THE PRODUCTION OF ELECTRONIC CHARTS FOR MARINE TRANSPORTATION

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ABSTRACT

Electronic Navigational Chart in S-57/3 format is a digital product for marine navigation. In Portugal is produced by the Instituto Hidrográfico. The rules for codification and modelling the information and the data of nautical charts are contained in the Special Publication number 57, 3rd edition, IHO Transfer Standard for Digital Hydrographic Data, from the International Hydrographic Organization (IHO).

The standard S-57/3, published in 1996 by IHO, is the result from 9 years of discussions, hard work and evolution in the area of the Marine Information Systems. It contains the Data Structure, a Theoretic Data Model, an Object Catalogue and the ENC Product Specification. This document, bears in mind an object-oriented (O-O) concept, presents as one of the advantages an intrinsic easiness in the maintenance and correction of data, when compared with the traditional methods of codification.

INTRODUCTION

The sustained development of the sea and the coastal areas, constitute an important mark for Portugal and Europe. The sea covers 70% of the world surface and it is a considerable source of resources: live or mineral resources, reservoir of biodiversity and renewable energies, means of transportation and resources for tourism and leisure. More than one half of the Portuguese population and about 60% of the European population live close to the sea.

The sea is always matter of innumerable threats, which has direct or non-direct consequences for the majority of human activities: pollution, biodiversity, constant attacks to the marine or coastal ecosystems, etc. It is still object of a growing number of conflicts related to marine activities, and it is a target of competition for space, mainly the coastal area, or by it resources.

The Man learned, sensibly from the Stone Age, how to use the sea as source of food and as a mean of transportation. By that time, the Man described probably in oral form the navigation routes through an exchange of experiences. He used a mental map but, as the time goes by and the ships increase their size, it became evident the need of a more detailed description of the sea. The mental map began to be supported by written descriptions.

In the XVII and XVIII centuries, these writing descriptions constituted private property and they were religiously kept and protected against illegal reproductions. The perfect knowledge of the navigation routes was the base of the supports for those that knew the routes very well, so for that reason, these first Pilots were also considered as military secrets. Besides these descriptions about known landmarks along the coast and other useful information, these Pilots also contained drawings and sketches, as well as the position of rocks and islands in relation to the coastline.

Man has self-confidence in what his eyes can see, and he truly believes that vision can guide him with safety. However, when the eyes reach the beach, the clear-sighted vision, suddenly, the sea becomes a uniform surface reflecting the sky. Here, there are no details that give him an indication on what exists below the sea surface. The physical properties of the water only allow him having a glimpse of what is below the surface of the sea. This led Man to the need of additional information to travel safely in the sea.

A chart contains information about the sea bottom, the coastline and land, the easily recognized landmarks, the lights, the buoying, the magnetic variation and other useful information to the mariner.

In Portugal, the development of the nautical cartography1 started in the XIV century, during the reign of King D. Dinis and one believes that has been due to two valuable aids:

- **Admiral Manuel Pessanha**, Italian hired by King D. Dinis in 1317, gave an important contribution to the discoveries, when bringing technicians fellow citizens to Portugal;
- **Jácome of Majorca** was in Portugal between 1420 and 1427, he was called by the *Infante D. Henrique* (Henry the Navigator) to give instruction to the mariners designated for the exploration of the African coast.

The oldest Portuguese chart is from 1471; Portuguese chart anonym of “circa”2, embracing the coasts of Europe and Africa, from Ouessant Island to the Golf of Guinea.

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2 "circa" means around or approximately.
Marine Transportation – its importance to the external trade

The transport of people and cargo is mostly done among countries. An important part of the European economy and the world economy too, depends on the sea, mainly through the marine transportation and the fisheries. More than 90% of the external European trade and 43% of its internal trade depends directly on marine transportation; more than thousand million tons of goods are loaded and discharged every year in several European ports. This sector, as well as, the services and associated industries, the insurance companies and the naval shipyards, constitute the base of subsistence of about two and a half million people in Europe.

![Graph showing External Trade of Portugal by mode of transport](image)

**Figure 1 – External Trade of Portugal according to the modes of transport**

Portugal, as outlying country of the European Union, imports 54 000 000\(^3\) tons of goods per year, from different countries of the world, being about 69% transported by sea, 25% by road and the remaining ones distributed by other means. The distribution from the several modes of transportation has not change along the years, but it has been increasing in the last years. Relatively to the European Union’s imports, the picture is a little different, 98% of the products that come to Portugal are transported evenly by sea and by road, whereas 2% are transported by other means. Looking to this numbers, one can conclude the importance of marine transportation and marine infrastructures have to Portugal. Almost all the products produced outside Europe and a part of those produced in Europe, arrive to Portugal by sea. The goods mainly imported by Portugal are:

- Energy products;
- Machineries and equipment for transports;
- Goods for the industry;
- Agriculture-alimentary products.

The world economy depends directly on the existence of marine transportation, especially important in large amounts of goods for long distances, in satisfactory economical and environmental conditions. The marine transportation constitutes an important premise for the operation of a modern Portugal. However, being Portugal an outlying country of small dimension, it cannot have ambitions of competing, in all the domains, with the high excellence levels that characterize the most open and global markets, but it should strive for expansion and modernization of its harbours, having, as a goal, the use of the national territory as an entrance door and rotational platform of goods that have as destiny other markets in Europe.

Maritime safety

Maritime safety is a combined term used to describe the conditions with the intention that navigation can take place safely, with fewer risks, for human lives and for the environment. Some of the conditions that influence the safety of navigation are:

- Speed and appropriate course according to the weather conditions;
- High conditions of water tight for the ship;
- Packing of the cargo safely;
- Existence of salvage equipment on board;
- Existence of navigational aids on board;

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2 A. Pinheiro Marques in *The dating of the oldest Portuguese Charts*, Lisboa, Imago Mundi.
3 INE – National Statistical Institute, [www.ine.pt](http://www.ine.pt), International Goods Transport, by mode of transport
Necessary conditions of experience and education of the crew. But even the most robust ship, with the best equipment and the best qualified crew, cannot cross the ocean in a safe and responsible way, without updated and corrected nautical charts and publications.

The international efforts to improve the safety on board the ships; it has been centred on the risk of loss of human lives – crews and passengers. With the decrease of this risk, the international cooperation has been extended to include the effects on the environment.

In spite of the effort in the prevention, surveillance and combat to the marine pollution, maritime transportation can cause considerable damages to the environment, due to accidents or due to inappropriate conduct. However, navigation constitutes a permanent and latent risk for the environment due to the possibility of grounding and collisions. The grounding of “Exxon Valdez” in Alaska cost, until today, 5 billions of American dollars, and the bill continues to increase everyday. The sinking of “Prestige” continues nowadays to provoke enormous damages at all levels. Even in Portugal, the maritime accidents are associated with names as ”Jacob Maersk”, “Marão”, “Aragon” and “Cercal”.

In 2001, in the United States, a commission was created, “Ocean Commission” with the purpose of studying and defining the future contours of a maritime policy. In April 2004, this commission published its provisional conclusions as a need of a deep change of the American policy regarding the Oceans. Also in Portugal, the “Strategic Commission of the Oceans” was created, and designated to elaborate a report regarding the definition of a strategy for the Oceans. The final work, published in 2004, pointed out two hundred and fifty recommendations and action lines that force to a deep reconsideration and mutation of the Portuguese policy in general and in relation to the Oceans. This kind of reports, serve as a base of strategies and recommendations to the countries towards the development.

International efforts

Shipping is more and more international than ever, and it is by that reason that the measures to improve the maritime safety have to be led through the international collaboration to be efficient. In general, it needs to be regulated at an international level, and in order to assure uniformity of rules and procedures, as the time goes by, a few international organizations were created, such as:

- **International Maritime Organization (IMO)** – it is a special agency of the United Nations created in 1948. It has 163 Member States, 3 Associated Members, 63 Non Governmental Organizations (NGO) and 36 Inter Governmental Organizations (IGO);
- **International Hydrographic Organization (IHO)** – it is an independent body created by 19 countries in 1921, among which was Portugal. Initially it was created with the designation of “International Hydrographic Bureau”, having been later on renamed for the actual designation. Nowadays, 74 States are members of IHO;
- **International Association of Lighthouse Authorities (AISM / IALA)** – it is an independent organization created by 20 countries in 1957. Today, 78 countries are Member States of this association, 67 are Associated Members and still more 28 are designated by Industry Members.

The Conventions, International Codes and Recommendations prepared by the international organizations were in majority ratified by Portugal and they are almost of them incorporated in the Portuguese legislation and norms, as well as in the production processes implemented by the Portuguese Hydrographic Office (IHPT).

The General Assembly of the United Nations, approved on November 24th, 1998 a Resolution, that states the following in the paragraph 21:

“Invites States to co-operate in carrying out hydrographic surveys and in providing nautical services goes the purpose of ensuring it removes navigation the well the to ensure the greatest uniformity in charts and nautical publications and to co-ordinate their activities alone that hydrographic and nautical information is made available on the worldwide scale.”

The area of responsibility of IHPT regarding the nautical charts is related with the work of IHO. The main purpose of the work of IHO is to assure that the different charts and nautical publications produced by several Member States contain uniform, updated and accurate information concerning the marine environment. This kind of work is of vital importance and brings economic and commercial benefits, very important within the marine trade and other activities related with the ocean. This effort is an important contribution in the prevention of accidents, which can lead to loss of human lives and property, as well as to cause environmental pollution. The use of the modern digital nautical cartography, as well as of nautical publications integrated in modern information systems, they constitute an immense potential to improve, in a substantial way, the maritime safety.

Evolution of ships and their technology

The development of traffic at sea shows a clear trend, decrease of ships and increase of cargo. This means that the ships are getting larger; they also have a greater draught and need more space to manoeuvre in connection with course changes. In 1948, by the time of creation of International Maritime Organization (IMO), the navigation was very different from nowadays. The ships were smaller and slow. The larger and faster ships were the ones that transport
passengers and operated in transatlantic routes. Shipping was dominated by a handful of nations with long maritime traditions, all of them located in Northern Hemisphere. Everything is very different today. In 1948, a ship of 20,000 tons was considered big; today we have some ships with 500,000 tons. They use flags of many countries. The passengers give now preference to the airplanes and the “giants of the oceans” are now the tankers and the bulk carriers. Just as in other fields of society, the maritime navigation also uses new technologies and it uses positioning systems commonly designated by GPS⁴ (Global Positioning System) and DGPS⁵ (Differential GPS). With the vulgarization of GPS and DGPS, the experience has been showing that usually, the ships navigate closer to the limits of the underwater obstacles, what leads to the introduction of what internationally it is designated for “GPS assisted grounding”. In old hydrographic surveys it may exist shoals and obstacles which position is not exactly known, because the shoal or the obstacle was surveyed in the 1900’s, can easily have a displacement up to 200 or 300 meters. If the mariners, due to the high confidence they have in DGPS, navigate close to the shoal or obstacle, they could ground, because the real position of the obstacle is different from the one it is shown on the chart. Jointly, this means that the risk of pollution provoked by accident it is increased.

HYDROGRAPHIC SURVEYS

The hydrographic surveys made in Portugal before 1900, are few and they are undoubtedly linked to other surveys, because most of the times there was corrections and updates of the first ones. Anyway, if we want to place them we can refer that had beginning in 1842. The systematic hydrographic surveys made in Portugal were initiated in 1900. The survey was done by lead line, and for each release of the lead, the position was measured or calculated. The measured sounding was quite accurate, however, the weak point resided in the fact that the depth between the soundings is still unknown. This survey method was used for some time and was very slow and extremely sensitive to the weather conditions. The development of machinery and technology, turn the hydrographic surveys made by lead line a bit more automatic, turning it faster and a little less dependent on the weather conditions. The invention of the echo sounders⁶ also in the beginning of the XX century turn possible the acquisition of several soundings along a line. The echo sounders turned possible the acquisition of more information along the line, but it still have a weak point that consists of the inexistence of information between the survey lines. The coverage by a single sounding is just some meters, even though the surveying by use of an echo sounder is more systematic, it is still time consuming. In the middle of the sixties appeared the side scan sonar⁷, which is used together with the echo sounders, but they are pulled along after the survey ship. While echo sounders emits a vertical sound impulse, the side scan sonar emits a vertical impulse but with a fan shape, we can say that the side scan sonar “looks out” for both sides. The side scan sonar turn possible the acquisition of information between survey lines, but as it uses a very high frequency, it has a very limited range and is therefore not a very good help to the required wide coverage. The next step was the coming out of the multibeam echo sounder. The multibeam echo sounder is the first instrument that allows the depth measurement along a swath, granting a full coverage of the bottom in a range up to three times the depth. Nowadays the existent technical capacities allow having information extremely precise about the seabed, but the speed of the survey still depends on the sound speed through the water and the speed of the survey vessel. Surveying still represent a costly and very time consuming task. Looking closer to the age of the surveys of the Portuguese waters, mainly in the coastal and port areas, we can easily see that they are partially based on information acquired in the last two decades. Just a small percentage of the Portuguese coastal areas were surveyed with the use of modern methods, with which the hydrographers can guarantee the lowest depth for that area. It should be noticed however, that even with the modern survey techniques, it would be necessary many years to complete the survey of all Portuguese waters.

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⁴ GPS is a satellite navigation system intended to provide highly accurate position and velocity information in three dimensions, precise time, and time interval on a global basis continuously.
⁵ DGPS is implemented by placing a GPS monitor receiver at a precisely known location. Instead of computing a navigation fix, the monitor determines the range error to every GPS satellite it can track. These ranging errors are then transmitted to local users where they are applied as corrections before computing the navigation result.
⁶ Echo sounder is an instrument for determining the depth of water by measuring the time interval between the emission of a sonic or ultrasonic signal and the return of its echo from the bottom.
⁷ Side scan sonar is a form of active sonar in which fixed acoustic beams are directed into the water perpendicularly to the direction of travel to scan the bottom and generate a record of the bottom configuration.
Figure 2 – Surveyed areas without resource to the multibeam echo sounder.

Grounding and shipwreck is less common nowadays than it was some years ago, but it continues to happen from times to times. Many reasons can exist to explain this, but there are no doubts that predominantly they are due to human error. The lack of knowledge of the depths and consequently lack of information in the chart can also constitute important contributing factor. A chart should be used with the necessary caution.

Evolution of nautical charts

The nautical chart and the information that it contains is used in several ways. The fisherman needs to find the places where is the fish, and he can interpret these places based on the variations of the depth, currents and temperature of the sea water among others. The marine biologist makes the same use of the chart, but for different reasons.

In situations of oil prospecting, it is necessary more information besides the depth, but also the thickness of the several materials contained on the seabed. The geological information is obtained in a separate way, but it is usually shown on the chart or as an additional layer of information in the chart. But the main purpose of a nautical chart is to give orientations about the navigation in a safe way, decreasing the grounding risk or accident. This principle is applied to all the mariners, be yachtman or professional sailor.

It is with this purpose in mind, which the format S-57(3) from Special Publication, edition 3 appears. This format appears as result of the evolution of the IHO documents that had as purpose the publication of standards that made possible not only the production of Electronic Navigational Charts (ENC) under the same format, internationally recognized, but also that facilitated the change of information among official producers (Hydrographic Services), users (mariners), and other institutions. During the XII IHO International Hydrographic Conference, in 1987, a temporary version of that would come to constitute the publication S-57 was approved by the large majority of its Member States. The emergence of the Electronic Chart Display and Information System (ECDIS), full of functionalities based on Geographic Information Systems (GIS), were an important mean of force to introduce some changes in the sense of include topological relationships and to develop an improved Object Catalogue. The second edition of that document was approved in March 1994. Starting from this date it became evident the need of an ENC Product Specification for the production of ENC, due to the countless possible interpretation forms of the standard. The edition 3 of the document, which already included for instance time varying objects and the description of four levels of topology for vector data, was approved by all the IHO Member States and it was published in November of 1996, having been frozen for a period of four years. In November of 2000 it was published the edition 3.1 of that standard and again was frozen for other period of four years. The successive freezing of this publication for periods of

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8 Special Publication 57, Edition 3 “IHO Transfer Standard for Digital Hydrographic Data”
9 ECDIS is an integrated system for maritime navigation that has the ability to integrate information came from a positioning system.
four years is destined essentially to facilitate the development of the final products, the software for production and quality control and the ECDIS.

**ENC Production at IHPT**

ENC should not only be considered as a chart. It is a database of cartographic objects, with attributes, starting from which the information can be displayed in a format of nautical chart, since appropriate programs are used. At a world level, the largest concern relatively to ENC production was to guarantee an excellent coverage in a consistent and quick way. The placement of this high level does not interfere with the necessary acquisition of very accurate data through the use of the most modern survey methods.

The acquisition of data and its permanent updating for the purpose of cartographic production, represents for any institution, intense work and very high costs, either at human or material resources level. Increase in an exponential and significant way the cartographic production of several hydrographic services with responsibility in this area, it is not a task that can be achieved by all, much less those hydrographic services belonging to countries with less economical resources. To achieve this goal, relatively to a fast and extensive coverage by ENC, the hydrographic services felt the need to establish folios based on paper charts, compile that information and reproduce it in S-57 format. IHPT, which since the beginning accompanied the process of creation of S57 standard, began in 1998 to produce ENC, having felt the need to acquire tools that, on one hand allowed to work with the same type of digital files that create the paper charts, and on the other hand, allowed to create in an independent way the digital files needed. The tools that were defined by IHPT for ENC production were the **CARIS Hydrographic Object Manager (HOM)** from **Universal Systems – Canada (USL)** and **ENC Tools** from **SevenCs – Germany**.

The strategic plan of ENC production was established with the purpose of satisfying, in a faster way, the most important needs for the maritime navigation in the whole extension of the Portuguese coast, and they take in account the traffic of cargo and passenger ships that pass near the Portuguese coast and that way they assure the essential maritime transport to the Portuguese and European economy. This way, maximum priority was given to the production of coastal ENC (compilation scale between 90 00 and 349 999) that collect the whole coast of Continental Portugal, in an area that is about 60 nautical miles of the coast line. Concluded the coverage of the coastal waters, it was proceeded with the coverage of the main harbours (Lisboa, Leixões, Setúbal and Sines). Following this and assisting the importance of the maritime transportation for the Madeira and Açores Archipelagos, as well as the extension of the Portuguese Exclusive Economic Zone (EEZ), the production of ENC from those archipelagos was initiate, allowing to any ship that crosses that waters, navigate along the coast or demand any one of these harbours with safety and efficiency.

**Quality Control / Quality Assurance**

Quality Control/Quality Assurance (QC/QA) of ENC requires not only the verification of the correct graphic representation of all the objects, accordingly to the defined in the S-57 dictionary, but also the integrity of the data in agreement with other publication of IHO and that is designated by S-58\(^{(11)}\). IHPT has defined that QC/QA of their ENC should be made using the programs included in the tools used for the ENC production, and also with other independent programs. As final phase of this process, someone outside the production area should make an external audit to the ENC. Face to that, the first step in this process is run **CARIS Hydrographic Object Manager (HOM)** from **USL**, and **ENCAnalyzer** from **SevenCs**. The first of these programs uses data of a HOB file (Hydrographic Object) for the features and an equivalent file CARIS for the spatial objects. Through the display, the program allows to verify incoherencies in the data, such as holes without information, depth contours on top or crossing the land area, inconsistency in the codification of objects, etc. It is also possible to make Quality Control through the interrogation of objects in order to verify mandatory attributes and primitive geometric, if they are codified correct and in agreement with the standard S-57.

The second one, **ENCAnalyzer**, runs under the S-57 file or its equivalent 7CB, that is proprietary format of **SevenCs**, and it will analyze the data in agreement with the verifications recommended in the S-58 standard. In a second phase, the QC/QA should be made by another software, independent of the production process, and in that case, the choice was **dKart Inspector**, from **HydroService AS**. Also in this case, the software runs under the S-57 file, and it verifies the information contained in the ENC, also in agreement with the list of recommended ENC validation checks already defined.

\(^{(11)}\) Special Publication 58, Edition 2 – recommended ENC Validation Checks.
External Audit

In that stage of the QC/QA procedures, great percentage of errors and warnings were already detected and corrected. It interests now that ENC is verified in the environment that they will be used, the ECDIS system and although they are verified by an external entity to the production area. ECDIS is an integrated system of navigation that integrates information of a positioning system (GPS or DGPS) showing that position in real time, and it also allows to make a selective choice of the information that the user wants to see. The risk of the navigation can be interpreted automatically through GIS operations as for example, the identification of variations of course or producing sound alarms whenever appropriate to the situation. Two software of certified ECDIS systems, Navi Sailor 2400 ECDIS from TRANSAS and ECPINS from Offshore Systems, are used for that purpose. These programs are installed in a desktop computer and the performance is identical to the systems installed on board. The software runs under the S57 file, interprets it and if this file is in agreement with the document S57, it converts it to a SENC format (System Electronic Navigational Charts). This SENC file, that represents the database used by ECDIS, is the equivalent to the updated paper chart and it can incorporate information coming from other sources. When being visualized in the display, it allows a manual verification of objects and attributes.

Classification of cartographic data

In the same way that certain confusion exists between an ENC and a SENC, it seems to exist a great confusion in the following aspects:
- Different types of electronic charts;
- Different formats in the market;
- Status of the data (official if they were created by a national hydrographic service).

Considering this classification, electronic charts can be classified as being in vector or raster format. If they are in vector format, they can be made in agreement with the S57 format or in agreement with other private format. The chart according to the S57 standard cannot be considered as ENC if it is not in agreement with the “ENC Product Specification”. The source of the chart, that could be under the responsibility of a hydrographic service or not, does not have any influence on the type of data (vector or raster) nor about the conformity with the standard (S57 or not). However, only the electronic charts (vector) produced according to the standard S57, in conformity with the “ENC Product Specification”, produced and updated under the responsibility of a hydrographic service can be considered as official Electronic Navigational Charts (ENC). For consequence, nowadays some electronic charts distributed by private companies (out of the responsibility of a hydrographic service) as being ENC they are not. On another hand, certain

![Classification scheme of electronic charts](image-url)

Figure 3 – Classification scheme of electronic charts.
types of electronic charts distributed under responsibility of a hydrographic service, they are not in conformity with the group of requirements described above and they cannot be compatible with the **ECDIS Performance Standards** established by IMO.

**Updates**

ENC, as well as paper charts, must also be corrected, and in this case take the name of updates. These updates are also produced by hydrographic services, and they can be permanent, preliminary or temporary. IHPT only produces permanent updates, because these can be automatically inserted in the cell by the ECDIS as soon as it receives them for any one of the configured means. The preliminary and temporary updates can also be read, in a general way, by ECDIS, but the in force dates are not identified and applied by the ECDIS. For that reason IHPT, does not produce them. These updates can however be introduced manually by the ECDIS operator on board.

**ENC Distribution - WEND scheme**

The first hurdle to the entrance in service of ECDIS, resides in the production of ENC in number and coverage. The scheme adopted in 1994 by IHO, had in mind a concept of world database (**WEND**—**Worldwide Electronic Navigational chart Database**), making a perfect distinction in one hand, the databases of national data constituted and updated by each Member State, and in another hand, with the production and diffusion of databases of regional data, under responsibility of the Regional Coordinating Centres (**RENC**—**Regional Electronic Navigational chart coordinating Centres**). The responsibility of elaboration of digital data (ENC and updates) it is inside each State for its own jurisdiction waters.

In September 1997, IHPT signed a **Memorandum of Understanding** with other European hydrographic offices, which under the IHO recommendation formed an association of countries whose purposes were the constitution of a database and the creation of means of common distribution of ENC produced by them. After an initial period of evolution and constitution of internal procedures and means, this organization of 10 countries, saw the daylight as official commercial activity on April 29, 1999, under the name “**PRIMAR official ENC service**”. The purpose of this organization was to share means and technology for the common distribution of ENC produced by the members. Besides the commercial advantages that this type of organization offers to the producers of hydrographic information, the relationship is also made through the continuous participation in several working groups, whose work contributed to the internal harmonization not only of methods but also to the effort of IHO in the creation of a worldwide ENC database.

In September 2001, due to the fact of S-57 cells commercialization were below from expectations, the operators of PRIMAR elaborated and published through IHO, a communication referring that after three years of experience, the cooperation needed adjustments. After some fruitless conversations with all Member States, two proposals for the creation of two regional coordinating centres were developed and presented.

For the commercialization and distribution of ENC, IHPT decided to work with the regional coordinating centre headquartered in England and that operates the **International Centre for Electronic Navigational Charts (IC-ENC)**. This coordinating centre markets and distributes ENC produced by the hydrographic services of the following countries: Spain, Germany, England, Netherlands, Belgium, Greece, South Africa and India. The ENC available are encrypted, distributed and placed to the users through an annual or bi-annual license. The supplying of hydrographic service is fully responsible for the quality of ENC and for the updates. IC-ENC established the figure of Value Added Resellers (VAR) as being the organizations in charge of selling data, and each one of these VAR can have a chain of resellers too.

Another regional coordinating centre exists in Europe; with headquarter in Stavanger, Norway called **PRIMAR - STAVANGER**. This centre markets and distributes ENC produced by the hydrographic services of France, Denmark, Sweden, Norway, Finland, Russia, Greece, Latvia and Estonia.

**CONCLUSIONS**

Several have been the efforts to increase the safety of navigation, in order to prevent and to reduce substantially the maritime accidents and the consequently damages. Studies carried out all over the world indicate use of ENC can reduce up to 40% the occurrence of maritime accidents and to contribute to avoid more damages for the environment, as well as for the reduction of insurance indemnity. The national hydrographic offices recognize the interest of these ENC as a mean of turning the marine navigation safely and more effective, and they strongly forced in its development. The GIS companies and ECDIS worldwide are continually developing software and hardware to provide the hydrographic services and the users, namely the mariners, tools to build and to visualize the data according to S-57 specifications.
The total coverage of ENC of the Portuguese coast is indispensable for the national maritime navigation but also for the international shipping lines that operate ships in the routes to/from the North of Europe as well as Mediterranean. IHPT fruit of the enormous pledge, experience and acquired knowledge of his technicians in the production, QC/QA of ENC, foresees to continue the ENC production in agreement with the defined strategic plan, as well as to maintain all the cells already produced updated.

IHPT is mainly known in the area of the hydrographic surveys and nautical cartography. But when that work is analyzed together with the characteristics of the Portuguese waters and of the intensity of maritime traffic that crosses Portuguese waters, and still, when one claims maritime transportation should constitute a decisive factor to bet other sea related activities, then the volume of the surveys and the charts, they have reached a point that a great effort should be made in the update and maintenance.

The only form of assuring that all the ships navigating in Portuguese waters have all the necessary and updated information, it is through a pronounced effort in the execution of hydrographic surveys and in the production and distribution of nautical charts.

The production of paper charts and electronic charts at the same time is a complex task, once the integration of the traditional methods, based on separation of colours and manual drawing, with a product of high technology and computerized as ENC, requests an entire change of procedures and production chain in a modern national hydrographic office. IHPT has been doing that effort and it will continue to invest in that sense in the future, in order to optimize the digital products based on GIS and the necessary tools to produce it.

The S-57 standard has been used for ENC production by all the hydrographic services, facilitating the exchange of information between the producing organizations, the users and other institutions. However, this standard needs to expand and pass to incorporate all the types of hydrographic data. For this, a work group is constituted in the jurisdiction of IHO, open to the participation of all the interested parts that seeks to assure that the next edition goes into the needs of all. The fourth edition of S-57 will be based on the enormous potentialities of the geospatial data standards produced by International Standards Organization (ISO) and turning it possible that the data can be read and manipulated by programs of the type Commercial Off The Shelf (COTS) without being necessary to develop specific programs for this format. In order to turn the task of S-57 expansion easiest and more practice, the work was divided in topics, existing nine for the moment.

The contribution of European Union

All these actions are of knowledge and followed by the European Union (EU) that is conscious of the big interest of the modern means of navigation as a way to guarantee the safety of navigation and to improve the environmental protection.

However, considering Europe strongly depends on the maritime transportation, for instance Rotterdam, the first port at world level, commercialize about 70% of the tonnage of the products exchanged between the EU and the other countries and approximately 30% of the tonnage exchanged among the several European countries. The development of the multimodal transport can be considered as a promising form to improve the European systems of transport, this requires an increasing interoperability among the maritime and fluvial transportation. It will be also necessary to define and establish principles and terms of reference for the development of a European maritime policy. In this sense, several have been the incentives from the EU to speed up ENC production.

REFERENCES

- Open ECDIS Forum (http://www.openecdis.org)
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