

“S-57CARTO” - AN EXPANDED S-57 DATA MODEL **TO SUPPORT THE PRODUCTION OF ENC CELLS AND PRINTED CHARTS FROM ONE COMMON DATABASE**

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ABSTRACT

The rapidly increased need for electronic navigational charts (ENC) has led many Hydrographic Offices to a situation where there are two separate production lines for two products, ENC cells and printed charts. However, a common production line would increase the level of consistency between the products. This would effect positively on the quality, and increase the safety of navigation. It would also eliminate the time and effort required to do the same updates twice in two different databases. Research and development in many Hydrographic Offices is now concentrated on the challenge of how to combine electronic and printed chart production.

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The International Hydrographic Organization (IHO) has developed a transfer standard for digital hydrographic data (S-57). A theoretical data model, data structure and detailed object catalogue are included in the standard, but the existing standard primarily supports the production of ENC. If the S-57 data model were used, it would be impossible to store all the cartographic information needed for printed chart production.

This paper describes the specific requirements of a “multi product” data model supporting the production of ENC cells and printed charts from one common database. The paper presents possibilities to expand the S-57 data model with cartographic features and attributes which would enable presentation of the data according to the presentation requirements of printed charts.

1 INTRODUCTION

Laitakari and Tuurnala (1999) introduced three noteworthy “challenges”, which must be solved before the production of ENC’s and printed charts from one common database is possible. These were as follows: cartographic presentation, multiple scale management and updating process. This paper concentrates on cartographic presentation by introducing some examples of the possibilities of storing cartographic appearance of the features along with the real world properties.

1.1 Differences between ENC and Printed Charts

Two chart products, Printed Nautical Chart and Electronic Navigational Chart (ENC) are often used by the same users, but the use method differs remarkably from each other. ‘Traditional’ printed charts are used as a printed paper document when ENC is a part of integrated navigation system on the bridge of a vessel. This paragraph describes the differences of these two products by comparing the characteristics of the products and by introducing some examples of the preparation work of the data to be published on the chart.

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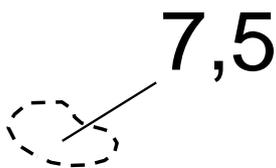
Printed charts present all important information as chart features with appropriate symbology and descriptive cartographic information texts and symbols. The volume of information is limited due to the size of the chart as well as the readability aspects of it.

One of the most important preparation aspects of the data to be published on the printed chart is cartographic generalisation and cartographic editing of the data. These include e.g. displacement, aggregation, selection, rotation and text width, font and placement [Jatkola, M. & Tuurnala, T. 1998]. Examples of features, which need cartographic editing are shown in figures 1.1 and 1.2.

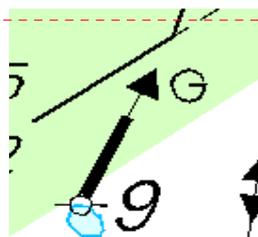
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Figure 1.1. Examples of features, which need cartographic editing. a) Displacement of depth figure (sounding) and b) Inclination of spar buoy

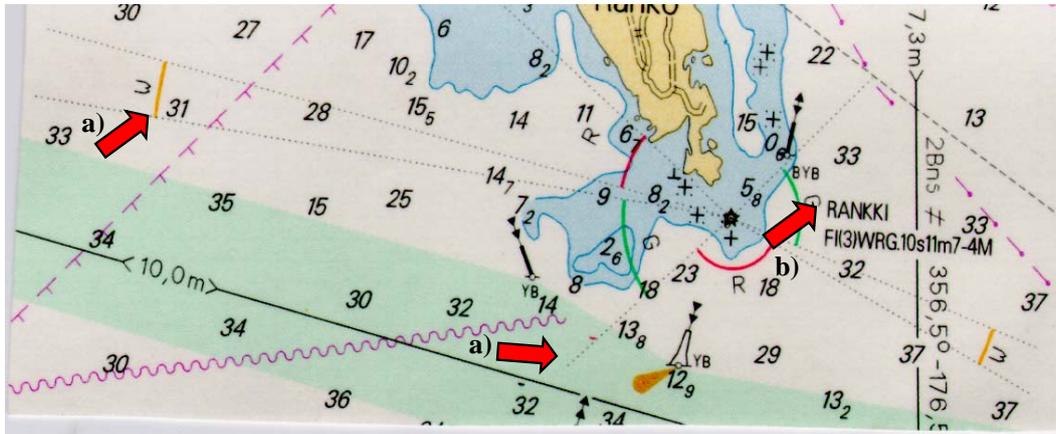


Figure 1.2. Sector light, an example of feature, which needs cartographic editing. The required cartographic editing operations are: a) positioning of sector arcs and lines and b) text placement

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In addition to informative text on the chart (e.g light character of a navigational aid) there is a need to give extra information about the chart to the user. This extra information could be, for example, mean sea level, navigational system of marks (IALA A / IALA B), updating date of the chart, projection and horizontal datum. This mandatory information is placed on the legend of the chart.

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ENC data is presented on the display of the ECDIS and the symbology of the chart features is determined by the object class and its attribute values as well as very dedicated conditional symbology rules, which take into consideration the current navigational situation and the nature of the surrounding data. It is easy to add and remove information on the ECDIS display, the user can select which object classes he/she wants visualised on the display (except 'display base' object classes, see: IMO, 1996). A large part of the attribute information does not affect to the symbology, and the mariner can have access to the information by a simple spatial query function. Some of the features do however have such important attribute information displayed on the screen as text without any separate query, if the mariner chooses that display option. ENC data also uses so called meta object classes in order to provide the mariner with information about e.g. the quality of the depth data or the direction of boyaage system applied locally. Should tidal information or traffic restrictions exist, these can be presented as raster images or text files, which are stored as 'annexes' to the ENC file and opened by attribute query to the appropriate ENC objects on the ECDIS display.

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The level of the presentation detail in ENC information is not limited by the size of the display and its readability aspects in the same manner as in paper charts since the user

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can select which information is presented at each moment. Together with ability to zoom in and zoom out on the data, the possibility to select information presented on the screen means that there is no need for cartographic editing of the data.

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1.2 S-57 – IHO Transfer Standard for Digital Hydrographic Data

The standard itself defines the scope of the S-57 standard as follows [IHO, 2000]: “The publication ‘S-57 Transfer Standard for Digital Hydrographic Data’ describes the standard to be used for the exchange of digital hydrographic data between national hydrographic offices and for its distribution to manufactures, mariners and other data users.” The first version of the standard was adopted as the official IHO standard, by the XIVth International Hydrographic Conference, Monaco, 1992. The present version of the standard, S-57 Edition 3.1, was released by the IHO in November 2000. It was decided that the Edition 3.1 will remain unaltered until at least November 2002.

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The standard is designed to model the real world, specifically those real world entities that are of relevance to hydrography. The model defines real world entities as a combination of descriptive and spatial characteristics. These sets of characteristics are defined in terms of *feature object* and *spatial objects*. An object may have attributes and may be related to other objects. Spatial objects contain (must contain) geometry and may have descriptive attributes. Feature objects contain attributes and do not contain any geometry. A feature object may exist without a relationship to a spatial object, but each spatial object must have a relation to a feature object [IHO, 2000].

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S-57 standard defines five cartographic object classes. These are Cartographic Area, Cartographic Line, Cartographic Symbol, Compass and Text. The definition for Cartographic Area, Line and Point objects is as follows [IHO, 2000]: “An area (/ a line / a point) with a certain cartographic symbolization.” The object Compass is meant to be used to transfer the parameters required to represent the magnetic and/or true compass cartographically.

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The S-57 standard does not define any rules for the presentation or display of information. Own specific presentation models must be provided by different applications (The presentation model for ECDIS is defined in IHO’s standard “Specifications for Chart Content and Display aspects of ECDIS, S-52”). The basic idea behind this is that the concept of keeping information storage independent of presentation provides for greater flexibility and versatility. This should allow the same data to be used for many purposes, for example on ECDIS screen and on printed chart, without requiring any change to data models structure or content. However, the standard has been developed mainly for ENC and does not completely fulfil the requirements of printed chart presentation.

2. EXAMPLES OF CARTOGRAPHIC ATTRIBUTES NEEDED FOR PRINTED CHART PRESENTATION

Examples of some important features of nautical chart, which need cartographic editing to be presented on printed chart was introduced in paragraph 1.1. These were sounding, spar buoy and sector light. The core element of the presentation of these features is to have presentation rules, provided by the application (printed chart production system), based on the real world attributes. For example sector light shall be presented by sectors based on light attributes (e.g S-57 attributes: COLOUR, LITCHR, SECTR1, SECTR2 etc.) and the texts, such as name of the navaid shall be deduced from the object name attribute (OBJNAM). The light character must be deduced from the composite objects (lights) of the navaid. In addition to real world attributes there must be some cartographic attributes to store cartographic appearance. Some of the cartographic appearances may be stored by using existing S-57 objects (e.g. \$TEXTS, \$COMPS) and attributes (e.g. ORIENT, \$TXSTR).

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Cartographic appearance of the feature may be different in different products. For example two overlapping printed coastal charts of the same scale sometimes need to have a different cartographic appearance of a feature if the location point of the feature is close to the edge of the chart. These are most frequently texts and light sectors. For example, a sector light is presented with full sectors on one chart, but on an overlapping chart it must be presented by using a “drop” symbol because of limitations of space. This can be managed, for example, by having separate cartographic objects linked to real world object and also having a link to a product, if needed.

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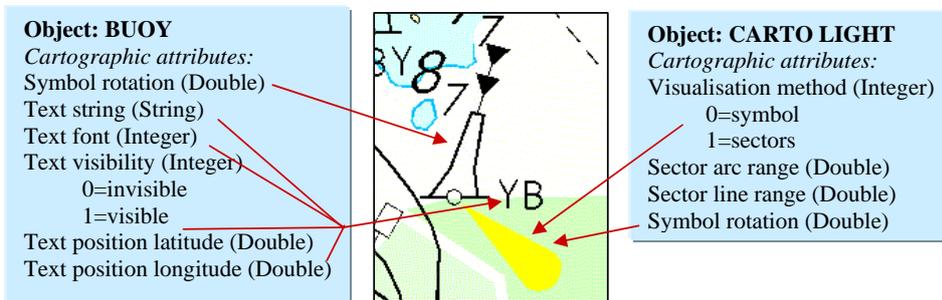


Figure 2.1: An example of storing cartographic editing of a buoy. Cartographic attributes of a BUOY object could be also stored as separate cartographic objects, linked to a buoy (as object CARTOLIGHT)

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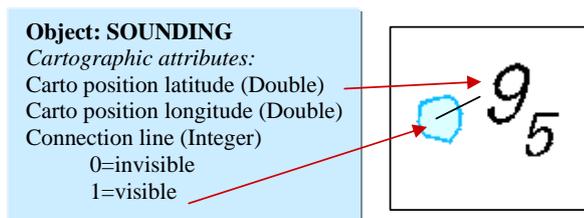


Figure 2.2: Cartographic attributes of displaced sounding.

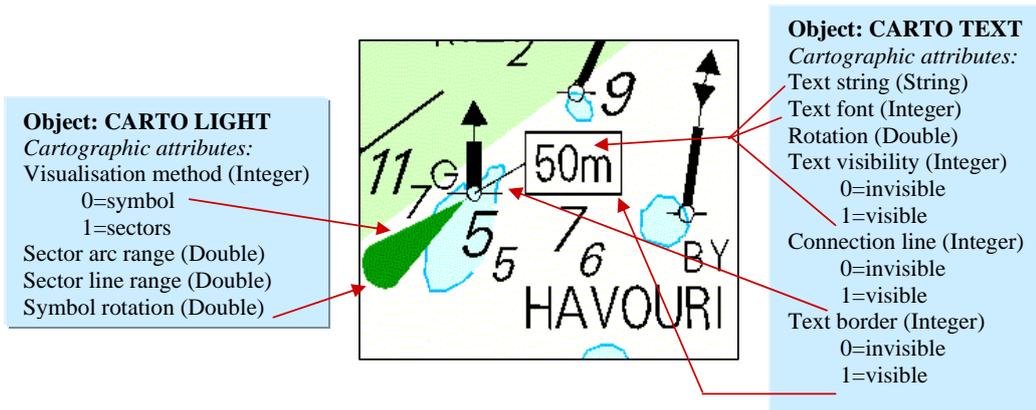


Figure 2.3: One possibility to store cartographic appearance of an edge mark. The number inside the box denotes the distance to channel border (deduced from real attribute of the navaid)

3. PRESENTATION RULES

In addition to presentation based on real world attributes and cartographic attributes, several other advanced presentation rules should be provided by the application (printed chart production system) to avoid excessive interactive editing work. These could be for example:

- Sector arcs and lines have readable default cartographic range values, which will be changed only when needed.
- Sector lights are visualised by full sectors, buoys with light are visualised by 'drop' symbol, without sectors.
- Texts belonging to one feature have default positions, which are not in conflict with one another.
- Text visualisation is based on feature type. For example a default attribute value for name of light houses is 'visible' and a default attribute value for name of buoys is 'invisible'.

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These settings should be able to be changed separately for each object by the cartographer whenever needed. The changes must be stored in the database as cartographic attributes or cartographic objects.

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4. IMPLEMENTATION AT THE FMA

Research and development in many Hydrographic Offices is now focussed on the challenge of how to combine electronic and paper chart production efficiently and economically. The Finnish Maritime Administration (FMA) has developed a new data management and chart production system to meet these new challenges. The first phase of this development project is called the Hydrographic Information System (HIS) Project. The HIS system is used to enter new data to the database, edit and maintain data quality and for ENC production. Currently there are two separate production lines for the two products, printed chart and ENC. The goal is to replace the existing printed chart production line with a new chart production system - nSector. At the beginning of next year FMA, will have one common chart data management and production system for both products and data maintained only once, in one common database (Oracle/SDE).

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The attribute based storing of cartographic edits has been in use at the FMA for several years. The existing printed chart system, Fingis, has an extension to store and edit navaisds cartographically. The settings for the cartographic presentation and cartographic corrections of navaisds specific to each chart are stored in the RDB tables. [Hirvonmäki, 1992]

The new chart production system is based on the ArcInfo8 technology. It will incorporate all the functions and features for producing the required products from the input data as a cartographically edited chart product with layout. In nSector the entire cartographic appearance of all features are stored to defined cartographic attributes. All cartographic editing is made against these attributes. The editing tools themselves have intelligence to help the operator with the editing process. 'Tools', for example, recognises the feature classes automatically from the screen and acts as defined to this particular feature class. All complex custom drawing methods within feature classes are implemented using draw methods. For example a fairway has the ability to draw itself using fairway depth and bearing. The texts derived from the "real world" attributes are automatically aligned with the fairway line and can be freely located within feature. The depth and bearing texts will automatically mask as invisible the line under the texts. [Chart Production System Specification, 2000][Chart Production System Functional Design, 2000]

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In addition to storing all cartographic edits related to chart objects, the layout and product management is based on product information stored in the database. Layout elements are divided into three categories; static elements (which are generated automatically from product information stored in the database), dynamic elements

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(edition related elements, which must be set by the operator. E.g. ISBN and NtM number) and other graphical elements (if needed). [Chart Production System Specification, 2000] The nSector database schemas are modeled using Unified Modeling Language, UML. This combines an entity-relationship approach to modeling with an object-component architecture. The system implementation is by a specialized GIS applications company, Novo Meridian Ltd of Finland.

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5. CONCLUSION

The production of Electronic Navigational Charts has dramatically effected the production processes of Hydrographic Offices. However, the existing production process, where ENC and printed charts are produced separately, is not a good solution in the long term. An integrated production system for both products has been the aim of FMA for several years and the research has been focused around this challenge. Finally, although we can now report that the technical solution has been established, the next real challenge, taking the system into practical use, training the users, changing the production processes and changing the mindset of traditional thinking must be pursued.

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