MEGURI 2040
Safety Assessment Seminar
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Presentation 5:
Study on Competency Requirements for Remote Operators of MASS

5.2 Monitoring of One Vessel

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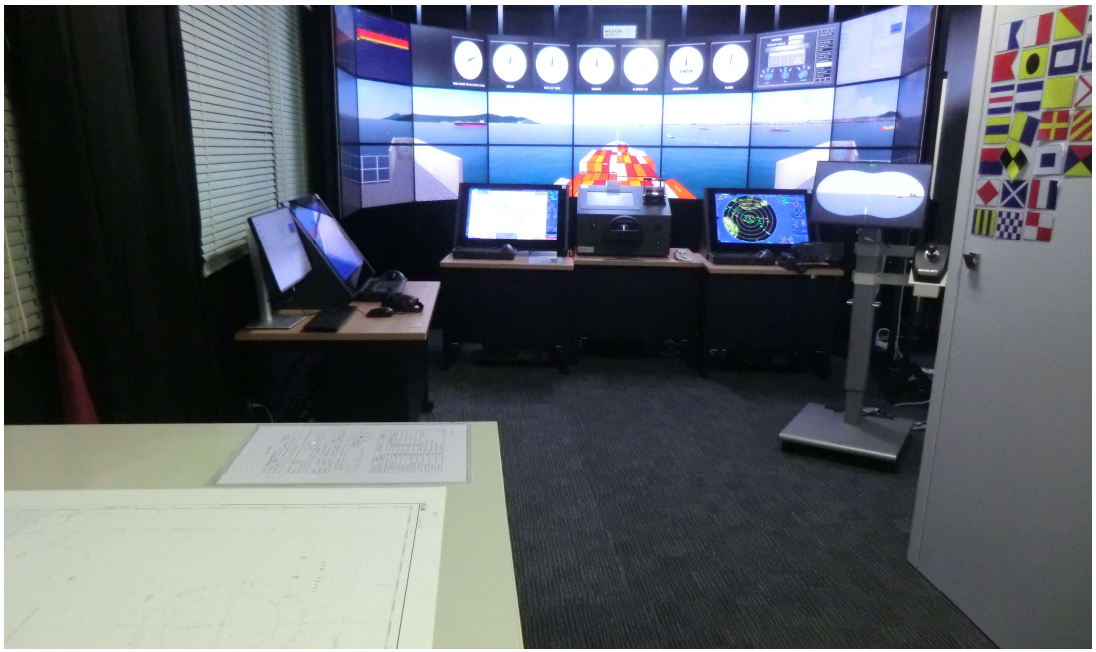


Objective

◻ Background

Labor shortages have become a major challenge in Japan. Autonomous navigation technologies and unmanned ships are expected to provide a solution, and demonstration projects supported by the Nippon Foundation are accelerating their practical implementation. To support the safe deployment of unmanned vessels, JMETS developed a training facility that simulates a Remote Operation Center (ROC) as part of the project conducted from 2023 to 2025.

◻ Objective

To identify the competency requirements of remote operators for collision avoidance in MASS and to develop a training method using an ROC simulator. This experiment focuses on ROC operations and data communications related to collision avoidance.

As remote operators are not yet in service, this study explores the competencies required for their acceptance by the maritime industry.

Assumptions

◻ Remote Operator Allocation and Roles in the ROC

Status	Role of ANS	Role of RO	Remote crewing	Bridge Watch (700 gross tonnes and over)
FA (Full Autonomous)	Delegate everything to the system	Monitoring Navigation (Under the status degraded until two-bridge-crew is established)	Level 1 or above: 1 person Level 2: 1 person **Under status degraded until 2 bridge crew, 2 onshore**	B0

◻ Roles undertaken by remote operators (shore-based personnel)

Level 1: Monitoring and Navigation Assistance

- Appropriate watchkeeping of the vessel and the surrounding conditions
- Detect signs of danger, and report the details with Level 2 and the crew on board
- Perform remote steering operations based on instructions from Level 2

Level 2: Navigation Decision-Making and Evasive Manoeuvres

- Maintain a safe watchkeeping with Level 1 and the crew on board
- Determine when to initiate evasive manoeuvres
- Execute appropriate evasive manoeuvres in a remote operating environment

Assumptions

□ Configuration of the Remote Monitoring and Operation Center

Item	Description
Geographical Area	Coastal waters excluding areas governed by the Maritime Traffic Safety Act and Port Regulations Act
Navigation Conditions	Daytime operation with visibility of at least 10 nautical miles
Weather Conditions	Wave height ≤ 2 m; wind speed ≤ 5 m/s
Communication Conditions	Continuous connection between the vessel and the shore-based Remote Operation Center (ROC)
Vessel Type	Container ship operating on a regular route
Traffic Conditions	Detection of surrounding vessels by AIS and ARPA; scenario based on the baseline experiment established in 2023
Collision Avoidance	Assumes implementation of an Autonomous Navigation System (**ANS**) capable of partially autonomous operation. At least one certified person is on board, and ultimate responsibility remains with onboard personnel.
Control Authority	Priority of control authority for steering and propulsion: **ANS < RC < On-board**
Communication Failure	Communication interruption limited to a maximum of 2 seconds

Early collision avoidance maneuvers are required, and hazardous maneuvers are prohibited.

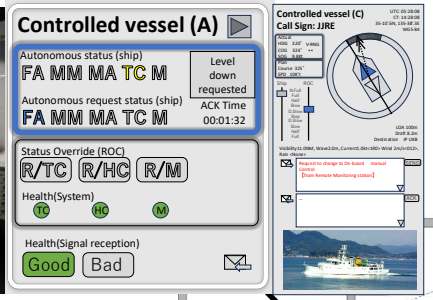
Human operator takes control in case of system failure or safety domain violation

ANS Alert	Description
Approach of another vessel	When another vessel is present whose **CPA** is less than the prescribed threshold (**ahead: 6.4L or 0.7 NM; port, starboard, and astern: 1.4L or 0.2 NM**) and whose **TCPA** is less than the prescribed threshold (**12 min**), the status is downgraded to **TC** or below.

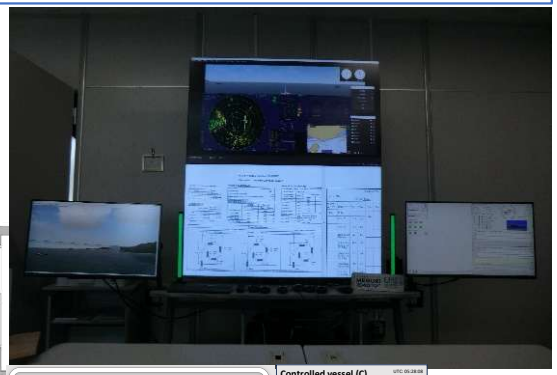
Experimental Setup

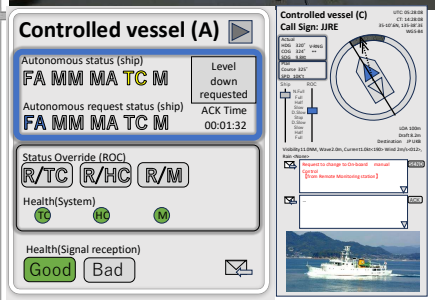
ROCsim

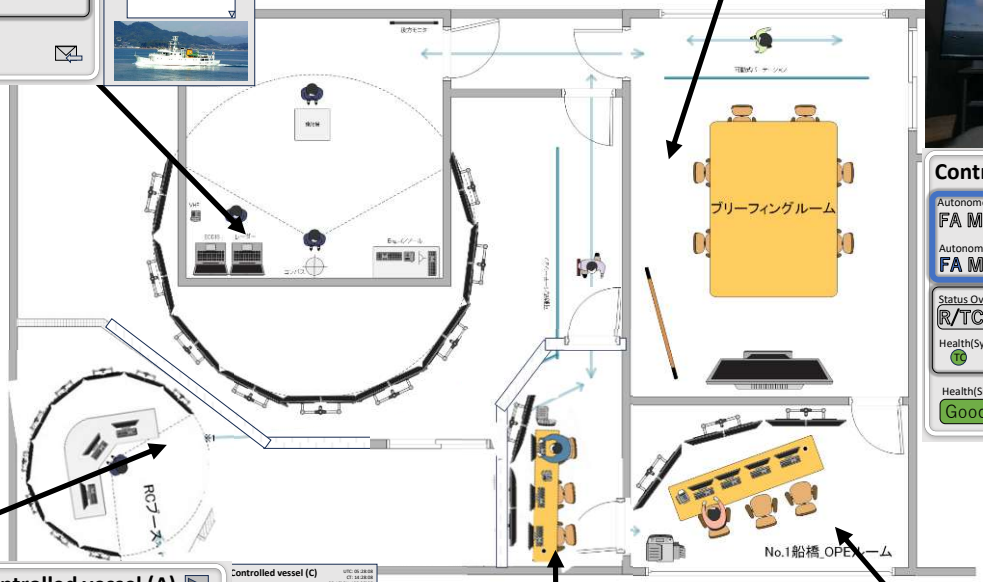
Onboard Ship Handling Station (SH St.)



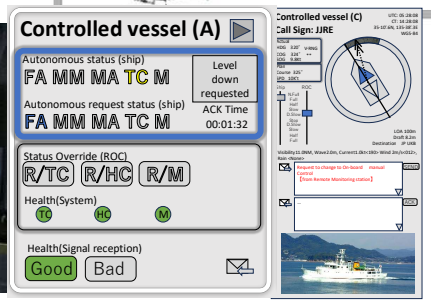
Remote Monitoring Station (RM St.)







Remote Control Bridge Station (RC St.)



RC Staff Booth

SH Staff Booth

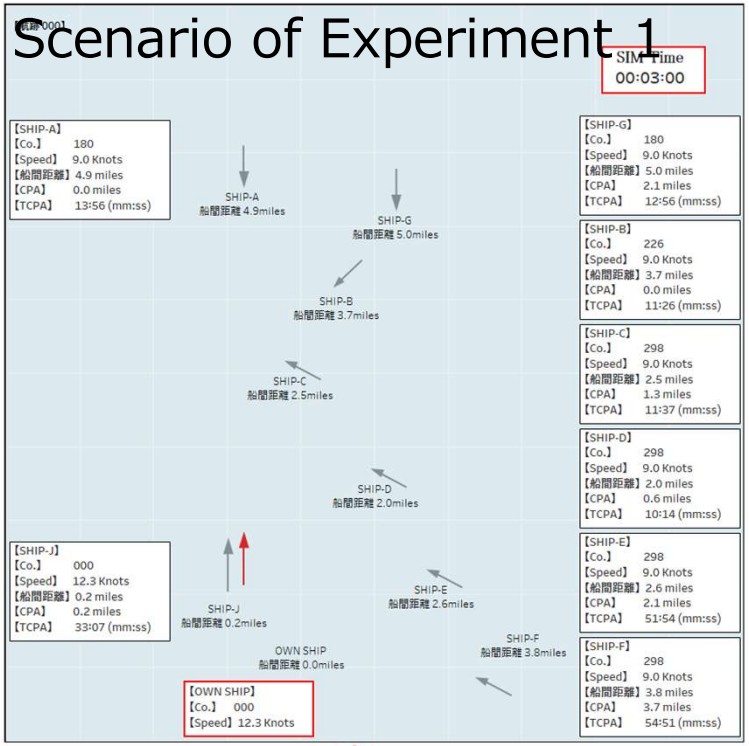
Method

Participants

- Hold a valid deck officer's certificate of competency
- Have at least one year of seagoing experience after obtaining the certificate
- Experiments conducted in pairs (two participants per session)

Position	Seagoing Experience	Age	Background
Pilot	10+ years	Early 50s	Merchant Vessel
Captain	10+ years	60s+	Merchant Vessel
Captain	10+ years	60s+	Merchant Vessel
Captain	10+ years	60s+	Merchant Vessel
Captain	5–10 years	60s+	Merchant Vessel
Captain	10+ years	60s+	Training Vessel
Captain	10+ years	60s+	Training Vessel
Captain	10+ years	Early 50s	Training Vessel
Captain	10+ years	Late 40s	Training Vessel
Captain	5–10 years	Late 40s	Training Vessel
Chief Officer	10+ years	Early 40s	Training Vessel
Second Officer	2–5 years	Early 40s	Merchant Vessel
Second Officer	2–5 years	Early 30s	Training Vessel
Third Officer	2–5 years	Early 50s	Merchant Vessel
Third Officer	2–5 years	Late 20s	Training Vessel
Third Officer	2–5 years	Late 20s	Training Vessel

Scenario of Experiment 1



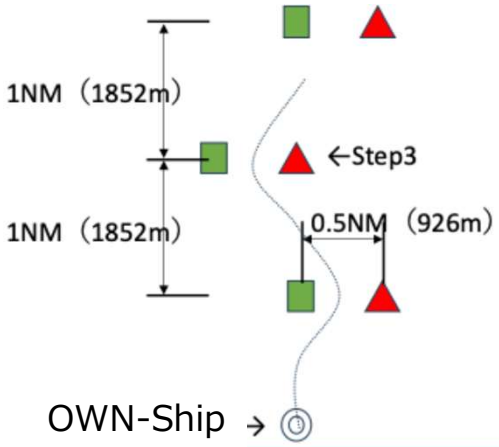
Method

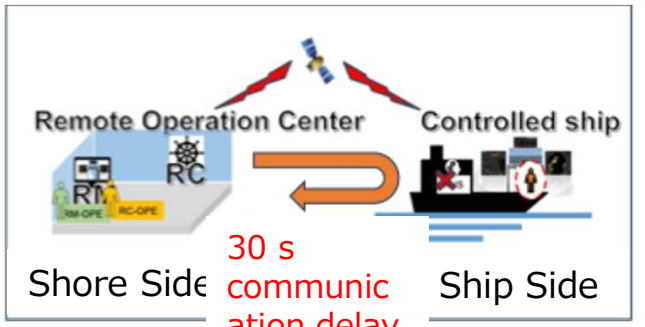
□ Experiment 1

Participants experienced a complete remote monitoring and collision-avoidance operation using ROCsim under scenarios requiring evasive maneuvering.

□ Experiment 2

Experience of remote ship handling under communication delays using ROCsim





After each experiment, participants completed a subjective questionnaire(Table 1) on the skills required for remote collision-avoidance operations. The questionnaire was developed based on relevant competencies in STCW Table A-II/1, previous experimental findings, and a literature review.

Method

Competence	Knowledge Understanding Proficiency(KUP)	Correspondence Analysis Label	item	Level1	Level2
Understanding of the manoeuvrability of the monitored MASS	**Knowledge of ship manoeuvring and handling in accordance with STCW Regulation II/1 (effects of rudder and propeller, stopping distance, turning circle, squat, shallow-water effects, wind, waves, current, ship interaction, bank effect, slow-speed operation, and propulsion characteristics)**		1_1	Lv1	Lv2
	Ability to alter course, maintain course, and adjust speed from the ROC taking into account the manoeuvrability of the monitored MASS	Remote manoeuvring considering ship manoeuvring performance	1_2	—	Lv2
Understanding of voyage planning, navigation, and position fixing of the monitored MASS	**Competence to plan and conduct a passage and determine position in accordance with STCW Table A-II/1**		2_1	Lv1	Lv2
	Ability to confirm the voyage plan of the monitored MASS	Confirmation of the voyage plan	2_2	Lv1	Lv2
	Ability to confirm vessel particulars and navigational information	Confirmation of vessel particulars and navigational information	2_3	Lv1	Lv2
	Ability to confirm meteorological and oceanographic information relevant to the monitored MASS	Confirmation of meteorological and oceanographic information	2_4	Lv1	Lv2
	Ability to verify the accuracy of information through communication with onboard personnel	Verification of meteorological information	2_5	Lv1	Lv2
Understanding of the status of control authority of the monitored MASS	**Ability to confirm the location of control authority for steering and propulsion**	Confirmation of the status of control authority	3_1	Lv1	Lv2
	Ability to confirm the automation level of the autonomous navigation system	Confirmation of the automation level	3_2	Lv1	—
Understanding that the monitored MASS maintains a safe navigational watch	**Competence to maintain a safe navigational watch in accordance with STCW Table A-II/1**		4_1	Lv1	Lv2
	Ability to respond appropriately to alerts generated by the autonomous navigation system	Response to ANS alerts	4_2	Lv1	Lv2
	Ability to share information necessary to maintain a safe navigational watch between the MASS and the ROC	Collection and sharing of external information	4_3	Lv1	Lv2
	Ability to supplement visual camera images with radar and AIS information	Supplementing visual information with radar and AIS	4_4	Lv1	—
	Ability to determine and execute the initiation of remote manoeuvring when safe watchkeeping cannot be maintained	Determination and execution of remote manoeuvring	4_5	—	Lv2
Understanding of radar and ARPA information for safe navigation	**Competence to use radar and ARPA to maintain safety of navigation in accordance with STCW Table A-II/1**		5_1	Lv1	Lv2
	Ability to operate ROC equipment displaying radar information and surrounding target information including CPA	Confirmation of CPA and target information by radar	5_2	Lv1	Lv2
	Ability to verify the accuracy of radar information through communication with onboard personnel	Verification of radar information	5_3	Lv1	Lv2
	Ability to interpret and utilize radar information on surrounding targets	Utilization of radar information	5_4	—	Lv2
Understanding of ECDIS information for safe navigation	**Competence to use ECDIS to maintain safety of navigation in accordance with STCW Table A-II/1**		6_1	Lv1	Lv2
	Ability to operate ROC equipment displaying ECDIS information equivalent to that onboard the MASS	ECDIS operation	6_2	Lv1	Lv2
	Ability to confirm chart information including depth and navigational hazards using ECDIS	Confirmation of depth and navigational hazards using ECDIS	6_3	Lv1	—
	Ability to verify the accuracy of ECDIS information through communication with onboard personnel	Verification of ECDIS information	6_4	Lv1	Lv2
	Ability to interpret and utilize ECDIS information	Utilization of ECDIS information	6_5	—	Lv2
Understanding of Alert Management System (AMS) information, including BNWAS, for safe navigation	**Ability to operate ROC equipment displaying AMS information equivalent to that onboard the MASS**	AMS operation	7_1	Lv1	Lv2
	Ability to confirm alerts (Alert/Warning/Caution) generated onboard the MASS	Confirmation of AMS alerts	7_2	Lv1	Lv2
	Ability to verify the accuracy of AMS alerts through communication with onboard personnel	Verification of AMS alerts	7_3	Lv1	Lv2
Understanding of ship-shore communication	**Ability to receive text messages from the monitored MASS**		8_1	ALL	
	Ability to send text messages to the monitored MASS		8_2	ALL	
	Ability to communicate by voice		8_3	ALL	
	Ability to identify communication failures		8_4	ALL	

Table 1. Minimum competencies required for ROs in understanding remote operation centers and data communications for collision-avoidance operations

☐ Identification of Unnecessary Items

The necessity of each item was evaluated using a 7-point Likert scale.

☐ Identification of Missing Items

Additional required skills were collected through open-ended responses.

☐ Classification of Item Characteristics

Each item was classified according to Katz's Three-Skill Approach:

- **T (Technical Skill):** Job-related and operational skills
- **H (Human Skill):** Interpersonal and communication skills
- **C (Conceptual Skill):** Analytical and conceptual abilities

Results—Identification of Unnecessary Items

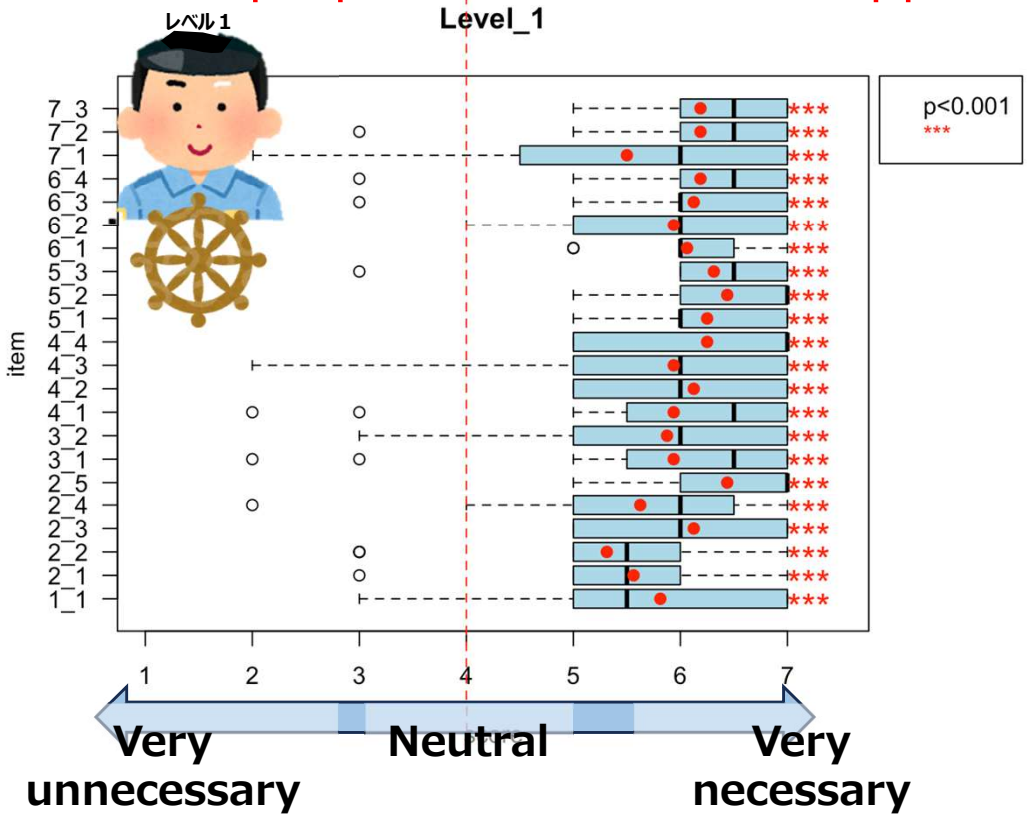
☐ Necessity Analysis (7-point Likert Scale)

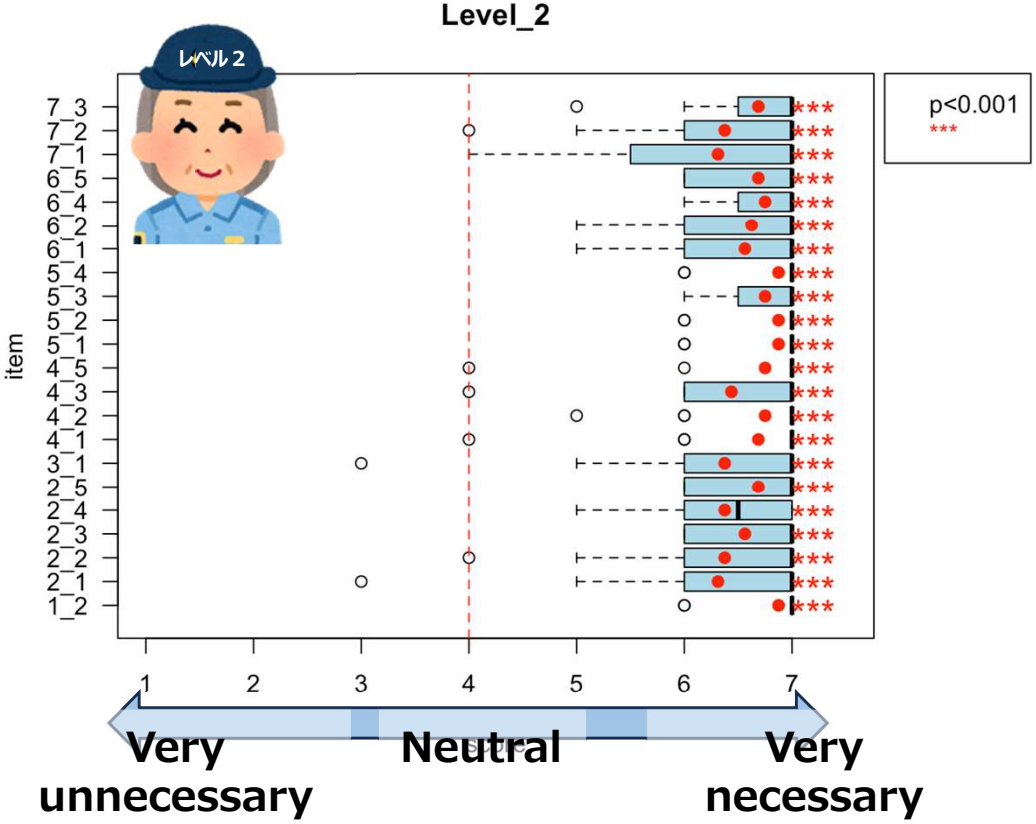
One-sample one-tailed t-test

- H_0: $\mu = 4$ (Neutral)
- H_1: $\mu > 4$ (Necessary)

☐ Results

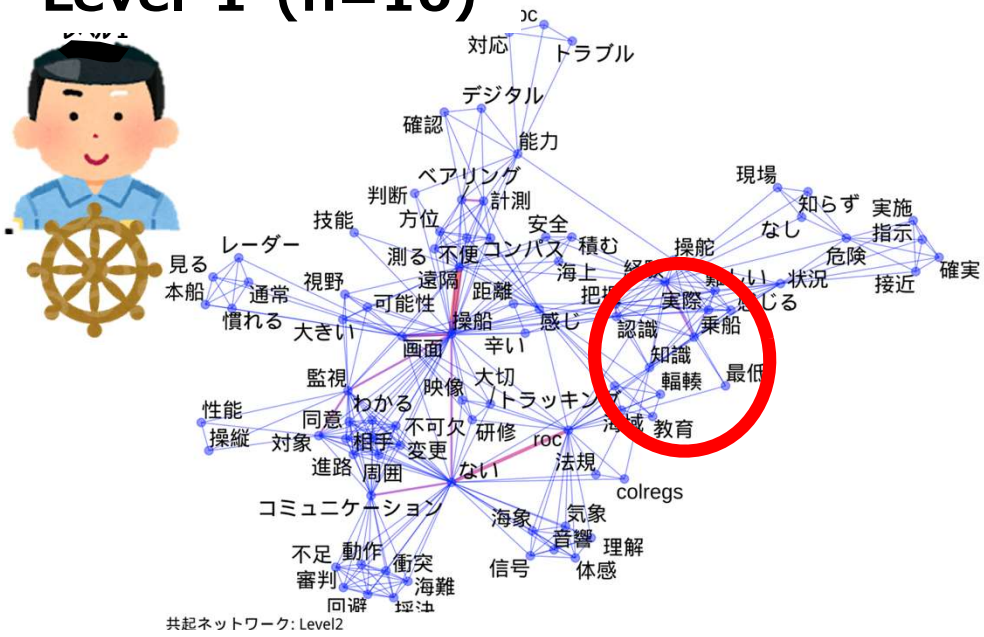
- All items were significantly greater than 4 ($p < 0.05$).
- All proposed items were supported as necessary.



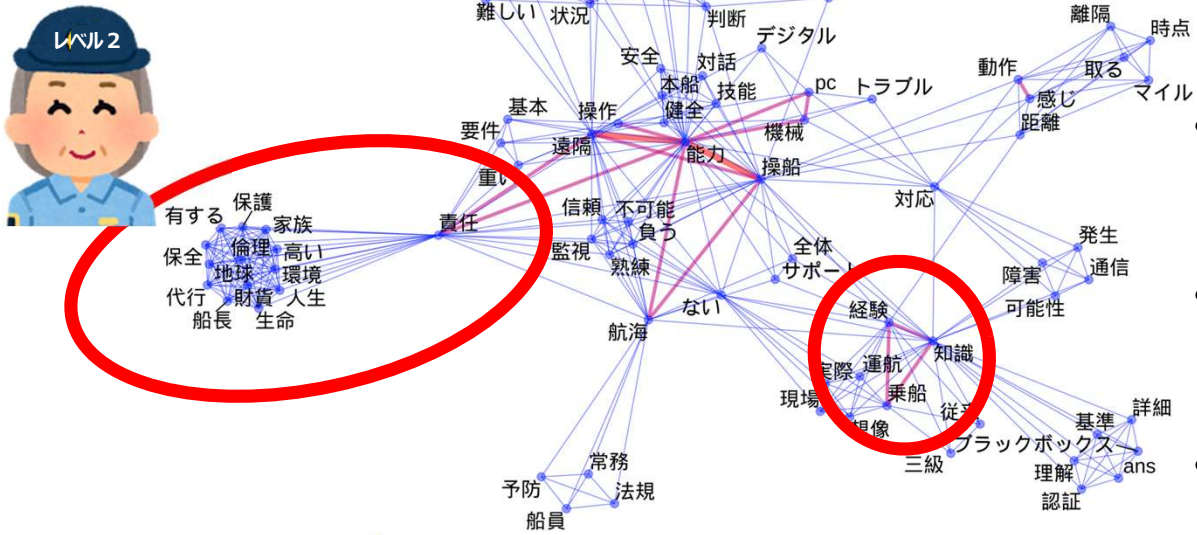


Results−Identification of Missing Items

Level 1 (n=16)



Level 2 (n=16)



□ Co-occurrence Network Analysis

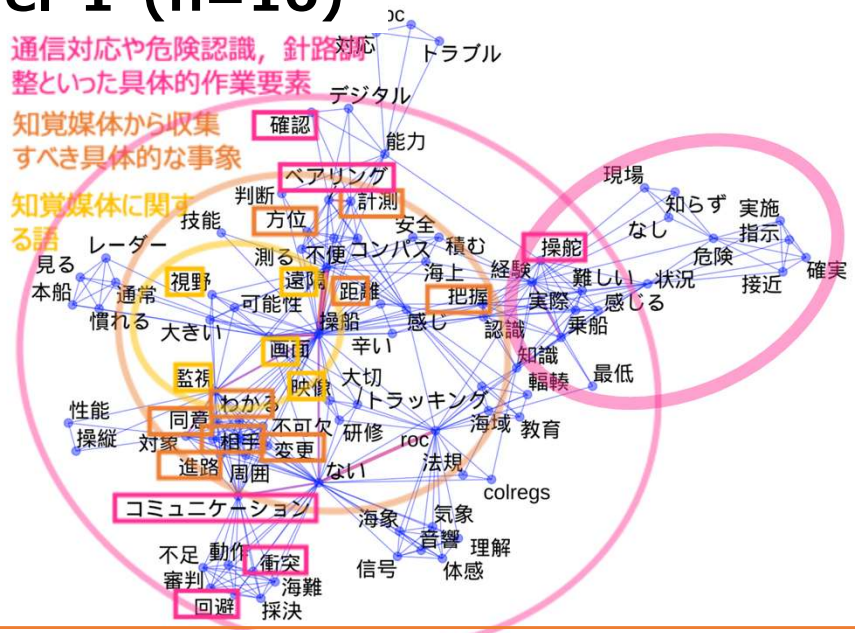
- Visualized relationships among words using a network of nodes and edges.
- Thicker (red) links indicate stronger co-occurrence.
- Interpretations were based on the consensus of six certified deck officers.

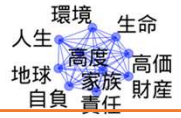
□ Key Findings

- Both Level 1 and Level 2 emphasized the importance of onboard experience.
- Participants highlighted the need for situation awareness in remote operation environments.
- Ethical awareness and responsibility derived from onboard experience were considered important.
- These qualities were regarded as core competency requirements, particularly at Level 2.

Results−Identification of Missing Items

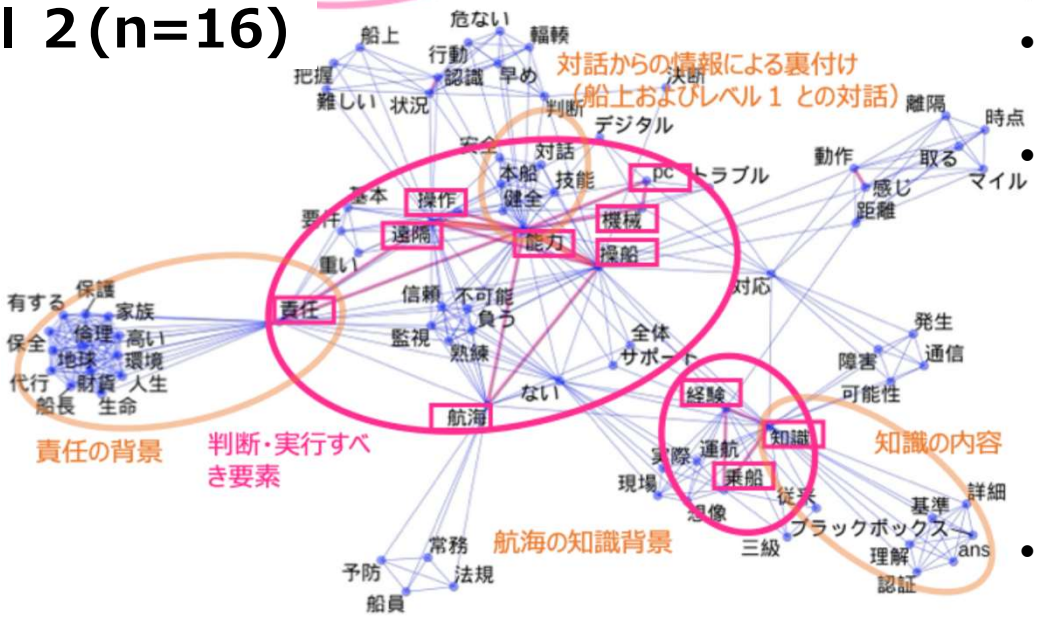
Level 1 (n=16)





- Co-occurrence relationships were distributed across multiple terms.
- Three word groups were identified:
  - Information sources (*from what*)
  - Information to be collected (*what*)
  - Operational actions (*how*)
- Lack of onboard experience was recognized as a risk factor in ship handling.

Level 2 (n=16)



- A highly concentrated co-occurrence structure was observed.
- Core elements:
  - Information obtained through communication
  - Onboard experience and ANS knowledge
  - Maritime regulations and responsibility
- The ability to integrate these elements and execute ship handling was considered essential.

Results–Classification of Item Characteristics

Level 1 (n=16)

◻ Correspondence Analysis

Visualized the relationships between items and the T/H/C classifications.

- Most items were located near Human Skills (H) and Technical Skills (T).

◻ k-Means Clustering

Clustered items based on distance similarity.

- Two distinct clusters were identified.

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	Ability to respond appropriately to alerts generated by the autonomous navigation system	Response to ANS alerts	4_2	Lv1	Lv2
	Ability to share information necessary to maintain a safe navigational watch between the MASS and the ROC	Collection and sharing of external information	4_3	Lv1	Lv2
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	Ability to confirm chart information including depth and navigational hazards using ECDIS	Confirmation of depth and navigational hazards using ECDIS	6_3	Lv1	–
	Ability to verify the accuracy of ECDIS information through communication with onboard personnel	Verification of ECDIS information	6_4	Lv1	Lv2
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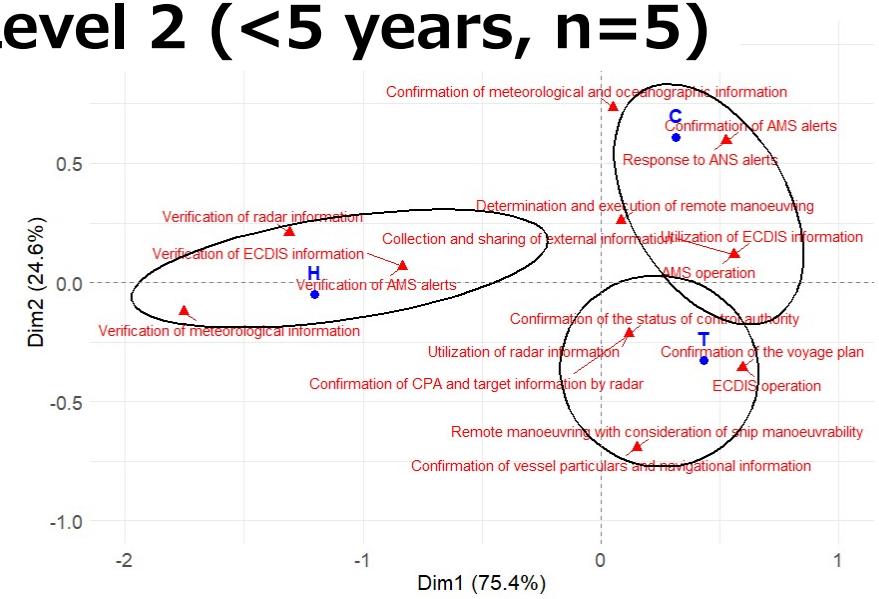
	Ability to communicate by voice		8_3	ALL	

Table 1. Minimum competencies required for ROs in understanding remote operation centers and data communications for collision-avoidance operations

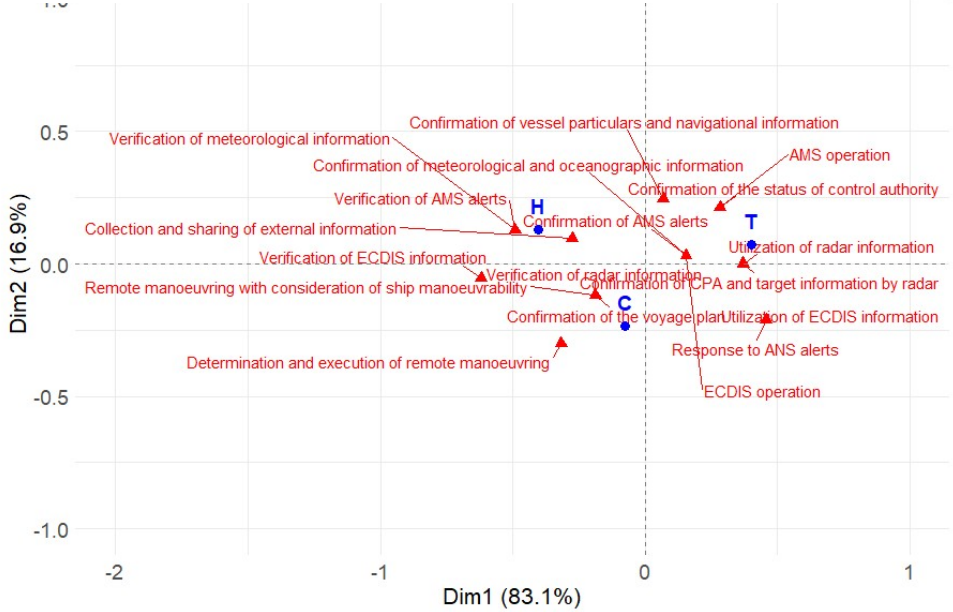
Results–Classification of Item Characteristics

Level 2 (<5 years, n=5)



- Items related to responding to system-generated information were located near **Conceptual Skills (C).**
- Examples:
  - Initiating remote ship handling
  - Confirming AMS alerts
  - Responding to ANS alerts

Level 2 (≥5 years, n=11)



- No distinct clusters were identified.
  - This suggests a continuous and integrated competency structure.
- Items reflected broader judgment based on vessel performance and voyage context, including:
  - Initiating remote ship handling
  - Remote ship handling considering vessel maneuverability
  - Verification of radar information
  - Confirmation of voyage plans

Discussion

Level 1

- Competencies differed substantially between Level 1 and Level 2.
- Emphasis was placed on interpreting weather and sea-state information from displays (e.g., radar) and performing specific operational tasks such as ship-to-ship communication, hazard identification, and course adjustment.
- These competencies mainly involve practical operational skills rather than advanced conceptual abilities.

→ Procedural, skill-based training is appropriate.

Level 2

- Integrated decision-making abilities were required to compensate for the limitations of situation awareness in remote environments.
- Participants with ≥5 years of seagoing experience tended to integrate reports from onboard crew and Level 1 operators and make decisions based on vessel performance and operational context.

→ Seagoing experience is an important prerequisite, and discussion-based training focused on remote decision-making is appropriate.

Implications for RO Training

- Seagoing experience is essential for both Level 1 and Level 2 remote operators.
- RO education should combine operational skill training, staged competency development, seagoing experience, and professional ethics/responsibility.

Future Work and Perspectives

- The competency requirements identified in this study were derived under specific assumptions regarding ROC ConOps and system configurations. If these assumptions change, the competency framework should be re-evaluated.
- For example, the finding that Level 2 operators may require more than five years of seagoing experience was based on a two-person remote-operation model. Different crew configurations (e.g., onboard crew working with remote operators) may reduce the competencies and experience required of remote operators.
- Emerging technologies and support systems may compensate for limitations in remote situation awareness by providing information that cannot be directly sensed.
- Future research should investigate the appropriate allocation of human roles and responsibilities when such technologies are introduced, contributing to the design of future ROC education and training programs.

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