



Application of membrane tanks in Arctic conditions

Arctic Passion seminar 2020



Aker Arctic, Helsinki, March 2020

Safety

Excellence

Innovation

Teamwork

Transparency

1

Company overview

GTT at a glance

A French **technology and engineering** company with **more than 50 years of experience** in the design of the Membrane Cargo Containment Systems.

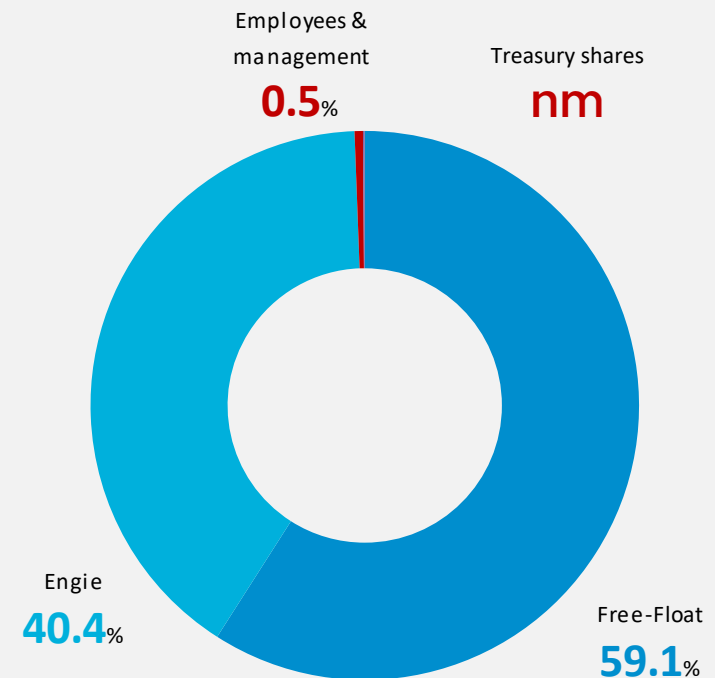
Expert in liquefied gas containment systems

GTT is a public company listed on the Euronext Stock Exchange (Paris)

456 highly qualified people⁽¹⁾, present worldwide



Shareholding structure as at December 31, 2019



Core Business as at December 31, 2019

A strong order book



FY 2019 movements

66 new orders

57 LNGC

6 VLEC

3 GBS

30 deliveries

27 LNGC

3 FSRU

Order book of 133 units

113 LNGC

6 VLEC

6 FSRU

2 FLNG

6 Onshore storage / GBS

Notes: LNGC – Liquefied Natural Gas Carrier, VLEC – Very Large Ethane Carrier,
FSRU – Floating Storage and Regasification Unit, FLNG – Floating Liquefied Natural Gas,
GBS – Gravity Based Structure



GTT - New Business (LNG as Fuel)



Order book of 19 units

- 14** ULCS (Ultra Large Container Ships)
- 1** Container vessel (converted to LNG)
- 1** Cruise ship
- 3** LNG bunker ships

FY 2019 movements

- 8** new orders
- 2** LNG Bunker ship
- 1** Container vessel
- 5** ULCS

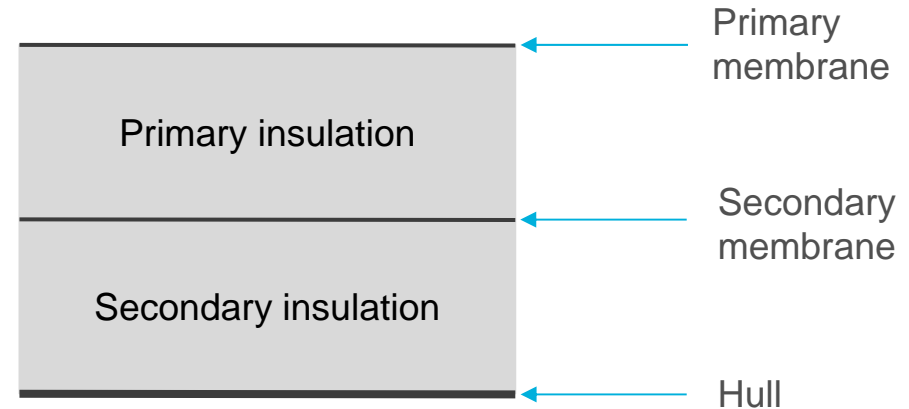
2

GTT Membrane Containment System

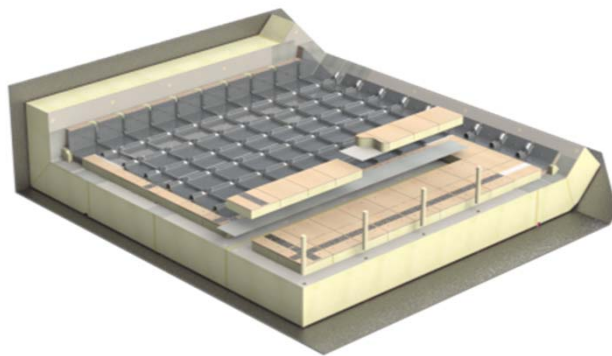
GTT membrane technologies

General principle:

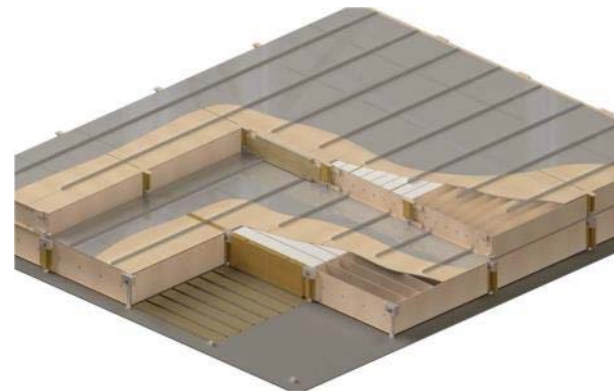
- Two membranes
- Two layers of insulations
- Containment system anchored to the inner hull



Mark III system



NO96 system



3

First electric hybrid cruise ice-breaker

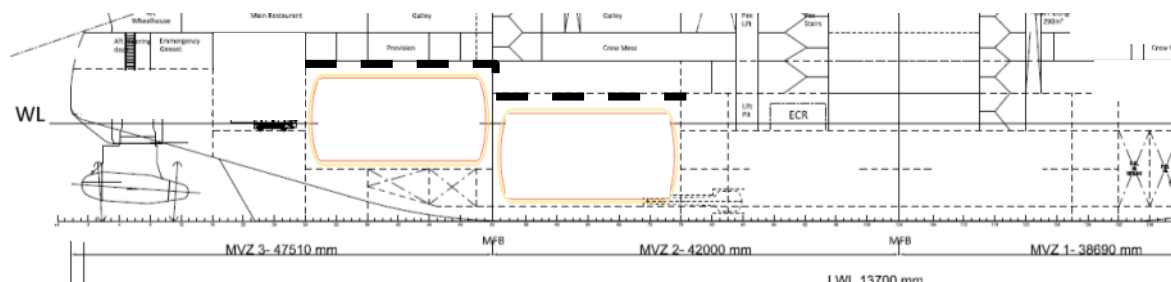
Cruise ice-breaker « Le commandant Charcot » for Ponant



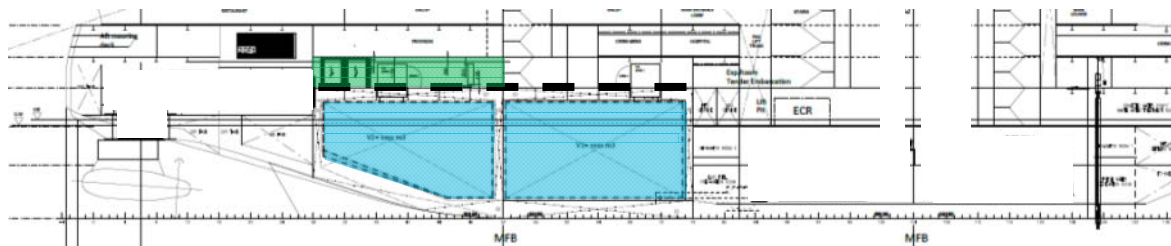
- Built by VARD
- 270 passengers & 180 crew
- Polar destination trip up to 4 weeks
- 30,000 GT, 150m long, 28m wide, 15 knots
- Class BV, PC2

Saving space for autonomy and cabins

2 type-C bilobe tanks 2,900 m³



2 membrane tanks 4,500 m³ 1 deck saved

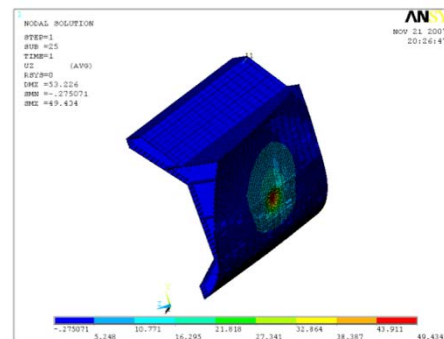


4

Validation of GTT technologies for use in Arctic conditions

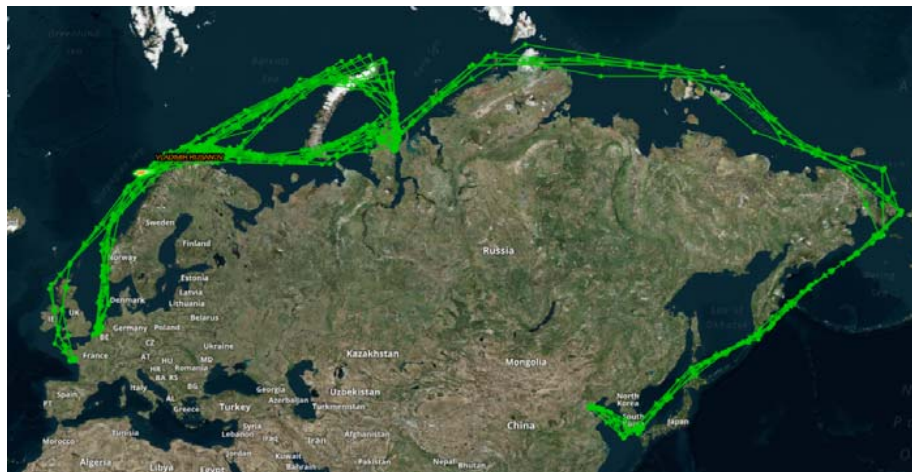
Ice navigation related studies

- GTT / Aker Arctic, 2007-2008
 - Design of a double acting membrane type LNG carrier for Arctic operation
- GTT / Krylov Shipbuilding Research Institute, 2007
 - Evaluation of deflections and strains in the inner side plating for side grillages of a membrane LNG carrier under emergency loads
- GTT / DSME / DNV, 2006-2008
 - Study & development of a 170 k LNGC Ice Class 1A
- GTT / SHI / ABS, 2006-2008
 - Study & development Project of a 208 k LNGC Ice Class 1A
- GTT / BV, 2008
 - Study of the winterization requirement for LNG carrier



Validation for ARC7 navigation conditions

- GTT's membrane systems (MARK III, MARK III Flex, NO96 GW & NO96 L03+) were validated to withstand the 40 years of navigation in arctic conditions.
 - ARC7/PC3 classification
- Cooperation program with:
 - 
 - 
 - 
 - 
- AiP:
- 15 LNG Carriers had been build for Yamal Project



Route of the « Vladimir Rusanov »
ARC7 LNGC

Studies performed to validate CCS for ARC7/PC3

- Sloshing
 - GTT methodology
 - Sloshing for arctic application

- Vibration
 - Methodology
 - Experimental tests

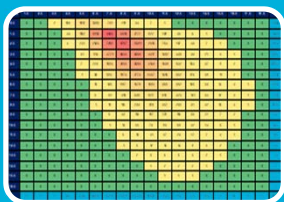
- Collision
 - Return of Experience
 - Collision test

5

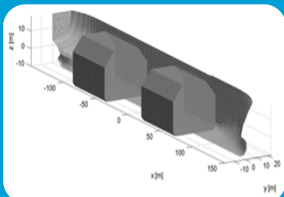
Sloshing

Sloshing key factors

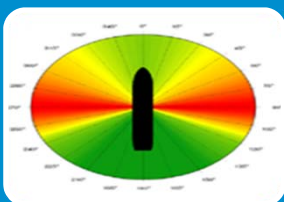
- Sloshing loads depends on



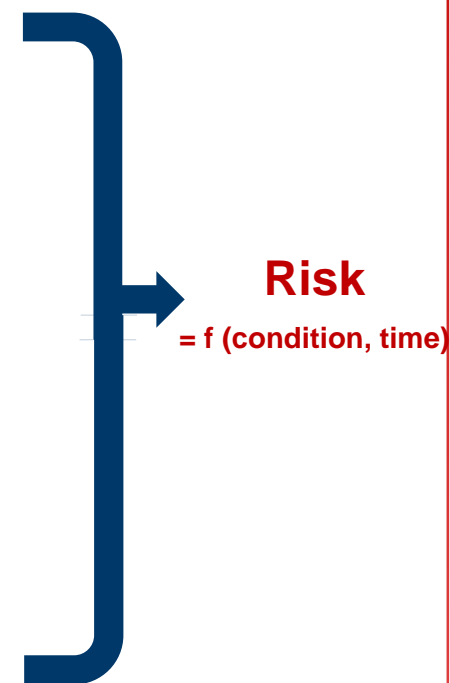
Environmental conditions



Ship design



Ship profile

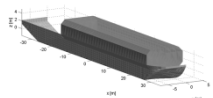


- Sloshing risk depends on
 - The time spent under each condition (ship profile & sea state)

Methodology Overview – Model tests



Metocean data



Sea Keeping



Model tests

Up to 300 sensors per tank



Test Rigs

- 6 d.o.f motions are driven by 6 high precision actuators
- Controlled by 6 independent measurement system

Instrumentation

- Up to 300 sensors per tank to catch the Sloshing impacts

Scale

- 1/10 to 1/80 can be tested

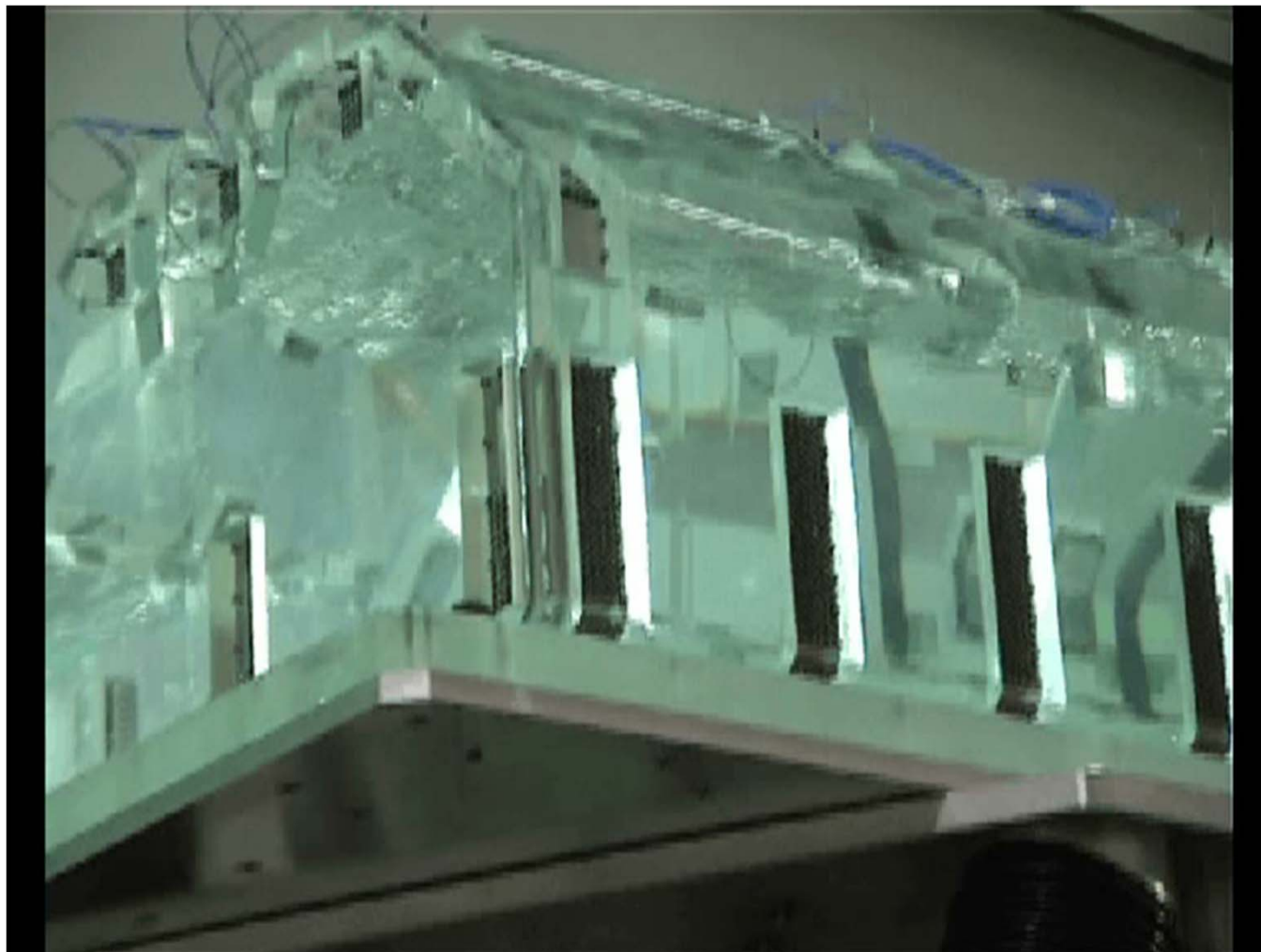
Density Ratio

- Same Density ratio at full and model scale

$$\left(\frac{\text{Natural gas}}{\text{LNG}} \right)_{\text{cold}} = \left(\frac{\text{SF}_6 + \text{N}_2}{\text{Water}} \right)_{\text{ambient}}$$



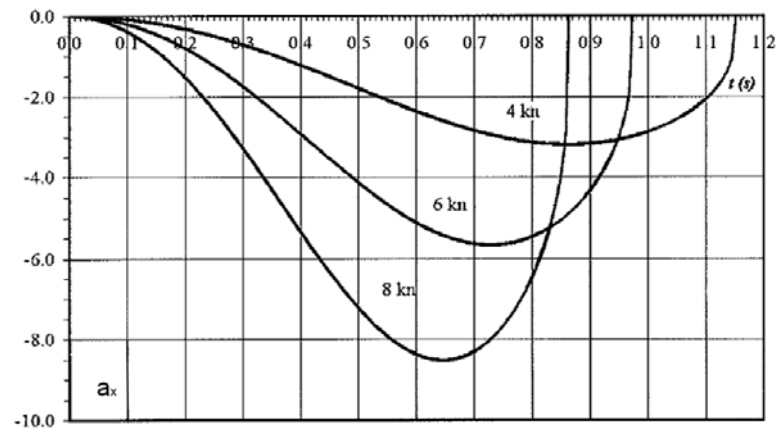
Methodology Overview – Model tests



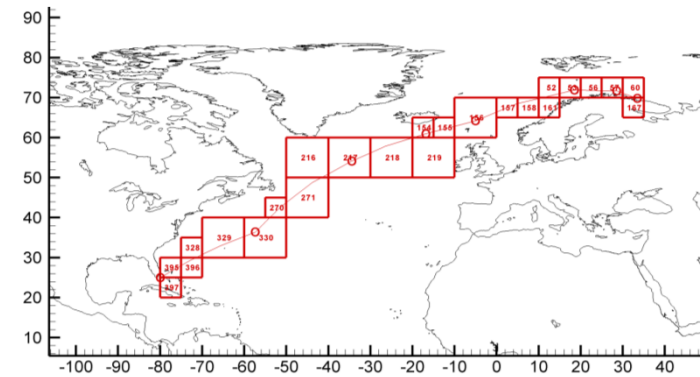
Sloshing for Arctic

- Ship features impacting sloshing
 - No bilge keels preventing from rolling
 - Arctic bow (no bulbous bow)

- Fast deceleration
 - Impact with thicker ice

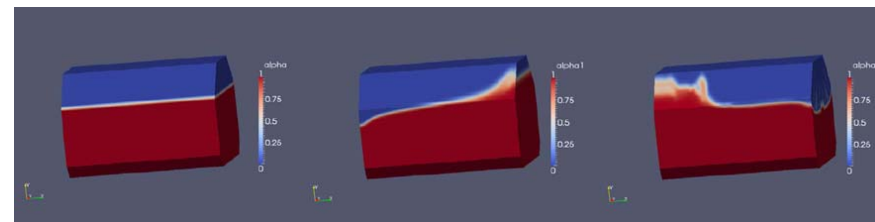


Tested acceleration profile



Ship's operational profile

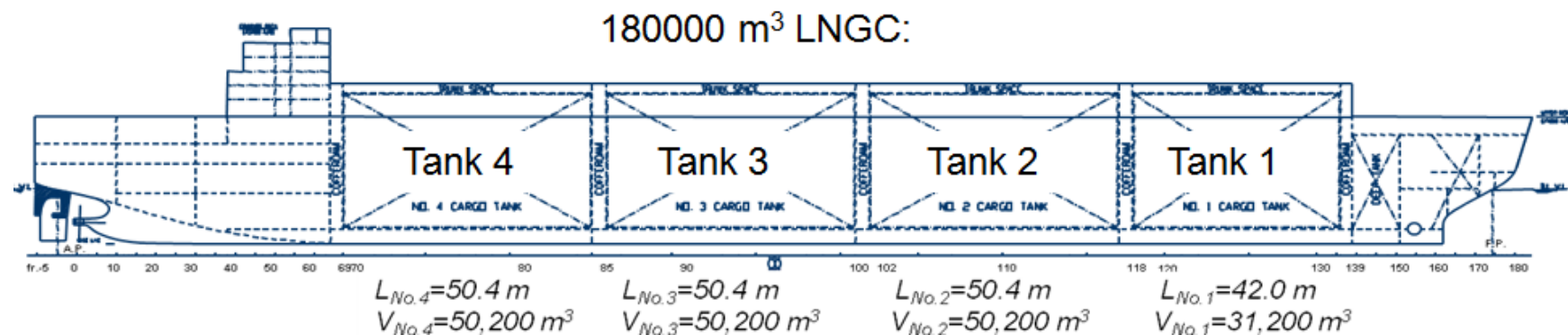
Sea route from Barents Sea to Gulf of Mexico through North Atlantic and Europe



6

Vibration

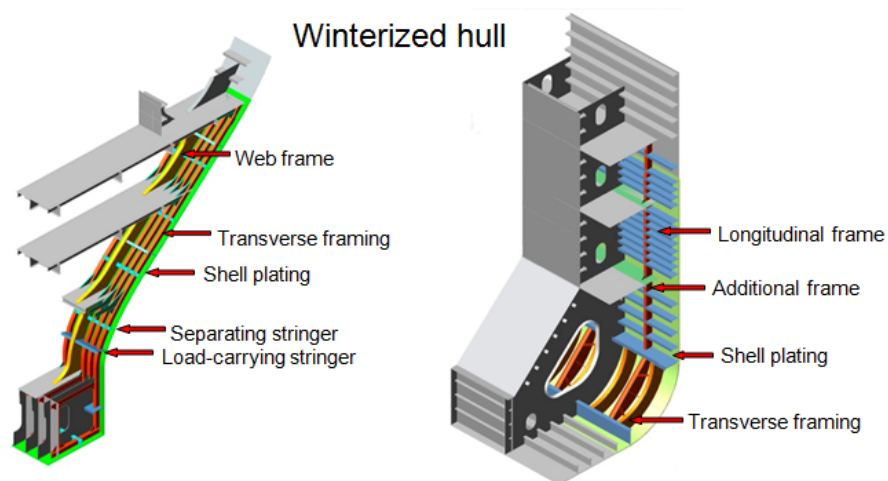
Ship and operationnal profile



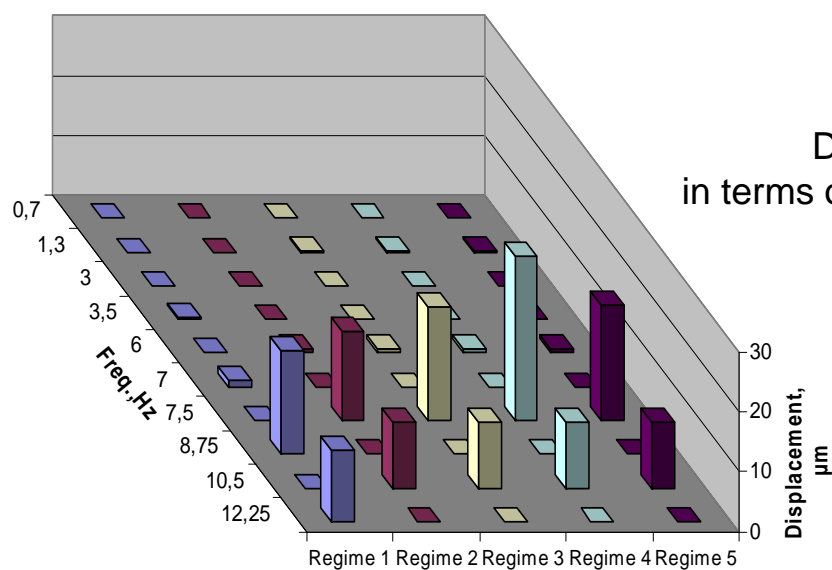
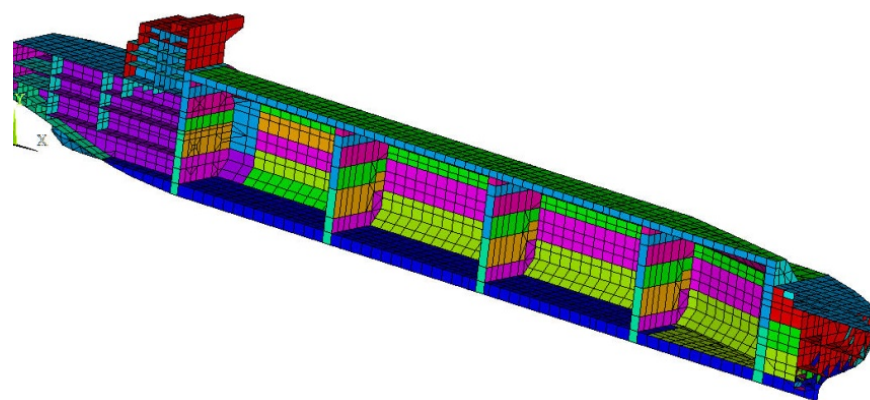
	Regime	Ice operation type	Ice thickness (m)	Operational speed (knots)	% duration (*)
ARC7	1	Independent	0.2	15.5	34,08%
	2	Independent	0.6	10.5	42,60%
	3	Independent	1.0	5.5	8,52%
	4	After one icebreaker	1.5	5.0	14,77%
	5	Impact against thick ice	5.0	8.2	0,03%

(*) of the time spent in ice conditions

Hull and vibration spectrum

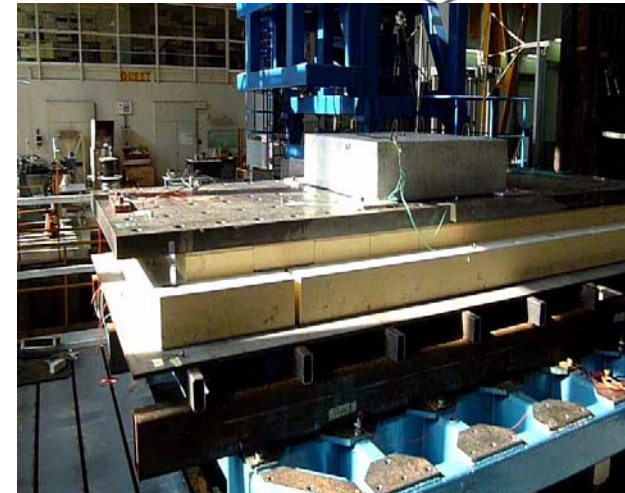
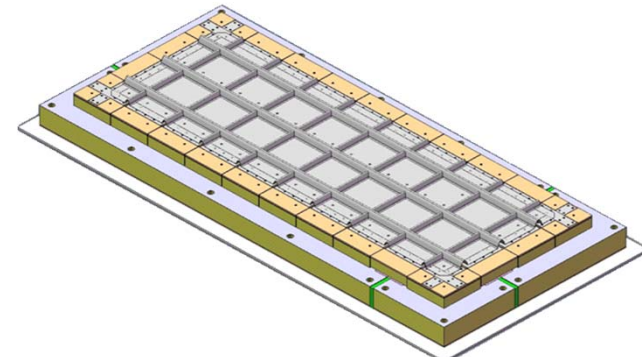
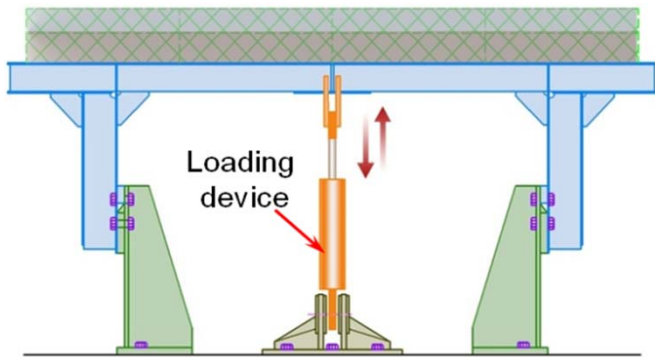


Global Fine Elements Analyses



Model testing

Displacement tests



Acceleration tests

Membrane CCS are suitable to sustain vibration loads due to Arctic environment.

7

Collision

Collision



« Maemi » Typhoon on
Korean shipyards



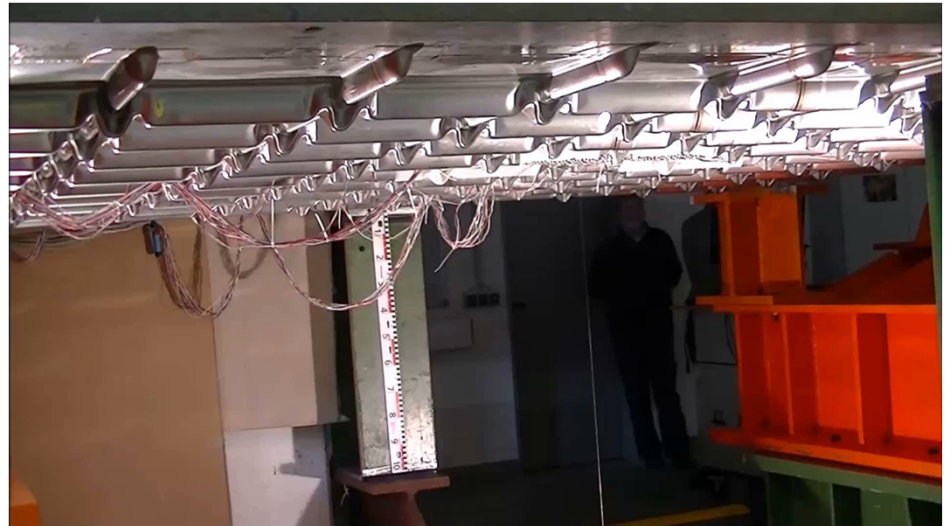
Grounding of « El Paso Paul Kayser » near
Gibraltar



Over pressurizing of
membrane during tests

Experiences on
accidental loads
on GTT's CCS

Collision – Large scale testing

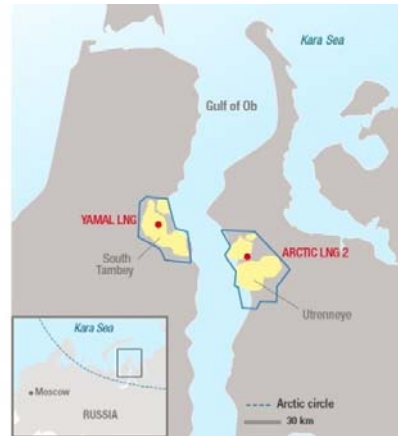
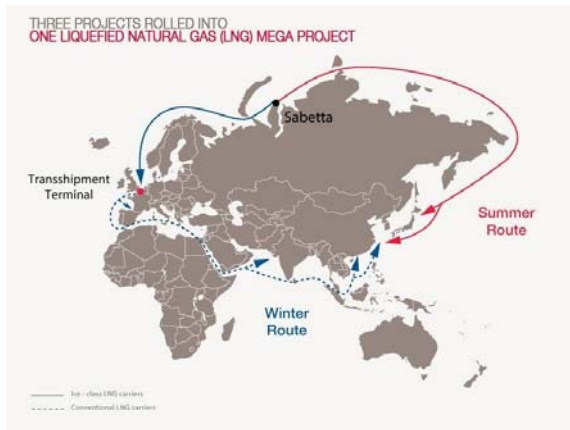


GTT's membranes can absorb very high level of deflection before rupture compared to the inner hull steel.

8

Other example of GTT system
application in Arctic conditions

ARCTIC LNG 2 Project: GBS innovative concept



Salmanokskoe (Ultreenee) OGCF LNG Plant (Gydan Peninsula)

3 stages 5.5 mtpa each
Implementation:

- 1st stage: 2022
- 2nd stage: 2024
- 3rd stage: 2025

3 GBS (Gravity Based Structure)

Concrete caissons

Built in a dry dock Novatek

Murmansk LNG construction center

Footprint: 324 m x 125 m x 30 m

2 LNG tanks volume : 219 000 m³

GTT GST® technology

9

Conclusions

Conclusions

- GTT containment systems (MARK III, MARK III Flex, NO96 GW & NO96 L03+) are suitable for Arctic navigation in Arc7/PC3 conditions
- Proved on 15 Yamal LNGC
- Cruise ice-breaker for Ponant and GBS for Arctic LNG-2 Project are under way
- GTT continue to work on the further validation of containment systems for LNGC in extended ice-going conditions and LNG fueled ice-breakers for Arctic LNG-2 Project.





Thank you for your attention

Renato BOLOGNESE – rbolognese@gtt.fr



Image courtesy of STX, Engie, Excelebrate, SCF Group, Shell, CMA CGM, Matthieu Pesquet, Conrad