Monohakobi Technology Institute

NYK GROUP

Digitalization as an enabler for safer and greener shipping

27th May 2021

Hideyuki Ando
MTI (NYK Group)

Outline

1. **Introduction of NYK and MTI**
2. Digitalization activities
3. Ship as system and system integration
4. Autonomous ship as a complex system
5. Conclusions

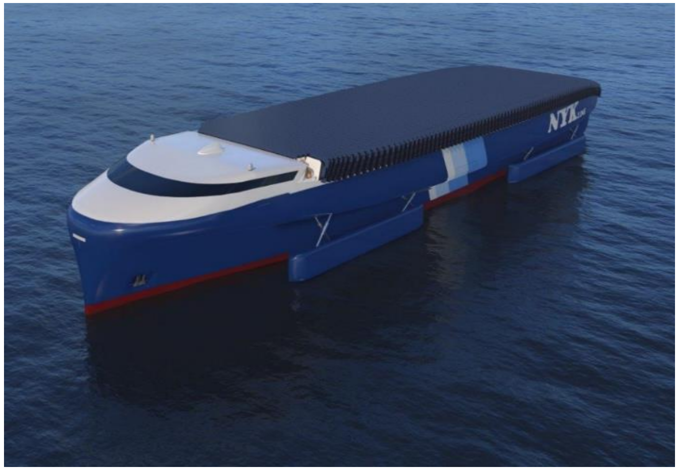
NYK LINE

- 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: 34,857 (as of the end of March 2020)
- Revenues: $ 15.8 billion (Fiscal 2019)

MTI (R&D arm of NYK LINE)

- Established : April 1, 2004
- Stockholder : NYK LINE (100%)
- Number of employees : 71 (as of 1st April 2021)



NYK Fleet

Container ships
58 vessels

Bulk Carriers (Capesize)
114 vessels

Bulk Carriers (Panamax & Handysize)
247 vessels

Wood-chip Carriers
43 vessels

Cruise Ship
1 vessel

Car Carriers
111 vessels

Tankers
56 vessels

LNG Carriers
78 vessels

Project ships & others
42 vessels

Shuttle Tankers
28 vessels

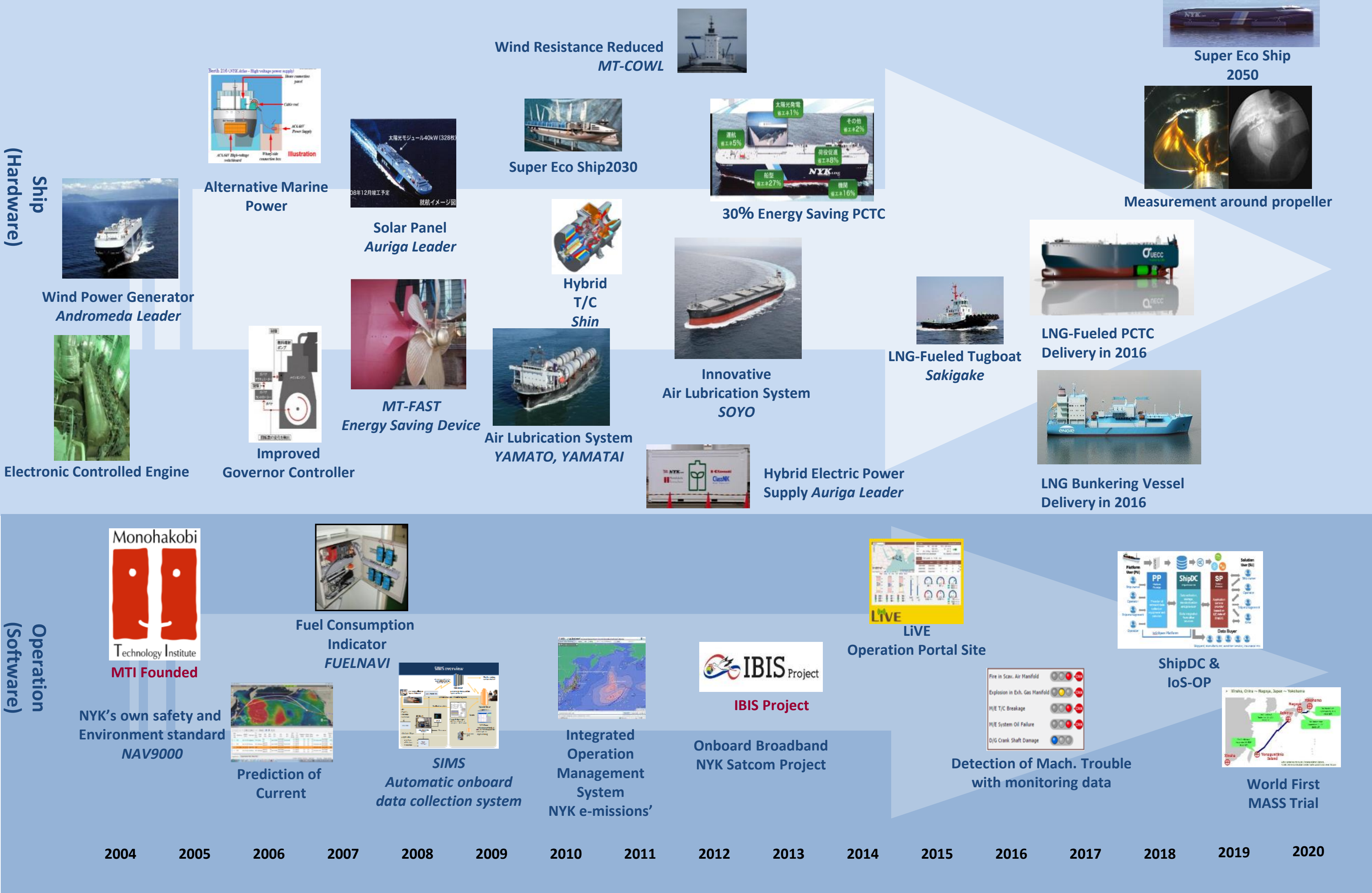
FPSO & FSO
5 vessels

Drill Ship
1 vessel

784 vessels
67,468 K DWT

(as of the end of March 2020)

R&D trajectory in NYK/MTI toward safer and greener shipping



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Value creating digitalization in shipping

1. Deep understanding of operating fleet and market
2. Optimized logistics and operations
3. Anticipation of failures

Better decisions

Continuous learning ↑

↓ Continuous Improvement

Pursuing total optimization of operation and ship

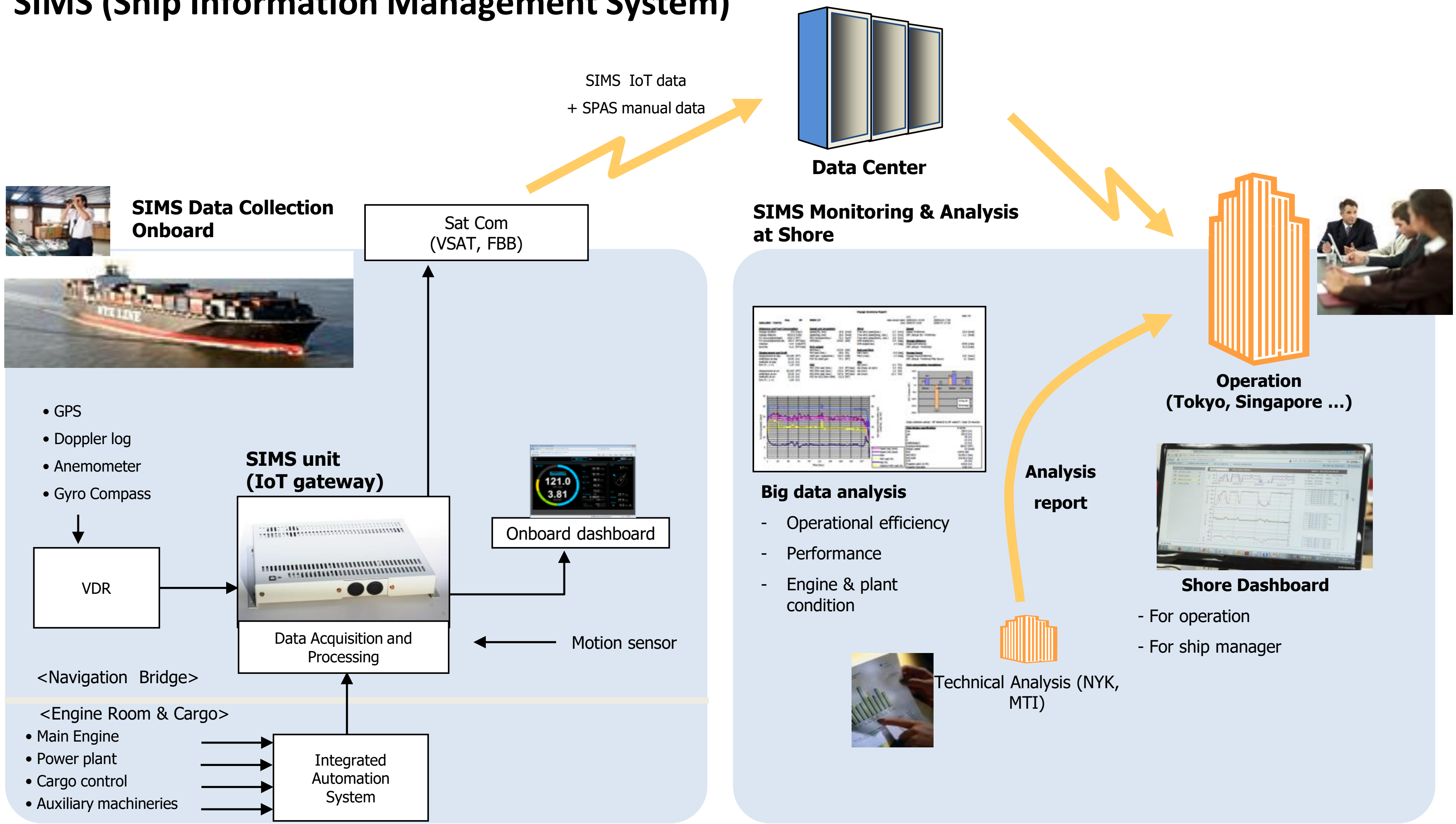
4. Incremental automation of ship functions
5. Monitoring fleet performance and improvement

Safer, more consistent operations

Reference) McKinsey Company, How digital innovation can improve mining productivity, 2015
https://www.mckinsey.com/industries/metals-and-mining/our-insights/how-digital-innovation-can-%20improve-mining-productivity

IoT platform of NYK

SIMS (Ship Information Management System)



How shipping can utilize Big data and IoT
- Identify right issues to solve -

Identified issues

Optimum operation
- Fuel saving
- Reasonably minimized margin

Support business decision
- Tactical ship/fleet allocation

Safe operation

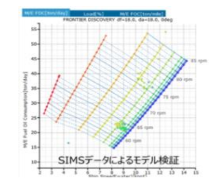
Big data

- IoT Data
- Report data
- AIS data
- Weather data

×

Analysis

Engineering knowledge
e.g. vessel performance



Data analytics & IT

Any useful data

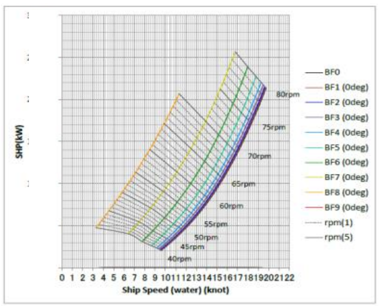
Operation data
- Schedule
- Route
- CB/HB
- AIS

Technical data
- Performance
- Sea trial
- Particular
- Paint

Market data
- Bunker cost
- Hiring cost
- Market

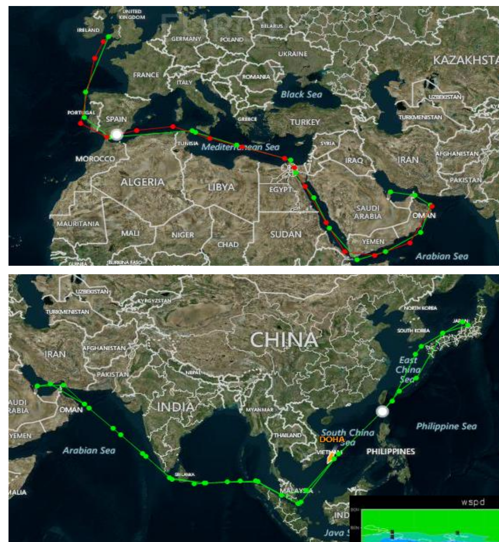
Commercial data
- Contract
- Fleet plan
- Owner info.

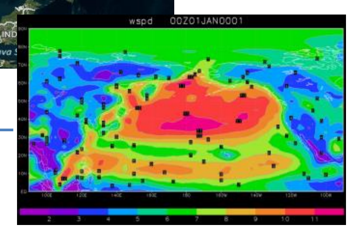
Understand seasonal impacts on ship operation



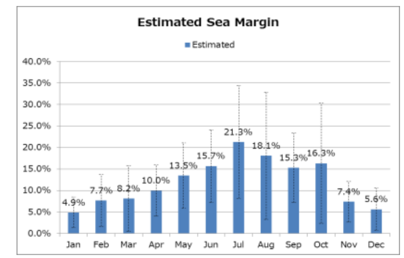
Ship performance model

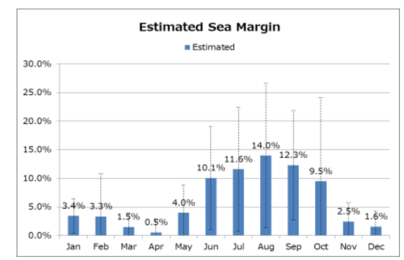
Service route





Voyage simulation with past weather data

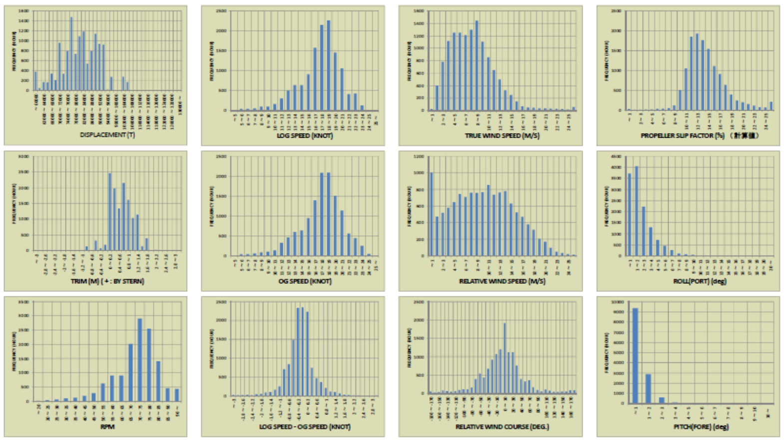




Estimation of
- Sea margin
- FOC and etc.

Combine ship performance model with weather data to optimize ship services

Improve bad performance ship



Operational profile

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

23 % CO_2 reduction was confirmed

Energy saving modification

- Bulbous bow modification
- Install energy saving device (MT-FAST)
- Replace propeller
- Engine de-rating

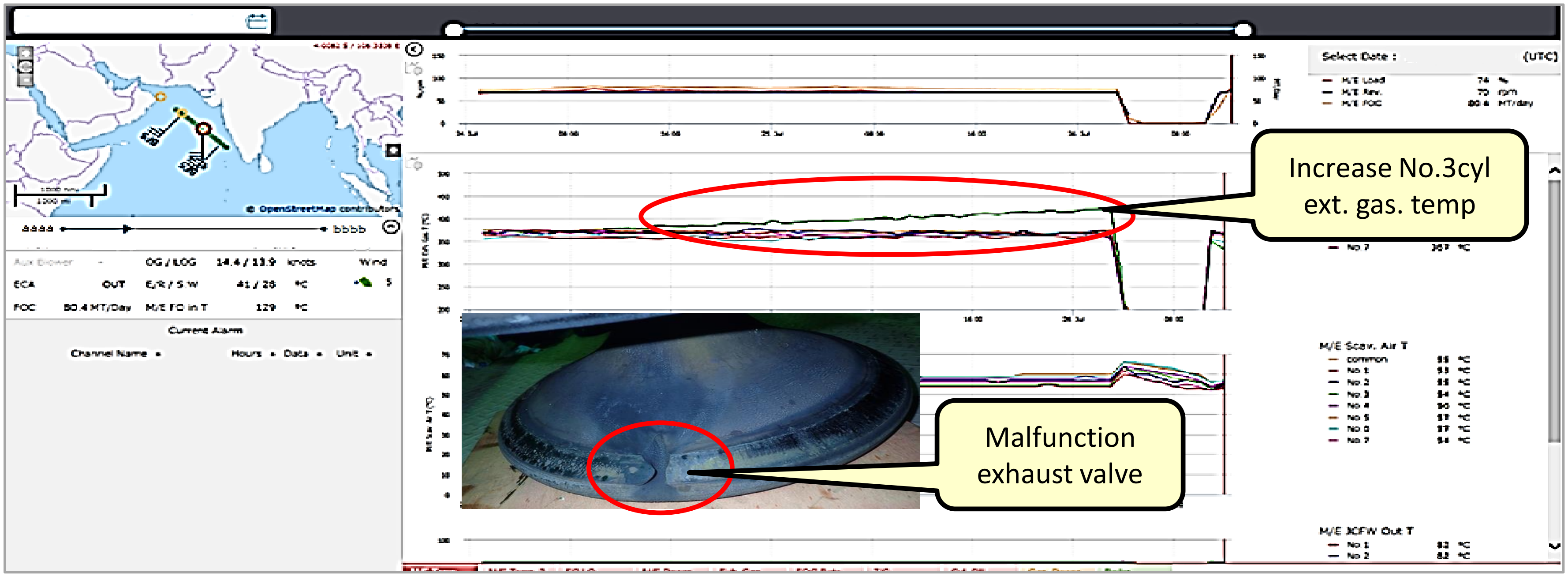
Modifications were conducted on 40 ships

Data and simulations played important roles to optimize ship design

Anomaly detection from the collected data

- Find trouble phenomenon from the IoT data -

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



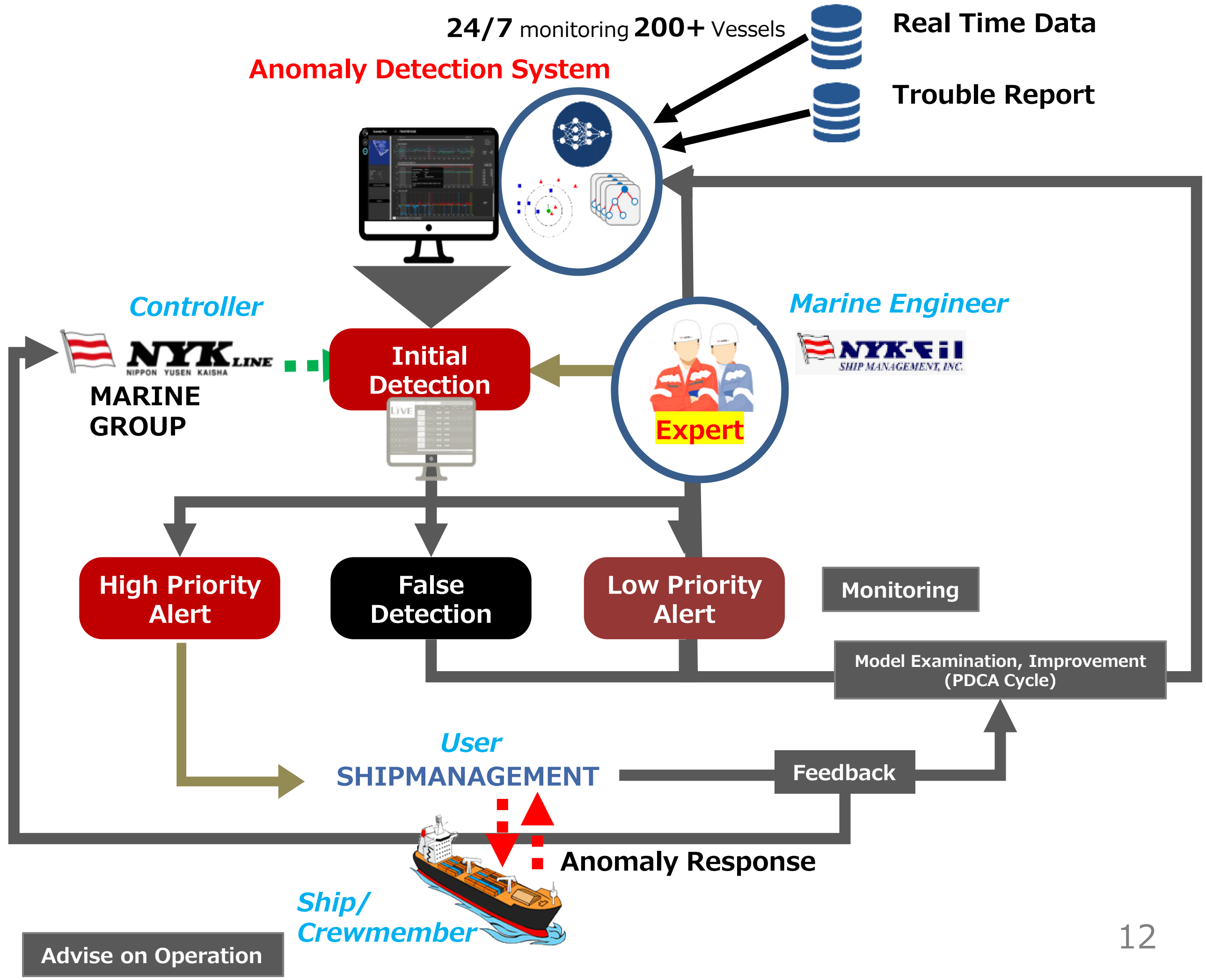
1. Visualization of data
2. Analysis by domain experts (marine engineer) . Accumulate cases.
3. Implement automatic anomaly detection functions by using accumulated cases.

Remote Diagnostic Center

The benefit of Expert-in-the-Loop are

- **Less detection misses**
- **Less false positive result**
- **Stricter threshold**
- **More learning data**
- **More explainable result**

Remote Diagnostic Center (Manilla)



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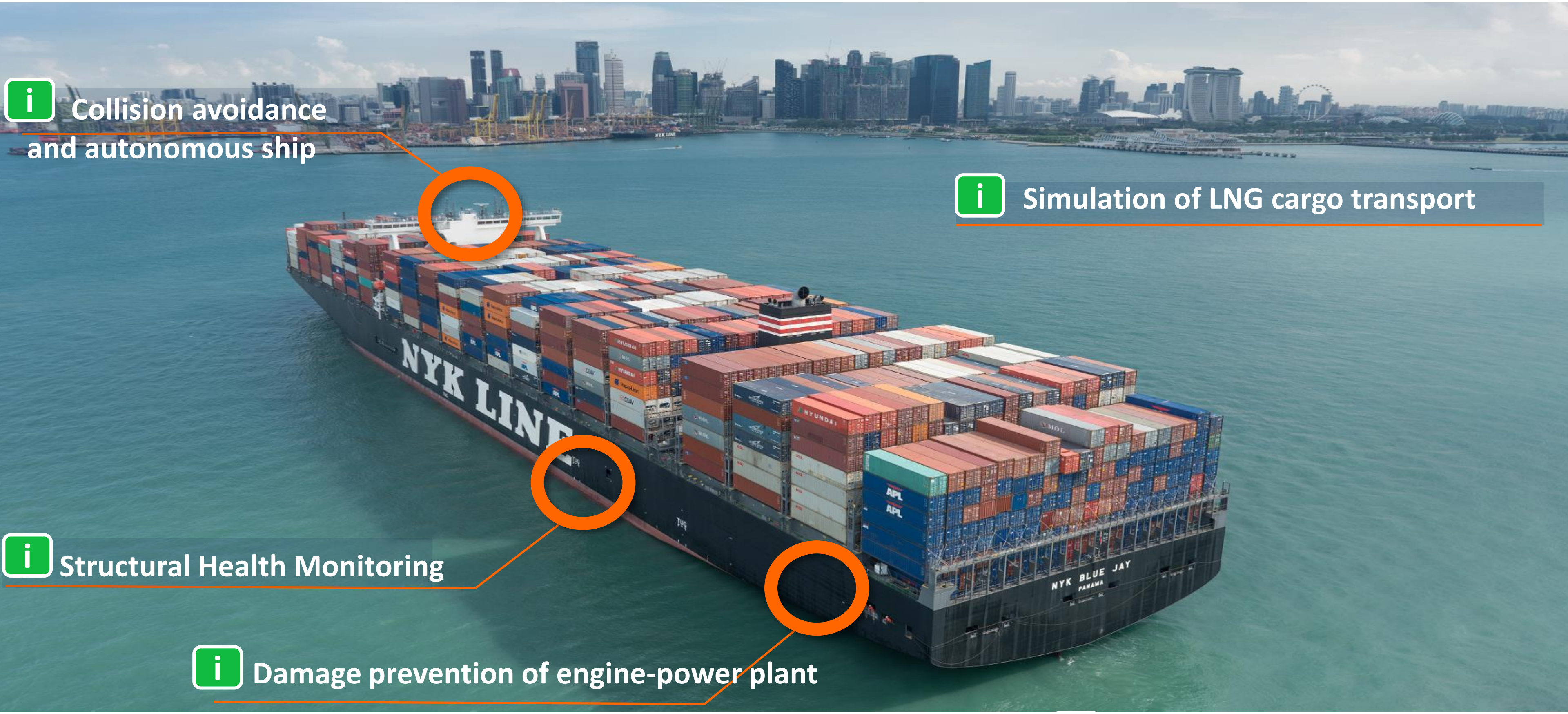
NYK/MTI R&D projects for safer operation

Open collaboration with industry partners



MLIT Ministry of Land, Infrastructure, Transport and Tourism

ClassNK

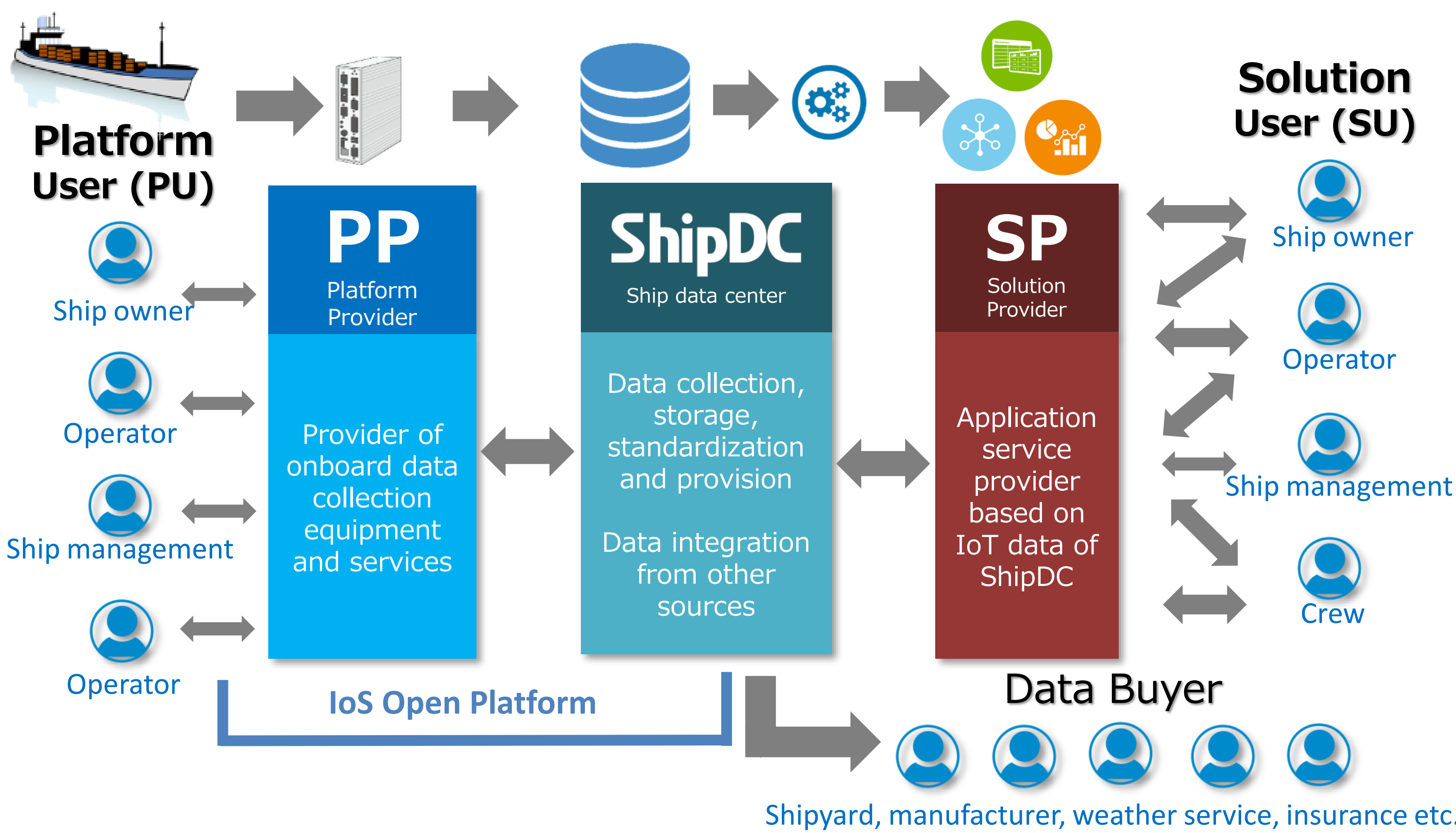
i-Shipping(Operation):
Japanese government funding R&D projects – IoT for safety (2016-2020)
Joint research with ClassNK

Internet of Ships Open Platform (IoS-OP)

56 members

- ✓ Stakeholder's role
- ✓ Data ownership rule
- ✓ Transparent and fair data sharing rule

→ Accelerate data driven innovation

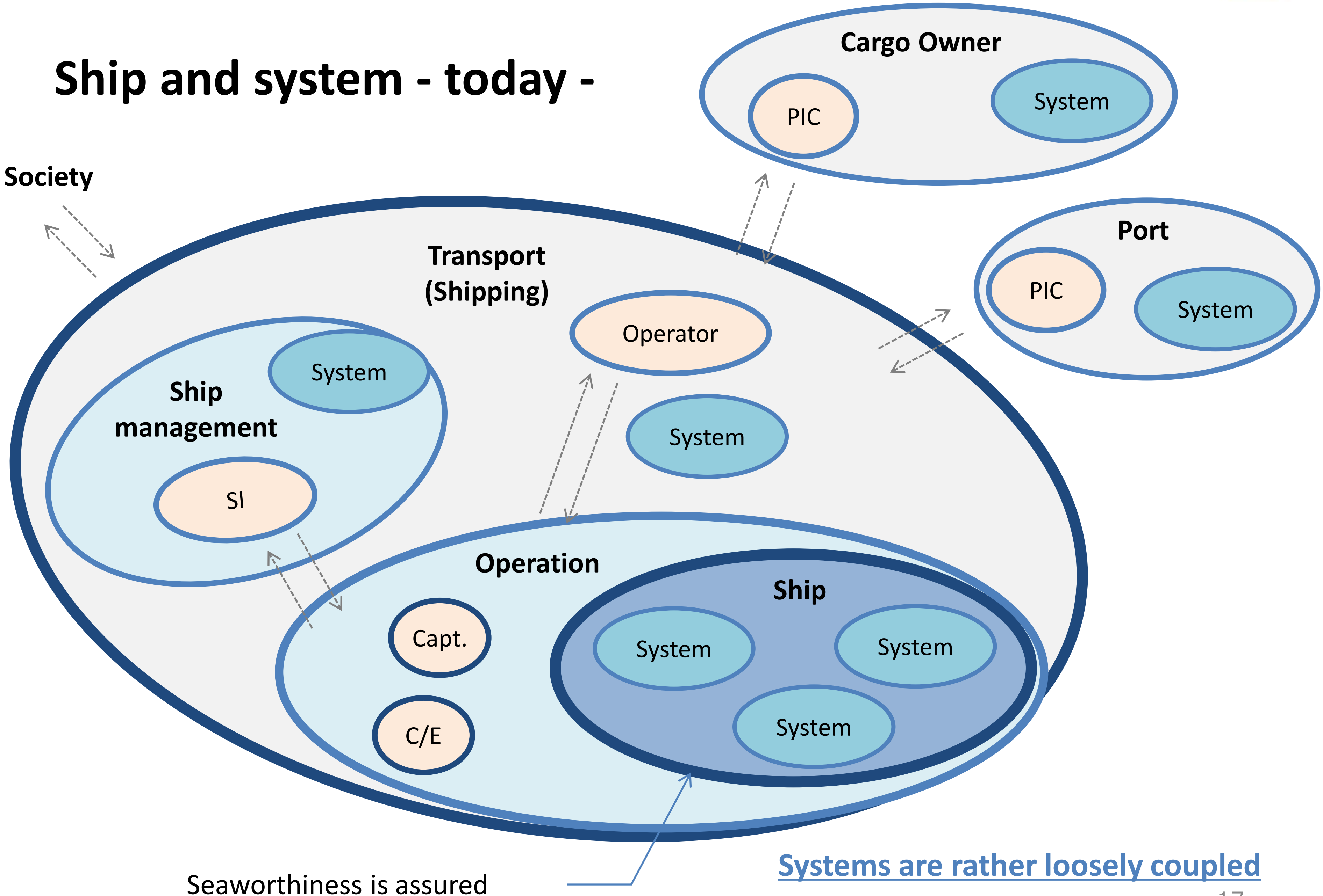


Outline

Ship as system

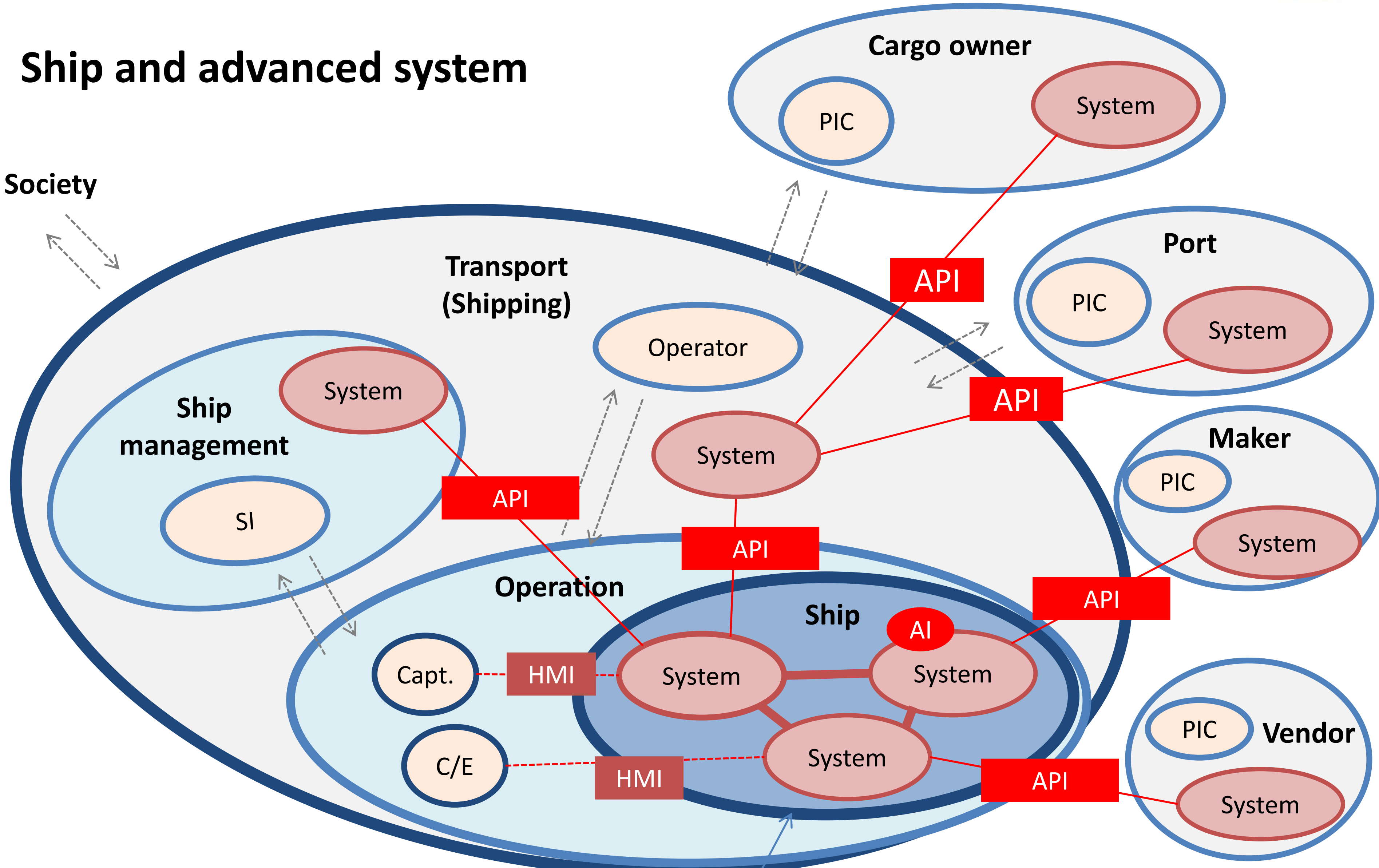
- For safer and greener shipping, complex system will be used onboard and ashore.
- Integrity of complex system will become critical. System conformity and reliability test will play important roles in system integration.
- System failures may happen and need to be properly considered and managed both in design and operation.
- Systems may apply AI, which will require frequent update of software programs or models.
- Cyber security (security by design and security management) is one of the pillars to achieve system reliability.

Ship and system - today -



Systems are rather loosely coupled

Ship and advanced system



Some elements of seaworthiness rely on external maker or vendor

Systems are more tightly coupled

System integration for computer-based systems

- Ship is considered as a group of functions
- Integrity of each function become more important, especially for critical functions
- Roles and responsibilities of owner/operator, system integrator and supplier at each product life cycle phase are defined in rule and guidelines

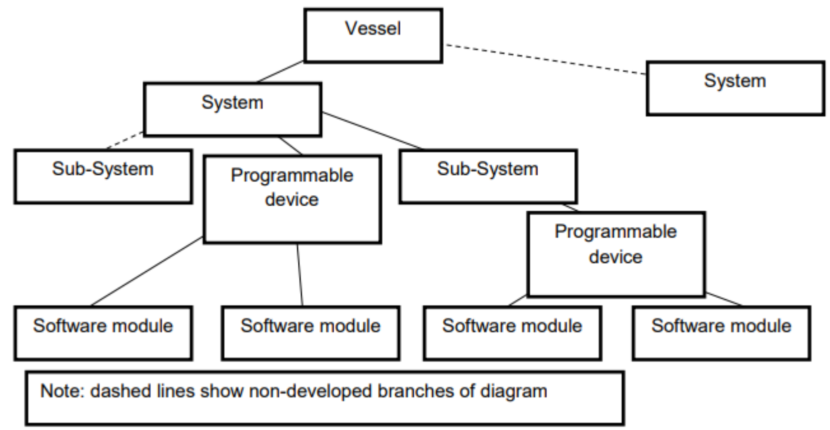
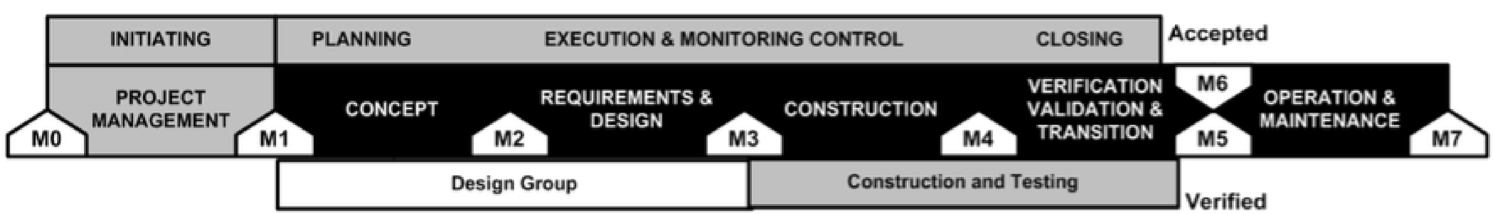


Figure 1 - Illustrative System Hierarchy

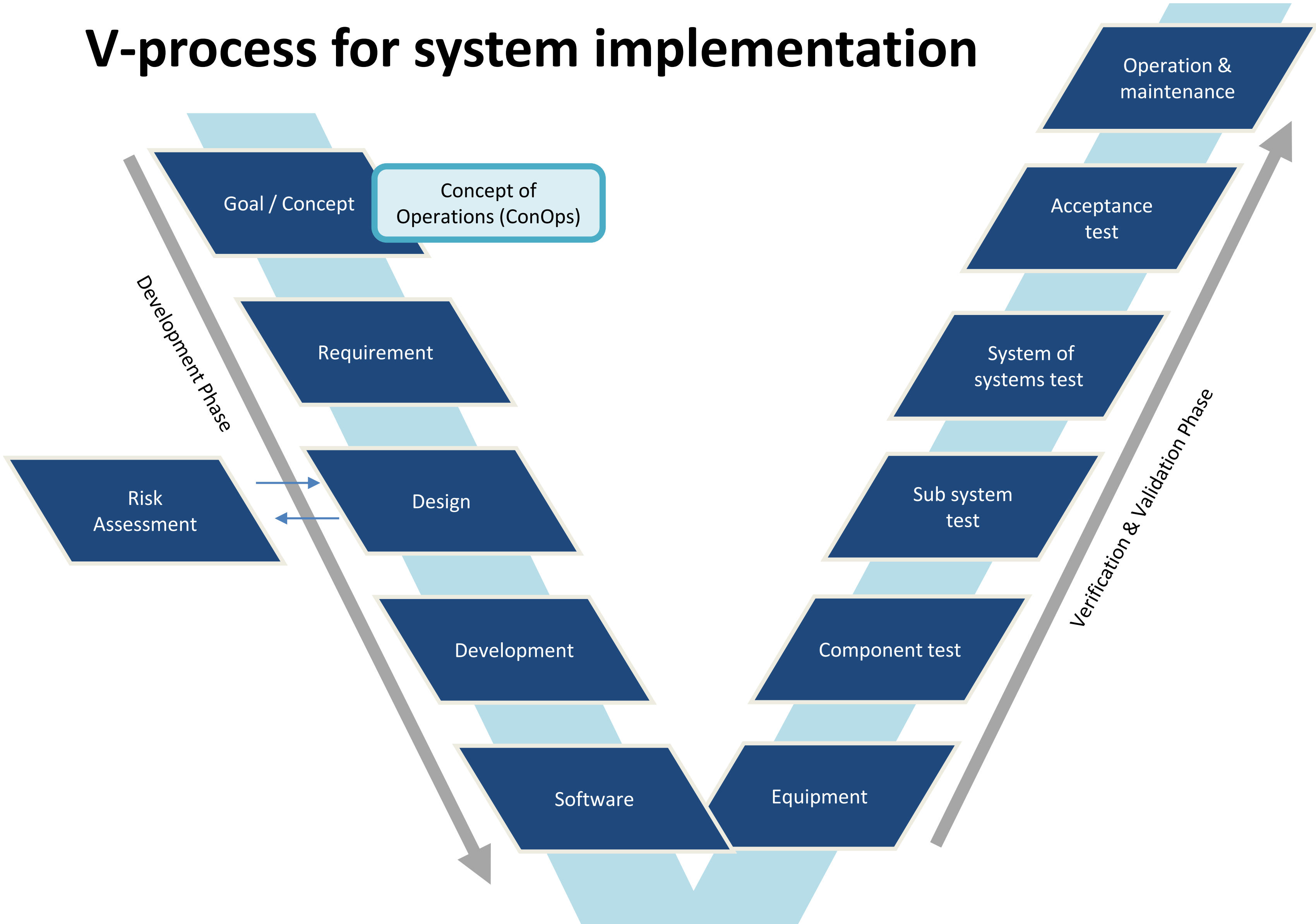
(Ref. IACS UR E22 Rev.2 CR)



(Ref. ABS ISQM)

Reference)
1) IACS UR E22 Rev.2 CR, On Board Use and Application of Computer based systems
2) DNV-GL / Integrated software dependent systems (ISDS), DNVGL-RP-D201 (Edition July 2017)
3) ABS, Guide for Integrated Software Quality Management (ISQM)

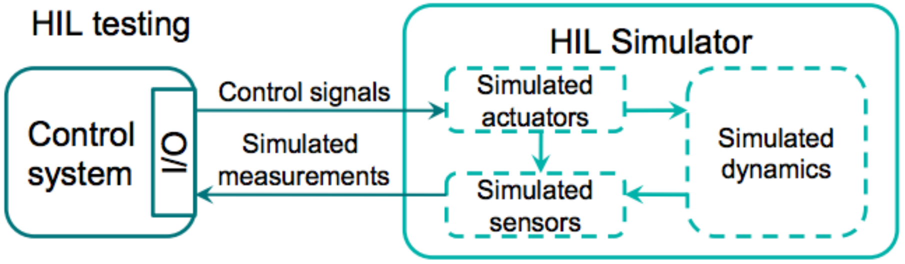
V-process for system implementation



- To develop shared process, methodology, tools and standards will be the key.

Simulation-based test

- Simulation-based test is indispensable for evaluating complex systems
  - MIL(Model-In-the-loop)
  - SIL(Software-In-the-loop)
  - HIL(Hardware-In-the-loop)



- Utilization of simulation-based test is the key for productivity of system development, verification & validation in V-process.

Ref) DNV Marine Cybernetics Advisory
https://www.dnvgl.com/services/hil-testing-concept-explanation--83385

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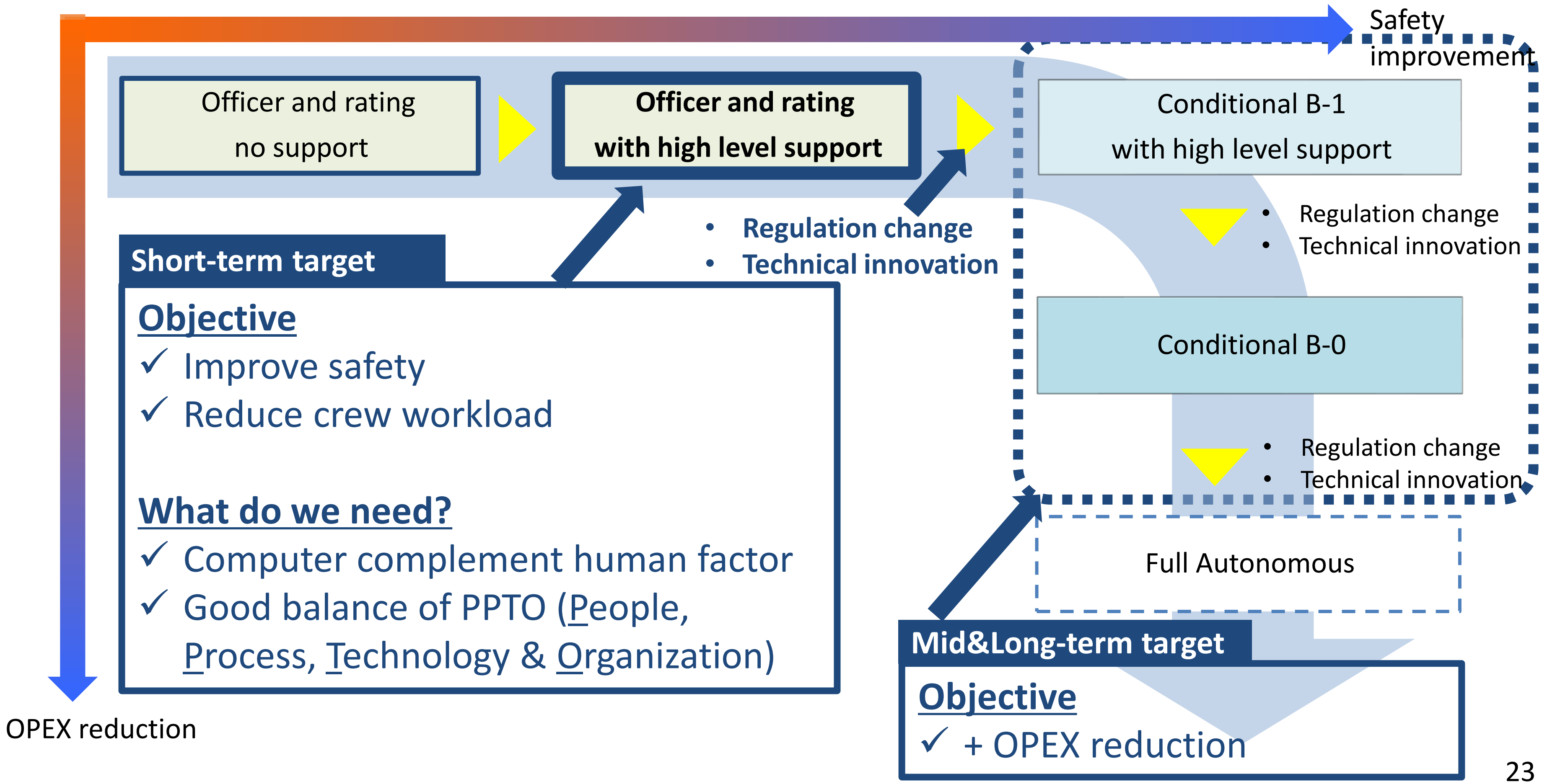
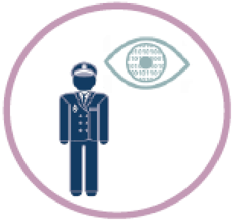
Contribution of Autonomous Navigation for Deep Sea Going Vessels



Manned-Autonomous Ship

Provided by Japan Radio Co. Ltd.



AL3

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

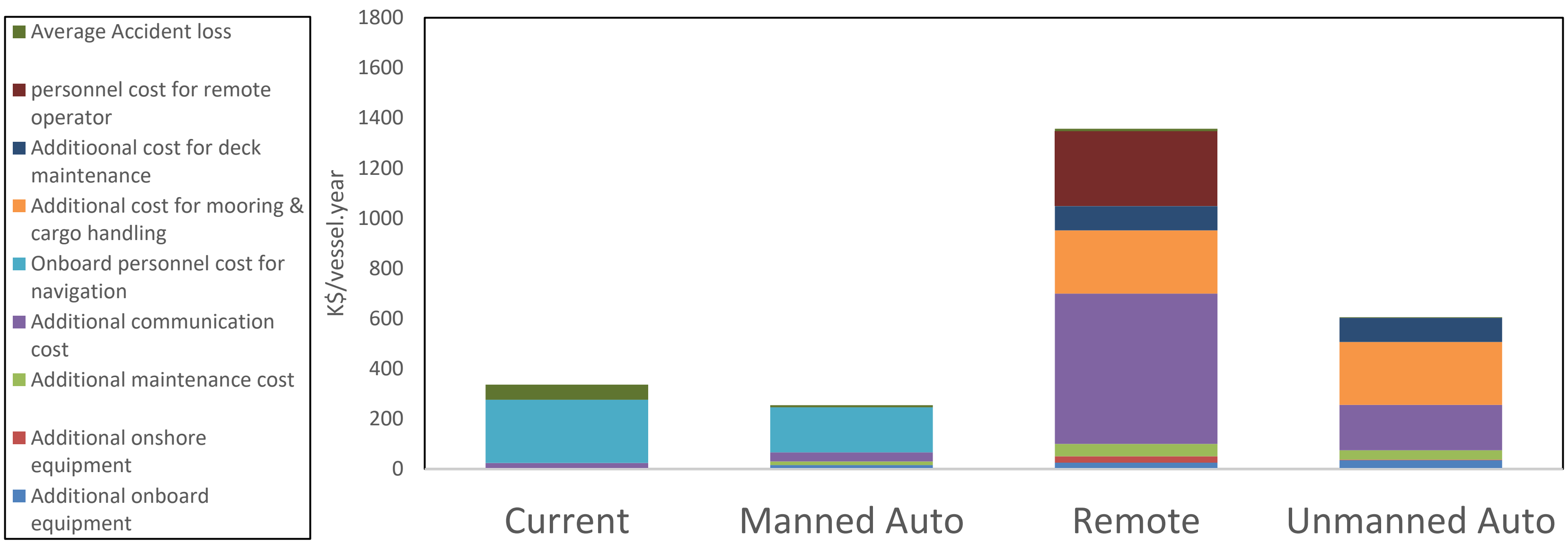
- Advanced support system … additional functions to assist cognitive process of human operator

	Information Acquisition	Analysis	Planning	Approval
Manned Autonomous	Onboard Equipment Crew	Onboard Equipment Crew	Onboard Equipment Crew	Crew

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 internal feasibility study, at 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	+	−	−

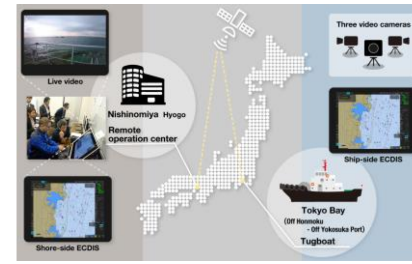
Tug Remote Operation Demonstration in Japan

- Objective: Demonstrate Remote Operation Concept
- Target ship: Tug boat “Yoshino Maru” (Shin-Nippon Kaiyosha)
- Project period: 2018.4 – 2021.3
- 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)

Open Innovation by
Diverse Expertise + Shared Concept + Project Management

Objective: Demonstration of the developed technology in i-Shipping (operation) project (2016-2020) and feedback to MLIT for their guideline & rule making

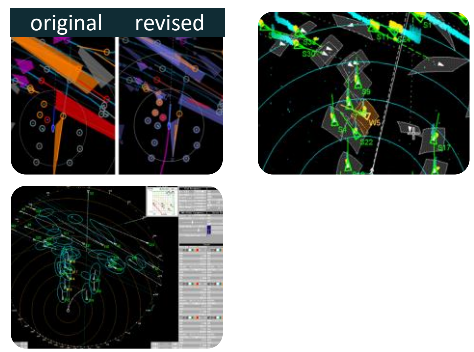
1st demonstration was conducted on 22nd January 2020.
2nd demonstration was conducted on 3rd December 2020.



Remotely operate tug-boat in Tokyo bay from ROC in Nishinomiya (500km away)

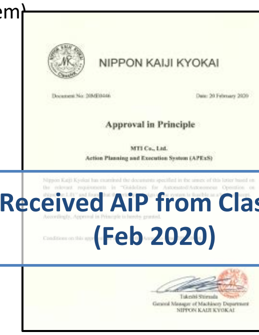
Enhanced situation awareness

- Visualize collision risk



Autonomous Ship Framework

- APExS (Action Planning and Execution System)



Received AiP from ClassNK (Feb 2020)

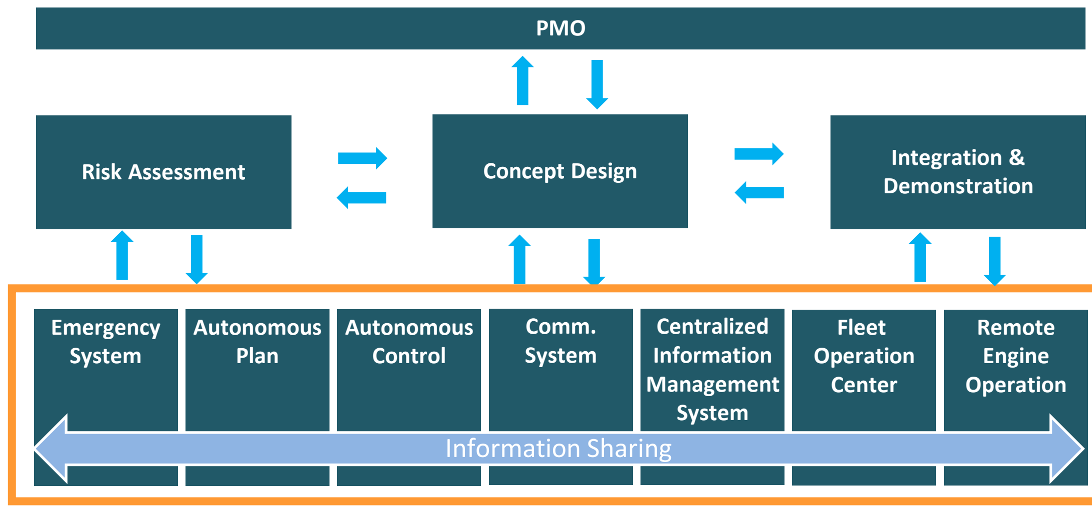
DFFAS (Designing the Future of Full Autonomous Ship) Project

- Objective
  - Demonstrate functions for full autonomous ship
- Project consortium & partners
  - Consortium: 27 organizations (domestic)
  - Partners: 20 organizations (global)
- Target schedule
  - **Demonstration in Feb 2022 (plan)**

無人運航船プロジェクト MEGURI 2040 | THE NIPPON FOUNDATION

Target ship and route	Container ship "Suzaku"

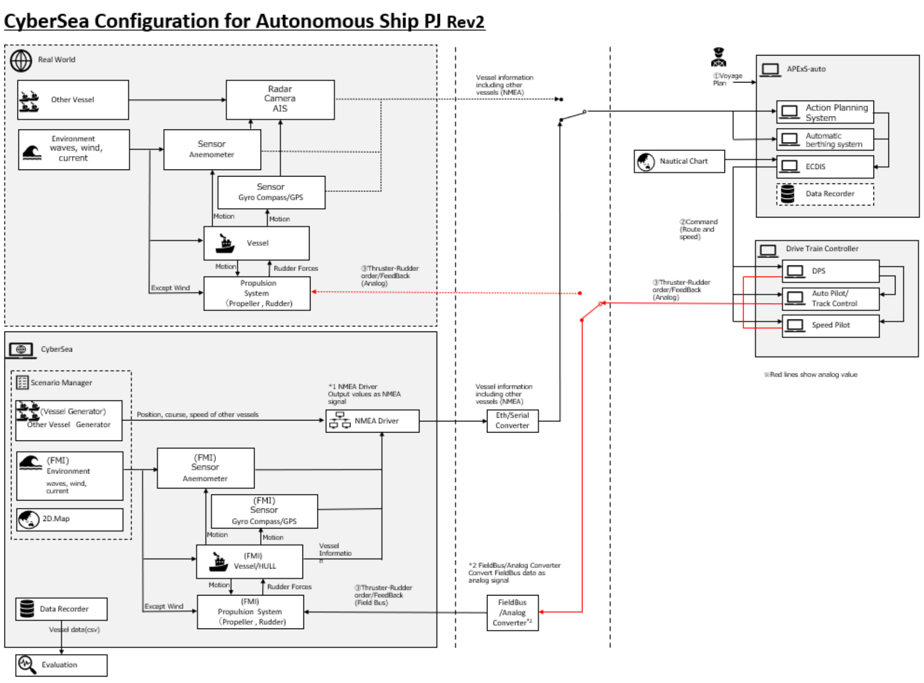
Organization chart of DFFAS PJ



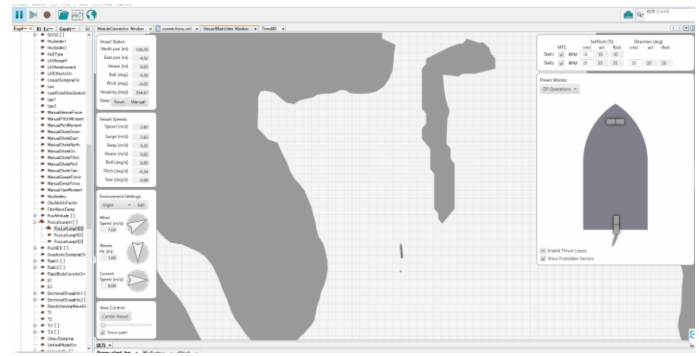
Operation Concept (ConOps), Risk Assessment, Model-based Systems Engineering (MBSE), System Reliability Test by using Simulation and Project Management → Development of Open Architecture & Open Process for Open Innovation for future complex system development & operation

Simulation-based test in DFFAS PJ

- Autonomous navigation system, a system of systems, is tested by using simulation platform
- Reliability of simulation itself is also very important



System configuration for simulation-based test



Simulation Platform, CyberSea, DNV

Ship scale-model in model basin

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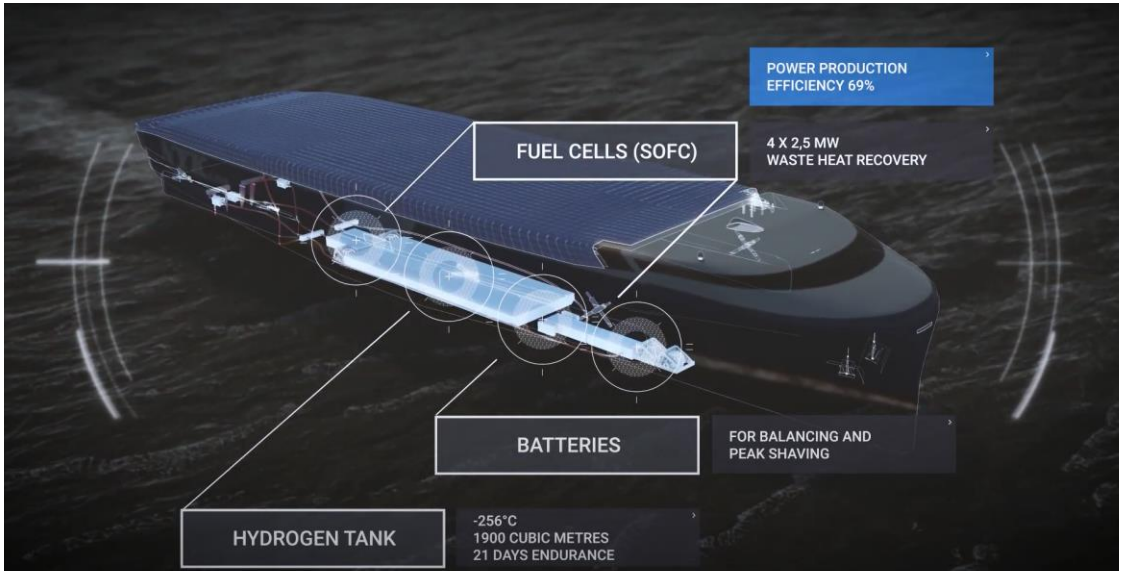
Digitalization will play important role in proceeding decarbonization

- System integration and V-process will be necessary in decarbonization projects.
- Simulation will play an important role in system design, development, commissioning and operation for decarbonization projects.
- Especially, combination of simulation and optimization will be crucial in system design.
- MTI started simulation team in April 2020 to enhance simulation capabilities.



Ref) NYK Super Eco Ship 2050
https://www.youtube.com/watch?v=bYIcgxqqJbE

Challenges when implementing V-Process

1. Shipping industries have to learn and experience the process, methodology and tools of V-Process.

2. V-Process requires large amounts of man-hours and costs. Improving productivity is necessary. Sharing knowledge, experiences and good platform as the industry will be the key. Standardization, simulation platform and simulation models are necessary.

3. Education and trainings of crews for such complex system and advanced automation system is crucial. Crews have to take the role of back-up when system fails.

4. Collaboration between users (captains & chief engineers) and designers in manufacturers (system integrators & suppliers) is crucial to develop practical goal & ConOps.

Summary

- Digitalization plays important role in safer and greener shipping.
- We are gradually facing the era of 'ship as system' and capability of system integration become critical.
- Players of maritime industry need to learn V-process methodologies and tools, and to develop shared experiences. Standards, shared simulation platform and shared model will be necessary.
- Reliability of simulation itself is also important.
- V-Process and shared experiences as the industry will be utilized in the coming decarbonization challenges.

We would like to seek possibilities further discussion and collaboration with ShippingLab !

Thank you very much for your attentions

Hideyuki Ando
Director, MTI (NYK Group)

hideyuki_ando@monohakobi.com