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SMART-Navigation in Service in Korean Waters

1 SUMMARY

Ministry of Oceans and Fisheries (MOF) of Korea implemented the IMO e-Navigation strategy in Korean waters through the SMART-Navigation project from 2016 to 2020. The six SMART-Navigation services developed through the project are Navigation Monitoring Assistance Service (NAMAS, SV10), Shipboard System Monitoring Service (SBSMS, SV20), Safe and Optimal Route Planning Service (SORPS, SV30), Realtime Electronic Chart Distribution Service (REDSS, SV40), Pilotage and Tug Assistance Service (PITAS, SV51) and Marine Environment and Safety Information Service (MESIS, SV52). Among them, SV10, SV30, SV40, and SV52 are being provided for ships sailing in Korean waters from January 2021. SV20 and SV51 will be launched after conducting a more detailed review in terms of policy for service provision. The SMART-Navigation service was developed mainly for non-SOLAS ships, but with the expansion to SOLAS ships in mind, e-Navigation-related international standards such as S-10X, Maritime Connectivity Platform (MCP), and Maritime Resource Name (MRN) were applied. In order to use the SMART-Navigation service, a dedicated ECS connected to the LTE-M transceiver is installed on the ship, or the navigator installs the Bada-Navi app on his/her mobile phone to provide location information during navigation. So far, more than 2,000 ECS have been installed on small fishing vessels and domestic vessels operating in Korean waters and are being used for SMART-Navigation subscription. To share the achievements of SMART-Navigation with the global maritime community, Korean and European partners are cooperating to plan the Global Maritime Digital Route Test Bed (GMDRT). GMDRT is expected to serve as a real catalyst to make the global route safer and greener.

2 BACKGROUND AND HISTORY

IMO's e-Navigation strategy, which was first discussed at IMO in 2005, has been implemented in various forms. Including EfficienSea1 and 2, various e-Navigation projects such as ACCSEAS, MONALISA, STM VP, and SEASAME were carried out. Korea officially started planning SMART-Navigation in 2013. After 2.5 years of planning study, feasibility study, and budget planning, the SMART-Navigation project started in 2016. After 4.5 years of development and various tests, the Ministry of Oceans and Fisheries (MOF) of Korea launched SMART-Navigation in January 2021. Through the SMART-Navigation project, the LTE-Maritime network was

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built along the coast of Korea along with the e-Navigation service system, and a total government budget of 100M USD was put into the project.

3 DESIGN CONCEPTS AND ARCHITECTURE OF SMART-NAVIGATION

SMART-Navigation was developed with the main purpose of reducing maritime accidents in Korean waters. For this reason, the design concept of SMART-Navigation includes the development of information services to reduce the frequency of accidents and information services to reduce the damage caused by accidents. Ship accidents targeted by SMART-Navigation are collision, allision, grounding, and capsizing. The aim is to provide information services to minimize the damage caused by fires and engine failures in ship systems. SMART of SMART-Navigation means (1) Sea-traffic optimization and coordination service, (2) Maritime domain-awareness service, (3) Active-proactive safety service, (4) Remote assistance service and (5) Maritime Telematics service do.

SMART-Navigation provides the navigator with the information necessary for the safe operation of the vessel in a timely manner, helping the vessel (1) to keep the vessel in a safe state; and (2) preventing the increase in the risk of accidents through appropriate maneuvering; (3) when an accident is imminent, it induces an immediate accident avoidance action. And in the event of an unfortunate accident, the damage caused by the accident is minimized by notifying the nearby ships and SAR authorities of the accident. For this, SMART-Navigation is designed to provide navigation-related safety information of four types: (1) information, (2) warning, (3) alarm, and (4) emergency alarm. Information is provided in advance so that it can be helpful when referenced or utilized for safe navigation. Warning is delivered to the ship when the probability of an accident is higher even though navigational safety-related information has been provided in advance. If appropriate measures are not taken, the alarm is transmitted to the vessel in the situation of an imminent accident with a very high probability of an accident. It is transmitted to propagate to nearby ships.

SMART-Navigation was developed on the premise of using broadband communication called LTE-Maritime, which enables high-speed wireless communication from coast to up to 100km. The main target of the service was set to Non-SOLAS ships. By setting non-SOLAS vessels as service targets, not SOLAS vessels subject to international standards, it is now possible to agile the application of the latest technologies and standards related to e-Navigation. Nevertheless, by actively utilizing related standards such as S-10X, Maritime Connectivity Platform (MCP), and maritime resource name (MRN), we prepared for the service usage demand of SOLAS ships in the future.

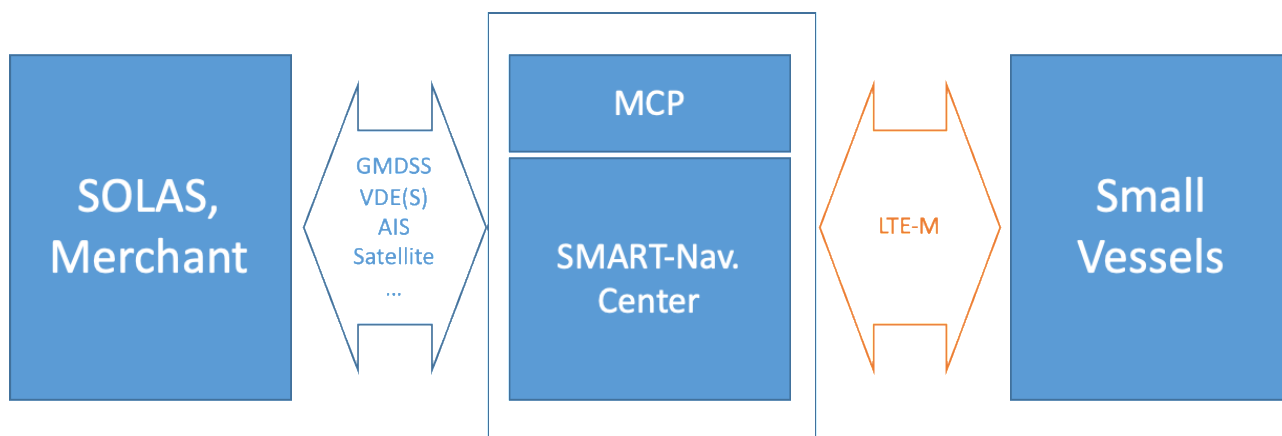


Figure 1: SMART-Navigation for safer navigation with wider connectivity

4 SMART-NAVIGATION AS THE MARITIME SERVICE PORTFOLIO AT KOREAN WATERS

Information service for maritime safety is automatically provided based on the ship's status and location, and it can be said that this characterizes the Maritime Service Portfolio of SMART-Navigation provided in Korean waters. The SMART-Navigation service secures the spatial and temporal coverage that an e-Navigation service portfolio called berth-to-berth should have. This chapter describes the NAMAS (SV10), SORPS (SV30),

REDSS (SV40), and MESIS (SV51) services that are currently being serviced among the six services developed through the SMART-Navigation project.

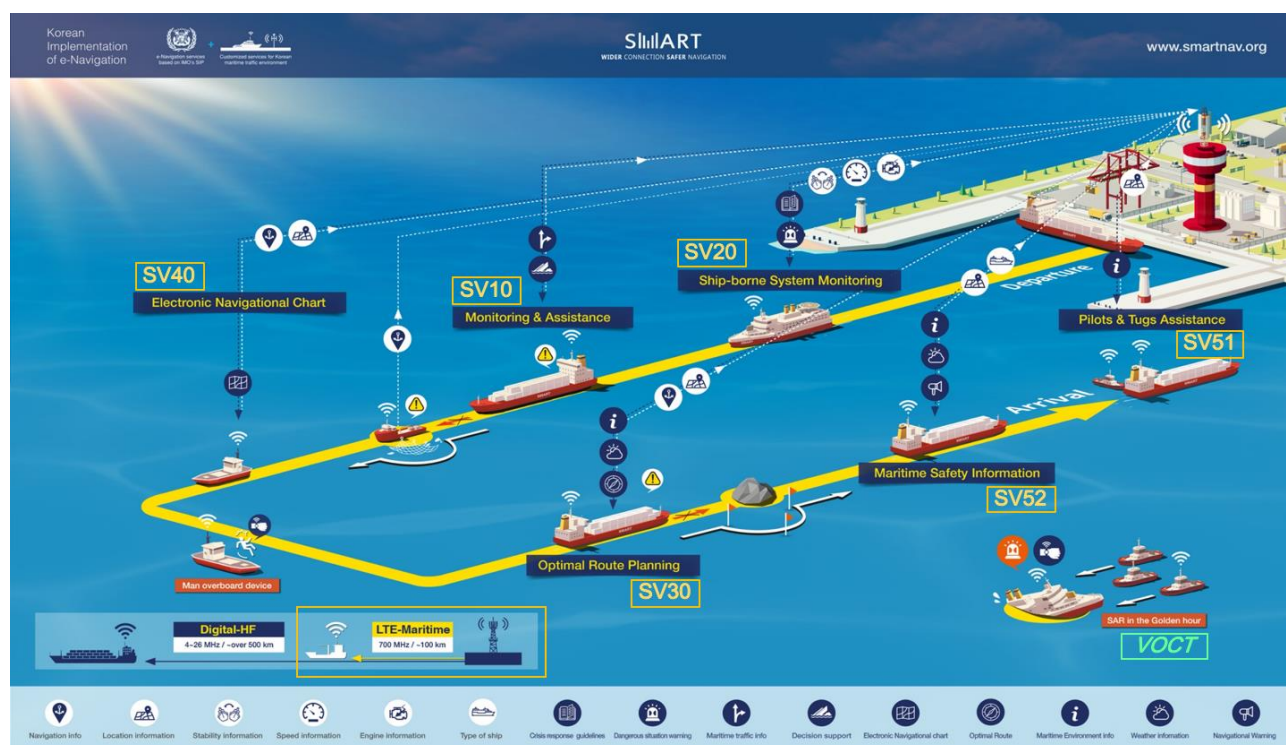


Figure 2: SMART-Navigation at a glance

4.1 Navigation Monitoring Assistance Service (NAMAS): SV10

NAMAS (SV10) provides a location-based service to reduce risks that may occur during voyage such as collision, stranding, entry into a no-go area, and reverse running of a traffic separation zone to a vessel in voyage. It was implemented to provide all information of the categories of information, warning, alarm, and emergency alarm defined in SMART-Navigation, but currently, except for emergency alarm, the remaining three categories of information are provided.

Information and warnings to prevent collisions are decided by using the classification model based on machine learning, which is constructed in consideration of the type of encounter between ships, TCPA, DCPA, SOG, current distance between ships, and ship length. Whether to provide higher level information, such as alarm and emergency alarm, is determined based on a rule-based system using fuzzy logic. For this, TCPA, DCPA, ship dimension, distance between ships, weather, tide strength, traffic density, accident statistics, fishing area, etc. are considered. Grounding and allision detection is based on a rule-based system using fuzzy logic, and the above-described four types of information are provided. When a vessel enters the traffic separation zone in violation of the traffic separation scheme, the violation is immediately notified with information, and information is sent by converting it into warning and alarm according to the duration. When the ship is heading to the no-go area, information is provided prior to entry so that the navigation can refer to the presence of the no-go area in front. A warning is sent immediately upon entering the no-go area. An alarm is sent when the ship stays in the no-go area continuously. Figure 3 shows the collision warning “A ship is approaching at 10 knots at 1 o'clock ahead” displayed on the electronic chart system (ECS).



Figure 3: Screen shot of collision warning by SV10

On the other hand, for collision analysis, ship position and speed information is required. Korean ships transmit their location information in four ways: AIS, LTE-Maritime, V-Pass, and VHF-DSC. The location information used in SV10 is the previous two. In particular, LTE-Maritime makes it possible to acquire ship's location information, SoG, and CoG every second, enabling much more accurate analysis than using information received through the existing AIS. V-Pass and VHF-DSC are location reporting systems used only in Korean waters and have a reporting period of more than 30 seconds, so they are not used as location information sources for collision analysis in SV10.

4.2 Safe and Optimal Route Planning Service (SORPS): SV30

SORPS (SV30), which is used when an optimal safe route is required during the establishment of a ship's navigation plan and operation, uses a standard database for fuel consumption by ship specifications, ship type, water depth information, tidal information, grid-based accident risk information, electronic chart feature information. An optimal safe route is automatically created by reflecting Maritime Safety Information (MSI), no-go area, traffic separation zone, fishing farm location, and nogo zone for oil tankers.

SORPS (SV30) pre-processes the electronic chart information to create a grid map, compose a graph for navigation, determine the weight for each edge of the graph to express the conditions to be reflected in route planning, and increase the search speed. After limiting the search range for route creation using A* algorithm, it calculates the shortest route using the Dijkstra algorithm and reduces the number of way points to simplify and straighten the route generated. Lastly, the expected fuel consumption rate is assigned to the created route to find the optimum engine speed using SQP (Sequential Quadratic Programming).

In addition, the SV30 service can be used to verify the route plan generated by human navigators. When verification of a route is requested, the SV30 utilizes all factors reflected in route creation to check whether there are any elements that pose a risk to safe navigation in the given route.

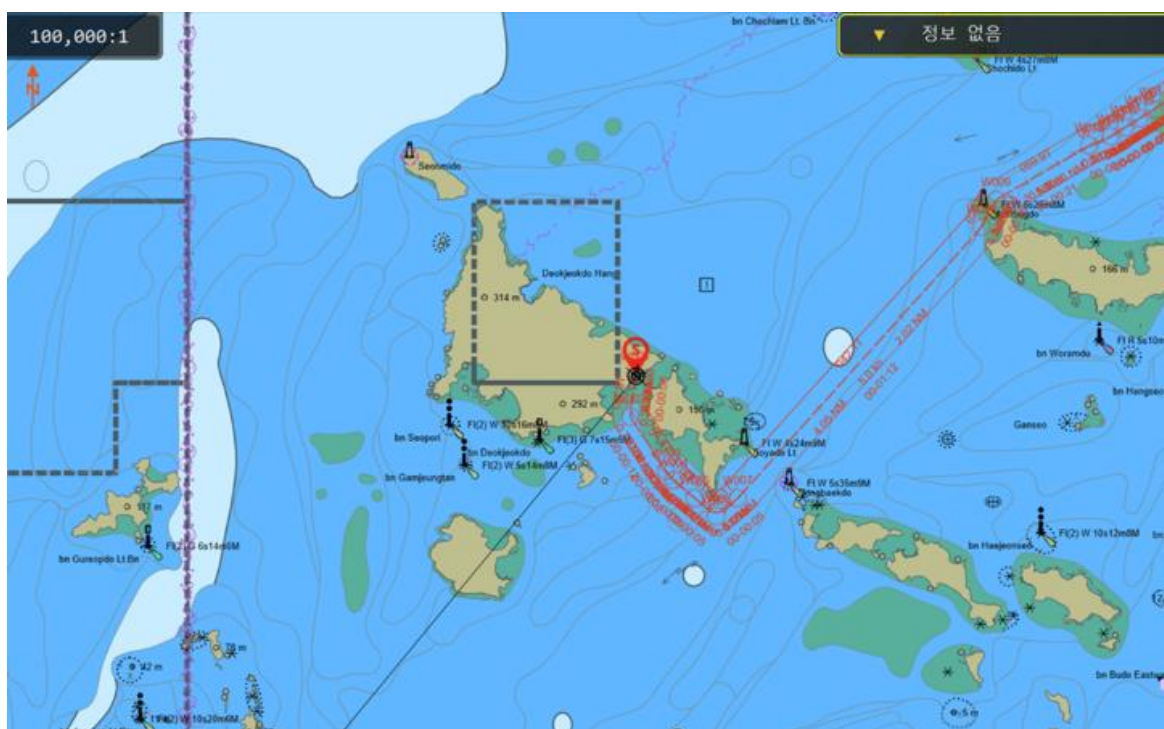


Figure 4: Automatically generated route plan using SV30

In order to use the flight, SV30, the ship must have the career/qualification/position of the navigator, the expected departure time, the target arrival time, the operating speed, the draft during operation, the course width, the cargo information (e.g. crude oil, etc.), the characteristics of the route to be inferred (e.g. passenger ship navigation routes, safety routes, efficient routes, and small ship routes) must be provided.

4.3 Realtime Electronic Chart Distribution Service (REDSS): SV40

REDSS (SV40) is a service to provide an electronic chart of the next-generation standard issued by KHOA, and provides an electronic chart manufactured according to the S-101 standard of the International Hydrographic Organization to ships using the service. This service consists of an electronic chart service for small ships and an electronic chart streaming service.

Vessels using ECS can update their electronic charts online, and vessels using mobile apps can use the tilemap generated based on the S-101 chart as a streaming service.

In order to use the electronic chart, ECDIS or ECS must have the correct license, and when using the SV40, an encrypted electronic chart based on the license is provided as ECS. All ECS used for SMART-Navigation have a certificate issued by MIR of MCP. In the process of issuing the certificate, licencing for the issuance of the electronic chart is carried out together. Through this process, it is possible to supply the certified electronic chart after confirming that it is the correct electronic chart license possessed by the certified terminal.

When the electronic chart is first installed on the ECS, the base files are downloaded. After that, update files are automatically downloaded whenever ECS is started. In addition, in case of continuous operation for a long time, it can be set to enable automatic update when a predetermined time elapses after operation. The ECS developer is set to suggest an automatic update method (a certain time elapsed, a specific time).

On the other hand, due to the nature of the online update, the electronic chart may be updated during voyage. Before the update is completed, the current electronic chart is displayed on the screen. When the update of the electronic chart is completed, the electronic chart is replaced with the updated electronic chart without rebooting or initializing the ECS. to be displayed In addition, an exchange set and a feature catalog and portrayal catalog are included, so the electronic chart is expressed according to the latest version of the feature/portrayal catalog. In particular, considering that most of the people sailing in Korean water are Koreans, a feature catalog using the Korean character Hangul was applied. Therefore, when selecting a symbol in ECS, the Korean feature name and attribute name are displayed.

4.4 Marine Environment and Safety Information Service (MESIS): SV52

In SMART-Navigation, maritime safety service (MS5), voyage publication service (MS12), weather information service (MS 14), real-time waterway and environmental information service (MS15) is provided according to the International Maritime Data Standard (S-100).

First, maritime safety information consists of navigation warnings and weather warnings according to the S-53 MSI Manual developed jointly by IHO, IMO, and WMO. To provide navigation warning, IHO's S-124 navigation warning standard is used, and to provide weather warning, WMO's S-412 marine meteorological standard is used.

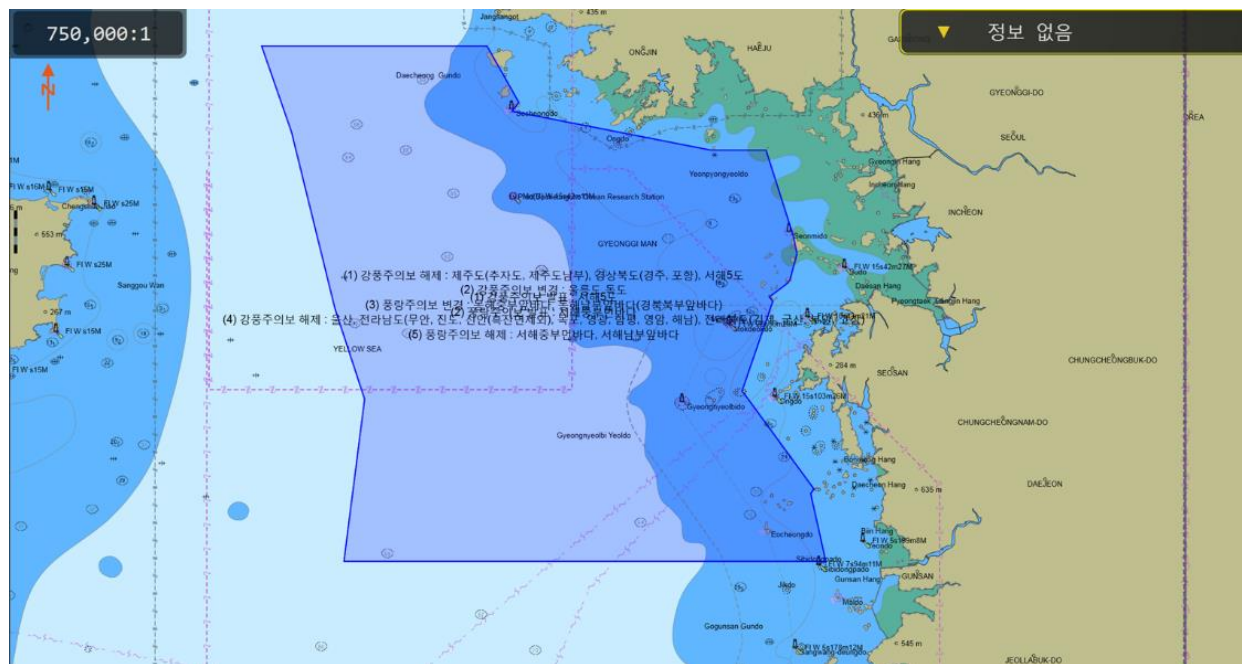


Figure 5: Weather data in WMO S-412

The nautical publication information corresponds to the sailing direction and is used as additional information of the electronic chart. To provide marine protected area data, the IHO S-122 marine protected area standard is used. The IHO S-123 maritime radio information standard is used to provide marine radio information data. IHO S-127 traffic management standard is used to provide traffic management information data.

Dynamic hydrographic information consists of seabed topography, navigation tides, and seawater flow produced by the KHOA. The IHO S-102 seabed topography standard is utilized to provide subsea topography data. The IHO S-104 navigational tide standard is utilized to provide navigational tide data. The IHO S-111 seawater flow standard is used to provide seawater flow data.

Marine meteorological information includes wind direction, wind speed, atmospheric pressure, water temperature, temperature, wave height, wave direction, and visibility. The WMO S-413 marine forecast data standard is used to provide marine weather forecast information, and the WMO S-414 marine forecast data standard is used to provide marine weather real-time information.

Meanwhile, MSI consists of navigation warnings and weather warnings. It was necessary to remove overlapping data between them. Source data for MSI are NAVTEX, navigation warnings, and weather warnings. In Korea, the Korea Coast Guard produces NAVTEX, and SMART-Navigation converts the NAVTEX message provided by the Korea Coast Guard into S-124 standard data. In KHOA, Navigational Warning is converted to S-124 standard data and provided to SMART-Navigation. Korea Coast Guard NAVTEX information includes engine failure, weather forecast, other failure information, anchor dragging, sea trial broadcast, overturn, stranding, propulsion failure, collision, sinking, flooding, typhoon warning, drift, navigation notice, maritime military training, and fire. SMART-Navigation excludes weather forecast, typhoon warning, and maritime military training from the NAVTEX information provided by the Korea Coast Guard.

It is sometimes difficult to install LTE-Maritime router and ECS on a ship. In this case, you can use SMART-Navigation using a mobile app instead of ECS. When using the mobile app, if you enter your own ship's registration number, SMART-Navigation recognizes the location and speed information sent from the app as that of the ship, and provides the relevant information to ships navigating around if necessary.

Meanwhile, as of September 13, 2021, more than 2,000 ECSs are installed on ships, and the mobile app has been downloaded more than 10,000 times. More than 2,000 ECS installation contracts are expected to be awarded by the end of 2021, and more than 5,000 ECS units in total are expected to use SMART-Navigation in Korean waters within the first half of 2022.

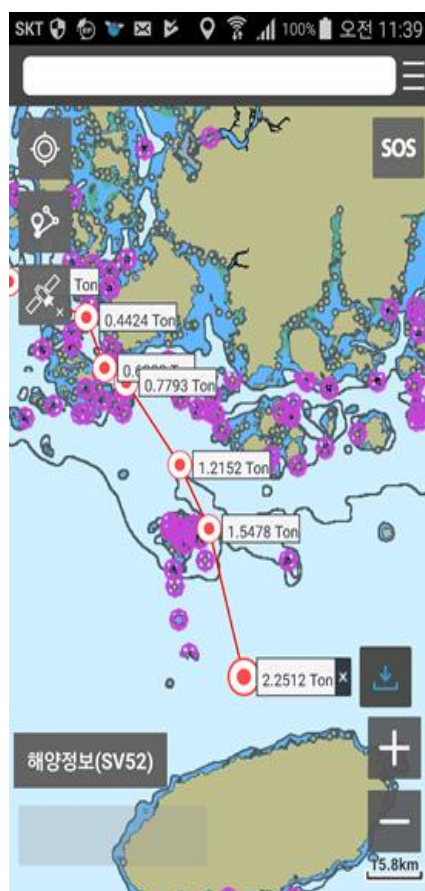


Figure 8: SMART-Navigation on Mobile App

6 CONCLUSION AND FUTURE WORK

SMART-Navigation was developed to provide e-Navigation service focusing on Non-SOLAS vessels in Korean waters. By setting the main target of the service to Non-SOLAS ships, it created an opportunity to apply new technologies challengingly. Efforts to apply international standards related to e-Navigation as much as possible were added to this opportunity. The combination of these opportunities and efforts led to the fruit of providing a maritime information service that fully applied the S-100 standard to the world's first S-101 chart-based electronic chart. The Global Maritime Digital Route Test Bed (GMDRT) is being planned to share the technological achievements of SMART-Navigation with the global maritime community. GMDRT aims to accelerate the development of related standards along with verification of effectiveness by applying various e-Navigation services developed for each project to global navigation. Through this, the standardization of e-Navigation service, which has been laid down through IMO HGDM activities, will be able to bear practical fruit, and ultimately, it is expected that global deployment of e-Navigation service that will make navigation safer and greener is possible.

7 ACTION REQUESTED OF THE COMMITTEE

The Committee is requested to note information provided in the document.