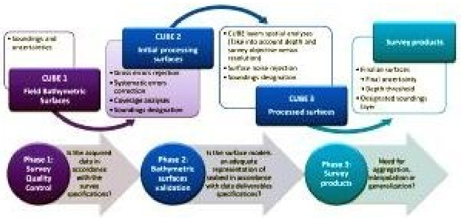
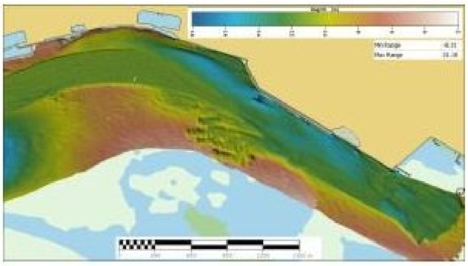
USING CUBE SURFACES FOR NAUTICAL CARTOGRAPHY AND DREDGED MEASUREMENTS

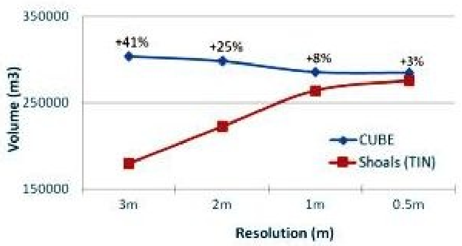
Multibeam Data Processing

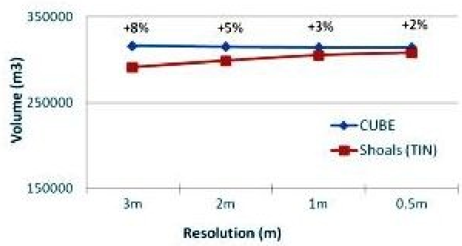


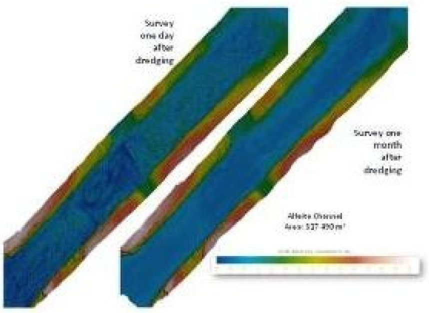


Surface	Resolution (m)	Shoal's comparisons	Average (m)	Standard Deviation (m)	Inside Special Order (%)	Inside Order 1 (%)
Object Detection	0.5	322717	-0.08	0.04	99.78	99,98
Complete Coverage	1	322801	-0.09	0.04	99.68	99,96

Surface	Resolution (m)	Designated Soundings	Average (m)	Standard Deviation (m)	Inside Special Order (%)	Inside Order 1 (%)
Object Detection	0.5	93	-0.25	0.48	77.42	90.32
Complete Coverage	1	93	-0.35	0.52	66.67	83.87







This article is about the evolution of acoustic sounders imposed on Hydrographic Service's new methodologies for the interpretation, handling and application of hydrographic information. Considering spatial resolution and high-density data acquired by multibeam echosounders (MBES), algorithms such as Combined Uncertainty Bathymetry Estimator (CUBE) are used in the processing workflow to generate depths and uncertainty estimates. Can bathymetric surfaces be considered the final survey product in exchange of the traditional shoals selection? IHPT conducted hydrographic surveys in order to evaluate CUBE processing for nautical cartography and for dredged volume calculation. Shoals validated by hydrographers were compared with CUBE estimated depths and produced a new processing workflow.

In traditional processing, soundings are validated by the hydrographer using filters and interactive tools associated to data processing applications. This is a time-consuming process based on conservative and subjective judgment, in which relevance is given to minimum soundings and creating a 'safety of navigation bias'. Bathymetric modelling is used as a tool for data cleaning and quality control allowing the identification of blunders and automatic rejection of outliers. The final result is a discrete subset of shoal soundings extracted from the dataset of validated soundings in order to create a manageable and storable product that represents the uncertainty as a regional non-discriminatory model.

A New Data Processing Workflow

In this concept, bathymetric modelling assumes a leading role in data processing and as the final stage of the process where the surface represents the final survey product. The workflow illustrates the phases of this process, where the bathymetric surface is repeatedly rebuilt (Figure 1). The proposed hydrographic data processing workflow is intended to be the most efficient approach for the creation of cartographic base products. Nevertheless, in exceptional cases where bathymetric modelling does not guarantee the requirements for nautical cartography, the responsibility to designate specific minimum soundings or other relevant structures for safety of navigation still rests on the hydrographer.

Case Studies Methodology

For the two case studies the following standards and applications were used:

- Software: CARIS-HIPS 7.1
- Hydrographic survey uncertainties in accordance with Special Order IHO requirements
- Hydrographic data grids in accordance with NOAA specifications and deliverables, namely, the bathymetric models (BM) of Object Detection Coverage (ODCBM) and Complete Multi-beam Coverage (CMCBM)
- CUBE parameters as defined by NOAA
- Final uncertainty presented on final bathymetric models as defined by NOAA
- Designated soundings not included on the gridded dataset

CUBE for Nautical Cartography

In April 2011, a Special Order survey was carried out at Setubal harbour North Channel (Portugal). This area is mainly flat, however, it contains several port constructions, some rocky outcrops and countless small scale objects (about $1m^2$). In order to evaluate CUBE processing for the purpose of nautical cartography, shoals soundings validated by a hydrographer were compared with those depths calculated by the CUBE algorithm. Both, ODCBM (0.5m resolution) and CMCBM (1m) bathymetric models were generated. (Figure 2)

Comparison Results

The comparison between CUBE estimated depths and the manually validated shoals shows an average difference of less than half of maximum Total Vertical Uncertainty (TVU). This falls within the special order and cases with differences greater than the maximum TVU occur predominantly in irregular seafloor areas, and thus more in the CMCBM.

In the presence of small objects the relevance of designated soundings was demonstrated. On an irregular seafloor several cases were found where the difference between CUBE depths and the manually validated shoals were greater than the maximum TVU allowed:

- On steep areas, soundings do not have a normal distribution
- 2D and 3D visualisation limitations hamper data analysis on traditional processing.

Except in areas of steep slopes, differences between traditional shoals and CUBE estimated depths are less than half of the vertical uncertainty required by IHO (Special Order). (Figure 3)

CUBE capabilities overall minimises inherent subjectivity in traditional processing, reducing processing time up to 33% on an irregular seafloor and about 67% on regular seafloor.

CUBE for Dredged Volume Calculation

The Alfeite Channel, Lisbon was used for the volume comparisons, because this area is regularly surveyed. For this case study, pre and post dredging surveys were performed under the same conditions, with the same equipment configuration and meeting the minimum requirements for Special Order surveys. (Figure 4)

Bathymetric models were built for initial and final hydrographic situations (pre and post dredging). From these bathymetric models difference surfaces were generated and dredged volume were calculated. The volume was calculated between the ‘shoals’ model and different stages of CUBE surfaces (CUBE 2 and CUBE 3) processing.

Three main findings can be concluded from the comparisons. When making use of the CUBE models the dredged volume is almost independent of the adopted resolution. Furthermore, the results also show that it is almost indifferent to use CUBE 2 or CUBE 3. Using shoals, consistent dredged volume differences are achieved only in higher resolution TIN models. (Figure 5)

However, to assess whether the dredging quotas were met it is recommended to use the highest resolution thus having a lower attenuation of the observed maximums.

Conclusions

CUBE is an algorithm for processing hydrographic data but is also used in the modelling of bathymetric surfaces. The results of this study indicate that it is possible to use bathymetric surfaces for various purposes, including those related to nautical cartography and calculation of volumes. The two case studies proved that CUBE has several advantages compared to traditional methods:

- More efficient quality control and standardisation of processing criteria
- One final product (CUBE surfaces and Designated Soundings) can be used in several applications
- Easy integration and comparison with other surveys
- Decrease in processing time (66% in regular seafloor and 33% in irregular seafloor).

Acknowledgements

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More Information

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- CARIS (2011): HIPS and SIPS 7.1 - User Guide, CARIS
- IHO (2008): S-44 IHO Standards for Hydrographic Surveys, 5ª Ed.
- NOAA (2011): NOS Hydrographic Surveys Specifications and Deliverables, National Oceanic and Atmospheric Administration, Office of Coast Survey, April 2011