Japanese MASS R&D Projects and Approaches for Ensuring Safety

National Maritime Research Institute (NMRI),
National Institute of Maritime, Port and Aviation Technology (MPAT)
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MLIT Ministry of Land, Infrastructure, Transport and Tourism
JSTRA 一般財団法人 日本船舶技術研究協会 JAPAN SHIP TECHNOLOGY RESEARCH ASSOCIATION
MPAT 国立研究開発法人 海上・港湾・航空技術研究所 海上技術安全研究所 National Maritime Research Institute NMRI
無人運航船プロジェクト MEGURI 2040
日本財団 THE NIPPON FOUNDATION

Trials for the development of MASS

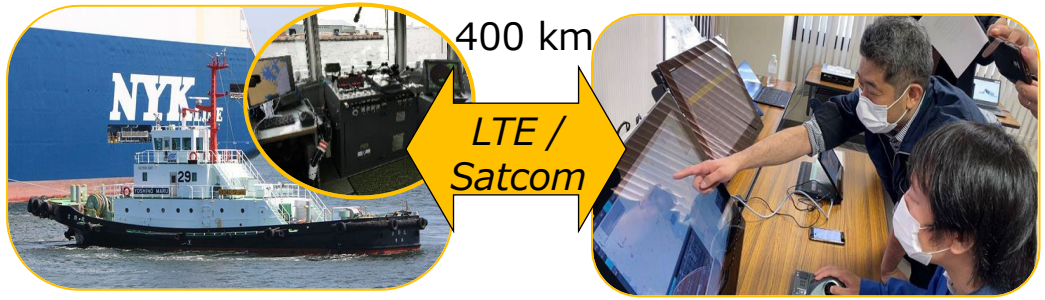
MLIT Ministry of Land, Infrastructure, Transport and Tourism

- Since 2018, MLIT has conducted the **first MASS trials in Japan**.
  - In 2018 : **simulation testing** to collect data for safety validation
  - In 2019 : checking simulation data against the **actual ship testing** data
  - In 2020 : development of **safety guidelines for MASS design**, as well as actual ship testing

Autonomous Operation Function

<Players>
Oshima Shipbuilding Co.,Ltd.
MHI Marine Engineering, Ltd.

Remote Control Function



<Players>
MTI Co.,Ltd., ClassNK, BEMAC Corp. etc.

Auto Berthing & Un-Berthing Function

<Players>
Mitsui E&S Shipbuilding Co., Ltd, Tokyo University of Marine Science and Technology, etc.

Realizing phase-II* MASS by 2025

*generally corresponding to the Degree 1 MASS

MEGURI 2040 Fully Autonomous Ship Program

- Demonstration tests of fully autonomous navigation for coastal shipping
- Promote innovation in Japan's logistics, economy and social platforms

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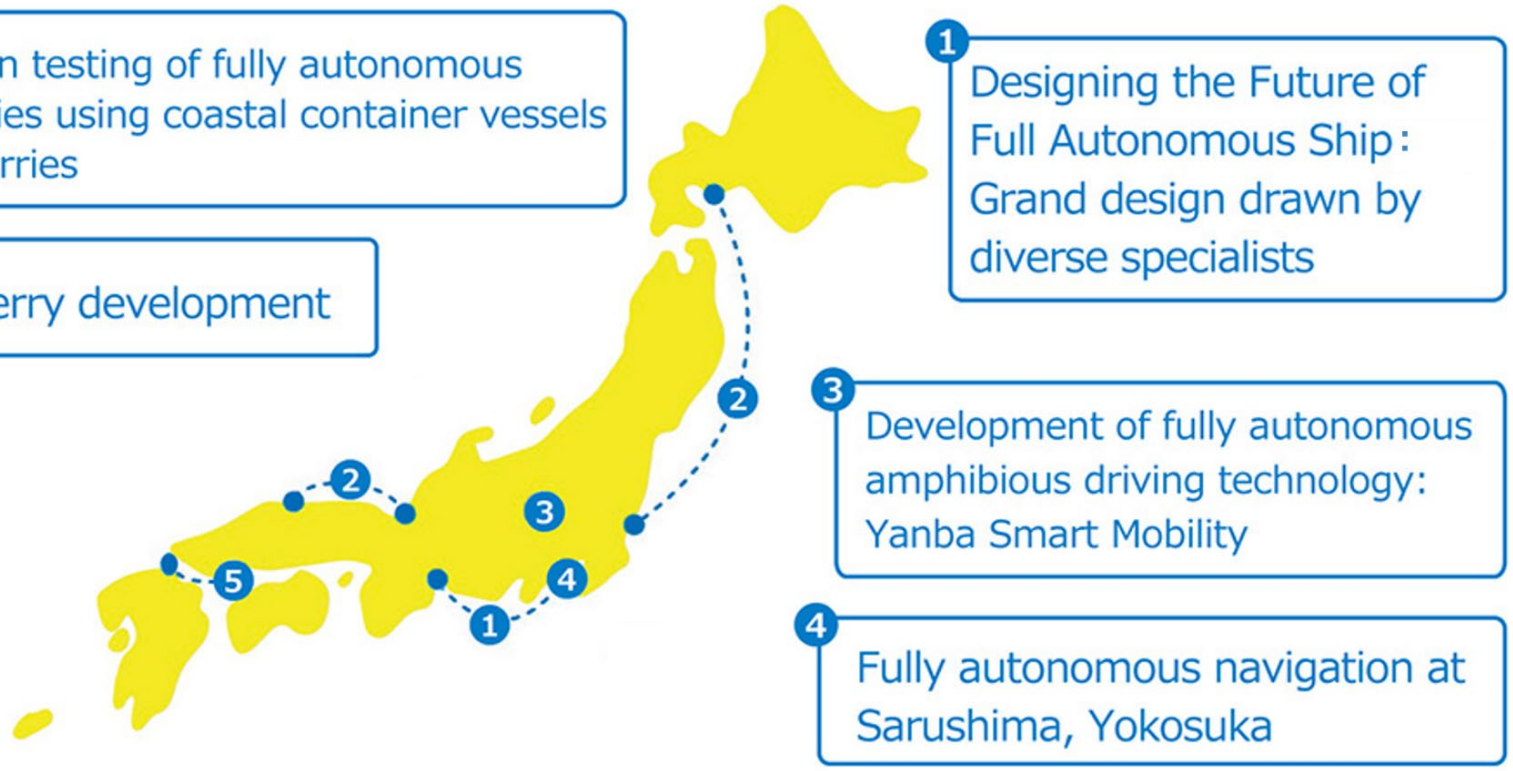


https://www.nippon-foundation.or.jp/en/what/projects/meguri2040

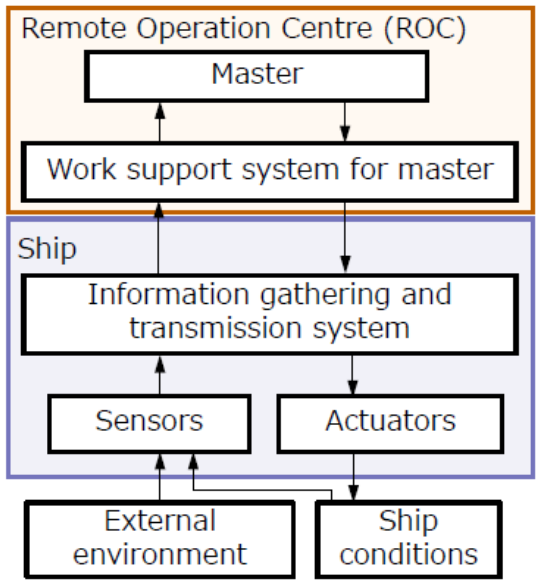
MEGURI 2040 Fully Autonomous Ship Program

① Designing the Future of Full Autonomous Ship (DFFAS): Grand design drawn by diverse specialists	Autonomous navigation in a congested sea area (roughly 500 ships pass each day), using a container ship "SUZAKU“.	
② Verification testing of fully autonomous technologies using coastal container vessels and car ferries	Autonomous navigation under rough weather and sea condition together with mooring operations by a drone, using a container ship "Mikage“.	
	Autonomous navigation in long distance of 750 km over about 18 hours, using a large car ferry "Sunflower Shiretoko“.	
④ Fully autonomous navigation at Sarushima, Yokosuka	Autonomous navigation (automated navigation from departure to berthing), using small passenger ship "Sea Friend ZERO“.	
⑤ Smart ferry development	Autonomous port berthing and unberthing using turning and reversing maneuver as well as autonomous navigation under high-speed (up to 26 knots), using a large car ferry "SOLEIL“.	

Risk Assessment for MASS Trials

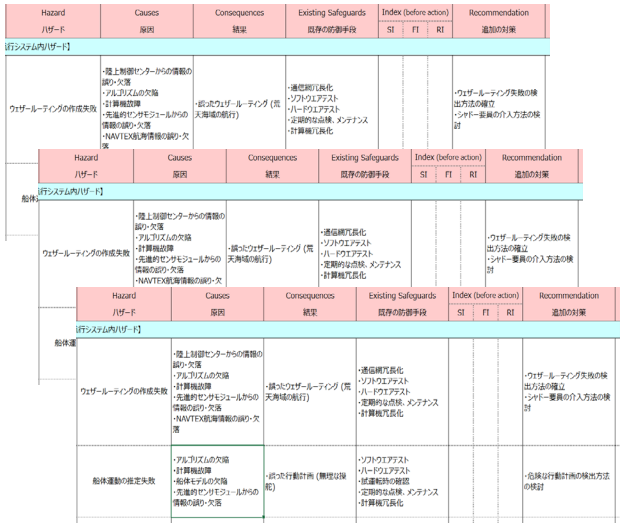
- Interim guidelines for MASS trials (MSC.1/Circ.1604) requires risk assessment prior to MASS trials.
- Specific methods or procedures of risk assessment for MASS trials are not prescribed in those guidelines.
- **NMRI supported each consortium to conduct risk assessment to ensure safety of MASS trails in MEGURI 2040 Program.**

System Modeling



Conceptual Structure of a MASS

Hazard Identification (HAZID)



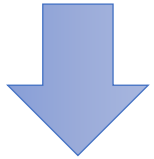
HAZID Worksheet

HAZID meeting

Ishimura et al. (2022) Risk Analysis for the Unmanned Navigation Trial of a Short-Range Small Tourism Boat, Conf. Proc. JASNAOE, Vol.34. pp.179-180, [In Japanese]
Itoh et al. (2021) Risk Assessment of Autonomous Ship Systems, pp.11-23, ClassNK Technical Journal No.4, 2021(II)

Risk Analysis Procedure Document

- Outcome of NMRI's supporting works for risk assessment
  - Ensuring safety of MASS trials
  - Improving safety of autonomous ship systems



Knowledge from the works

- NMRI developed a Procedure Document for Risk Analysis on Autonomous Ships.
- It has been referred to in Safety Guidelines for MASS published by MLIT.
- It will contribute to reduce a burden on developers and certifiers, and facilitate MASS R&D and commercialization.

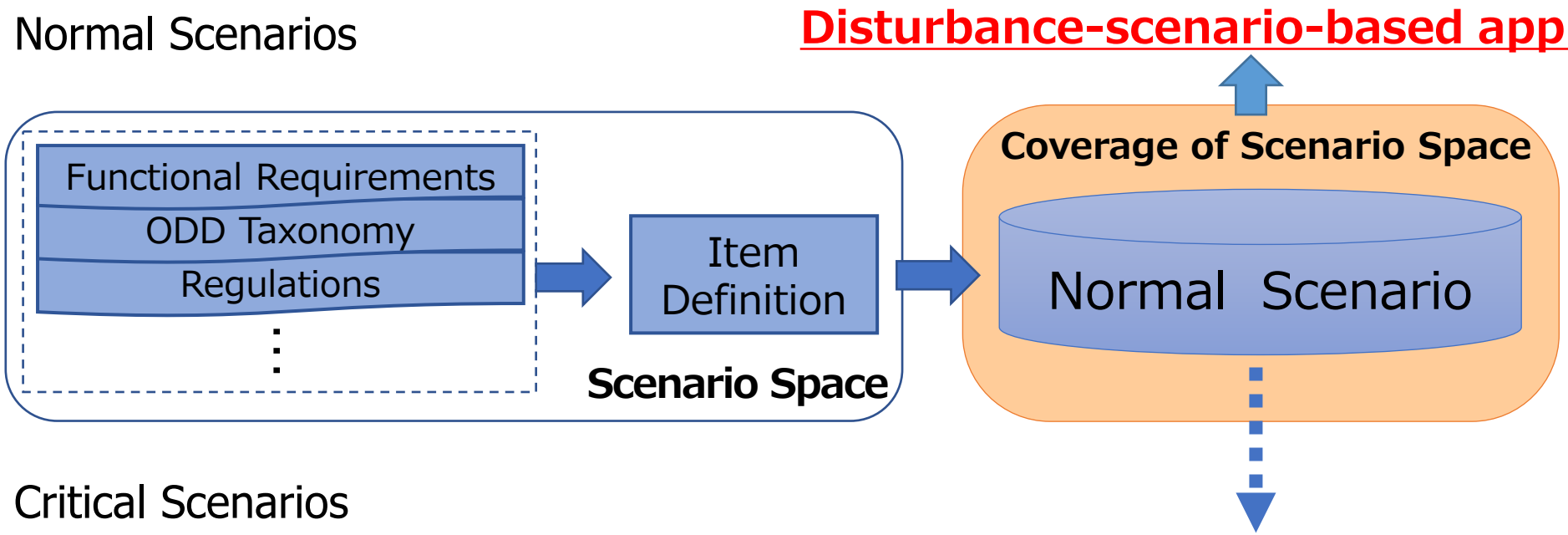
Examples of types of hazards presented in the Procedure Document

Classifi-cation	Types of hazards
External conditions	• Rough weather
	• Poor visibility
	• Congested sea area
	• Unexpected behavior of other ships
Failure of automated system or related system	• Loss of signals from sensors
	• Disorder of hardware of automated system
	• Bugs of software of automated system
	• Loss of power in automated system or related system
	• Inappropriate HMI

Yuzui et al. (2022) Development of a Procedure Document for Risk Analysis on Autonomous Ships, Conf. Proc. JASNAOE, Vol.34. pp.193-194, [In Japanese]

Safety Evaluation Method using Simulation

- NMRI decided to use a scenario-based approach to ensure comprehensiveness of test scenarios.
- Scenario Creation
  - Normal Scenarios

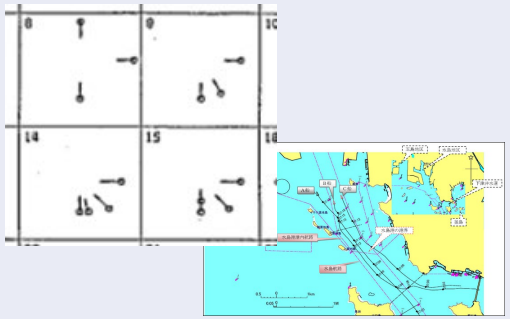
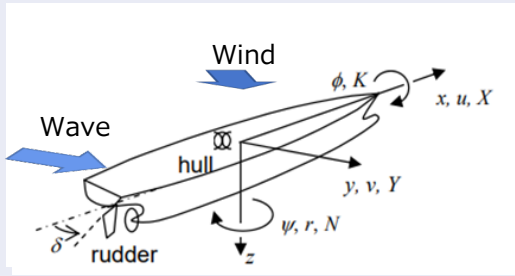


  - Critical Scenarios

    There are
    - critical risk factors derived from maneuvering among the normal scenarios.
    - system-derived critical risk factors such as failures, malfunctions.
    - emergency measures such as fallbacks.

Disturbance-scenario-based approach

- NMRI proposed a method for making disturbance scenarios considering the sub-tasks of navigation tasks.
- Each navigation task is decomposed into perception, judgement, and control sub-tasks, and scenarios are created based on the disturbances corresponding to each subtask.

Sub-tasks	Perception	Judgment	Control
Disturbance	Perception disturbance	Traffic disturbance	Ship motion disturbance
	Sensors : radar, camera, GPS, etc. 	Encounter situation, geographical conditions and the behavior of other ships etc. 	Mechanical disturbances acting on the hull due to weather, sea conditions, loading conditions, etc. 

Safety Guidelines for MASS

MLIT Ministry of Land, Infrastructure, Transport and Tourism

- In February 2022, MLIT has compiled points to consider at designing, installing and operation phases of MASS and published ***Safety Guidelines for MASS***

Example of contents of the guidelines

■ **Points to consider at the designing phase of MASS**

1. Defining Operational Design Domain (ODD)
2. Human Machine Interface (HMI) settings
3. Smooth transition measures for crews to maneuver in the event of Automated Operation System (AOS) failure
4. Installing of recording devices
5. Ensuring cyber security
6. Ensuring an operating environment to perform the evasion and auto (un-)berthing function
7. Ensuring an operating environment to perform remote control function
8. Identification of important parameters of AOS
9. Conducting risk assessment
10. Preparation of manuals, etc. for AOS
11. Prompt notification and response when AOS malfunctions are discovered

Safety Study WG for MASS

Chair: Prof. Hayama IMAZU
Professor emeritus, Tokyo University of Marine Science and Technology (TUMST)

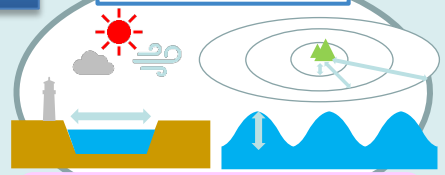
Member:

- TUMST
- Nihon University
- NMRI
- Class NK
- Japan Agency of Maritime Education and Training for Seafarers
- Japan Captains' Association
- Japan Marine Engineers' Association

Overview of the points to consider for MASS

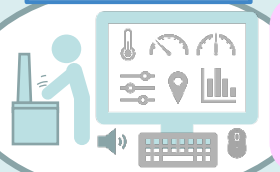
Design

Defining ODD



It is necessary to define an ODD for each AOS in accordance with the performance and usage of the individual MASS or AOS

HMI setting

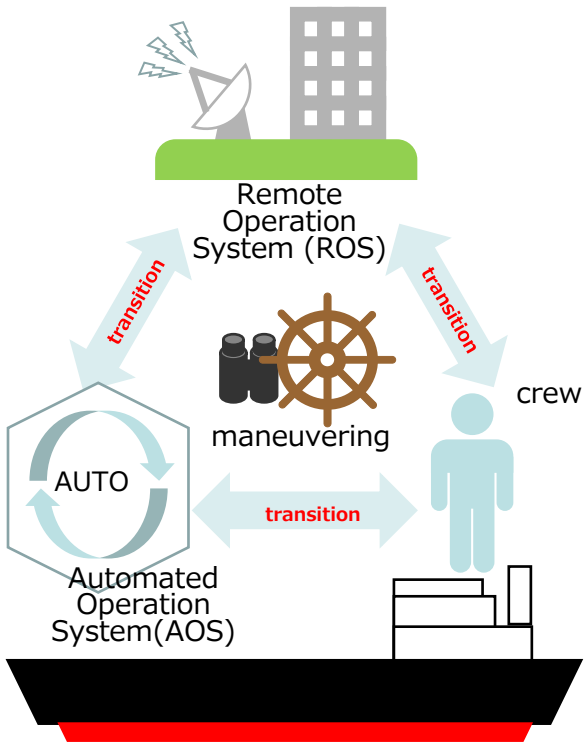


It is necessary to have a function to enable crews to easily and reliably recognize information about judgements made by the AOS

Ensuring cyber security

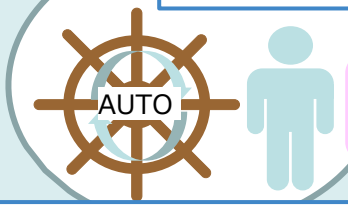
It is necessary to prevent unauthorized access to the AOS from outside, unauthorized communications shall be blocked by firewalls or other means

Compliance to laws and regulations



Operation

Implementation of appropriate ship maneuvering using AOS

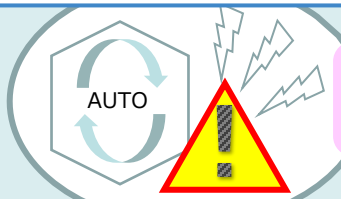


Crews who are proficient in the operation of the AOS must be properly assigned

Maintenance management of AOS

It is necessary to properly manage the version of the AOS, and to confirm that interoperability with the info collection devices etc., is not impaired when the version is changed

Prevention of misuse of AOS during operation



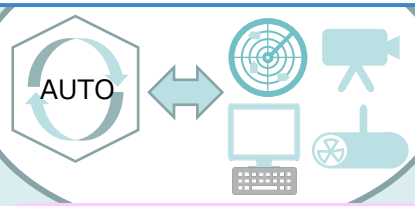
Important operations should be performed by crew members who are proficient in handling the AOS

Installation

Documents to be provided for MASS

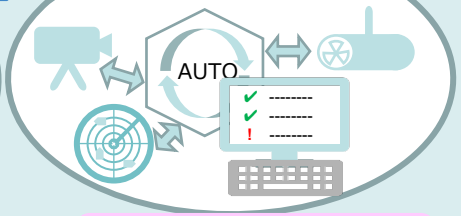
AOS manuals should be kept in a location that is easily accessible for review by the crews using the AOS

Ensuring cooperation between AOS and other equipment and facilities



It shall be confirmed through connection tests, etc., that the equipment and devices that make up the AOS are properly connected

Implementation of system integration tests on board



The soundness of the relevant system, etc., shall be confirmed by actually operating the AOS

Conclusions

- This presentation introduced Japanese MASS R&D Projects and Approaches for ensuring safety.
  - Trials for the development of MASS by MLIT
  - MEGURI 2040 Fully Autonomous Ship Program by the Nippon Foundation
  - Risk assessment prior to demonstration tests by NMRI
  - Scenario-based Safety evaluation method with simulators by NMRI
- **Japan would like to continue to contribute to development of IMO regulations including the MASS Code to ensure safety of MASS.**

Thank you for your attention!

This presentation is prepared in cooperation with the following organizations.

- Ministry of Land, Infrastructure, Transportation and Tourism (MLIT)
- The Nippon Foundation MEGURI2040
- Japan Ship Technology Research Association (JSTRA)
- Autonomous Ship Project Team in National Maritime Research Institute (NMRI)