The Application of Big Data for Ship Operational Efficiency

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Ship performance in seaways

Effecting factors
- Ship speed
- Draft and trim
- Weather (wind, wave, current)
- Ship motion
- Condition of hull and propeller
- Performance of engine

Example: Speed drop and fuel consumption increase in rough sea

BF 8
wave height: 5.5m
wind speed: 20m/s

@ Engine Rev. 55 rpm

<table>
<thead>
<tr>
<th>Weather</th>
<th>Calm</th>
<th>B.F. 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>14 knot</td>
<td>8 knot</td>
</tr>
<tr>
<td>Fuel Cons.</td>
<td>45 ton/day</td>
<td>60 ton/day</td>
</tr>
</tbody>
</table>
Effecting factors on ship operational efficiency

- Ship speed
- Draft and trim
- Weather (wind, wave, current)
- Ship motion
- Condition of hull and propeller
- Performance of engine

- Early arrival
- Drifting
- Port congestion
- Port close

- Departure delay
- Bunker margin

- Service design
- Ship allocation
- Speed margin estimation

- Schedule change
- Non optimum speed allocation
- Non optimum engine plant operation
- Course deviation by bad weather
Big data for shipping

• According to technical advances, detail and highly frequent data can be collected at shore
  – 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
Big data and its processing flow

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

Performance management is organizational improvement process by using performance monitoring

- Share objective among related parties
- Continuous improvement and learning cycle with performance monitoring
- Pursue target by Information sharing and collaboration
Example of ship data collection
SIMS (Ship Information Management System)

SIMS Data Collection System Onboard

- VSAT/Inmarsat-F/FB
- VDR / ECDIS
- GPS
- Doppler log
- Anemometer
- Gyro Compass

<Velocity in Navigation Bridge>

<Engine Room>

- Main Engine
- FO flow meter
- Torque meter

Data Acquisition and Processing

- Engine Data Logger

SIMS unit

Data Center

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

Weather routing service provider

SIMS Monitoring & Analysis System at Shore

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

- Motion sensor

- Viewer

- Technical Analysis (MTI)

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

<Communications via Technical Management>

<Feedback to captains>

Operation Center

- Report
  - Singapore, ....

Voyage Analysis Report

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

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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

<table>
<thead>
<tr>
<th>Beaufort</th>
<th>Wind speed (m/s)</th>
<th>Wave height (m)</th>
<th>Wave period (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BF3</td>
<td>4.5</td>
<td>0.6</td>
<td>3.0</td>
</tr>
<tr>
<td>BF4</td>
<td>6.8</td>
<td>1.0</td>
<td>3.9</td>
</tr>
<tr>
<td>BF5</td>
<td>9.4</td>
<td>2.0</td>
<td>5.5</td>
</tr>
<tr>
<td>BF6</td>
<td>12.4</td>
<td>3.0</td>
<td>6.7</td>
</tr>
<tr>
<td>BF7</td>
<td>15.6</td>
<td>4.0</td>
<td>7.7</td>
</tr>
<tr>
<td>BF8</td>
<td>19.0</td>
<td>5.5</td>
<td>9.1</td>
</tr>
<tr>
<td>BF9</td>
<td>22.7</td>
<td>7.0</td>
<td>10.2</td>
</tr>
</tbody>
</table>

0deg (wind, wave) – head sea

Base line performance
Wind and wave effect
Integration of weather routing and monitoring

**Weather Routing (PLAN)**
- Voyage plan
  - course, speed, RPM, FOC, weather
  - ship performance model

**Monitoring (CHECK)**
- 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.
Optimum trim model and its validation

Optimum trim estimation
(reasoning by model test, simulation)

Trim trial with performance monitoring

Comparison

The relation of propulsive performance and trim are physically complex problem.
Monitoring of engine and power plant

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

Example of trend graph of D/G outputs
Post-voyage analysis

- Support **corrective action** for operation improvement
- **Information sharing** between operators and vessels
- Contents (about 10 pages)
  - Voyage overview
  - Breakdown analysis of FOC
  - Comparison with records
  - Evaluate weather routing
  - Advice for fuel saving

**Analysis of fuel consumption factors (patented)**

- Increase in voyage distance
- Ship speed distribution
- Increase in ship speed
- Wind force, waves, and tides
- Use of generators
- Hull and propeller fouling
- Draft and trim
- Ship-specific performance

*FOC: fuel oil consumption*
Long-term analysis

- **Share awareness** for vessel performance degradation

- **KPI**
  - $\Delta V$ ... 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
Application of ship performance model
- Business optimization

Accurate vessel performance model contributes to optimization of vessel deployment.
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
Estimated ship motion in rough sea and its validation for safe operation

- Ship motion simulation
- 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)

- LR guideline Max Az = 10.95 m/s^2
- Estimated Max Az = 10.0 m/s^2 in 10 years
- Slamming effect
- Rigid body motion

North pacific 5 vessels in 10 years
Possibilities of Ship Big Data

- Cargo traffic monitoring
- Energy Saving Operation
- Performance Monitoring
- Ship Design
  - Speed trial in services
  - Engine remote maintenance
  - Life cycle support
  - Class inspection
  - Insurance
  - Remote maintenance of onboard machineries

- Marketing for new building
- Education / training
- Safety operation
- Incident analysis
- Vessel Traffic Management
- Marine observation
- Weather forecast
- Supply Chain Management
- Secured loan of cargo
- Hull health monitoring
- Education / training
- Performance Monitoring
- Speed trial in services
- Life cycle support
- Class inspection
- Insurance
- Remote maintenance of onboard machineries

Ship Big data
Summary

• Shipping company faces large volume dataset that beyond the ability of traditional approach

• 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

• We expect further applications of Big data, especially to increase values for cargo owners