INTRODUCING BATHYMETRIC ENCS ON THE EXAMPLE OF THE PORT OF ATLANTIS

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Abstract

The present generation of the ENCs is produced by digitising paper charts. This process leads to a considerable loss of detail of the bottom topography when compared with the source survey data. This is particularly important in the areas where the bathymetry is likely to be changeable, either due to natural processes like sand waves or to human activities, e.g. dredging. Frequently the new bathymetric data are available on a much shorter notice than the standard ENCs are produced or updated. These data can be incorporated in the ENCs carried by the vessels either as gridded depths or as the fields of individual soundings interleaving with other ENC data. The onboard software can then produce the required contour lines. Tests have shown that these amendments can be carried out with the minimal effort. This process does not involve any changes in topography or in other chart information hence the name "bathymetric ENCs". It is fast and results in the increased safety of navigation. This paper discusses the development of bathymetric ENCs using the Port of Atlantis (imaginary so far, not yet discovered) as an example.

1. Introduction

Any chart, be it paper or electronic, is a snap picture of the marine world frozen in time. In reality all objects which make up a chart, including coastlines and bathymetry, change with time at varying speed and frequency, and with varying level of predictability. For practical purposes, the cartographic objects are considered as constant while time variable navigational objects represent the dynamic variability of the elements surrounding the ships.

One can think of many types of time varying information that could be incorporated in ECDIS, but before considering them, three questions must be answered:

Is the information essential to safety of navigation?
What do the mariners need or want?
What data are available?

The first question is most important. And the most important variable which can be a difference between safety and disaster is the depth of water. The mariners must have this information, it

must be up to date, and the data, usually providing much more detail than the official ENCs, are available from various sources.

2. Present day ENCs

At present, the depths shown in the ENC are digitised from the paper charts, rather than obtained from the original high density digital surveys. This reduces the accuracy of the bottom topography and remains the ground for the present prohibition of dynamic depth display, where bathymetry is combined with tidal and other data influencing the water level (e.g. storm surges). In addition, any changes, including those to bathymetry, whether natural or man-made, take time before they make their way to the onboard ECDIS, the updating process being still rather slow. To improve the provision of the bathymetric data to the ships, SevenCs developed a methodology to facilitate the incorporation in the ENCs of the new bathymetric data from various sources.

3. Bathymetric ENCs

The knowledge of the amount of water under one's keel can be a difference between safe passage and disaster. This knowledge not only leads to an improvement in safety of navigation, but also shows clear economic benefits. Every extra centimetre of draft is worth thousands of dollars to the ship owner and also additional income for the port authorities.

Modern survey systems are capable of collecting huge amounts of bathymetric data in a short time with very high accuracy. This allows for the production of high precision ENCs containing depth contours at sub-meter or decimetre intervals. New bathymetric data can be made available on a much shorter notice than the standard ENCs are produced or updated. These data can be converted into S-57 format to be incorporated in an ENC and displayed in conjunction with other ENC data carried by the vessels. These amendments can be carried out with the minimal effort. Since this process does not involve any changes in topography or in other chart information we called the idea "bathymetric ENCs".

A bathymetric ENC must not be overlaid on top of the standard ENC, it might easily obscure important navigational information. SevenCs uses the methodology called interleaving to prevent this from happening. Interleaving allows the bathymetric ENCs to be inserted above the original bathymetric data but below the layer containing the navigational information.

The introduction of bathymetric ENCs would facilitate drastically the incorporation of survey-sensor based depth information during the ENC production process, as it doesn't have to be merged with data from other sources or incorporated in existing ENCs.

The content of bathymetric ENCs is limited to the bathymetry data only. The depth information is encoded by means of the S-57 object classes depth area (DEPARE), depth contour (DEPCNT) and soundings (SOUNDG). Meta Objects are used to describe information related to the contained features (accuracy and quality information), that can not be stored in the dataset header

The bathymetric ENCs, unlike the standard ENCs, do not necessarily have to be rectangular. The meta object M_COVR with CATCOV=1 is used to represent the geographic area containing data. It can overlap two or more of the standard ENCs cells. Although the bathymetric ENCs will be most likely used within geographically small areas, like ports or port approaches, there will be exceptions to this, e.g. when large areas have to be resurveyed after a heavy storm (a usual occurrence in the North Sea).

4. Port of Atlantis – new survey

According to our research department, the Port of Atlantis is located on the western side of Atlantic, and not in Europe as traditionally thought. Recently, a new survey has been conducted (thanks to the NOAA Ship WHITING for acquiring the Hampton Roads Data) in the area to ascertain the suitability of the approaches to the port for the heavily loaded war galleys. Rather than wait for the official Atlantean chart makers to come up with an update to their original product (Fig.1), we decided to use the digital data kindly provided to us by the Centre of Coastal and Ocean Mapping (CCOM) to enable us to bring home safely the loot from the latest expedition (Fig. 2).

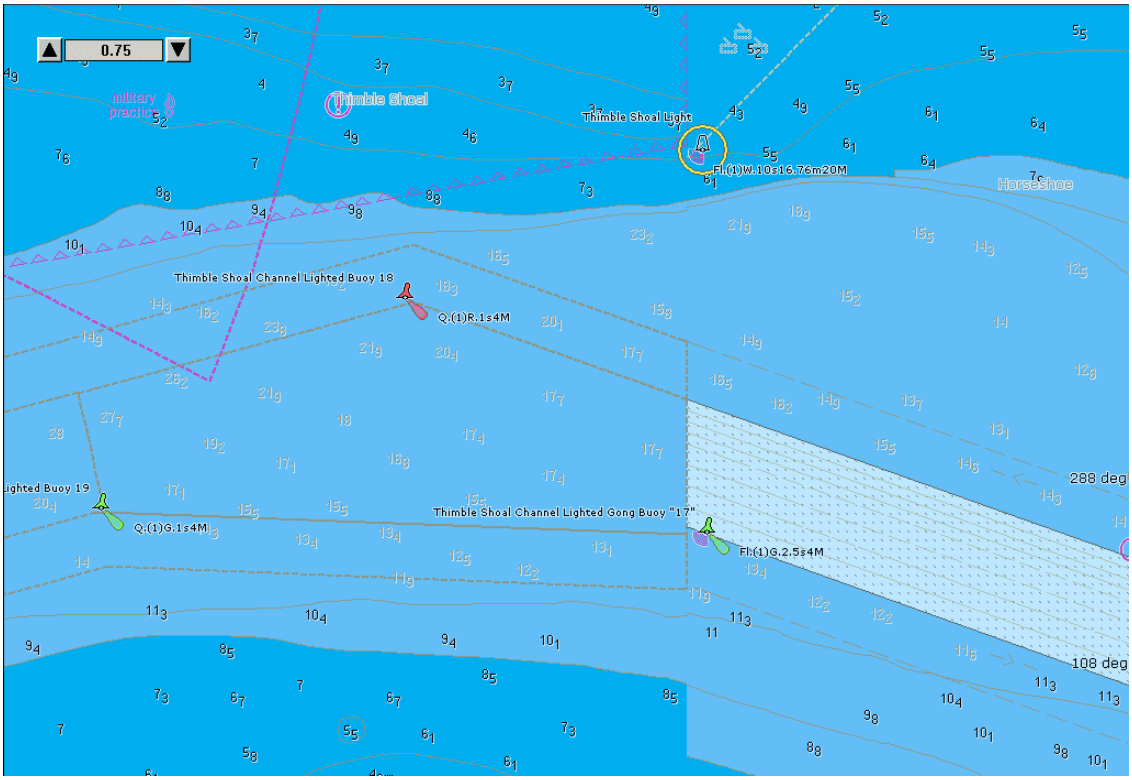

Fig. 1. The original chart showing the approaches to the port (US5VA15M.000 US5VA19M.000)

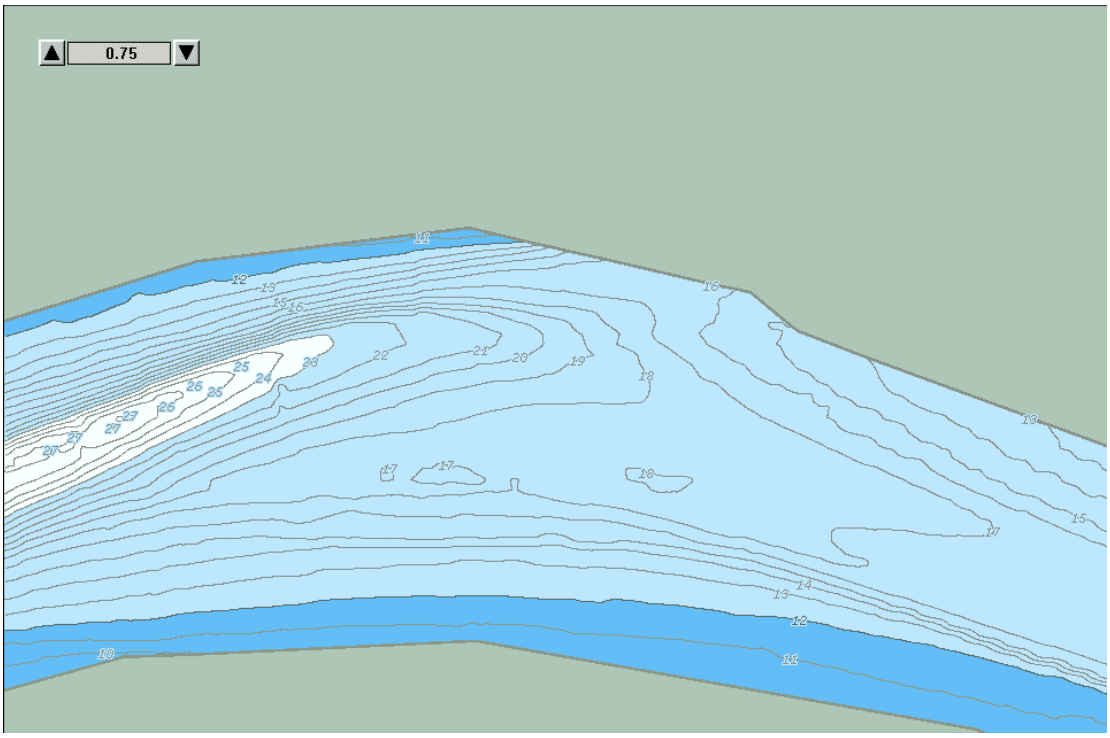

Fig. 2. The new survey of the port approaches (bathymetric data only)

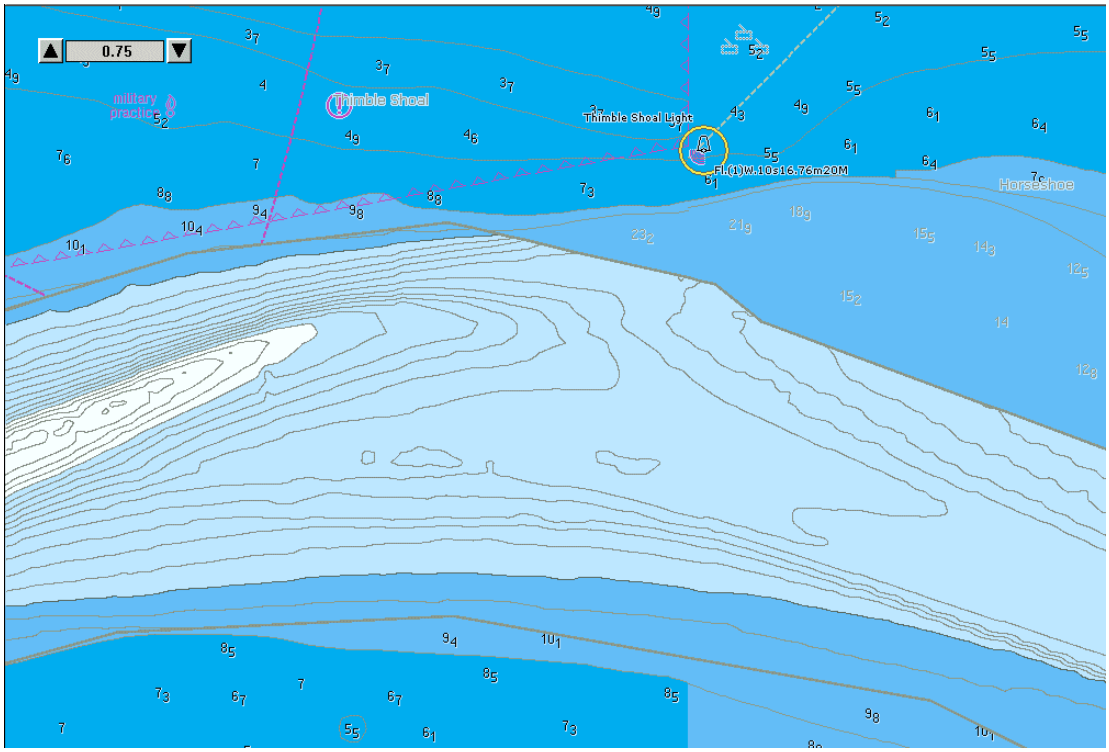

Fig.3. Survey data on top of the original ENC, navaids obscured.

As can be seen in Fig. 2 the survey does not cover the full width of the channel, only the part vital for the deeper draft vessels. The bathymetric data, once converted into S-57, can be easily presented on the ECDIS screen, but simply overlaying it on top of an ENC (Fig.3) obscures the navaids thus breaking the main rule of displaying the additional information on the ECDIS screen which requires that any such information must not obscure the navigational information. The methodology of interleaving prevents obscuring, the results being shown in the Fig.4.

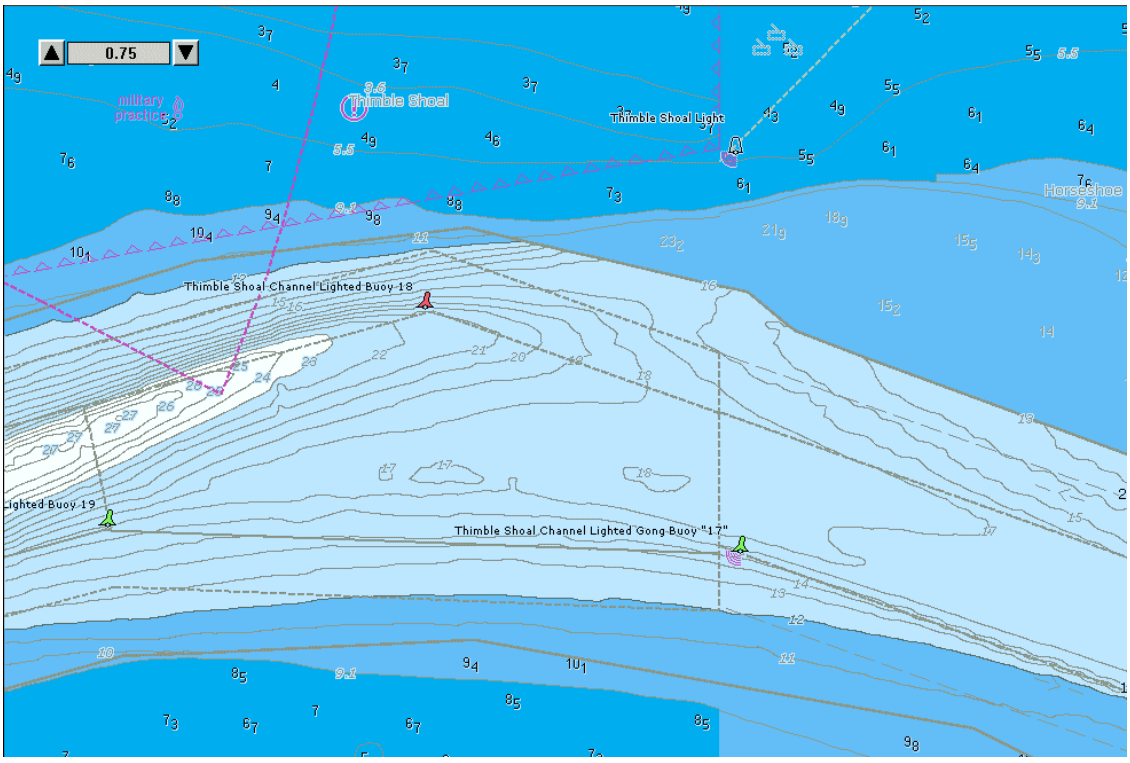

Fig. 4. Survey data interleaved with the original ENC, all navaid information visible

5. Bathymetric data and their presentation

The use of bathymetric ENCs will be optional. However, it is expected that with the support of the port authorities, the usage of them will be widespread in the areas where the navigational waters are subject of frequent dredging or natural changes to the bottom topography (e.g. sand waves or storm induced changes). Applications using this approach should have the capability to switch on/off the bathymetric ENCs. The application should indicate when the function is turned on.

When data query and anti-grounding alarm functionality are provided, it must be indicated if bathymetric ENCs have been taken into account or not. It is expected that most of the ECDIS systems can take them into account.

Bathymetric ENCs contain bathymetric data only, but no coastlines or navigational information like navigational aids, traffic separation zones, restricted areas, etc.. Thus, as mentioned earlier, the bathymetric ENC must not obscure the navigational information of the standard ENC. When bathymetric ENCs and standard ENCs are drawn simultaneously the bathymetric ENCs will overdraw depth contours (DEPCNT), depth areas (DEPARE, depare) and spot soundings (SOUNDG) of the standard ENCs. The resultant clear break between the standard ENC and the bathymetric ENC is shown as a grey line in the Fig. 4. The difference in the density of data on both sides of the grey line shows how much more data are provided by the latest survey in comparison with the original digitised paper chart. This, and the discontinuity of the contour lines should not bother the mariner who is interested in the data in the navigable waters.

The existing presentation standards for ENC and/or Inland ENC data (S-52) are sufficient to visualize bathymetric ENCs

6. Bathymetric ENCs and Navigation Surface

The Navigation Surface Approach recently developed at the Centre for Coastal and Ocean Mapping (C-COM) [1] proposes a new way of chart production. The Navigation Surface Database (NSDB) can be used to generate various cartographic products. Within the NSDB the bathymetric data are stored at the highest resolution. Depending on the needs of the final product (e.g. bathymetric ENCs) the data are generalized to the required scale and stored in a product grid.

Bathymetric ENCs are meant to be suitable for all types of ships (different draft, size) and all kind of tasks (approaching the harbour, docking). Assuming that the source data was collected by means of modern survey systems, bathymetric ENCs will provide the user with more accurate depth information.

The source data (bathymetric data sets e.g. from Navigation Surface), are processed by means of standard modelling algorithms (DTM generation, contouring). The resulting contours are used to generate S-57 compatible line and area objects. Unless they are generated in an on-the-fly process (see below) bathymetric ENCs can contain depth contours at small intervals (sub metre) covering the depths range of e.g. 0 to 20 meter.

Should a competent authority certify such a product grid as “safe for Navigation”, as proposed by the Navigation Surface Approach (i.e. it obtains the status of a navigational product), it could be passed to the onboard software and used to create the bathymetric ENC on-the-fly. The onboard software could create dynamically the relevant contour lines (the relevance being selected by the operator) directly from the product grid.

The on-the-fly approach has another big advantage: tidal corrections could be applied directly to the grid data. Then the contours would be updated on-the-fly. The on-the-fly approach, also referred to as a “dynamicENC", is more accurate than trying to apply tidal corrections to the static contour lines since it creates always the contour lines at the desired depth and does not change the values of the existing contour lines. Should this methodology finally be approved by the IMO and IHO (and the idea has been floated several years ago) the problem of non-standard

vertical datums will disappear immediately; the ships will have the real-time water depth information on their ECDIS screen.

7. Proposal for product specification

At this stage the S-57 product called "bathymetric ENC" does not exist, nor does a product specification. It is proposed that the 'bathymetric ENC" be developed as a new S-57 based product in addition to the already existing products (ENC, Inland ENC, AML).

To make use of bathymetric ENCs in conjunction with ENCs or Inland ENCs a dedicated Product Specification for bathymetric ENCs is required. Such a product specification should describe the dataset structure, topology, contents, meta information, object classes/attributes etc.. The product specification should serve as guide line for both data producers and application builders who want to implement the use of bathymetric ENCs.

SevenCs prepared a proposal of a product specification for bathymetric ENCs. The proposal doesn't contain any instructions regarding the presentation of bathymetric ENCs. However, it is required that inland ECDIS and/or ECDIS applications that want to make use of the bathymetric ENCs integrate loading and symbolization algorithms that allow for a simultaneous display of standard and bathymetric ENCs.

It is proposed that the Product Specification for the bathymetric ENCs be submitted to the TSMAD Working Group of the IHO for consideration to include it in the ENC Product Specs to ensure that the usage of the bathymetric ENCs would not have a detrimental effect on the type approval of the onboard ECDIS.

As mentioned earlier, the existing presentation standards for ENC and/or Inland ENC data are sufficient to visualize bathymetric ENCs. However, it should be specified in detail, which items of the standard ENCs must not be obscured by the bathymetric ENCs.

8. Data Distribution

So far we have shown that from the technical perspective it wouldn't be much of an effort to introduce the bathymetric ENC as an additional S-57 product and utilize it. However there are also legal and logistic issues that need to be considered.

The source of data for the bathymetric ENCs can be private survey companies or, in the harbour areas, the relevant port authorities who are responsible for data collection and product generation. Their products are not meant to be distributed directly to the public but it its original form used internally and provided to the pilots. These data are made available to the public only via the relevant HOs to which the survey companies and port authorities send their survey data. These survey data are then used for creation of the chart correction datasets. Considerable amount of detail is lost during the process as the original data are being decimated to the level required by the paper charts and hence standard ENCs.

In addition to the legal issues that might be facing the port authorities, the main reason for the inaccessibility of the survey data to the public is the fact that the bathymetric datasets are not compiled in a standardized format. The situation is different if the bathymetric source data were used to generate bathymetric ENCs in the international S-57 format.

Bathymetric ENCs could be used for both internal use (e.g. Vessel Traffic Services, Portable Pilot Units) and the general customers (e.g. ECDIS, ECS users). This could potentially open a new market niches for the port authorities. The question is if the port authorities are willing to provide their data to the public and if they are also ready to support the production of bathymetric ENCs including quality control and quality assurance without which the public could not trust the new product.

The question of the logistics of the distribution of the bathymetric ENCs will also have to be addressed. It may appear easy on the local level, but proper infrastructure must be in place once the distribution is to reach the vessels offshore or in the foreign ports. Chart and/or shipping agents may step in to fulfil the role of distributors.

9. Future developments

Most of the marine variables are three-dimensional in their effect. Trying to represent them on an electronic copy of a paper map restricts us to the methods used by the paper print technology. ECDIS can free the user from these restrictions of the old technology. Innovative techniques for marine data conversion, display and modelling in ECDIS are being developed to accommodate the users' needs, e.g. three-dimensional displays.

The present approaches are focusing on a 2 dimensional display of the data, whether bathymetric or topographic or other. However, the better the horizontal and vertical accuracy of the data and the higher the density of depth information, the more options for new functionality to support safe navigation will be available. The three dimensional display will play a bigger role in the future, e.g. for docking situations or high precision navigation.

A 3D display lends itself for the dynamic depth information.. The Chart of the Future project of CCOM [2] has already confirmed the concept of a dynamic chart display. Real time tide corrections or tide predictions can be included for route planning purposes. The next step will be to use it for route monitoring. The combination of the navigational surface information (gridded bathymetry) and 3D display is particularly exciting. As we have said in section 6 above, the bathymetric data are stored within the NSDB at the highest resolution and then are generalized to the required scale depending on the demands of the final product. This could be extended to the user's choice of the level of detail depending on the selected level of generalisation.

Will the ECDIS standards keep track of these exciting developments or will the standard makers try to stifle them? S-57 Edition 4 is under construction, to quote: "The primary goal for the next edition of S-57 (Edition 4) is to support a greater variety of hydrographic - related digital data sources, products, and customers. This includes matrix and raster data, 3D and time-varying data (x, y, z, and time), and new applications that go beyond the scope of traditional hydrography (e.g. high-density bathymetry, seafloor classification, marine GIS)" [3].

The inclusion of matrix data will also open new ways of visualization in the ECDIS environment, hopefully without too many constraints.

10. Summary

Bathymetric ENCs could be used to add high density bathymetry to standard ENCs with minimal effort. Introducing this idea will require support from port authorities in whose interest it is to provide the latest data to the ships using their facilities.

The existing and forthcoming standards appear to be sufficient for the integration of the bathymetric and standard ENCs. A proposal for a bathymetric ENC product specification is available from SevenCs. It is hoped that this solution is accepted and standardised by the IHO.

Acknowledgements

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References

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[2] Arsenault, R.. et al, *Fusing Information in a 3D Chart of the Future Display*, Conference Proceedings, U.S. Hydro 2003, Biloxi, MS, 2003.

[3] S-57 Edition 4.0 Information Paper*; The Next Edition of IHO S-57 (4.0)*, IHO Website http://www.ohi.shom.fr