Hydrodynamic Optimization for Energy Efficient Ship Design

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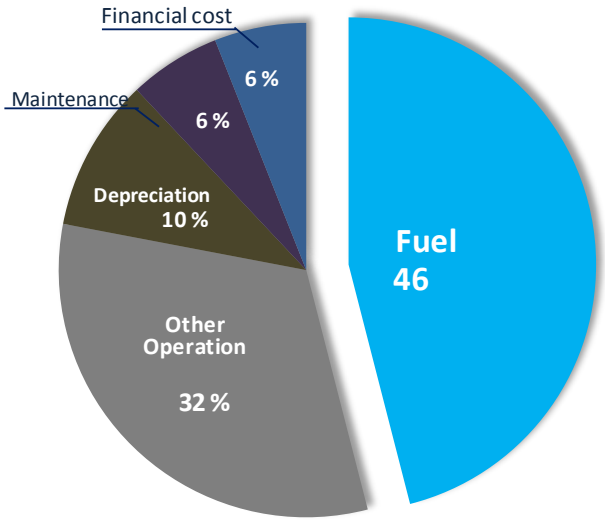
Contents

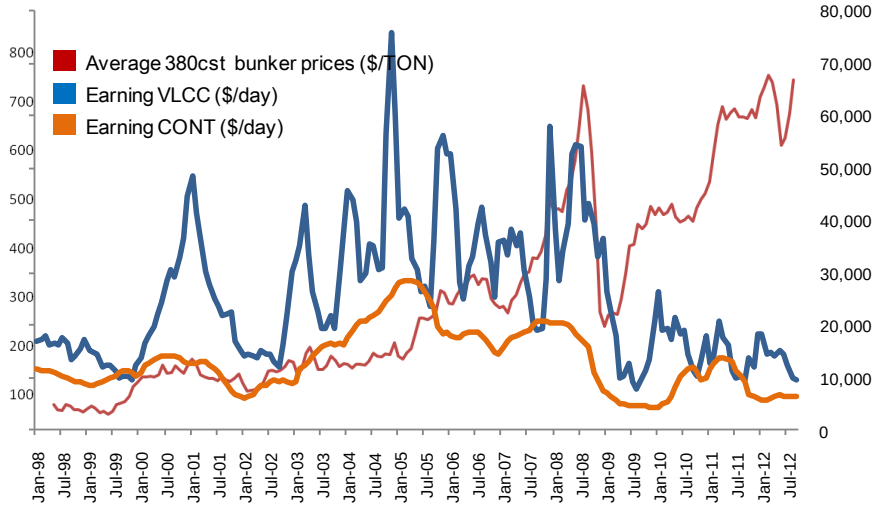
Why More Efficient Ship Design ?

1. **GHG emission Reduction**
   - New MARPOL regulations for EEDI, SEEMP will enter into force on 1 Jan 2013
2. **High fuel oil price**

COST ANALYSIS OF OPERATION



BUNKER PRICE & SHIPPING EARNING



2. Technical Issues for Energy Efficient Ship

EEDI

Engine efficiency

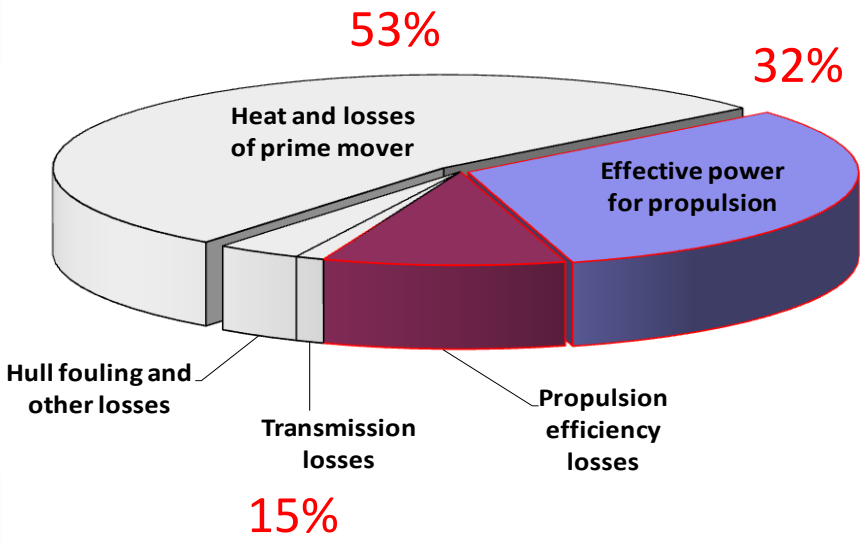
Heat Recovery System

Energy Saving Technology

$$\frac{\left(\prod_{J=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{MEi} C_{FMEi} SFC_{MEi}\right) + \left(P_{AE} C_{FAE} SFC_{AE}\right) + \left(\left(\prod_{J=1}^{M} f_j \sum_{i=1}^{nPTI} P_{PTIi} - \sum_{i=1}^{neff} f_{effi} P_{AEeffi}\right) C_{FAE} SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{effi} P_{effi} C_{FMEi} SFC_{MEi}\right)}{f_i Capacity\, V_{ref}\ f_w}$$

Optimum hull form design

- **Optimize prime mover**
  - Fuel optimized engine selection
- **Optimize resistance and propulsion**
  - Dimension parameter
  - Concept of hull form
  - Twin or single propulsion
- **Energy saving devices**
  - Recovery of propulsion losses
  - Resistance reduction



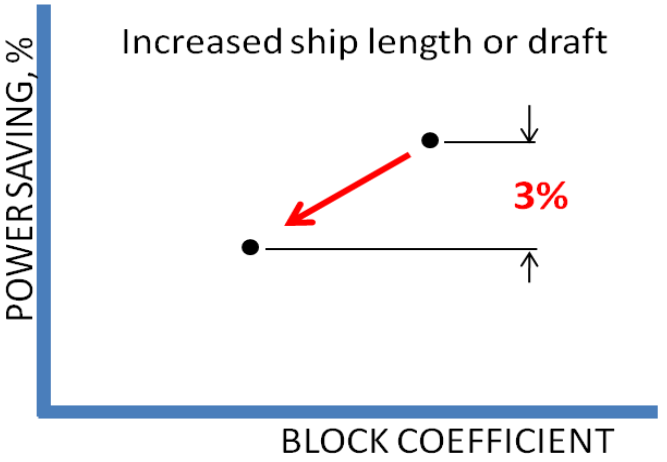
3. Reference for Fuel Savings

300k DWT VLCC

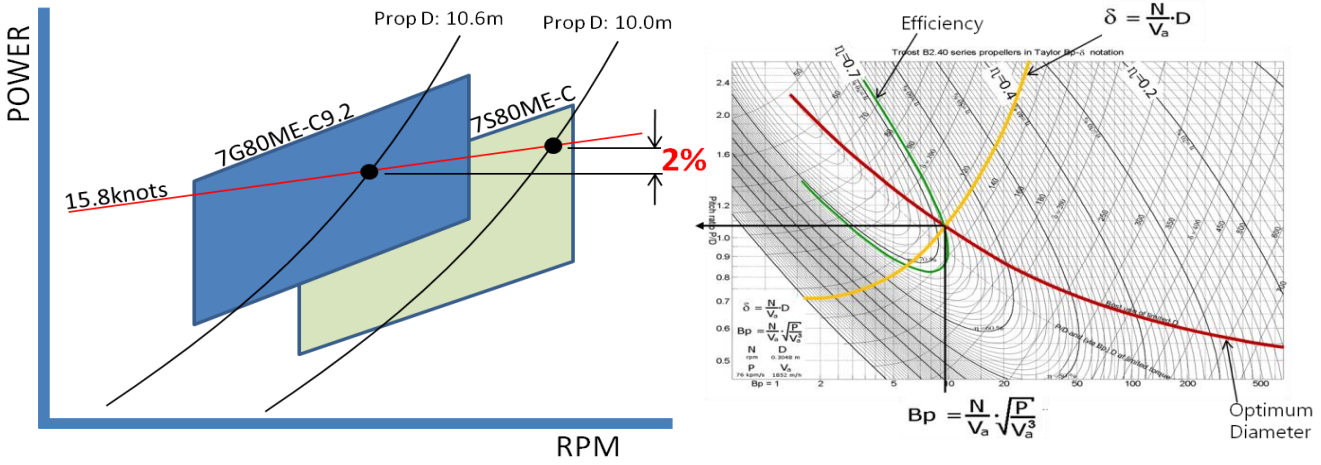
about 12% of fuel saving has been achieved by,

- Dimension parameter : +3%
- Hull form optimization : +2%
- Low RPM, Larger Diameter : +2%
- Application of energy devices : +5%

Dimension optimization



Low RPM, Larger Diameter



Application of energy devices

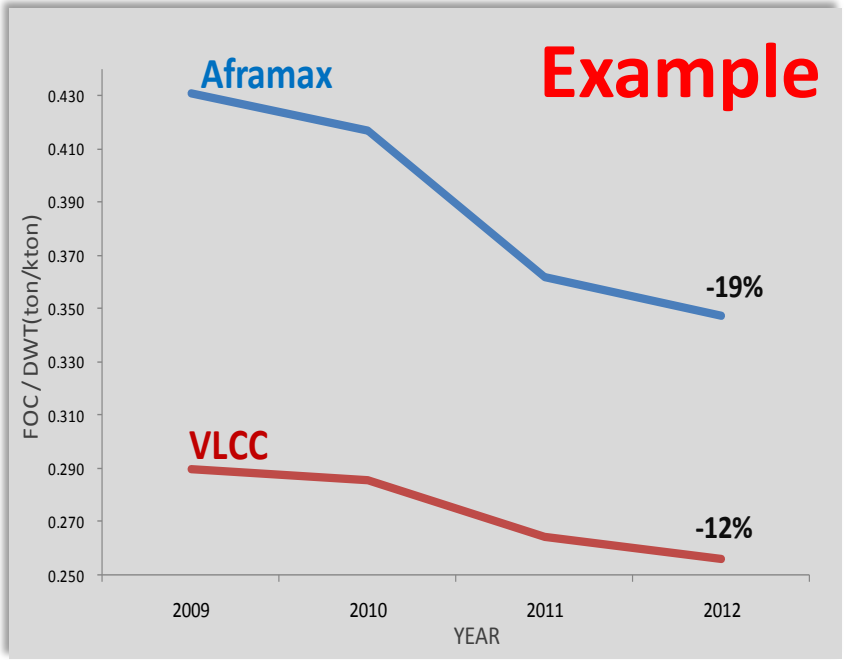
3. Reference for Fuel Savings

Tankers

About 10~20% of fuel saving have been achieved in tankers during last 4 years.

Major technologies:

- Optimized dimension parameters
- Optimized hull shape
- Low RPM & larger prop. Diameter
- Energy saving devices

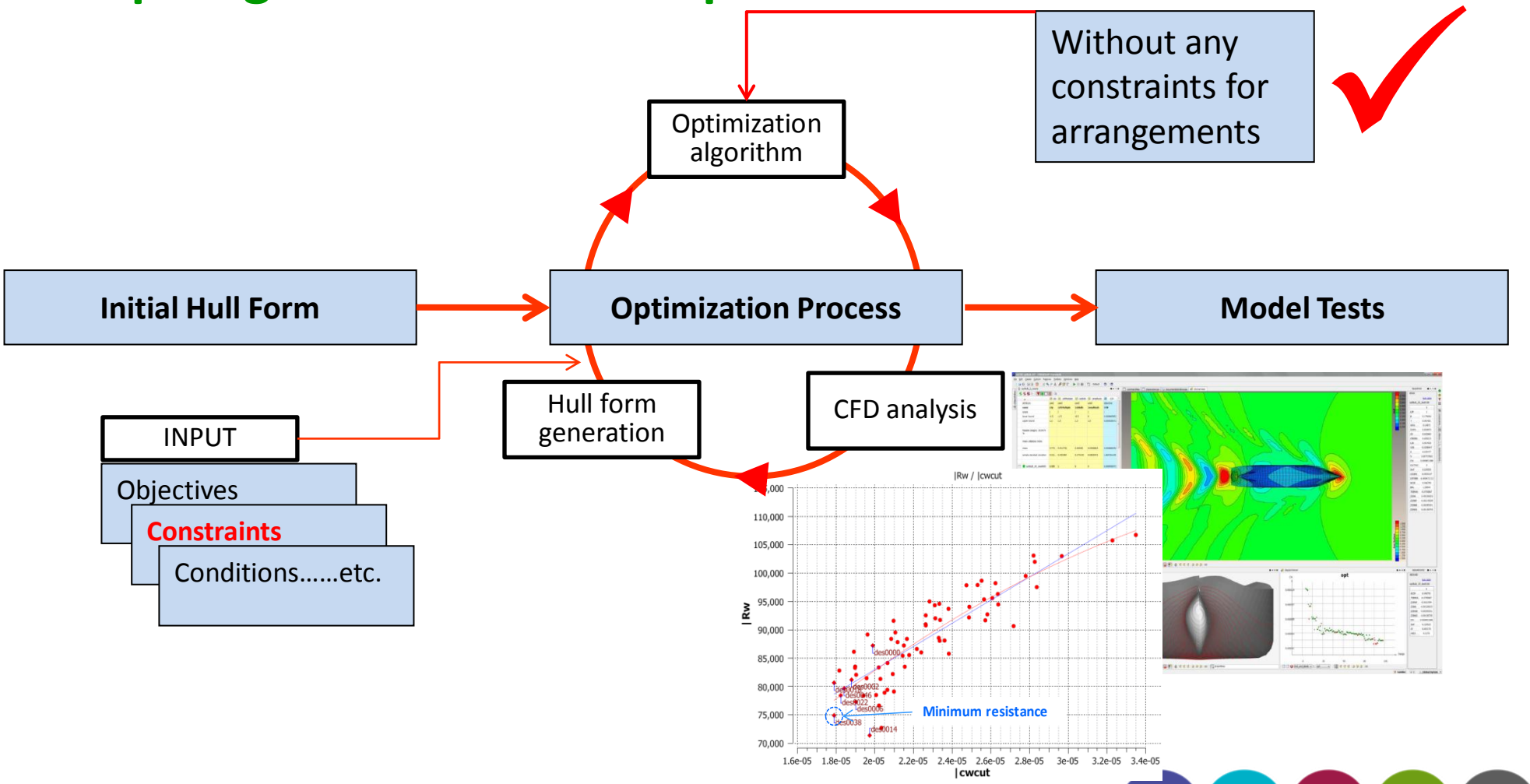


Solution 1 – Tough Design Target

Setup target resistance for optimization

Check, minimum resistance

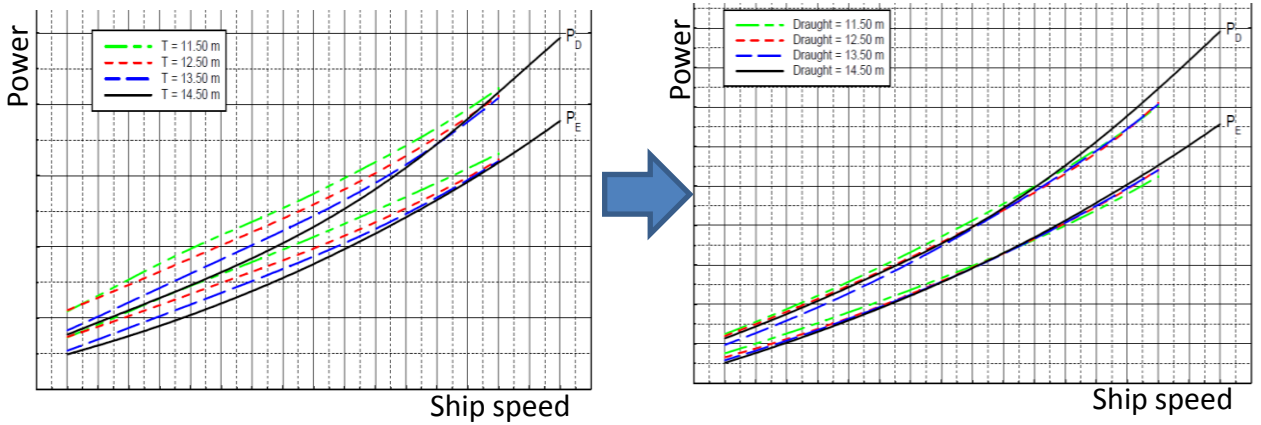
Without any constraints for arrangements

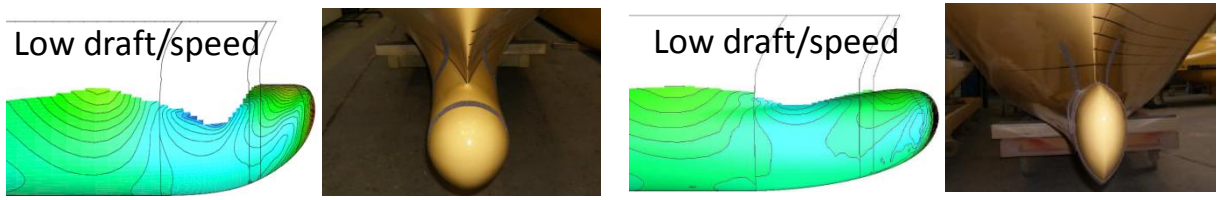


Solution 2 – Performance Trade-off for Actual Voyage

Design target is not only for contractual point, but also actual operating condition (sea state, ship speed and draft conditions)

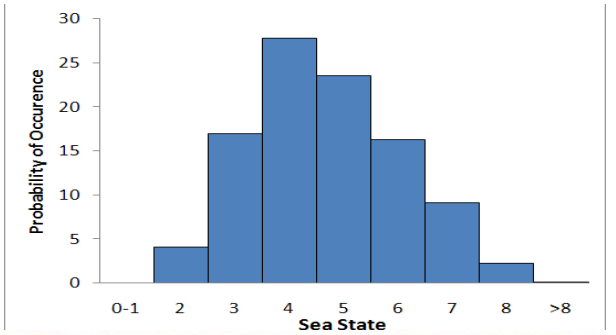
Optimization for multi-draft & speed conditions





Optimization considering sea condition in operating route

Probability of Sea State in Operating Route(OWNER DATA)



Solution 3 – Searching for better dimension

Wide beam with slow steaming gives higher transportation efficiency

Ship Length →

B \ L			Series	0	1	2	3	4	5	6	7	8	9	10
			LOA	260.0	275.0	300.0	315.0	330.0	345.0	365.0	380.0	395.0	410.0	425.0
			LPP	249.6	264.0	288.0	302.4	316.8	331.2	350.4	364.8	379.2	393.6	408.0
Series	Breadth	ROW	& BAY(DECK)	16	17	18	19	20	21	22	23	24	25	26
0	32.2	13	Td	12.0	12.0	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	14.5
			LWT	17668.8	19177.8	21811.5	23462.9	25167.8	26926.1	29353.5	31236.5	33172.8	35162.5	37205.7
			DISP't	68211.0	72146.3	81984.4	89527.0	93790.2	101824.6	111717.4	120462.4	125217.5	129972.6	134727.7
			14T HOMO	3610	3783	4298	4719	4902	5350	5883	6373	6575	6772	6966
1	34.9	14	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	14.5
			LWT	19150.4	20785.9	23640.4	25430.3	27278.2	29183.9	31814.9	33855.7	35954.3	38110.9	40325.4
			DISP't	77011.0	81454.0	88858.9	96[illegible]9	101654.6	110362.7	121085.0	130563.3	135717.1	140871.0	146024.8
			14T HOMO	4133	4333	4658	[illegible]	5313	5798	6376	6908	7126	7340	7550
2	37.6	15	Td	12.5	12.5	12.5	[illegible]	13.0	13.5	14.0	14.5	14.5	14.5	14.5
			LWT	20631.9	22394.0	25469.3	273[illegible]	29388.5	31441.6	34276.2	36474.9	38735.9	41059.3	43445.1
			DISP't	80945.3	85615.2	93398.4	101991.1	[illegible]7.8	116000.8	127270.9	137233.4	142650.5	148067.6	153484.7
			14T HOMO	4308	4516	4852	5238	[illegible]	6040	6642	7197	7422	7643	7860
3	40.3	16	Td	12.5	12.5	12.5	13.0	[illegible]	13.5	14.0	14.5	14.5	14.5	14.5
			LWT	22113.4	24002.0	27298.3	29365.1	31[illegible]	[illegible]3699.4	36737.5	39094.1	41517.5	44007.8	46564.9
			DISP't	88926.8	94057.2	102607.8	112047.8	117383.[illegible]	[illegible]8.9	139820.3	150765.1	156716.4	162667.6	168618.9
			14T HOMO	4772	5004	5379	5906	6135	[illegible]	7363	7977	8228	8476	8718
4	43.0	17	Td	12.5	12.5	12.5	13.0	[illegible]	[illegible]	14.0	14.5	14.5	14.5	14.5
			LWT	23595.0	25610.1	29127.2	31332.5	33609.2	3[illegible]	39198.8	41713.3	44299.1	46956.2	49684.6
			DISP't	94884.7	100358.8	109482.3	119554.7	125247.8	13597[illegible]	[illegible]87.9	160866.0	167216.0	173565.9	179915.9
			14T HOMO	5092	5339	5740	6302	6546	7144	[illegible]	8511	8780	9044	9302
5	45.7	18	Td	[illegible]	12.5	12.5	13.0	13.0	13.5	[illegible]	14.5	14.5	14.5	14.5
			LWT	[illegible]	27218.2	30956.1	33399.9	35719.5	38215.0	4[illegible]	44332.5	47080.6	49904.6	52804.3
			DISP't	100[illegible]	[illegible]6660.4	116356.8	127061.6	133112.1	144515.1	15859[illegible]	[illegible]066.9	177715.6	184464.3	191213.0
			14T HOMO	54[illegible]	[illegible]5674	6100	6697	6957	7593	8350	[illegible]45	9331	9611	9886
6	48.4	19	Td	12.5	[illegible]	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	14.5
			LWT	26558.1	[illegible]	32[illegible]5.0	35267.3	37829.9	40472.7	44121.5	[illegible]6951.7	49862.2	52853.0	55924.1
			DISP't	106800.4	11[illegible]	[illegible]23231.2	134568.5	140976.5	153053.2	167923.1	181067.8	188215.2	195362.6	202510.0
			14T HOMO	5732	60[illegible]	6460	7093	7368	8041	8843	9580	9882	10179	10470
7	51.1	20	Td	12.5	12.5	[illegible]5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	14.5
			LWT	28039.6	30[illegible]4.3	[illegible]	37234.7	39940.2	42730.5	46582.8	49570.9	52643.8	55801.4	59043.8
			DISP't	112758.3	[illegible]19263.6	13[illegible]	142075.4	148840.9	161591.3	177290.7	191168.7	198714.8	206260.9	213807.1
			14T HOMO	6051	[illegible]6345	6[illegible]	7489	7779	8490	9336	10114	10434	10747	11055
8	53.8	21	Td	12[illegible]	[illegible]2.5	12.5	[illegible]3.0	13.0	13.5	14.0	14.5	[illegible]4.5	14.5	14.5
			LWT	29521.[illegible]	[illegible]32.4	36442.8	[illegible]	42050.6	44988.3	49044.1	52190.1	55425.3	58749.8	62163.5
			DISP't	1187[illegible]	[illegible]25565.2	136980.2	[illegible]	156705.3	170129.4	186658.3	201269.5	209214.4	217159.2	225104.1
			14T HOMO	[illegible]	6680	7181	[illegible]	8190	8939	9830	10649	10985	11315	11639
9	56.5	22	Td	[illegible]	12.5	12.5	13.[illegible]	[illegible]13.0	[illegible]3.5	14.0	14.5	14.5	14.5	14.5
			LWT	[illegible]2.7	33650.5	38271.7	41169.5	[illegible]0.9	47246.1	51505.4	54809.3	58206.9	61698.2	65283.3
			DISP't	[illegible]674.0	131866.8	143854.7	157089.3	[illegible]569.7	178667.5	196025.9	211370.4	219714.0	228057.6	236401.1
			14T HO[illegible]	6691	7015	7542	8280	8601	9387	10323	11183	11536	11883	12223
10	59.2	23	Td	12.5	12.5	12.5	13.0	13.0	13.5	[illegible]4.0	14.5	14.5	14.5	14.5
			LWT	32484.3	35258.6	40100.7	43136.9	46271.3	49503.9	53966.8	57428.5	60988.5	64646.6	68403.0
			DISP't	130631.9	138168.4	150729.1	164596.2	172434.1	187205.6	205393.5	221471.3	230213.6	238955.9	247698.2
			14T HOMO	7011	7351	7902	8676	9012	9836	10816	11717	12088	12451	12807

Ship Breadth ↓

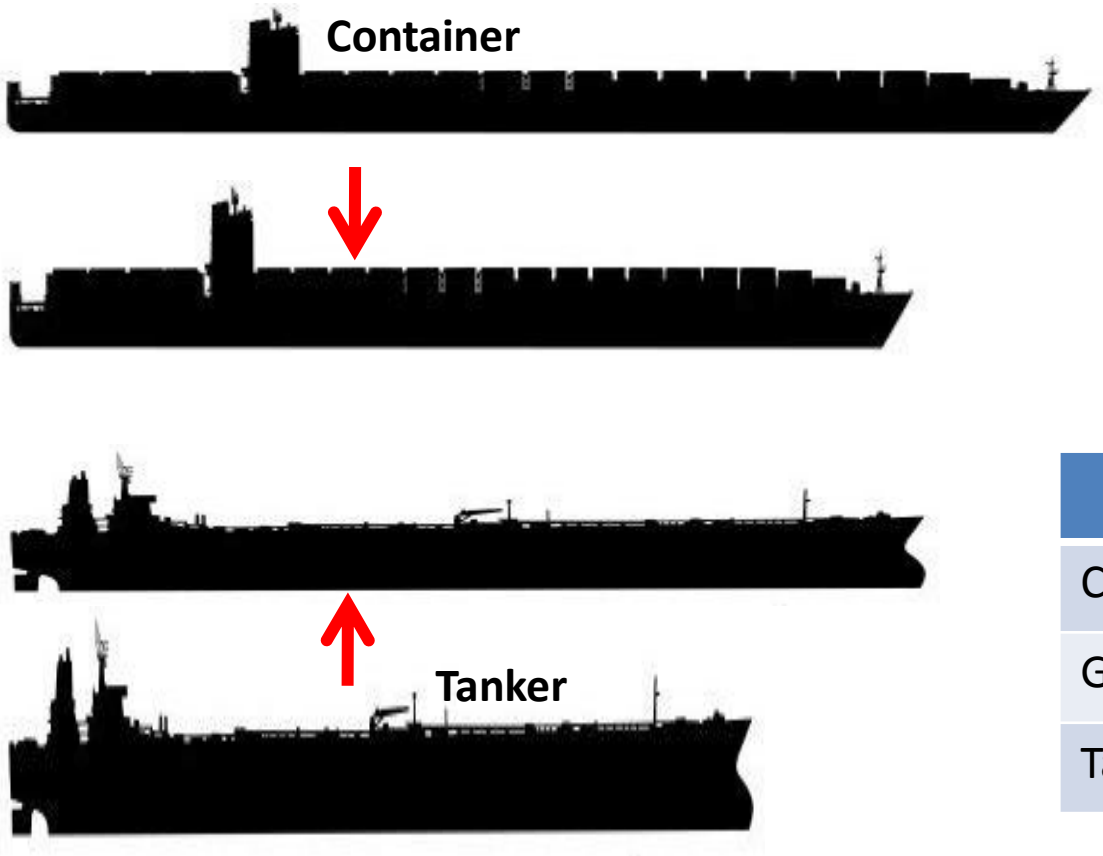
Conventional, L/B 7.5

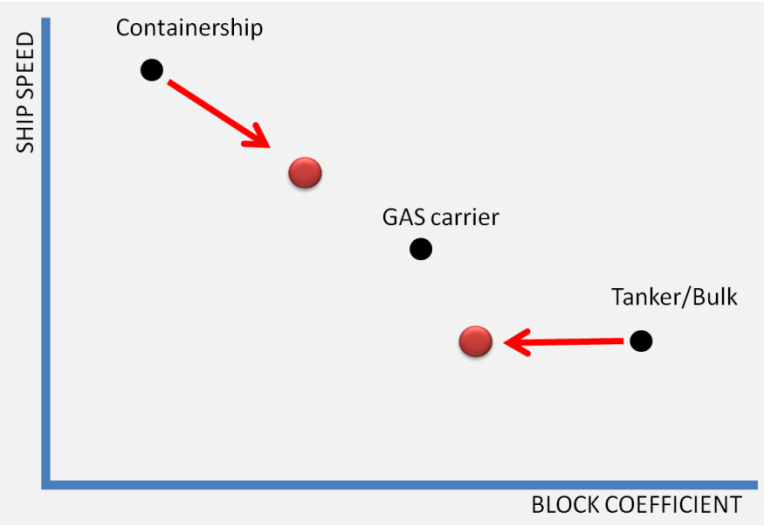
Slow steaming, L/B 6.5

Identical Capa.

Solution 3 – Searching for better dimension

Seeking less fuel consumption by adjustment of dimension parameters





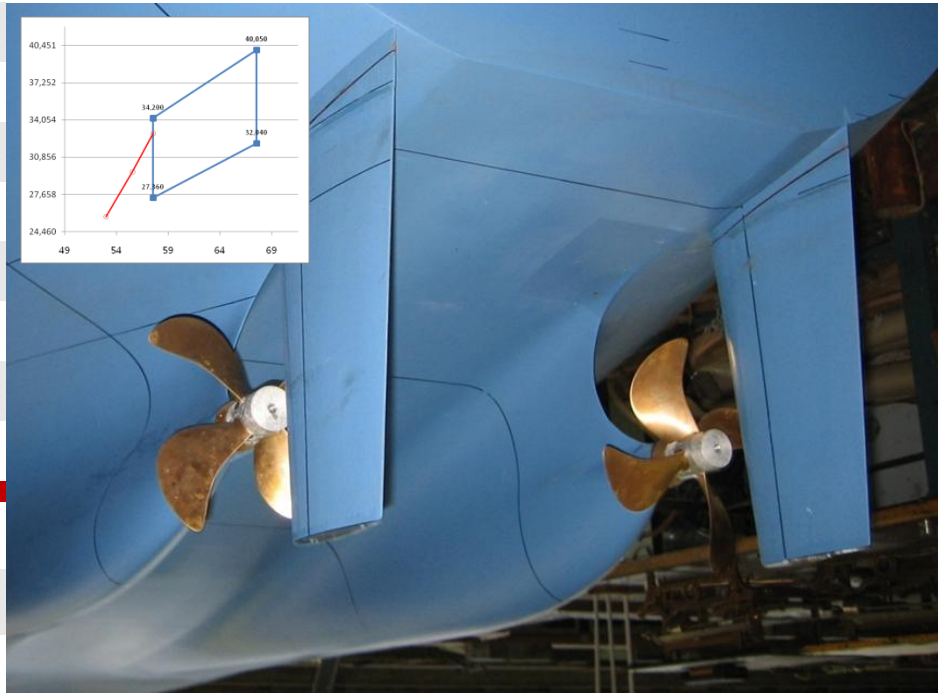
	Vs, kn	C_B
Containership	25 → 23	0.6 → 0.7
GAS Carrier	19.5	0.75
Tanker/Bulker	15.5	0.85 → 0.8

Solution 4 – Twin propulsion gives better efficiency
Higher propulsion efficiency in twin skeg can be a solution

Case study – 12,000TEU Containership

PARAMETER	SINGLE	TWIN
LBP, m	363.0	363.0
Beam, m	51.2	51.2
Draft, m	14.0	14.0
WSA, m3	21810	22623
ENGINE	12K98ME-C	9G80ME-C9 x 2
MCR, kW x RPM	72240 x 104.0	32900 x 58.0
NCR, kW x RPM	65020 x 100.4	29610 x 56.0
No of Propeller	1	2
Prop Dia, m	8.9	10.3
No of blade	6	5
Resistance	**-**	**4% increase**
P. efficiency	**-**	**13% higher**
Expected req. power	**-**	**9% reduced**

Abt. 9% fuel saving can be expected with twin propulsion with long stroke engine.



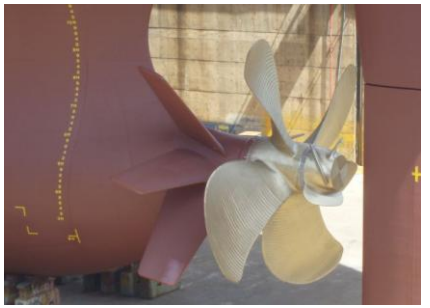
Solution 5 – Energy Saving Devices
Devices for recovery of rotational losses

Devices in front of the propeller

Combination of vane wheel & hydrodynamic fin system

Low Viscous Resistance Fin, LV Fin

Wake equalizing duct



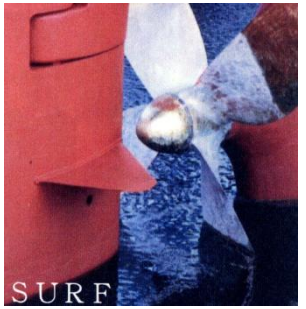
Pre-swirl stator & PBCF

Devices behind the propeller

MHI Contra-rotating propeller

Propeller Boss Cap Fin, PBCF

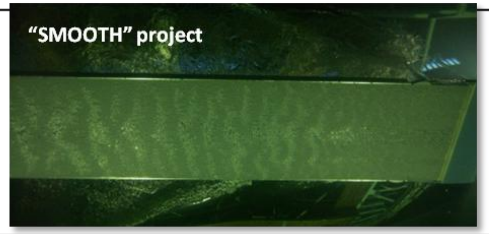
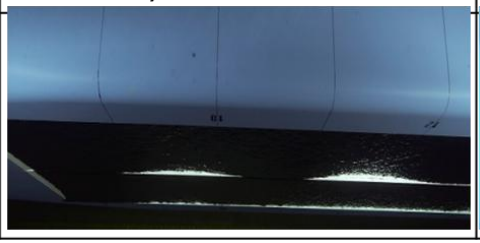
Costa bulb



Rudder fin

Solution 5 – Energy Saving Devices
Devices for resistance reduction

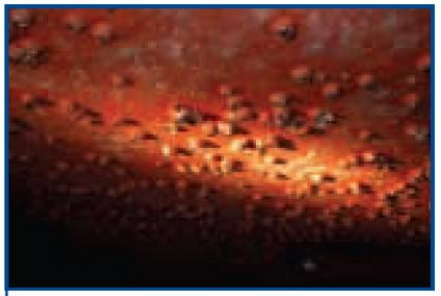
Air Lubrication System

Micro Bubble	Air Cavity	Air Layer
		

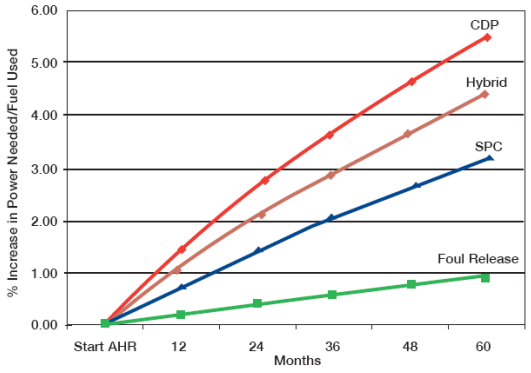
Low Friction A/F Coating

Slime: 1~2% increase in vessel drag

Weed: up to 10% increase in vessel drag



Shell: up to 40% increase in vessel drag

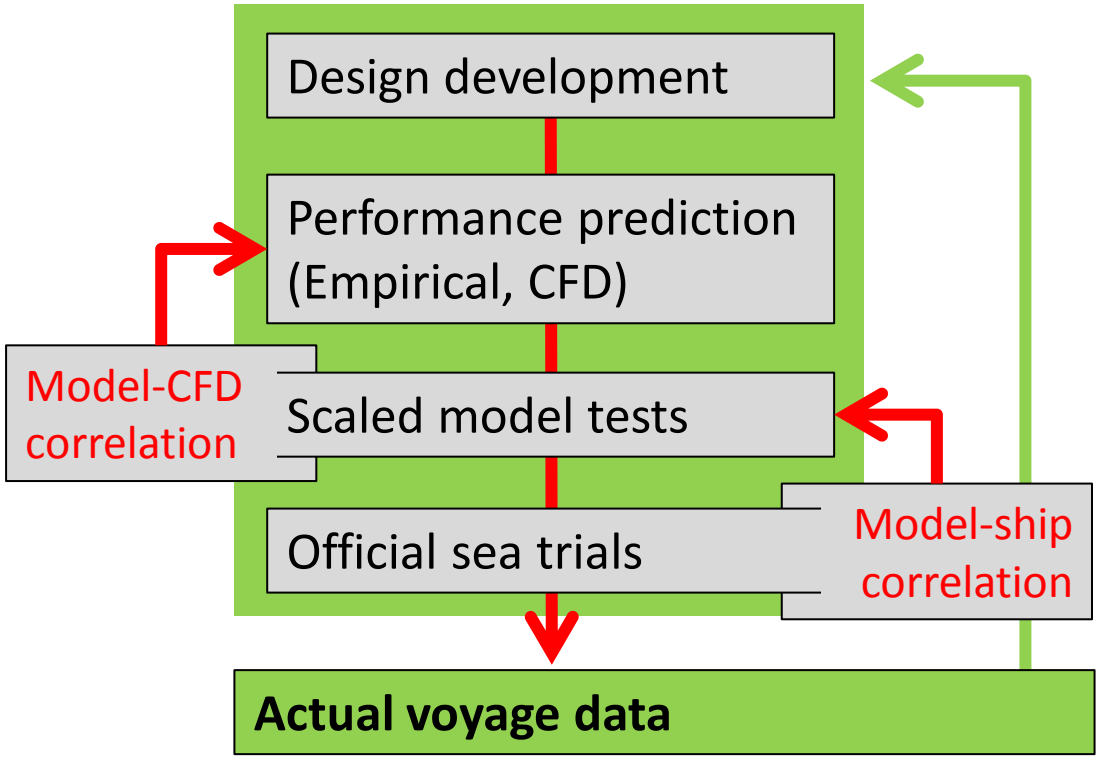


Source: International Marine Coatings

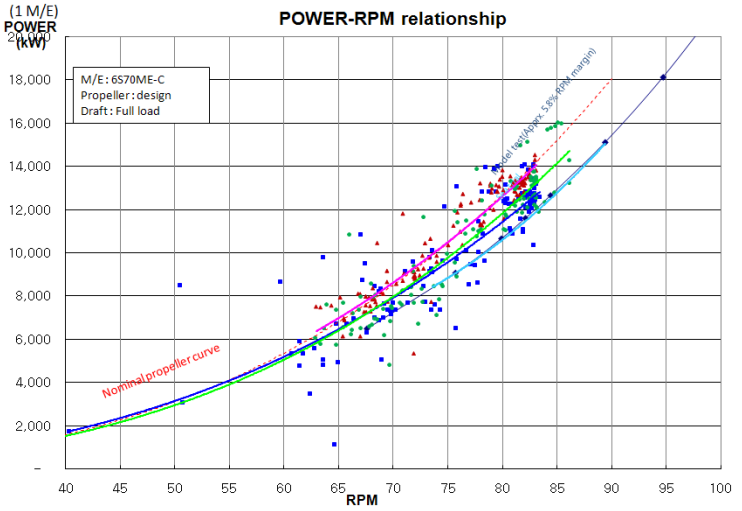
Solution 6 – Feedback from actual voyage

Need feedback from actual voyage for step forward

Performance feedback



Example of actual voyage data



5. Summary

1. Energy efficient ship design is not an option, a matter of survival
2. Design solutions for efficient design are proposed
   - set up tough design target
   - design for actual voyage
   - find better dimension parameter
   - consider twin propulsion
   - apply energy saving device
3. For further design improvement, we need feedback from actual voyage of the vessel

Q&A

DSME DAEWOO SHIPBUILDING & MARINE ENGINEERING CO.,LTD.