How we tackle IoT of Ship
- Data Utilization and Standardization -

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Hideyuki Ando, MTI (NYK group)
Outline

1. IoT and Big data
2. Data utilization
3. Standardization
4. Summary
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IoT (Internet of Things)

“Instrumentation and control” and “Internet” are to be bridged

* PLC: Programmable Logic Controller
Big data in shipping

Examples of Big data in shipping

**Voyage data**
- Automatically collected data (IoT)
- Noon report

**Machinery data**
- Automatically collected data (IoT)
- Manual report data
- Maintenance data

**AIS data**
- Satellite AIS / shore AIS

**Weather data**
- Forecast / past statistics

**Business data**
- Container transport data
Industrial Internet (IoT of Industry machineries)

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

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

Change way of working

Reference) https://www.ge.com/sites/default/files/GE_IndustrialInternet@Work_WhitePaper_20131028.pdf
Same concepts are applicable to marine industry

**Target**
- Prevent unpredicted downtime *(owner)*
- Energy efficiency in operation *(operator)*
- Reduce maintenance cost *(owner)*

**Measure**
- Condition monitoring
- Big data analysis
- Support service engineer
- Intelligent machinery
  - Self diagnostics

**Change way of working**
Ship operator’s view of management

Customer/Society

Quality Assurance

Ship Operator

Quality Management

Ship Operator’s Fleet

Ship Owner

Ship

Ship Owner

Ship

Ship Owner

Ship

Ship Owner

Ship

Quality Shipping
- Safety
- Environment
- Schedule
- Cost
Ship owner’s view of management

Customer/Society

Quality Assurance

Ship Operator

Ship Operator’s Fleet

Ship Owner

Ship

Ship

Ship

Ship

Quality Shipping
- Safety
- Environment
- Schedule
- Cost

Ship Owner’s view of management

Ship Owner

Ship Owner

Ship Owner

Ship Owner

Ship
# IoT and Big data application areas

<table>
<thead>
<tr>
<th>Role</th>
<th>Function</th>
<th>Example of Big data application</th>
</tr>
</thead>
</table>
| **Ship operator** | **Operation**    | • Energy saving operation  
• Safe operation  
• Schedule management |
|                 | **Fleet planning** | • Fleet allocation  
• Service planning  
• Chartering     |
| **Ship owner**  | **Technical management** | • Safe operation  
• Hull & propeller cleaning  
• Condition monitoring and maintenance  
• Environmental regulation compliance  
• Energy saving retrofit |
|                 | **New building** | • Design optimization |
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Big data processing flow

It is cross functional and organizational process to change action
Ship performance – key technology for analysis

6500TEU Container Ship
Wave height 5.5m, Wind speed 20m/s
BF scale 8, Head sea

@ engine rev. 55rpm
<Calm sea performance>
speed: 14 knot
FOC: 45 ton/day

<Performance in the rough sea (BF8)>
speed: 8 knot
FOC: 60 ton/day

Effecting factors
1. Weather (wind, wave and current), 2. Ship design (hull, propeller, engine), 3. Ship condition (draft, trim, cleanliness of hull and propeller, aging effect)
Ship performance in all weather

<Target vessel>
6500TEU Container
Draft 12m even

Sea condition
Beaufort scale

<table>
<thead>
<tr>
<th>Beaufort scale</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

Wind and wave effect
Base line performance
Optimum weather routing with performance 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

Feedback

Ship model and weather forecast are inherently include errors.
But feedback loop by monitoring can make this system work better.
Operation optimization

Combine ship performance model with weather data to optimize ship services
Fouling risk assessment and maintenance

Fouling risk assessment will be conducted by using the following information:

- Operation profile
- Long term performance analysis
- Lay-by days/area/season

To recommend under water inspection and hull / propeller cleaning
Energy saving hull modification

23% CO2 reduction was confirmed

Operation profile

- Speed, RPM, Power
- Draft, trim, displacement
- Weather
- Sea margin
- etc

Energy saving modification

- Bulbous bow modification
- Install energy saving device (MT-FAST)
- etc
Condition monitoring for maintenance support

• Estimate condition status from observed data
  – Faulty situation finding
  – Support service engineer

• Data analysis methods
  – Rule-base
  – Machine learning
  – Etc.

Observation: data data data data data data data data

State: T T T T T T F F ...

Shore dashboard for Fleet technical manager
If scopes are bounded, implementations of Sensors, Knowledge Base, Controller and Communication are possible. E.g. Self diagnosis system of machinery and equipment
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Smart Ship Application Platform (SSAP) Project - Japanese Society of Machinery and Equipment Manufacturer -


- Submitting Organization: Japan Ship Machinery and Equipment Association (JSMEA) Smart Ship Application Platform WG
- Point-of-Contact: Dr. Hideyuki Ando (MTI: Research company of NYK group), hideyuki_ando@monohakobi.com
- Functional Capabilities: Provide current and past numerical data on Weather routing, Trim, Performance monitoring, Engine monitoring, Hull and cargo condition monitoring, Power plant energy management and Remote maintenance.
- Intended Purpose: The target is to design a master database, interface prototypes, specifications of communication system between ships and shore facilities and international standards of data server requirements and structure of machinery and equipment so that as many application services as possible can be built on.
- Portrayal examples: Not specified special display devices for this SSAP.
- Last edited: April 22, 2014

Proposal for new ISO in May 2015

- ISO/PWI19847 - Shipboard data servers to share field data on the sea
  - Specifications of ship data server
- ISO/PWI19848 - Standard data for machinery and equipment part of ship
  - Specifications of dictionary and format
Onboard data collection (now)

Onboard and shore applications

To Shore

- Optimum trim
- Weather routing
- Engine monitoring
- Remote maintenance
- Plant energy management

Similar data are sent to shore from each onboard software

Onboard equipment

- ECDIS
- VDR
- Engine Data Logger
- Ballast Control System

Cabling and interfacing one by one (N to N)
Onboard data collection (future)

Onboard and shore applications:

- Optimum trim
- Weather routing
- Engine monitoring
- Remote maintenance
- Plant energy management

To Shore (broadband):

Master Database

Ship’s LAN for onboard equipment (ISO16425):

- ECDIS
- VDR
- Engine Data Logger
- Ballast Control System

Onboard equipment
Image of ship – shore open platform

Ship
- M/E
- D/G
- Boiler T/G
- VDR
- Radar
- ECDIS
- BMS
- Cargo crane
- ...

LAN

Master DB

Software agent

broadband

Data Center

Data center (operated by neutral bodies)

Asia

Security / access control

request

data

Shore

Service Provider

Performance monitoring

Weather routing

Engine monitoring

Europe

Energy management

Remote maintenance

Europe

Marketing and Big data analytics

User

Ship operator

Ship owner

Ship Management company

Class Society

Shipyard

Engine maker

Ship equipment maker

...

Onboard application
- Weather routing
- Performance monitoring
- Engine maintenance
- Plant operation optimization

Courtesy of Smart Ship Application Platform (SSAP) Project of JSMEA 2014-15
What are the benefits of such platform?

✓ Safety and energy-efficiency service application providers can concentrate on software function, quality and usability without spending resources for data collection

✓ Equipment manufacturers can develop their remote maintenance services by using the standardized platform

✓ Ship owners investment cost (CAPEX and OPEX) for onboard applications and shore services will be reduced

✓ Ship owners can use robust and reliable data center services to access ship operation data

✓ Shipyards and equipment manufactures can collect data from running equipment to improve service levels of their products

✓ Ship owners can manage/control ship data transmission to shore
## Image of the open platform pilot project

<table>
<thead>
<tr>
<th>Item</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data server onboard</td>
<td>SSAP proposes the specification of the hardware and protocol/format</td>
</tr>
<tr>
<td>Shore data center</td>
<td>Shore independent data center hosted by class society</td>
</tr>
<tr>
<td>Ownership of data</td>
<td>Ownership of the data belongs to the ship owner. Under agreement by the owner, 3rd party service providers can utilize the ship IoT data</td>
</tr>
<tr>
<td>Security and access control</td>
<td>Data security and data access control shall be implemented</td>
</tr>
<tr>
<td>Business model and contract template</td>
<td>Business model and contract templates shall be established</td>
</tr>
</tbody>
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Ship IoT

- Good collaborations of IoT platform and marine domain understandings are necessary for Ship IoT

- SSAP project will provide the foundation of Ship IoT
# Expected Applications of Ship IoT and Open Platform

<table>
<thead>
<tr>
<th>Role</th>
<th>Application of Ship IoT and open platform</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shipping</strong></td>
<td>Ship owner and operator needs applications for energy saving, minimize downtime and safety transport and environmental conservation</td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
<td>Remote maintenance, preventive maintenance and self diagnostics</td>
</tr>
<tr>
<td><strong>Shipyard</strong></td>
<td>Data analysis services for ship owners, life-cycle support and feedback to new design</td>
</tr>
<tr>
<td><strong>Service provider</strong></td>
<td>Fleet management system, big data analysis services, condition monitoring services and IoT platform</td>
</tr>
<tr>
<td><strong>Academy</strong></td>
<td>Research on big data analysis, numerical simulation methods and trainings</td>
</tr>
<tr>
<td><strong>Class society</strong></td>
<td>Shore data center and class inspection</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td>... utilization for e-navigation and MRV</td>
</tr>
</tbody>
</table>
Summary

• IoT has been prevalent such as Industry Internet. The concept and technology are also applicable to marine industry.

• Several examples of IoT data utilization are introduced. There are two different views of ship owner and operator who utilize the Big data.

• Smart Ship Application Platform (SSAP) project aims at developing standard of onboard data server and data format / protocol for IoT of Ship

• To achieve Ship IoT, combination of good IoT platform and marine domain understandings are important to make good solutions.
Thank you for your attention