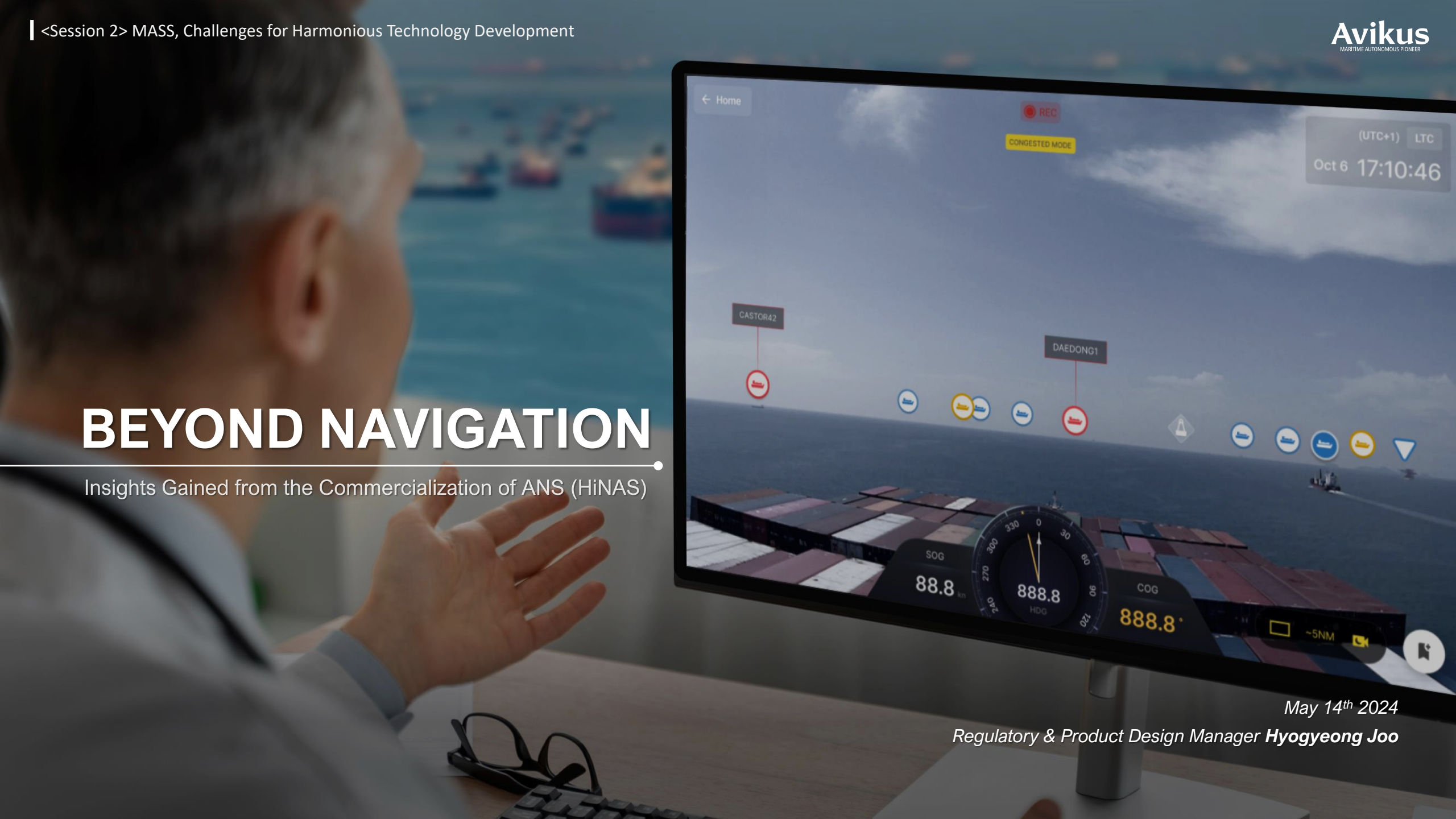
Avikus
MARITIME AUTONOMOUS PIONEER

BEYOND NAVIGATION

Insights Gained from the Commercialization of ANS (HiNAS)



May 14th 2024

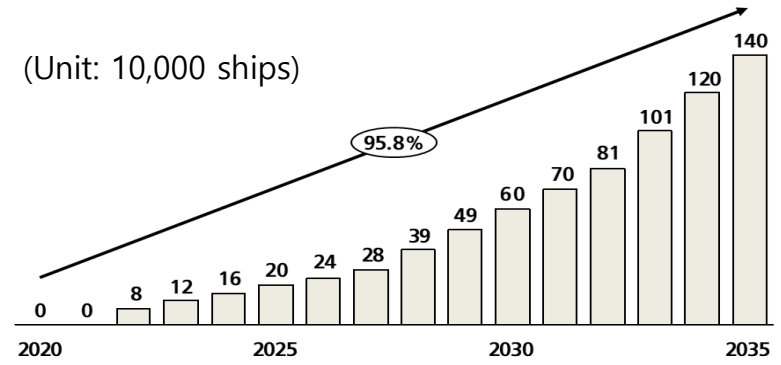
Regulatory & Product Design Manager ***Hyogyeong Joo***

Sailing together:
Striving for a future-proof IMO MASS Code

MASS industry will grow rapidly, reaching nearly 10% of all ships by 2035

If technological maturity is secured, and relevant social infrastructure is in place, the introduction of autonomous ships is expected to accelerate.

In particular, partial autonomy is likely to dominate over remote control or uncrewed MASS.



(Source: Clarksons Research, McKinsey & Company, UN - FAO, NSA, HIS)

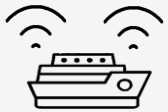
Current business area of Avikus

NOW

Ship with automated processes and decision support

Remotely controlled ship with seafarers on board

Remotely controlled ship without seafarers on board



Fully autonomous ship

FUTURE

- In compliance with current regulations
- Relatively easier to advance toward commercialization

- Need to consider product liability
- May vary depending on the concept of the ship

- Uncertain & technically challenging
- Prospect for the very distant future

As provided in document MSC 107/INF.18, feasibility of autonomous navigation system(HiNAS) has been proven through transoceanic autonomous navigation demonstration

A one-time test for technology validation

(MSC107/INF.18) Results of a transoceanic voyage test with autonomous navigation system (HiNAS2.0)

IMO INTERNATIONAL MARITIME ORGANIZATION

E

MARITIME SAFETY COMMITTEE
107th session
Agenda item 5

MSC107/INF.18
28 March 2023
ENGLISH ONLY
Pre-session public release: ☒

DEVELOPMENT OF A GOAL-BASED INSTRUMENT FOR MARITIME AUTONOMOUS SURFACE SHIPS (MASS)

Results of a transoceanic voyage test with autonomous navigation system

Submitted by the Republic of Korea

SUMMARY

Executive summary: This document provides information on the results of the world's first transoceanic voyage with an autonomous navigation system with autonomous navigation, manoeuvring, collision detection, and collision avoidance (CDCA) functions, as well as information that autonomous navigation system improves the safety and economic efficiency of ship operations.

Strategic direction, if applicable: 8

Output: 2.23

Action to be taken: Paragraph 9

Related documents: None

Introduction

1 With the soaring development of digital technologies and artificial intelligence (AI), research and development of technologies of autonomous ships and systems are being conducted all over the world. In line with this, the Republic of Korea is continuously researching and developing autonomous navigation systems and conducted the world's first autonomous transoceanic voyage test with an autonomous navigation system that has the functions of autonomous navigation, manoeuvring, collision detection, and collision avoidance (CDCA).

The MASS development status in the Republic of Korea

2 The Republic of Korea is carrying out the development of some core technologies for MASS through the Korea Autonomous Surface Ship (KASS) Project. Intelligent navigation systems, machinery automation systems, and some other key technologies are under development. In line with these efforts of the public sector, Avikus Co. Ltd. in the Republic of Korea also participated in KASS Project and pushed forward in the development and testing of the MASS.

I:\MSC\107\MSC 107-INF.18.docx

MARPOL AT 50

MSC 107/INF.18
Annex 2, page 5

7: HiNAS2.0 camera module

llowed by the simulation test procedure and test procedure
rch and 6 April 2022. Avikus conducted the transoceanic
is conducted based on the test programme reviewed by
e below tasks. All the tasks are conducted under the
sonnel (officers/captain).

erformance (AIS, Radar, Camera Image)
d following (Autonomous heading control, Speed control)
e with detected targets

ucted manually to prove the effect of fuel saving by the
ction

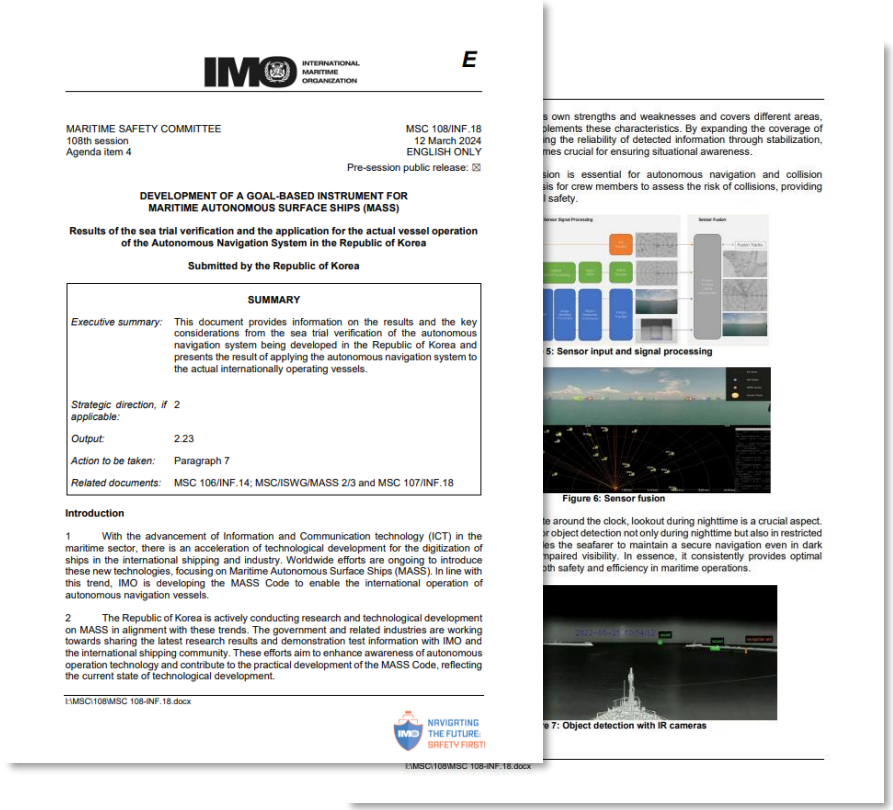
	Demonstration Conte
ern	- Captain/officer inte - Navigation pattern - HiNAS2.0 internal
ack	- Intermittent HiNA sections (Autono avoidance) - Captain/officer fee software update
ion	- Autonomous na without any interve - World's first auto demonstration

ransoceanic voyage test sc

eport, USA (2 May depar
te was from Panama to sc

Results from deploying the actual product for commercial use and operational use

(MSC108/INF.18) Results of the sea trial verification and the application for the actual vessel operation of the Autonomous Navigation System in the ROK



IMO INTERNATIONAL MARITIME ORGANIZATION

E

MARITIME SAFETY COMMITTEE
108th session
Agenda item 4

MSC 108/INF.18
12 March 2024
ENGLISH ONLY
Pre-session public release: ☒

DEVELOPMENT OF A GOAL-BASED INSTRUMENT FOR MARITIME AUTONOMOUS SURFACE SHIPS (MASS)

Results of the sea trial verification and the application for the actual vessel operation of the Autonomous Navigation System in the Republic of Korea

Submitted by the Republic of Korea

SUMMARY

Executive summary: This document provides information on the results and the key considerations from the sea trial verification of the autonomous navigation system being developed in the Republic of Korea and presents the result of applying the autonomous navigation system to the actual internationally operating vessels.

Strategic direction, if applicable: 2

Output: 2.23

Action to be taken: Paragraph 7

Related documents: MSC 106/INF.14; MSC/ISWG/MASS 2/3 and MSC 107/INF.18

Introduction

1 With the advancement of Information and Communication technology (ICT) in the maritime sector, there is an acceleration of technological development for the digitization of ships in the international shipping and industry. Worldwide efforts are ongoing to introduce these new technologies, focusing on Maritime Autonomous Surface Ships (MASS). In line with this trend, IMO is developing the MASS Code to enable the international operation of autonomous navigation vessels.

2 The Republic of Korea is actively conducting research and technological development on MASS in alignment with these trends. The government and related industries are working towards sharing the latest research results and demonstration test information with IMO and the international shipping community. These efforts aim to enhance awareness of autonomous operation technology and contribute to the practical development of the MASS Code, reflecting the current state of technological development.

I:\MSC\108\MSC 108-INF.18.docx

NAVIGATING THE FUTURE SAFELY-FIRST!

I:\MSC\108\MSC 108-INF.18.docx

s own strengths and weaknesses and covers different areas,
lements these characteristics. By expanding the coverage of
ng the reliability of detected information through stabilization,
mes crucial for ensuring situational awareness.

ion is essential for autonomous navigation and collision
is for crew members to assess the risk of collisions, providing
safety.

5: Sensor input and signal processing

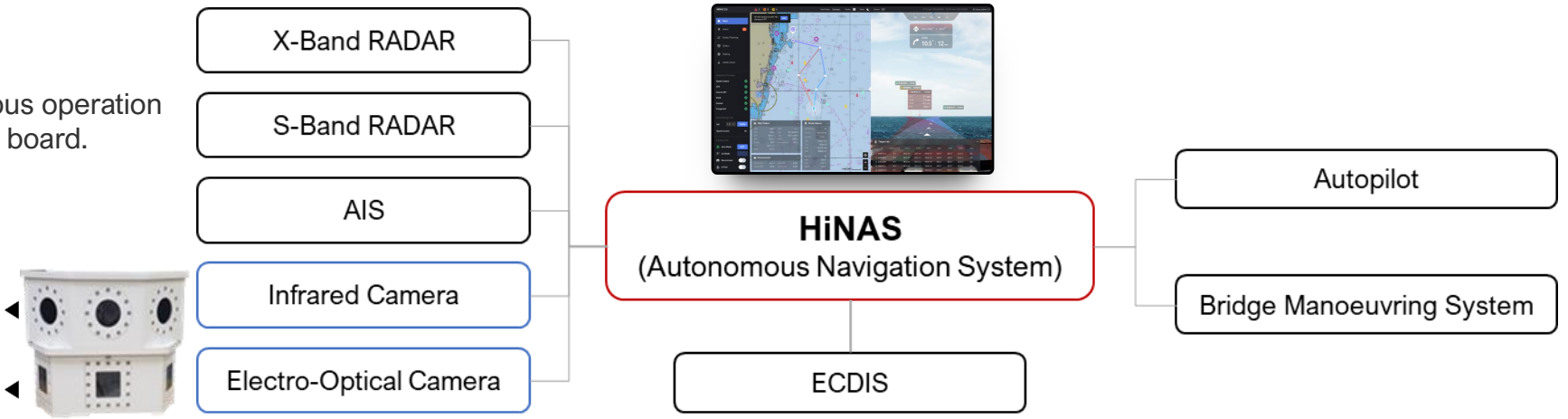
Figure 6: Sensor fusion

e around the clock, lookout during nighttime is a crucial aspect.
r object detection not only during nighttime but also in restricted
es the seafarer to maintain a secure navigation even in dark
mpaired visibility. In essence, it consistently provides optimal
th safety and efficiency in maritime operations.

e 7: Object detection with IR cameras

The concept of the HiNAS is to assist the navigation and manoeuvring work of the seafarers by autonomously performing the behaviours of humans.

Since this system is designed for assistance,
it is a partially autonomous system,
which means all the responsibility of autonomous operation
is belonging to the certified officers/captain on board.

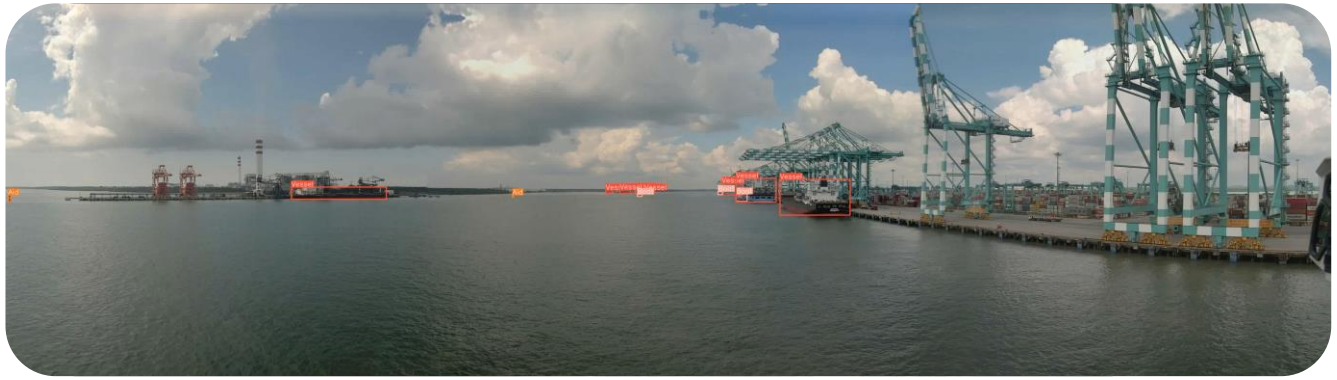


Situational Awareness

Collision Detection & Collision Avoidance

Cyber Security

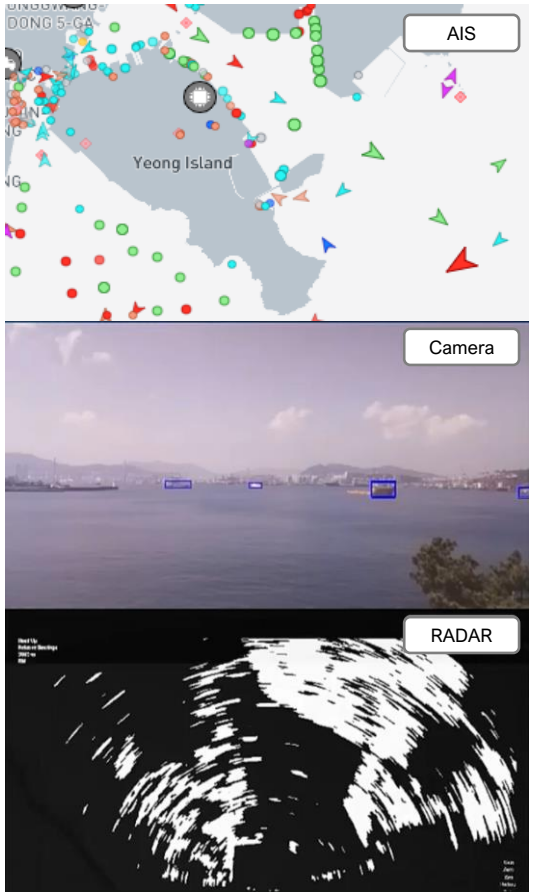
Enhancing situational awareness at night or in restricted visibility using infrared cameras, complemented by blended technologies for mutual reinforcement



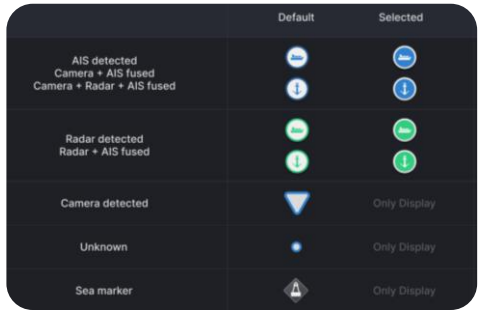
- Computer vision and deep learning-based target detection
- IR camera-based target detection at night or restricted visibility
- The EO camera has low visibility
- IR camera cannot distinguish colors, making object classification difficult.
- EO/IR camera with blended image

Sensor fusion technology enhances accuracy by complementing individual sensor strengths and weaknesses, providing a more complete understanding of the situation.

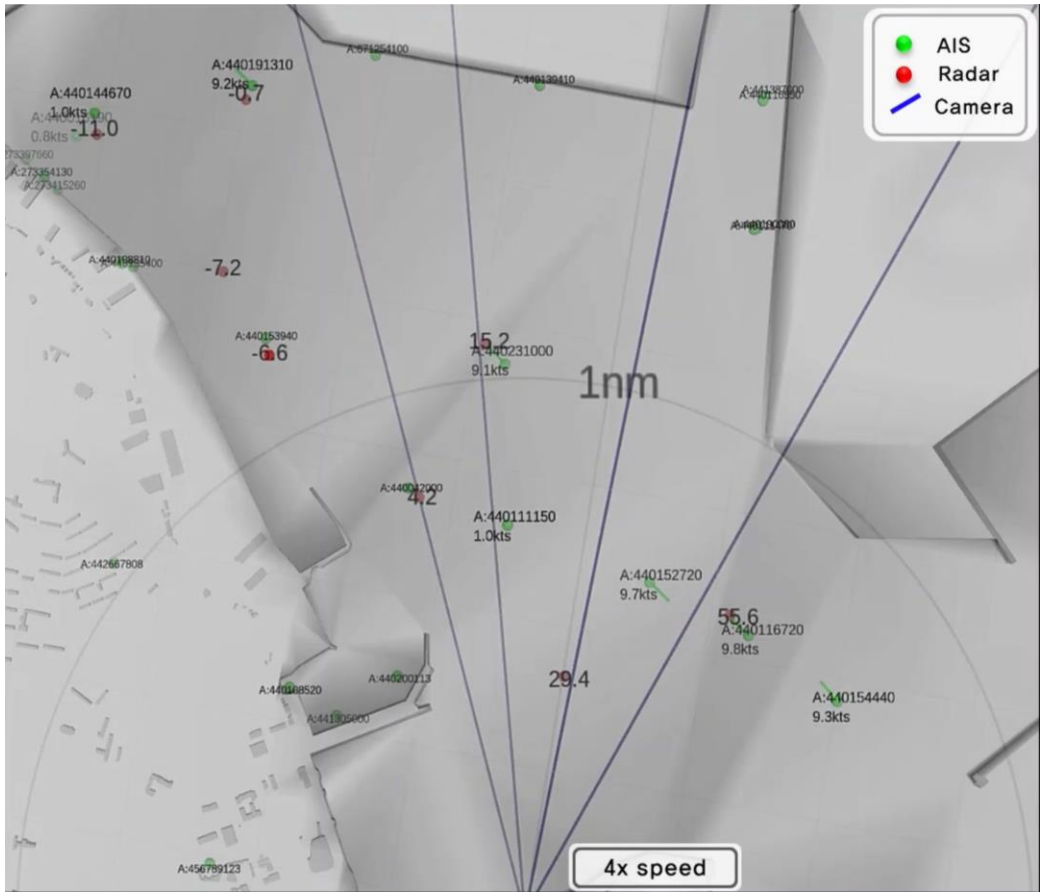
Sensor Input



Sensor Signal Processing



Enhancing accuracy by using sensor fusion technology

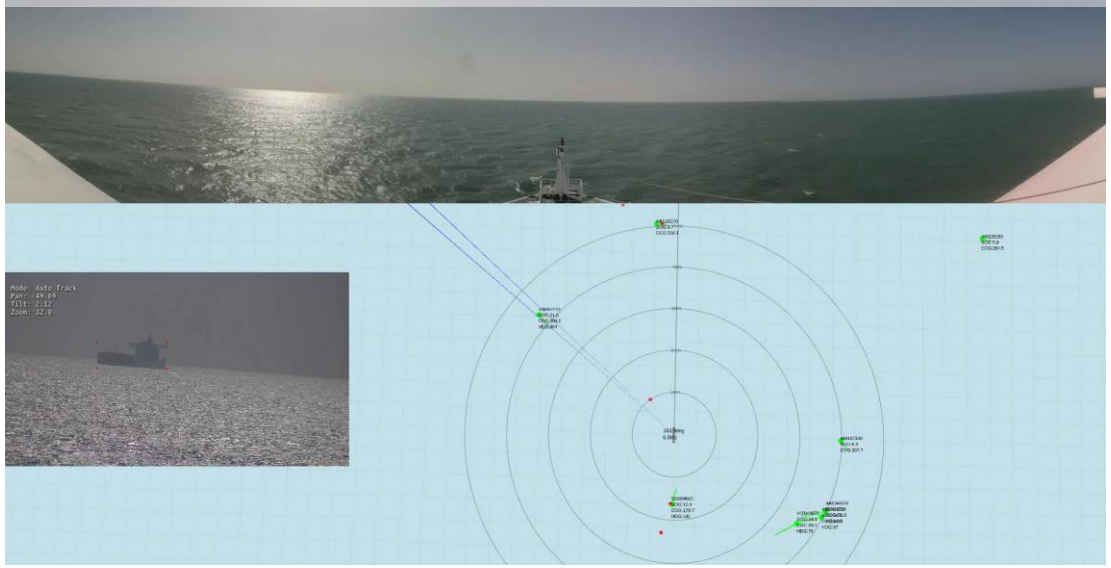


Pan-Tilt-Zoom cameras has been implemented to enhance the detection performance of distant objects, while also closely imitating traditional visual lookout patterns

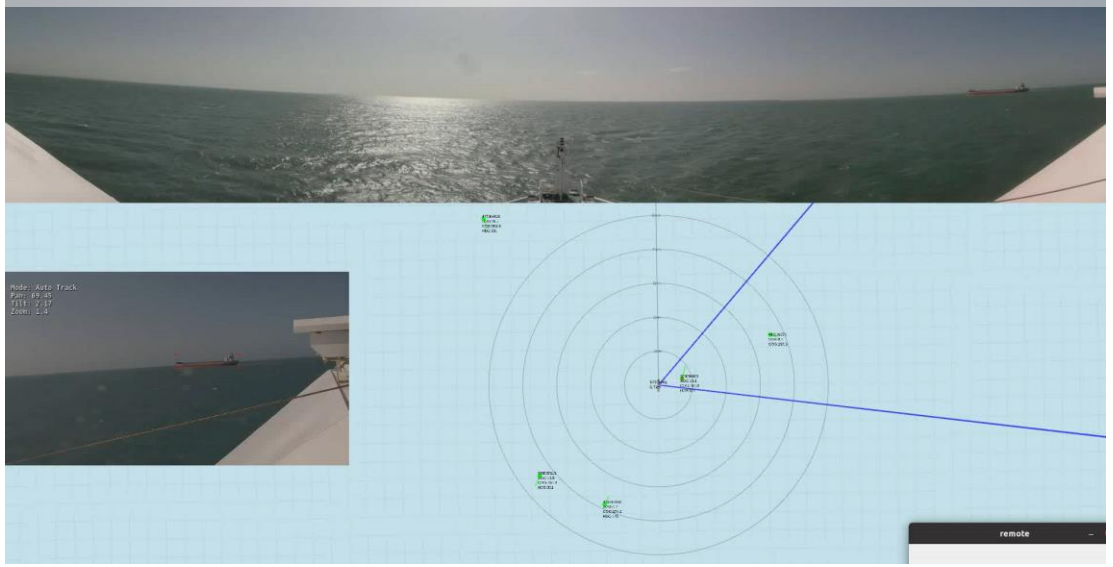
Zooming with auto-tracking

- Auto target tracking using a PTZ(Pan-Tilt-Zoom) camera
- Following the behavior patterns of a navigator using a binocular

Ex 1) Implementing Auto Track Mode in a ‘Head-on’ situation

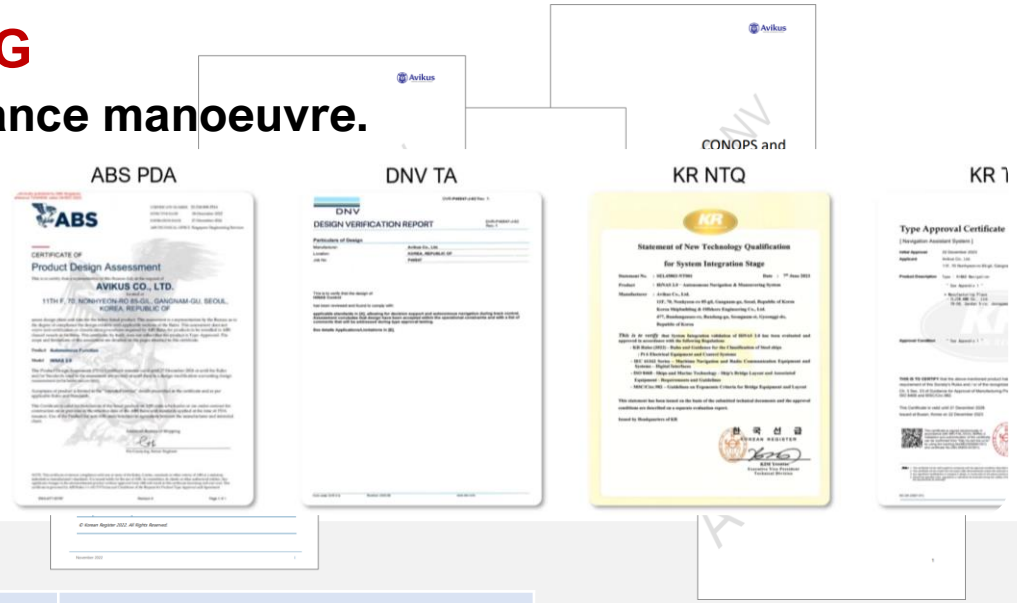


Ex 2) Implementing Auto Track Mode in an ‘Overtaking’ situation

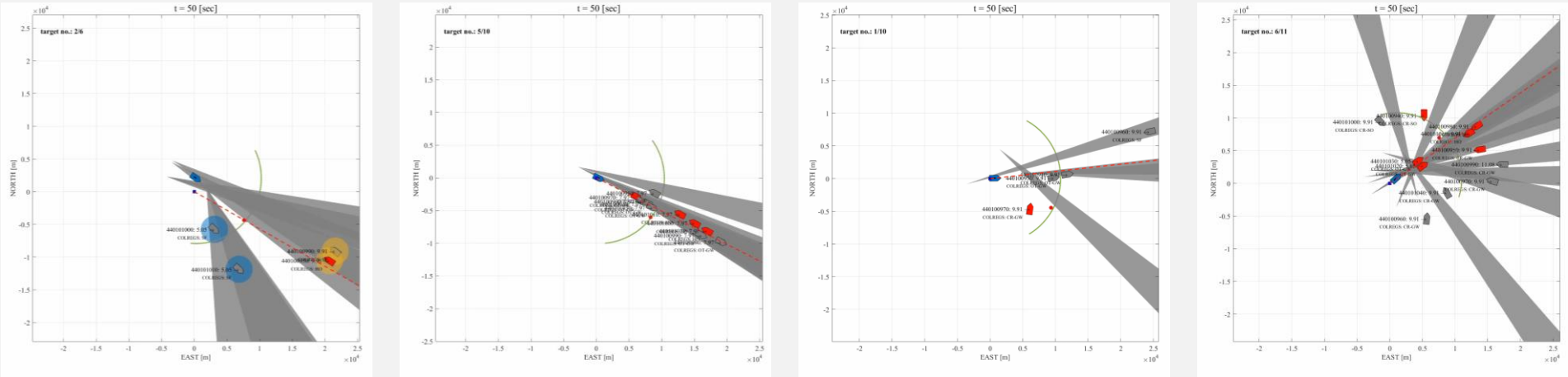


HiNAS classifies encountering situations based on COLREG but prioritize safety first while conducting collision avoidance manoeuvre.

- Simulating various scenarios (testing over a hundred cases) before transitioning to actual operations as below
- After sufficient V&V, certification(type approval) is obtained from various classifications
- Various tests are being conducted in the large commercial ship sector under the following commissioning procedures

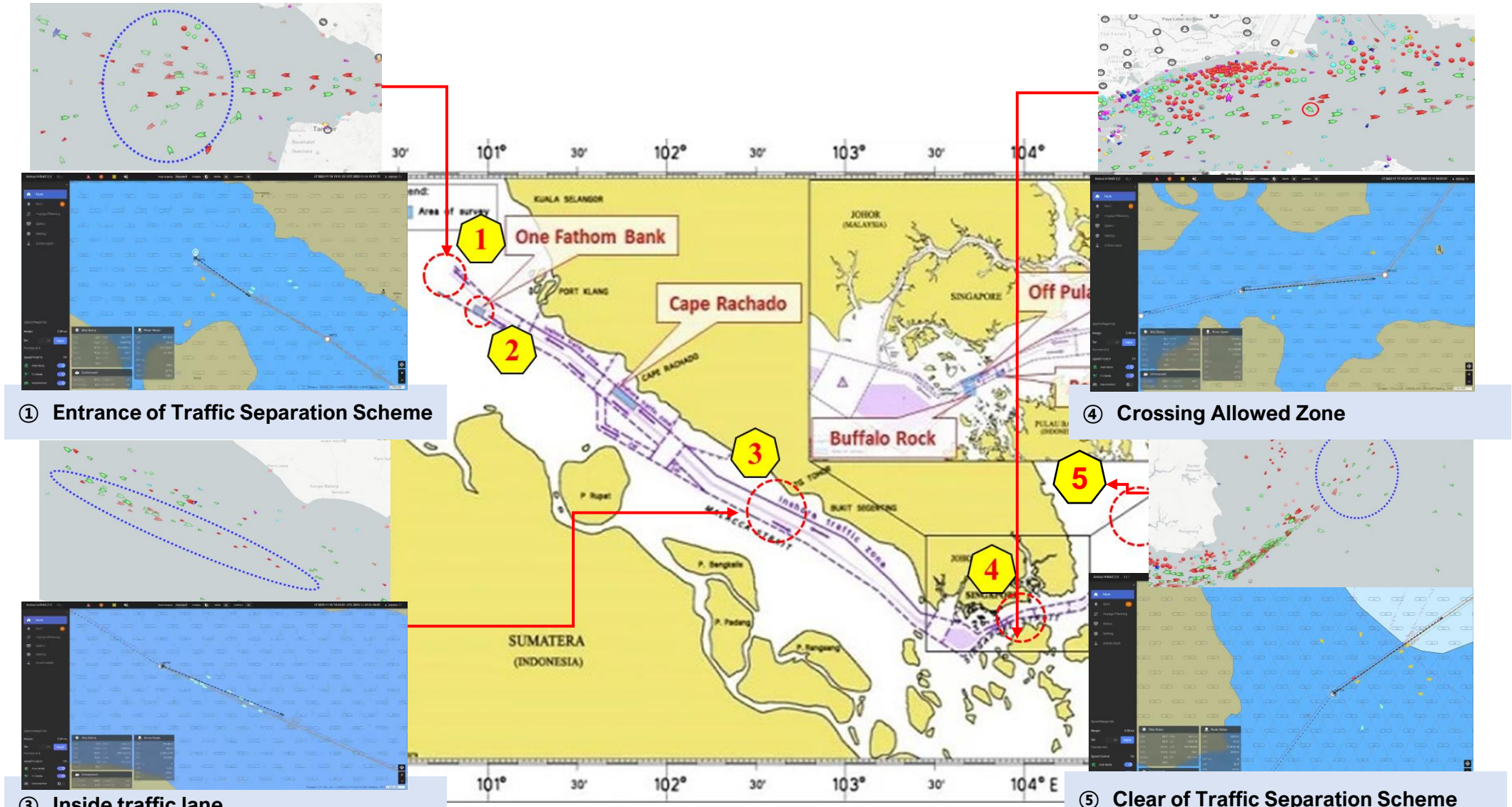


Entrance of Traffic Separation Scheme	Inside traffic lane	Crossing Allowed Zone	Clear of Traffic Separation Scheme



1) system health check test
2) basic function test
3) interface fail test
4) route planning test
5) display requirement test
6) operation mode change test
7) cyber security test

We conducted concurrent real-life testing and Hardware-in-the-Loop (HIL) testing, recognizing that it is not always possible to create desired collision avoidance scenarios in actual navigation situations

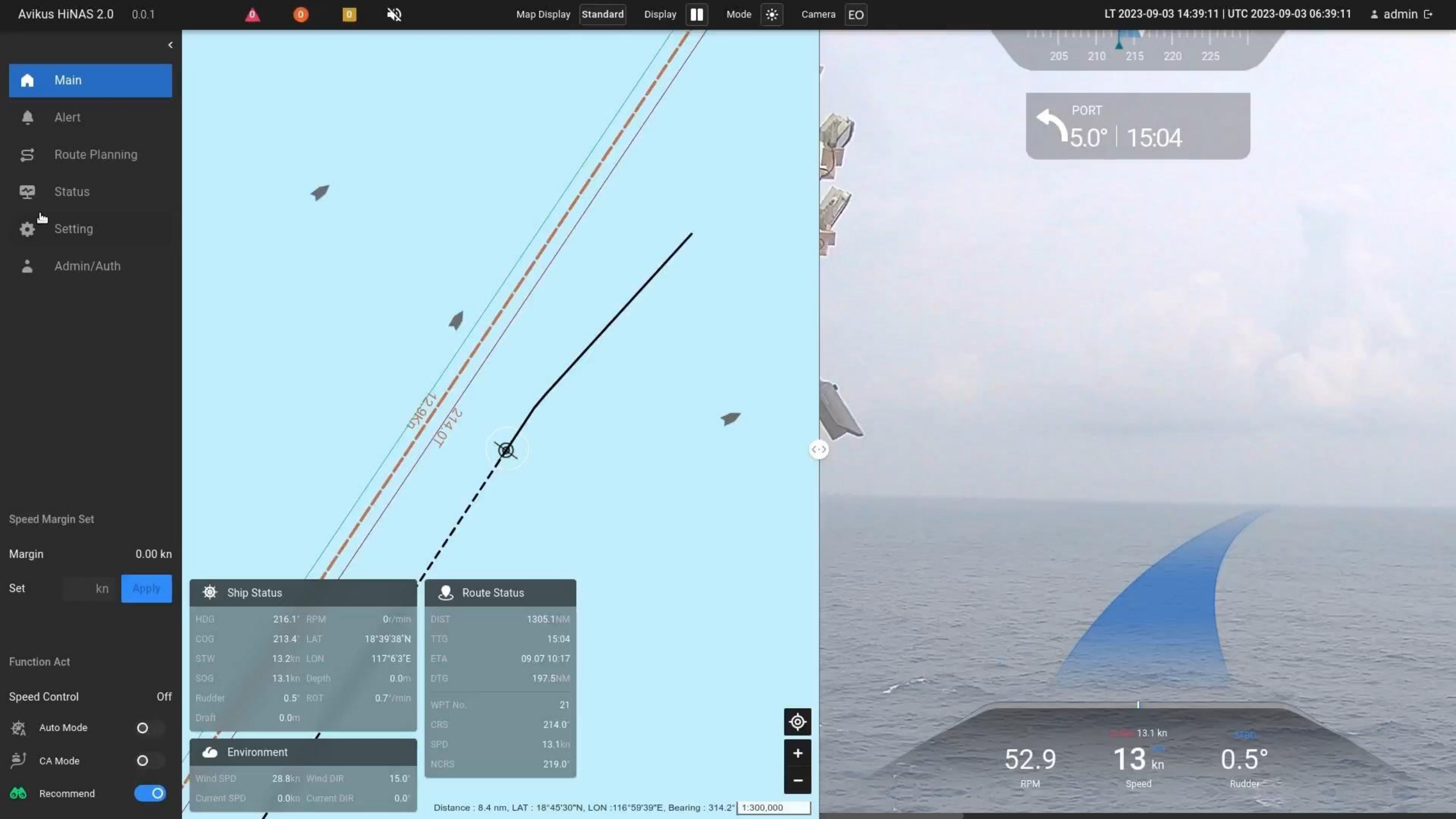


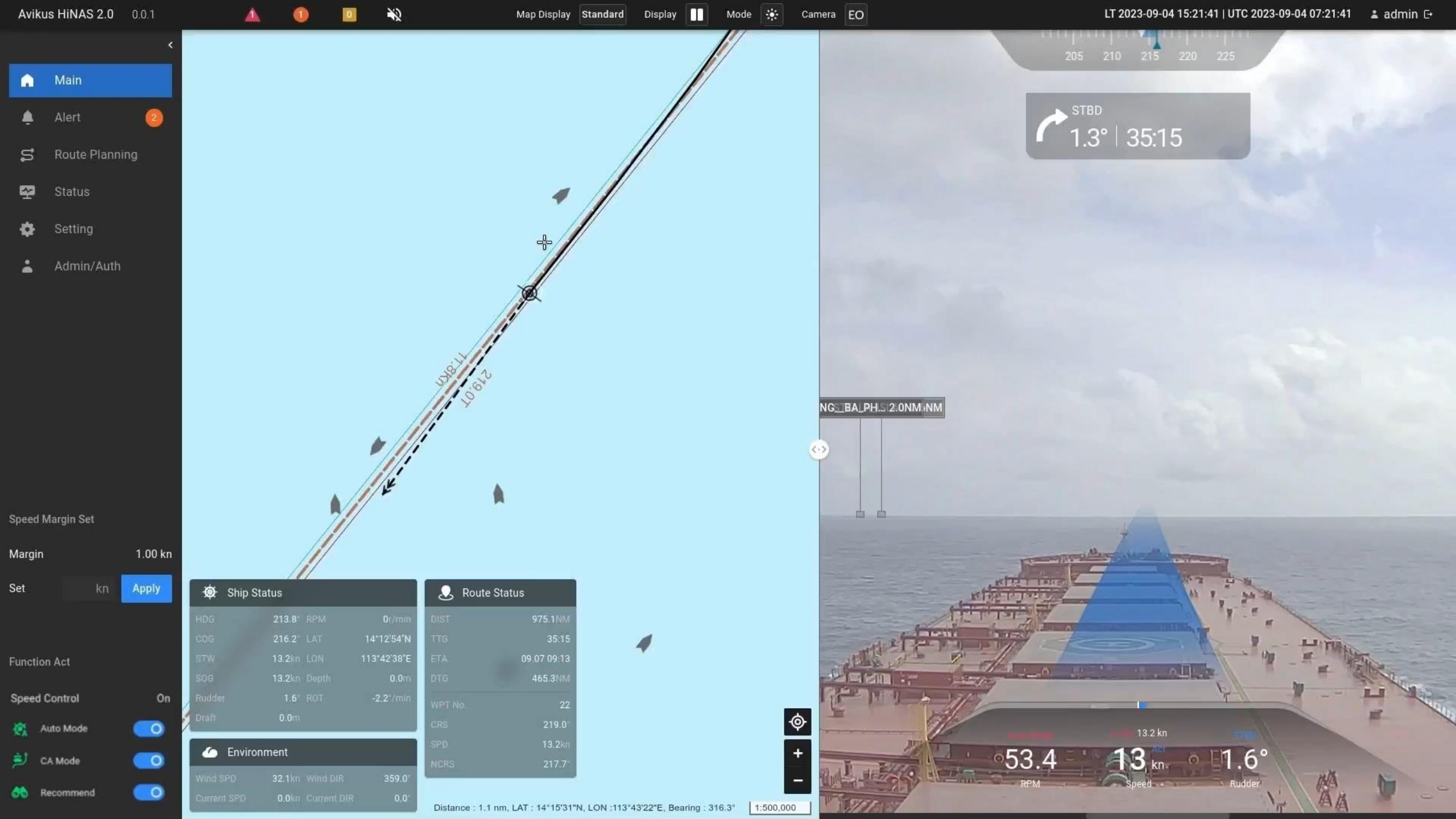
① Entrance of Traffic Separation Scheme

④ Crossing Allowed Zone

③ Inside traffic lane

⑤ Clear of Traffic Separation Scheme


Avikus HiNAS 2.0 0.0.1
Map Display Standard
Display
Mode
Camera EO
LT 2023-09-03 14:39:11 | UTC 2023-09-03 06:39:11
admin
Main
Alert
Route Planning
Status
Setting
Admin/Auth
Speed Margin Set
Margin 0.00 kn
Set kn Apply
Function Act
Speed Control Off
Auto Mode
CA Mode
Recommend
12.9Kn
214.0T
Ship Status
HDG 216.1° RPM 0r/min
COG 213.4° LAT 18°39'38"N
STW 13.2kn LON 117°6'3"E
SOG 13.1kn Depth 0.0m
Rudder 0.5° ROT 0.7°/min
Draft 0.0m
Route Status
DIST 1305.1NM
TTG 15:04
ETA 09.07 10:17
DTG 197.5NM
WPT No. 21
CRS 214.0°
SPD 13.1kn
NCRS 219.0°
Environment
Wind SPD 28.8kn Wind DIR 15.0°
Current SPD 0.0kn Current DIR 0.0°
Distance : 8.4 nm, LAT : 18°45'30"N, LON :116°59'39"E, Bearing : 314.2°
1:300,000
205 210 215 220 225
PORT
5.0° | 15:04
13.1 kn
52.9
RPM
13 kn
Speed
0.5°
Rudder


Avikus HiNAS 2.0 0.0.1
Map Display Standard
Display
Mode
Camera EO
LT 2023-09-04 15:21:41 | UTC 2023-09-04 07:21:41
admin
Main
Alert 2
Route Planning
Status
Setting
Admin/Auth
Speed Margin Set
Margin 1.00 kn
Set kn Apply
Function Act
Speed Control On
Auto Mode
CA Mode
Recommend
11.8KN
219.0T
Ship Status
HDG 213.8° RPM 0r/min
COG 216.2° LAT 14°12'54"N
STW 13.2kn LON 113°42'38"E
SOG 13.2kn Depth 0.0m
Rudder 1.6° ROT -2.2°/min
Draft 0.0m
Route Status
DIST 975.1NM
TTG 35:15
ETA 09.07 09:13
DTG 465.3NM
WPT No. 22
CRS 219.0°
SPD 13.2kn
NCRS 217.7°
Environment
Wind SPD 32.1kn Wind DIR 359.0°
Current SPD 0.0kn Current DIR 0.0°
Distance : 1.1 nm, LAT : 14°15'31"N, LON :113°43'22"E, Bearing : 316.3°
1:500,000
205 210 215 220 225
STBD
1.3° | 35:15
NG BA PH 2.0NM NM
13.2 kn
53.4 RPM
13 kn Speed
1.6° Rudder

HiNAS considers as below and we have obtained KR Cybersecurity Type Approval, designed based on the international standards IEC 62443 and 61162.

The IACS UR E26 and E27 requirements are being mandatory compliance requirements from July 2024 onwards

- IACS UR E26 – Cyber Resilience of Ships
- IACS UR E27 – Cyber Resilience of On-Board Systems and Equipment

Cyber security infrastructure includes:

-Building its own security infrastructure to protect the in-ship network and autonomous system

-Application of firewalls, intrusion prevention systems (IPS), access logs and event management systems

Cyber security policy includes:

-Establish and apply security policies such as solution access control, data protection, encryption, and authentication

Cyber security risk assessments include:

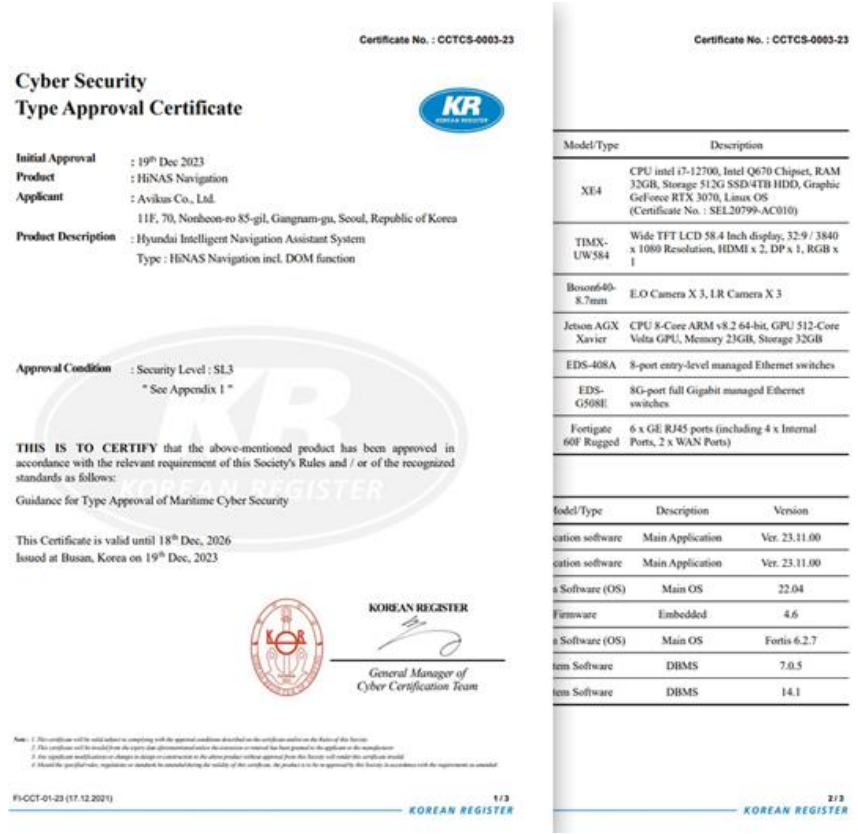
-Risk assessment identifies and manages security vulnerabilities to improve security levels

-Apply remote updates such as necessary security measures through the application of OTA functions

Security monitoring and alert system include:

-Application of traffic monitoring and anomaly detection and warning system for equipment

-Remote monitoring with functionality for remote security monitoring



Certificate No. : CCTCS-0003-23

Cyber Security
Type Approval Certificate

Initial Approval	: 19th Dec 2023
Product	: HiNAS Navigation
Applicant	: Avikus Co., Ltd.
	11F, 70, Nonheon-ro 85-gil, Gangnam-gu, Seoul, Republic of Korea
Product Description	: Hyundai Intelligent Navigation Assistant System
	Type : HiNAS Navigation incl. DOM function
Approval Condition	: Security Level : SL3
	" See Appendix 1 "

THIS IS TO CERTIFY that the above-mentioned product has been approved in accordance with the relevant requirement of this Society's Rules and / or of the recognized standards as follows:

Guidance for Type Approval of Maritime Cyber Security

This Certificate is valid until 18th Dec, 2026
Issued at Busan, Korea on 19th Dec, 2023

KOREAN REGISTER

General Manager of
Cyber Certification Team

FI-CCT-01-23 (17.12.2021) 1/3 KOREAN REGISTER

Certificate No. : CCTCS-0003-23

Model/Type	Description
XE4	CPU intel i7-12700, Intel Q670 Chipset, RAM 32GB, Storage 512G SSD/4TB HDD, Graphic GeForce RTX 3070, Linux OS (Certificate No. : SEL20799-AC010)
TIMX-UW584	Wide TFT LCD 58.4 Inch display, 32:9 / 3840 x 1080 Resolution, HDMI x 2, DP x 1, RGB x 1
Boson640-8.7mm	E.O Camera X 3, I.R Camera X 3
Jetson AGX Xavier	CPU 8-Core ARM v8.2 64-bit, GPU 512-Core Volta GPU, Memory 23GB, Storage 32GB
EDS-408A	8-port entry-level managed Ethernet switches
EDS-G508E	8G-port full Gigabit managed Ethernet switches
Fortigate 60F Rugged	6 x GE RJ45 ports (including 4 x Internal Ports, 2 x WAN Ports)

odel/Type	Description	Version
ation software	Main Application	Ver. 23.11.00
ation software	Main Application	Ver. 23.11.00
Software (OS)	Main OS	22.04
Firmware	Embedded	4.6
Software (OS)	Main OS	Fortis 6.2.7
tem Software	DBMS	7.0.5
tem Software	DBMS	14.1

2/3 KOREAN REGISTER

Sailing together: Striving for a future-proof IMO MASS Code

MASS, Challenges for Harmonious Technology Development

SAFE

Safety First with User-Centric Value

Revealing various sources of satisfaction beyond enhanced safety and reduced workload, based on real user feedback.

Detection of Man Overboard(MOB)

Utilizing generative AI to train for specific scenarios such as MOB incidents and developing adequate detection capabilities.

Effective Use for Anti-Piracy etc.

Enabling real-time 360-degree view without blind spots in 3D mode, with intuitive visualization accessible from any location onboard.

In the commercial ship industry, AI ADAS is gaining significant recognition and is poised to become industry standard in the near future

FUTURE IS HERE

Captain of the container ship

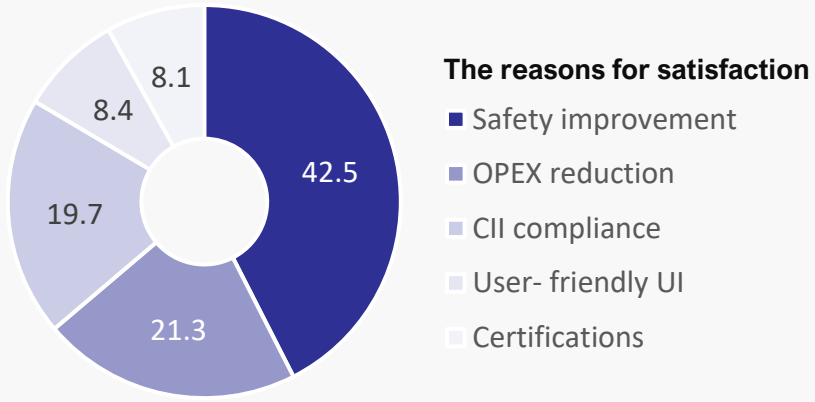
"The new display is **simple yet effectively** present the necessary navigation information, making it very nice!

Especially, it is **intuitive to perceive the risk of collision** using the congested mode and extremely convenient with the addition of wide/full-screen mode."

- Received orders of more than **400** sets
- **Standard spec.** of HD Hyundai's new building ships (150~200 sets/year)

Q *How satisfied were you with the features and services provided by HiNAS*

Extremely satisfied/Satisfied ——— **98%**



Survey conducted among crew members actively using the HiNAS, 98% evaluated the solution as a valuable tool for navigation with 94% expressing that it contributes to workload reduction

OPEX reduction

FOC(Fuel Oil Consumption) 10~15% reduction (1M $/year fuel cost saving per ship)

Environmental regulation compliance

The most effective solution to respond to IMO's CII(Carbon Intensity Index) regulation

User-friendly UI

A UI designed to evoke empathy based on user research and feedback

Certifications

Obtained certifications(TA, PDA) from reliable authorities such as class and flag states

Utilizing generative AI to train for specific scenarios

such as MOB incidents and developing adequate detection capabilities

Training data augmentation by generative AI

Logging data

INPUT

Segment

Avikus Generative AI

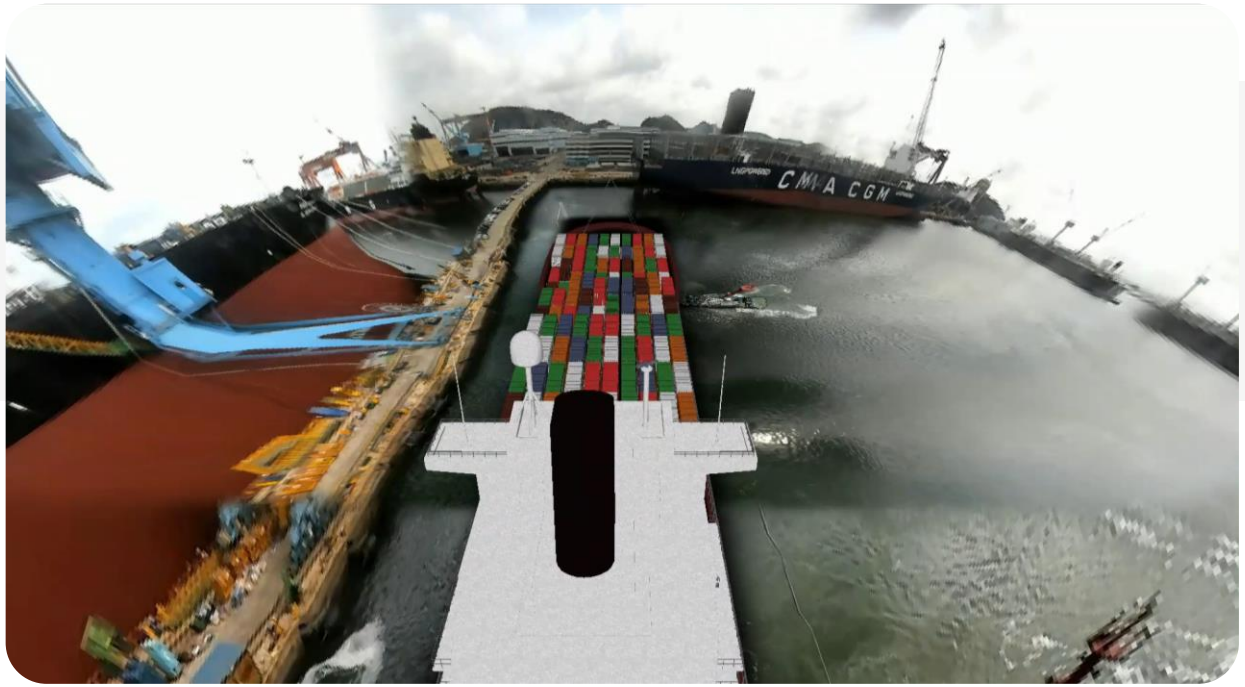
InPaint

Prompt: **"Aircraft carrier on the sea"**

OUTPUT

Enabling real-time 360-degree view without blind spots in 3D mode, with intuitive visualization accessible from any location onboard

- Useful when passing canal, narrow channel, berthing/unberthing
- Prevent the risk of armed robbery, stowaways, smugglers, etc.
- Actual Example from Korean Ship Owner
  → They caught an attempt of a stowaway in advance using HiNAS
- Monitoring from anywhere onboard using the portable device



ENVIRONMENTAL

Reducing GHG Emissions

During the world's first transoceanic voyage, we demonstrated that HiNAS reduced greenhouse gas emissions by 5%.

Reducing FOC about 15%

Through the long-term actual test, we could verify that about 13% of fuel oil consumption was reduced.

Cost-Effective Green Solution

HiNAS presents effective strategies for environmental regulations and holds the potential to lead the era of eco-friendly and fuel-efficient technology.

During the world's first transoceanic voyage, we demonstrated that HiNAS reduced greenhouse gas emissions by 5%

Baseline Setting

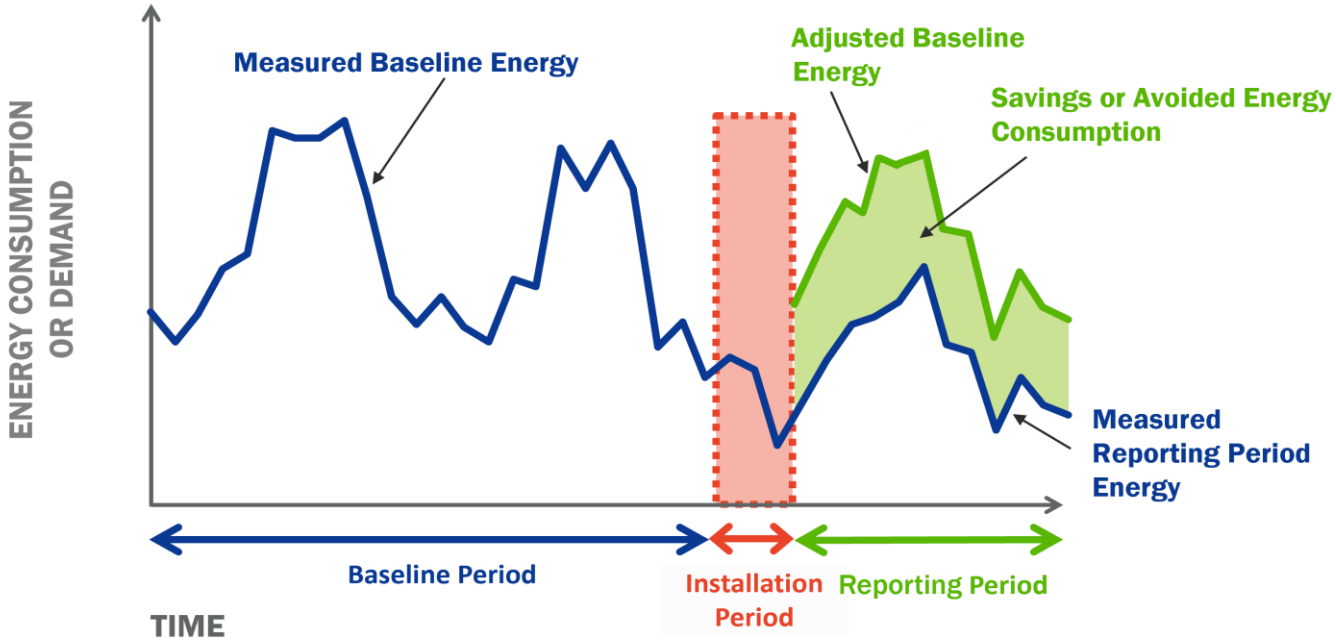
- **Ship Performance**
  Data-driven model based on the past 6month's voyage data

- **Assumption**
  Ship voyages at a constant speed without speed change from departure and arrival at designated RTA (Comparison target)

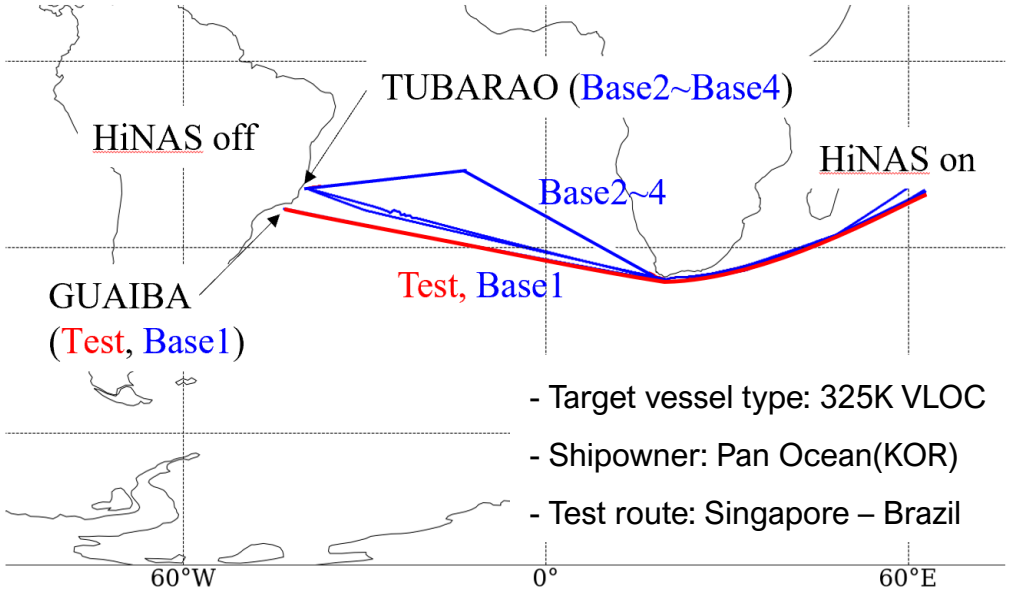
Comparison

- Fuel Saving = Comparison Target – Actual

* G/E 50% load assumption



Through the long-term actual test, we could verify that about 13% of fuel oil consumption was reduced



- Approximately the same route
- Collecting voyage data from same vessel
  → With HiNAS /Without HiNAS (Historical data for same route)
- Analyzing Fuel Oil Consumption for each historical/test case and simulated case

Confirmed achieving a **fuel savings effect** of **5-15% through HiNAS**

HiNAS presents effective strategies for environmental regulations and holds the potential to lead the era of eco-friendly and fuel-efficient technology

[Comparison of Fuel Saving Devices for Ships]

HiNAS

Air Lubrication System

Rotor Sails

Cost-saving benefits	Avg. 15%	5~8%	3~8%
Main function	• Automatically control steering and speed via Autopilot, BMS • Suggesting Optimal route and voyage conditions	• Emitting small air bubbles onto the hull surface • Reducing friction resistance	• Install the rotating cylindrical columns • Utilizing the pressure difference to assist propulsion

SUSTAINABLE

Beneficial for Seafarers

It's not about reducing existing maritime jobs; rather, it's about alleviating burdens on seafarers while enhancing safety and environmental benefits.

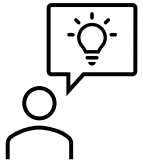
Sustainable for Both at Sea & Onshore

Supporting sustainability through cloud services by enabling monitoring of ships or fleets both at sea and onshore.

Need for Comprehensive Cooperation

Maximizing the ripple effect of MASS requires comprehensive cooperation across technical, regulatory, social, and economic impacts.

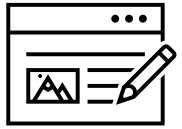
It's not about reducing existing maritime jobs; it's about alleviating burdens on seafarers while enhancing safety and environmental benefits



Enhancing safety and efficiency

Autonomous ships not only enhance navigation safety but also benefit crew mental health by reducing the burdens of navigation and improving management process efficiency.

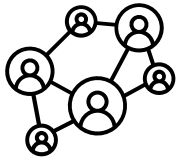
This will improve productivity and job satisfaction by providing a safer and more efficient working environment for seafarers.



Empowering seafarers to gain industry expertise

Seafarers can prepare for the future of the shipping industry by enhancing their expertise in the operation and management of autonomous ships.

Seafarers' expertise in ship navigation remains crucial and offers them broader opportunities to advance their specialized skills.



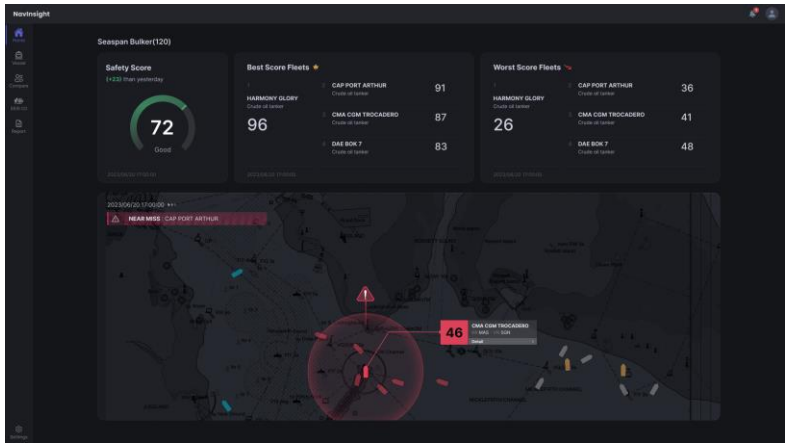
Transforming industries through technological advancements

New jobs may emerge for example, technical engineers, data analysts, and maintenance and repair specialists to operate and monitor autonomous ships.

These roles enable seafarers to adapt to new responsibilities and technologies in the evolving maritime industry.

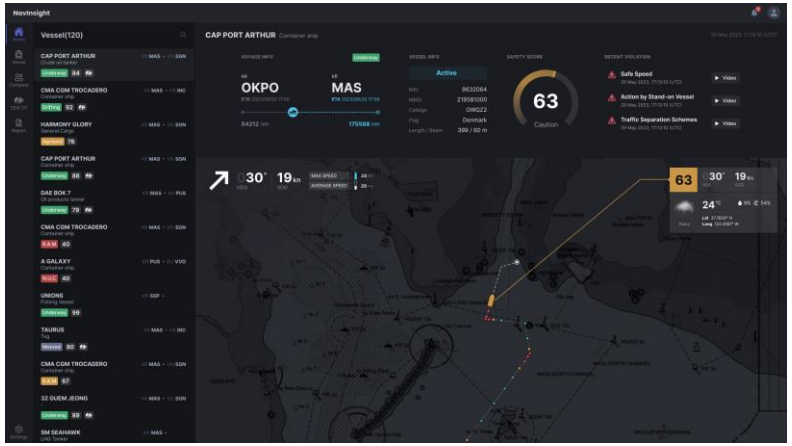
Supporting sustainability through cloud services by enabling monitoring of ships or fleets both at sea and onshore

- Providing schedule monitoring, location tracking, OTA software update, black box function, etc.
- Real time fleet monitoring for safety, fuel consumption, and GHG emission.



Safety score

Identify hazardous situations



Vessel status

Monitor operations remotely

Video analysis

Analyze video footage overlaid with contextual data

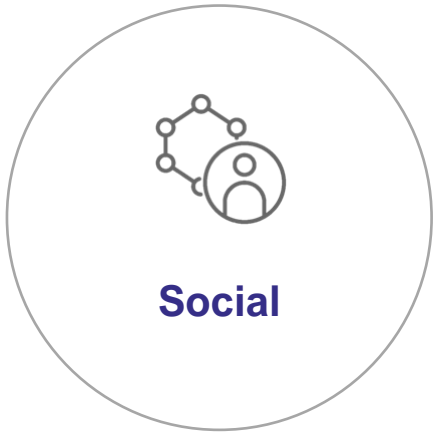
Maximizing the ripple effect of MASS
requires comprehensive cooperation across technical, regulatory, social, and economic impacts.

Technical

- Development of AtoN suitable for MASS
- Cooperation with VTS
- Data and comm. standards

Regulatory

- Consideration of potential risks
- Regulations for uncrewed MASS
- Practical regulatory framework



Social

- Acceptance and trust
- Safety awareness
- Employment impact

Economic

- Initial investment cost
- Operational efficiency
- Optimized DoA for each vessel

Impacts and Insights Gained from the Commercialization of ANS (HiNAS)

Deploying the actual product for commercial use and operational use

The necessity of assuring

- Situational Awareness
- Collision Avoidance & Collision Detection
- Cyber Security

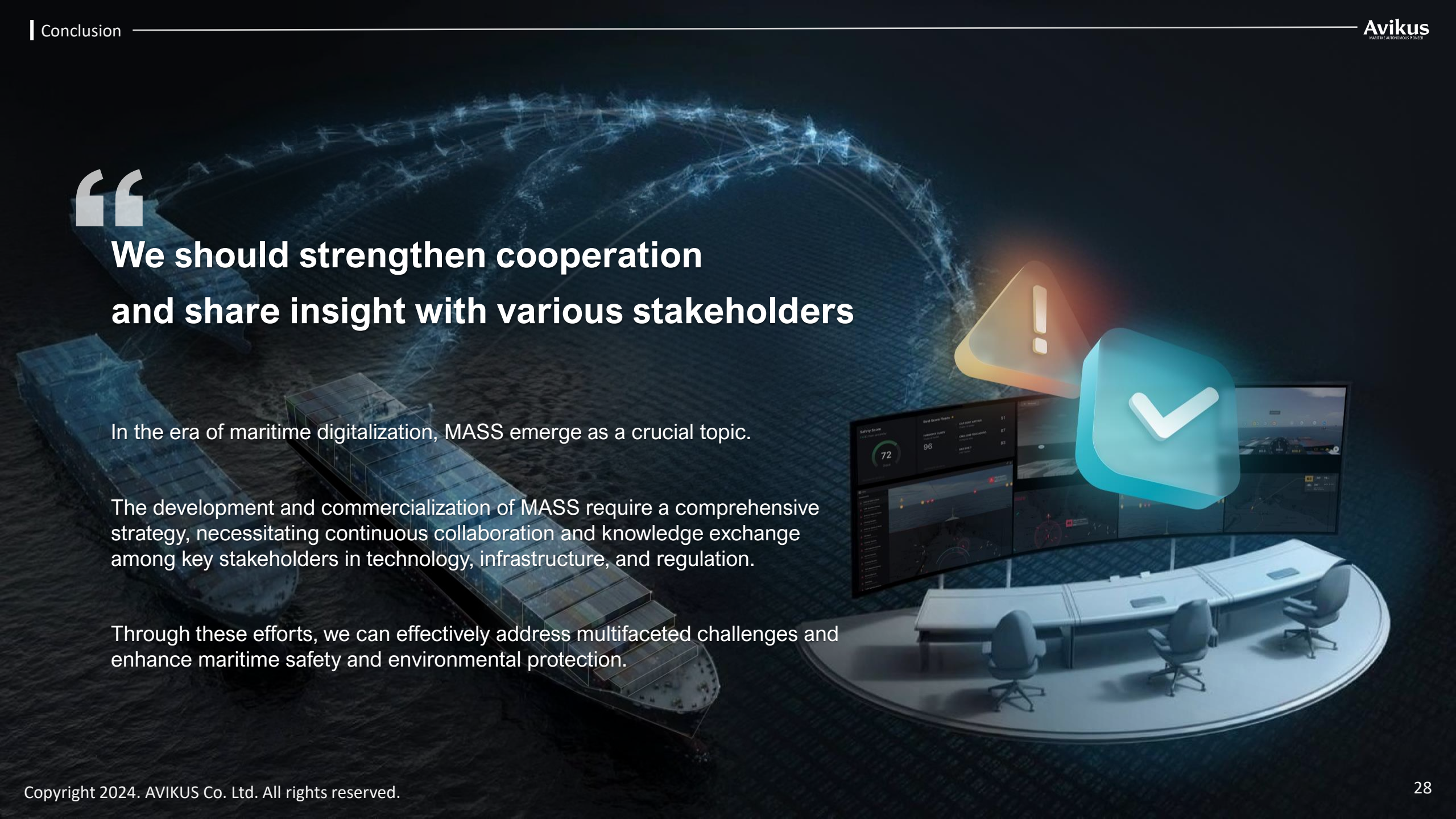
SAFE

ENVIRONMENTAL

SUSTAINABLE

Sailing together

We should strengthen cooperation and share insight with various stakeholders



In the era of maritime digitalization, MASS emerge as a crucial topic.

The development and commercialization of MASS require a comprehensive strategy, necessitating continuous collaboration and knowledge exchange among key stakeholders in technology, infrastructure, and regulation.

Through these efforts, we can effectively address multifaceted challenges and enhance maritime safety and environmental protection.

Your partner for safer and greener voyage

THANK YOU

Hyogyeong Joo
Mobile : +82-10-4101-5049
Email : hyogyeong.joo@avikus.ai, www.avikus.ai

Copyright 2024. AVIKUS Co. Ltd. All rights reserved.