BIPC 2024

Current Status of Commercialization of Autonomous Ship Technology

September 2024

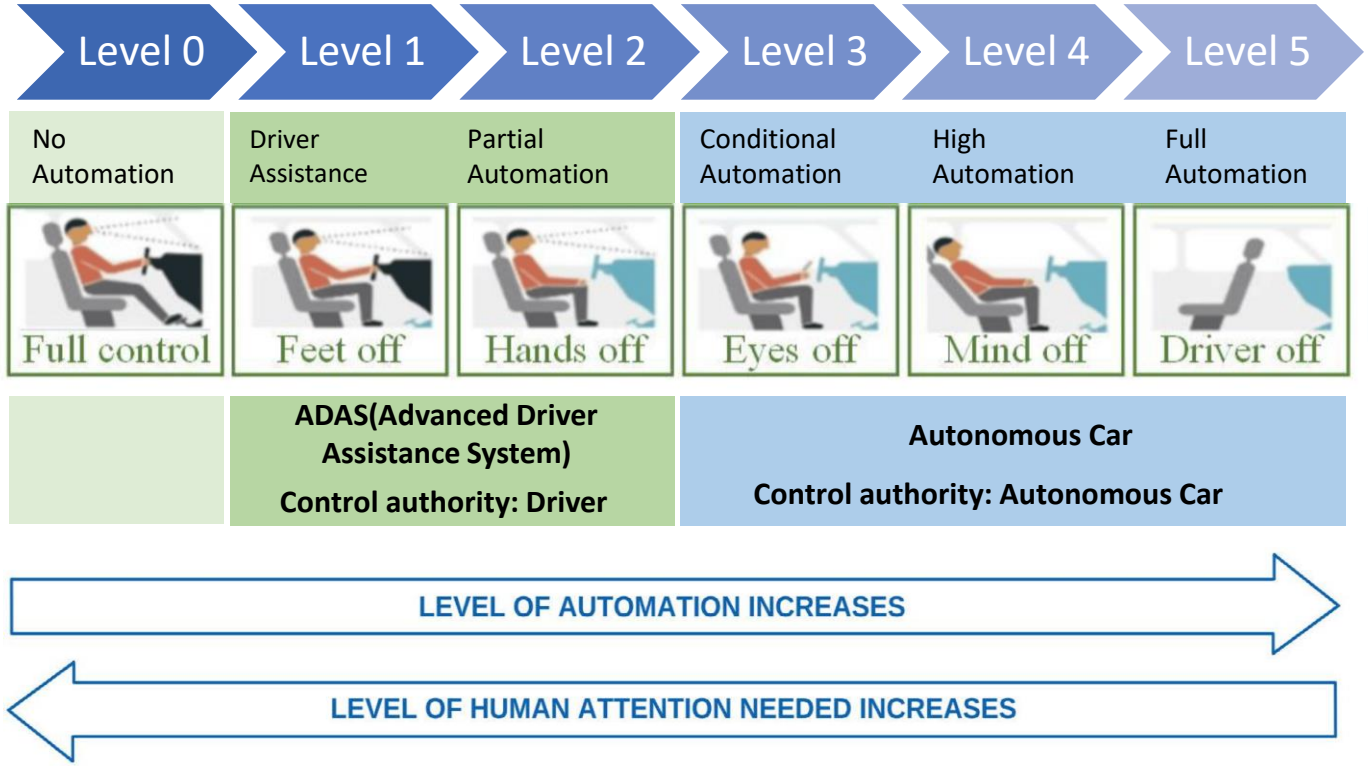
Dohyeong Lim Ph.D, CEO

HD HYUNDAI Avikus

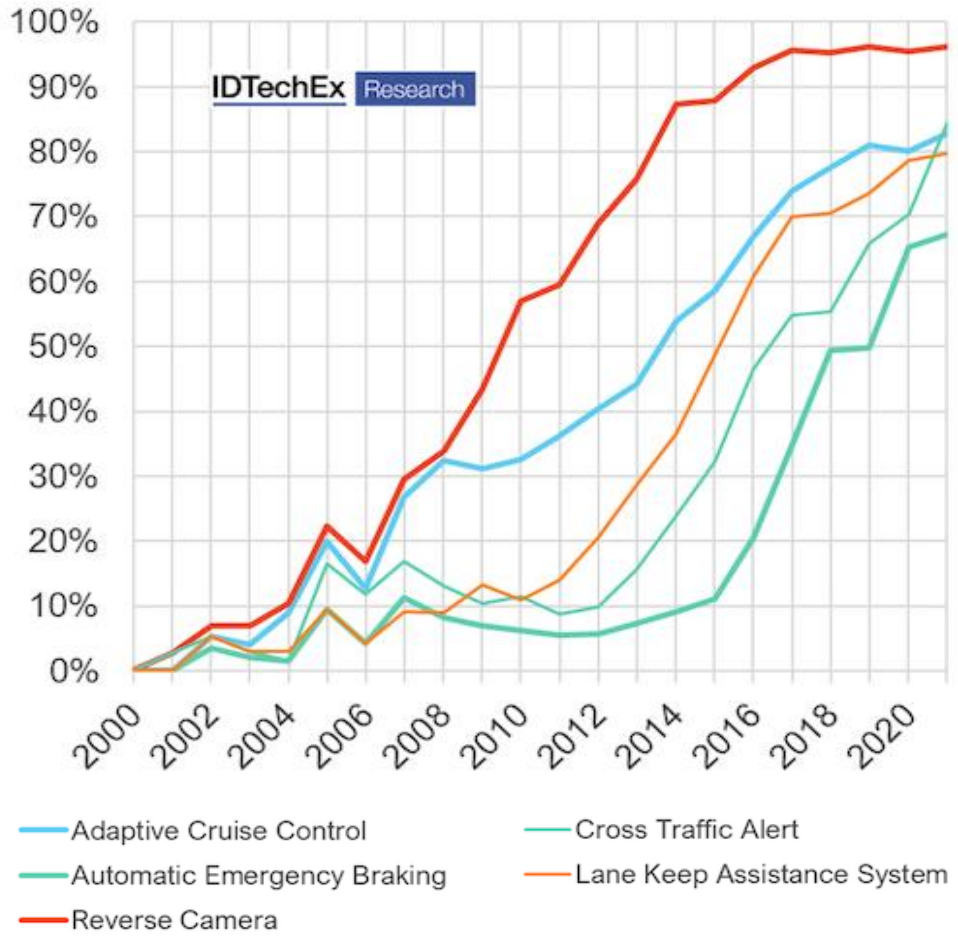
Trends of autonomous car industry

Level 2 and below autonomous driving has been validated as a mature technology that provides sufficient value in terms of safety and convenience, and is now being installed in almost all new vehicles

Level of Autonomy in Car Industry(SAE)

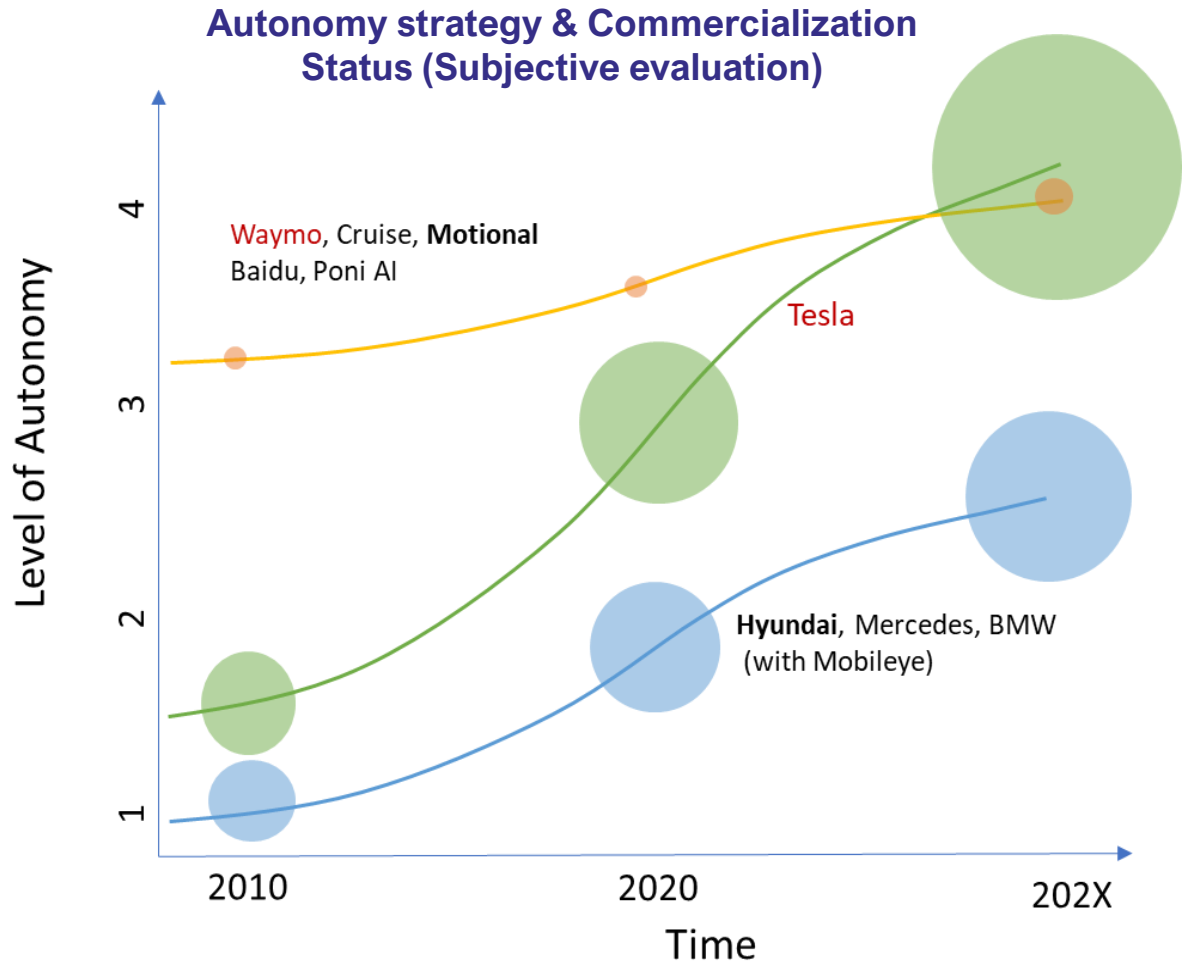


ADAS Features Adoption Rates



Trends of autonomous car industry

Tesla is selling Lv.2 solutions with a smart strategy, is simultaneously succeeding in technology development and commercialization.
However, Lv. 3 and above are expected to take longer to commercialize due to technical imperfections, product liability, consumer expectations, etc.



Tesla FSD V12 End-to-end learning

Cruiser Robotaxi loses its self-driving license due to safety issues

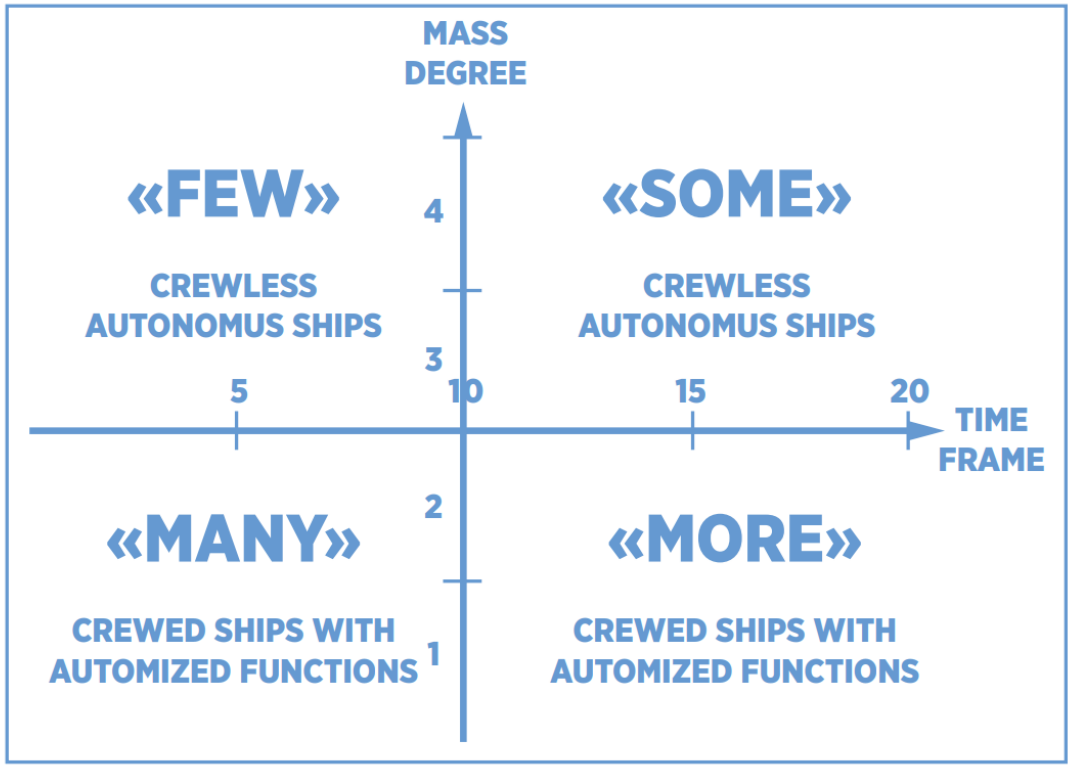
Insights from autonomous driving technology

1. With the development of AI (S/W, H/W) and sensor technology, autonomous technology that has become widespread in automobiles is rapidly expanding to other area such as ships, robots, UAM, etc.

2. It took 20 years for autonomous technology in automobiles to be commercialized, but the technology has been proven in automobiles, so it will be commercialized at a much faster speed when applied to other fields.

3. It will take time for autonomous ships of Lv. 3 or higher, as there are many issues to be resolved, such as technological confidence, economic feasibility, rule and regulation, product liability, and stakeholder acceptance.

4. So, even if high-autonomous technology appears, most ships will be crewed ships with automized functions within 20 years (IALA)



(Source: IALA Report 2024)

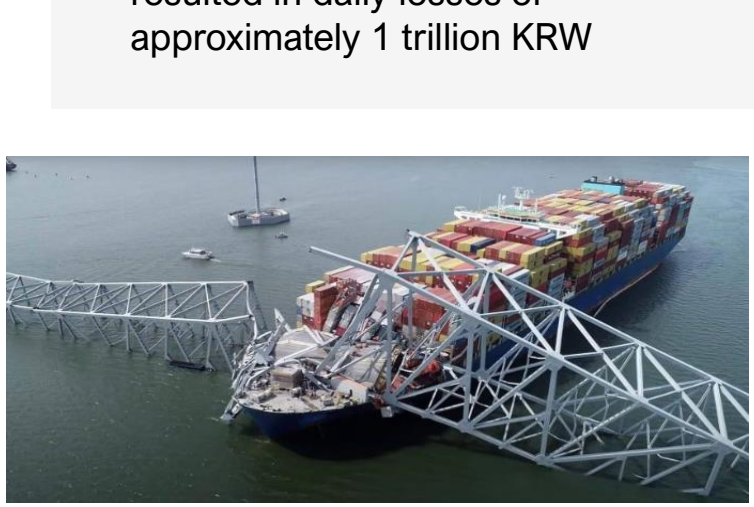
Driving force of autonomous ship

The automation and autonomy of ships are a megatrend, aiming to address the shortage of seafarers, enhance safety by preventing human errors, and improve operational efficiency.

150,000

Lack of seafarers

- Shortage of around 150,000 seafarers within 5 yrs
- Over 50% of Japan's domestic vessels are aged 50 years or older.



80%

Safety of navigation

- Approximately 80% of maritime accidents are due to human error
- The Suez Canal incident in 2021 resulted in daily losses of approximately 1 trillion KRW

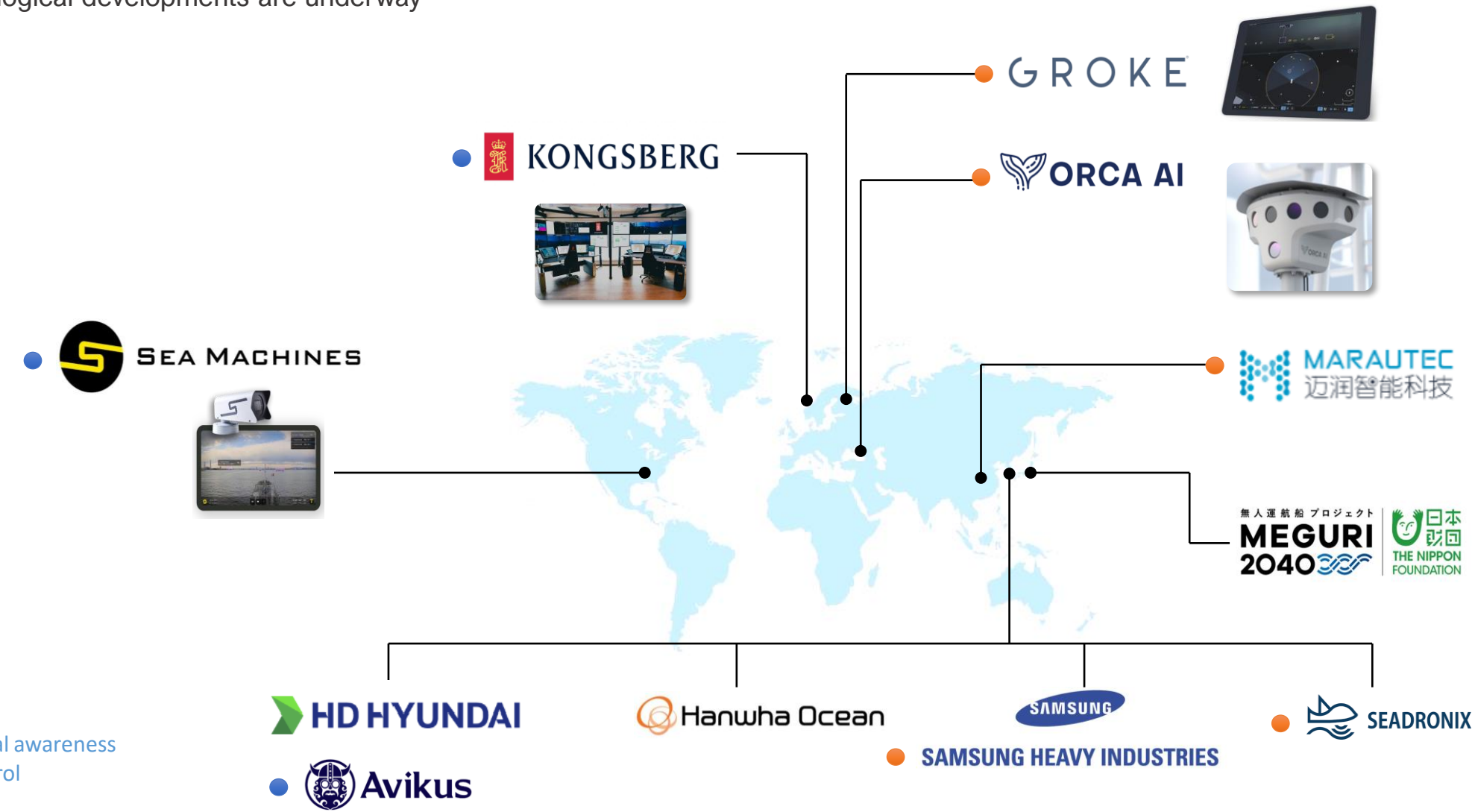
13%

Efficiency

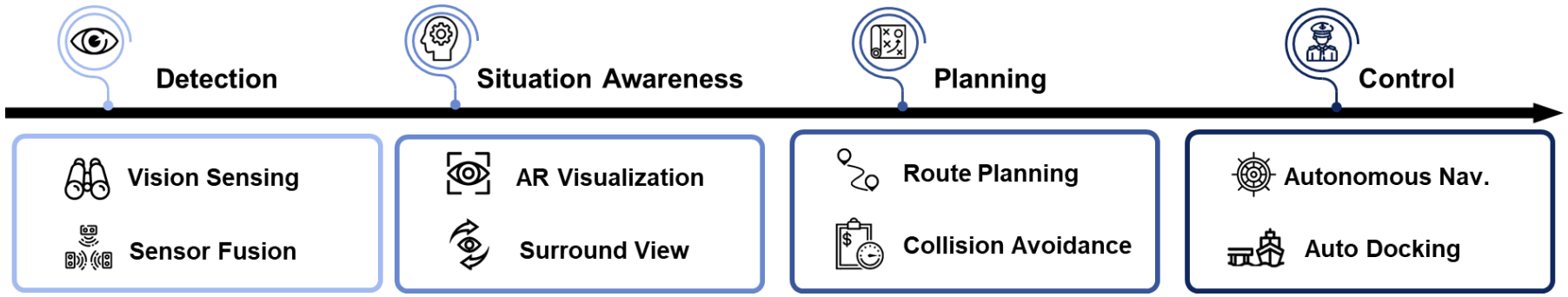
- Maritime transportation accounts for 13% of GHG emissions
- 0% reduction in carbon emissions is necessary by 2030
- Vessels unable to meet IMO regulations face operational bans

Market trends

Diverse technological developments are underway

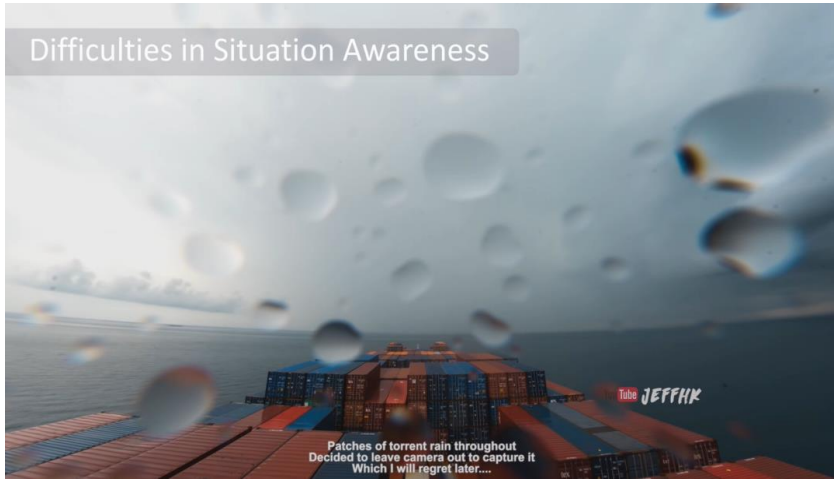


Autonomous Ship Technology



Conventional manner in autonomous things,

But different approach to tackle maritime characteristics



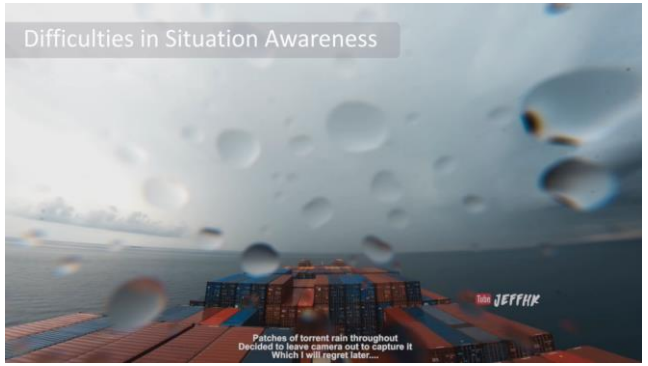
- Small object detection
- Limited visibility at ever-changing sea weather
- Scene diversity

- No lane
- Collision avoidance strategy in congested areas
- Grounding due to unknown underwater

- Sensitive to disturbances(wind, current, waves)
- Slow response time in controlling ship
- 6 DOF motion

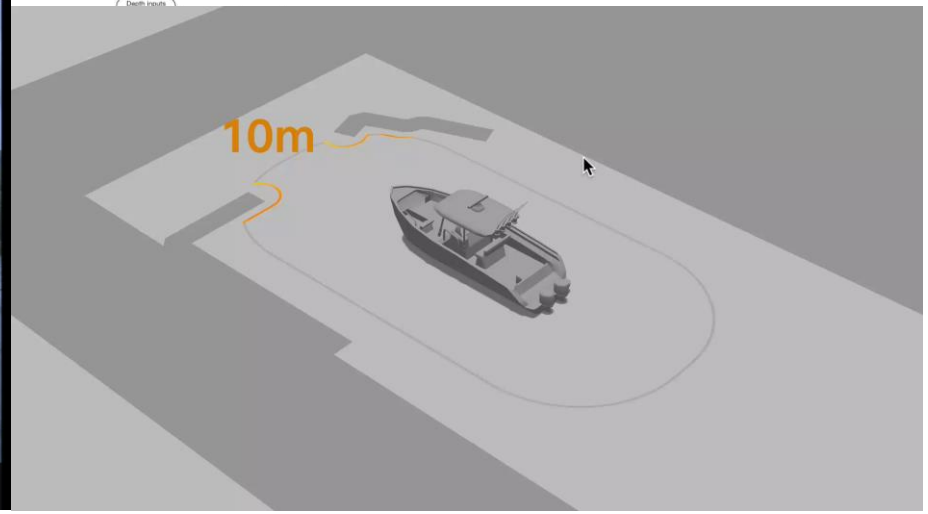
Novel Approach to Tackle These Challenges

Through Roof Shot, Not Moon Shot

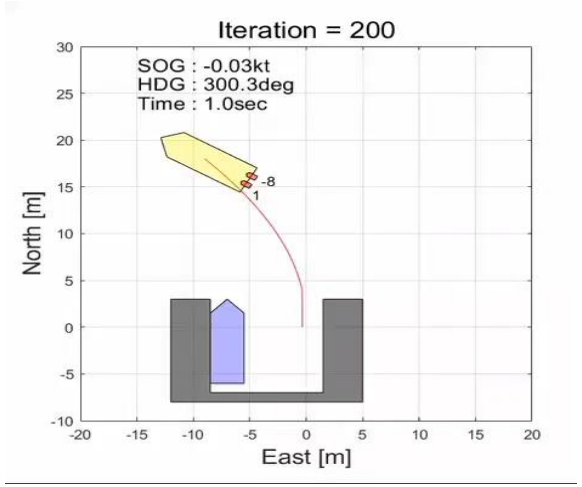


Training data generation with generative AI

Ship specific sensor combination & custom AI model



Human-like auto docking: Reinforcement learning



Steadfast Growth of Avikus

A Continuous and Upward Trajectory

Founded in January '21 by HD HYUNDAI, No.1 Shipbuilder in the world

10+ years of unprecedented "smart ship" R&D legacy of HD HYUNDAI

Industry-leading track records and data leadership with 600+ orders and 100+ installations

All HD HYUNDAI vessels are equipped with Avikus solutions(200+ every year)

100+ researchers & engineers joined from all over the world and the number will be 150~200

Attracting top-tier talent in AI, computer vision, software, and control from each industries

Technology is scalable for all types of maritime surface vessel from 20ft to 1,000ft +

References include commercial ships, leisure boats, coast guard ships and workboats

Stepwise Footprint of Avikus

From the World's First to the World's Best

'21

Pohang Canal Cruise Autonomous Navigation Demonstration

World's 1st Canal Cruise Autonomous Navigation Demonstration

Business Strategy of Avikus

Considering Technological Advancements and Market Trends

MASS
Maritime Autonomous Surface Ship

Current business area of Avikus

NOW → **FUTURE**

Ship with automated processes and decision support	Remotely controlled ship with seafarers on board	Remotely controlled ship without seafarers on board	Fully autonomous ship
• 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

Elevate the Autonomous Navigation Experience

With HiNAS for Ships and NeuBoat for Boats

Unleash the infinite potential of the ocean by leading the paradigm shift of marine mobility

Safety	• Reduce accidents caused by human error • Respond to the rack of experienced seafarers
Economy	• Improve fuel efficiency (Just-in-time) • Reduce operation and new building costs
Sustainability	• Support emission regulations • Provide relief to seafarers

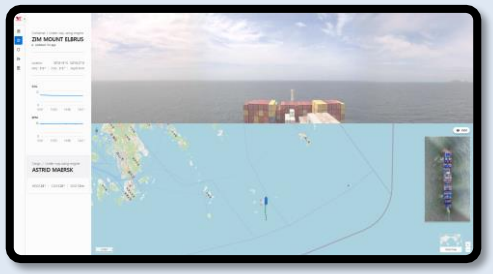
Safety	• Reduce accidents caused by human error
Convenience	• Make boating easy and accessible to all
Pleasure	• Reduce driving-related anxiety and maximize carefree leisure time

One and only “all-in-one ADAS for ship” in the market

HiNAS

- HiNAS is the ship navigation assistance system, like automotive ADAS, that enhances safety and convenience. As a Level 2 autonomous system, it supports pilot, but the pilot has responsibility for the navigation.
- HiNAS uses radar, cameras, and AIS to detect surroundings, providing intuitive displays for safer navigation and berthing. It optimizes routes and speed based on various factors and interfaces with Autopilot and BMS for automatic navigation, avoiding collisions, groundings and allisions.

HiNAS CLOUD

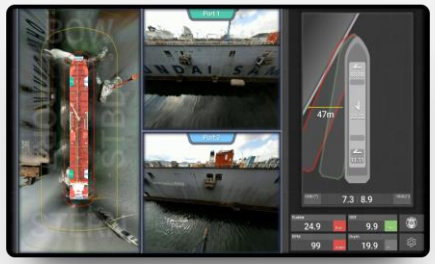


- Camera based Real time fleet management
- Safety, FOC, CII score display

Onshore Fleet Management

60+ sets order

HiNAS SVM



- Real time surround view
- Collision/Allision alarm

420+ sets order

HiNAS NAVI

- EO/IR camera object detection
- Vision/Radar/AIS fusion

170+ sets order

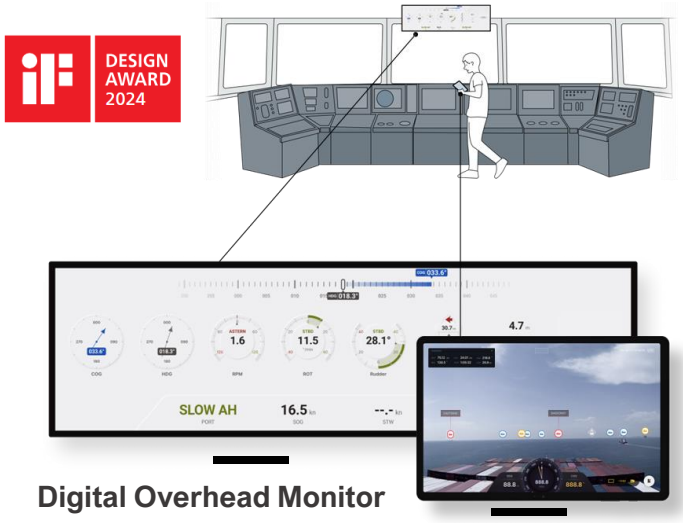
HiNAS CONTROL

- Voyage optimization & auto-navigation
- Collision avoidance control

Enhanced Situational Awareness

+ Autonomous Navigation

DESIGN AWARD 2024



Digital Overhead Monitor

Tablet

User Interface Designed for Safety and Convenience

Avikus Targets DNV Type Approval for Its Autonomous Vessel Technology

MarineLink September 6, 2024

Avikus CEO Dohyeong Lim shaking hands with Knut Ørbeck-Nilssen, CEO Maritime, DNV and Jarle Coll Blomhoff, Head of Digital Ship Systems at DNV. (Photo: Avikus)

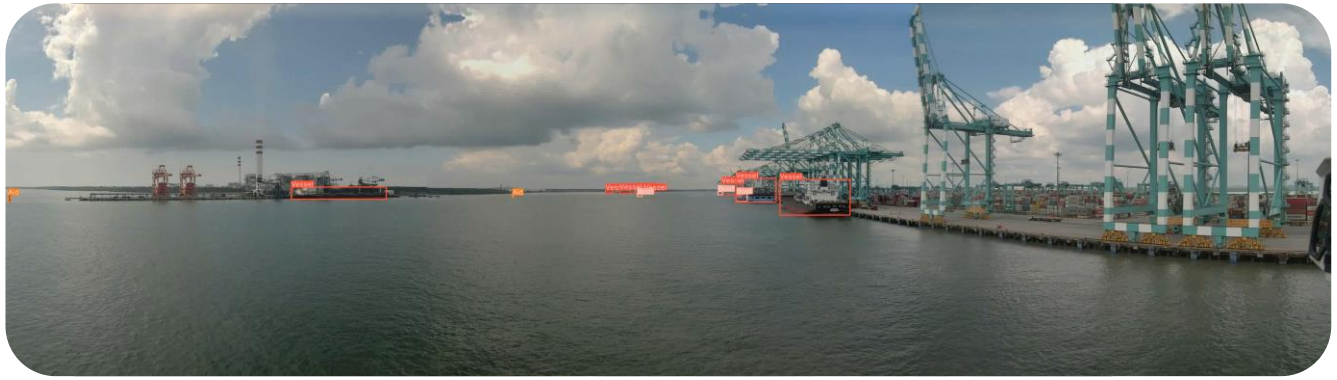
Avikus on Friday announced it is working toward gaining word-first DNV Type Approval for its innovative autonomous vessel systems.

The South Korea-based marine technology company said it cemented its partnership with classification society DNV with an agreement signed this week at the SMM maritime trade fair in Hamburg, Germany.

Avikus said it is progressing through DNV's System Qualification process for its autonomous navigation system, HiNAS Control, under DNV-CG-0264 and relevant international standards. The system is undergoing rigorous

Enhanced situational awareness at night or in restricted visibility

Electro-Optical & Infrared camera based vision sensing using AI



▶ IR(Infrared) Camera (120 deg. FOV)

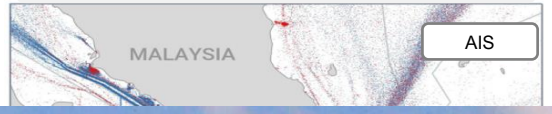
▶ EO(Electro-Optical) Camera (180 deg. FOV)

- 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

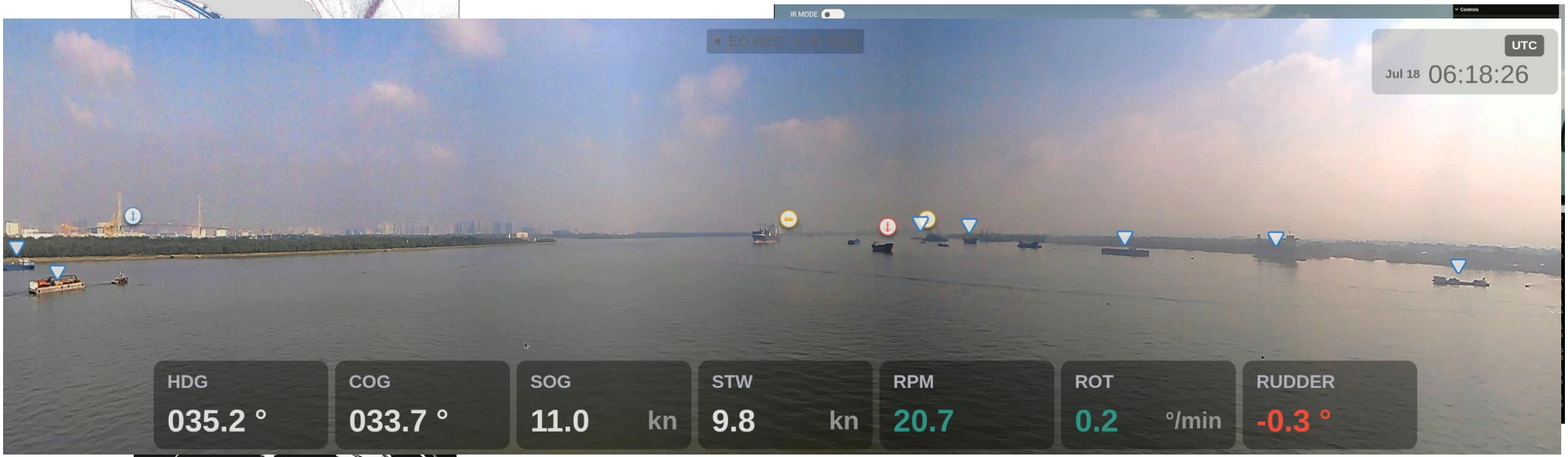
Comprehensive situational awareness by Sensor fusion technology

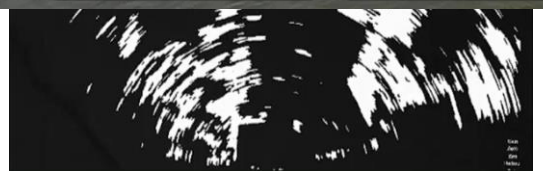
overcome the limitations of individual sensors(AIS, EO/IR Camera, S/X-band radar)

Sensor Input



Enhancing accuracy by using sensor fusion technology

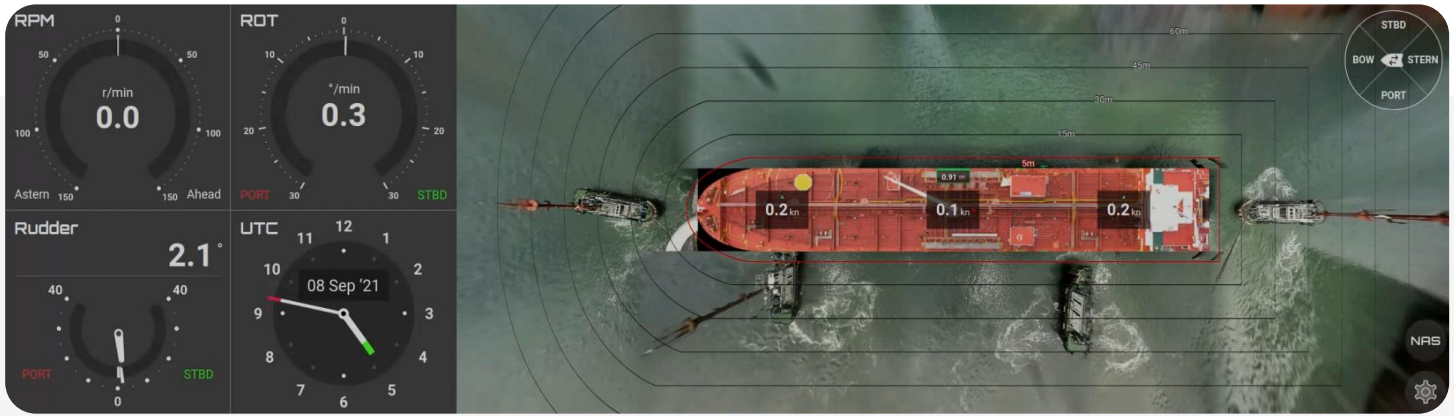




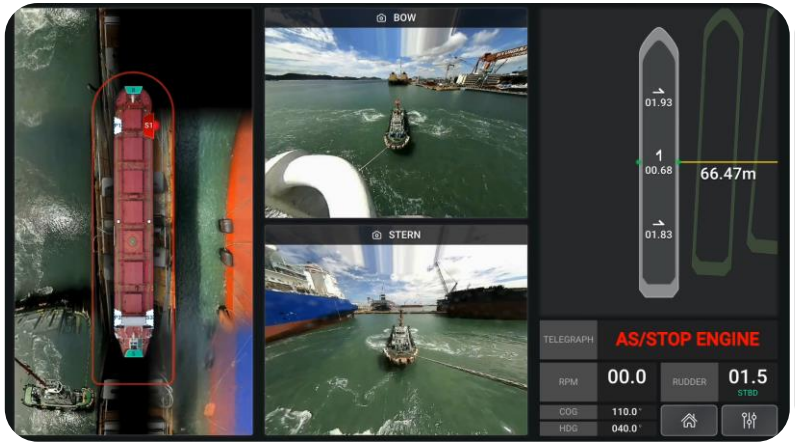
Real-Time 360º View

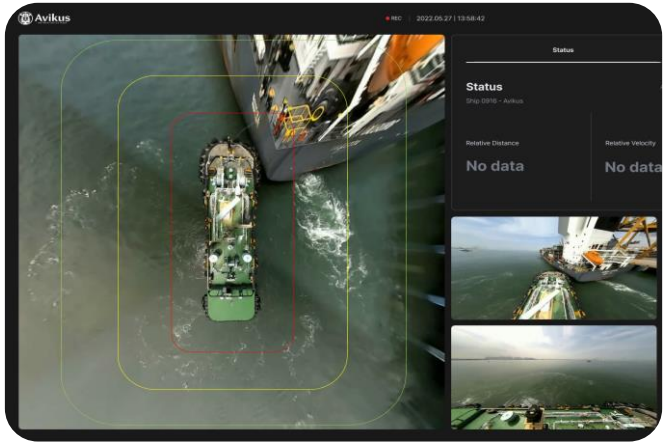
Key Feature of HiNAS SVM

- Useful when passing canal, narrow channel, berthing/unberthing
- Prevent the risk of armed robbery, stowaways, smugglers, etc.
- Monitoring from anywhere onboard using the portable device
- Distance alarm using camera based deep learning tech.



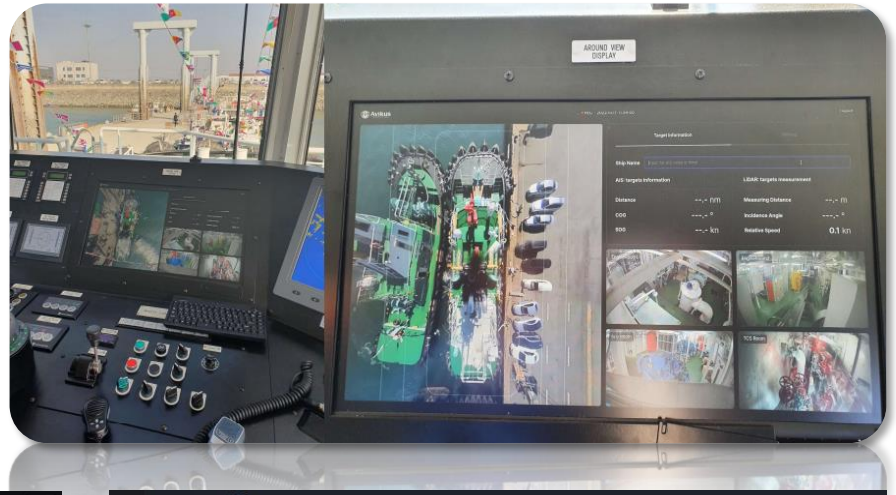
Use Case: Seaspan, CNTR



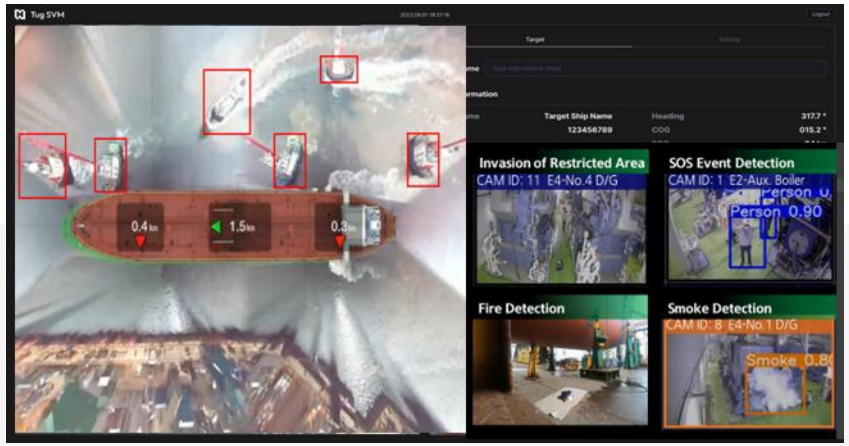


Real-Time 360º View

Key Feature of HiNAS SVM

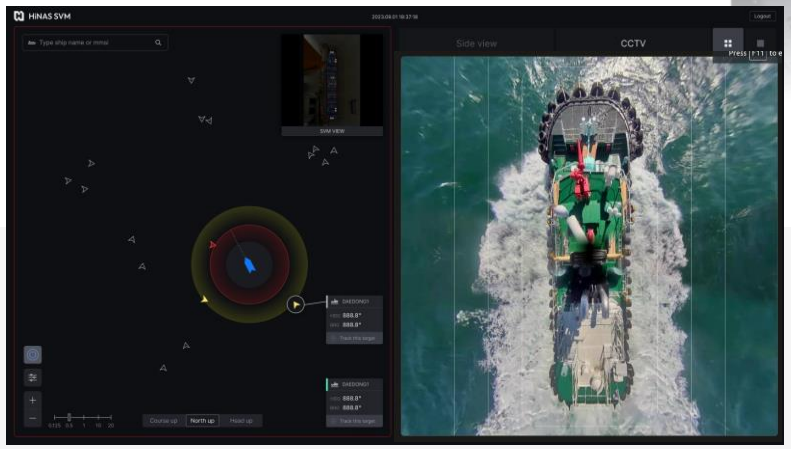


Use Case: HD Hyundai Heavy Industries, Tug boat



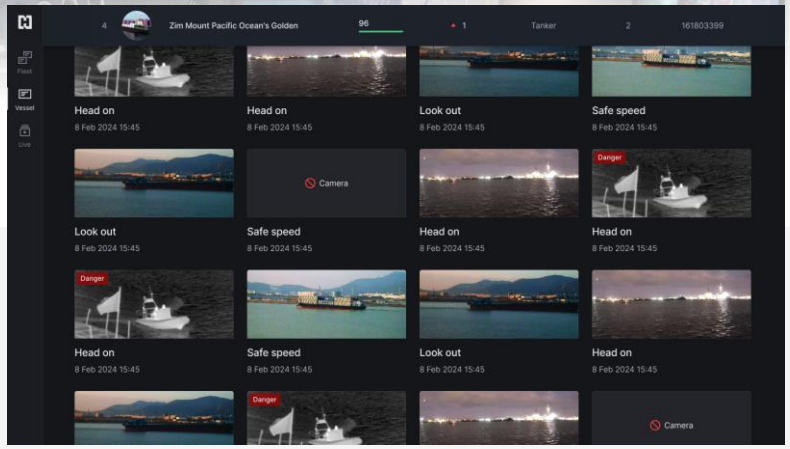
Camera based inference(’24 4Q ~)

Interfaced CCTV allows users to monitor the both surrounding and onboard the vessel



Situational Awareness with AIS (’24 4Q ~)

Visualize other ships around own ship based on AIS data. It makes it easily to check information on the mother ship



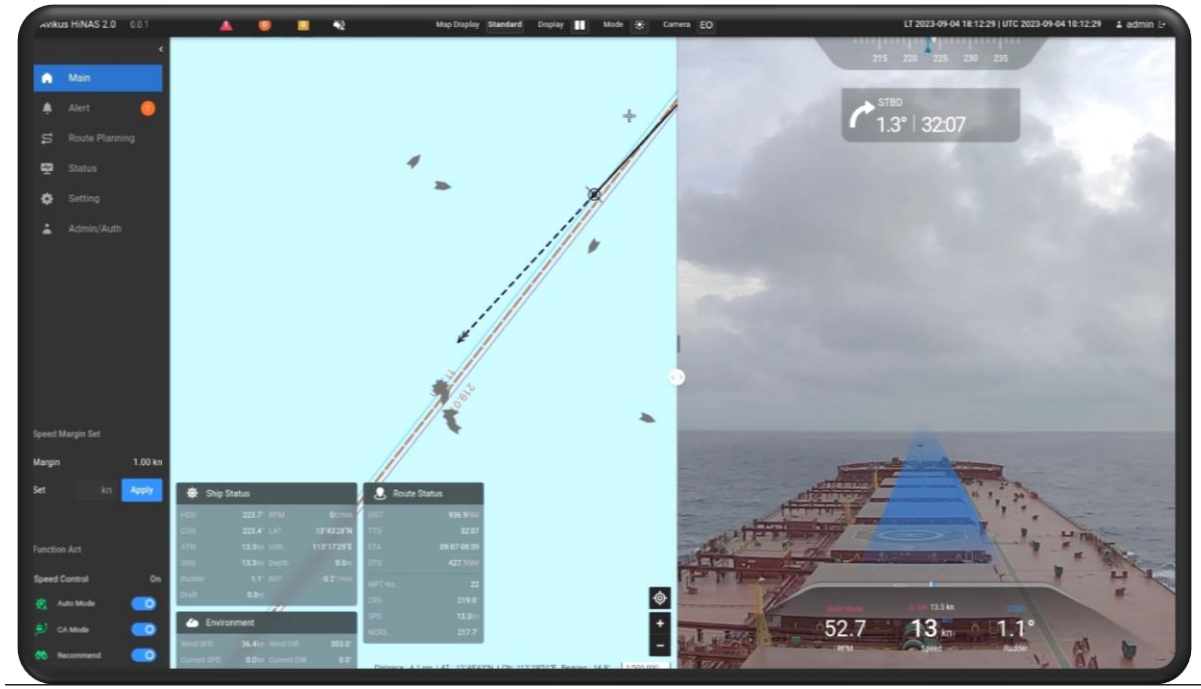
Video Recording & Remote Monitoring

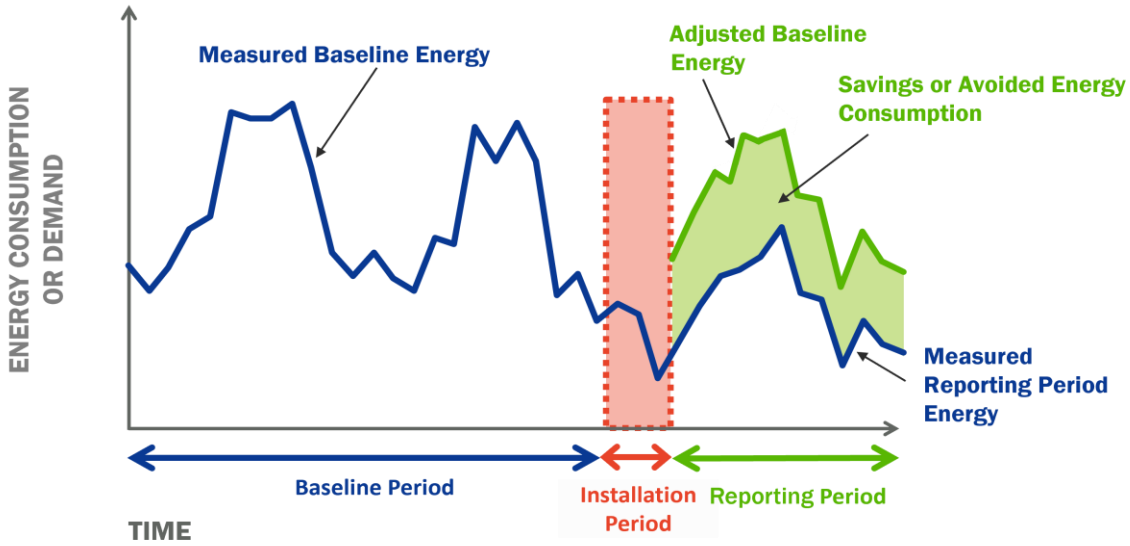
Monitoring from anywhere onboard using the portable device for insurance and training

Voyage planning & Autonomous Navigation

Key Feature of HiNAS Control

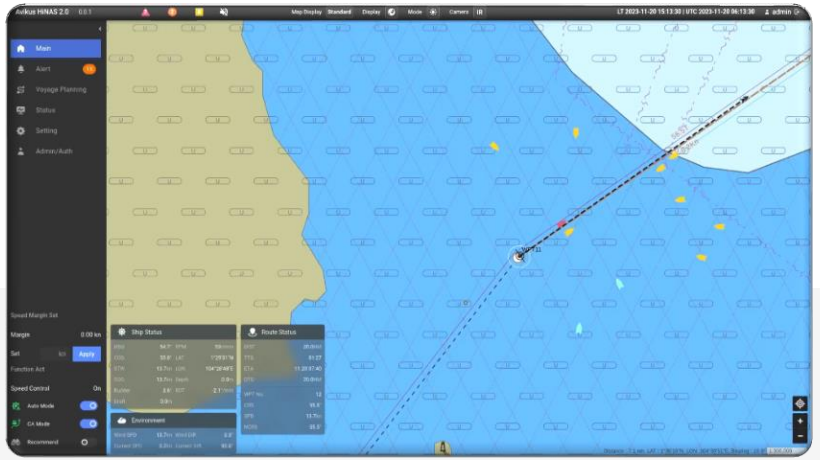
- Providing optimal voyage plan considering weather information
- Executing autonomously through the interface with Autopilot and BMS
- Increasing fuel efficiency, while reducing greenhouse gas emissions





Collision Avoidance

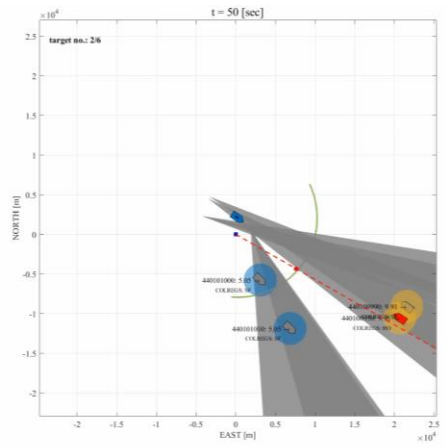
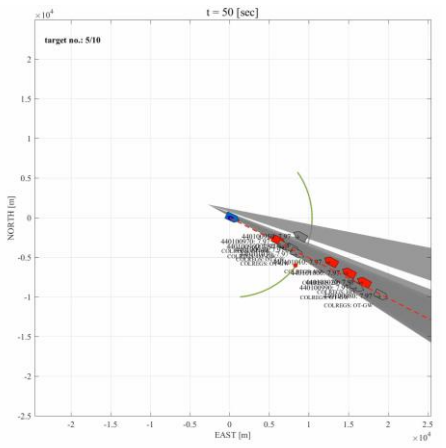
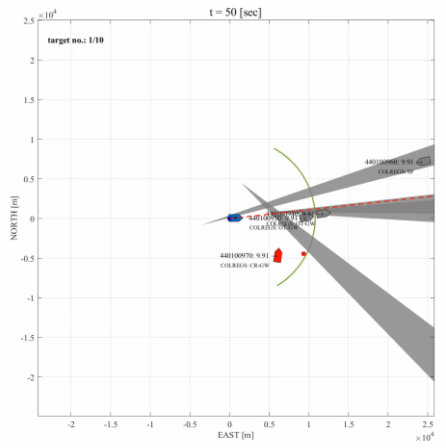
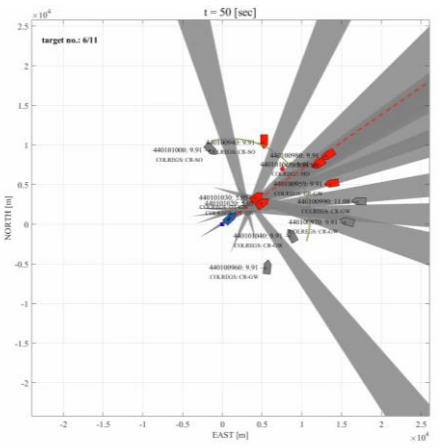
Key Feature of HiNAS Control



HILS(Hardware-in-the-Loop Simulations)

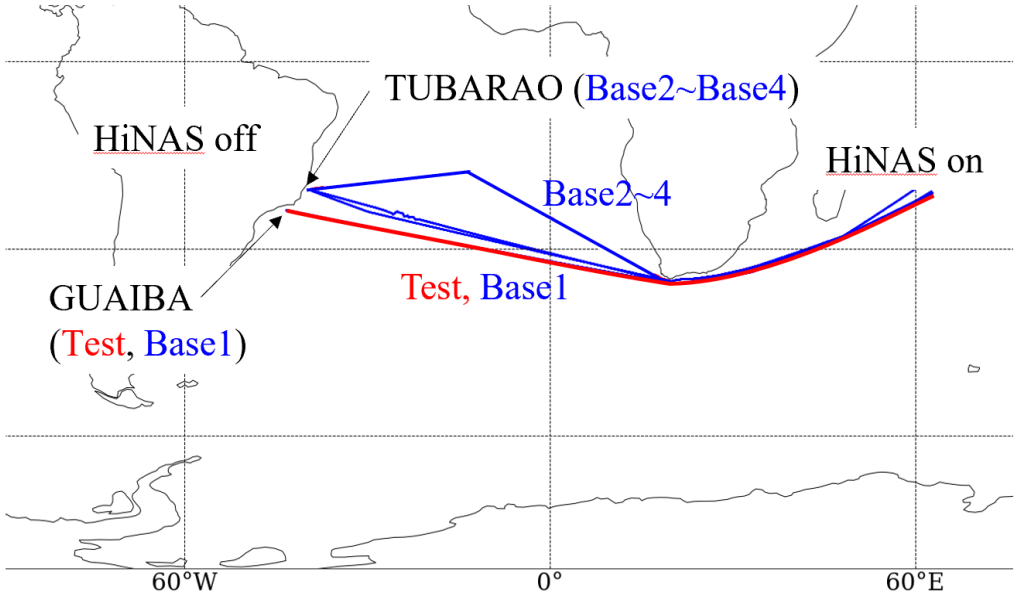
- Real-time collision detection and autonomous collision avoidance
- Incorporating experienced seafarers' know-how into algorithms, basically based on COLREG*

*International Regulations for Preventing Collisions at Sea

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

HiNAS Control Case Study(1/2)

- Target vessel type: 325K VLOC
- Shipowner: Pan Ocean(KOR)
- Test route: Singapore – Brazil



- **Approximately the same route**

- **Collecting voyage data from same vessel**
  - With HiNAS Control
  - Without HiNAS Control(Historical data for same route)

1. Reduced workload

- Navigation with HiNAS was possible for 30 days without any human intervention except for just one button click per day for weather update

2. Reduced Fuel Consumption

- **Analyzing Fuel Consumption**

  for each historical/test case and simulated case (following pages)

HiNAS Control Case Study(2/2)

Average fuel saving of 15% by the Korean Register(KR) certified methods

Measurement - Adjusted baseline calculation

Category	SOG[1)] (kts)	STW[2)] (kts)	FOC saving(%)
With HiNAS	13.08	12.87	-
Base #1	11.68	11.15	13.9%
Base #2	12.45	11.93	12.5%
Base #3	12.37	12.17	16.8%
Base #4	11.81	11.49	24.8%

1) SOG : Speed Over Ground
2) STW : Speed Through Water
3) FOC : Fuel Oil Consumption
4) Normalization data

Calibrated simulation

Data Type	Actual (w/HiNAS)	Comp.
Traveled Distance (NM)	5,791.7	
Avg. Speed (kn/hr)	13.08	
RPM	50.1 (avr.)	50.7
Net Saving (%) Actual/Comp.	4.9%	

Comp. is the estimated value from the virtual voyage
- Constant rpm to meet the voyage schedule
- The virtual voyage model has a 1.12% error in FOC estimation
- Constant rpm is found to be 50.7

Examples of fuel saving effects(5% Assumption)

FOC Saving

Vessel Type	Avg. DFOC (ton)	Operation (days)	Avg. annual FOC (ton)	FOC Saving (%)	FOC Saving (USD/yr)
VLOC	50	200	10,000	5%	293,000
VLCC	75		15,000		439,500
CNTR(15K)	135		27,000		791,100

Carbon tax savings – EU-ETS

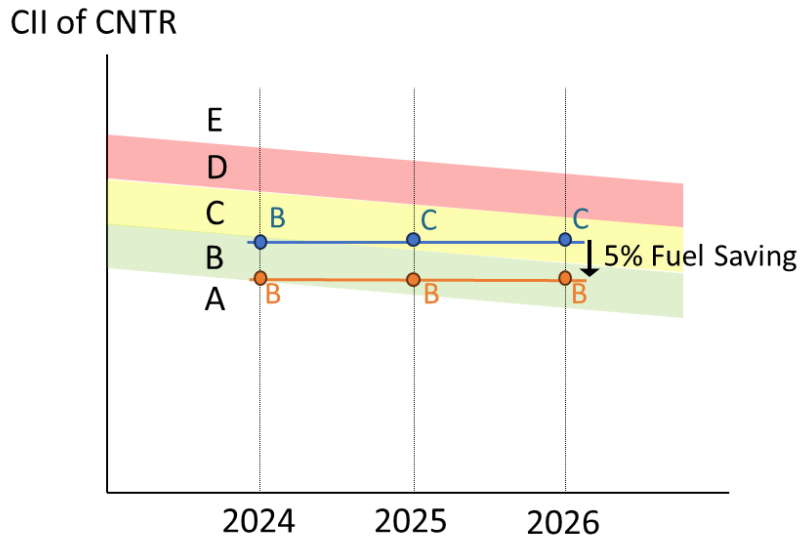
Vessel Type	Avg. DFOC (ton)	MRV Operation (days)	Avg. annual saving (ton)	Reduced CO2 Emission (ton)	Saving (Euro/yr)
VLOC	50	MRV route : 200	500	778	**50,602**
VLCC	75	MRV route : 200	750	1,167	**75,903**
CNTR(15K)	100	MRV route : 200	1,000	1,557	**101,205**

Examples of fuel saving effects(5% Assumption)

CII(Carbon Intensity Index) Grade can be maintained

Vessel Type	Avg. annual FOC (ton)	Avg. Speed (knots)	Distance (NM)	Attained CII	CII Ref.	Rating to CII Ref.	Attained CII (5% FOC Saving)
VLOC	10,000	12.5	60,000	1.65	1.95	2024 : 7%	1.57
VLCC	10,000	12.5	60,000	1.73	2.39	2025 : 9%	1.65
CNTR(15K)	20,000	17.5	84,000	5.23	6.00	2026 : 11%	4.98

CII Grade can be maintained for 2~3 years through operating HiNAS Control



CAPEX/OPEX effective green solution

Comparison of Fuel Saving Devices for Vessels

HiNAS Control

Air Lubrication System

Rotor Sails

Cost / investment	**1**	**X 10** + increasing with ship size	**X 15** + increasing with ship size
Main function	Automatically adjusting steering & speed via Autopilot, BMS based on route, weather	Emitting small air bubbles onto the hull surface, reducing friction resistance	Install rotating cylindrical columns, utilizing pressure difference for propulsion
Installation time	2-3 days	4-6 weeks (DD required)	6-8 weeks (DD required)
Cost-saving benefits	5-15% depending on starting point	**5-8%**	**3-8%**

Value Proposition of HiNAS

Although a low-level autonomy solution, HiNAS helps with safety, convenience, and cost-efficiency.
Customer value will continue to increase as the autonomy level improves with technology enhancements.

Safe Voyage

- Reducing human error by enhanced situational awareness
- Safe decision-making for collision and grounding avoidance
- 360-degree surveillance for detecting pirates and other hazards.
- Event recording for insurance and education

Convenient Voyage

- Autonomous path tracking and collision avoidance
- Autonomous navigation was possible for 30 days with just one button click per day, without human intervention
- Contributed to crew welfare, leading to a higher preference for boarding vessels equipped with HiNAS

Economic Voyage

- Voyage optimization based on ship dynamics, weather and ETA
- Automatic speed control and steering following the optimal voyage plan
- Verification test results show fuel cost savings of 5-15%
- potentially contribute to reduced manning

Sustainable Voyage

- Optimizing fuel and energy consumption
- Supporting emission regulations
- Contributes to improving CII & EEXI grades
- Reducing EU-ETS cost(50k~100k Euro/year)

HiNAS SVM
HiNAS NAVI
HiNAS CLOUD

HiNAS CONTROL

HiNAS CONTROL
HiNAS CLOUD

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THANK YOU

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