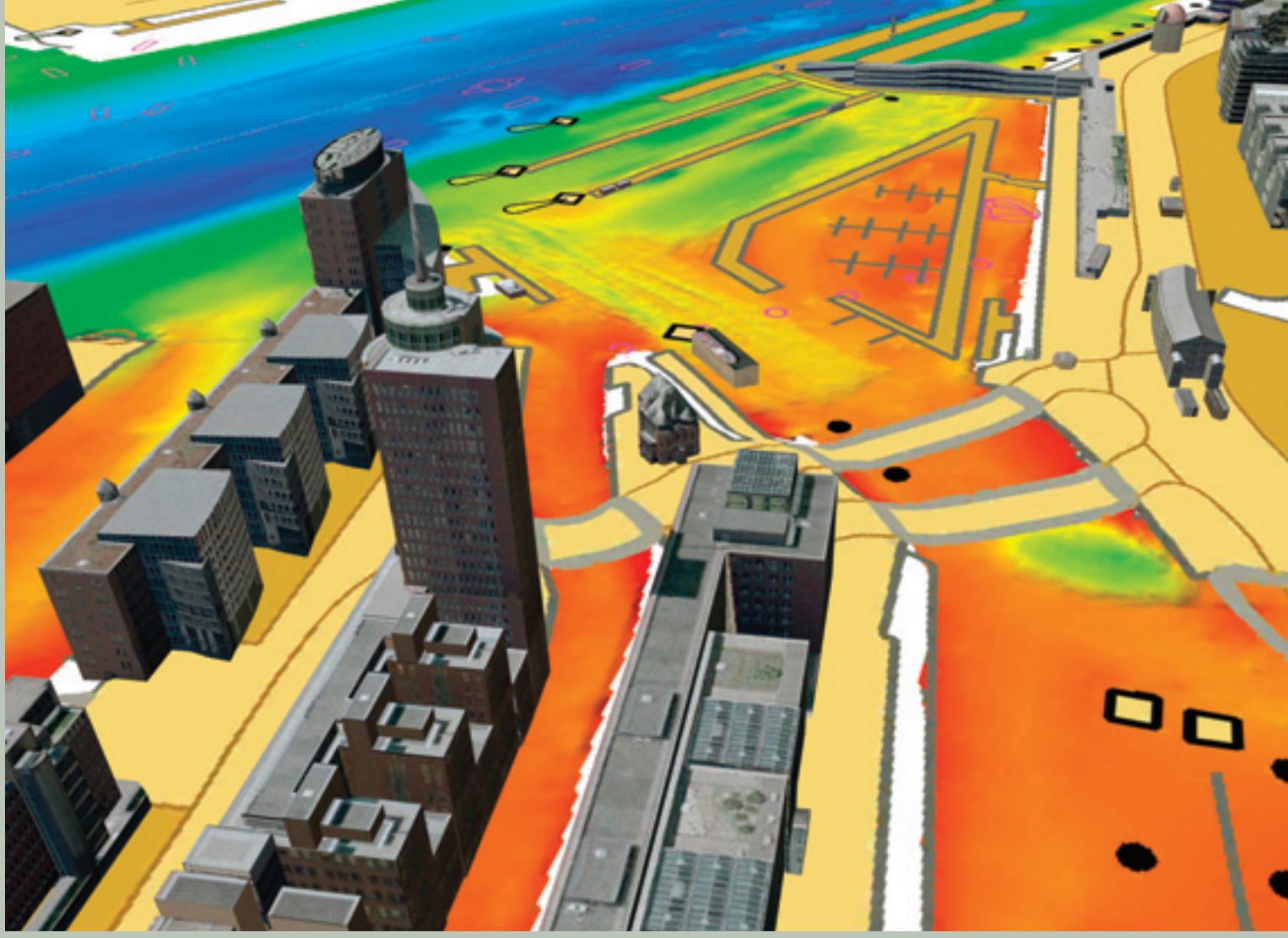


MARINE SDI FOR HYDROGRAPHIC

HOW HYDROGRAPHIC SURVEYS CAN BENEFIT FROM IMPLEMENTATION OF MARINE SPATIAL DATA INFRASTRUCTURES

MAIN IMAGE: HafenCity: Produced by the Hamburg Port Authority using CARIS BASE Editor and CARIS HIPS and SIPS, this is a 3D image of the biggest European inner city construction site with bathymetry shown in Google Earth. At around 155 hectares, HafenCity is one of the most prominent city centre development projects in Europe and will increase the size of Hamburg city centre by 40 per cent.

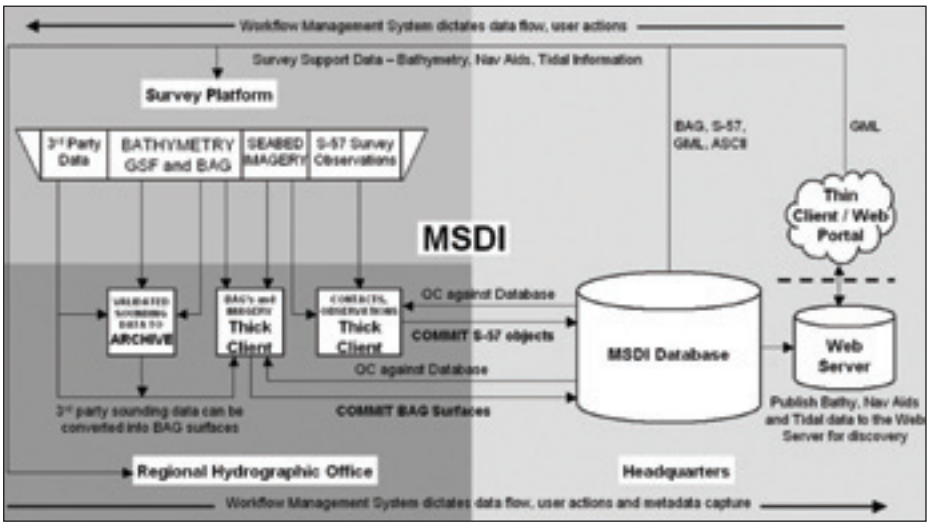
Hydrographic agencies could benefit greatly from a Marine Spatial Data Infrastructure (MSDI) that gives easy access to its hydrographic spatial information. An MSDI can provide agencies with robust data management for costly data resources; it can ensure valuable metadata is captured for these resources; it will allow easy data discovery so that others in the agency can find data, enhancing inter-agency data exchange. A MSDI sample follows which outlines the workflows required in establishing an MSDI that handles hydrographic information and facilitates its integration in a National SDI (NSDI).

Geospatial information made available through an MSDI is accessible because of its interoperable nature. The sample MSDI deals with three main hydrographic data types: Bathymetry, Navigational Aids and Tide. In order to describe this MSDI t workflows areas have been explained:

- Workflows adopted by the Survey Platforms for MSDI access before survey launch,
- Workflows adopted by the Survey Platforms for data deliver to the MSDI, and
- Workflows followed by the Regional Hydrographic Offices when dealing with incoming data from the Survey Platforms.

Support Data for Survey Platforms

Hydrographic Survey Platforms require a variety of support data before starting a new survey mission. Extracting to files or accessing this data directly is a good fit for a MSDI. Such data could include information



Typical architecture for the proposed MSDI

about existing charted bathymetry, location and appearance of navigational aids in the area in question and the tidal models for the survey area.

All available information should be locatable with easy catalogue searches through a central Portal. The search will return all relevant information about the area in question. These catalogue searches will likely be based on entry of geographic coordinates or by keyword searches based on populated ISO 19115[1] metadata. A web-mapping interface should also be available through the Portal allowing the results of the catalogue search to be viewed graphically [2].

Bathymetry Data for Survey Platforms

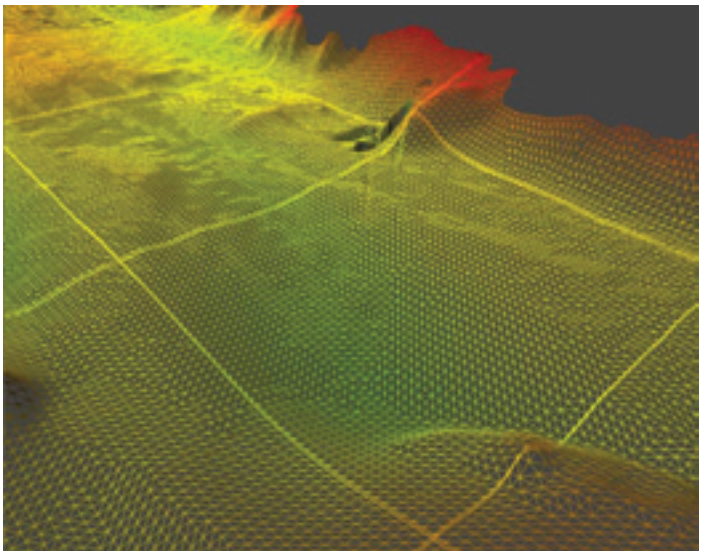
An agency's bathymetric data (e.g. sounding sets, DEM's) should ideally reside and be managed in an interoperable database capable of storing gridded arrays and point clouds. Modern hydrographic surveys generate very dense bathymetry datasets and will require a great deal of disk space.

Prior to conducting a new survey, a search for existing bathymetry data in the area in question should be performed through the Portal. The relevant surveys should be listed based on geographic extent or keyword content searches and the information provided about the physical location of the dataset within the database. The bathymetric DEM's from previous surveys should also be viewable through a thin web-mapping client (HTML based client that connects to a web server) that can draw data from the database through a bathymetry web service.

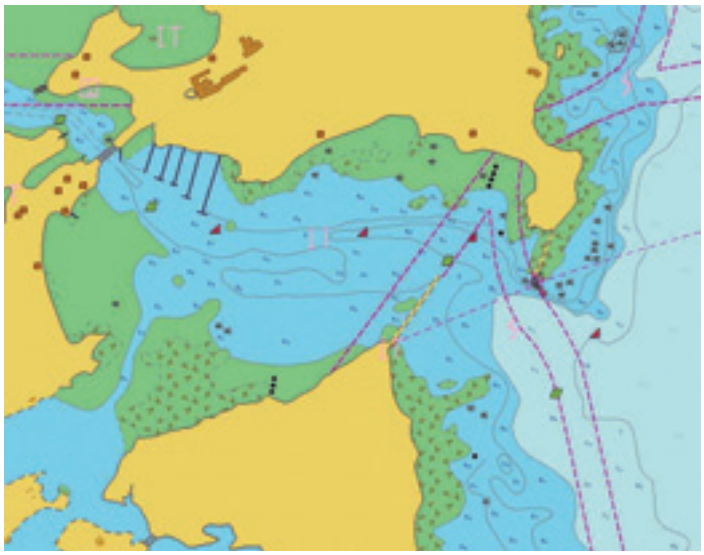
Thick clients (a desktop application with a dedicated purpose that is used to manipulate the data in the database) of the database can be used to locate the actual surveys displayed in the catalogue or web map. These surveys would ideally utilize the Bathymetry Attributed Grid (BAG) [3] format, which is an open format that is quickly becoming recognized as the standard for gridded bathymetry data. The BAG files generated will contain ISO 19115 metadata. Non-gridded bathymetry datasets that reside in the database can be extracted as ASCII XYZ with an accompanying ISO 19115 XML file.

Navigational Aids for Survey Platforms

Navigational aids (e.g. lights, buoys) should reside and be managed in an interoperable database capable of storing point, line and area vector objects. The navigational aids are used for mission planning, shipboard operations and spatial context within the survey area. The navigational aids that exist in the database should be viewable through a thin web-mapping client connected through a special web service. The bounding polygon that contains the navigational aids will be viewable and available for query and each navigational aid should be selectable and exportable from the thin client as GML [4].



Bathymetry data is a key component of an MSDI



Navigational aids data is another important element in any Marine SDI

Alternatively, a thick client of the database can be used to access the appropriate of navigational aids and allow an extraction to an S-57 000 file [5].

Tidal Information for Survey Platforms

Tidal information (stations and tide models) should reside and be managed in an interoperable database. This tidal information is useful for mission planning in order to determine survey line plans based on available water depth and for tidally reducing the soundings that are collected during the survey.

Prior to conducting a new survey a search for tidal information in the area in question can be performed through the Portal. The relevant ports should be listed based on geographic extent or keyword content searches, links should also be provided to the tide models in question that reside within the database. Tide stations will have ISO 19115 metadata associated with them.

The tide stations should also be viewable through a thin web-mapping client connected through a special web service. The tidal models and the locations of the tide stations and their appropriate attributes should be viewable. The station locations should also be selectable and exportable from the thin client using GML.

A thick client can be used to examine the tidal characteristics of the survey area in question. These tide models can be extracted as ASCII tide files and be applied to the bathymetry onboard.

Deliverables from Survey Platforms

The Survey Platforms conducting a survey mission produce a variety of deliverables. These deliverables must undergo the appropriate quality control procedures and have metadata associated with them by relevant experts. These deliverables must then be committed into the MSDI so that a) products can be derived and b) to ensure that the data can be discovered again in the future, either for survey support or further analysis.

Such deliverables would include bathymetric survey data in various forms, information about specific targets or exceptional areas, seabed imagery in the form of georeferenced mosaics and digital survey observations relating to existing or new navigational aids.

Bathymetry Data from Survey Platforms

Bathymetry data is not only acquired by the hydrographic agency in question; other agencies, such as geological surveys and possibly third party survey contractors, may also gather data. It is therefore likely that incoming bathymetry will have been collected using different sensors and processed using different software. With this in mind it is essential to standardize on a format for storage of bathymetric data within the MSDI. Two open and increasingly recognized standard formats are GSF [6] for the archived full density bathymetry data and BAG format for the bathymetric surfaces or DEM's, which will be stored in the Database. Bathymetric data in either of these formats could be deliverables from the Survey Platforms to the RegionalHydrographic Office.

Seabed Imagery from Survey Platforms

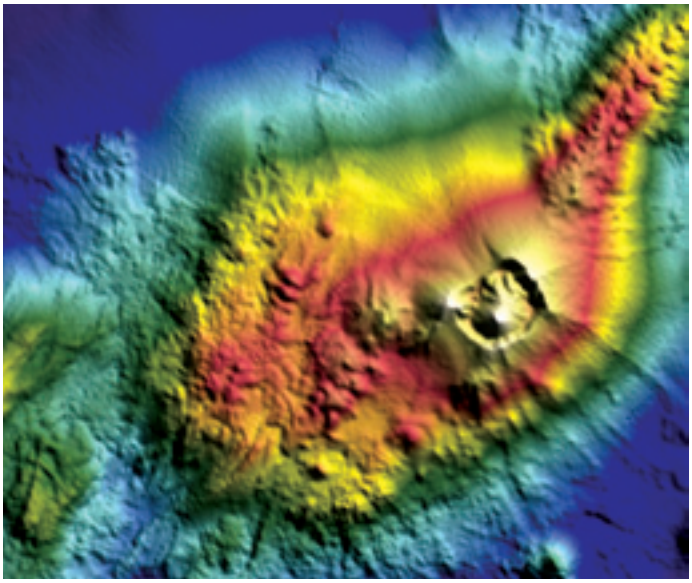
Backscatter data from multibeam sonar is a source of seabed imagery. This imagery data is likely to be accommodated by the BAG format in the future. With this in mind, a valuable evolution of the MSDI will be to store seabed imagery in the database alongside the bathymetric BAG surfaces. This could be a deliverable from the Survey Platforms.

Seabed Contacts from Survey Platforms

High-resolution bathymetry and imagery from side scan sonar or sonar backscatter can be used for contact detection which is a required deliverable from some surveys. The Survey Platform should be able to digitize these contacts digitally and encode them using S-57, to ensure easy incorporation into the MSDI.

Navigational Aids from Survey Platforms

In addition to bathymetry data and sonar contacts, another deliverable could be other hydrographic observations from the survey mission. For example, if a navigational aid such as a light is out of position when



Caldera in the Monzier Rift - image produced from data collected during surveys conducted by Univ. of Tasmania, supported by Geoscience Australia, processed using CARIS HIPS and SIPS.

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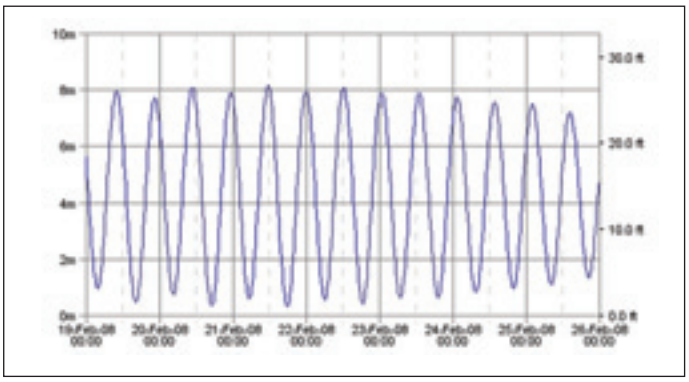


Tidal information is key to all MSDIs]

Example of the Hydrographic Data Discovery Portal

compared to the information that was supplied to assist with mission planning, then an observation should be captured digitally as an S-57 object. S-57 would allow the Survey Platform to not only capture the positional information about the observation in question but also add attributes and additional notes describing the reason for making the observation. These observations would be recorded in 000 files, which would be delivered to the Regional Hydrographic Office.

Incorporation of deliverables into MSDI by Regional Hydrographic Offices

It is anticipated that Regional Hydrographic Offices would conduct further quality controls on the deliverables of the Survey Platform. Once the data is accepted, relevant experts at the regional office would associate additional ISO 19115 metadata using a cataloging utility that is accessed within the Portal. It is expected that the standard ISO 19115 profile will be extended to meet the required level of attribution. Once these quality control and metadata tasks have been conducted the survey deliverables will be committed to the database at headquarters for incorporation into the MSDI.

Bathymetry into MSDI by Regional *Hydrographic Office*

The incoming BAG surfaces may already have been partially populated with metadata captured at the time of data acquisition and processing. The BAG surfaces will be catalogued and additional metadata populated through the Portal. The complete metadata profile for the BAG file will be stored in a XML file encoded using the ISO 19139 standard [7]. The thick client should be used to commit the BAG surfaces to the database using the following suggested workflow.

A regional expert will define a survey object in the thick client. This is a bounding polygon covering the entire survey mission area. Survey objects could have more than one BAG surface associated with them, as it is possible that multiple ships were acquiring data. The survey object should have its own metadata fields that relate to the mission in general e.g. project name, vertical datum, horizontal coordinate system, time frame. Once defined, the associated surfaces are added to the survey object and stored in the database. The survey objects and their corresponding surfaces will now be available for future discovery.

When a thick client user connects to the database they will see bounding polygons of all the survey missions that are recorded in the database. They will also see the coverage polygons for each of the corresponding surfaces / DEM's. Both survey and surface objects can be selected and their metadata profiles displayed.

When soundings and contours are derived for production purposes, metadata from the survey and surface objects will be used to auto-populate the S-57 attribution that is associated with SOUNDG and DEPCNT objects. This will give a complete audit trail back to the original survey data.

Seabed Contacts into MSDI by Regional Hydrographic Office

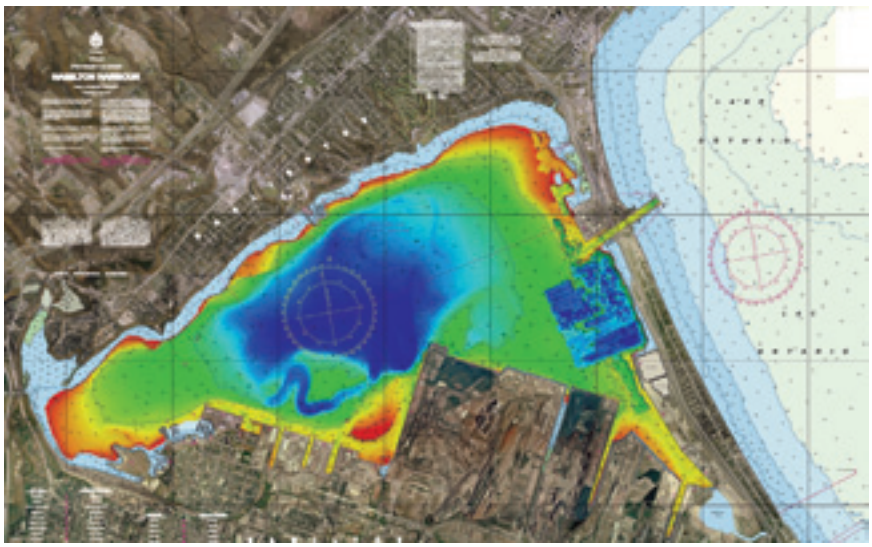
The incoming contact information from the ships will be in 000 format. The Regional Hydrographic Office should be able to open the 000 as a background layer in the thick client of the database. The new contacts should be compared to wrecks, rocks and obstructions that already exist in the database for discrepancies and to replace the data where applicable.

Hydrographic Observations into MSDI by Regional Hydrographic Office

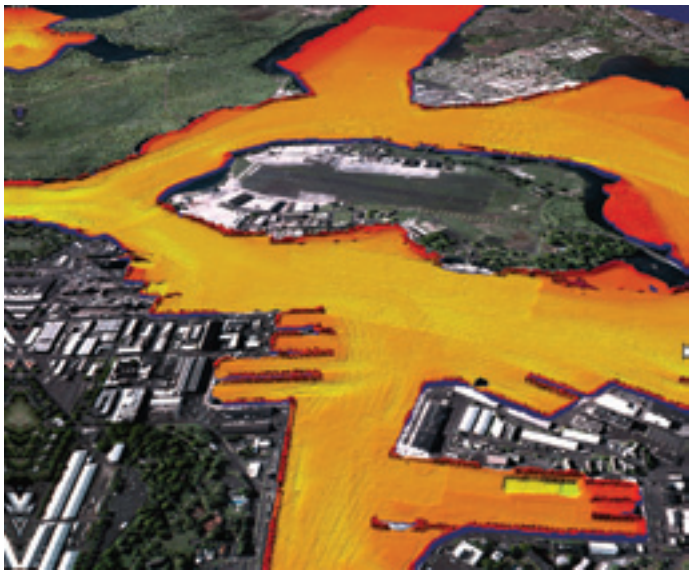
The incoming hydrographic observations will be in 000 format. These files will be catalogued and additional metadata captured through the MSDI Portal. Using the thick client, the regional expert should display each 000 file as a background layer in the thick client. This client should be connected to the database allowing the Regional Hydrographic Office to compare the incoming observations against the current content of the database for discrepancies and to replace the data where applicable.

Conclusion

The MSDI described here has an interoperable database core. The data that resides in this core can be accessed through thick clients, via industry standard formats like S-57 and BAG, or thin web clients that use OGCä [8] formats like WMS and WFS. All the data that enters the



Hamilton Harbour - composite in CARIS Bathy DataBASE of Hamilton Harbour navigational chart produced by Canadian Hydrographic Service, orthoimagery and 3D rendering of harbour bottom using multibeam bathymetry processed with CARIS HIPS and SIPS.]



Pearl Harbor - Pearl Harbor Naval facilities from CARIS BASE Editor looking west toward Ford Island. US Army Corps of Engineers Portland and St. Louis Districts collected the bathymetry for the US Navy.

MSDI will have metadata associated with it to aid easy discovery, the ISO standard 19115 will form the basis of this although it will need to be expanded to meet the metadata needs of hydrography. Both the metadata capture and subsequent data discovery will take place through the MSDI Portal. The Portal should utilize the latest web mapping and catalogue technology.

MSDI has been recognized internationally as very important to hydrography. Agencies responsible for hydrographic data would benefit greatly by having easy access to their own data while meeting a growing need and desire for nations to share hydrographic data. Furthermore, other related agencies and departments within a nation can avoid duplication of effort by sharing their data interoperably.

Service Hydrographique et Océanographique de la Marine (SHOM) [9] is one agency who is adopting an MSDI approach to data management and discovery. SHOM is the agency responsible for hydrographic and oceanographic data in France and is working with CARIS, a Geospatial Software Solutions provider, to implement an MSDI for its hydrographic data.

References.

[1] ISO 19115:2003 defines the schema for describing geographic information and services - www.isotc211.org.

[2] the OGC's OpenGIS Web Map Service (WMS) Implementation Specification was adopted as international standard ISO 19128 - "ISO 19128:2005 Geographic information - Web map server interface" in 2005.

[3] The Open Navigation Surface Working Group (ONSWG) develops and maintains the BAG format specification - see www.thsoa.org/hy05/05_4.pdf.

[4] To learn more about GML please see www.opengeospatial.org/standards/gml.

[5] IHO S-57 is the IHO transfer standard for digital hydrographic data - see www.iho.shom.fr/publicat/free/files/31Main.pdf.

[6] GSF is a generic format for a variety of sensors developed for the US Naval Oceanographic office. See the specifications at www.ldeo.columbia.edu/res/pi/MB-System/formatdoc/gsf_spec.pdf.

[7] ISO 19139:2007 defines Geographic MetaData XML (gmd) encoding, an XML Schema implementation derived from ISO 19115 - see www.isotc211.org.

[8] Open Geospatial Consortium develops geomatic interoperability specifications - www.opengeospatial.org.

[9] SHOM – Service Hydrographique et Océanographique de la Marine - www.shom.fr

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