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S-100 Overlays: A Brave New World?

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Abstract:
Marine Information Overlay (MIO) is a generic term used to describe chart and navigation-related information that supplement the content already contained in an ENC. This includes both static and dynamic information such as tide/water level, current flow, meteorological, oceanographic, and environmental protection. With the advent of IHO S-100 and S-101, there is increased interest in providing a wide variety of 'new' overlay information. This paper provides a brief history of IHO S-57 MIOs. Examples of navigational and non-navigation MIOs are given in terms of how currently used, by who, and for what purpose. Recommendations are provided for making a transition from S-57 MIOs to S-100 overlays that can be used with the 'Next Generation' ENC and the e-Navigation concept. This includes: what has been proposed, how should they work, who will provide, and some future challenges/opportunities related to development and implementation.

Introduction

ECDIS and other types of electronic charting systems (e.g., ECS and Portable Piloting Units) provide mariners a navigation tool capable of displaying a wide variety of information. As an automated decision aid capable of continuously determining a vessel's position in relation to land, charted objects, aids-to-navigation, and unseen hazards, electronic charting is an entirely new approach to maritime navigation. However, to fully realize its potential, ECDIS and other electronic charting systems should provide information beyond that which is contained in an ENC whose contents are primarily based on paper nautical charts.

Marine Information Overlay (MIO) is a generic term used to describe chart and navigation-related information that supplements the minimum information contained in the IHO S-57 ENC Product Specification [1]. In terms of being "supplementary", MIOs are not part of the ENC. Instead, a MIO is additional information (i.e., an overlay) that is displayed in conjunction with the overall System ENC[1] (Figure 1). This is similar in concept to displaying radar/ARPA and AIS targets or Additional Military Layers (AMLs) that are used with a NATO Warship ECDIS [2]. As non-mandatory information, MIOs provide additional information not contained in an ENC, such as sea ice coverage, tide/water levels, current flow, meteorological and oceanographic

[1] As specified in the IMO Performance Standards for ECDIS, a System ENC (SENC) is the data held in the ECDIS system resulting from the transformation of the ENC for appropriate use by the mariner.

information, marine protected areas, etc. In addition to IHO S-57 data (e.g., objects and attributes), MIOs can also be provided in other formats including: AIS Application Specific Message (ASM), proprietary electronic chart format, gridded bathymetry, and as graphics or imagery from remote sensing (e.g., LIDAR or satellite).

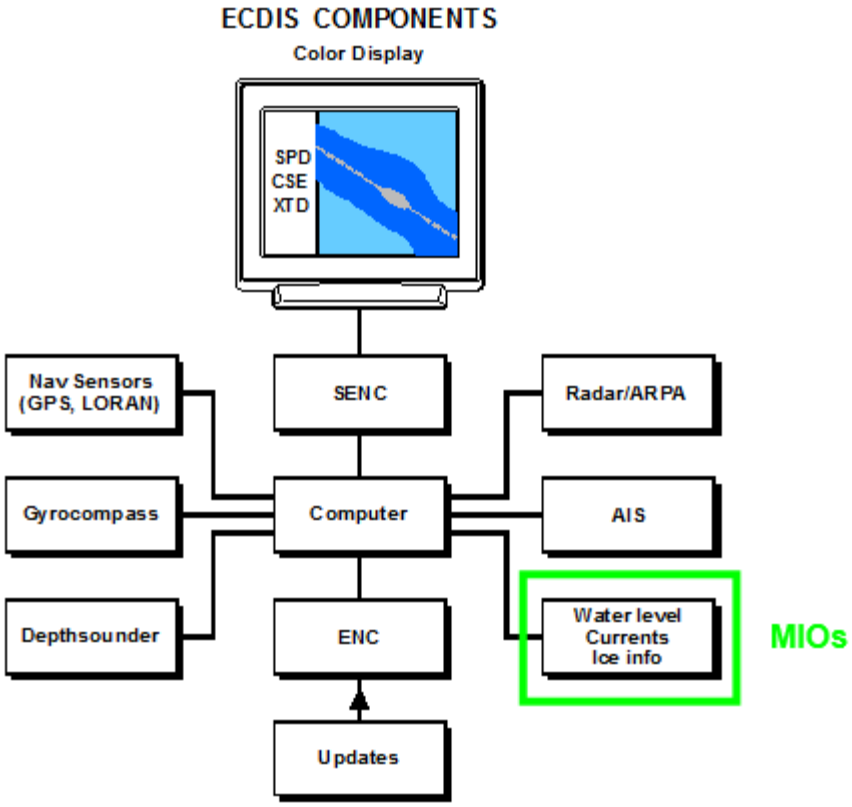

Figure 1 – MIOs as a functional component of ECDIS

Brief History of IHO S-57 MIOs

First called Marine Information 'Objects', beginning in the late 1990's, MIOs began to be referred to as 'Overlays'. This change in terminology was appropriate since MIOs were intended to be supplemental information that was 'overlaid' on the SENC being displayed on ECDIS. In 2001, a Harmonization Group on MIOs was established between IHO and IEC to recommend additional data and display specifications that may be incorporated into future editions of IMO, IHO, and IEC standards [3].

MIO-related Standards

Although MIOs or 'overlays' were not specifically mentioned in the IMO Performance Standards for ECDIS that were first adopted in 1996, Section 6.1 pertains to their use:

> *6.1 Radar information or other navigational information may be added to the ECDIS display. However, it should not degrade the SENC information, and should be clearly distinguishable from the SENC information.* [4]

In December 2004, IMO adopted *Performance Standards for the Presentation of Navigation-Related Information* (MSC.191(79) [5]. As stated in Section 1, the purpose of this performance standard is to: *"supplement and in case of conflict, take priority over presentation requirements of the individual performance standards…"*. In turn, IEC Publication 62288 [6] was issued in August 2008 and contains the methods of testing and required test results for equipment/systems that conform to this performance standard. Collectively, both standards (IMO and IEC) affect how MIO information becomes a component of an overall harmonized display of navigation-related information on ECDIS and other shipboard systems. In addition, these performance standards now influence the display of e-Navigation related shore-based and shipboard information.

In 2007, IHO issued *Recommended Procedures for the Development MIOs* [7]. This document provides guidance on:

- How a "competent organization" should identify MIO-related requirements.
- Information content for a MIO category.
- Development of new S-57 objects and attributes.
- Appropriate colors and symbols, based on IHO S-52.
- Test and evaluation.
- Production/dissemination of MIO data.
- Potential regulatory requirements on proper use.

At the same time, IHO also approved a *General Content Specification for MIOs* [8]. Most companies who provide S-57 data production tools (e.g., CARIS, *ESRI, Jeppesen Marine - C-Map/DeKart* and *SevenCs)* use this content specification.

In November 2008 a decision was made at the 20th IHO CHRIS Meeting to "retire" HGMIO as a CHRIS Working Group, and for it to become an independent technical group [9]. This was primarily due to the fact that IHO Member State involvement in HGMIO had been minimal, with the majority of participation by representatives of maritime safety administrations, NGIOs, and commercial providers developing specific MIOs in support of sea ice coverage, status of Aids-to-Navigation (AtoN), and Marine Protected Areas (MPAs).

In 2009, a MIO Website was established by *CARIS USA* to continue the work of HGMIO (www.hgmio.org). The website is a one-stop 'gathering place' for information, examples, and specifications about MIOs. Included are articles and information papers, PP presentations, and examples of MIOs that were in use and/or in development. In addition, copies of both general and specific MIO specifications were listed. The website also described various types of software and freeware that could be used to create and view MIOs. This website continues to be maintained by CARIS and the Center for Coastal and Ocean Management (CCOM) at the University of New Hampshire [10].

Examples of S-57 MIOs and other types of 'Overlays'

There are two basic categories of MIOs: static and dynamic. A static MIO is relatively fixed or constant information that is not subject to frequent or continual change. This includes information on marine habitats, seafloor characteristics, or regulated marine protected areas. Dynamic MIOs are more temporal and deal with real-time data that has instantaneous value or is constantly changing. Examples of dynamic MIOs include tide/water level, current flow, and

weather information that are continually being updated. However, these two categories are not mutually exclusive and there can be a combination of predicted, forecast, and so-called "now-cast" (i.e., a forecast that is continually being updated) information. At present, most static MIOs are provided in IHO S-57 format, while dynamic MIOs are being broadcast as AIS Application Specific Messages (ASMs) [11]. MIOs can also be provided via the Internet.

The following are some examples of MIOs that were previously developed and described for sea ice coverage, tide/water level, current flow, and marine protected areas [12].

Ice Coverage

For some shipping regions (e.g., Baltic Sea, Great Lakes and Canadian Maritimes), knowing where ice is (or is not) can be a crucial factor in voyage planning during the winter season. In most cases, this information is currently provided to mariners via fax, text messages and the Internet. While several demonstration projects have shown that providing MIOs is technically feasible, there are no government agencies or organizations in North America or Europe that provide a regular service. The challenge is not really technical. Instead, it involves establishing the necessary operational infrastructure (i.e., inter- and intra-governmental agency cooperation) and providing a regular service.

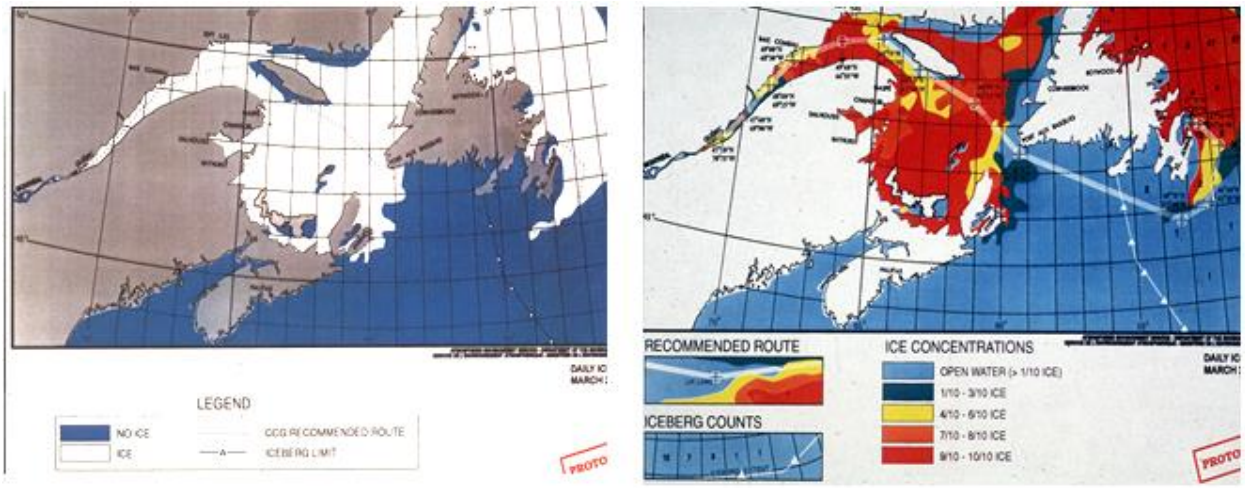

Figure -2 – Two examples of sea ice coverage information

While several demonstration projects have shown that providing additional information as MIOs is technically feasible, there are no government agencies or organizations in North America or Europe that, as yet, provide this type of service. However, the goal is still achievable. Using existing telecommunications infrastructure, government agencies can warn marine operators of hazardous ice conditions by the timely provision of digital data that is easily displayed as an overlay on an electronic chart. The challenge is not really technical; rather, it is how to establish the necessary operational infrastructure (i. e., inter- and intra-governmental agency cooperation).

Tides/Water Levels

Several electronic chart system manufacturers provide tidal information as an additional functional capability. This information can be displayed as alphanumeric text (in the form of tide tables), or as graphs showing the height of tide for a selected geographical area. Some of the

selected parameters include date, time, and number of days to be calculated. While highly useful, this information is usually displayed separate from the electronic chart.

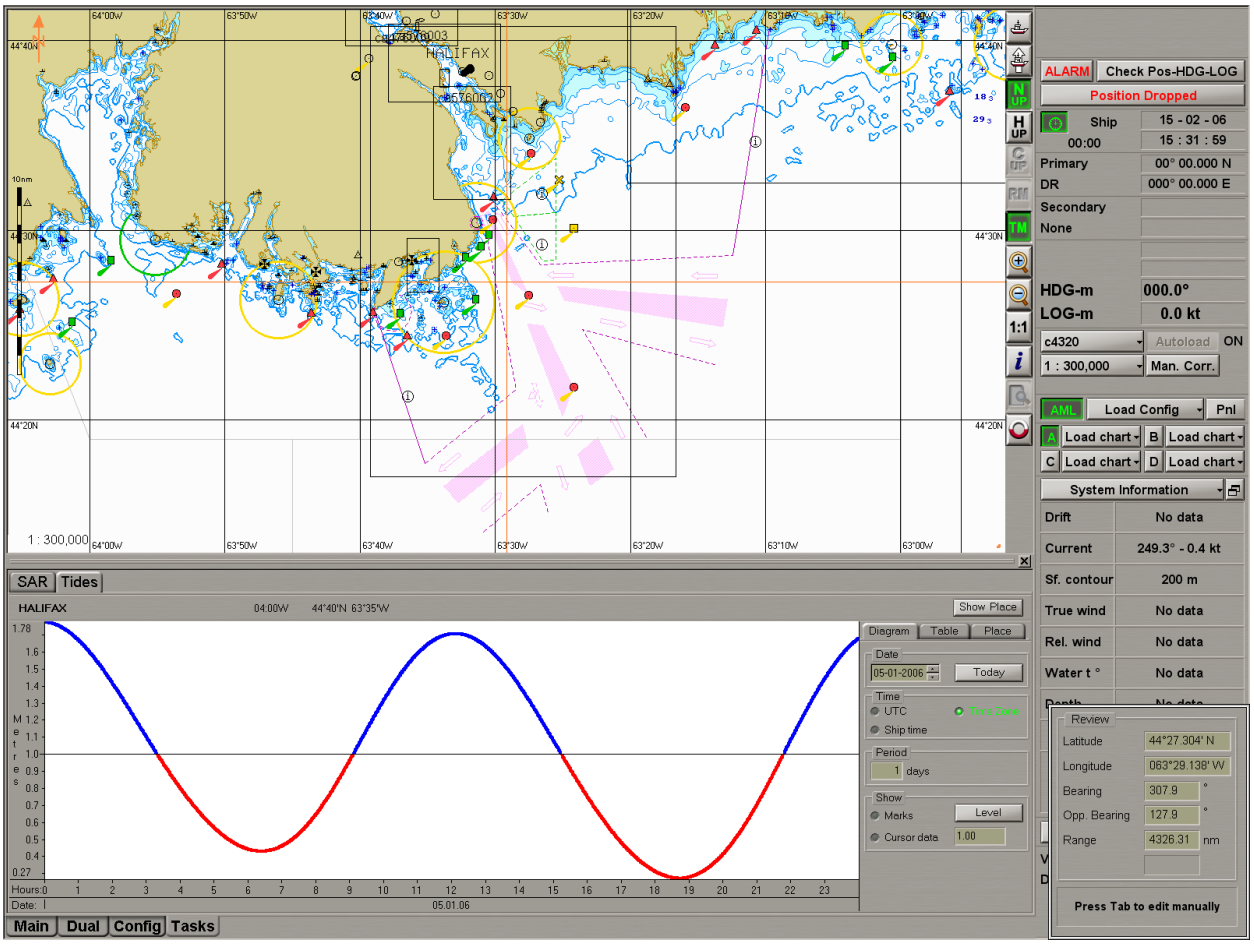

Figure 3 - *Transas Marine NaviSailor 3001* tidal prediction display (time-series graph).

In 2001, *SevenCs* developed a simulation model for a "tide-adjusted" ENC. Prototype ENC data sets were produced for two ports: Singapore and Schelde/Vlissingen in The Netherlands. Using one-meter contour depth areas, a simulated 10-metre tidal range was then applied, and the display of "safe water" continuously adjusted based on time and ship's safety depth contour (see Figure 15-3). Further enhancements included the establishment of designated tidal zones within the overall area. When coupled with either forecast or real-time tidal information, the main benefit to the mariner would be decision support for voyage planning. With a tide-adjusted ENC, two types of information are particularly useful:

1) time/duration for vessel transit (high vs. low tide)
2) amount of vessel draft (and/or under-keel clearance) that would occur.

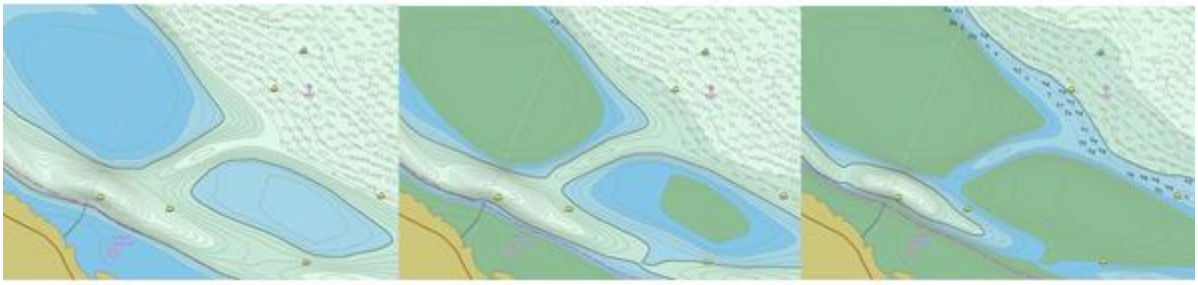

Figure 4 - *SevenCs* example of a time sequence of "tide-adjusted ENC" showing changes that occur for depth areas.

While the benefits of this functional capability are clear to most mariners – particularly those operating deep draft vessels -- the operational implementation of this functional capability with ENCs and ECDIS has yet to occur. This is due in part to the fact that the current IHO S-57 data standard does not allow for ENC depth information to be "adjusted" based on tides or water levels. Another factor is that most ENCs were digitized from paper nautical charts and do not contain the necessary depth contour intervals needed to support such a function. A third factor is the misperception by some that a "Tide-Aware" or "Dynamic" ENC will replace the HO-issued 'Maritime' ENC. The reality is that both are used. A dynamic ENC is first used for voyage planning (what when, and where), and the Maritime ENC is then used for route monitoring.

Current Flow

Similar to tidal/water level information, several electronic chart system manufacturers provide information on tidal streams and current flow as a functional capability. Since most of the flow that a vessel encounters is caused by tidal changes, this information is most often provided in a similar format to tide tables (e.g., alphanumeric text). However, like tides, some electronic chart systems provide graphics or charts showing current flow vectors (icons) that indicate current flow velocity and direction within a selected geographical area. Similar to tidal heights, selected parameters include date, time, and number of days to be calculated. Again, this type of current flow overlay information (vectors showing when, where, direction, and velocity) would be used for decision-support while planning the voyage.

Weather/Oceanographic

Several electronic chart systems have a capability to receive and display a variety of weather and oceanographic-related information. Information parameters include:

- temperature
- wind speed and direction
- wave height, direction and period of swell
- atmospheric pressure
- type of precipitation (e.g., rain, snow)
- likelihood of freezing spray

Depending on the installed electronic chart system and shipboard communication systems, some users can subscribe to weather forecast information provided by organizations such as the UK Meteorological Office or the National Ocean Service, NOAA (USA). In addition to being an important factor for route/voyage planning, weather/oceanographic information can be critical for search and rescue (SAR) and recovery operations. Figure 15-4 shows a SAR pattern

(expanding square) in which current set is a calculated factor within the search area. Wind set/drift is another factor that can also be used.

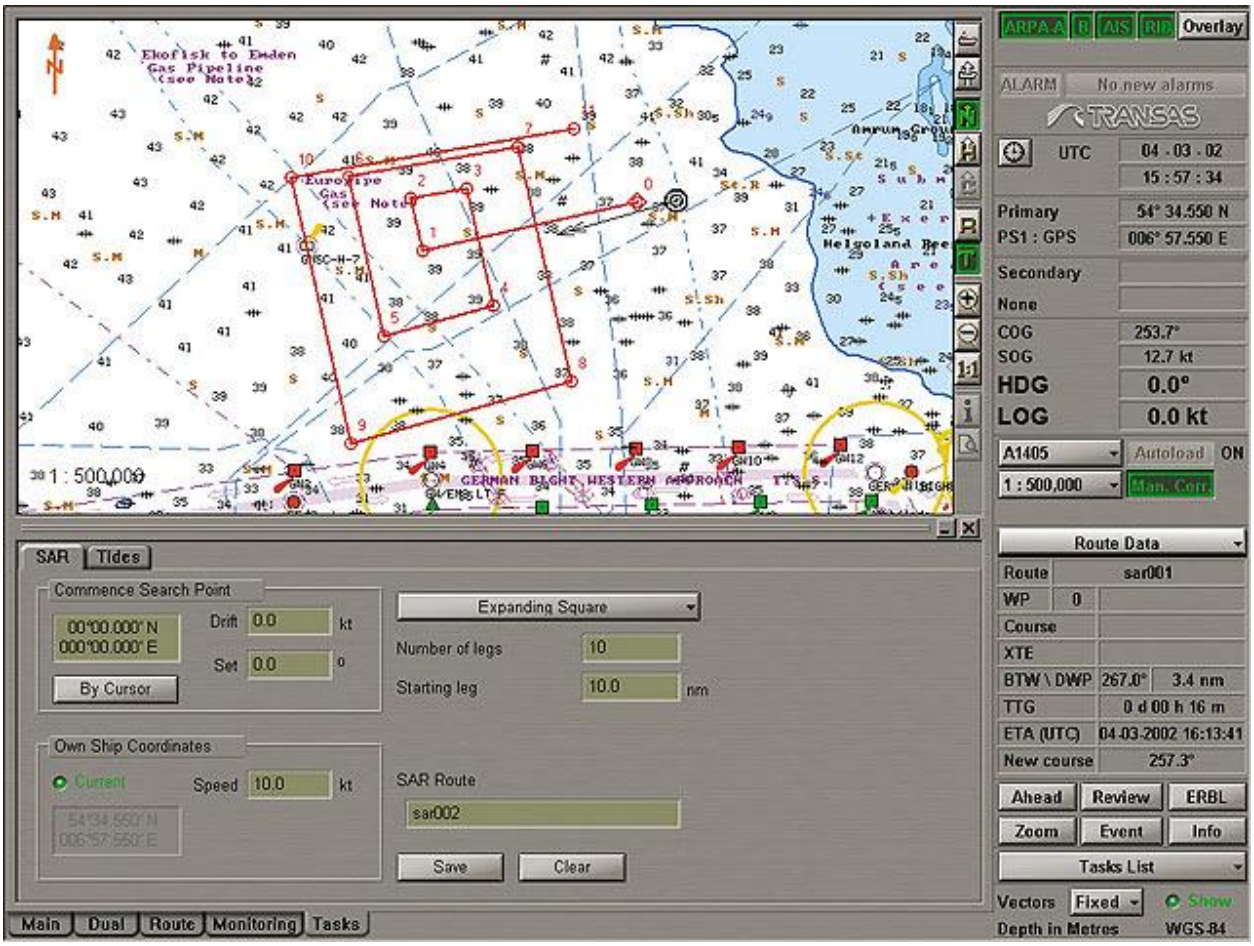

Figure 5 – A Search and Rescue (SAR) pattern displayed on an electronic chart that factors in current drift. [Source: *Transas NaviSailor 3000*]

Marine Protection Areas

Because the current IHO ENC Product Specification (IHO S-57 Edition 3.1) cannot be easily upgraded, MIOs can serve to provide important supplemental information not easily accommodated in an ENC. A good example of this is a designated marine protected area (MPA). While the basic area and limitations can be included in an ENC, additional details such critical habitats and regulated/permitted activities are not included. In the United States, there is a pilot project in the Florida Keys National Marine Sanctuary to convert existing coral reef habitat and MPA/zones into MIOs that can be used with ECS equipment [13]. The project goal was to strengthen marine resource conservation by bringing critical coral, MPA, and other environmental protection-related information to the mariners operating within the Sanctuary. This testbed can also be useful in determining what new S-57 object classes are needed and how they should be portrayed.

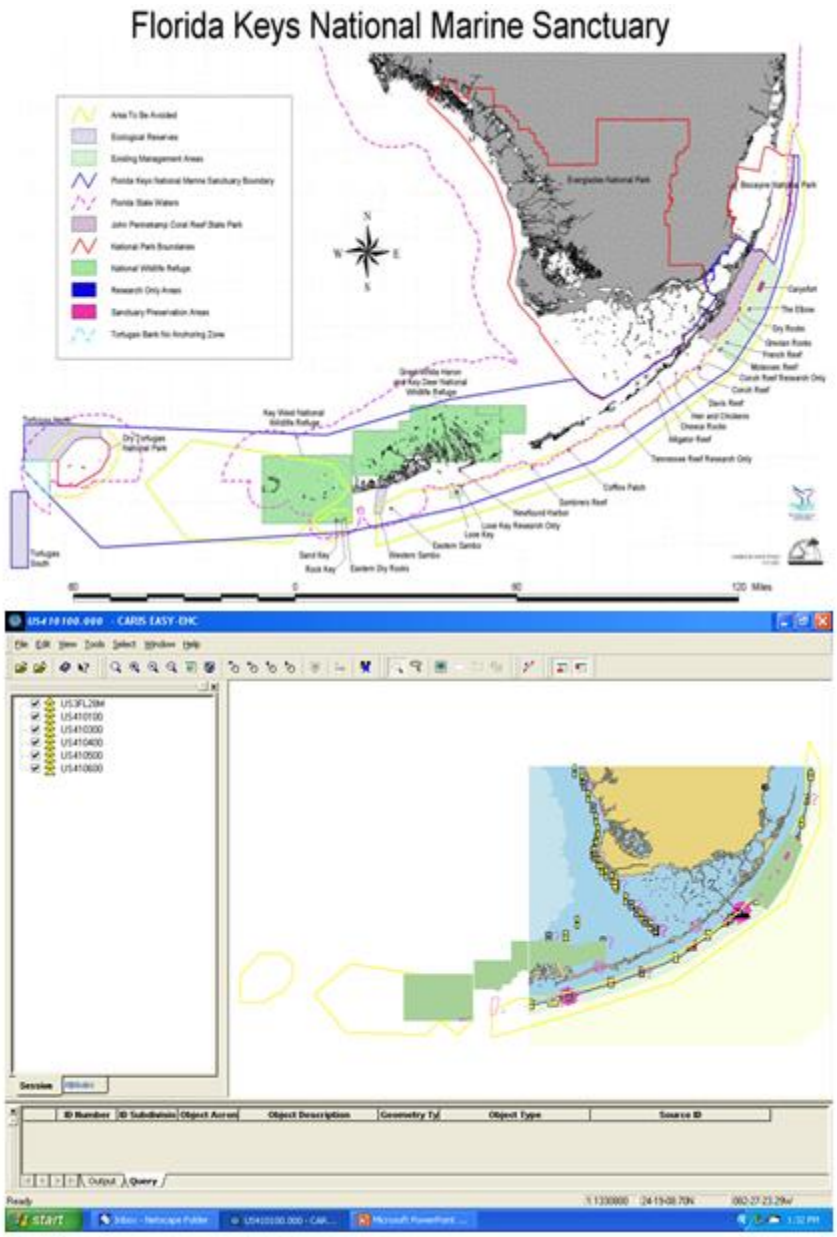

Figure 6 – a) Marine Protection Areas (Florida Keys National Marine Sanctuary)
b) MIO of coral reef and regulatory information displayed on an ENC. [Source: *CARIS*]

Another MIO implementation involves the protection of whales. The North Atlantic Right Whale (*Eubalaena glacialis*) is among the world's most endangered whale with a population of less than 300 individuals -- and declining. The decline is due primarily to high mortality from human activities, most notably fishing gear entanglements and vessel collisions. Currently, there is an initiative being conducted in the Stellwagen Bank National Marine Sanctuary (near Boston, MA) whereby the presence/location of right whales is determined by acoustic sonobouys [14]. With rapid dissemination of right whale location via the Internet and by the use of AIS ASMs, mariners using ECS equipment can plan and/or modify their voyage plan to avoid transiting through an area where Right Whales have been detected.

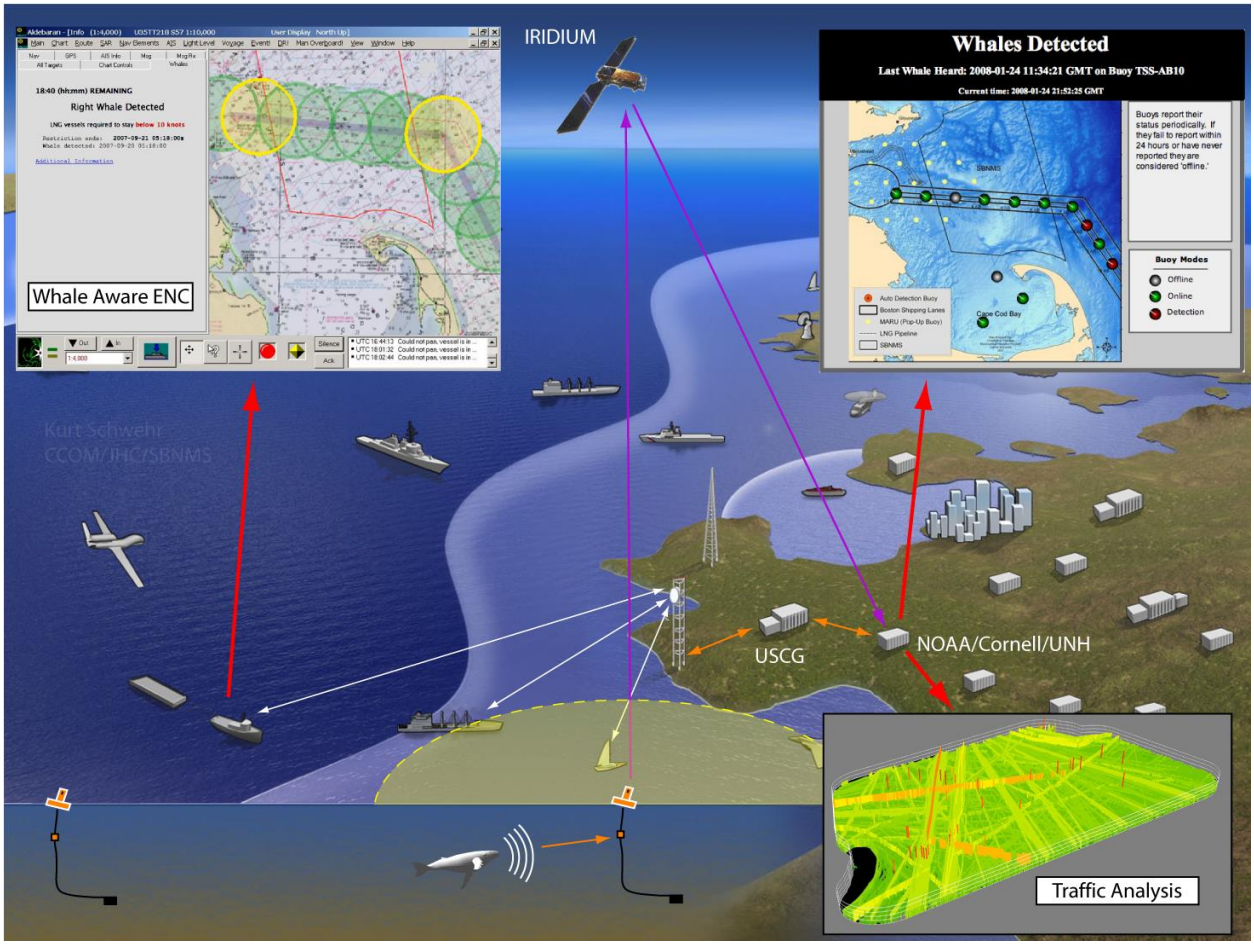

Figure 7 – Location of Right Whales broadcast via AIS and displayed on an electronic chart as an MIO. [Source: Kurt Schwehr, CCOM/University of New Hampshire]

S-100 Overlays

Following the completion of the first edition of S-100 in 2001, there has been increased interest in using IHO S-100 to produce 'overlay' information. As listed on the IHO website [15], there are a number of Product Specifications that are planned or under development (see Figure 8). This includes Product Specifications being developed by IHO as well as by:

International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA)
Intergovernmental Oceanographic Oceanographic Commission (IOC)
Inland ENC Harmonization Group (IEHG)
WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JTCOMM) – Sea Ice

At this stage, it is not known which may eventually become 'overlays', but most likely it will be similar to those that currently exist in IHO S-57 format.

S-100 Based Product Specifications *Spécifications de produits basées sur la S-100*			
No / *N°*	**Title / *Titre***	**Status / *Etat***	**Edition** (English version) *(version anglaise)*
Product Specifications being developed by the **IHO** (Numbers S-101 to 199) *Spécifications de produits élaborées par l'OHI (Numéros S-101 à 199)*			
S-101	Electronic Navigational Chart (ENC) / *Cartes électroniques de navigation*	Under Development *En cours d'élaboration*	S-101 Information page See also Roadmap document
S-102	Bathymetric Surface / *Surface bathymétrique*	Published / *Publiée*	Ed 1.0.0 (April 2012)
S-10x	Tidal product for surface navigation	Under Development *En cours d'élaboration*	
S-103	Sub-surface Navigation / *Navigation sous la surface*	Under Development *En cours d'élaboration*	
S-111	Surface currents / *Courants de surface*	Under Development *En cours d'élaboration*	Working Draft 1.0
S-112	Meteorological and Hydrographic Data AIS Application-Specific Message Dynamic Water Level Data Product Specification	Under Development *En cours d'élaboration*	Working Draft 0.0.0
S-121	Maritime limits and boundaries / *Limites et frontières maritimes*	Under Development *En cours d'élaboration*	
S-122	Marine Protected Areas / *Aires marines protégées*	Under Development *En cours d'élaboration*	
S-123	Radio Services / *Services radio*	Under Development *En cours d'élaboration*	
S-124	Navigational warnings / *Avertissements de navigation*	Under Development *En cours d'élaboration*	
S-125	Navigational services / *Services de navigation*	Planned / *Prévu*	
S-126	Physical Environment / *Environnement physique*	Planned / *Prévu*	
S-127	Traffic Management / *Gestion du trafic*	Planned / *Prévu*	
S-1xx	Marine Services / *Services maritimes*	Planned / *Prévu*	
S-1xx	Digital Mariner Routeing Guide *Guide numérique du navigateur sur l'organisation du trafic*	Planned / *Prévu*	
S-1xx	Harbour Infrastructure / *Infrastructure portuaire*	Planned / *Prévu*	
S-1xx	S-1xx (Social/Political) / *(Social / Politique)*	Planned / *Prévu*	
Product Specifications being developed by the **International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA)** (Numbers S-201 to 299) *Spécifications de produits élaborées par l'**Association internationale de signalisation maritime (AISM)** (Numéros S-201 à 299)*			
S-201	Aid to Navigation Information / *Information sur les aides à la navigation*	Under development *En cours d'élaboration*	
S-20x	Inter-VTS Exchange Format / *Format d'échange inter-STM*	Planned / *Prévu*	
S-20x	Application Specific Messages / *Messages d'applications spécifiques*	Planned / *Prévu*	
S-20x	Maritime Safety Information / *Renseignements sur la sécurité maritime*	Planned / *Prévu*	
Product Specifications being developed by the **Intergovernmental Oceanographic Commission (IOC)** (Numbers S-301 to 399) *Spécifications de produits élaborées par la **Commission océanographique intergouvernementale (COI)** (Numéros S-301 à 399)*			
Product Specifications being developed by **other Organizations** (Numbers from S-401) *Spécifications de produits élaborées par d'autres **organisations** (Numéros à partir de S-401)*			
S-401	Inland ENC (Inland ENC Harmonization Group [IEHG]) *ENC intérieures (Groupe d'harmonisation des ENC intérieures [IEHG])*	Under Development *En cours d'élaboration*	
S-411	Sea Ice (WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology [JCOMM]) *Glace de mer (Commission technique mixte OMM-COI pour l'océanographie et la météorologie marine [JCOMM])*	Under Development *En cours d'élaboration*	Draft Ed 1.1.0, (June 2014)
S-412	Met-ocean forecasts (JCOMM) *Prévisions météo-océanographiques (JCOMM)*	Under Development *En cours d'élaboration*	

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Figure 8 – List of S-100 based Product Specifications. [http://www.iho.int/iho_pubs/standard/S-100_Index.htm

Marine Electronic Highway Project - Environmental MIO

The Marine Electronic Highway (MEH) Project in the Straits of Malacca/Singapore has a MIO component. In order to reduce the environmental impact of shipping and coastal activities, environmental MIOs will be produced from existing geo-spatial information that has been produced by environmental agencies and natural resource managers. This includes sensitive habitats (e.g., spawning habitat and migratory areas), Marine Protected Areas (MPAs), endangered species habitats, and social-economic factors. While most national HOs are not directly responsible for marine environmental protection, it was agreed that a HO is an appropriate body to produce and maintain an environmental MIO (e-MIO) database. As such, a marine environment MIO Working Group under the East Asian Hydrographic Commission (EAHC) was organized to establish regional e-MIO specifications and datasets [16]. Led by the Republic of Korea, key tasks include:

- Develop exchange standards and product specifications for e-MIO in both IHO S-57 and S-100/10X.
- Develop specifications for e-MIO objects and attributes in consultation other national authorities, environmental agencies, VTS centres, and oil spill response agencies.
- Use existing ENCs as a basis for the development of a regional database.
- Review existing standards developed by the IMO, IHO, IALA, IOC and IEC related to the provision and display of supplemental chart and navigation-related information on ECDIS. Establish a database framework for a regional e-MIO, including an Environmental Sensitivity Index (ESI).
- Investigate the process required to transition from an S-57-based ENC and associated e-MIO to an S-101 ENC and S-10X-related datasets and product specifications.

As reported at the 6th IHO HSSC Meeting [17], the e-MIO Working Group is currently focusing on:

- Inclusion of the e-MIO into the S-100 Feature Concept Dictionary
- Development of an S-10X standard linked with the proposed S-122 (Marine Protected Areas)
- How to transfer an S-57 e-MIO into S-10X using a S-57 to S-10X convertor
- Establishing an S-10X test bed on marine environment.

Future Challenges/Opportunities

1. For the foreseeable future, the current S-57 ENC Project Specification will continue to be used with ECDIS.

- In particular, the implementation period for mandatory ECDIS carriage established by IMO will not be completed until 2018. Afterwards, it will be 4-6 years before IMO and IEC adopt a new ECDIS Performance Standard requirements that would specify the use of IHO S-101 or S-10X related datasets that are intended to provide 'overlay' information.

2. ECDIS is a component of a broader concept of operation – e-Navigation.

- ECDIS should not be regarded as a stand-alone system. Interoperability is key in terms of its use with required shipborne equipment, data, interface, sensors, and display [18].

- Since the ability to display an 'overlay' on ECDIS is currently limited, other types of electronic chart equipment could be used, including ECS or Portable Piloting Units (PPUs) [19].

3. There continues to be a reluctance to recognize that overlays are supplemental information, and not intended to replace what is already contained in the ENC.

- For instance, at the 6th IHO HSSC Meeting, a paper was introduced on the 'Relevance of information overlay services with respect to IHO standards [20].' The basic concern is that "the provision of information overlay services may negatively affect the credibility of the underlying ENCs". Further, "ENC producers may be unaware of the impact on their ENCs since there is no established reporting system about the overlay content back to the ENC Producer." This matter is currently under consideration.

Recommendations on Way Forward

We offer several recommendations as to the best way forward.

1. Determine what types of supplemental information could/should become 'overlays'.

- Not everything needs to be integrated or included in the "Next Generation" S-101 ENC. Overlays, are meant to supplement – not replace – the information contained in an ENC.
- Once the information contained in the 'overlay' is used to make an informed decision, then this information no longer needs to be shown (i.e., just the underlying ENC is displayed).

2. There is no need to re-invent the wheel.

- Whenever possible, the information content for an S-10O-related 'overlay' should be based on international standards that have been developed by other international organizations (e.g., use IMO SN.1/Circ.289 for met/hydro information content).

3. Learn from the experience of others who worked in the past on developing and implementing IHO S-57 based MIOs. Despite good intentions, not all initiatives were successful.

- Put another way, those that don't know history are doomed to repeat it.

4. Just because something is technically possible, does not mean that it will become 'accepted' or operationally available.

- The development and implementation of 'overlays' requires a commitment by a responsible government agency(s) to establish the necessary infrastructure and service that enables overlays to be received and used in a timely manner.
- This was a key lesson-learned during the Canadian Electronic Chart Pilot Project during 1995-1999. The so-called "Acceptance Dilemma" occurs when marine equipment manufacturers and shipping companies wait for a proven technology (or government legislation) before use new equipment/products while government agencies wait for real-world operational experience before committing to establish the necessary government infrastructure or service [21].

5. Currently, few manufacturers are willing to implement additional functionality beyond what is called for in a type-approved ECDIS. But, there are two ways that 'overlays' could be implemented.

a) In the near term, it can be by using a separate, supplemental display on the bridge of a ship. This already occurs when maritime pilots bring onboard their Portable Pilot Unit (PPU) which interface to a 'pilot plug' to receive AIS and GPS information. Unlike ECDIS, PPUs are not constrained by mandatory performance standards that limit functionality. Since pilots already use PPUs to display overlays, masters and mates could use a similar type of ECS as well. Quite likely, this will be the initial way for mariners to display other types of e-Navigation related information.

b) A longer term solution may be the so-called "Plug and Play" concept. As described in IHO S-100, this would be the ability to define new product specifications under an overall standard specification. The goal is that a system built 'today' can accept a new product 'tomorrow' without changing the software. Further, it would enable updates to feature catalogues and portrayal to be provided on-the-fly. In concept, a compliant system would be able to recognize and use new products and content defined under the overall performance standard. It should be noted that this is concept, and yet to be fully tested for use with shipboard navigation systems. Regardless, manufacturers who implement this functionality would have a distinct market advantage. In addition, 'Plug and Play' may be the main thing that will create an actual demand for mariners to want to use S-100 datasets.

Looking Ahead

While there is increased interest by the maritime community in using 'overlay' information, practical consideration dictates that overlays must be capable of being used in conjunction with existing shipboard equipment and systems (e.g., ECDIS and AIS). This, in turn, raises challenges related to developing appropriate data formats capable of dealing with time-varying information (i.e., x, y, z and time). Also, consideration must be given to the simultaneous display of overlays with other chart and navigation-related information, and the potential impact in terms of an overly-cluttered display. With the adoption by IMO of *Performance Standards for the Presentation of navigation-related Information on Shipborne Displays,* [5] and the advent of e-Navigation [18], overlays will continue to evolve with regard to data formats, portrayal, and precedence.

In the not-to-distant future, a realization will eventually occur that the real benefit of 'overlays' lies in decision support (i.e., the "what if"). This is a far more important consideration than either the data format (IHO S-57 vs. IHO S-100 family of standards) or what the information looks like when displayed on an electronic chart system. Ultimately, what, how and when any any type of 'overlay' is used will depend on three main things:

1. current situation (e.g., route planning or route monitoring)
2. task-at-hand (e.g., grounding avoidance or collision avoidance -- or both)
3. preference of the user (e.g., minimum or maximum amount of information) [

In this regard, the type of supplemental or overlay information that is actually needed is best decided not by the provider, but by the user – **Mariners**.

References

[1] *IHO Transfer Standard for Digital Hydrographic Data* (S-57), Edition 3.1.1 January 2007, Appendix B1 – ENC Product Specification, Ed. 2.2

[2] NATO Warship ECDIS, *Additional Military Layers – Product Specification*, Version 3.0, 1 November 2007, UK HO.

[3] Report of the Activities of the IHO/IEC Harmonization Group on Marine Information Overlays (HGMIO), IHO CHRIS 12-12.17.1B, 23-25 October 2000.

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