Ship Transportation of Natural Gas

Market and Technology.

Presented by

Jan Koren,

Business Director – Tankers

26th May, 2005

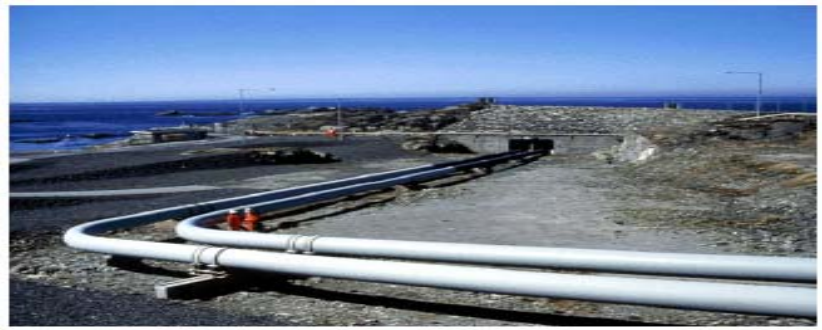
The Scene is changing – what is happening?

- Dramatic increase in number of LNG carriers
- Significant increase of ship size and size of cargo tanks
- New yards (building and docking yards)
- New owners and ship managers
- New officers/crews and superintendents
- New terminals and terminal operators
- New trades – including heavy weather (wind, waves, darkness, cold climate, etc)
- Spot trade – partly filled tanks. Sloshing?
- Longevity: 40 years life expectancy?
- Heavier competition – lower profit margins
- Compressed Natural Gas (CNG) arriving as a supplement to LNG

Consequences for safety?

Transportation of Natural Gas

- Pipeline



- By ship as liquefied natural gas (LNG)

- By ship as compressed natural gas (CNG)

What is LNG/CNG ?

Liquefied Natural Gas

- cryogenic liquid
- -160ºC
- 0.25 bar
- 0.42 t/m3
- gas/liquid: 600/1

Compressed Natural Gas

- pressurized gas
- 45ºC to -30ºC
- 100-275 bar
- 0.2-0.25 t/m3
- gas/liquid: ~ 300/1

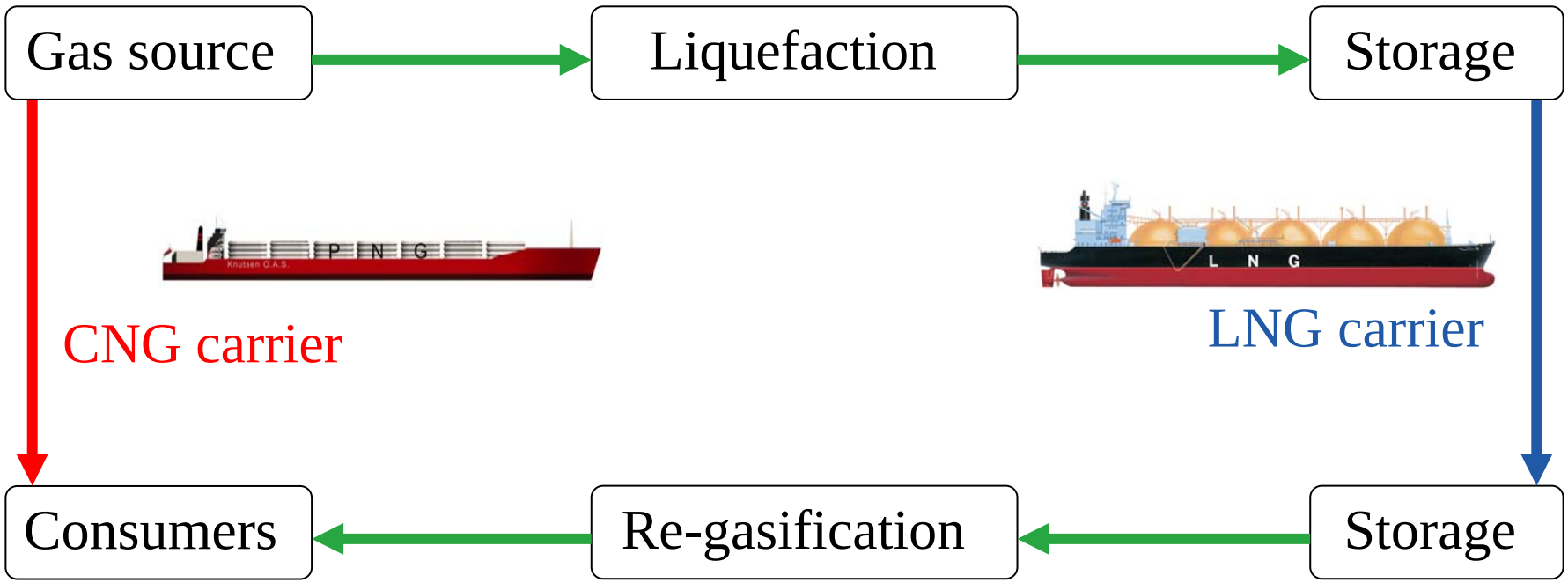
Energy loss by gas transformation and transportation

Current status (typical figures)

- Pipelines : 3-5 % loss
- CNG ships : 5-8 % loss
- LNG ships : 15 % loss
- GTL : 30-40 % loss

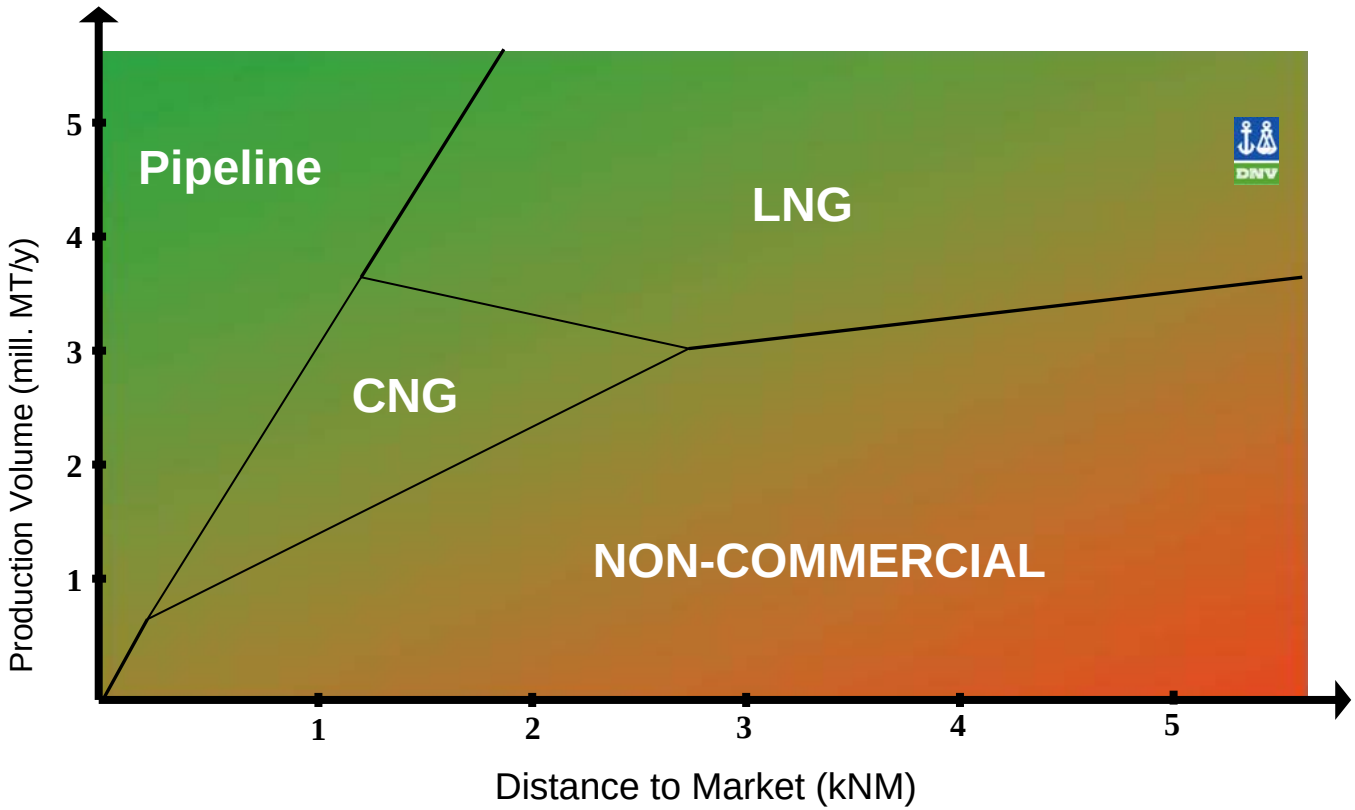
Future technological developments may change the picture

LNG / CNG business chains



- CNG = **C**ompressed **N**atural **G**as

Marine transportation alternatives



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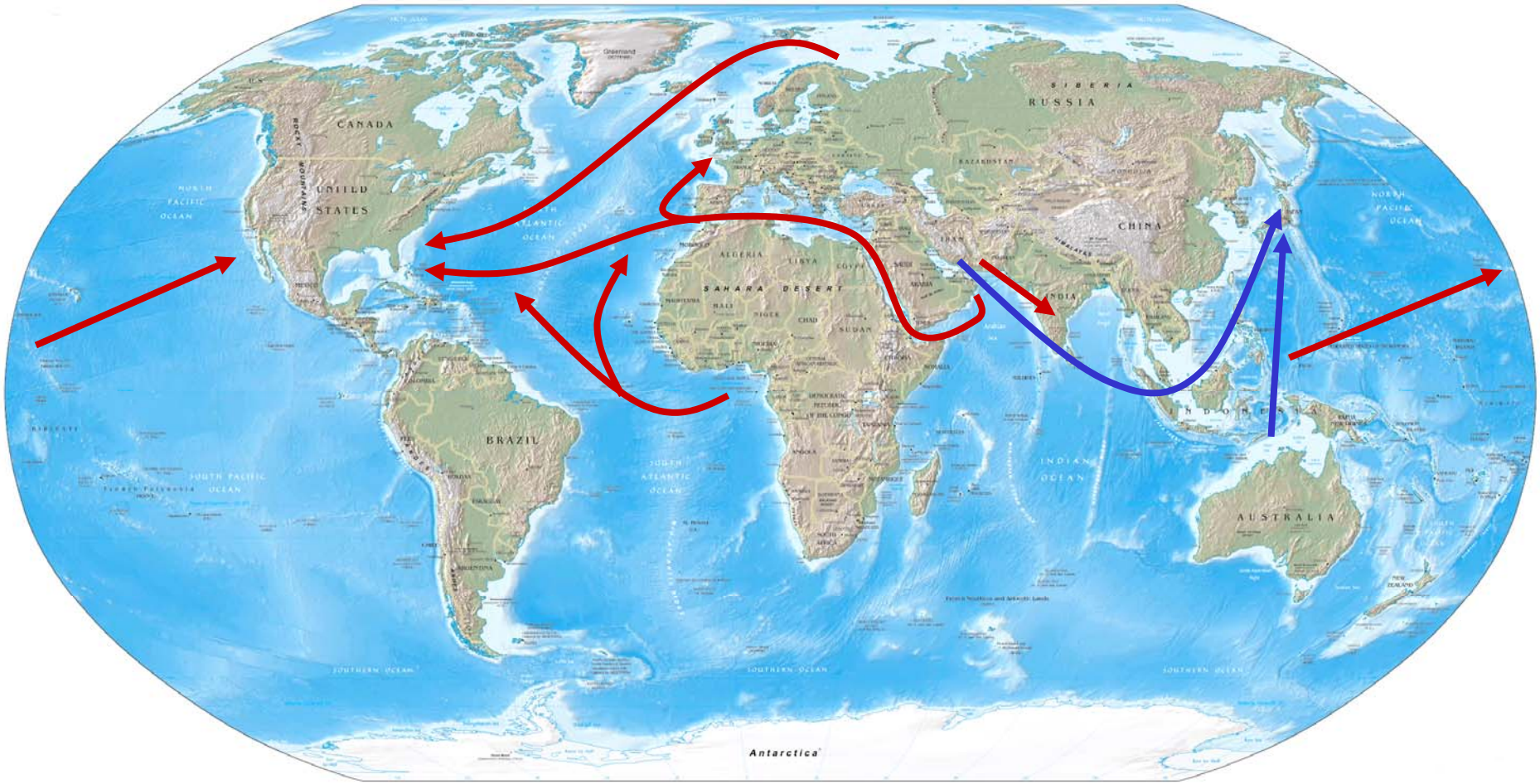
Present and future LNG Trades

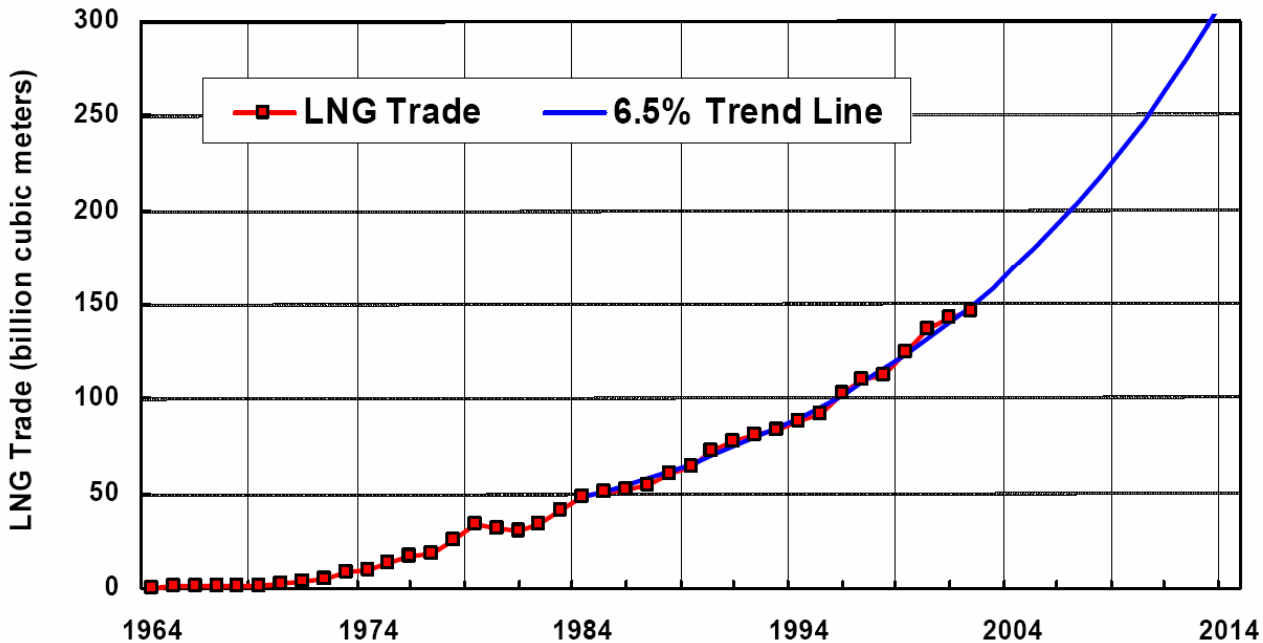


Well established main LNG trades

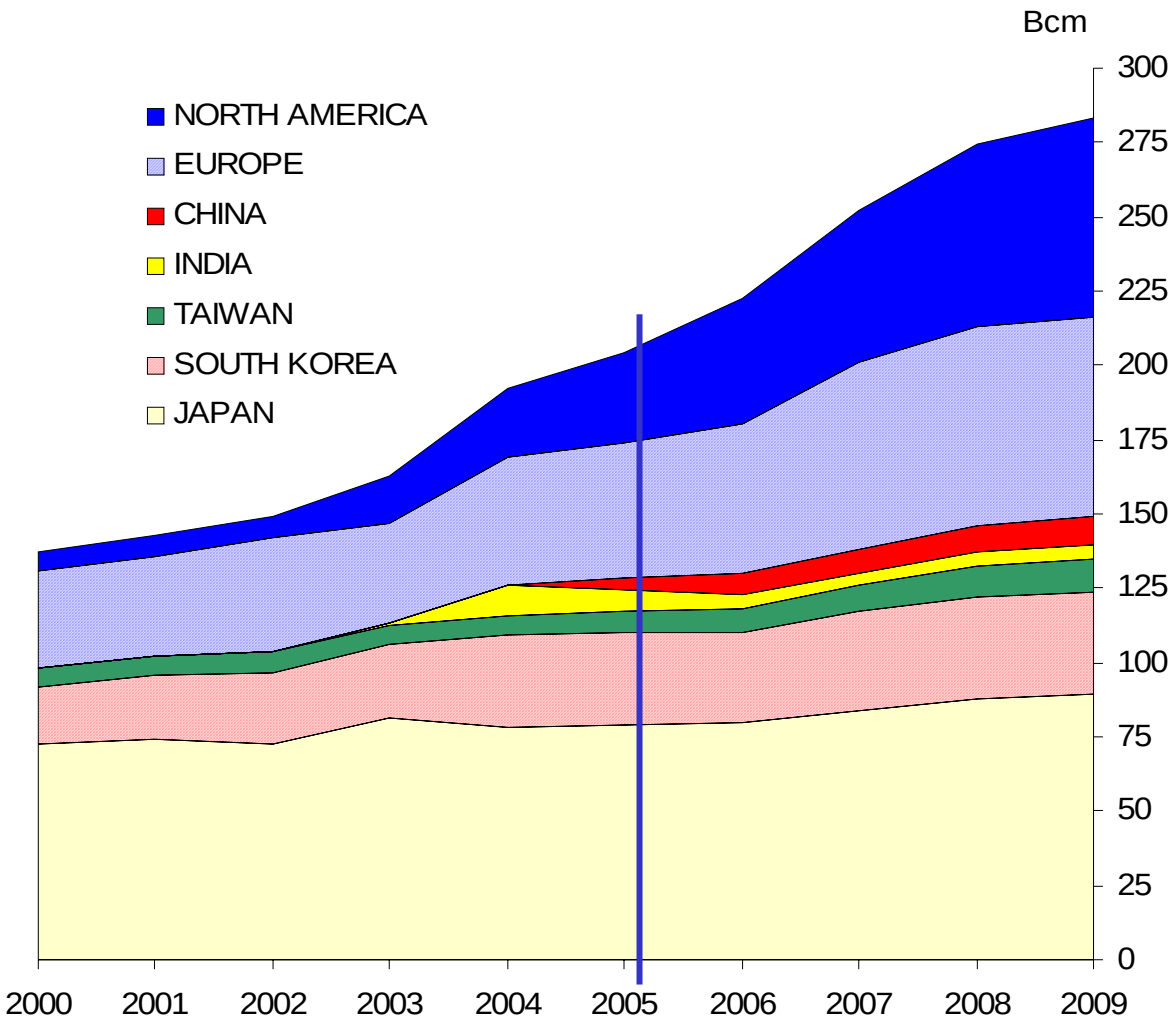
New main LNG trades

MANAGING RISK DNV

Growth in LNG Shipping



DEMAND OUTLOOK FOR LNG TRADE 2003 – 2009



R.S. Platou
Economic Research a.s

Average yearly growth in traded volume:

1990's	**6.6%**
1998-2003E	**8.2%**
2003-2009	**9.2%**

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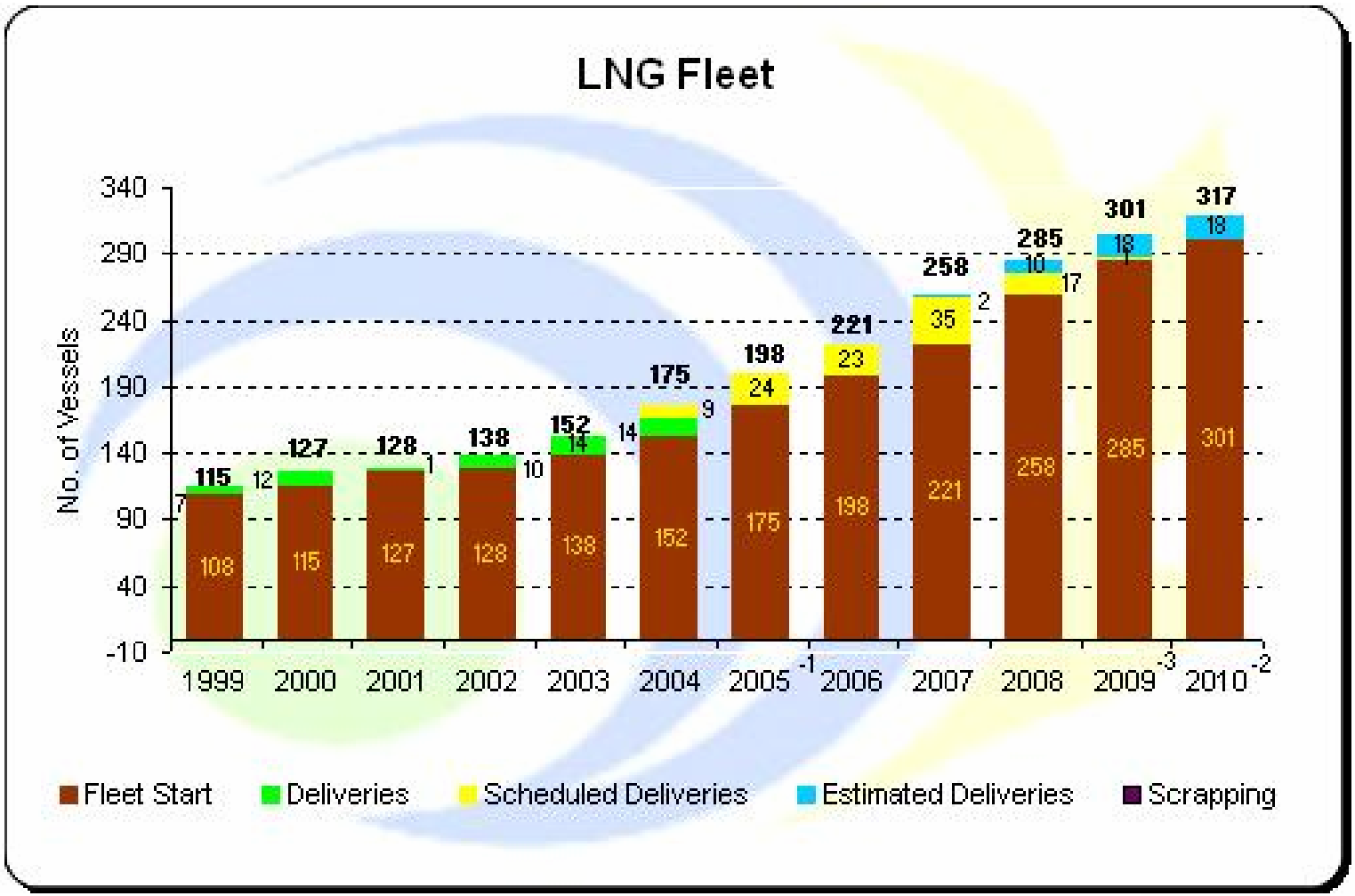
Development of LNG Fleet



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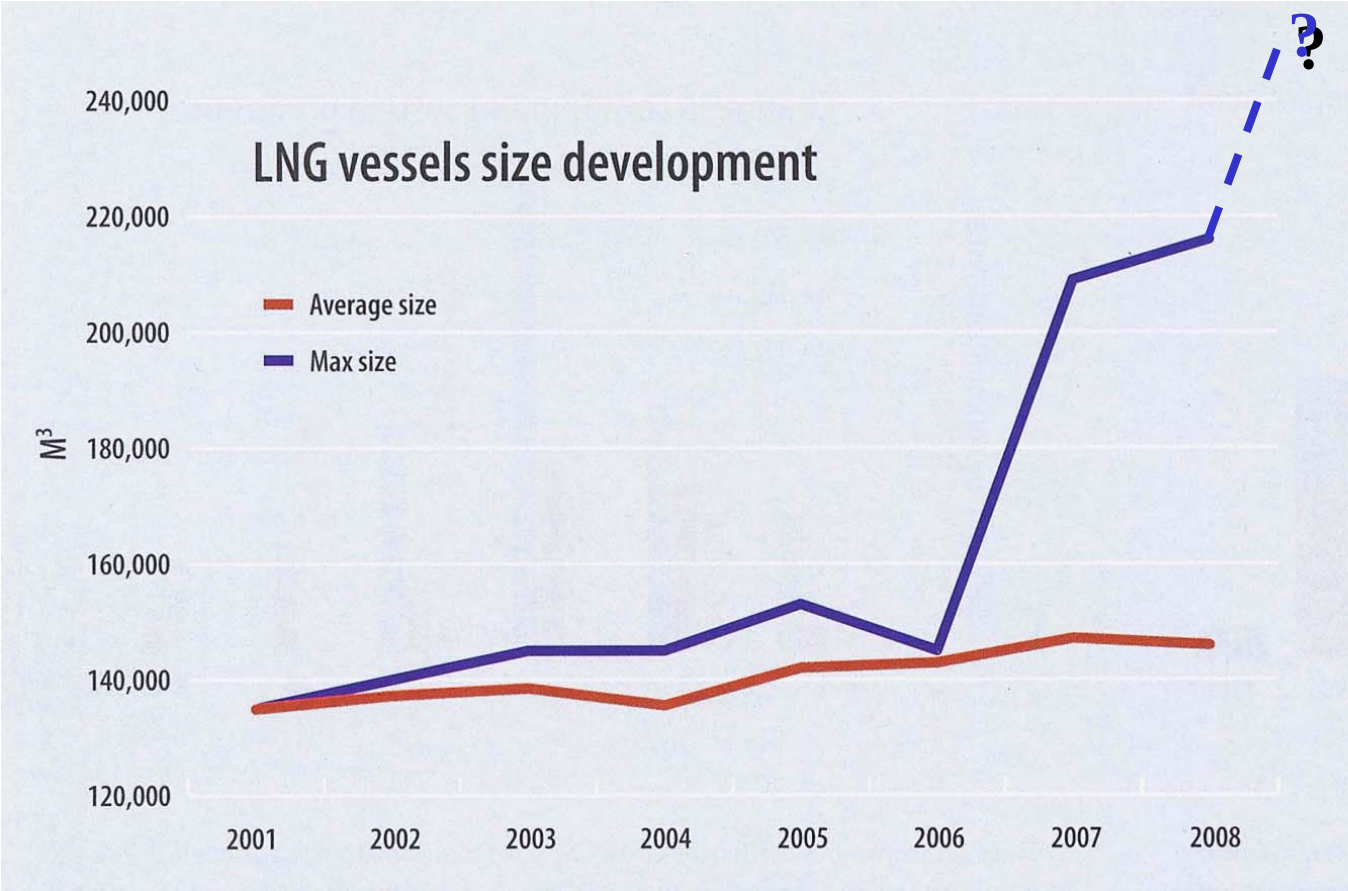
LNG Fleet Development



Source: Fairplay

World LNG fleet

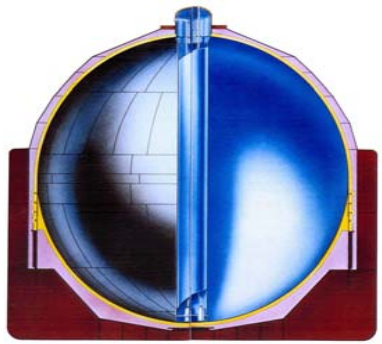
31 December 2004

	World	DNV
Current Fleet	176	25 (14%*)
Order book	108	22 (20%*)

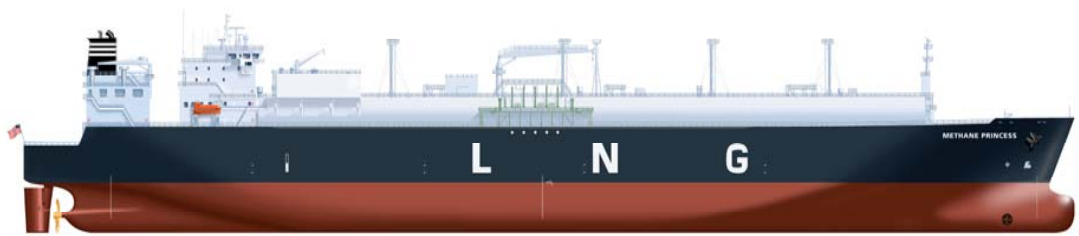
* Based on number of ships

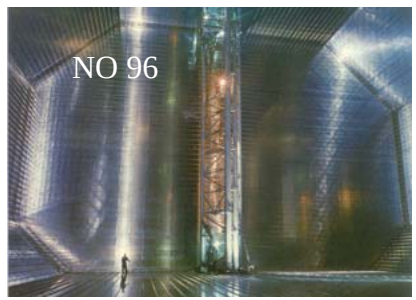
2 dominating LNG Cargo Containment Principles

- Spherical tanks (Moss Design) :

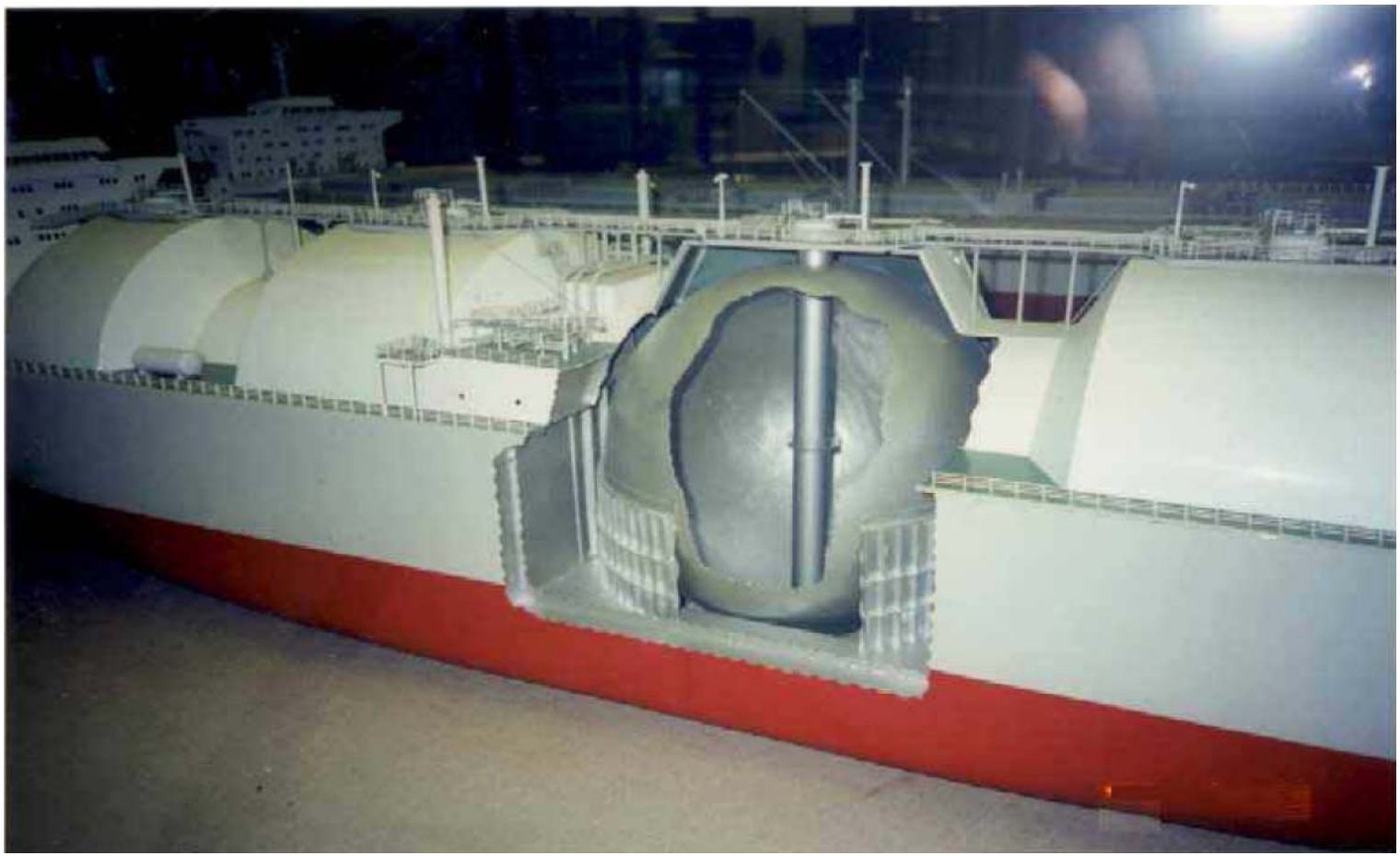


- Membrane Design :

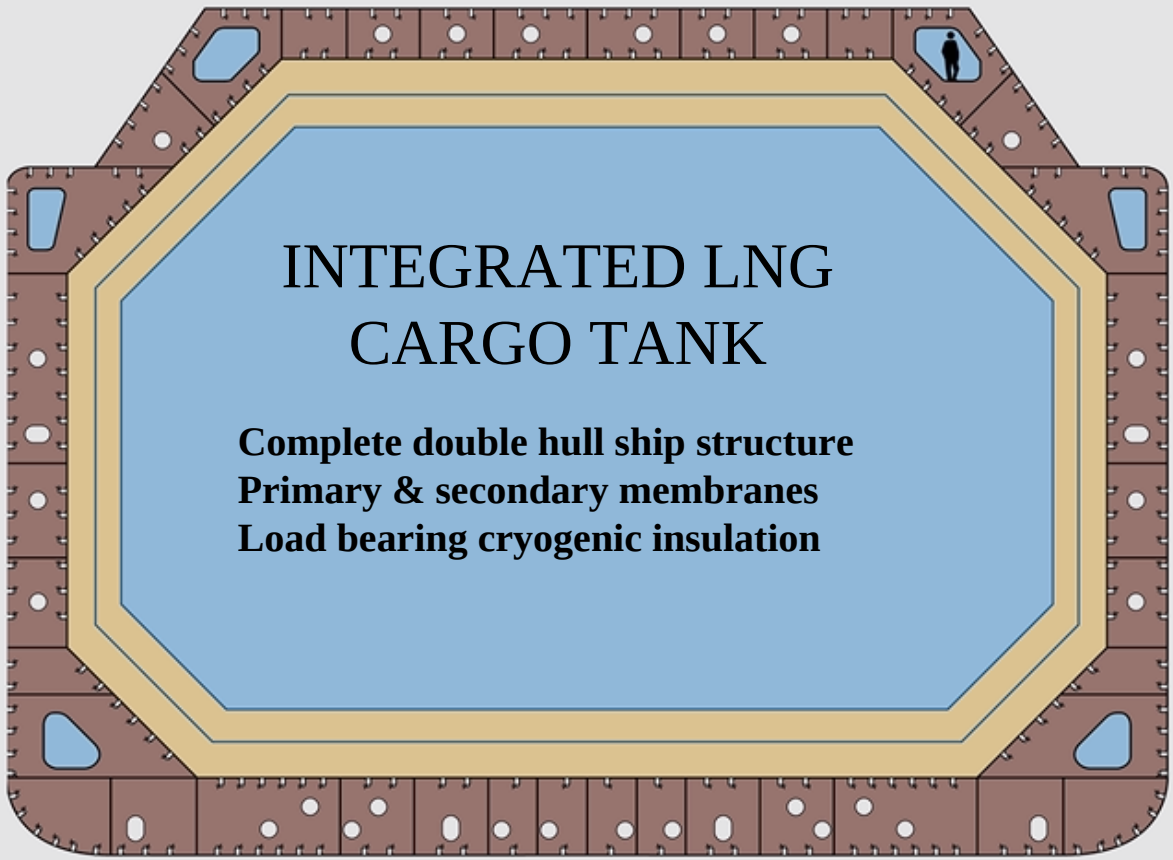




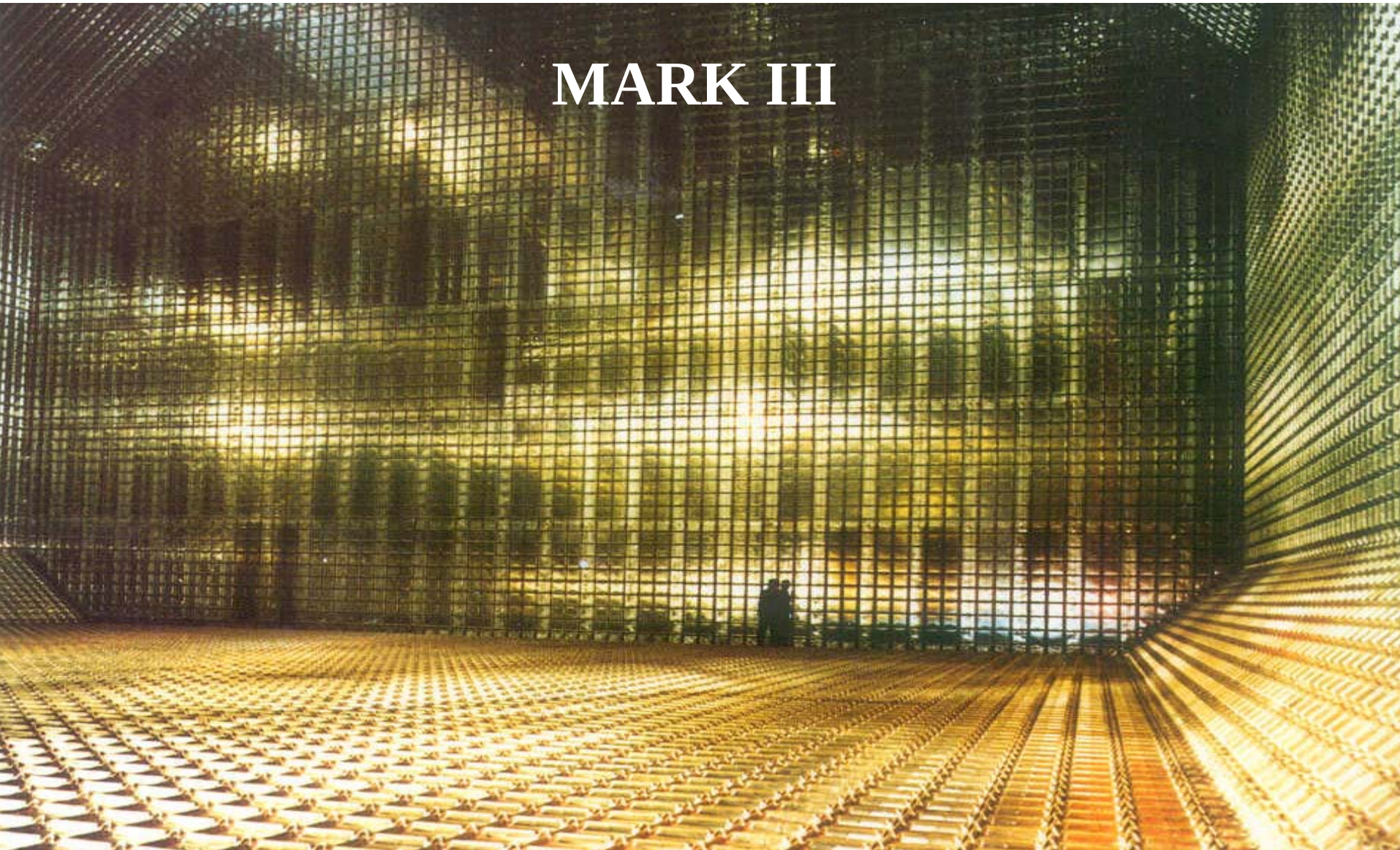
3 membrane designs:
- Mark III
- GT NO 96
- CS 1



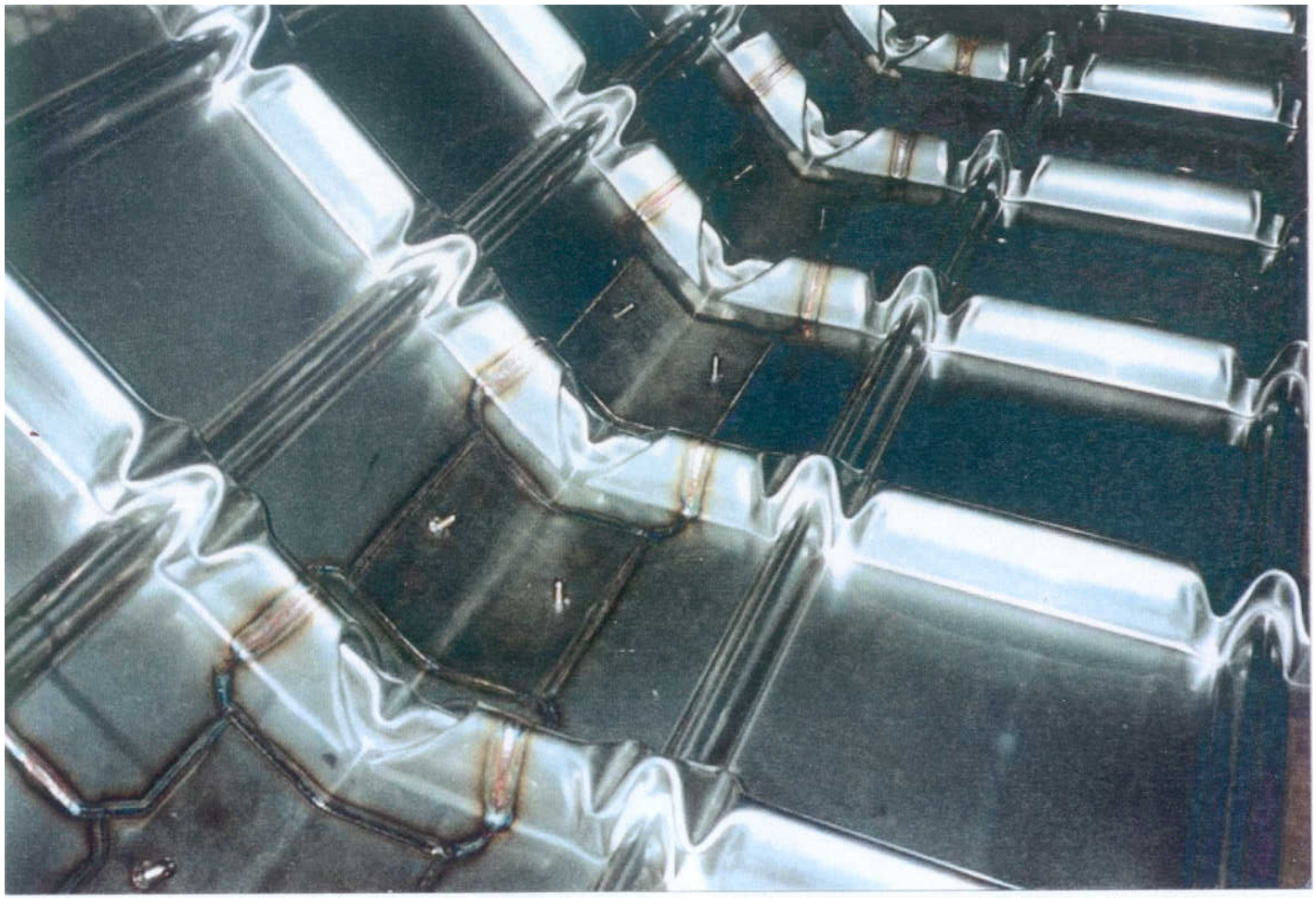
Membrane Concept



Membrane Cargo Containment System

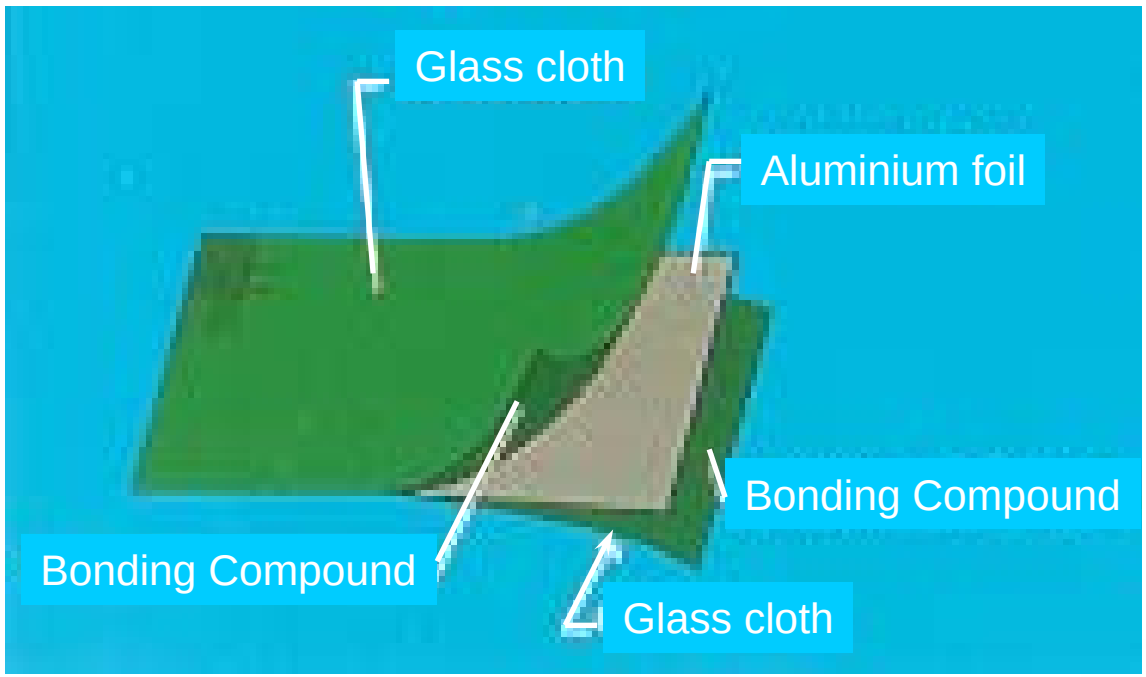


SUS Membrane Standard Corner Panel Mark III

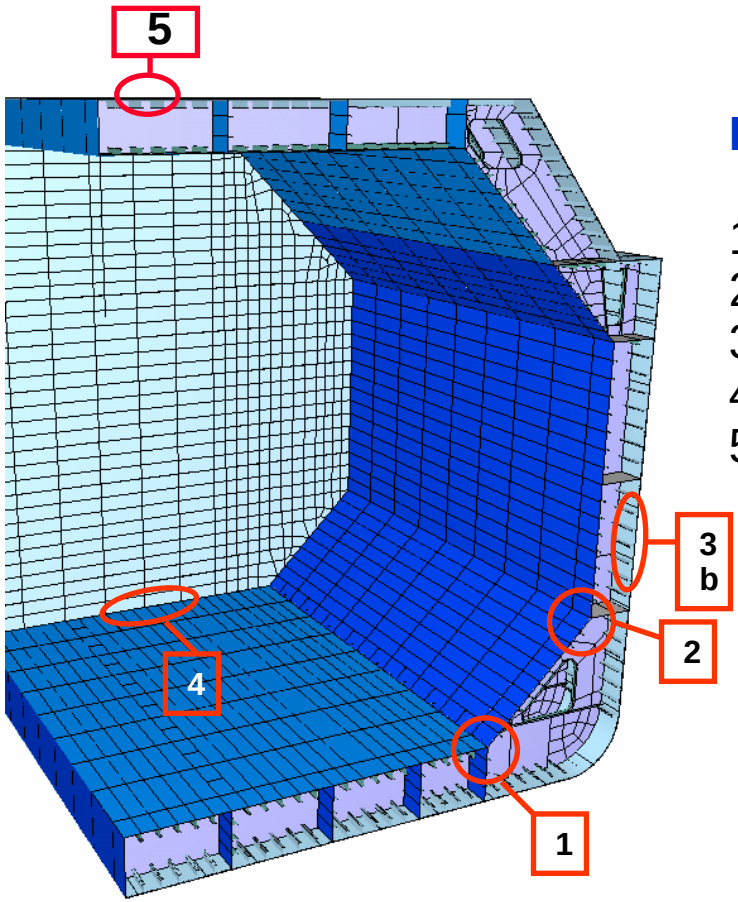


Triplex Membrane Mark III

- Aluminium foil between two glass cloths
- Glued between primary and secondary insulation during prefabrication
- Triplex strip joining panels glued after erection



Highlighting Critical - Fatigue

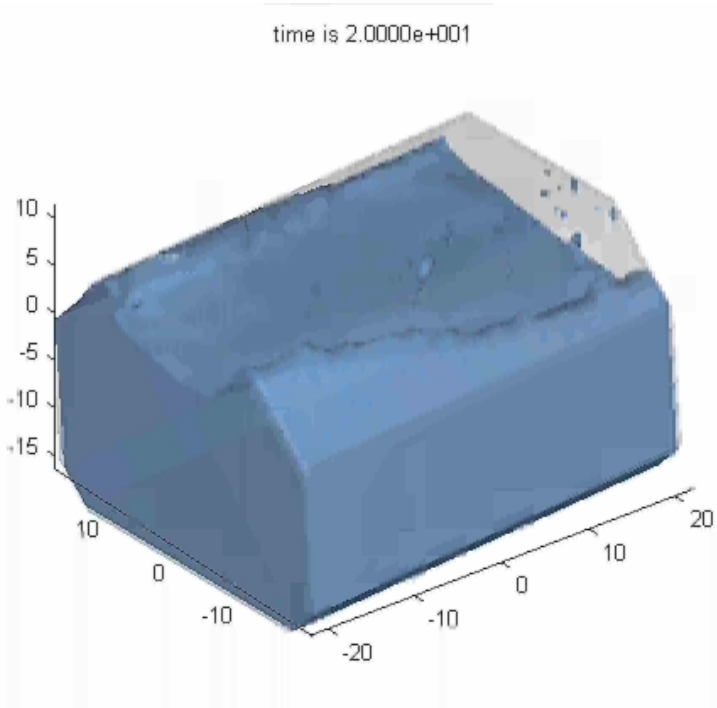


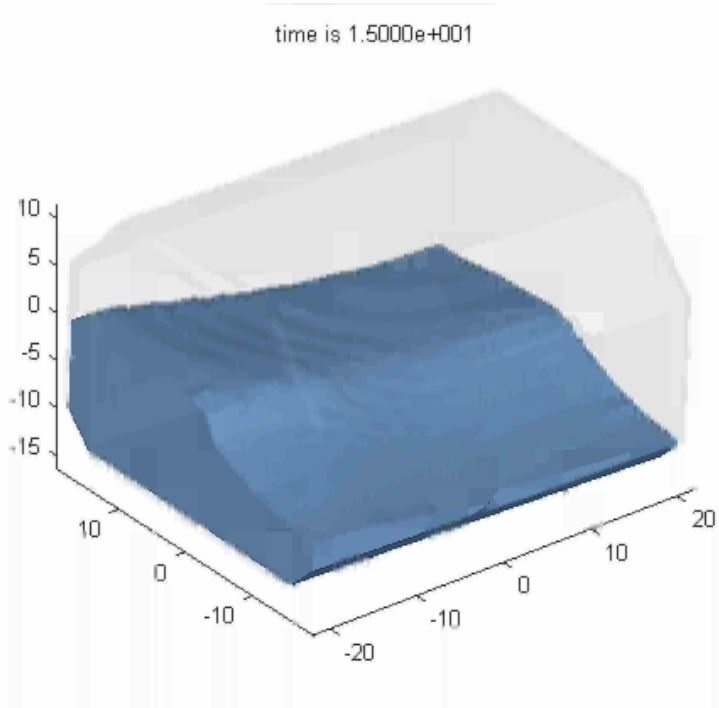
Details to pay particular attention to:

1. Hopper tank, lower knuckle
2. Hopper tank, upper knuckle
3. Side longitudinals
4. Alignment, bulkhead - bottom structure
5. Deck opening

Life expectancy 40 years for LNG carriers

Sloshing simulations - COMFLOW animations





80% filling
-bow quartering seas

30% filling
-bow quartering seas

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The Future Membrane LNG Carrier Design?

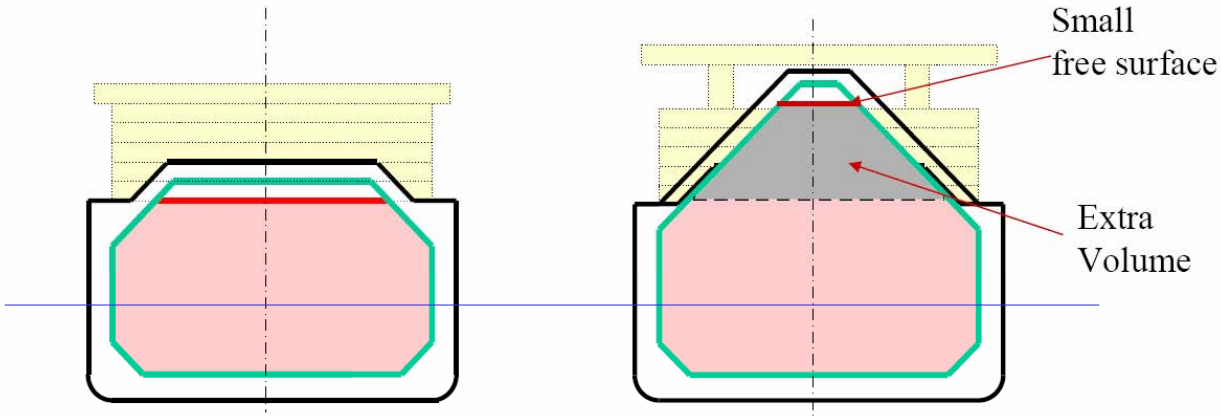
Image: Conoco Marine

COP Marine envisages LNG super tankers with innovative trapezoid-shaped tanks for containing the cargo that will allow use of shorter vessels

New Membrane Concept

Prism Tank Development

(patents pending)



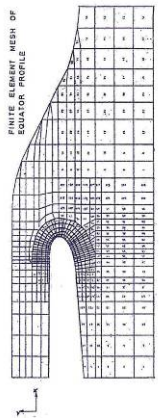
Conventional Shape

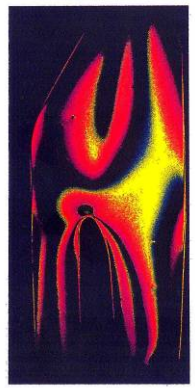
Large free surface
Sloshing
Limited Volume for low SG LNG
Boil Off ~0.15%/day

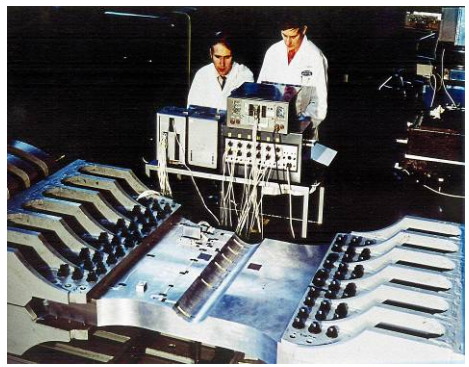
New COP Prism Tank Shape

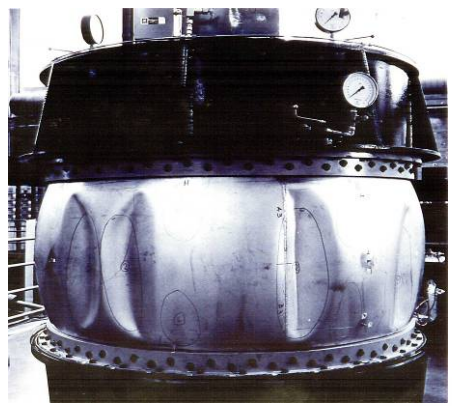
Small free surface
Limited Sloshing
Increased Volume for low SG LNG
Boil Off ~0.13%/day

LNG Technology Support by DNV









- Development of Moss design was heavily supported by DNV laboratories and in-house experts during the 60’ties

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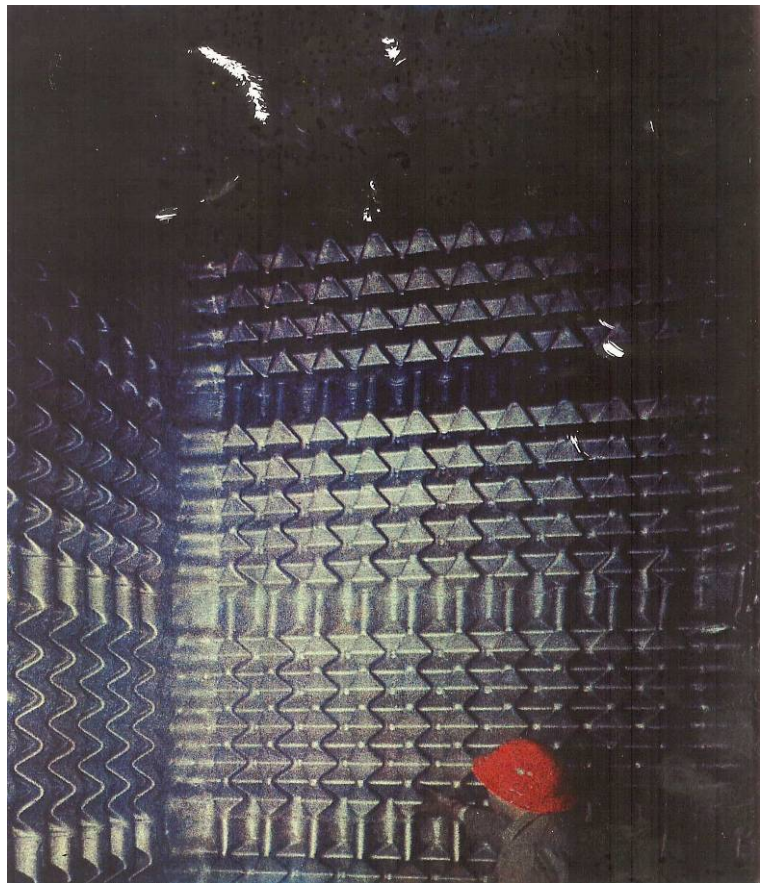
LNG Membrane Design invented by DNV



- Invented by DNV, first membrane model tank, built in Oslo 1962
- Patented and later sold to France

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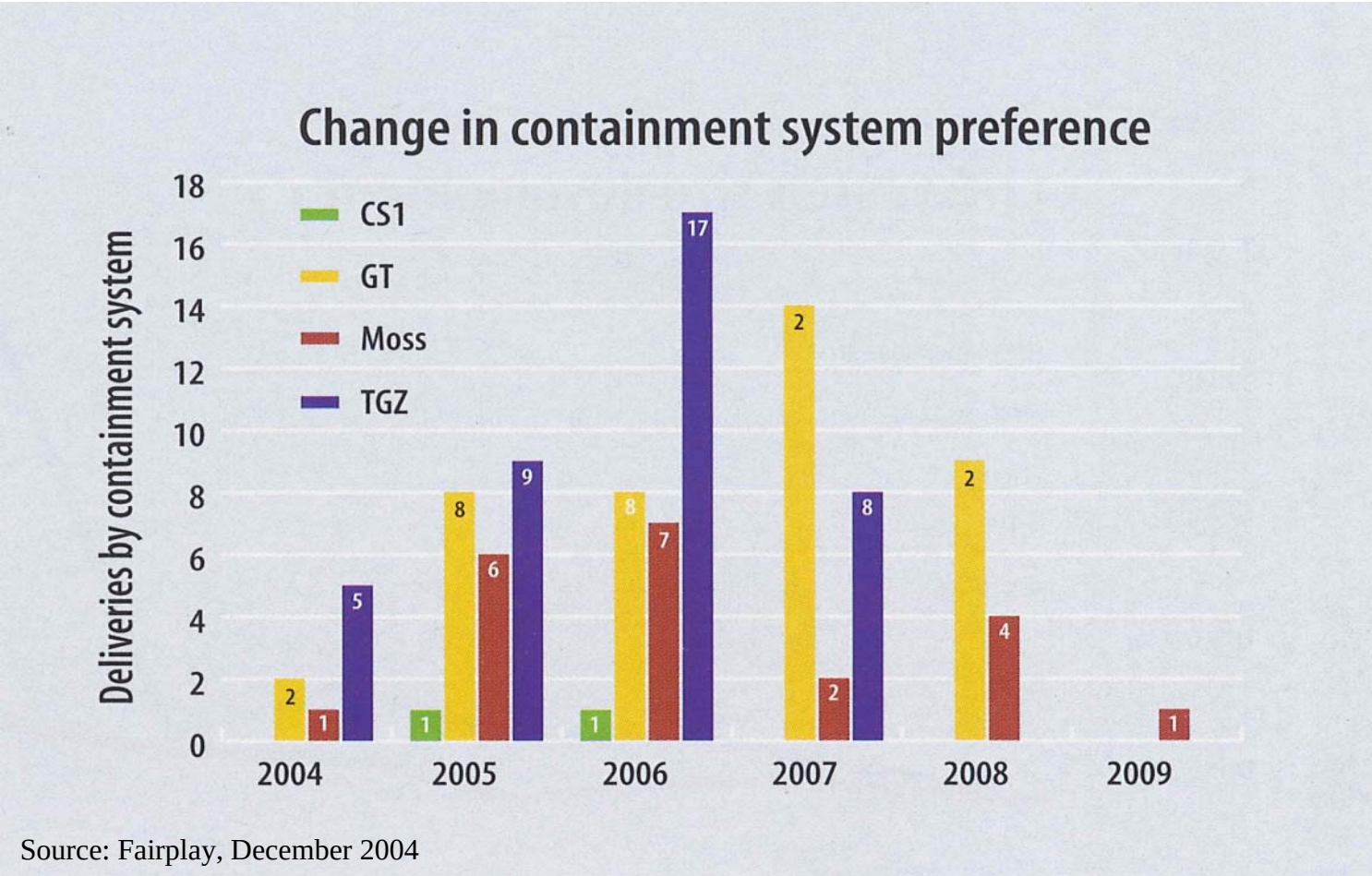
Different Containment Systems: Market Shares



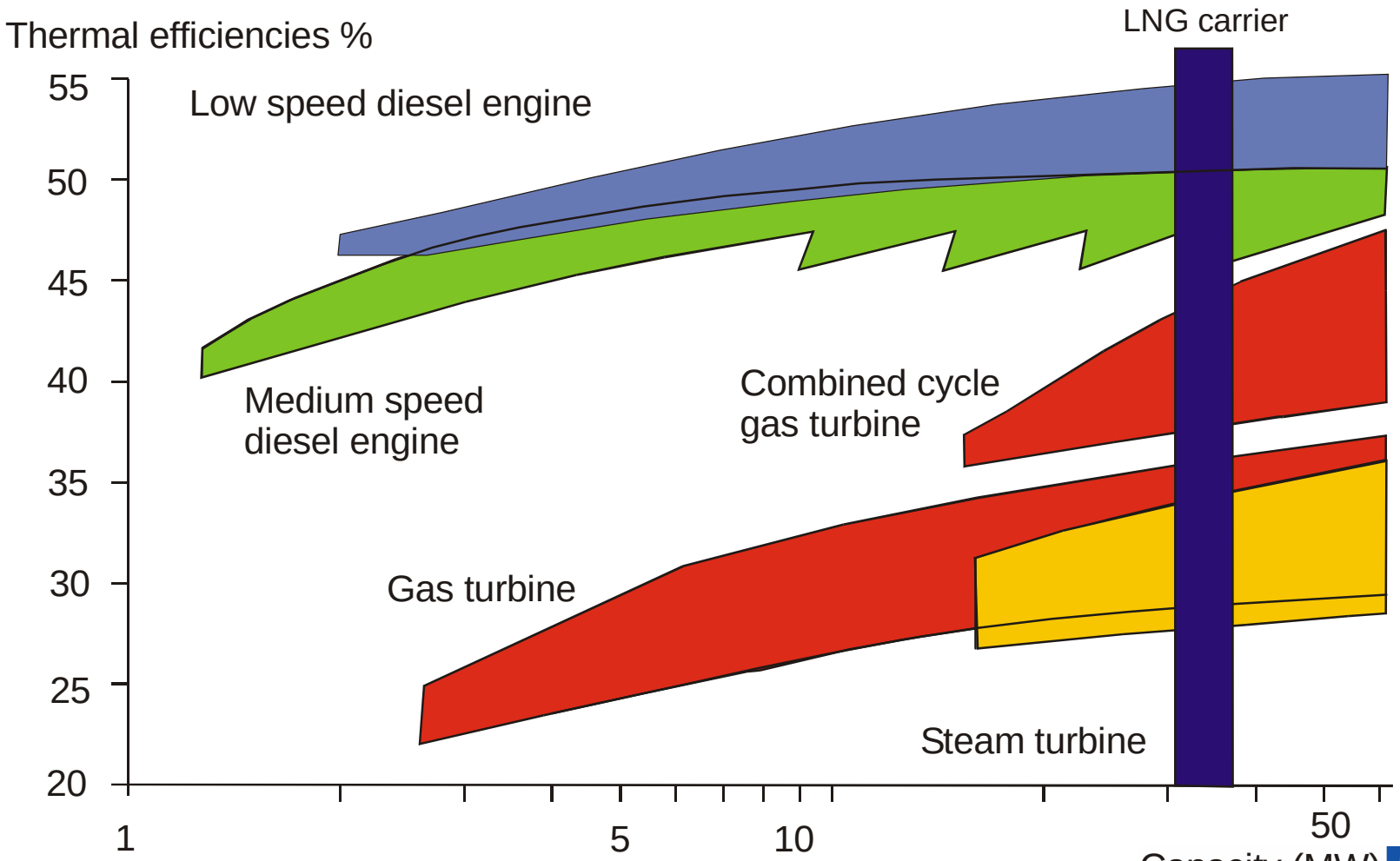
Source: Fairplay, December 2004

Spherical/membrane: ~ 20/80

Coastal LNG carrier: “Pioneer Knutsen”

- delivered 2004, 1 100 m3 cargo carrying capacity
- 2 x engines for gas fuel only + 2 diesel engines , - diesel electric propulsion
- 2 pods for main propulsion
- redundant propulsion

Thermal efficiencies



Source: MAN B&W

Gas emissions from LNG carriers

	Fuel	NOx	SOx	CO2
Steam turbine	HFO + LNG	200	2.400	180.000
Low speed diesel + re-liquefaction	HFO	3.950	1.800	120.000
Dual fuel electric	LNG only	240	0	100.000
Gas turbines and COGES	LNG only	850	0	108.000

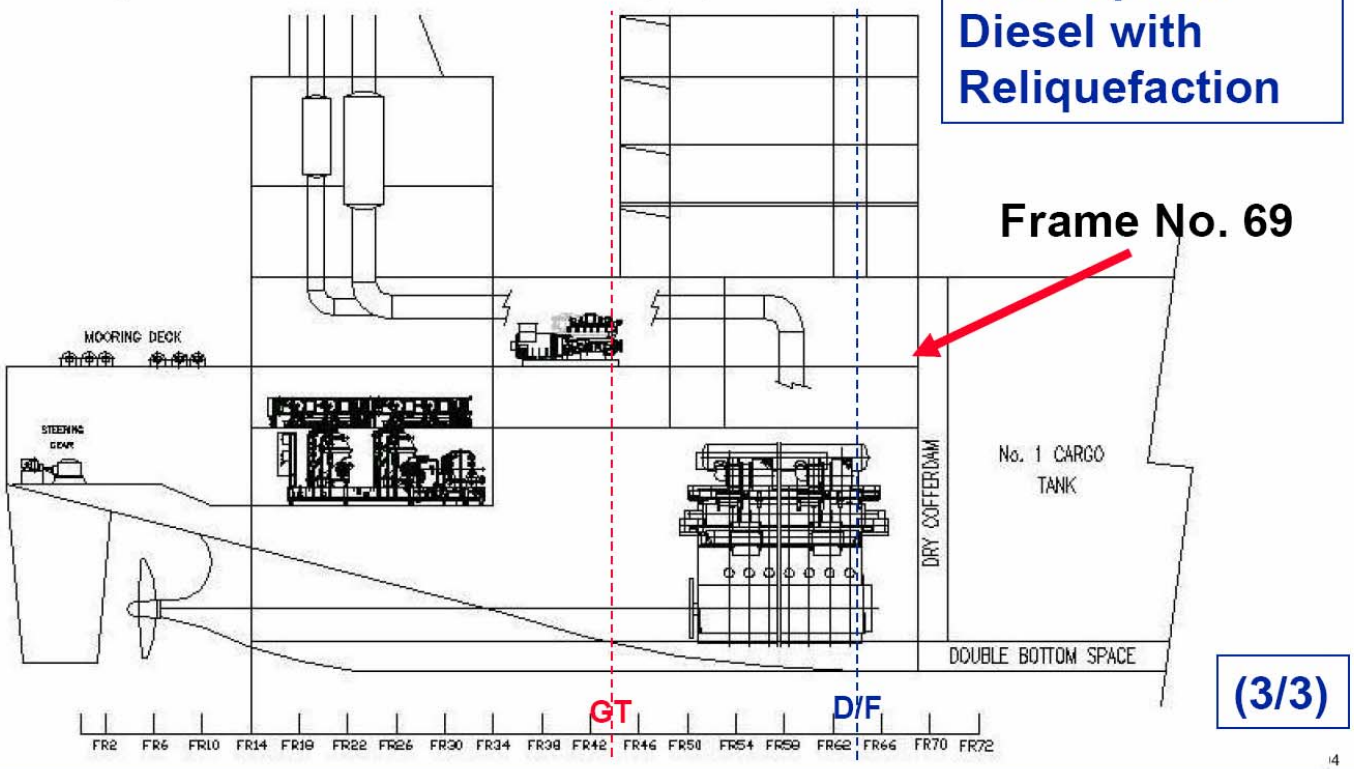
Source: ALSTOM

Emissions: Tonnes / year / ship

The Capacity Advantage

Based upon an LNG carrier of around 200,000 m³ capacity – Twin Skeg

Slow Speed Diesel with Reliquefaction



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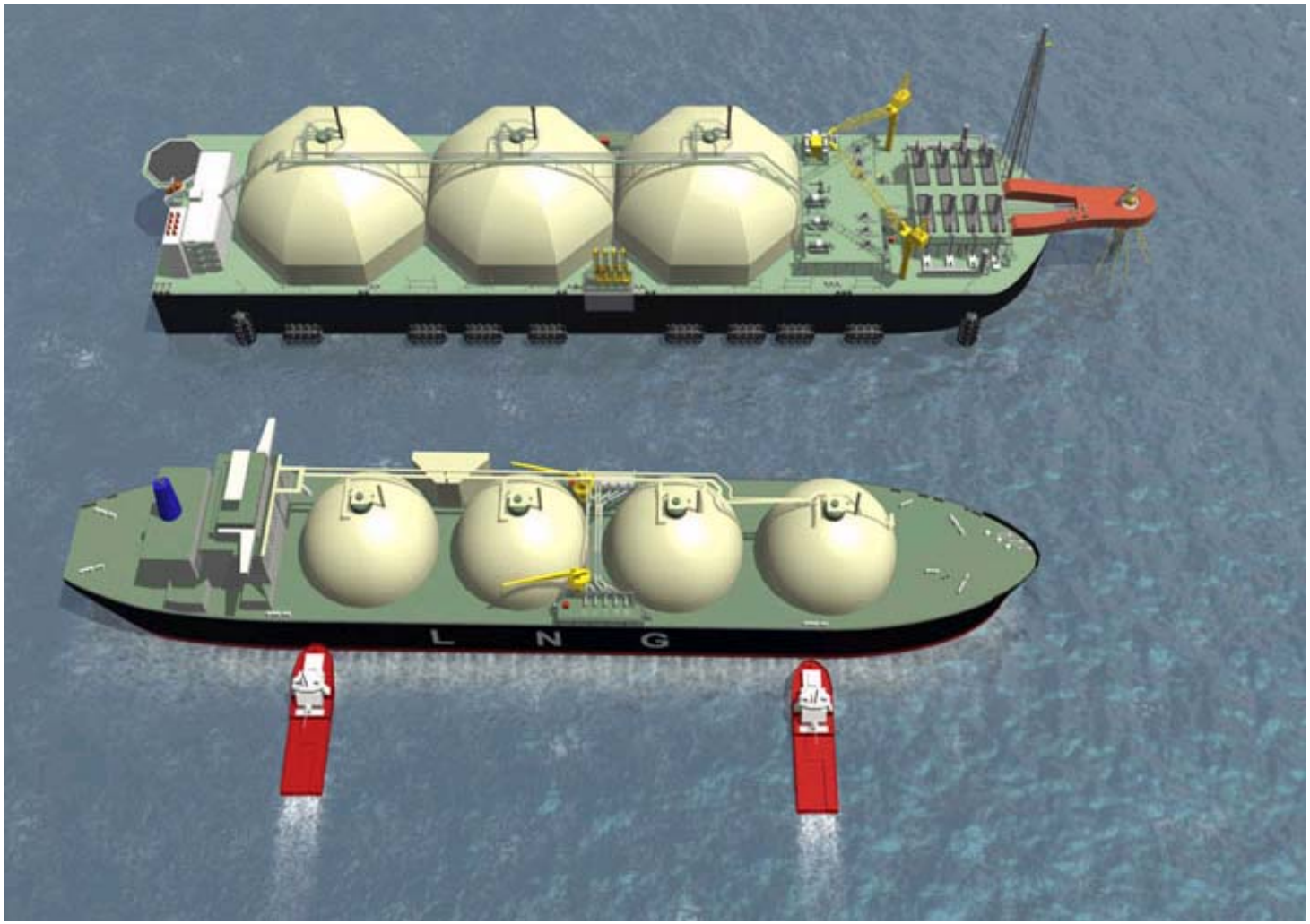
Rolls-Royce data

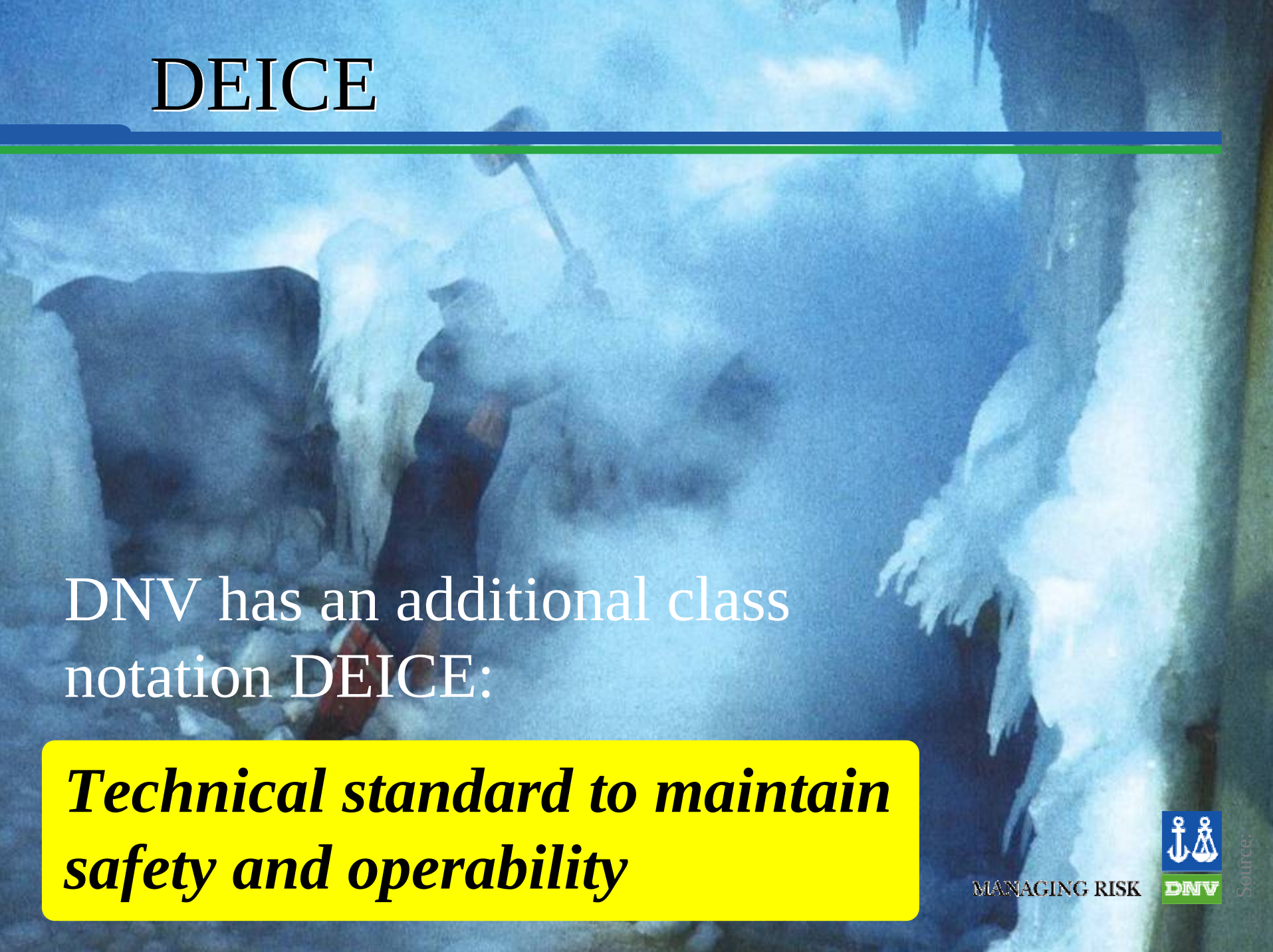
LNG storage and re-gasification



LNG Trade in cold Climate

- Cold climate: Is this the future environment for LNG carriers?

DEICE



DNV has an additional class notation DEICE:

Technical standard to maintain safety and operability

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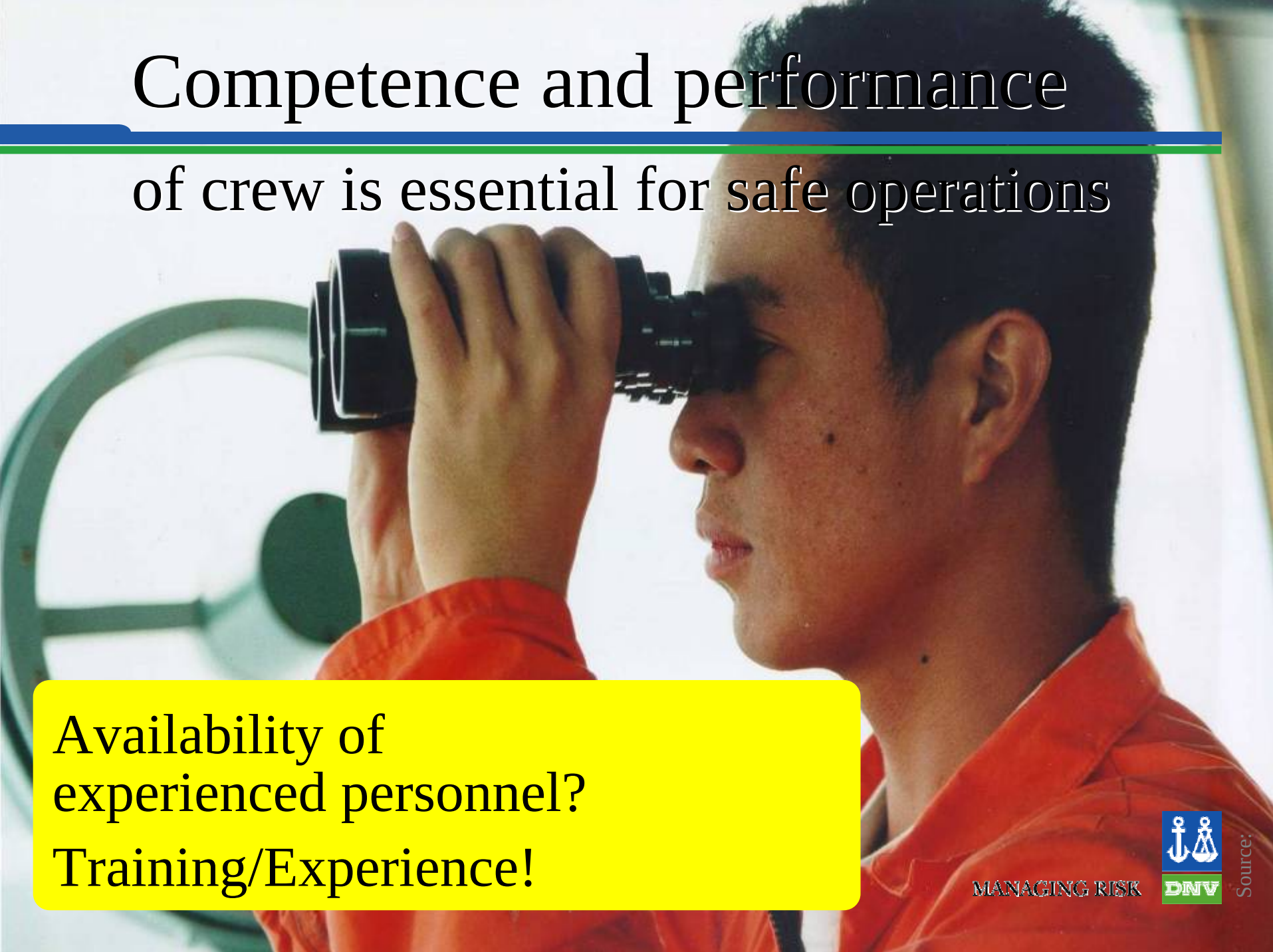
DNV

Source:

Competence and performance of crew is essential for safe operations



Availability of experienced personnel?

Training/Experience!

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Source:

Experienced personnel, - a serious challenge !

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MARKET FOCUS

BOXSI

LNG crew crisis turning critical

The world fleet of LNG carriers is rapidly expanding and crunch time is coming for finding suitable crew.

Lucy Hine London

The much talked-of LNG shipcrewing shortage has moved into the critical zone and the fight is getting dirty.

Last month John Fredriksen-controlled Golar LNG announced it was putting the management of its LNG ships out-of-house to the care of independent ship managers Barber and Thome. Golar's decision appears to have been prompted by several factors but problems in providing enough crew for its raft of LNG newbuildings was one of the driving forces.

Golar had made much of its access to a pool of Croatian seafarers but as one close observer of the company said: "They [the officers] were going out the door faster than they were walking in."

Sharp-tongued shipping types

A FEW GOOD MEN: Shipowners are facing a dearth of qualified crew as LNG-carrier delivery dates fast approach. Shown here, the crew of the 74,000-cbm newbuilding LNG carrier "Gaz de France Energy" (built 2004), at the shipyard Chantiers de l'Atlantique in St Nazaire

Photo: Lucy Hine

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.. insufficient supply of competent people may have a knock-on effect on other shipping sectors ?

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DNV

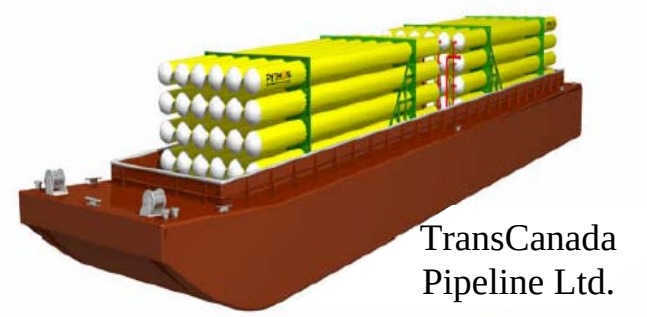
Compressed Natural Gas - CNG

- Why is it necessary to look for new concepts for NG transportation ?
  - more than 50% of offshore NG is stranded: small to medium size fields in remote areas
- What are the most important performance factors of CNG concepts?
  - Containment system
  - Operation & logistics

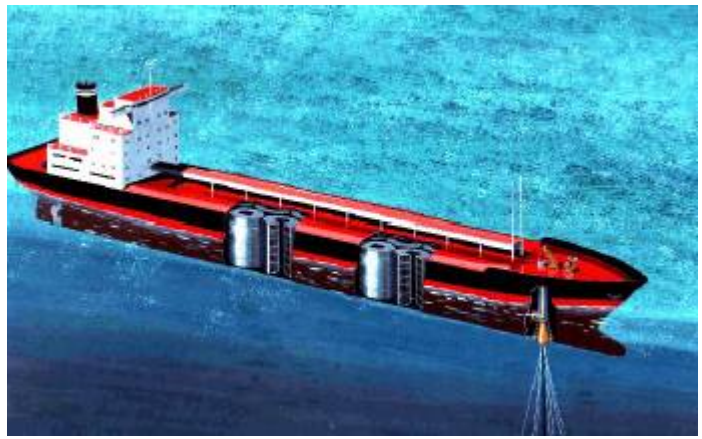
Recent CNG Carrier Concepts

- Many concepts proposed - most are based on transportation in “pipeline” pressure vessels
  - Williams Coselle (steel, coiled, 275 bar, ambient)
  - Knutsen (steel, vertical pipes, 250 bar, ambient)
  - EnerSea (steel, vertical pipes, 130 bar, -29°C)
  - Trans Ocean Gas (composite)
  - CETech: (Statoil, Teekay, Höegh)
    (steel, horizontal pipes, 200-250 bar, ambient)
  - TransCanada Pipeline (wrapped steel liner)
  - Institute Français du Pétrole (IFP)
    (steel/GRP composite hybrid, 130-135 bar, -35°C)

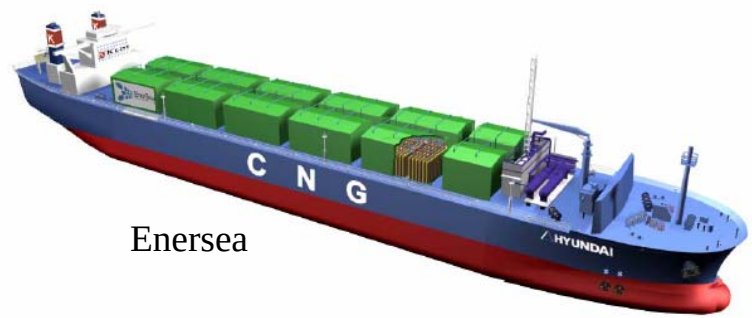
Recent CNG Carrier Concepts



TransCanada Pipeline Ltd.



Williams (Coselle)



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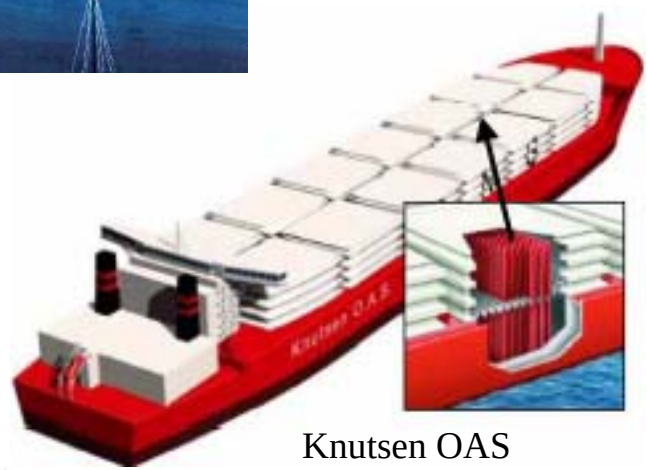

Knutsen OAS

Trans Ocean Gas

CETech

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Ship and cargo containment cost

LNG : Proven concept with established cost level

CNG : Ship cost well established as for normal cargo vessels: Cost of cargo containment system becomes key to success for CNG

CNG Cargo containment cost

- If designed as normal pressure vessels the weight becomes excessive

- If designed according to modern risk based standards for offshore pipelines, CNG may become viable

The DNV CNG Rules

- Issued January 2003
- Based on DNV pipeline standard, DNV-OS-F101 :
  - Used for most deepwater offshore pipelines today
  - Used for all known CNG concepts
- CNG: based on safety level equivalent to LNG (International Gas Code)

End of Presentation

Thank you !

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