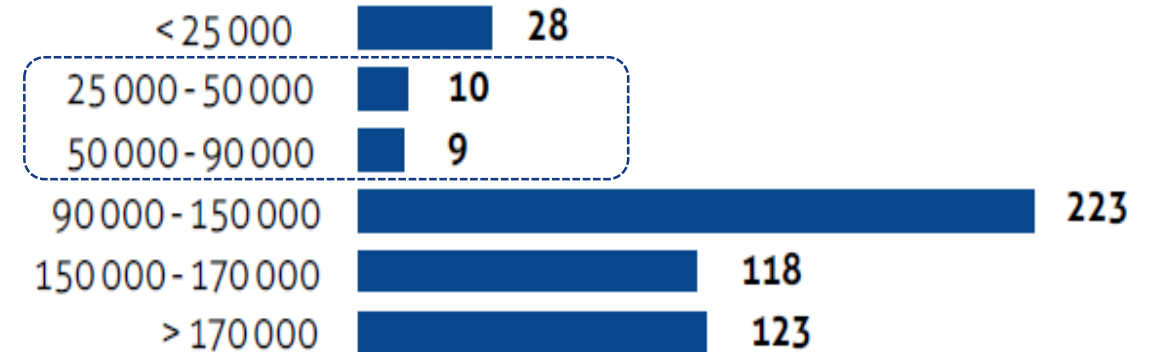
LNG trade 2017



Small scale LNG demand forecast



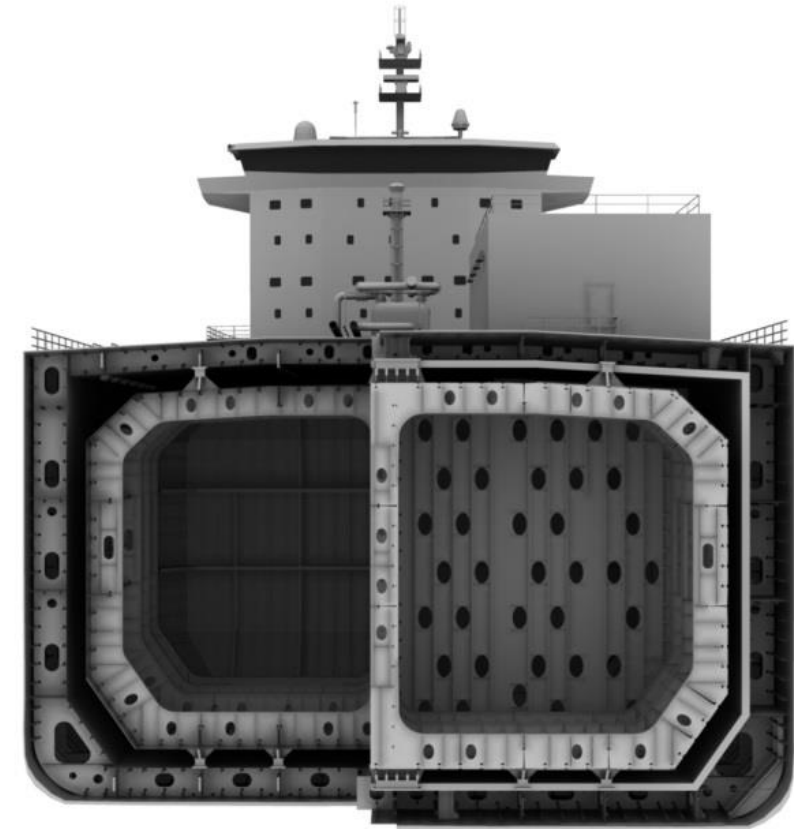
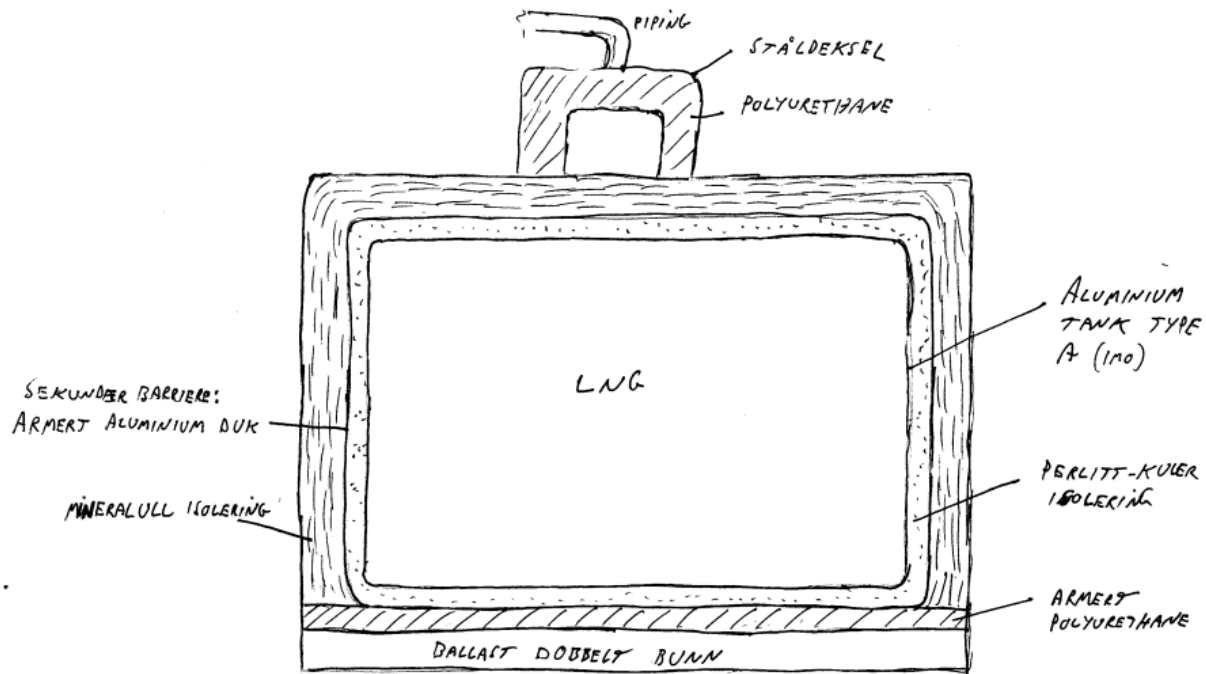
LNG fleet by size (2018)



- Small scale LNG demand is projected to reach **30 mill ton in 2020**, and **95 mill ton by 2030**.
- As a reference, today's large scale market of approx. 250 mill ton is served by about 500 large vessels.
- A significant growth in the number of small and mid-scale LNG carriers will be required to serve the small scale market for LNG power, marine LNG and LNG trucks.

# The idea

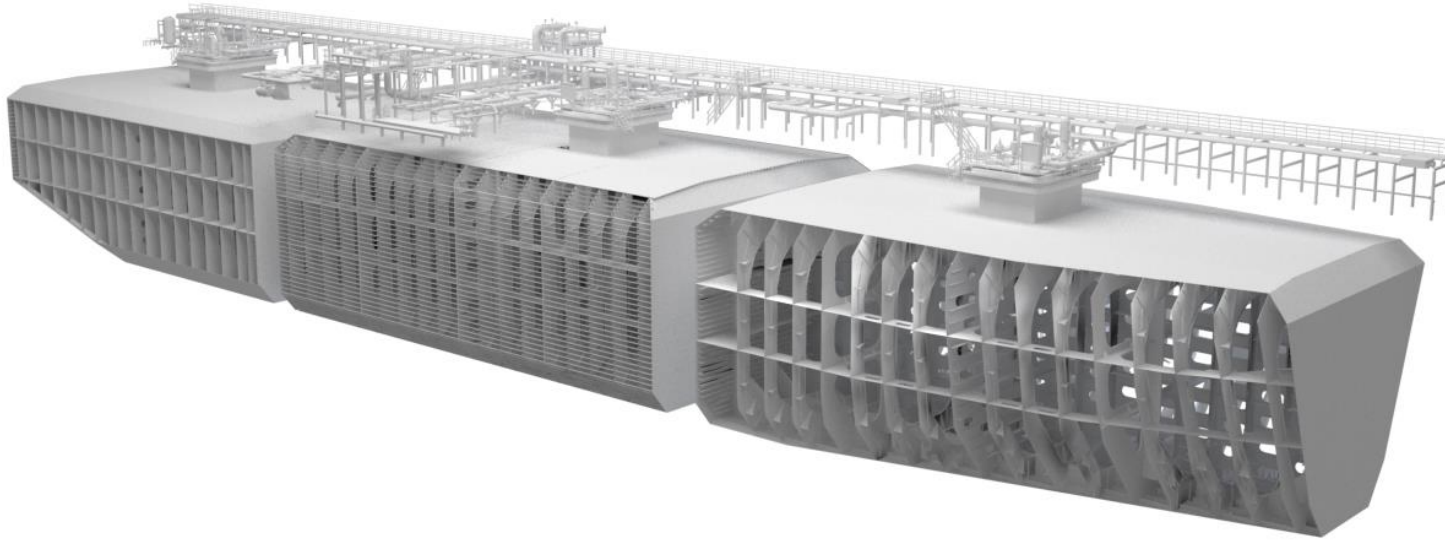
- Develop a simple and efficient cargo containment system for LNG.
- A system that can enable more shipyards to build the LNG carriers.



- 
- **Development process**
    - *Intellectual Property Rights*
    - *Partnerships*
    - *Class approvals*
    - *Testing*



# IMO independent tank type A



**IMO**



**Building friendly**

- Type A tanks are constructed primarily of flat surfaces and designed according to classical ship structural procedures

**Qualified workers**

- Reasonable welding and construction requirements

**Qualified yards**

- Limited infrastructure requirements at building yard

**Flexible**

- Type A tanks can be designed and built for various densities, design pressure and material grades



Type A tank is the industry standard for fully refrigerated LPG carriers



# Historical designs – concepts with similarities prior to the IMO IGC code

## Esso Brega class of ships

- Later known as **LNG Elba** and **LNG Palmaria**
- Double walled prismatic aluminum tanks, with outer wall defined as secondary barrier
- Operated successfully for many years.

## Conch designs

- **Methane Pioneer**, and the first two commercial vessels **Methane Princess** and **Methane Progress**
  - *Prismatic tank placed on load bearing thermal insulation based on balsa wood and plywood secondary barrier*
  - *Operated successfully for many years.*
- **125,000m3 El Paso vessels**
  - *Balsa wood insulation panels were considered too expensive and substituted with a sprayed-on foam insulation system on the hull structure*
  - *Total failure – extensive cracks and delamination due to thermal stress*

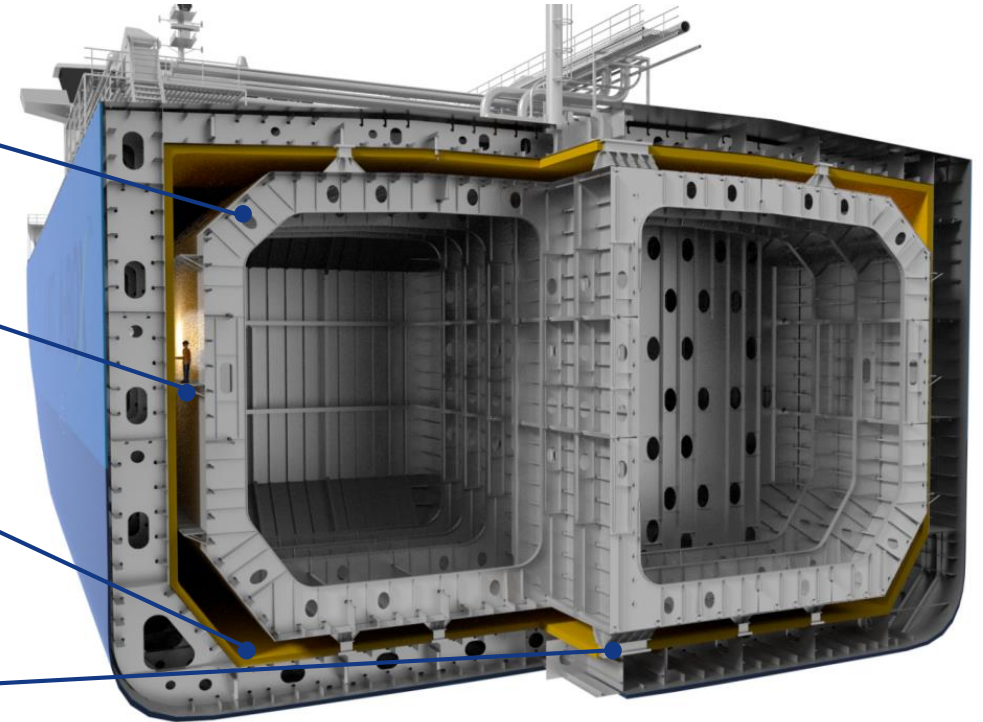
# Independent tank type A requires a full secondary barrier

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

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

**Secondary barrier:** *Liquid tight insulation acting as full secondary barrier*

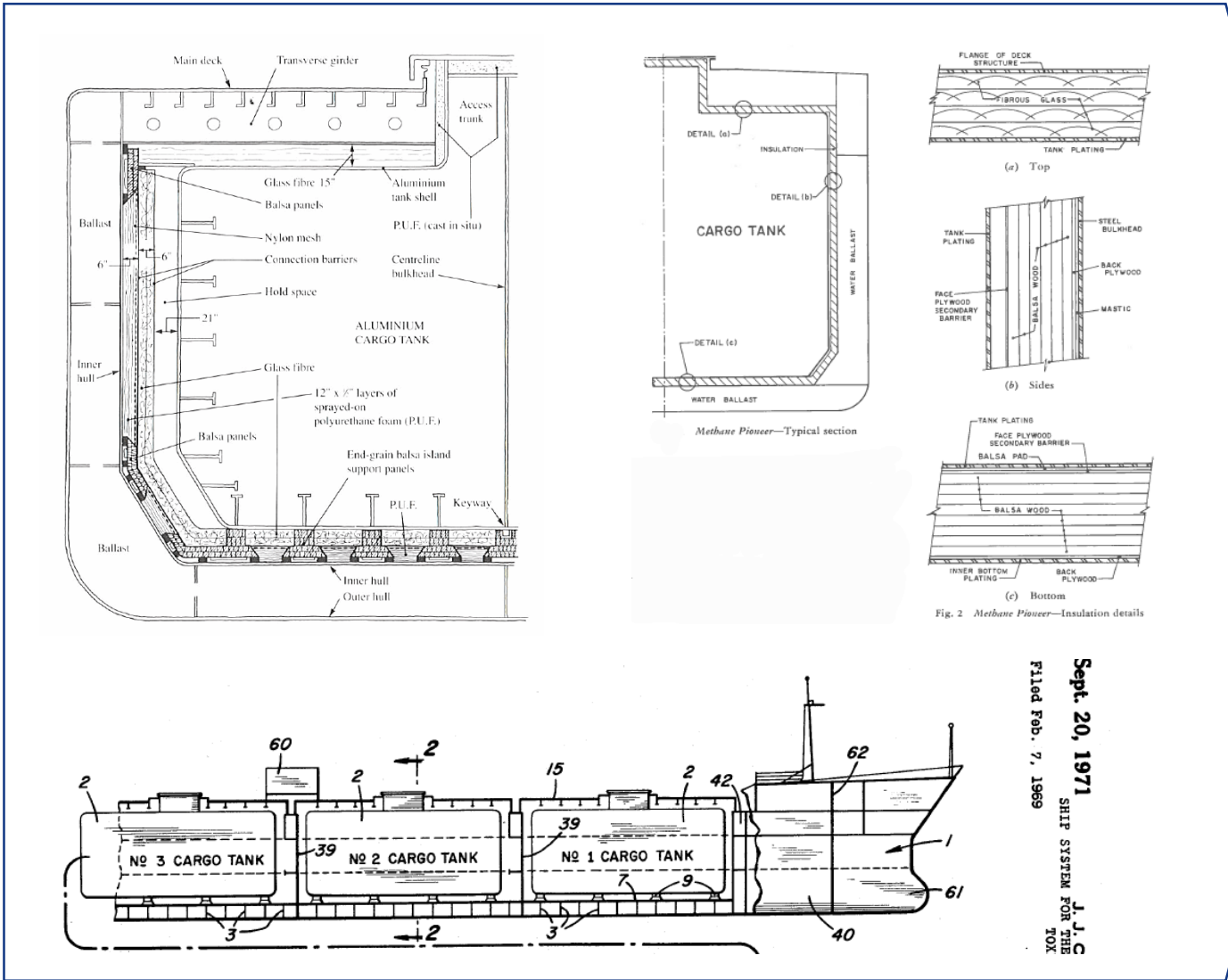
**Cargo tank support:** *Preventing bodily movement of the tank*



An un-insulated IMO independent tank type A in an insulated hold space ➡ **LNT A-BOX®**



# Considerable in-house resources and time spent on IPR



Sep. 20, 1971  
Filed Feb. 7, 1969  
J. J. C  
SHIP SYSTEM FOR THE  
FOX

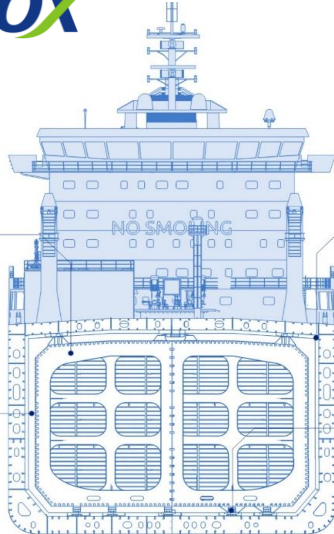
## LNT A-BOX®

### Cargo tanks:

- Cargo tank structure
- Internal fittings
- External fittings
- Welding procedures
- Test procedures

### Auxiliary systems:

- Arrangement and access
- Gas detection systems
- Bilge systems
- Atmosphere control
- Instrumentation
- Sounding & alarm
- Cofferdam heating

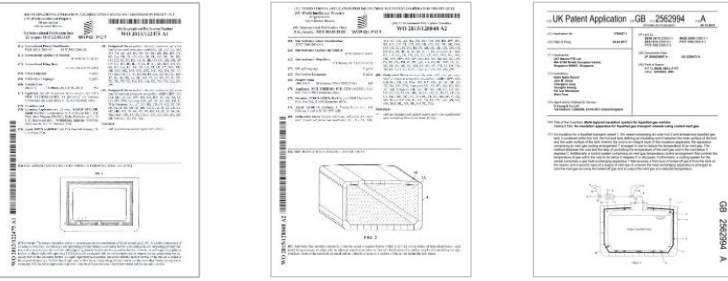


### Secondary barrier:

- Material specifications
- Arrangement drawings
- Installation procedures
- Quality control procedures
- Technical assessments
- Thermal distribution & BOG

### Cargo tank support:

- Specifications
- Wooden support system
- Alignment procedures
- Installation procedures



The company holds an IPR portfolio consisting of several patents as well as trademark

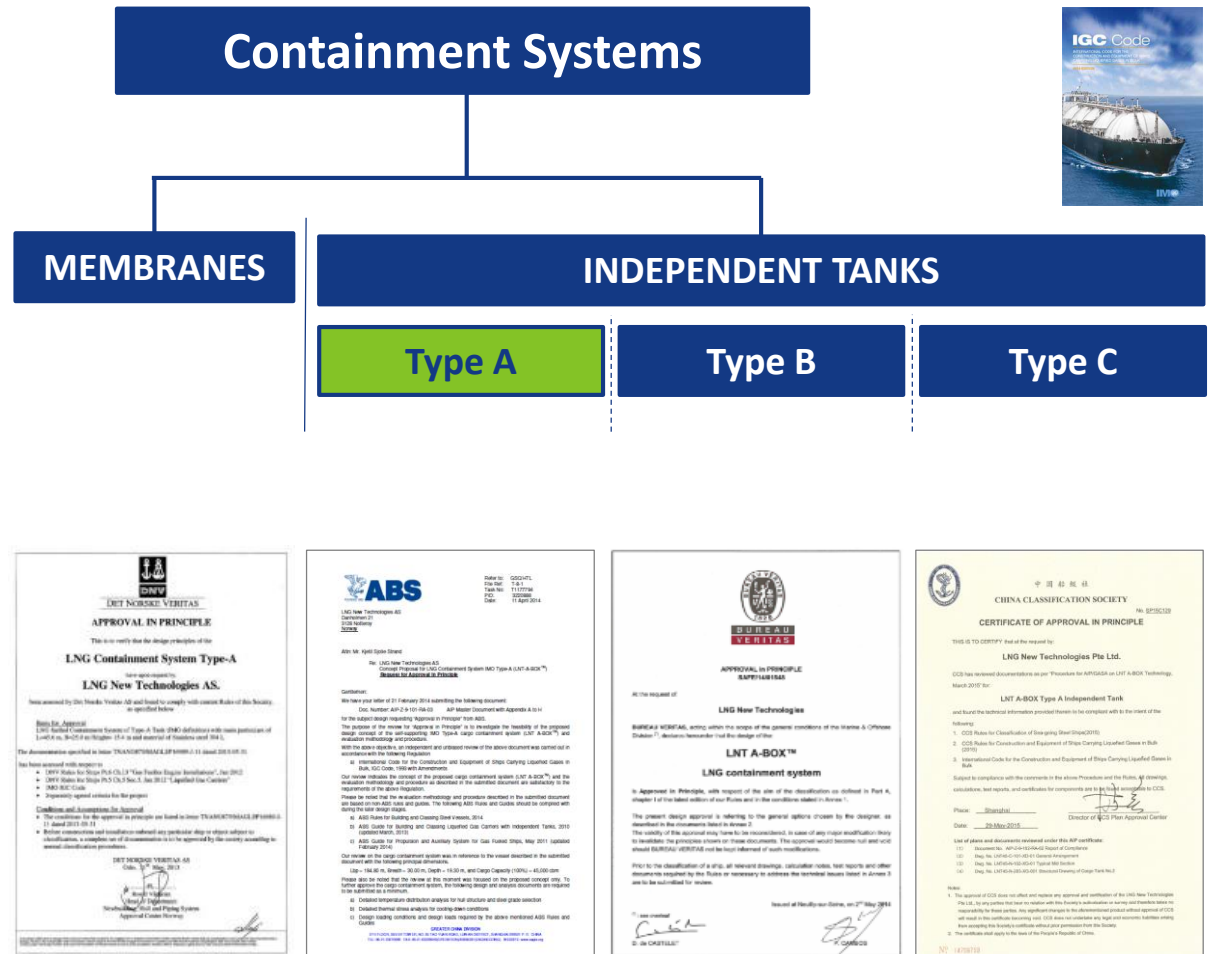
# Partnerships for joint development

*If you want to go quickly - go alone,  
if you want to go far - go together.*  
African proverb



# Class approvals

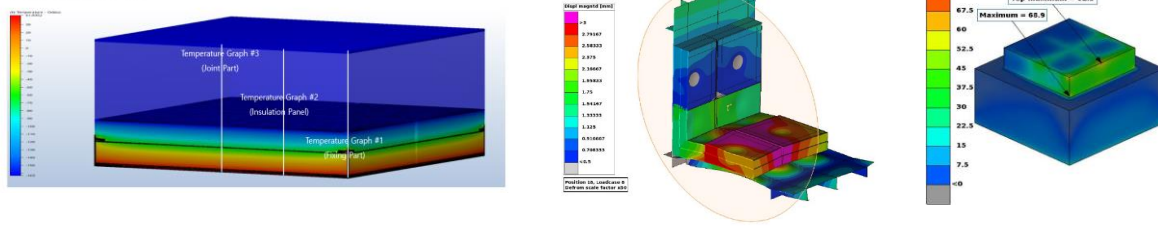
- Approval in Principle (AiP) for feasibility and interpretation of regulatory framework.
- First insulation system AiP issued in 2010.
- Complete system AiP process started with DNV in 2012 and certificate issued in 1H 2013.
- Later same process with ABS, BV and CCS
- Class societies have also issued General Approval for Ship Applications (**GASA**), General Design Approvals (**GDA**) for the insulation & secondary barrier system.
- In addition, class has assisted to establish test criteria and witnessed and number of key tests during the course of development.



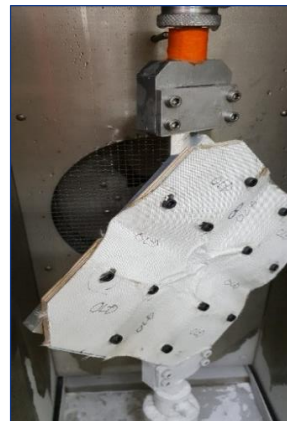
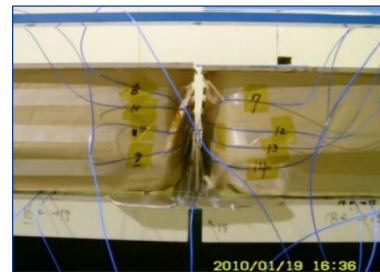
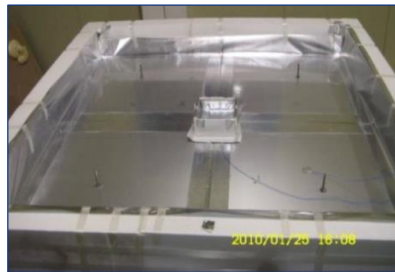


# Testing

4.1 FEM Image of Flat Panel



Expert competence, experience, advanced CAD, FEM and other tools for design and analysis can take you a long way, but for the development of a novel containment system, testing is needed.



*By three methods we may learn wisdom:*

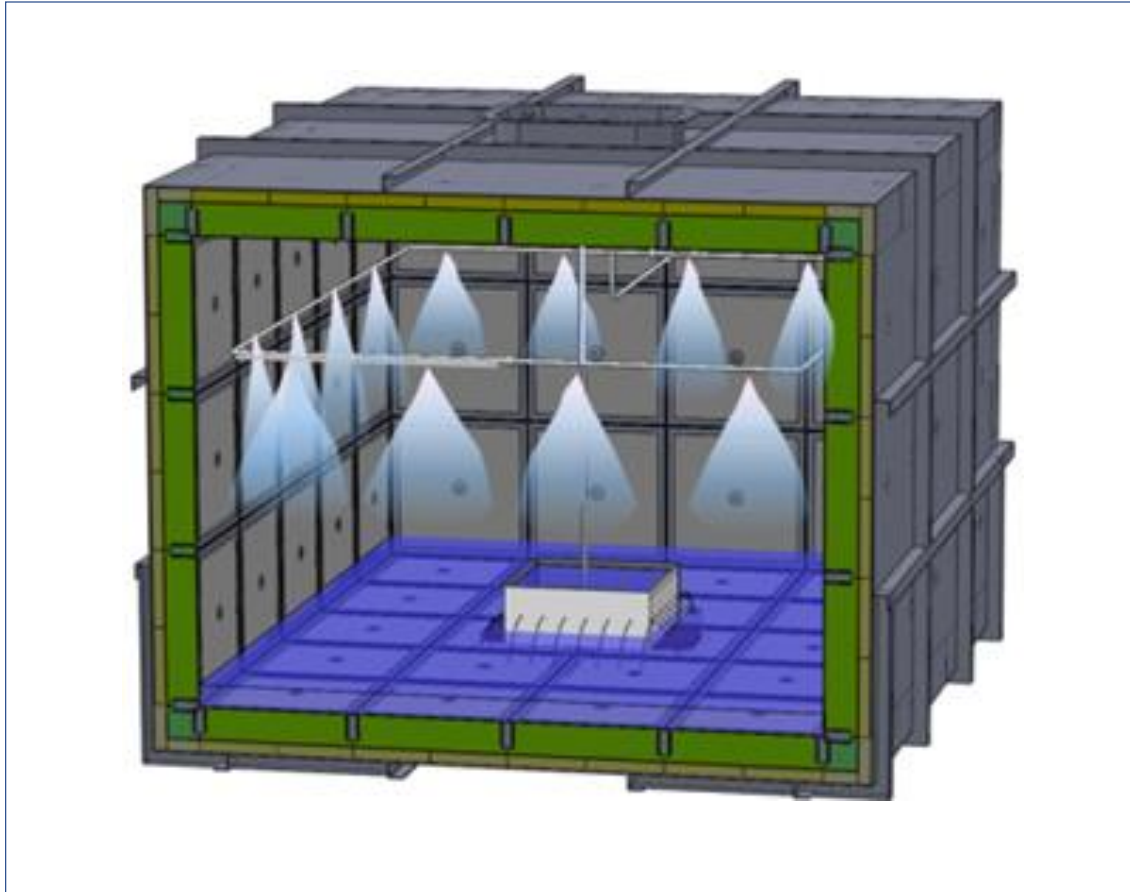
*First, by reflection, which is noblest;*

*Second, by imitation, which is easiest;*

*and third by experience, which is the bitterest.*

Confucius (551 BC - 479 BC)

# Mock-up – testing installation and simulating collapse of the primary barrier



*"A life spent making mistakes is not only more honorable,  
but more useful than a life spent doing nothing."*

- Georg B. Shaw (1856 – 1950)

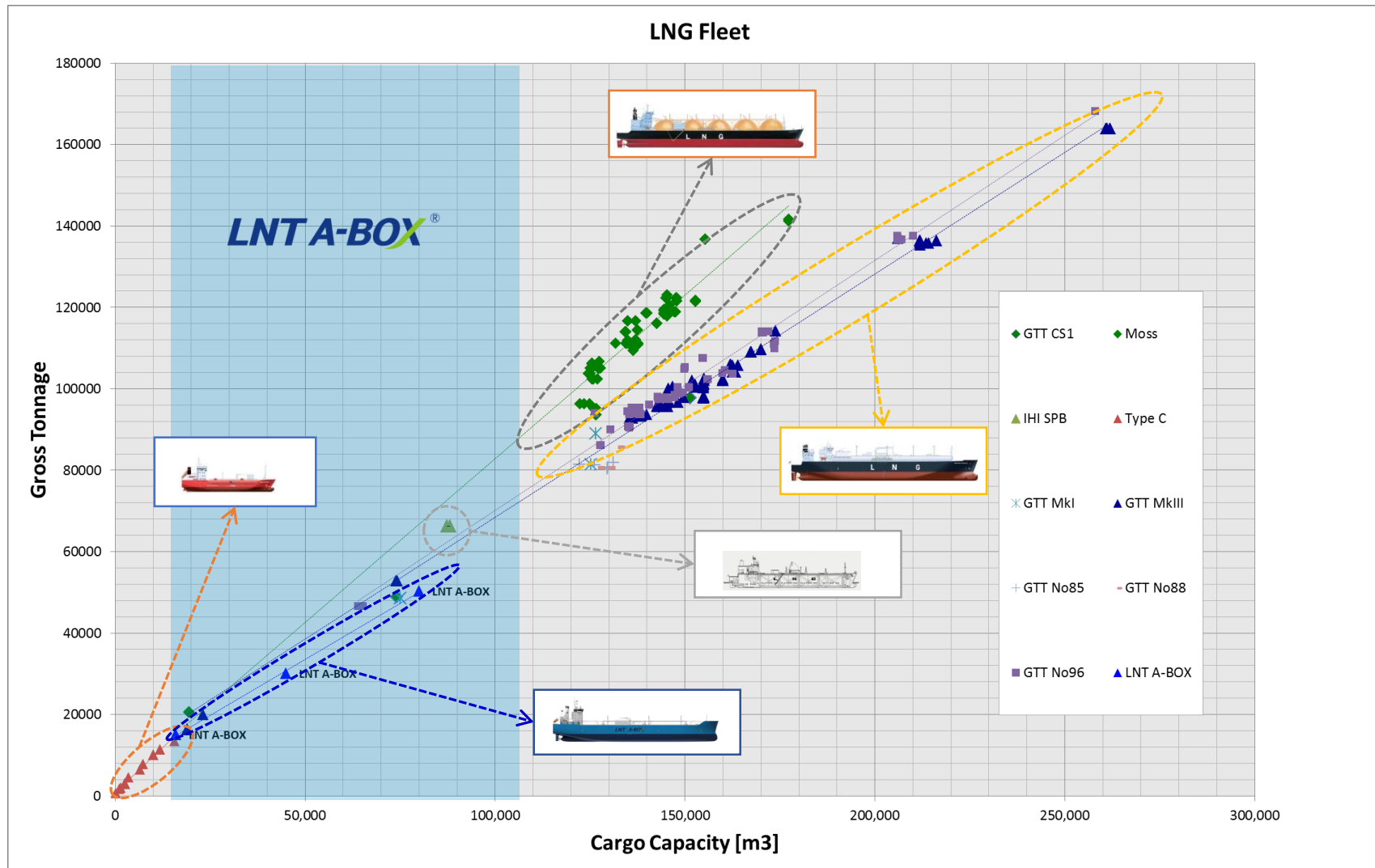


- **Ship project development**
  - *Market entry*
  - *Specifications & contract*
  - *LNT45 – Saga Dawn*
  - *Construction process*
  - *Testing & trials*





# Market entry – mid-size LNG



- Membrane type and Moss dominating the large scale market.
- Type C is efficient for small scale ships
- No existing technologies with a clear market leader position in the mid-scale segment;
- Whilst the market development points towards a need for more mid-scale tonnage.

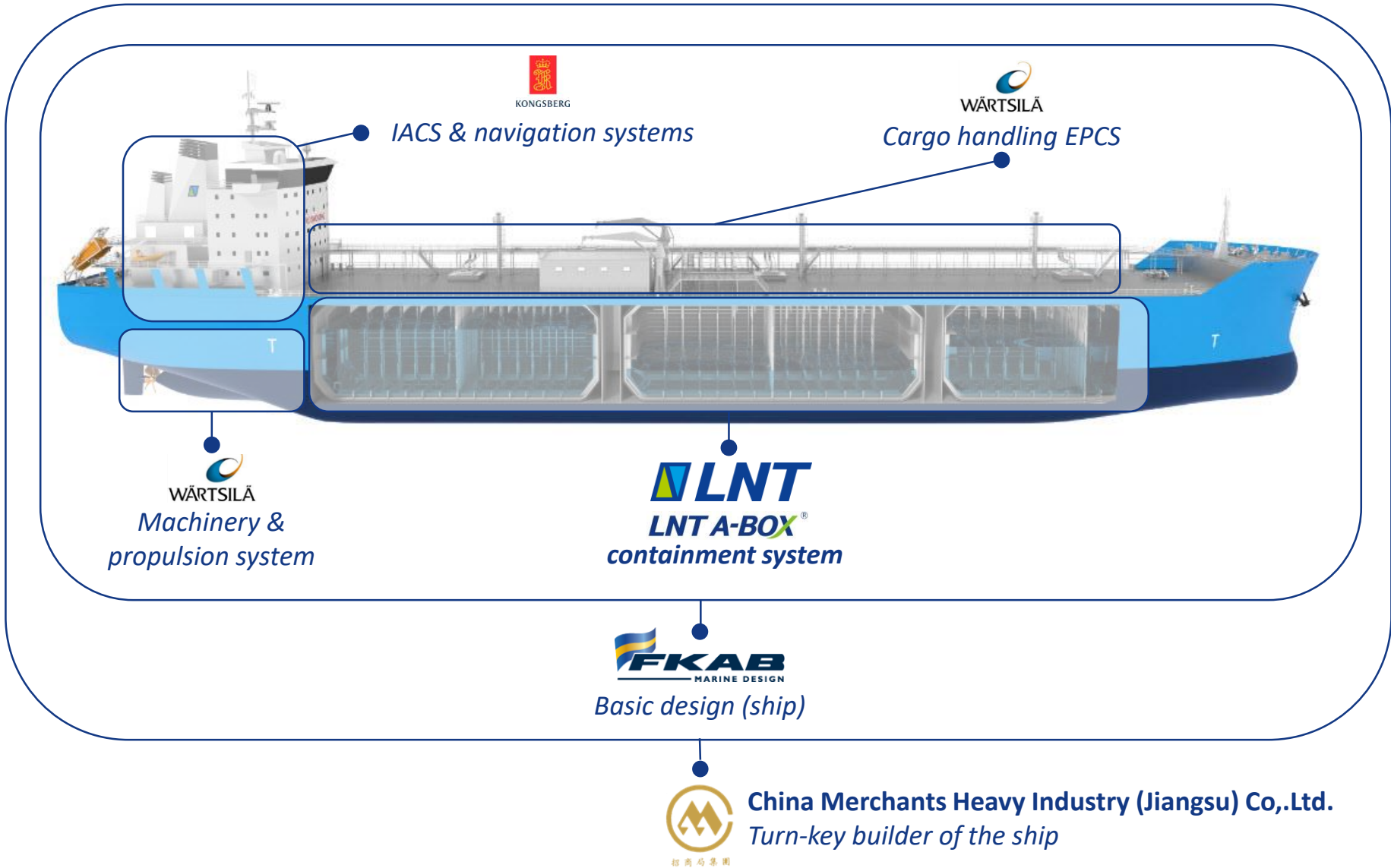
# LNT45 concept design, specifications and contract



LNT45 – 45,000m<sup>3</sup> LNG carrier



# LNT45 – Saga Dawn



## Main Dimensions

Loa	195.30 m
Lpp	184.80 m
Beam	30.00 m
Depth	20.00 m
Design draught	9.00 m

## Service Speed

Service speed:	16.5 knot
----------------	-----------

## Machinery & Propulsion

Dual fuel main engine:	approx. 11,700 kW
Auxiliary engines:	approx. 2,500 kW

## Cargo System

Containment system:	LNT A-BOX <sup>®</sup>
No. of cargo tanks:	3 -
Total capacity:	45,000 m3
MARVS:	0.4 bar g
Design density:	0.6 ton/m3
Min.temp.:	-163 °C
BOR:	0.15 %/day



# Tank construction at SWS Shenghui – under supervision by LNT Marine



- Tank construction subcontracted to SWS Shenghui, specialized in pressure vessels and low temperature steels.
- Tank material, Chinese domestic 304L stainless steel
- Basic design and class approval by LNT
- Detail design by SWS.
- Challenges with heat deformations and tolerances on supports, but in the end very good results.



## Tank no.3





# Open mock-up for verification, training and qualification





# Onboard installation





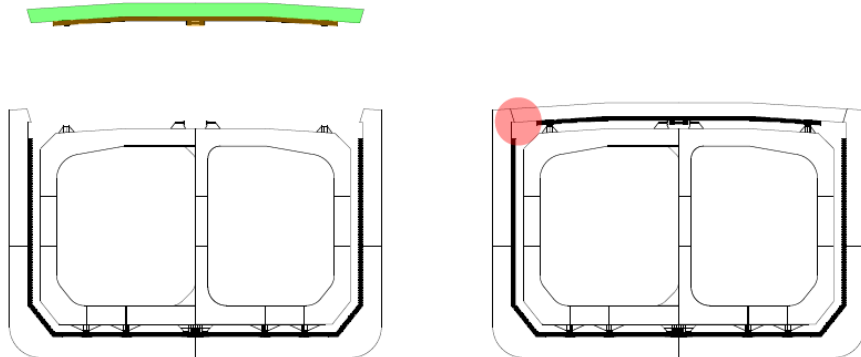
# Cargo tank installation





# Cargo tank installation

- Support interface check and verification
  - Installation of ship support key system
  - Lifting and installation of cargo tanks
  - Lifting and installation of deck sections
- 
- Final verification of touch of sliding surfaces and tank position
  - Hydrostatic pressure test
- 
- Pump installation and alignment
  - Dome sealing and tightness test
- 
- Global tightness test of secondary barrier






# Testing & trials





# Gas trial completion

- 
- A group of five men are standing on the deck of a ship, likely an LNG carrier, given the context. They are all smiling and giving thumbs up. From left to right: a man with grey hair in a white shirt; a man in a white shirt, a dark baseball cap, and sunglasses; a man in a white shirt and glasses; a man in a white shirt and a white hard hat with a logo; and a man in a white shirt and a white hard hat. The background shows the ship's complex structure with cranes and railings, and the sea under a clear blue sky. A semi-transparent text box is overlaid on the bottom half of the image.
- Cooling down and loading liquid into the first tank at the Wuhaogao LNG terminal outside Shanghai.
  - Further trials conducted in the East China Sea.
  - All three cargo tanks were cooled down and loaded with liquid during the course of testing
  - Secondary barrier system tightness was tested prior to and after cool down
  - All completed with satisfactory results.



# Summary





# Some concluding remarks

- The LNT A-BOX® is the result of a visionary idea to develop a simple and efficient cargo containment system for LNG
- It has been many years (more than ten!) of:
  - *Hard work*
  - *Strong partnerships*
  - *Patience (and funding)*
- Development of new technologies is by nature challenging, and the LNG industry is rather conservative.
- We managed to follow the path we set out and the system is now proven and ready for the market.

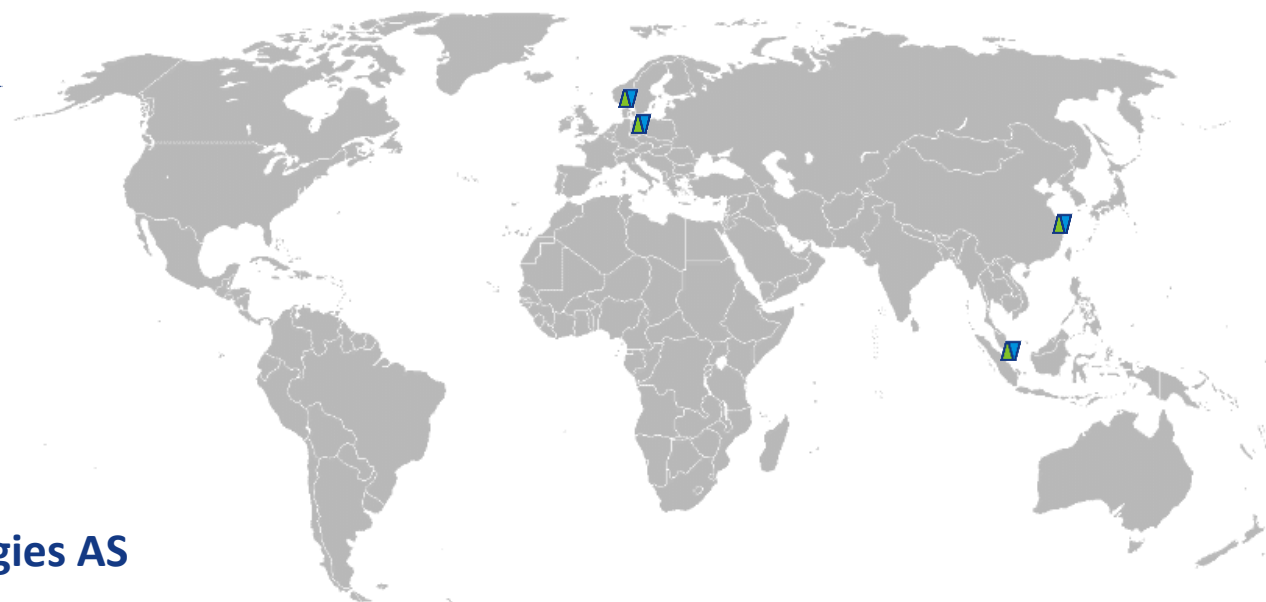


**LNT A-BOX®**  
**Robust | Flexible | Efficient**

# THANK YOU

**LNT Marine**

[www.lntmarine.com](http://www.lntmarine.com)



### **LNT Marine Pte.,Ltd.**

3 International Business Park #04-07/08  
609927 Singapore  
SINGAPORE



### **LNT Marine AS / LNG New Technologies AS**

Bragernes Torg 1  
3017 Drammen  
NORWAY



### **LNT Marine Sp.z o.o.**

Street Leborska 3b  
80-386 Gdansk  
POLAND



### **LNT Marine (Shanghai) Co.,Ltd.**

1518 Minsheng Road, Jinying Plaza, Building B, Room 502B  
Pudong New District, Shanghai  
P.R.CHINA

