6th Meeting of the IHO Council

S-100 Testbed Project in 2022

Agenda Item C6-04.1C

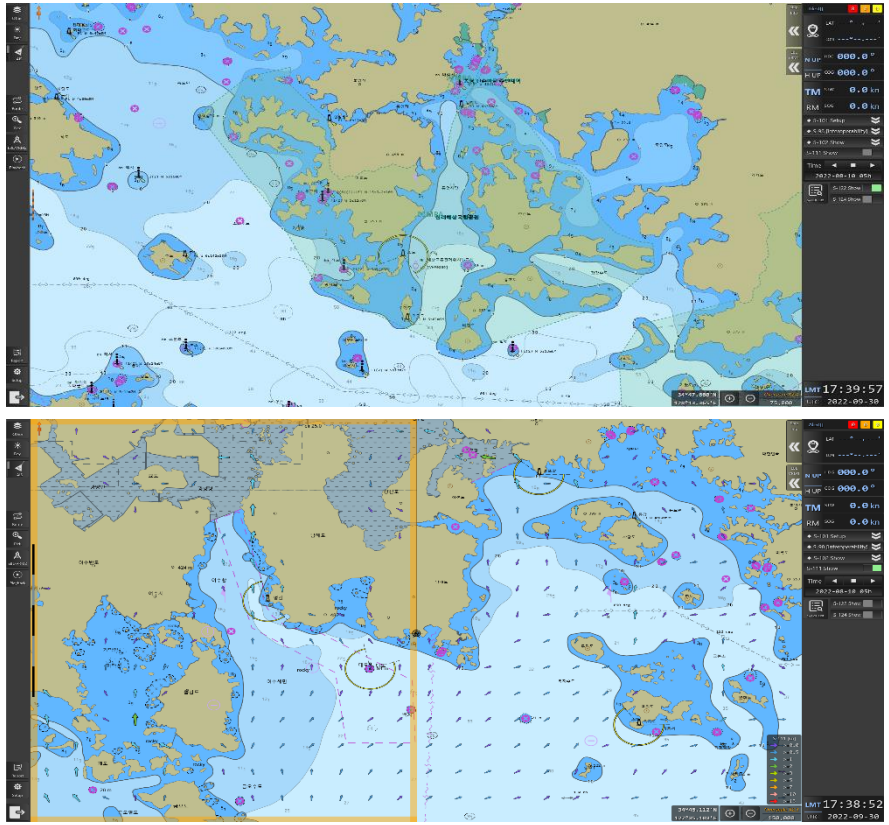
C-6, IHO Secretariat, Monaco, 18 - 20 October 2022

INTRODUCTION

- Decision C5/60
  - The Council noted the approach proposed by the KHOA-NOAA S-100 Testbed project to measure the efficiency quantitatively for the use of S-100 data service and invited Member States to join the project and suggest other quantitative measures (safety of navigation, efficiency) as appropriate
- Scope of S-100 testbed project in 2022
  - Technical issues of S-100
    - S-98 Interoperability
    - DF-mode in S-100 testbed system
    - Up-to-dateness of S-100 data using the S-128 dataset
  - Usability of S-100 service
  - Economic efficiency test of S-100 service

TECHNICAL ISSUES OF S-100

- Technical issues with S-100 testbed system
  - S-98 Interoperability

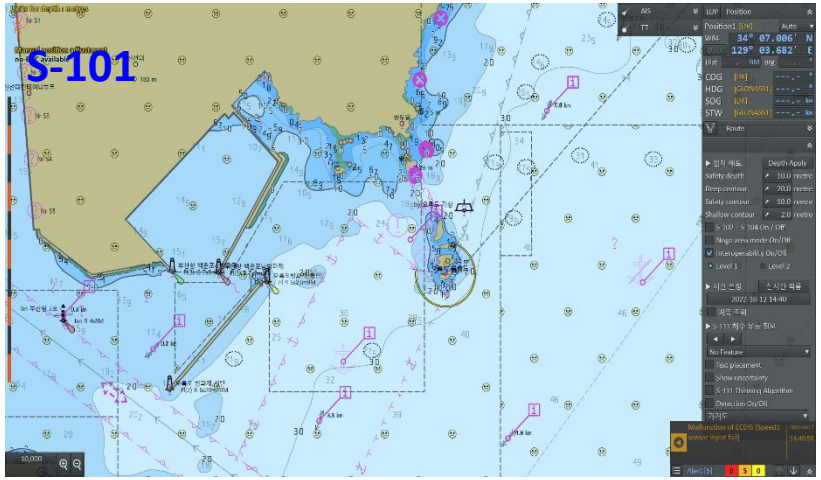


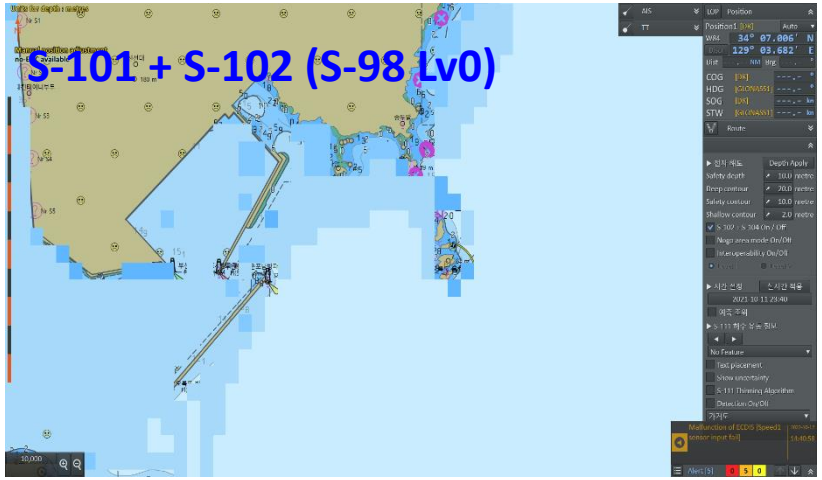
Test summary and recommendations

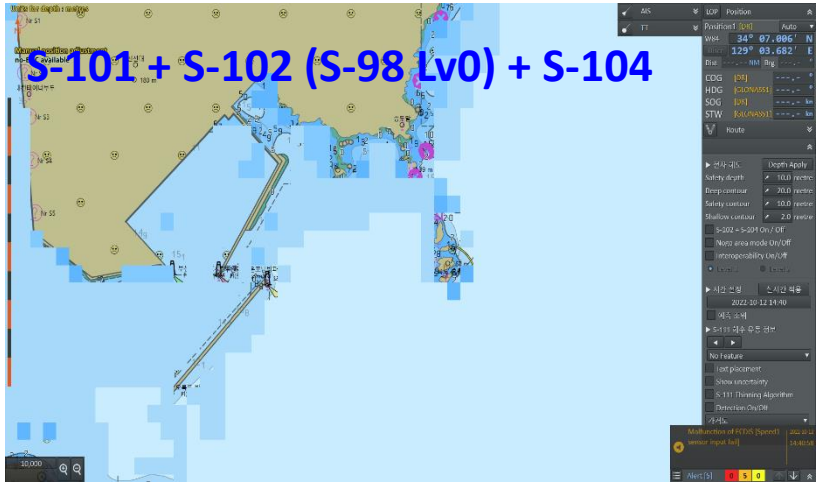
✓ROK-US joint project is improving the S-98 IC (Interoperability Catalogue) and it will be useful for OEMs and related stakeholders.
✓S-98 IC applied for harmonized display between S-10X data and scenario-based TDS for levels 1 and 2 are required.
✓Current version of the draft IC needs to be refined.
✓Recommend taking S-98 IC as a part of S-164 TDS for type approval.

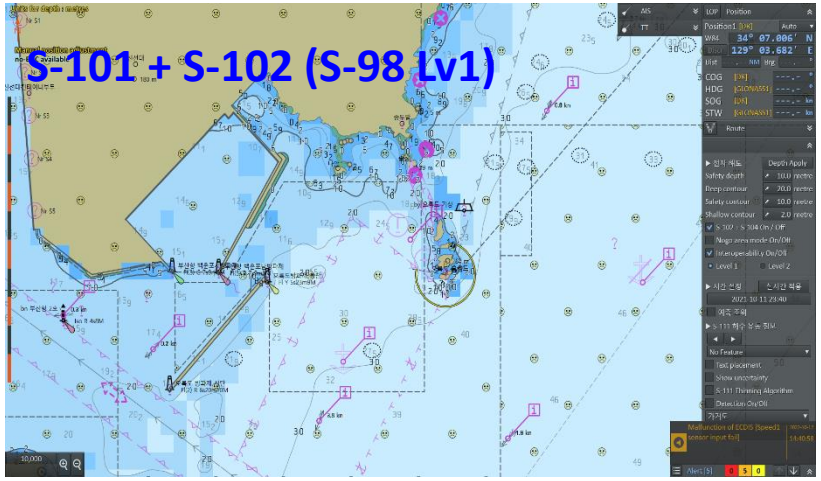
TECHNICAL ISSUES OF S-100

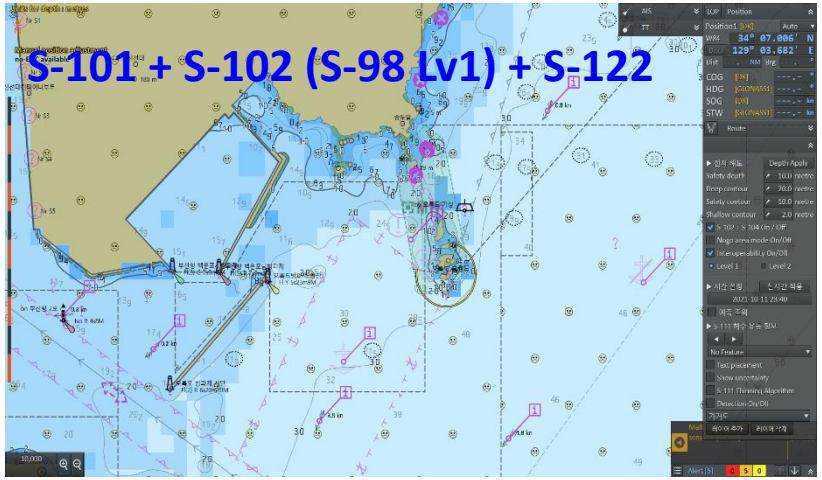
- Technical issues with S-100 testbed system
  - S-98 Interoperability

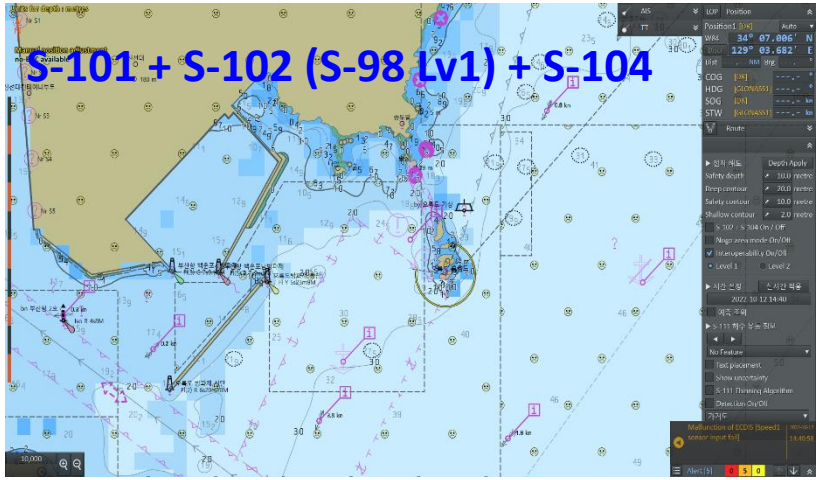






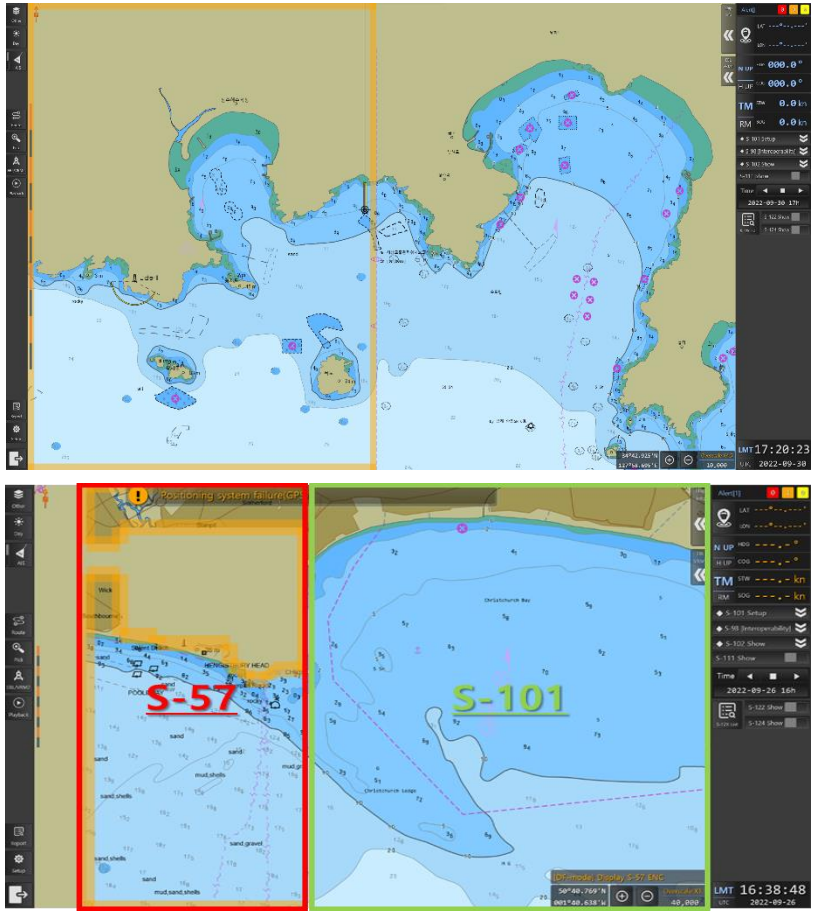






TECHNICAL ISSUES OF S-100

- Technical issues with S-100 testbed system
  - DF-mode in S-100 testbed system



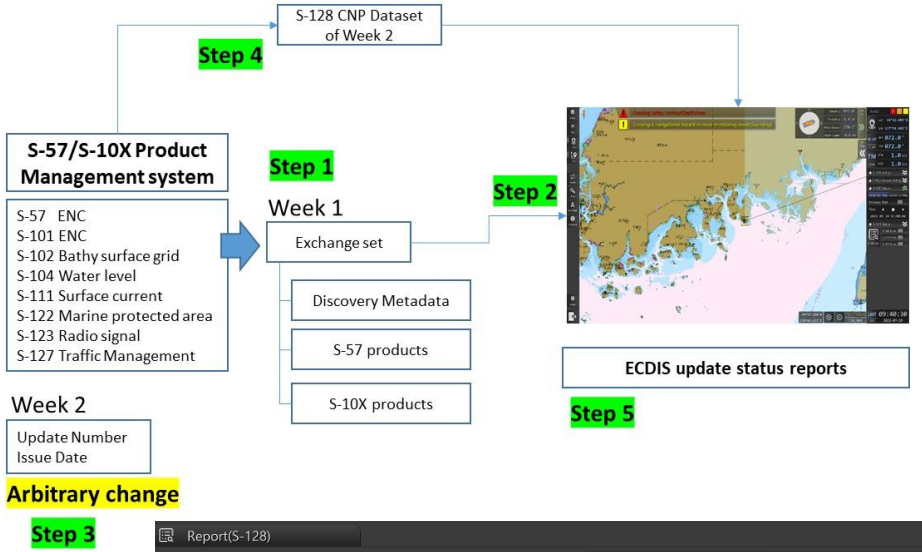
UKHO contributed their S-100 based data sets for DF test
Simultaneous display of S-57 and S-101 ENC

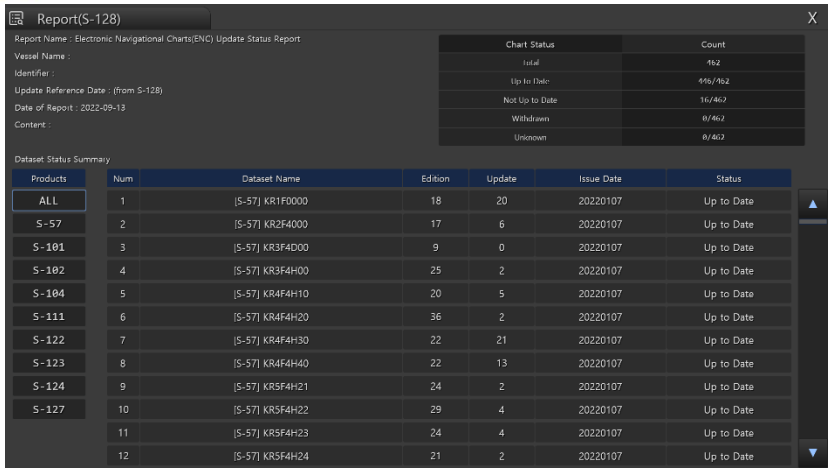
Test summary and recommendations

- ✓ Contrary to the initial concern, there was no technical difficulty in developing the DF function on the S-100 navigation system
- ✓ If the color table, seamless portrayal of symbols, connection of shoreline, display of specific feature types in curve and polygon is adjusted and solved, DF-mode will work well
- ✓ Recommend to provide the technical guideline for indicating the boundaries between S-57 ENC and S-101 ENC when they are simultaneously on the screen

TECHNICAL ISSUES OF S-100

- Technical issues with S-100 testbed system
  - Up-to-dateness of S-100 data using the S-128 CNP dataset





Verifying the up-to-dateness using S-128
S-100 data update status report

Test summary and recommendations

- ✓There was no issue for the S-128 data model while verifying the up-to-dateness
- ✓Detailed scenarios for short interval products S-104 and S-111 should be defined
- ✓S-98 Annex C guideline of S-100 data update status report for S-100 navigation system needs to be improved for its details
- ✓The test bed proposes the way to produce S-128 TDS by considering different S-100 products and occasions (new, re-issue, update and cancel), and to apply it as the S-164 TDS.

USABILITY TEST OF S-100 SERVICE

- Purpose and testing procedure
  - Traditional products(S-57 ENC and NPUB) vs S-100 data service
  - Quantitatively measure usability levels for two types products

Test condition

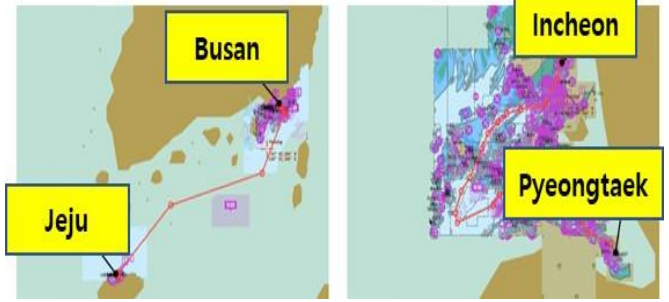
- Conducted for 10 mariners with more than 3 years of navigation experience
- Testing procedure: Assignment of voyage planning missions with different levels of difficulty between “Busan↔Jeju” and “Incheon↔Pyeongtaek” routes. (4 courses in total)

Test equipment

S-57 ECDIS S-100 testbed system Eye tracker

Test scenario

- Task 1. Update of nautical products
- Task 2. Navigational warning
- Task 3. Route planning
- Task 4. Check the surface current
- Task 5. Confirmation of route and save



USABILITY TEST OF S-100 SERVICE

- Usability evaluation
  - Qualitative indicators (for questionnaire survey)
  - Quantitative indicators (for measuring eye movements)

Evaluation indicators

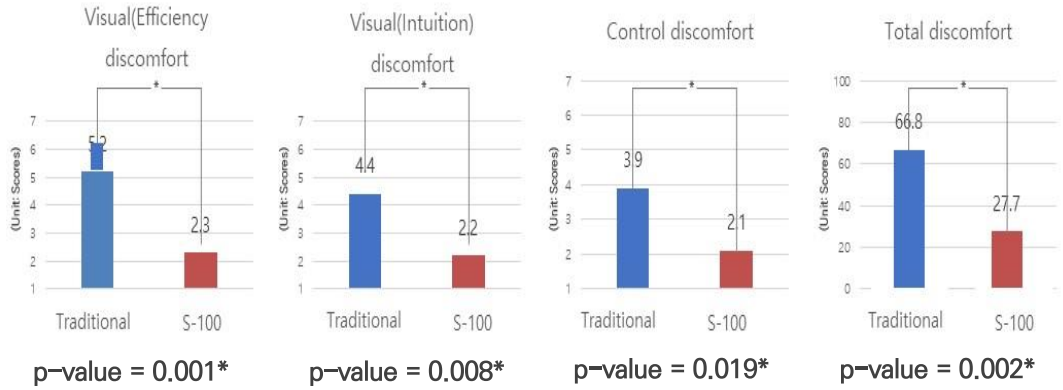
- Qualitative evaluation indicators: Questionnaire for subjective discomfort (visual, control, total), 7 point scale for visual and control discomfort (from 1 for very comfortable to 7 for very uncomfortable) 100 score scale for total discomfort
- Quantitative evaluation indicators: Utilization of eye tracking data to track eye movements during conducting each task by participants.

USABILITY TEST OF S-100 SERVICE

- Evaluation results

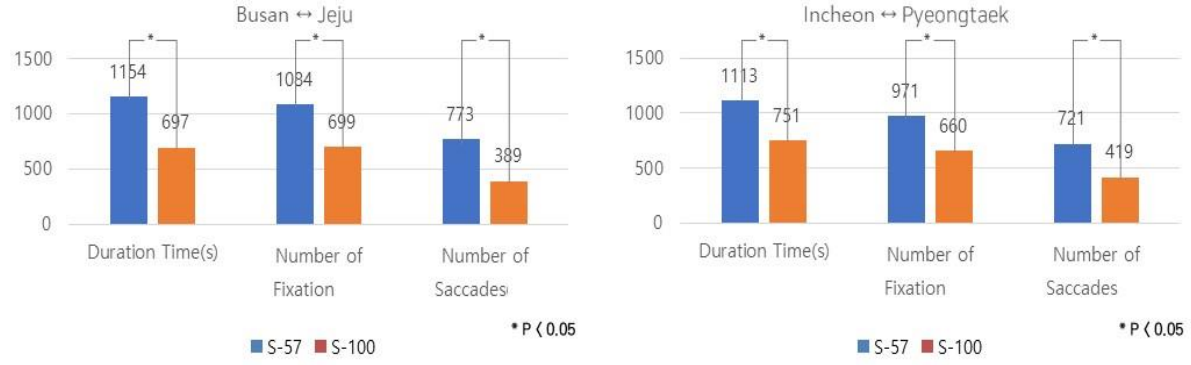
Qualitative evaluation results

- Visual (efficiency) discomfort: **5.2** for traditional products and **2.3** for S-100 based product service
- Visual (intuition) discomfort: **4.4** for traditional products and **2.2** for S-100 based product service
- Control discomfort: **3.9** for traditional products and **2.1** for S-100 based product service
- Total discomfort: **66.8** for traditional products and **27.7** for S-100 based product service



Quantitative evaluation results

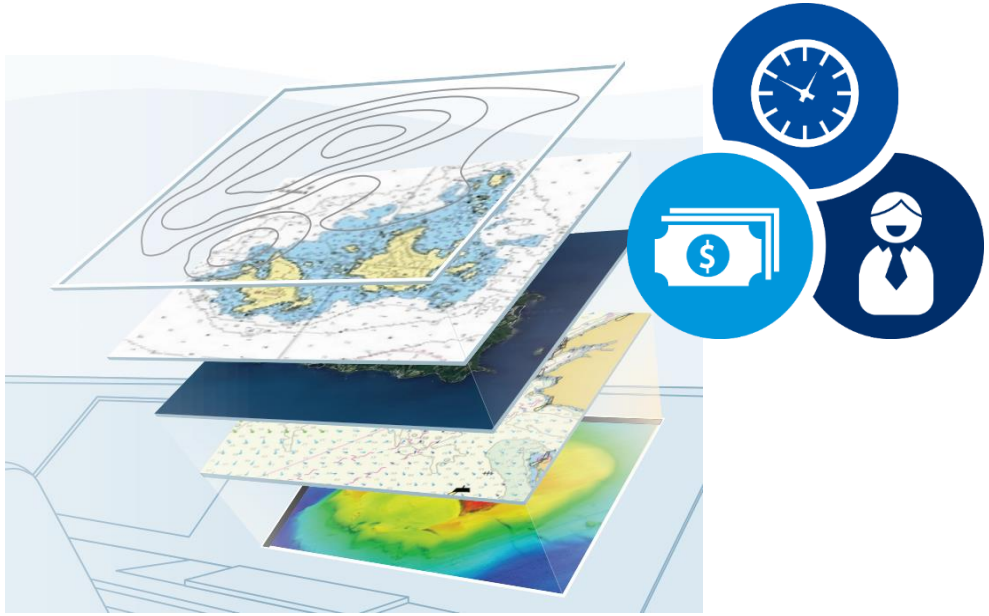
- Measuring value using eye tracker: Duration time, number of fixation, number of saccades
- When comparing data by item according to equipment, a significant difference was confirmed at the statistical reliability level of 0.05
- Duration time: task execution time, S-57 > S-100
- Number of Fixation: number of gaze fixations, S-57 > S-100
- Number of Saccades: number of gaze movement: S-



USABILITY TEST OF S-100 SERVICE

- Summary of evaluation result
  - Discomfort level test, operating S-100 based products are comfortable
  - Duration time, number of fixation and number of saccades test shows that S-100 based product service is more efficient compared to the S-57 ENC with nautical publications
  - S-100 test bed system provides a higher usability compared to the traditional products in updating nautical products, navigational warning, and checking surface current in arrival port.

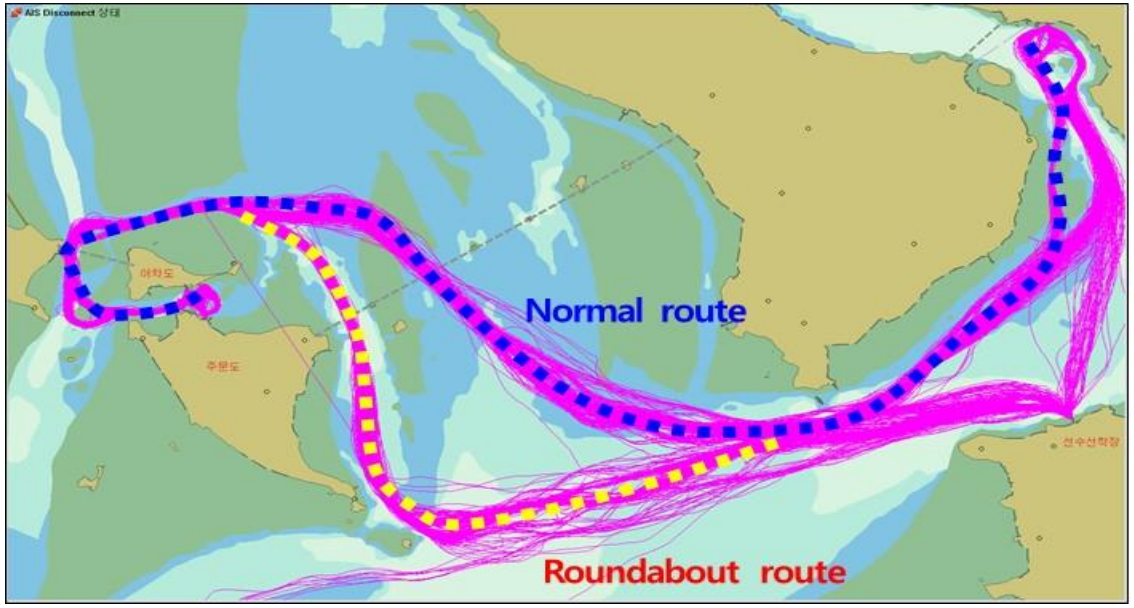
S-57 + Nautical publications



S-100 ECDIS

ECONOMIC EFFICIENCY OF S-100 DATA SERVICE

- Purpose and Procedure
  - (Major indicators) navigation distance, time required according to speed, fuel consumption, and operation time
  - The area with strong tides – 2 official routes(Normal and Roundabout)
  - Three routes (Normal, Roundabout, Alternative with S-100)
  - Identify an alternative route with a shorter distance using S-100 data

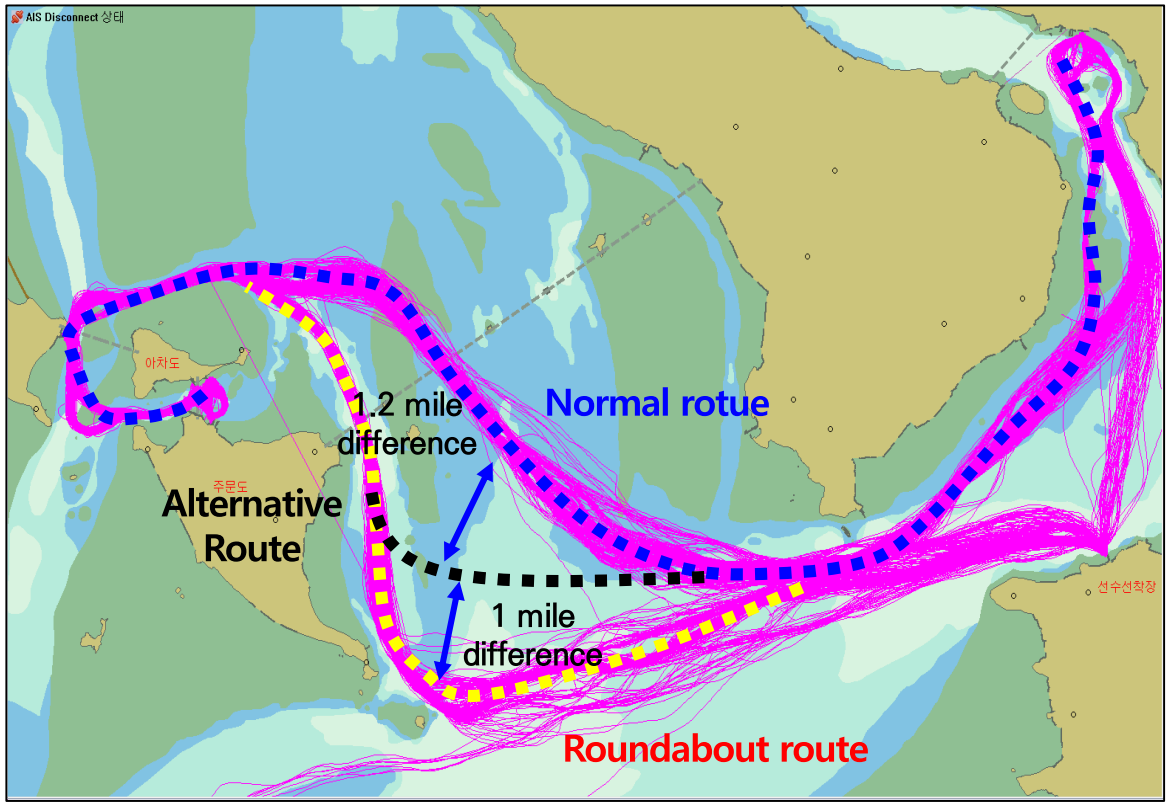


Sambo passenger ship operating between Oepo ↔ Jumun
6 rounds a day and 2,190 rounds a year

Num	Jumun Departure	Oepo Departure
1	07:00	08:50
2	11:00	12:50
3	14:30	16:20

ECONOMIC EFFICIENCY OF S-100 DATA SERVICE

- Alternative route
  - Safer and optimal alternative routes were identified for roundabout routes operated at low tide, Time and distance were calculated



Economic analysis process

- The roundabout route was 4,157m, the alternative route using the S-100 data service was calculated to be 2,306m,
- The number of possible roundabout and alternative routes out of the total number in coastal navigation schedule was 1,196.
- Assuming that the fuel consumption per hour is 1,000 liters and the fuel cost per liter is calculated as $1.25, the formula for economical analysis of operation efficiency can be applied as follows

(Route distance) X (Numbers of Roundabout/Alternative route navigation) / (Vessel speed – 12kn) X (Fuel consumption per hour) X (Fuel cost per liter)

ECONOMIC EFFICIENCY OF S-100 DATA SERVICE

- Economics analysis of coastal passenger ships

Passenger ship Route	Roundabout route	Alternative route explored using S-100 data service
Estimated distance (m)	4,157	2,306
Distance difference between normal and roundabout/ alternative(NM)	2.2	1.2
Total number of navigation	2,190 rounds	
Expected number of roundabout/alternative route	1,196 rounds	
Fuel consumption per hour	1,000 liters	
Fuel cost per liter	$1.25 per liter (include 0.01% MGO tax)	
Economics analysis of coastal passenger ships	(Route distance) X (Numbers of Roundabout/Alternative route navigation) / (Vessel speed – 12kn) X (Fuel consumption per hour) X (Fuel cost per liter)	
	(A) **$273,209**	(B) **$149,023**
	(A) - (B) = **$124,186 (45.5% savings)** Total annual cost savings of $124,186 (45.5% savings) would occur when the alternative route was used	

CONCLUSION

- S-100 testbed system to check the technical aspects of the S-100 **(S-98, DF concept, S-128 up-to-datenss)**
  - The essential functions to go to Full S-100 ECDIS was developed
- Usability and economic efficiency of S-100 service
  - Conclude using S-100 based product service can bring **higher usability and economic efficiency** compared to the traditional products in terms of updating nautical products and integrating required information
  - Plan to see economical efficiency with S-111 surface current
- Safe Navigation of S-100 service
  - Digitalization and automation with S-100 based product services can reduce human errors.
  - Plan to find the direct relations between digitalization and reducing human errors

ACTION REQUIRED OF [COUNCIL MEETING]

- Note the results of the S-100 test bed project conducted by KHOA in 2022.
- Invite Member States to participate in the S-100 Testbed

See Annex A / Annex B / Annex C for detailed research report
Technical issues and testbed activities will be discussed in the upcoming S-100WG meeting