The Digital Hydrographic Office – Challenges and Prospects of Hydrography in the Evolving Geographic Information Infrastructure

Horst Hecht
Federal Maritime and Hydrographic Agency (BSH), Germany
Hamburg•Rostock

1. Introduction

The task traditionally given to Hydrographic Offices is to provide for reliable surveys of the waters in the area of responsibility, and to deliver a nautical information service to commercial and naval shipping, consisting of charts and nautical publications. It is probably for that reason why this paper has been associated with a session on ECDIS. Likewise, Hydrography is often interpreted as *"That branch of applied science which deals with the measurement and description of the physical features of the navigable portion of the Earth's surface and adjoining coastal areas, with special reference to their use for the purpose of navigation."* [Hydrographic Dictionary, IHO Pub. S32]

No doubt, navigation-related services will remain a core business for Hydrographic Offices. But will that be sufficient, for HO´s to meet the demands they will be facing in the longer run? The following considerations examine the potential of hydrography beyond the scope of navigation, and try to derive a recommendation for the future orientation of Hydrographic Offices.

2. Revisiting the term "Hydrography"

The definition of hydrography given above is a historical one reflecting basically times when the seas have only been used for shipping. The purposes of shipping were sea transport, fishing and warfare. Obviously, providing for safe navigation was the pre-eminent objective of hydrography.

Positioning has been improved several times since, and has reached, with today´s GPS, a level of reliability even unimaginable in the old times. Other technologies have developed in addition, not only communications and computer technology, but also technologies to gradually explore and utilise sub-marine resources.

It is nothing new that new technologies enable new applications which, in turn, open markets for new technologies. This has happened also with hydrography: Satellite positioning, sophisticated high-power computer technology and electronic communications have made hydrographic surveying and oceanographic data measurement more efficient, using e.g. multibeam echosounding systems or doppler current meter profiling systems. At least the Continental Shelves are increasingly becoming explored and utilised by offshore technology, fish farming or wind driven power generation plants. Japan has even built a large offshore airport on its continental shelf. All this requires extensive knowledge of the sea floor and the dynamics of the water body, and even its biology.

Already in 1978, experts assembled at the 2nd United Nations Regional Conference for the Americas recognised the need to considerably extend the scope of the term hydrography. They proposed (quoted after "Challenges and Opportunities Canada") the following definition for hydrography:

Hydrography: The science of measuring and depicting those parameters that are necessary to describe the precise nature and configuration of the seabed, its geographical relationship to the land mass, and the characteristics and dynamics of the sea. The parameters encompass bathymetry, geology, geophysics, tides, currents, waves, and certain other physical properties of the sea water." (The definition goes on describing the primary use of the data and the most important applications relevant at those times).

The term "depicting" refers to the, at those times, almost only way of making the data available to the user by visualising them cartographically. From today´s perspective, this seems to be too narrow. More generically, I would suggest to replace "measuring and depicting" by "measuring and processing". It is no longer the cartographic presentation which is the only possibility to make use of the data: the methods provided by computer technology are far more comprehensive and flexible, allowing many more ways of exploiting the data. For example, the results of a hydrographic survey using a multibeam system may be used as a high resolution digital terrain model of a complex sea bottom within a hydrodynamical model to study the current regime of the sea area, e.g. for off-shore construction purposes.

Hydrography, in this broader scope, has been given much attention by the United Nations Convention on the Law of the Sea (UNCLOS) as the science necessary for determining the limits of the maritime boundaries. This is being outlined in a number of articles of UNCLOS, and additionally technical committees associated with the operation of UNCLOS require the participation of hydrographic experts. This is well known. Less well known, though, is that UNCLOS in Section 3 in Articles 275, 276 and 277 requires signatories to operate national and regional marine scientific and technological centres "in order to stimulate and advance the conduct of marine scientific research, and to enhance their national capabilities to utilise and preserve their marine resources for their economic benefit". Article 277 explicitly mentions "acquisition and processing of marine scientific and technological data and information" as one of the prime functions of regional centres. This reference to “data and information”, in my view, essentially embraces in short terms the core of hydrography today and in future.

Traditionally, hydrography has always been related to the marine sphere. However, also inland waters like rivers and lakes must be taken into account, as there is little difference in the data related to these waters, and the techniques and methods employed to collect them. It would be more appropriate, therefore, to refer to the hydrosphere in general as the domain of hydrography.

This leads to the following attempt for a new, more comprehensive definition:

"Hydrography is the total set of spatial data and information, and the applied science of its acquisition, maintaining and processing, necessary to describe the topographical, physical and dynamical nature of the hydrosphere and its borders to the solid earth, and the associated facilities and structures."

This definition has something in common with the definition of the term "chart" provided by the new Chapter V of SOLAS: It attributes highest priority to the set of data. One can see this as development going on not only in hydrography but everywhere: The versatility of use typically associated with digital data bases has made data bases becoming often more important than products derived from them.

3. Geo-spatial Infrastructure

We have to distinguish between two basic types of services to be provided by HOs:

- product services, such as provision of paper charts and ECDIS data for mariners,
- data and information services, mainly for professional experts, e.g. Coastal Zone administrators, and commercial companies wishing to develop value-added products and services

The first service type can well be served by traditional means of distribution, e.g. ECDIS data compiled on CDs. This will not be considered here. So the following considerations will focus on spatial data services.

The internet leads to very interesting sites providing information about initiatives concerned with the development of a geospatial infrastructure, such as:

- The National Spatial Data Infrastructure (NSDI) – implementation plan for the Department of Commerce (www.esdim.noaa.gov)
- The Big Picture: Digital Earth and the Power of Applied Geography in the 21st Century (www.digitalearth.gov),
- Global Spatial Data Infrastructure (GSDI) (www.gsdi.org),
- Distributed Geolibraries – Spatial Information Resources (www.nap.edu/html/geolibraries/,

just to mention a few.

The US and Canada must be credited for having been the first countries recognizing the potential of geo-spatial data. It is not surprising therefore that the initiatives for establishing a geo-spatial infrastructure basically all have their origin in North America.

It is the objective of all these initiatives to facilitate access to geo-spatial data for all purposes. To quote from "The Digital Earth": *"The Digital Earth will be a virtual representation of our planet that*

enables a person to explore and interact with the vast amounts of natural and cultural information gathered about the Earth."

It is important to note that all initiatives focus on providing access to the data, not any derived products. Software today is powerful enough allowing one to create a product yourself, tailored to your own needs. This certainly will not eliminate the need for pre-defined mass products like printed charts or maps just because they are mass products which can be produced efficiently. But it is the individual use of the data which increases in importance with growing availability and efficiency of access.

Government offices, with or without partners from the private sector, still play a key role in geographic information as they are the responsible authorities for nationally collecting and maintaining geographic data as a public good. The re-invention of government as "E-Government" has opened in some countries already free, at least as yet, access to geographic data virtually unavailable before. In other countries, such data are getting been marketed already by government agencies as commercial data.

The activities and visions described in the various geospatial initiatives are almost completely focussing on topographic data. Hydrography – if mentioned at all – is playing a minor role. One can speculate about the reasons for this situation: the public demand for topographic data, and its associated commercial value, seems to be much higher, or at least much more obvious, than for data of the hydrosphere. This may be so because obviously no people are living permanently at sea.

On the other hand, in many if not most countries, the economy, social life, natural environment are depending one way or the other on the sea. Many may still be believing that it is navigation what hydrography is all about, a service satisfied by nautical charts. However, the Internet is changing our life, and to a rapidly growing extent we are becoming information consumers, rather than users of hard products. For somebody looking for some data or information, it has become customary to first search the Internet.

John Spittal, Chief Hydrographer of New Zealand, has stated in his paper "A Future for Hydrographic Authorities and Industry" (unpublished) that *"It is unwise to assume that the all embracing products and services of the past will continue to satisfy all of the needs of the future information users. It is more likely that market segmentation will occur and each sector will require their own tailored solution*."

In times of downsizing Government, Hydrographic Offices will hardly be in the position to address a wider variety of market segments, let alone markets they are even not yet aware of. Fortunately, the technology today permits to serve all markets with that subtle matter all products and services are based on: The source data.

Of course, a set of digital information is also a product, but depending on its structure, it is versatile, ready for getting transformed into many different representations, and input into complex information

processing systems. The obvious solution, therefore, is instead of customizing products and services to every market segment, provide the sets of data from which the user can derive the products himself, and from which industry can develop market-oriented services. The intrinsic versatility of information will in turn change markets, and may bring about more diverse applications. Nicholas Negroponte in his famous book “Being Digital” (Alfred A. Knopf Inc, 1995) calls this paradigm shift “*the change from atoms to bits*” – the change from hard physical items towards immaterial information, and he states that this change is “irrevocable and unstoppable”.

Thus: *Hydrographic information is the true asset owned by HOs. The business of HOs will move from product development towards provision of hydrographic information services.*

Every “hard” product, i.e. a product in the traditional meaning, has an individuality that only allows for being transported as a single entity. Information can be broadcast, transmitted via, or accessed through communication channels thereby will automatically, and at almost no cost, reproduce, i.e. copy itself. Communication is the means to share information between many interested parties. And the existence of information will establish the demand for getting access to it. Thus information ultimately will lead to networking for the information exchange.

Any evolution of hydrographic information provision services will meet with the currently forming geospatial data infrastructure driven mainly by the purposes of topographical data usage. It appears very unlikely that a hydrographic data infrastructure could develop and survive in isolation: hydrography will rather be absorbed soon within the all-embracing geospatial data structure. This is something the HOs as the hydrographic information service providers must prepare themselves for.

The conclusion, therefore, is: *Hydrography will complement the evolving, at present strongly topography-dominated spatial infrastructure towards a comprehensive geospatial data infrastructure.*

All what can be seen yet is what is accessible through the Internet. While geospatial data are offered by some websites for download (particularly US government sites like NOAA), most geographic information on the Net is just products like chart or map images. A functioning geospatial data infrastructure doesn´t exist yet; it is still a vision. Such a data infrastructure depends on the existence of a set of widely accepted data standards, which ideally are mutually interoperable, and, based on these standards, geospatial data sets and applications powerful enough to process them, and to develop on-demand products.

Digital cartographic information certainly is available in large data sets already today. However, these data are typically derived from charts and maps, for the purpose of rationalizing maintenance and production of the same type of products. Their data sets are built from graphical features; and geographic space is described by means of graphically represented items just as we are used to see on maps. This does not satisfy for a true geospatial data set: what is needed is an spatially exhaustive digital information model of the space to be described. The criterion is that space is completely

decomposed into individual information items, each of them uniquely georeferenced. Spatial description necessarily must be based on two- (or more-) dimensional geometric items from which a topology can be built.

Standards satisfying the criteria mentioned above do exist, but data coverage is only gradually developing. Hydrography has one of the most advanced and most powerful geospatial standards: The IHO Transfer Standard for Digital Hydrographic Data, named for short "S-57" after the respective IHO publication. This standard is today already in use for the Electronic Chart Display and Information System (ECDIS), the navigation information system that satisfies, as an electronic system, the carriage requirement of nautical charts for seagoing vessels. However, the potential of S-57 as can be seen from the data model goes far beyond ECDIS, and its Object Catalogue can readily be extended to accommodate virtually all imaginable spatial objects. But ECDIS data already contain enough information to serve the purpose of a limited marine GIS.

Thus, Hydrography is in an excellent starting position for entering the arena of the evolving geospatial data infrastructure. What we need is data. But is ECDIS data all we need?

4. The case for a Digital Hydrographic Office

In hydrography, the availability of ECDIS data is still unsatisfactory today, but it is growing fast, fortunately. While ECDIS data, by virtue of its powerful data standard, already qualifies for the geospatial data infrastructure, one should not overlook that most of the available data still is digital cartographic data, though in a modern structure: the data mostly are data digitised from charts. This fundamentally constrains the usage potential. For example, as the positional accuracy of the data cannot exceed paper chart accuracy, the data cannot be zoomed in beyond the scale of the chart. However, practical use of an electronic chart in navigation differs considerably from the use of paper charts, and experience shows that navigators like to zoom into the data as much as possible while navigating in narrow waters. The master of a large ferry (35.500 tons, 200 m long) commuting between Germany and Sweden, when asked where he needs an ECDIS most, responded immediately: "for turning the ship in port!" It is clear that data digitised even from a harbour plan would be strained beyond limits if zoomed to such an extent.

Functional requirements of navigation, but also of administrative usages, e.g. in Coastal Zone Management will soon prove that digital data will be requested to offer the best possible accuracy – the geodetic accuracy and spatial resolution of the source data. One can expect that for any kind of professional use the full potential of geospatial data will be required in the longer term.

But there are also other reasons indicating that digital data derived from paper products will not be acceptable for HOs any longer: simple reasons of cost and efficiency of production and maintenance. The S-57 standard used for ECDIS data is a true GIS standard, not a product standard. Deriving

ECDIS data from a cartographic data base used for paper chart production would mean extra steps of production and data maintenance. It is more logical then to use S-57 as starting point, and to populate the data base from source data transformed into the S-57 structure. At the same time the problem of new demands for “source data” can be readily solved from the same database.

What is source data? Certainly not the raw data from surveys. In the narrow sense, source data means the official, i.e. processed and quality controlled data, at the original data resolution, accuracy and currency as released by the originating authority. No degradation, neither in content and currency nor in accuracy, is involved here. A typical example would be the final data base resulting from the latest multi-beam hydrographic survey of a particular area. Based on source data, source data products may be generated. They represent a compilation of data from source data, retaining original accuracy, but selected from the original data bases. An example would be an official ECDIS data set compiled from source data (as opposed to data derived from digitized charts). Source data services then is the provision of source data or source data products.

HOs are not fully autonomous with regard to data acquisition for their services. For example, ECDIS data are not only completely seaborne data. For high-resolution chart coverage in ports best quality data from other authorities, e.g. Port Authorities, are needed. In many countries, fairway maintenance is in the responsibility of other agencies who, therefore, have to provide the national HO with latest information about dredged channels or new surveys along fairways.

Conversely, authorities responsible for coastal protection will need up-to-date data of the offshore areas. More fundamentally, while land development plans exist already in most countries for a long time, the marine counterpart of a systematic “*offshore development plan*” is missing yet, even in developed countries. Not for long anymore, probably. The administration of the territorial waters and the EEZ becomes increasingly complex and intertwined with economical and ecological issues requiring more detailed and up-to-date information from the offshore areas than ever. Thus mutual demand for data exchange is growing for which the most efficient solution ultimately will be the formation of a national network between agencies once reasonable coverage with digital data is achieved. This means that hydrography will have to be joined with the national topographic data infrastructure.[1]

HOs can take over a function as a nodes within a spatial data network only if they meet the essential requirements of the emerging infrastructure. Much of the infrastructure is about standards, both data standards and network-related ones. At present, topographic agencies are the driving forces behind the NSDI-initiatives. HOs, therefore, have to take part in these activities.

[1] The advantages of having all data under one administration have been clearly described by John Spittal, New Zealand (loc. cit.). Entering into a network with other data sources would at least overcome some of the difficulties countries have where the administrations are separate.

The future HO, hence, can be envisioned a *Digital Hydrographic Office*, that may be described as follows:

- *all hydrographic data available for access in data bases based on source data,*
- *services and products will be provided by HOs from hydrographic source data*
- *HOs, for their own products and services, will exchange source data services with other agencies,*
- *the hydrographic data form part of the national spatial data infrastructure (which will in turn become part of an international/global one), by complying with a defined set of national and international standards, and accessible through networks for public and administrative purposes.*

Particularly the migration from cartographic data to source data will require considerable efforts from many HOs as it means that they have to turn their production lines upside-down. To orient oneself to the requirements of the digital world often needs a change in thinking. For example, Sailing Directions are still a standard product of HOs. Their concept has not changed for many decades. Within ECDIS, information contained in Sailing Directions is mostly missing, and an S-57 application profile for them does not exist yet. It appears necessary to cover that part of information – navigation instructions as well as e.g. information about traffic regulations, restrictions and port facilities within ECDIS to provide a comprehensive information set. The easy way out, however, to just put the longwinded textual information on a digital file to make it available in an ECDIS, even if chapters have some geo-reference, and are cross-referenced with HTML-links, appears as an ill-conceived compromise. What is needed is a clear re-structuring and re-definition of all information contents into geo-referenced information objects which fit into the S-57 model[2]. That would ultimately facilitate data maintenance in a comprehensive source data product base for ECDIS, and make this data really usable in an ECDIS. Unfortunately, persuading HOs into changing their sacred Sailing Directions from a novel-style publication to a GIS-type data base seems to be a difficult exercise.

Summing up, HOs:

- have to actively take part in the NSDI developments in their countries,
- network themselves between each other and other agencies of the NSDI,
- re-structure their products and services so as to meet the requirements of the digital age.

ECDIS is only the begin for HOs to become digital. ECDIS is an important step, considering that IHO already has a powerful GIS standard which needs only to be expanded to cover all digital needs in hydrography, and by that becoming an essential building stone of the Global Spatial Data Infrastructure. Its purpose could be put into the vision:
"Accurate and up-to-date, high-resolution geographic information will be readily available from anywhere on the globe (land, sea) and for any purpose".

[2] BSH Germany is currently developing an ECDIS Sailing Direction in S-57 style, with promising results.