

# KASS Verification Centre & Sea Tests

The sea-trials for demonstration of  
KASS developed technologies

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Evaluation Research Centre(ASVERC)

Korea Research Institute of  
Ships and Ocean Engineering(KRISO)





# 1

# KASS Project

Korea Autonomous Surface Ship Project

Korea Research Institute of Ships &  
Ocean Engineering



## Project

**Development of Autonomous Ship Technology**

## Funded by

**Ministry of Trade (Industry and Energy) & Ministry of Oceans and Fisheries**

## Period

**2020-2025** (1st~4th year : System development & integration / 5th~6th year : Demonstration)

## Vision

**Leading the future ship market and international standards through the development of MASS technology**

## Objectives

- ✓ Development of **Core technology of Autonomous ship<sup>1)</sup>**
- ✓ **Laying the foundation for Commercialization<sup>2)</sup>** through Phased demonstration

### 1) Core technology of Autonomous ship

- ① Intelligent Navigation System
- ② Machinery Automation System
- ③ Performance Demonstration Center and Demonstration technology
- ④ Operational Technology and Standardization

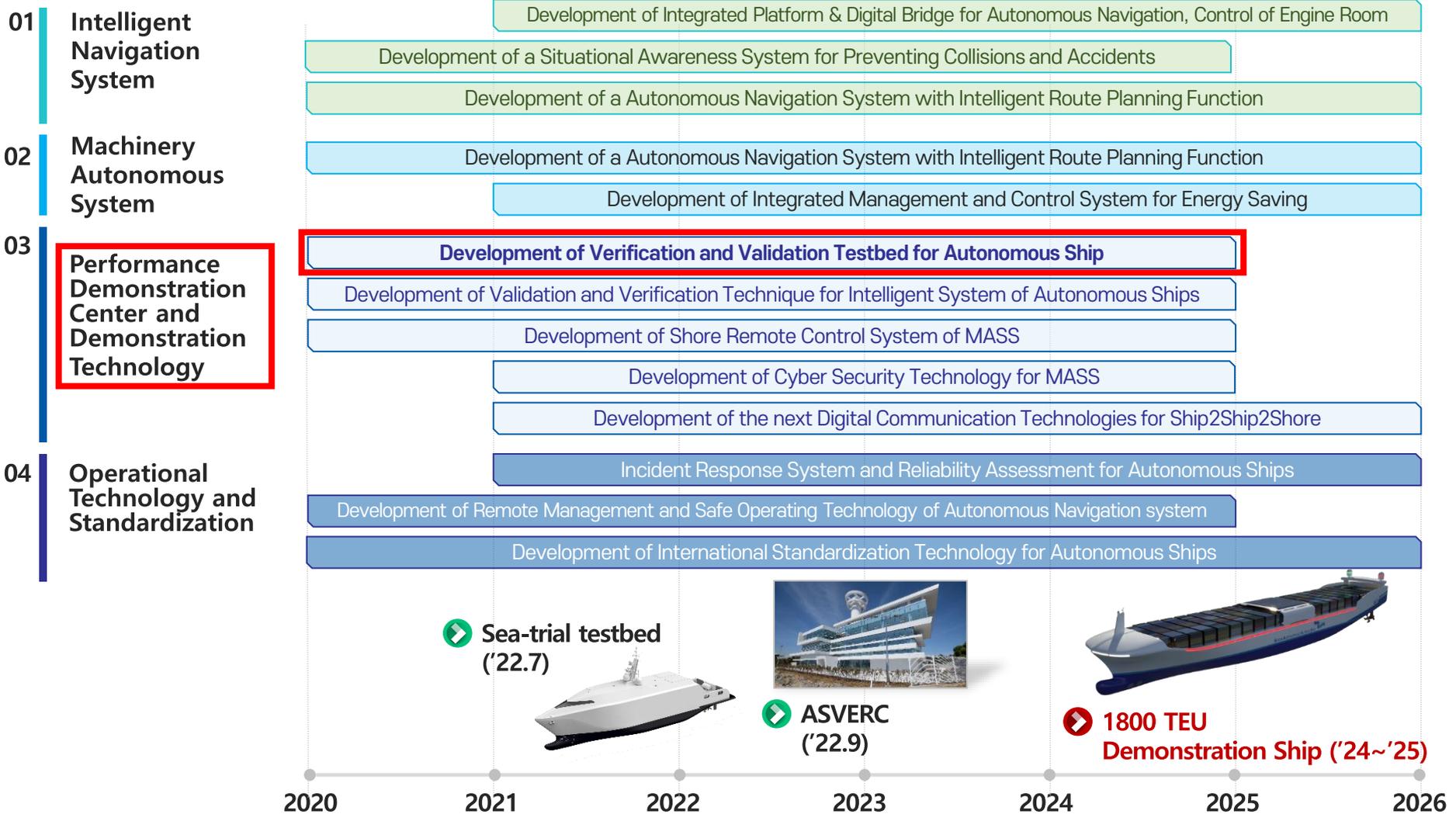
### 2) Commercialization target

**MASS engaged on International voyages (Mid-sized merchant ship)**  
(Ocean : IMO Level 3 / Coast : IMO Level 2) Vessel

**※ 2 General tasks, 4 Core technologies, 13 detailed tasks (51 participating organizations)**

# 1. KASS Project

## KASS R&D PLAN





# 2

# ASVERC

Autonomous Ship Verification & Evaluation Research Center

Korea Research Institute of Ships &  
Ocean Engineering

# 2. ASVERC – Main Facilities

## Big Data Platform

- Servers & Data for MASS operation



## Sim.-based Testbed for Auto. Ship

- MASS evaluation system under virtual



## Sea-trial Testbed Vessel

- HAEYANG NURI



## Digital Twin Bridge/Engine (DTB/E) Monitoring

- Real-time monitoring system of MASS



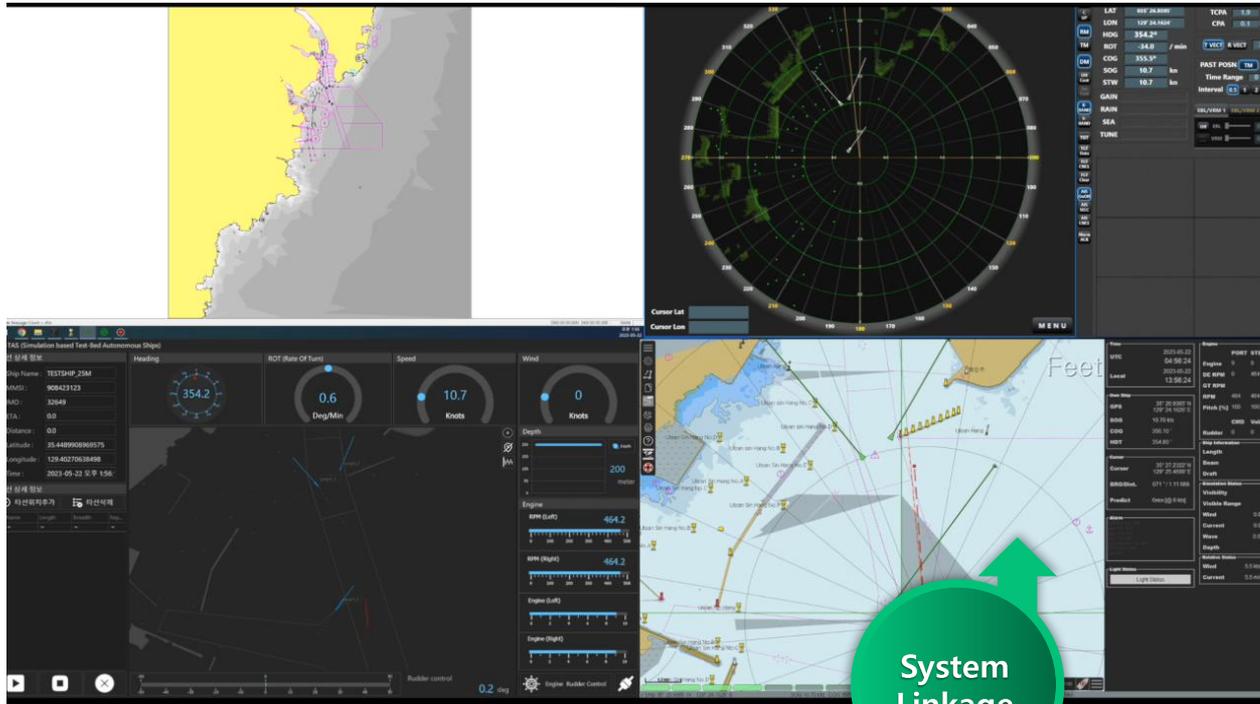
## Vessel Traffic Service for Sea Tests

- Safety management of MASS & sea-trial area



# 2. ASVERC – Facility #1

## Simulation-based Testbed for Autonomous Ship (S-TAS)



### S-TAS Navigation

#### PURPOSE

Test assessment during the system-development stage prior to the sea trial via simulation **without physical constraints** such as time, space, and cost

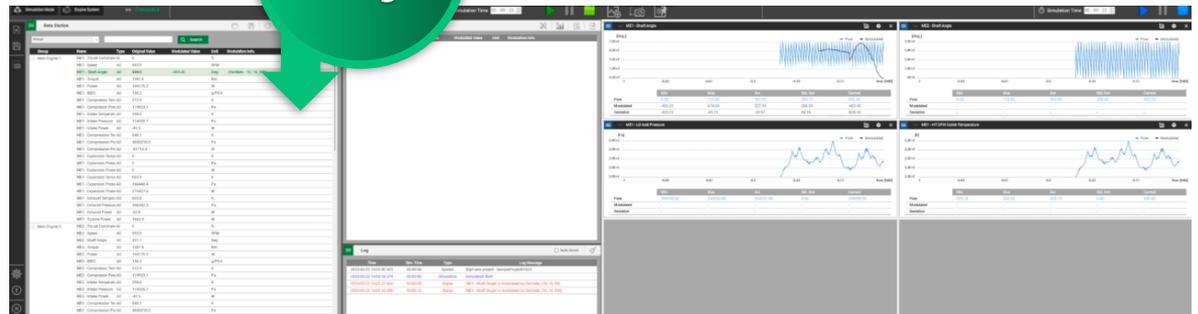
#### CONFIGURATION

- ① Solver
- ② Radar Simulation
- ③ S-TAS
- ④ ECDIS Simulation

### S-TAS Engine

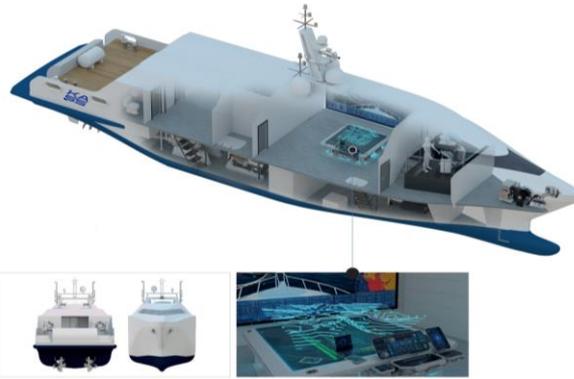
Assessing the engine system and power management system (PMS) during the MASS operation in simulation **connected with S-TAS Navigation**

- ① Data List
- ② Data Graph (w/ manipulation)



# 2. ASVERC – Facility #2

## Sea-trial Testbed Vessel - 'HAEYANG NURI'



### Purpose

- Real-sea verification of MASS technology equipment, algorithms, and systems (At developing stage).
- Acquisition real-sea training & validation data for MASS technologies (e.g. Situational awareness system)

### Main feature

- Mast
- Server rack
- VDGS\*
- Multi control mode
- Intelligent navigation system

\*Virtual Data Generation System

# 2. ASVERC – Facility #2

## Sea-trial Testbed Vessel - 'HAEYANG NURI'

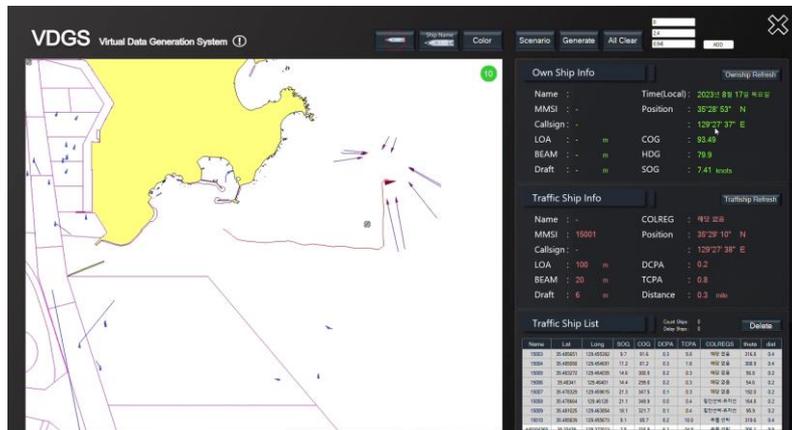
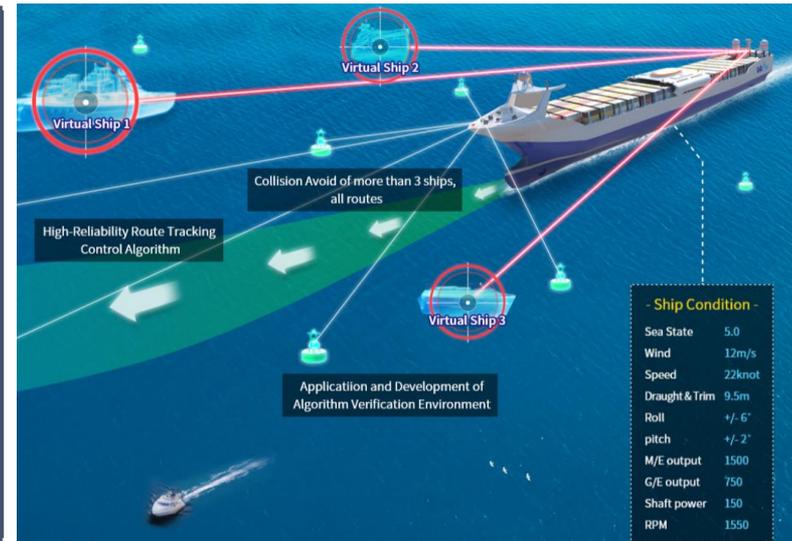
### VDGS (Virtual Data Generation System)

#### Purpose

- To diversify verification environment without being constrained by space and time.
- To provide a safe and efficient testing environment

#### Function

- Generation of navigation/engine data such as virtual sea-object or situation used by autonomous navigation system

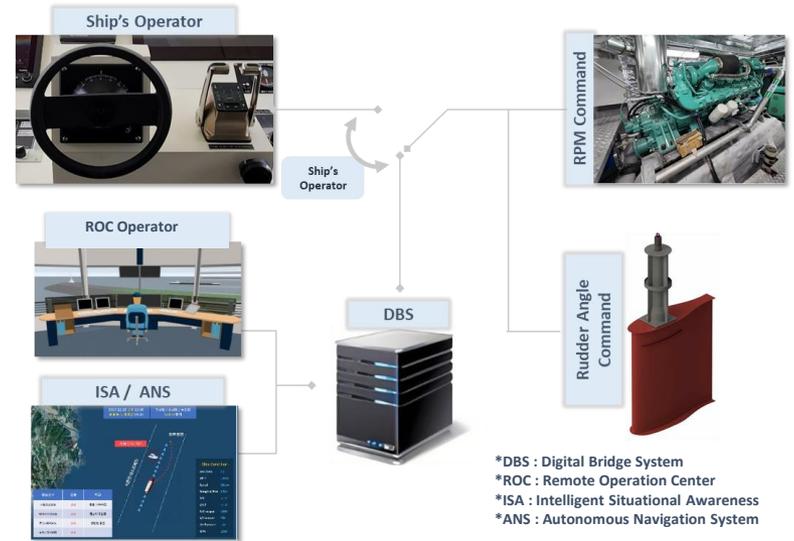


# 2. ASVERC – Facility #2

## Sea-trial Testbed Vessel - 'HAEYANG NURI'

### Multi Control Mode

- Navigation by three different operation mode
  - A. Onboard crew
  - B. Intelligent navigation system(Onboard system)
  - C. Operator in the ROC(Remote Operation Centre)
- Navigation using data along with ISA and ANS algorithms in 'B' mode.
- Remote control by operator in the ROC in 'C' mode



Operation Mode of Sea trial testbed vessel (Left: A, Center: B, Right: C)

# 2. ASVERC – Facility #3

## Digital Twin Bridge/Engine (DTB/E)



## Configuration



## MASS Traffic Control

### PURPOSE

Shared the status of sea-trial area and traffic

### CONFIGURATION

- ① CCTV
- ② VOC
- ③ Weather condition
- ④ Shore Radar

# 2. ASVERC – Facility #4

## Vessel Traffic Service for MASS sea test area

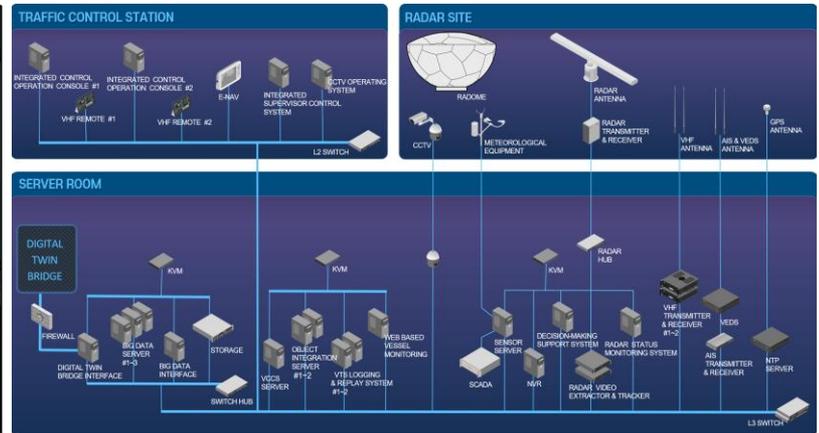
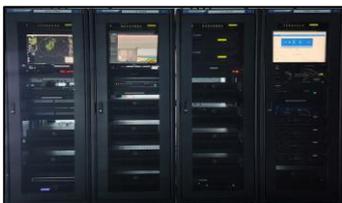
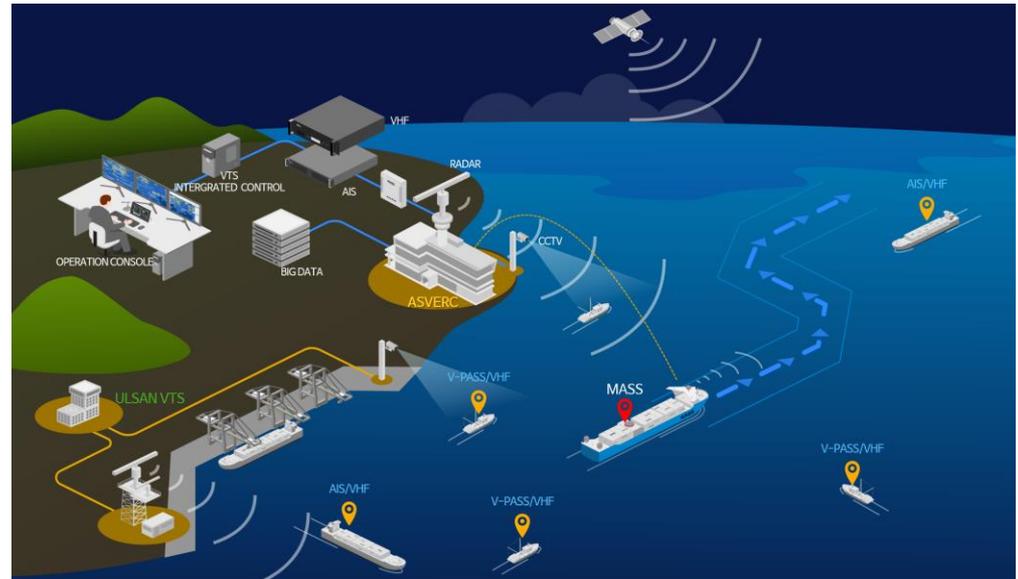
### Traffic service system

#### PURPOSE

- ① Safety management of MASS & Sea-trial area
- ② Support for remote operation of test vessels

#### MAIN EQUIPMENT

- ① SSPA X-Band digital radar & radome
- ② AIS & VDES (VHF Data Exchange System), VHF
- ③ Operator Console
- ④ Data Management & Storage System
- ⑤ Digital Twin Bridge Interface System





3

# Sea tests

Autonomous Ship Verification & Evaluation Research Center

Korea Research Institute of Ships &  
Ocean Engineering

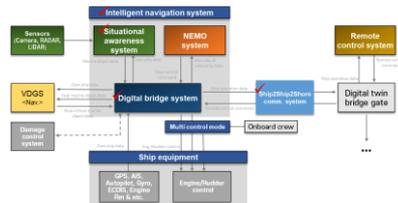
# 3. Sea tests

## Progress & Plan

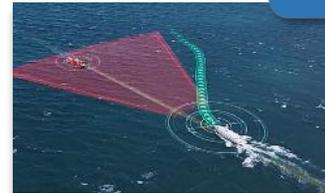
Individual system installation & test

- Intelligent situational awareness
- Digital bridge system
- ...

System integration test at Quay



The 1<sup>st</sup> Intelligent navigation sys. test at sea



The 2<sup>nd</sup> Intelligent navigation sys. test at sea



Installation KASS systems commenced

'23 FEB

'23 JUN

'23 JUL

'23 AUG

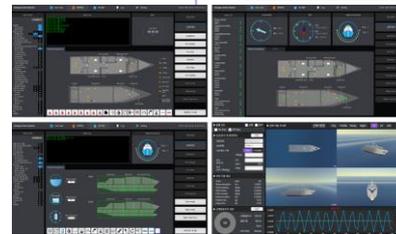
'23 SEP

'23 OCT

'23 NOV

2024

'24 APR



Sea test demonstration vessel

- Installed KASS systems
- Situational awareness system
  - Digital bridge system
  - NEMO System
  - Ship2Ship2Shore communication
  - ...

# 3. Establishment of cooperation with regional authorities



# 3. Sea Test

## Sea test with test vessel

**Application**  
Organization in demand

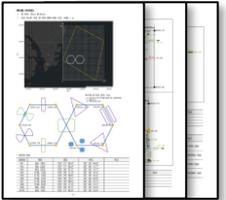
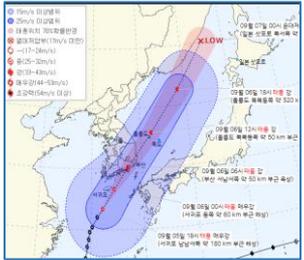
**Application form**

구분	항목명	내용	구분	항목명	내용
1. 시험 목적	1.1 시험 목적	본 시험의 목적은 ...	2. 시험 계획	2.1 시험 일정	2023.08.16 ~ 2023.08.17
	1.2 시험 대상	본 시험의 대상은 ...		2.2 시험 장소	ASVERC 해상시험장
	1.3 시험 방법	본 시험의 방법은 ...		2.3 시험 장비	ASVERC 시험장비
	1.4 시험 결과	본 시험의 결과는 ...		2.4 시험 인력	ASVERC 인력
	1.5 시험 예산	본 시험의 예산은 ...		2.5 시험 예산	ASVERC 예산
	1.6 시험 위험	본 시험의 위험은 ...		2.6 시험 위험	ASVERC 위험
	1.7 시험 안전	본 시험의 안전은 ...		2.7 시험 안전	ASVERC 안전
	1.8 시험 환경	본 시험의 환경은 ...		2.8 시험 환경	ASVERC 환경
	1.9 시험 절차	본 시험의 절차는 ...		2.9 시험 절차	ASVERC 절차
	1.10 시험 평가	본 시험의 평가는 ...		2.10 시험 평가	ASVERC 평가



**Scheduling & review**

- ✓ Weather condition
- ✓ Ship inspection
- ✓ Scenario design
- ✓ Risk assessment
- ✓ Test plan cooperation



**Sea test**

- ✓ Safety education
- ✓ Briefing of the test
- ✓ Risk management



**Analysis**

- ✓ Sea trial report
- ✓ Feed back

**시험선 기반 지능항해시스템 시험 보고서**

일자: 2023.08.16 - 08.17

주최기관: KASS 해운1세부

담당자: 지능항해시스템

지역명: 서울국제선박시험장, 항로주변 실험역 상습시험

Summary:

본 시험은 대양 시스템의 안전항해기능을 검증하기 위해 시험역에 사내 시험선과 함께 대양 시스템의 성능을 검증하고, YD05A 상선 기항선과 함께 선박을 통제하여 시험을 수행한 결과 다음과 같다.

본 시험은 시험 범용성을 위한 YD05A 상선(Ship) 및 1.7m, 30m, 30m 등 3종 크기의 시험선으로 실시되었다.

본 시험의 시험 시스템을 활용하여 유용한 시험 결과를 얻었고, 특히 유용한 데이터와 함께 시험을 수행하여 시험 목적을 달성하는 데 크게 공헌하였다.

시험 결과 검토를 통해 시험 결과, 항로주변시험역 위치 및 10m 시험역 위치를 수정하는 것을 확인하였다.

**KASS 해운2세부 - (주)실크테크노**  
다중해상통신 게이브웨이 시험선 통신시험 계획(안)

**A provisional plan**

○ (시험역) 및 (시험선) 등

○ (시험역) 및 (시험선) 등

□ 주요 내용

○ (요청) 검토(안)



ASVERC

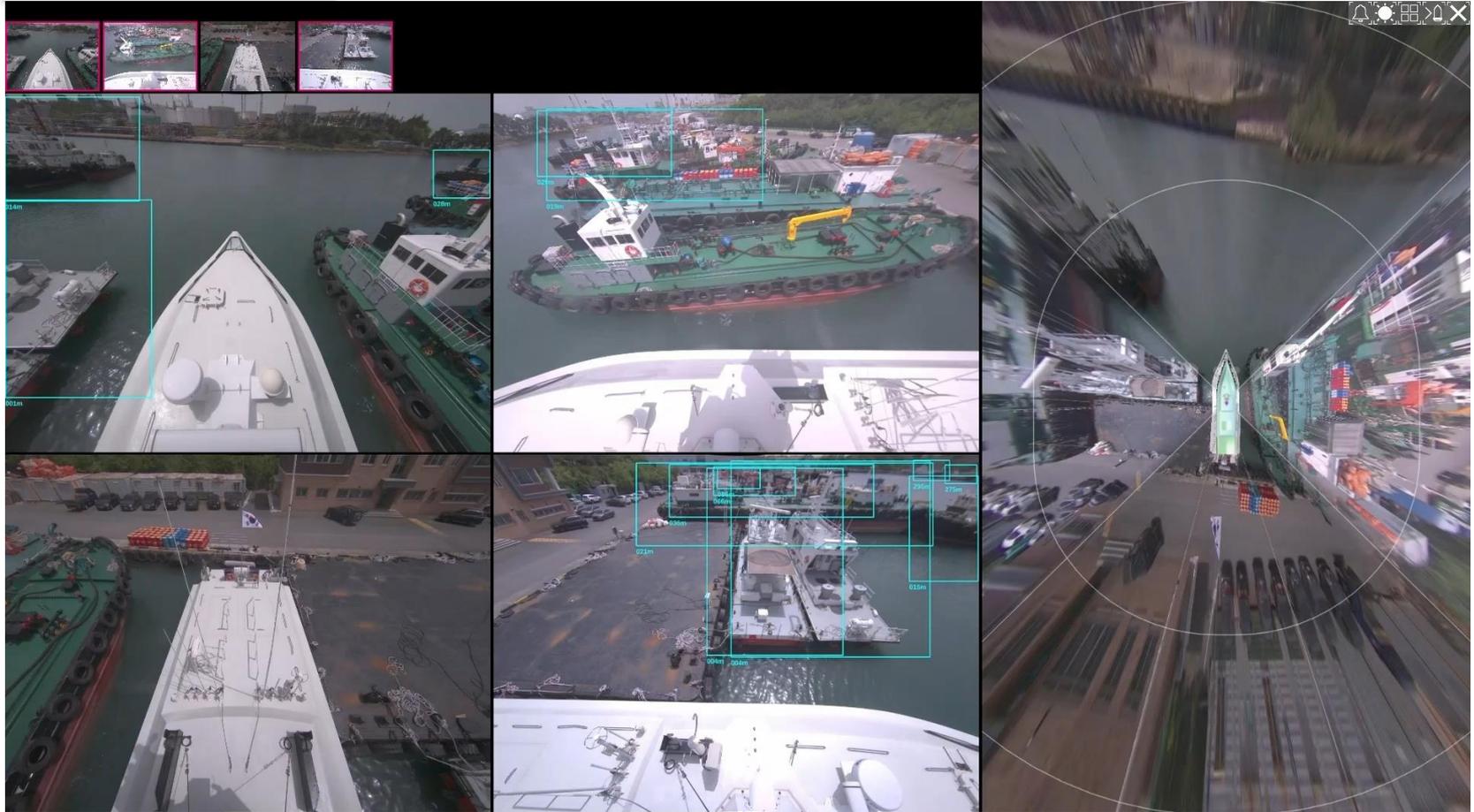
Testbed vessel

ASVERC

# 3. Sea-test with 'Testbed vessel'

## ▶ Sea-test with 'Testbed vessel'

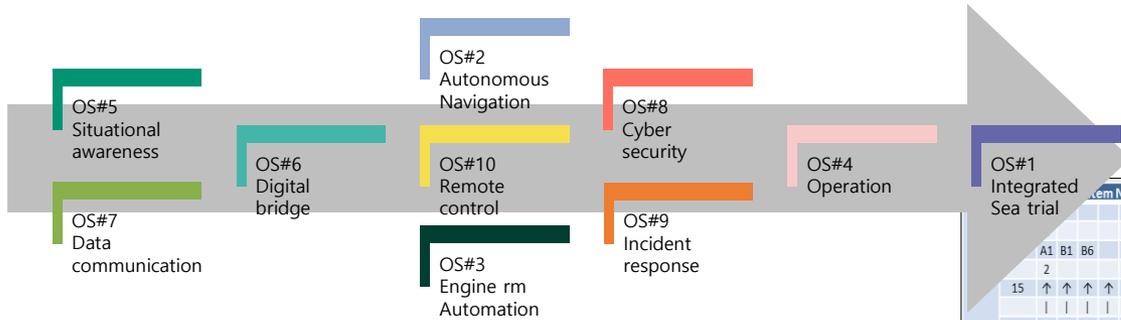
### Sea-trial overview



# 3. Test procedure

## ▶ Test procedure

### ▶ Sea-trial procedure under development



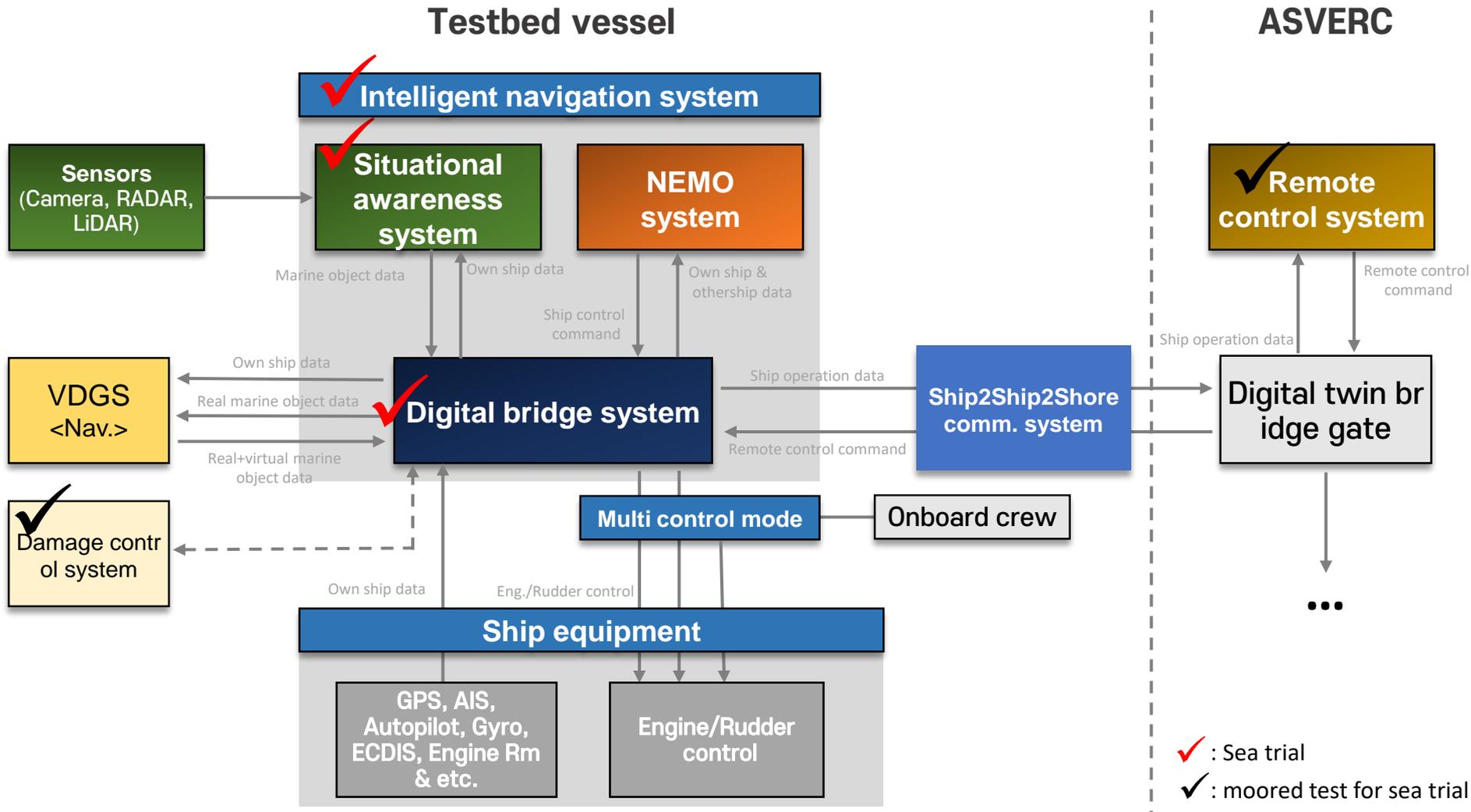
<Sea-trial scenario considering technical interrelationships>

Item No.	Test Items	Category	Checklist
<b>*Sea Trial opening meeting &amp; safety drill</b>			
<b>1. Preparation for departure</b>			
<b>2. Shifting to Sea[Test area]</b>			
A1 B1 B6	A1. Data collection and connection status check between devices	Digital bridge Integrated platform	A1
15	A2. Transmission items check according to communication status		A2
	A3. Takeover request between ship, shore and systems		A3
16	B1. Function check of multi-sensor information matching output system		B1
	B2. Function check of navigation service platform		B2
17	B3. Function check of predictive maintenance solution		B3
	B4. Function check of energy integrated control system	B4	
18	B5. Function check of integrated security management system	B5	
	B6. Function check of Virtual Data Generation System for performance validation	B6	
19	C1. Testing by detection distance	Situational awareness	C
	C2. Testing by detection target		C
20	C3. Testing by detection background		C
**	D1. Route decision making	Intelligent route decision- making system	D1
21	D2. COLREGS based collision avoidance		D2
	D3. Intention inference based collision avoidance		D3
22	D4. Waypoint tracking		D4
	E1. Communication network conversion test	Data Exchange & communication	E1
06	E2. VDES message transmission/reception and transmission success rate check		E2
A1 B1 B6	E3. VDES receive power and sensitivity check		E3
07	F1. Respond to attack scenarios (spoofing, sniffing, etc.)	Cyber security	F1
	F2. Access control between the ship's lower network and detection after abnormal signs		F2
08	F3. DPI performance confirmation		F3
	F4. Warning test after receiving cyber threats		F4
09	G1. Fire detection and response	Incident response	G1
	G2. Flooding detection and response		G2
10	G3. Black out recovery test		G3
	H1. Speed control	Shore remote control	H
11	H2. Rudder angle control		H
	H3. Speed & rudder control		H
12	** Come back to harbor		
**			

<Sea-trial procedure under development>

# 3. Sea tests with 'Testbed vessel'

## Shipboard systems and tested items



### 3. Sea tests with 'Testbed vessel'



#### ➤ Test objects

- Digital bridge system
- Intelligent situational awareness system
- Intelligent navigation system
- Shore remote control system
- Damage control system

- 
- 
-

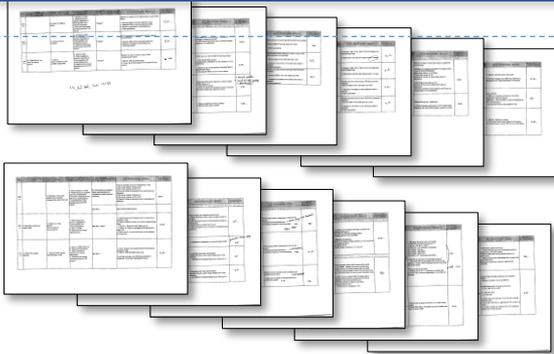
# 3. Sea tests with 'Testbed vessel'

## Digital bridge system

### Purpose

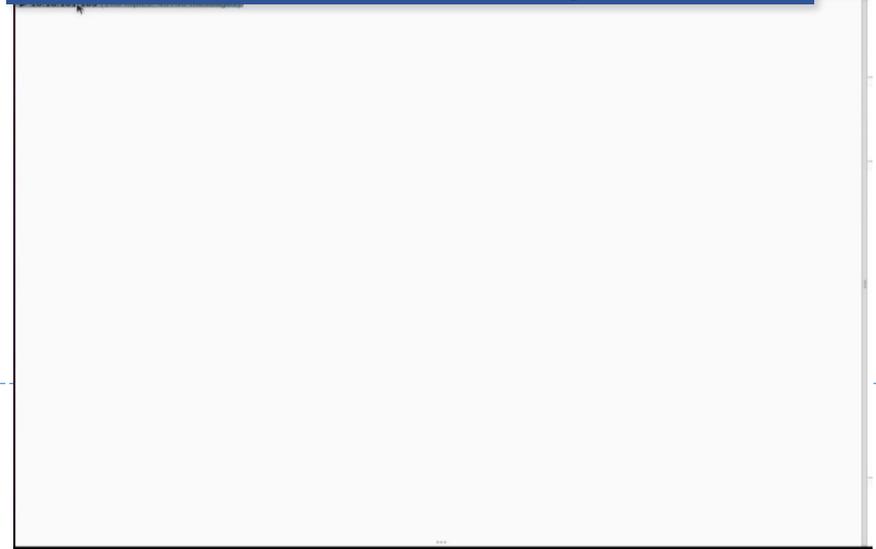
- To verify function as shipboard **data interface**
  - Data acquisition & distribution

### Test procedure based on risk assessment



\* "Development of Integrated Platform & Digital Bridge for Autonomous Navigation, Control of Engine Room" (NS4980)

### Data acquisition & Distribution monitoring (MQTT explorer)



### Function test as per scenario



### Digital bridge dashboard



# 3. Sea tests with 'Testbed vessel'

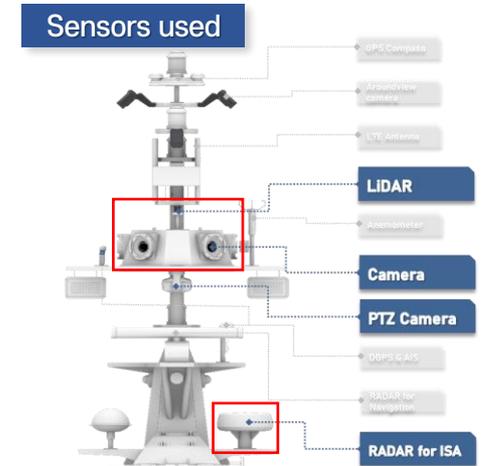
## Intelligent Situational Awareness System (ISAS)

### Purpose

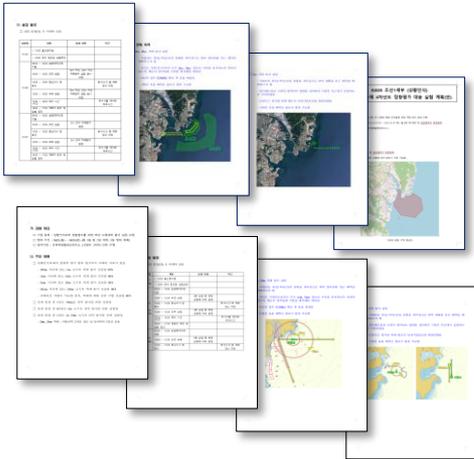
- To **verify maritime target detection performance** as per scenario
- To **acquire verify & train data for detection algorithms**

### Result & Plan

- Acquire data for derivation of detection success rate
- Improve/train detection algorithm based on acquired data for next sea-trial



### Sea trial schedule & scenario plan



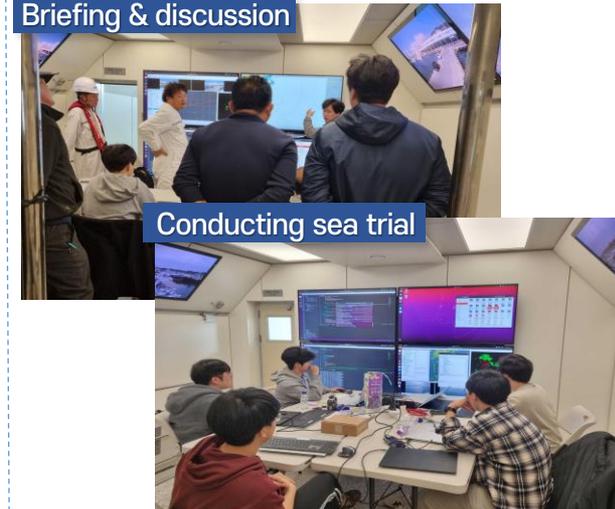
### Target conditions



### Background



### Briefing & discussion



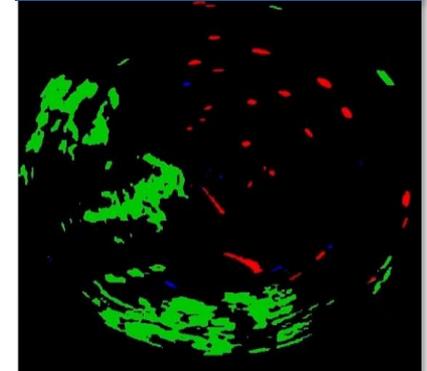
# 3. Sea tests with 'Testbed vessel'

## ▶ Intelligent Situational Awareness System (ISAS)

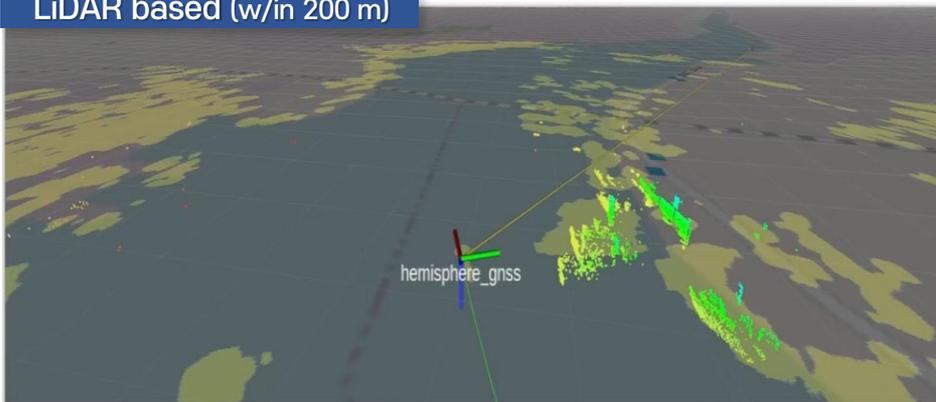
Camera based (w/in 10 km)



RADAR based (w/in 20 km)



LiDAR based (w/in 200 m)



Multi sensor fusion visualization



\* "Development of a Situational Awareness System for Preventing Collisions and Accidents of Autonomous Ships" (NS4890)

# 3. Sea tests with 'Testbed vessel'

## Intelligent navigation system

### Purpose

- To verify route tracking & collision avoidance performance as per scenario at real sea condition

### ➤ The 1<sup>st</sup> sea trial (16<sup>th</sup>~17<sup>th</sup> Aug. 2023)

#### Overview

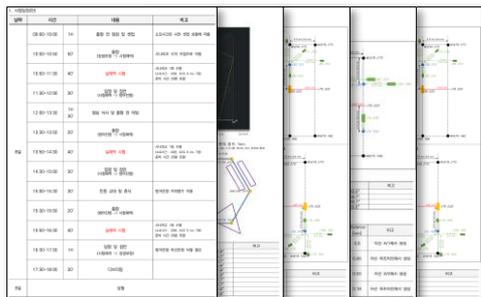
: Route tracking & **simple encounters** w/ **1 real target ship** and virtual ships

### ➤ The 2<sup>nd</sup> sea trial (6<sup>th</sup>~10<sup>th</sup> Nov. 2023)

#### Overview

: **Complex encounters** w/ **3 real target ships** and virtual ships

Sea trial schedule & scenario plan



Pre-test on quay



Sea trial briefing & discussion



Conducting sea trial



\*"Development of Autonomous Navigation System with Intelligent Route Planning Function" (MS5881)

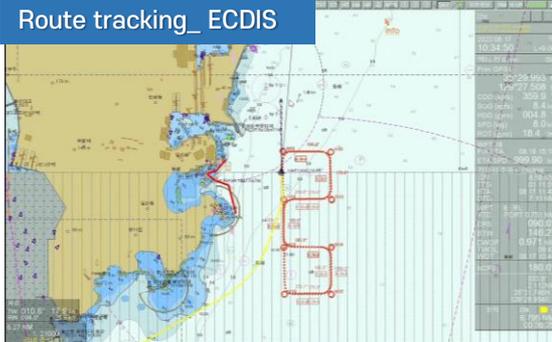
# 3. Sea tests with 'Testbed vessel'

## Intelligent navigation system

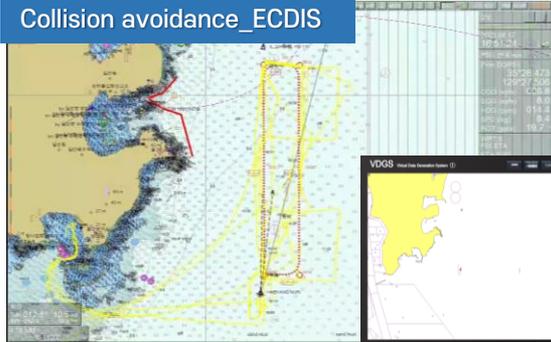
### The 1<sup>st</sup> sea trial

: Route tracking & **simple encounters** with 1 real target ship and virtual ships  
Situations such as **head-on & crossing**

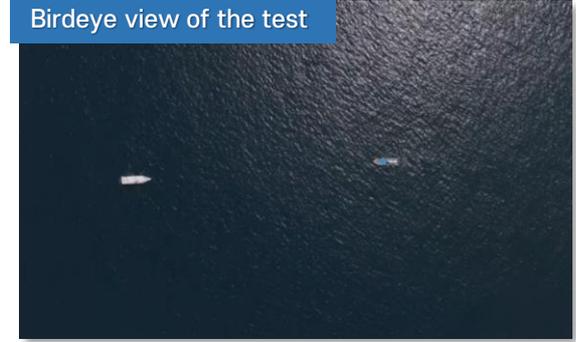
Route tracking\_ECDIS



Collision avoidance\_ECDIS



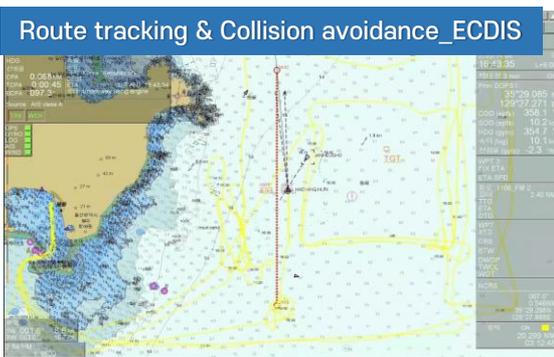
Birdeye view of the test



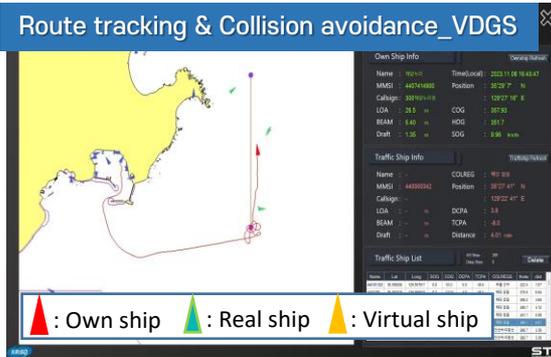
### The 2<sup>nd</sup> sea trial

: **Complex encounters** with 3 real target ships and virtual ships  
Situations such as **head-on, overtaking, overtaken, crossing and etc.)**

Route tracking & Collision avoidance\_ECDIS



Route tracking & Collision avoidance\_VDGS



▲ : Own ship   ▲ : Real ship   ▲ : Virtual ship

Birdeye view of the test



\*The result of "Development of Autonomous Navigation System with Intelligent Route Planning Function" (MS5881)

# 3. Sea tests with 'Testbed vessel'

## Remote control system

Assured

- Data communication
- Control mode
- Remote control command



## Switching control mode as per procedure



## Data status monitoring



\*This result was supported by National R&D Project "Development of Validation and Verification Technique for Intelligent System of Autonomous Ships" (NS4930)

# 3. Sea tests with 'Testbed vessel'

## Damage control system'

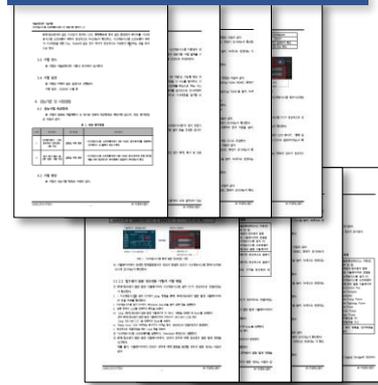
- Incident situation monitoring
- Operation of response system

from shore side

Incident situation	Fire	Flooding
Response action	Fire door & damper close	Ship stability calculation
	Vent. fan stop	shutoff valve
	Fire fighting valve & pump activation	Bilge pump activation

\* The results of "Incident Response System and Reliability Assessment for Autonomous ship"

### Test schedule & scenario

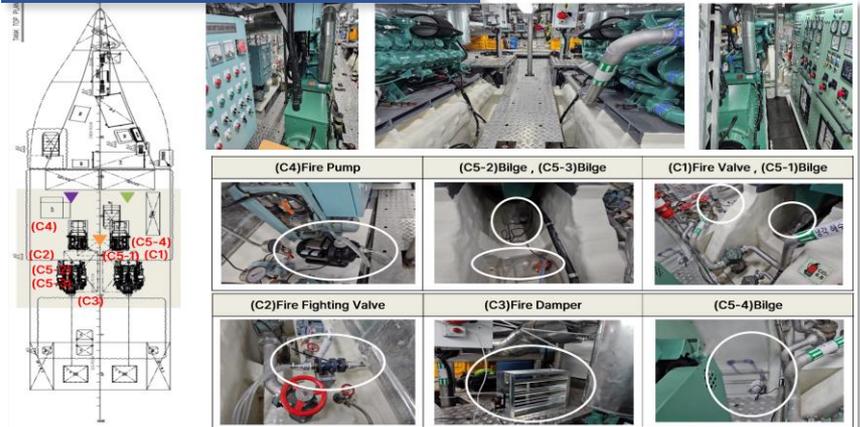


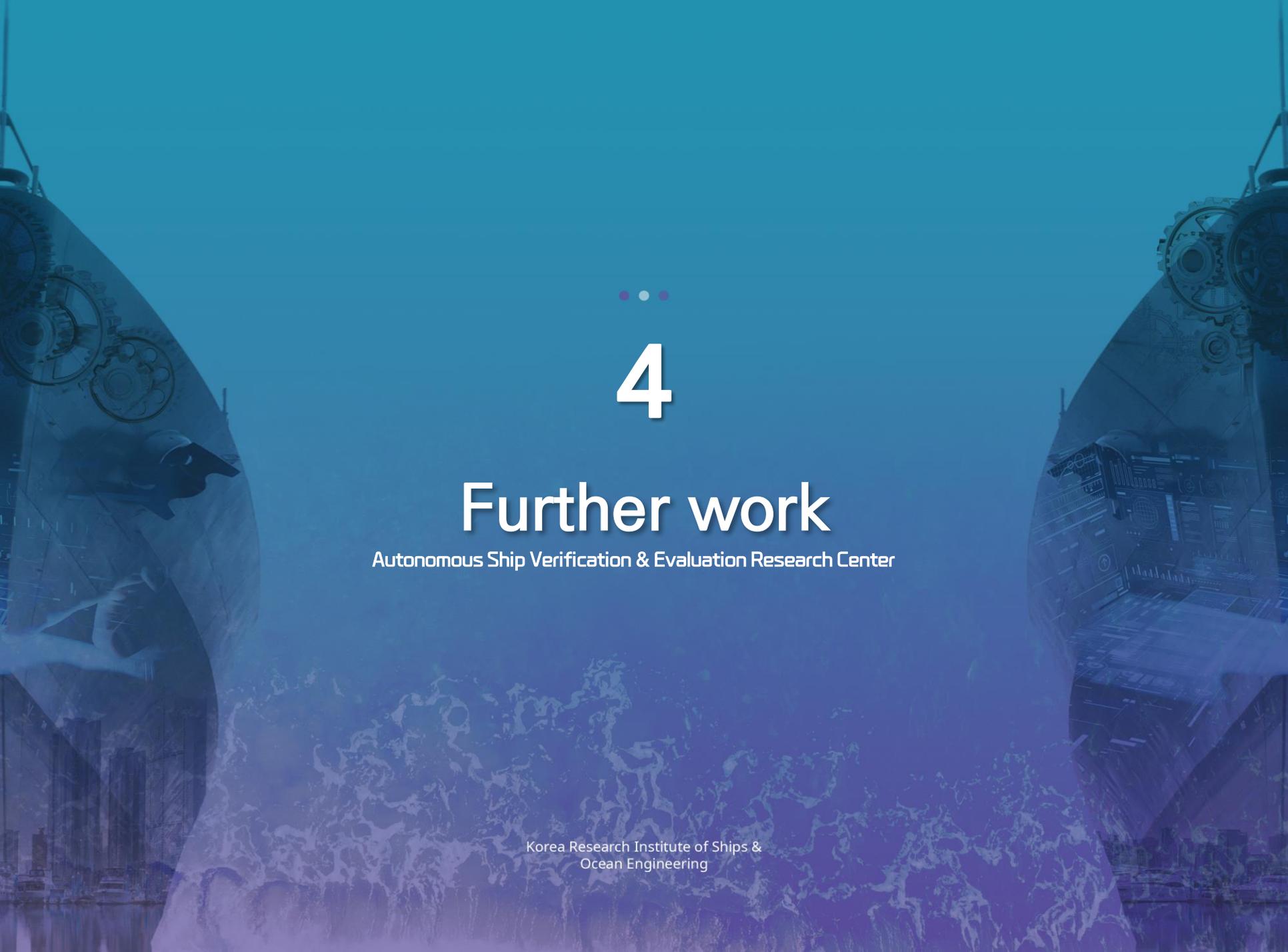
### Simulator\* stand with sensors



\*Create incident situation for safe & efficient test

### Installation of the system(temp.)





4

# Further work

Autonomous Ship Verification & Evaluation Research Center

Korea Research Institute of Ships &  
Ocean Engineering

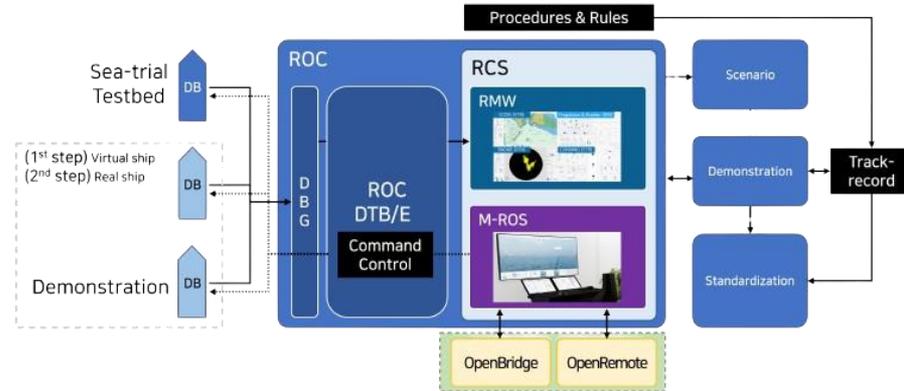
# 4. Remote Operation Centre

## Remote Operation System

Prototype (1 ship)



## Remote Operation of Multiple MASS



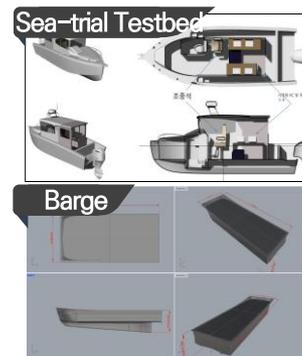
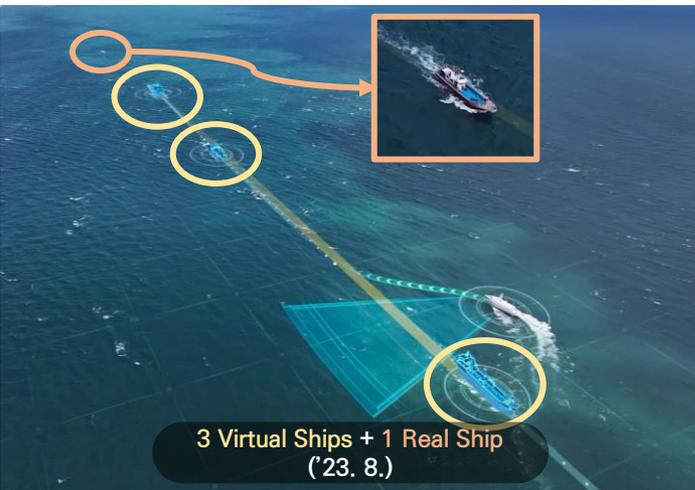
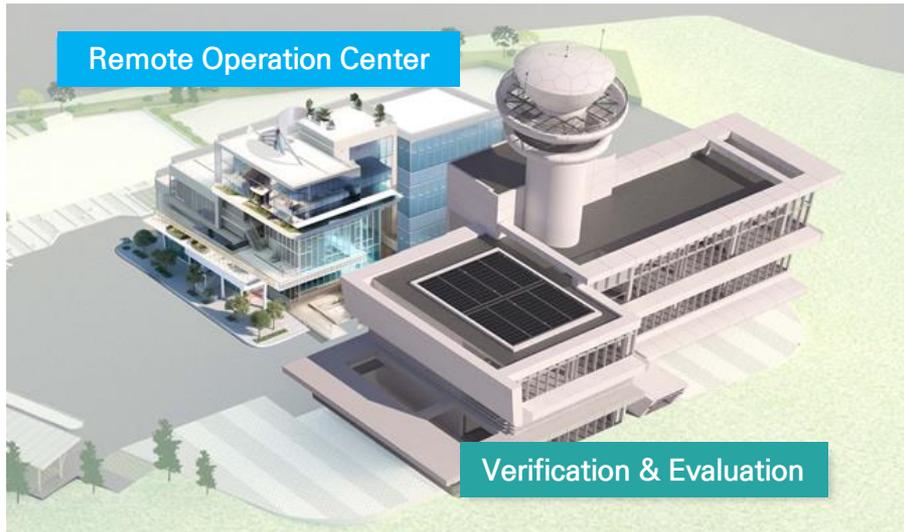
\* This project co-works with OpenBridge & OpenRemote, Norway international projects.



- Remote Operation Centre (ROC)
- Remote Maritime Workstation (RMW)
- Multi-Remote Operation System (M-ROS)
- Virtual Ship Modeling

# 4. Infrastructure extension

## Enhancement of test environment (less virtual, more physical)



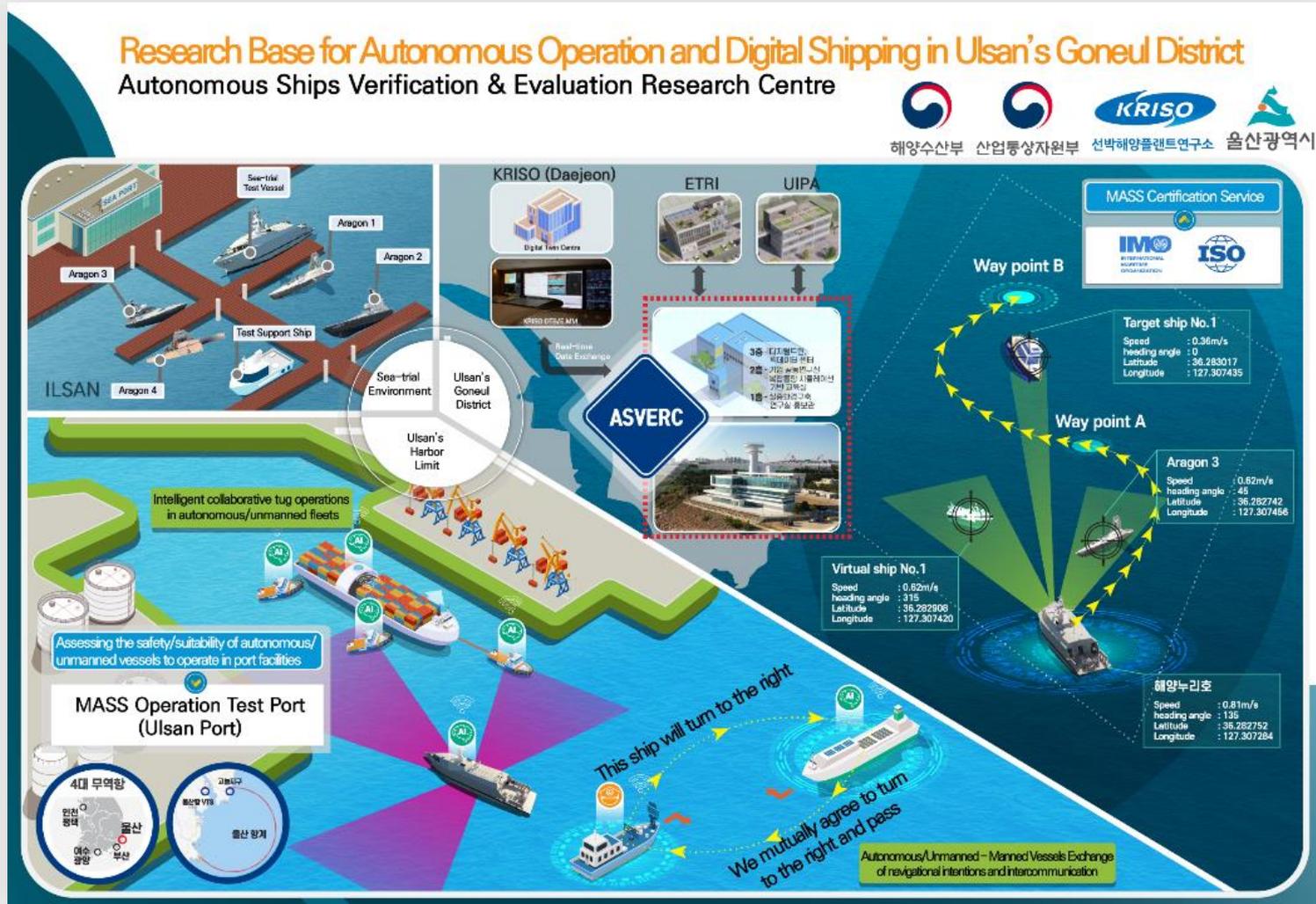
- LIST**      **< NOW >**
- Sea-trial Testbed (HAEYANG NURI)
  - Simulation-based Testbed (S-TAS)
  - Digital Twin Bridge/Engine (DTB/E)
  - Traffic Control System
  - Big Data Platform

- < PLANNING >**
- Remote Control Center (ROC)
  - Maintenance Facility
  - Full Mission Bridge MASS Simulator
  - Barge & Mooring System
  - Sea-trial testbed vessels
  - Smart Buoy
  - Drone



# 4. Expand ASVERC

## ASVERC functionality in near future



Safe Ship

Clean Ocean

Deep Sea

# Thank You