Journal of Navigation and Port Research International Edition
Vol.36, No.2 pp. 105~112, 2012 (pISSN-1598-5725/eISSN-2093-8470)
DOI : http://dx.doi.org/10.5394/KINPR.2012.36.2.105

Application of S-100 Standard in the field of e-Navigation

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Abstract : *In order to improve the existing S-57 standard, International Hydrographic Organization(IHO) has developed S-100 standard, a Universal Hydrographic Data Model(UHDM) expanded from ISO 19100 series standard to hydrographic area, and is in the process of its implementation. International Maritime Organization(IMO) has established CMDS based on e-Navigation strategy data standard as International Association of Lighthouse Authorities(IALA) established IHDM based on aids to navigation data standard and each data standard is linked with the S-100 standard. Fundamental concept and core principles of S-100 standard is suitable not only for the development of a wide range of hydrographic data and service production standard, including the next generation ENC, but also the development of product specification of non-hydrographic area. This study has examined the operation principle of S-100 standard and analyzed its implementation process as e-Navigation data in relation with ENC. It also noted the utilization of S-100 standard based e-Navigation and its potential effect via examining the development cases of S-100 standard-based product specification, such as nautical publication, ship reporting and pilot request, digital routing guide, tide and water level transmission and other important data cases of e-Navigation field.*

Key words : *Universal Hydrographic Data Model, S-100, Digital Nautical publication, ship reporting and pilot request, Digital routing guide, e-Navigation*

1. Introduction

In order to improve the S-57 standard, the transmission specification of hydrographic data, the International Hydrographic Organization(IHO) completed the development of S-100 standard, which profiled the 19100 series standard of ISO into hydrographic area, and is in the process of implementation since January, 2010(Brown, 2007).

The distinct feature of S-100 standard is that it manages the standardization elements of the maritime GIS field, such as object, attribute, Meta data, portrayal, publishing country code, and product specification, in a digital, systematic method through adopting standardization registry. S-100 standard establish standardization system that can develop a wide range of vector grid data standard or hydrographic service standard, including former ENC independent production standard to next generation ENC standard. Another essential matter is the adoption of Plug and Flag system, which consistently displays and revises the maritime safety and the environment data produced by the maritime GIS associates in various application systems, and automatically updates the subsequent object and attribute without full maintenance. In short, S-100 standard is a standardization system which consistently displays the core elements as well as the associated data and service within the application system for standard hydrographic data production and service publication, including the core element that allows its constant management.

The adoption of S-100 standard has led to the next generation ENC standard, known as the S-101 standard, which is currently being developed in 4 stages, and is expected to be completed by December, 2012. S-100 standardization Registry defined the object and attribute for ENC publication as Hydro Register, and has also defined Nautical publication Register for the development of Digital Nautical publication to carry forward a 'paperless movement' within bridge in the publication area(KHOA, 2008).

Meanwhile, Common Maritime Data Service(CMDS) was established for the data standard in e-Nav area according to the e-Navigation strategy promotion of the IMO, and S-100 standard was adopted as the baseline of its development. Furthermore, project BLAST, intended for Northern Europe maritime safety and coastal governance, has developed digital routing guide standard based on S-100 standard hydrographic object and publication object,

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and was introduced in the 10th IALA e-Nav Committee Annex as ship reporting and pilot request related product specification. This study examines the operation principle of S-100 standard, which is being considered as the data standard for implementation of IMO e-Navigation strategy, and analyzed the implication method in the field of e-Navigation. Also, it analyzed the development progress of digital routing guide standard which becomes the basis of realizing e-Navigation data standard, and noted the analysis of S-100 utilization case and its method for utilization.

2. Operation principle of S-100 standard

2.1 Major Structure of S-100 standard

S-100 standard can be defined as a methodology that allows standardized utilization of marine geospatial information produced by different bodies in various application systems. Fig. 1 is a diagrammed concept on the necessity of S-100 Standard Frame work in order to utilize Vector data and Grid data produced by the marine geospatial information producer body, such as Mapping agencies, Geological surveys and Hydrographic Offices, and Coastal administrations, through ENC Viewer, Navigation equipment, and ENC Production Software. According to the concept, this utilizes the marine geospatial information in a standard manner, and makes feedback and management of the marine geospatial information program possible(Lee, 2004).

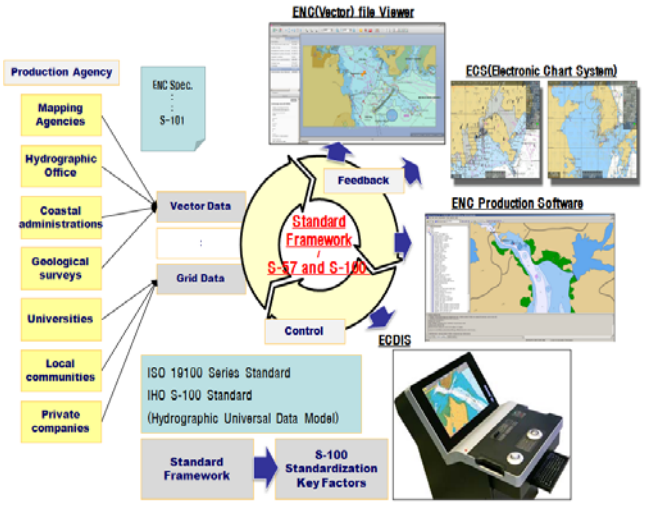

Fig. 1 S-100 Standard Framework

UHDM can be categorized as Standardization Registry and Standard elements as in Fig.2. Standardization Registry refers to object, attribute, Meta data, Portrayal method for consistent management in standard system, and, with the participation of exclusive organ for standardization Registry and professionals, it can be utilized and managed according to different versions. Whereas, key elements for hydrographic information standardization are standardization registry and register structure, Feature concept dictionary structure, Portrayal method, Meta data items and structure, Feature catalogue structure, Spatial schema, imagery and gridded data model, encoding method, including product specification encoding guideline for S-100 based S-10X product specification(IHO, 2008).

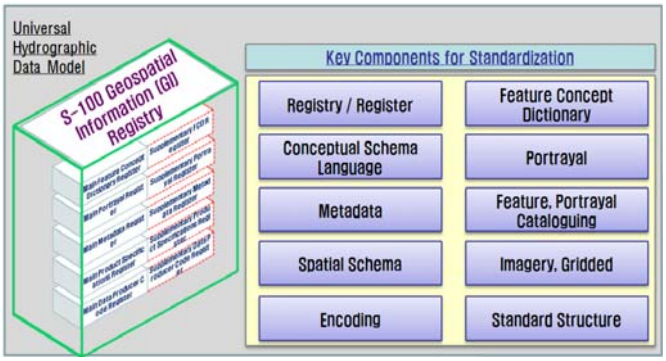

Fig. 2 Registry and Standard elements of S-100

2.2 Operation process of Vector Data based on S-100 standard

S-100 standard, the UHDM, covers Vector data and Grid data, and this study will define the operation process of ENC which is a typical Vector data. As in Fig.3, ENC is consisted of 3 stages: (1) Vector data parsing process, (2) SENC composing process, (3) SENC portraying process.

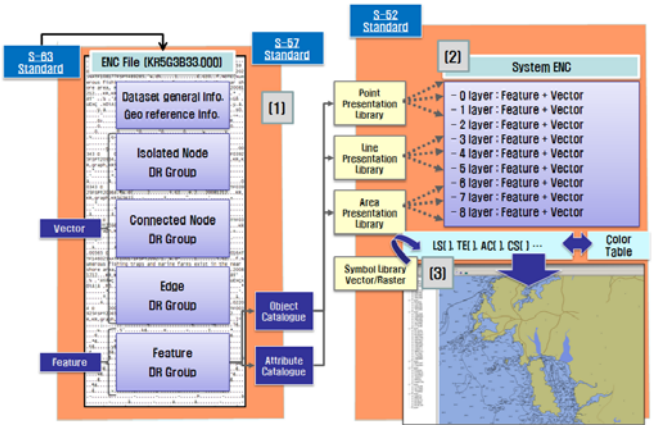

Fig. 3 Operation process of UHDM

Initial stage is the Vector data parsing process. In order to facilitate data transmission, ENC saves the spatial information shared by multiple objects once, while each

object saves only the connecting information of its related spatial information. Therefore, the file of an ENC is consisted of general information record group, spatial information record group, and feature information record group, while the spatial information is again classified into isolated node record group, which is an independent point data, connected node record group, which indicates the beginning point and the end point of line segments, and edge record group, which indicates the middle node of the line segments. In order to compose the SENC format in the next stage, each feature information refer to each record group according to its space type as indicated in Fig. 4. For example, in case of point-type, it refers to isolated record group, and in case of line-type, it refers to edge record group and connected record group of beginning point and the end point. Area-type refer to edge record group and then to the connected group as the line-type. The beginning point being equivalent to the end point is a distinct feature of the area-type.

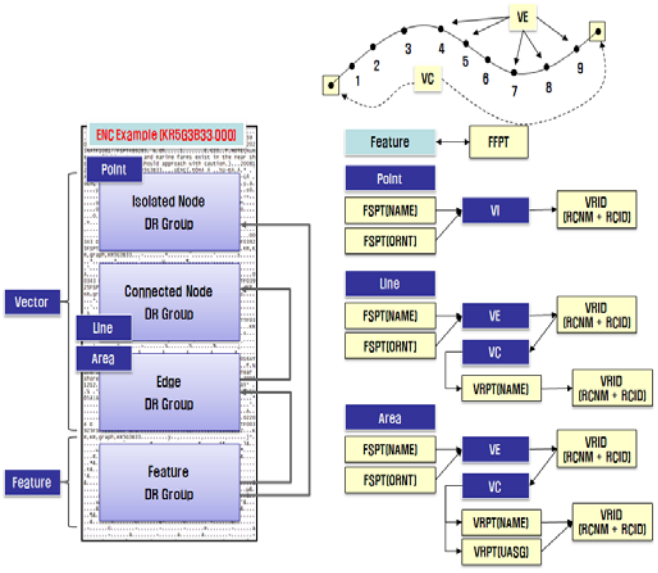

Fig. 4 Parsing process of ENC data

The second stage is the production process of SENC format, and in this stage, standard feature catalogue and portrayal catalogue of the UHDM is used to decide the marking order and structure of each layer of ENC. In ENC, code values are saved instead of the name of each feature, so as in Fig. 5, identification of feature abbreviations for each code value is necessary, and in order to apprehend the layer group of the related feature, layer group and portrayal method can be identified according to the related abbreviation and attribute value construction of Portrayal catalogue, also known as the look-up table.

Fig. 5 Production process of SENC DB

The last stage of the UHDM implementation process is SENC format portraying process, where portrayal method of feature information is defined according to S-52 standard and Presentation Library, which are the standards for color and symbol of hydrographic information. The area of ENC portrayal method is operated by Annex PL version 3.4 of S-52 standard, and is mainly consisted of the concepts of feature information portrayal, and 6 core concepts. The core concepts of feature information portrayal manages the display of feature information on the ECDIS screen through examining information such as the expiration date of each feature information included in ENC, reference to Look-up table, SCAMIN satisfaction. Whereas, as in Fig. 6, core concepts of feature information portrayal are consisted of (1) Symbol, line-type, pattern-filling, (2) ECDIS Chart 1, for confirming symbol portrayal result, (3) color value computing method for each display equipment (4) digitally processable color, Look-up table, digital file of symbol portrayal method (5) Look-up table of point, line, and area (6) symbol generating process function according to situation.

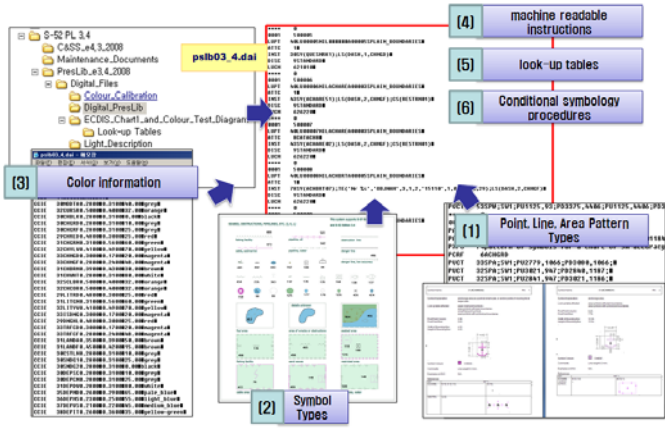

Fig. 6 Portrayal process of SENC DB

Specifically, the Look-up table for point, line and area is consisted of (1) the 1st field: feature abbreviation, (2) the

2nd field: harmonization of properties, (3) the 3rd field: Symbol portrayal guide, (4) the 4th field: layer group, (5) the 5th field: Radar imagery priority, (6) the 6th field: IMO portrayal category, (7) the 7th field: View group. Symbol portrayal guide in the 3rd field refers to object's display function, and as the types of functions, there is SHOWTEXT, which indicates the property title of objects, SHOWPOINT, which indicates the symbol inside a polygon or a specific point, SHOWLINE, which draws line segment, SHOWAREA, which depicts polygon, and SYMPROC, a symbol portrayal function according to situation. In conclusion, according to the UHDM, Vector data, such as ENC, is operated in the process of (1) data parsing, (2) SENC format conversion, (3) portrayal process of SENC format and the application system can be constructed by utilizing standard feature catalogue and portrayal catalogue produced to S-100 standardization registry.

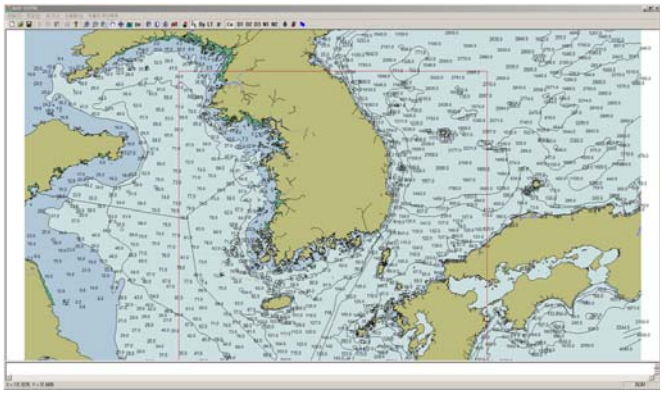

Fig. 7 Example of ENC Viewer

2.3 Method of Expanding S-100 standard to Non-Hydrographic Area

S-100 standard defines standardization registry and operation process of Vector and Grid data. If object and attribute of non-hydrographic area can be defined according to the S-100 standard to its related registry, standardization can be constructed. As in Fig. 8, this is possible through establishment of register on non-hydrographic object and attribute, such as IMO or IALA, in S-100 standardization registry, and objects registered can be classified as feature type object and information type object. Application schema, consisted of feature schema and spatial schema, is constructed for establishing product specification for each area, and the feature schema for each area consist each application schema by referring to hydro object for chart publication, and Npub object for nautical publication as basis object.

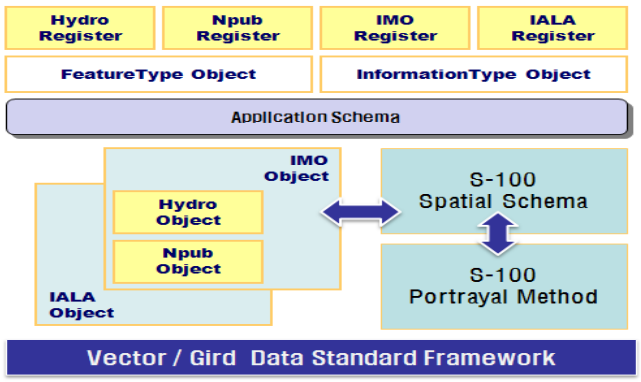

Fig. 8 S-100 Implementation of non hydro domain

3. Application Cases of S-100 to e-Navigation

3.1 Development of Electronic Nautical Publications based on S-100 Standard

The eighth clause of article 2 in the Hydrographic Law in Korea defines Nautical publication as hydro publication except charts, and it is produced for the use of mariners to have access to a wide range of information that is unavailable in charts. Effort towards the development of nautical publication has been made worldwide in various forms of booklets, PDF files, or Flash based systems, and in order to formulate publication data into ECDIS, IHO has standardized nautical publication geographic data unlisted in the S-57 object catalogue by applying S-57 data model and is in the process of developing nautical publication product specification based on S-100, the next hydro data standard. IHO SNPWG(Standardization of Nautical Publications Working Group) has categorized paper-based publication as NP1, digital-based publication such as PDF file or Flash file as NP2, publication transferable to ECDIS based on S-57/SNPWG model as NP3, depending on the nautical publication development forms in each country(Mililan, 2007).

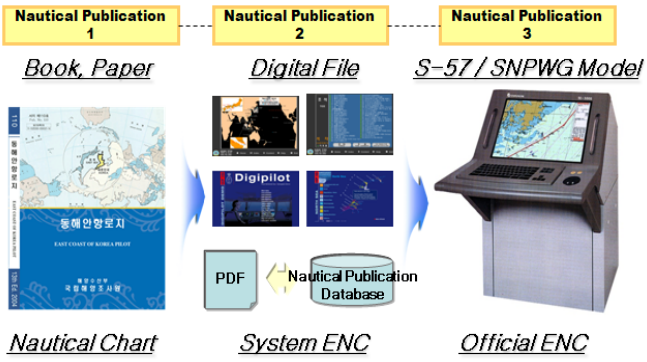

Fig. 9 A Class of Nautical Publications

National Oceanographic Research Institute has published and distributed 49 types of Nautical publication in 2009, and has produced 4 Digital Nautical publication programs such as list of lights(Korean coast), tide table(the Pacific and Indian Ocean), tide table(Korean coast) and almanac, which are the initial stages of Digital Nautical publication. In addition, digital nautical publication XML database was established along with the development of its management system and application system for the maintenance and publication of NP2 level digital nautical publications.

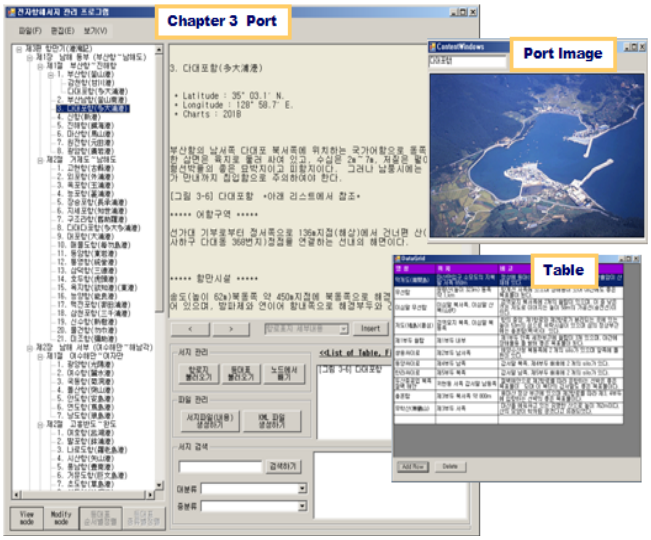

Fig. 10 Management System for Digital Nautical Publications

Meanwhile, SNPWG of IHO is in the process of developing digital nautical publication standard to overlay with ENC in ECDIS, and has developed MPA(Marine Protected Area) standard draft for marine protected area as its first Vector data product specification. MPA standard is consisted centrally around a feature type object, MarineProtectedArea, and is associated with various information type objects, such as, advises, contact details, service hours, navigation informations, restrictions, regulations, authorities, permissible vessel, and ship reporting. Currently, MPA standard draft is under examination, and the study is in progress, as in Fig. 11, for the portrayal method of the Vector data screen display.

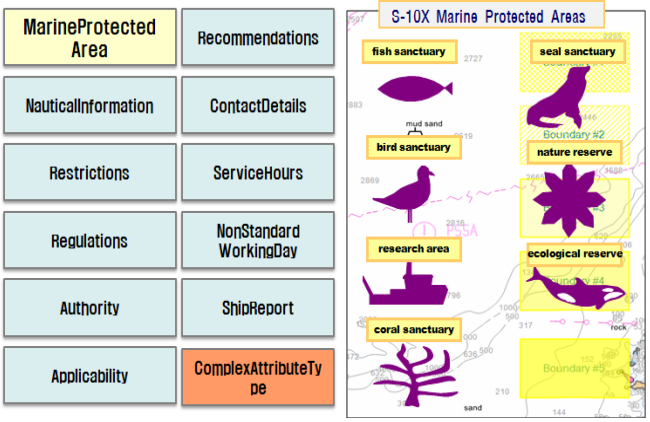

Fig. 11 Product Specification of Marine Protected Area

3.2 Product Specification on Ship Reporting and Pilot Request

In order to promote the e-Navigation strategy of IALA, an expert committee has been structured and recently held its 10th meeting(2011). In this meeting ship reporting and pilot request standard draft was submitted for the examination of S-100 based e-Navigation applications. Ship reporting is a system for reporting the responsible body when a vessel enters certain areas, and in the case of VTS center in Busan harbor, Port arrival notification, Passing position notification line, Port arrival notification, Shifting notification, and Port departure notification are reported via VHF CH 12 as in Fig. 12. Ship reporting and pilot request standard used publication objects of hydrographic object, port area and contact details to define arrival information, departure information, and vessel information as ship report objects, while redefining pilot request as pilot information object.

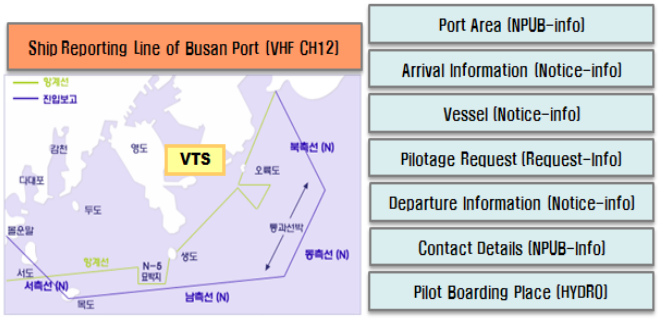

Fig. 12 Product Specification of Ship Reporting

3.3 Product Specification of Digital Routing Guideline

North European coastal states are currently promoting BLAST project with the support of EU for ENC quality improvements, maritime safety, and development of environmental protection standard technology, and have developed S-100 based digital routing guideline standard on this. This standard was developed by constructing the application schema required for traffic separation scheme and route planning in connection with the port area object of existing S-100 standard chart publication field, marine

protection area object of nautical publication field, contact details object, and information object of authorities concerned. Fig. 13 is the application schema diagram on digital routing guideline, and this standard is thought to be utilized for supporting route construction.

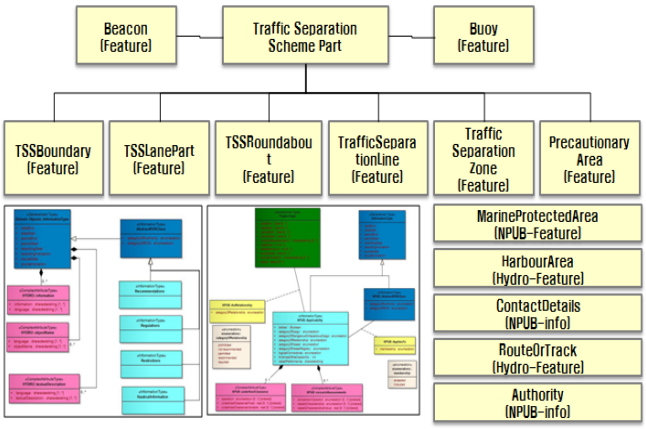

Fig. 13 Product Specification of Digital Routing Guideline

3.4 Tide and water level Transmission Specification

Increase in marine traffic and huge vessels have made tide and water level information very important, and the method for dynamic information portrayal has been studied from various angles. The IHO working group of tide and water level has reviewed the tidal information of the current S-57 standard and considered the method to adjust its details, and in order to transmit those information in real time, transmission guide study is in progress. Fig. 14 is a depiction on the application of tide information object. If tide and water level information is defined as objects and High Density ENC, consisted of high density contour information, can be overlaid with the current ENC to be applied in ECDIS, navigable waters can be displayed according to real-time water level.

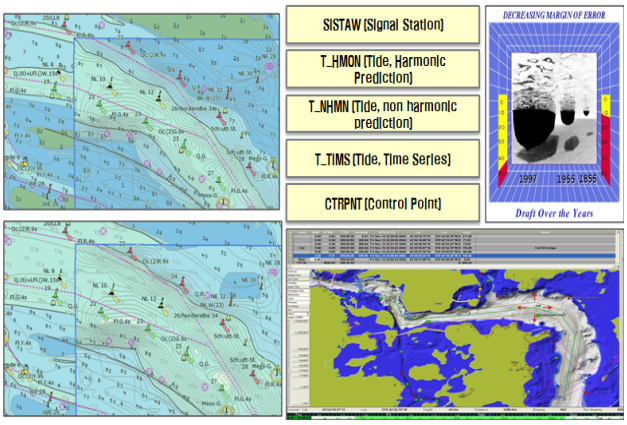

Fig. 14 Product Specification of Tide and Water Level

4. Application Method of S-100 e-Navigation

4.1 Basic Concept of S-100 Standard

S-100 is the standard on consistent hydrographic data as well as service publication, and standard utilization as application system, which contains the key points as the content of the standard as in Fig. 15, and holds the basic concept of utilizing non-overlapping information in the form of S-10X information layer, based on Vector data, the next generation ENC.

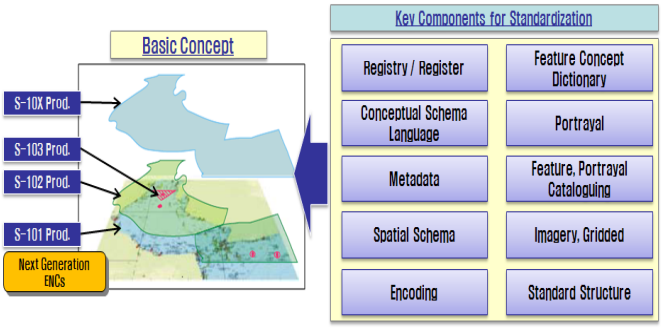

Fig. 15 Basic Concept of S-100 Standard

Furthermore, procedural maintenance and automatization of standardization element were promoted through the adoption of standardization registry and register concept, such as object and attribute, Meta data, and portrayal method. This led to the establishment of a general framework that can accommodate marine application system without defining the object, attribute, and portrayal method internally to construct the system that implements related products and service via object catalogue and portrayal catalogue provided to S-100 standardization registry. Fig. 16 is a depiction of the relation between the S-100 standardization registry and the application system, in which catalogue builder is used to build standard object catalogue and portrayal catalogue in the S-100 registry.

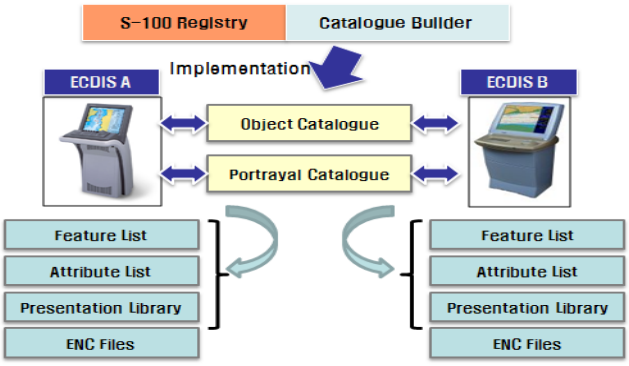

Fig. 16 Update Concept of Application S/W

According to the S-100 application principle above, when feature type object, information type object and portrayal object of the associated field are defined, standard automatized information portray and operation, including ECDIS, becomes possible for international organizations that are outside of the traditional field of hydrographic chart production in IHO. Fig. 17 depicts the implementation of IHO CMDS and IALA IHDM by utilizing the S-100 standardization registry and by reporting the distinct information of each area to S-100 registry except chart publication and nautical publication object, operation becomes possible as the management owner of the related registry.

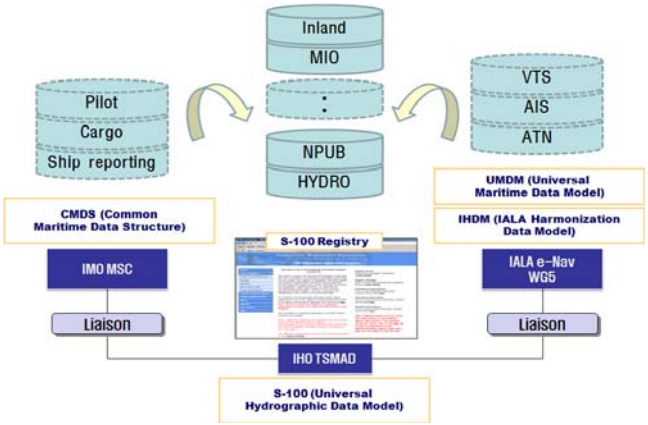

Fig. 17 S-100 Registry and Register

4.2 Ripple Effects of S-100 Implementation

IMO is currently reviewing the e-Nav strategy for the maritime safety and marine environment protection, and ECDIS, which is regarded as the core system of the strategy, has been selected as mandatory carriage requirement in the project starting from 2012 to 2018, according to the amended SOLAS agreement. The mandatory requirement of SOLAS agreement is closely related to the Port State Control(PSC), and has made ECDIS a mandatory navigation equipment. Currently, ECDIS refers to standards such as S-57 and S-52 of IHO, and is certified by certificate authorities, such as the Korean Register of Shipping, based on IMO quality standard for ECDIS quality, and IEC 61174 examination standard for ECDIS examine. The certified navigation equipments become ECDIS and those that are not become ECS, and SOLAS requirements can be satisfied only when official ENC and certified ECDIS are loaded. In the near future, revision in ECDIS regulation related to S-101 is expected due to the adoption of S-101 standard, and not only S-10X data, but also various data and service of IMO and IALA is expected to be applied to ECDIS after e-Navigation strategy is sufficiently progressed.

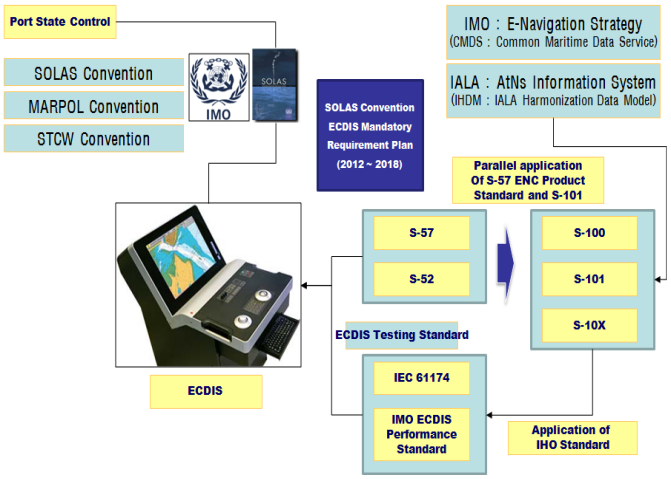

Fig. 18 Effect of S-100 Implementation

5. Conclusion

IHO has developed the UHDM S-100 standard and is in the process of developing S-10X based on it. IMO has established e-Navigation strategy of Single Window concept, defined CDMS data model, and referred to S-100 standard as the baseline of its development. S-100 standard is consisted of the core elements for consistent hydrographic data product and service publication together with the core elements for standard implementation and maintenance as application system. It is also structured to utilize and be connected with non-hydrographic field outside of IHO. This study has first examined the operation principle of S-100 standard, and elaborated on the utilization method of S-100 standard e-Navigation through analyzing the examples of S-100 based standard development such as digital nautical publication, shipping report, pilot request, digital routing guide, tide and water level transmission, other than the traditional ENC publication. Currently, object of S-100 is largely consisted of feature type object, which refers to geographic information, and information type object, which is linked to information provision and other feature type object. The portrayal method of feature type object is expected to apply the method of existing S-52 standard, but nothing is defined for the portrayal method of information type object other than the concept of Pick report. An in-depth study is necessary for the method of portrayal and information

display of information type object, as well as the development of application schema and product specification for data and service in the e-Navigation field, including the building of necessary test bed.

Acknowledgements

This study was supported by KORDI project "Technology Strategy establishment of e-Navigation for next generation marine transportation system(PE98713)".

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Received 9 February 2012
Revised 7 March 2012
Accepted 12 March 2012