Introduction to the KASS Project

- Developing validation process for intelligent system

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Ministry of Trade, Industry and Energy

해양수산부
Ministry of Oceans and Fisheries

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KASS Project

Outline

Project name Korea Autonomous Surface Ship(KASS) Project

Funded by Ministry of Oceans and Fisheries &
Ministry of Trade, Industry and Energy

Project Period 2020~2025 (1^{st}~4^{th} year : System development & integration / 5^{th}~6^{th} year : Validation)

Budget 160.3 billion won (133.3 million dollars)

Objectives Development of Core technology of Autonomous ship,
Laying the foundation for Commercialization through Phased Validation Procedures

1) Core technology of Autonomous ship :
① Intelligent Navigation System
② Machinery Automation System
③ Test-bed and Validation Techniques
④ Operational Technology and Standardization

2) Commercialization target : MASS engaged on International voyages vessel (1,800teu Container ship)
(Ocean : IMO level 3 / Coast : IMO level 2)

The KASS Consortium (51 organizations)

KRISO KOREA RESEARCH INSTITUTE OF SHIPS & OCEAN ENGINEERING
KR KOREAN REGISTER
SAMSUNG SAMSUNG HEAVY INDUSTRIES
KSOE KOREA SHIPBUILDING & OFFSHORE ENGINEERING
DSME
Lloyd's Register
HMM OCEAN SERVICE
POSSM
STR SafeTechResearch
Penta SECURITY enterprise · iot · blockchain
SEANET MARINEPLANET
Avikus MARITIME AUTONOMOUS PIONEER
@ANGEL
MTI
ace antenna
CCL
scanjet macron
GCSC GLOBAL CONTROL SYSTEMS
Marine Electronics marineworks
SEADRONIX
SYNC TECHNO
LAB02
KL Net Korea Logistics Network
INNOSIMULATION
i-storm Innovative wireless technologies
Zinnos digital@marine
KJ ENGINEERING
T1 INFORMATION TECHNOLOGY
(주)코메스타
AD!A LAB.
LEEYOUNG SND (주)리영에스엔디
GMT
KNDE
KIMM KOREA INSTITUTE OF MACHINERY & MATERIALS
KOMSA KOREA MARITIME TRANSPORTATION SAFETY AUTHORITY
한국해양수산연수원 KOREA INSTITUTE OF MARITIME AND FISHERIES TECHNOLOGY
RIMS 중소조선연구원 Research Institute of Medium & Small Shipbuilding
ETRI 한국전자통신연구원 Electronics and Telecommunications Research Institute
KOMERI
KMI KOREA MARITIME INSTITUTE
서울대학교
KAIST
USN University of South-Eastern Norway
CHANGWON NATIONAL UNIVERSITY
KOREA MARITIME & OCEAN UNIVERSITY 1942
WORLD MARITIME UNIVERSITY 1983
INHA UNIVERSITY 1954
PUKYONG NATIONAL UNIVERSITY
AJOU UNIVERSITY 1973

Core Technologies and Sub-Projects

1. Autonomous Navigation System

- Development of Integrated Platform & Digital Bridge for Autonomous Navigation, Control of Engine Room
- Development of a Situational Awareness System for Preventing Collisions and Accidents of Autonomous Ships
- Development of Autonomous Navigation System with Intelligent Route Planning Function

2. Autonomous Engine System

- Development of Performance Monitoring and Failure Prediction and Diagnosis Technology for Engine System of Autonomous Ships
- Development of Integrated Energy Control System for Autonomous Ships

3. Test-bed and Verification Techniques

- Development of Evaluation and Validation Testbed for Autonomous Ship Performance
- Development of Validation and Verification Technique for Intelligent System of Autonomous Ships

4. Operation Techniques and Standardizations

- Development of Shore Remote Control System of MASS
- Development of Cyber Security Technology for Maritime Autonomous Surface Ship
- Development of the Next Digital Communication Technologies for Ship2Ship2Shore
- Incident Response System and Reliability Assessment for Autonomous ship
- Development of Remote Management and Safe Operating Technology of Autonomous Navigation System
- Development of International Standardization Technology for Autonomous Ship

KASS Test Ship Platform(`22.04)

KASS Remote Control Center (`22.09)

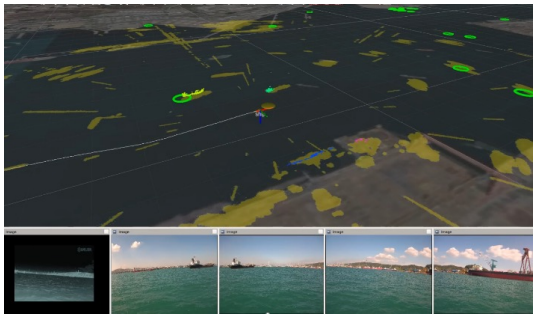
Commercial Ship to be built(`24~25)

2020 2021 2022 2023 2024 2025 2026

Situational Awareness System

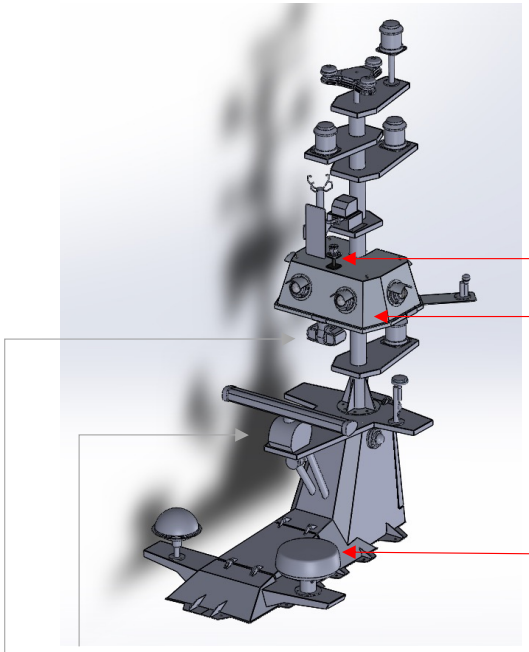
iSAS (Intelligent Situational Awareness System)

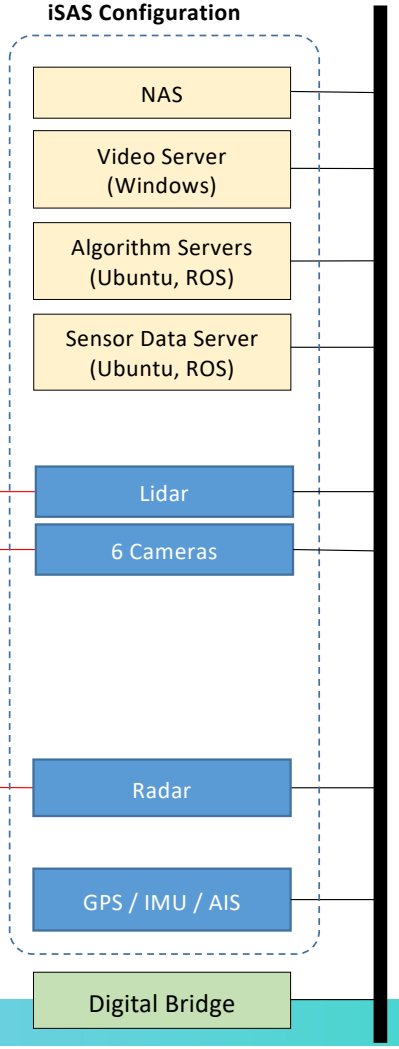
- deep learning based detection algorithms using cameras, a radar and a LiDAR,
- a probabilistic-based data association and tracking algorithm, and
- a semantic information based collision risk evaluation method.



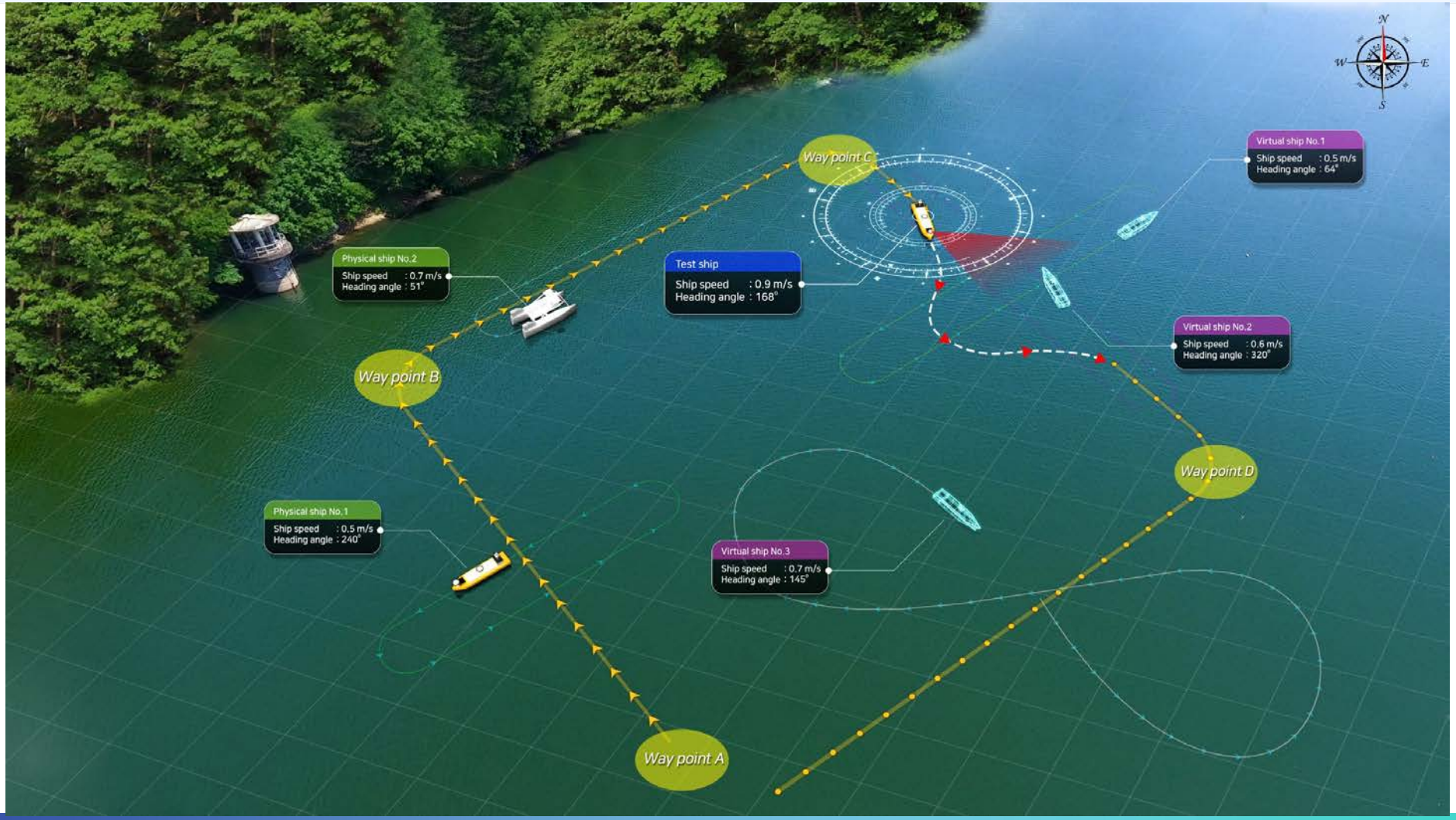
Visualization of the data when entering Ulsan Port

Detection results under Incheon Bridge





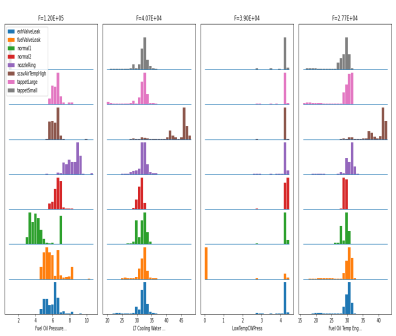
Intelligent Navigation System

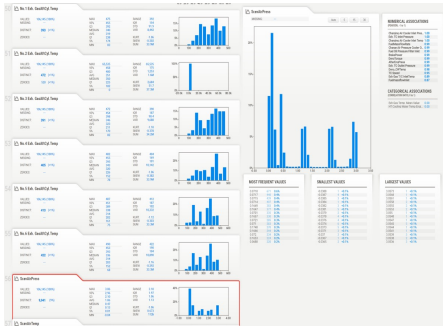


Automation of Engine Room

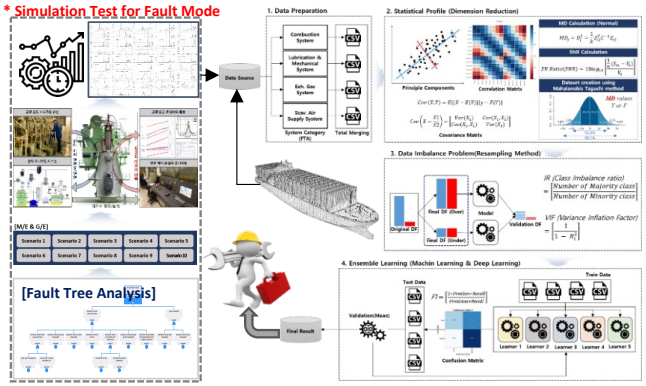
- Development of failure mode data production research and failure diagnosis/prediction algorithm for autonomous ship engine system(main engine, generator engine, purifier, pump, pipe)

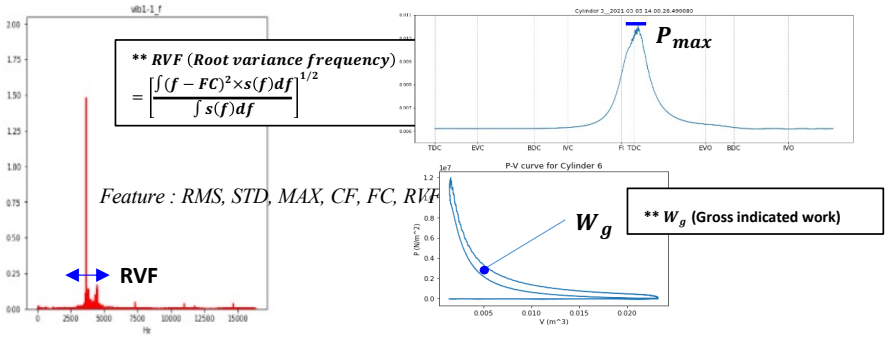
Failure experiments for data production





Explore of sensor data





Feature extraction

Contents

Shore control center & testbed vessel

Test control

- DTB/E (Digital Twin Bridge/Engine) monitoring System: Monitoring of overall test vessel status and remote control(if needed)
- KASS-VTS, RADAR: Monitoring of overall status of test sector (especially traffic)

Simulation tests

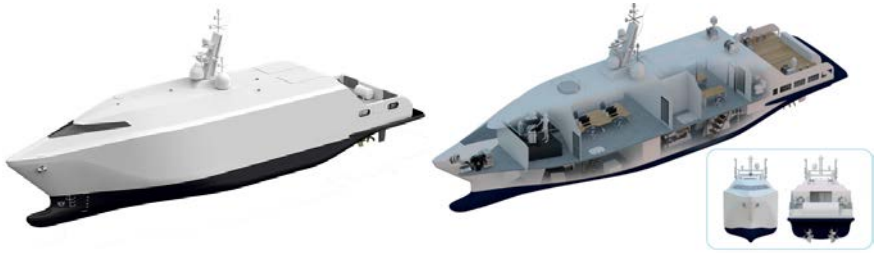
- S-TAS (Simulation Testbed for Autonomous Ship)

Test data management

- Data server for sea-trial data and S-TAS data

Shore control center (Ulsan)

Principal particulars	
LOA, LPP, B, D	23.5m, 21.0m, 6.0m, 2.9m
Speed	15.0 KNOTS
Propulsion & Steering	Twin screw-Twin Rudder

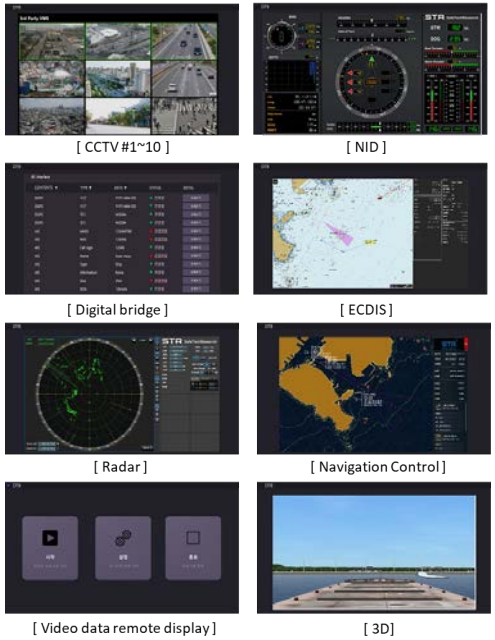


Testbed vessel

DTB/E (Digital Twin Bridge/Engine) monitoring system

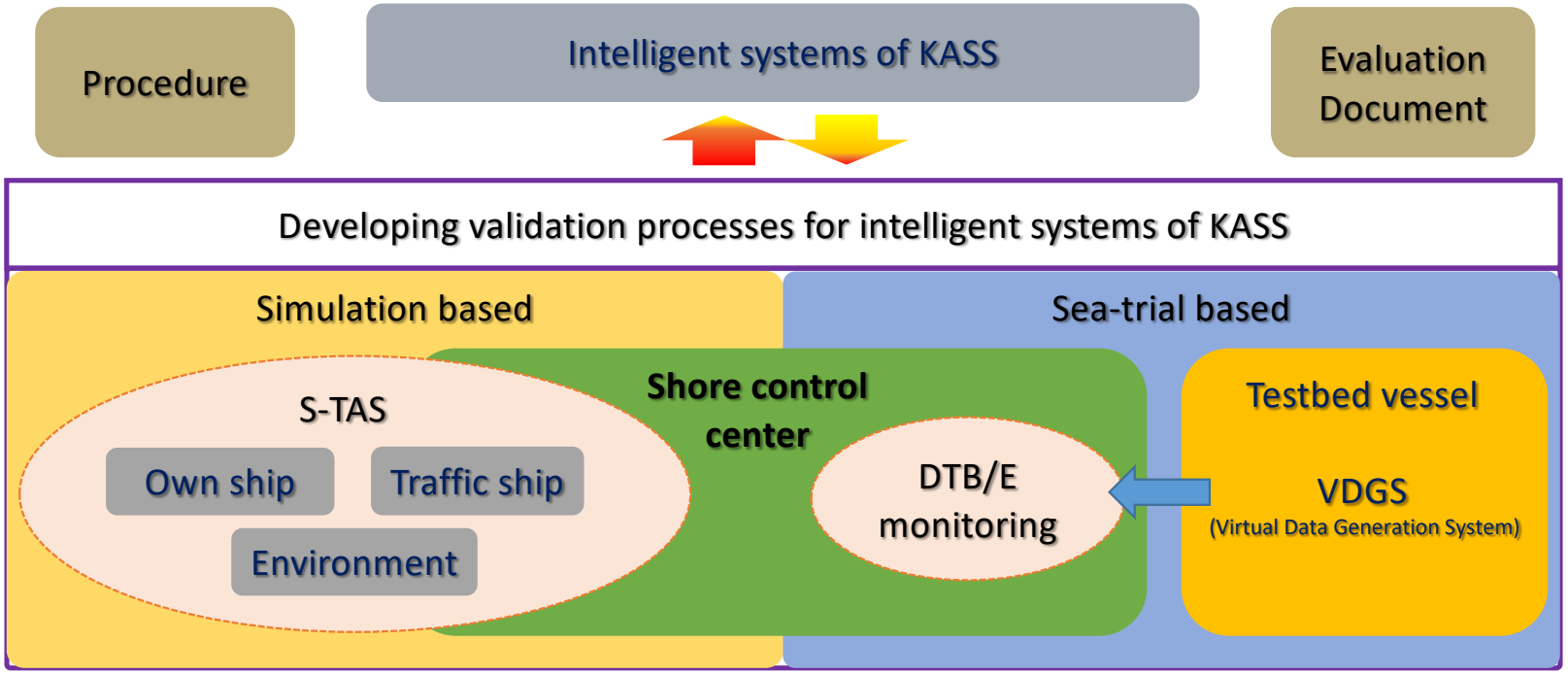
- **Remotely monitoring and control of sea trial tests**
- **DTB/E (Digital Twin Bridge/Engine) monitoring mirror system (KRISO, Daejeon)**
  - ☑ Prototype of DTB/E monitoring system of KASS shore control center
  - ☑ Monitoring of sea trial tests conducted at KASS shore control center

DTB/E monitoring mirror system (KRISO)



Monitoring contents

Research on establishing validation process



Contents

Registration (Customer)

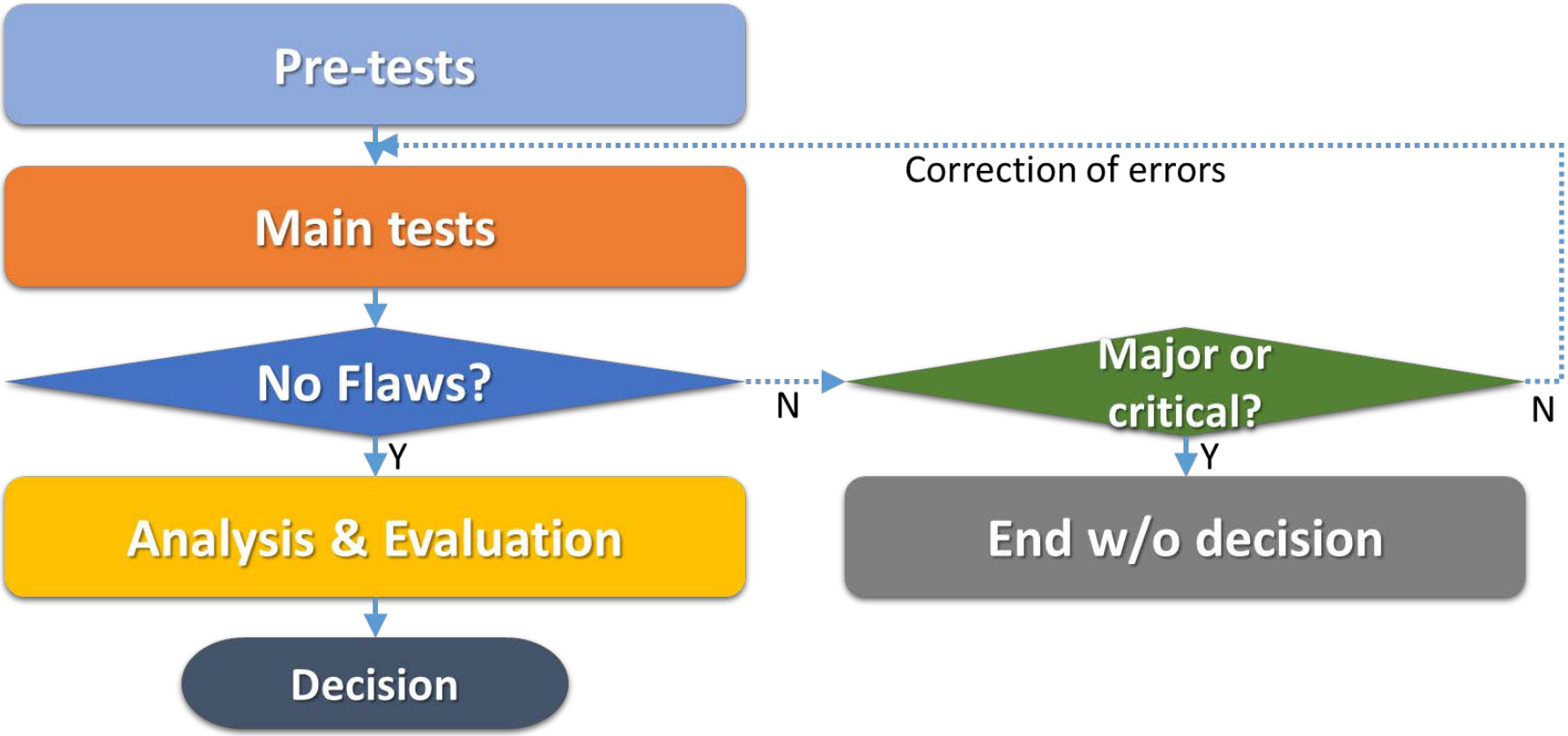
General information

- Target ship
  - Ship type, class, purpose, etc.
- Operation area
  - Overseas, adjacent seas, coastal, etc.

System type

- Application field
  - Monitoring, navigation and control, engine automation, etc.
- Category
  - A: Monitoring
  - B: Pilot assistance w/ (system) information
  - C: Active control w/ human supervision
  - D: Active control w/o human supervision, w/ human monitoring

Procedure for validation



Pre-tests

Checking system purpose & level & requirements claimed by the customer

- ☑ Define purpose of the system based on registration information
- ☑ Confirm the application field and category of the system
- ☑ Prepare requirements of the system for confirmed application field and category

Function analysis

- ☑ Listing required functions of the confirmed application field and category
- ☑ Check functions of the claimed system for tests
- ☑ Comparison btw. listed functions and functions of the claimed system

Interface analysis

- ☑ Check data interface of the claimed system for tests

Preparation of Application Programming Interface (API) (if needed)

- ☑ Prepare API for I/O data interface
- ☑ Setting interface for adjusting test speed (simulation tests only, in applicable)

Main tests – 1/2

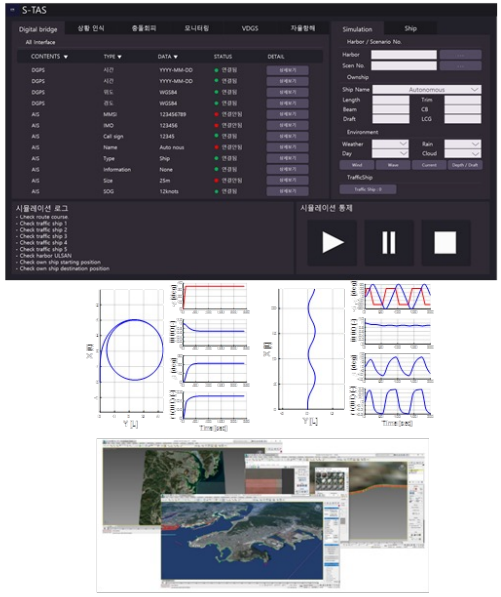
Data interface tests

- ☑ Confirm I/O between test system and test monitoring & managing system

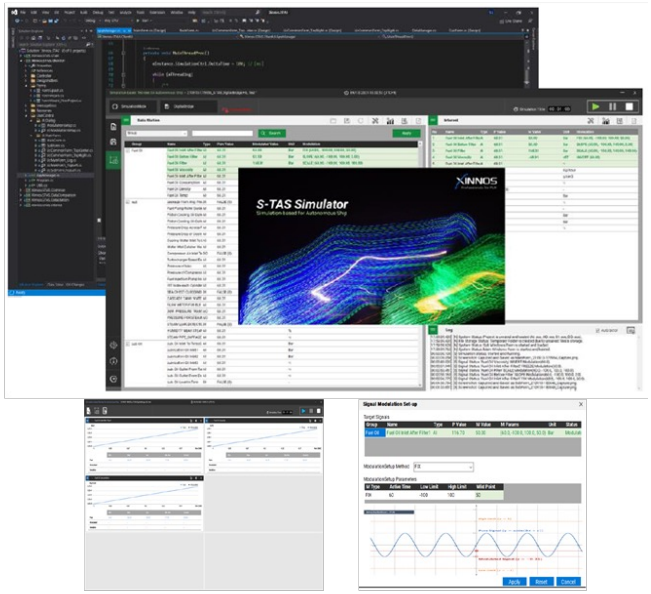
Simulation based tests

- ☑ Numerous simulations of all possible/expected cases
- ☑ Simulations of dangerous/expensive cases

Concept image of S-TAS



S-TAS (navigation)



S-TAS (engine)

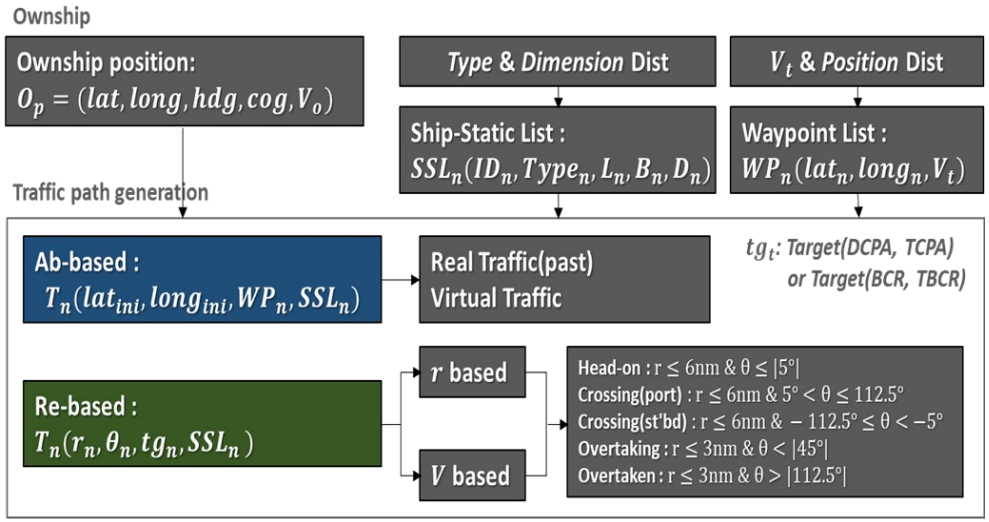
Main tests – 2/2

Sea-trial tests

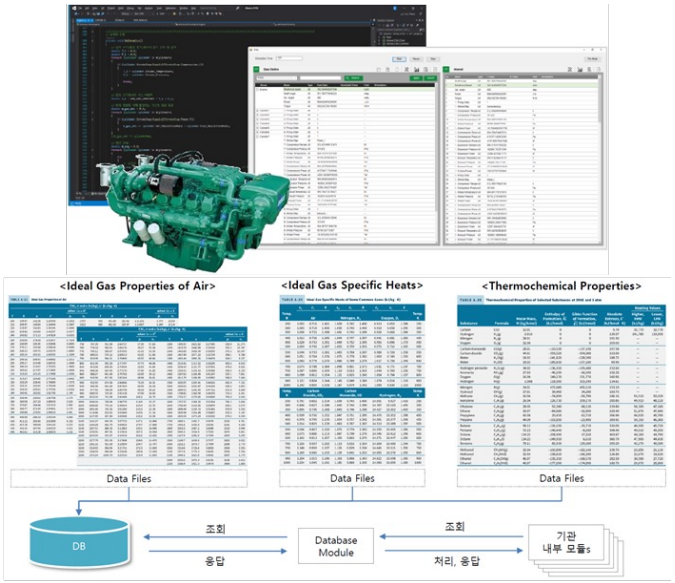
- ☑ Functions those can be checked in real world must be confirmed through sea trial

Hybrid test (Sea-trial tests w/ augmented reality (virtual data))

- ☑ Generation of augmented reality traffic for tests of navigation and control systems
- ☑ Generation of virtual error data for tests of engine automation/monitoring systems
- ☑ Dangerous/expensive but essential tests



Virtual traffic generation



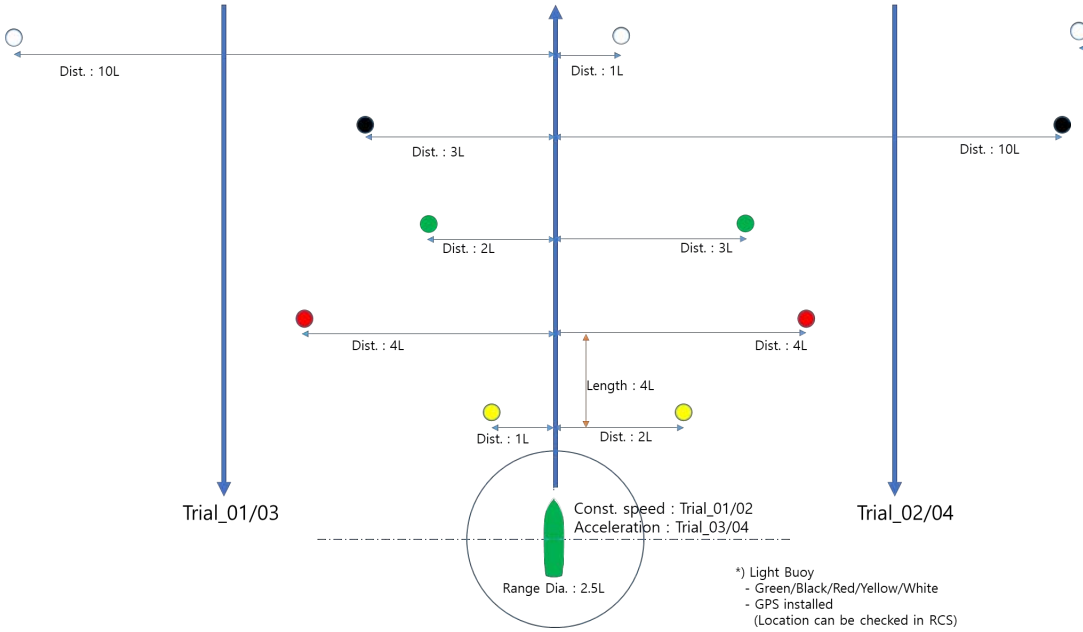
Virtual engine data generation

Contents

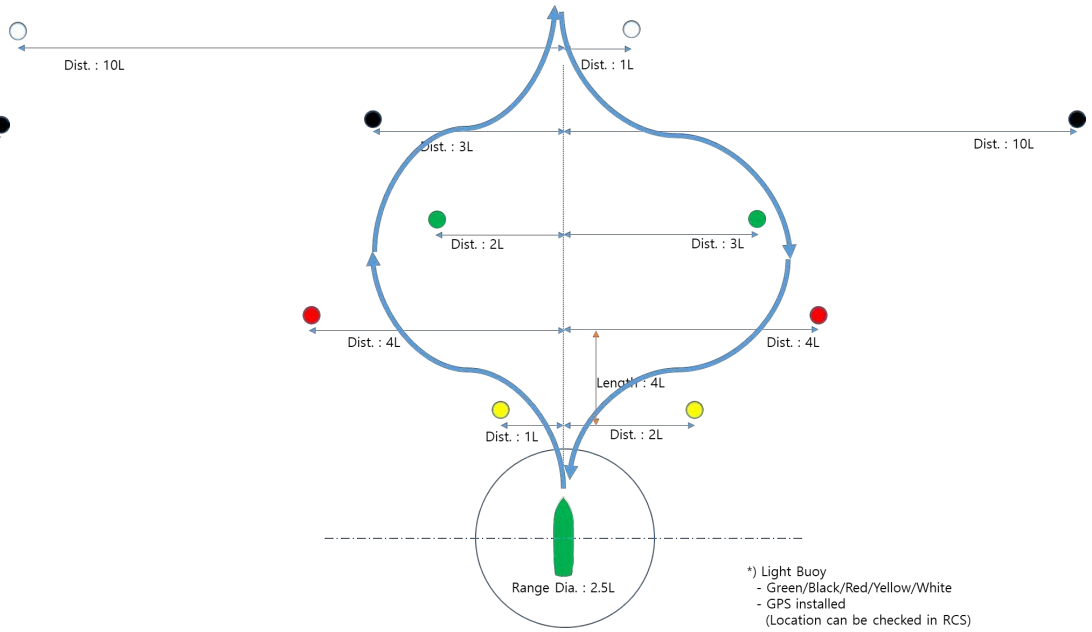
Situation awareness system – 1/2

Fixed target awareness scenario

- ☑Stationary targets like Aids to Navigation (AtoN)
- ☑Confirmation w/ Vision, Lidar, Radar, AIS



Tests w/ constant heading

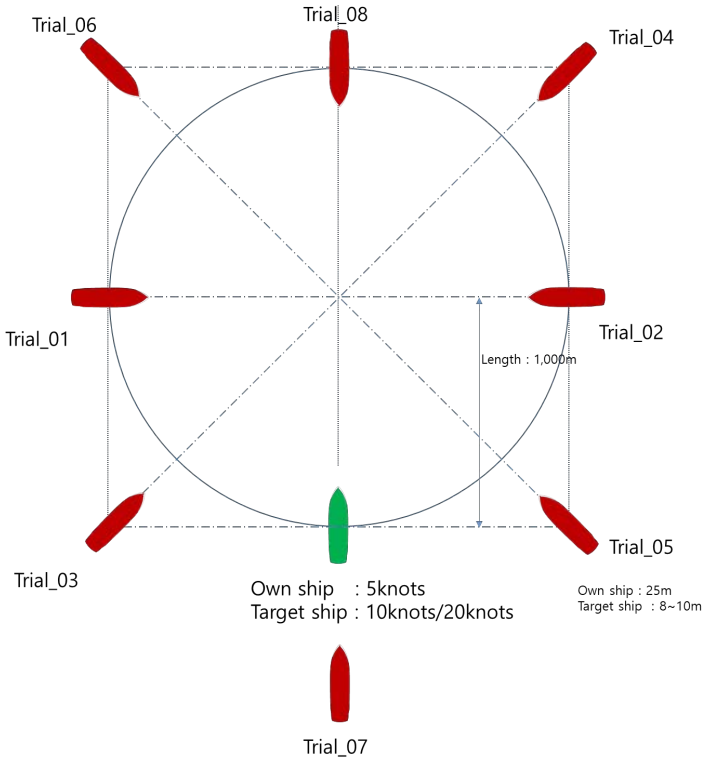


Tests w/ course changing

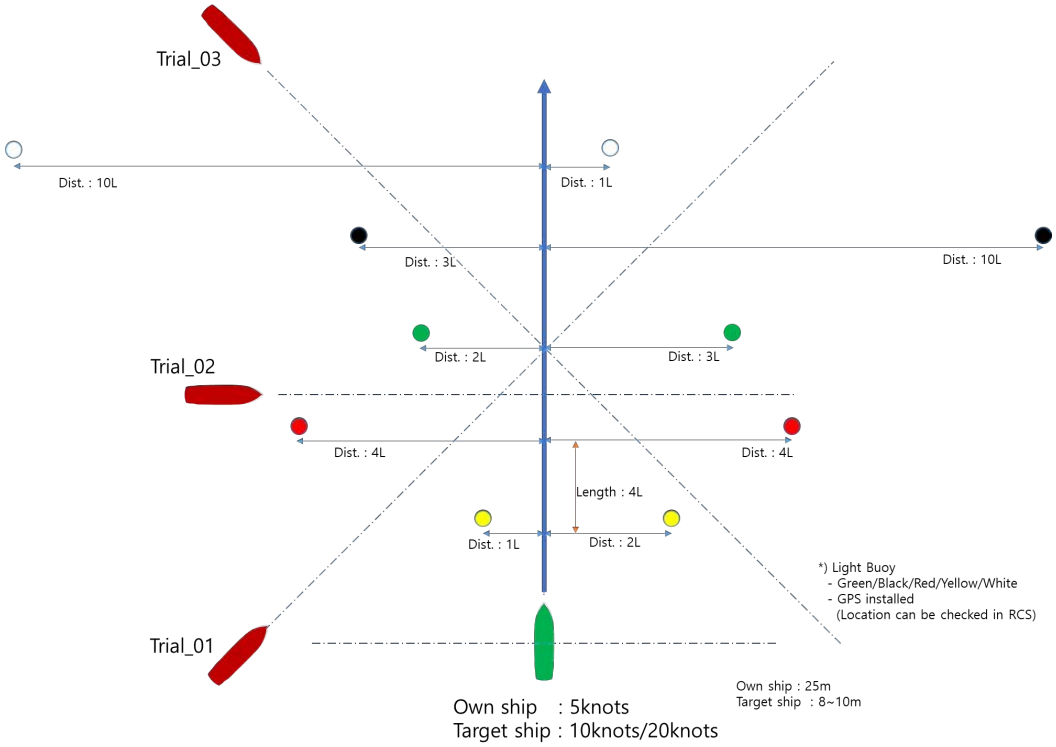
Situation awareness system – 2/2

Moving & mixed target awareness scenario

☑Traffic ships and stationary targets



Tests w/ moving targets



Tests w/ mixed targets

Guidance and control system – 1/4

Parameters related to the system performance

- ☑Test Ship: speed, course, motion
- ☑Traffic ships: speed, course, distance, size, type, motion
- ☑Environments: light, weather, visibility, wave, wind, current, water depth, tide, passage restricted area
- ☑Sensors: performance, error, sampling rate

* : controllable only in virtual world

Testing non-controllable parameters

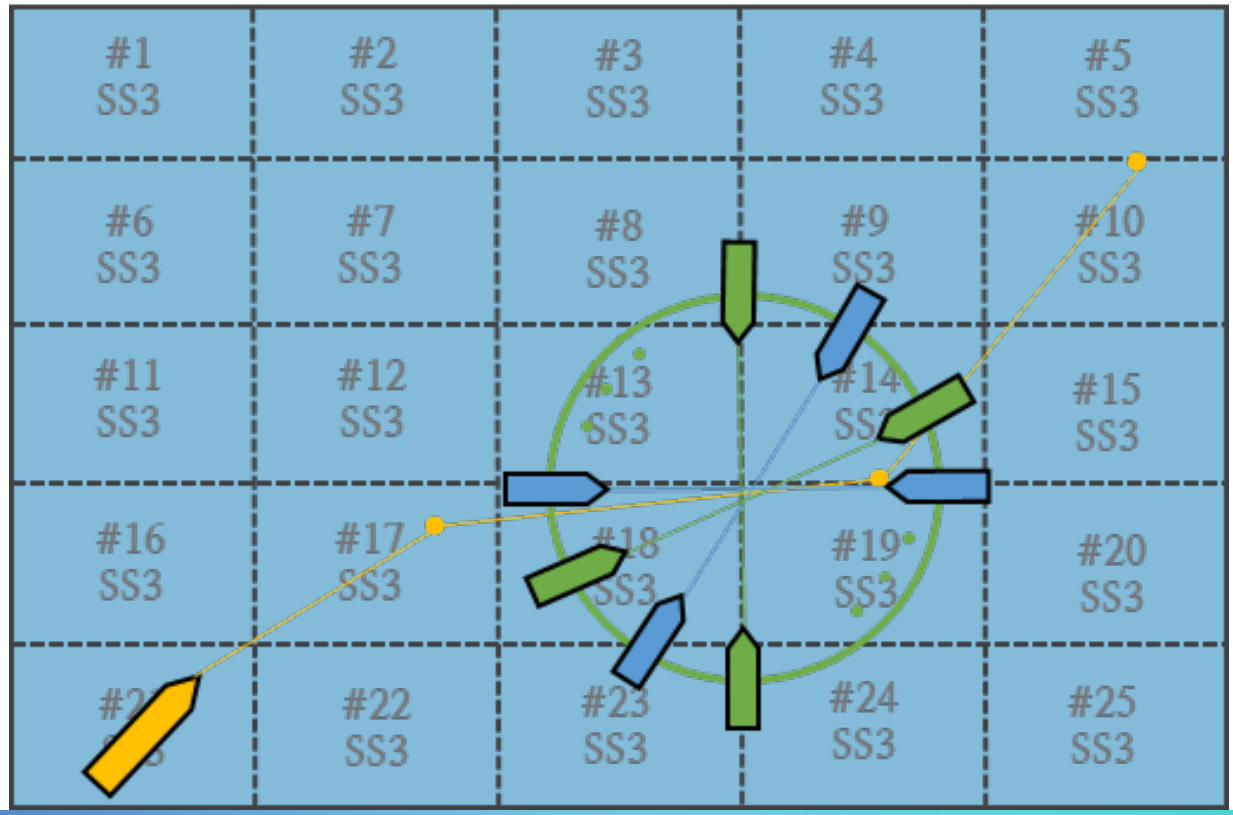
- ☑Simulation based Tests
- ☑Augmented sea-trial test w/ VDGS (traffic ships only)

Guidance and control system – 2/4

Single traffic ship scenario

☑Combinations of (ownship speed & course) – (traffic ship speed & course)

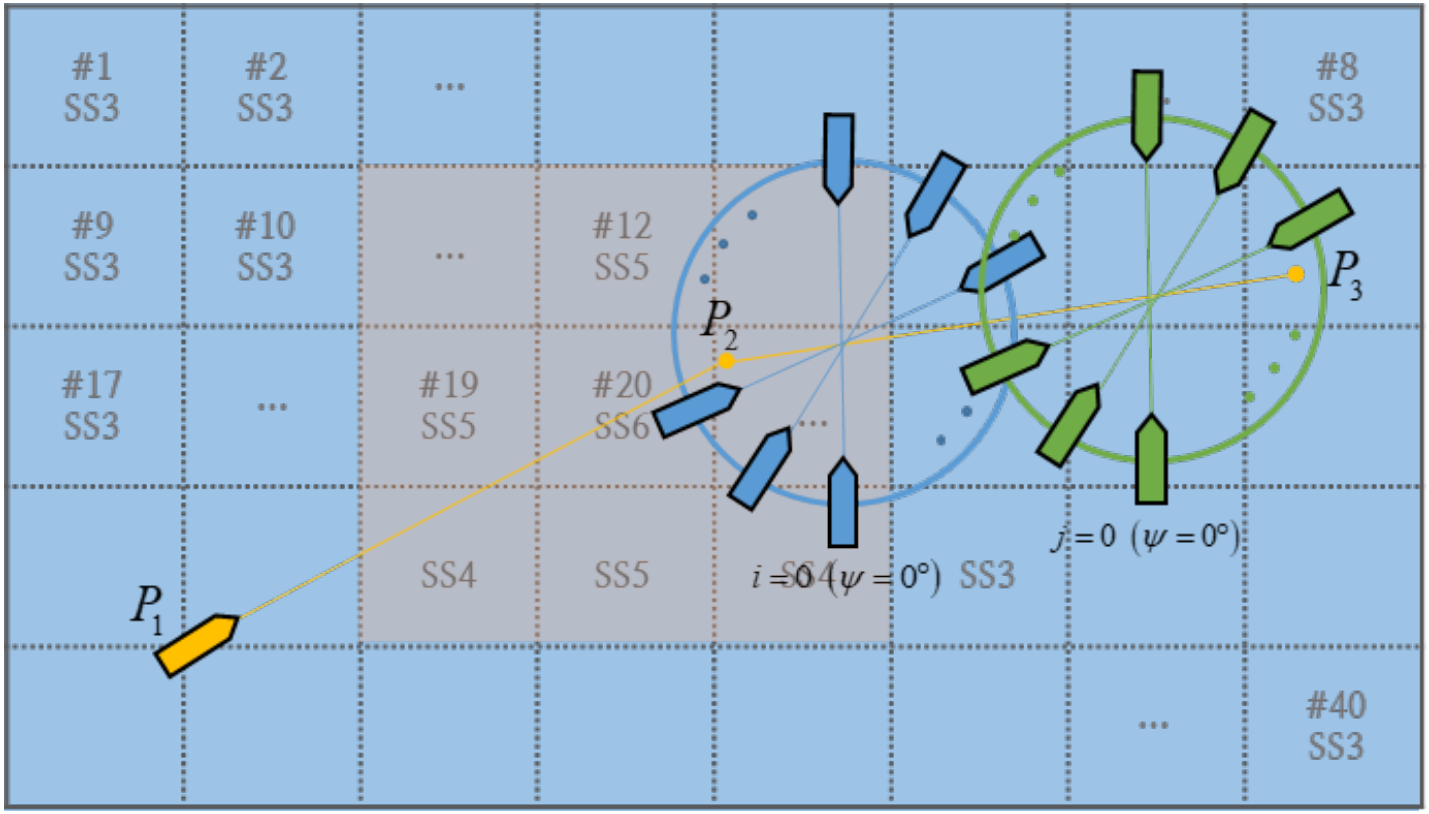
- Head-on
- Crossing
- Overtaking



Guidance and control system – 3/4

Multiple traffic ships scenario

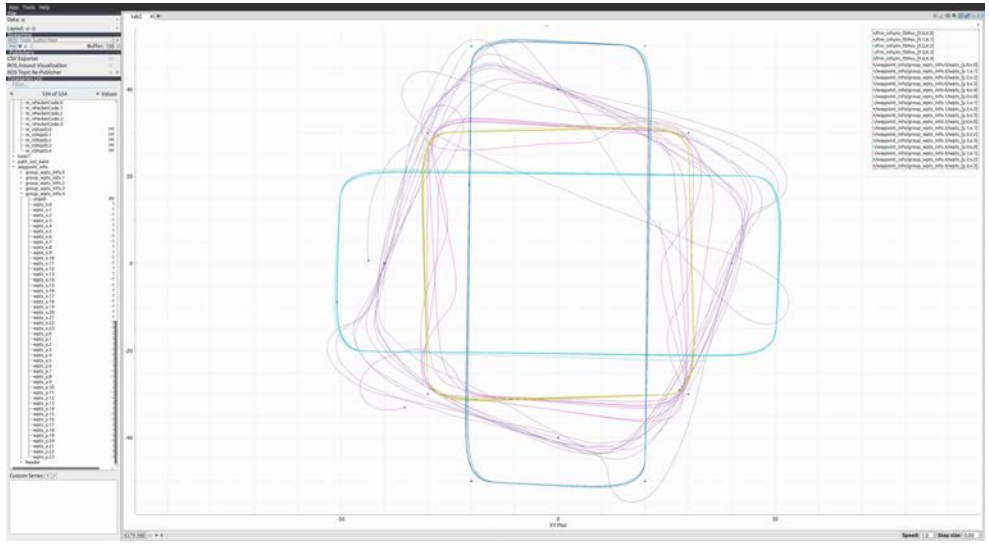
☑Combinations of (ownship speed & course) – (traffic ships speed & course)



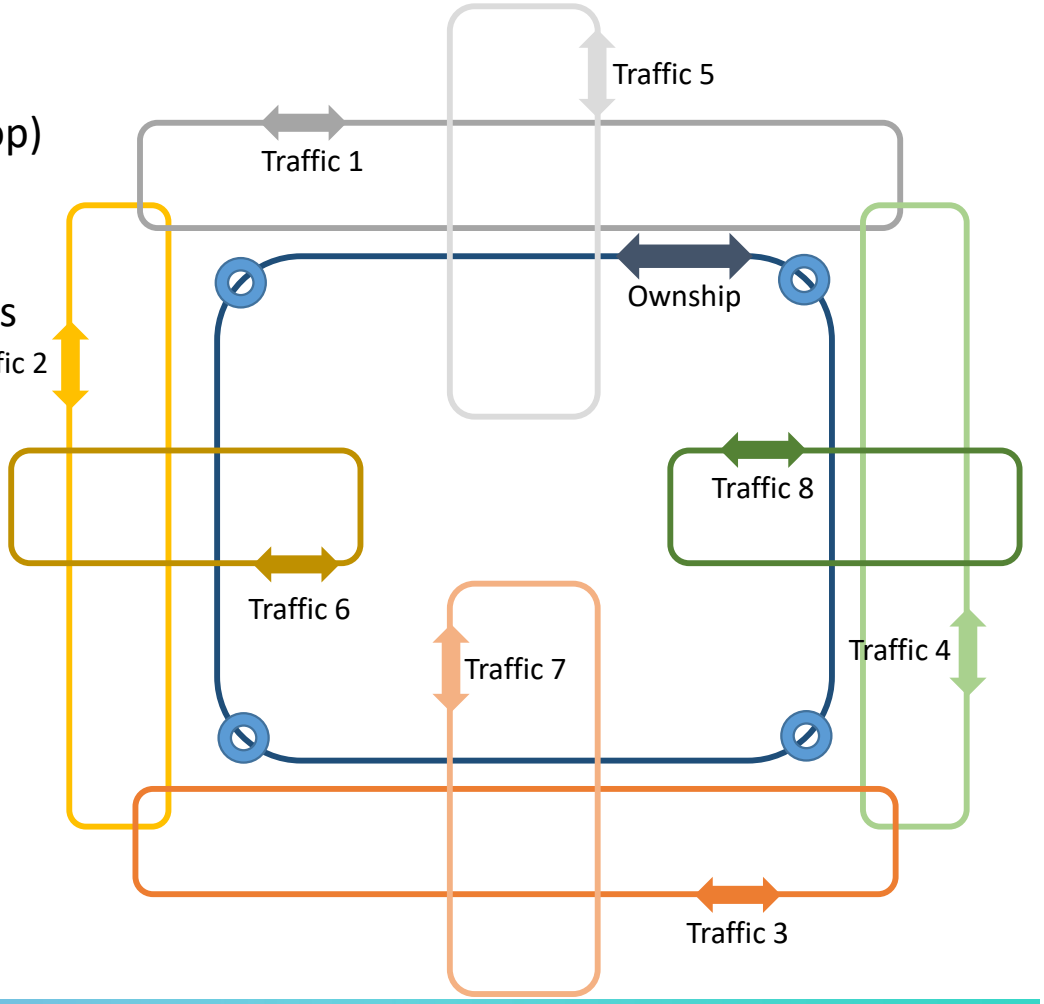
Guidance and control system – 4/4

Advanced scenario

- Random Mote-Carlo like scenario
- Combinations of (ownship loop) – (traffic ships loop)
- Real & Virtual traffic ships
- Loop tests w/ all different traffic situations
- COLREG violative / COLREG non-violative situations
- Applying passage restriction area



Sample simulation



Validation Issues Summary

- **Each Digital System (Situation Awareness, Collision avoidance, Engine monitoring etc.) is now being evaluated through LR Digital compliance and Risk Assessment.**
- **How effectively do we integrate all digital system and verify them?**
- **How to evaluate the Integrated Autonomous System?**
  - Need more detailed breakdown of autonomy level for MASS and each component systems. (Navigation, Engine, Remote control, etc.)
  - By setting detailed autonomy level for MASS and each components, detailed requirements for each component can be determined. Evaluation process of MASS and its components can be described based on the requirements.
  - Need scenarios and procedures to evaluate the autonomous ship through either simulation based test or actual sea trial
  - Need a standardization for testing infrastructures and procedures for evaluation of the integrated autonomous system
  - Output of KASS project would suggest the appropriate scenarios and procedures on this purpose.


Thank you for your attention.
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