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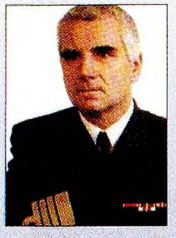

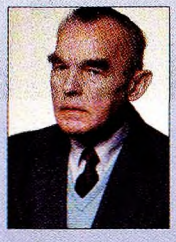

Hydrography: Its Present State and Future Development

By Z. Kopacz, W. Morgas and J. Urbanski, Institute of Navigation and Hydrography, Naval University of Gdynia, Poland

In this paper, considerations on the state of hydrography today and its development trends are discussed and presented. The subject of hydrography and the objectives of hydrographic activities are discussed. Also discussed are the reasons, as well as the results, of changes, both those that have been already accomplished and those that are now being accomplished. This paper provides the authors' opinion regarding the present state of hydrography and its future development trends.

Introduction

Hydrography is generally considered as the science, which deals with the features of the water as an element of the geographical environment, i.e. the science as well as the human activity, which deals with the measurements, description and depiction of these water features. In such a formulation, hydrography may be considered as part of physical geography.

Hydrography can be considered as a pure science or as an applied science. We consider hydrography as an applied science, i.e. hydrography being a part of physical geography, which fulfils the additional requirements regarding navigational safety as well as efficiency of human activities both at sea and in other kinds of water environment. Such kind of hydrography in some countries is called 'nautical hydrography', i.e. 'Seahydrographie' in Germany; 'hydrografia morska' in Poland, etc.

Hydrography, being the subject of our considerations, can be also considered as a branch of marine science whose means and methods can also be applied to the inland waterways, lakes, etc.

The subject of hydrography constitutes the measurement, description and depiction of the water and coastal features, but only these features, the knowledge of which directly enhances the navigational safety as well as efficiency of all human activities carried out in any kind of water environment.

The following issues are presented below: the definition of the 'hydrography'; the definition of hydrographic information; means, methods and products of today's hydrography; the impact of the computer, information and space sciences and technologies of hydrography and; the probable trends of hydrographic development.

Definition of the Hydrography

Today's hydrography, being a branch of marine science, has developed mainly during the last three centuries. It main objective was to enhance the safety of navigation by means of gathering, processing and supplying ships with hydrographic information that was presented in the form most suitable for the navigation of ships.

In the past, the main users of hydrographic information were merchant, fishing and naval surface vessels. However, today the circle of hydrographic information users has increased enormously. Today's hydrographic information is not the same as it was even half a century ago. The amount of different types of hydrographic information has grown considerably. But at the same time, traditional kinds of information have changed immensely. Therefore, below are given three definitions of today's hydrography. All of them are true, but they differ in the degree of generalization and, therefore, in the extent of their meaning. The first definition is most specific and most narrow. The last one is the broadest and most general.

However, it should be stressed that hydrography is both a kind of human activity and a branch of applied science. Therefore, the definition of the term 'hydrography' must contain both the subject of the hydrography, i.e. what is being done? as well as the objective function, i.e. for what is it being done?

The definition of the term 'hydrography', according to the Hydrographic Dictionary (IHO Special Publication No 32) reads:

Hydrography: the branch of applied science which deals with the measurements 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.

The term 'hydrography' which also takes into account the 'non–navigational' needs of the users of the sea, can be expressed as follows:

Hydrography: the branch of marine science which deals with the acquisition, processing and depiction of data about the physical features of seas, oceans and their coast for ensuring the safety of navigation and for enabling and facilitating the realisation of all tasks and missions at sea.

The third, broadest and, therefore, most general definition of the term 'hydrography' may be expressed as follows:

Hydrography: the branch of physical geography which deals with the collecting of the topographic, geophysical and geomorphologic data about the seas, oceans, inland waters and their coasts, and also with processing it into the final hydrographic products, for ensuring the navigational safety as well as the efficiency of all kinds of human activities being performed in any water environment.

Further considerations regard mainly the second version of hydrography's definition, i.e. hydrography as a kind of marine science. However, the further transformation of hydrography into the one described by the third definition is evident and unavoidable.

Hydrographic Information

Hydrographic information constitutes the mixed set of information composed of many subsets of different kinds of information. Hydrographic information is a subset of geographical information. Hydrographic information also constitutes the major part of navigational information. Therefore, hydrographic information can also be considered as the main subset of navigational information. In the last case, hydrographic information constitutes this kind of information, which describes all the geographical environment of maritime navigation. (Kopacz, Morgas, Urbanski; The navigational and hydrographical provision of ships' special tasks... 2001).

Hydrographic information necessary for ensuring navigational safety, i.e. information of the geographical environment of maritime navigation, is composed of the following kinds of information:

- Bathymetric information (depths and depth contours)
- Sea bottom information (types of seafloor, wrecks and other obstacles)
- Selected oceanographic information (sea surface temperatures, salinity, tides, currents, etc.),
- Aids to navigation
- Magnetic variation
- Important seacoast features, including the coastal navigation infrastructure

However, today's hydrographic information is necessary not only for ensuring the navigational safety for surface ships but also for enabling and facilitating the realisation of all other human activities, including those carried out underwater. Today, hydrographic information, besides the necessity of ensuring the safety of surface and underwater navigation of all kinds of ships and craft, is also necessary for:

- Exploration and exploitation of hydrocarbon and mineral deposits
- Establishing and maintaining the exploitation's infrastructure
- Underwater warfare activities:

  - Submarine and antisubmarine warfare activities
  - Mine warfare activities
  - Special warfare activities
  - Amphibious warfare activities
- Fishing
- Fish farming
- Crustacean farming
- Coastal zone management
- Marine environment and natural resources protection, and many other activities

Today's hydrographic information can be divided into three main kinds of information, as follows:

- Topographic information, comprising the seabed geomorphology (including bottom obstacles) and sea coast topographic information
- Geophysical, information, i.e. oceanographic information, and information regarding the Earth's physical fields (gravity, magnetism, electricity, etc.)
- Geomorphologic information, i.e. information regarding not only the sea–bottom upper layers and their hydroacoustical and mechanical properties, but also regarding the sub-bottom–sediment layers, including their structure, types and thickness, etc. The greater the penetration into the sea bottom sediment layers are known the better is this kind of hydrographic information

It should be emphasized that the permanent growth of the amount of the geomorphologic information in the set of the hydrographic information is one of the main characteristics and trends of hydrographic development at present.

The Means, Methods and Products of Today's Hydrography

The subject of hydrography, as a kind of human activity, encompasses:

- Acquisition and collection of the hydrographic information (data)
- Processing the hydrographic information into final hydrographic products
- Providing the users of the sea with hydrographic information in the most suitable forms for their needs
- Keeping up to date all the navigation safety information

Hydrography's means, i.e. its equipment and systems, can be divided into the following groups:

- Data acquisition and collection means
- Data processing means
- Data distribution and updating means

First, the means of acquisition of hydrographic data will be briefly discussed. Hydrographic information, as has been already noted, contains three main kinds of information; these are:

- Topographic
- Geophysical
- Geomorphologic

The topographic information can be divided into two main parts:

- Coastal topographic information
- Seafloor topographic information

The seafloor topographic information is just bathymetric information. Further, only the acquisition means of this kind of information will be discussed. Although the means of acquisition of coast–topography information is not discussed, it should be stressed that remote sensing means, including both satellite and aerial, are crucial for acquisition of this kind of information. These means are also becoming more and more important for acquisition of this kind of information.

Geophysical information, being part of hydrographic information, consists mainly of that part of oceanographic information which regards sea water properties and water dynamics as well as of information regarding the Earth's physical fields. Although this part of hydrographic information is very important, the means and methods of its gathering are not discussed in this paper. The reasons are 1) this kind of information (excluding tidal information) is rather typical for physical oceanography and marine geophysics; 2) only the typical means and methods of hydrography are discussed in this paper.

Taking into account the above statement, only the means of acquisition and processing of two main kinds of hydrographic information are discussed below; these are:

- Bathymetric information
- Geomorphologic information

The acquisition of bathymetric information can be divided into three kinds of activities, which are:

- Measuring the values of particular kinds of information (data)
- Determining the geographical coordinates of the measured data
- Pre-processing and recording data (allowing the corrections, excluding errors, combining the accurate three dimensional geographical co-ordinates with the measured values of the data, and recording these data as the geospatial data (information))

This process is usually performed automatically, by most of the measuring systems. Today's bathymetric measurements are accomplished mainly by two kinds of systems:

- Sonar systems, i.e. hydroacoustic sensing systems
- Electromagnetic sensing systems

The most effective sonar systems today are the side–scan sonars, but especially, the multi beam echo sounders (mbes). There are a wide variety of such systems which can incorporate from several to several dozen beams that are transmitted from one or two transducer arrays. The angular coverage sectors, i.e. the beam sectors, range from about 60 to 160 degrees. These sounding systems provide high precision mapping with 100 percent coverage. The width of the swath can reach eight times the depth. These swath-sounding systems are very promising survey systems. Their wide use at present remains limited by the high prices.
Among the electromagnetic sensing sytems the following are the most important:

- Aerial stereophotogrammetric systems
- Airborne laser sounding systems

Both systems are very effective but only for shallow water areas (stereophotogrametry: to several meters; laser sounding: from a dozen to several dozen meters). The demand for geomorphologic information by the users of the sea is becoming higher and higher. This kind of information is acquired almost exclusively now by hydroacoustic means, i.e. by echosonders. Among echo sounders the most effective are:

- Multifrequency echo sounders
- Frequency–variable echo sounders i.e. the chirp sonars and other sub-bottom profilers

These system, especially sub-bottom profilers, allow the acquisition of almost all geomorphologic characteristics of the sub bottom–sediment layers, i.e. the structure of these layers, the sediment type, the thickness of the particular layers of the sea bed, to a depth of about 50m and even more. These data also allow evaluating the hydroacoustic properties of sea bottom as well as the mechanical properties of the subbotom–sediment layers.
As was already mentioned, the requirements for geomorphologic information is becoming more and more important, especially for the offshore and inshore industry, for coastal management and for naval warfare activities. Therefore, it might be expected that sub-bottom profilers will be developed rapidly.
The means of acquisition of hydrographic information, besides the hydrographic information sensors, also includes the position–fixing systems.
Since the middle of the 1990s, we have seen the introduction of the Global Positioning System (GPS) and the GLONASS system, and their regional (WAAS, EGNOS) and local (DGPS, RTK) augmentation systems. The GALILEO System is now being developed and expected, to become available by 2008. These systems satisfy almost all today's hydrography's positioning requirements. It is expected that by 2010 the local augmentation systems will be able to provide the users with positioning accuracy of a few centimetres. Therefore, it may be concluded that the present, but especially the future Global Navigation Satellite System (GNSS–2) will satisfy all the positioning requirements of today's and tomorrow's hydrography.
The last components of acquiring hydrographic information are the data pre-processing and recording subsystems. Today, the whole data pre-processing and recording process is being realised in real–time by special on-board subsystems of the hydrographic ships, boats, airplanes, helicopters, etc. Modern hydrographic survey systems, such as the previously noted multibeam echo sounders and similar systems can not only pre-process the measured data but also transform them into coloured, 3D bathymetric–contour maps of surveyed areas. It should be stressed that the ability exists today of producing high-resolution digital terrain models being the most important product from which the contour maps can be derived. In the past, hydrographic data were transformed

into the final hydrographic products exclusively for the purpose of editing and issuing paper graphical and descriptive products (mainly charts and nautical publications).

Today the development level of information processing technologies, including the very advanced software tools, enable the creation of complex and highly specialised hydrographic data bases which allow the creation and operation of Geographical Information Systems (GISs). These systems comprise sets of computer hardware, software, geographical data and personnel designed to acquire, store, update, manipulate, analyse and display all forms of the geographically referenced products. These systems today replace the traditional cartographic product. It is expected that their importance will grow and, therefore, in a wider and wider extent they will they replace the traditional way of editing and issuing the final hydrographic products (Monahan, Hecht, Wells, Kenny, Campos: 2001)

A substantial part of the GIS systems constitute maritime GIS systems. Widely known, and beginning to be widely used, are the Electronic Chart Display Information Systems (ECDIS). GIS systems are also widely operated in the Hydrographic Offices (HO) and by other hydrographic information providers.

However, it is evident that not only now, but also in the future, there will be a great amount of users (mainly recreational and sports craft owners and operators) who will continue to use the paper products. However, it may be expected that these products can be and will be 'printed on demand', by the hydrographic information providers, as the printed output–data of GIS systems. In the same way, the highly specialised hydrographic information may also be provided for the hydrographic support of non–navigational tasks, works and other kinds of activities, i.e. the industrial, coastal zone management, underwater naval warfare, and other similar activities.

Hydrographic information, especially in the form of specialised data bases, can be already distributed and updated in the form of disc files by telecommunications means. It is also expected that Internet will contribute to much wider distribution of hydrographic information.

The Impact of the Computer, Information and Space Sciences and Technologies upon Hydrography

The fast development of today's computer, information and space sciences and technologies highly influences the development of almost all kinds of human activities, including the hydrographic activities and hydrography as an applied science.

The following factors impact, to a high degree, the development of modern hydrography:

- Computer and information technologies
- Space technologies
- Remote sensing
- Digital information processing
- Telecommunications and information transmission

We are not going to discuss the influence of all the above particular factors upon hydrography's development and its change. They are sufficiently known. We are only going to stress how all these factors together influenced and are influencing hydrography, both as a human activity and as an applied science.

1. The development of the above mentioned technologies is already partly solved, and is going to solve definitely the problem of real–time, high–accuracy positioning of nearly all kinds of geospatial measurements
2. Remote sensing is becoming one of the main ways of collecting topographic information regarding the sea coast and shallow water areas
3. Creation and operation of GIS have dramatically changed the whole process of transferring hydrographic data to users. They have shortened the time of data processing, and dramatically improved access to hydrographic information and its use
4. The introduction of swathe–surveying of the sea bottom also enables the real–time mapping of surveyed areas, what is not only a great achievement but also the forerunner of the new era of sea surveying, i.e. the era of hydroacoustic sensing
5. New information and space technologies, especially the data–transmission technologies have resulted in new possibilities of distribution and updating hydrographic information. Now, there exist all necessary conditions for ensuring the constant maintenance of hydrographic information, at least for its main users
6. New computer, information and space sciences and technologies also create the possibility and

necessity for integration of the near–related branches of science into the new kinds of science. One of the most characteristic examples coming into existence of the new branch of science: 'geomatics' which comprises: geodesy; positioning and navigation; digital imaging (mapping and remote sensing); and GIS

7. New computer, information and space technologies also influence to a high degree the qualifications and education of the personnel of the Hydrographic Offices and other hydrographic information providers. The substantial part of the personnel of these institutions, but especially the personnel of the hydrographic (geographic) information management systems, constitute today the computer and information scientists. Also the hydrographers, even these who are involved in sea surveying are becoming information scientists dealing with hydrographic information

The fast progress in developing and manufacturing the new data-collecting and data processing equipment and systems leaves far behind the possibility of their application in practice for economical reasons.

The Probable Trends of Hydrographic Development

In the near and distant future, the development and change of hydrography will be influenced both by general development tendencies and their reasons, and by the tendencies and reasons, which are proper only to the activities being realised in the maritime environment.

The general development tendencies influencing progress in hydrography include development in science and technology and improvements in integration processes. The means, tools, systems, activities and processes are converging, including the integration of the branches of science. The coming into being of 'geomatics' corroborates this tendency.

The development tendencies regarding human maritime activities, which influence now and will also influence in the future hydrography and its activities, are the following:

1. There is an increase in the number of ships and maritime craft, especially recreational and sports craft
2. There is an ongoing increase in the dimensions of ships, especially merchant vessels
3. There is an increase in the amount of dangerous cargoes being transported by sea
4. There is an increase in the amount and kinds of industrial activities, especially those that concern the exploration and exploitation of hydrocarbons and mineral deposits
5. There is a steady growth of the amount of activities being performed under the sea surface, on the sea bottom and in the bottom sediments. Most of these activities belong to the industrial and underwater warfare activities
6. There is a steady increase in the depth of the subsurface layer in which human activities are being performed
7. There is a steady growth in the amount of human activities being carried out in the coastal zone, which results in the necessity to maintain much more effective coastal management system
8. Today's development level of global-coverage communications as well as the necessity of solving and managing many global issues, among them the necessity to protect the marine environment, ensuring maritime traffic safety, and other global issues, results in the further centralisation of the management of these issues. This manifests itself in a growing need for international regulations and international standards

Hydrography carries out its tasks by itself. However, in realisation of more general and more complex maritime tasks hydrography participates, together with other marine sciences, in their fulfilment. Therefore, the current as well as future hydrography's objectives can be expressed as follows:

1. Participate in ensuring the navigational safety of all users of sea, i.e. all ships, and craft as well as underwater vehicles and even divers
2. Participate in ensuring the high efficiency of all kinds of human activities being realized at sea
3. Participate in ensuring maritime safety, but especially in the protection of the marine environment and natural resources, and in coastal-zone-management process (Kopacz, Morgas, Urbanski; The Maritime Safety System...2001)

Taking the above into account, but especially the impact of computer, information and space sciences and technologies upon hydrography, the following conclusions regarding hydrography's development can be drawn:

1. The most characteristic feature of tomorrow's hydrography will be the permanent increase of geomorphologic data as part of hydrographic information
2. Hydrography is being integrated with other branches of marine and other sciences into a new marine applied science, which can be considered as ' marine geomatics (hydromatics)' whose objective is to deal with all aspects of gathering and processing hydrographic data and providing all users of sea with all kinds of hydrographic information
3. Hydrography is being transformed to a higher level of development which subject has been defined by the third definition of this term
4. However, hydrography's means and methods, to a higher and higher degree, will also be acquired and used by other branches of marine sciences, e.g. marine geophysics and others, which will also try to take over a part of hydrography's tasks, especially these which regard to ensuring the high efficiency of human activities being realised at sea

Hydrography, being a branch of applied science, is also a type of human activity. This activity is carried out by proper governmental or civil institutions (offices, services, bureaux, etc.). The mentioned changes of human activities as well as expected scientific and technological progress – will also result in changes of hydrographic institutions, i.e. their tasks, organization, etc. It seems that the following changes are evident and unavoidable:

1. Hydrographic institutions dealing now mainly with the tasks of 'nautical hydrography' will integrate with other institutions participating in ensuring the navigational safety of all sea users as well as with these which participate in ensuring the maritime safety, but especially with environment and natural-resources' protection and coastal zone management. An example of this tendency is the existence of Federal Maritime and Hydrographic Agency of Germany. There are many reasons, which justify such process
2. It becomes evident that in crude oil and gas exploration and exploitation industries as well as in other marine industries, new services (mainly the geophysical ones) are coming into existence. They carry out all tasks (including gathering, processing and provision with not only hydrographic but also with all other kinds of information) being necessary for enabling and ensuring high efficiency of industrial processes at sea. Taking into account the very high efficiency of modern means of data gathering, processing and information provision, it seems that some (or even many) tasks of ensuring the high efficiency of human activities at sea will be taken over by commercial hydrographic and marine geophysical institutions

One further and final conclusion regarding the most probable changes of hydrographic institutions.

The main objective of governmental and/or government-authorised hydrographic institutions would be enabling and ensuring the navigational safety of all human activities being realised at sea as well as enabling and facilitating the environment and natural resources protection and coastal-zone management. However, the tasks regarding the enabling and ensuring high efficiency of human activities realised at sea will be in higher and higher degree carried out by commercial hydrographic and marine geophysical institutions. The last ones seem to be much more effective and competitive.

Conclusions

In the above paper, the authors' opinions are presented regarding the subject of hydrography, its present state and the most likely trends of its change. The fast development of computer, information and space sciences and technologies resulted in major changes of all kinds of human activities, but mainly these activities, which deal with information acquisition, its processing, and providing users with the updated information. Such kind of activity is just hydrography. The process of hydrography changing and its adaptation to the new conditions and requirements will be continued. Some further changes in hydrography seem to be evident. The authors tried to guess only these less evident. However, the authors are aware that their conclusions stated in this paper may be and should be considered only as very approximate.

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Biographies

Zdzislaw Kopacz, Ph.D. and professor of Naval University of Gdynia. Born in 1940. Graduated from the Naval Higher School in 1964. Since 1968 until now he is working in the Institute of Navigation and Hydrography of Naval University. For many years, Head of the Research Department of Navigational and Hydrographic Support, and Director of the Institute. Fields of educational and research activity: maritime navigation; hydrography; navigational and hydrographical support; establishing and operation of aids to navigation; and navigation assistance systems.

Waclaw Morgas, Ph.D. and professor of Naval University of Gdynia. Born in 1947. Graduated from the Higher Naval School in 1969, and from Naval Academy in Leningrad in 1976. Since 1976 until now he is working in the Institute of Navigation and Hydrography of Naval University. For many years, Head of the Department of Ships Equipment and Systems. Since 2000, Director of Institute. Fields of educational and research activity: maritime navigation; ships equipment and systems; navigational and hydrographical support; surveying equipment and systems; and automation and computerisation of hydrographic works.

Józef Urbanski, Ph.D. and professor, Born in 1929. Graduated from the Naval School in 1951 and from Naval Academy in Leningrad, in 1959. Since 1959 to 1984 he worked in Naval University of Gdynia as Head of the Chair of Navigation and later, as Director of the Institute of Navigation and Hydrography. For six years, he worked beyond the University. Since 1990 until now, he is again working in the Institute. Fields of the educational and research activity: maritime navigation; navigational and hydrographical support; safety of navigation; and maritime safety.

E-mail: wmorgas@amw.gdynia.pl