

Harmonizing Chart and Navigation-related Information on ECDIS

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Abstract: ECDIS is a real-time navigation system that integrates a variety of chart and navigation-related information. More than simply a replacement for a paper nautical chart, ECDIS is capable of continuously determining a vessel's position in relation to land, charted objects, aids-to-navigation, and unseen hazards. Increasingly, ECDIS is being used for both navigation and collision avoidance tasks. In this regard, there is growing concern about the display of ever-increasing amounts of chart and navigation-related information. When it comes to using ECDIS, more information is not necessarily better. Too much information can clutter the display and confuse the user. In this regard, there is need "harmonize" the simultaneous display of both chart and navigation-related information.

This paper provides some examples of problem areas, and proposes a basic approach that could be followed. Experience gained includes results from sea-trials and test bed projects being conducted in North America, as well as in Europe. Specific examples of problem areas associated with ECDIS display issues include: base and standard display, SCAMIN, data vs. information, temporary vs. permanent, a 24-hour color background scheme, and incorporation of Marine Information Objects (MIOs). Also discussed is the need to find a means to reduce and simplify the display, ECDIS as a decision support system, and implications for Mariner training/certification.

Introduction

ECDIS is a real-time navigation system that integrates a variety of chart and navigation-related information. More than simply a replacement for a paper nautical chart, ECDIS is capable of continuously determining a vessel's position in relation to land, charted objects, aids-to-navigation, and unseen hazards. Increasingly, ECDIS is being used for both navigation and collision avoidance tasks. In this regard, there is growing concern about the display of ever-increasing amounts of chart and navigation-related information. When it comes to using ECDIS, more information is not necessarily better. Too much information can clutter the display and confuse the user. In this regard, there is need "harmonize" the simultaneous display of both chart and navigation-related information.

Background

Roles of Various Organizations

Several international organizations have been involved in the development of information display standards for ECDIS. The International Maritime Organization (IMO) adopted Performance Standards that broadly specified the types of information and levels of display (e.g., Base and Standard display). The International Hydrographic Organization (IHO) developed the colours and symbols specifications for chart-related information. However, this was done independently from the navigation-related symbols to be developed by the International Electrotechnical Commission (IEC) and the International Association of Lighthouse Authorities (IALA). Navigation symbols include own-ship, radar/ARPA, Automated Identification System (AIS) targets, and VTS-related information.

Display Standards and Specifications

It is useful to review what is stated in the various performance standards and specifications that pertain to the display of chart and navigation-related information on ECDIS.

In November 1995, the IMO adopted Performance Standards for ECDIS [1]. In Section 2.2 it is specified that for chart-related information, the Electronic Navigational Chart (ENC) contains:

all the chart information necessary for safe navigation, and may contain supplementary information in addition to that contained in the paper chart (e.g., sailing directions) which may be considered necessary for safe navigation” (Section 2.2).

It is further stated in Section 4.1 that the chart database be used in ECDIS conform to IHO S-57 standards [2]. IHO took this one step further when it specified an ENC Product Specification in Appendix B.1 of IHO S-57 Edition 3.0. In terms of how the chart information is to be displayed, Section 8.1 specifies that:

“IHO recommended colours and symbols (S-52) should be used to represent System ENC (SENC) information.” (Section 8.1)

For this, IHO developed IHO S-52, Appendix 2, Colours and Symbols Specifications [3].

As it pertains to navigation-related information, the IMO Performance Standards specify that:

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 (Section 6.1).

More over,

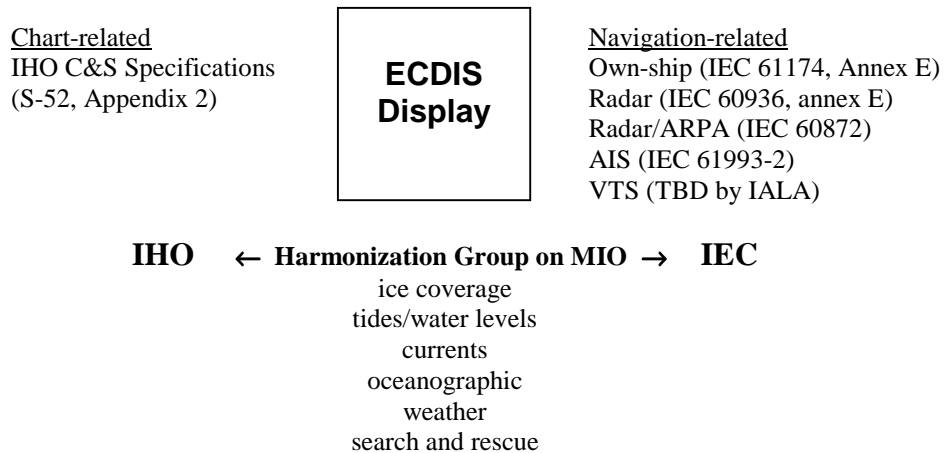
the colours and symbols other than those mentioned in 8.1 [pertains to SENC colours and symbols] should be used to describe the navigational elements and parameters listed in Appendix 3 and published by IEC Publication 61174 (Section 8.2) [4].

While the intent of all this seems relatively clear and straight-forward, what was not realized early on is that the simultaneous display of both chart and navigation related information can lead to problems.

IHO-IEC Harmonization Group on MIOs

In November 1999, a Workshop on the Development of Marine Information Objects (MIOs) for ECDIS was held in Burlington, Ontario, Canada [5]. MIOs include such information as tides/water levels, ice coverage, current flow, weather, oceanographic, etc. During this Workshop, considerable discussion focused on whether MIOs were primarily chart-related or navigation-related, – or both. It was also recognized that two primary organizations were involved in regard to the simultaneous display of ECDIS information: IHO for chart-related and IEC for navigation-related (see Figure 1). For this reason, at the 11th Meeting of the IHO Committee on Hydrographic Resources and Information Systems (CHRIS), it was proposed that an IHO/IEC Harmonization Group on MIOs (HGMIO) be formed.

Figure 1 - Standards for Chart and Navigation-related Information on ECDIS



Based on a Terms of Reference that is being finalized between the IHO CHRIS Committee and IEC Technical Committee No. 80 – Marine Navigation and Radiocommunications Equipment and Systems (IEC TC80), the first meeting of the IHO/IEC HGMIO should be early fall 2001.

Experience Gained – Lessons Learned

During the past 10 years, considerable experience has been gained regarding the combined display of chart and navigation-related information on ECDIS. These include:

- U.S. ECDIS Testbed Project [6]
- Canadian Electronic Chart Pilot Project [7]
- BAFEGIS Project [8]
- Great Lakes ECDIS Sea Trials [9]
- FGAN Ergonomics Study [10]
- Product Specifications for Marine Information Objects [11]

MIOs

Currently, work is being performed on developing additional S-57 objects as well as symbols for the display of MIOs associated with ice information, water levels, currents, and weather. In particular, there has been considerable effort in Canada related to the development of ECDIS Ice Objects [12]. There has also been work by SevenCs GmbH on proposed Object Classes and

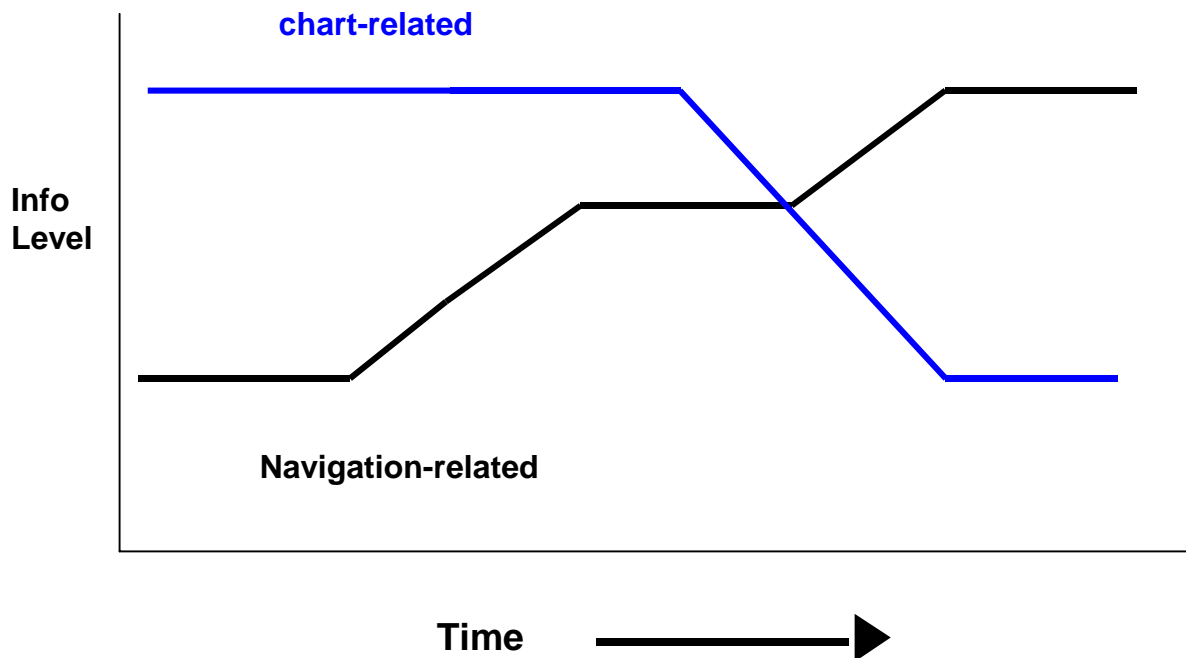
Attributes for Weather Information [13]. Additional project work is also being performed by SevenCs related to water levels and currents.

Some ECDIS manufacturers have the ability to display MIO-related information. In particular, the Transas Marine NaviSailor 2500 can display information pertaining to wind speed and direction, tidal heights and periodicity, wave heights and direction, current flow and direction, and climatic data (weather) [14]. This information can be of particular use for route planning. However, there is a dilemma. While this capability could be made available on the Transas NaviSailor 2400, there is concern that this may affect the ECDIS type-approval certification. As such, Transas Marine offers this capability on more-advanced versions of their systems, that have not yet been type-approved.

Future Trend

Regardless of how MIOs will be displayed on ECDIS, it will have to be in conjunction with other chart- and navigation-related information. Already the trend is toward increasing amounts navigation-related information being displayed on ECDIS (Figure 2). This includes such information as radar, automated radar piloting aid (ARPA), shipborne automatic identification system (AIS), and vessel traffic services (VTS). Couple this information with the current display levels of chart-related information (e.g., base and standard display), and the ECDIS display soon becomes rather cluttered. The challenge is not to arbitrarily decide what each type of information should look like. Instead, the focus should be toward how any information should be displayed in conjunction with other chart and navigation-related information.

Figure 2 – Future trend of the simultaneous display of chart- and navigation-related information on ECDIS.



Problem Areas

The following discussion provides some examples of issues that warrant particular attention. The intent is to inform about some problem areas that need attention, not to provide specific solutions. Similar to teaching a class, the first step is to try to impart an appreciation of the overall concept and broad issues. After that, you then try to provide on some specific examples.

Data vs. Information

While these terms are often used interchangeably, there are fundamental differences between data and information. The term “*information*” pertains to the knowledge or description of something. Once interpreted and understood, information can be used to make decisions. Books, and nautical charts are traditional examples of printed media that are used to transfer information. However, the information content is independent of the means of the media or means of transfer. When this information is “packaged” for transfer, the information becomes “*data*.” Obviously, there can be many types of data, depending on medium and on transfer technology (e.g., analog or digital). However, the data as such, has no use or utility if it cannot be interpreted and understood. For instance, digital ENC data stored on a CD-ROM is useless unless you have a computer-based system (e.g., ECDIS) that converts it into a meaningful display of information.

In the case of ECDIS, it is the ENC (a database) that contains all the chart-related data that a Hydrographic Office considers is necessary for safe navigation. This data is packaged and distributed in digital format. However, the data is not displayed until first converted into a System ENC (SENC) by the ECDIS. What is actually displayed as information is up to the user to decide (e.g., base or standard display). To say that an ENC is “equivalent to a paper chart” is incorrect. As defined in Section 2.3 of the IMO ECDIS Performance Standards: [1]

the SENC... that is actually accessed by ECDIS for the display generation and other navigational functions, and is the equivalent to the up-to-date paper chart. The SENC may also contain information from other sources. (Section 2.3)

The information from other sources can be either chart- or navigation-related.

Standard vs. Base Display

In the ECDIS Performance Standards, both a Standard Display and Base Display of SENC information are defined. [1] Aside from the inconsistent use of an adjectives and nouns in the wording of the ECDIS Performance Standards (i.e., using correct English grammar it should be “standard display” and “base display” – not display base), the following definitions apply.

***Standard Display** means the SENC information that should be shown when a chart is first displayed on ECDIS. The level of information it provides for route planning and route monitoring may be modified by the mariner according to the mariner’s needs. (Sec. 2.4).*

***Display Base** [sic] means the level of SENC information which cannot be removed from the display, consisting of information which is required at all times in all geographical areas and all circumstances. It is not intended for safe navigation. (Sec. 2.5).*

Some have incorrectly assumed that these two different displays ought contain a level of information content similar to that of a paper chart. Alternatively, some believe that mariners are not capable of knowing what is important chart information for the task at hand. Unfortunately, both of these mistaken perceptions were implemented into the IHO Colours and Symbols specifications.

One example is the mandatory inclusion of fixed and floating aids to navigation in the Base Display. Although Section 2.3 of Appendix 2 of the IMO Performance Standards for ECDIS specifies that fixed and floating aids-to-navigation be part of the Standard Display, the IHO Colours and Symbols Presentation Library includes fixed and floating aids as part of the Base Display. The justification given for this decision by IHO Colours and Symbols Working Group was that the wording contained in Section 1.4 of Appendix 2 indicates that buoys and beacons should be considered “isolated dangers which lie within the safe water.” While many mariners would consider this to be an illogical argument (i.e., in concept and in practice, aids-to-navigation are **aids** -- not hazards), this implementation means that aids to navigation are always shown -- regardless whether the mariner wishes to see them. At a small scale display often used for route planning, this can lead to a very cluttered display where the buoy symbols may obscure a channel. Also, when operating with radar/ARPA in confined waters, there are often times during route monitoring when it is critical to be able to quickly decide which targets are (and are not) aids to navigation. The fact that the colours used for radar targets and some buoys are both green, can lead to further problems of misinterpretation.

SCAMIN and Soundings

Scale Minimum (SCAMIN) is an attribute contained in the IHO S-57 specifications for ENC data. However, this attribute has significant implications in terms of display issues. As defined in IHO S57, Appendix B.1, Annex A - “Use of the Object Catalogue for ENC”: [2]

The SCAMIN of an object determines the display scale below which the object must no longer be displayed, in order to reduce clutter. In setting this level, the producer should consider both clutter and the scale which the object is no longer likely to be necessary for navigation.

The most widespread use of SCAMIN involves decisions by ENC producers on what should be the density level for individual spot soundings. Under the SCAMIN concept, the density of soundings being displayed should change with the scale of the display (i.e., when zooming in or zooming out). Some (not all) electronic chart data producers try to base SCAMIN to so-called “navigational purpose.” Navigational purpose pertains to the general scale that the ENC was compiled and intended for use in ECDIS (e.g., overview, general, coastal, approach harbour, and berthing). However, this somewhat subjective decision mixes data and display (information) issues. For instance, the number of soundings contained in the ENC database could be very high. Depending on the desired scale, the density of displayed soundings can be relatively high at small scale) or low and larger scale. Using SCAMIN to try to achieve a uniform density of sounding per display area (e.g., 100 soundings per a 10cm x 10cm display area on the ECDIS monitor) may give an impression that the spot sounding information is uniform throughout the entire ENC database. This can be misleading since sounding data is often based on the

type/amount of survey data collected and/or the data compilation scale. Even within a single ENC cell, the sounding data is not always spaced uniformly.

To further complicate the issue, regardless of how SCAMIN deals with soundings, there is a belief by some chart producers that mariners always want to see spot soundings displayed -- regardless of the situation. This occurs even when there are contour layers showing a ship's "safety contour." The fundamental flaw in this logic is that it is the mariner -- not the ENC producer -- who decides what needs to be displayed for safe navigation. Likewise, depending on the task at hand (e.g., route planning or route monitoring), different levels of display are required for the same geographic area depending on the situation.

Perhaps the best way to deal with SCAMIN is to refer to Murphy's Laws of Science and Non-illogical Experimental Design:

"When you find yourself performing transfinite amount of work trying to decide what to do, the answer can usually be found by simple inspection." [15]

As mariners gain experience using ECDIS, they soon appreciate that they can turn on/off different content levels of display. This is one of the fundamental benefits of ECDIS compared to paper charts. However, this concept of temporary and permanent information is new to many traditional chart makers.

Temporary vs. Permanent

The issue of what should be permanent and what can be temporary is a complicated and subjective issue. For many chart makers, their basic concept is a paper chart where "what you see is what we have decided you need to know." In practice, this decision is based on many years of experience and knowing what chart information is/is not important for safety of navigation. While this approach makes sense in terms of what should be contained in the ENC database, it is not the same for the display. ECDIS provides a dynamic, real-time display of both chart and navigation-related information.

What type of information and/or content level is necessary for the current situation, is up to the user to decide. For instance, many times a day a person may check their wristwatch to see what time it is. This can usually be done in just a few seconds, and does not require that the watch be held in front of a person's face all the time. The same applies to certain types of chart and navigation related information on ECDIS. Displaying individual depth soundings of a particular area can be important when a vessel is proceeding to anchorage. However, it is not necessary to clutter the display with sounding information at all times. What is important is that the mariner knows that this *data* is contained in the ENC (a database!) and how to display this *information* (i.e., turn on/off) when needed.

24-hour colour scheme

Currently, five different background color schemes are contained in IHO S-52 Colours and Symbols Specifications for ECDIS. The intended purpose of doing this is that depending on the time of day and lighting conditions on the bridge of a ship, displaying a white background during

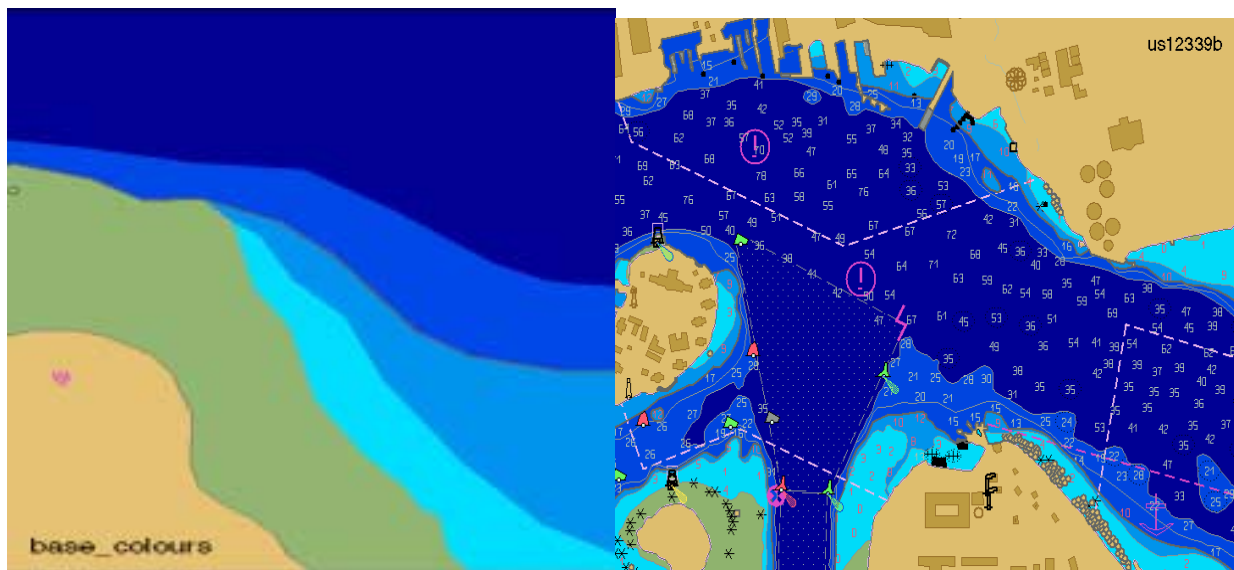
the day is fine, but at night it would adversely impact the mariner's night vision. As such the Section 4.1.5 IHO Colours and Symbols Specifications [3] list the following colour tables:

1. bright sun
2. day-white background
3. day-black background
4. dusk
5. night

Some feel that this is an example of “over-specification” on the part of IHO. Others feel that some of these colour schemes are not ineffective, or counter-intuitive. In some cases, mariners do not use the IHO colours at all, and prefer those developed by ECDIS manufacturers [9].

At the 1999 meeting of the IHO Colours and Symbols Maintenance WG meeting in Burlington, Ontario, it was agreed that a new "Day Blue" (i.e., bathymetric) colour scheme should be investigated (Figure 3). Ideally, it could be used 24 hours a day rather than having to switch from day-bright (white background) to some other colour palette during dusk or night. The primary benefit is that day or night, the colours and symbols remain the same. At night, all the user needs to do is adjust the brightness or intensity of the display.

Figure 3 – Proposed “Day Blue” colour scheme for ECDIS display.



Clearly, a fair amount of simulator and at-sea test and evaluation is needed before this is decided upon as a standard. However, it is quite likely that this day-blue colour scheme may be preferred for ECDIS - particularly when it is used with radar, ARPA, AIS, VTS information, and other types of marine information objects (MIOs). In addition to being a preferred display by Pilots (inside a VTS Center or Port Authority), it also has major implications for use onboard Navy vessels that may wish to have the same colour ECDIS display in the Operations Centre as on the Bridge. Finally, as more and more ECDIS installations include flat-panel displays, a blue background may be the preferred colour scheme to use since a “true” black background is difficult to achieve.

The Way Forward

The previous examples are intended to demonstrate some of the challenges associated the simultaneous display of chart- and navigation-related information. Like it or not, there will need to be some changes made in the type and amount of chart-information being shown. However, rather than proposing specific solutions, I suggest that an initial two-fold approach be followed: When ever possible, 1) reduce and simplify, and 2) adhere to guiding principles.

Finding a Means to Reduce and Simplify

Similar to the Laws of Natural Selection first identified by Charles Darwin, organisms (and human-developed systems) need to evolve and adapt to changing conditions. Like what occurred with whales and dolphins, appendages that no longer served any useful function were eliminated or evolved into fins. Also, whales and dolphins developed new capabilities that their land predecessors never had (e.g., sonar location and acoustic imaging). For a variety of reasons, we need to make a concerted effort reduce and simplify some of the chart-related specifications that were originally developed for ECDIS.

First, we need to re-confirm (or re-establish) that IHO specifications are “minimum.” They should not be regarded as the only way in which something can be accomplished. For one thing, over-specification stifles innovation and developing new/better ways to doing things. Since adding additional information is not just “allowed” but called for in the IMO Performance Standards, IHO needs to look at more elegant means of displaying only essential information. Also, additional or alternative displays should be regarded as “in addition to” rather than “instead of” what is called for in the minimum specifications.

In this regard, there are some ongoing efforts by the IHO Colours and Symbols Maintenance Working Group to reduce and simplify some of the colours and symbols currently specified in IHO S-52, Appendix 2. The current “dotted wallpaper” pattern used to denote a ‘dredged area’ will be changed to a small depth symbol within a narrow-lined border. Also, the “hashed lines” (derisively called ‘prison bars’) currently used to indicate an over-scale display, will be reduced to a small box denoting a scale change. These changes are helpful, but more are needed. Also, they should be based on an overall framework of guiding principles.

Some Guiding Principles

When it comes to the display of both chart and navigation-related information, there are some basic guiding principles that should be followed.

1. **simple symbols** should be used to display basic information (KISS approach).
2. **uniform and consistent** symbology
2. **uniqueness** – only one possible meaning
3. **non-ambiguous** – ability to determine differences (i.e., distinct)
4. **intuitively obvious** – differentiate between own-ship symbol vs. ARPA or AIS targets
5. **availability** - critical information is readily available
6. **uncluttered display** – only show the necessary information for the task at hand

While these principles may seem to be rather basic or obvious, these criteria are being used in the development of Shipborne Automated Identification System (AIS) symbology [16]. For a number of reasons, it would be appropriate to use these criteria to re-evaluate the current IHO Colours and Symbols for chart-related information in conjunction with the simultaneous display of navigation-related information.

Looking Ahead

ECDIS as a Decision Support System

In the coming years, ECDIS will transition from primarily a "display" of chart and navigation information, to a decision support system. For the "Next Generation ECDIS", the chart information will be come the background on which to display increasing levels of navigation-related information including:

- own-ship (past track, current position, planned route)
- radar overlay and ARPA targets
- AIS targets
- VTS (vessel traffic service)
- MIOs (ice, water level, currents, wave, etc.)
- Additional Military Layers (AMLs)

ECDIS will no longer be primarily a two-dimension system (X and Y). In the future, mariners will increasingly expect ECDIS include Z and time dimensions. Currently, we have the ability of conduct high-density hydrographic surveys capable of producing electronic chart databases that can display decimeter contour levels. The capability coupled with both forecast and real-time water levels will enable mariners to more precisely determine planned and actual under-keel clearance. Unfortunately, there exists some confusion about water levels in terms of data and display considerations.

In The Netherlands, a project has been conducted that demonstrated the utility of displaying changing contour levels and soundings based on a 12-hour tidal regime. This information can be highly useful in terms of forecasting the time and depth under-keel for heavily laden vessels entering a port. However, it is not clear if IHO S-57 Edition 3 "allows" the ability to display varying depths [2]. Nor is it clear if S-57 standards (e.g., objects) are the best way forward. Alternatively, some would argue that dynamic water levels is not a database but a display issue.

Implications for Mariner Training/Certification

There is a common-sense adage: "A system is only as good as who is using it and what it is being used for." Regardless of the capability of the system (e.g., type-approved ECDIS equipment), or the source and content of the ENC (e.g., HO-issued ENC data), or the accuracy of the positioning system (e.g., DGPS), it is the human factor that will ultimately determine how the system is used -- and how well it performs. Similar to the employment of computers in the workplace, the proper use of ECDIS will require increasing levels of training for users. While many are becoming more knowledgeable about ECDIS, Training Certificates in the Operational Use of ECDIS will require a demonstrated level of proficiency [17].

Final Thoughts

In the final analysis, the three key aspects related to the proper use of (and dependence on) ECDIS will be:

- 1) Using data that is accurate and up-to-date (both chart- and navigation-related)
- 2) Understanding the capability and limitations of the entire system (hardware, software, data, sensor inputs, and display).
- 3) Knowing what information needs to be displayed -- and when.

Capt. Jean-Luc Bedard (Harbour Master for the Port of Montreal) said it best when he remarked: “When it comes to ECDIS, I don’t want more information. I want better.” Better information is that which is required for the task at hand. Any more than a person driving a car should constantly be barraged with unnecessary visual or auditory information, a mariner needs accurate and up-to-date information clearly presented to meet his/her current needs. What goes into the ENC database can be decided upon by hydrographers. However, deciding what type and how much information should be displayed, is best left up to the mariner.

References Cited

- [1] IMO 1995. Performance Standards for Electronic Chart Display and Information Systems (ECDIS), IMO Resolution A.817(19), International Maritime Organization, London, 23 November 1995.
- [2] IHO Transfer Standard for Digital Hydrographic Data, IHO Special Publication No. 57 (IHO S-57), 3rd Edition, November 1996, Monaco
- [3] IHO Specification for Chart Content and Display of ECDIS, IHO Special Publication No. 52 (IHO S-52), 4th Edition, December 1996, Monaco.
- [4] IEC 61174, Edition 1: Maritime navigation and radiocommunication equipment systems – Electronic chart display and information system (ECDIS) – Operational and performance requirements, methods of testing, and required test results. August 1998. International Electrotechnical Commission, Geneva, 55pp.
- [5] Minutes to 10th Meeting of IHO Colours and Symbols Maintenance Working Group, Burlington, Ontario, Canada, November 1999.
- [6] Gonin, I.M., M.L. Dowd, and L. Alexander. 1996. *Electronic Chart Display and Information System (ECDIS) – Test and Evaluation, Summary Report*. U.S. Coast Guard Research and Development Center, Report No. CG-D-20-97. 31pp.
- [7] *(Canadian) Electronic Chart Pilot Project – Final Report*. 1996. Offshore Systems Ltd., Vancouver, BC. 76pp.
- [8] Jönson, Jan and Kent Lyktberg. 1999. “*Evaluation of the Work Environment and the Equipment in the BAFEGIS Project*”, Kalmar Maritime Academy, Sweden, 40pp.
- [9] Fowler, David. 1999. *Great Lakes ECDIS Sea Trials – Final Report*. Canadian Hydrographic

- Service, Central and Arctic Region, Burlington, Ontario, Canada. 60pp.
- [10] Motz, Florian and Heino Widdel. 2000. *Ergonomic Design for Presentation of AIS Information on Ships*. Final Report for the Federal Ministry of Transport, Building and Housing, Germany. Project 40.345/1999. FGAN, Wachburg, Germany. 60 pp., & appendices.
- [11] Pacheco, Miguel. 2000. *Product Specifications for Marine Information Objects*. Technical Report No. 206 (a Masters Thesis), University of New Brunswick, Fredericton, Canada. 101pp.
- [12] ECDIS Ice Objects, Version 3.0. 2001. Canadian Ice Service, Ottawa, Ontario, Canada. 58pp & appendices.
- [13] Schulze, Jana. 1999. *Proposed Object Classes and Attributes for Weather*. SevenCs GmbH, Hamburg, Germany. 41pp.
- [14] Transas Marine Ltd. (<http://transas.com>)
- [15] (authors anonymous). 1986. “Murphy’s Laws of Science and Non-Illogical Experimental Design”. Yale School of Forestry and Environmental Studies Ph.D. Student Brown-Bag Seminar Series. 4pp.
- [16] Minutes of Meeting of IEC TC80/WG8A, Display Sub-Group, May 2000.
- [17] Hempsted, Christian and L. Alexander. [2001]. *Developing and Implementing the First U.S. Coast Guard Approved Operational ECDIS Training Course*. Proceedings: RTCM Annual Assembly Meeting, St. Petersburg, FL. May 2001.

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