IoT and Big data in shipping
– an approach of NYK Line -

15th April 2019

BV AA Committee

Yasuo Tanaka , MTI

Outline

1. **Introduction**
2. IoT and Big data in Shipping
3. Platform for digitalization
4. NYK's view on Autonomous Ship

What NYK/MTI is

NYK Corporate Profile

NYK LINE (NIPPON YUSEN KAISHA)

- 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

NYK Head Office in Tokyo

- Employees: 34,270 (as of the end of March 2016)

- Revenues: $ 22.7 billion (Fiscal 2015)

What NYK/MTI is

NYK Fleet (as of the end of March 2018)

NYK LINE NIPPON YUSEN KAISHA

Container ships (including semi-container ships and others)

95 vessels / 6,700,000 DWT

Bulk Carriers (Capesize)

110 vessels / 21,615,000 DWT

Bulk Carriers (Panamax & Handysize)

251 vessels / 15,399,000 DWT

Wood-chip Carriers

42 vessels / 2,267,000 DWT

Cruise Ship

1 vessel / 7,000 DWT

Car Carriers

119 vessels / 2,183,000 DWT

Tankers

65 vessels / 10,207,000 DWT

LNG Carriers

29 vessels / 2,185,000 DWT

Others

43 vessels / 708,000 DWT

755 vessels

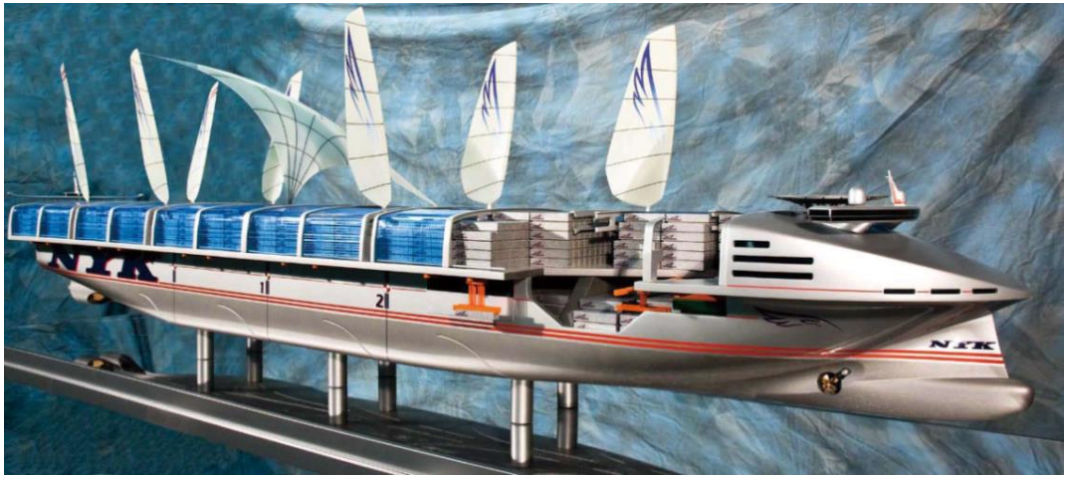
61,275 KT (1,000 DWT)

What NYK/MTI is

MTI Company Profile

- MTI is “Monohakobi (= quality transport) Technology Institute”
- Established : April 1, 2004
- Equity capital : JPY 99 million
- Stockholder : NYK Line
- Number of employees : 62 (as of 1st April, 2016)
- Head office : 2-3-2 Marunouchi, Chiyoda-ku, Tokyo, 100-0005, Japan
- URL : www.monohakobi.com/en/

Monohakobi Technology Institute



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

SINGAPORE BRANCH

- 1 Harbour
- Front Place #13-01
- HarbourFront Tower One
- Singapore (098633)

YOKOHAMA LAB

- (Transportation Environment Lab)
- 5-32-84, Sugita, Isogo-ku, Yokohama,
- Kanagawa, Japan

Monohakobi Technology Institute

NYK GROUP

Smarter ship and operation in NYK/MTI

Now — Future

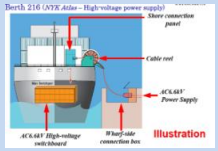
OIL — LNG — HYDROGEN

Ship (Hardware)

Operation (Software)

Super Eco Ship 2050

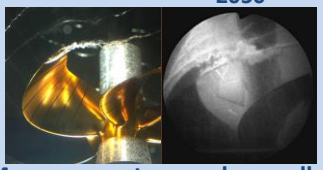
Wind Resistance Reduced
MT-COWL



Alternative Marine Power

Super Eco Ship2030

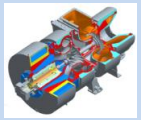
30% Energy Saving PCTC



Measurement around propeller

Wind Power Generator
Andromeda Leader

Solar Panel
Auriga Leader



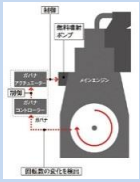
Hybrid T/C
Shin Koho

Innovative
Air Lubrication System
SOYO

LNG-Fueled Tugboat
Sakigake

LNG-Fueled PCTC
Delivery in 2016

Electronic Controlled Engine



Improved
Governor Controller

MT-FAST

Air Lubrication System
YAMATO, YAMATAI

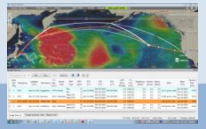
Hybrid Electric Power Supply
Auriga Leader

LNG Bunkering Vessel
Delivery in 2016

Monohakobi Technology Institute

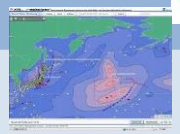
MTI Founded

NYK's own safety and Environment standard
NAV9000



Prediction of Current

Fuel Consumption Indicator
FUELNAVI

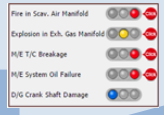


Integrated Operation Management System
NYK e-missions'

IBIS Project

IBIS Project
Onboard Broadband
NYK Satcom Project

LiVE
Operation Portal Site



Detection of Mach. Trouble with monitoring data

ShipDC &
IoS-OP

2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019

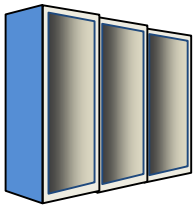
Outline

1. Introduction
2. **IoT and Big data in Shipping**
3. Platform for digitalization
4. NYK's view on Autonomous Ship

IoT platform of NYK

SIMS (Ship Information Management System)

SIMS IoT data
+ SPAS manual data



Data Center

SIMS Data Collection Onboard

Sat Com
(VSAT, FBB)

- GPS
- Doppler log
- Anemometer
- Gyro Compass

SIMS unit

Onboard dashboard

VDR

Data Acquisition and Processing

Motion sensor

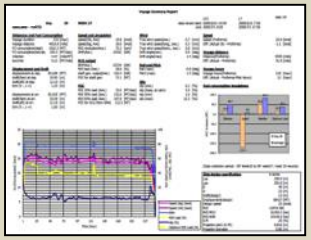
<Navigation Bridge>

<Engine Room & Cargo>

- Main Engine
- Power plant
- Cargo control
- Auxiliary machineries

Integrated Automation System

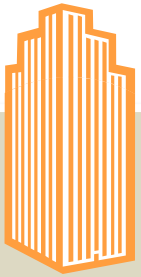
SIMS Monitoring & Analysis at Shore



Performance Analysis

- Long term analysis
- In service performance

Analysis



Operation Center (Tokyo, Singapore ...)

Shore Dashboard

- For operation
- For ship manager

Technical Analysis
(NYK, MTI)

Ship performance in service

6000TEU Container Ship

Wave height 5.5m, Wind speed 20m/s

BF scale 8, Head sea @ Trans-Pacific (Oakland, US – Tokyo, JP)

@ engine rev. 55rpm

<**Calm sea** performance>

speed: 14 knot

FOC*: 45 ton/day

* FOC: Fuel Oil Consumption

<**Rough sea(BF8)** performance>

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, cleanness of hull and propeller, aging effect)

In-service ship performance model

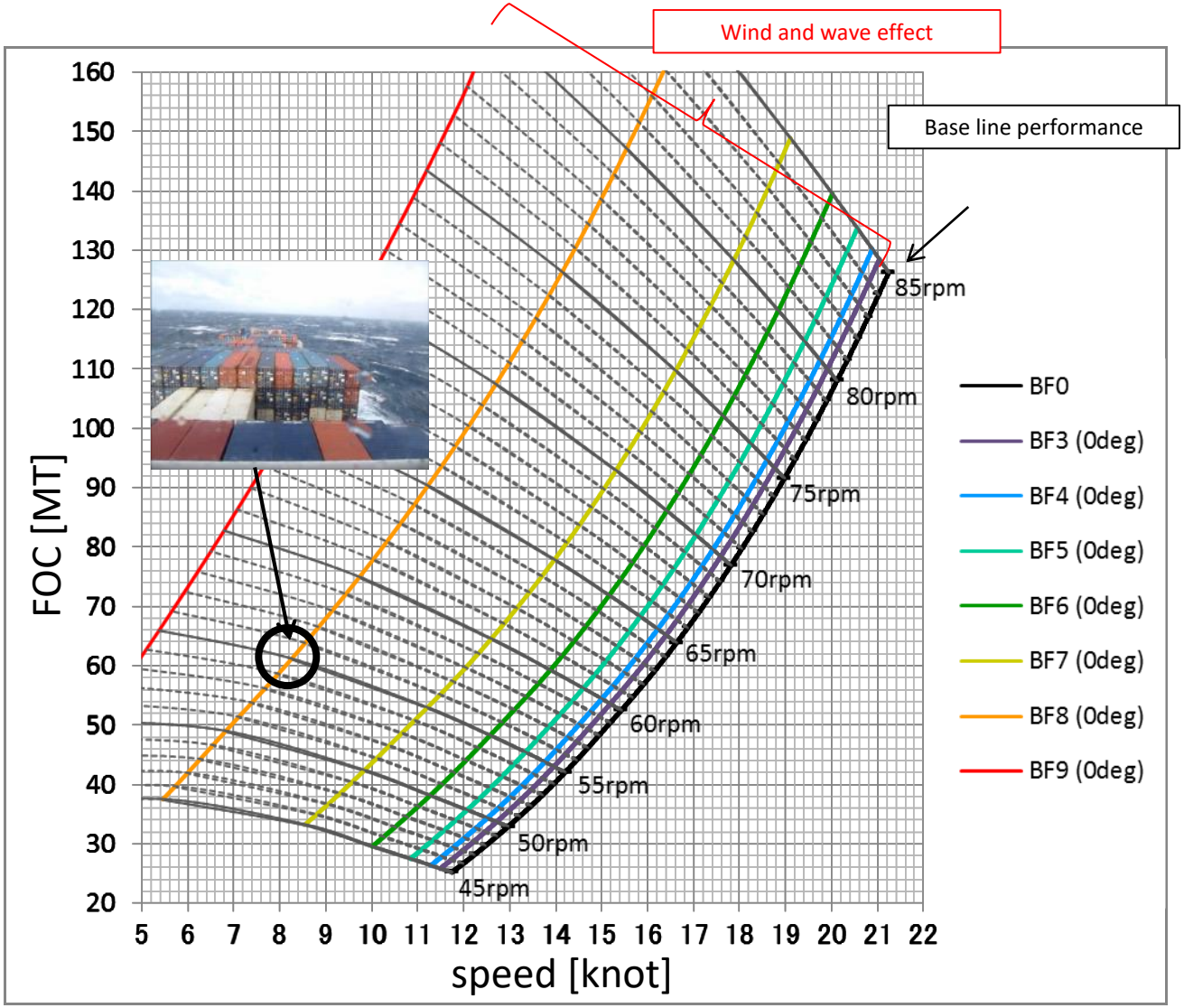
<Target vessel>
6000TEU Container
Draft 12m even

Sea condition

Beaufort scale

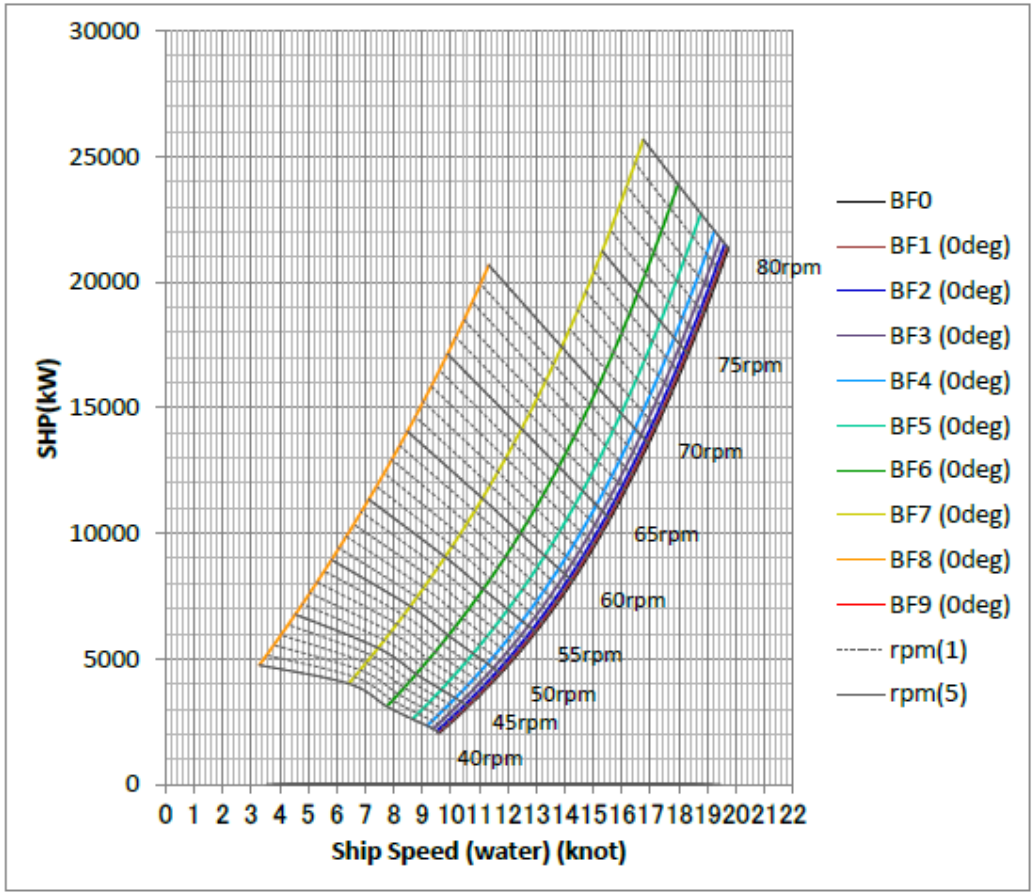
	wind speed (m/s)	wave height (m)	wave period (sec)
BF0	0.0	0.0	0.0
BF3	4.5	0.6	3.0
BF4	6.8	1.0	3.9
BF5	9.4	2.0	5.5
BF6	12.4	3.0	6.7
BF7	15.6	4.0	7.7
BF8	19.0	5.5	9.1
BF9	22.7	7.0	10.2

0deg (wind, wave) – head sea



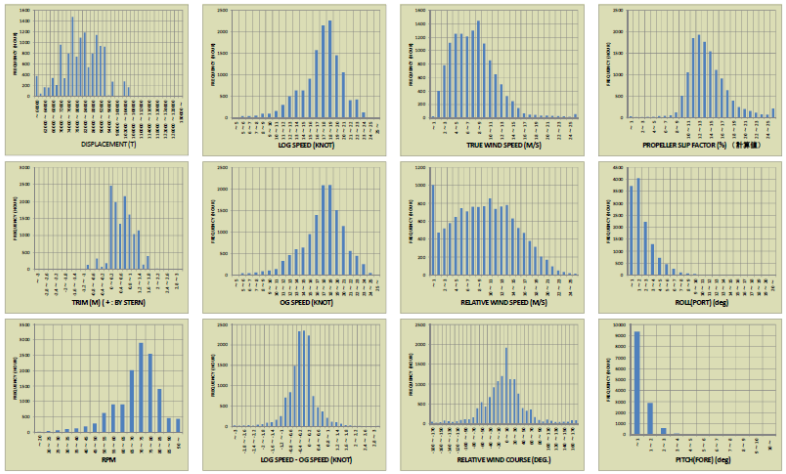
Estimation of seasonal sea margin

Ship performance model



Combine ship performance model with weather data to run simulations

Improve bad performance ship



23 % CO2 reduction was confirmed

Operational profile

- Speed, RPM, Power
- Draft, trim, displacement
- Weather
- Sea margin
- Etc.

Energy saving modification

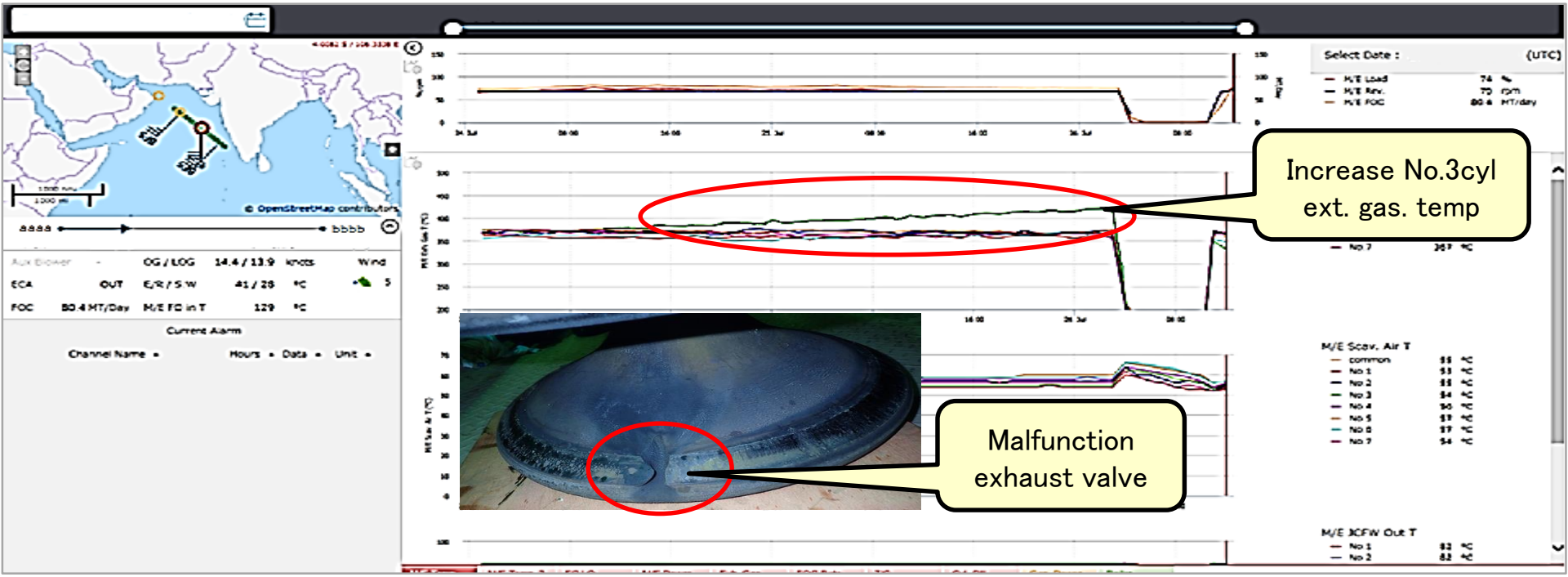
- Bulbous bow modification
- Install energy saving device (MT-FAST)
- Etc.

‘Digital Twin’ will be more used not only for energy efficiency but also for improving safety

Anomaly detection from IoT data

- Find trouble phenomenon in engine & power plants -

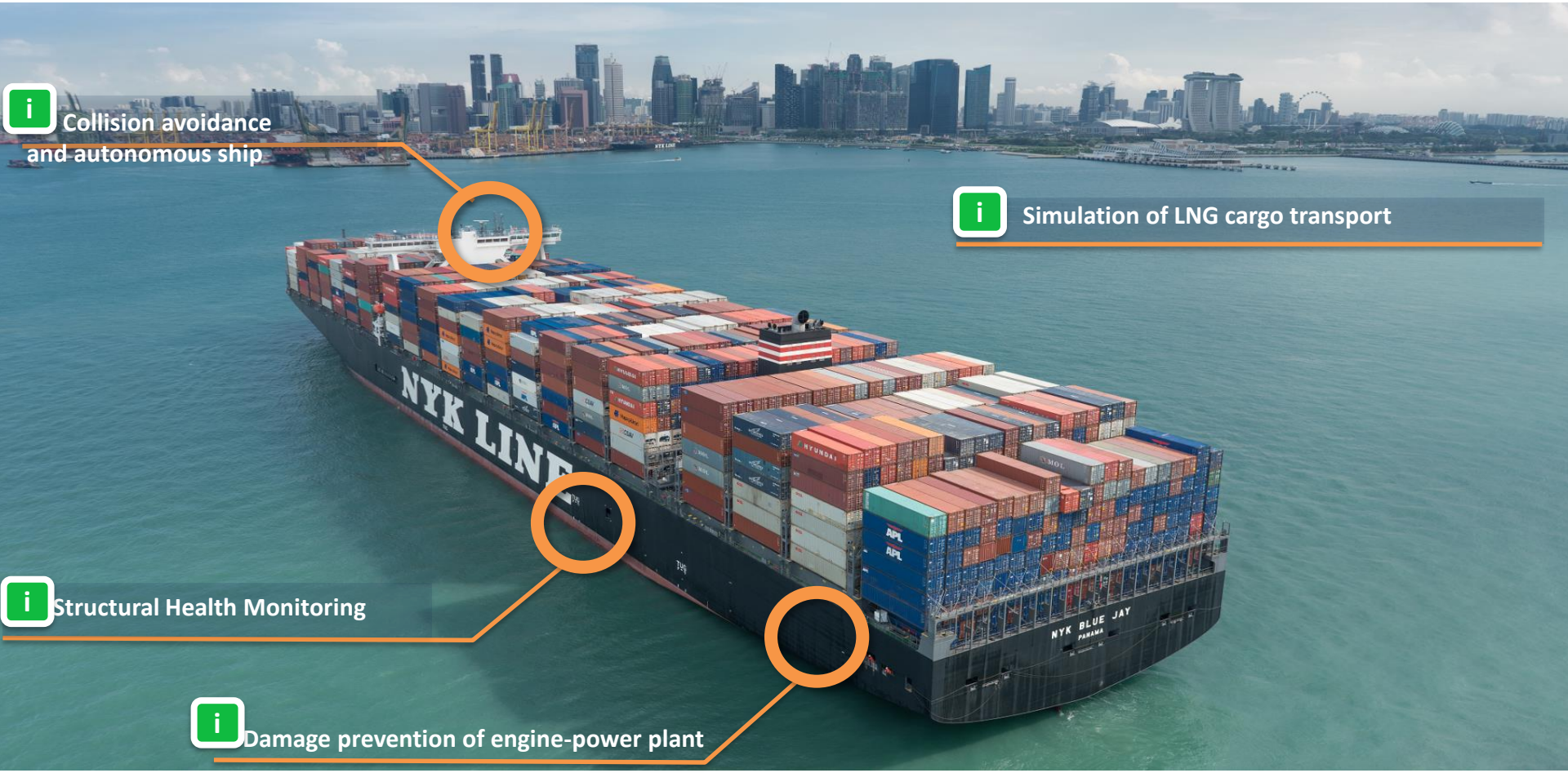
Case) M/E (Main Engine) No.3 cylinder abnormal exhaust gas temperature



1. Visualization of data
2. Analysis by domain experts (marine engineer) . Accumulate cases.
3. Implement automatic anomaly detection function by using the accumulated data.

Utilizing IoT data for safer operation

- Open collaboration with industry partners -



MLIT Ministry of Land, Infrastructure, Transport and Tourism

ClassNK

i-Shipping(Operation): Japanese government funding R&D projects – IoT for safety (2016-2020)
Joint research with ClassNK

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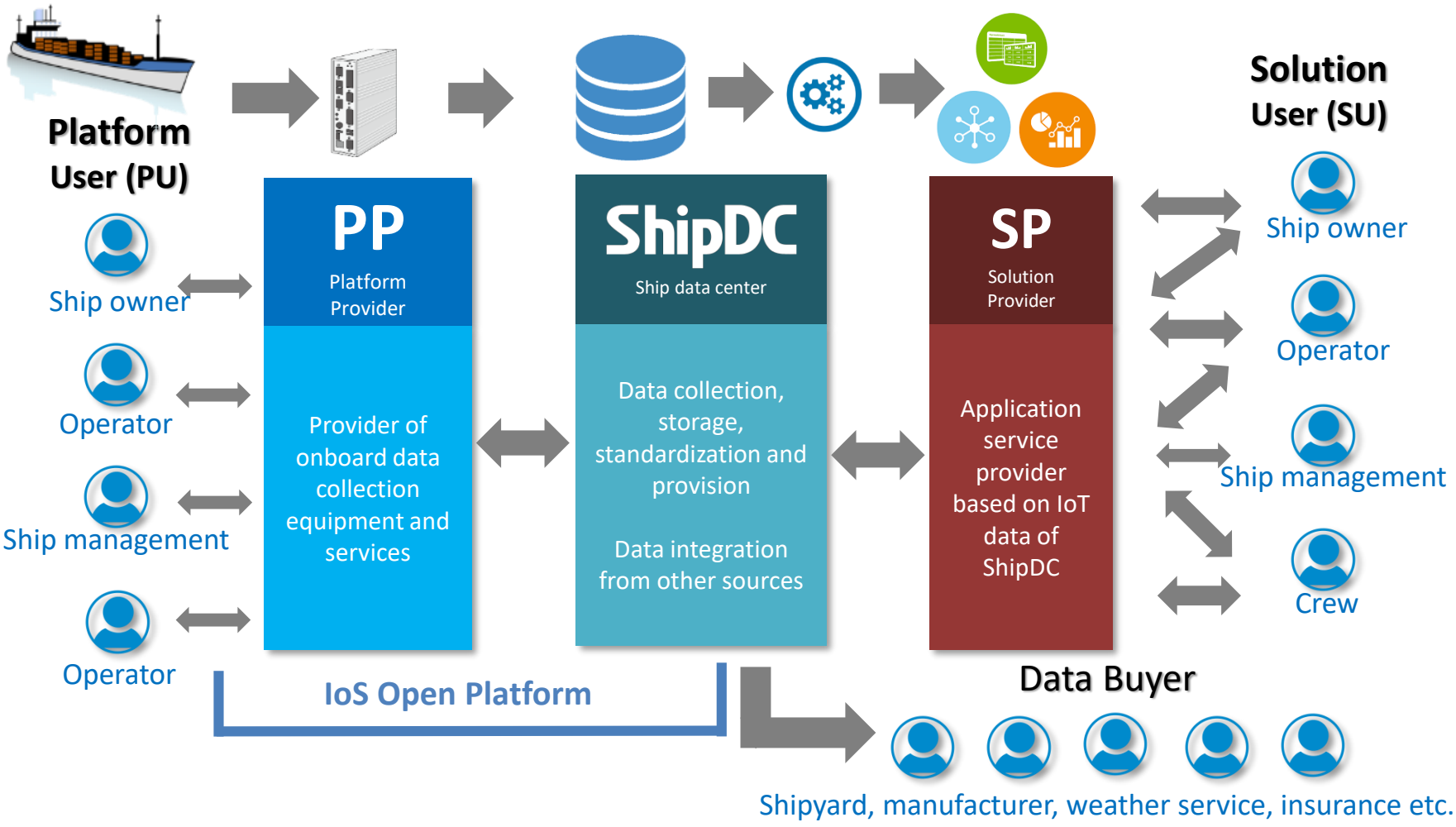
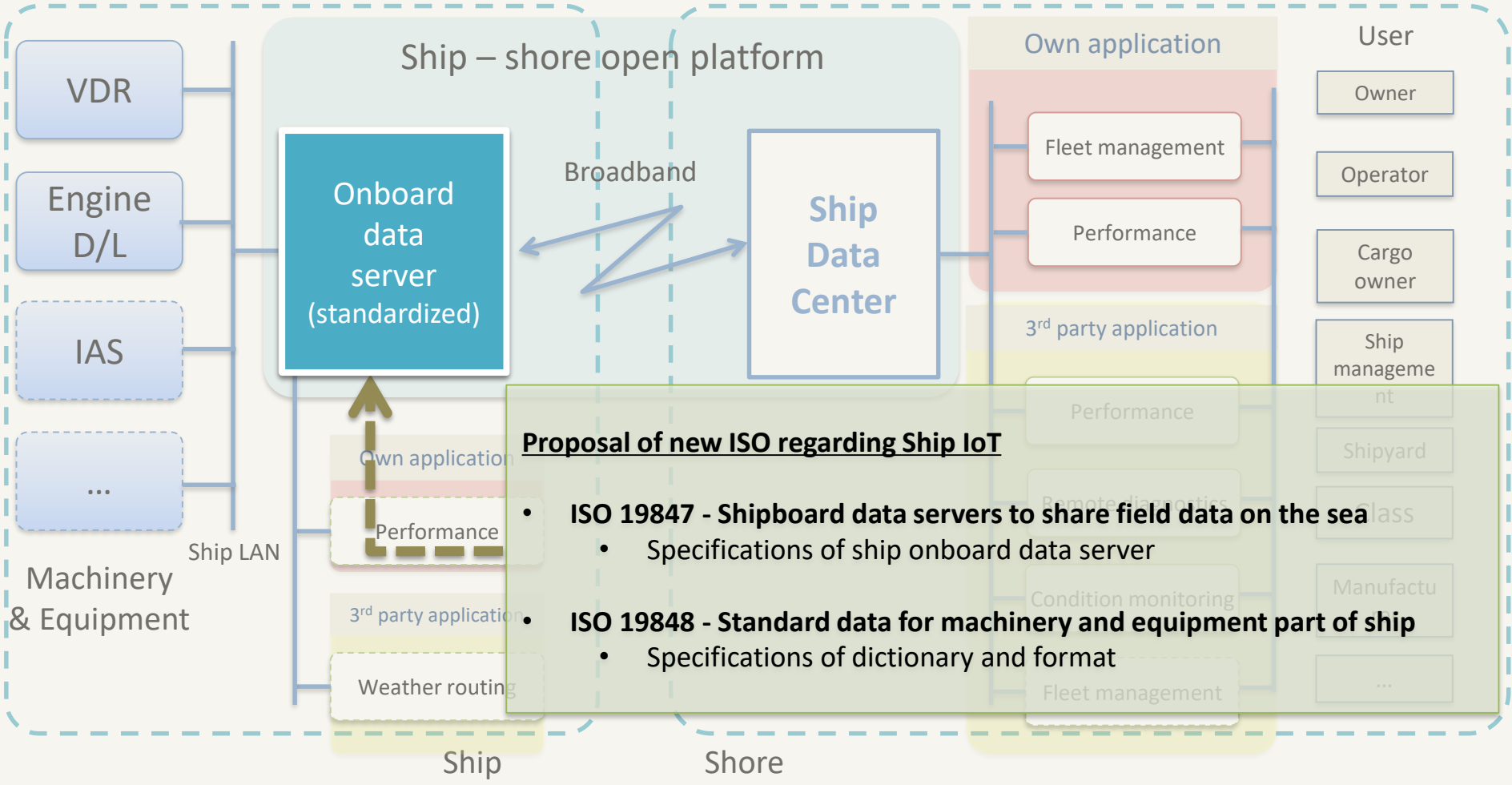
Internet of Ships (IoS) Open Platform

ShipDC

Roles are defined and each player provides their expertise on the Internet of Ship(IoS) platform. Data governance and business rules have been built by IoS OP Consortium under ShipDC.



Standardization activities of Ship IoT platform
(SSAP3: Smart Ship Application Platform 3 Project by JSMEA)



JSMEA: Japan Ship Machinery and Equipment Association

Cyber Security

Cyber risk management will need to be implemented. Protection of Industry Control System is crucial

The Guidelines on Cyber Security onboard Ships - Version 3, BIMCO – Nov 2018

Cyber security guidelines in shipping

- **IMO, MSC (98)** – Cyber risk management onboard ships should be included in SMS as of 1 Jan 2021 (Jun 2017)
- **BIMCO** – the guidelines on cyber security onboard ships – version 3 (Nov 2018)
- **ABS, DNV-GL, LR, BV etc.** – Guidelines and notations of cyber security onboard ships (2016)
- **IEC 61162-460** – Safety and security standards for navigation and radio communication equipment
- **IACS** Maritime Cyber System Recommendations (MCSR)

Cyber security guidelines

- **NIST Framework and 800-53** – computer security policies, procedures and guidelines
- **ISO 27001/2** – ISMS: Information Security Management System

Source) BIMCO
https://www.bimco.org/products/publications/free/cyber-security

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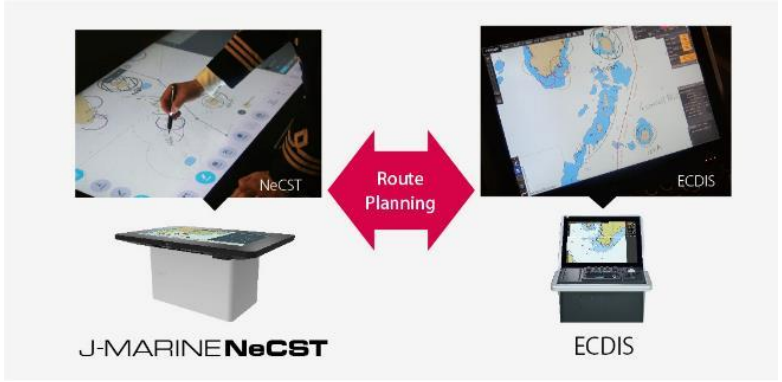
Integrated Navigation Support System J-Marine NeCST

NYK/MTI and Japan Radio Co. Ltd. jointly developed navigation support tool that enables officers to better manage and share navigational information
(Press Released at 17th May 2017)

- **Gathering all necessary information for navigation by using IoT**
- **Integrated navigation information management system**
- **Contribution to safe & efficient navigation**

<Features of J-Marine NeCST>

1. Handwritten inputs
2. Compatibility with ECDIS
3. Implementation of meteorological and hydrographical forecasts
4. Information sharing with other ships and land
5. Flexible customization



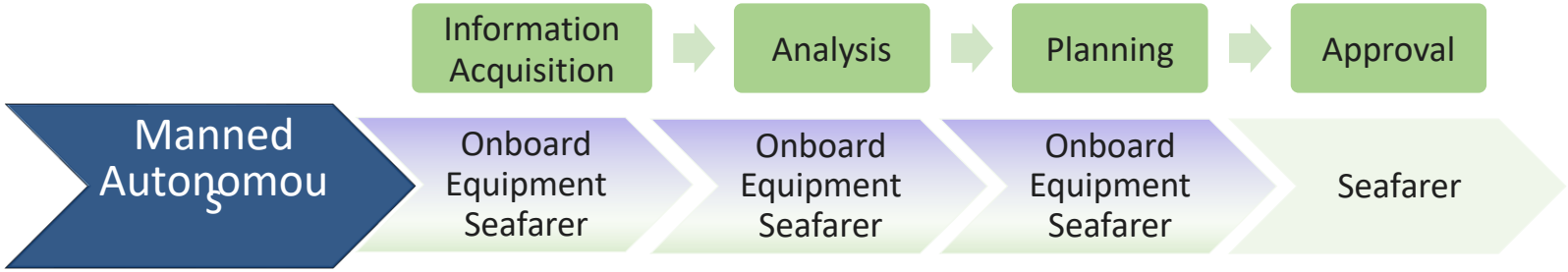
Manned-Autonomous Ship

Provided by Japan Radio Co. Ltd.

AL3

- Cyber access for autonomous/ remote monitoring and control
- onboard permission required
- onboard override possible

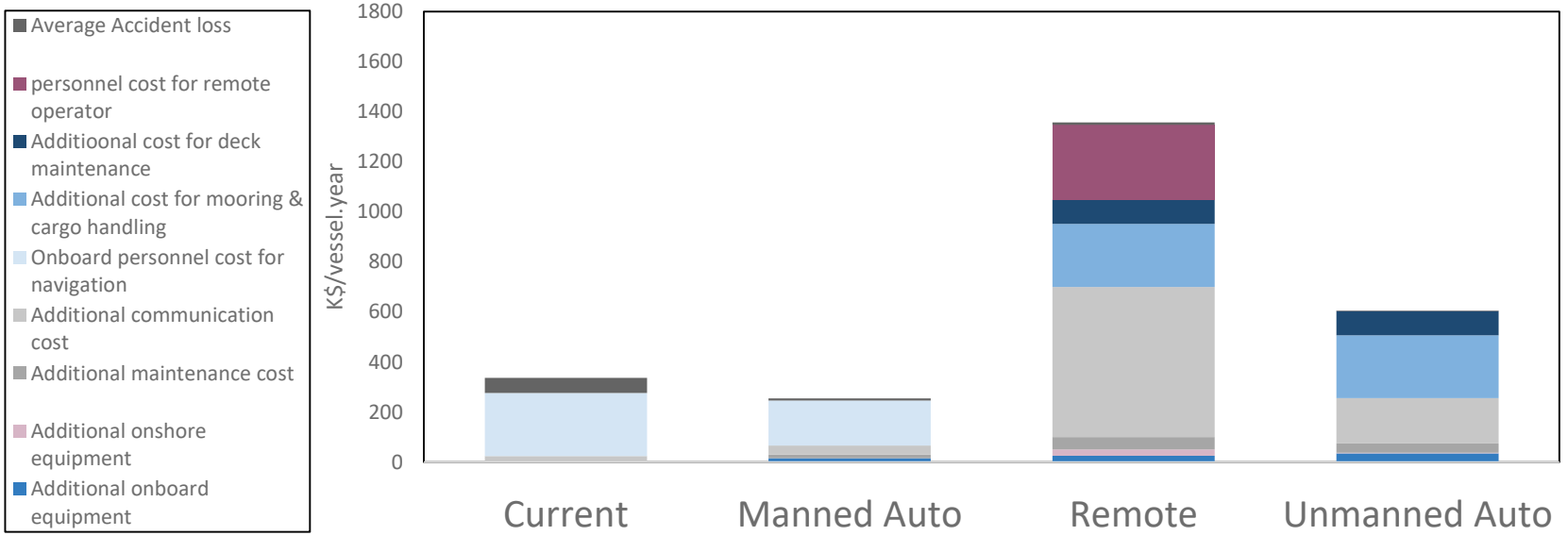
- Advanced support system … additional functions to assist cognitive process of human operator based on existing navigation system
- Autonomous operation under approval of human operator



Reference：1) Lloyds Register, “Current and Emerging Cyber Risks facing Maritime Industries”, European Maritime Cyber Risk Management Conference, London, June 2017

Economic evaluation (case: deep-sea going vessel)

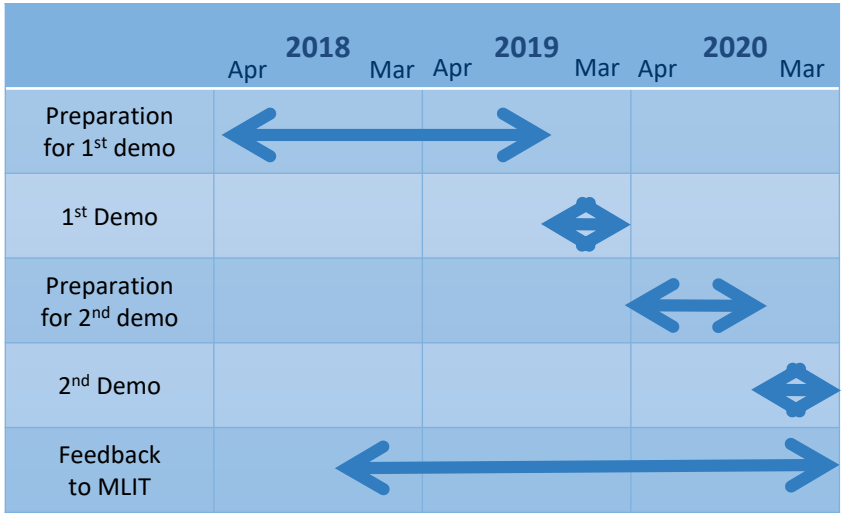
Based on our feasibility study, at the current stage, manned-autonomous navigation has the highest economic performance with practicability.



Cost efficiency	Base	+	−−	−
Incident risk	Base	+	+	++
Workload	Base	+	++	++
Cyber risk	Base	Base	−−	−
Total reliability	Base	+	−	−

Demonstration Project in Japan t/w MLIT

- Objective: Demonstrate APS concept
- Target ship: Tug boat (Wing Maritime Service Corp.)
- Period: 2018 – 2020
- Project members: company name (role)
  1. MTI (project coordinator/concept design)
  2. JMS (project coordinator/simulator)
  3. NYK (project coordinator/ship owner)
  4. IKOUS (ship owner)
  5. Furuno Electric (navigation equipment)
  6. Japan Radio (navigation equipment)
  7. Tokyo Keiki (navigation equipment)
  8. BEMAC (DPS)
  9. Keihin Dock (shipyard)
  10. Mitsubishi Shipbuilding (engineering)
  11. Sky Perfect JSAT (satellite communication)
  12. NTT DoCoMo (4G/5G network)
  13. NTT (system provider)
  14. Niigata Power Systems(propulsion)
  15. ClassNK (verifier)
  16. NMRI (risk assessment)



Demonstrations in 2019 Winter (the 1st demo) and 2020 Winter (the 2nd demo) are the targets.

Thank you very much for your attention