High definition bathymetry production, distribution and updating.

In the last 10 years, technology changed the way we are looking at our world. Canadian hydrographic service is at the forefront in term of using technology to reach the objectives. CHS main mandate is to maintain a portfolio of navigation charts and provide water level information all across Canada. High-resolution surveys are now part of CHS usual business. Now the pressure is on to provide high-resolution bathymetry to a wider audience. Developing new products involve a lot of work and putting it into production will be an enormous challenge. The S-100 series product specifications are now at the final draft stage. S-100 will inherit many things from what we know now from S-57. Think about all the S-57 objects, attributes… the new standard will use what is in place to ensure a smooth transition. In this paper, I will talk about the bathymetry layer. CHS Quebec region has realized some test projects for specific clients concerning high-resolution bathymetry. Some lessons were learned from theses projects, and we are in position to propose some solutions to the numerous challenges that arise when you want to provide clients with high-resolution bathymetry.

Two year ago the St-Lawrence Seaway Management Corporation approach CHS to transform their multibeam survey data into S-57 files. Requirements were ten centimeters contours and sounding selection every five meters. Of course before going to deep into the work some investigation were made to ensure source data was up to the task. Some corrections were made in terms of data processing methods to ensure data was good enough to produce the high-resolution S-57 files. The files had to be continuous, the contours had to match from one file to another. We accepted the challenge even if we had some concerns.

Using the latest technology available, we started the production of the files. From the start, we know we had to work with the navigation surface concept developed at University of New Hampshire and later on integrated in the CARIS Base Editor software. Generating contours at every 10 centimeters using a half meter resolution grid would be feasible but the result would be jagged contours and enormous number of vertex for every contour. Finally, we would end up with files exceeding the S-57 limit of 5 Mo. .Using the navigation surface concept we decided to generalize and defocus our grids in order to help contour generation without sacrificing too much information. The other challenge was to have continuity between the files. If you want contour continuity, the contours must be derived from the same surface. Using Base Editor, we combined all the surveys to end up with a surface from which we could extract contours and soundings. The combine function is shoal bias for obvious reasons. The S-57 files were cut following the survey zones of the seaway corporation roughly 1 kilometer along the navigation channel, and the files were named after survey zones numbers. Quality control step on S-57 files was the part of the project where we had most of the problems. All sorts of problems related to geometry affected our files. Software is not adapted to that kind of work and some manual editing was required on the files. Of course, providing the grids or product surfaces instead of S-57 files would have been easier but the standard to do that was still not defined.

Last year CHS Quebec region held an S-100 workshop meeting with mariners, pilots, harbor authorities, other federal agencies and software manufacturers. CHS wanted to get the needs of the main players and see if the ``Draft Product Specification towards a Profile of the S-100 Standard for bathymetry`` was on the right track. This meeting was a good opportunity to

exchange ideas about the future needs and see if S-100 would be able to handle it. As a summary, a consensus was reached by the various representatives of the end-user community of high definition bathymetric data who were present at the workshop on the following needs:

Resolution and rendering: user selectable methods of displaying the bathymetric data allowing for a higher chart resolution especially in shallow areas and in dredged areas. (in which water depths should be provided)
Information updates and delivery: frequent survey updates and associated product deliveries must be provided in a timely manner.
Data quality: Hydrographic Organisation certification (CHS in Canada) is considered to be a proof of data quality by the community of bathymetric products users. From the perspective of users, providing uncertainties for individual surveys has not been identified as a high priority.
Temporal variation: Indications on the age of the data is valuable to provide the validity of the data (especially with respect to areas of high sedimentation levels).
Compatibility with already existing format or specifications (S-57, DNC, AML, …).

In addition, it was quite clear that nobody wanted to be tangled up in chart projections and non regular chart scheme. Working in geographics certainly fits what we have got in place now with S-57 spatial reference frame.

Building on the discussion of the S-100 workshop, we started asking ourselves if we were on the right track with the S-57 files we generated for the seaway corporation. The product was respecting S-57 spatial reference frame but the grid used were all projected grids. Therefore, if we had to deliver grids to our client we would have found us in a dead-end because everything was based on the Mercator projection. The clients are clear, they do not want to be tied to a projection so the only way out is to generate our grids on a geographic reference frame. Practically we won't grid at 1 meters but at something like 0.00002 degrees… If we push further, what about the file extent ? The extents of the files done for the seaway were about 1 kilometer long but that will not work everywhere. Every organization involved in hydrographic surveys uses different survey zones, we certainly don't want to be tied to something that won't hold the road everywhere. In the mean time the S-101 ENC Product Specification (August 2007) is talking about going toward three usages. With that in mind, we are pushing forward to work with rectangular geographic cells. We could think about the following arrangement:

Harbour entry – current approach and harbour scale data sets combined (Navigation from the pilot point to berth).
Proposed extent = 0.02 degrees X 0.02 degrees

Coastal – medium scale continental shelf (for coastal navigation and approach to pilot points).
Proposed extent = 0.1 degrees. x 0.1 degrees

Overview – small scale world (route planning and oceanic passage).
Proposed extent = 1 degrees x 1 degrees

In reality, that arrangement fit the S-57 spatial reference system (max resolution 0.0000001). Working with multiples of 0.0000001, we make sure we have a coherent schema. Following that line, we can propose some grid resolutions.

Harbour entry *0.02 degrees / 1000 = 0.00002 degrees*
Coastal *0.1 degrees / 1000 = 0.0001 degrees*
Overview *1 degrees / 1000 = 0.001 degrees*

Using that scheme, we do not have to maintain any specific survey zone frame. The geographic rectangular cells save many complications. Like traditional marine chart portfolio, some areas will be covered by the ``Harbour entry`` type cells and in others areas only the ``Overview`` will be available because the source data is not suitable to support a high-resolution grid. Creating products using a scheme like this help putting some automatic processes in place for product creation. What you need is a data warehouse where you put all your survey surfaces at maximum resolution. Next, you want to extract from that data warehouse, combine the surfaces, generalize and defocus using parameters that suits the product usage, and finally use the geographic cells has a cookie cutter to generate your products. Seems simple, it must be simple because the numbers of cells to generate will be impressive. As mentioned before, one thing that we are still missing is the capability to grid in geographic coordinates. It is important because if you try to cut a Mercator grid using a geographic cell scheme you will end up with data gap at the borders. Creation of the first issue of the cells is likely to occur in the ``Harbour entry`` usage. This is the area where the pressure is on to provide more detailed information to the people involved in maintaining, managing and navigating in restricted waters. One thing were bathymetry layer will not be a great benefit is for example, along wharfs. S-57 has a horizontal resolution of 0.0000001 degrees, grids in the ``Harbour entry`` usage will use resolution of 0.00002 degrees (1-2 meters at latitude 48). The result of this is that we will not have a perfect fit between the wharf line and the bathymetry layer. Because of the horizontal resolution difference, it is just not possible.

Updating theses grids in a timely manner will be a challenge. Working with cells will help. Every new survey coming in will have a survey extent. Using that extent it will be easy to know which cells will need updating. Updating the bathymetry layer will be quite different from what we know from S-57. A cell update mean a new cell will need to be computed and put in the products warehouse. Without going too much in detail, efficient data processing and quality control from end of survey to cell update will be the key to fast turn-around time. Manual intervention must be kept to a strict minimum all along the way.

From a data producer point of view, we have big concerns about distribution and updating of the products. The traditional way of updating marine chart does not fit with that approach. On the producer side, emphasis will be put on automation, the same thing must happen on the user side. To support that, we could adopt strategies that are working well in others area. Think about the way our antivirus software works. You install the software, the minute installation is completed the software connect to the internet to see if updates are available, and if so downloads and install the updates. Internally, logs of transactions are kept so software is able to keep track the updates. That method, could certainly be use to distribute and update high-resolution cells. On the producer side, we need to put in place a web service for distribution and updating. On the user side, the software used to work with bathymetry cells must be able to connect to that web service and interact with it to download the required files. Wireless internet access coverage is growing

very fast and this is an opportunity we must use to improve the way products are passing from data producer to data user. Of course, software manufacturers will need to develop functions that will be able to connect to web services, they are part of the total solution.

For about 10 years now hydrographers use grids to help them interpret, clean and analyze bathymetric data. Software manufacturers involve in data processing worked hard to give great tools to hydrographers to they can be efficient in their work. Great experience was aquired during theses years. Now that we close to providing grids to a wider audience that expertise must be transferred to end users and software manufacturers that are on the end user side. Of course, training will be a major issue. High definition cells will be use to take critical navigation decisions so people working with this information must have the proper training to use to the data to their benefit.

The St-Lawrence River is one of the test areas for the next standard for gridded bathymetry. Seamless vertical datum, water level models, squat models, high-density source data, frequent surveys… are all in place. In the test, we want to make sure we have the total solution, from survey to bridge. Many challenges need to be address. Selected solutions must use new and emerging technologies to ensure efficient and secure workflow.

References:

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