RINA 2017
Annual President's Invitation Lecture

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November 22, 2017

Challenge of mega boxship

Prepared by James S C Tai
Date: November 22, 2017

Company Porfile

- Headquartered in Hong Kong and listed on HK Stock Exchange
- Principal business activities:

  Container transport and logistics
- US$5.3 billion revenue in 2016
- Over 330 offices in more than 70 countries
- Employing over 10,000 staff globally

Our Managed Fleet Capacity

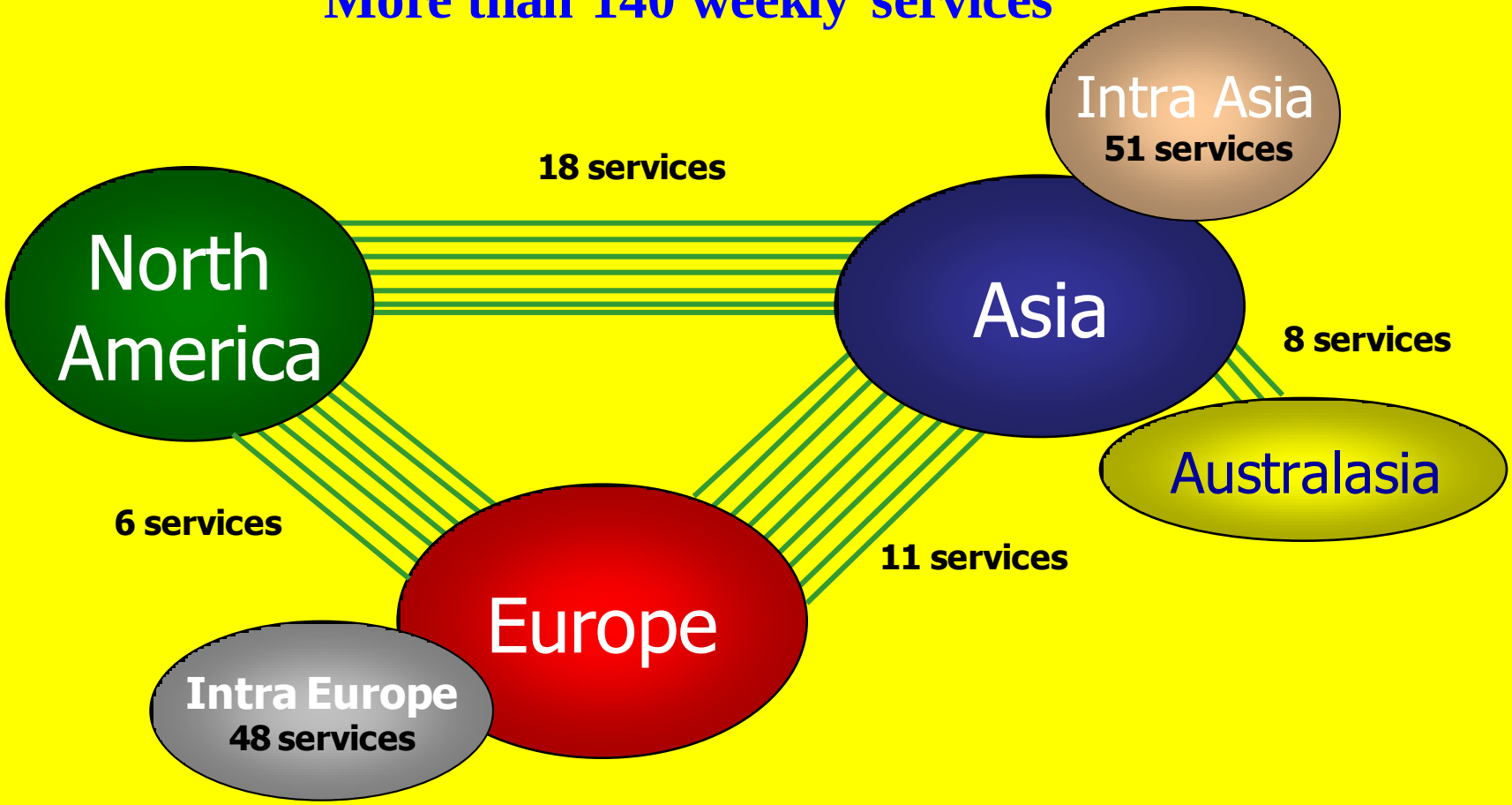
Current operating capacity: 700,558 TEU

	# of Vessels	Capacity (TEU)	Average (TEU)
Owned	60	522,406	8,706
Charter in	40	178,152	4,454
Total	**100**	**700,558**	**7,006**

Large percentage of vessels owned or under long term charter – makes for a competitive and stable cost structure

Our Global Service Network

More than 140 weekly services

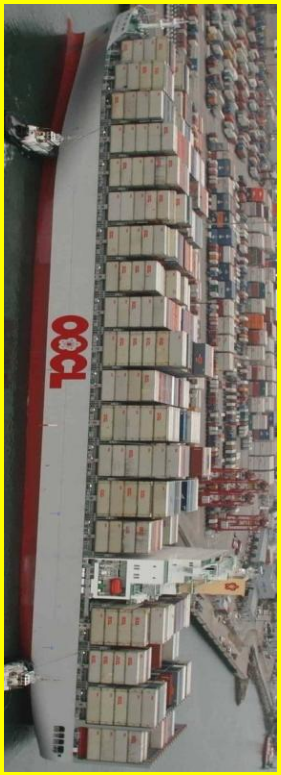


As of Nov 01, 2017

Size/Scale Comparison

Height

8,888 TEU Vessel



335 m

John Hancock Center, US

344 m

13,208 TEU Vessel

366 m

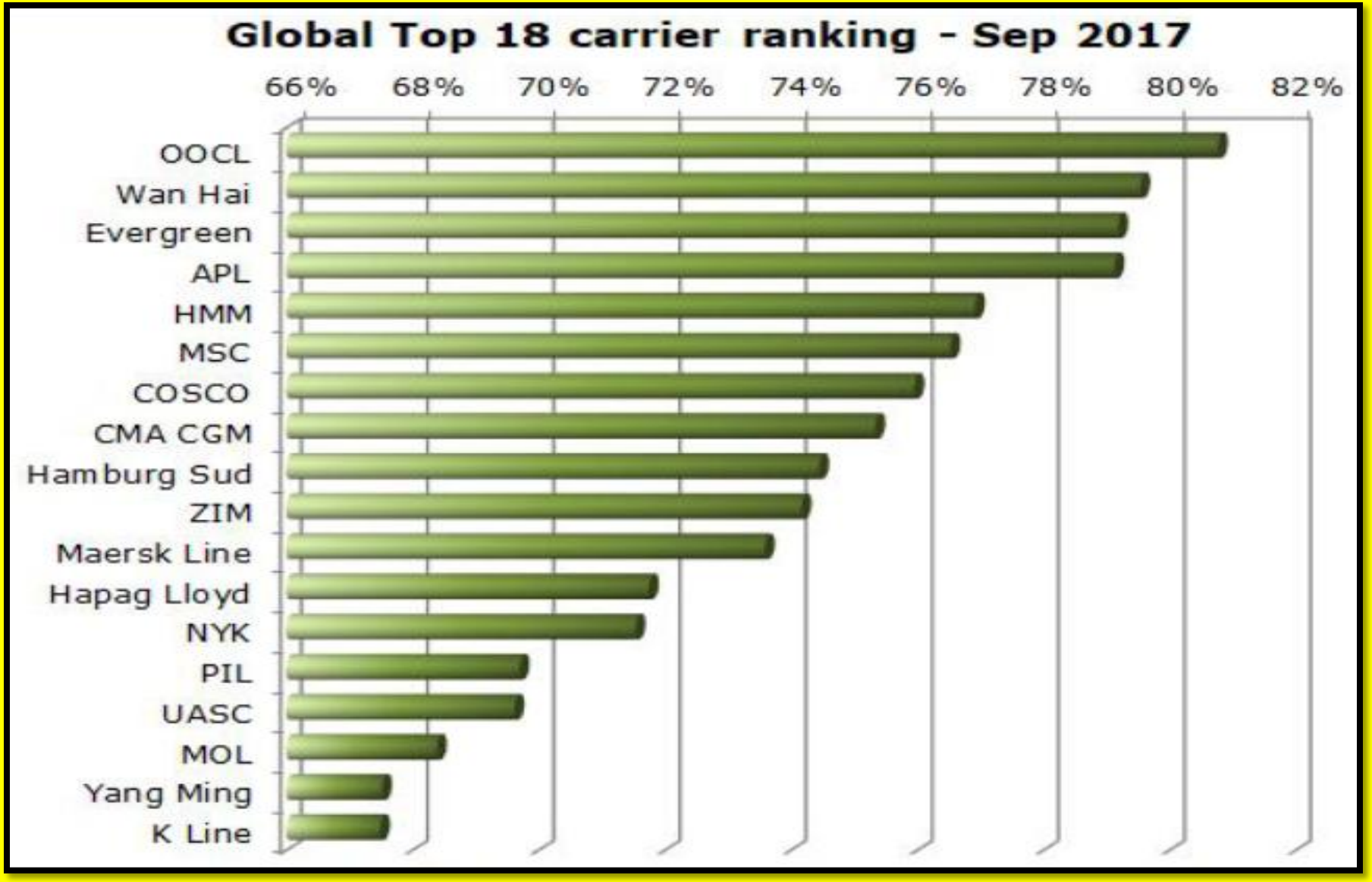
Petronas Towers, Malaysia

379 m

21,413 TEU Vessel

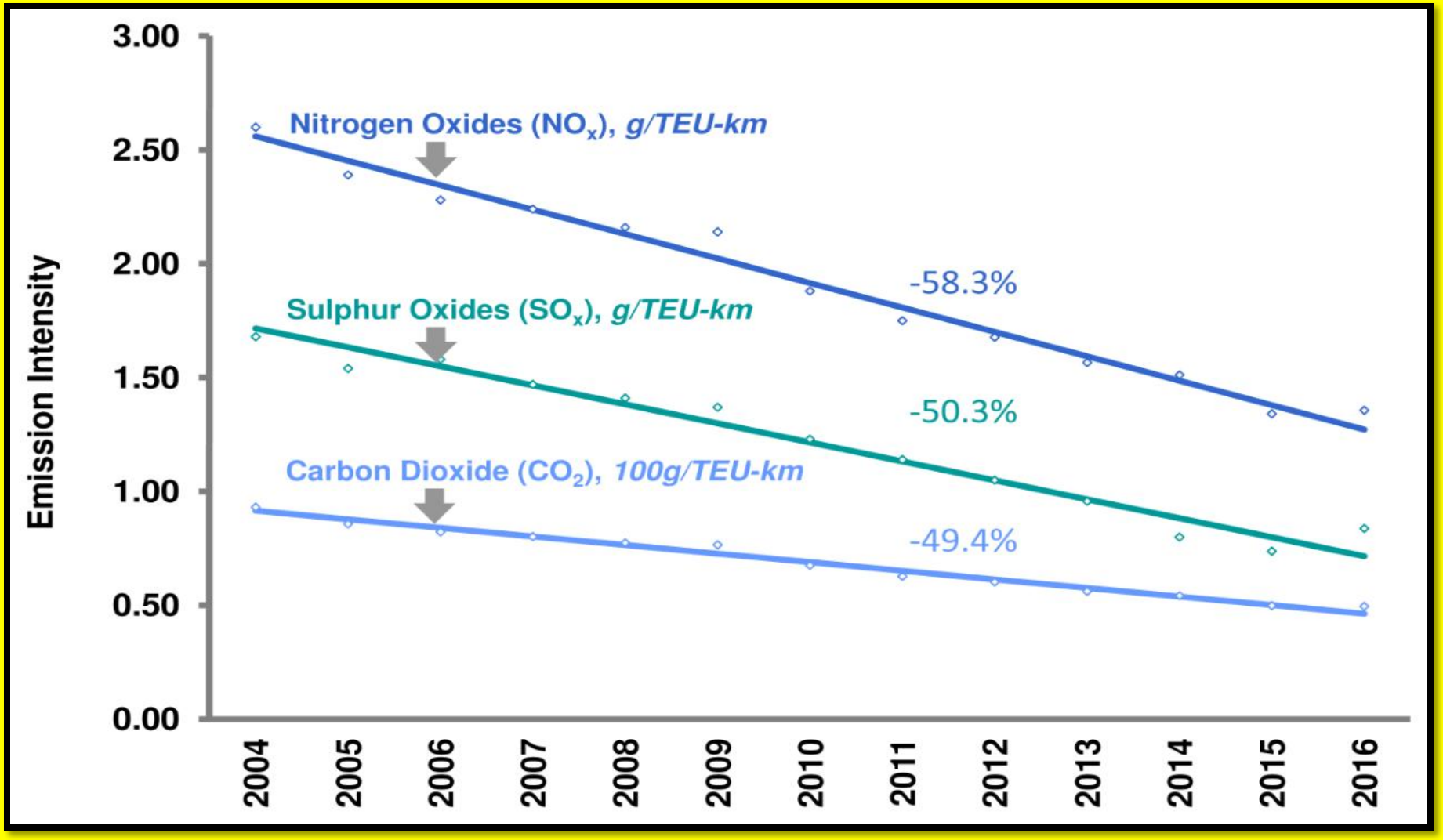
400 m

Top Schedule Reliability Performer (Sept 2017)

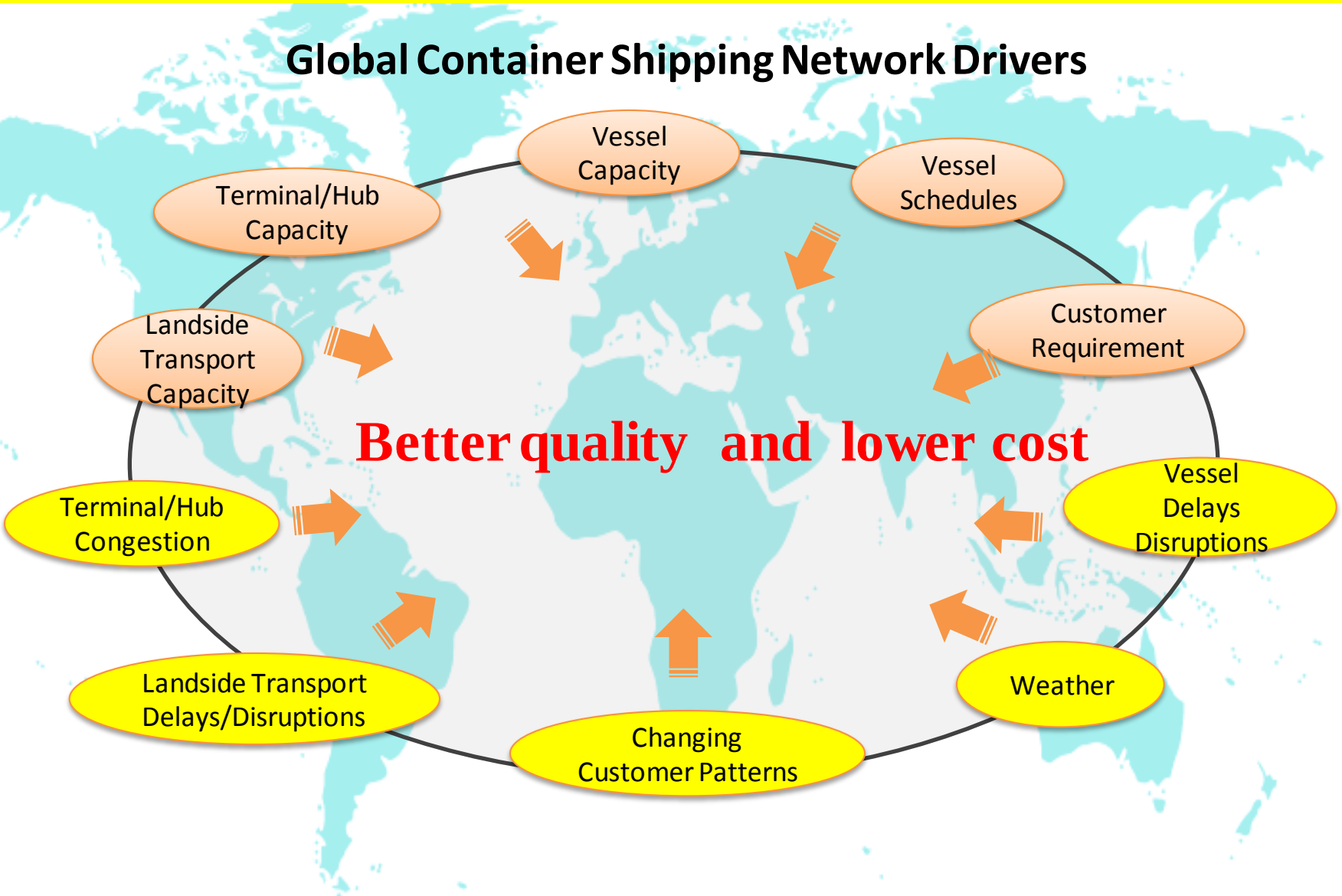


Source: SeaIntel – Global Liner Performance report – Oct 2017

Average Emission Intensity (CO_2, SO_x, NO_x) from OOCL Owned Vessels



Digitization for our overall business Value



Update
of
Boxshipping Market

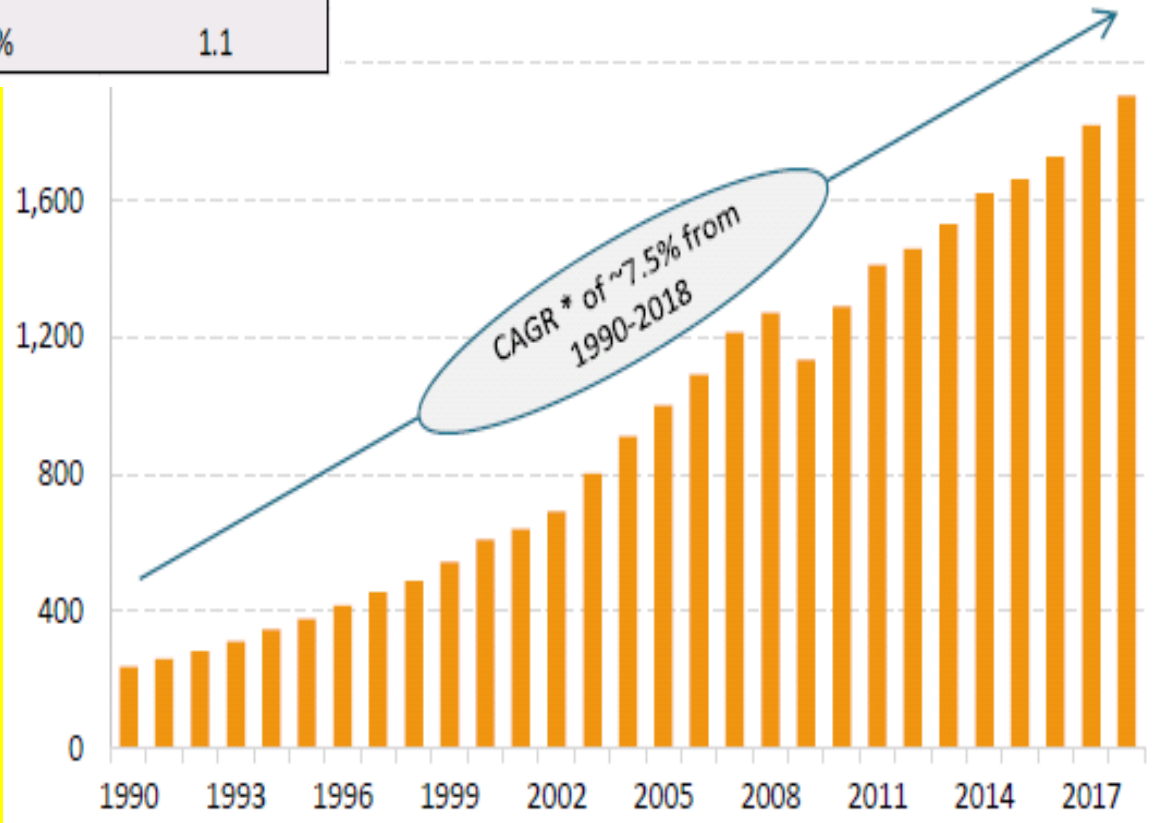
Seaborn Box Trade Growth

		Annual GDP (OECD Countries)	Annual Trade Growth	Trade-to-GDP Ratio
2011-2016 Average		3.4%	4.6%	1.3
Last 2 Years	2015	3.8%	2.2%	0.6
	2016	3.3%	3.8%	1.2
Forecast	2017P	4.2%	5.2%	1.3
	2018P	4.3%	4.8%	1.1

GDP is the one of indicators of prospective box volumes.

With Consumers Confidence have resumed to Pre-Crisis level, thus, 2017-18 forecast reflects a return of normal trade-to-GDP ratio.

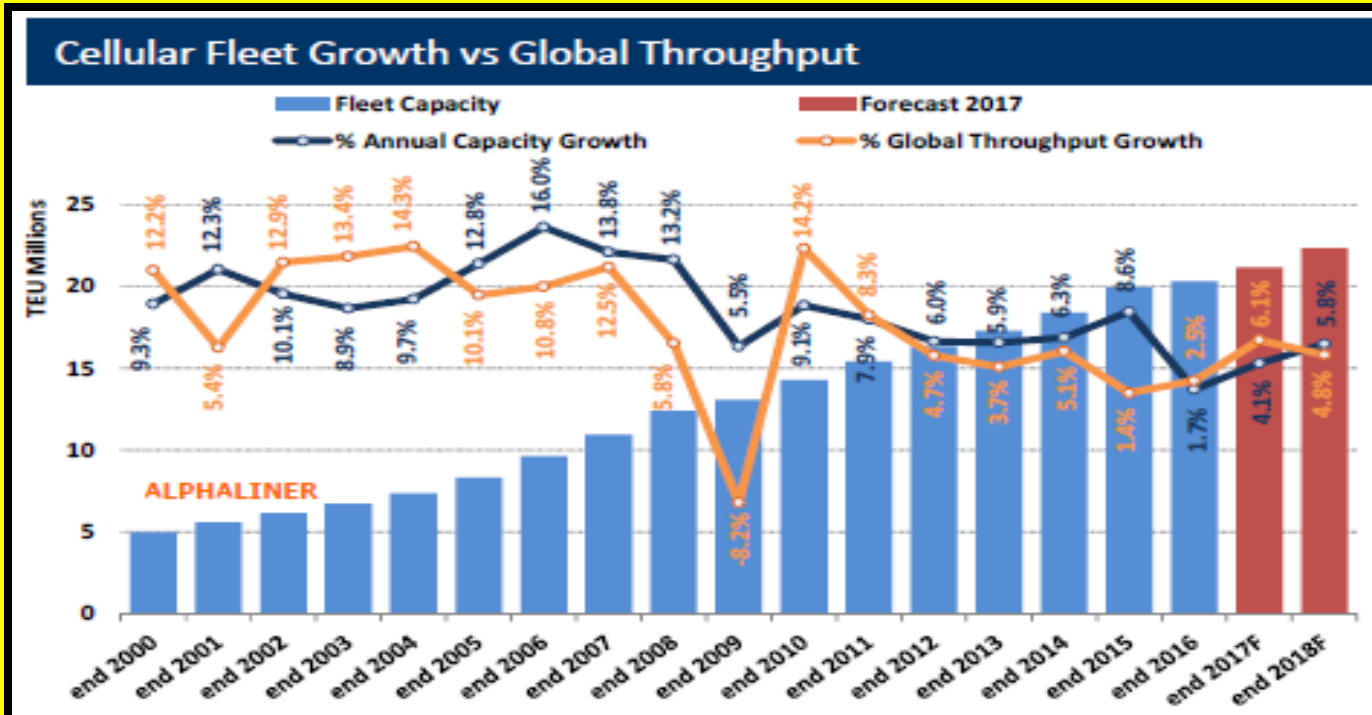
World economical growth will drive the rebound of boxshipping



Global Supply

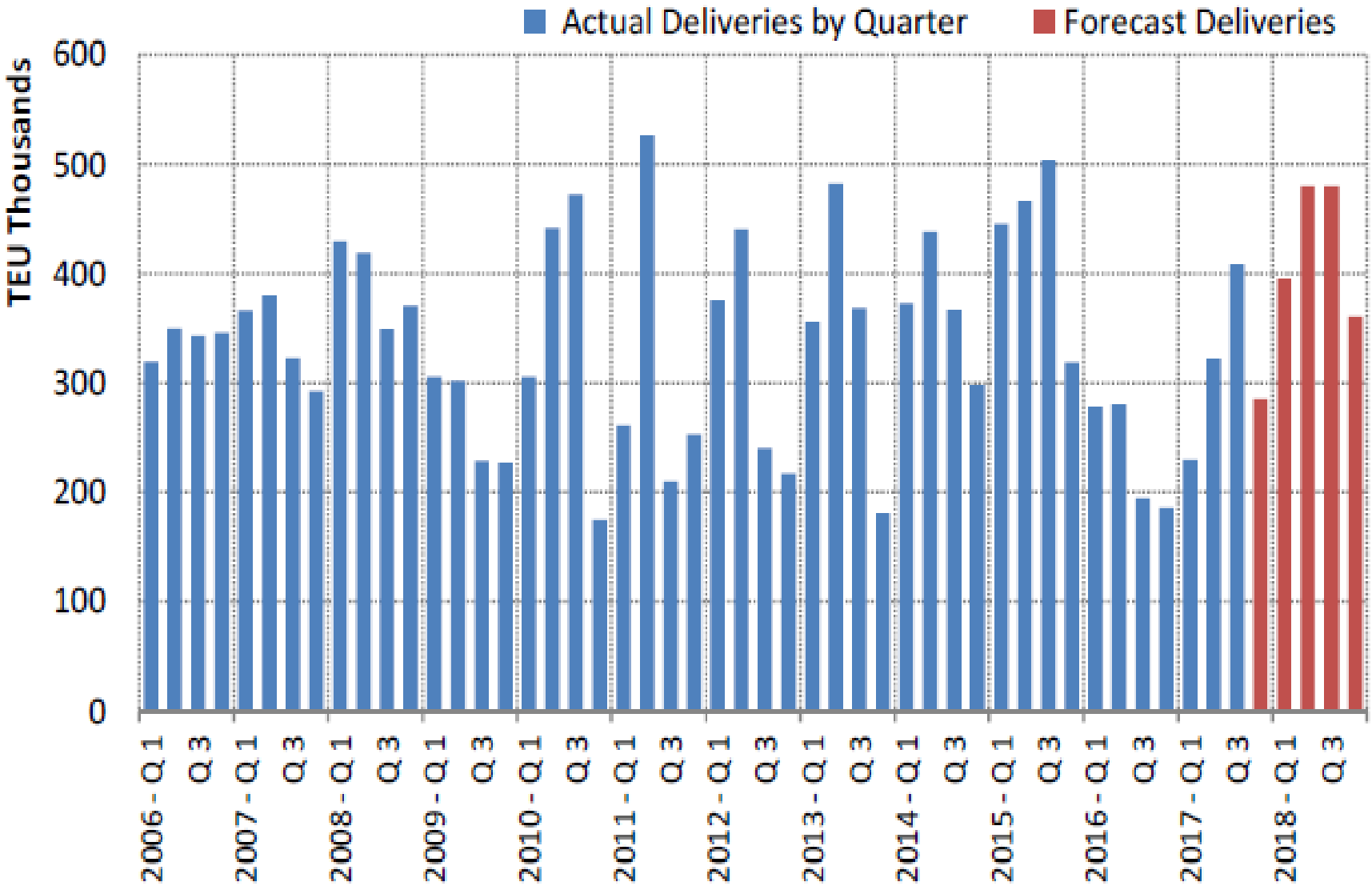
Liner Fleet as at 1 October 2017	
No. of liner ships incl. non-cellular	**6,035 units**
Total liner capacity (teu)	21,342 Mteu
Year-on-year increase %	3.1%

No. of cellular ships	**5,163 units**
Total cellular capacity (teu)	20.936 Mteu
Year-on-year increase %	2.9%
Chartered fleet %	54.9%
Cellular fleet as % of liner total	98.1%
% of cellular fleet idle	1.9%
Orderbook	2.817 Mteu
Orderbook as % of current fleet	13.5%
Deliveries Jan-Sep 2017	123 units/963,070 teu
Deletions Jan-Sep 2017	131 units/364,414 teu
New Orders Jan-Sep 2017	67 units/587,138 teu



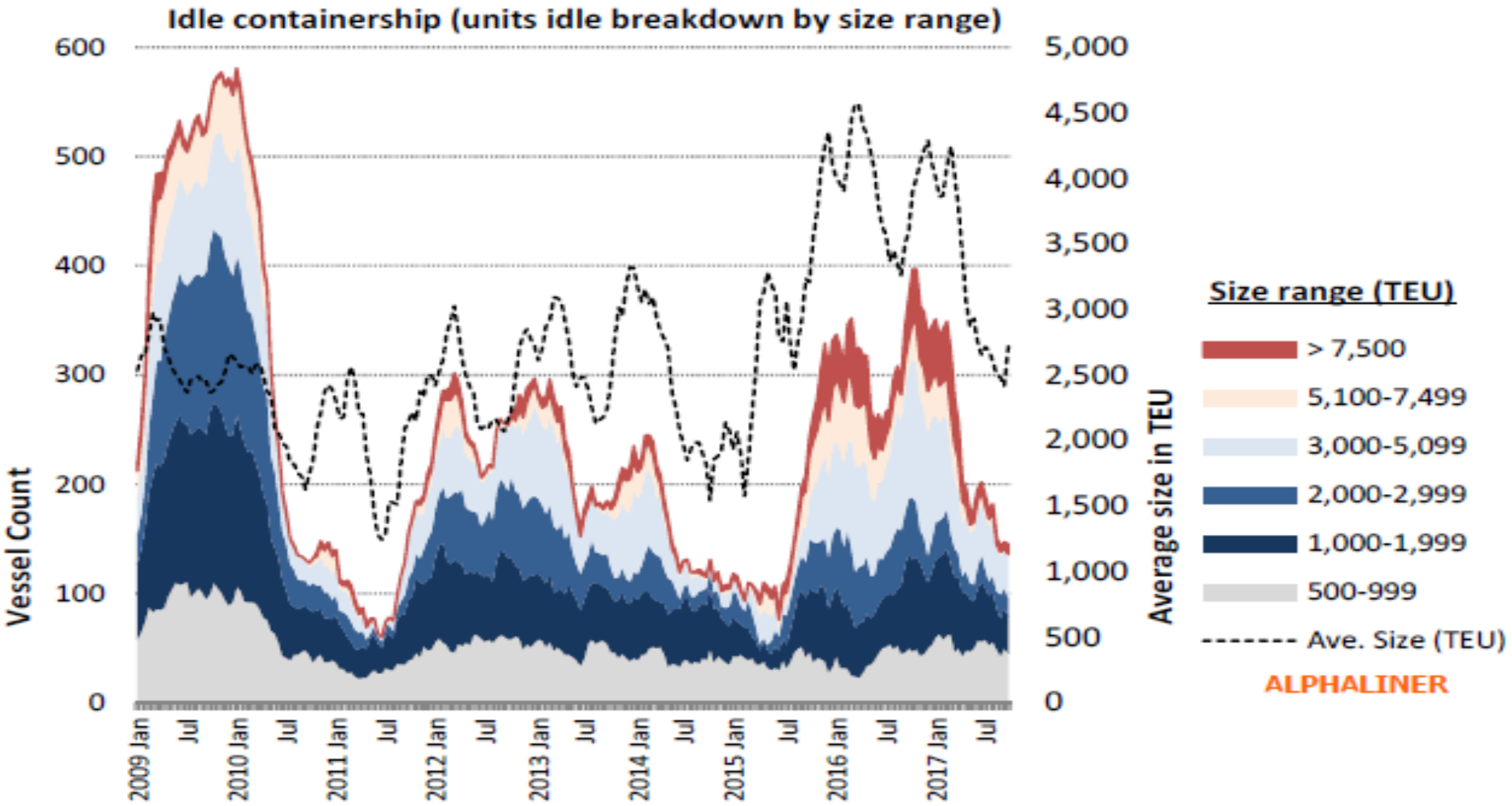
Source: Alphaliner Monthly, Oct 2017

Boxship Newbuilding deliveries by Quarter



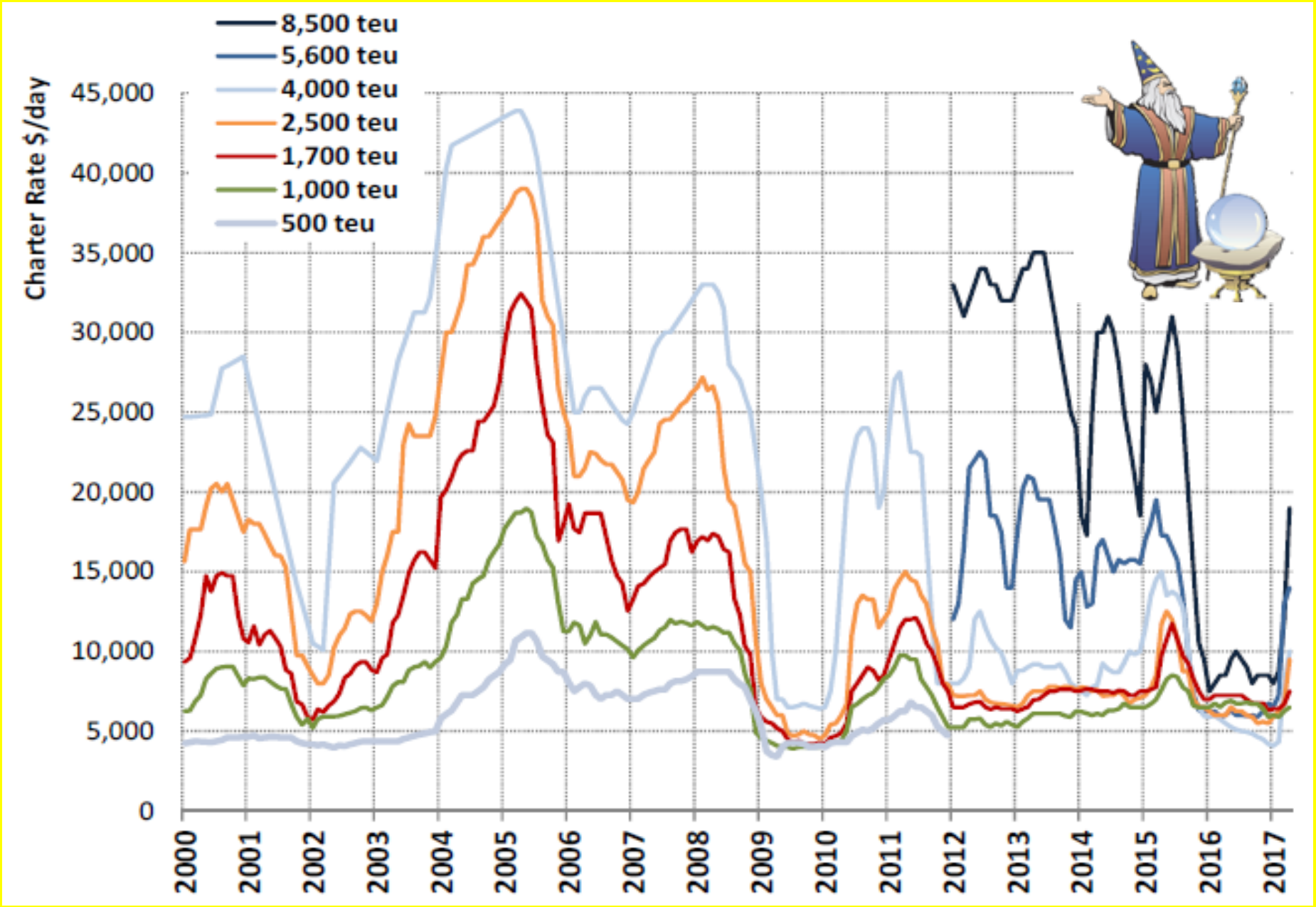
Source: Alphaliner Monthly, Oct 2017

Boxships Idling Capacity

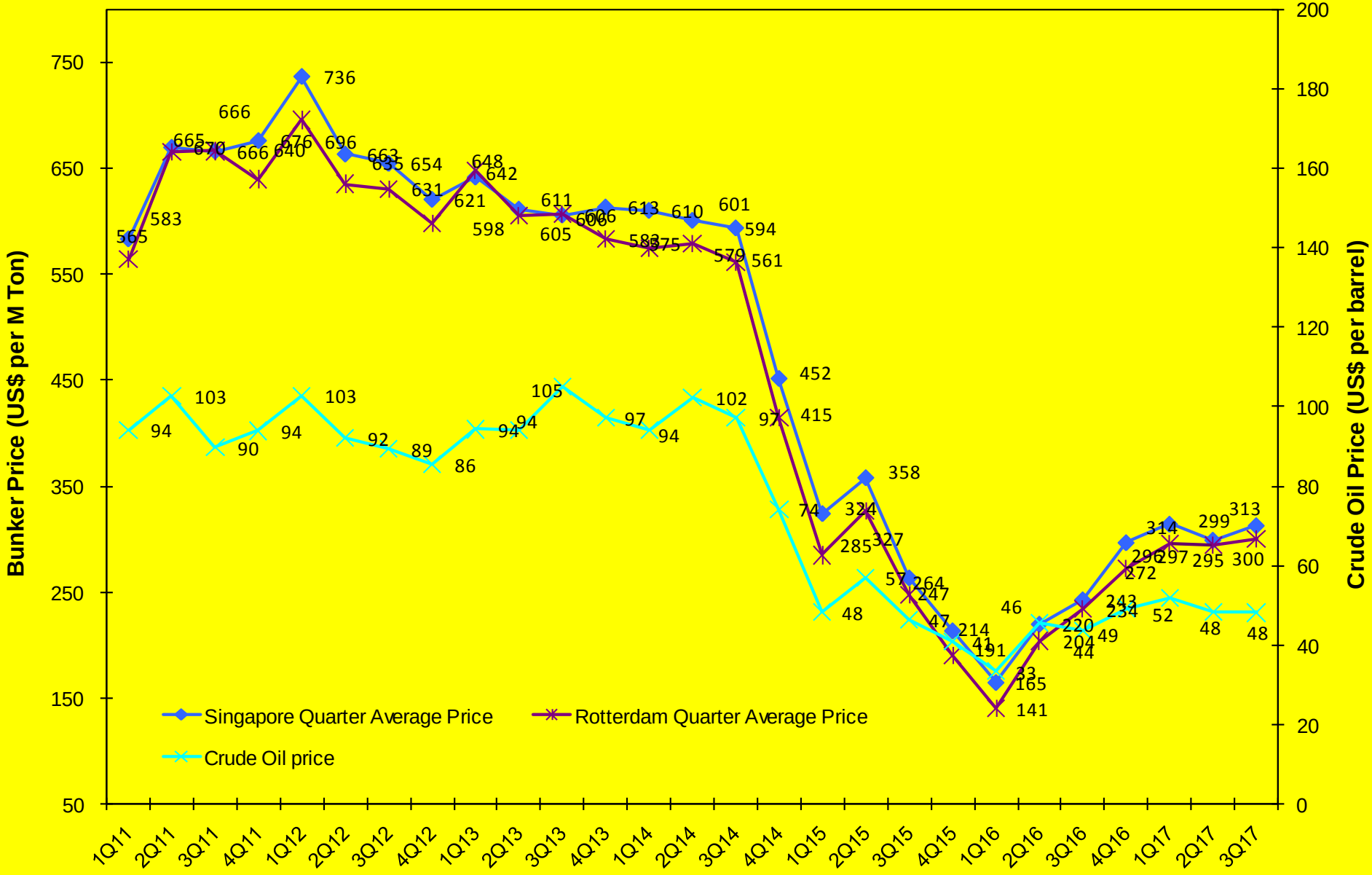


Source: Alphaliner Monthly, Oct 2017

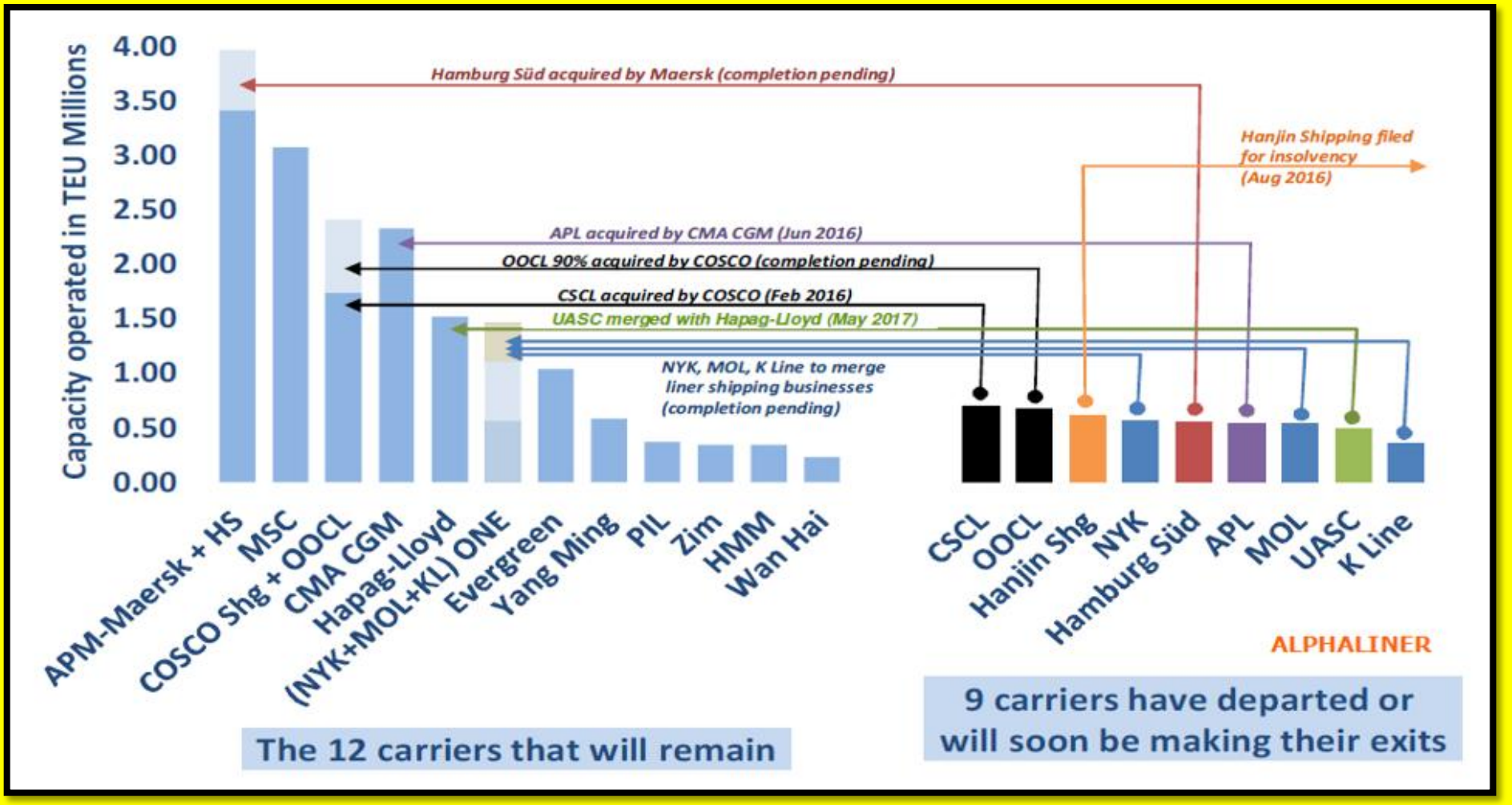
Charter Rates Records



Fluctuating Bunker Price



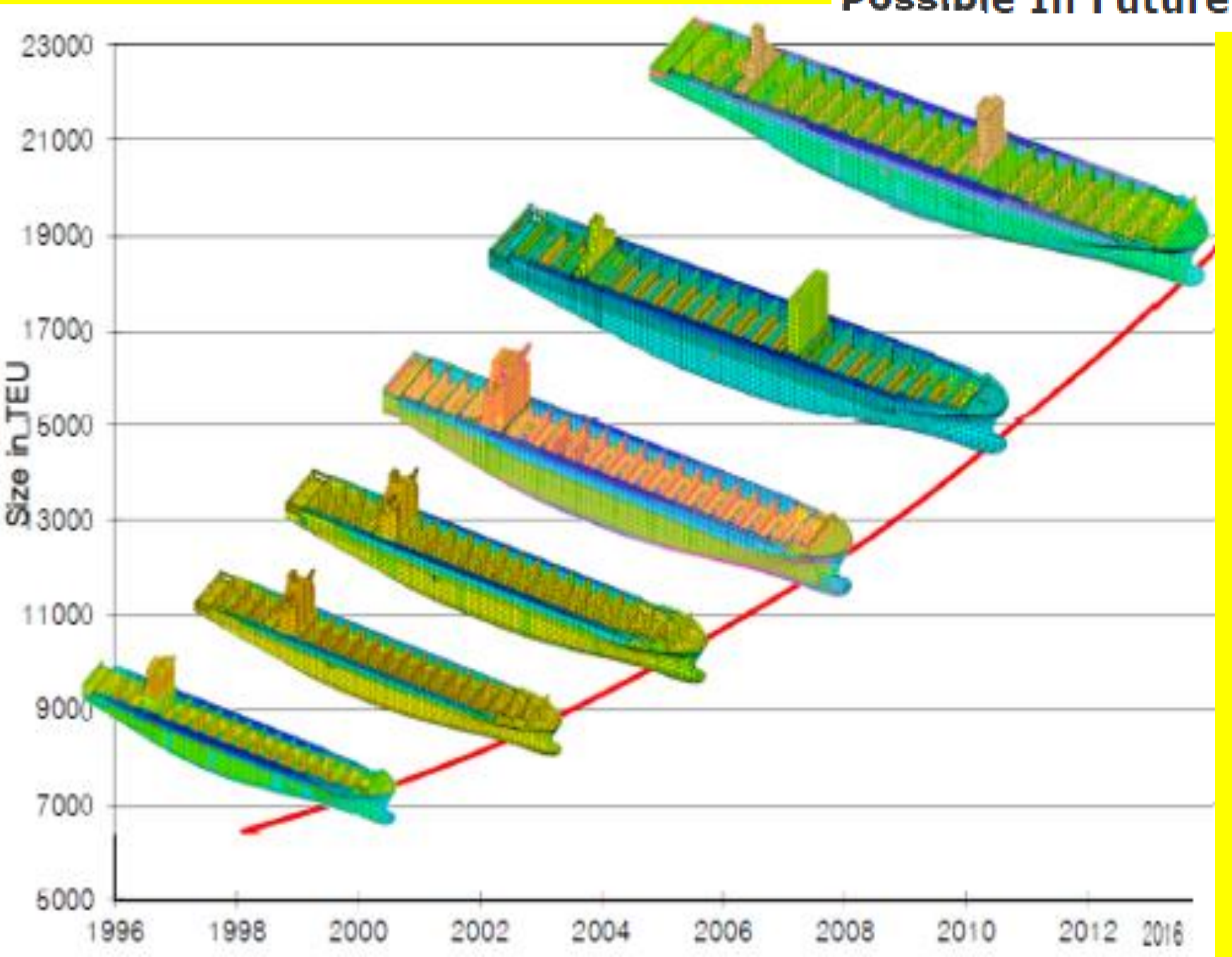
Evolving Boxshipping Landscape



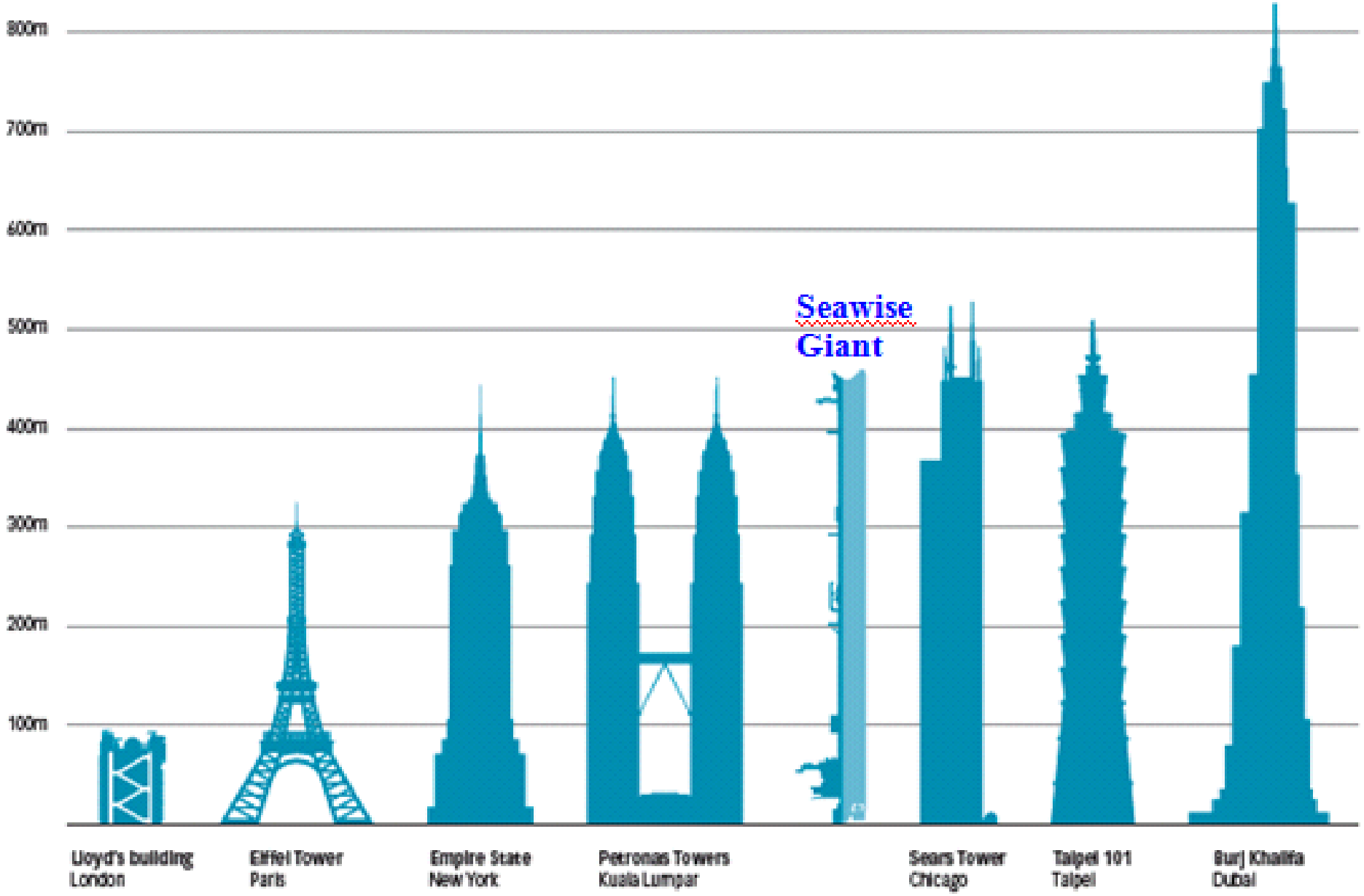
Source: Alphaliner

Design
of
Mega Boxship

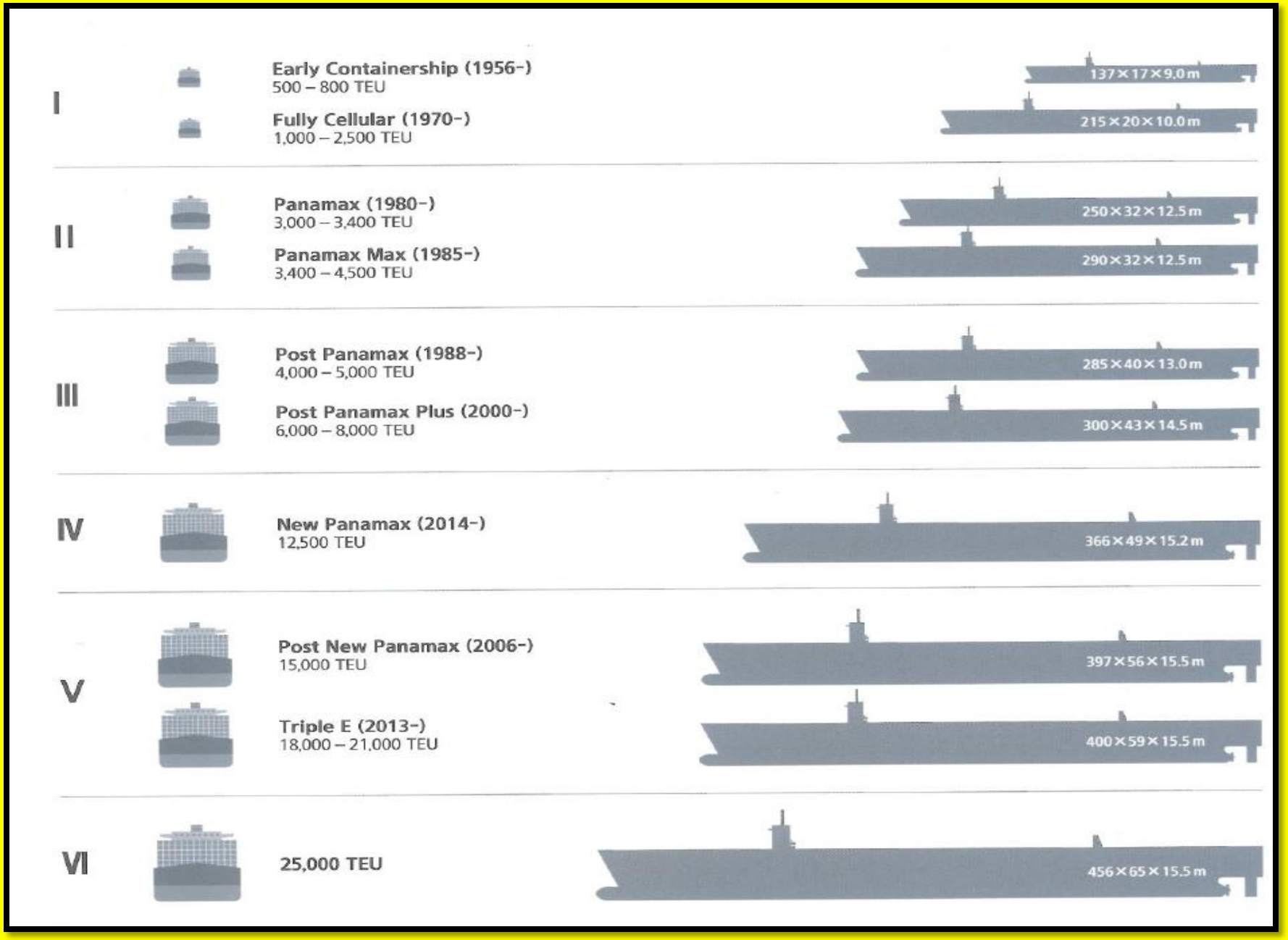
Possible In Future ?



Can Ships getting bigger?



Evolution of Mega Boxship in Size



Environmental Friendly

Features on OOCL Newbuildings

OOCL takes voluntary green initatives by incorporating the latest technology in all new ship designs to meet internationally recognized standards such as EEDI, the "Green Passport", as well as the "ENVIRO" or "EP" notations.

Alpha lubricator on main engine, for less cylinder oil consumption and less emissions

Electronically controlled Main Engine to optimize energy efficiency and emission control

Electric deck machinery instead of hydraulic oil type to avoid possible marine pollution (P Class)

World's largest waste incinerator to burn sludge oil instead of dumping, without emitting harmful substances

Tin and copper free self-polishing hull paint

Special ballast piping system for Ballast Water Management programme

Homogenizers installed to improve combustion quality and reduce sludge

Large capacity low-sulphur fuel tanks to control SOx emissions

Ballast treatment system fitted for our mega ships

Main engine with emission control to reduce NOx emissions

Black and grey water storage tank fitted for our mega ships

R407 C refrigerants for zero ozone depletion and lower Global Warming Potential

High efficiency rudder and propeller for lower fuel consumption and less emissions

Main Engine de-rating and EGB design for lower fuel consumption

Shaft generator for generating electricity at lower fuel consumption (SX class)

Air type stern tube seal with biodegradable stern tube oil system

Larger bilge tank storage enabling environmental friendly waste disposal ashore

CERTIFICATE

With a registered capacity of 8,063 TEU (i.e. standard shipping containers), the 322.97 m (1,059.61 ft) long OOCL Shenzhen is the world's largest container ship. The vessel, which was launched on 30 April 2003, was built by Samsung Heavy Industries Co., Ltd (South Korea) and is owned and operated by Orient Overseas Container Line Ltd (OOCL).

Keeper of the Records
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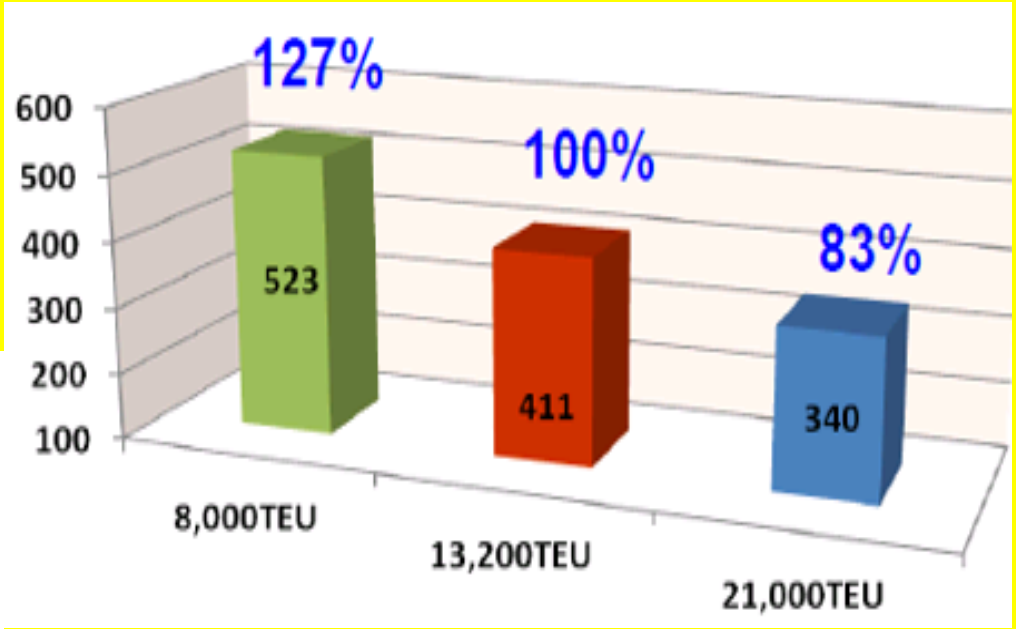
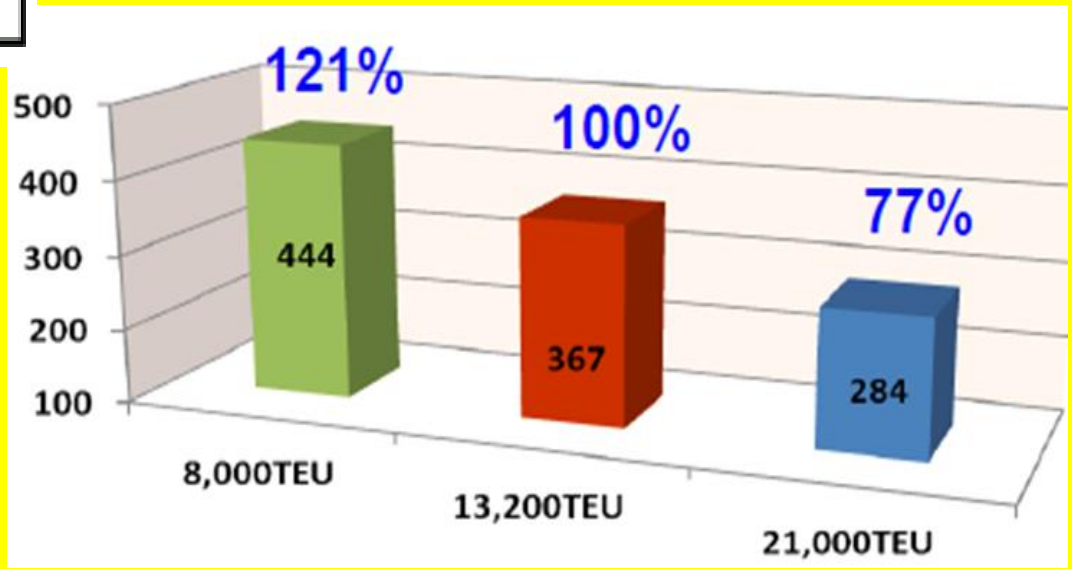
Feasibility Study by RFR on Ship Size and Speed

23 knots

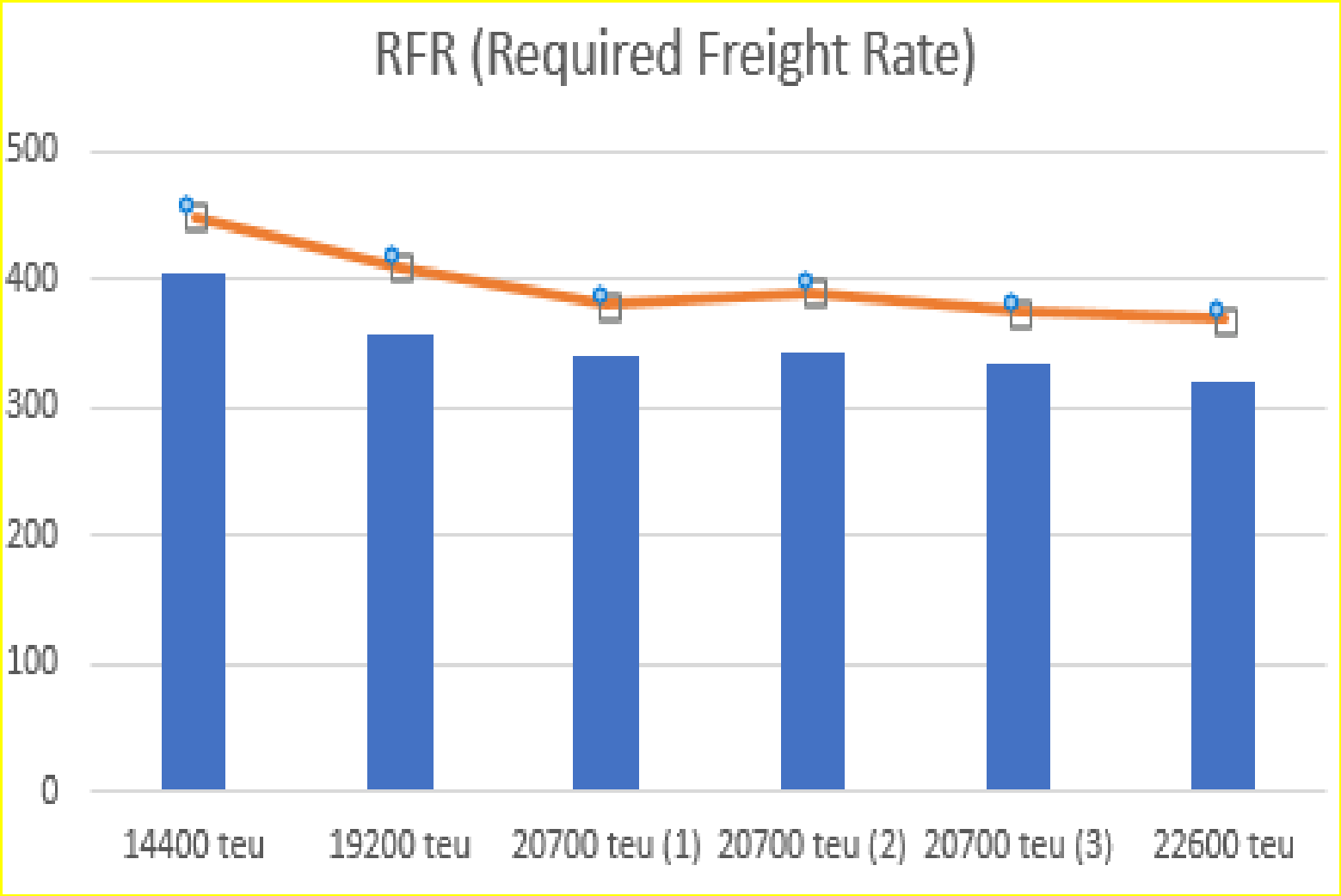


$$RFR = \frac{\text{Total Expense}}{\text{Carrying TEU}} \quad (\$/TEU)$$

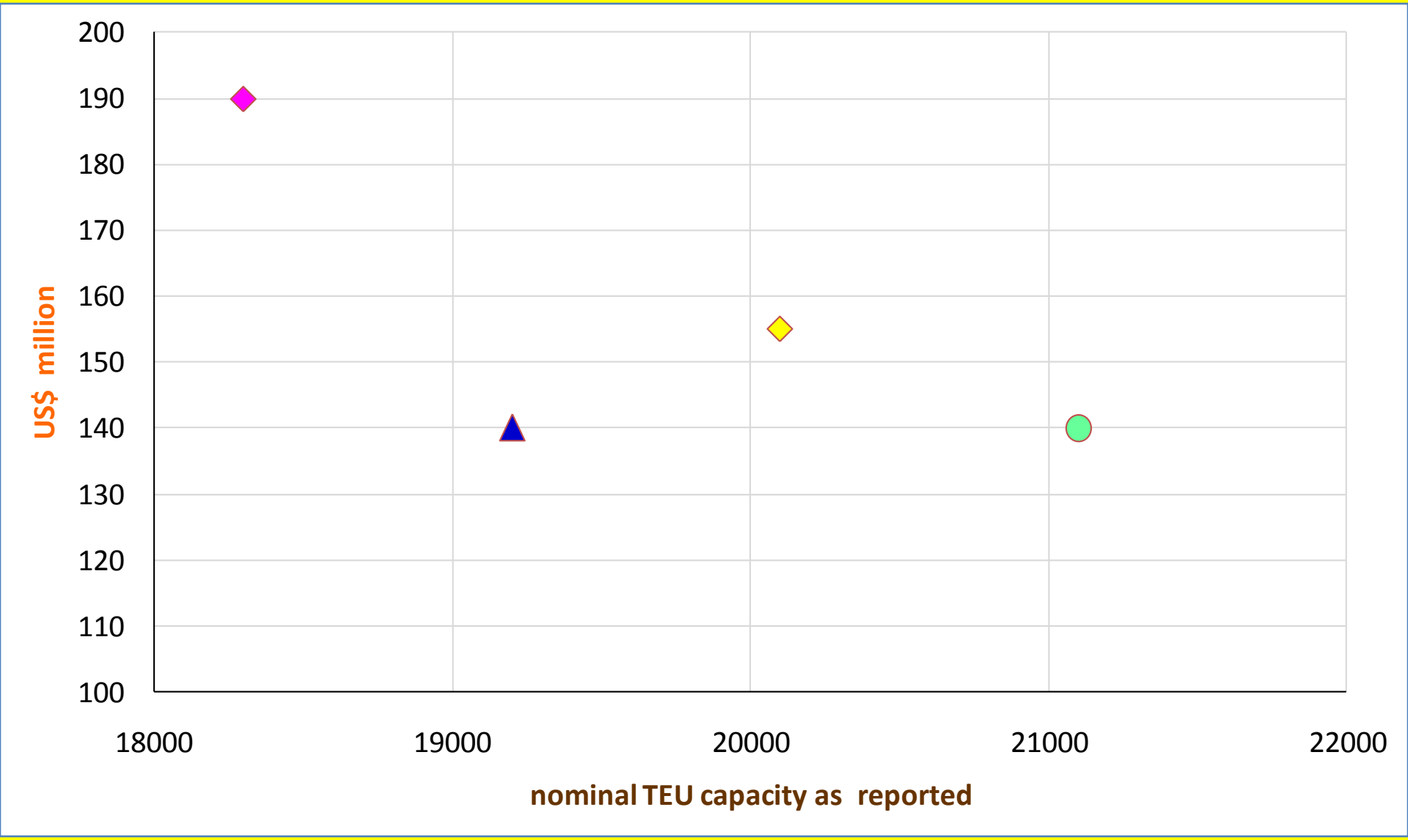
16 knots



Economic Analysis by RFR

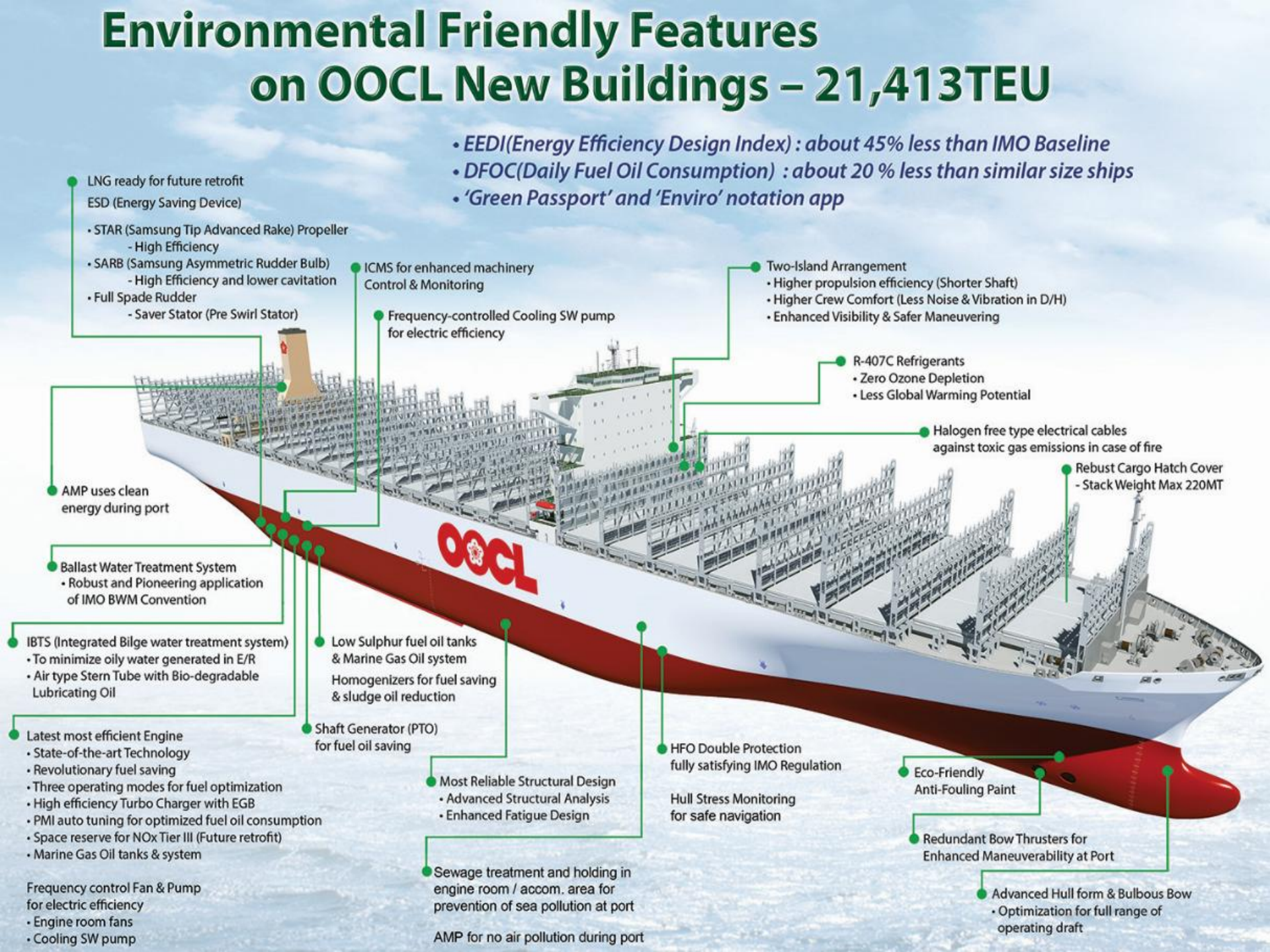


Reported mega boxship NB prices of representative units



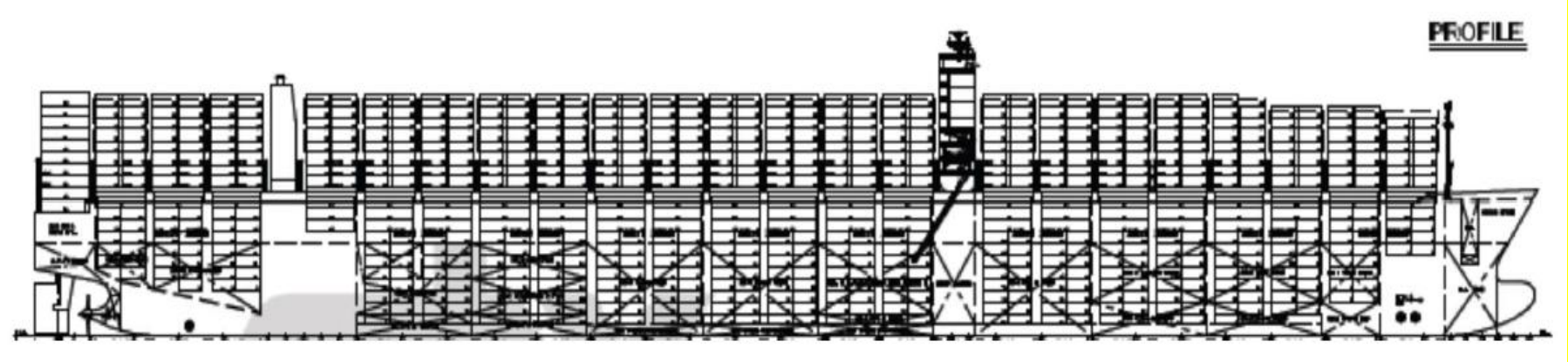
Environmental Friendly Features on OOCL New Buildings – 21,413TEU

- *EEDI(Energy Efficiency Design Index) : about 45% less than IMO Baseline*
- *DFOC(Daily Fuel Oil Consumption) : about 20 % less than similar size ships*
- *'Green Passport' and 'Enviro' notation app*




GUINNESS WORLD RECORDS™
CERTIFICATE
The largest container ship named OOCL Hong Kong with a registered capacity of 21,413 TEU, and was achieved by Orient Overseas Container Line Ltd, in Hong Kong, China, on 18 May 2017
OFFICIALLY AMAZING

Parameter of the ship length for Mega Boxship

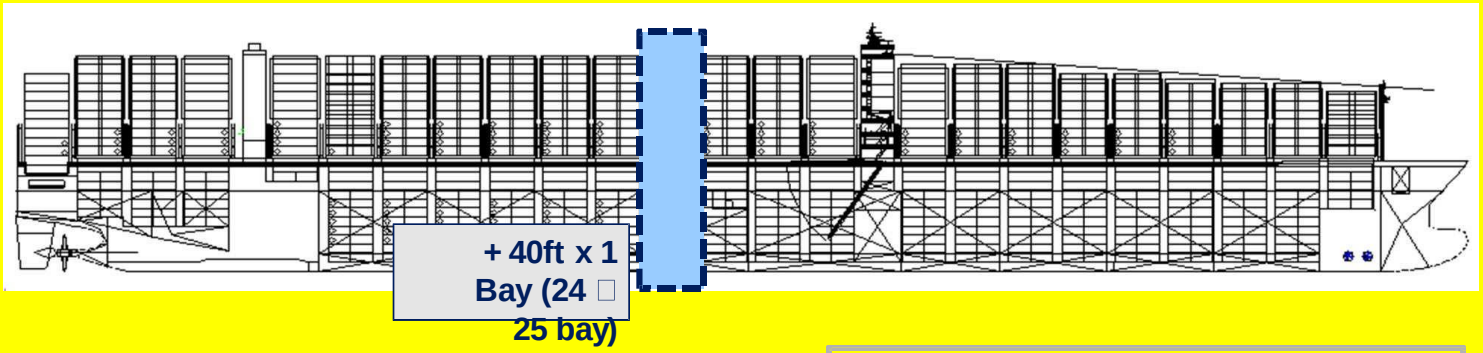


- An even number of 40´bays is needed between the engine room and deck house area from damage stability point of view
- The arrangement aft of engine as well as forward of the deck house has an influence on the nominal and loadable container capacity
- Ship length has the largest influence on the global strength

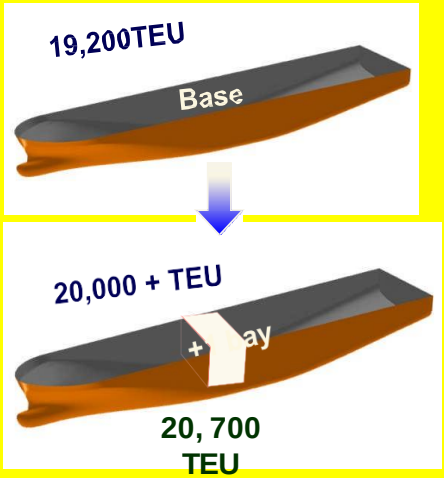
Case 1 ≅ 21,000TEU (Length Increase)

❖ **Profile**

19,200 TEU (Basis) → 20,694TEU (+1 bay addition)



Item		19,200 TEU (Basis)	20,700TEU Case 1
Ship's Length		400 m	415 m
Bay (on Deck)		24	25
Total	Deck	10,964	11,996 (+1,032)
	Hold	8,190	8,698 (+508)
	Total	19,154	20,694 (+1,540)



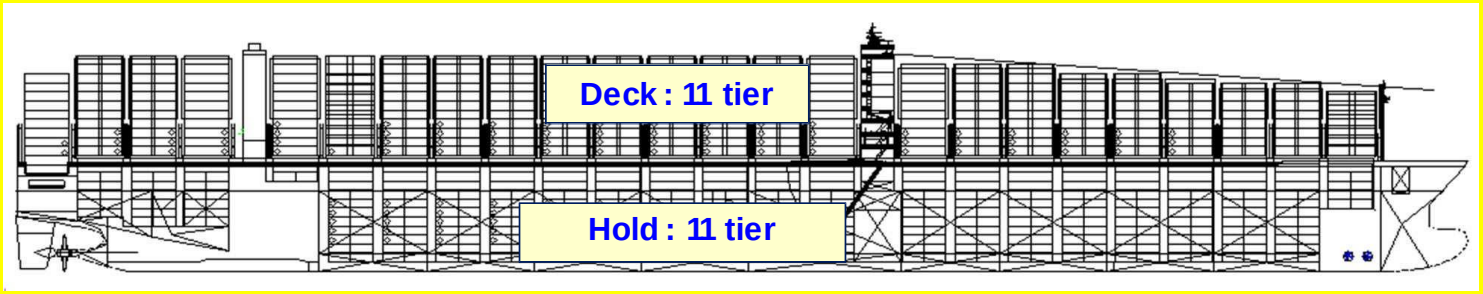
[Case 1]

Case 2 ≃21,000TEU (Breadth Increase)

❖Profile

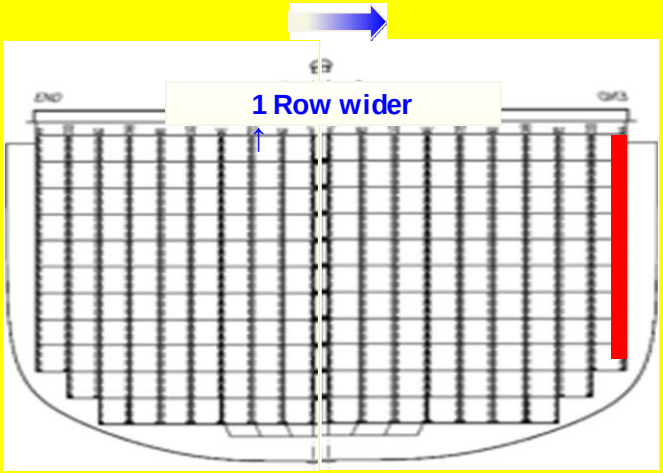
19,200 TEU
(Basis)

20,722TEU
(+1 row addition)



❖Particular

Item		19,200 TEU (Basis)	20,700TEU Case 2
Ship's Breadth		58.8 m	62.0 m
Row (on Deck)		23	24
Total	Deck	10,964	12,072 (+1,108)
	Hold	8,190	8,650 (+460)
	Total	19,154	20,722 (+1,568)

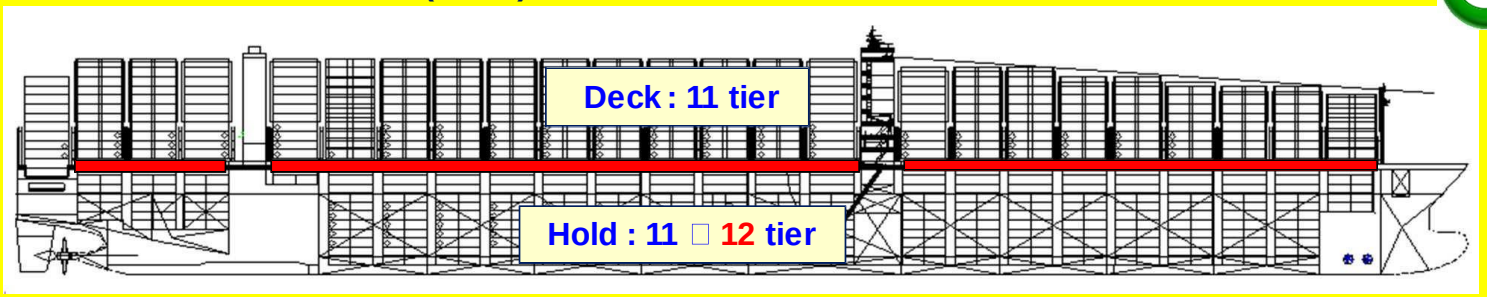


Case 3 ≒21,000TEU (Depth Increase)

❖Profile

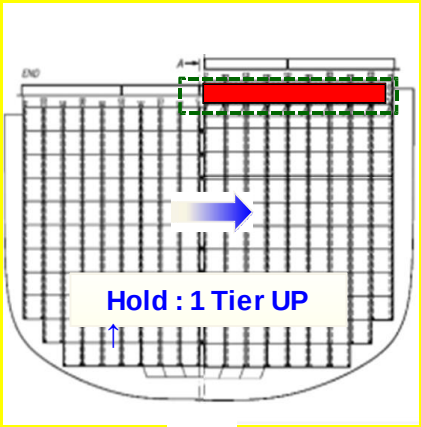
19,200 TEU
(Basis)

20,752TEU
(In Hold +1 tier)



❖Particular

Item		Base	20,700TEU Case 3
Ship's Depth		30.2 m	32.8 m
Tier (in Hold / on Deck)		11 / 11	12 / 11
Total	Deck	10,964	11,562 (+598)
	Hold	8,190	9,190 (+1,000)
	Total	19,154	20,752 (+1,598)



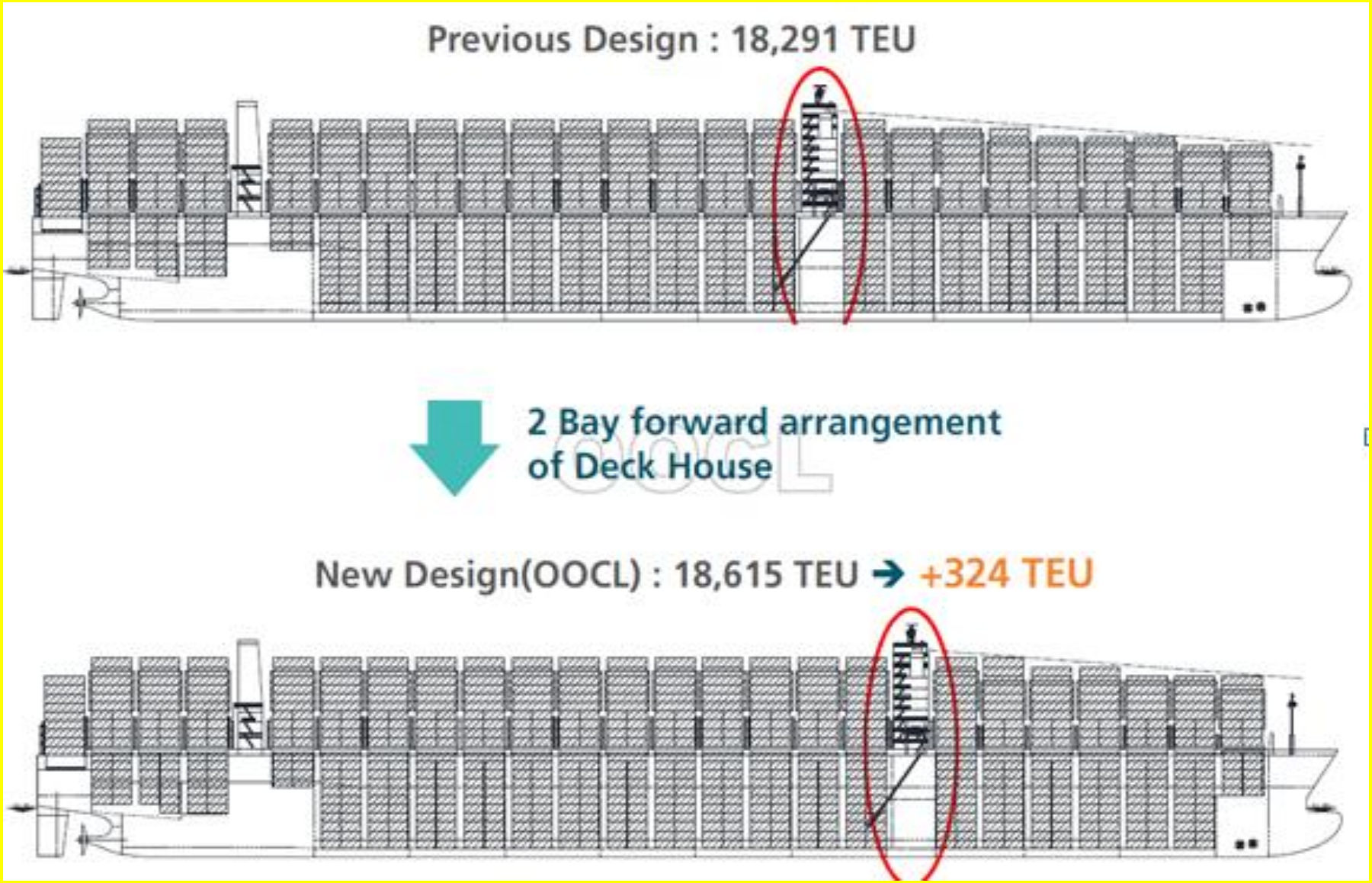
20,700 TEU
[Case 3]

Feasibility Study on 20,000+teu ships

Ship Size			19,000TEU	21,000TEU			22,800TEU
				Case 1	Case 2	Case 3	
Capacity		teu	19,000	20,500	20,700	21,000	22,800
LOA / B / D		m	400 / 59/ 30	415 / 59/ 30	400 / 62/ 30	400 / 59/ 32.5	415 / 62 / 32.8
Bay		Bay	24	25	24	24	25
Row		Row	23	23	24	23	24
Tier	On Deck	Tier	11	11	11	11	11
	In Hold		11	11	11	12	12
Dimension		-	Base	Length Increase	Breadth Increase	Depth Increase	+Length +Breadth + Depth

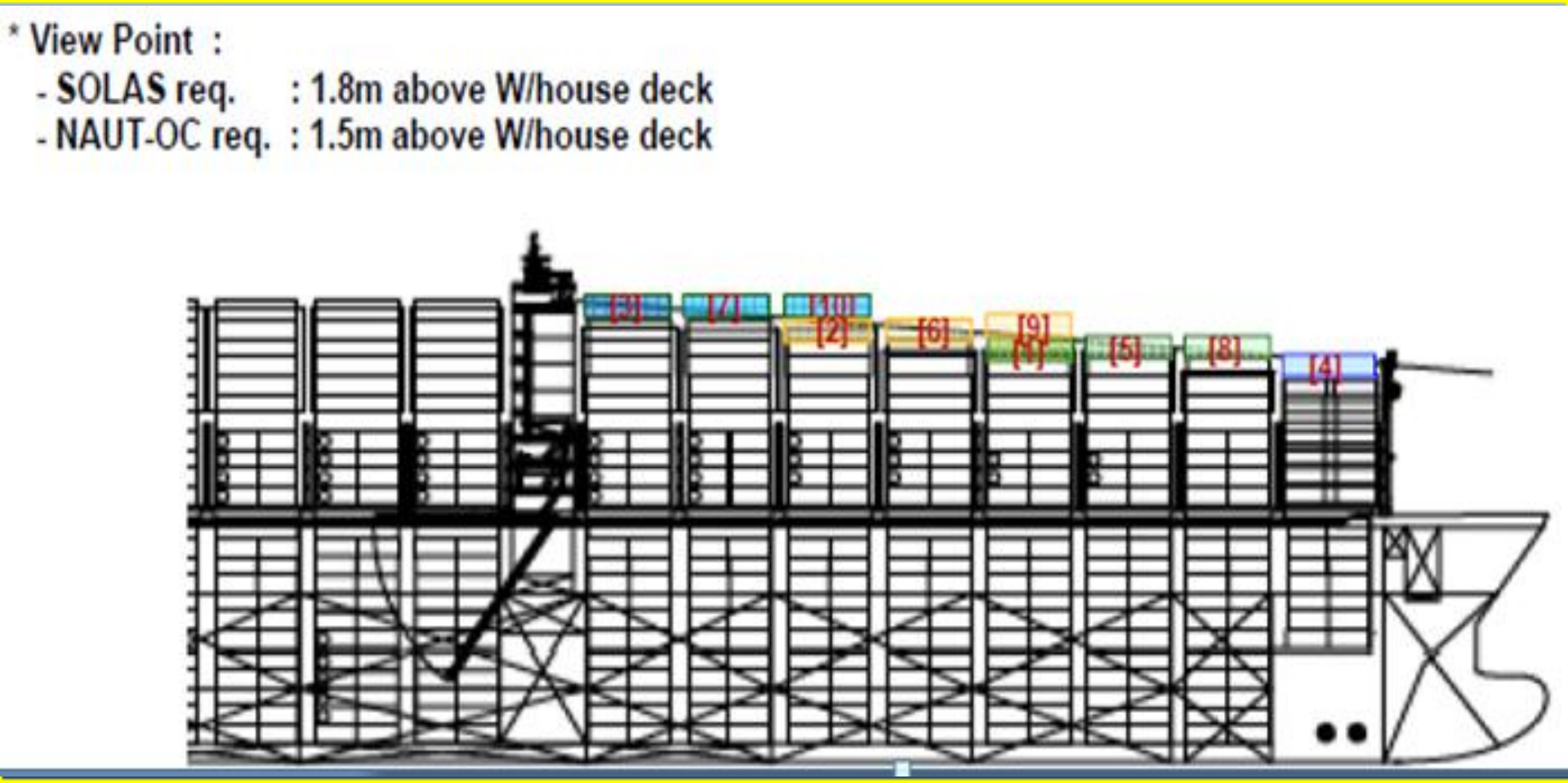
Bay / Row	23 (L=385m)	24 (L=400m)	25 (L=415m)
22 (56.5 m)		17,000TEU	
23 (59.0 m)		19,000TEU (Base)	20,800 TEU (Case 1)
24 (62.0 m)		20,700 TEU (Case 2)	22,800 TEU

Capacity study verse Deckhouse location

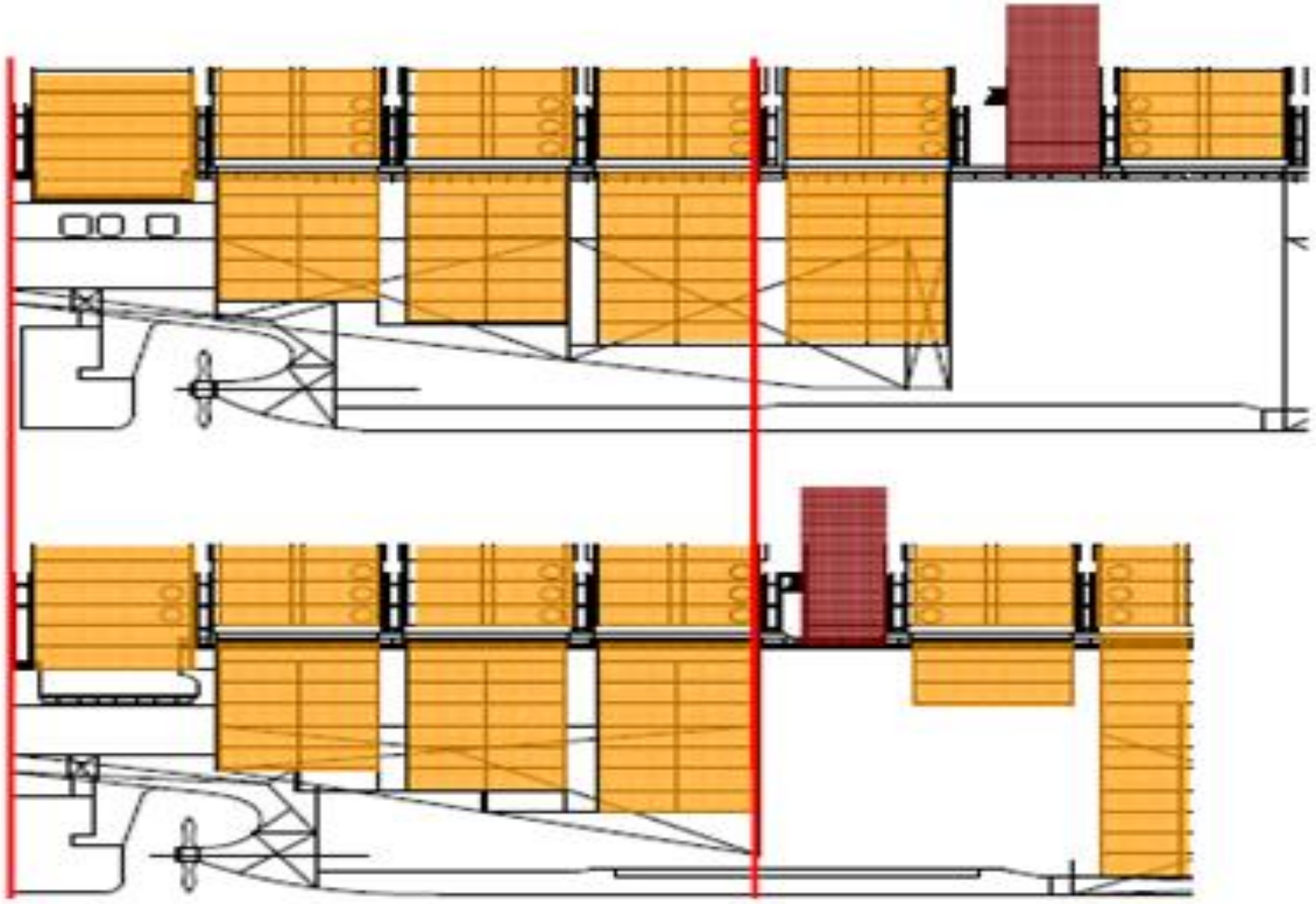


Feasibility study on Capacity verse Air Draft

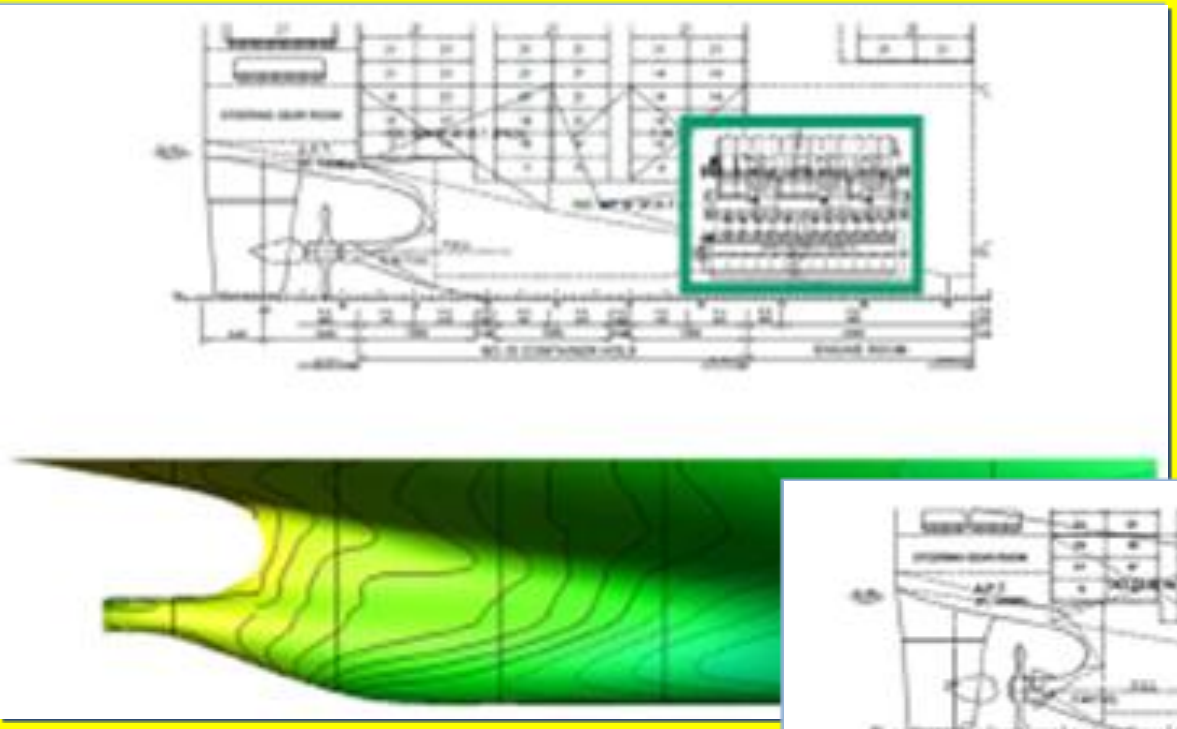
* View Point :
  - SOLAS req. : 1.8m above W/house deck
  - NAUT-OC req. : 1.5m above W/house deck

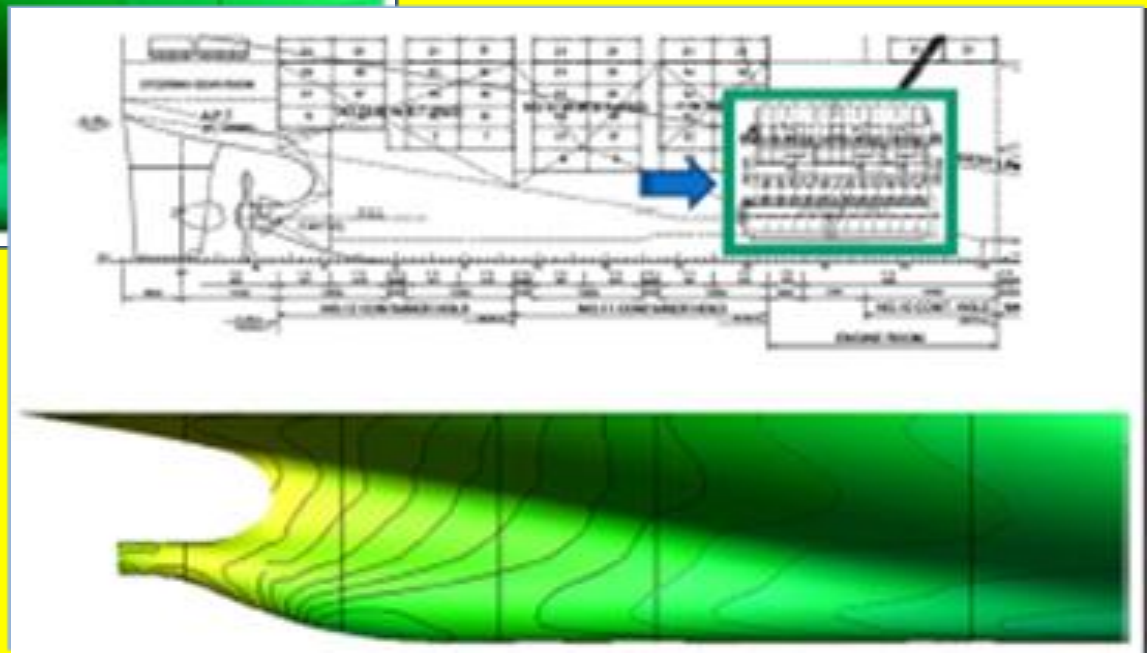


Capacity study verse Funnel location



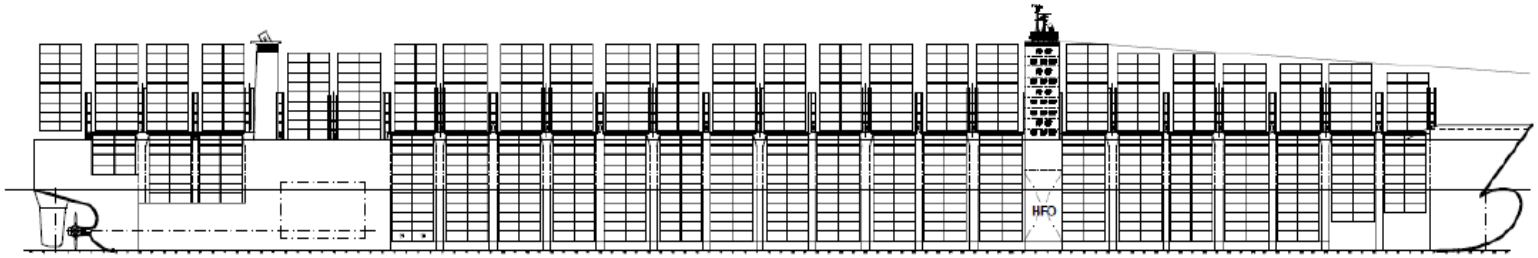
Fuel Efficiency Study verse M/E location



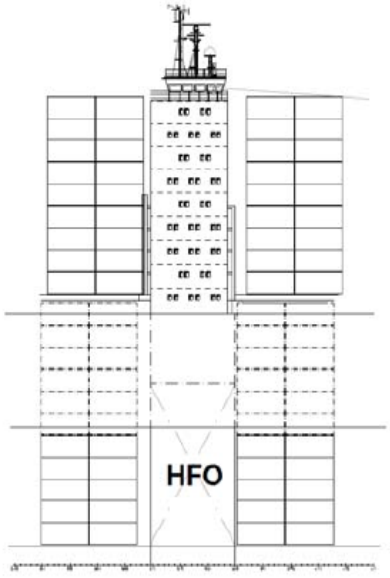


Influence of fuel on the principal dimensions

- **Dual fuel main engine and auxiliaries**

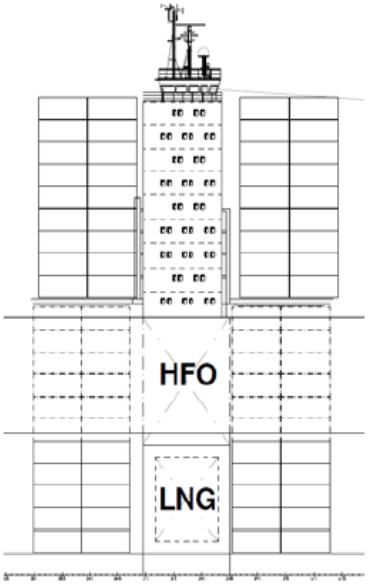


40 days range on HFO



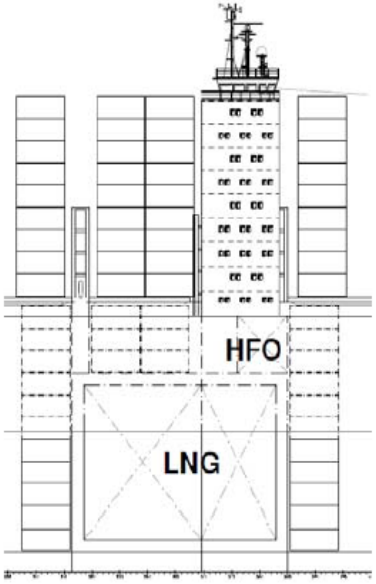
33 days range on HFO

7 days range on LNG

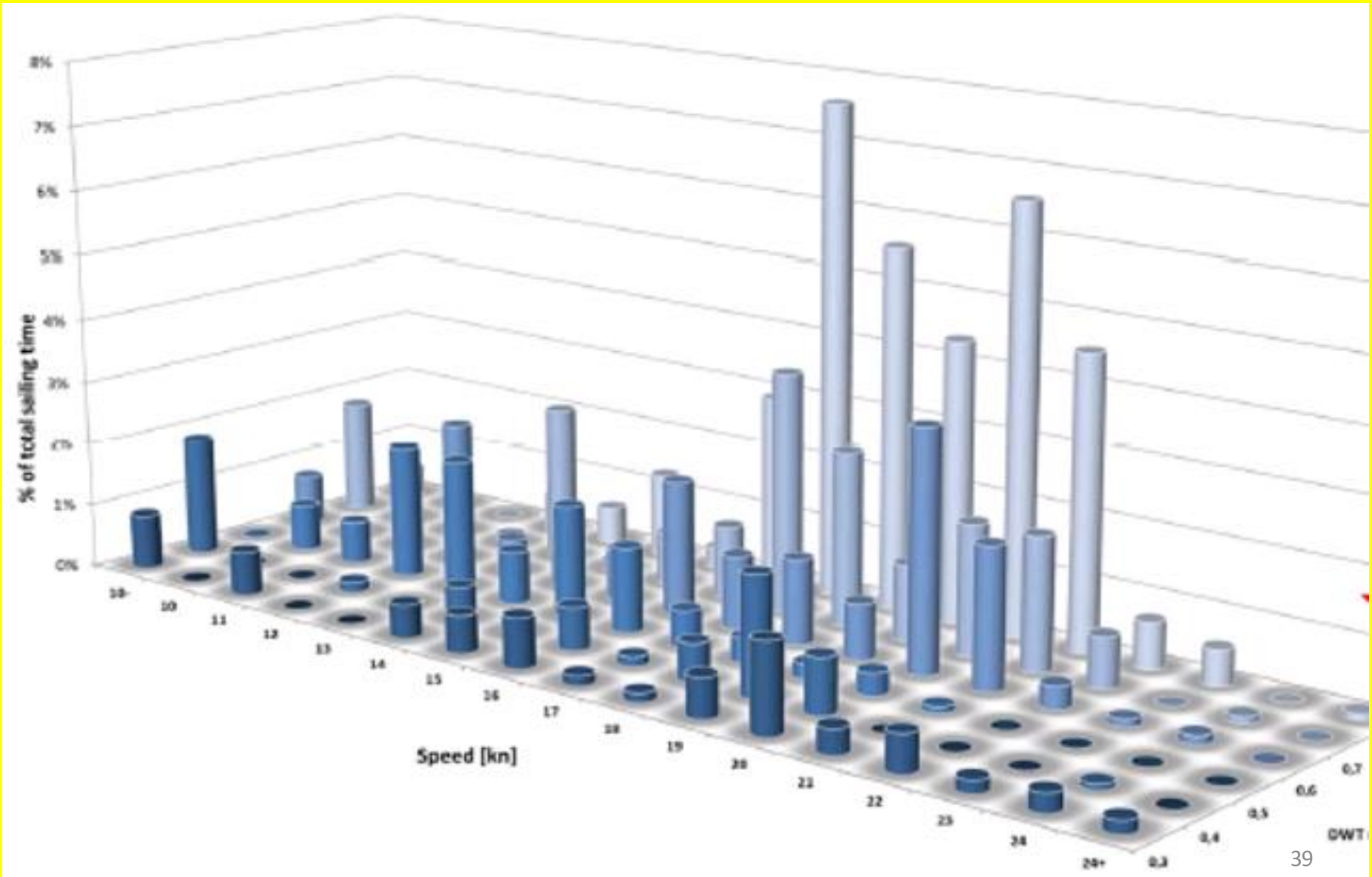


7 days range on HFO

33 days range on LNG



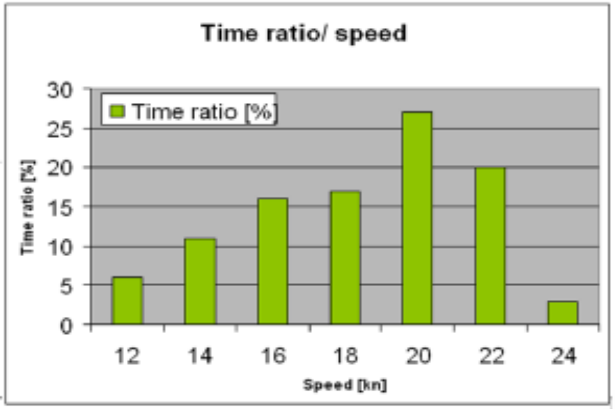
Operation Profile for Hull Optimization



Optimization for Operational Profile

Optimization for operational profile

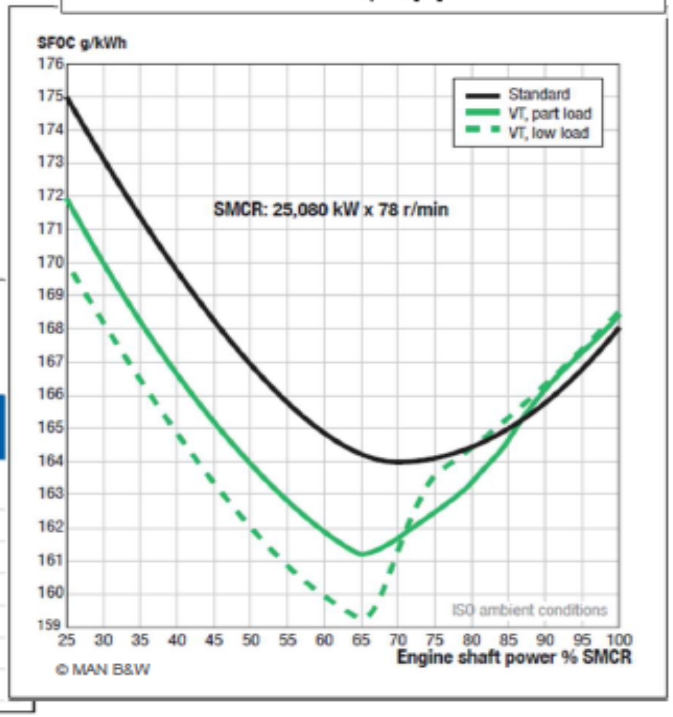
- SFOC optimized load ranges
  - High load
  - Part load
  - Low load
- Measures
  - T/C cut-out
  - Variable T/C turbines (VT)
  - Exhaust Gas Bypass (EGB)
  - Engine Control Tuning (ECT)



- ECT: Engine Control Tuning
- VT: Variable Turbine Area
- EGB: Exhaust Gas Bypass

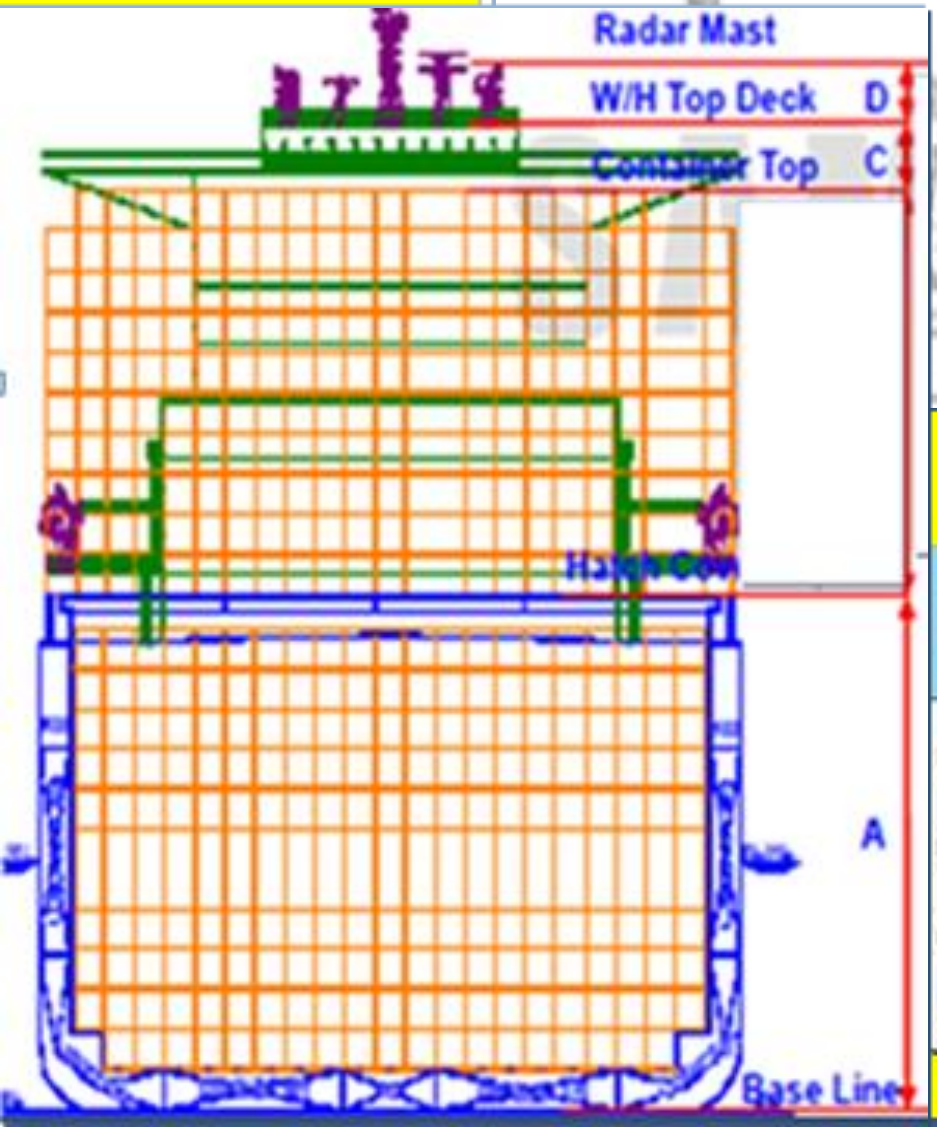
© MAN B&W

SFOC optimised load range	Tuning methods	SFOC Change [g/kWh]				
		35%	50%	65%	80%	100%
High load (85–100%)	Standard L_1 engine	3.5	–1	–3.5	–3.5	0
Part load (50-85%)	ECT	2.5	–2	–4.5	–4.5	3
	VT	0.5	–4	–6.5	–4.5	0.5
	EGB	0.5	–4	–6.5	–4.5	1.5
Low load (25-70%)	ECT	1	–3.5	–6	–3.5	1.5
	VT	–1.5	–6	–8.5	–3.5	0.5
	EGB	–1.5	–6	–8.5	–3.5	1.5



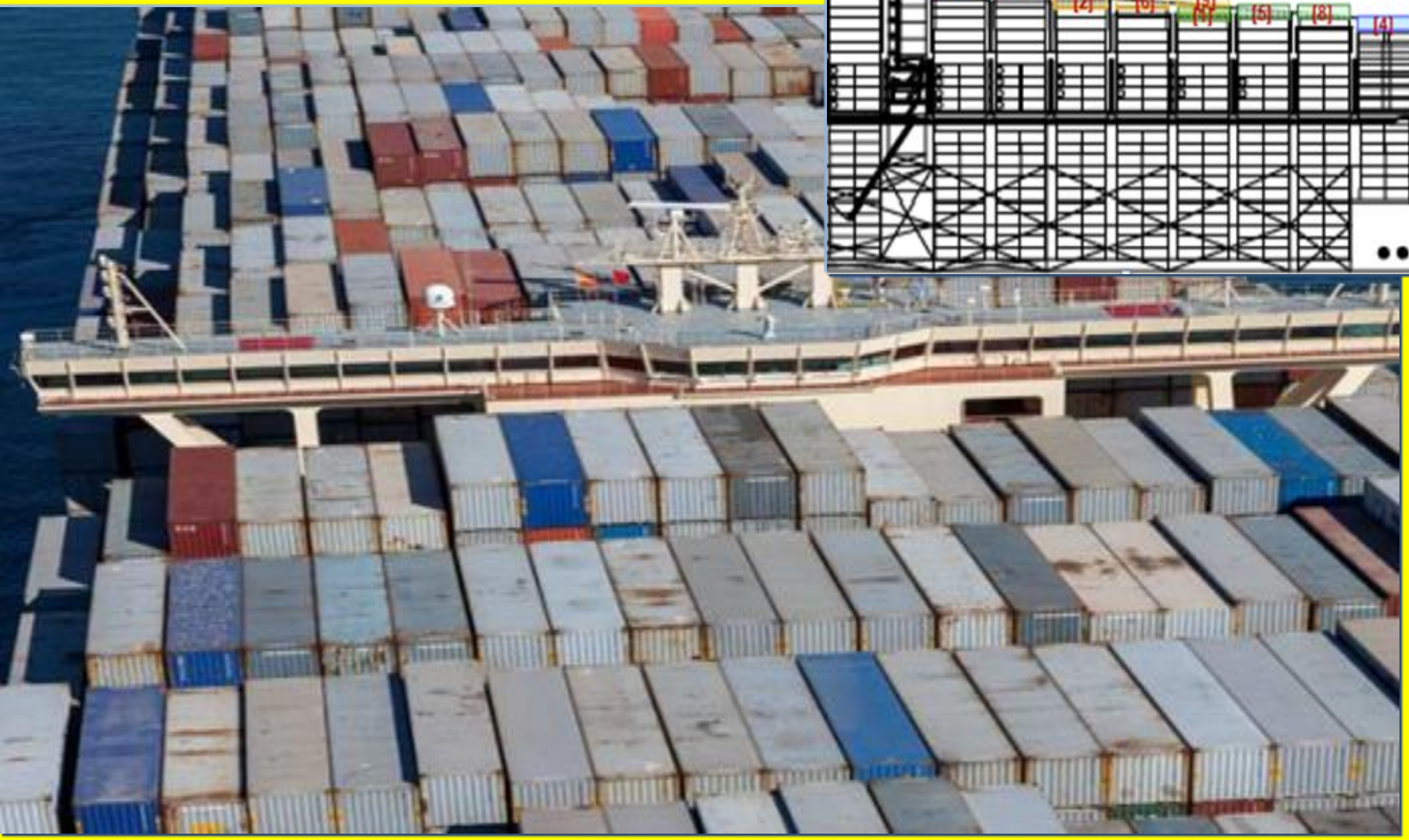
Study on Ship Air Draft at Terminal

Detail Radar Mast



Port	Air draught from water level
Gerald Desmond Bridge	47,55 m
Osaka Bay Bridge	47,30 m
Chiwan Bridge – Hong Kong	53,00 m
Koehlbrand Bridge	53,00 m

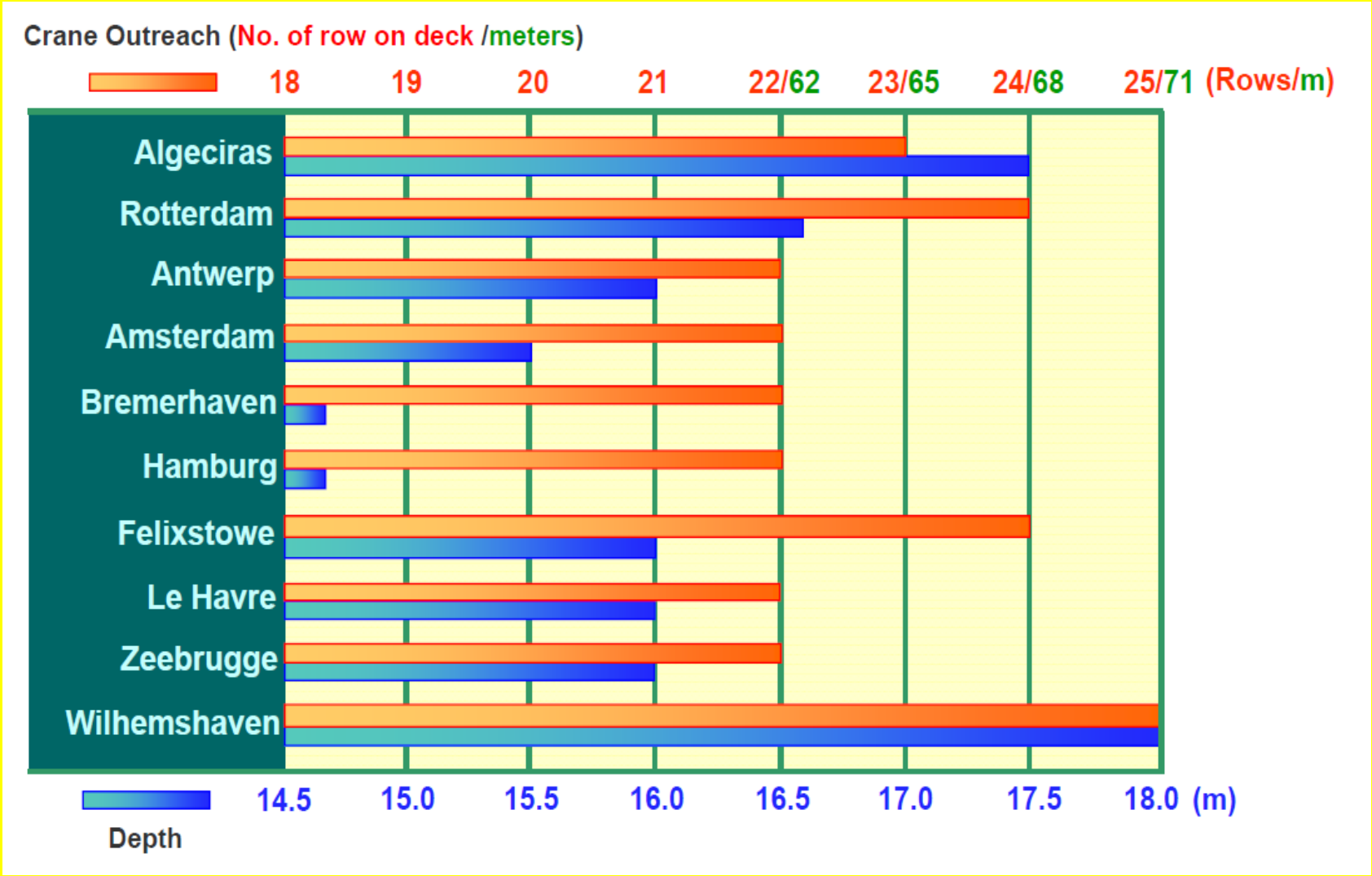
Visibility for the Seafarer and Pilot



Major container terminals on the Asia/Europe route

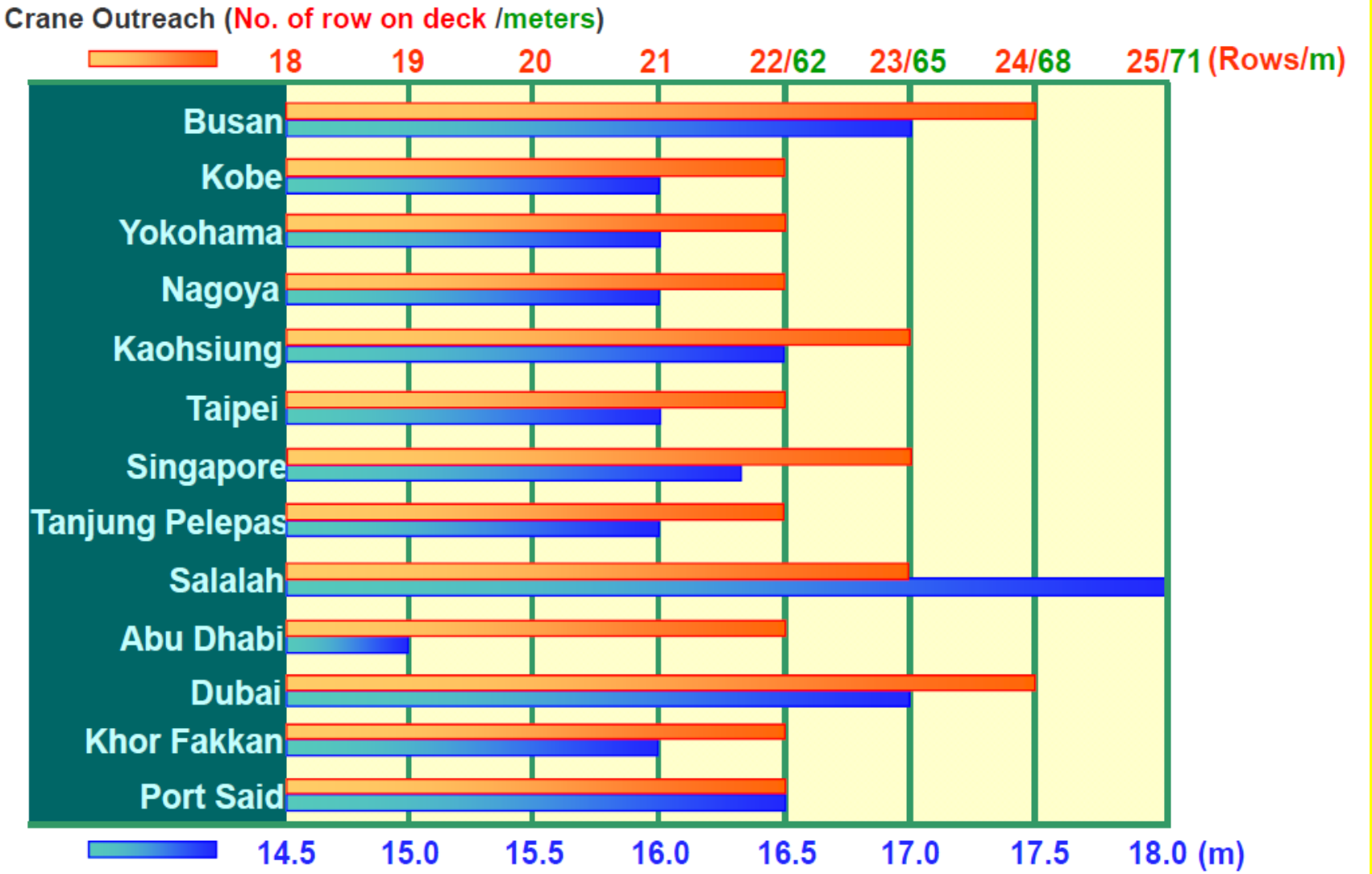
Port Limitation of various ports

(Crane outreach and waterfront depth **in Europe)**



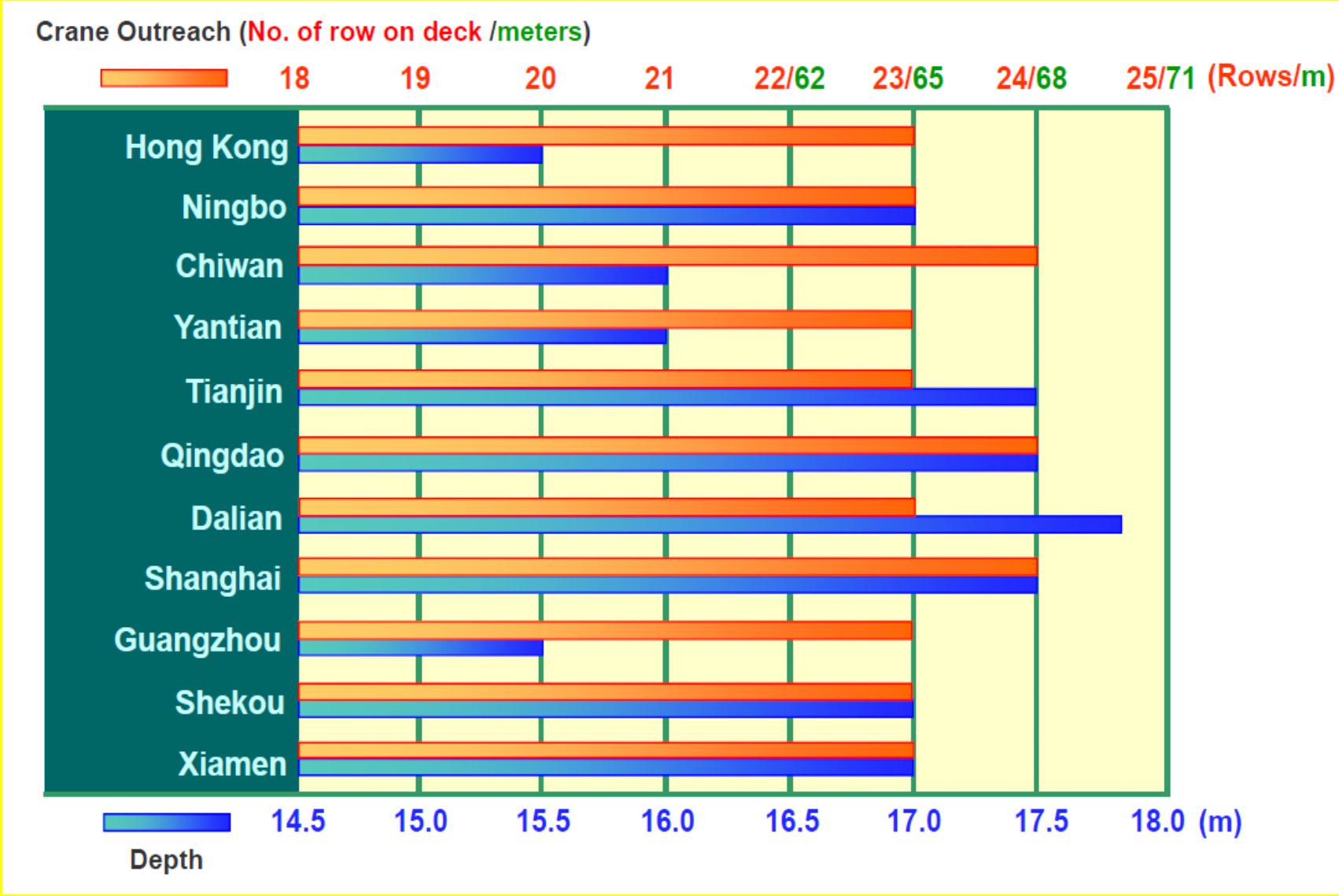
Port Limitation of various ports

(Crane outreach and waterfront depth in Asia / Middle-East)

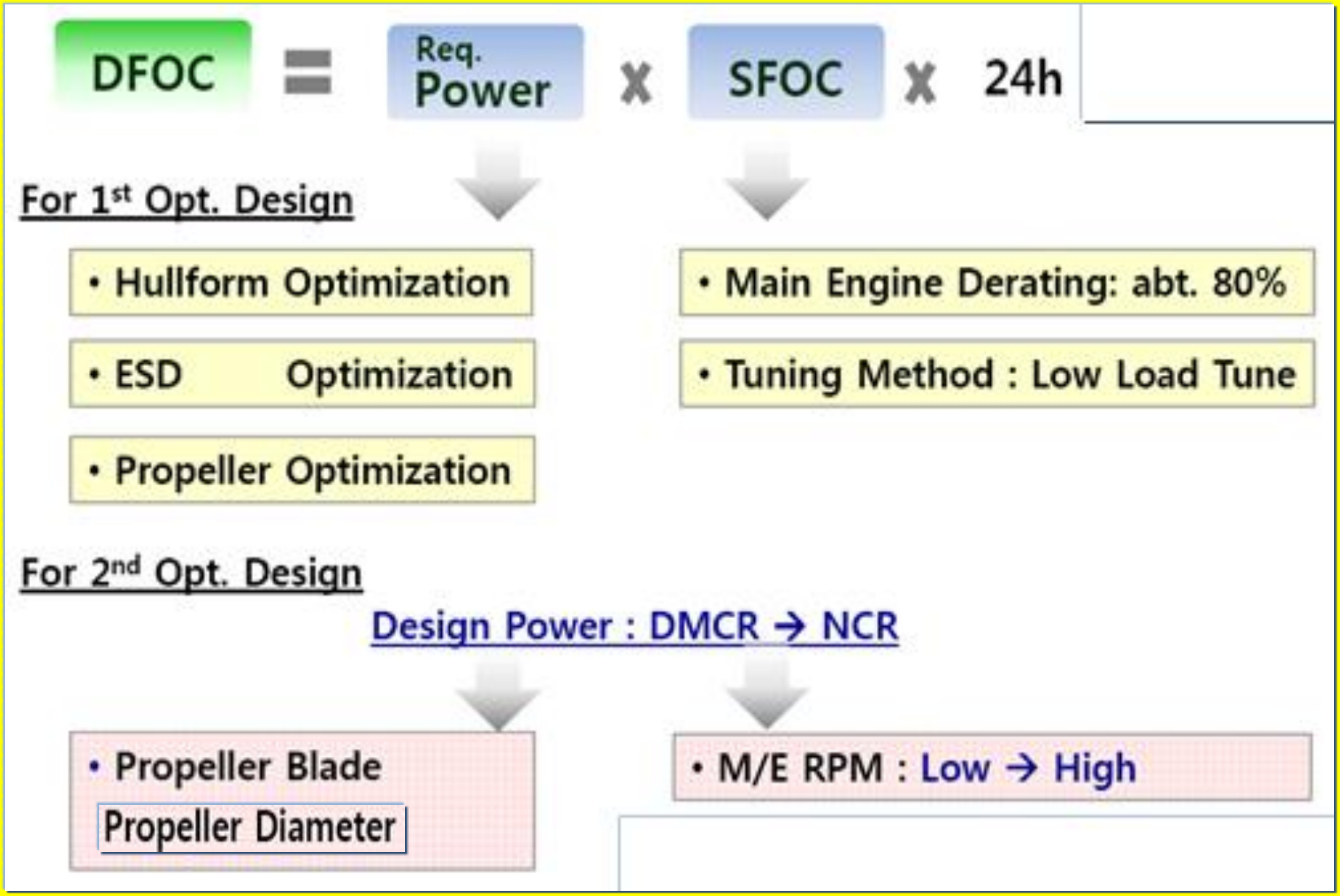


Port Limitation of various ports

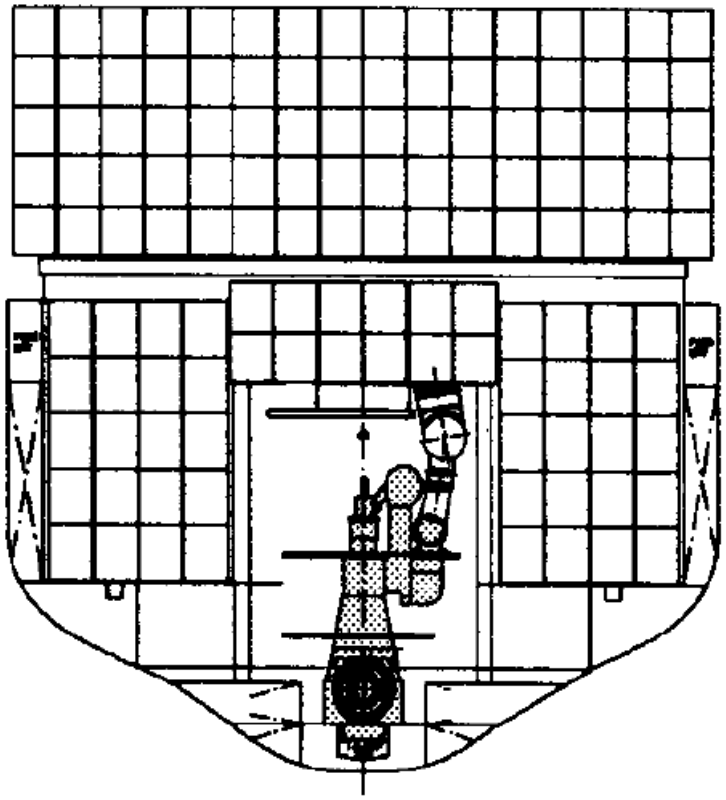
(Crane outreach and waterfront depth in China)



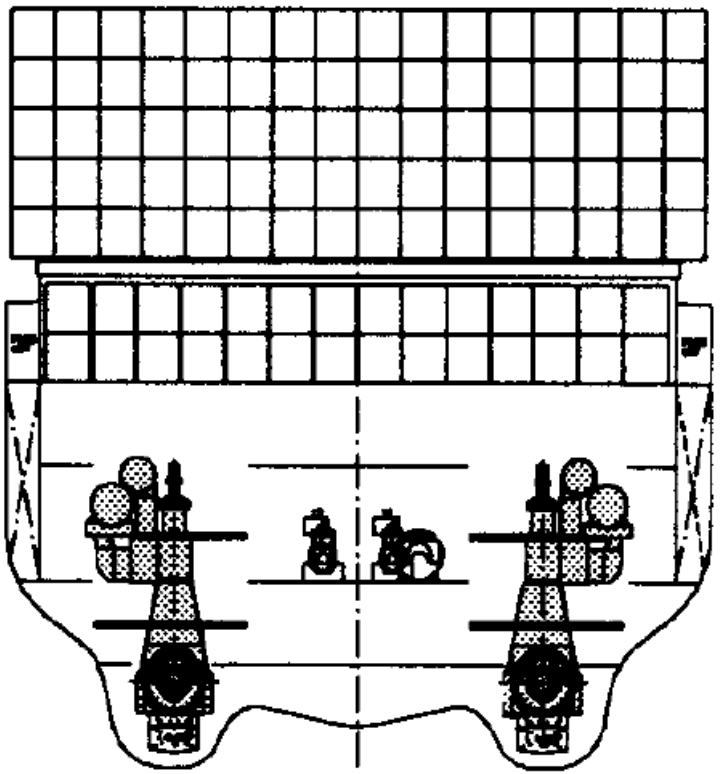
Progress to enhance the Ship's Fuel Performance



Selection on Single or Twin screw design

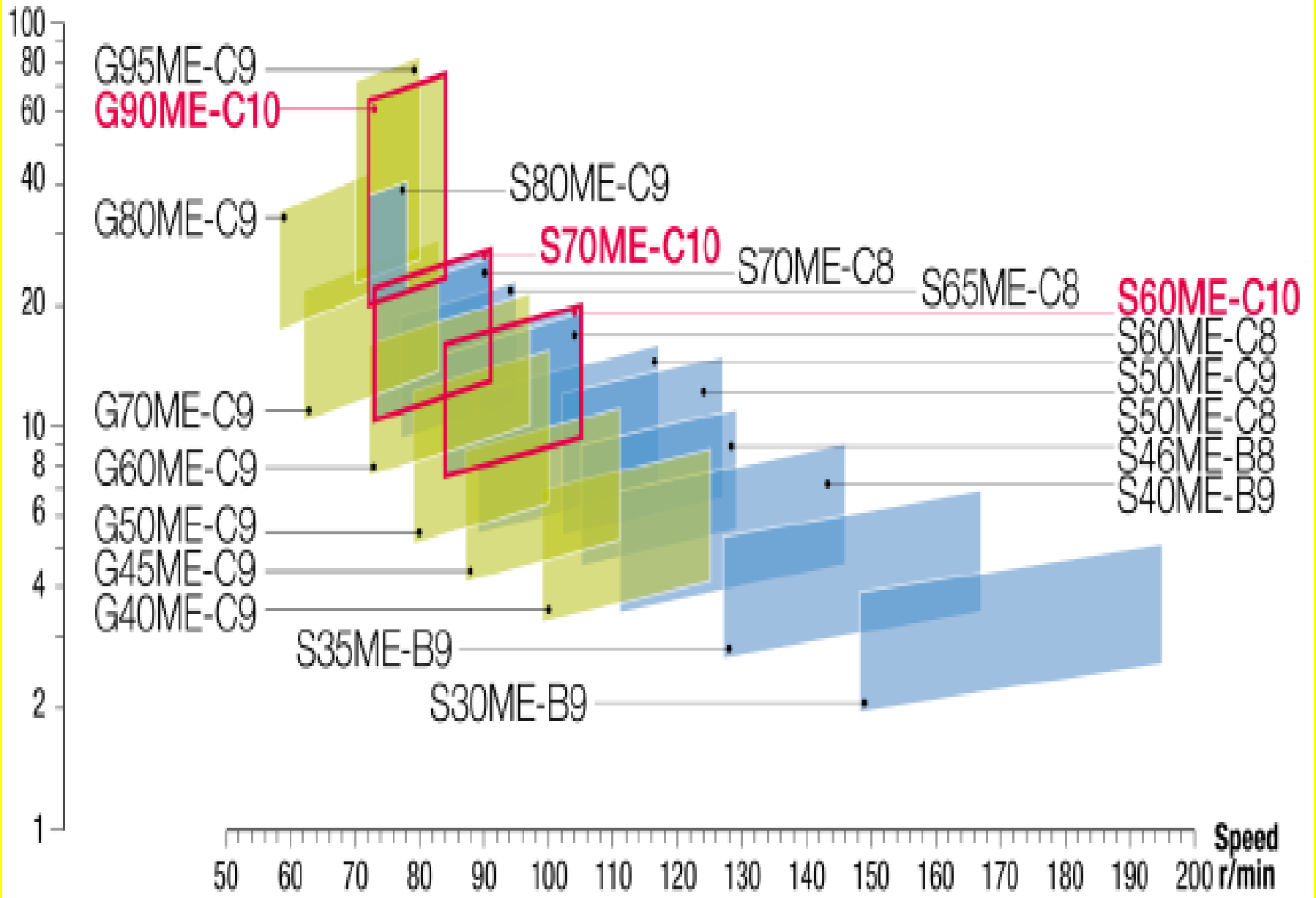


12 or 14-cylinders

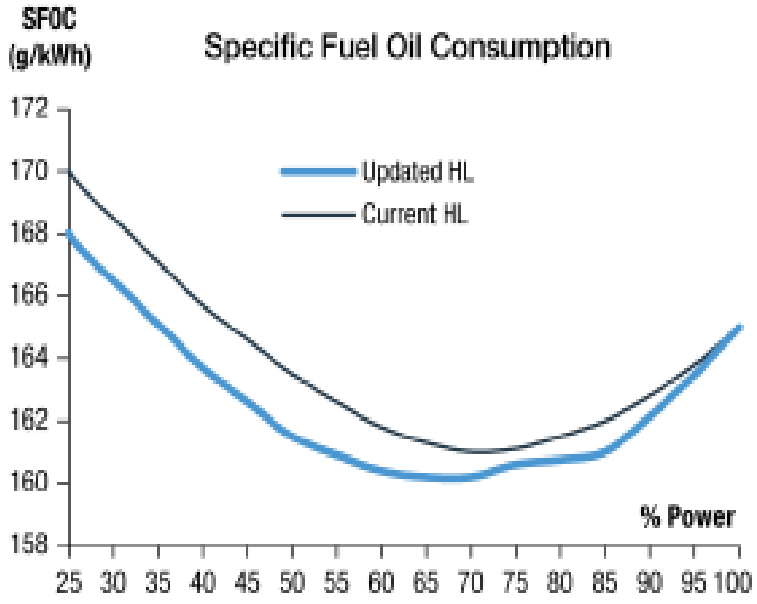


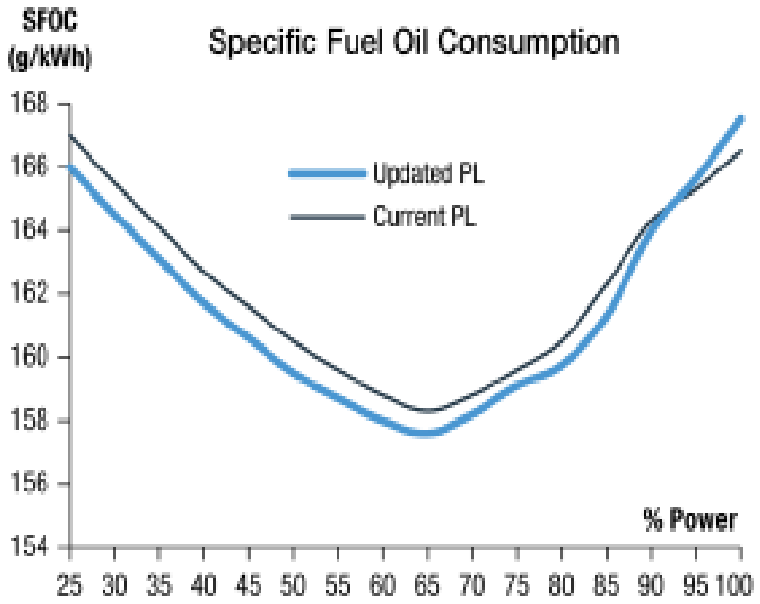
2 x 8-cylinders

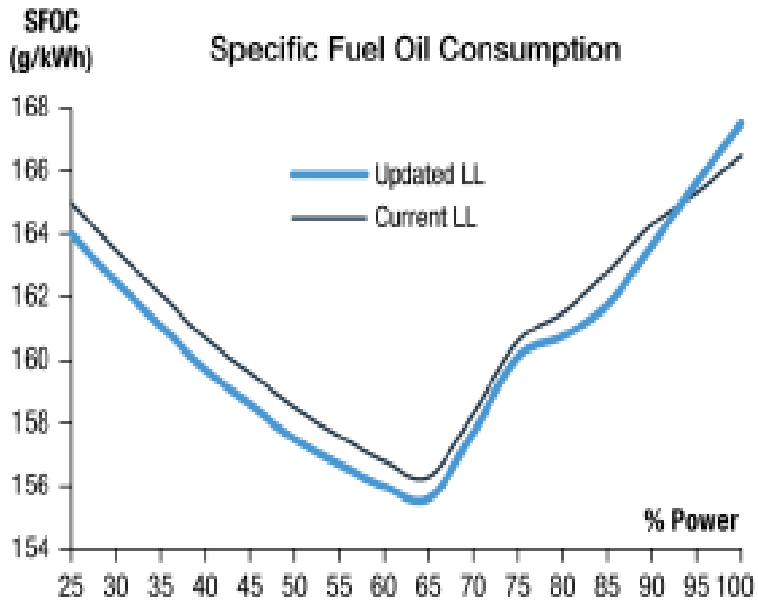
Main Engine Type Selection



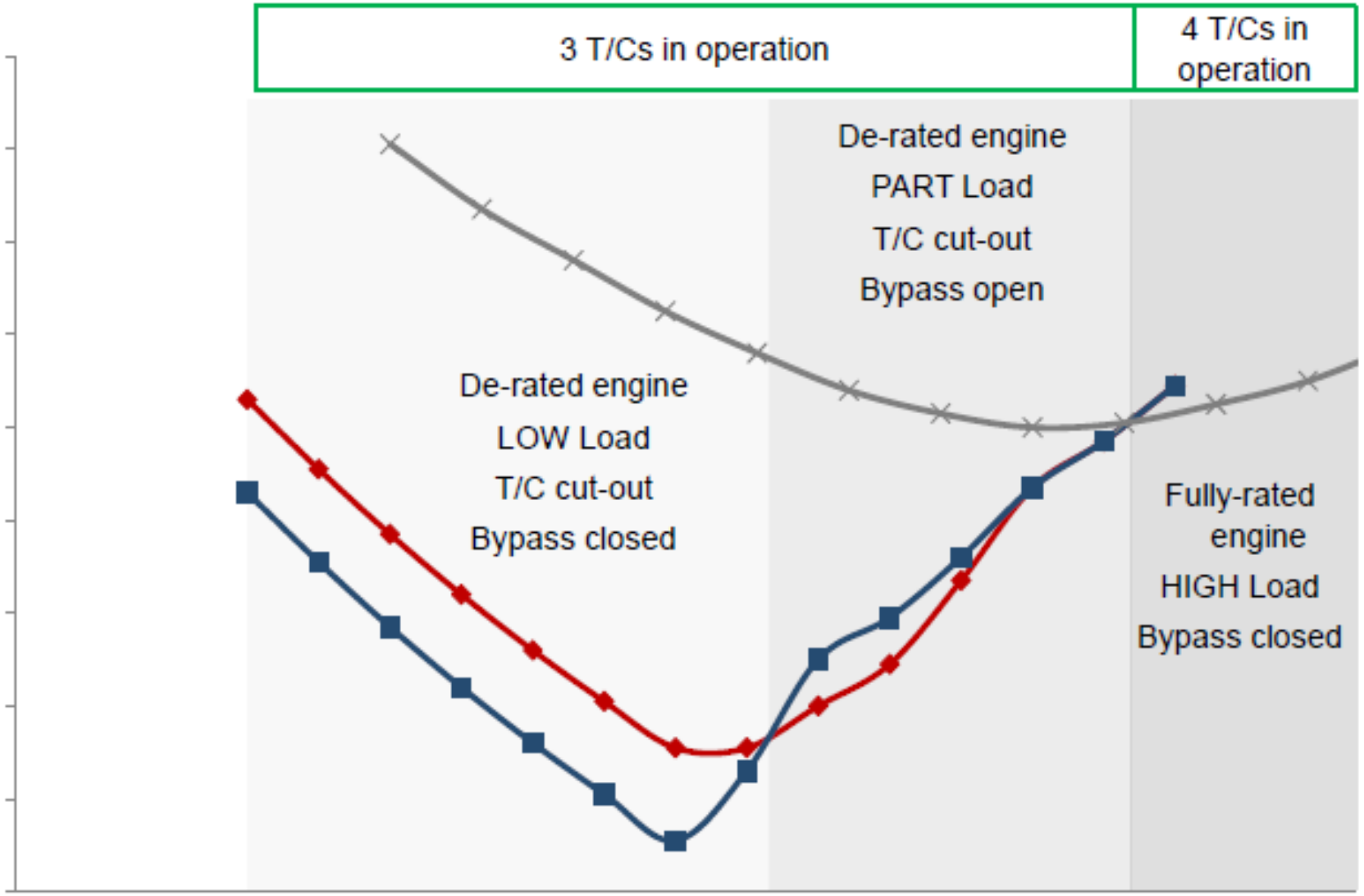
Specific Fuel Oil Consumption (SFOC)







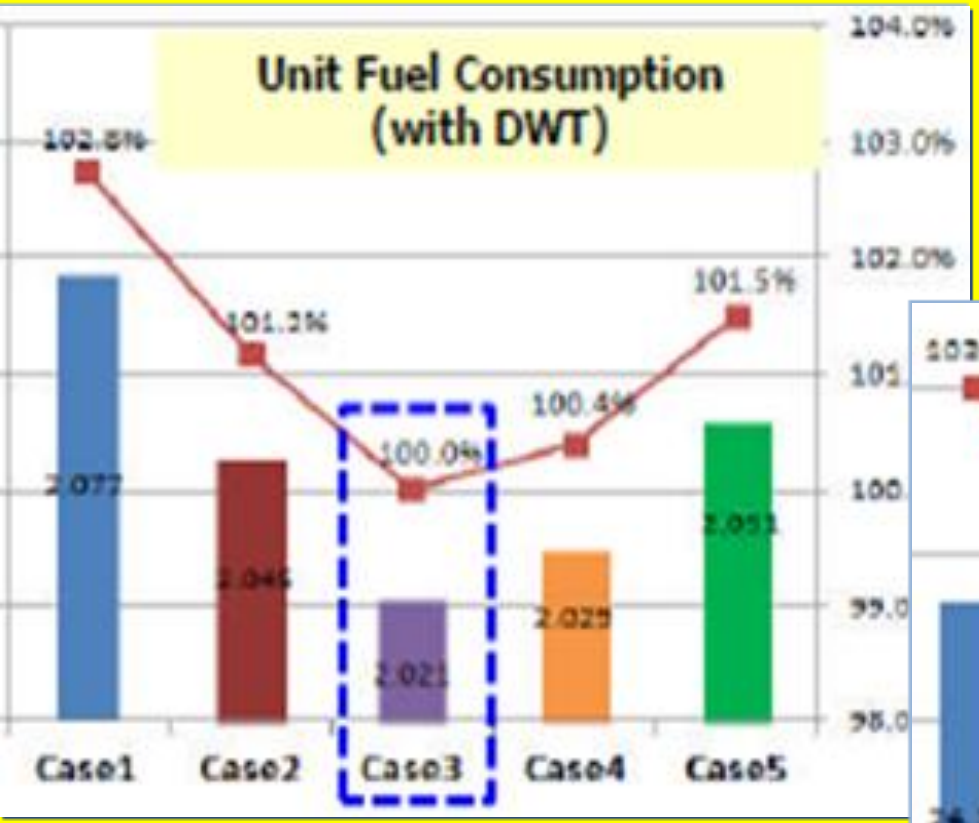
SFOC at different Operation modes

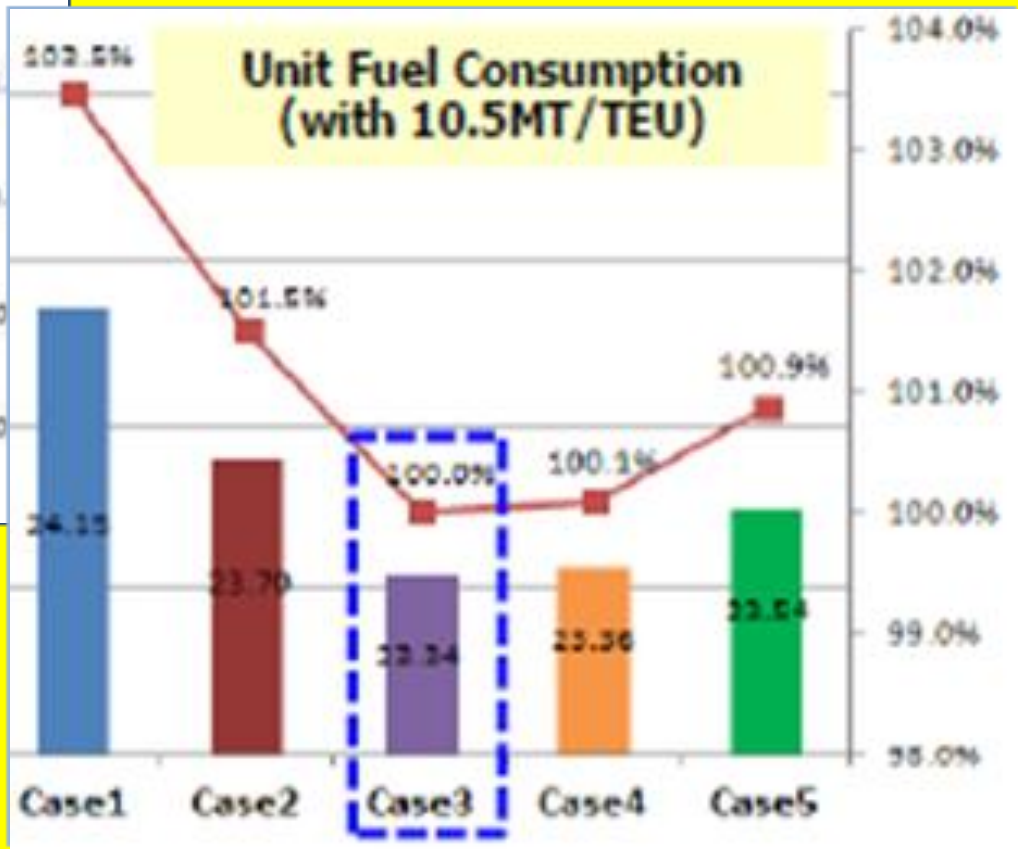


Comparison on the Daily FOC (DFOC)

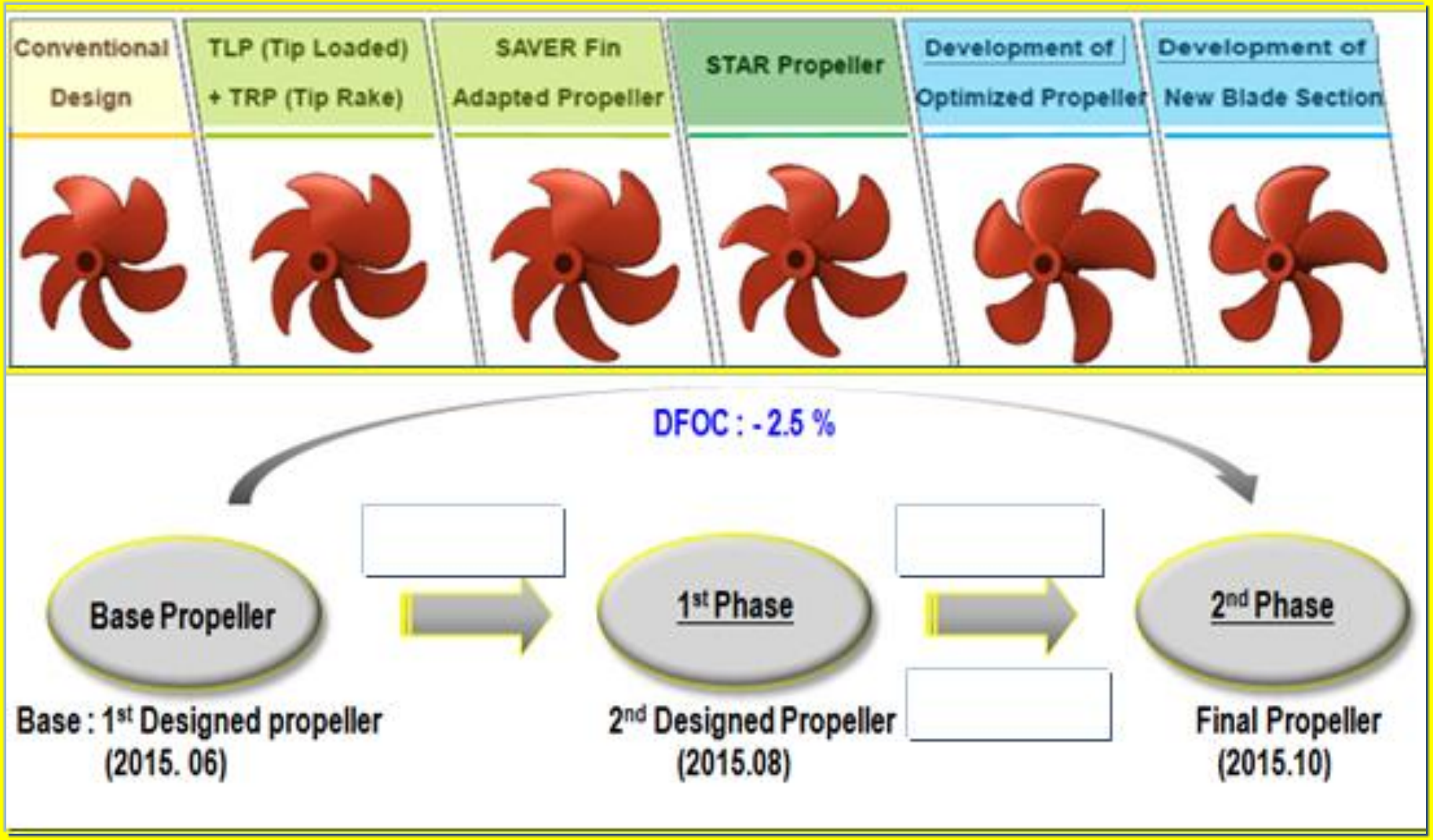
Item		Contract [A] (March 2015)	Opt. Hull Design [B] (October 2015)	Saving [B] / [A]
Required Power at 23 kts		(100 %)	(96.8 %)	3.2%
DFOC At Dd	23 kts	(100 %)	(94.6%)	5.4%
	22 kts	(100 %)	(93.6 %)	6.4%
	21 kts	(100 %)	(93.5 %)	6.5%
	20 kts	(100 %)	(93.1 %)	6.9%
	19 kts	(100 %)	(93.5 %)	6.5%
	18 kts	(100 %)	(92.5 %)	7.5%
	17 kts	(100 %)	(93.2 %)	6.8%
	16 kts	(100 %)	(92.0 %)	8.0%
	15 kts	(100 %)	(93.1 %)	6.9%
	14 kts	(100 %)	(91.7 %)	8.3%

Hull Form and Deadweight Selection

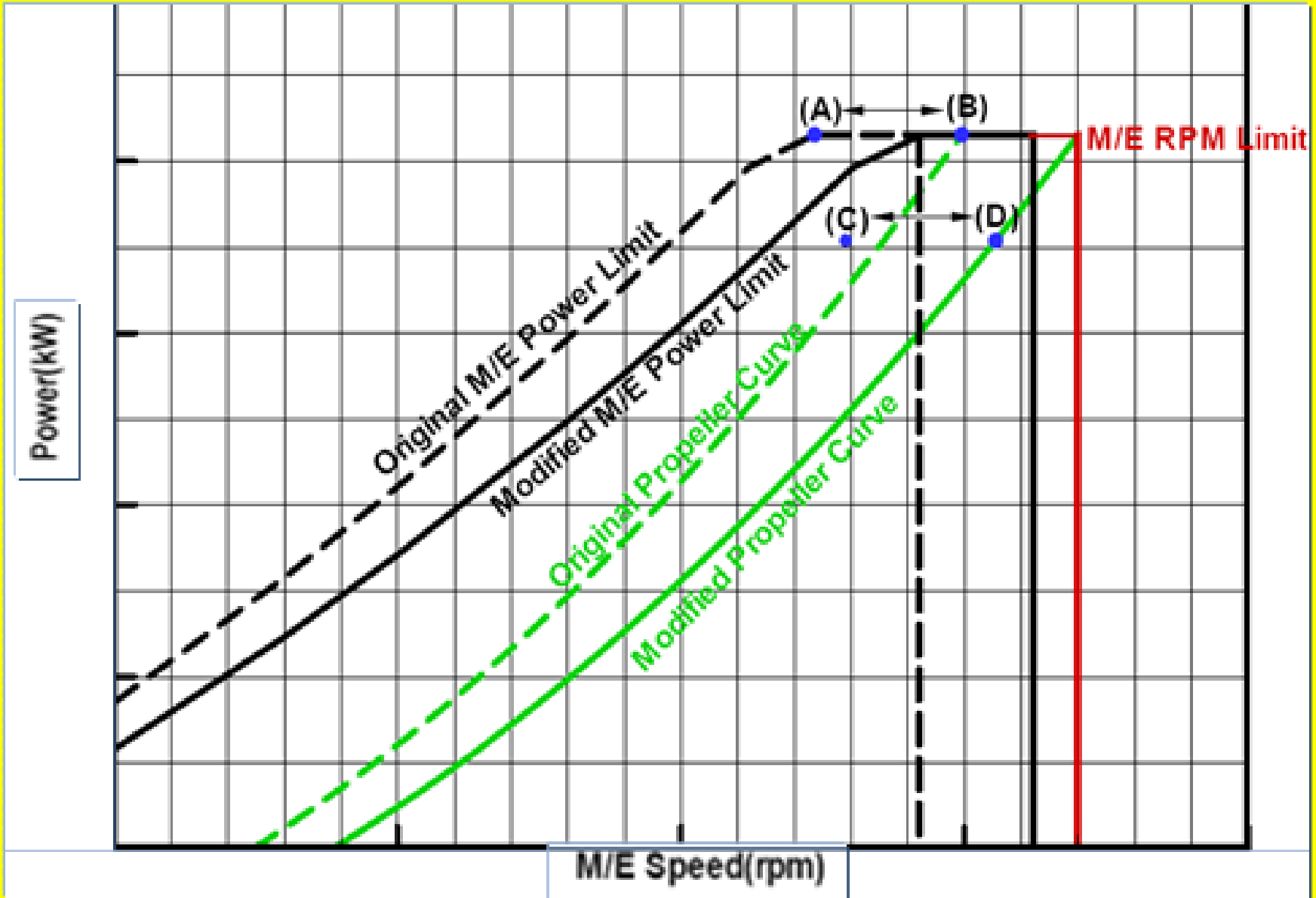




Progress of Propeller Design



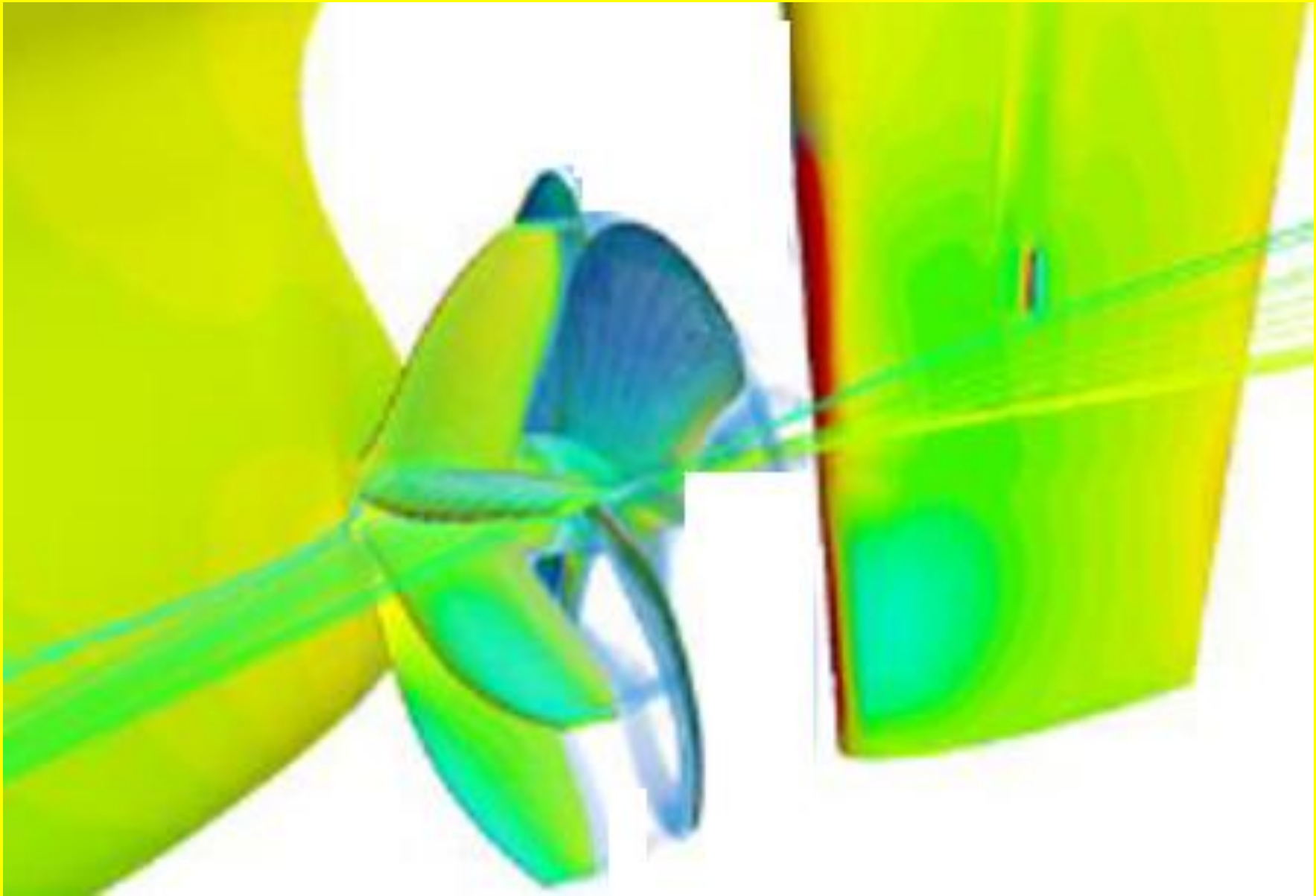
Improvement of M/E RPM & Propeller Curve



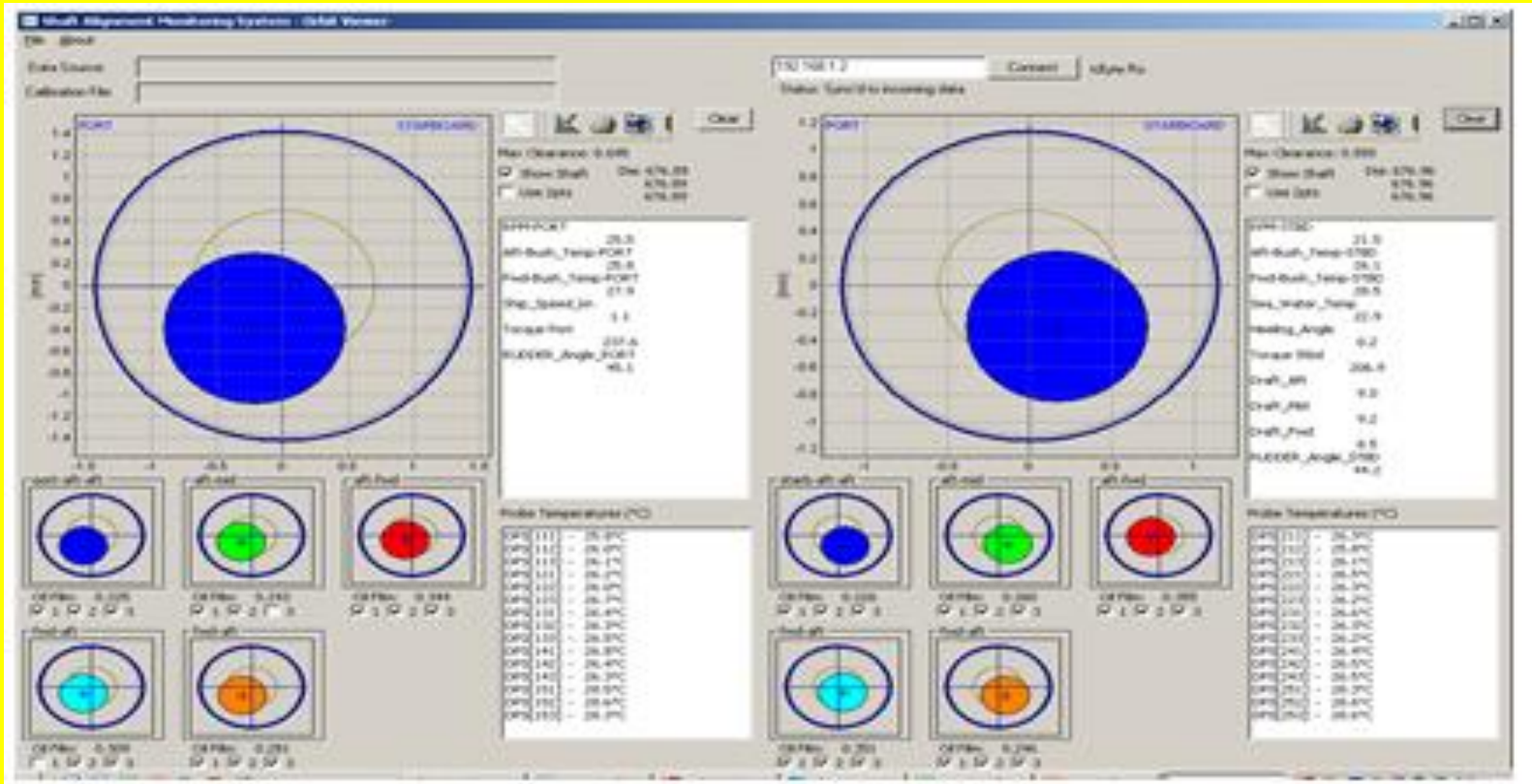
Shape of leading edge of Rudder

Twist No Twist Less Twist More Twist

Energy Saving Device

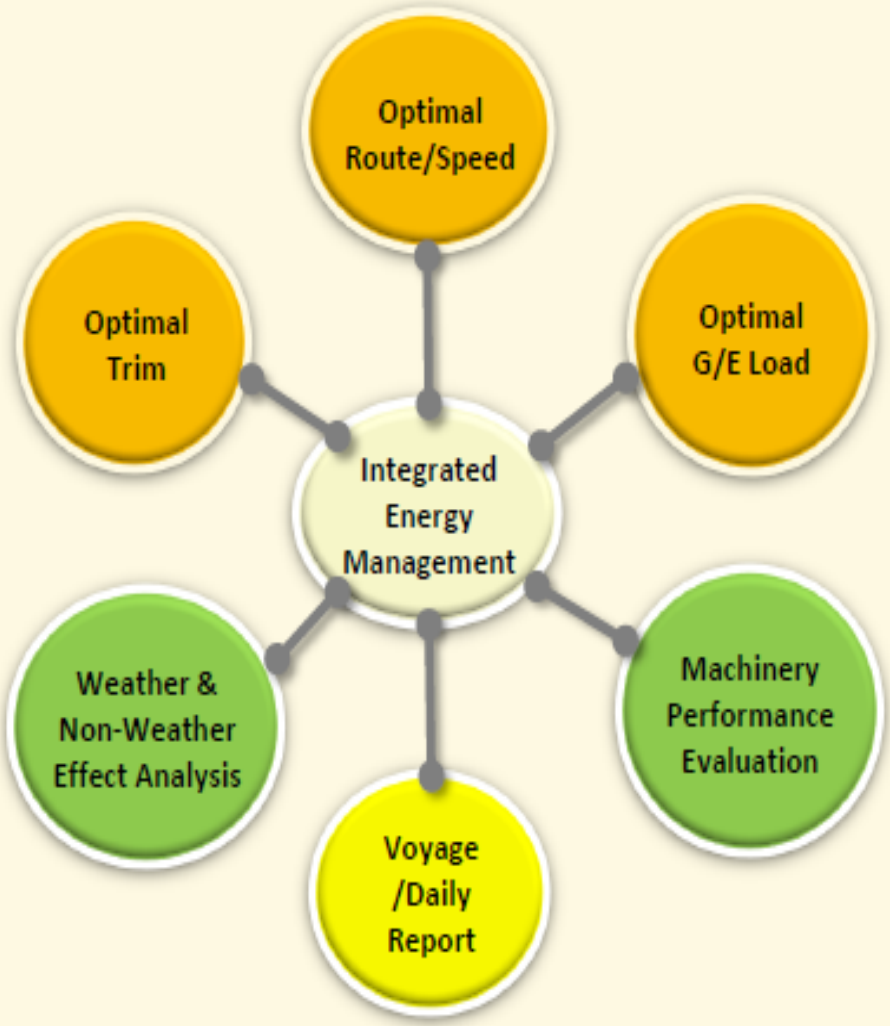


Digital Shaft Alignment Monitor (D-SAM) system



Digital Shaft Alignment Monitor (D-SAM) system

Ship Energy Management System



Integrated Optimization Solution

- Optimal Trim
- Optimal Route & M/E Speed
- Optimal G/E Load Allocation

Advanced Ship Performance Evaluation

- Weather Effect Analysis
- Non Weather Effect Analysis
- Machinery Performance Analysis

Easy SEEMP Application

- Embedded SEEMP Process
- Automatic Daily Report Generation
- Voyage Report with Performance Evaluation

The evolution of an index

- The principle:
- Japan: MEPC 57/4/12
- Denmark: GHG-WG 1/2/1
- MEPC 58/4
- USA: MEPC 58/4/35
- MEPC 58/23
- MEPC.1/Circ.68

$$\frac{Environmental\ cost}{Benefit\ for\ society}$$

$$\frac{C_F\ SFC\ P}{Capacity\quad V_{ref}}$$

$$\frac{\prod_{j=1}^{M} f_j \sum_{i=1}^{NME} C_{FMEi}\ SFC_{MEi}\ P_{MEi} \;+\; \prod_{k=1}^{L} f_k \sum_{i=1}^{NAE} C_{FAEi}\ SFC_{AEi}\ P_{AEi}}{Capacity\quad V_{ref}}$$

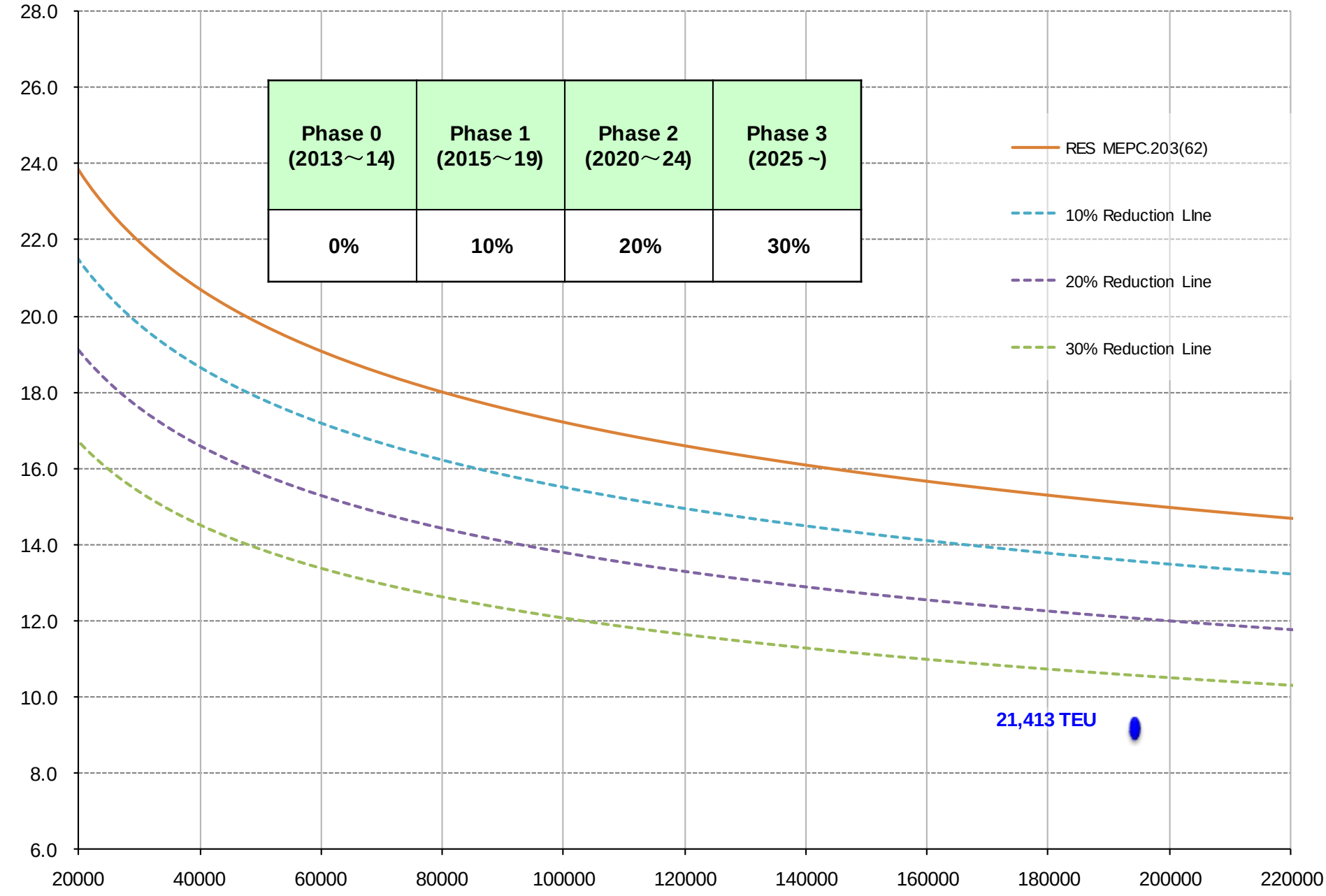
$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{NME} C_{FMEi}\ SFC_{MEi}\ P_{MEi}\right)+\left(\prod_{k=1}^{L} f_k\right)\left(\sum_{i=1}^{NAE} C_{FAEi}\ SFC_{AEi}\ P_{AEi}\right)}{Capacity\times\quad V_{ref}\times f_W}$$

$$\frac{\left(\sum_{i=1}^{NME} C_{FMEi}\ SFC_{MEi}\ P_{MEi}\right)+\left(\sum_{i=1}^{NAE} C_{FAEi}\ SFC_{AEi}\ P_{AEi}\right)-\left(\sum_{eff=1}^{Neff} f_{eff} C_{Feff}\ SFC_{eff}\ P_{eff}\right)}{Capacity\quad\times\quad V_{ref}\times f_W}$$

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} C_{FMEi}\ SFC_{MEi}\ P_{MEi}\right)+P_{AE}C_{FAE}SFC^{*}_{AE}+\left(\sum_{i=1}^{nPTI} P_{PTIi}-\sum_{i=1}^{nWHR} P_{WHRi}\right)C_{FAE}SFC_{AE}-\left(\sum_{i=1}^{neff} f_{eff}P_{eff}C_{FMEi}SFC_{MEi}\right)}{f_i\quad Capacity\quad V_{ref}\quad f_W}$$

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{MEi}\cdot C_{FMEi}\cdot SFC_{MEi}\right)+\left(P_{AE}\cdot C_{FAE}\cdot SFC_{AE}\,*\right)+\left(\left(\prod_{j=1}^{M} f_j\cdot\sum_{i=1}^{nPTI} P_{PTI}-\sum_{i=1}^{neff} f_{eff}\cdot P_{AEeff}\right)\cdot C_{FAE}\cdot SFC_{AE}\right)-\sum_{i=1}^{neff} f_{eff}\cdot P_{eff}\cdot C_{FMEi}\cdot SFC_{MEi}}{f_i\cdot Capacity\cdot V_{ref}\cdot f_w}$$

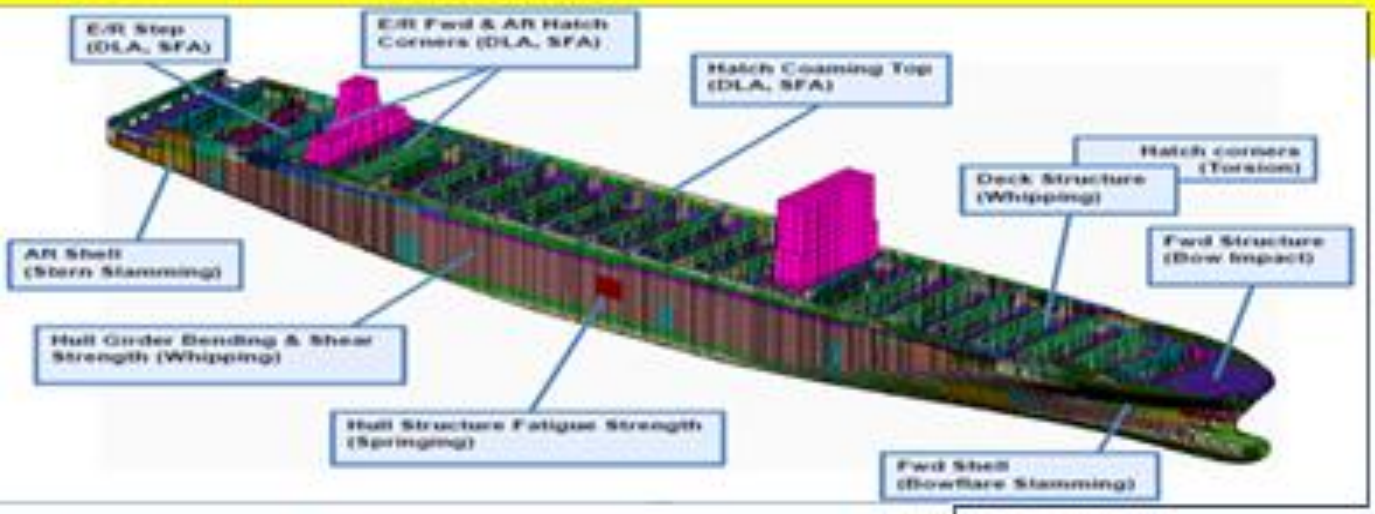
Energy Efficiency Design Index (EEDI)

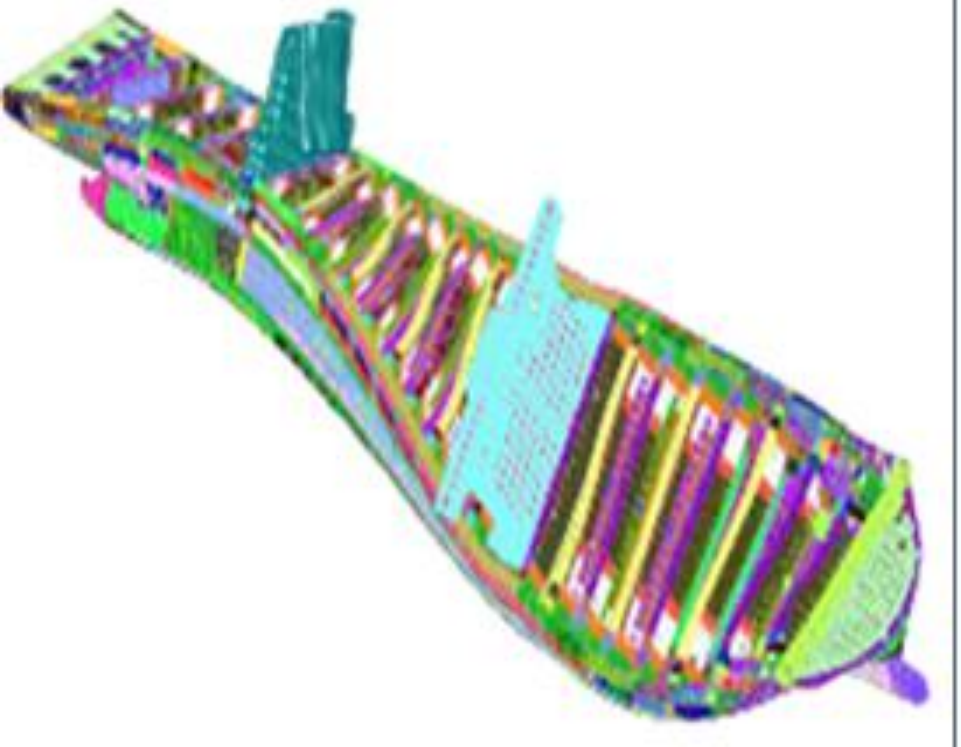


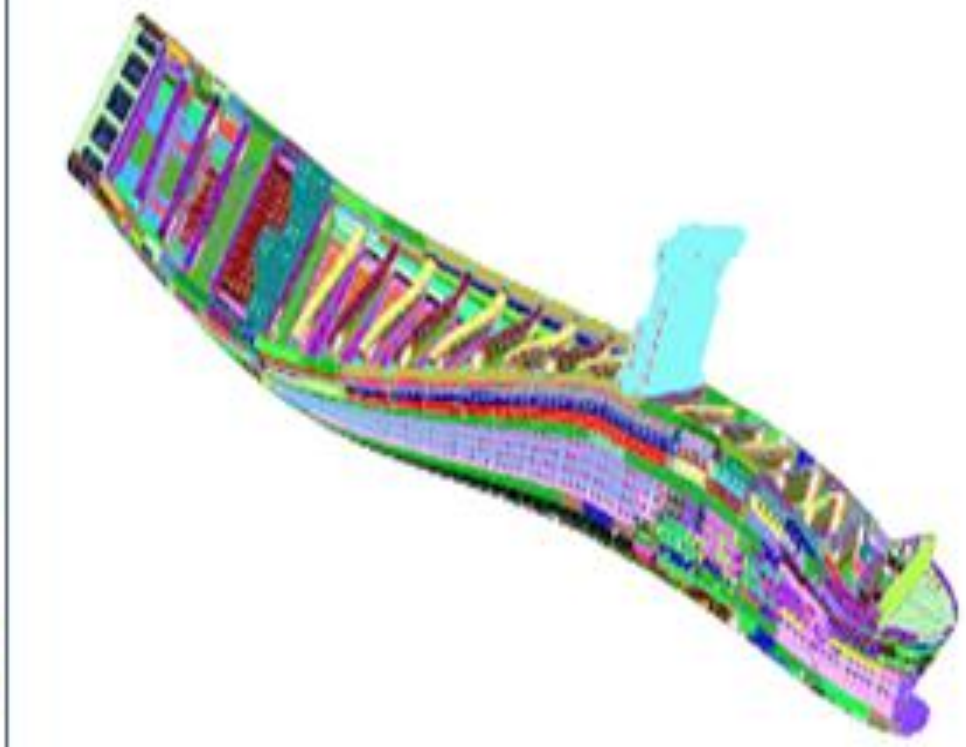
Update
on
Challenge of Operation
of
Mega 21413teu Boxships

Hull Stress at sea

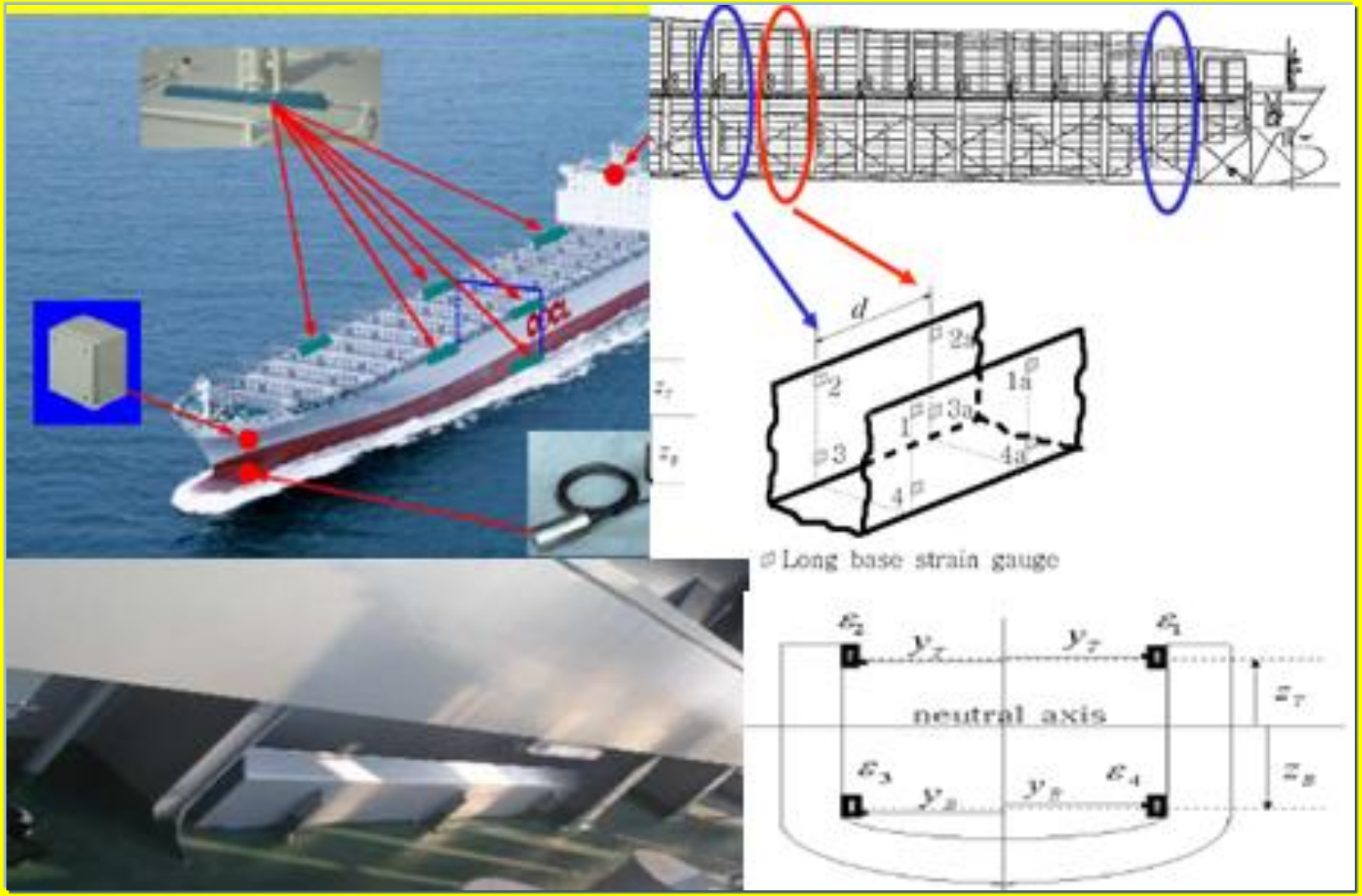
Critical areas of ship hull structural design







Hull Stress Monitoring System

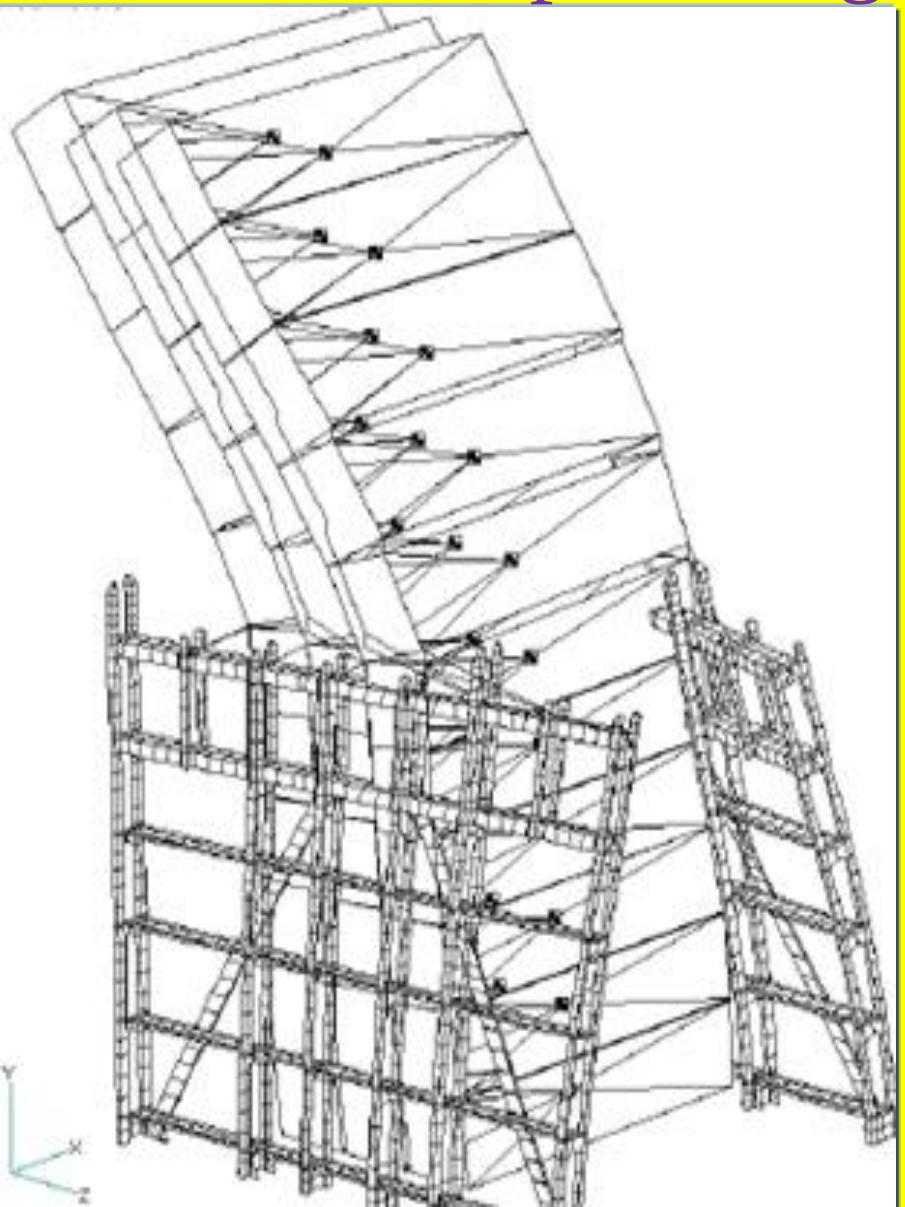


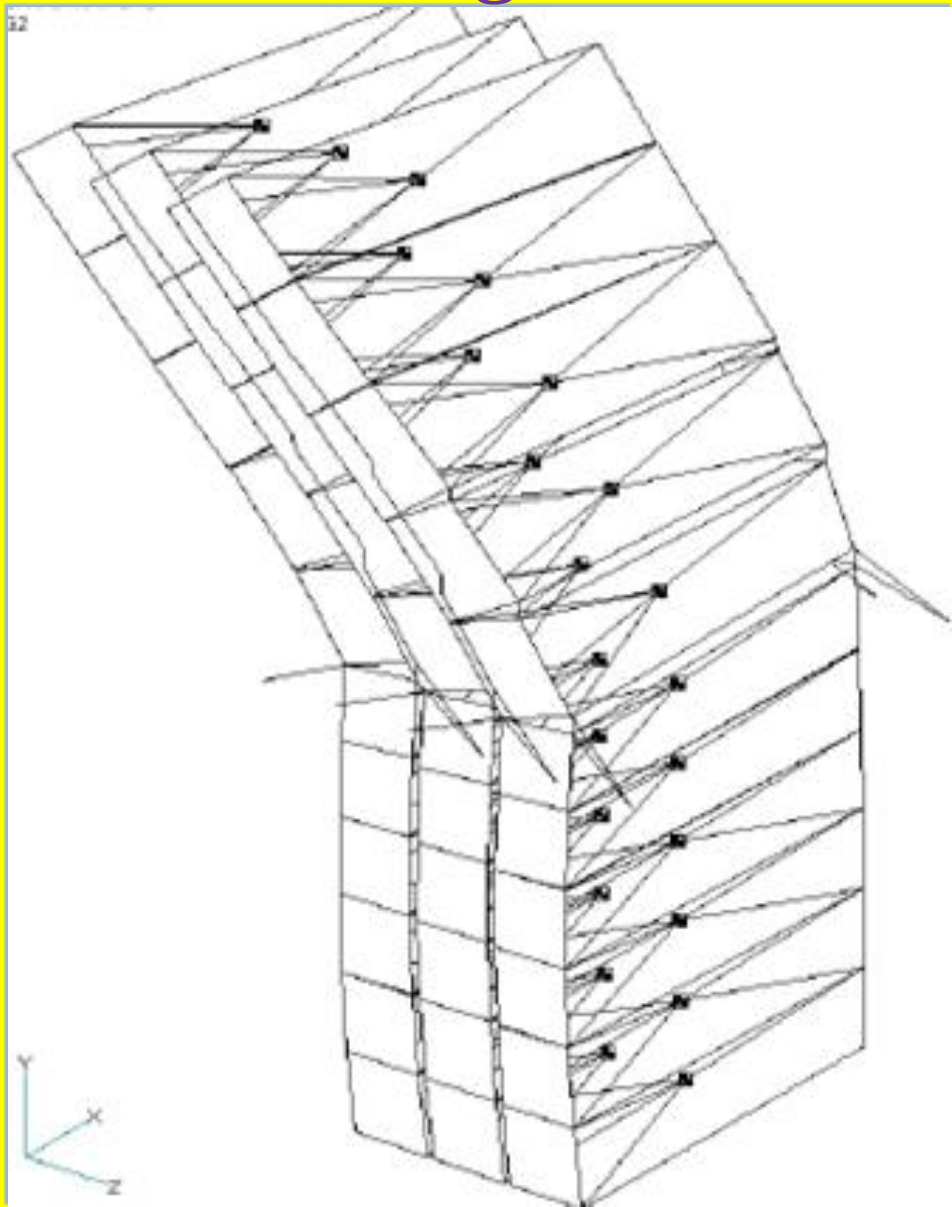
Hull Stress Monitoring System

- To monitor the hull girder bending moment and bow acceleration to assure that the vessel operates within safe operational limits.
- To provide assistance to the crew for better handling of difficult sea states.
- Sensors
  - **Long base strain gauges (LBSG)**
  - **Accelerometer**
  - **Motion sensors – roll, pitch**
  - **Navigation data**

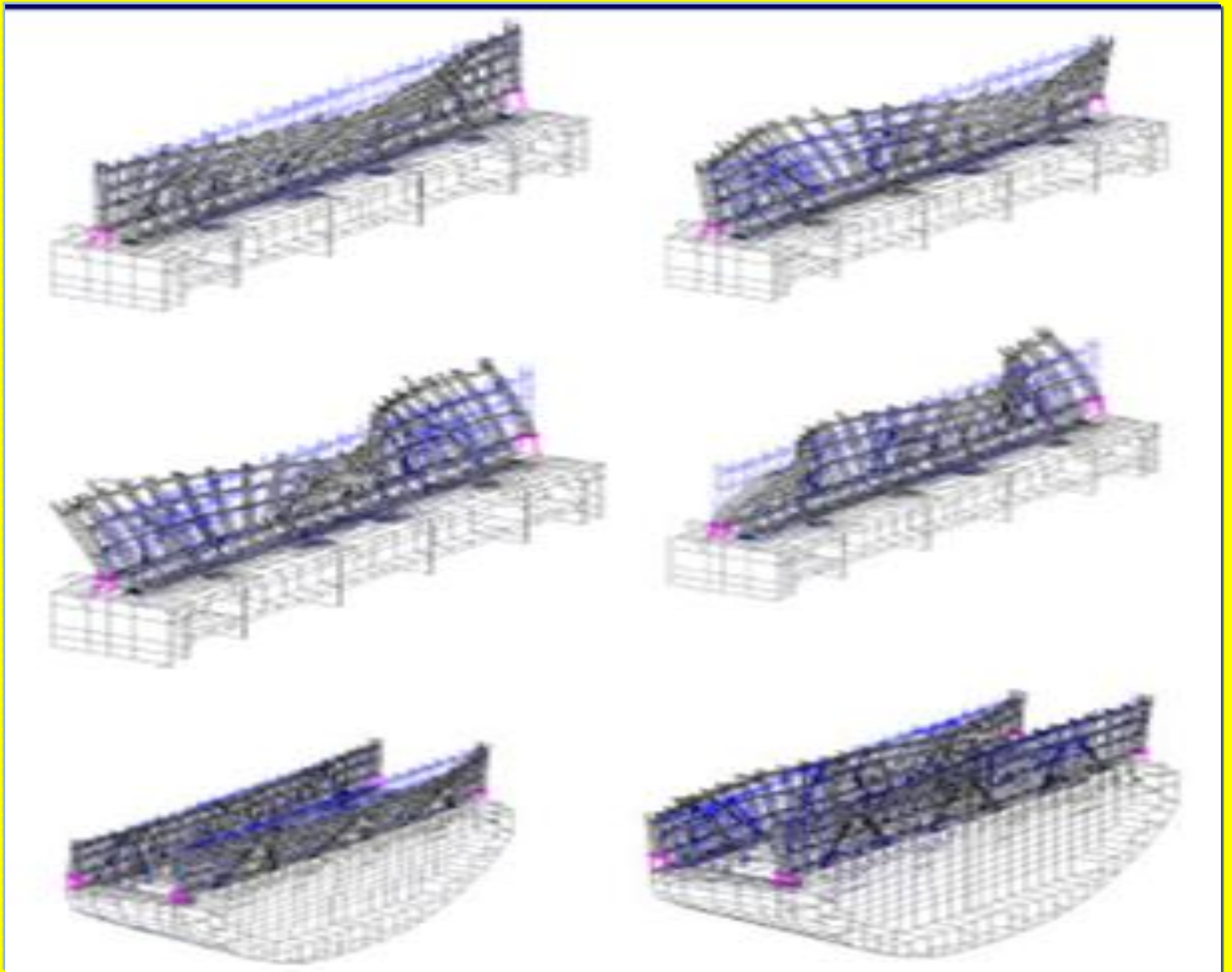
✓ Ship's position
✓ Heading, speed
✓ wind speed & direction etc.

Container Box movement on Lashing bridge when ship Rolling and Pitching at sea

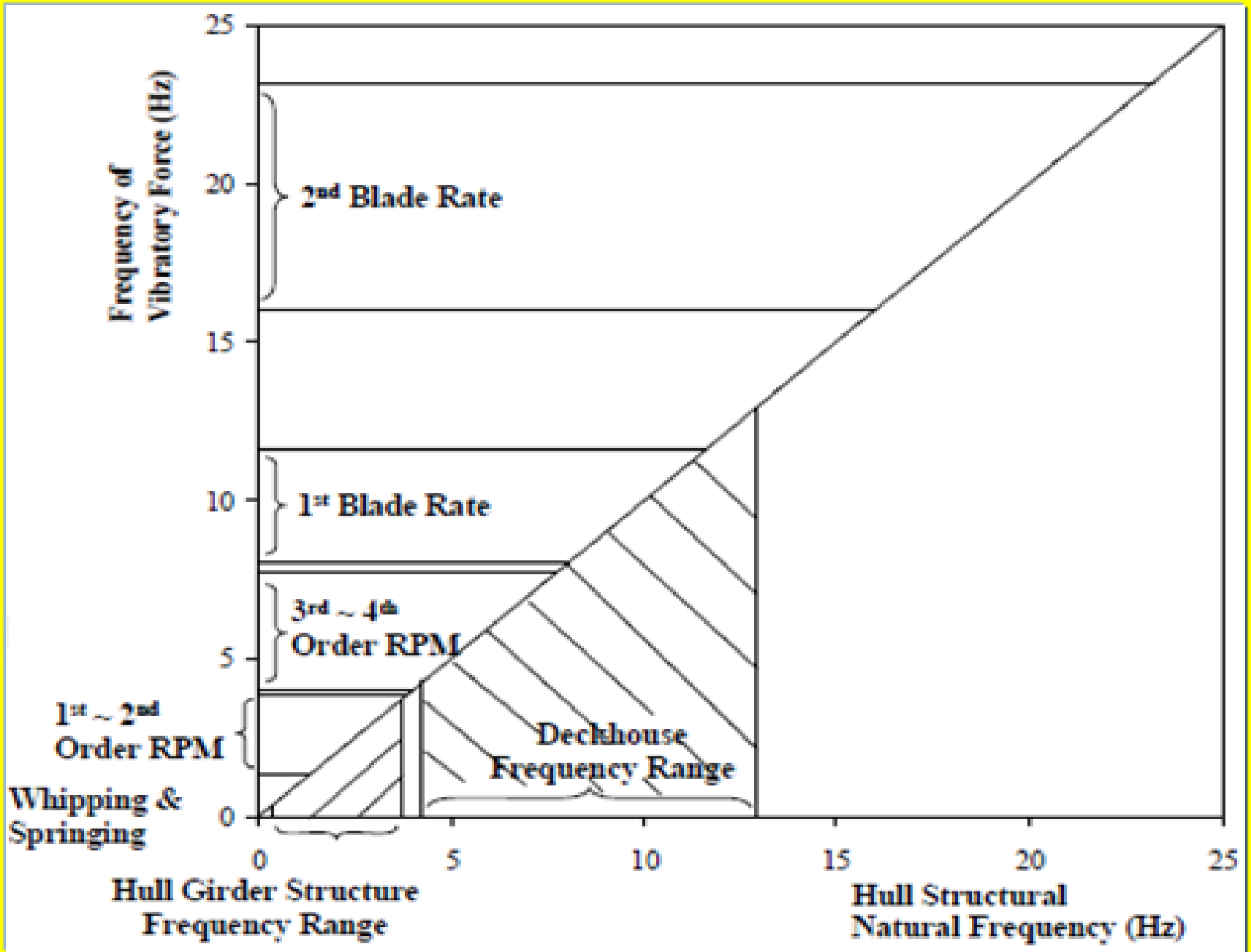




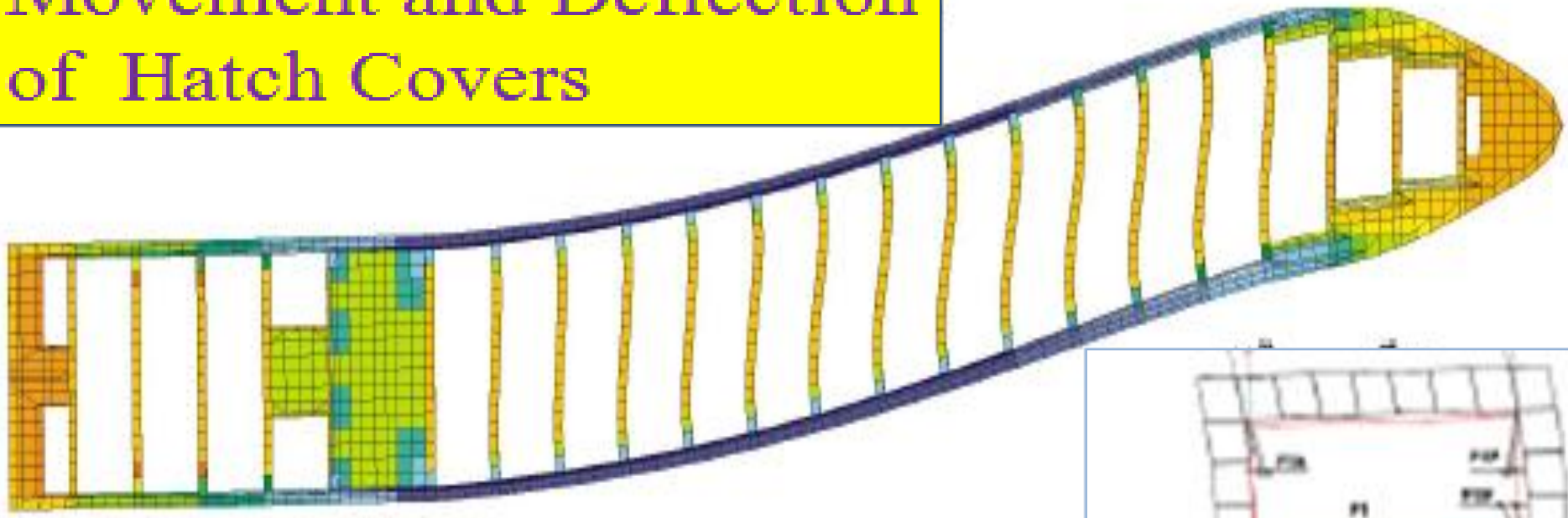
Lashing Bridge Movement whilst ship at sea

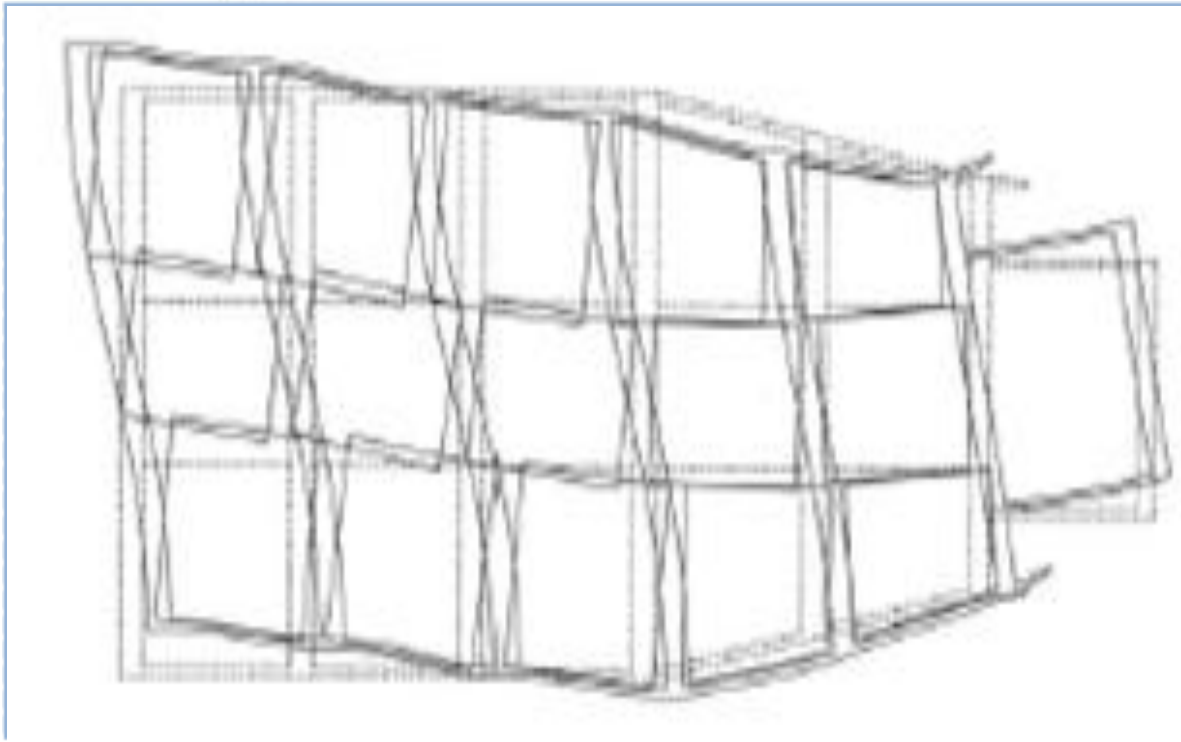


Lashing Bridge Vibration during ship enrouting at sea



Movement and Deflection of Hatch Covers





Mooring systems for large windage area

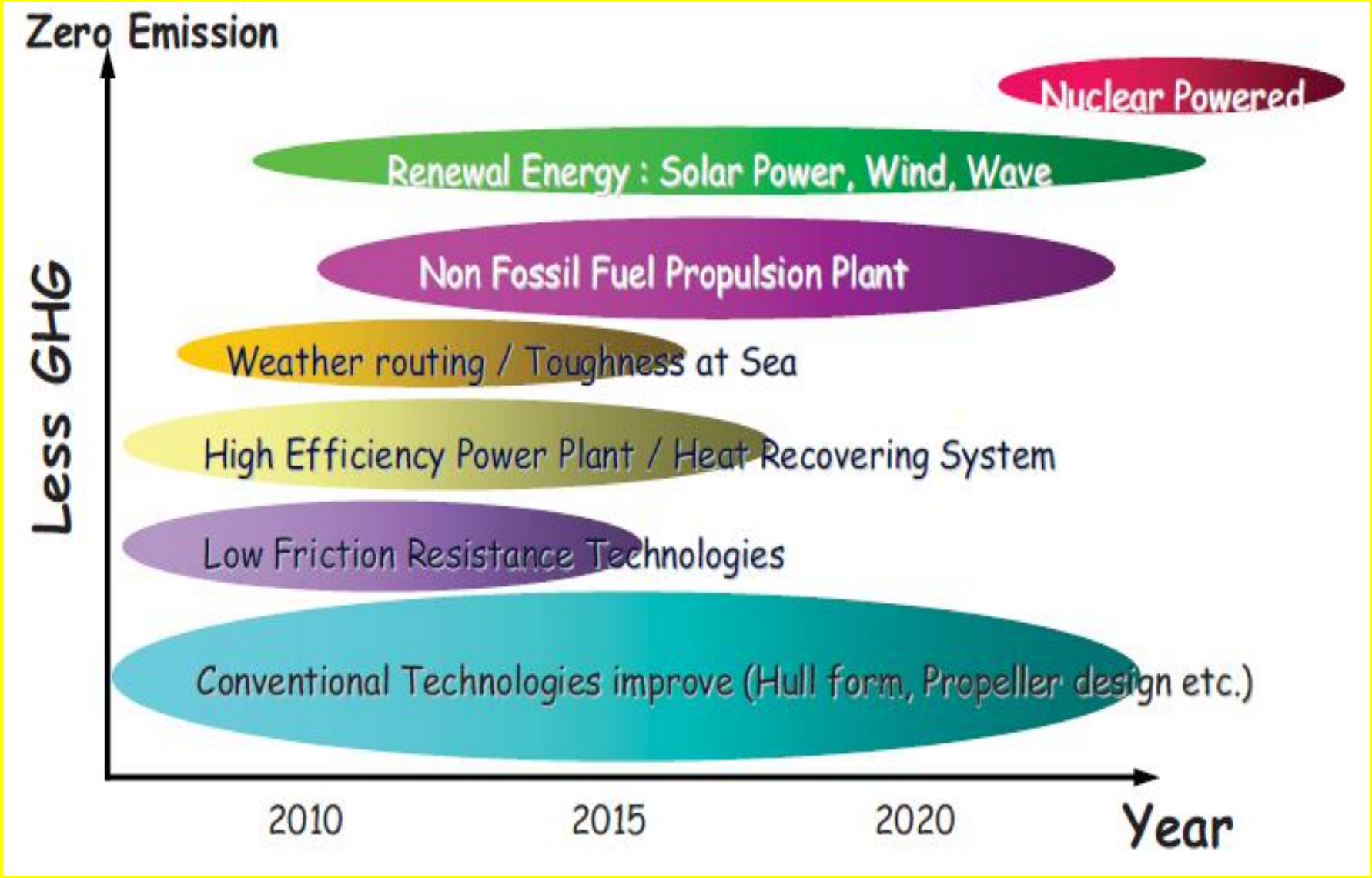
Fire Fighting System

Fire explosion due to mis-declared cargoes

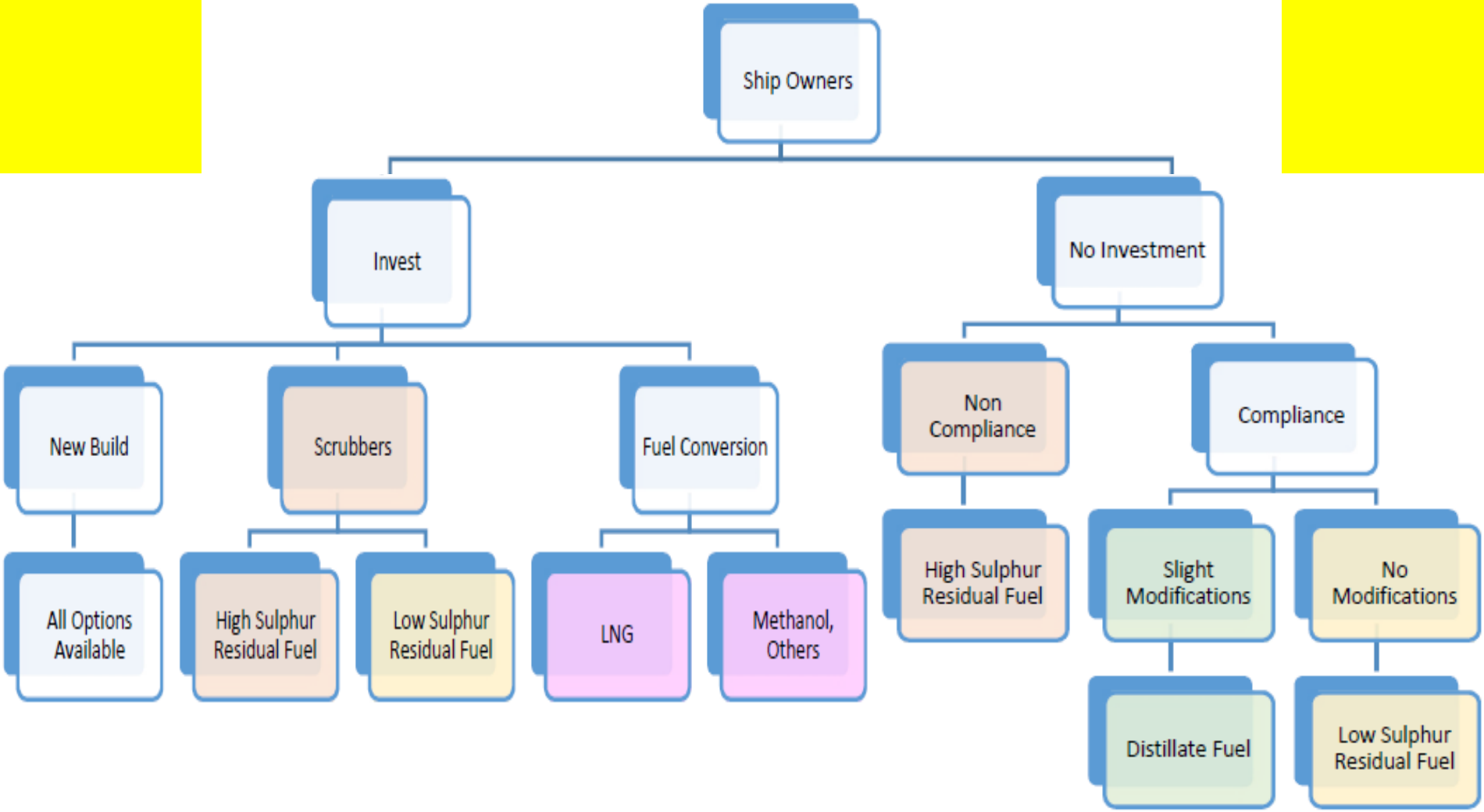
H&M Insurance ?
Cargo Claims ?


APL
APL
APL
APL
APL
H&M Insurance ?
Cargo Claims ?

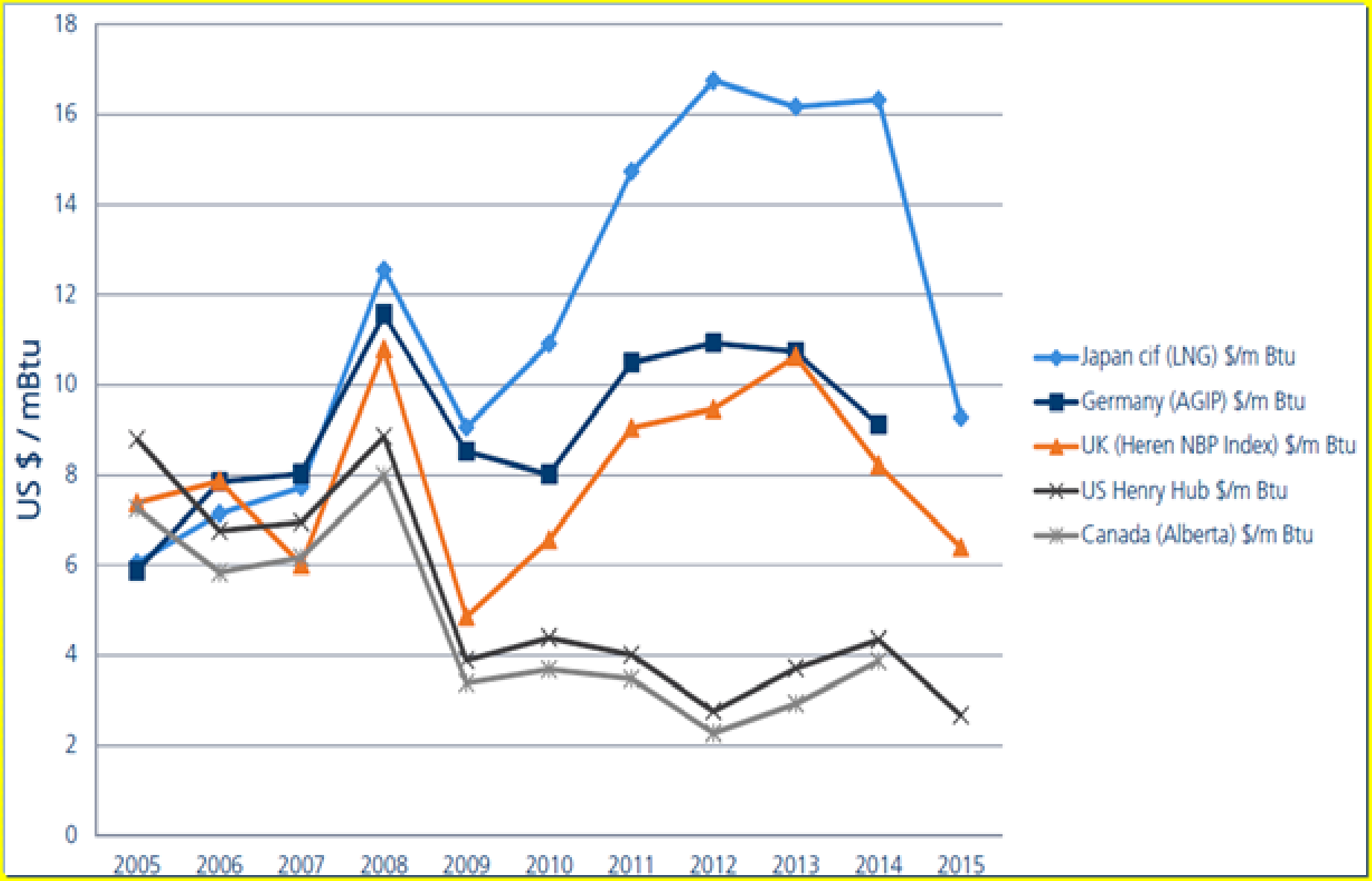
Initiative for emission control from ships



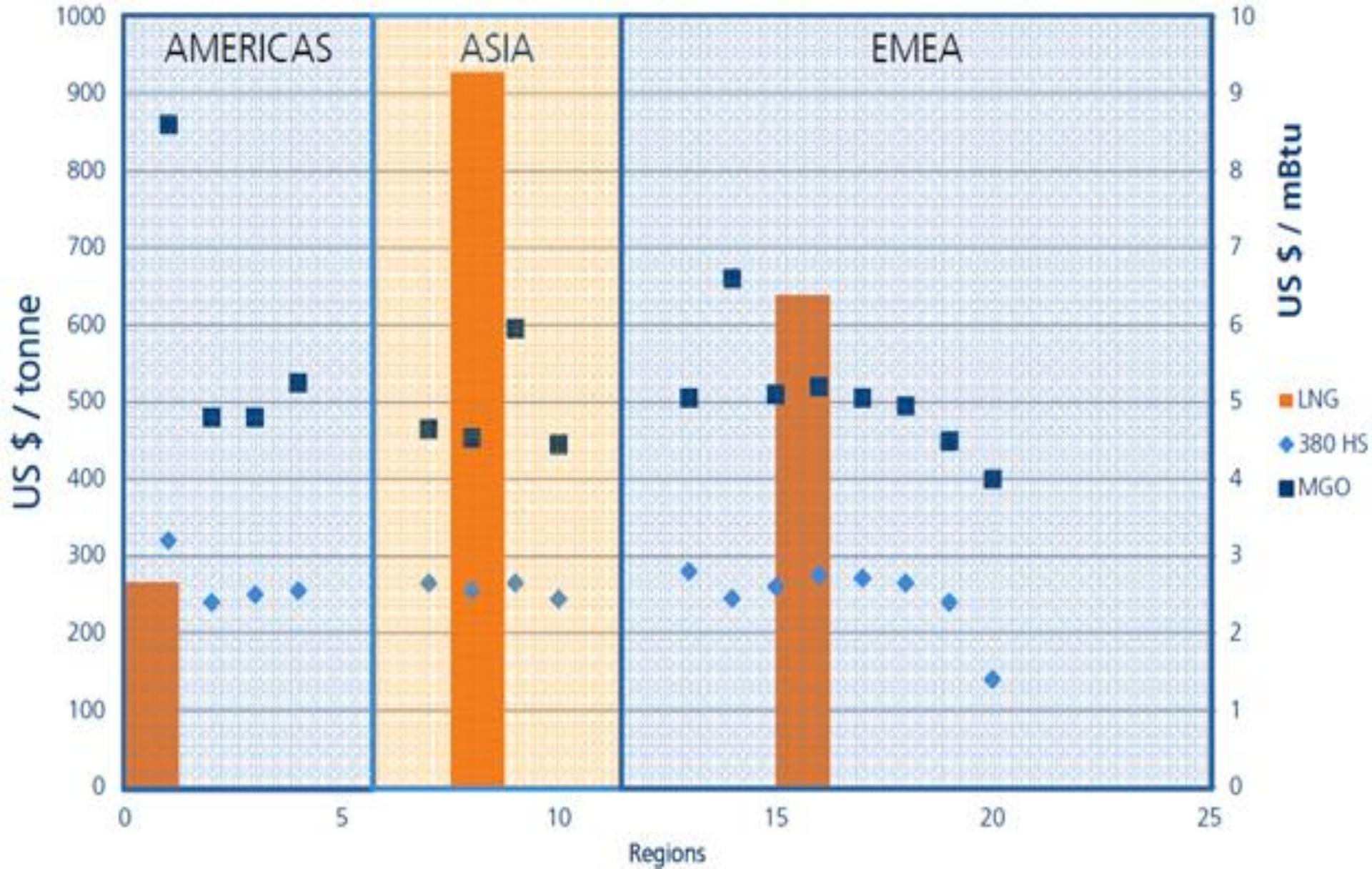
Decision Making for MarPol Compliance



The Availability/Price Trend of LNG

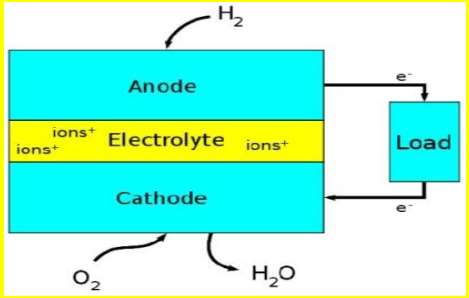


The Availability/Price Trend of Fuel



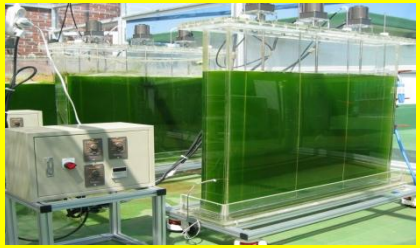
Emerging New Technologies for Emission Reduction

Fuel cell (H_2, natural gas, etc.)



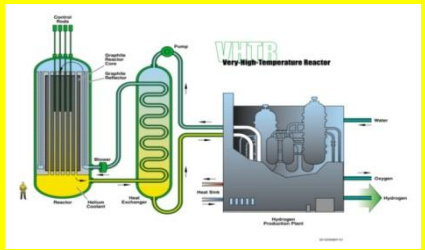
Wind Power

Bio Fuel



Solar Power

Nuclear Power



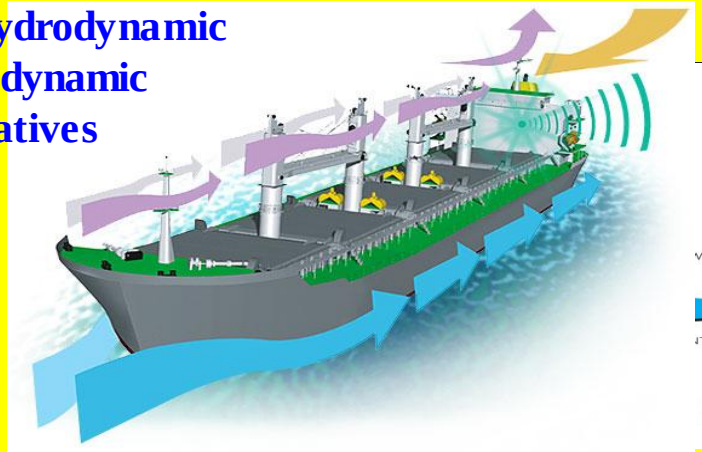
Concept Demonstrators

Example of Eco Technologies

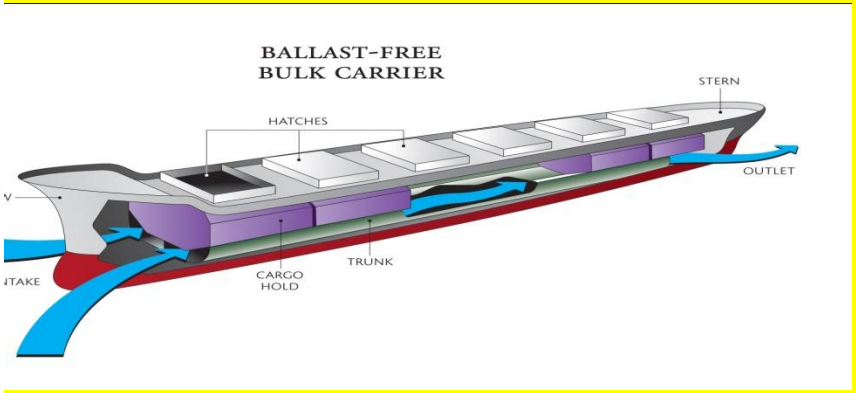
wind-powered ships

Boxships powered by solar, wind, fuel cells

Greenwave (UK firm) developing Hydrodynamic and Aerodynamic alternatives



Ballast free ships (ballast = water intake to weigh/ balance) to avoid pollution caused by foreign creatures and algae

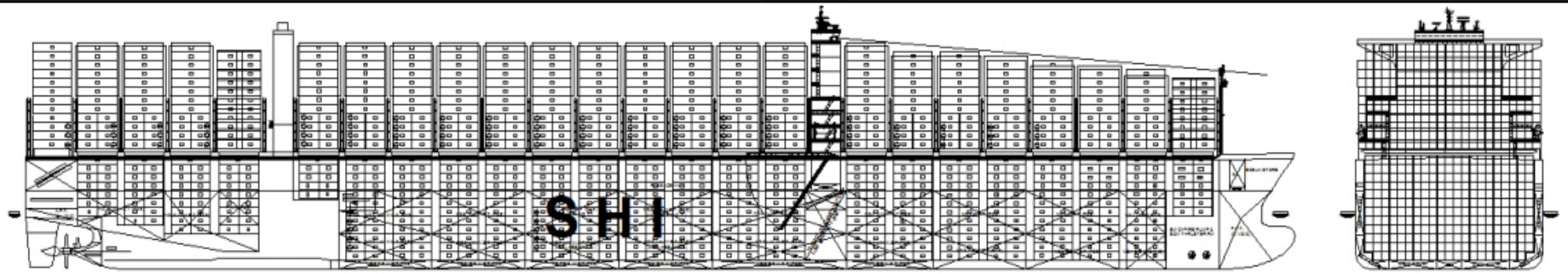


Future Solar-powered Mega Boxship ?

Novel mega Green boxship ?

nrrpSAMSUNG HEAVY INDUSTRIES CO., LTD. GEOJE SHIPYARD
530, Jangpyeong-Dong, Geoje-si, Gyeongnam-Do, Korea, 656-710
E-MAIL : ship.design@samsung.com
HOMEPAGE : shi.samsung.co.kr

SAMSUNG HEAVY INDUSTRIES



MAIN PARTICULARS

Length over all	approx.	400	m
Length between perp.	moulded	383.0	m
Breadth	moulded	58.8	m
Depth	moulded	32.5	m
Designed draught	moulded	14.5	m
Scantling draught	moulded	16.0	m
Air draught from B.L.		73.5	m

DEADWEIGHT

At designed draught	approx.	160,617	MT
At scantling draught	approx.	191,317	MT

TANK CAPACITIES

Heavy fuel oil	approx.	12,700	m^3
Marin diesel oil	approx.	1,200	m^3
Fresh water	approx.	600	m^3
Ballast water tanks	approx.	65,000	m^3

CLASSIFICATION

ABS

✠A1(E), Container Carrier, ✠AMS, ✠ACCU, SH, SHCM, SH-DLA, SFA25, FL(25), UWILD, ENVIRO, BWT+, NIBS, RW, CRC, CSC, GP, CPS, POT, HVSC, SElev, SLAM-B/S, TCM, CLP-V, BWE

REGISTRATION

Hong Kong

SERVICE SPEED

23.0 kts

(at design draught, NCR, 20% sea margin)

MAIN ENGINE

MAN Licensee made	MAN D&T 11G95ME-C9.5 with LLT(EGB)
NMCR	75,570 kW x 80.0 RPM
DMCR	61,530 kW x 74.7 RPM
NCR (90% DMCR)	55,377 kW x 72.1 RPM
Bow thruster	2 x 2,500 kW

FUEL OIL CONSUMPTION OF MAIN ENGINE

D.F.O.C at NCR approx. 214.7 MT/day
(L.C.V=10,200 kcal/kg, Low Load Tuning)

Cruising range at NCR approx. 21,500 NM

POWER SUPPLY

Main diesel generators	4	Sets x 4,300 kW
Emergency generator	1	Set x 350 kW
Shaft generators	4	Sets x 3,800 kW

CARGO HATCH COVER

Type	:	Steel pontoon type
Stack weight	:	120MT/20ft & 220MT/40ft & 45ft
Panel weight	:	Max.45.0MT of each panel (excluding container loose fittings)

CONTAINER CAPACITIES

With max. number of Containers

	IMO Visibility Guideline
On deck (12 tiers)	12,198TEU
In hold (12 tiers)	9,064 TEU
Total	21,262 TEU

Rows max. in holds/on hatches	21 / 23 Rows
Tiers max. in holds/on hatches	12 / 11 Tiers

El. Plugs (for reefer Container)

On deck	1,500 UNIT
In hold	150 UNIT
Total	1,650 UNIT

NAVIGATION EQUIPMENT

4 – Radar Plant
2 – ECDIS
2 – DGPS
1 – Auto Pilot
2 – Gyro Compass
1 – AIS / VDR

COMPLEMENT

36P + 6 Suez crews

SAMSUNG 21,100 TEU CONTAINER

Project No.	SN2172s
Revision No.	Interim
Date	2015.04.24

1.东方香港

21413TEU

2.Madrid Maersk

20568TEU

3.MOL Triumph

20150 TEU

4.Barzan

19870 TEU

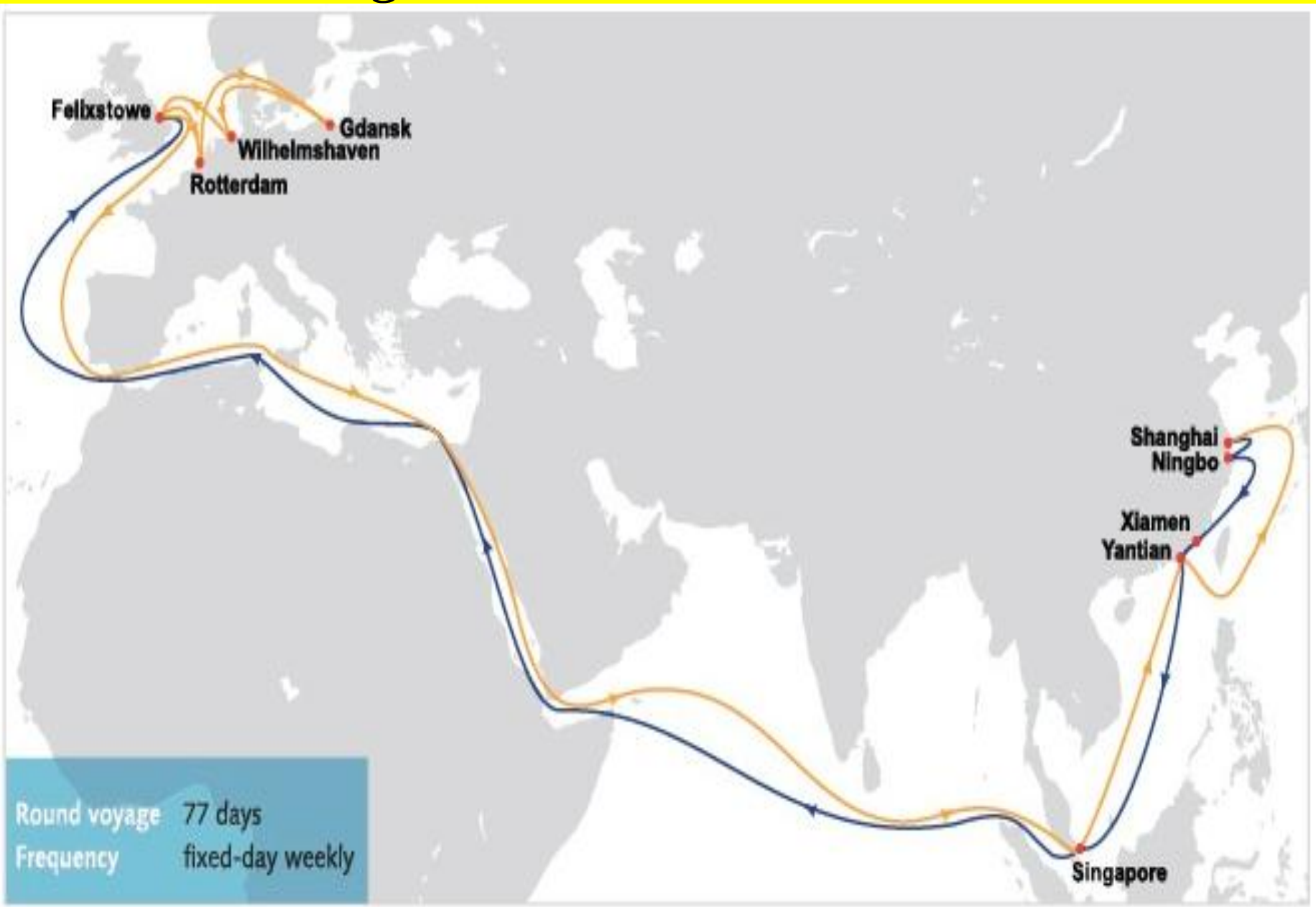
5.MSC Oscar

19224TEU

6.中海环球

19100 TEU

Trading Lane for the 21K teu vessels



Monitoring of Main Engine Cylinder Liners

Engine Control Room

Engine Control Console

Arrangement of Oil Purifiers in E/Room

Diesel Generators in Engine room

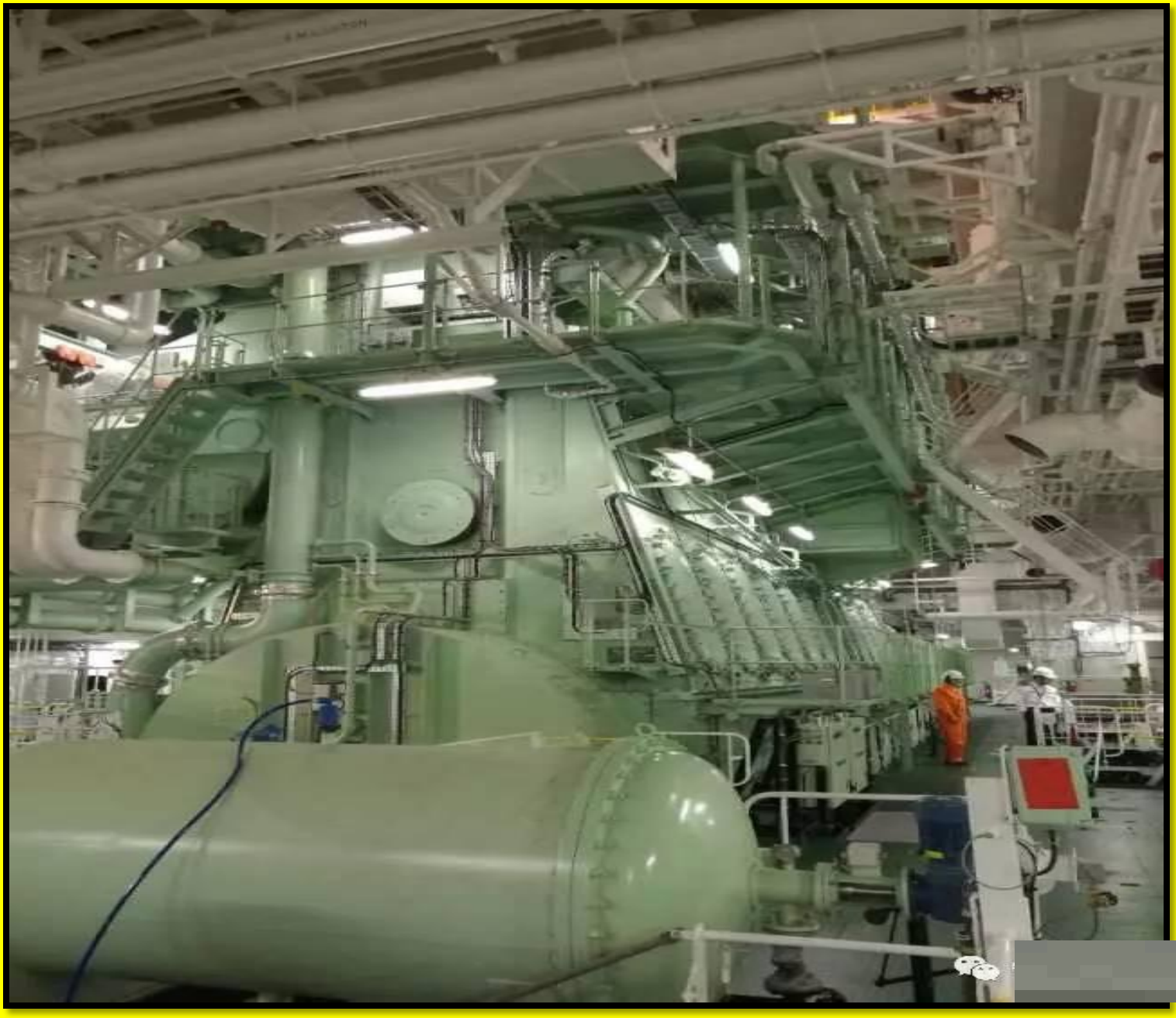
Spare Main Engine Liners

Spare Piston for Main Engine

Air Cooler of Main Engine

Single Main Engine of 11 Cylinders

Crank Casing area of the Main Engine



Under deck Passageway from Cabin to E/Room

Passageway on Upper Deck

Mooring Winches at Ship Stern Deck

Arrangement of Bridge

Thank you
for
your kind attention !