ClassNK
R&D PROJECT

Green Shipping Technologies of NYK Group
-Introduction of MTI's R&D-

8 April, 2014

Tomonori ISHII

MTI Co., LTD Singapore Branch
NYK Group R&D company

NYK GROUP

MTI (Monohakobi Technology Institute)

Established	1st April 2004
Shareholder	NYK (100%)
Location	Tokyo (in NYK HQ building)
Number of employees	58

Monohakobi Technology Institute
Innovative Technology for a better world!

Web: http://www.monohakobi.com

Business Areas

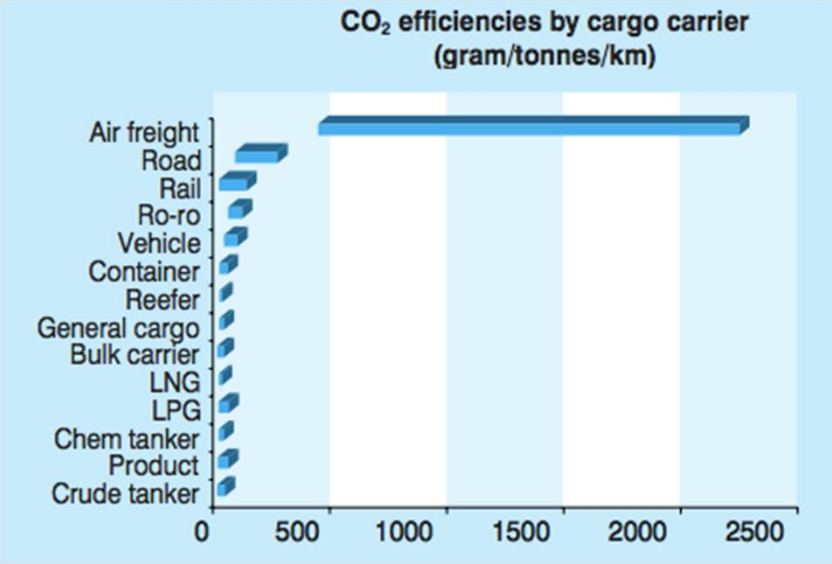
Research and Development for
- Logistics Technology
- Maritime Information Technology
- Maritime Technology

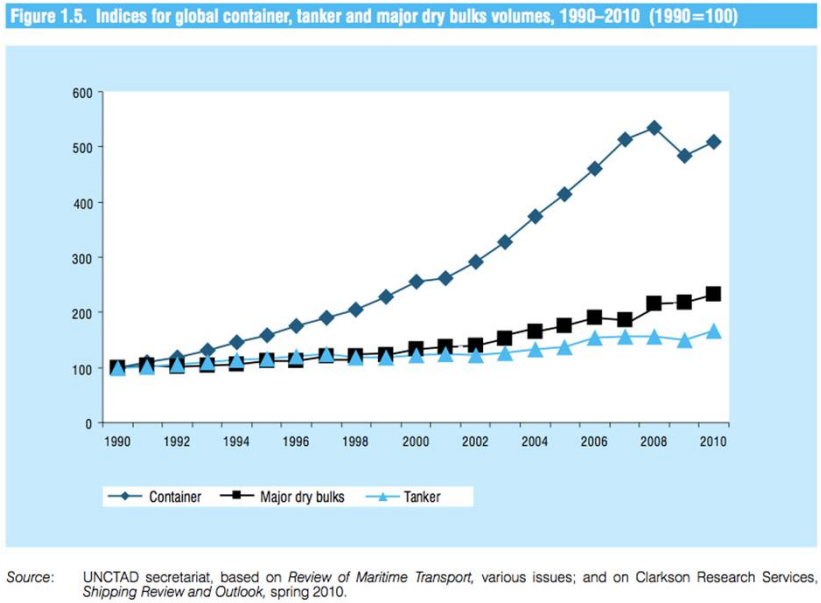
Singapore branch office registered on 26th September 2013

Background

CO2 emission from international shipping

- Shipping is the most energy efficient mode of transport
- World seaborne trade grows
  - In the past, yearly growth rate : 4.1 % (average of 1995 – 2006)
  - In the future, yearly growth rate 3% is expected



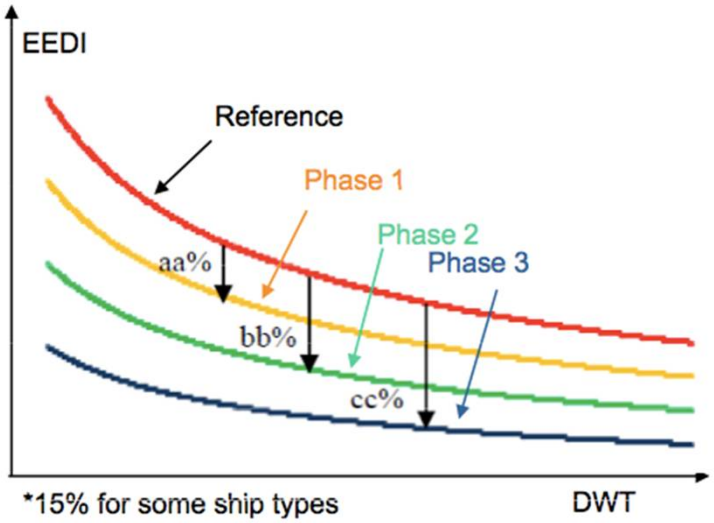


Source: UNCTAD, "Review of MARINE TRANSPORT 2009", "Review of MARINE TRANSPORT 2010"

International regulations for CO2 emissions

- IMO MEPC 62 (June 2011) adopted revisions of MARPOL Annex VI introducing EEDI and SEEMP
  - EEDI: Energy Efficiency Design Index
  - SEEMP: Ship Energy Efficiency Management Plan
- Entry into force date: 1 January 2013

$$EEDI = \frac{CO_2\ emission}{transport\ work}$$



DWT: dead weight ton - cargo load

Table 1. Reduction factors (in percentage) for the EEDI relative to the EEDI Reference line

Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
Bulk carrier	20,000 DWT and above	0	10	20	30
	10,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Gas carrier	10,000 DWT and above	0	10	20	30
	2,000 – 10,000 DWT	n/a	0-10*	0-20*	0-30*
Tanker	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Container ship	15,000 DWT and above	0	10	20	30
	10,000 – 15,000 DWT	n/a	0-10*	0-20*	0-30*

SEEMP - PDCA management for energy efficiency

- SEEMP (Ship Energy Efficiency Management Plan)
  - MEPC 62 adopted revisions of MARPOL Annex VI introducing EEDI and SEEMP
- Entry into force date: 1 January 2013

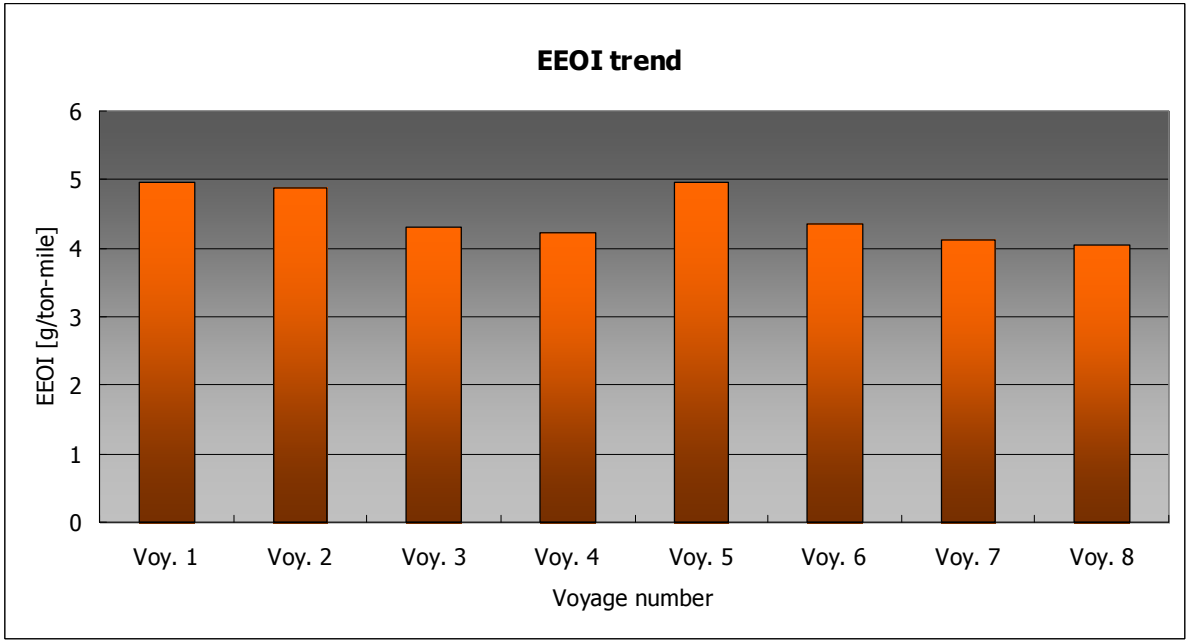
Operational measures

- slow steaming
- weather routing
- hull and propeller maintenance

….

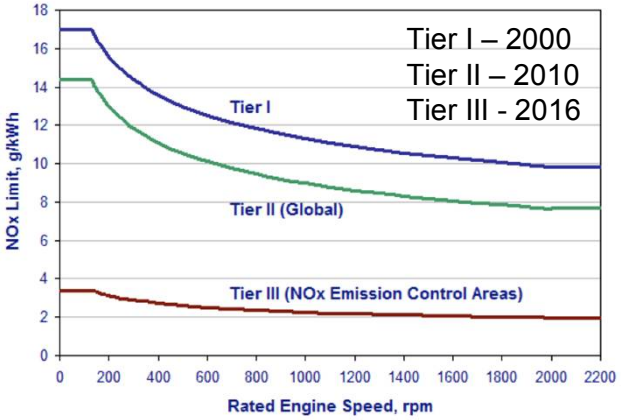
Plan Do Check Act

Continuous monitoring & improvement

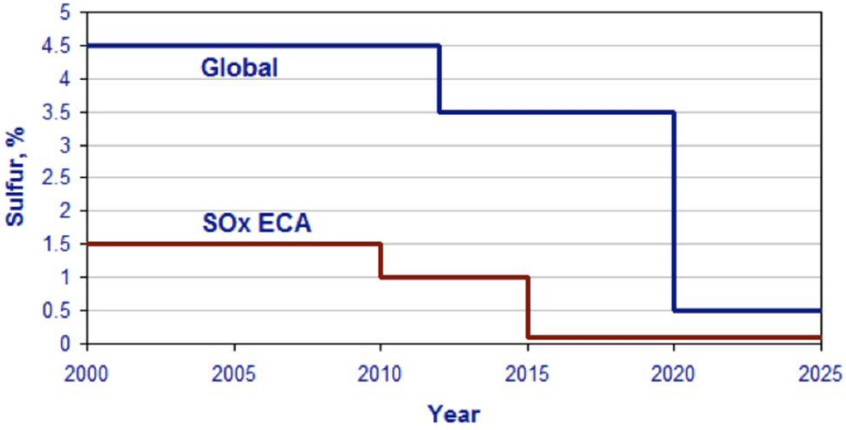


IMO regulations for ship engines

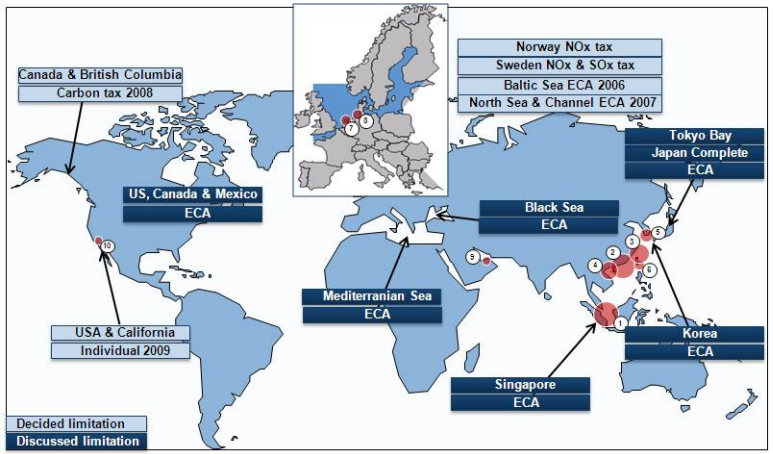
NOx limits



Sulpher limits



Emission Control Area (ECA)



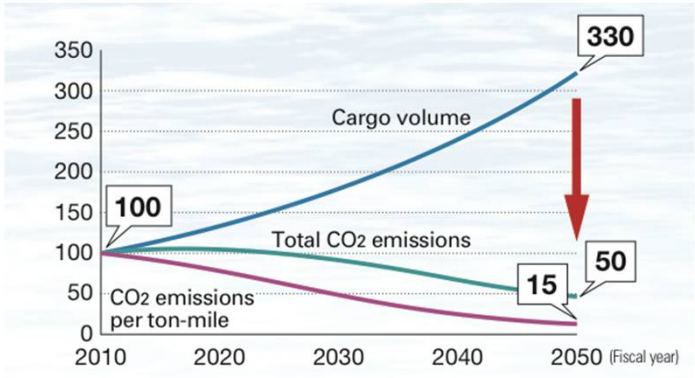
Existing ECA:
1.Baltic Sea (SOx, adopted: 1997 / entered into force: 2005)
2.North Sea (SOx, 2005/2006)
3.North American ECA, including most of US and Canadian coast (NOx & SOx, 2010/2012).
4.US Caribbean ECA, including Puerto Rico and the US Virgin Islands (NOx & SOx, 2011/2014).

Short term and long term target of development

CO2 emission reduction in NYK Fleet

- CO2 emission from NYK fleet in 2007 was 16.97 million ton
  - 1.95% of global shipping
- Short term target
  - 10 % reduction in 2013 comparing to 2006
- Long term target
  - Contribute to global effort to cut G.H.G. by half in 2050
  - Considering to marine transport growth 3% per year, innovations are necessary to 85 % CO2 reduction per ton-mile.

Ship type	CO2 emission index (g-CO2/ton-km)		CO2 reduction ratio (v.s. 2006)
	2006	2010	
VLCC	3.4	3.1	8.8%
Car Carrier	57.0	47.6	16.5%
Container	14.0	9.9	29.3%
Bulk (chip)	7.5	7.3	2.7%
LNG Carrier	17.9	15.9	11.2%



Source: Materials distributed by NYK Line at an August 2008 press conference to announce the NYK Cool Earth Project.

Source: NYK CSR Report http://www.nyk.com/csr/report/

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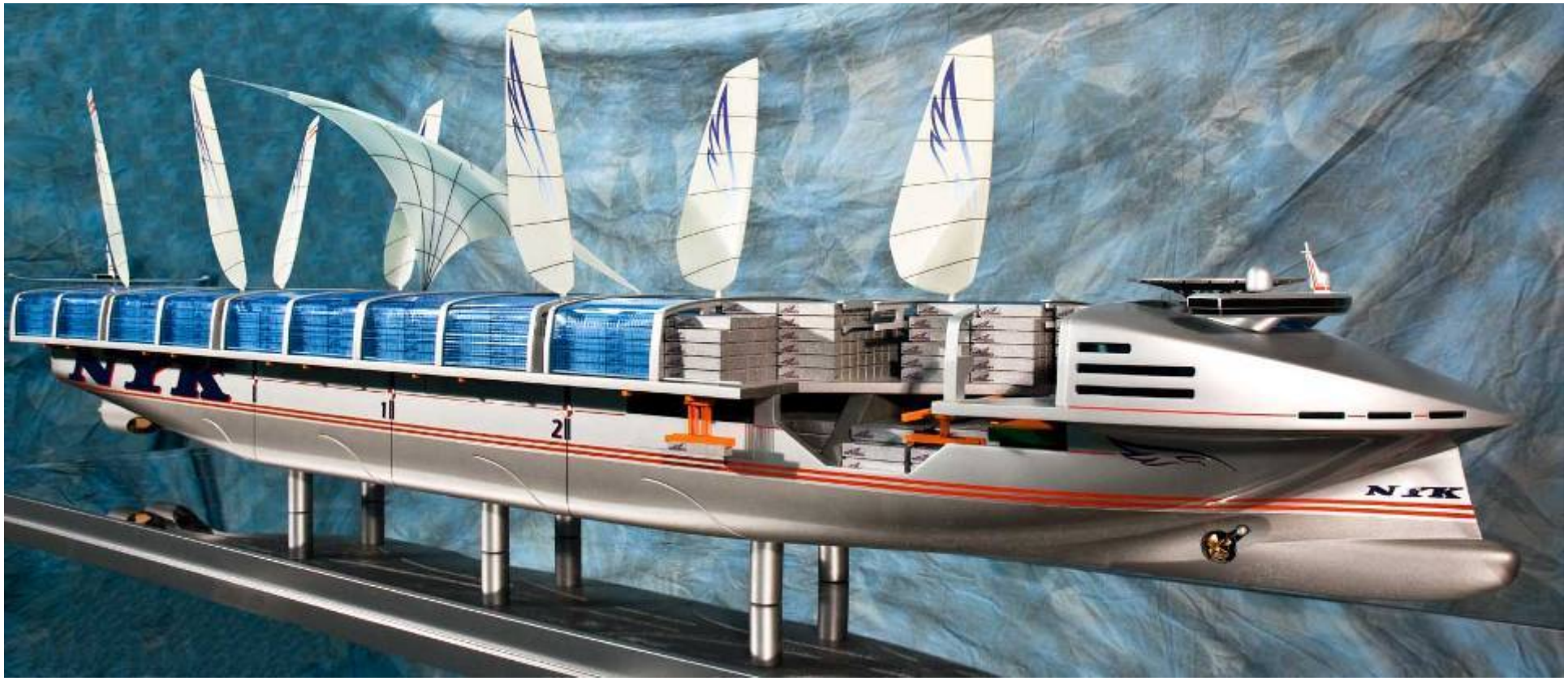
NYK Super Eco Ship 2030



Year 2030, Container ship
Length :353 meter
Speed : 25 knot

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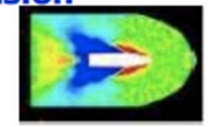
Future concept ship – NYK Super Eco Ship 2030

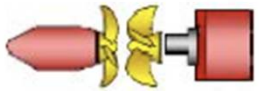
Reduction of Energy for Propulsion


Weight savings 9%


Hull friction 10%


Hull form optimisation 2%


Wind resistance 1%


Propulsion efficiency 5%


Superconductivity 2%


Reduced power for ship use 2%

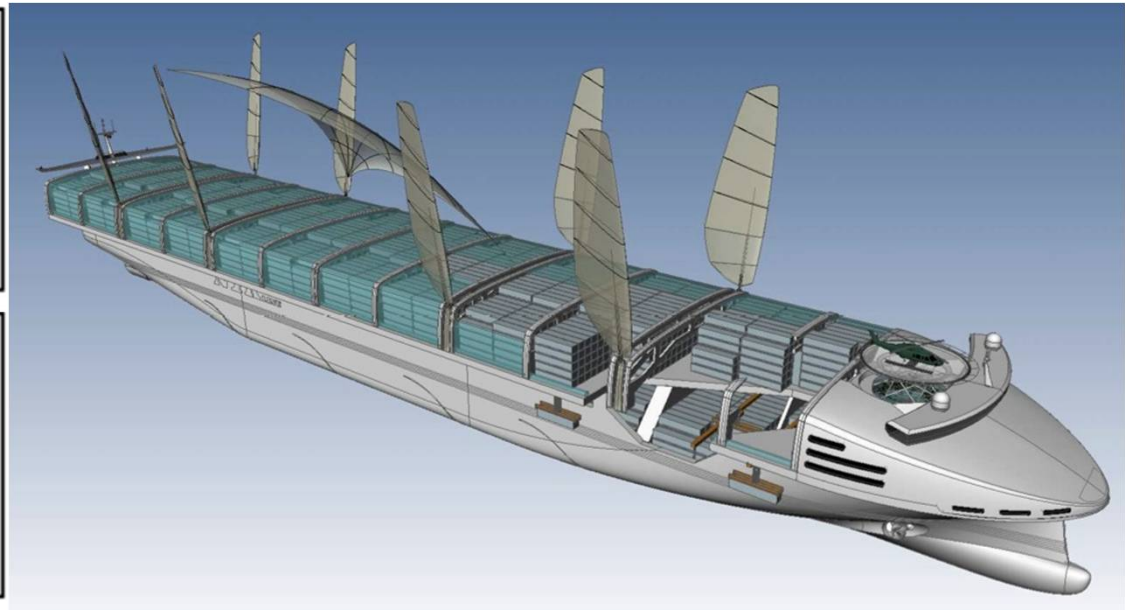
Energy Conversion


Fuel cells / LNG fuel 32%

Use of Natural Energy


Solar power 2%


Wind power 4%



CO2 emission ▲69%

ELOMATIC Garroni Design Monohakobi Technology Institute

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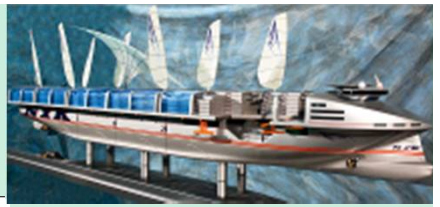
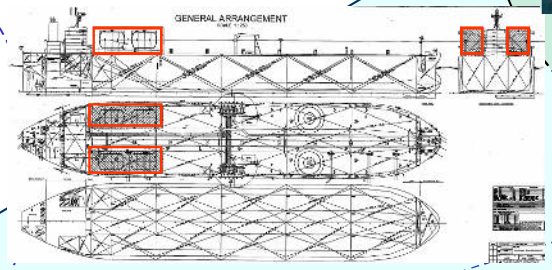
Roadmap for Next Generation Vessel



NYK super
ECO ship 2030

Energy Saving Device (ESD)

LNG fuel



50% Eco PCC

ESD
MT-FAST

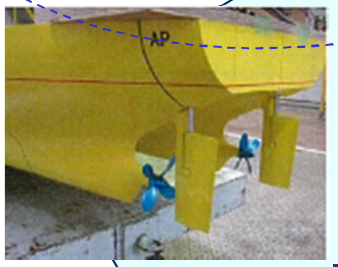
ESD
Bow thruster cover

CRP pod

Lubrication air
capture & reuse

Air lubrication
for all ship types

Air Lubrication Technology

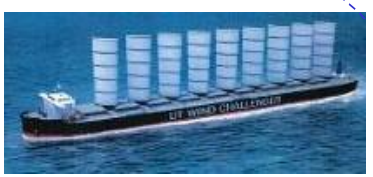


Dual Propulsion

Air lubrication
with scavenging

Air lubrication
technology

Wind energy



Photovoltaic
Cell & rechargeable
battery

Wind resistance reduction

Renewable Energy

2010

2015

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Our activities for short term target

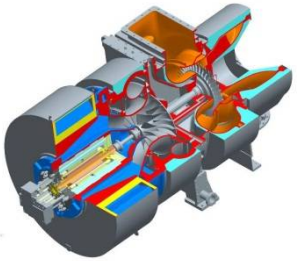
Examples of technical development and implementation

Reduction of resistance

- Air lubrication system
- Low frictional coating

Power plant efficiency

- Hybrid turbo charger
- Waste heat recovery system



ClassNK R&D PROJECT

Those projects were carried out with the support of ClassNK as part of the ClassNK Joint R&D for Industry Program.

Performance monitoring

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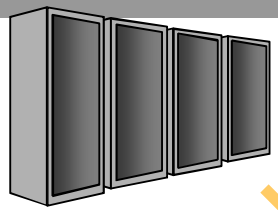
SIMS Overview
(Ship Information Management System)

Data Center



Weather routing service provider

SIMS auto logging data (per hour)
& SPAS electronic abstract logbook data (per day)

SIMS Data Collection System Onboard

Inmarsat-F/FB

SIMS Monitoring & Analysis System at Shore

Communications via Technical Management

Feedback to captains

Operation Center
Singapore, ...

- GPS
- Doppler log
- Anemometer
- Gyro Compass

FuelNavi

Viewer

VDR / ECDIS

Data Acquisition and Processing

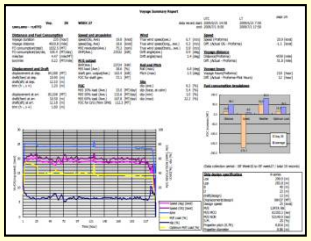
Motion sensor

<Navigation Bridge>

<Engine Room>

- Main Engine
- FO flow meter
- Torque meter

Engine Data Logger



Voyage Analysis Report
Break down analysis of fuel consumption for each voyage

Report

SIMS Viewer

-Trend monitoring of speed, M/E RPM, fuel consumption and other conditions per hour

- Comparing planned schedules and actual schedules

Technical Analysis (MTI)

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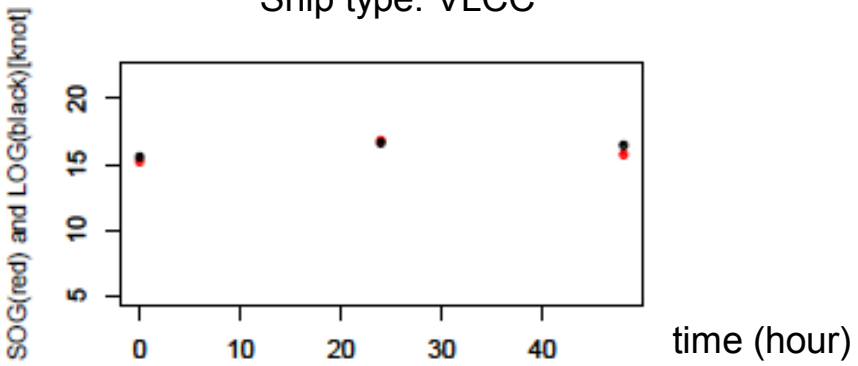
Interval of monitoring data

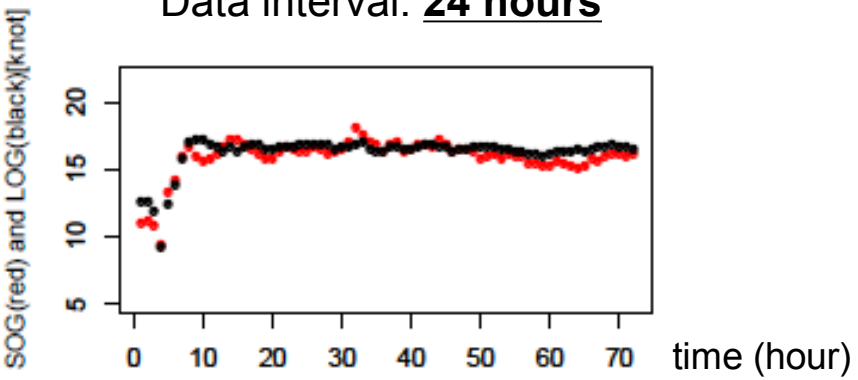
- Existing data collection approaches
  - Manual reporting (every 24 hrs)
  - Automatic data collection (sampling can be every 1 sec)

- Every 1 hour data give detail information about performance
  - Speed increasing profile and effect of current can be seen in the 1 hour interval graph.

Data interval comparison
red: OG speed, **black**: log speed
Ship type: VLCC



Data interval: **24 hours**



Data interval: **1 hour**

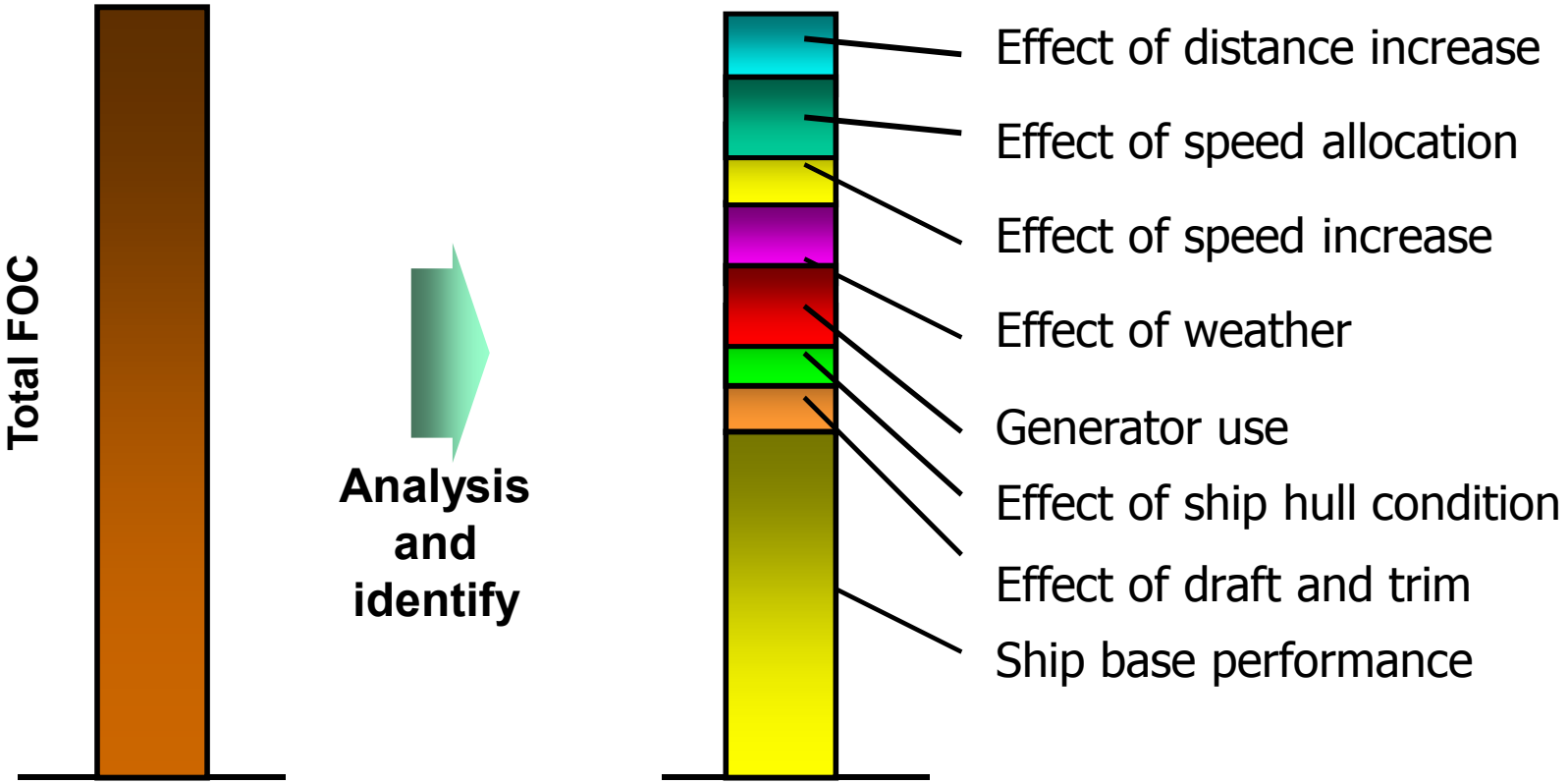
Onboard performance monitoring

- Real time performance indicator in bridge
  - Provide awareness to ship
- Performance index
  - OG speed / fuel consumption [NM/MT]
  - Fuel consumption [MT/day]
- Trip meter function for onboard performance trial
  - Energy efficiency comparison

FUELNAVI monitor

Identify each cause of fuel consumption

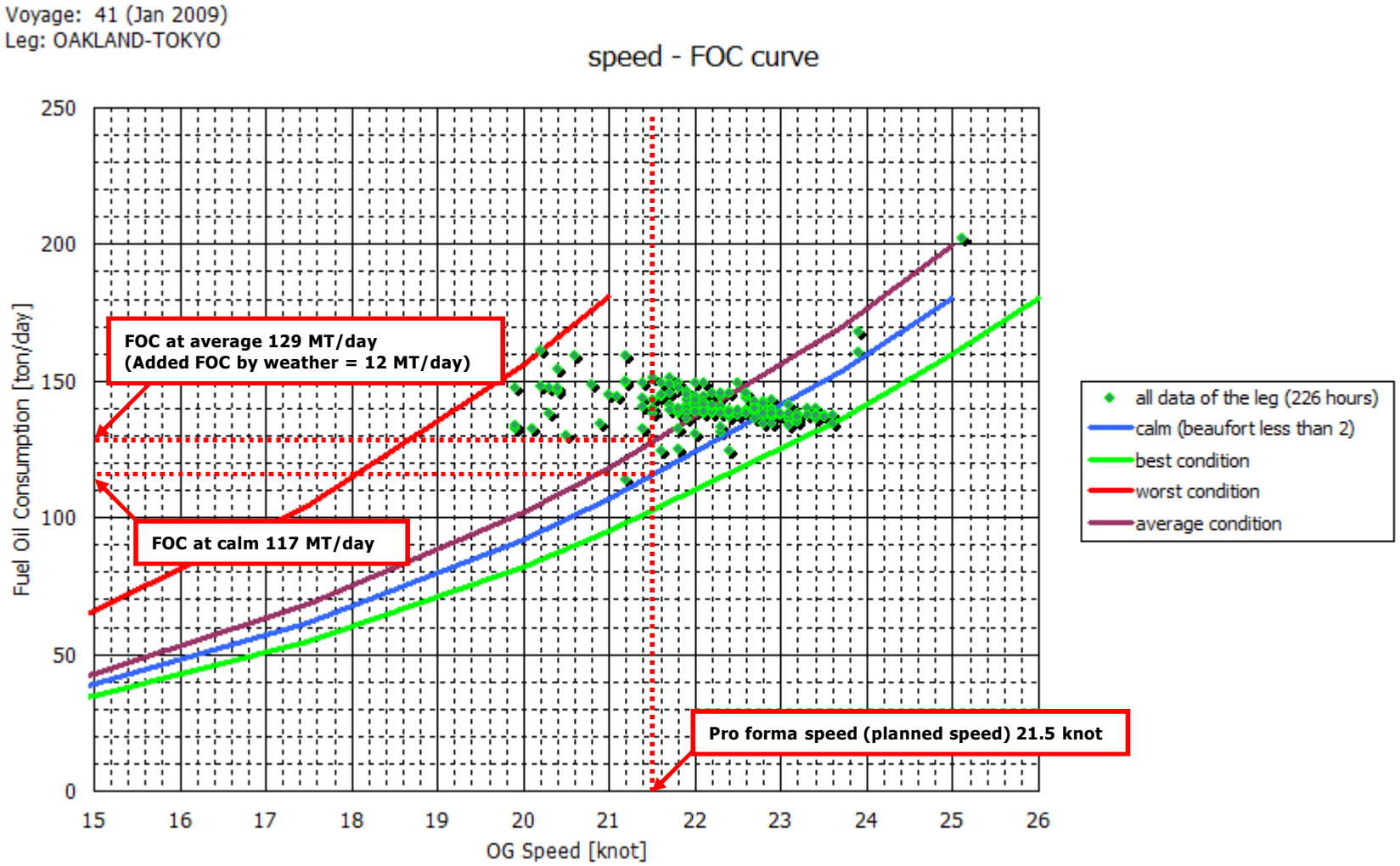
- By using detail monitoring data and appropriate analysis methods, total FOC can be breakdown into each cause.
- It will be the key concept for SEEMP management too.



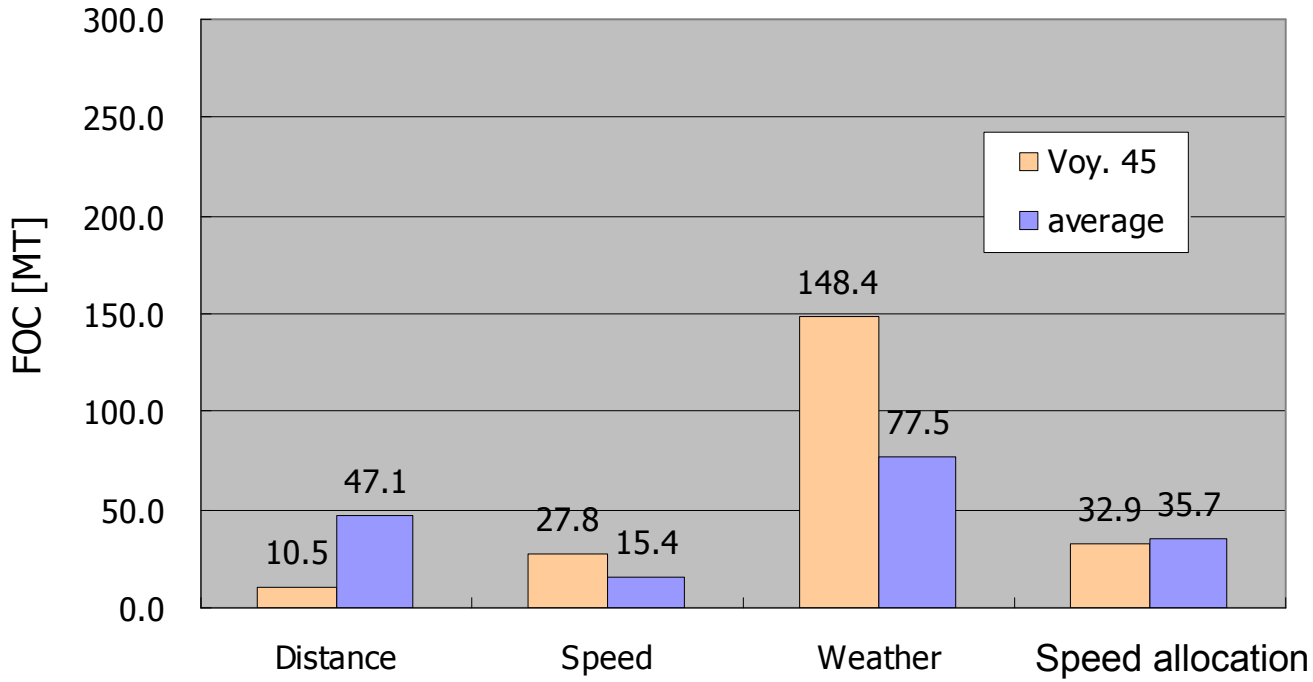
Factors of additional fuel consumption

1. Higher average speed than planned speed
2. Longer voyage distance than planned distance
3. Effect of bad weather and against current
4. Speed allocation
5. Effect of displacement and trim
6. Ship design difference
7. Maintenance condition of engine, propeller or hull

Identify baseline and added FOC by weather



Breakdown analysis of additional FOC



- As the result of break down analysis, factors for additional FOC in the voyage are shown quantitatively
- Compare each FOC factor with past average provides qualitative information

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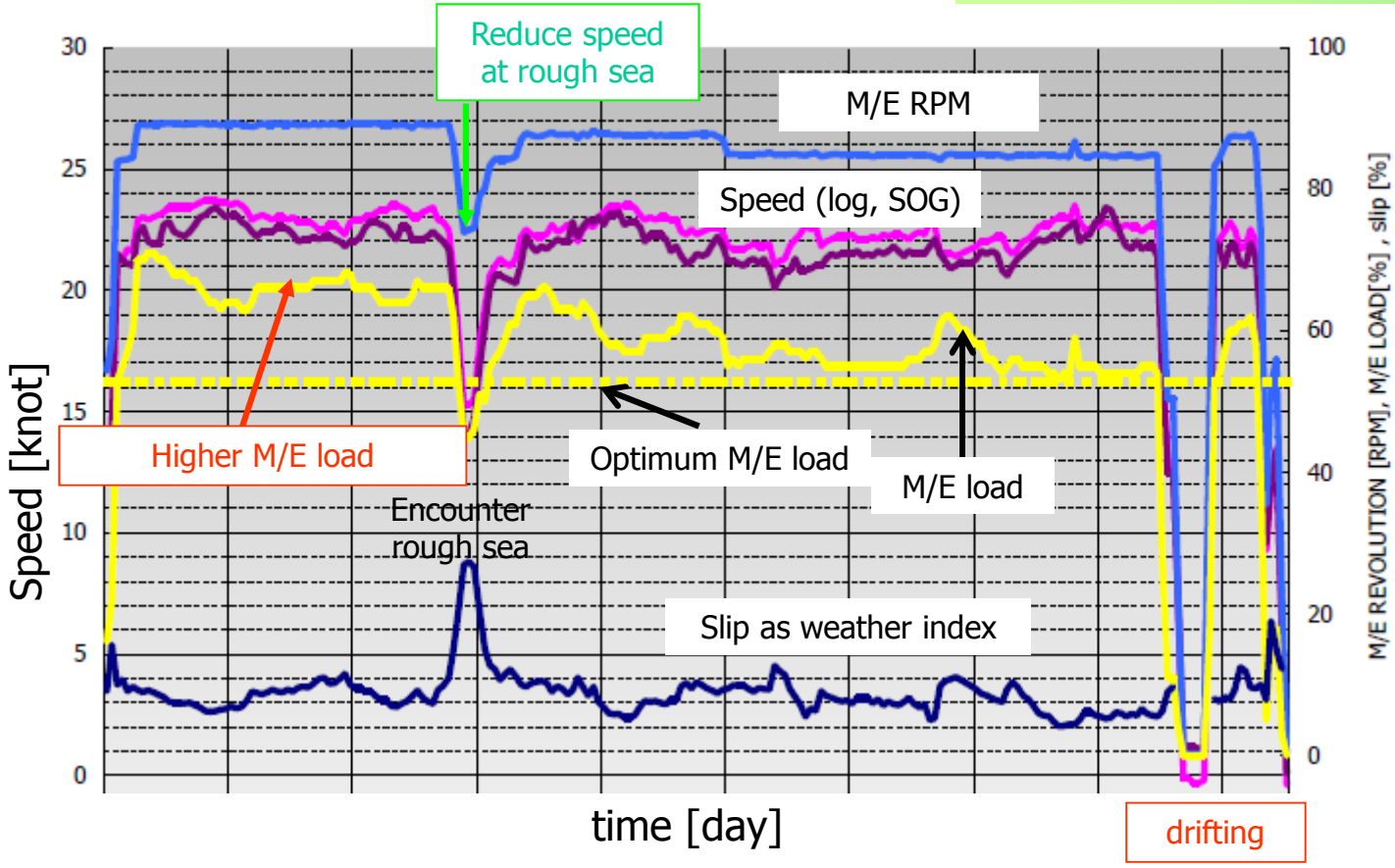
Practice that can be improved

Check point of eco voyage
- ✓ No drifting, No early arrival
- ✓ Reduce speed in rough weather
- ✓ Constant M/E load

OAKLAND - TOKYO



Additional FOC: comparison to optimum M/E load = 8,2 %

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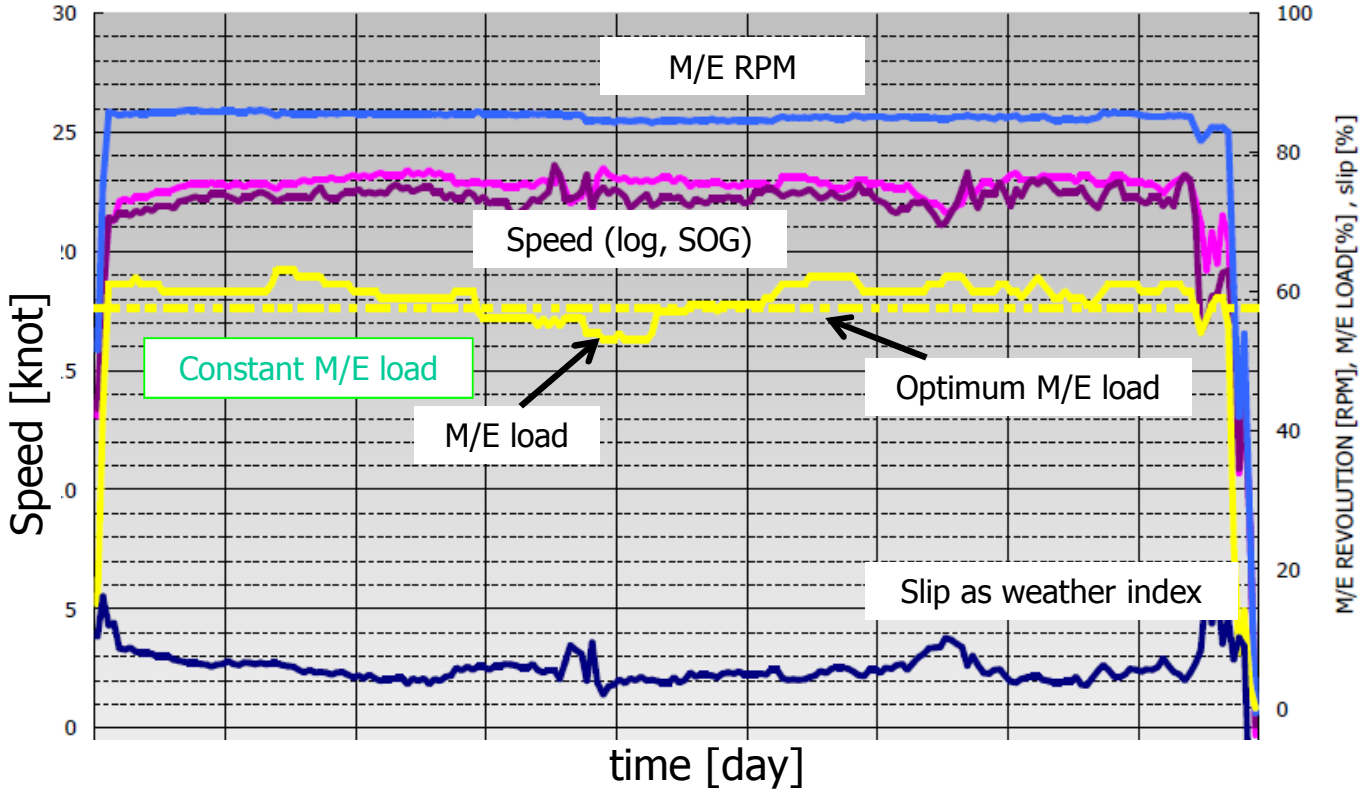
Good practice

OAKLAND - TOKYO

Check point of eco voyage
- ✓ No drifting, No early arrival
- ✓ Reduce speed in rough weather
- ✓ Constant M/E load



Additional FOC: comparison to optimum M/E load = 0.5 %

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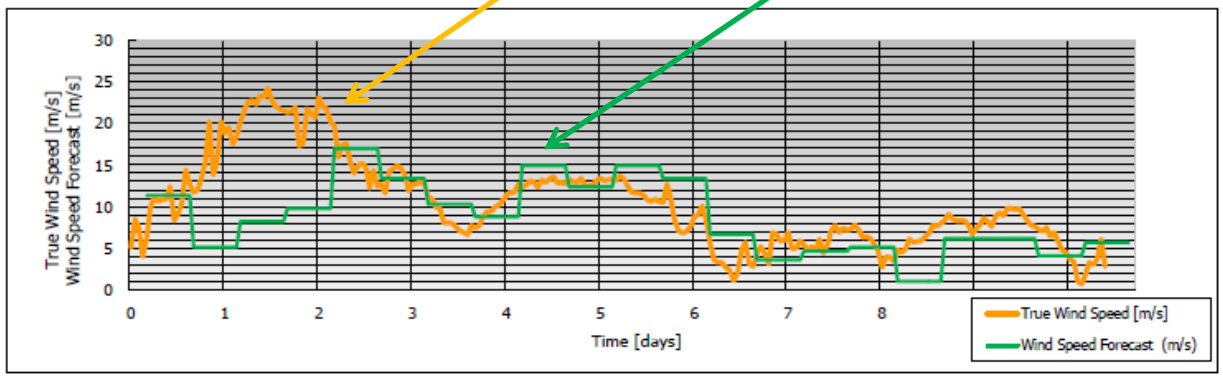
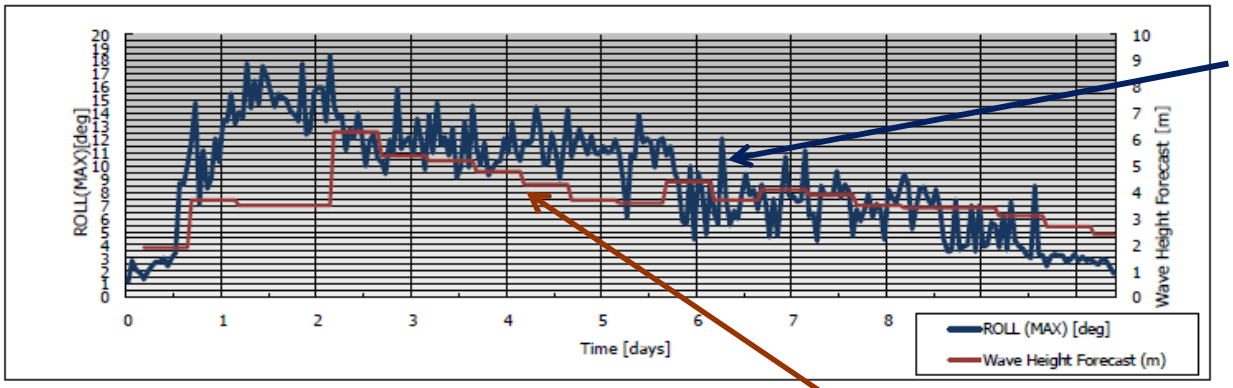
Feedback actual weather

- Measured wind and ship motion data are feedback to weather routing provider





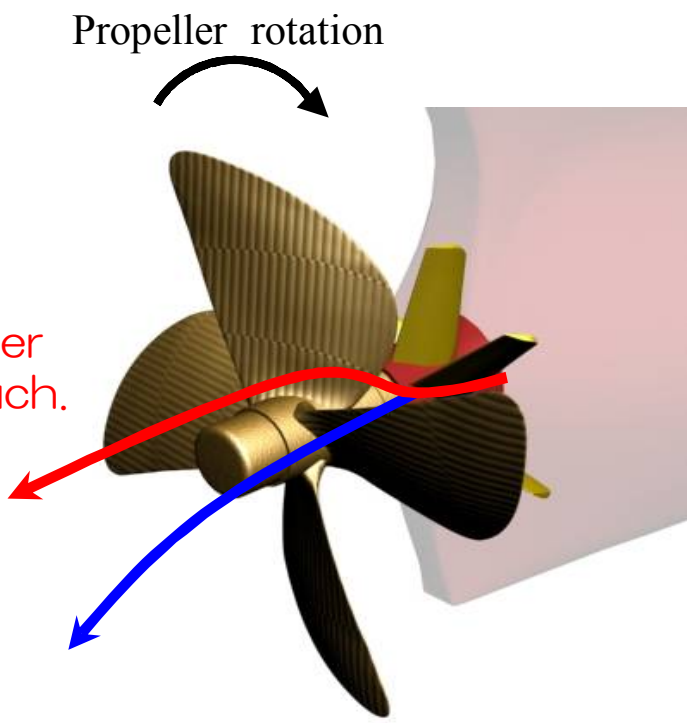
Ship motion (Maximum roll angle in one hour)

Wave height (forecast)

Data analytics

Energy Saving Device “MT-FAST”

Pre-swirl type Fins developed by MTI and Tsuneishi Shipbuilding



Red: with Fin
Flow after propeller
is not rotating much.

Blue: without fins
Flow is rotating after propeller
That means loss of energy

- First application was May, 2008 (ship delivery basis)
- Many references since then.

MT-FAST
MTI & TSUNEISHI FALCATE ATTACHABLE STATOR

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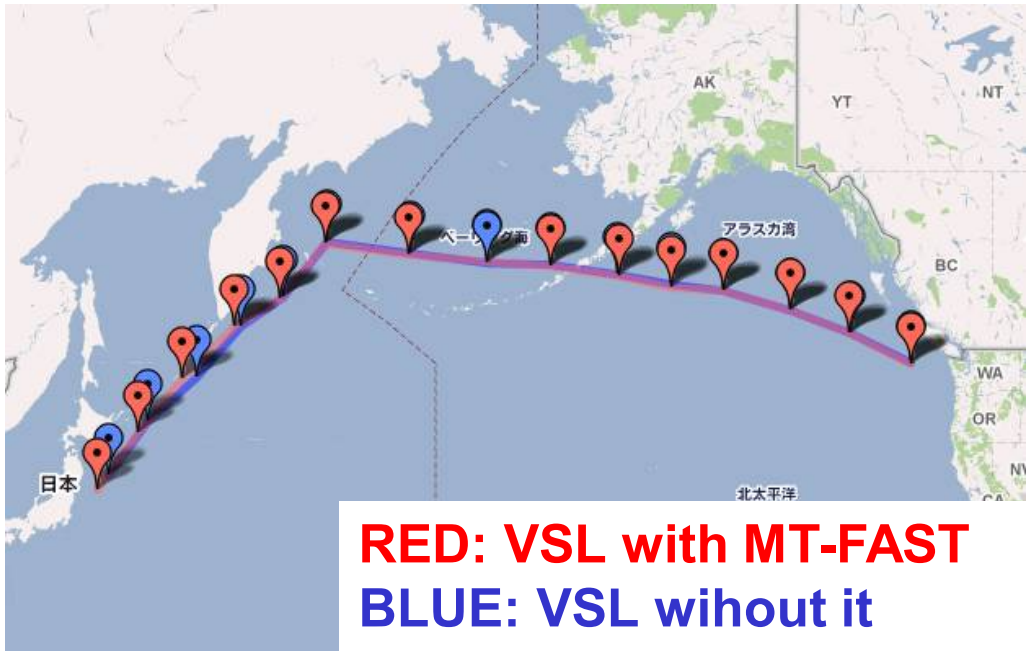
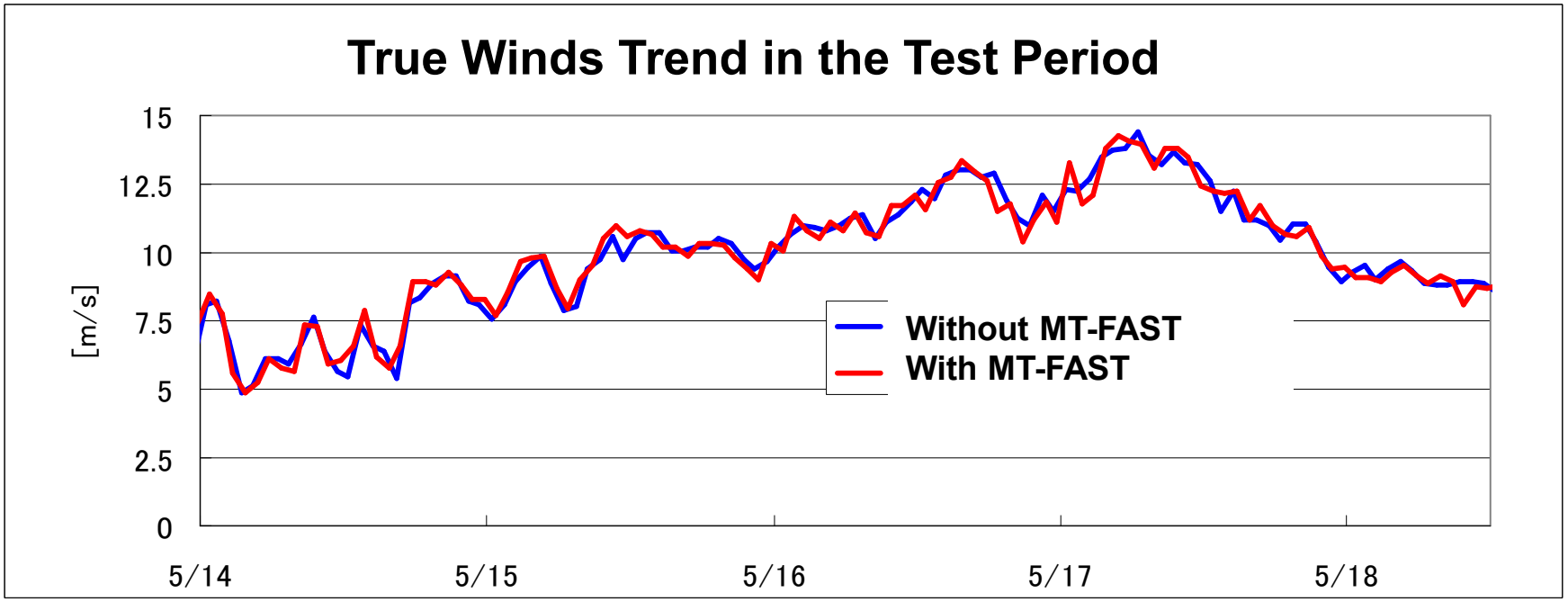
Validation of MT-FAST (comparison on vessels)

- Using two sister vessels, one is with MT-FAST, the other is without it
- sailed across the Pacific Ocean at the same route away from 2NM each other

Route of the two vessels

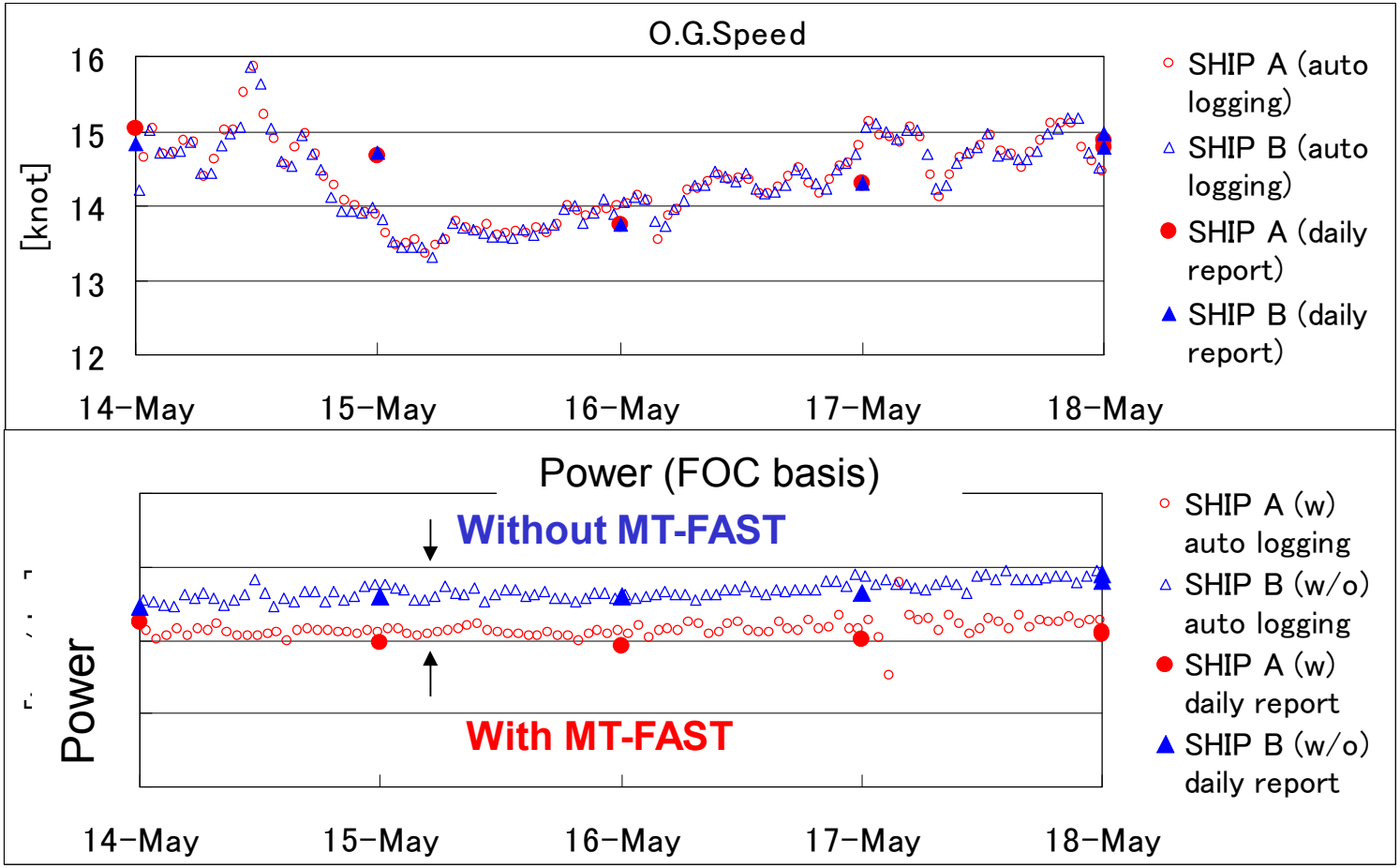


Comparison - Weather Conditions



- Wind speed was almost same.
- 5m/s~14m/s（BF3~BF7）(wave height around 3 meters, estimated)

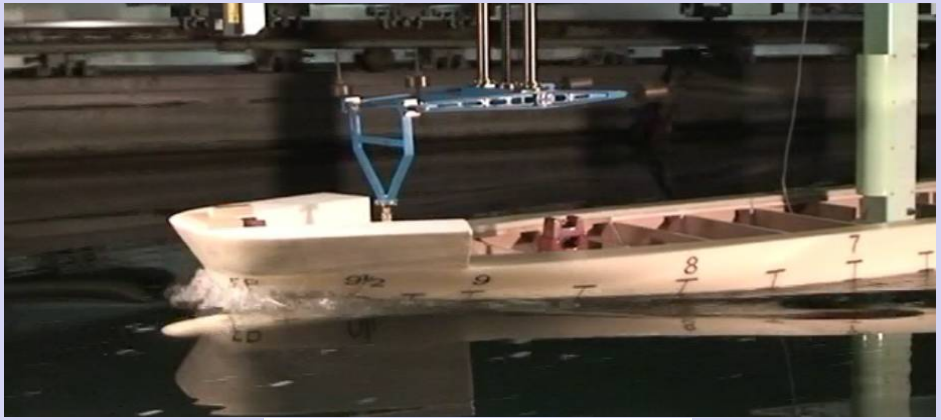
Comparison – Speed and Power



Confirmed 4.8% improvement

Trim Chart

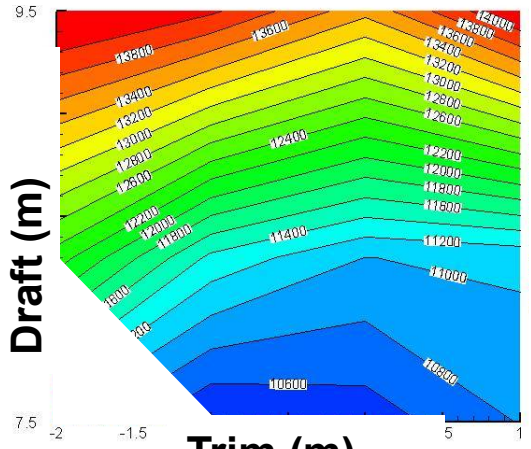
- Results of tank test etc. are made clear in “trim chart”.
- Power largely differs by trim at the same displacement.
- Trim chart helps finding optimum trim condition.



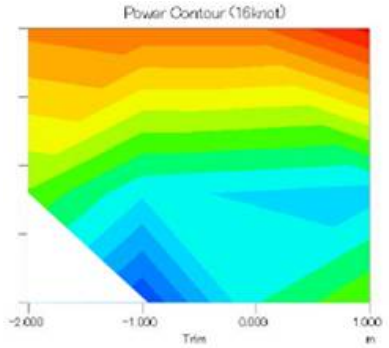
Tank test

Power to draft and trim is shown as contour .

Image of trim chart

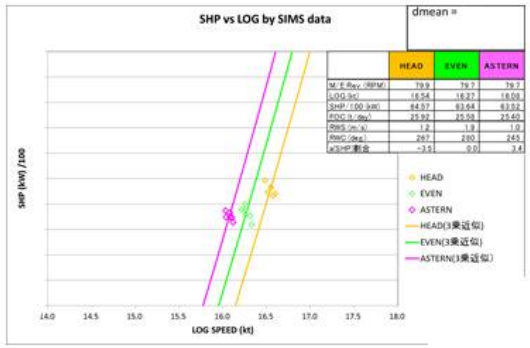


Optimum trim in services



Optimum trim estimation
(reasoning by model test, simulation)

Comparison



Trim trial with
performance monitoring

The relation of propulsive performance and trim are physically complex problem.

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Conclusion remarks

Concluding remarks

- Recent environmental regulations require technical and operational improvement of marine transportation.
- Sharing short term and long term visions are necessary for R&D. It's a very important issue to make the goal come true.
- Our strong point is not only install equipments but also can validate using NYK Group operation vessels. Of course can feed back to R&D.
- MTI continues R&D efforts in order to support "Green Shipping" of NYK Group.
- Asking for your cooperation because MTI is not a maker's R&D company but a user's. It's difficult to achieve the goal by only ourselves.

NYK GROUP

Thank you very much for your attention

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