WAIC Shanghai

27th July 2025

NYK's approach for realizing autonomous navigation in commercial shipping

17th July 2025

Dr. Hideyuki Ando

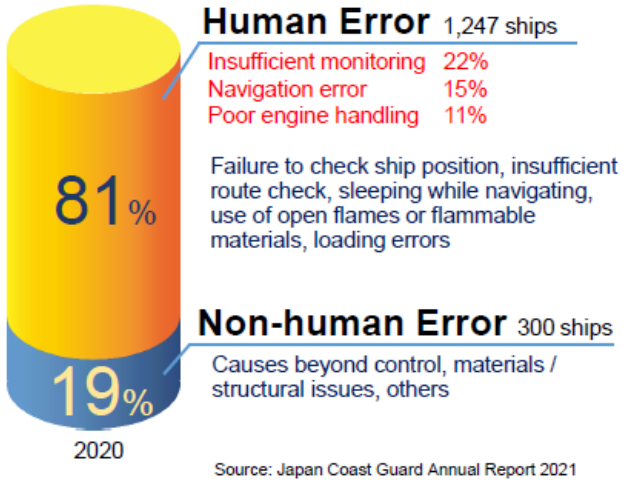
MTI (NYK Group)

無人運航船プロジェクト MEGURI 2040

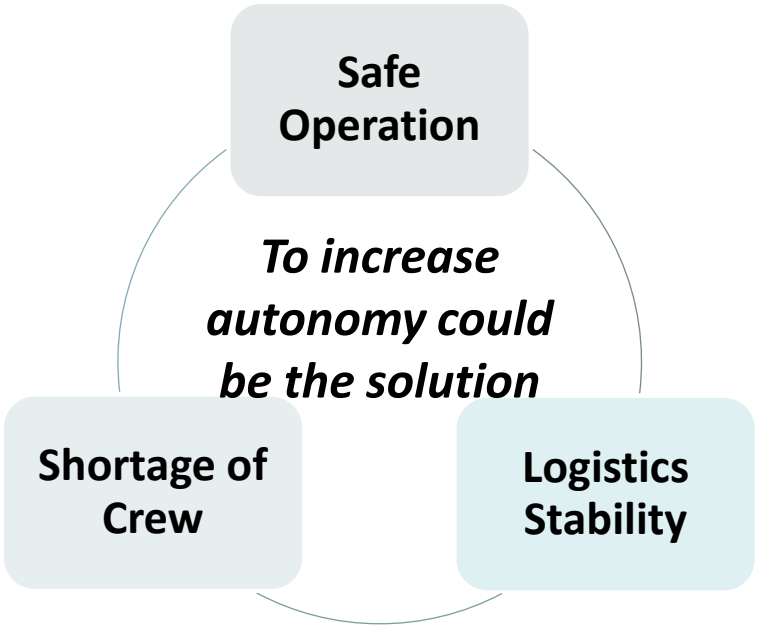
THE NIPPON FOUNDATION

Why do we need Autonomous Ships?

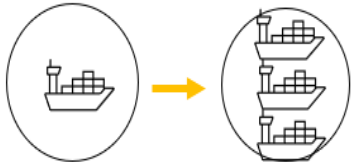
Sustainability of shipping is fundamental for global economy



✓ Navigation accidents are caused mainly by **human errors (abt. 80%)**



Bigger ships with smaller engines



More congestions due to increased ships

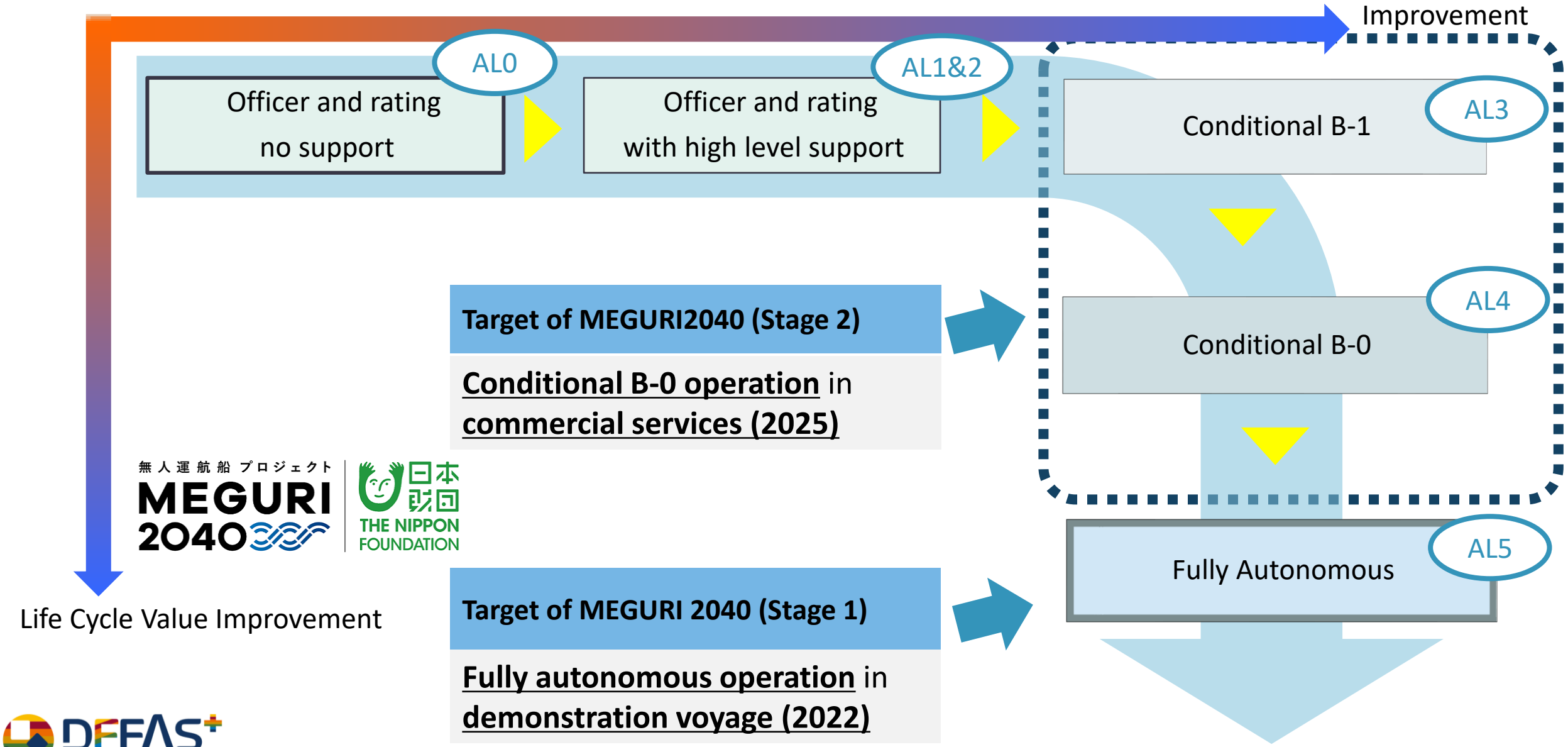
✓ Reduced maneuverability in congested routes
→ **Early action** is important

✓ **Global seafarer shortage 8.8%,** highest ever
✓ **Shortage of seafarers** in Japan's domestic shipping
(by 2040 there will be a 30% shortage of seafarers)

✓ **Future increase in maritime transport demands in each region** (from trucks to shipping and trains)

Ref) M. Unno, Fully Autonomous Ship Project "MEGURI2040" –Project Overview, Dec 4th, IMO MSC 109

Autonomous navigation roadmap and target of MEGURI2040 Stage 1&2



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

DFFAS Project in MEGURI2040 Stage 1

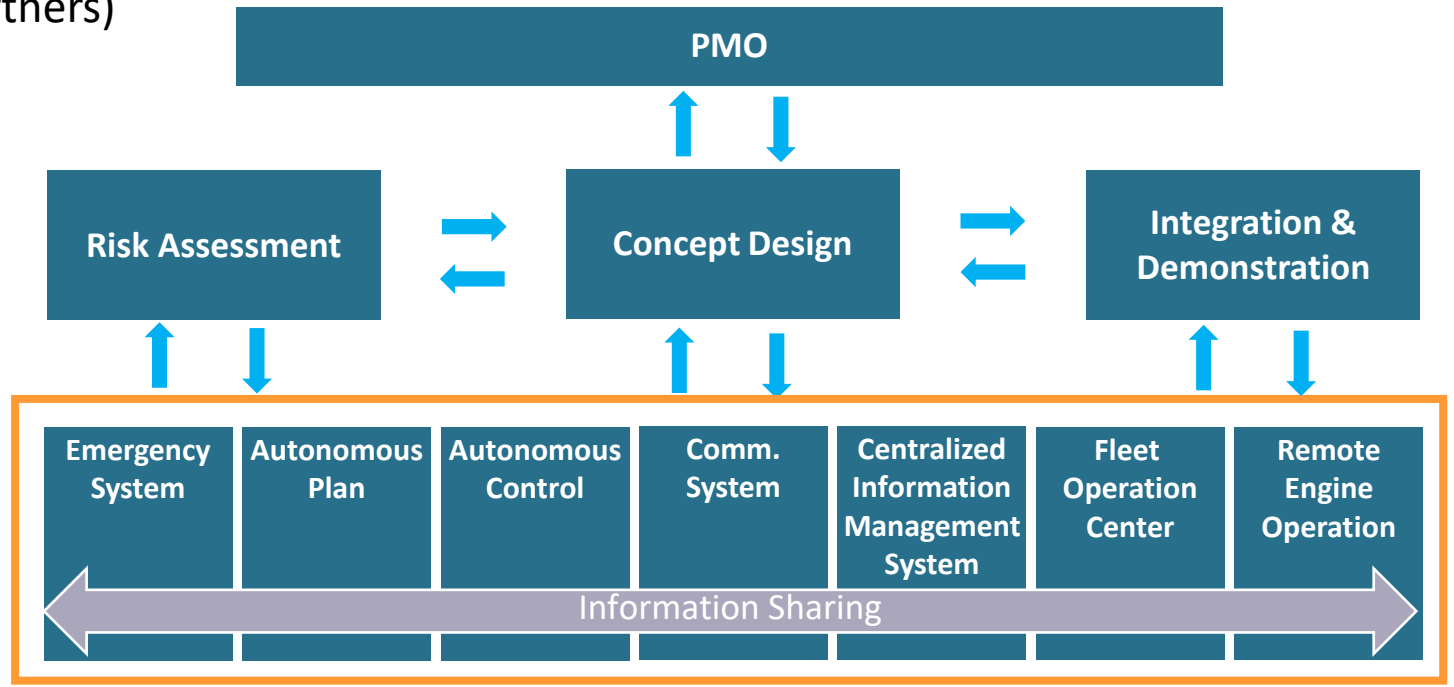
DFFAS (Designing the Future of Fully Autonomous Ship)

- **Target**
  - Demonstration of fully autonomous ship navigation under MEGURI2040
- **DFFAS consortium members & partners**
  - Consortium: 30 organizations (domestic)
  - Total: 60+ organizations (including global partners)
- **Schedule**
  - Feb 2020 – Mar 2022 (abt. 2 years)

Target ship and route	Container ship “Suzaku”, 749GT Tokyo bay – Ise bay

Project Director
Capt. Satoru Kuwahara

Organization of DFFAS Project



DFFAS+ Consortium for MEGURI2040 Stage 2

- In MEGURI2040 Stage 2, 53 companies form the DFFAS+ Consortium
- Project period: October 2022 to March 2026 (3.5 years)
- Total grants: 50 mil. USD granted from the Nippon Foundation

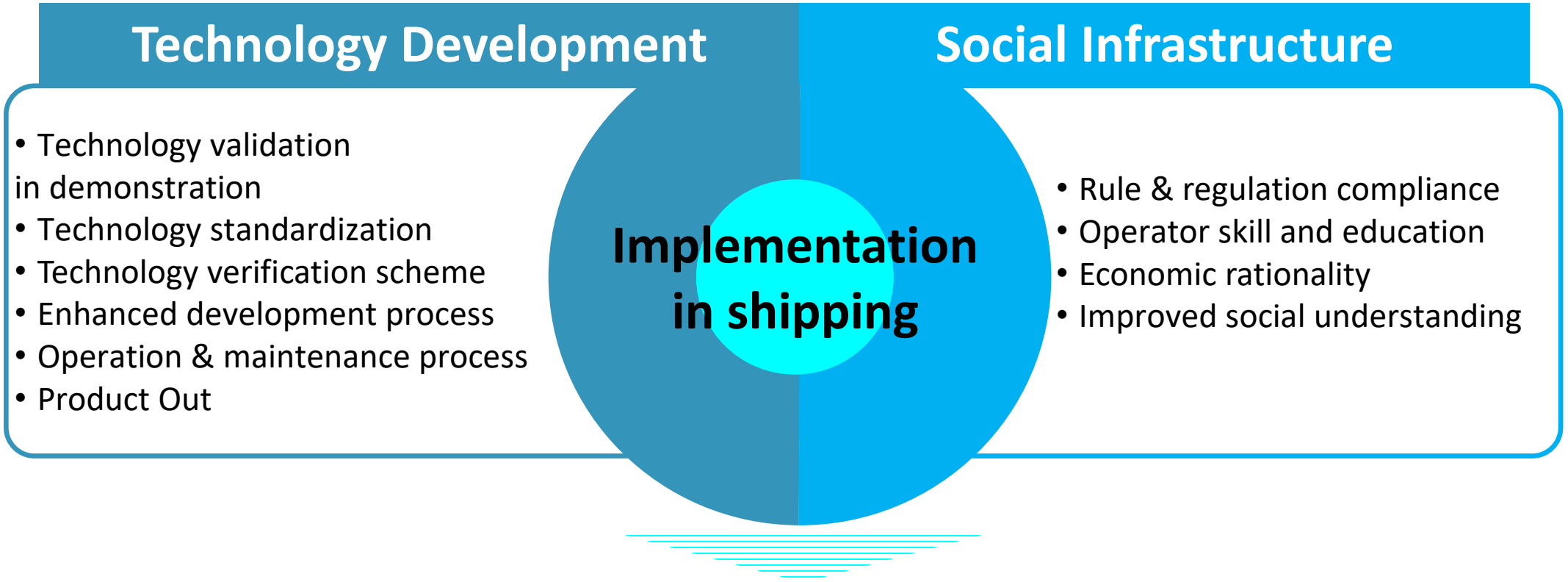
DFFAS+ Designing the Future of Fully Autonomous Ships

Demonstration in MEGURI2040 Stage 2

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

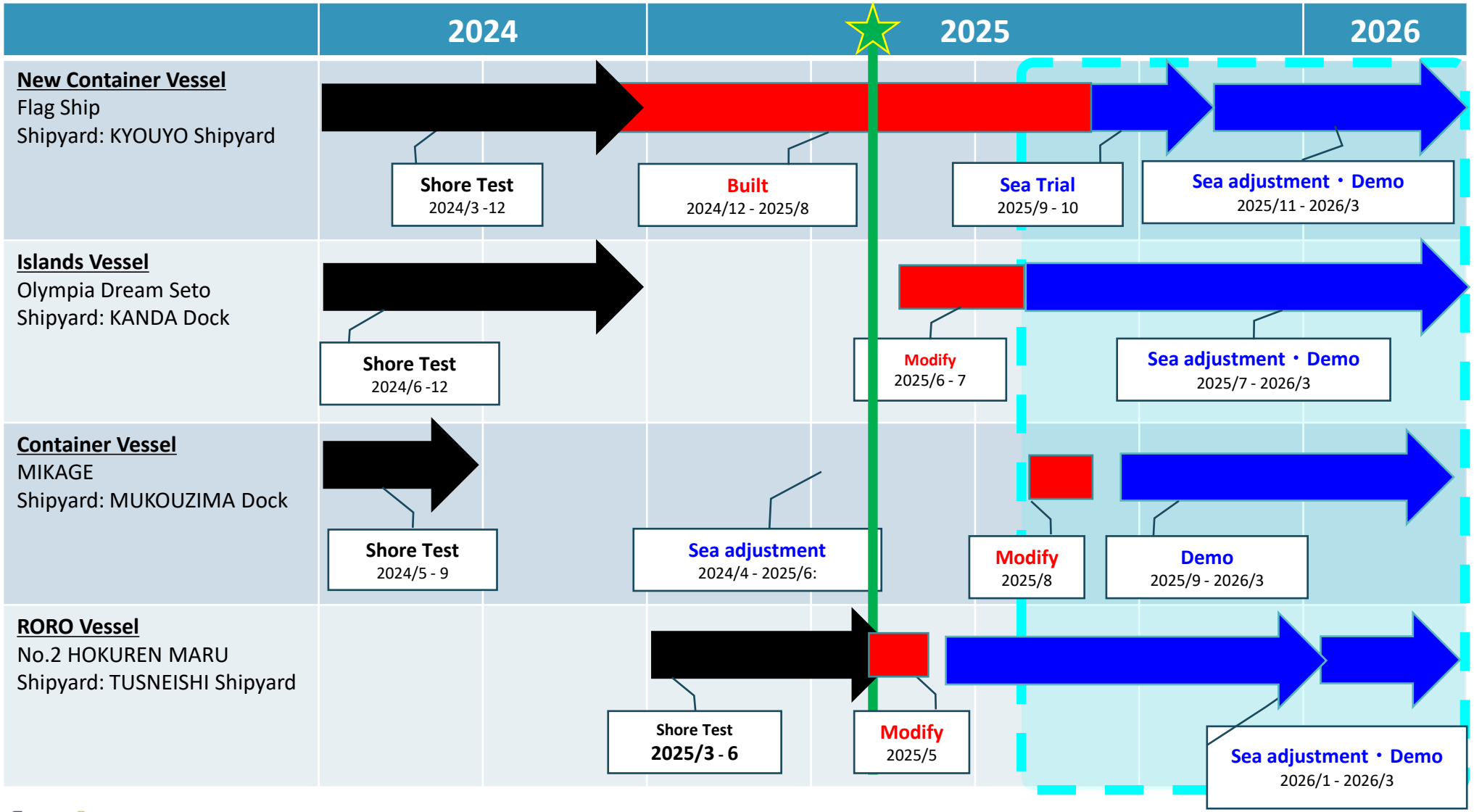
Period	Type, name, size & operation area	Ship	Companies
Nov 2025 - (5 months)	Newly built Container Vessel (about 7,800GT/Coasting area)	(Delivery in Sep 2025)	**MTI (Lead)** Ikous, Japan Marine Science, JMU, Furuno Electric, BEMAC, Tokyo Keiki, Nabtesco, Sunflame, Mitsui E&S Shipbuilding, Space Compass,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

Target of DFFAS+ Project in MEGURI2040 Stage 2

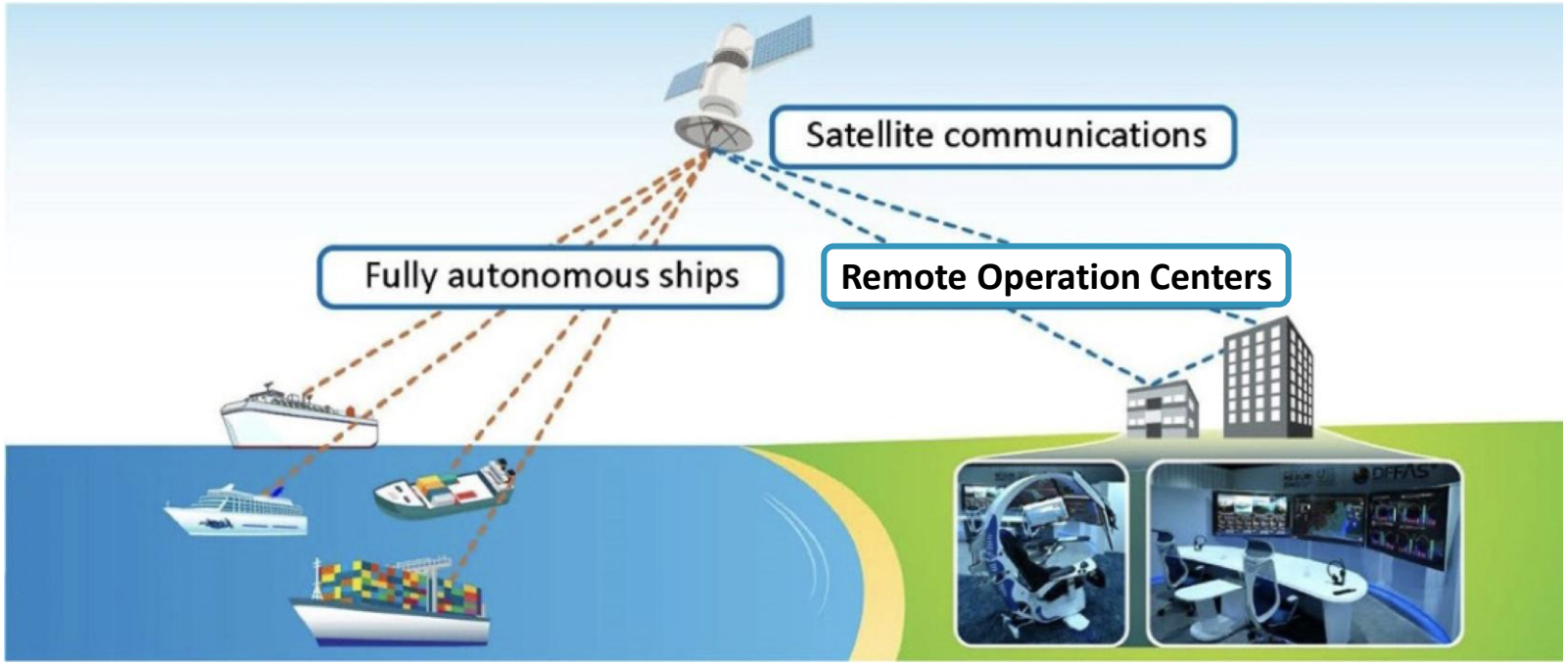


- Autonomous navigation demonstrations in commercial operations on various ship types (2 container ships, 1 passenger ship, 1 RoRo ship) will be conducted.
- Long term practical use of the autonomous navigation systems → Non-technical issues need to be considered, such as human-machine interface, comfortable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

DFFAS+ Project - Schedule



DFFAS+ Autonomous System Overview – the Key additional functions



The Key additional functions

Navigation
- New sensors
- Integrator
- Planner
- Controller

Others
- Status management
- Data recording
- Cyber security

Machinery
- Abnormalities detection

ROC
- Voyage planning
- Engine & power plant remote monitoring

Modified based on Ref) T. Nakashima, et. al, Addressing systemic risks in autonomous maritime navigation: A structured STPA and ODD-based methodology, Reliability Engineering & System Safety, Volume 261, September 2025

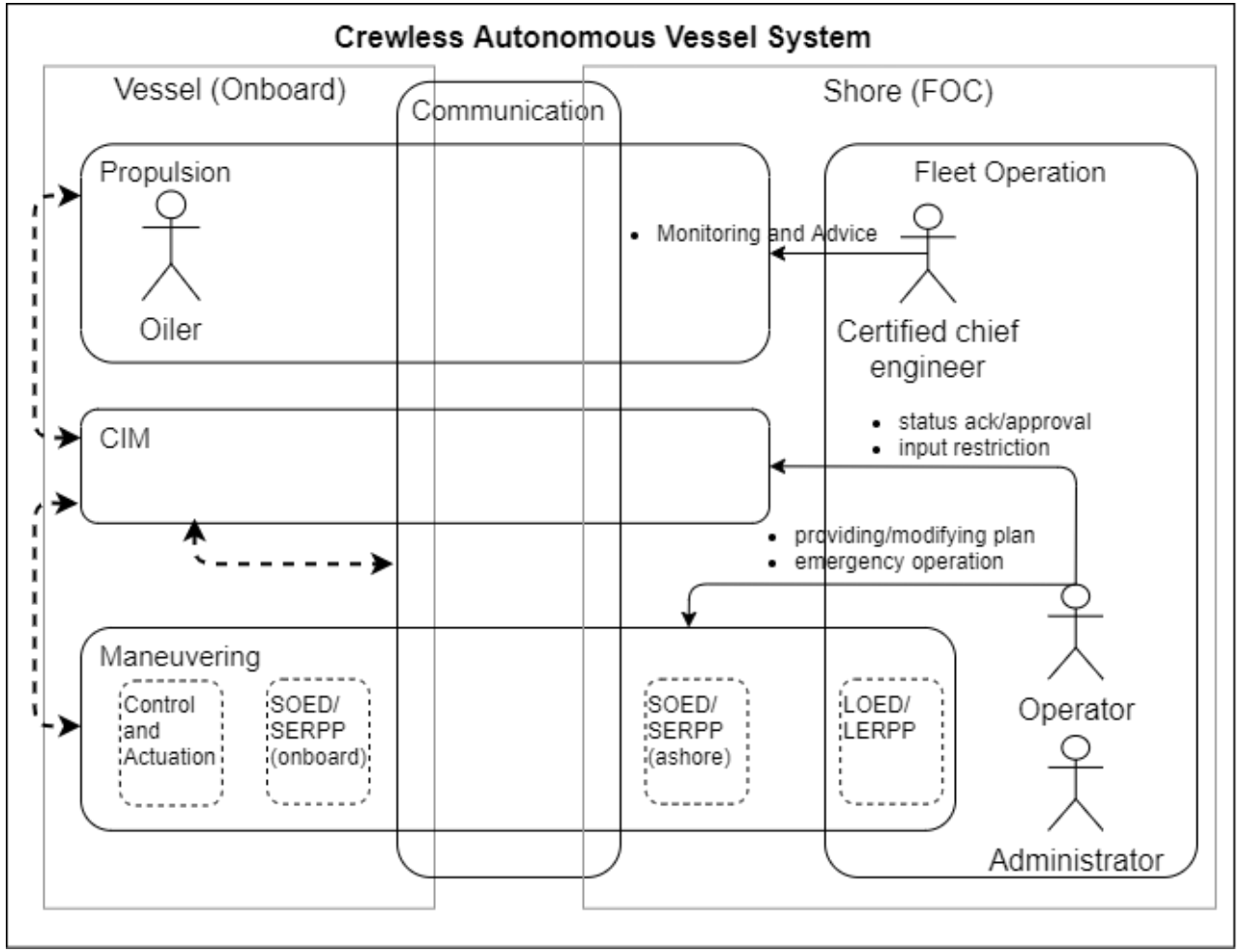
Definition of system requirements in ConOps

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
- Who, When, What, How
- Operational Design Domain (ODD)
  - Environmental conditions
- Functional Requirements
- Rules and regulations



High level system conceept description by using use case diagram

Navigation mode for classifying sea areas

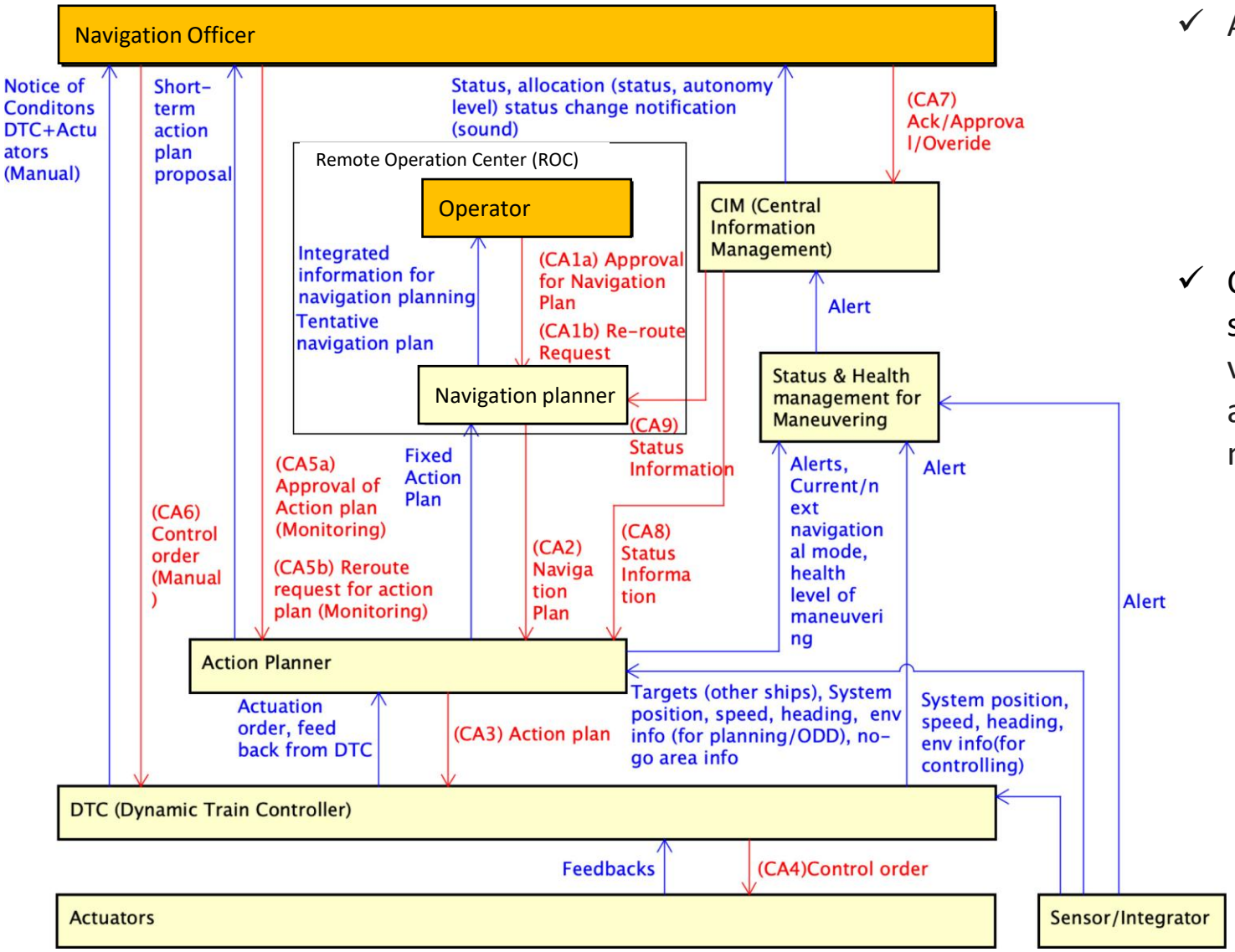
- System configuration could be different depend on navigation mode.

Table 4. Navigational mode used in DFFAS Plus project.

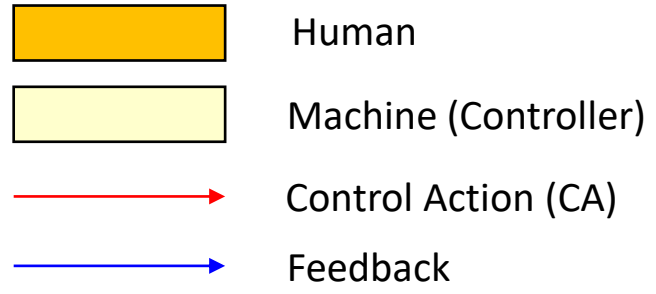
Navigational mode	Definition
Unberthing	Attitude control, unberthing operations
Leaving	Attitude control, speed control possible (speed: lower than upper limit at the operation and/or area)
Harbor Out	Track control, speed control possible (speed: from 0 knots to upper limit of the ship)
Coastal	Track and speed control possible if speed is above the operational minimum (avoiding auxiliary blower cycling) and below the ship's maximum
Ocean	Track control
Harbor In	Track control, speed control possible (speed: from 0 knots to upper limit of the ship)
Approaching	Attitude control, speed control possible (speed: lower than upper limit at the operation and/or area)
Berthing	Attitude control, berthing operations

Ref) T. Nakashima, et. al, Addressing systemic risks in autonomous maritime navigation: A structured STPA and ODD-based methodology, Reliability Engineering & System Safety, Volume 261, September 2025

Example) Control structure of the maneuvering subsystem

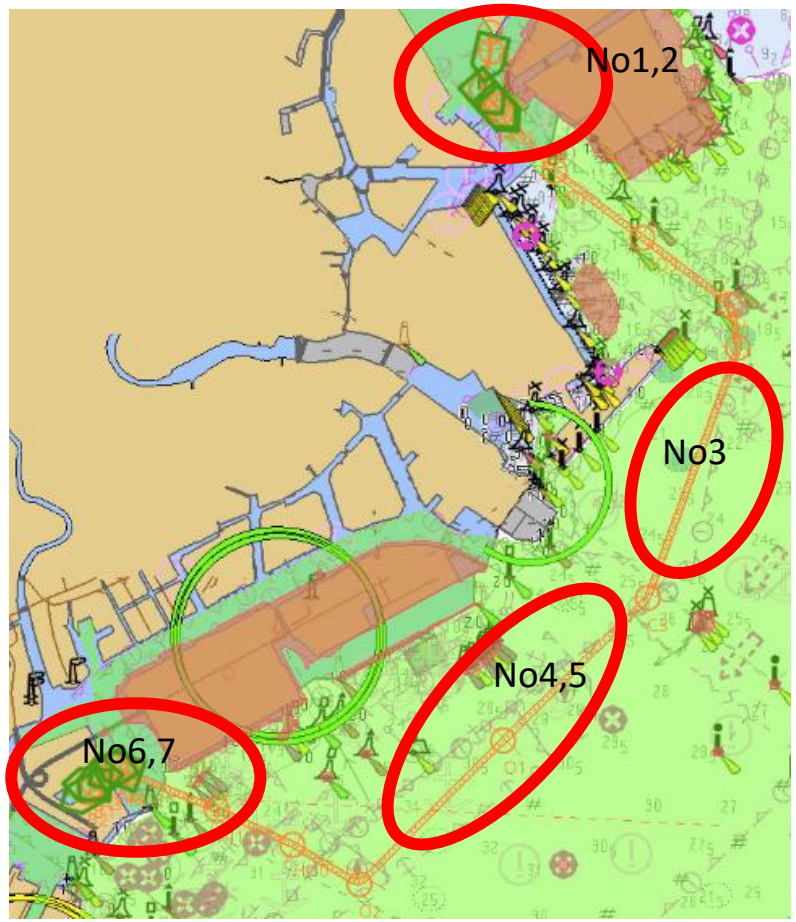


- ✓ Autonomous navigation statuses:
  - ☐ Fully Autonomous
  - ☐ Monitoring (by navigation officer)
  - ☐ (normal) Track Control
  - ☐ Manual operation.
- ✓ Control structure changes depend on navigation status, layer of control task, short- or long-term voyage planning, navigation mode, etc. To run risk assessment and to extract loss scenario, each case need to be considered.



Modified based on Ref) T. Nakashima, et. al, Addressing systemic risks in autonomous maritime navigation: A structured STPA and ODD-based methodology, Reliability Engineering & System Safety, Volume 261, September 2025

Simulation test scenarios – virtual voyage for HIL test



1. Preparation for navigation
    1. Route transfer from shore
    2. Thruster preparation, offshore route optimization, route monitoring, etc.
2. Maneuvering away from shore
    1. MMS operation
    2. Autonomous navigation start
    3. DTC control Engine/navigation coordination (automatic thruster shutdown)
3. Evasive maneuvers
    1. Normal avoidance (FA/MA)
    2. Fallback
4. Abnormal occurrence
    1. APU stop (equipment running TCS)
    2. 1 GPS unit stopped → 2 GPS units stopped → MRM/MRC operation
5. ODD
    1. EODD over (wind/waves/currents)
    2. Passage of watch area
6. Shore arrival operation
    1. Engine/navigation coordination (automatic thruster start)
    2. Automatic application of berthing route
    3. DTC berthing (including End Of Track control)
    4. End of autonomous navigation → MMS maneuvering
7. Completion of navigation

Roadmap for the goal-based MASS code and EBP

SESSIONS OF MSC	WORK PLAN
MSC 110 (June 2025)	- 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)	- **Further develop the non-mandatory MASS Code**
MSC 111 (May 2026)	- 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)	- Develop a framework for an Experience-building phase (EBP) post adoption of the non-mandatory MASS Code
MSC 1XX (2028)	- **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	- Adoption of the mandatory Code (latest 1 July 2030 for entry into force on 1 Jan 2032)

Ref) IMO MSC 10/WP.8, Annex 2, Page 1, 5 December 2024

- 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.

✓ To improve technology, education, process and organization for coming the MASS mandatory code

✓ To share experiences with IMO MSC and other stakeholders to proceed implementation of autonomy in shipping.

Summary

- In MEGURI2040 Stage 1, we successfully completed a demonstration voyage of DFFAS in 2022 and are currently advancing the DFFAS+ project as Stage 2 for demonstration in this year.

- The DFFAS+ project aims to introduce autonomous navigation systems into shipping and is currently preparing for several months long demonstration in commercial services.

- The DFFAS+ project employs a new risk analysis method STPA based on system control structure and analyze loss scenario that failure potentials lead to accidents. Simulation tests, onboard tests and monitoring after delivery will be conducted based on the analyzed failure potentials.

- Going forward, we believe it is essential to transparently and openly share with legal experts the types of errors that developers anticipate during system development, in order to advance the realization of a safer autonomous system in shipping.