

Presentation for Abu Dhabi Department of Municipalities and Transport - Integrated Transport Centre

Open Innovation in the Development of Autonomous Ships in NYK Group

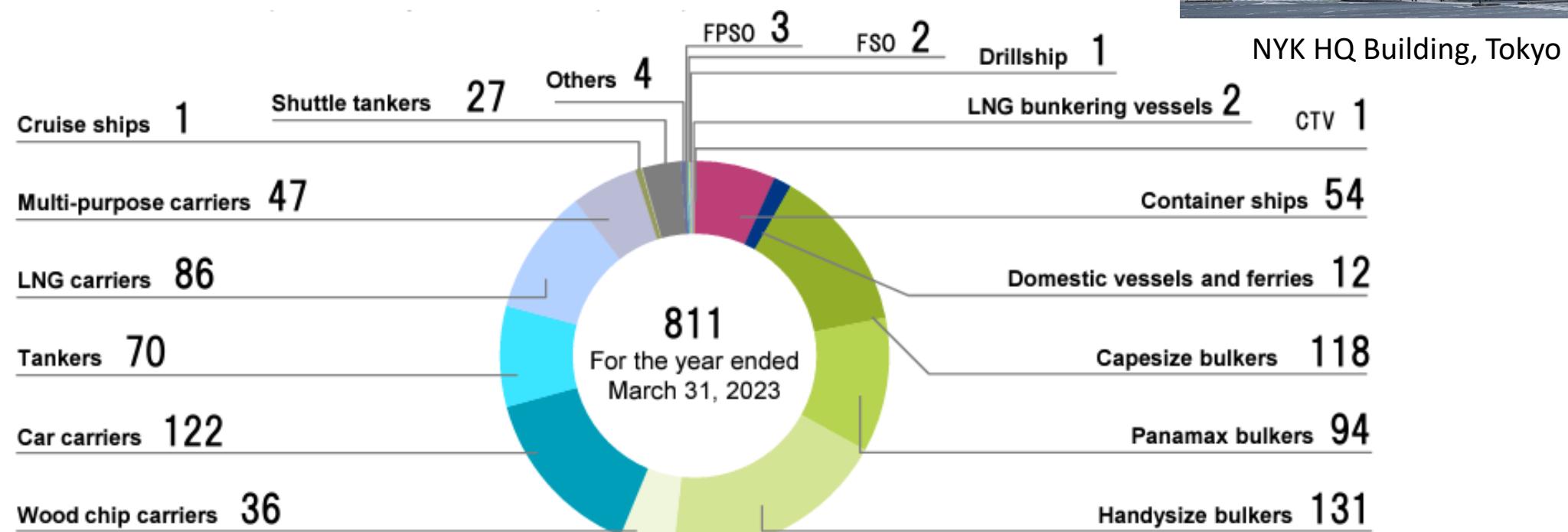
16th Sep. 2025

Capt. Satoshi Togashi



Introduction of NYK Line www.nyk.com/english/

- Trade Name: Nippon Yusen Kaisha (NYK) or NYK Line
- President: Mr. Takaya Soga
- Head Office: Tokyo, Japan
- Founded: September 29, 1885
- Employee 35,243 (as of the end of Mar 2024)
- Revenue 2,387,240 (millions of yen)

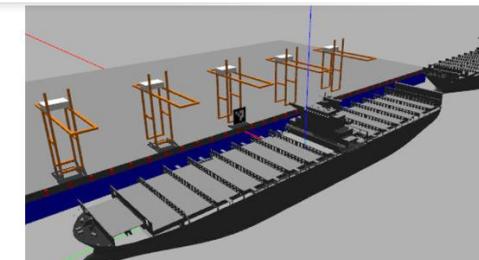


Introduction of MTI

R&D arm of NYK Line

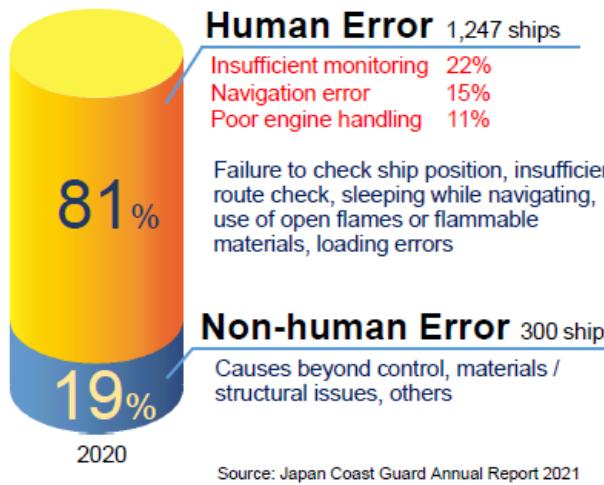
- Company Name: MTI Co., Ltd.
- President: Mr. Hideki Suzuki
- Founded: April 1, 2004
- Stockholder: NYK Line (100%)
- Employee: 70 (as of April 2024)
- Locations: Tokyo and Singapore
- R&D Projects: Abt. 80 projects per year
 - Abt. 90% for NYK
 - Abt. 10% for External
- Total budget: 10-12 million USD per year

www.mohohakobi.com/en/

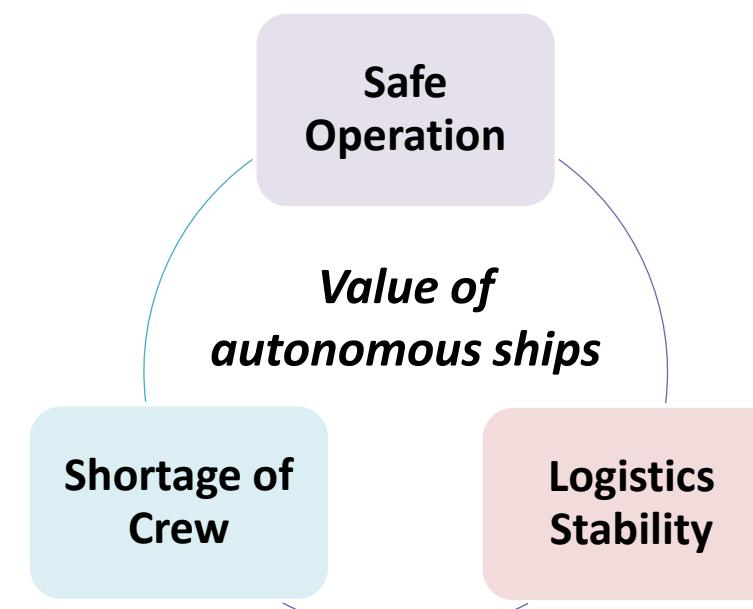
 ESG	 Ship System	 Autonomous Ships
ESG Activity Support	Power System Integration	Autonomous Ships
Installation of Energy-Saving Devices		Autonomous Ships
Data Utilization		
 Engine system solutions	 Ship and Logistics IoT	 Simulation
Main Bearing CBM of Diesel Main Engine	SIMS3	Simulation Platform
Performance Analysis	Cybersecurity	Sensor Simulation
Kirari NINJA	Ship-to-Shore Data Communication	Simulation of Ship Motions
Remote Diagnostic Center		Simulation of Ship Maneuvering Motions
LNG R&D		

Why do we need Autonomous Ships?

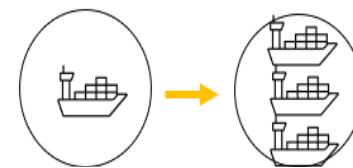
Safe operation, shortage of seafarers, logistics stability



- ✓ Navigation accidents are caused mainly by **human errors (abt. 80%)**
- ✓ **Global seafarer shortage 8.8%**, highest ever
- ✓ **Shortage of seafarers** in Japan
(by 2040 there will be 30% shortage of seafarers)



Bigger ships with smaller engines



More congestions

- ✓ Reduced maneuverability
→ **Early action** is important
- ✓ **Future increase in maritime transport**
(from trucks to shipping and trains)

The NYK Group's actions for realizing autonomous ships



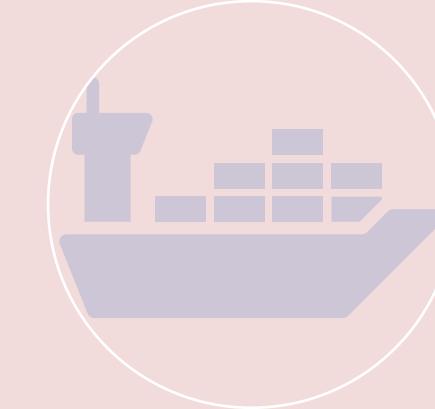
Rule

- Participation in IMO's MASS code development via supporting Japanese government



Standard

- Develop international technology standards for autonomous ships

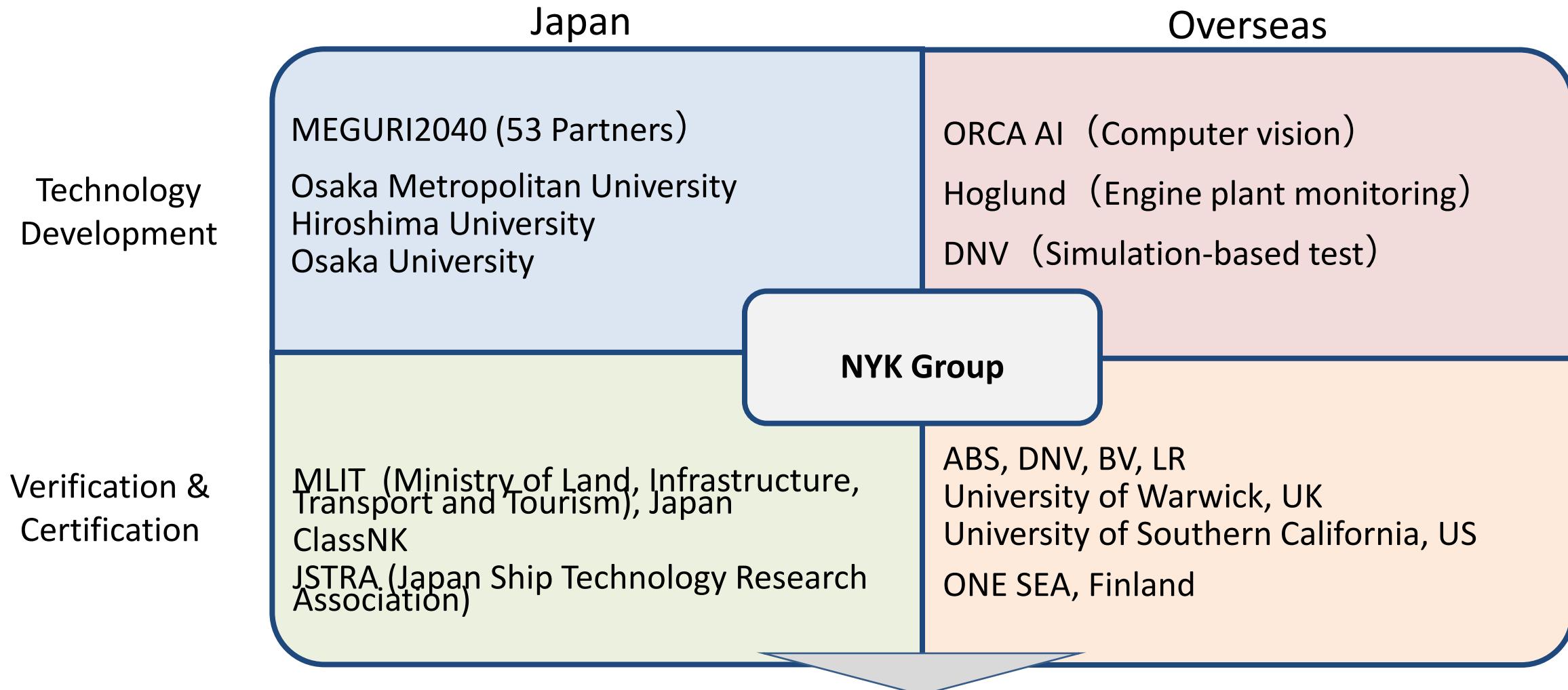


Development

- Lead autonomous navigation technology development in MEGURI2040

Combination of actions is **important**

Open collaboration for realizing autonomous ships



Open collaboration with domestic and international partners are the basis in technology development, verification and certification.

IMO rules, class rules and technology standards

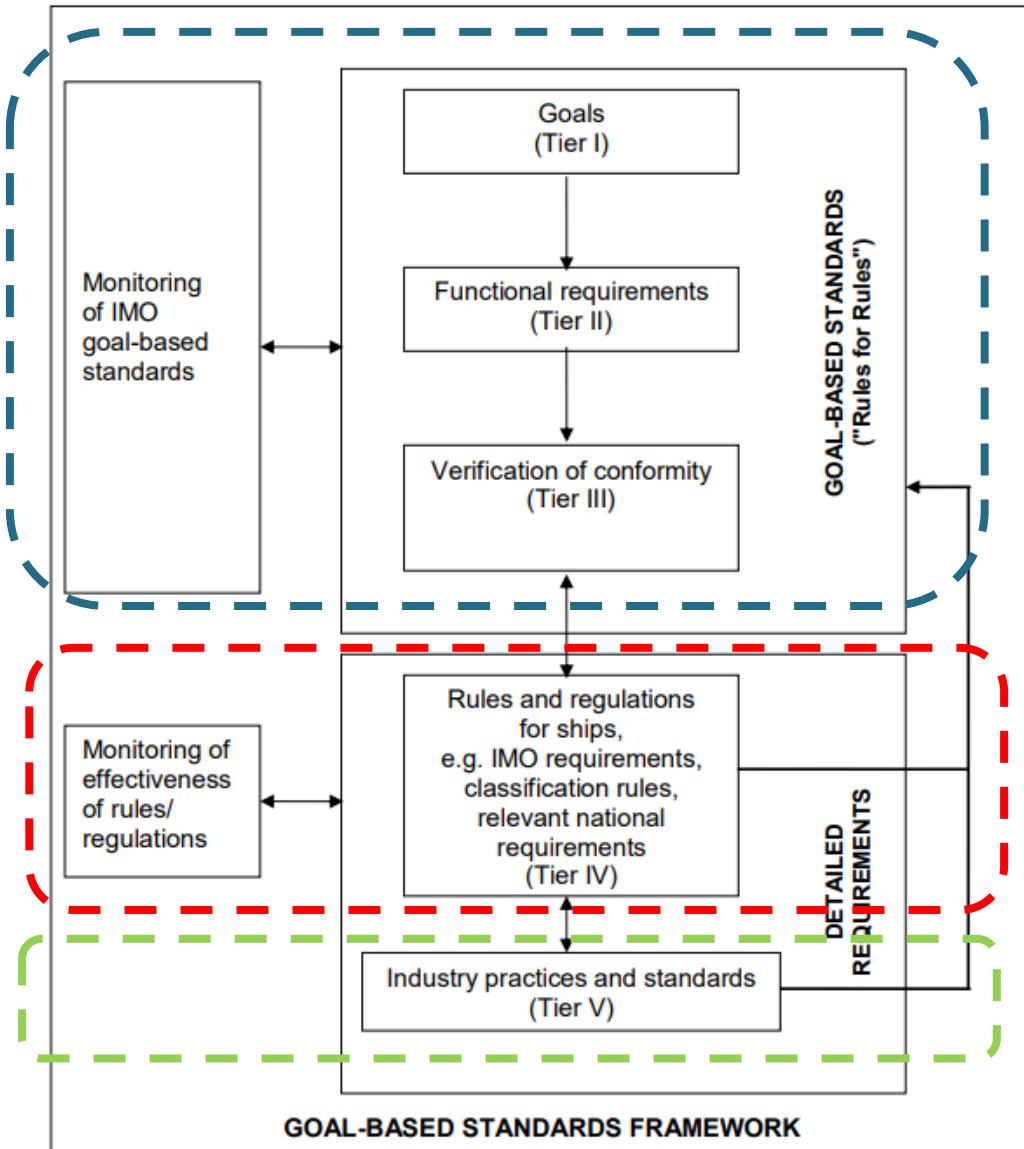
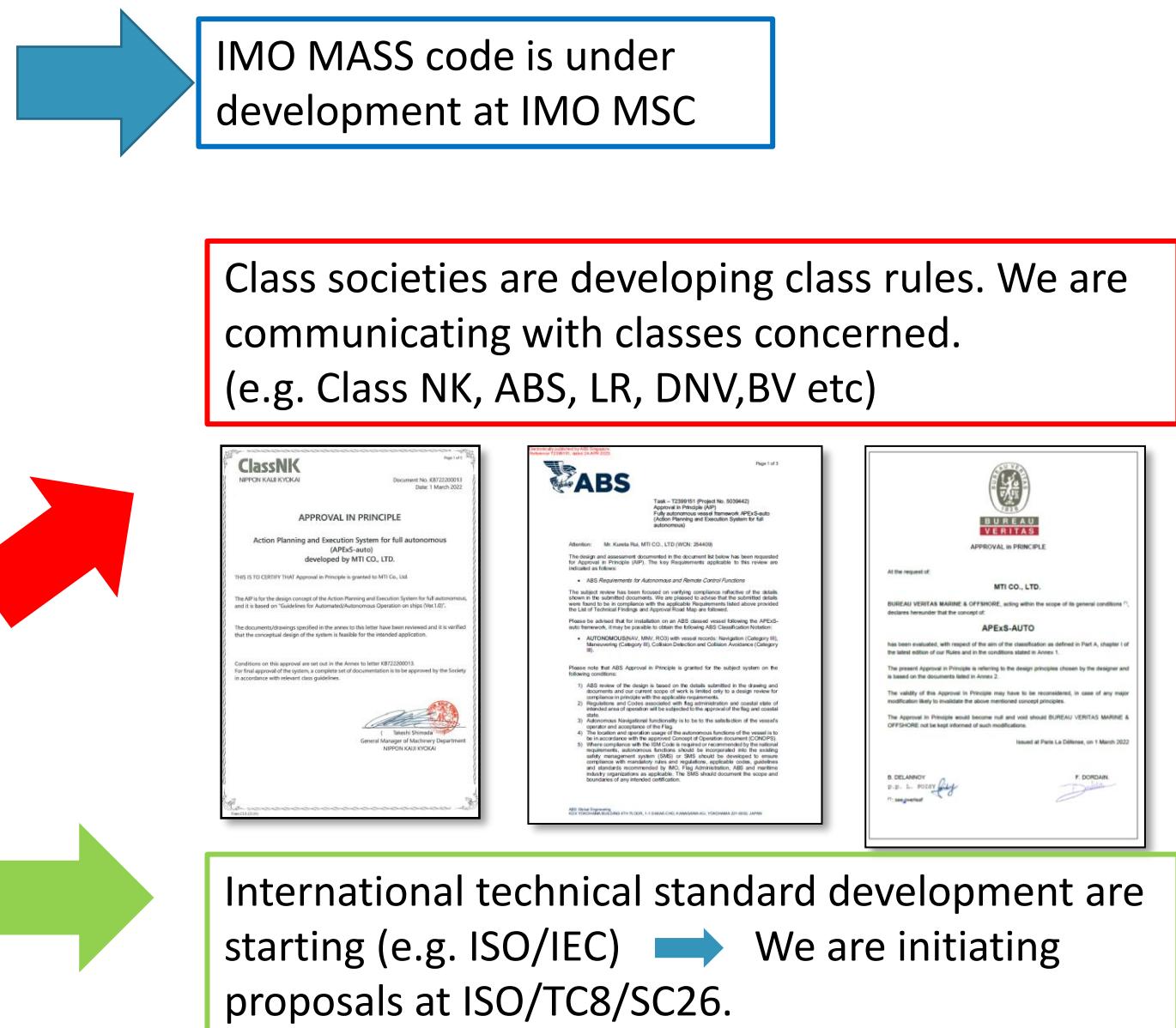


Figure 1
Goal-based standards framework



Trajectory of autonomous ships development in the NYK Group



2018 - 2020

- Remote control system using tugboats.
- Development of AI-based collision avoidance algorithms



2016 - 2020

Research on elemental technologies for autonomous navigation systems and remote-control systems

2019 - 2022
MEGURI2040 Stage1 DFFAS

(Designing the Future of
Fully Autonomous Ship)



2022 - 2026

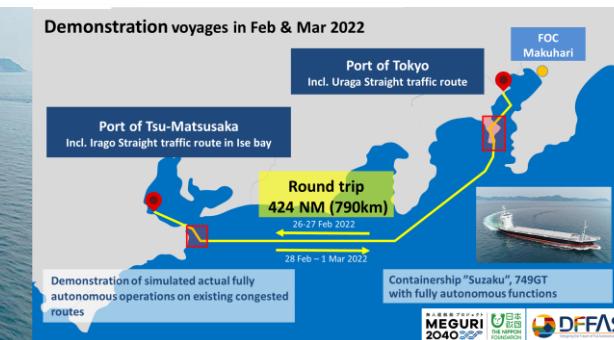
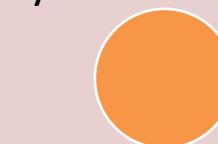
MEGURI2040 Stage2 DFFAS+ PJ



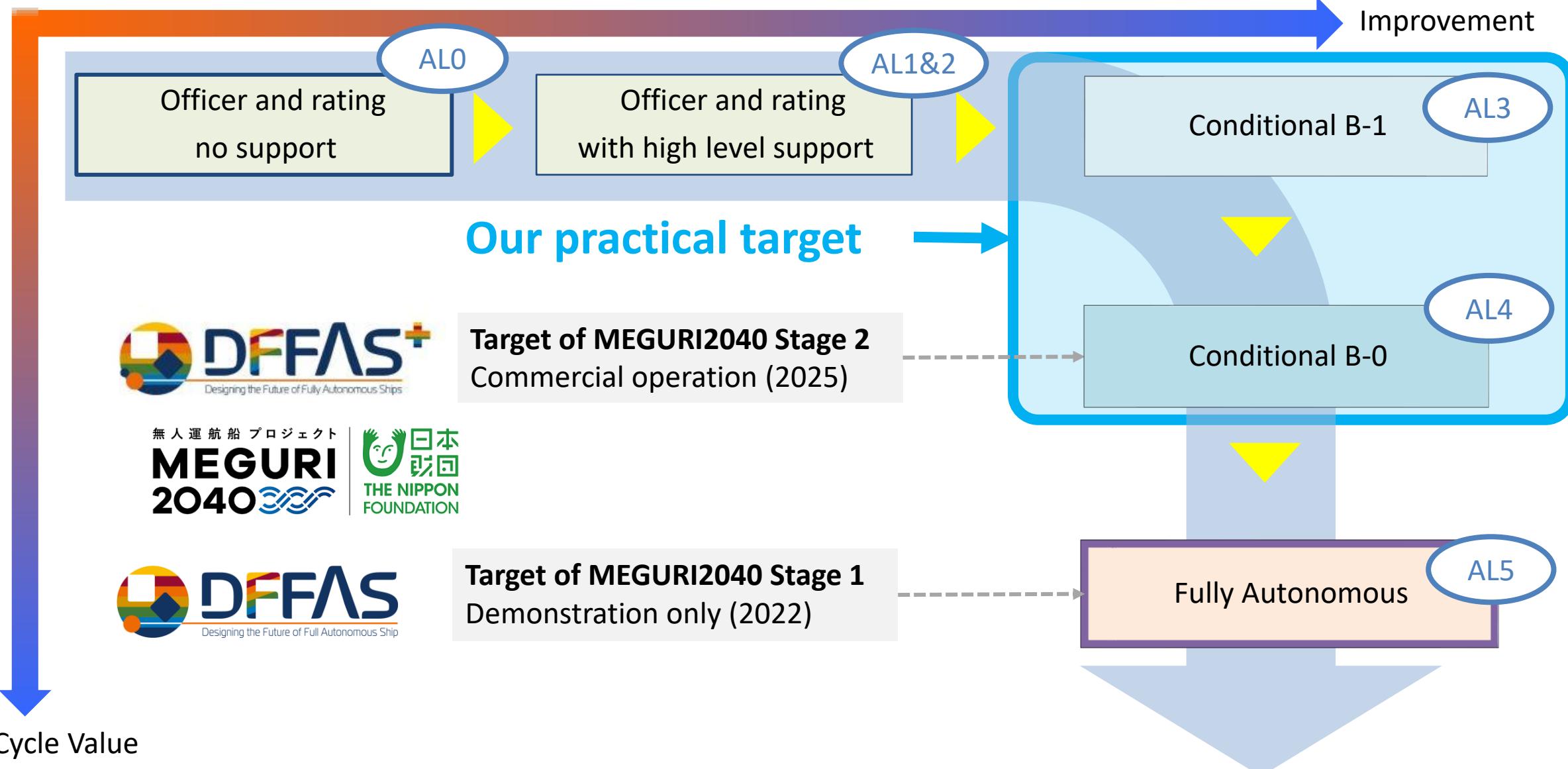
無人運航船プロジェクト
MEGURI
2040

日本財團
THE NIPPON
FOUNDATION

2024 -
Autonomous navigation
system on NYK PCCs



Autonomous levels and the targets

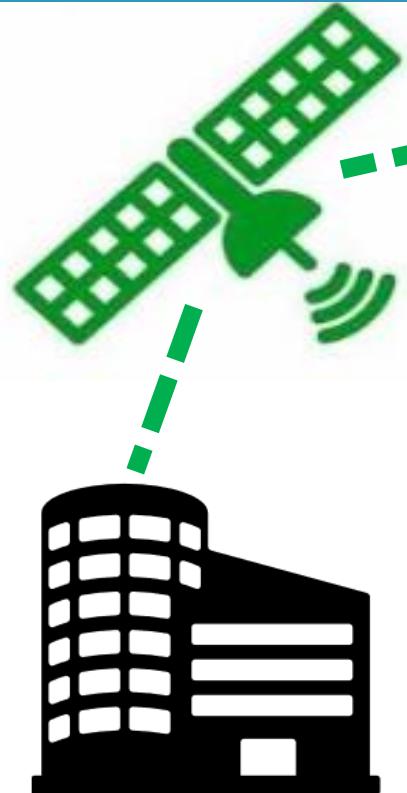


* AL0 – 5 refers autonomy level (AL) definition by Lloyd's Register, Cyber-enabled ship, 2016

DFFAS System Overview (2022)



Telecommunication system
(3 satellites and 1 terrestrial communication line,
information management & control)



DFFAS

DFFAS

**Onboard system
(autonomous functions)**



MEGURI 2040

Land-based system
(land-based support functions)



Integrated Display Block

(ship information collection, monitoring & analysis)
(engine remote monitoring, control & anomaly detection)



Emergency Response Block
(remote operation function)

Results of DFFAS Project (2022)

Demonstration of fully autonomous functions in congested coastal routes in Japan

Port of Tokyo
Incl. Uraga Straight traffic route

FOC
Makuhari

Port of Tsu-Matsusaka
Incl. Irago Straight traffic route in Ise bay

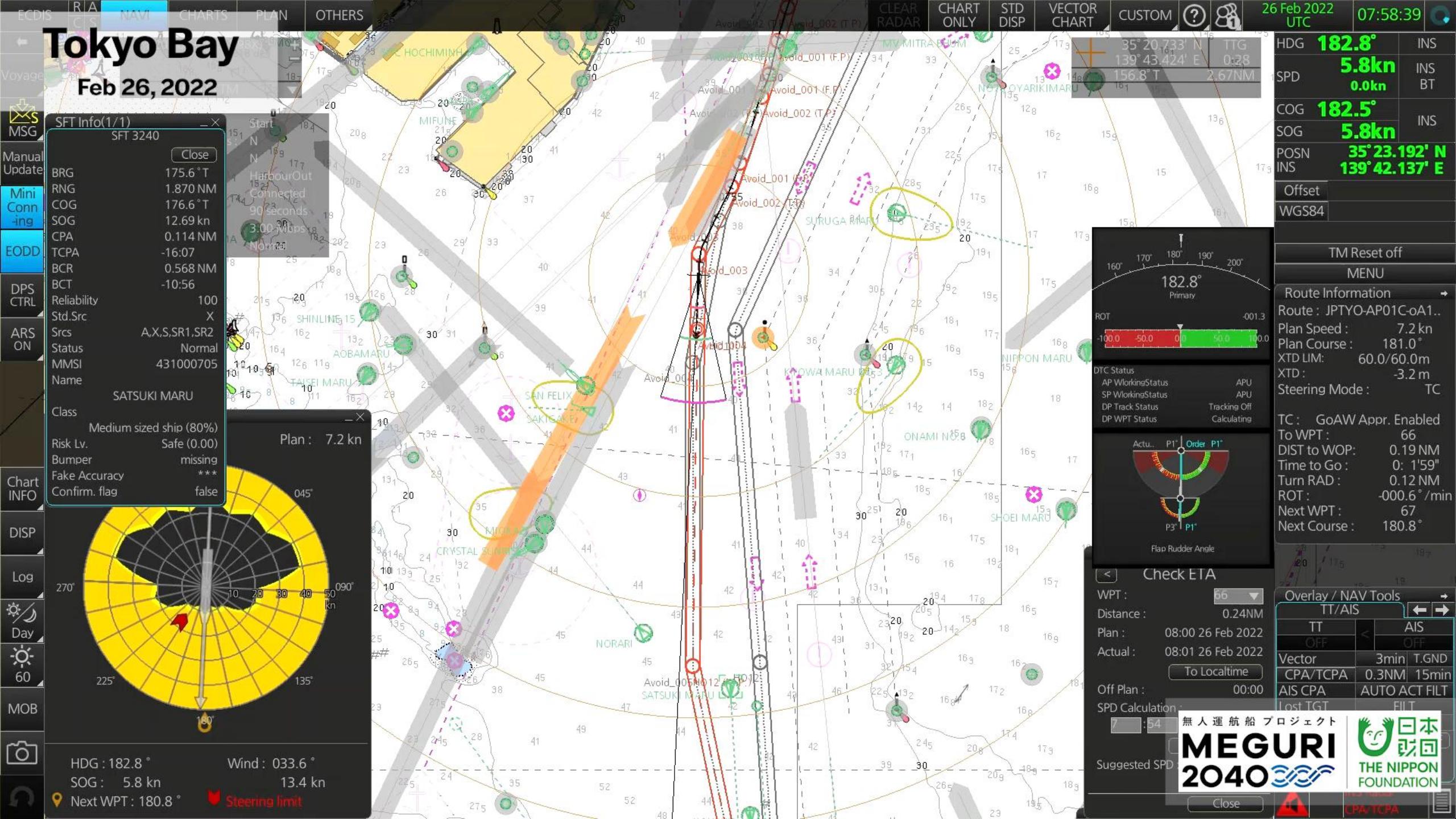
Round trip
424 NM (790km)

26-27 Feb 2022

28 Feb – 1 Mar 2022

Achieved 98.5% of fully autonomous navigation in the demonstration voyage

Containership "Suzaku", 749GT with fully autonomous functions

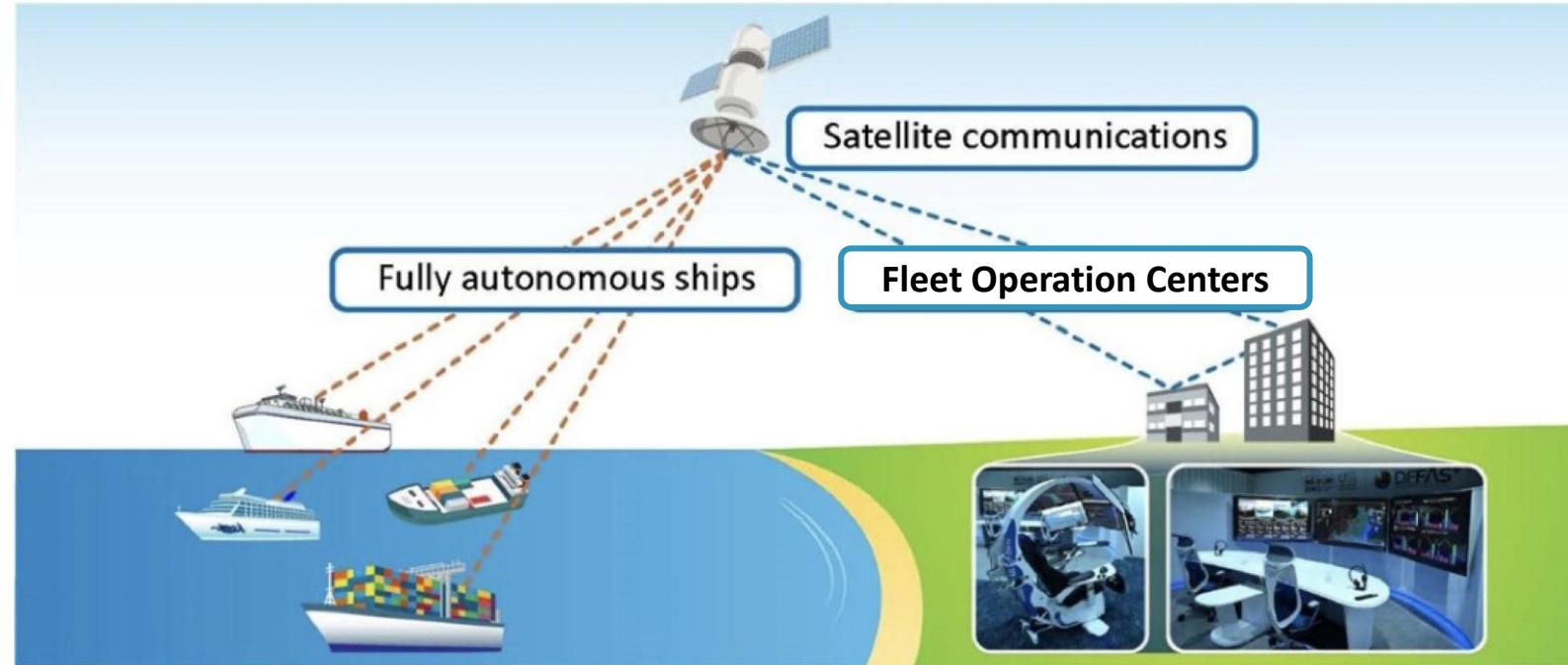


DFFAS+ of MEGURI2040 Stage 2 Project

1. Project period
 - October 2022 to March 2026 (3.5 years)
2. Project members
 - 53 companies and organizations

NYK group acts as the PMO





The Key additional functions

Navigation

- New sensors
- Integrator
- Planner
- Controller

Machinery

- Abnormalities detection

FOC

- Voyage planning
- Engine & power plant remote monitoring

Others

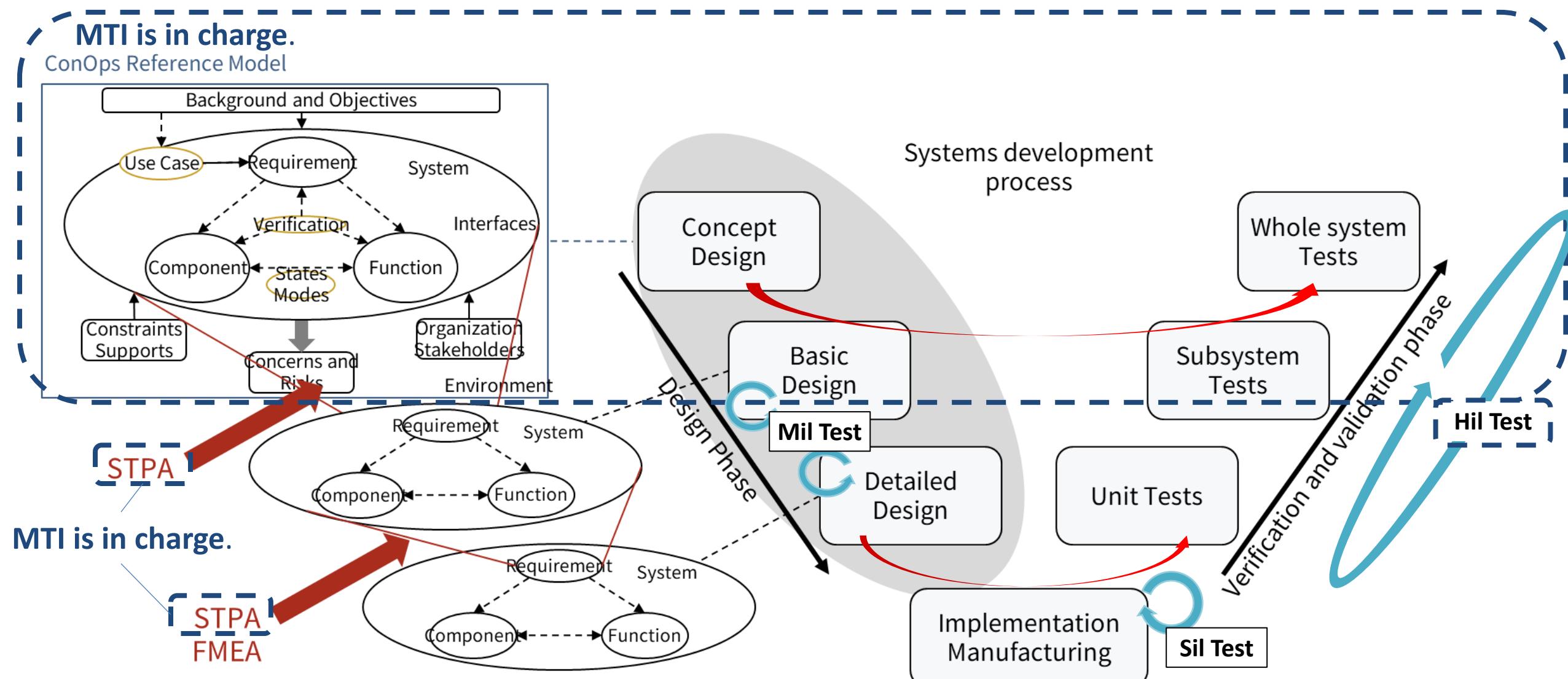
- Centralized information management
- Data recording
- Cyber security

Four target ships in DFFAS+ of MEGURI 2040 Stage 2 (trial operations in 2025-2026)

Demonstration of 4 autonomous ships in commercial operations with support from 2 Remote Operation Centers(ROC).

Period	Type, name, size & operation area	Ship	Companies
Oct 2025 - (5 months)	Newly built Container Vessel (about 7,800GT/Coasting area)	(Delivery in Sep 2025)	MTI (Leader) Ikous, Japan Marine Science, JMU, Furuno Electric, BEMAC, Tokyo Keiki, Nabtesco, Sunflame, Mitsui E&S Shipbuilding, Space Compass, JRCS, TerasakiElectric, NaikoMirai, WNI, EIZO
July 2025 - (9 months)	Island Vessel OLYMPIA DREAM SETO (942GT/ Smooth water area)		Japan Marine Science (Leader) Ryobi Ferry, Mitsui E&S Shipbuilding, Mitsubishi Shipbuilding, Furuno Electric
Sep 2025 - (6 months)	Container Vessel MIKAGE (749GT/Coasting area)		Mitsui O.S.K. (Leader) Imoto Lines, Furuno Electric, Mitsui E&S Shipbuilding
Oct 2025 – (a few voyages)	RO-RO Vessel No.2 HOKUREN MARU (11,413GT/ Limited major coasting area)		Kawasaki Kisen (Leader) Kawasaki KinkaiKisen, Japan Radio, YDK

DFFAS+ development, verification & validation process

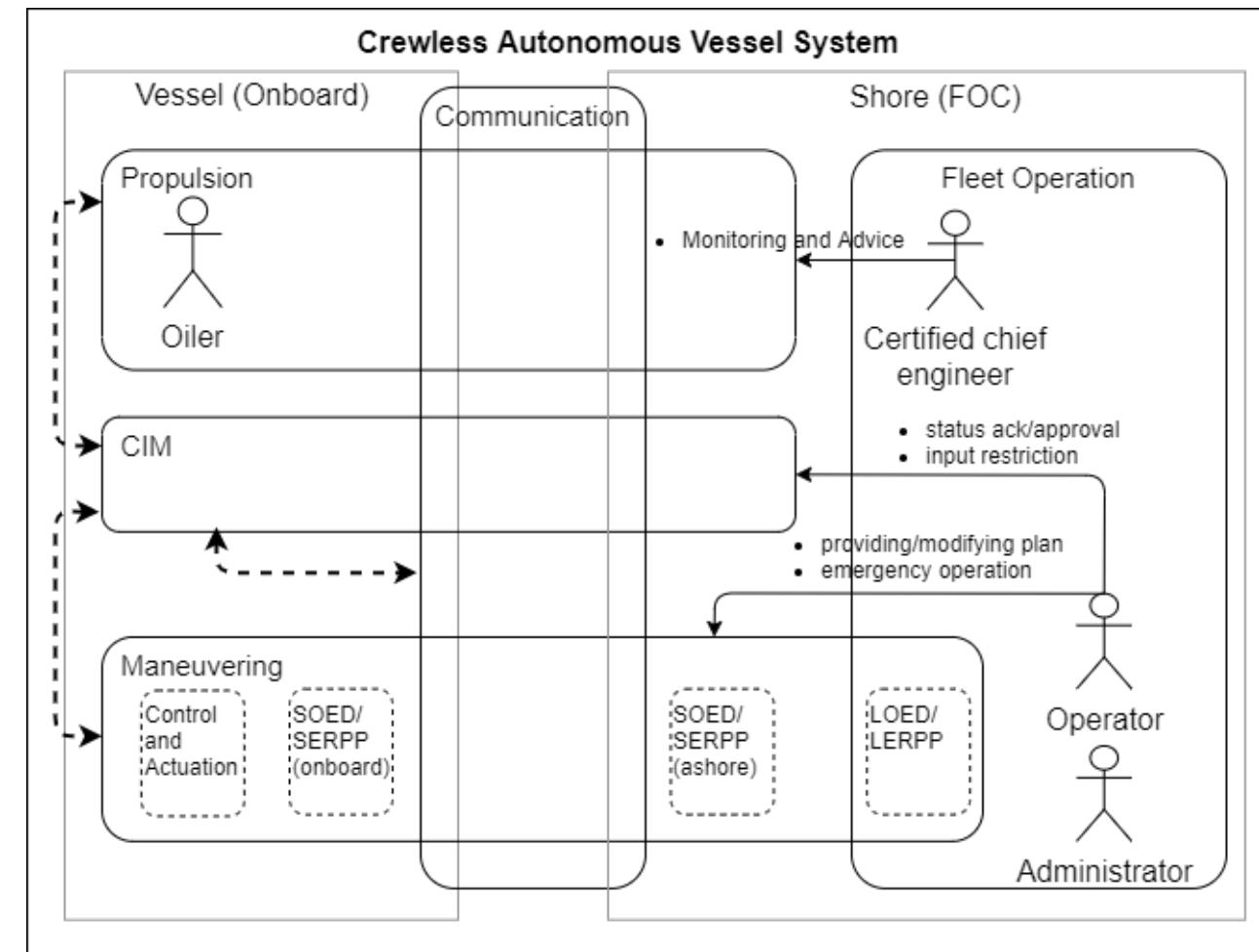


STPA: Systems Theoretic Process Analysis

FMEA: Failure Mode and Effects Analysis

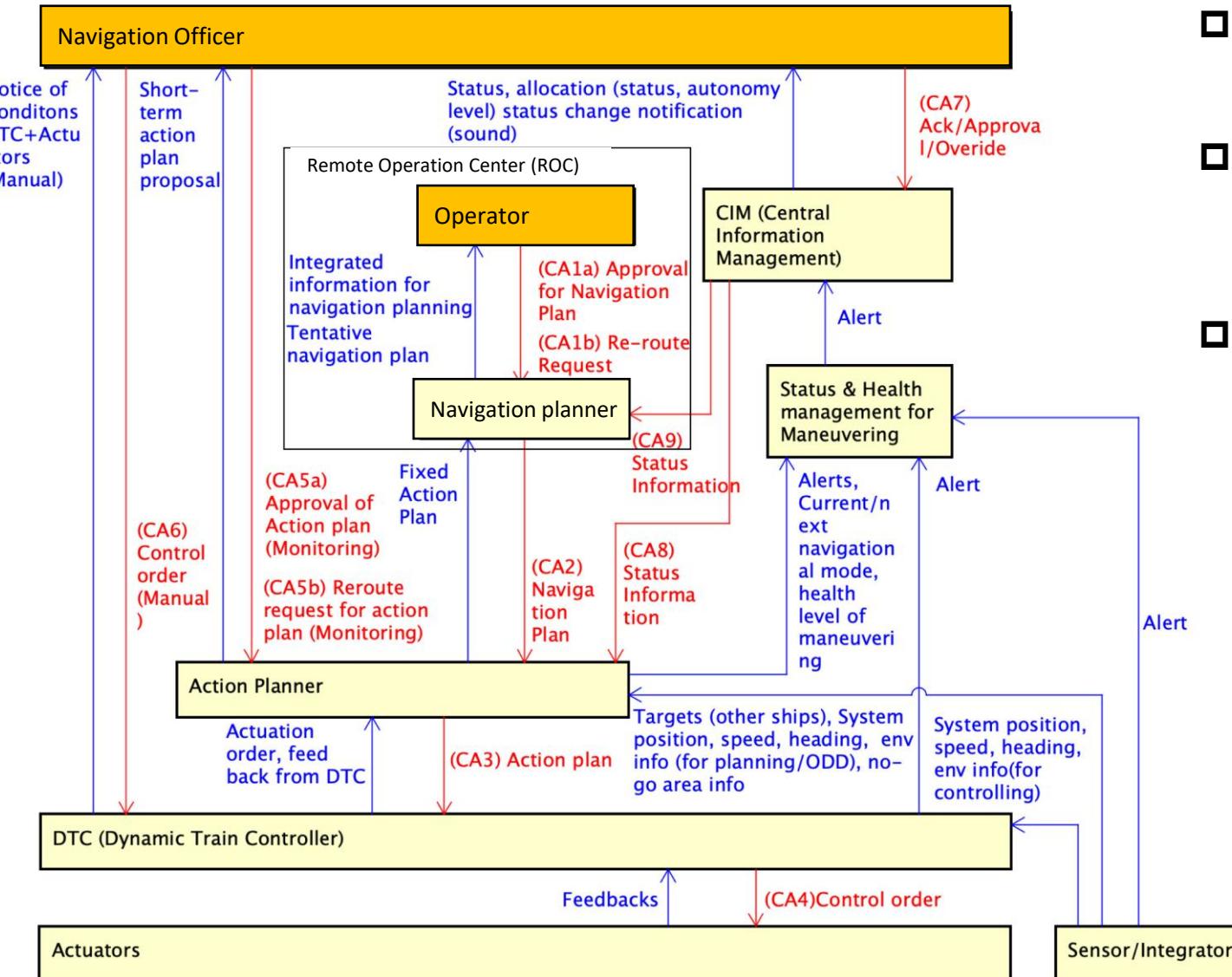
Definition of concept of operations (ConOps) for the novel system

- Define Concept of Operations (ConOps)
 - Master mariners and chief engineers, who are well versed in ship operations, define the ConOps in cooperation with engineers of manufacturers and system engineering specialists.
 - For eliciting system requirements Model-Based Systems Engineering (MBSE) and risk assessment, such as STPA, are used.
- Key features of ConOps
 - Ship specifications
 - Use case scenarios
 - Operational Design Domain (ODD) (boundary of the system design)
 - Functional Requirements (from operational perspectives)
 - Rules and regulations

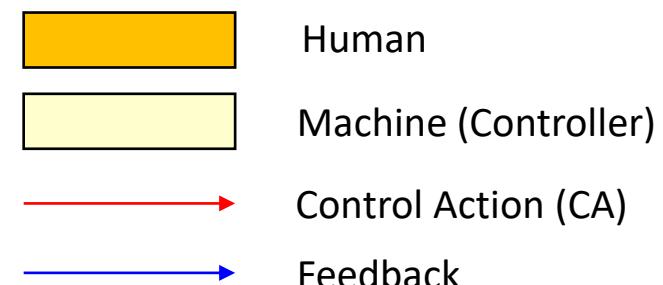


High level system concept description by using use case diagram

Control structure of the maneuvering subsystem for analyzing risks of human–machine system

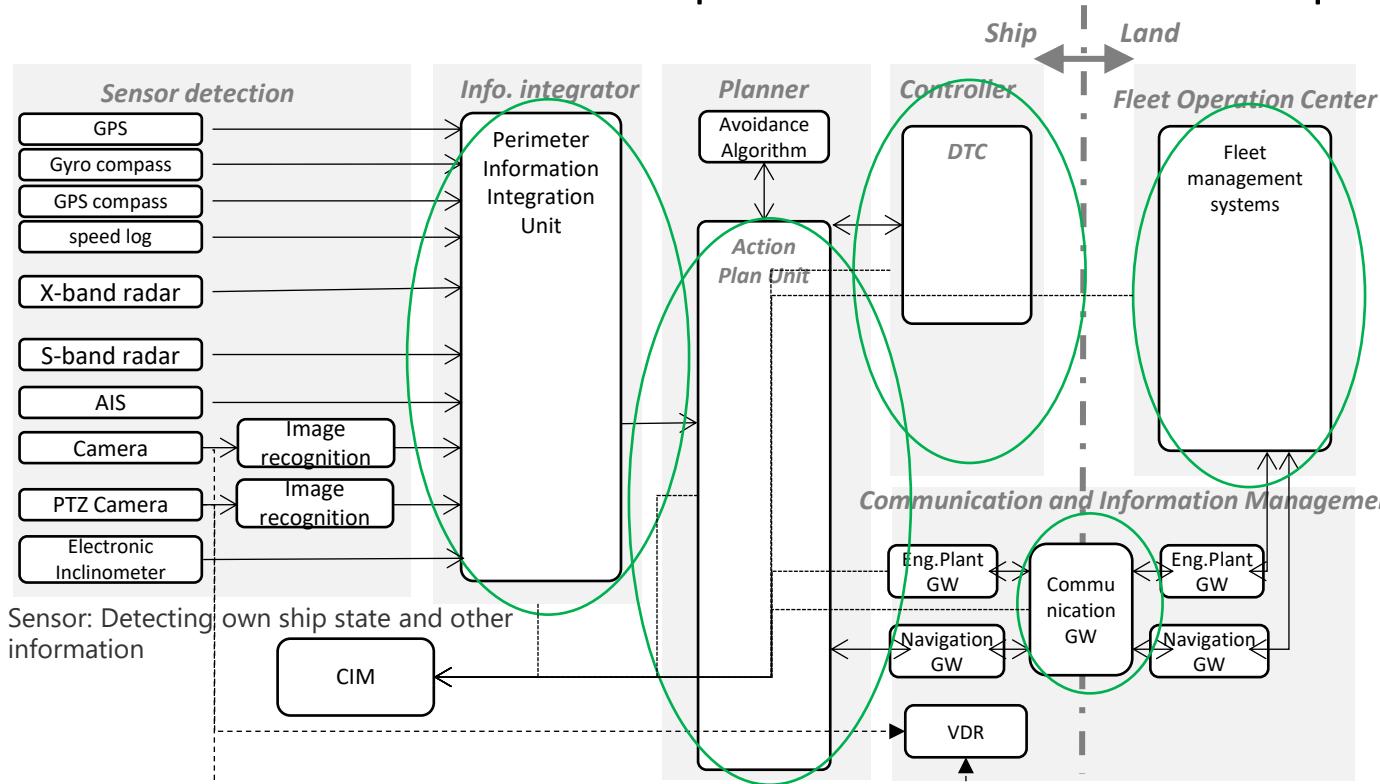


- For safety assessment of the human-machine system, control structure diagrams are used.
- Control actions (CAs) and feedbacks differ in accordance with autonomous navigation status, navigation mode, short-term or long-term task, etc.
- By running STPA analysis based on the control structures, loss scenarios are extracted. The scenarios are the basis of risk assessment and the system tests.



Subsystems and tasks at DFFAS+ autonomous system

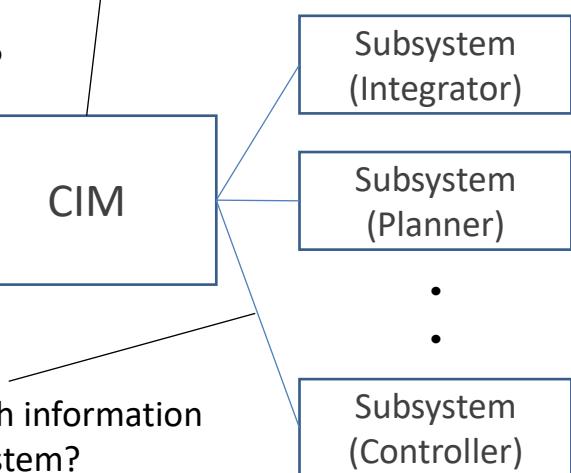
- CIM
 - Collect health level of subsystems and determine overall status (autonomy level) of whole system
 - Change operating privileges based on system status
- Maneuvering: situation awareness, planning track and controlling
- Propulsion: propulsion & power management, remote assist from shore
- Communication: shore-ship communication and corresponding security



What functions are needed to manage autonomous functions?

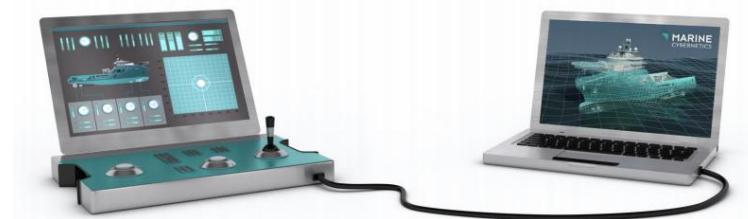
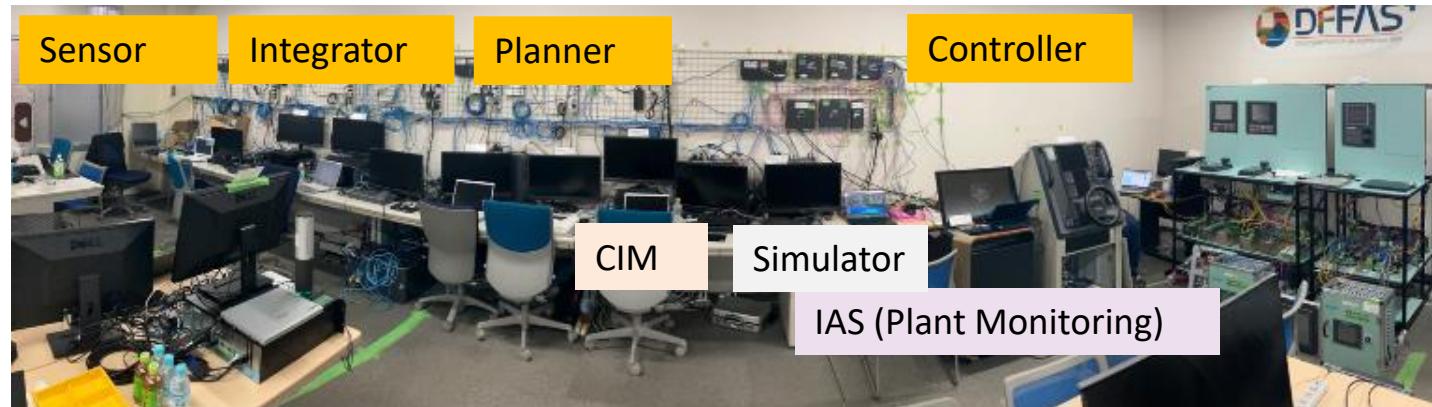
How to design the UI?

Human



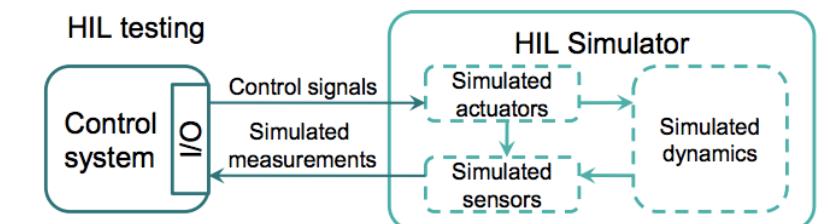
How to get health information from each subsystem?

HIL(Hardware In the Loop) test arrangement



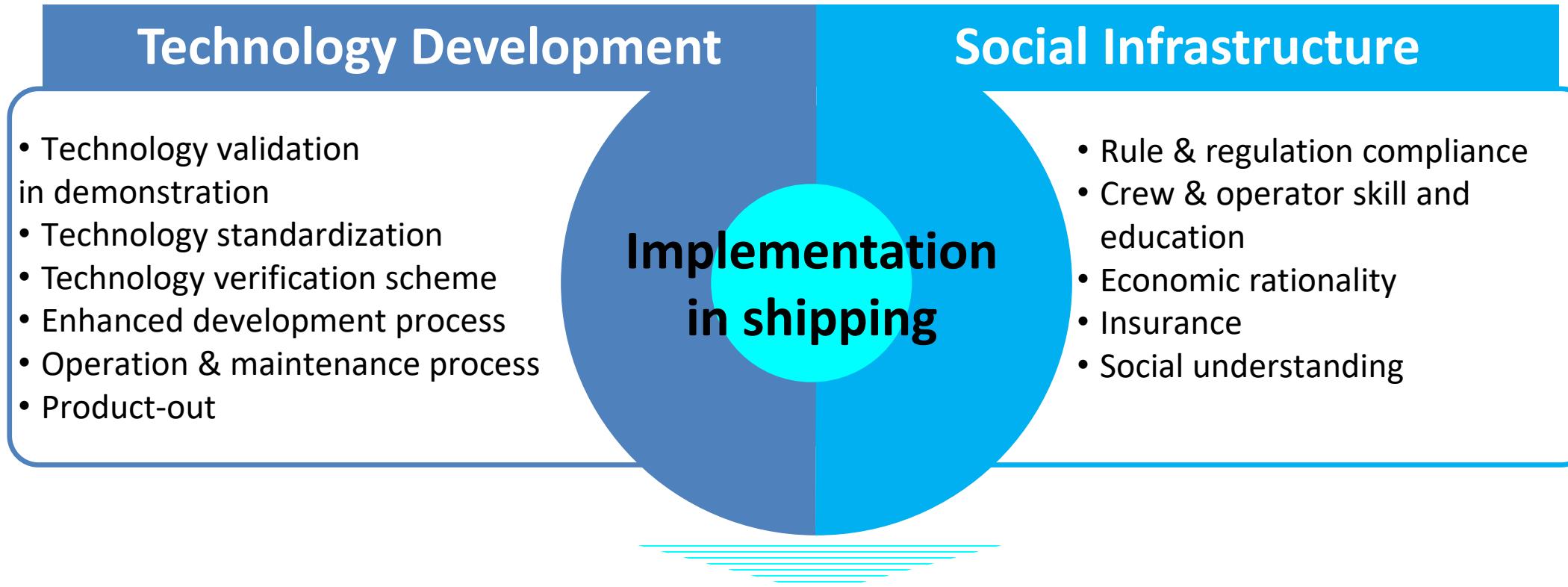
Control system
(Autonomous Navigation System)

simulator



Courtesy) DNV, CyberSea

Target of DFFAS+ Project in MEGURI2040 Stage 2



- Autonomous navigation demonstrations in commercial operations on various ship types (2 container ships, 1 passenger ship, 1 RoRo ship) will be conducted in 2025 - 2026.
- Long term & practical use of autonomous navigation systems → Non-technical issues, such as human-machine interface, comfortable work environment, crew familiarizations and trainings, are also needed to be considered.

Roadmap for the MASS code development and data collection in EBP

SESSIONS OF MSC	WORK PLAN
MSC 110 (June 2025)	<ul style="list-style-type: none">- Consideration of the outcome of the MASS-CG, established at MSC 108- Further develop the non-mandatory MASS Code- Update this road map
MASS-ISWG 4 (2nd half 2025)	<ul style="list-style-type: none">- Further develop the non-mandatory MASS Code
MSC 111 (May 2026)	<ul style="list-style-type: none">- Consideration of the outcome of MASS-ISWG 4- Finalization and adoption of the non-mandatory MASS Code- Invite relevant sub-committees to review the non-mandatory Code- Update this road map
MSC 112 (December 2026)	<ul style="list-style-type: none">- Develop a framework for an Experience-building phase (EBP) post adoption of the non-mandatory MASS Code
MSC 1XX (2028)	<ul style="list-style-type: none">- Commence development of the mandatory MASS Code, based on the non-mandatory Code and result from the EBP and review conducted by the relevant sub-committees, and consider amendments to SOLAS (new chapter) for the Code's adoption
MSC 1XX	<ul style="list-style-type: none">- Adoption of the mandatory Code (latest 1 July 2030 for entry into force on 1 Jan 2032)

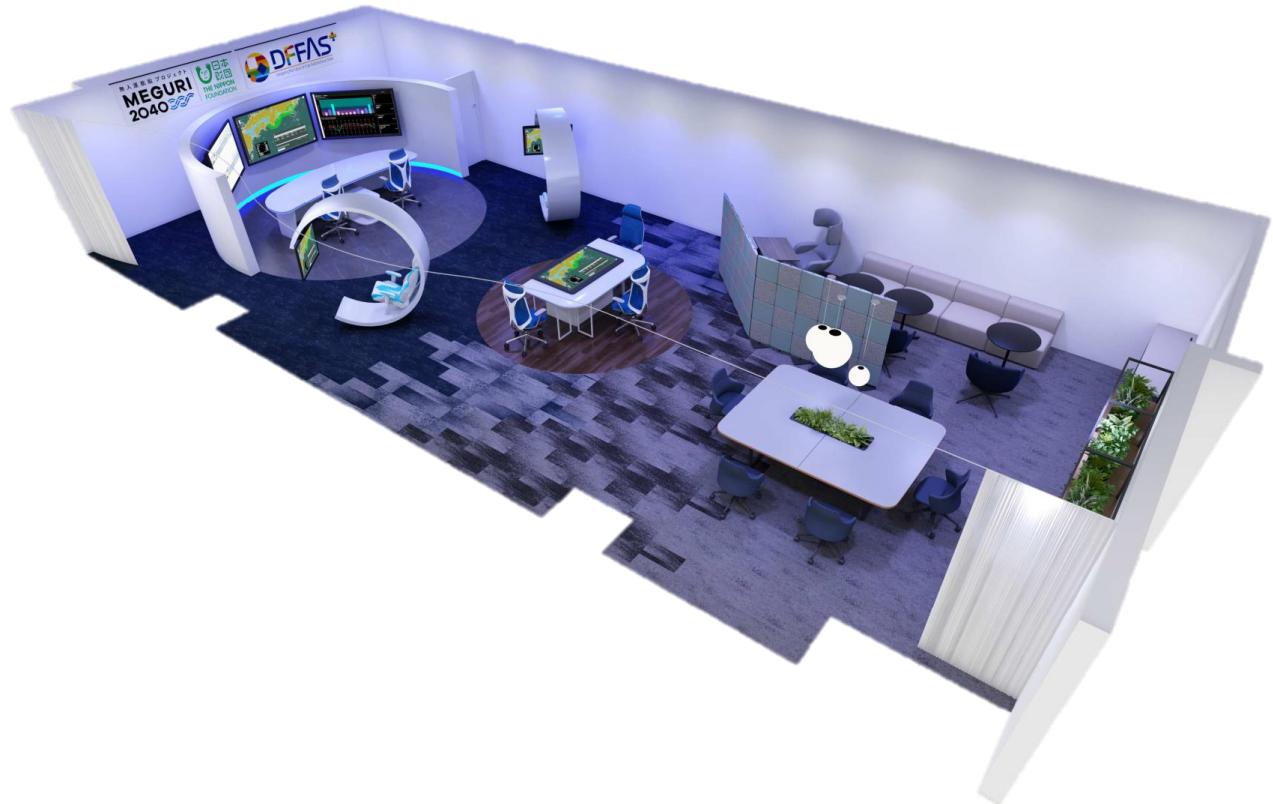
- The target of finalization and adoption of the non-mandatory MASS Code is MSC 111 in May 2026
- A framework for experience-building phase (EBP) will be developed in MSC 112 in December 2026



NYK group intends to accumulate experience and data through demonstrations in EBP, and share them with international experts at IMO, ISO and other places to achieve safer shipping operations.

Summary

- The NYK Group is working to develop autonomous ships to enhance the safety of shipping operations, solve the shortage of seafarers, and ensure stable logistics.
- To achieve this, the NYK Group is collaborating openly with partners in technology development, standards development, and supporting rulemaking.
- The NYK Group is currently leading the DFFAS+ project in the MEGURI 2040 program of the Nippon Foundation, which focuses on developing technology, technical standards, and social infrastructure. Trial operations will begin in summer 2025 and continue for several months.
- MTI is leading these activities by utilizing systems engineering methodologies and project management.



Source: DFFAS+ CONSORTIUM

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Thank you for your listening.