Hullpic 2017

Vessel Performance Model and its Utilization in Shipping Company

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Takashi Yonezawa (MTI)
Hideyuki Ando (MTI)
Ryo Kakuta (MTI Singapore)

Outline

1. Introduction of NYK/MTI
2. Vessel Performance Management System
3. Vessel Performance Model
4. Utilization of vessel performance model
5. Conclusion

NYK Corporate Profile

- NYK Line (Nippon Yusen Kaisha)
- Head Office: Tokyo, Japan
- Founded: September 29, 1885
- Business Scope:
  - Liner (Container) Service
  - Tramp and Specialized Carrier Services
  - Tankers and Gas Carrier Services
  - Logistics Service
  - Terminal and Harbor Transport Services
  - Air Cargo Transport Service
  - Cruise Ship Service
  - Offshore Service
- Employees: 1,583 (NYK, as of the end of March 2016)
  34,276 (NYK Group, as of the end of March 2016)
- Revenues: $ 22.7 billion (Fiscal 2015)

NYK Head Office in Tokyo

NYK Fleet (as of the end of March 2016)

Containerships
(including semi-containerships and others)
99 vessels / 5,820,781 DWT

Bulk Carriers
(Capesize)
108 vessels / 21,248,606 DWT

Bulk Carriers
(Panamax & Handysize)
269 vessels / 16,411,393 DWT

Wood-chip Carriers
47 vessels / 2,509,047 DWT

Cruise Ships
1 Vessel / 7,548 DWT

Car Carriers
119 vessels / 2,165,138 DWT

Tankers
68 vessels / 11,030,601 DWT

LNG Carriers
29 vessels / 2,176,681 DWT

Others
42 vessels / 695,974 DWT

782 vessels
62,065,769Kt (DWT)

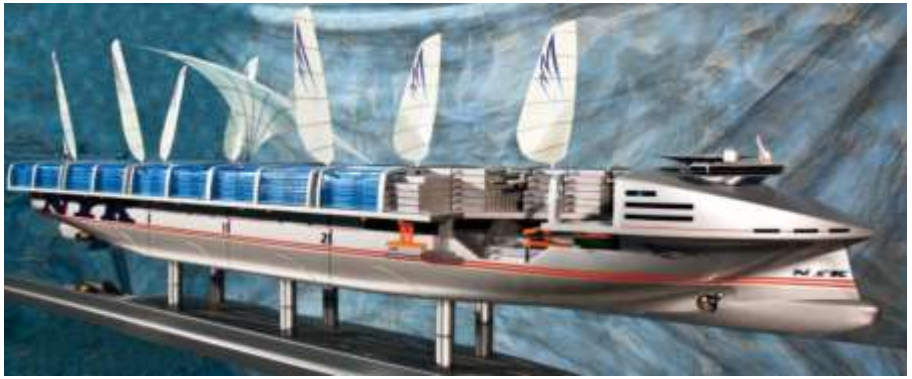
MTI (*Monohakobi* Technology Institute)

- strategic R&D arm of NYK Line -

http://www.monohakobi.com/en/

- Established : April 1, 2004
- Stockholder : NYK Line (100%)
- Number of employees : 62 (as of 1st April, 2016)
- Location
  - Head Office : 7th Fl., Yusen Building, Tokyo, Japan
  - MTI CO.,LTD. SINGAPORE BRANCH, Singapore
  - MTI YOKOHAMA LAB (Transportation Environment Lab), Yokohama, Japan

Multi Cargo Simulator
At YOKOHAMA LAB



NYK SUPER ECO SHIP 2030 (Concept ship for the future 69% less CO2 emissions)

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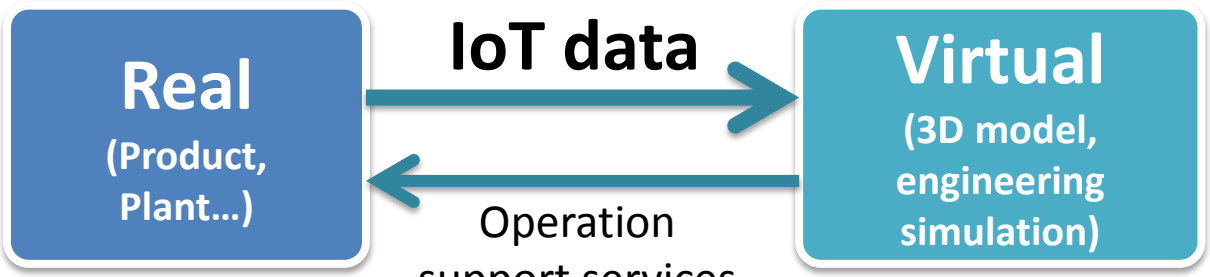
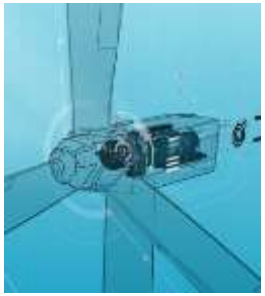
Digital Twin – Utilization of IoT in other industries

An approach of Product Lifecycle Management(PLM) to extend computer-based engineering capabilities to operations





Reference)
1. http://www.gereports.com/post/119300678660/wind-in-the-cloud-how-the-digital-wind-farm-will/
2. Michael Grieves, Virtually Perfect: Driving Innovative and Lean Products through Product Lifecycle Management (English Edition), 2012

Vessel Performance Management System

- Auto-log system on board
- Dashboard for ship and office
- Recommendation for fuel saving
  - Optimum trim

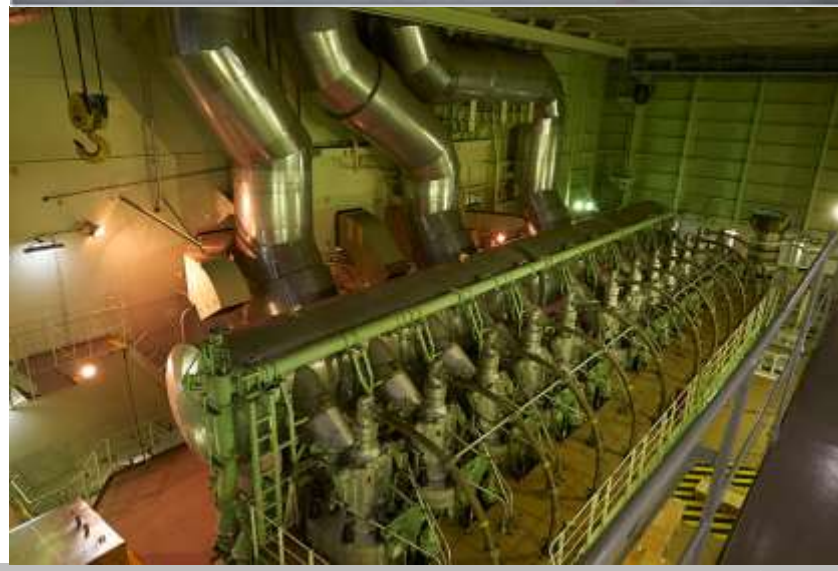
Utilize IoT in shipping

Target

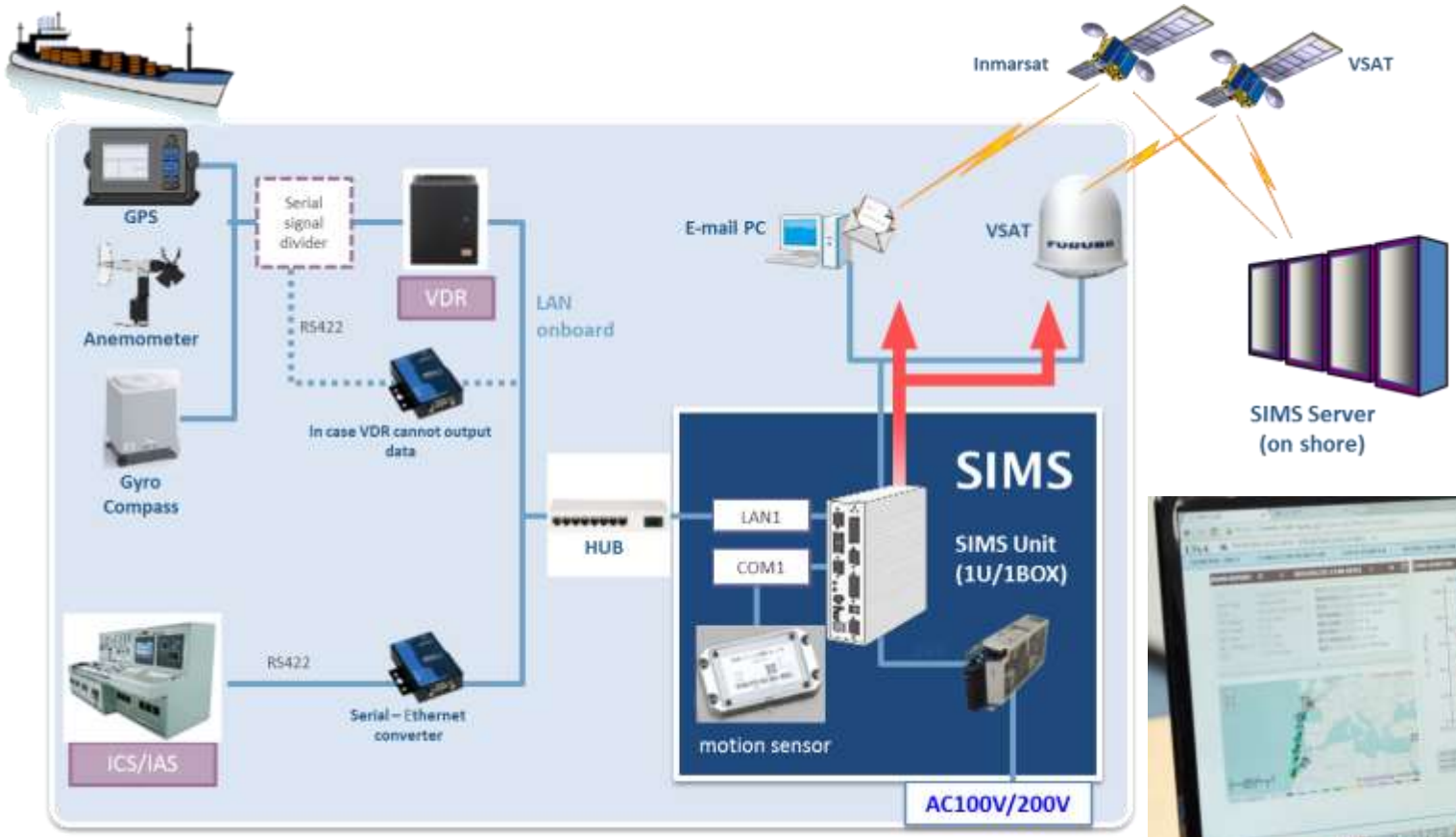
- Energy efficiency in operation
- Prevent unpredicted downtime
- Reduce maintenance cost

Measure

- Digital twin
- Condition monitoring
- Big data analysis
- Support service engineer
- Intelligent machinery
  - Self diagnostics



Example of VPMS:
SIMS(Ship Information Management System)
IoT Platform of NYK



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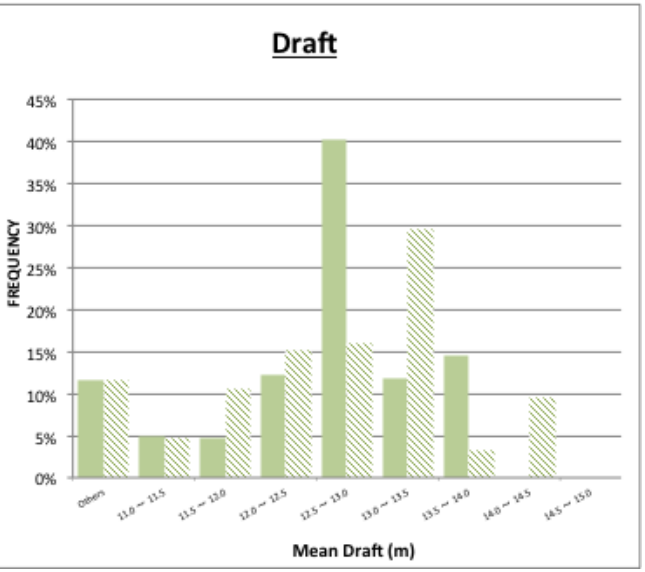
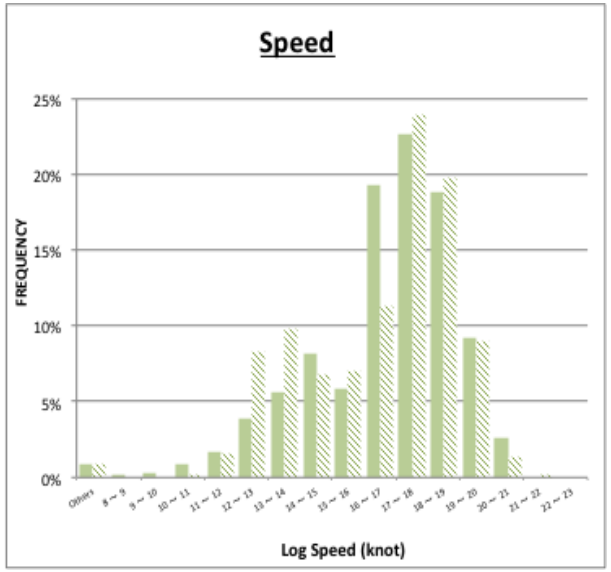
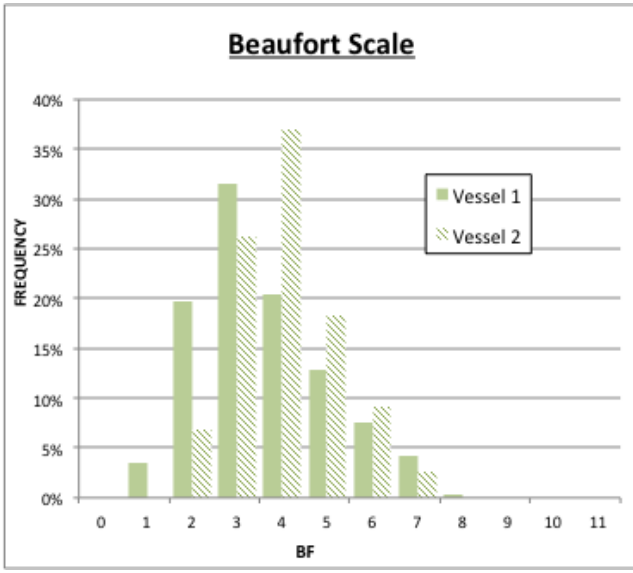
Requirement to "Digital Twin" of vessel performance

- The following factors must be included in vessel performance model
  - Effect of speed
  - Effect of draft
  - Effect of weather

Conventional "speed-consumption" curve includes only effect of speed







Difference of two similar size container vessels' operation profile deployed in different service

Expectation to “Digital Twin” in shipping company

- Digital twin for estimating vessel performance in actual service condition is most expected
  - In-service performance model

- Vessel operators need accurate operational cost estimation for various decision making
  - Vessel deployment
  - Vessel chartering
  - Service schedule design

Vessel performance model as “Digital Twin”

Development methods of performance model

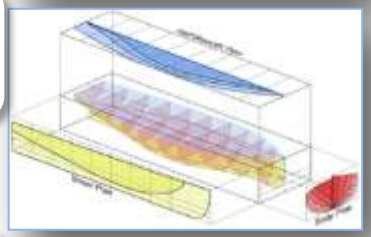
1. Towing tank test or/and CFD
2. Estimation by ship design data
3. Estimation by using measurement data

Experimental

Towing tank test or CFD

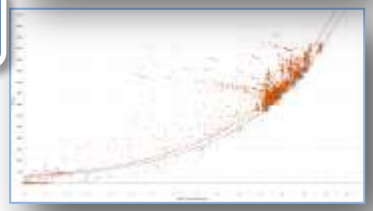
Theoretical/ Empirical

Ship’s Design

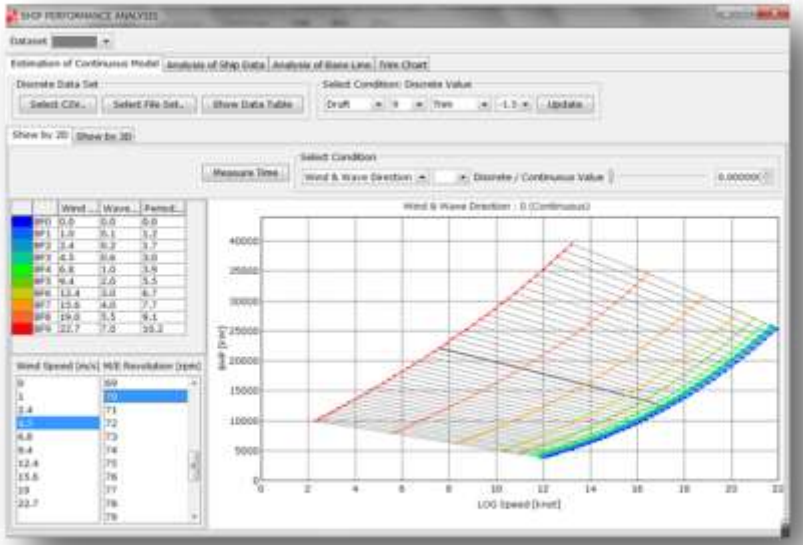


Statistical

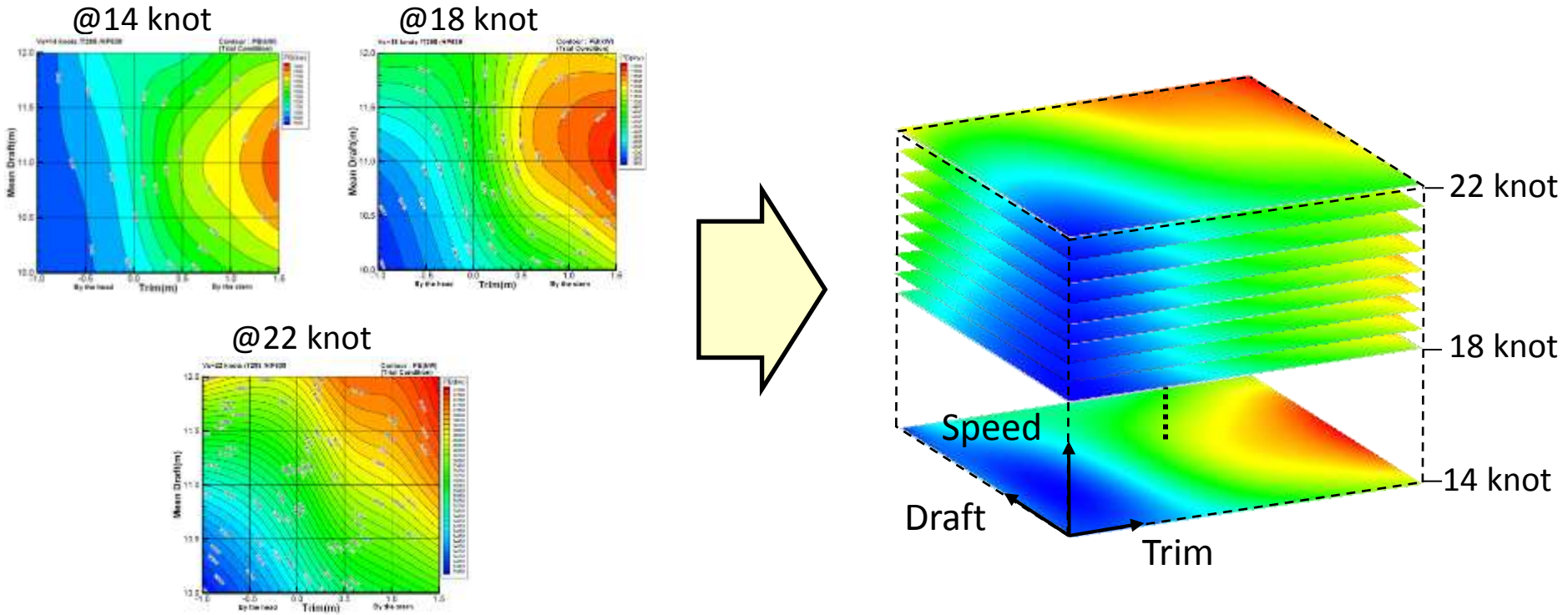
SIMS data



All weather performance model incl. draft and trim effect

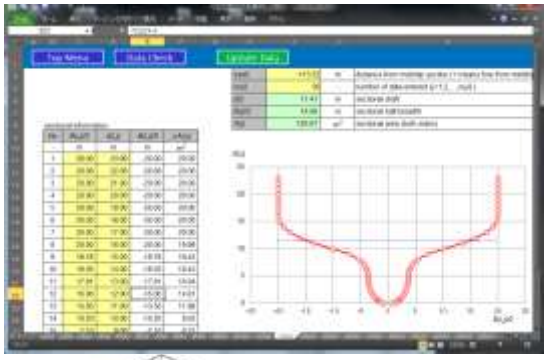


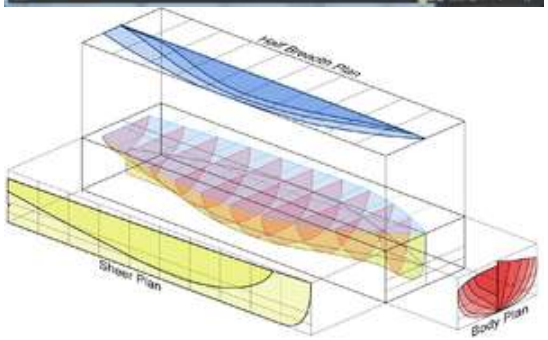
Continuous model to represent discrete performance data – draft and trim



Extend 3-dimensional B-spline volume to multi-dimensional volume to represent continuous data (Joint research with AIST)

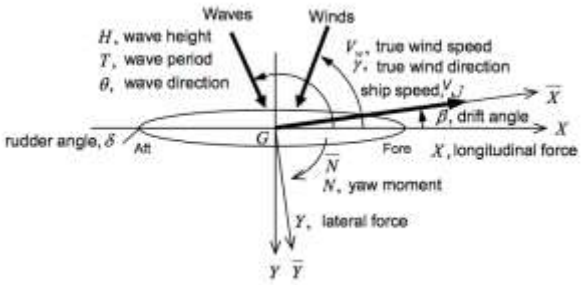
Theoretical estimation of wind and wave effect (Joint research with NMRI)





Considered forces and moments

1. Resistance in still water
2. Hydrodynamic forces and moments
3. Propeller thrust
4. Rudder forces and moment
5. Wind resistance
6. Added resistance in short crested irregular waves



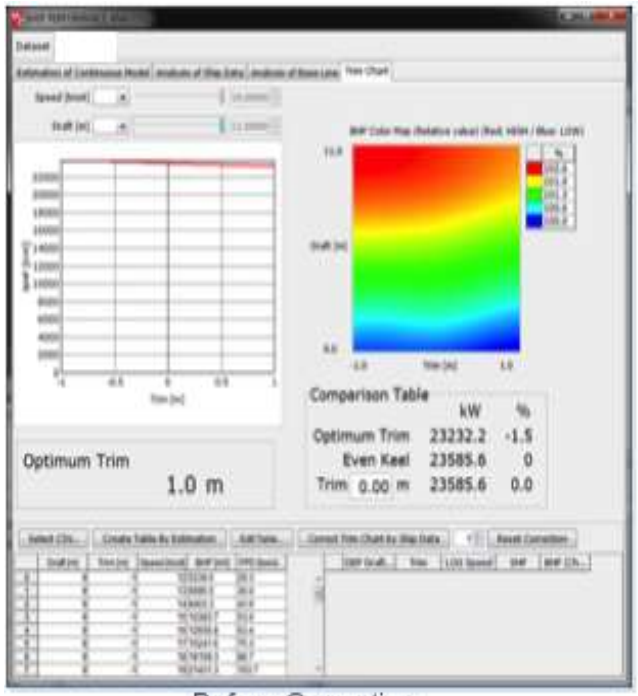
$$X = X_0(V_S) + X_D(\beta) + (1-t)X_P(N_P, V_S) + X_R(\beta,\delta) + X_A(V_r,\gamma_r) - R_{AW}(V_S,\beta;H,T,\theta) \quad (27)$$

$$Y = Y_D(\beta) + Y_R(\beta,\delta) + Y_A(V_r,\gamma_r) \quad (28)$$

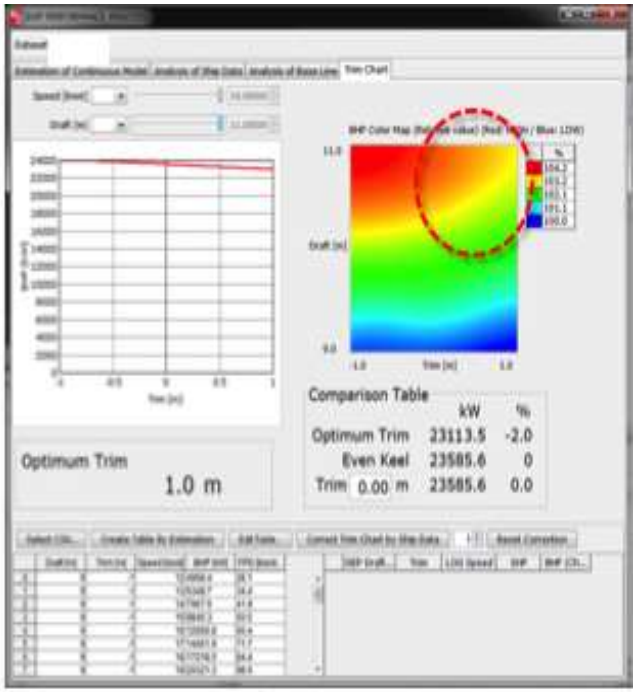
$$N = N_D(\beta) + N_R(\beta,\delta) + N_A(V_r,\gamma_r) \quad (29)$$

Reference) M. Tsujimoto, et.al,: Development of a Calculation Method for Fuel Consumption of Ships in Actual Seas With Performance Evaluation, ASME 2013 32nd International Conference on Ocean, Offshore and Arctic Engineering(OMAE),2013

Performance model correction



Before Correction



After Correction

Baseline performance analysis by SIMS data

- ✓ Data filtering
- ✓ Weather correction

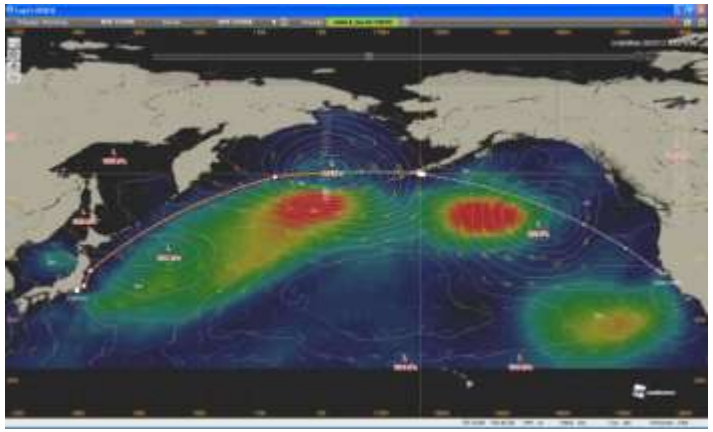
Update of all weather performance model

The performance model is periodically corrected by statistical regression of measurement data

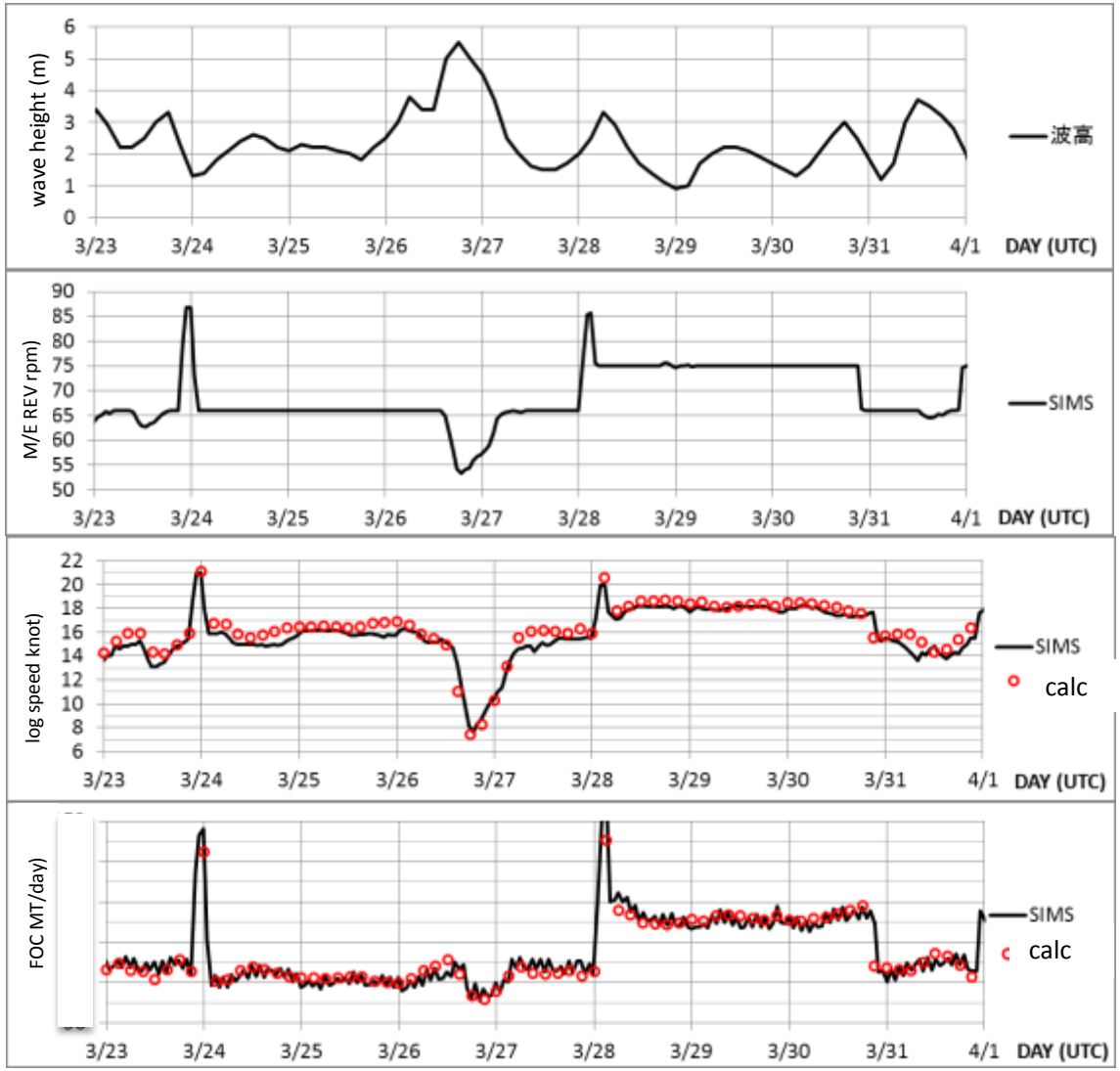
An example of model validation

Container vessel

Voyage : OAKLAND-TOKYO



Accuracy of vessel performance model was confirmed.



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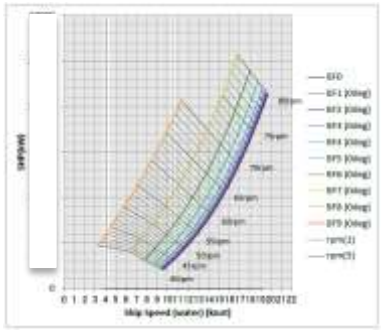
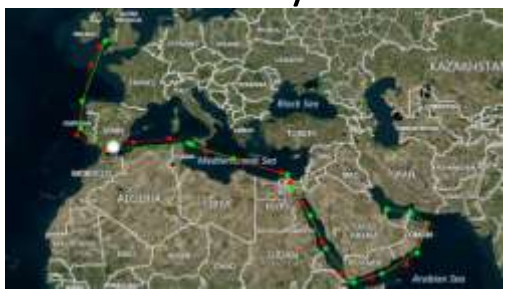
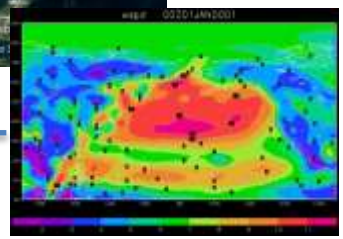
Utilization of vessel performance model
- Sea margin estimation



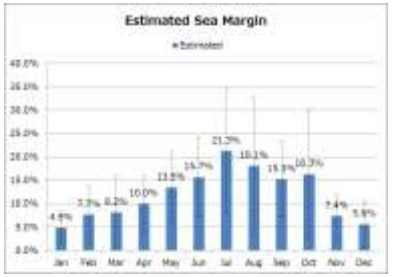
Vessel performance model

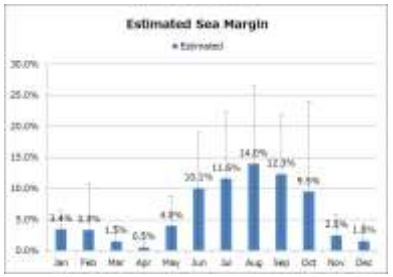
Service route/schedule





Hindcast weather data

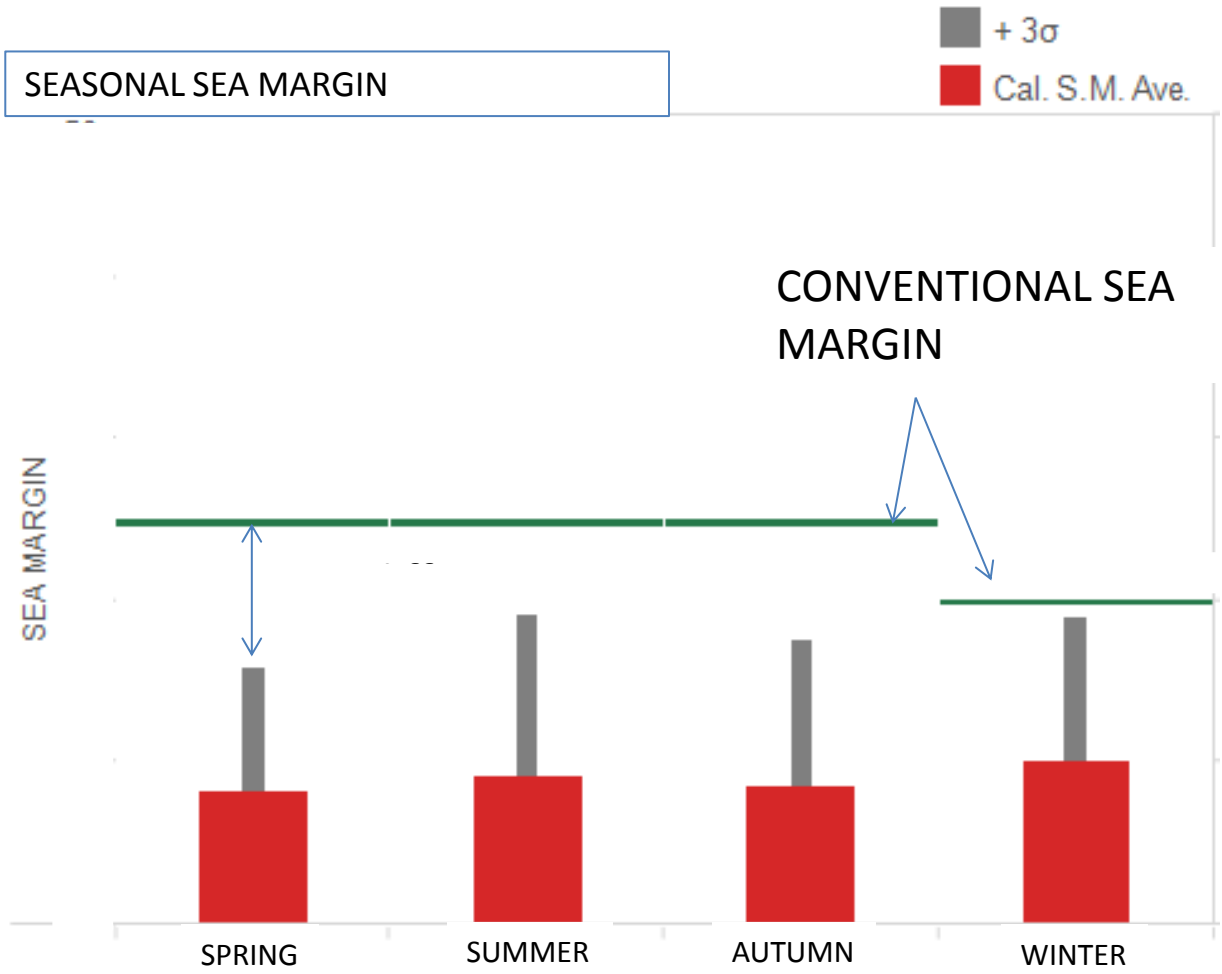




Estimation of
- Sea Margin
- Sailing time
- Average Speed
- Total FOC

Accurate sea-margin estimation is useful for various decision making of ship operators

Sea margin estimation based on voyage simulation - Example of cape size bulk carrier -



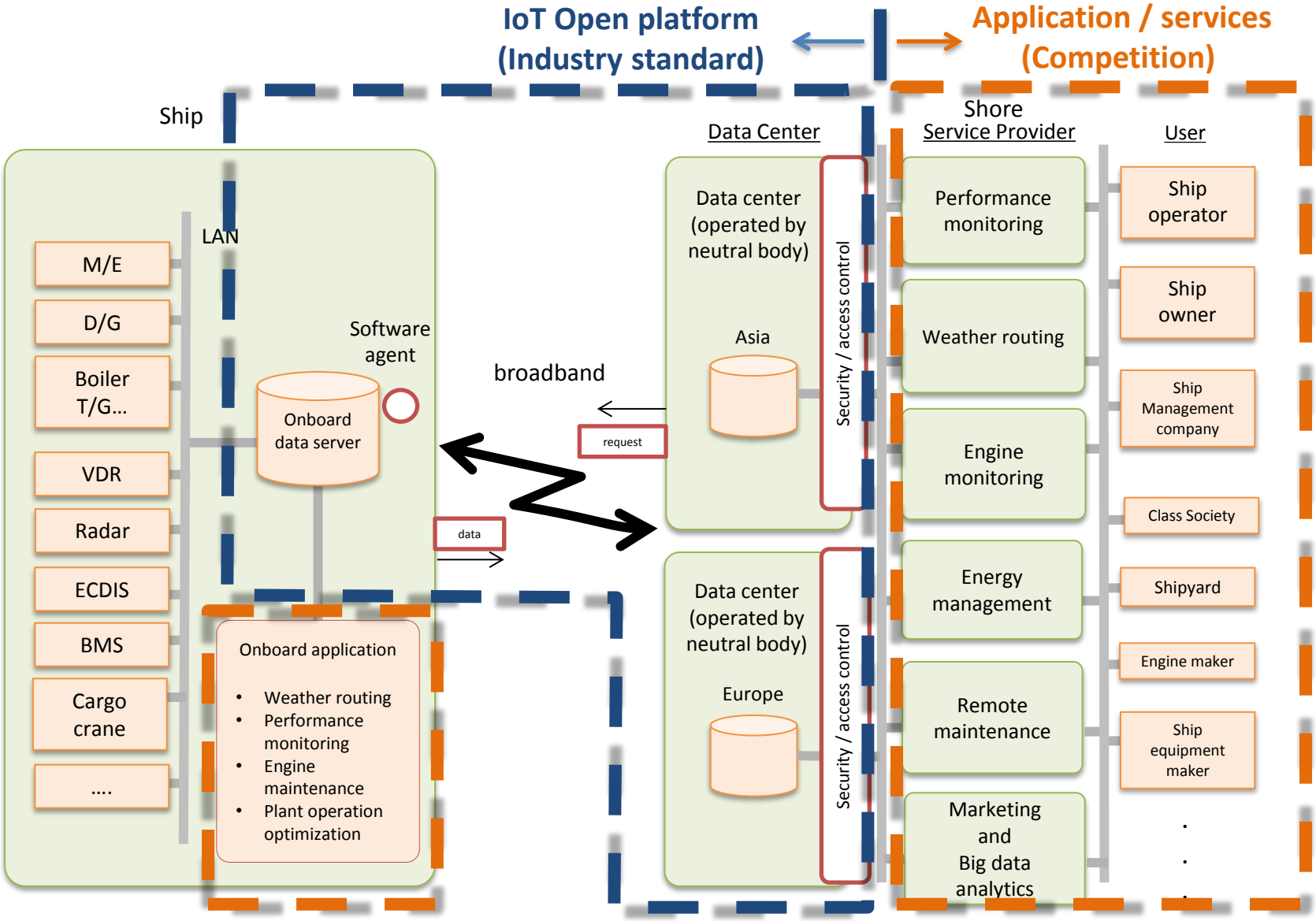
Simulation results show conventional sea margins are much larger than required for some routes

NYK/MTI's R&D activities for digitalization

- Open collaboration with industry partners -

i-Shipping: Japanese government funding projects Ship IoT for safety (2016-2020)

Open platform for maritime industry



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Conclusion

- Concept of “Digital Twin” can be applied to shipping
- Vessel operators require in-service performance model as “Digital Twin” for estimating operational cost accurately
- Vessel performance models have been developed in NYK and utilized in business decision making
- Application of “Digital Twin” will be expanded to other areas of vessel such as engine and LNG cargo
  - Open collaboration using IoT open platform will contribute to digitalization of whole vessel

Thank you for your attention