IGRC Seoul 2011
International Gas Union Research Conference

Future perspectives in LNG transportation

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GDF SUEZ

GTT

History of the LNG industry

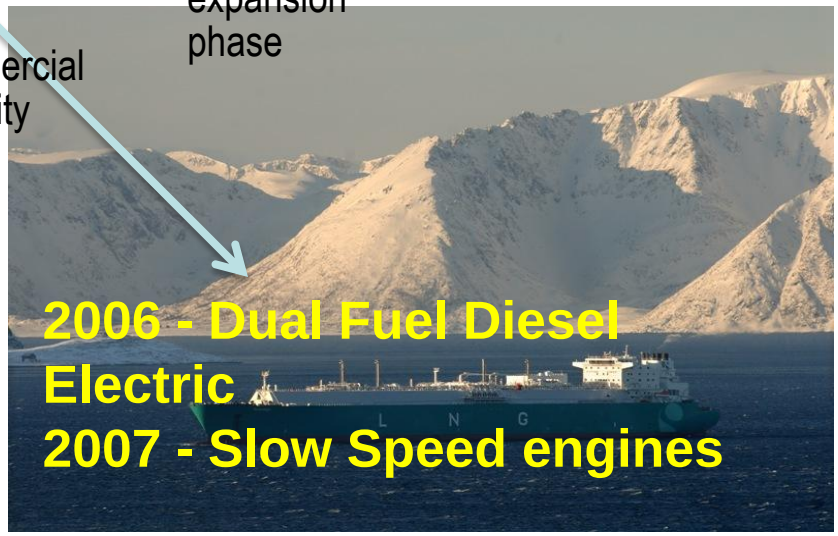
1964 - Steam Turbine

1955 – 1965
Pioneer age

1965 – 1975
Industrial and commercial development

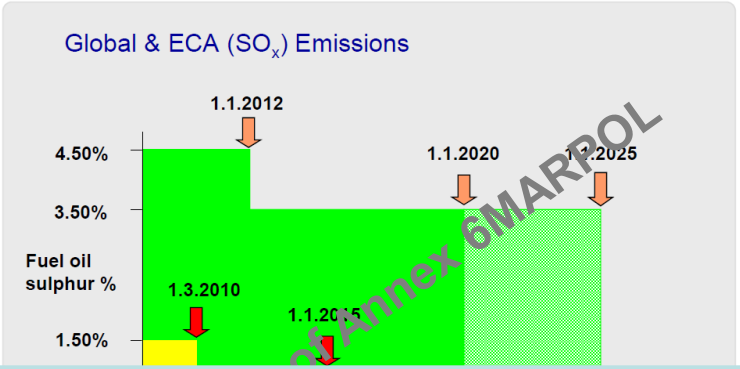
1975 – 1995
Industrial and commercial maturity

1995 – present
New expansion phase

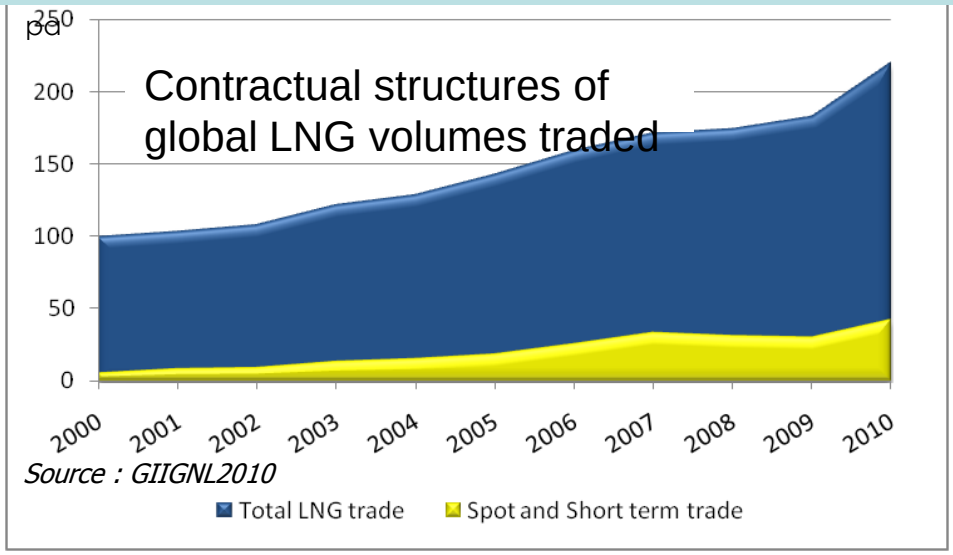


2006 - Dual Fuel Diesel Electric
2007 - Slow Speed engines

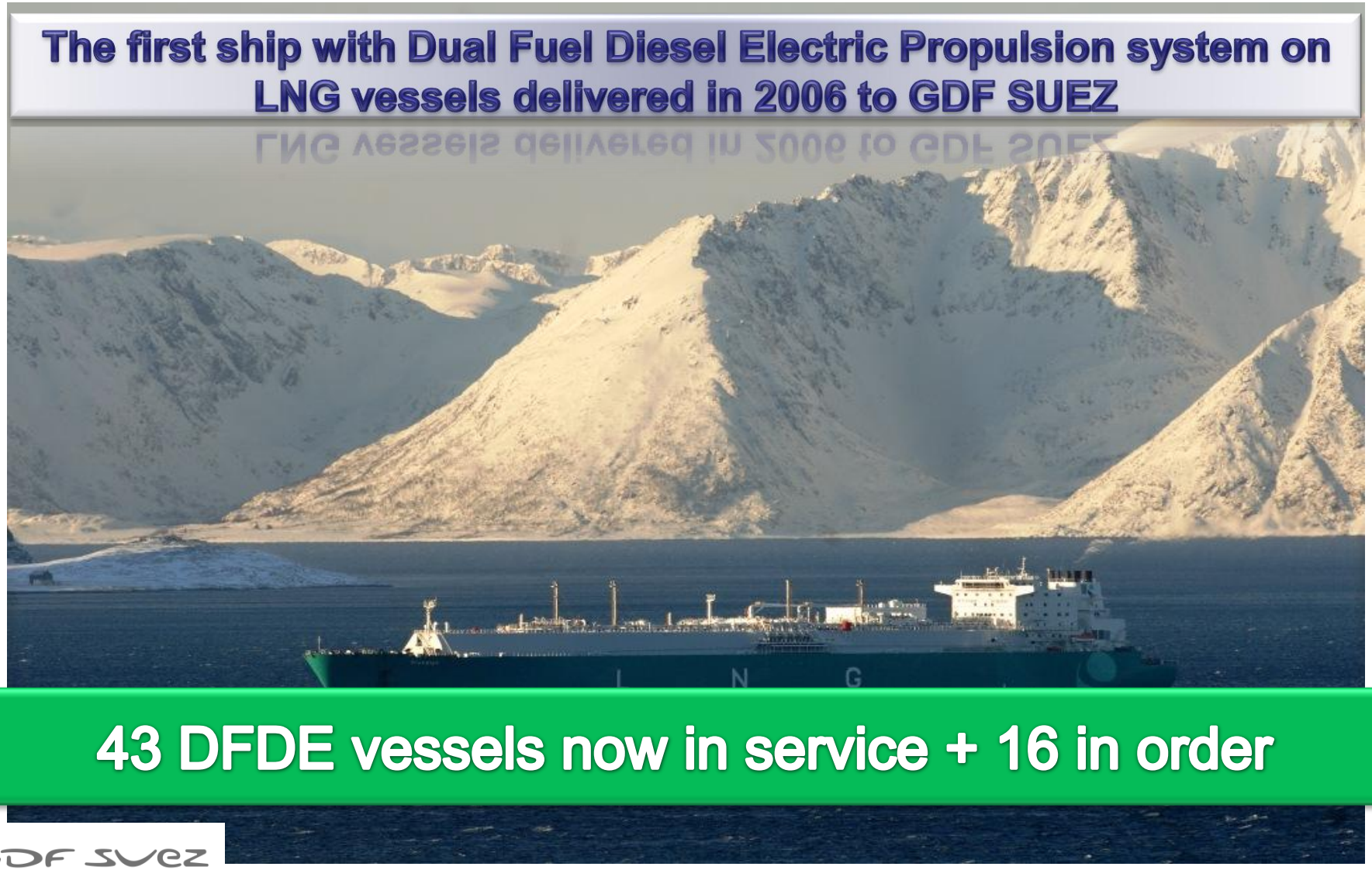
Environment -- Market



Innovation in LNG shipping technologies to fulfill with commercial and rules requirements

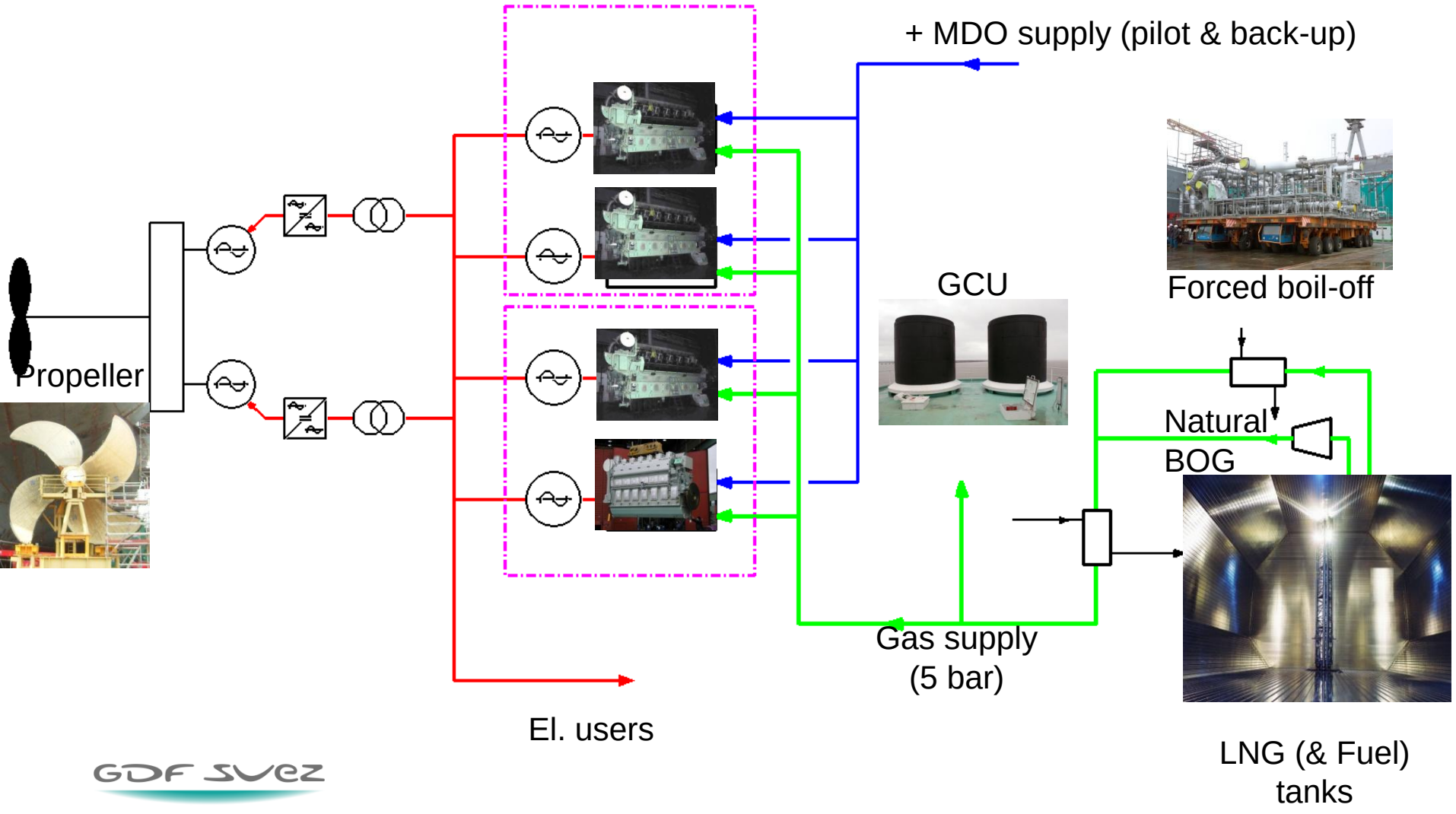


Dual Fuel Diesel Electric propulsion system



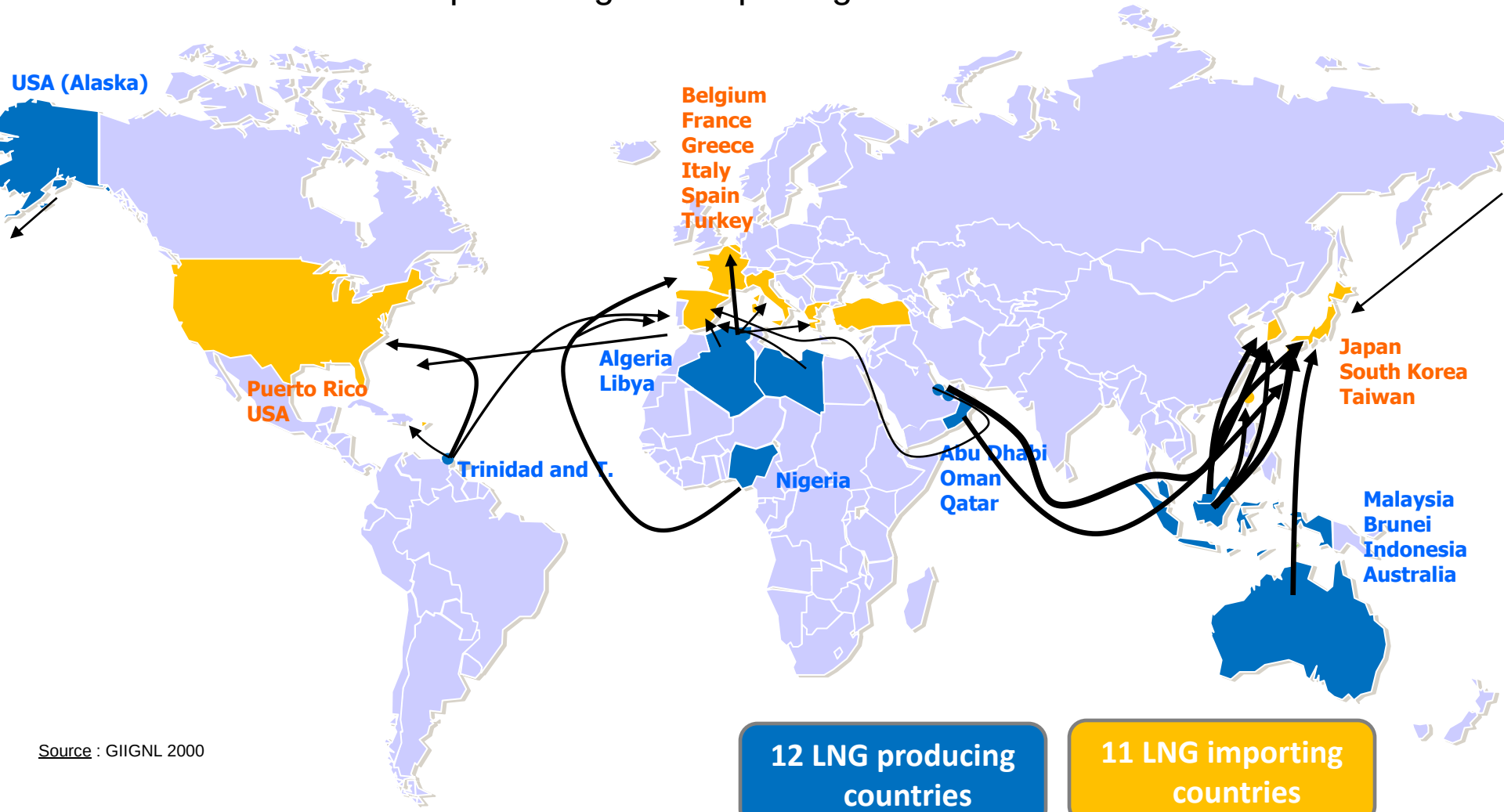
43 DFDE vessels now in service + 16 in order

The DFDE Propulsion System



What happened in 2000?

LNG producing and importing countries - Main flows in 2000

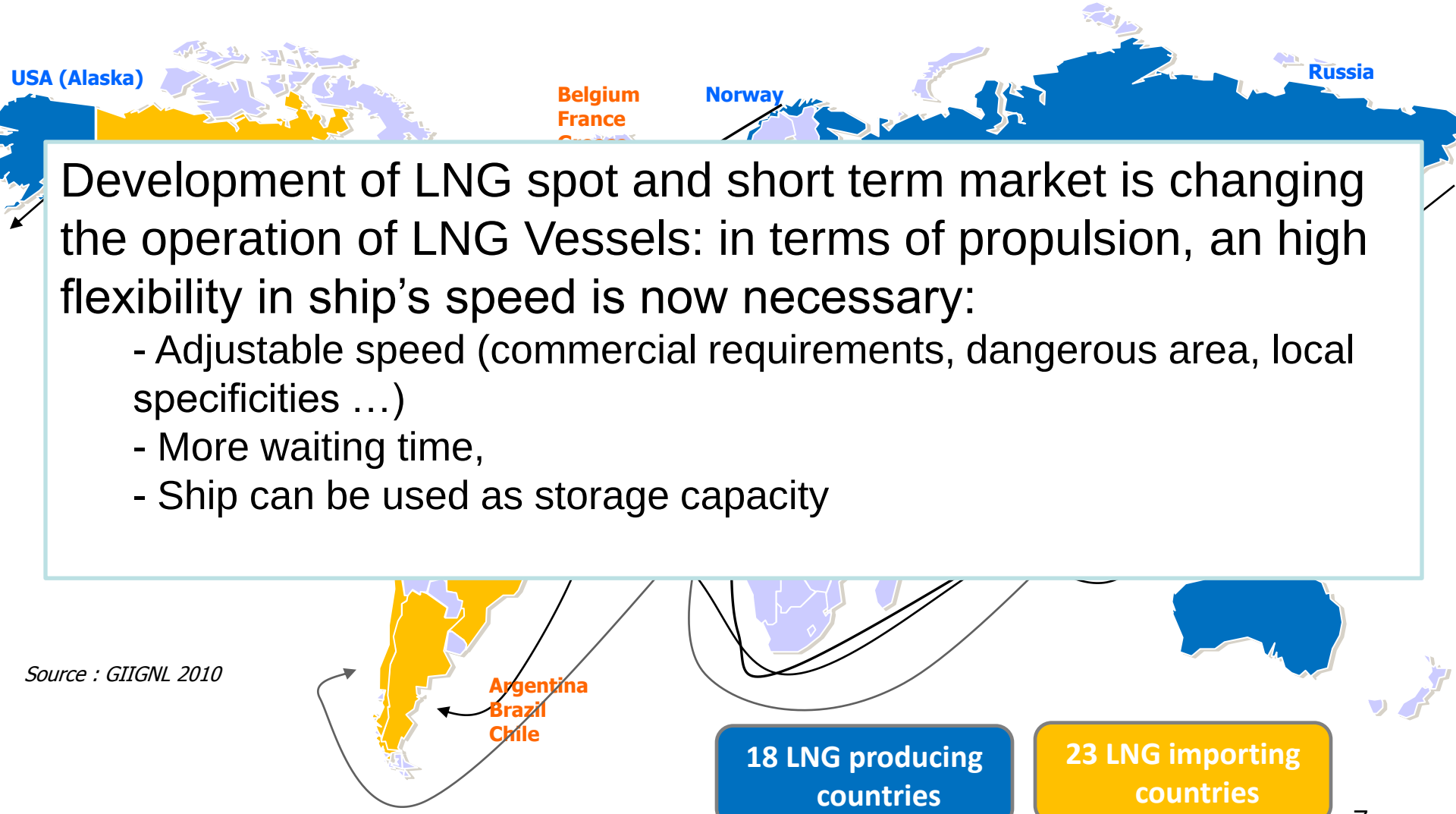


Source : GIIGNL 2000

12 LNG producing countries

11 LNG importing countries

All is going faster and faster…
Main flows in 2010



Development of LNG spot and short term market is changing the operation of LNG Vessels: in terms of propulsion, an high flexibility in ship's speed is now necessary:

- Adjustable speed (commercial requirements, dangerous area, local specificities …)
- More waiting time,
- Ship can be used as storage capacity

Source : GIIGNL 2010

18 LNG producing countries

23 LNG importing countries

Now and tomorrow?

- The DFDE for LNG ships was designed to accommodate the new market requirements and the new rules
- The near future will be a lot of “small” improvements on this technology and its surrounding:

Use of gas as main fuel and HFO or MDO as backup

To continue technological improvement of NOx removal systems

Reducing the maintenance costs by developing the Condition Based Maintenance

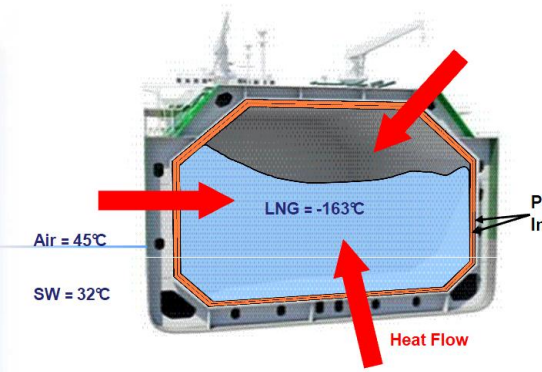
Improving the gas operating window of engines operation (gas quality control, …)

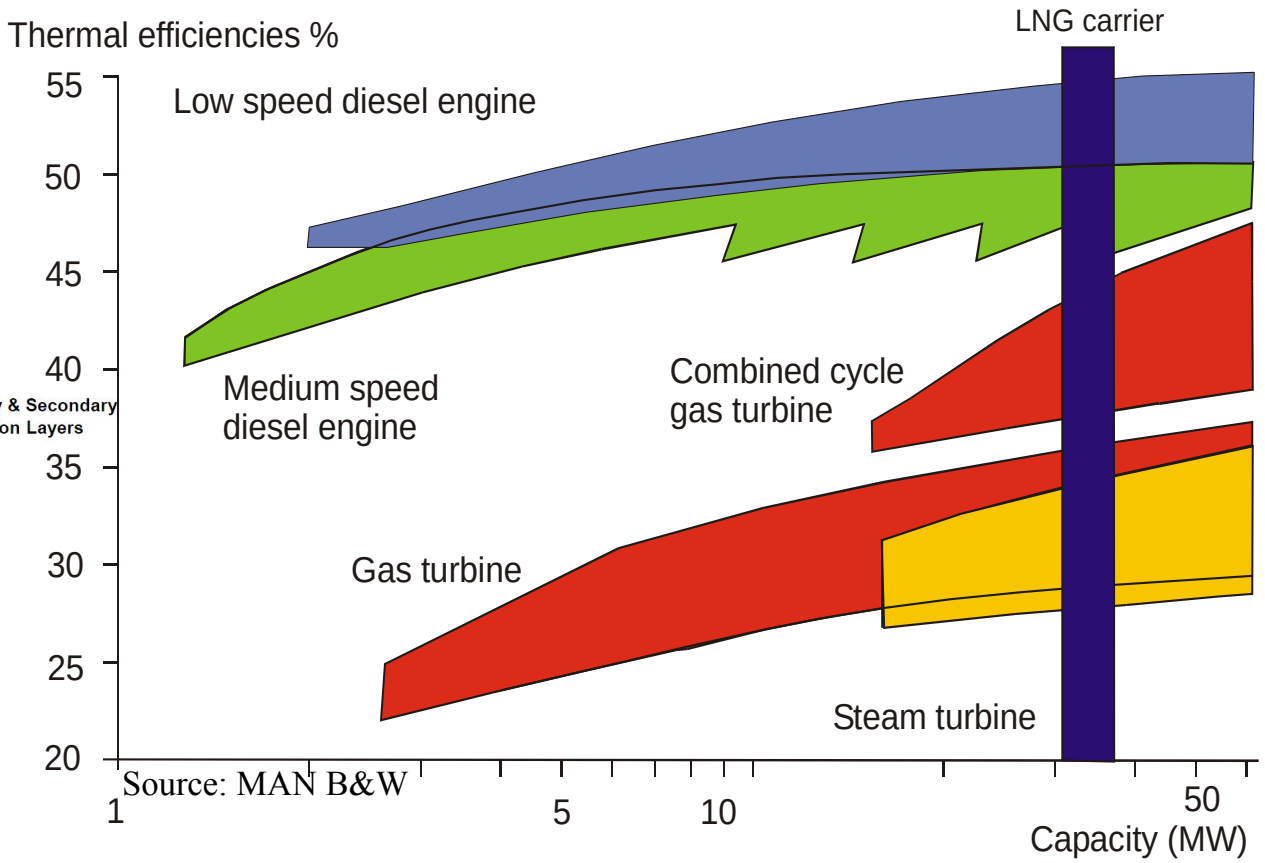
To get more flexibility by operating the fuel gas (BOR) “a la demande” (speed adjustment)

Small reliquefaction plant

Reducing the Boil Off Rate

Market Requirement: lower Boil-Off Rate (BOR)





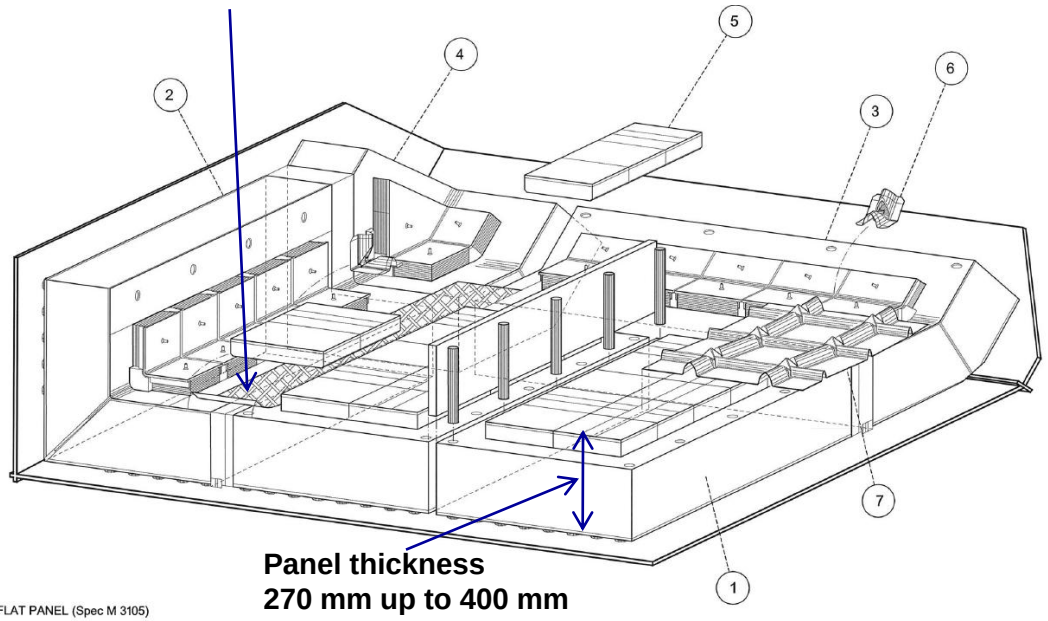
Target selected: 0.1% BOR for a 170 000 m3

For small capacities, lower BOR more difficult to achieve due to a higher ratio Tank surface / Tank volume

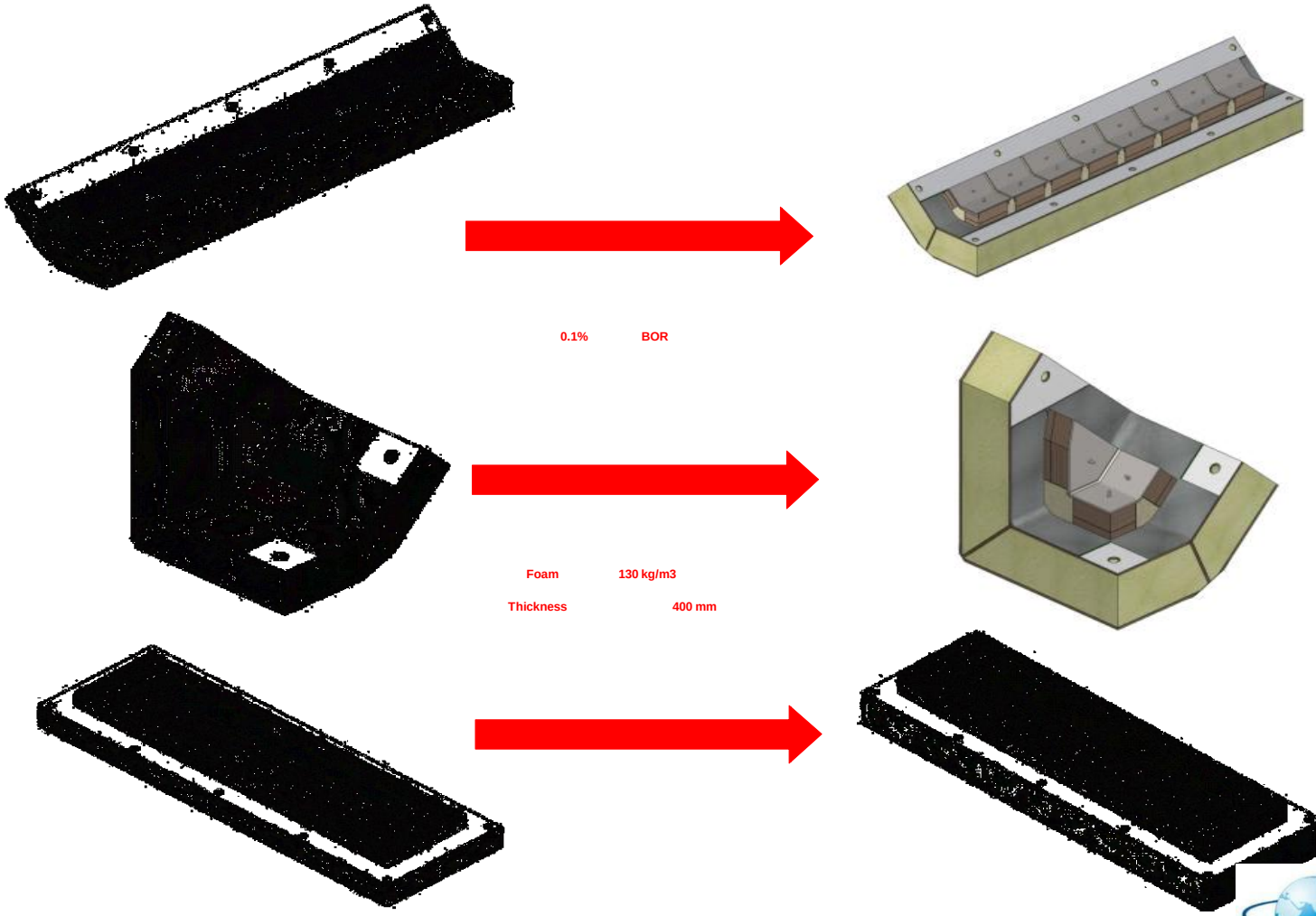
Mark III Flex :Developments

BOR Performance: increase of insulation thickness to provide lower BOR in case of standard density foam use in order to reach an objective of **0.1% BOR**

All « PU » adhesive for bonding of 2dary barrier

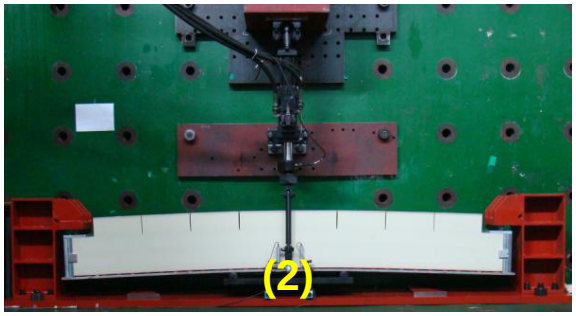


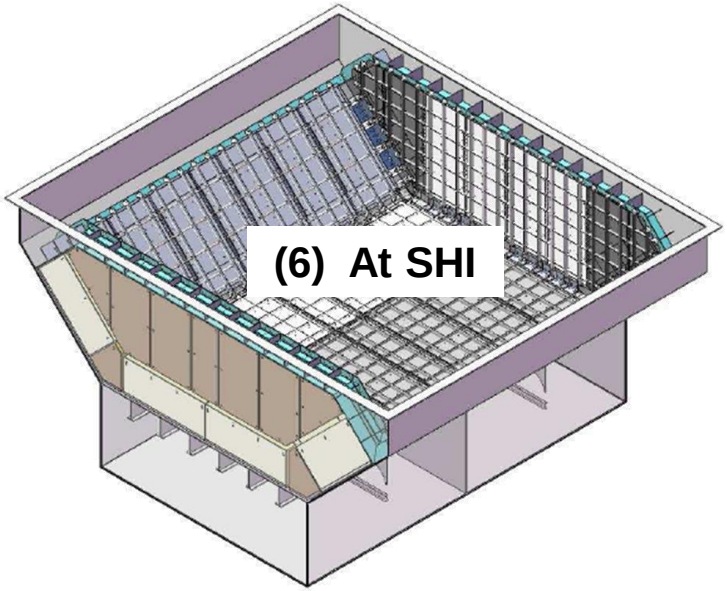
Mark III Flex :Developments

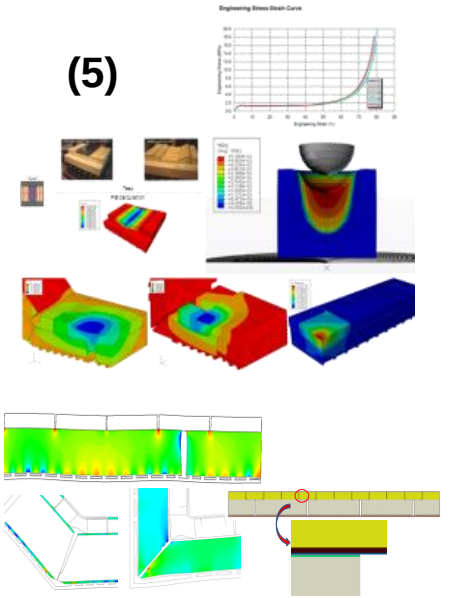


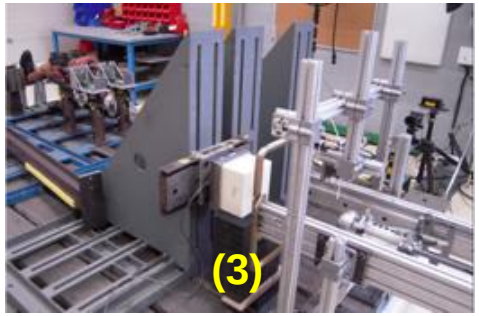
Mark III Flex : Qualification program

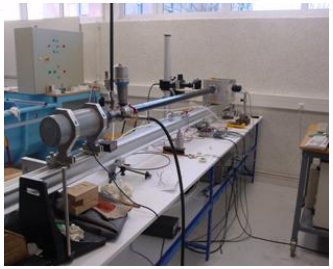
An extensive qualification program has been completed and includes Static and fatigue tests (1), bending tests (2), impact tests (3), material tests (4), finite element analyses (5) and mock-up tests (6)











Mark III Flex : summary results

All the studies completed so far have provided satisfactory results

Fatigue tests demonstrated the ability of the CCS Mark III Flex to withstand full thermal cycles, ship bending cycles and repetitive sloshing events

The panel / hull anchoring was remaining fully satisfactory when submitted to bending test and mock-up ballast tests

DET NORSKE VERITAS

APPROVAL IN PRINCIPLE

This is to verify that the design principles of the

Mark III FLEX membrane type containment system for LNG

have upon request by:

Gaztransport & Technigaz S.A.s

been assessed by Det Norske Veritas AS and found to comply with current Rules of this Society, as specified below.

Basis for Approval
The documentation specified in letter NACNO385/TOOE/P13803-J-49, dated 2011-06-24, has been assessed with respect to
- DNV Rules for Ships Pt.5 Ch.5, January 2011
- IMO IGC Code

Conditions and Assumptions for Approval
- The conditions for the Approval in Principle and General Approval for Ship Application are given in letter NACNO385/TOOE/P13803-J-49, dated 2011-06-24.
- Before construction and installation onboard any particular ship or object subject to classification, a complete set of documentation relevant for the particular ship is to be approved by the Society according to normal classification procedures.

DET NORSKE VERITAS AS
Oslo, 24th June 2011

Head of Section
Cargo Handling and Piping Systems

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Approval In Principle (AIP) received from DNV (24th June 2011) and ABS (26th August 2011)

GTT is working on the next stage of Approval and started to proceed approval phases with the other major Classification Societies.

ABS

Ref.: TASK# 788432 - AIP
Date: 26 August 2011

Certificate of Approval in Principle

As requested by:

Gaztransport & Technigaz, France

ABS has reviewed documentation as specified in ABS letter ref: 788432 dated 26th August 2011 for:

GTT Mark III Flex Concept

and found the technical information provided therein to be compliant with respect to the intent of the following:

1- ABS Rules for Building and Classing Steel Vessels, Jan. 2011
2- ABS Guide for Building and Classing Membrane Tank LNG Vessels, Oct. 2002 (Updated Oct. 2008)
3- ABS Guidance Notes on Strength Assessment of Membrane-Type LNG Containment System under Sloshing Loads, Apr. 2006 (Updated Jul. 2009)
4- International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

subject to compliance with the comments in the above letter and the Rules. All drawings, calculations, test reports, and certificates for components are to be found acceptable to ABS.

ABS EUROPE
R. M. Bell,
Manager, London Ship engineering

ABS CORPORATE, Technology
Yung S. Shin,
Head of Cargo Containment Systems Group

Some LNG Carriers are already ordered with MarkIII Flex technology for 0.1% BOR application

NO96 improvement: decrease of BOR

- Present design with available approved insulation materials
  - Glass wool instead of perlite
  - Low density PU foam instead of perlite
  - PVC foam (35 Kg/m^3) instead of perlite
- New low BOR secondary box

Change of insulation material is under progress

New secondary box under development
AIP expected for the end of 2011

Optimization of BOR

BOR as an global optimization

The more reinforcement, the more BOR

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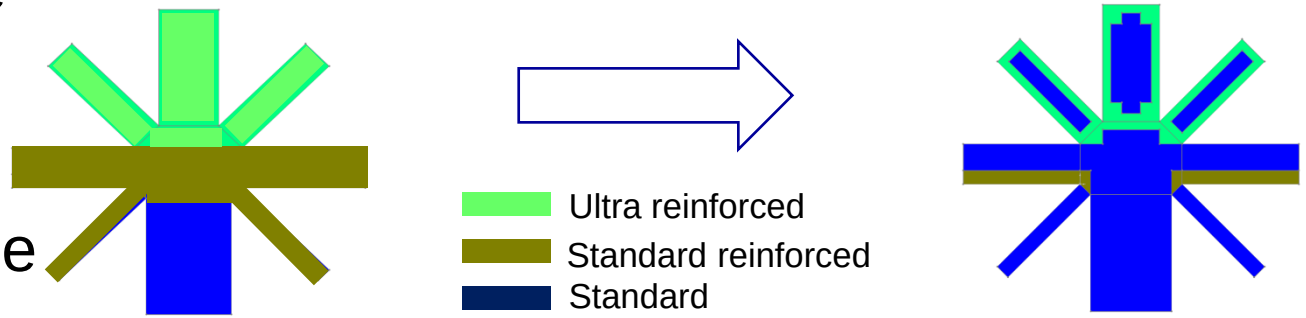
Reinforcement to be applied only in sloshing area to reduce the reinforced area



Reducing operational BOR by taking into account the environment of the CCS

- Paint on trunk deck, in the trunk space
- Reducing hydrodynamic BOR

Conclusion

- Consolidation of new propulsion technologies seems to be the rule in the 10 coming years with adaptations to fulfill new market requirements and new rules
  - **Gas becomes the main fuel**
  - **Optimization of the gas engines operation**
  - **Small reliquefaction plant on existing ships**
  - **Tanks with reduced BOR on new ships**

- GTT is adapting the two technologies to the new 0.1% BOR target
  - **New Mark III Flex system already approved by classification societies and ordered**
  - **New NO96 design under discussion with shipyards**
  - **Consideration to be given to the surrounding of the Cargo Containment System**