

# **Navigation Surface Creation and Use for Charting Example- Seacoast New Hampshire**

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## **Abstract**

The navigation surface is a database and a collection of tools for creating and utilizing bathymetric models for navigation. The approach has the potential to improve the hydrographic survey process by streamlining manual processes and automating cartography. In addition, by modelling uncertainty as well as depth at each model node, it gives the hydrographer and the cartographer a rigorous methodology for managing the survey process and for making decisions about cartographic precedence among surveys in a common area.

This approach is demonstrated in the Great Bay estuary and approaches (Portsmouth Vicinity). The goal of the project was to create a model of the seafloor that is suitable for navigation all the way to the shoreline. The data in the area consist of everything from leadline to old reconnaissance-density singlebeam to modern multibeam. First, each data source is individually modelled to create a collection of models of depth and uncertainty. Next, rules were established for superseding one survey with another. The resulting collection of models represents the navigation surface.

As the first step in the product creation stage, the individual models are combined into a single model which covers the geographic area of interest. Next, the model is downsampled and generalized (defocused) to the scale of the planned product. Finally, the model is contoured and selected depths are taken from it to populate a traditional-looking product (ENC).

Examples are given of other uses of the navigation surface database, including habitat mapping, circulation models and coastal engineering.

The Navigation Surface approach was described at Shallow Survey 2001 in Portsmouth, NH and a paper was published in the August 2002 issue of the International Hydrographic Review.

## Introduction

In a paper in the International Hydrographic Review, The Navigation Surface: A New Database Approach to Creating Multiple Products from High-density Surveys, we described the Navigation surface approach. This paper will examine an extensive example of this approach throughout the Great Bay estuary and the approaches to Portsmouth, NH. The basic approach will not be described in great detail, but the author refers the reader to the IHR paper.

## Methods

### *Surface Creation*

For this project, twenty-three surveys were compiled into Navigation Surface models and combined into a single product. There were four multibeam surveys processed using a clean sounding set, one multibeam survey processed using CUBE a surface, one survey from a sweep system, three leadline surveys, and fourteen single beam surveys. Each survey was used to create a model of depth and depth uncertainty over the entire area covered.

For the singlebeam and leadline surveys, the seafloor was interpolated between soundings using a Triangular Irregular Network (TIN). The TIN was then resampled into a regular grid. The uncertainty at each measurement, lacking other information, was estimated to be  $0.5\text{m} + 5\%$  of depth. The uncertainty of interpolated nodes was estimated as a function of the uncertainty of the nearest measurement, distance to the nearest measurement, and the local roughness of the seafloor. For the surveys which include shallow water, the photogrammetrically-derived shoreline was used as a boundary condition to tie the last soundings with the shore.

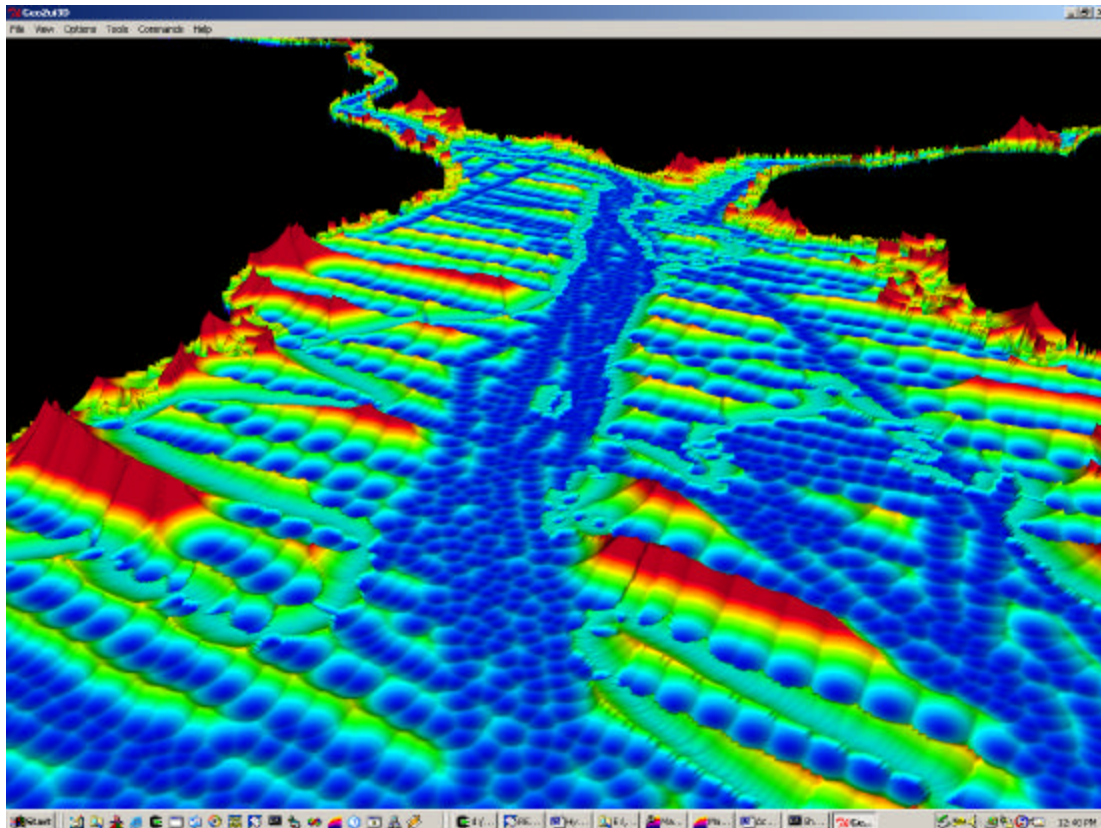
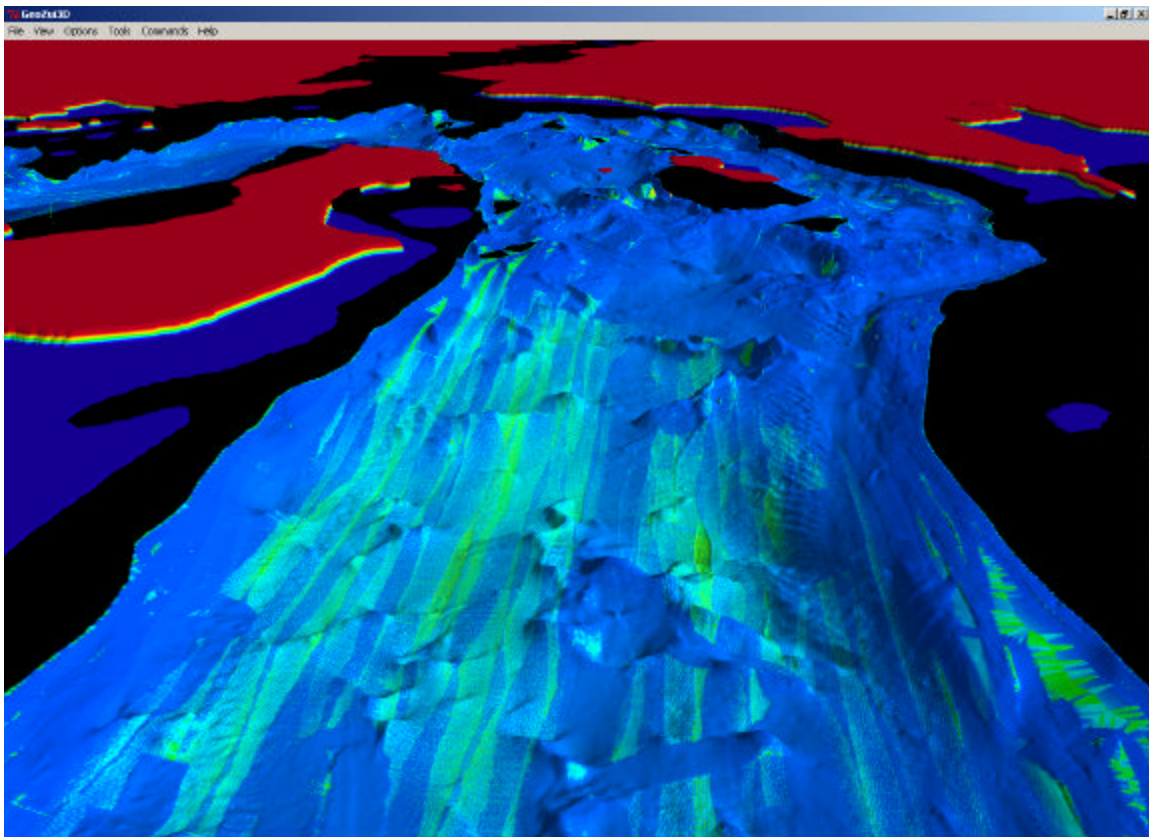


Figure 1-Uncertainty of a surface derived from a singlebeam survey. Notice the surface has generally lower uncertainty in areas of tighter line spacing.

For the multibeam and sweep surveys using cleaned soundings, the depth at a node was estimated using the weighted grid algorithm first implemented at the University of New Brunswick by John Hughes-Clark, and subsequently integrated into Caris HIPS. A second stage process was used in areas of special navigation significance (high points of shoals, etc) to adjust the node nearest to the least depth to the actual shoalest measured depth.

The uncertainty at each of the nodes was the greatest of the predicted uncertainty derived from the measurement uncertainty, and the observed 95% bounds of the distribution of the points around the mean. In the cases where the measurements agreed well with each other, the measurement uncertainty was used. In the cases where the distribution of the points was greater than would be explained by predicted measurement error, the 95% bound would be used.



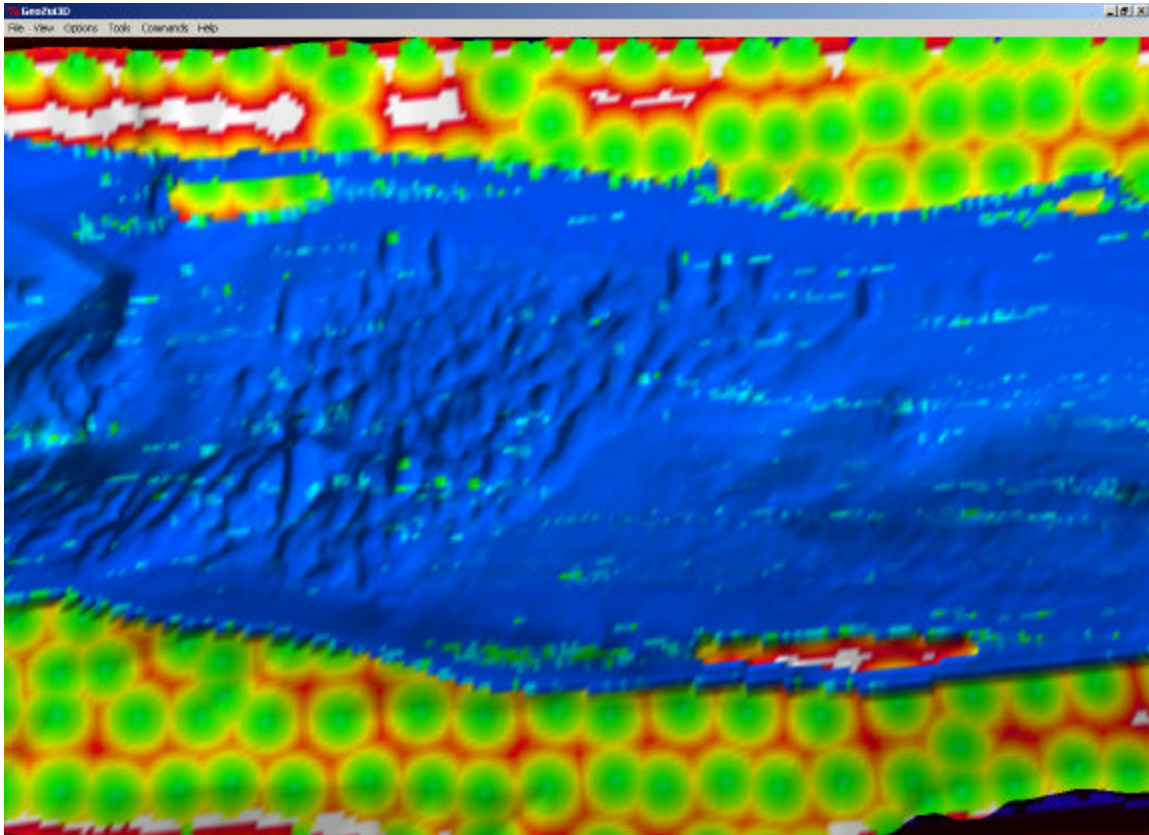
**Figure 2-Uncertainty by color over a multibeam weighted grid. Notice the green stripes in areas where errors in tides among multiple days led to higher uncertainty.**

### ***Product Creation***

After each surface from a single source was prepared, a product was defined which encompassed the entire estuary and extended to the Isles of Shoals. Each surface was then resampled into the product grid, preserving shoals during the resampling. For these

surveys, the vintages were distinct enough that a complete supersede of an old survey with a new one was indicated.

The product model can then be generalized to have the properties of the required product. By generalizing the model, we can drastically reduce the amount of manual linework which must be done at the cartographic level. Alternately, we can automatically produce a model which could be used in a 3D navigation package.



**Figure 3-Multibeam data (center) supersedes singlebeam data (top and bottom). Due to the density of measurements in the multibeam area, the surface model uncertainty is generally lower. The small green stripes in the multibeam are areas of thin coverage because of inadequate overlap.**

## **Discussion**

### ***Problems in Model Creation***

The most time consuming part of this process was getting the shoreline boundary condition right. In some cases, the modern shoreline was actually different than the shoreline at the time of the survey, with old soundings plotting where there is now a landmass. In these cases, the soundings in question were merely removed from the survey.

In a few cases, the NGDC data contained blunders, where a sounding differed from its neighbors by an even hundred feet, most likely caused by digitization errors. This is clearly visible in the DTM, and the offending point was identified and removed. Time did not allow for returning to the scanned smooth sheet to correct the problem.

In two very old reconnaissance surveys, H00741a and H00741b, around the Isles of Shoals, the line spacing was inadequate to create a model, and these surveys were not included in the product. There are no other digital surveys in the common area.

In some very narrow channels, there is inadequate coverage in the singlebeam record to define the channel properly, resulting in the channel being modeled as closed. These sections were removed from the model. The best solution would be to acquire modern survey data.

On steep slopes in multibeam data, a relatively wide distribution of measurements is observed around each model node. While this is merely a result of horizontal error, the calculated standard error is nonetheless valid at a fixed node, which has no horizontal error.

### ***Comments on the Process***

The process shown here can largely be accomplished without a great deal of operator interaction once the soundings are validated. For this example, I was able to write a single script which took each survey from a grid and measurements to a gridded surface which includes node uncertainty.

A second script takes the collection of models and a new model definition, and supersedes, merges, and defocuses the product model.

A third script takes the product model, creates a cartographic border, creates selected depths, and passes the model to Caris for contouring.

### **Conclusions**

While the process described here represents a good first cut at this process, there are some inelegant shortcuts which could be resolved in a proper implementation. In addition, there are some more fundamental questions which require further research.

In spite of these limitations, the navigation surface process described here has enough advantages over current processes to be attractive in its current state.

## References

Calder, R.R. and L.A. Mayer, *Automatic Processing of High Rate, High Density Multibeam Echosounder Data*, submitted to *Geochem., Geophys., Geosyst.* (G3, g-cubed.org), DID 2002GC00486, December 2002.

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