



LNT Fuel-BOXTM

Solutions of IMO type A LNG fuel tanks

CCS Maritime Technology Seminar, Marintec China, December 2017

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- **LNT Marine**
- **LNT A-BOX® technology**
- **LNT Fuel-BOX**
 - *Tank design*
 - *Thermal insulation & BOR*
 - *BOG management & fuel gas supply*
- **Case study**
- **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.



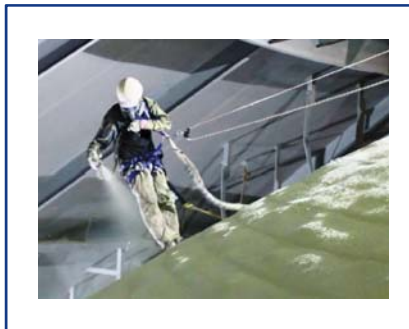
LNT Marine is engaged in different business segments with complementing competence creating synergies

1. LNG containment systems



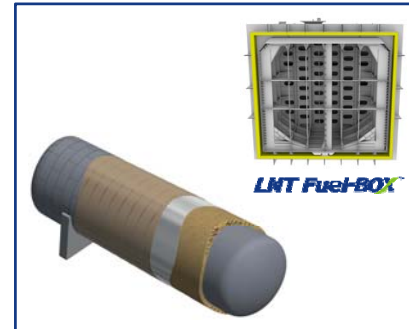
- LNT A-BOX is a containment system for LNG and other gases at temperatures below -55°C.
- LNT Marine offer system engineering and supervision as well as supply of insulation and secondary barrier system.

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 Marine is providing the fuel tank insulation for the world's first series of LNG powered cruise ships



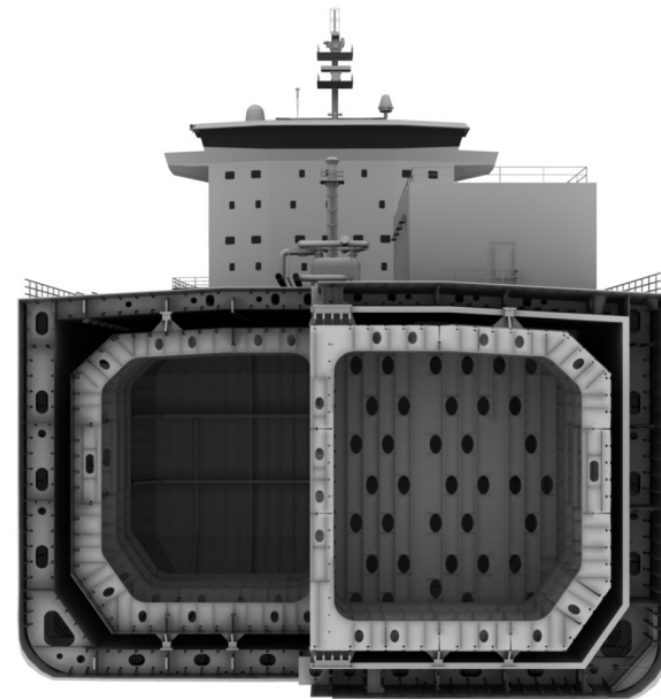
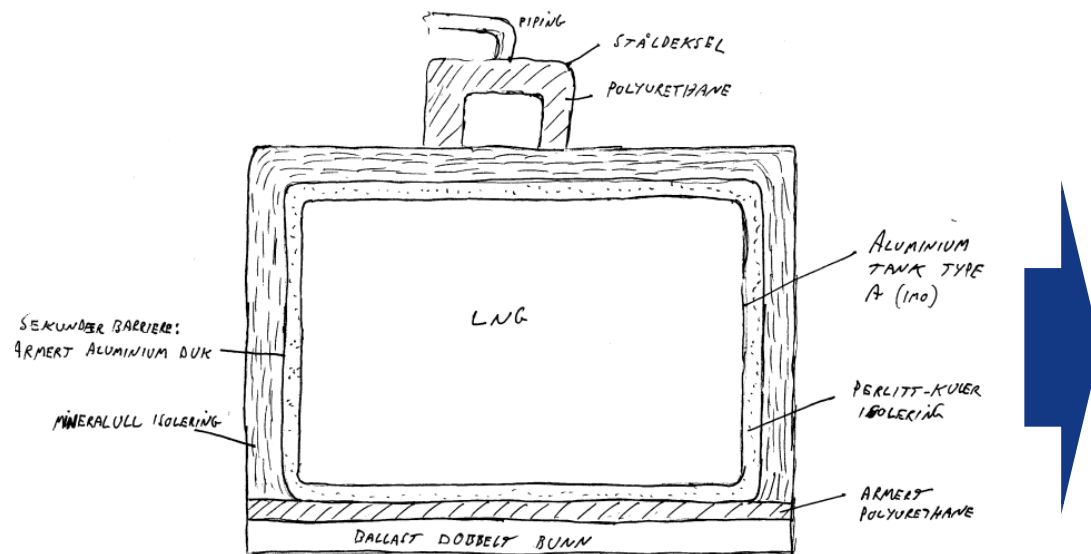
- 7+7 ship sets at Meyer Werft for Carnival Corporation, 180,000 GRT Cruise Ships
- 3 x IMO type C fuel tanks with thermal insulation, total capacity 3,500m³

LNT A-BOX[®]



The idea

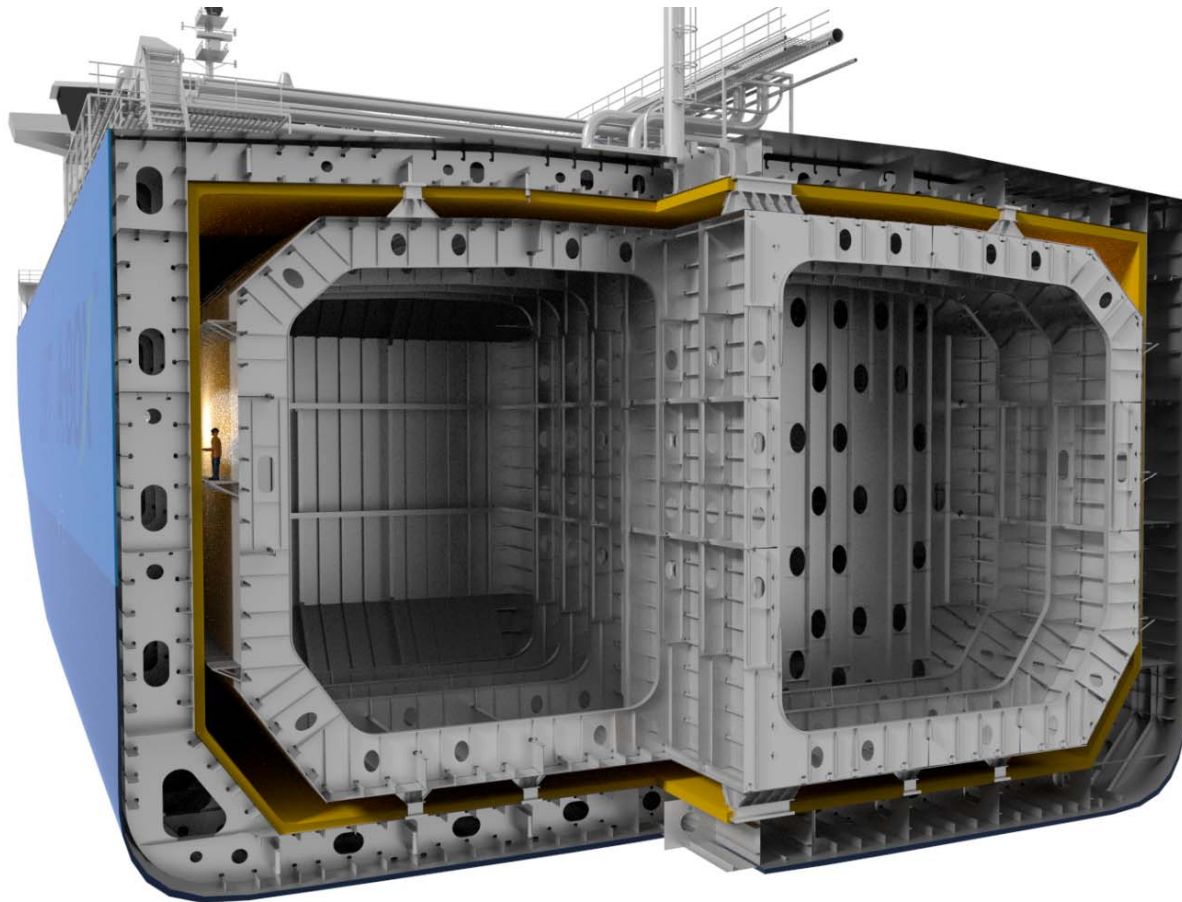
- Develop a simple and efficient cargo containment system for the mid-size segment.
- A system that can enable more shipyards to build the LNG carriers.



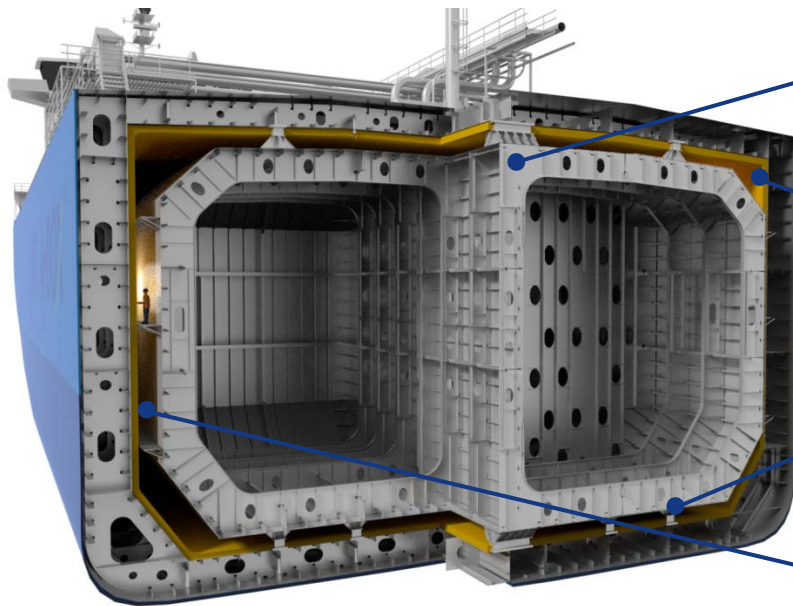
TEGN ①



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

LNT A-BOX® - advantages

Building capacity and costs

- Simple and cost-efficient design
- Independent tank construction
- Enabling more yards to build LNG carriers



Safety

- Robust tank design
- No filling restrictions
- Independent barriers
- Easy inspection and maintenance

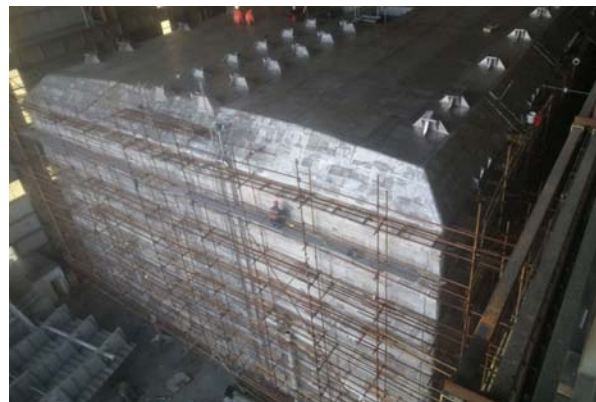


Efficiency

- Excellent volume utilization
- Excellent thermal insulation
- Design flexibility



LNT A-BOX[®] first vessel under construction and ready for commercial operation in 2018



LNT45 – Design particulars



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
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Machinery & Propulsion

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

Cargo System

Containment system:	LNT A-BOX®
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

Classification

- ✕ A1, © LIQUEFIED NATURAL GAS CARRIER with Independent Tanks, SH-DLA, SFA(25), SH, SHCM,
- ✕ AMS, ✕ ACCU, NIBS, DFD, GCU, ENVIRO+, GP, POT, RRDA, BWT, TCM, UWILD

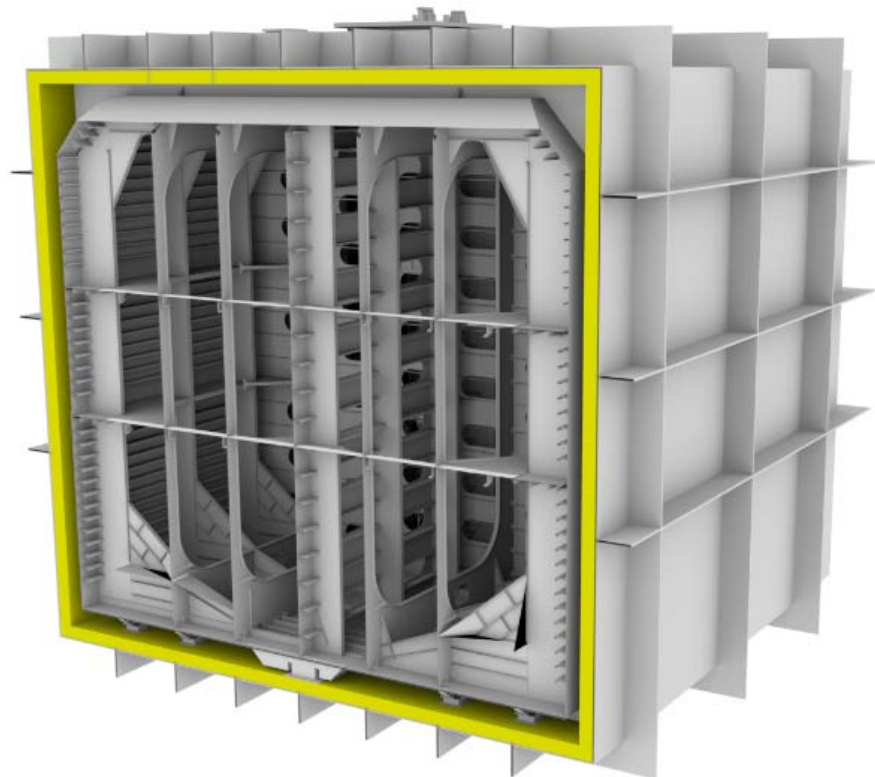


LNT Fuel-BOX™

Tank design

Thermal insulation & BOR

BOG & fuel gas supply



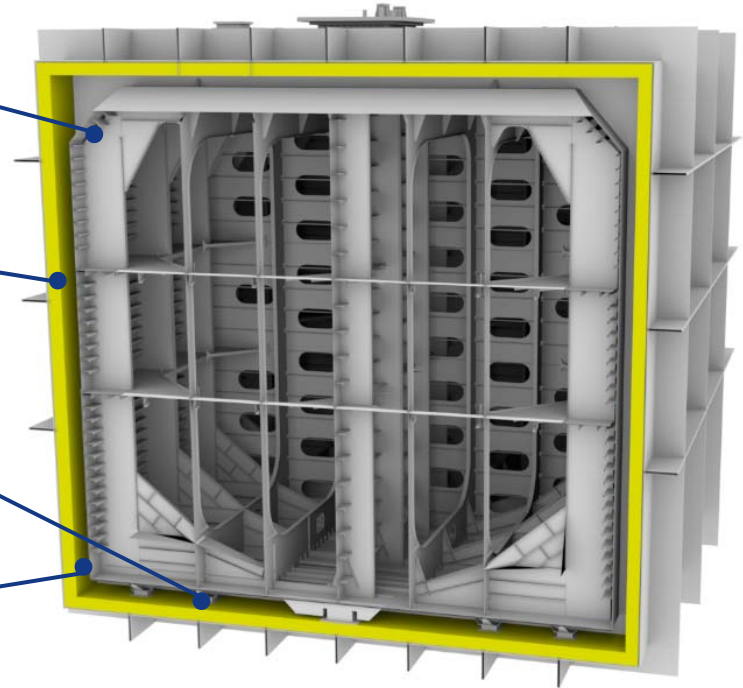
LNT Fuel-BOX is based on the principles of the LNT A-BOX, optimized for LNG fuel storage

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*

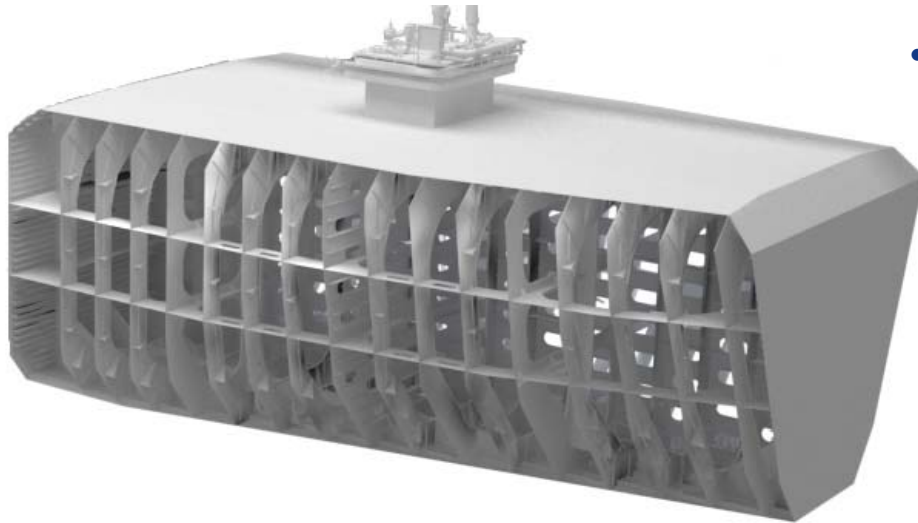


Tank pressure:
Possibility for increased tank pressure for maximum operational flexibility

Thermal insulation:
Possibility for additional removable thermal insulation in the cold interbarrier space

Containment frame:
Outer containment frame structure to interface with hull structure (retrofit projects)

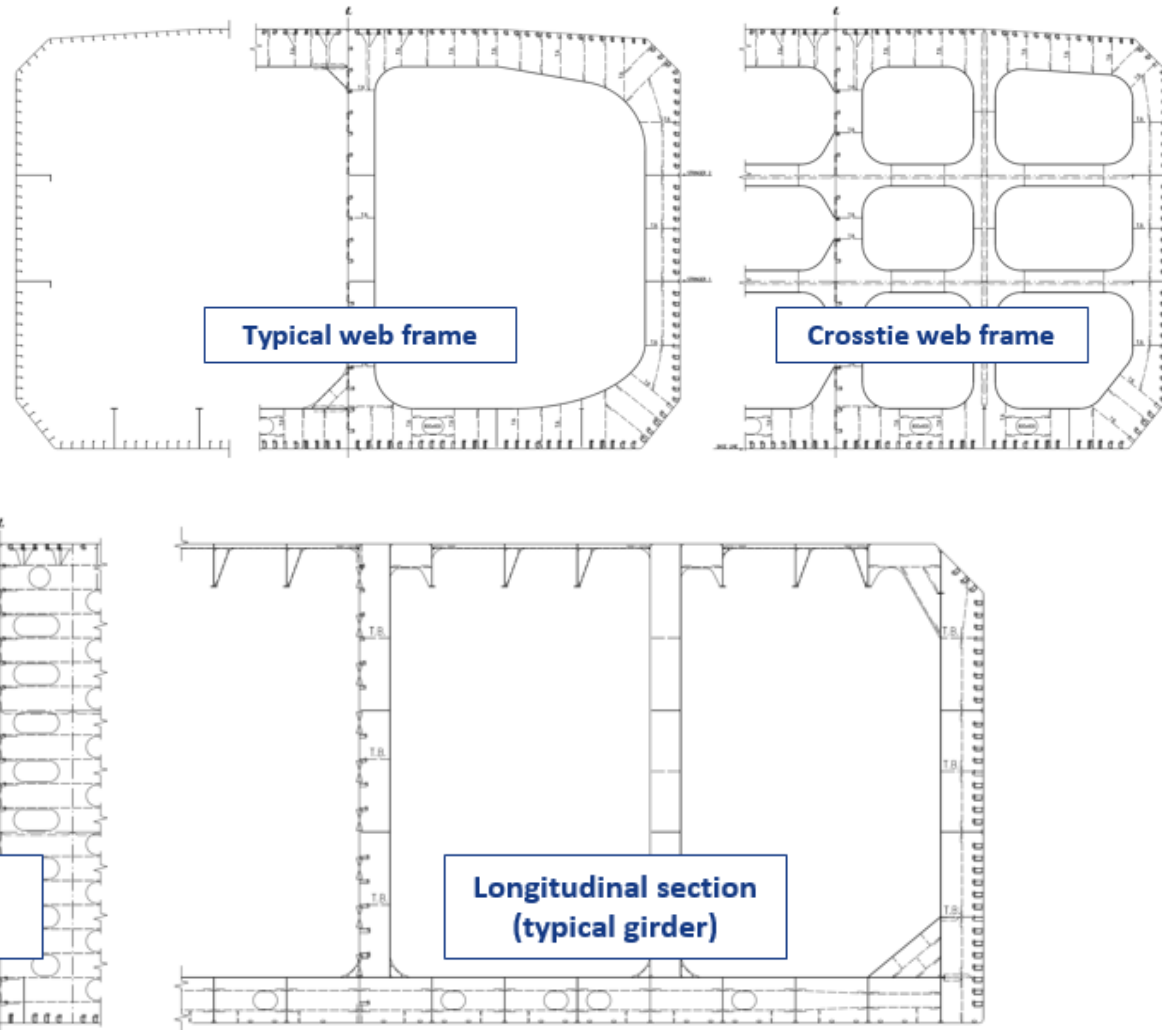
Tank structure – primary barrier



- Basis independent tank type A:
 - *Self-supporting tank built independently from the ship's hull.*
 - *Constructed primarily of flat surfaces and designed according to classical ship structural procedures*
 - *Flexible in terms of geometry as well as tank material.*
- For the LNT Fuel-BOX we are proposing two alternatives:
 - 1) Conventional IMO type A as per IMO IGC code and max. design pressure 0.7 bar g.
 - 2) Semi-pressurized tank, as per IMO IGC code 4.27, Novel Concepts.
 - The Fuel-BOX with increased design pressure (2 bar g) will basically have the same layout as the ordinary tank, but due to the increased internal pressure the design methodology will follow Limit State design as per IGC Appendix 5.
 - The weight will be higher, approx. 30%, but additional cost will be less significant.

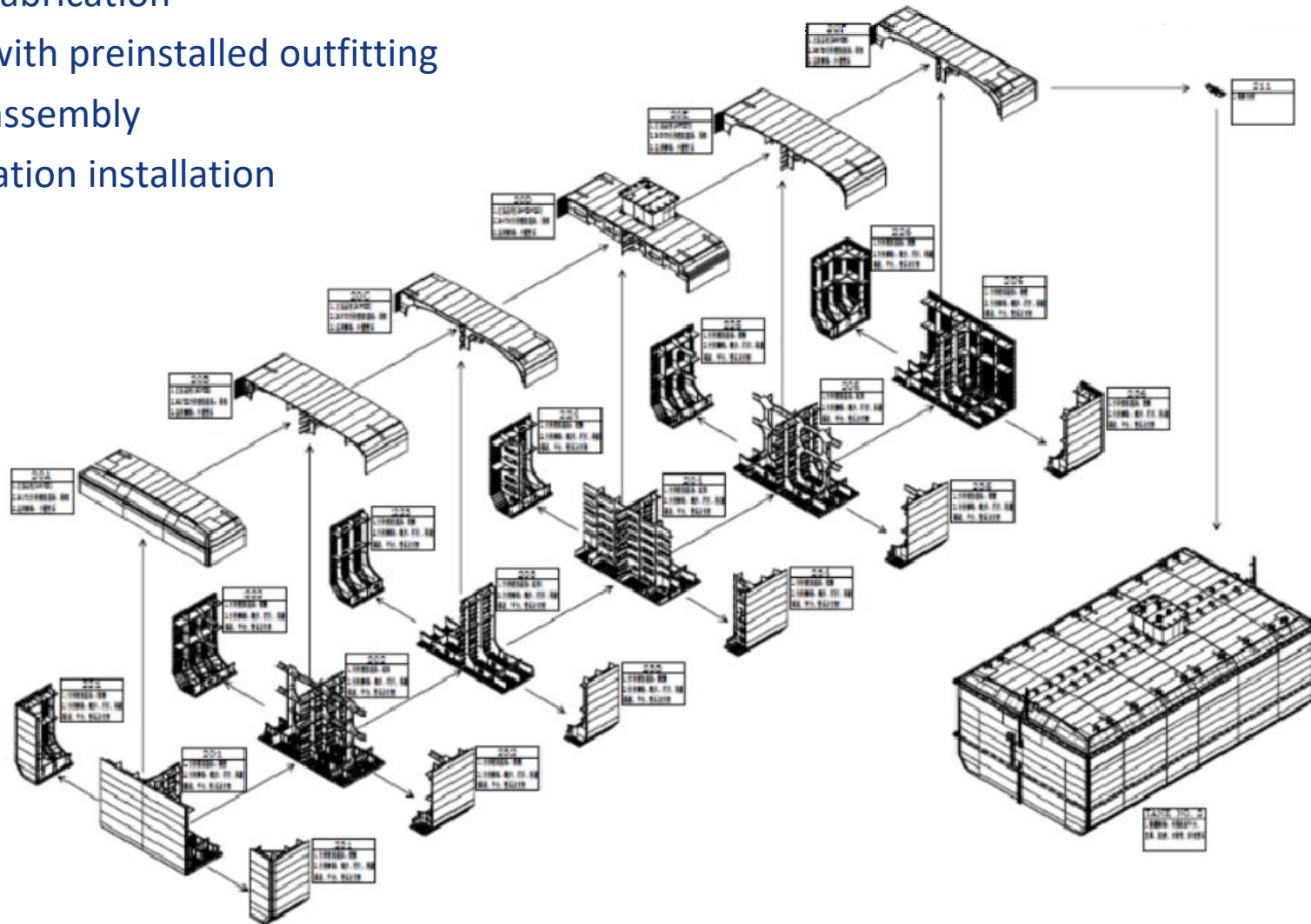
Tank structure – structural design principles

1. Primary structure in way of standard web and crosstie web frames
2. Secondary structure in way of girders and stringers
3. Shell plate with profiles forms the primary barrier



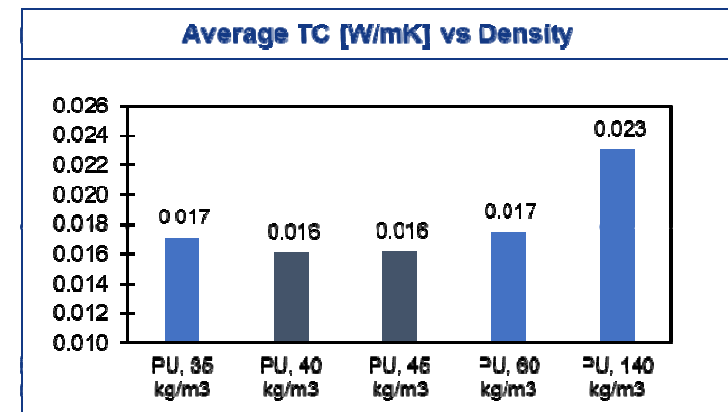
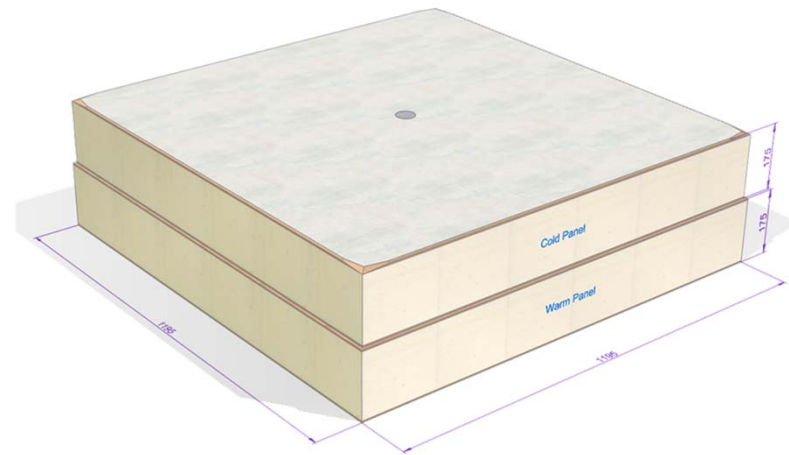
Tank structure – construction principles

- Panel fabrication
- Block with preinstalled outfitting
- Block assembly
- Foundation installation

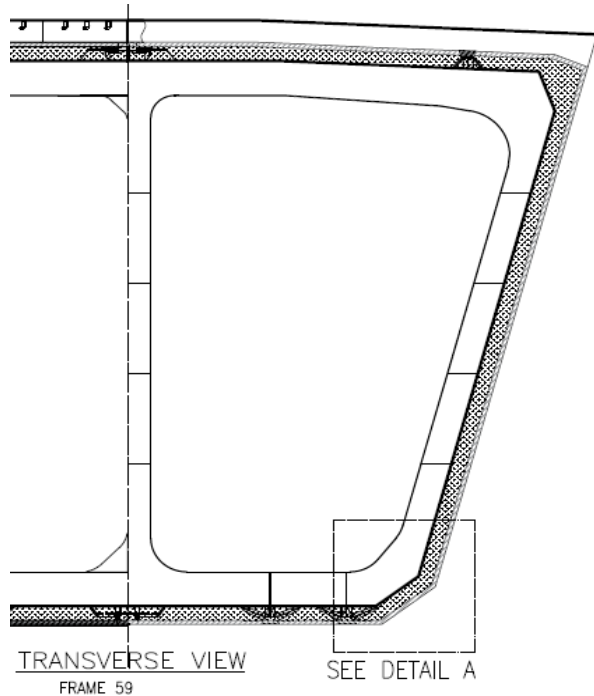


Thermal insulation & secondary barrier - BOR

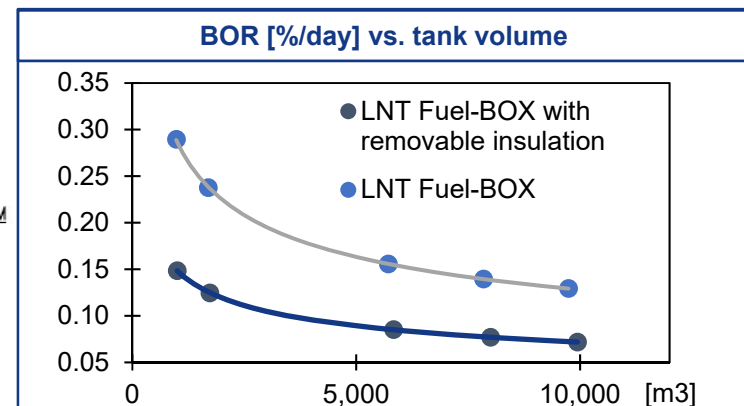
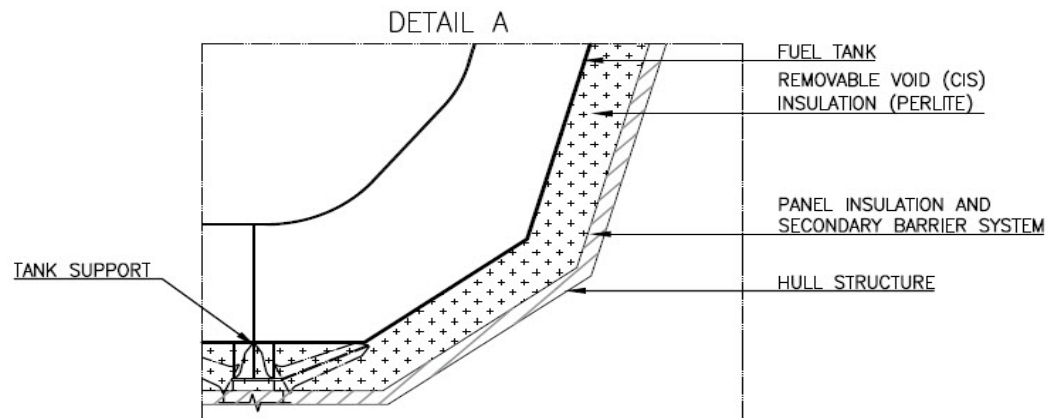
- The insulation system is designed with full secondary barrier according to IGC code.
- The system consists of pre-manufactured panels which are secured to the compartment plating with stud-bolt and an anchoring system.
- In order to eliminate global load transfer, panels are fixed at their center point and jointed together by flexible joints.
- For the LNT A-BOX® and LNT Fuel-BOX™ the insulation system is not exposed to static nor dynamic load from the cargo
- Thus, the insulation system is optimized for best possible thermal performance
- The insulation system thickness is flexible and can be adjusted to meet the BOR requirements.



Thermal insulation & secondary barrier - BOR



- The unique cold interbarrier space between tank and insulation may be used for additional (removable) thermal insulation
- Due to the cryogenic temperature, additional insulation will have very positive effect, and BOR may be reduced with up to 50%.
- Non-evacuated perlite or EPS may be used for this purpose. Perlite in bulk has been used in cryogenic storage tanks for centuries and has also been used in bulk in the void space on fully refrigerated LPG carriers in the past.



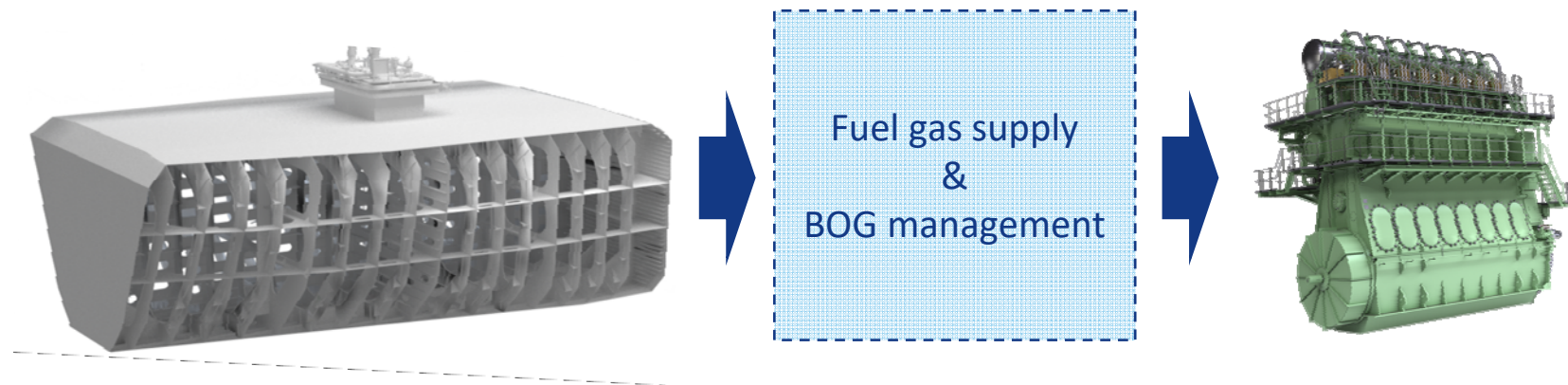
Fuel gas supply system & BOG management

Fuel gas supply system will be designed according to engine installation requirements.

- Low pressure (4-stroke) engines may be supplied by compressors
- High pressure 2-stroke engines shall be supplied by high pressure pumps. High pressure pumps will require reliquefaction plant or cold heat recovery.

BOG management will be designed according to ship operational conditions

- Conventional IMO type A, 0.7 bar g, may require compressors to feed BOG to engines, plus reliquefaction plant – depending on minimum hotel load
- Limit state design approach, 2 bar g, and cooling by cold heat recovery can eliminate need for big BOG compressors and reliquefaction plant.



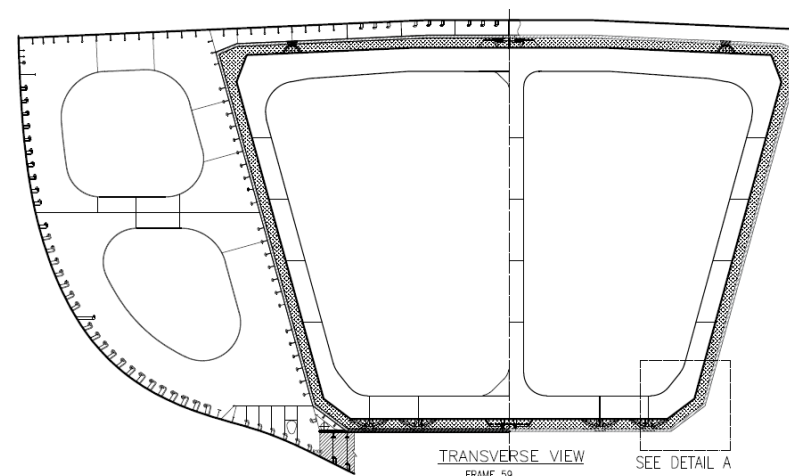
Case study: 400,000 DWT VLOC



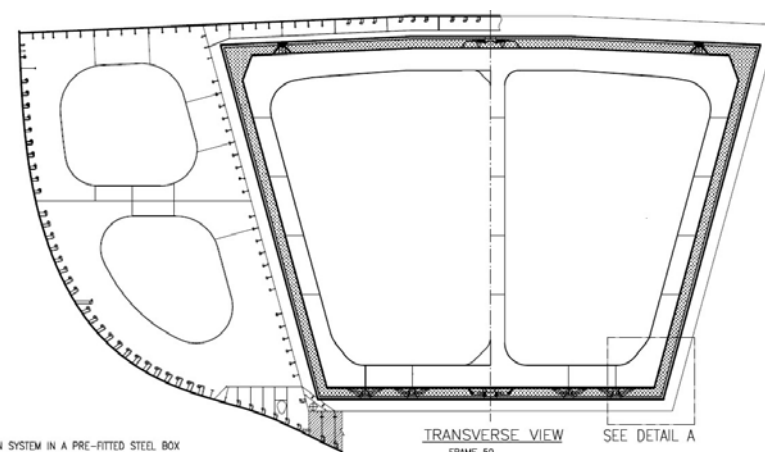
LNG fuel tank for 400,000 DWT VLOC

- Hold space reserved for LNG fuel approx. 18,000 m³. Inclined transverse bulkhead aft.
- We have considered and investigated two alternative solutions based on the LNT Fuel-BOX™ system for this project.
 - Option 1 is an integrated solution based on installation of the fuel tank system directly into the existing hull structure
 - Option 2 is based on the fuel tank system prefabricated in an independent steel structure to be lifted onboard as a complete unit.
- Some key data for the two solutions are summarized in the table below:

	Option 1	Option 2
Fuel tank capacity	13,200 m ³	11,500
BOR	0.09 %/d	0.10 %/d

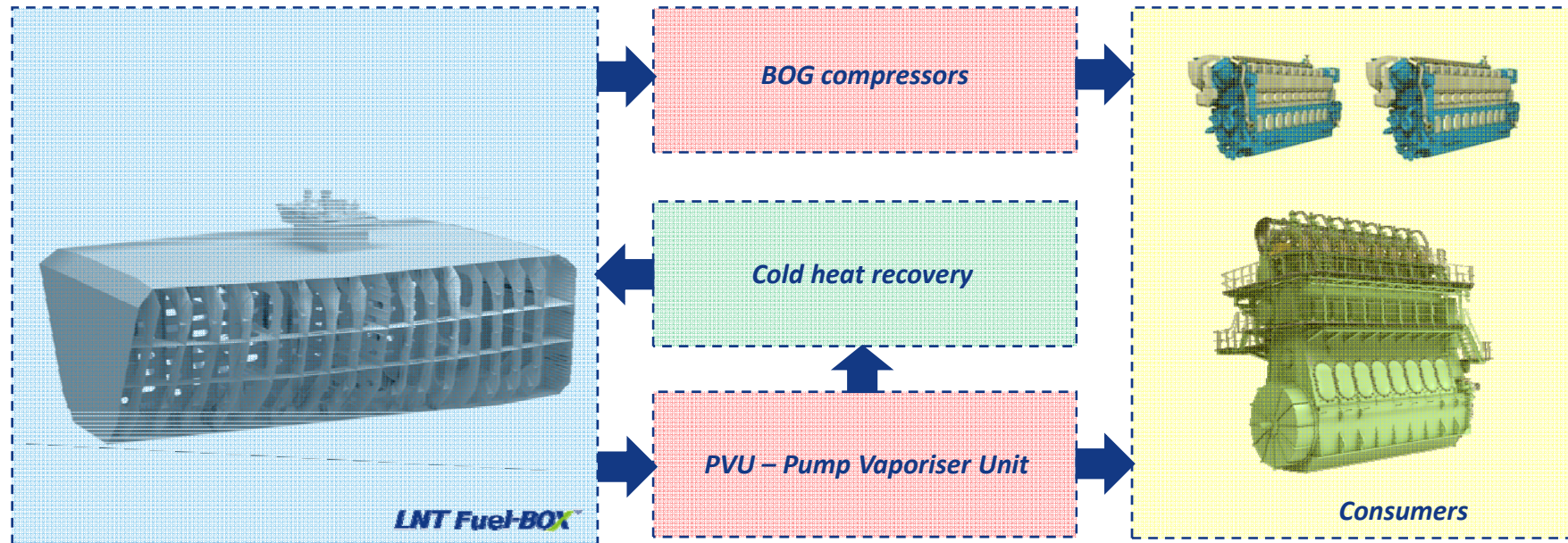


NOTES:
INSULATION SYSTEM DIRECTLY ON INNER HULL
MINIMUM 800 MM BETWEEN TANK AND INNER HULL



NOTES:
INSULATION SYSTEM IN A PRE-FITTED STEEL BOX
MINIMUM 800 MM BETWEEN TANK AND BOX
GENERAL 800 MM BETWEEN TANK BOX AND INNER HULL,
LESS INN TOP REF SINGLE DECK

Fuel gas supply & BOG management example



- High pressure pumps supplying high pressure MAN ME-GI engine
- Cold heat recovery for tank cooling
- BOG compressors for supply to auxiliary engines and gas fired boiler when idle.

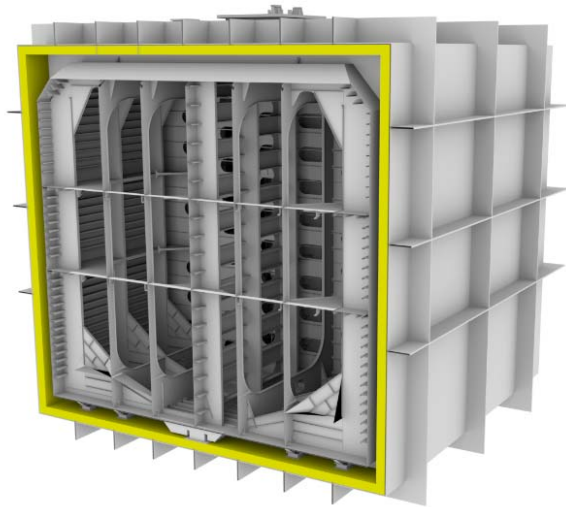
Summary



Summary

- LNT Fuel-BOX offers a simple and robust primary barrier that is built independently and in parallel with the hull.
- The system is flexible and offers high volume utilization. Sloshing is mitigated by internal structure, and the system is accessible for inspections and maintenance.
- Very low BOR gives long pressure build-up (holding time) and flexible BOG management and fuel gas supply system.

LNT Fuel-BOX™



Flexible

Efficient

Robust

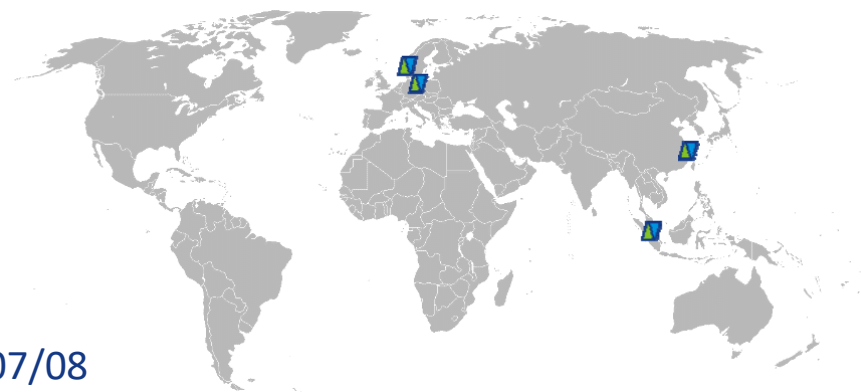
Accessible



THANK YOU

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