Specificity of ENC Data Representation on an Archipelagic Sea Area – Example of the East Coast of the Middle Adriatic Sea Area

T. Duplančić Leder
Hydrographic Institute of Republic of Croatia, Split, Croatia

ABSTRACT: Production of ENCs is based on the theory of multiscale data management (usage bands) and multiple representation of ENC data, controlled by scale minimum (SCAMIN) attributes. This paper presents a solution to the problem of multiscale data management and multiple representation as a part of ENC data production for archipelagic sea areas, using the east coast of the Middle Adriatic Sea area as a typical example. This study is based on a long-standing experience in the production of paper charts and recently ENC production for eastern coast of the Adriatic Sea, which is believed to be the second largest archipelagic area in the Mediterranean. A new method of using SCAMIN attributes for archipelagic seas was proposed, based on Canadian method. Also, a new usage band scale range, compilation scale (twice the chart scale) for all navigational purposes and method of using SCAMIN attributes for archipelagic seas are proposed.

1 INTRODUCTION

The Hydrographic Institute of the Republic of Croatia (HIRC) issues about 100 navigational charts and 30 nautical publications. Production of electronic nautical charts (ENC), according to International Hydrographic Organization (IHO) specifications S-57 Edition 3.1, started in HIRC in 2001. Croatia started ENC production within the North Adriatic VRENC international pilot project, in cooperation with the Italian company C-Map (Altamura, 2003). HIRC and C-map adopted the paper chart compilation scale, which proved to be inadequate for an archipelagic sea (Duplančić Leder and Lapaine, 2005).

The Croatian part of the east coast of the Middle Adriatic Sea area is archipelago area (which is believed to be the second largest archipelagic area in the Mediterranean), filled with islands and shallow waters. In an archipelago area navigation is demanding and complex. Besides, the proposal of chart classification according to navigational purposes does not meet specific qualities of the Croatian part of Eastern Adriatic coast (archipelago area), and it is not consistent with the HIRC tradition of paper chart production.

In 2006 HIRC started its own production of ENC data. During the ENC production of an archipelagic area, the high object density on the computer screen was apparent. It was concluded that an ENC produced with the paper chart compilation scale contained too many objects that then caused clutter on an ENC. In order to reduce the clutter or density of objects on the display, a new usage band scale range for the Croatian part of the Adriatic Sea and ENC compilation scale for all navigational purposes has been proposed. Moreover, a new method of real-time generalization of ENC content by using method of SCAMIN attribute coding was proposed.

2 ENC CHARACTERISTICS

2.1 *ENC usage band and navigational purposes*

The same area and ENC cell objects could be used on different representation levels in different themes or navigational usage, called multiscale data management model. Such model imposes that the data be passed to users on board grouped into **usage bands** according to **navigational purposes**, which mariners use depending on the situation. For example, when a ship approaches harbour from the open sea, navigational purposes change from an overview one (minimum details), through general, coastal, approach, and harbour navigational purposes to anchorage navigational purpose (most details).

S-57 standard (IHO, 2000) requires that each ENC cell be marked into 6 categories or usage bands (Table 1) according to navigational purpose, depending on the scale of the source material. Each ENC producer shall be responsible for assigning a navigational purpose to a particular cell. By assigning usage bands to ENC cells, their users will get information for which navigational purpose the ENC was produced (IHO, 2002 and 2003).

S-57 standard does not prescribe the scale ranges assigned to particular usage bands or the minimum or maximum scale for each usage band. The standard

allows chart compilers to adapt the scale range within a navigational purpose to their needs. It is recommended that the selection of ENC compilation scale be based on the standard radar sequence (Urlich et al., 1997; Table 1).

Table 1. Interdependence of usage band, navigational purpose, scale range, compilation scale and radar range (according to IHO, 2004a and b; Urlich et al., 1997)

Navigational purposes	Usage band	Scale Range 1:	Available compilation scales 1:	Radar ranges (NM)
Overview	1	<1 499 999	1 500 000 – 3 000 000 and smaller	96 – 200
General	2	350 000 – 1 499 999	350 000 – 700 000	24 – 48
Coastal	3	90 000 – 349 000	90 000 – 180 000	6 – 12
Approach	4	22 000 – 89 999	22 000 – 45 000	1,5 – 3
Harbour	5	4 000 – 21 999	4 000 – 8 000 – 12 000	0,25 – 0,5 – 0,75
Berthing	6	> 4 000	3 999 and larger	< 0,25

Most of ECDIS systems allow their users to select the display of ENCs according to usage bands, but not according to navigational purposes, which requires that the relation between the scale group and navigational purpose of the chart be defined (Table 1). By designing the process of ENC production, to each usage band a particular scale range is assigned. For example, an approach ENC of usage band 4 will appear on the ECDIS screen at 1:22 000 to 1:45 000 scale, which corresponds to a radar range of 1.5 to 3 NM. Position coordinates in a cell are calculated from the centre (according to established standard the ship position is plotted in the centre of the screen display) (Greenslade, 2003). Figure 1 shows the concept of ENC reading into memory by selecting ENC from the chart list. When a ship approaches harbour from the open sea, ENCs of different usage bands and navigational scales from A through B, C, D and F to G change on ECDIS (Hecht and all., 2002).

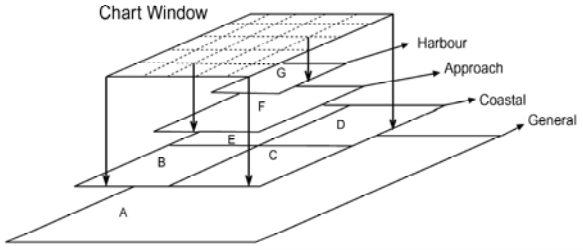

Fig. 1. Selection of chart from the preliminary chart list (according to Hecht et al., 2000)

2.2 *Proposal of usage band range for the Croatian part of the Adriatic*

According to Recommendation for Consistent ENC Data Encoding (IHO, 2002, 2004a and b) adopted at the meeting of CHRIS Working Group, it has been proposed that the compilation scale should be assigned to each navigational purpose (Table 1). It is a modified proposal based upon two IC-ENC documents (IHO, 2004b), adopted at the meeting of TSMAD Working Group. These documents are intended to give recommendation and guidance to Hydrographic Offices in the production of ENCs. However, it should be pointed out that they leave them a possibility of assigning their own scale ranges to particular areas by means of specified navigational purposes.
Studying of different proposals and recommendations for the classification of scale ranges for each of the six navigational purposes proposed by CHRIS and TSMAD Working Groups (Table 1; IHO, 2004a and b) has led to a conclusion that none of the proposed classifications is adequate for the Croatian part of the Adriatic. Taking into consideration the proposed recommendations, a new classification of scale ranges for navigational purposes is proposed to be adopted at the HIRC. In Table 2 it is proposed to assign navigational purposes to a number of scales, with respect to archipelagic characteristics of the Croatian part of the Adriatic Sea and cartographic tradition of the HIRC.

Table 2. Assigning of navigational purposes to a number of scales (according to Duplančić Leder and Lapaine, 2005)

Navigational purposes	Usage band	Scale Range 1:	Available compilation scales 1:	Selectable radar ranges (NM)
Overview	1	400 000 and smaller	400 000 and smaller	48 - 96 - 200
General	2	90 000 – 399 999	180 000 - 350 000	12 - 24
Coastal	3	45 000 – 89 999	45 000 – 90 000	3 - 6
Approach	4	22 000 – 44 999	22 000	1,5
Harbour	5	4 000 – 21 999	4 000 – 8 000 – 12 000	0,25 - 0,5 - 0,75
Berthing	6	4 000 and larger	3 999 and larger	< 0,25

2.3 *Proposal of the compilation scale for the Croatian part of the Adriatic*

Compilation scale is the scale at which the data was originally compiled, for example, it may define the scale of the paper chart from which the data was digitized (IHO, 2000). It turned out that using the

paper chart scale as compilation scale often resulted in a cluttered screen display (Duplančić Leder and Lapaine, 2005), especially in archipelagic areas with numerous islands and islets. Being difficult for navigation, such areas are heavily marked with navigation signals (lights, beacons and buoys). On the basis of the scientific research carried out by the HHI it was proposed that the ENC compilation scale for the Croatian part of the Adriatic should be twice as large as the paper chart scale (Fig. 2).

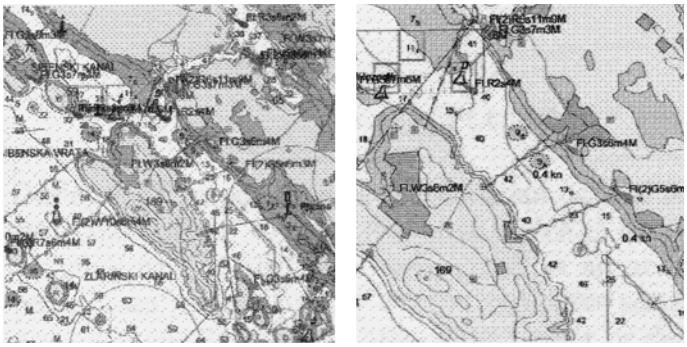

Fig. 2. Example of ENC of Šibenski Cannel with a compilation scale equal to that of the paper chart (left) and compilation scale twice the paper chart scale (right)

3 USING SCAMIN

3.1 *Using SCAMIN attributes for multiscale data management on the east coast of the Adriatic Sea*

According to S-57 standards, the ENC database was build as a multiscale database which stores nautical data at different scale levels (several digital dataset - ENC cells). This makes it possible for the data be provided to the ship as a set of "navigational usage", allowing the navigator to adapt appropriate usage to the situation. According S-57 standard, ENC is assigned to one of the 6 usage bands dependent on its intended navigational purpose (IHO, 2004b). As a vessel moves from the open sea towards port, the navigational usage shifts from an overview (least detailed), through general, coastal, approach and harbour level to berthing level (most detailed).

When zooming out the compilation scale (the scale on which the data was originally compiled - attribute "Compilation Scale of Data" CSCALE; IHO, 2000) or using ENC cell for other navigational purposes, an ECDIS display becomes crowded. Therefore, to reduce clutter on an ECDIS display it is necessary to use SCAMIN (scale minimum) attributes. SCAMIN is the S-57 attribute designed to provide the means for controlling on-line generalization and multiscale ENC data management in the ECDIS (Vachon, 2003). SCAMIN attribute represents the minimum scale at which the object may be used (e.g., for an ECDIS presentation). In order to optimize the performance and clarity of the ENC data, it is strongly recommended that SCAMIN is used (IHO, 2000). SCAMIN attribute allows optimal nautical data representation for any scale and purpose.

The experiences of other countries in using SCAMIN attributes, reported by Bisset and Fowle (IHO, 2003), indicate that most of the hydrographic offices use one of two methods: the semi-automatic method proposed by an expert group from the Canadian Hydrographic Service (Vachon, 2003), and an automatic method suggested and initiated by the expert group of 7Cs, a German producer of the software package for ENC cell creation (Ulrich et al., 2003). The German (7Cs) and Canadian (CHS) methods of assigning SCAMIN attribute values are based on their own experiences. In analysing these methods we determined that neither of them was entirely suitable for archipelagic sea areas (e.g., eastern Adriatic, Croatia, Greece, Sweden, Norway, Finland, etc.). Therefore we propose a new method of using SCAMIN attributes for archipelagic seas.

Among available methods, we took the Canadian method of on-line generalization and then modified and adjusted it further for an archipelagic sea such as the Middle Adriatic.

A new method (named the Croatian method) of cartographic rules for applying SCAMIN objects coding based on the tradition of compiling charts at the HIRC (Duplančić Leder and Lapaine, 2005), classified all ENC objects into 4 groups according to their navigational purpose and each group includes objects that should be used for the particular navigational purpose (Duplančić Leder et all, 2007). The objects on harbour and berthing charts belong to the same group.

SCAMIN value for the particular group was calculated by the formula:

$$SCAMIN\_value = (CSCALE * SCAMIN\_factor) * 0{,}9 \quad (1)$$

CSCALE is compilation scale of ENC cell.

This formula was obtained by experimental examination of percentage decrement of SCAMIN value, ranged from 5% to 25%, by comparison and result analogy with the Canadian method. It was found that the SCAMIN value decreased by 10% gives the optimal density display for an archipelagic sea area (Duplančić Leder, 2006). So, formula (1) is a modification of the Canadian formula, in such a way that SCAMIN value is decreased by 10%. The SCAMIN values resulting from formula (1) are in agreement with the Croatian method of navigational purposes assignment to scale range and compilation scale proposal for Croatian part of the Eastern Adriatic Sea (Table 2).

The method of real-time ENC content generalization was presented in Duplančić Leder et all (2007; Fig 3).

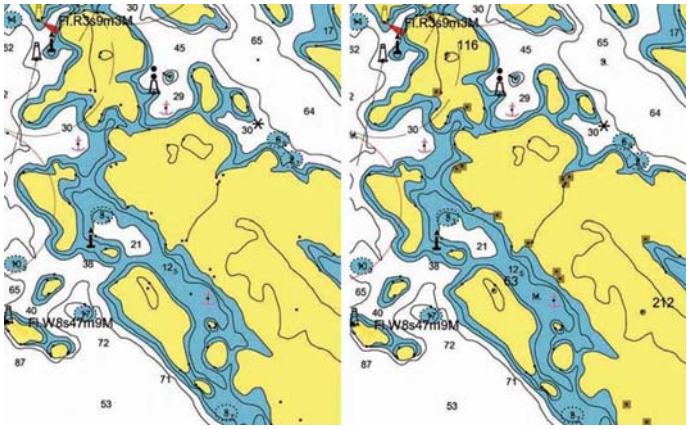

Fig. 3. Wider area of Telašćica Bay (scale 1:90 000) without SCAMIN (left) and with SCAMIN (right)

4 CONCLUSION

During ENC production of the Croatian part of the east coast of the Adriatic Sea area, which is a very complex navigational area, considered as an archipelagic sea, object density on the computer screen was apparent. In order to reduce the clutter or density of objects on the display, especially when zooming out, a new usage band scale range for archipelago sea area and compilation scale (twice the chart scale) for all navigational purposes has been proposed, according to IHO guidelines and IC-ENC recommendation for "Improving ENC Consistency". In addition, a new method of multiscale ENC data management by using method of SCAMIN attribute coding was proposed. This method, as opposed to previously known methods, used a new formula for calculating SCAMIN attribute value and proposed a new classification of Geo object groups, in compliance with specific features of the Adriatic Sea. This method was developed by modification of the Canadian method. Since this method brought some original solutions we named it the "Croatian method of multiscale ENC data management". The method is in compliance with the traditional production of charts at the Hydrographic Institute of the Republic of Croatia and was demonstrated on a coastal ENC of Šibenik Cannel and Telašćica Bay. With slight modifications, this method could be applied to other archipelagic sea areas.

REFERENCE

Altamura F., 2003. Mediterranean North Adriatic Pilot Project, 2nd International ECDIS Conference "ECDIS for Coastal and Ocean Navigation", http://www.ecdisnow.org/ (1. 6. 2005.)

Duplančić Leder, T. 2006. A New Approach to Electronic Navigational Charts Production in Croatia, Doctor Thesis, Geodetic Faculty of Zagreb University, 136. (in Croatian)

Duplančić Leder, T., Lapaine, M. 2005. Assigning S-57 SCAMIN attributes for archipelagic seas: Eastern Adriatic Coast Experience, The International Hydrographic Review, Vol., 6 No. 1, 33-43.

Duplančić Leder, T., Lapaine, M. 2007. Multiscale ENC Data Management on Eastern Coast of the Adriatic Sea as an Archipelagic Sea Area, Journal of Navigation, Vol., 60 No. 2, in press.

Greenslade, B. 2003. UKHO Generic ECDIS Kernel, TSMADWG meeting, www.iho.shom.fr (1. 6. 2005.)

Hecht, H., Berking, B., Büttgenbach, G., Jonas, M., Alexander, L. 2002. The Electronic Chart: Functions, Potential and Limitations of a New Marine Navigation System, GITC bv, Lemmer, Netherlands, 283.

IHO 1994. Hydrographic Dictionary, IHO Special Publication No. 32, Edition 5, International Hydrographic Bureau, Monaco, 280.

IHO 1997. Glossary of ECDIS - Related Terms, III Edition, International Hydrographic Organization, Monaco, 24.

IHO (2000). IHO Transfer Standard for Digital Hydrographic Data. *3.1 Edition*, IHB, Monaco.

IHO 2002. Minutes of 9th TSMADWG meeting, October 2002, IHB, Monaco, www.iho.shom.fr (1. 6. 2005.)

IHO 2003. Minutes of 10th TSMADWG meeting, October 2003, International Hydrographic Bureau, Monaco, www.iho.shom.fr (1. 6. 2005.)

IHO 2004a. Recommendation for Consistent ENC Data Encoding, www.iho. shom.fr/COMMITTEES/CHRIS (1. 6. 2005.)

IHO 2004b: Improving IC-ENC Consistency, CL 47/2004, www.iho.shom.fr (1. 6. 2005.)

IHO 2004c. Electronic Navigational Chart (ENCs) "Production Cookbook" – A guide to the requirments and processing necessary to the produce ENCs, IHB File No. S3/8152/WEND.

Vachon, D. (2003). Canadian Implementation of SCAMIN Attribute for ENC. online at http://www.openecdis.org/

Ulrich C., Rottmann, E., Büttgenbach, G.B. (2003). SCAMIN - The Tool to control Online Generalization, http://www.openecdis.org/ discussion/scamin /scamin.Html