FUEL SAVING TECHNOLOGY

2015.11

TECHNICAL DEVELOPMENT TEAM

KOREAN REGISTER

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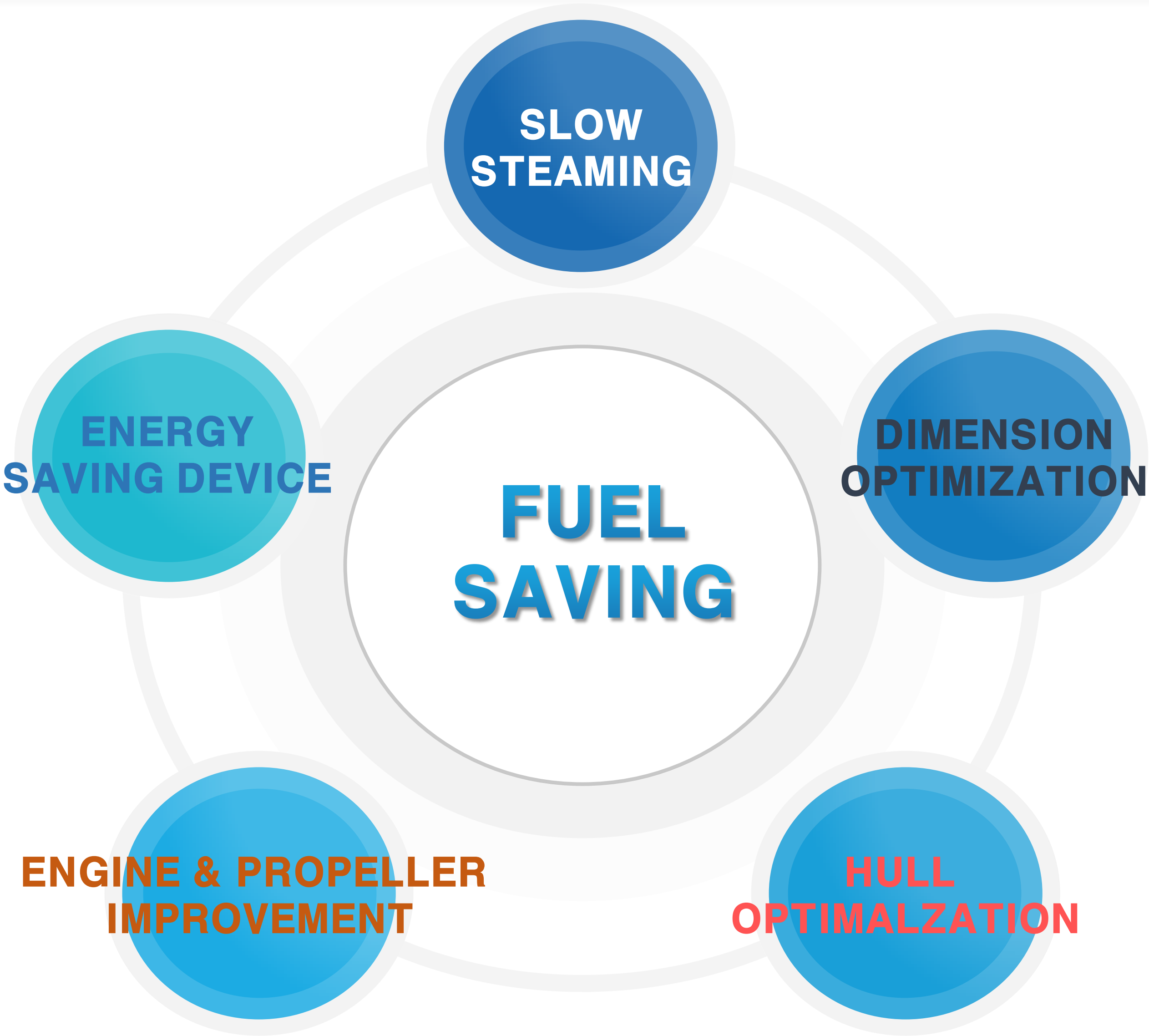
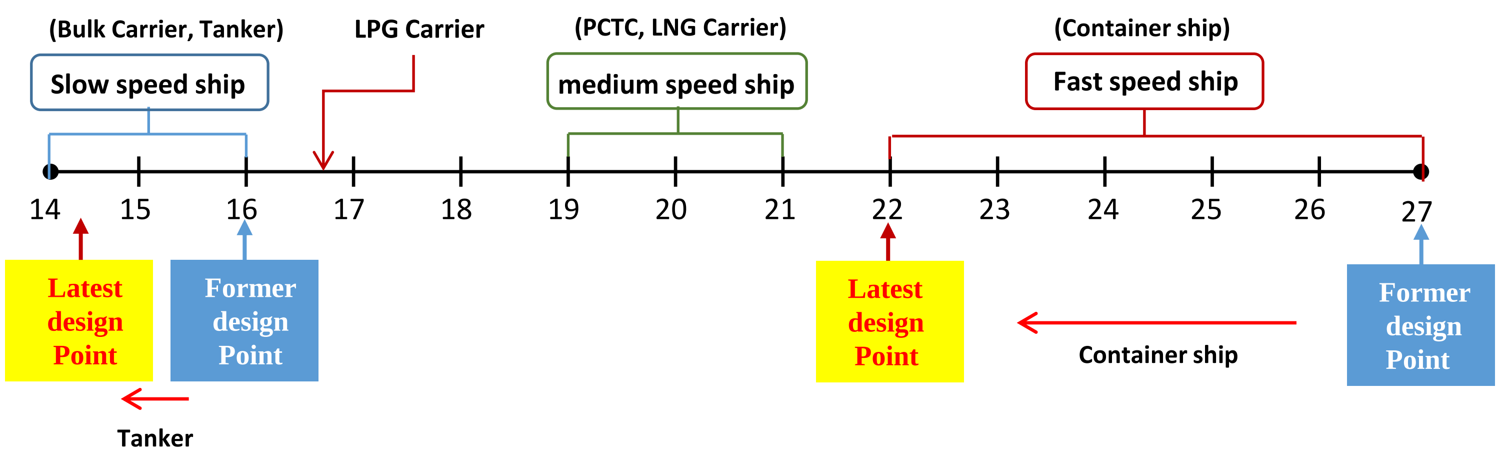
FUEL SAVING TECHNOLOGY



DESIGN SPEED REDUCTION

Fuel consumption = f (speed)^3 → **SLOW STEAMING !!**

- ✓ Fast ship - large speed drop
- ✓ Slow speed and Medium speed ship - small speed drop
- ✓ LPG Carrier - No change



WIDE BEAM SHIP – LR1 Tanker

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Particulars	Conventional 2013 (A)	Wide beam LR1 (B)
LBP [m]	219	219
B [m]	32.24	**40.0**
D [m]	20.65	19.0
Td / Ts [m]	12.2 / 14.3	12.2 / **12.8**
L/B [-]	6.79	5.48
Deadweight [mt]	73,400	74,000
Cargo hold volume [m^3]	83,650 (100.0)	**87,600 (104.7)**
Payload (at river draft) [mt]	45,524 (100.0)	**52,540 (115.4)**
Main Engine type	6S60ME	6S60ME
DMCR [kW X rpm]	9,660 X 89.0	9,660 X 89.0
Service speed [knot]	14.5	14.0
75% MCR speed [knot]	14.2	**14.4**

WIDE BEAM SHIP – LR1 Tanker

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○ In Comparison with Conventional 2013(A)

- ✓ increased cargo hold volume: 3,950m3 (4.7% up)
- ✓ improved Payload (at river draft) : 7016 Ton (15.4% up)
- ✓ Less Annual FO Cost : 0.14 Million USD (abt. 4.5% down)

Items	**Conventional 2013 (A)**			**Wide beam LR1 (B)**		
Condition	Ballast	Design	Scantling	Ballast	Design	Scantling
Speed [knots]	12.5	12	12	12.5	12	12
DFOC [ton/day]	18.0	18.0	20.4	17.5	17.1	19.4
*Operating Profile [%]	20	40	40	20	40	40
FOC [ton/year]	1,009	2,020	2,281	982	1,919	2,168
	5,310			5,068		
**Annual FO Cost	abt. $3,080,000 (100.0)			abt. $2,940,000 **(95.5)**		

WIDE BEAM SHIP – 7,300 Unit PCTC

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Particulars	7,300 UNIT	7,400 UNIT (Wide beam)	**Change, Improvement**
Loa [m]	200.0	200.0	
B [m]	**35.4**	**38.0**	**+2.6m**
Td / Ts [m]	9.0 / 10.0	8.7 / 9.7	
Deadweight (Td / Ts) [mt]	14,600 / 20,050	11,300 / 17,200	-22.6% / -14.2%
CAR capacity [Unit]	**7,280**	**7,400**	**+1.6%**
BALLAST WATER at RT43 Loading [MT]	**3,600**	**Not required**	**-100.0%**
Main Engine type	7S60ME-C8	7S60ME-C8	
DMCR [kW X rpm]	13,070 X 102	13,750 X 105	
Service speed [knots]	19.4	19.8	**+0.4knots**
DFOC at 19.8 knots [Ton /day]	**41.9**	**38.6**	**-7.9%**

- **WIDE BEAM**
- **MINIMUM BALLAST WATER**
- **FUEL EFFICIENCY IMPROVEMENT**

HULL OPTIMALZATION

HULL FORM DESIGN

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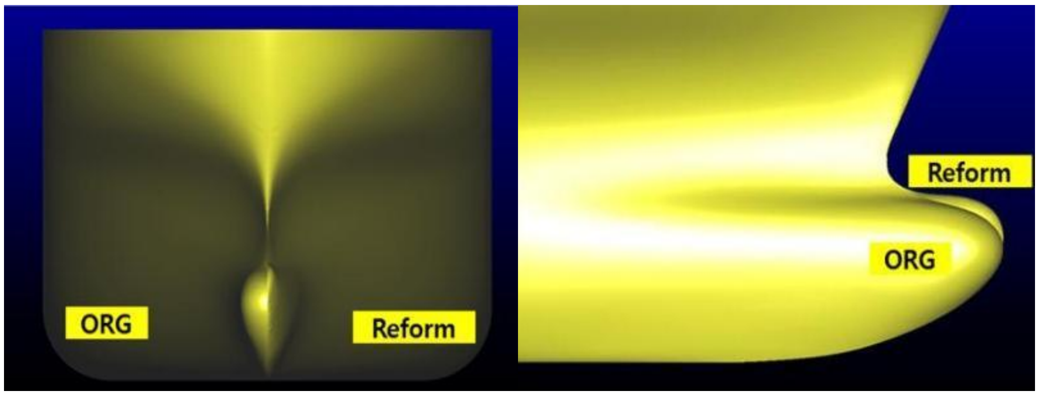
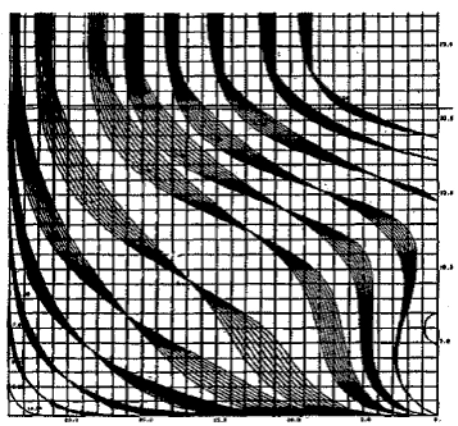
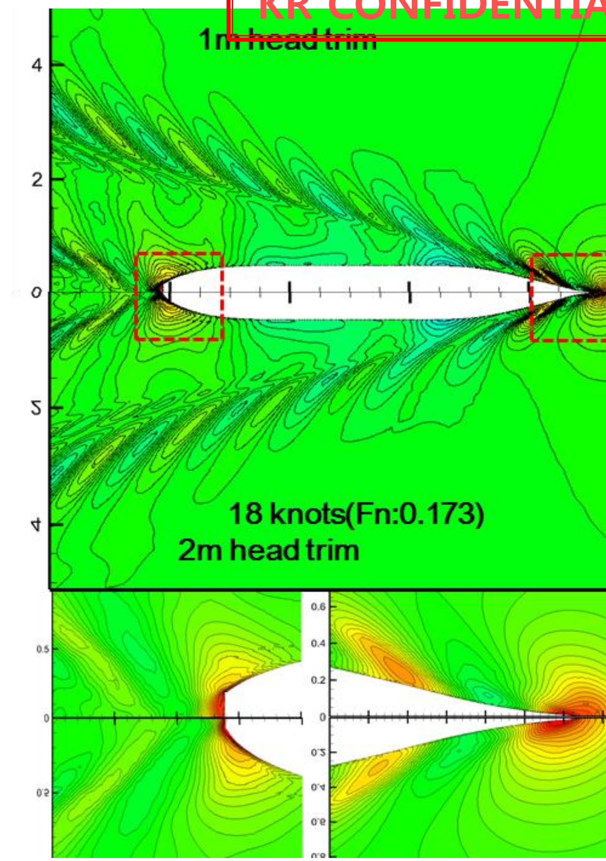


Bulbous Bow design for slow speed

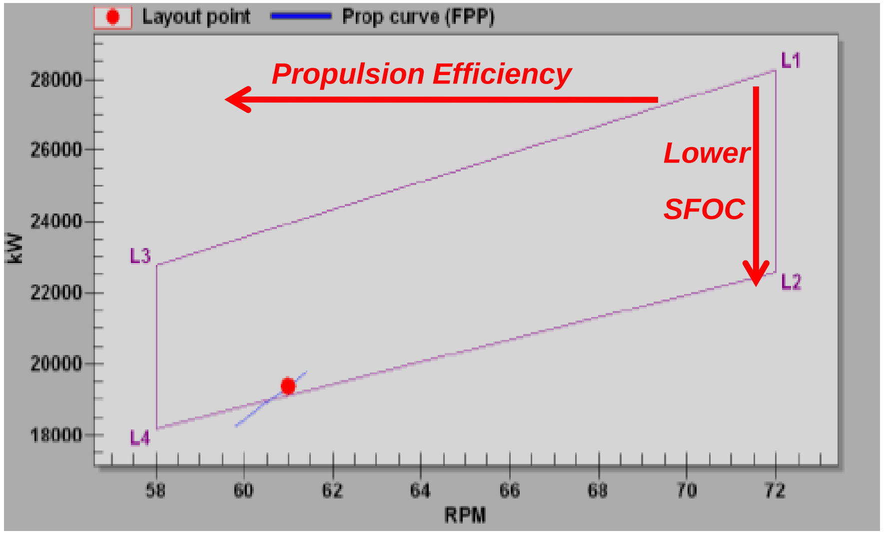


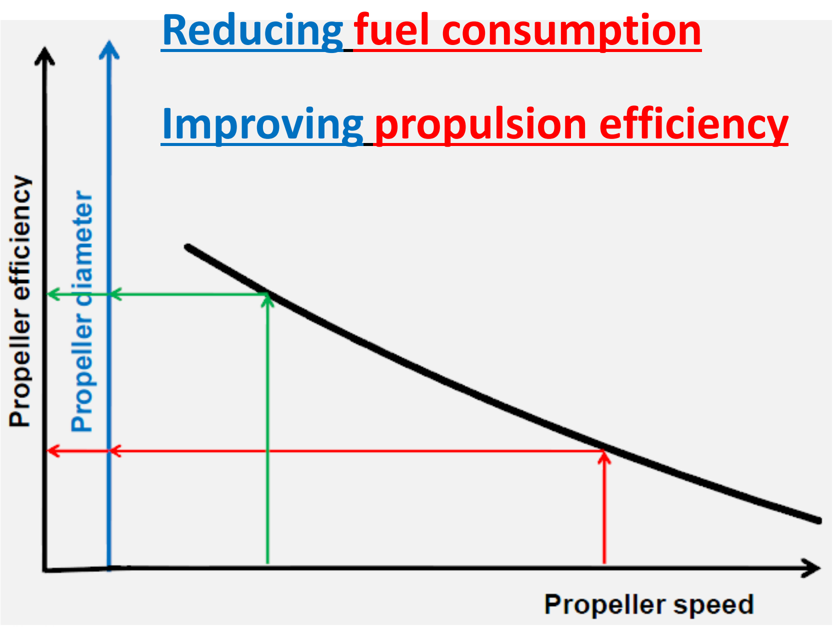
Stern shape change for
- improved propulsion efficiency
- reduced resistance
- larger propeller diameter

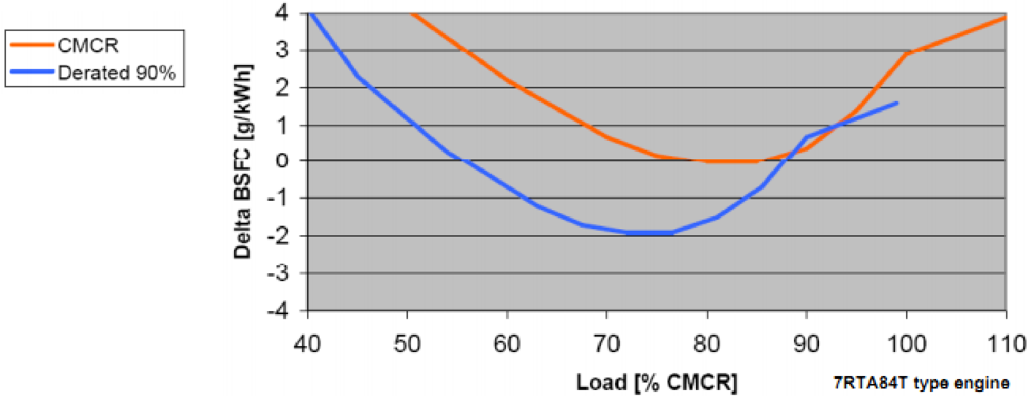


Opimization for multi point (speed, draft, trim)

MAIN ENGINE OPTIMIZATION (DERATING)



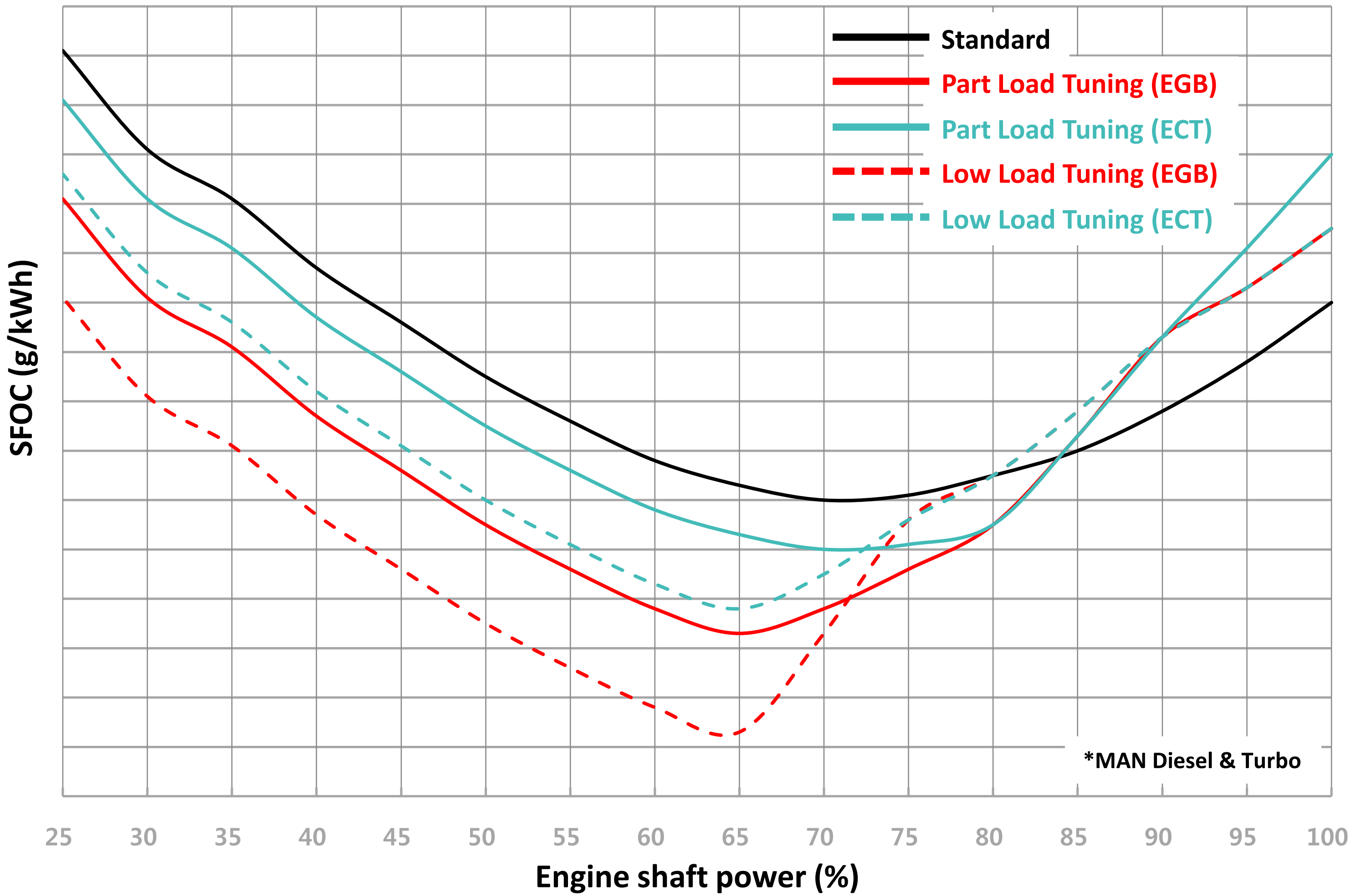




Propeller

- Optimized longer stroke
- Optimized lower rpm
- Optimized larger propeller
- Improved efficiency

LOW-LOAD & PART-LOAD TUNING



OPTIMAL ENERGY SAVING DEVICE

TANKER & BULK CARRIER

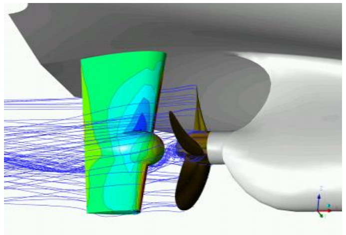

Mewis Duct

MEWIS & Pre Swirl duct
Wake equalizing effect and
Reduction of the rotational losses

Pre Swirl stator
Reduction of the rotational losses
in the propeller slipstream

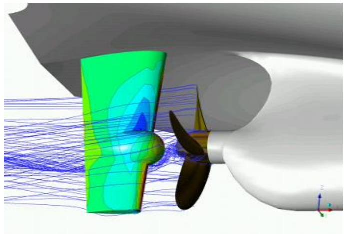
CONTAINER VESSEL


Pre-swirl stator


Rudder Bulb

GAS CARRIER

Rudder bulb
Reduce the Hub vortex losses


Rudder Bulb

HOW MUCH IMPROVEMENT

MR TANKER

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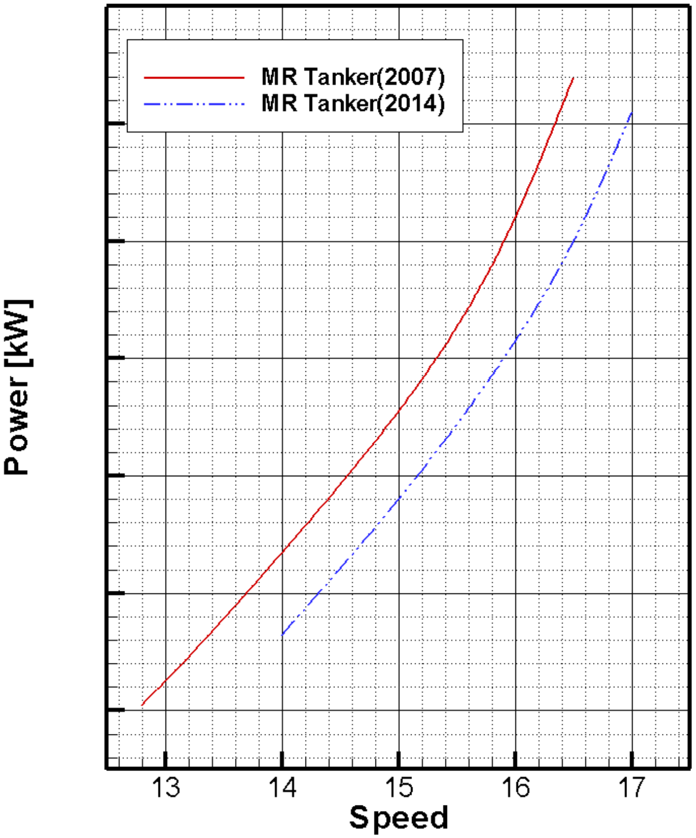
○ **In Comparison with 2007 designed MR Tanker**

Measures for improvement	
Hull Form	Bow, stern hull form development Reduced Cb
Speed	10% slow steaming
Main Engine	Adopted Gtype Engine De-rating
Propeller	17% Diameter increase NPT Propeller
ESD	Mewis Duct, PBCF

Improvement	
Power	14%
DFOC	19%



BULK CARRIER

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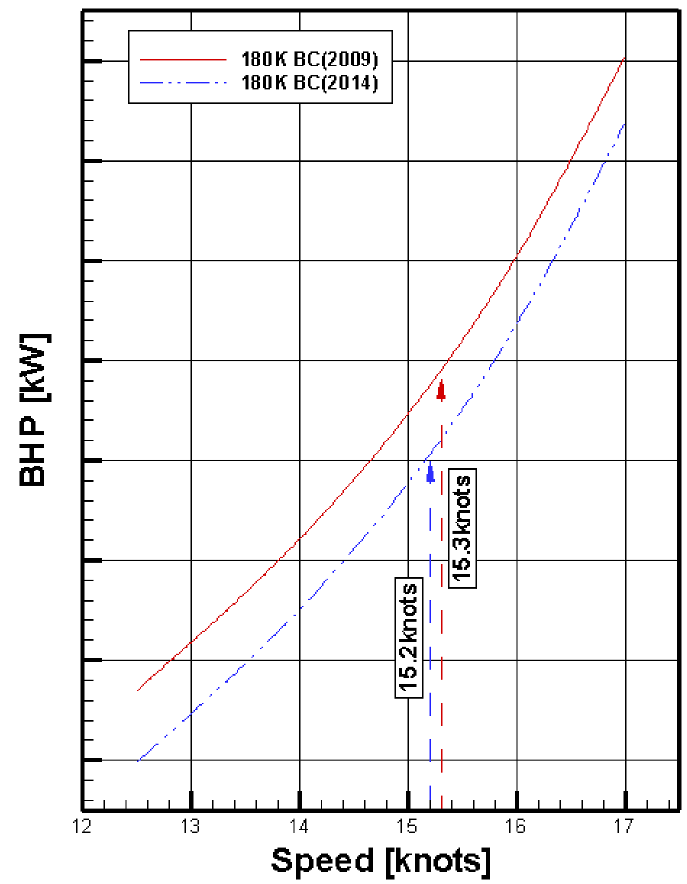
◯ **In Comparison with 2009 designed 180K DWT Bulk Carrier**

Measures for improvement	
Hull Form	Hull form development
Speed	6% slow steaming
Main Engine	Adopted Gtype Engine De-rating
Propeller	10% Diameter increase
ESD	Mewis duct



Improvement	
Power	10%
DFOC	14% (15.2knots based)

HOW MUCH IMPROVEMENT

CONTAINER VESSEL

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◯ **In Comparison with 2008 designed 9000TEU**

Measures for improvement	
Hull Form	Hull form development
Speed	19% slow steaming
Main Engine	Adopted X type Engine De-rating, Tuning
Propeller	9% Diameter increase
ESD	Twist Rudder& Rudder bulb

Improvement	
Power	19%
DFOC	22% (22.0knots based)

HOW MUCH IMPROVEMENT

LPG CARRIER

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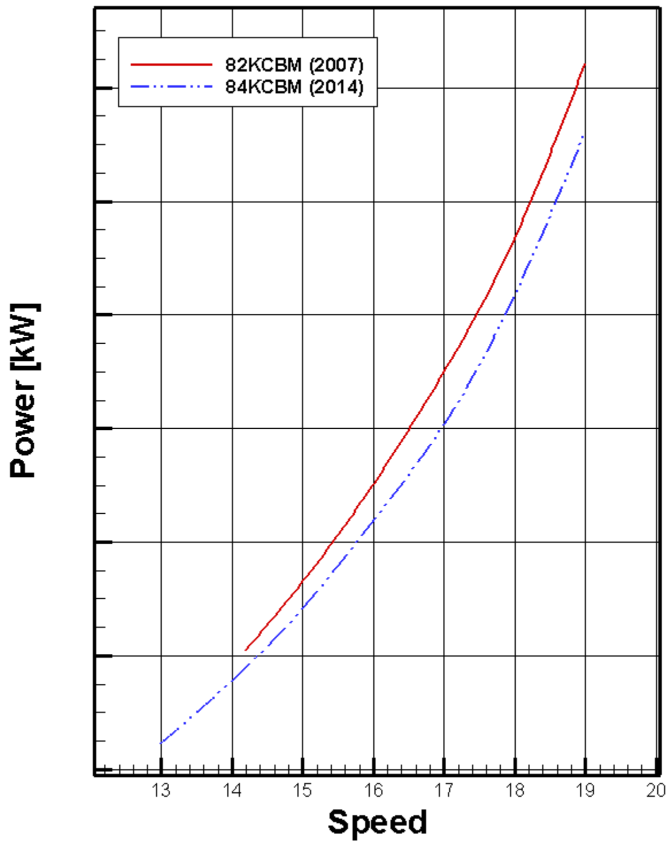
○ **In Comparison with 2007 designed 84K CBM LPG Carrier**

Measures for improvement	
Hull Form	Hull form development - leadge bow
Speed	-
Main Engine	Adopted Gtype Engine De-rating
Propeller	6% Diameter increase
ESD	Rudder bulb

Improvement	
Power	8%
DFOC	12%



MAIN DIMENSION OPTIMIZATION

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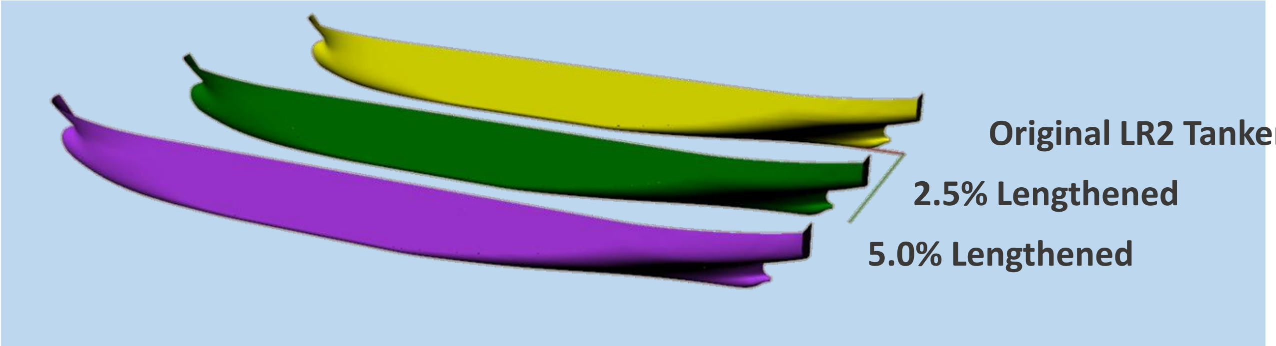
◯ **Comparison of Hull form for Original LR2 Tanker and Lengthened**



	Resistance [%] at Ts, 14.5knots	Annual FO cost [%]	EEDI
Original LR2	100.0	100.0	Phase II
2.5% Lengthened	97.1	94.2	Phase III
5.0% Lengthened	94.4	88.2	Phase III

WHAT IS NEXT?

ALTERNATIVE ENERGY

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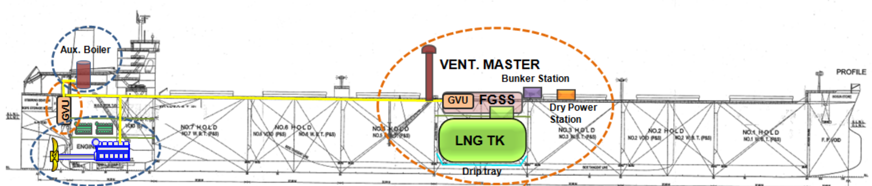
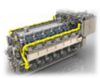
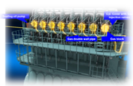
○ LNG – Ready ship, Fueled ship




[4st DF engine]


[ME-GI]

LNG Fuelled Engines
(M/E, G/E, Aux. Boiler)

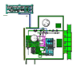
- Gas Fuelled Main Engine
- Gas Fuelled Generator Engine
- Gas Fuelled Aux. Boiler

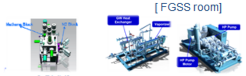
➕

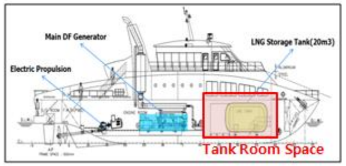
LNG Stor. & Supply Equipments
(LNG TK & FGSS incl. GVU)

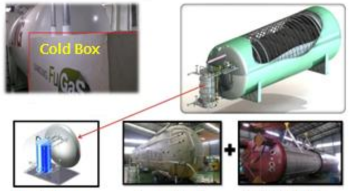
- LNG Fuel Tank (Type B) with drip tray
- FGSS(Fuel Gas Supply System)
- GVU (Gas Valve Unit)
- Vent Master
- Bunker Station
- Dry Power Station


[LNG fuel TK]


[FGSS room]

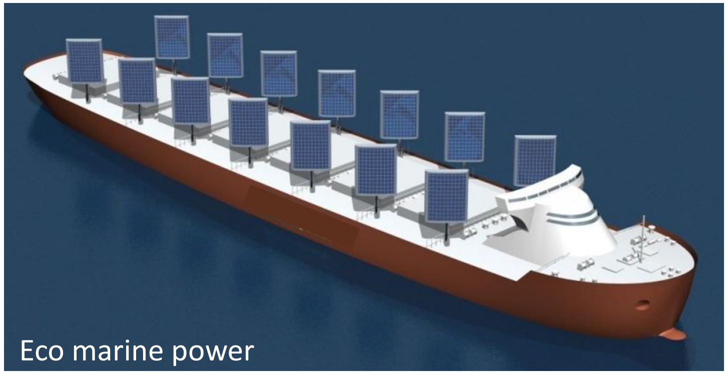

[GVU] [HP Vaporizer] [HP pump]





Tank Room (Cold Box) | Inner Shell + Outer Shell

○ Wind and Solar power ship


Eco marine power


Kite-assisted sail

MINIMUM BALLAST

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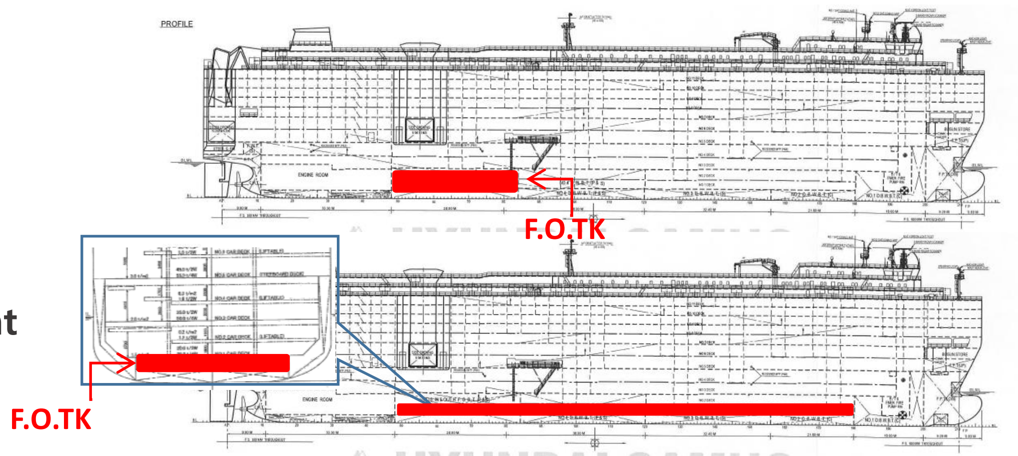
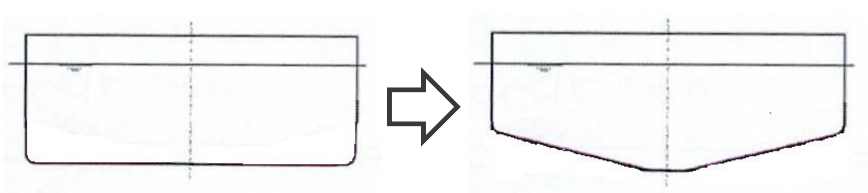
○ **Fuel oil re-arrangement(PCTC)** – reduced ballast water for stability & trim

- ✓ Original
- ✓ Re-arrangement



○ **Optimum Ballast tank arrangement**

○ **Innovative hull design (VLCC)** Source: Namura Shipbuilding Co.,Ltd



- ✓ Length & beam : No change
- ✓ Depth & Draft : +1m
- ✓ Ballast water weight : abt. 30,000MT (65% reduced)

IMPROVING SHIP PERFORMANCE IN WAVES

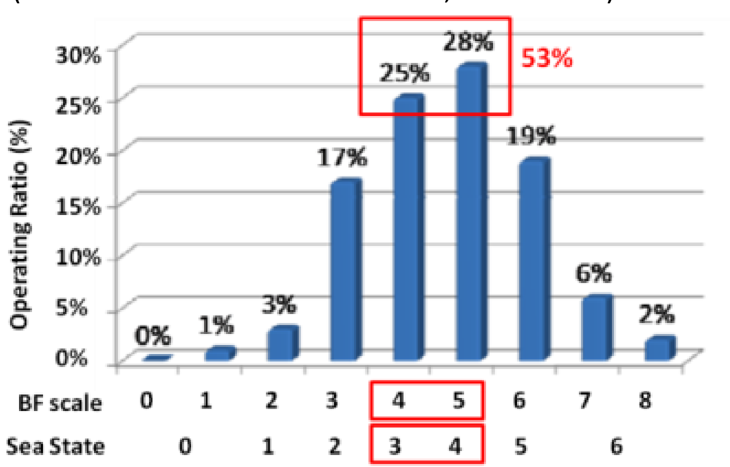
◯ **Vessels are traditionally optimized and designed for**

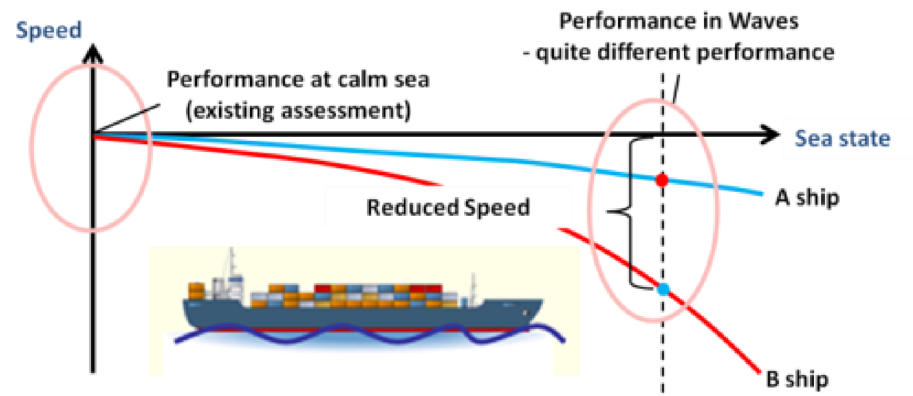
- a single condition (normally the contract speed at design draft) on calm water condition
- **but, actual operating conditions are quite different from design point.**

◯ **Difference of ship performance between at calm sea and in waves**

- Ship having same performance at calm sea have different performance at weather condition.

(based on North American routes, 2002~2007)





*Performance assessment in real sea condition

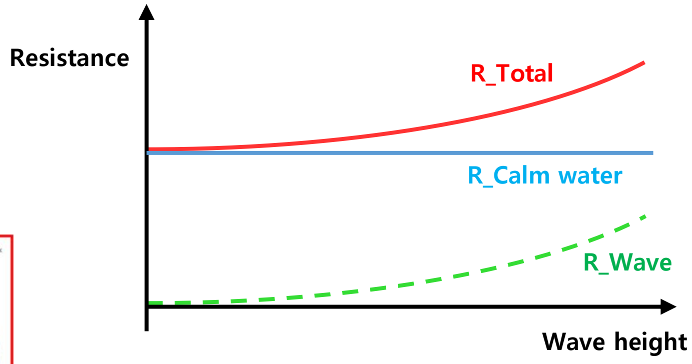
IMPROVING SHIP PERFORMANCE IN WAVES

○ **Development of Program(WISH)** for prediction of Added resistance in waves

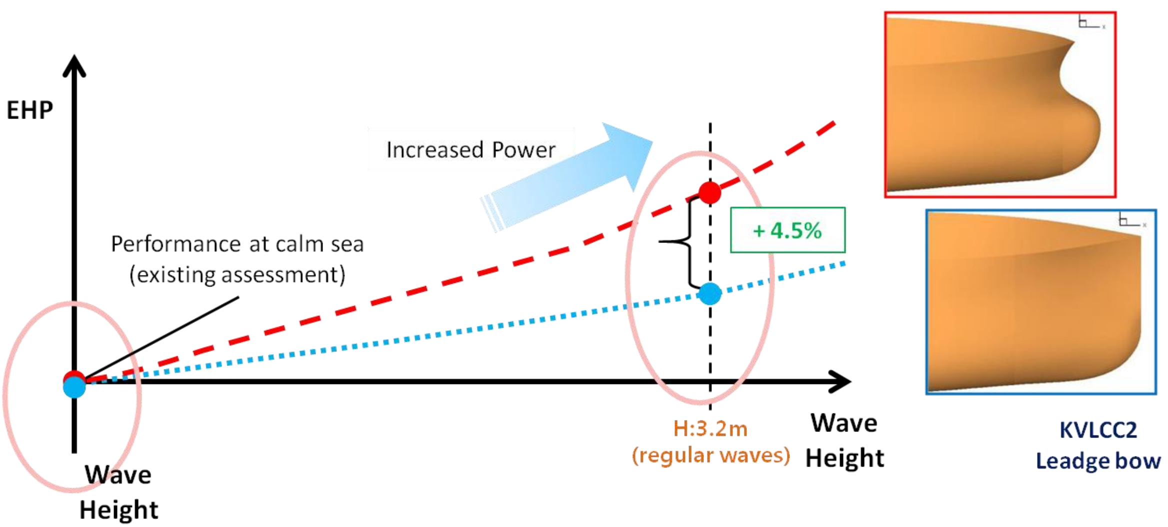
- JIP for Ship hydro-elasticity and Green-ship Technology (2013~2015)

○ **Development of prediction technology** for Added resistance in waves

- Program : STARCCM+



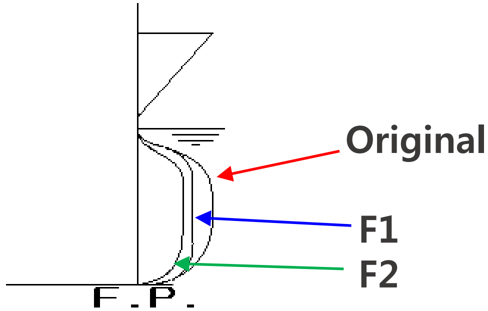
○ **Effective Power accordance with wave height**

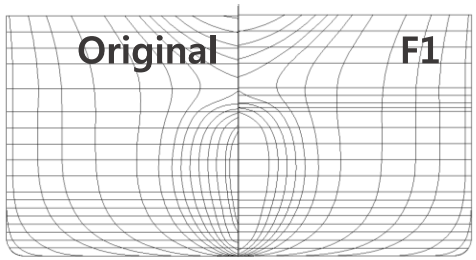


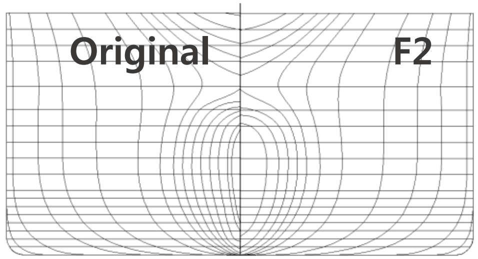
IMPROVING SHIP PERFORMANCE IN WAVES

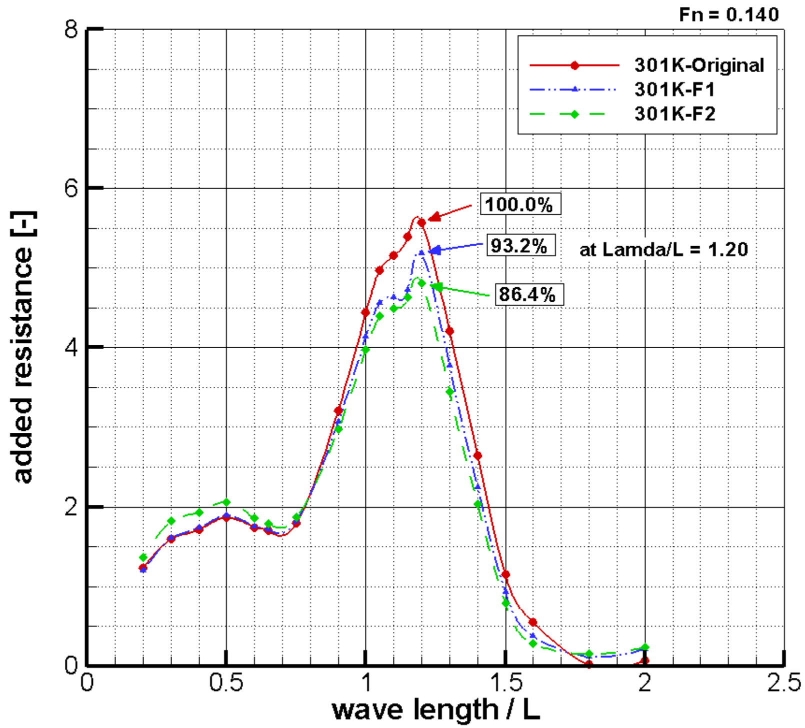
◯ **Development hull form design for reduced Added resistance in waves** (on going project)

- with a shipping company









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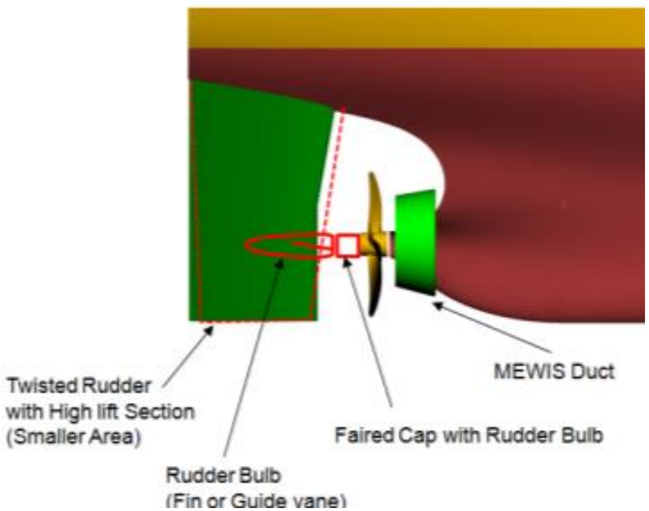
SOME THOUGHT ON FUEL EFFICIENCY

ESD EFFECTIVE AS CLAIMED?

- Optimized and designed for a single condition
  - normally contract speed at design draft
- Guaranteed for model test not for sea trial
- Combination effects of ESDs ?



FUEL EFFICIENCY AND EEDI

- EEDI and Fuel Efficiency different in certain cases

	300K C.O.TK (A)	300K C.O.TK (B)
Main Engine	MAN 7G80ME-C9.2	MAN 7G80ME-C9.2
MCR (kW x rpm)	24,020 x 65	26,460 x 66
Speed at Td (knots)	14.8	14.8
DFOC at NCR (mt/day)	**66.68**	**63.5**
EEDI(ATT./REQ.)	**-20.5%(2.06/2.59)**	**-16.6%(2.16/2.59)**

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DISADVANTAGE FROM IMPROVEMENT?

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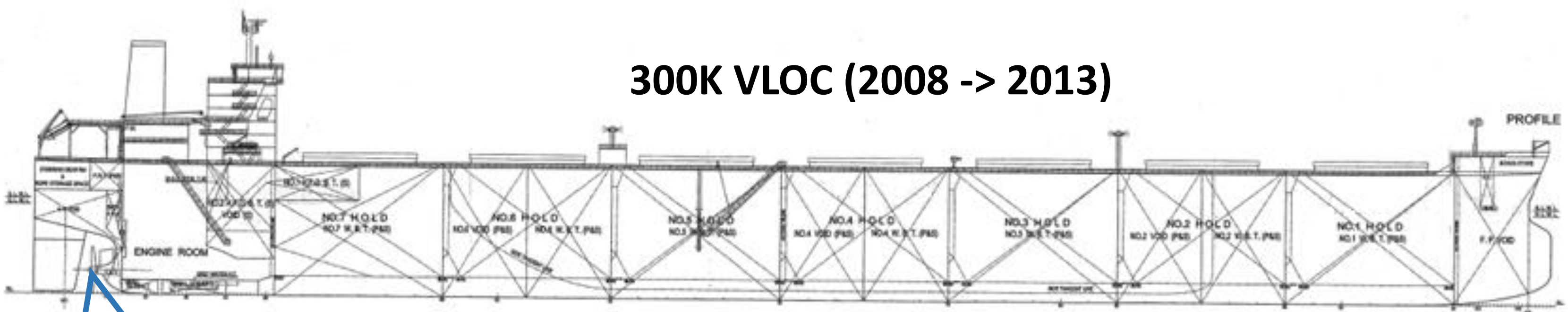
- More ballast water required
  - Due to larger propeller
  - For propeller immersion

300K VLOC (2008 -> 2013)



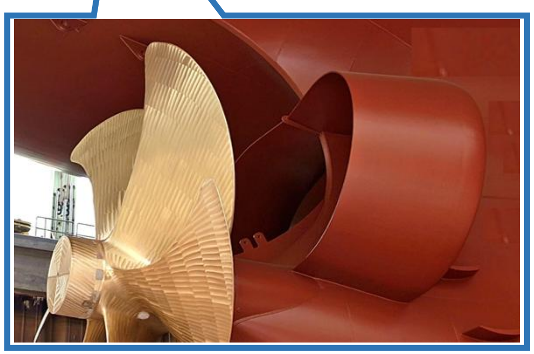


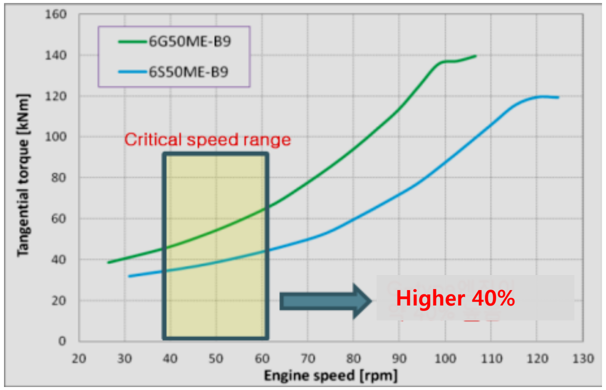
Image Credits: schneekluth.com

- Principal dimension & arrangement unchanged (ballast draft +0.6m)
- Adopted G-type engine and Larger propeller (9.7m -> 10.3m)
- Due to additional ballast water, fuel efficiency decreased by 4 %

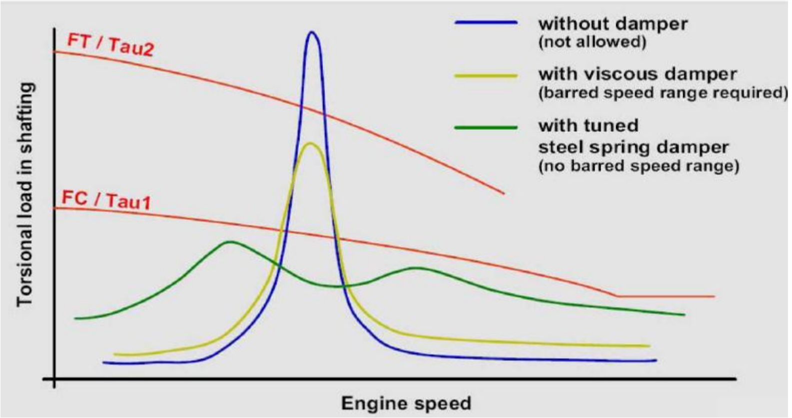
DISADVANTAGE FROM IMPROVEMENT?

- **Torsional vibration problem due to higher excitation torque**

  - Longer stroke
  - Higher excitation torque
  - Peak value of torsional vibration to be reduced by torsional vibration damper



[Excitation Torque]



[Vibration control with torsional vibration damper]

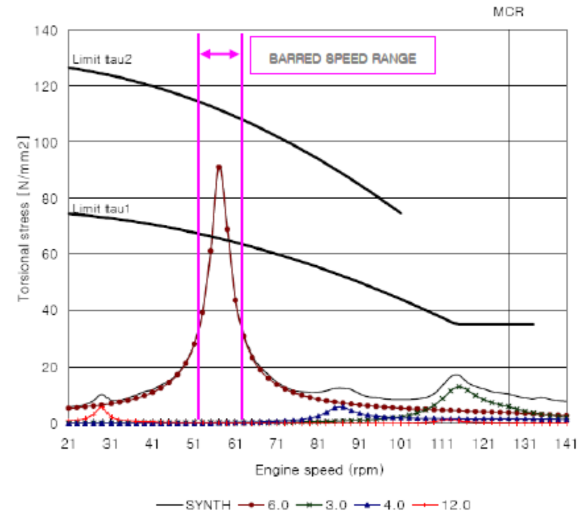
DISADVANTAGE FROM IMPROVEMENT?

- **Delayed rpm acceleration**

Caused by
- excessive de-rating power
- larger propeller diameter

Leading to
- longer time to pass barred rpm range
- longer time to reach MCR

Associated problem includes
- shaft fatigue failure
  (torsional vibration induced)
- Maneuvering difficulty



Conclusion

- **Fuel saving technology** currently being applied was reviewed

- **Fuel efficiency improvement** from each ship type was reviewed

- **Further effort will be given for fuel efficiency improvement**, some of which may involve new build cost increase.

- There are some **disadvantage from fuel efficiency improvement**. The disadvantage are being addressed by maker and shipyard.

Thank you !

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