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Open standards and formats used in the implementation of a marine spatial data infrastructure at The Directorate of Hydrography and Navigation of the Brazilian Navy

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1. Introduction

In the last few years, the Brazilian economy has been growing to the point that today Brazil is one of the biggest markets in the world. This is also due in great part to the attention the nation pays to its coast, ports and rivers in an effort to guarantee proper use of natural resources and safe transportation through its massive water bodies.

Hydrographic organizations around the world are responsible for the compilation and management of large volumes of marine spatial data, which is used primarily to ensure safe navigation within their national waters, as well as the proper management of natural resources, national security, environmental protection and many other tasks that are essential to the existence of a nation. The Directorate of Hydrography and Navigation of the Brazilian Navy (DHN) is responsible for mapping the Brazilian jurisdictional waters and creating and maintaining the corresponding nautical cartography and related products. Although hydrographic mapping can be financially costly it is a very important matter for nations, especially in a large country such as Brazil, where natural resources are one of the main components of the country's economy.

2. Mapping the Brazilian waters

Charting the Brazilian waters is not a simple undertaking, especially given that Brazil has a coastline of approximately 8.500 km, its economic exclusive zone is approximately 3,500,000 km^2 and there are more than 40.000 km of navigable inland waterways that need to be mapped and maintained. The implementation of a marine spatial data infrastructure is helping DHN in mapping Brazilian waters in order to provide better data, products and services to the mariners and stakeholders, and also will be able to reduce the production times.

According to the International Hydrographic Organization (IHO), a nautical chart is defined as a cartographic product specifically designed to meet the requirements of marine navigation, showing depths of water, nature of bottom, elevations, configuration and characteristics of the coast, existing dangers and aids to navigation. These real world features can be represented in a paper chart, electronic navigational chart (ENC) or a raster navigational chart (RNC) which are also referred to as nautical charts, hydrographic charts, or simply charts. DHN has the mandate to produce paper charts, ENCs and RNCs for the maritime sector, as well as for the inland

waterways. In order to be able to tackle the creation and maintenance of these nautical products DHN has to follow different international open standards and specifications, such as IHO S-4 and INT1/INT2 for paper chart production and the IHO S-57 for ENC production. In addition, there are also standards and product specifications for Inland ENC production that are regulated by the Inland ENC Harmonization Group (IEHG). At the moment DHN has to maintain around 660 paper charts for the maritime and inland waters as well as 137 ENCs and there are plans to produce around 20 ENCs more in order to cover the main ports and the Brazilian territorial waters.

3. Data volumes

The volume of hydrographic data that can be collected is huge and it creates new requirements to handle the increasing data volumes in processing, management, and analysis as well as product creation. For example a quick and coarse estimation suggests that 2TB of disk space may be required per 24 hours of high resolution data collection of imagery and bathymetry in order to use this information to determine depths and classify the nature of the seabed and identify obstructions and ship wrecks, which constitute in themselves potential hazards to navigation.

The bathymetric data from hydrographic surveys, until about 2010 was stored in "flat files", making it difficult to search the data and organize metadata. The use of bathymetric databases to store this information, along with associated metadata, has been very beneficial. The metadata can be used to search for bathymetry data within the database and can provide the criteria for data manipulation and analysis. Metadata compliant with the ISO19115 standard can accompany data exported from the system so that the data can be used by others with confidence.

4. Challenges and data storage

With the increased volumes of data being collected and the demand for multiple products Hydrographic Organizations are entering the realm of “Big Data” and the proper management of this data constitutes a very big challenge for agencies. There is a myriad of occurrences in which the same marine spatial information can be used to satisfy requirements for a wide range of other applications including; defence, coastal zone management, environmental studies, natural resources management, fisheries, security, inundation modelling and many more. The implementation of a Marine Spatial Data Infrastructure (MSDI) using open industry formats and standards from organizations like the International Hydrographic Organization (IHO), International Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC), allows DHN to ensure interoperability within the organization and with other stakeholders, as well as increase the use of the marine spatial information in the greater GIS community.

In 2009, DHN initiated the migration to a new solution for the cartographic production, based on a computing environment where all cartographic features are stored in a single Oracle database. The cartographic products (paper charts, raster charts and ENCs) are produced from the same source information, stored and validated in the database. This integrated solution ensures consistency between products eliminates redundancies in the validation and facilitates the better synchronization in the production of paper charts, raster charts and ENCs. The data is

stored using the S-57 data model that is an open format and standard for transfer digital hydrographic data. The changes in workflows from traditional file based chart production systems to the use of relational database management systems with open standards and formats as well as the implementation of metadata profiles allow DHN to gain efficiencies in the administration, visualization, production and distribution of data, and data storage.

5. Discovering marine data

The hydrographic data is not being used only for nautical chart production and DHN would like to make the data more accessible for the general public and other stakeholders through open standards and formats for web mapping. In 2014 DHN started a pilot project to extend the workflows to include data distribution via web. The idea is to distribute through the web some of the data including, vector representations, raster charts, and bathymetry in the near future. The OGC services; WMS (Web Map Service) will be used to allow users to browse the map, WFS (Web Feature Service) will be used for query and features download, and WCS (Web Coverage Service) will be used for bathymetry data downloads.

6. The use of marine information beyond the nautical charts

The use of marine information will be maximized in the near future with the adoption of the new Universal Hydrographic Data Model S-100, developed by the IHO. The S-100 standard will use and extend the ISO 19000 series of geographic standards for hydrographic, maritime and related information. A new series of product specifications based on the S-100 standards will be developed for nautical charting, Nautical Publications, Gridded Data, Maritime Boundaries, etc. The new S-100 data model is a more flexible standard than the previous S-57 one and will allow DHN to provide hydrographic and marine information in a more interoperable way and the data will be discoverable by more users because there will be more compatibility with web services for analysis and access to the data and products. The use of extended metadata included in the S-100 standard for the hydrographic data will also help DHN and the users to have more information about the data and the products.

7. Conclusion and benefits

At the moment, there is a big effort to migrate the hydrographic related data from different formats and in single files to this database driven environment, because the data validation should be made during the data compilation process and not on the products. After this initial phase, the production of the first products, and their maintenance (update) becomes faster, since the system indicates to the reviewer only what has been modified and needs to be validated. In 2014, the first paper charts were produced using this new system. The paper and raster nautical charts of the Tocantins River were produced following a new production work-flow using databases for bathymetric data collected during the hydrographic surveys, and for the cartographic production. The systems are fully compatible and use interoperable open standards that allow optimizations in the production work-flows, reducing the time for the generation of various products and traceability of cartographic information because the features are stored once but used many times. The system is ready to extend the data model to support the new S-100 which will make the use of hydrographic data easier and allows preparing and integrating the additional layers of information into the web mapping application that is a key component in this MSDI implementation.