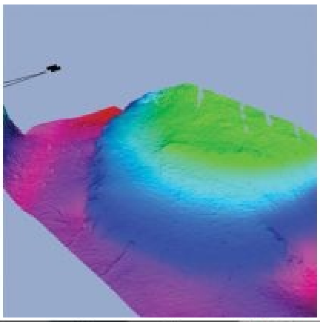
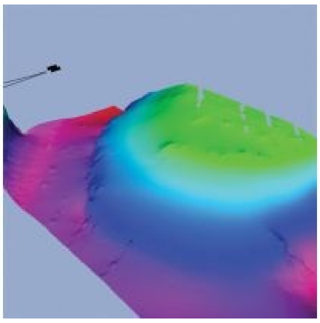
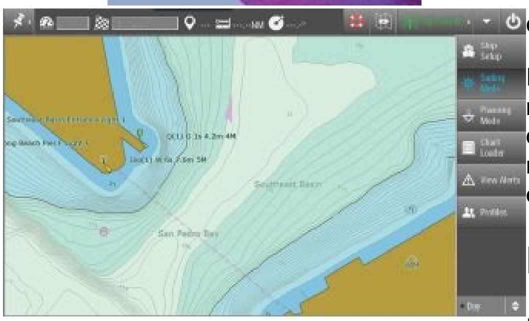
ADVANCED TECHNICAL SOLUTIONS NEED TO BE IMPLEMENTED

New Challenges for Digital Chart Production





Hydrographic Offices (HOs) have realized that bathymetric data is not sufficiently represented in Electronic Navigational Charts (ENCs). A few aspects of this topic have already been touched upon in the presentation 'Innovative approach in automated contour generation' (Moggert-Kägeler, 2017) that was presented at Hydro 2017. This article focuses on the challenges of high-density bathymetry chart production and introduces a new approach to cope with it.



In the past, ECDIS (Electronic Chart Display and Information System) users have repeatedly complained about the lack of bathymetric detail in ENCs. The resolution of depth information is too coarse to adequately display the extent of areas that are safe for navigation. The article 'Bathymetric ENCs in Confined Waters' (Di Lieto et al, 2018) explains this in an excellent manner.

Recent Initiatives

In the last few years, the topic of high-density bathymetry ENC production has been discussed at various IHO meetings. Most HOs supported the initiative, but concerns were expressed including additional manual effort, 5MB file size limit for ENCs, and new ENC layout.

In February 2018, UKHO announced (Admiralty Press Release, 2018) that it had issued a high-density ENC. The ENC covers a small area of the Bristol Channel (2.2 by 1.3km). To confirm accuracy the results were checked manually. In addition, the Australian Hydrographic Office (AHO) in 2018 described their successful experiences with the production of high-density ENCs. The transition from a proof of concept to the implementation of an operational service is the next big challenge.

Existing Solutions

Solutions for the automated production of high-density Bathymetry ENCs have existed for many years. Even though the data is usually technically correct and standard compliant it misses the cartographic 'touch'. All solutions have a focus on automation and efficient processing of large data volumes. Often, the resulting contours are jagged, not generalized to scale and prone to clutter. Some manufacturers use basic methods to update ENC depth information. Hence, the resulting ENC bathymetry is not smoothly integrated and resembles a single bathymetry patch. Other manufactures have come up with solutions where high-density bathymetry is maintained and provided in separate S-57 layers complementing the regular ENCs.

Nevertheless, all these manufacturer-specific solutions have been implemented successfully on a regional basis in close cooperation with local stakeholders and authorities (ports, waterway authorities, pilots). They have not been designed to be used in ECDIS at all. The data is mainly used in portable navigation systems for pilots. However, from an HO perspective it may not fulfil all quality standards.

A New Approach

More recently an approach has been introduced that provides an improved solution to produce high-density bathymetry ENCs. It reduces the amount of manual work for the creation of contours and selected soundings, supports automation and honours cartographic principles. Ideally the workflow should start where the underlying source datasets are managed.

The approach derives contour lines from a Nautical Elevation Model (NEM) – a shoal-biased smoothed-out and generalized underwater terrain model. It can be imagined as a draped sheet over rough bottom topography. If a little bit of tension is applied to this sheet it will form a smooth surface. This new surface touches the original model at shallow peaks and bumps and smoothes out noisy terrain and deeper holes as seen in figure 1a and figure 1b.

Creating the contours directly from a rough source terrain model would result in 'noisy' and jagged contour lines. Usually line smoothing algorithms are not shoal-biased – therefore NEM is used instead. If derived from a smooth surface, the resulting contours have a smooth appearance as well. This is not only an aesthetic aspect but contributes to better chart readability and overall acceptance. The shoal-biased character guarantees that the resulting contours correctly represent the minimum depth.

The NEM can be generalized to a distinct product scale. The degree of generalization is controlled by means of a parameter set that is used by the processing algorithms.

Some aspects of the NEM are similar to the cartographic extraction methods of the Navigation Surface approach (Australian Hydrographic Office, 2018). Both use a kind of sheet model for generalization and smoothing of gridded bathymetry. Such sheet models tend to 'over-generalize' steep terrains and features like edges of dredged or natural channels. This is why the NEM integrates methods to dynamically configure the degree of generalization at different vertical levels.

Once the appropriate generalization parameters have been defined and the NEM has been generated, contours can be created. An additional process automatically creates the area-polygons of the depth areas between the contour lines.

The proposed solution can be used to generate contours at much denser intervals than usually found in traditional ENCs. Special effort was made to make sure that the results comply with the strict topology rules for ENCs (IHO S-57, ENC Product Specification, and S-58 Validation Checks).

When contours are created at metre or sub-metre intervals not all contouring algorithms achieve error-free results. This is especially true in terrains where contours are getting pushed very closely to each other.

Once automated production workflows for the generation of high-density bathymetry charts are in place, it is no longer practical to check and validate the results manually – instead automated validation will be used. To confirm the reliability of the contour generation methods, S-58 validation software was improved to be able to handle the large number of lines and areas.

Dozens of high-density S-57 datasets were created and repeatedly tested with the S-58 validation software in order to fine-tune the contour generation process. Finally, a no-error quota of 99% was achieved. This means 1/100 datasets would require manual corrections.

How S-100 Deals with High-density Bathymetry

IHO's S-100 is the framework for the definition of multiple future digital products required by the hydrographic and maritime community. Within the S-100 family, S-101 is the new specification for ENCs, and S-102 describes a gridded representation for high-density bathymetry.

S-101 ENCs can include high-density contours in the same way as S-57 ENCs. Both represent depth information by means of soundings, depth contours and depth areas. Hence the production procedures described above are suitable for both S-57 ENCs and S-101 ENCs.

S-102 uses a completely different model for depth information. It's based on a gridded structure and does not use line or area features. In a high-resolution S-102 grid (e.g. 1m x 1m), each grid node represents a single depth value.

S-102 is seen as bathymetric complement to ENCs in ECDIS. It has some advantages over the line and area bathymetry of ENCs: it allows for 3D display of depth information, it is suitable for applying advanced water level correction models (e.g. to show real water depths) and it can represent bathymetry close to survey resolution.

However, since S-102 has some disadvantages as well (large file size, too much detail and tendency to cause clutter), high-density gridded bathymetry in S-101 ENCs and S-102 should complement each other.

Up to defined depths, larger scale ENCs could contain high-density bathymetry where they cover channels and fairways. The data should be complemented by S-102 gridded bathymetry in congested or extremely shallow waters and areas where safe navigation is affected by strong variances of water level.

Conclusion

Hydrographic Offices will face new challenges if they decide to take the step into regular production of high-density bathymetry ENCs. Advanced technical solutions are available and will have to be implemented to cope with the new challenges. The introduction of S-100 based digital products will provide additional options.

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