World NAOE Forum 2014
The Use of Big Data in Marine & Ocean Engineering

Big Data in Ship Operation

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What is big data ?

- "Big data" refers to datasets whose size is beyond the ability of typical available software tools
- Definition of how big a dataset is subjective and moving
  - It depends on industry / sector and technology advances over time

How "Big data" creates "values"

1. Creating transparency
2. Enabling experimentation to discover needs, expose variability, and improve performance
3. Segmenting populations to customize actions
4. Replacing/supporting human decision making with automated algorithms
5. Innovating new business models, products, and services

Reference) *James Manyika, et. al.*, "Big data: The next frontier for innovation, competition and productivity", McKinsey Global Insitute Report, May 2011

Big data for shipping

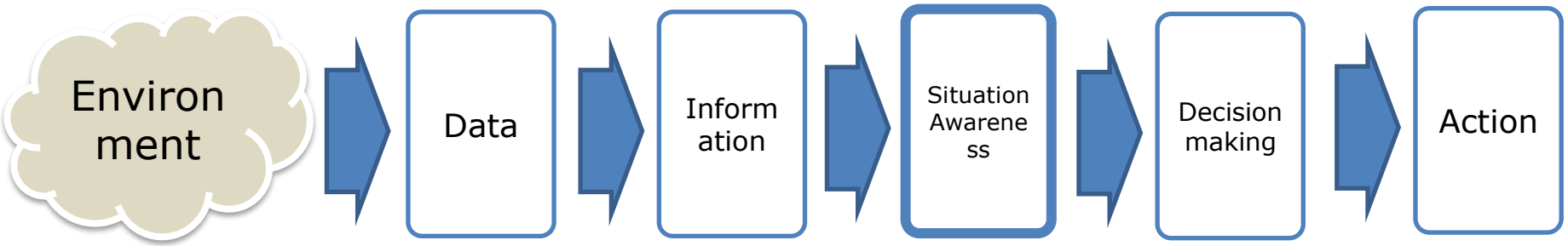
in operation

- Conventionally, noon reports and several e-mails per day have been the information sources of ship sources

- According to technical advances, detail and highly frequent data can be collected at shore
  - VSAT and Inmarsat FBB provide high speed and continuous network between ship and shore
  - Onboard equipment have been computerized and networked

- Shipping company faces large volume dataset that beyond the ability of traditional approach ⇒ Era of "Big data"
  - Shipping companies who can manage "Big data" can differentiate themselves from others in global competition

The roll of "Big data" and its flow



Necessary Technology

- Sensor
- Measurement
- Network
- Communication
- IT

- Data analysis
- Statistics
- Engineering
- Visualization
- Web

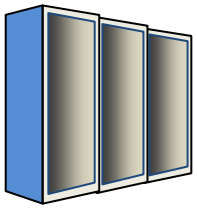
- Business knowledge
- Workflow
- Collaboration
- Organization

- Management
- Business

- Command
- Assistance
- Training
- Incentive
- PR
- Change Business

- Provide information to right people at right time for assisting their situation awareness for right decision and action

Example of ship data collection
SIMS (Ship Information Management System)



Data Center

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

Weather routing service provider

FOP Data Collection System Onboard

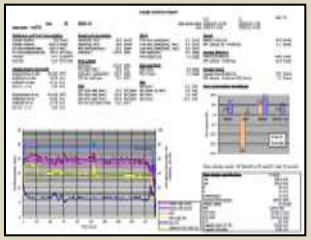
VSAT/Inmarsat-F/FB

SIMS Monitoring & Analysis System at Shore

Communications via Technical Management

Operation Center
Singapore, ...

Feedback to captains



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

Report

FOP Viewer

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

- Engine monitoring

- GPS
- Doppler log
- Anemometer
- Gyro Compass

FOP unit

Viewer

VDR / ECDIS

Data Acquisition and Processing

Motion sensor

<Navigation Bridge>

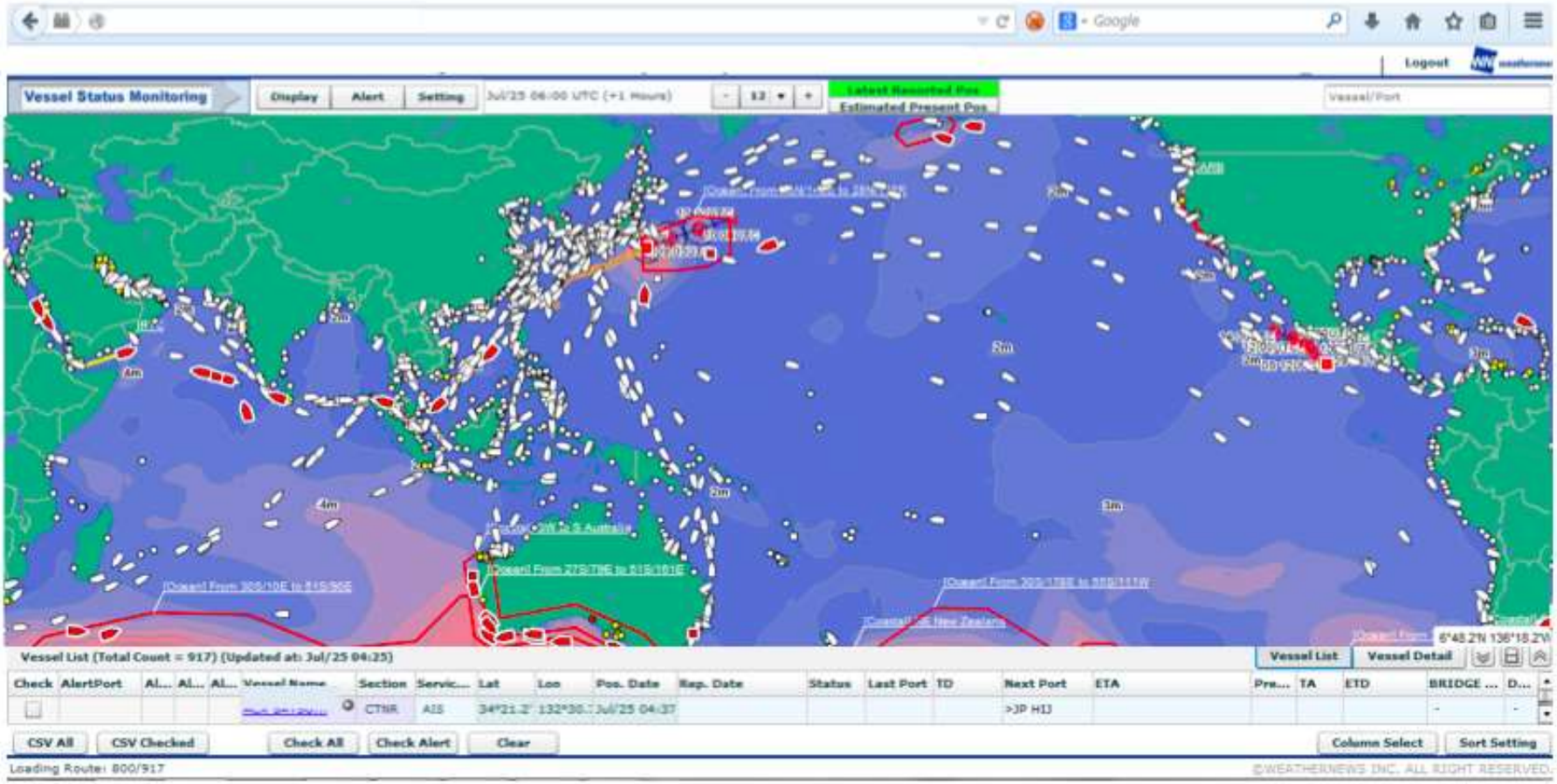
<Engine Room>

- Main Engine
- FO flow meter
- Torque meter

Engine Data Logger

Technical Analysis (MTI)

Fleet monitoring



- Ship position and voyage schedule
- Weather forecast information is overlapped

Optimum weather routing

- Role of weather routing
  - (past) Avoiding severe weather
  - (now) Optimum weather routing

    Best balance of
    - Safety
    - Schedule keep
    - Economy
    - Environment

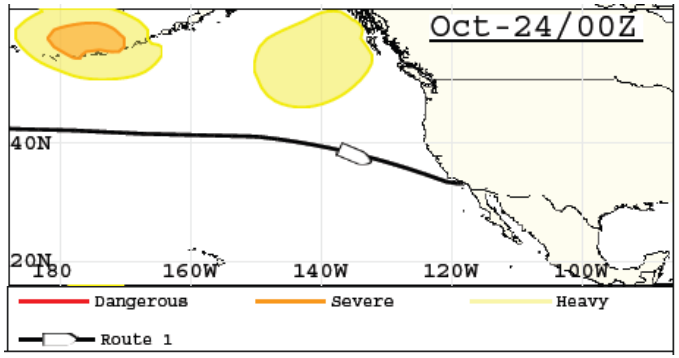
- Necessary technology for optimum weather routing
  - Ship performance model
    - RPM – speed – fuel consumption
  - Ship motion and performance in severe weather

[Major Waypoints of Route 1]

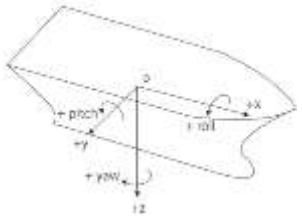
Major waypoint	DateTime	Nav.	Dist	OG SPD	RPM	Remarks
				(OG SPD:Over Ground Speed)		
Latest Reported Position						
41N/150W	Oct-22nd 1345Z	RL	780	20.7	77	nil
		GC	1445	20.6	77	nil
SW of San Miguel Is.	Oct-25th 1200Z	RL	133	17.0	77	nil
LOS ANGELES	-					

Req.Ave.OG SPD:20.2 kts for RTA/remaining distance.

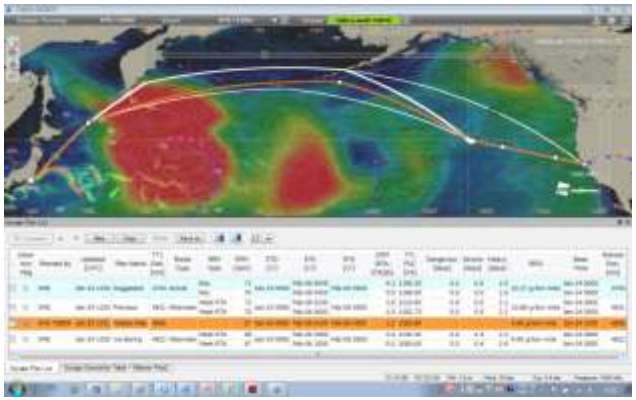
Way points

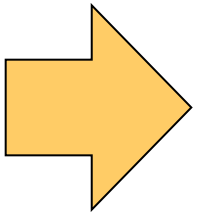


Routes and weather



Integration of weather routing and monitoring

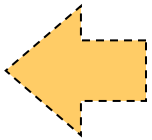




Weather Routing（PLAN）

Monitoring（CHECK）

- Voyage plan
  + course, speed, RPM, FOC, weather
  + ship performance model



Feedback

- Voyage actual
  + actual speed – RPM, RPM - FOC
  + actual weather

Ship model and weather forecast are inherently include errors.

But feedback loop by monitoring can make this system work better.

Ship performance model and its validation

6500TEU Container Ship

Wave height 5.5m, Wind speed 20m/s,
Head sea

Propeller rev. 55rpm

<Calm sea performance>

speed: 14 knot

FOC: 45 ton/day

<Performance in the rough sea>

speed: 8 knot

FOC: 60 ton/day

<Factors of performance change>
1. Wind and wave, 2. Ship design (hull, propeller, engine), 3. Ship condition (draft, trim, cleanness of hull and propeller, aging effect)

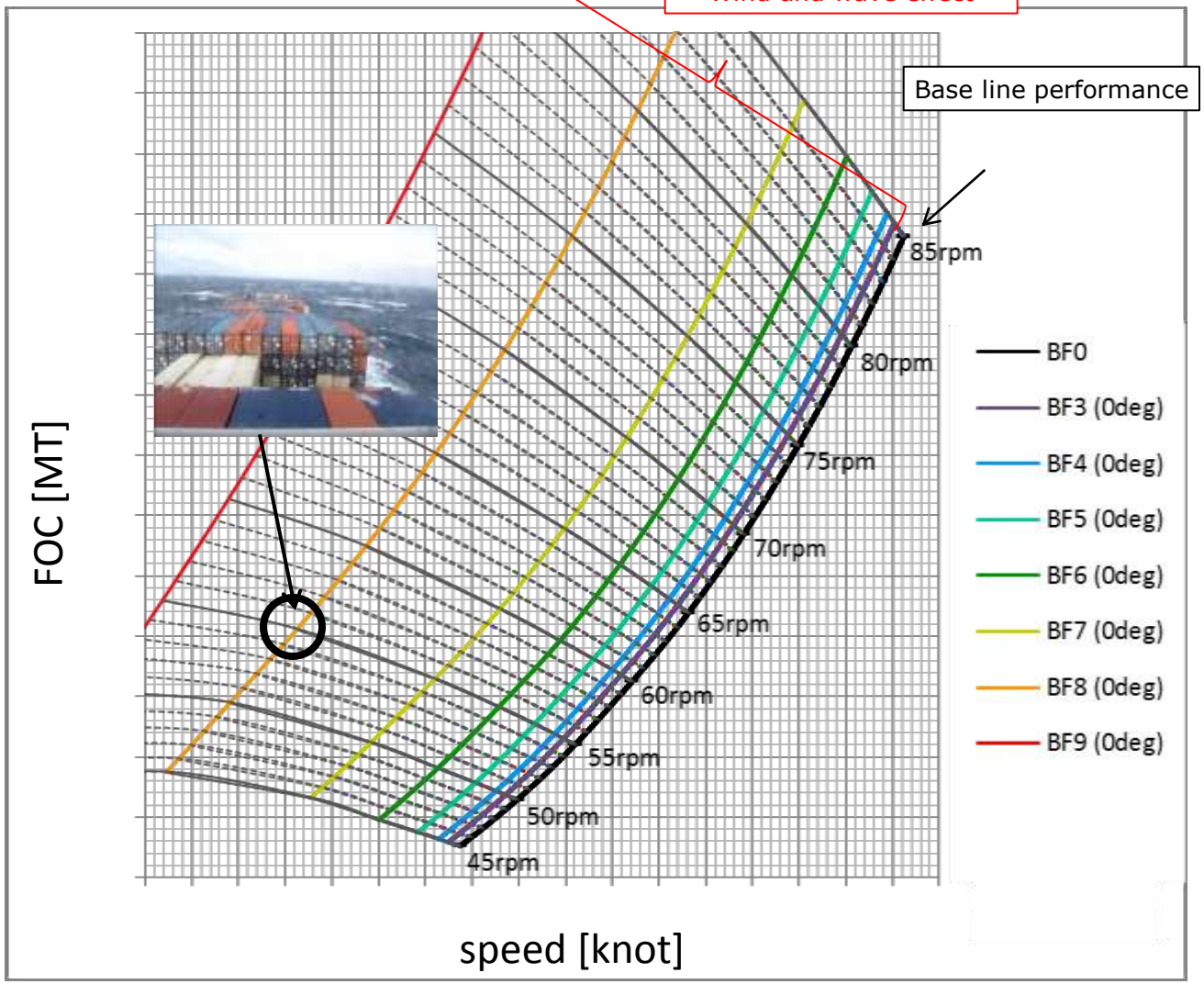
Ship performance model and its validation

<Target vessel>
6500TEU Container
Draft 12m even

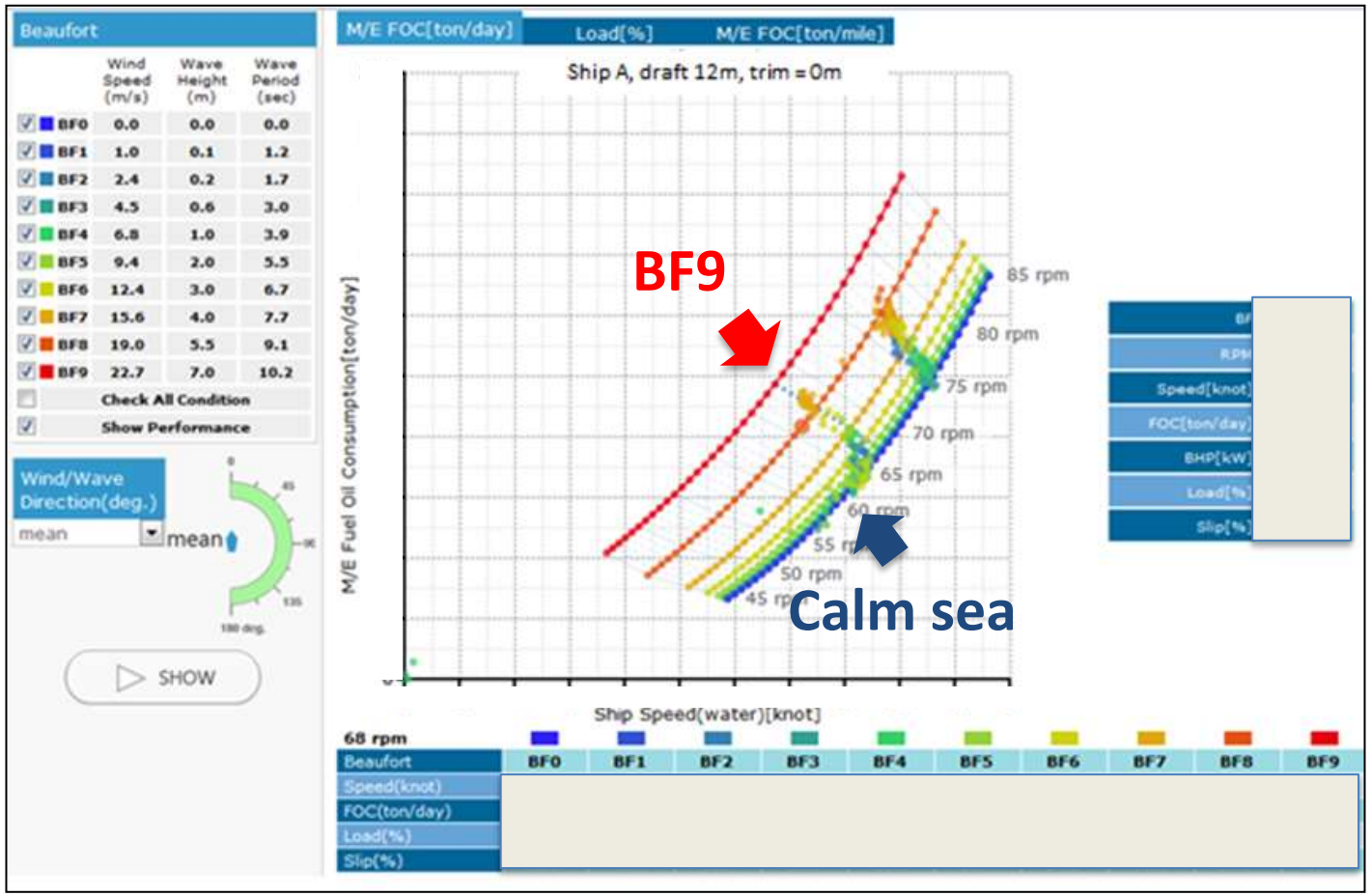
Sea condition
Beaufort scale

	wind speed (m/s)	wave height (m)	wave period (sec)
BF0	0.0	0.0	0.0
BF3	4.5	0.6	3.0
BF4	6.8	1.0	3.9
BF5	9.4	2.0	5.5
BF6	12.4	3.0	6.7
BF7	15.6	4.0	7.7
BF8	19.0	5.5	9.1
BF9	22.7	7.0	10.2

0deg (wind, wave) – head sea

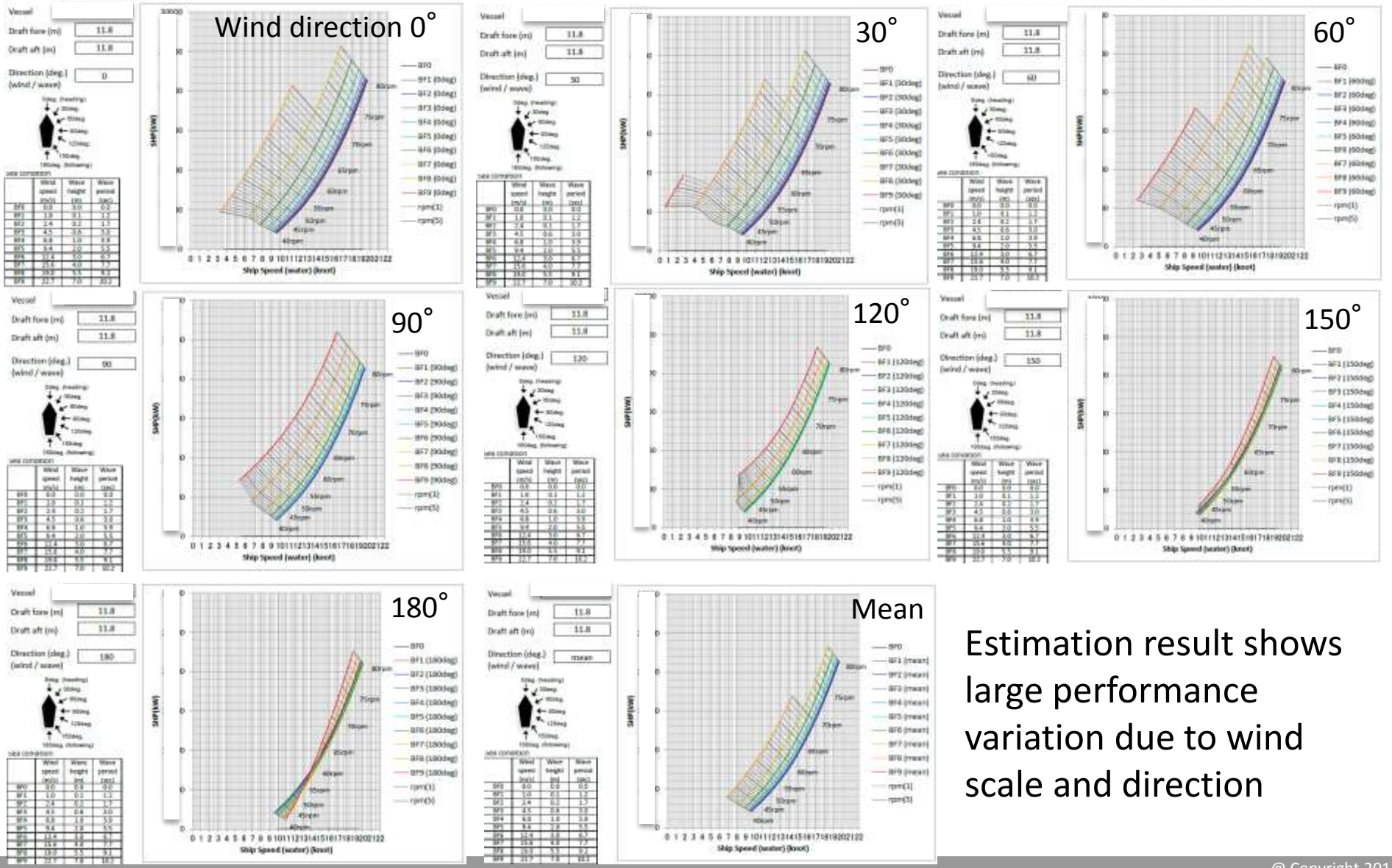


Performance analysis in service



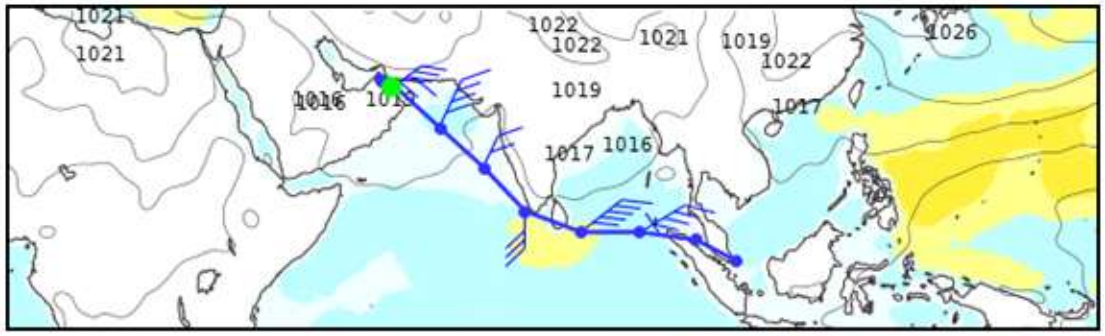
- Ship performance model is modified and validated by SIMS data.
- Performance in calm sea is automaticallycorrected to reflect the hull and propeller condition change.

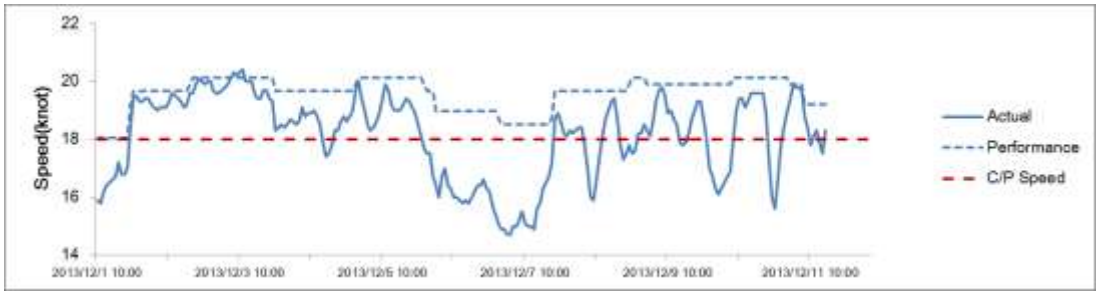
Example of ship performance model (LNG carrier)



Estimation result shows large performance variation due to wind scale and direction

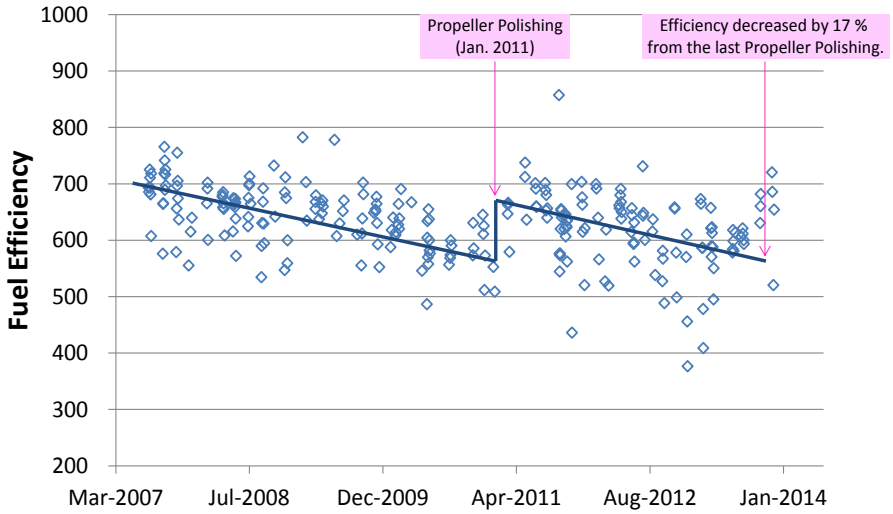
Post voyage analysis

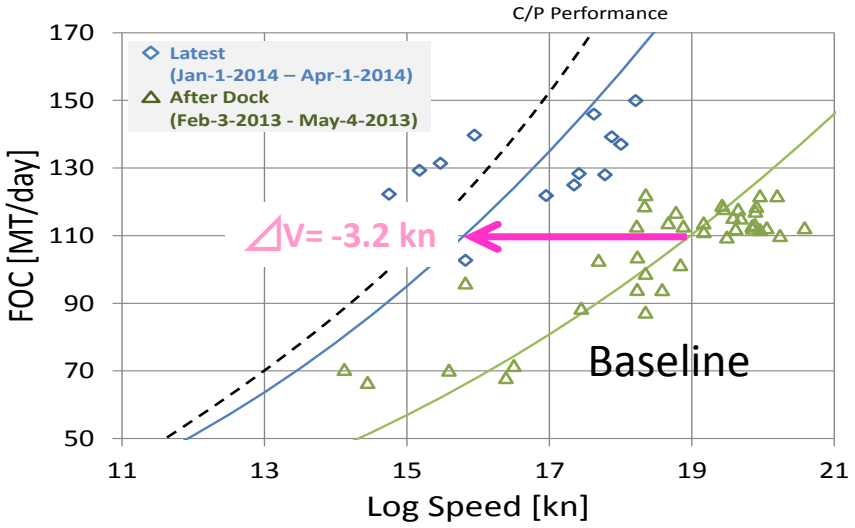




- Post voyage analysis to evaluate energy efficiency in the voyage

Long-term analysis

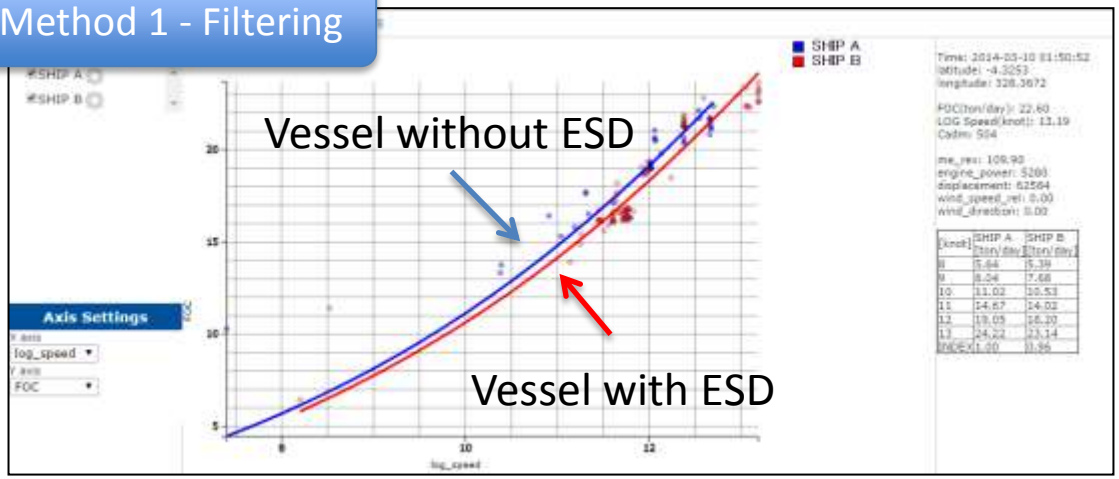




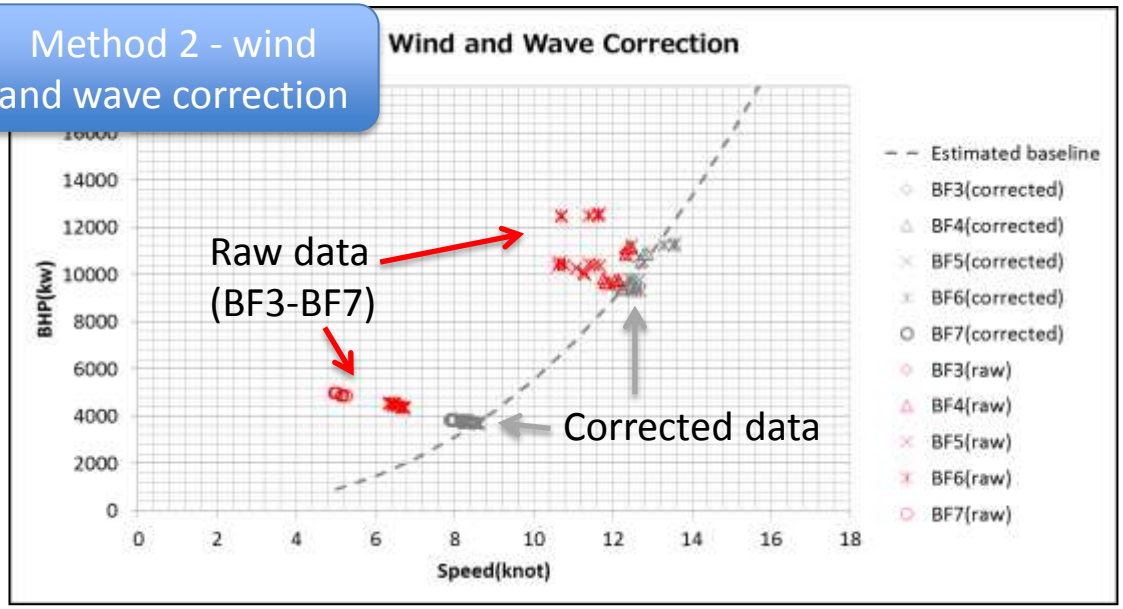
- <u>Share awareness</u> for vessel performance degradation
- KPI
  - ⊿V … speed drop from baseline
  - Baseline … performance at right after previous dock
  - Reference line … current performance
- Decision making support
  - Hull/propeller cleaning timing and ROI (return on investment)
  - Evaluation of effect of hull/propeller cleaning
  - Evaluation of energy saving device/paint

Evaluation of energy saving devices/paints

Method 1 - Filtering



Method 2 - wind and wave correction



Method 1 - Filtering

- Performance comparison of two vessels with or without energy saving device
- Use only calm sea condition data

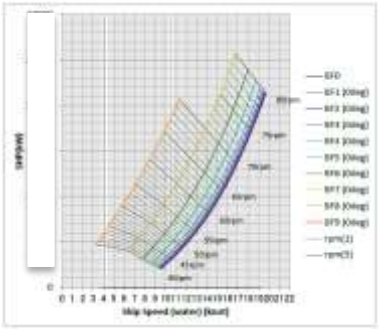
Method 2 - Wind and wave correction

- Estimation of calm sea performance based on rough sea data and performance model

Our experiences with SIMS data

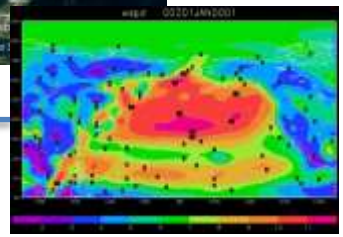
- 8 energy saving devices
- 2 AF paints
- 2 autopilot systems
- 1 propeller

Application of ship performance model
- Business optimization

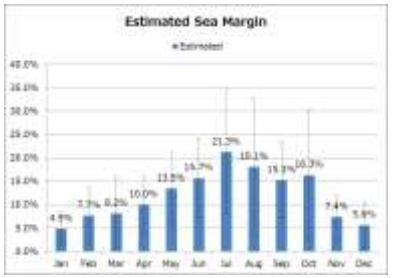


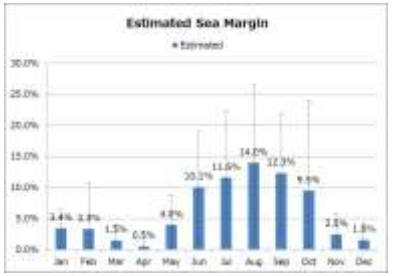
Ship performance model

Service route



Hindcast weather data

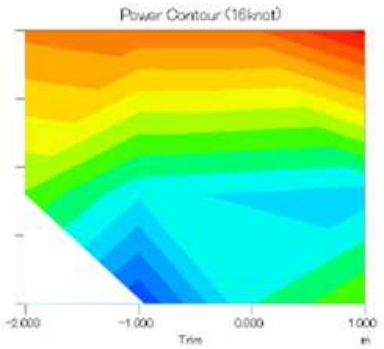




Estimation of
- Sea Margin
- Sailing time
- Average Speed
- Total FOC

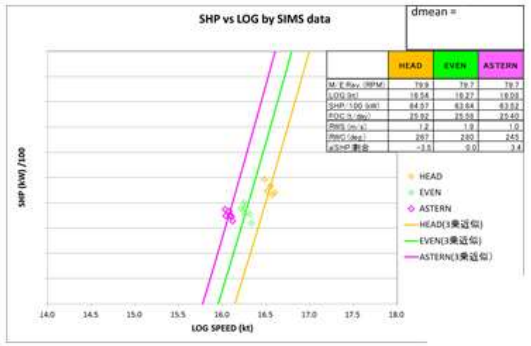
Accurate vessel performance model contributes to optimization of vessel deployment.

Optimum trim model and its validation



Optimum trim estimation
(reasoning by model test, simulation)

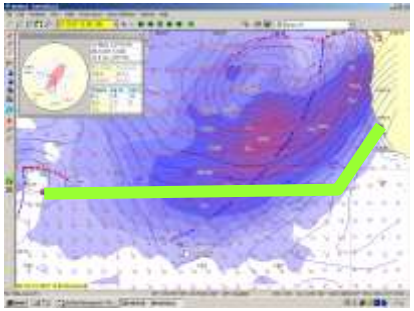
Comparison



Trim trial with
performance monitoring

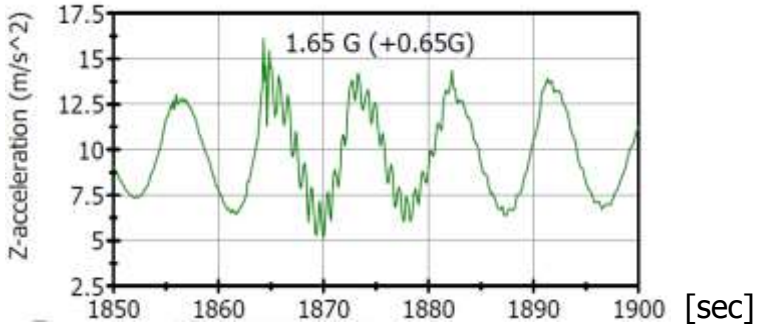
The relation of propulsive performance and trim are physically complex problem.

Estimated ship motion in rough sea and its validation



ship motion simulation

criteria

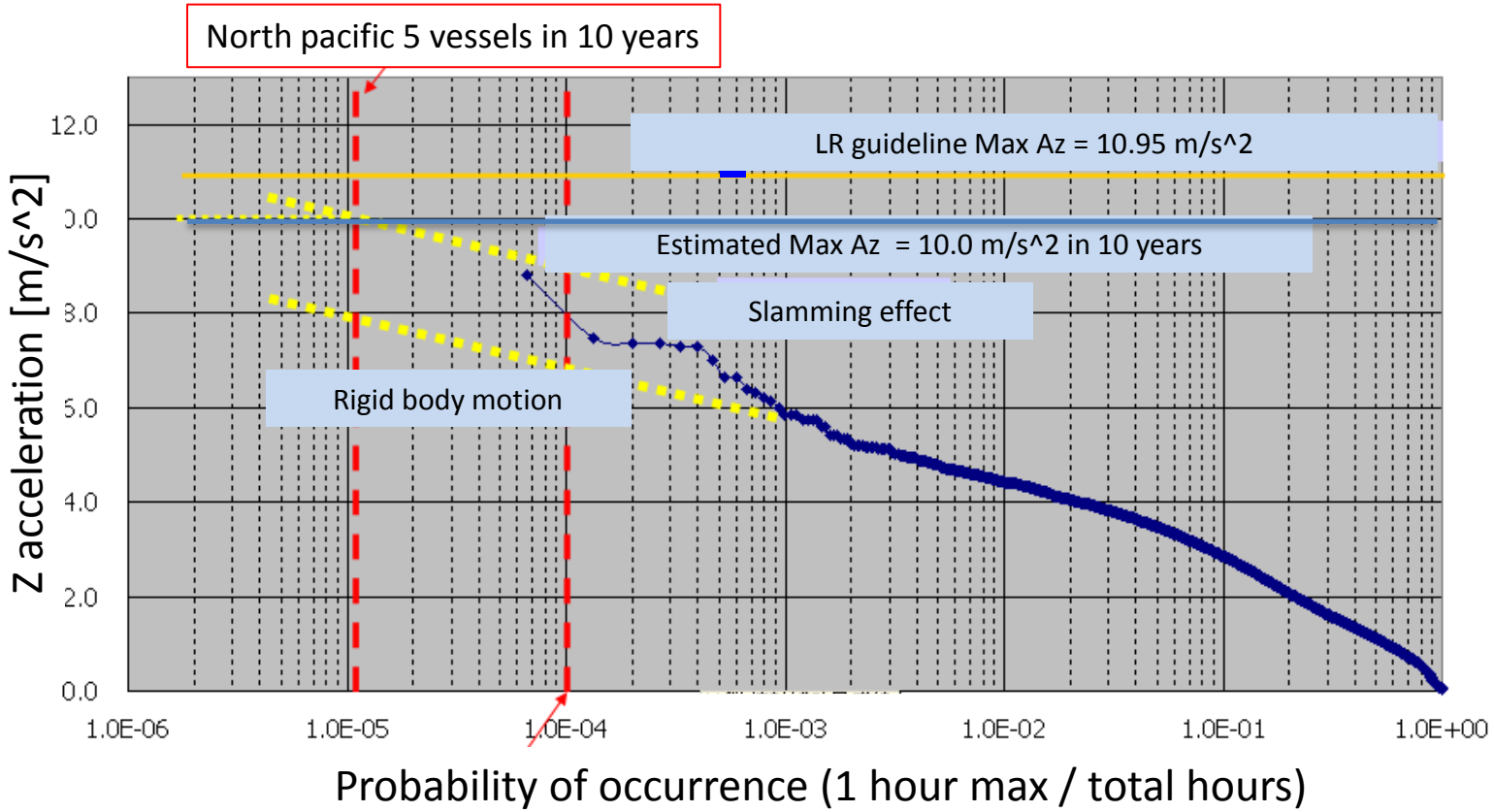


actual ship motion and acceleration

cargo securing & ship structural safety

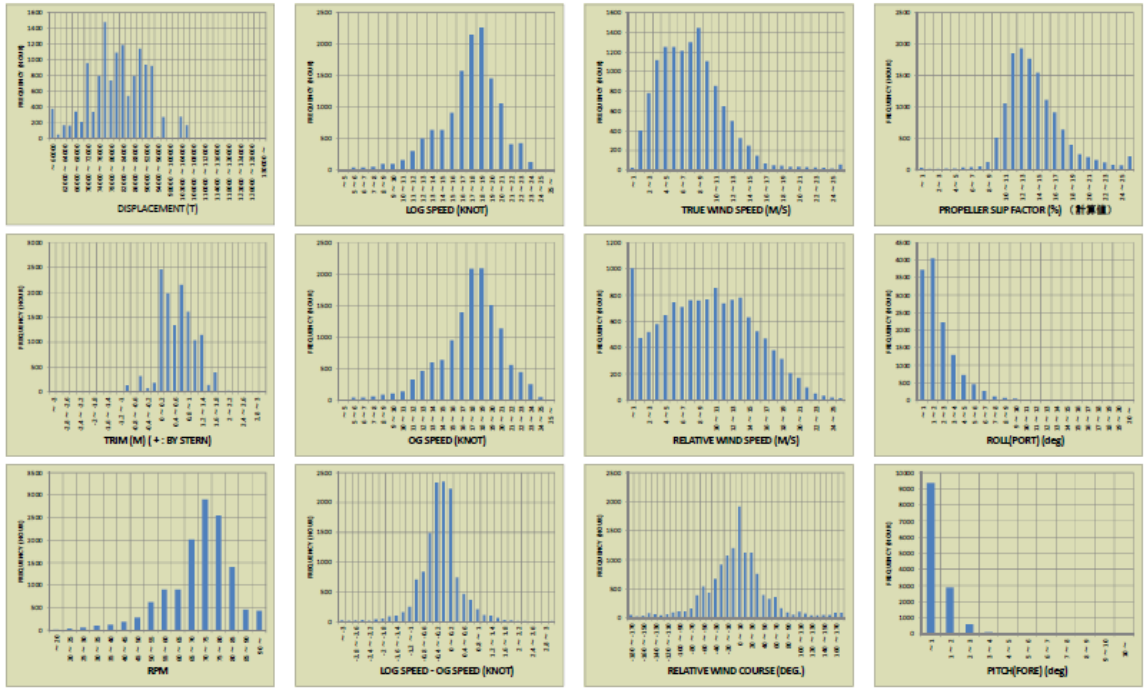
Long term probabilistic estimation - maximum acceleration in operation

Maximum Z acceleration estimation based on onboard measurement data (RoRo – Pure Car Carrier)



Operation profile
- feedback to new building

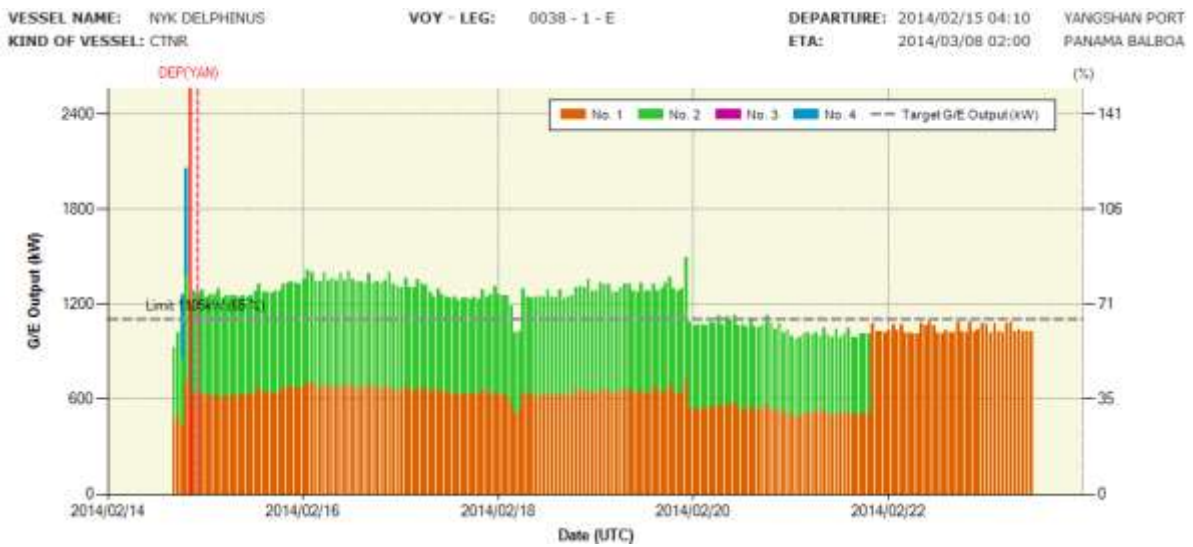
- Operation profile
  - statistics of how ships are used in operation
- Considerations of operation profile are necessary for maximize life cycle values of ships



Engine and power plant monitoring

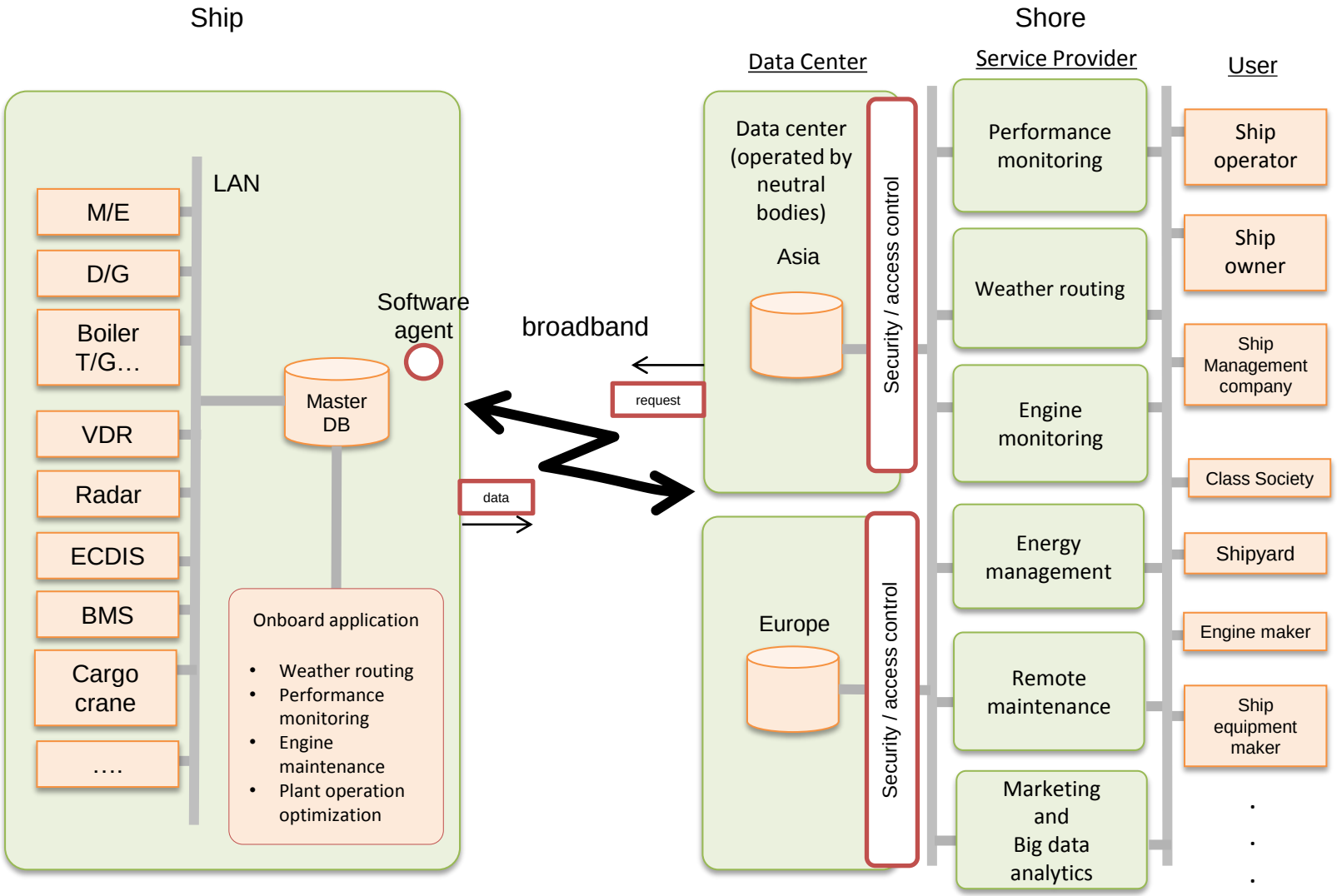
Purposes:

- Early finding of abnormal conditions
- Improve energy efficiency in plant operation
- Trouble data analysis for future prevention



Example of trend graph of D/G outputs

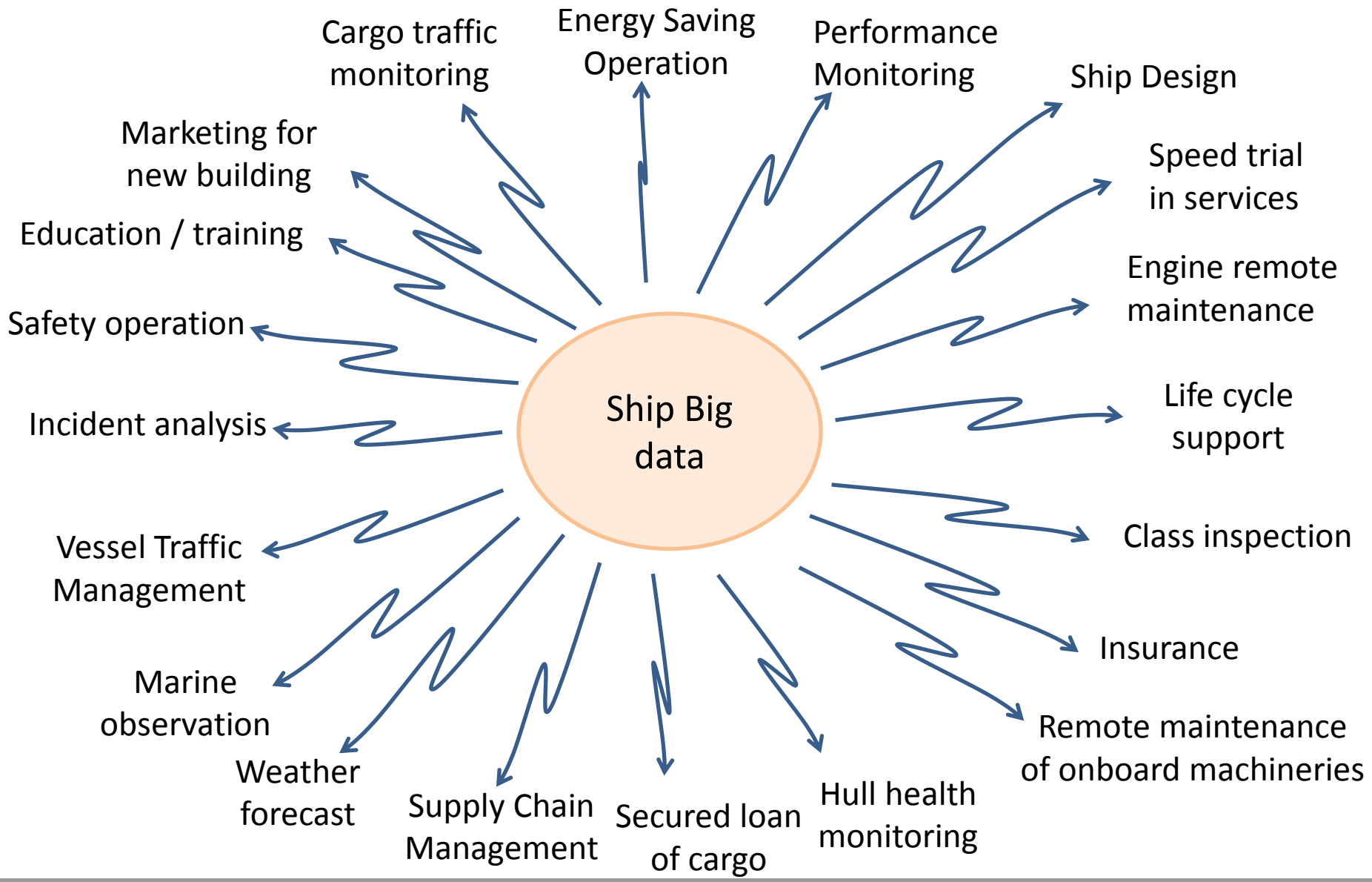
Image of ship – shore open platform infrastructure



What are the benefits of such infrastructure ?

- ✓ Application providers can easily provide onboard and shore application software / services
- ✓ Equipment manufacturers can easily provide their services, such as remote maintenance -> Ship owners can get remote maintenance supports directly from manufacturers
- ✓ Ship owners investment cost (CAPEX and OPEX) for onboard applications and shore services will be lower -> more big data applications will be used
- ✓ Shipyards and equipment manufactures can collect data from running equipment -> better understanding for service performances
- ✓ Ship owners can manage/control ship data transmission to shore
- ✓ Standardized format and protocol will enhance application development

Possibilities of Ship Big Data



Summary

- Shipping company faces large volume dataset that beyond the ability of traditional approach ⇒ Era of “Big data”
- The first target of utilizing Big data is fuel efficiency. To accurately grasp individual ship performance in service is the key to pursue fuel efficiency in operation
- To utilize Big data in safety operation is the next target. For instance, cargo securing and engine plant operation might be supported by using Big data
- Business relations, such as ship owner and charterers, and their profit sharing scheme are important to pursue further possibilities of operational improvements
- We expect standardized open data platform to collect onboard data and further applications of Big data can be expected