

Completion of S-55 using GIS: A Practical Planning Tool.

By Lt.Cdr. Rafael Ricardo Torres Parra, Colombian National Navy.

Abstract

IHO Publication S-55 “**Status of Hydrographic Surveying and Nautical Charting Worldwide**”, is a most important publication of the International Hydrographic Organization (IHO) and is designed to provide a diagnosis of hydrographic requirements, due to the complete database on international hydrographic knowledge that it contains. This paper presents a methodology proposed by Colombia to calculate the status of the hydrographic surveys and nautical chart availability utilizing a Geographic Information System (GIS), a methodology that may be used as a guide for any country determining the information needed for S-55. It was found that following this methodology the way, in which calculations of hydrographic capabilities are determined, may be standardized, and the result can provide an important planning tool to optimize the investment of hydrographic resources at a national and regional level.

1.- Introduction

Colombia took over the chairmanship of the Meso-American and Caribbean Hydrographic Commission (MACHC), at the VIth Commission's meeting held in Cartagena, in September 2004. The meeting considering the regional shortcomings detected in the 3rd edition of S-55, agreed that all the Commission members should complete the questionnaire submitted by the International Hydrographic Bureau (IHB), in order to assess objectively the regional needs by an analysis of the information. The main purpose was to facilitate the IHO Capacity Building Committee (IHOCBC) in properly managing the scarce resources available.

Colombia, when starting to update its national information, as well as to review the data of the region contained in S-55 to detect any weaknesses, found two special situations. First, it found that there was a lack of a clear methodology to calculate the percentages required to report on the status of the Hydrographic Surveys and Nautical Cartography, and second, that the information, contained in S-55 in percentages, does not allow the ideal analysis of the needs in the region. Due to this it was decided to establish a new methodology to measure and record the state of hydrography using Geographic Information Systems - GIS.

On the 30 May 2005, a Technical Workshop on " Development Phases of the Capacities of Hydrographic Surveying and Nautical Cartography " was held in Cartagena de Indias. Colombia. It was directed towards the Members of the MACHC Commission, especially to the islands states of the Eastern Caribbean, . The Workshop was organized by the IHOCBC. During the workshop, the GIS methodology used by Colombia to complete S-55 and how S-55 could be used as a tool for the analysis of the weaknesses and hydrographic needs, was reported. The proposal was accepted and received with great interest by the participants. This

situation motivated the preparation of this paper, in order that the positive Colombian experience could be shared.

2.- S-55 Background.

IHO publication S-55 deals with the world-wide status of hydrographic surveying, nautical cartography and marine safety information, with the purpose of displaying the worldwide coverage of the three main elements of hydrography as identified in the IHO publication M-2 “ Hydrographic surveying, Nautical cartography and Marine Safety Information (MSI)”.

The first effort to evaluate the progress of hydrography at a global level was initiated by the United Nations in 1970, and requested the IHO to continue with a detailed study, which culminated in 1991 with the first edition of S-55 covering 46% of the maritime nations. In 1998 the second edition was published with coverage of 47% of the States. Today the third edition is available on the IHO web site with information of 81% of the maritime States, with the possibility of being updated by the countries by means of the Internet.

This publication is maintained by the IHOCBC, supported by the Regional Hydrographic Commissions (RHCs), which facilitates the diagnostic research of the needs (S-55) with the investment of resources in capacity building.

3.- Analysis of the Publication S-55

To prepare the information for S-55, each country evaluates its level of development in each of the three main capacities of which hydrography is composed. In the case of hydrographic surveys and nautical cartography, information is displayed in percentages. Nevertheless, a methodology did not previously exist that could serve as a guide for countries in calculating their individual levels of coverage. This lack of methodology entails two problems. First, the difficulty for countries with limited hydrographic experience in calculating their percentage of coverage. The second is the variety of possible criteria available to calculate the percentage that can be used by countries. This lack of standardization makes it difficult to execute any comparison and make an objective regional and global evaluation.

The database in S-55 displays the coverage of the hydrographic capacities at a global level, but the database is not by itself the final objective. S-55 must provide a tool to detect weaknesses, thus helping the prioritization process in the allocation of resources to support capacity building initiatives. It is in the use of the database where a new limitation is found, because the percentages although important indicators, make it difficult to analyze the information with an important spatial component. Therefore it is necessary to consider GIS when analyzing S-55, as it allows visualizing spatially the information and also offers its use as a planning tool.

Finally, the fact that countries like Colombia, which are members of more than one Regional Hydrographic Commission, must provide differentiated information of their real situation because areas covered by different Commissions may not have the same degree of development, preventing an objective analysis of the information under a total geographic perspective.

4.- Proposed methodology with GIS

The Hydrographic Service of Colombia has developed a methodology to calculate the percentage of hydrographic surveys and cartography using GIS, with the initial purpose of sharing the experience at a regional level, especially with those countries that have had difficulty in calculating their own percentages. The following guide not only provides knowledge of the spatial status of hydrography in the country, highlighting the shortcomings, but also allows it to conduct medium term planning, focusing the hydrographic resources where they appear needed.

4.1.- Status of Hydrographic Surveying .

Initially a revision of the database that contains information of all the surveys made by the Colombian Hydrographic Service in Colombian maritime territory from 1984 was made. An evaluation was made of each survey to decide whether they were to an acceptable standard or if new surveys were needed. Factors such as order of the survey, date of accomplishment, equipment used, participant personnel, among others, were considered.

After finishing this initial phase, the limits of all the surveyed areas were digitized with the help of GIS. These areas were classified in two layers. One consisting of the surveys considered to be to an acceptable standard, assigning them a green colour, and another one consisting of those surveys that need to be repeated, assigning them a yellow colour. The areas never surveyed were kept without colour.

To facilitate the evaluation of the status of shallow versus deep waters, in agreement with the requirements provided in S-55, the 200 meters contour surrounding the mainland as well as to the islands was digitized.

For the shallow water calculation 100 % was adopted that would correspond to the total area of the Colombian maritime territory between the coastline and the 200 meters contour. To make the calculation, the areas were determined with GIS, including the areas of the approaches to the mainland and islands including shoals, banks and reefs. To determine the percentage of shallow waters surveys, both, surveys that were considered acceptable and those needing a new survey were added. In the Colombian case all surveys were classified in the first category. The percentage turned out to be the ratio between the addition of all surveyed area compared with the total area existing between the coastline and the 200 meters contour.

For the calculation of the deep-water percentage, 100 % of the area would correspond to all the Colombian maritime territory between the 200-metre contour and the external limit of the Exclusive Economic Zone (EEZ) of Colombia. To calculate it, the areas were measured with GIS and the values added. In order to determine the percentage of the status of the deep-water surveys, the areas acceptably surveyed and those requiring a new survey were measured separately. In the Colombian case all the surveys were classified in the first category. The percentage resulted from the comparison of the areas surveyed and the total area between the 200 meters contour and the external limit of the EEZ.

Considering that Colombia has coasts in two oceans belonging to different Regional Hydrographic Commissions, it was necessary to follow the proposed methodology to calculate separately the Caribbean Sea and the Pacific Ocean to assess the status of the surveys in both sectors.

In figure 1 a GIS image of the Caribbean shows in green the shallow water surveyed areas and in dashed green the deep waters. It was calculated that 69.2 % of the shallow waters were surveyed to an acceptable standard. As far as deep waters are concerned, the 17.2 % has been surveyed systematically to an acceptable standard, whereas 82.8 % requires surveying by the Colombian Hydrographic Service.

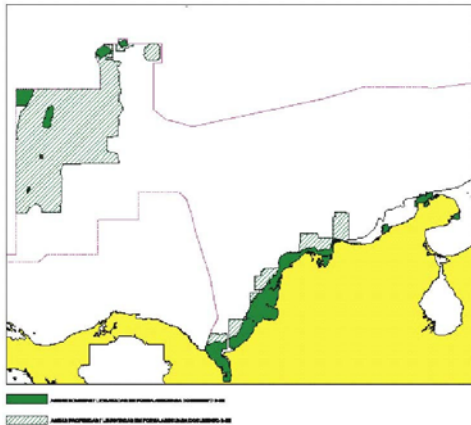


Figure 1: Hydrographic surveys in the Caribbean.

In figure 2 a GIS image of the Pacific shows a coverage of 55.4 % of the shallow waters and only 1.8% of the deep waters, to have been acceptably surveyed, thus highlighting the main survey needs.

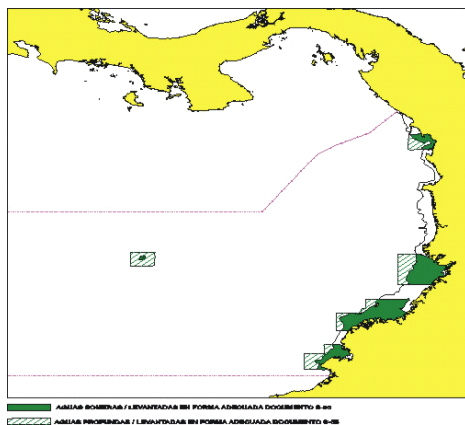


Figure 2: Hydrographic surveys in the Pacific

4.2.- Status of Nautical Cartography .

Next the methodology followed by Colombia is provided for the calculation of the paper nautical charts only, as the Hydrographic Service does not produce official navigation charts in raster format, and the Electronic Navigation Charts (ENCs) are

not yet available for distribution and sale. Nevertheless the proposed methodology can be applied for the calculation of all the formats.

Unlike the previous calculation of the hydrographic capacity, it is not possible to take as a reference all the maritime territory, as it is covered by more than one nautical chart within the same range of scales. For that reason it is necessary to rely on the Nautical Cartography Plan, which is the main tool in the long term to define the cartographic needs of a country, as it describes all the charts at different scales necessary to suitably cover the national maritime territory. In order to initiate the proposed methodology it is necessary to consult the Nautical Cartographic Plan.

Using the GIS the limits of all nautical charts in the Cartographic Plan were digitised, assigning a colour to those already published, and a different colour to those planned but not yet published. These charts were organized in three thematic layers in agreement with the scale range indicated in IHO publication M4. Small scale those 1:1,500,000 and less. Medium scale those greater than scale 1:1,500,000 and less than 1:150,000. Large scale those of scale 1:150,000 and greater.

Considering that S-55 divides the cartographic coverage according to the scale of the charts, the percentage must be calculated for each one of these ranges. In order to calculate the percentage of small scale or offshore charts, 100 % was considered to be the addition of all planned scales in that scale in the Cartographic Plan, which is obtained adding all the areas of published and non published charts, digitized in the thematic layer of the GIS corresponding scale. To calculate the covering percentage all areas of published charts were added after being digitized with GIS in small scale. From the comparison of these two measured areas, the coverage percentage is obtained. The same procedure should be followed to calculate the percentage for the medium and large scales.

In figure 3 a GIS image is provided showing the medium scale cartographic plan in the Caribbean Sea. The published nautical charts are shown in blue, the planned charts not yet published, are shown in red. Out of a total of 36 planned charts, 27 have been published, with 80 % covered.

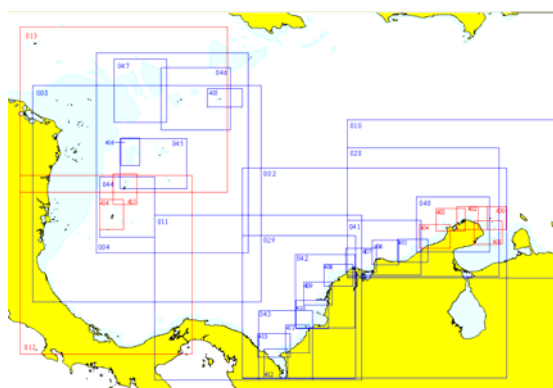


Figure 3. Medium Scale Chart of the Caribbean.

Figure 4 shows a GIS image showing the medium scale charts in the Pacific Ocean using the same convention as above. Out of 23 planned charts, 7 have been published, with 86% of the area covered. Again the need to separate the information for each ocean, in the calculation of S-55 data of countries with two coasts is highlighted.

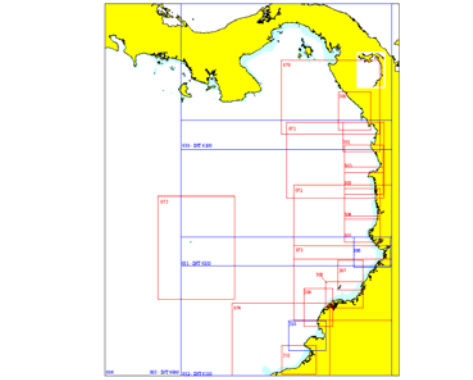


Figure 4. Medium Scale Chart of the Pacific

5.- Favourable results when following the methodology

Colombia has established a clear methodology to calculate periodically the status of its hydrographic capacities in surveys and nautical cartography. This will allow the measurement of advances in hydrography in an objective way, because the methodology assures that the calculation of percentage is always under the same standard. At the end of each calendar year S-55 changes will be evaluated according to areas surveyed and charts published, allowing the assessment of the hydrographic effort, identifying if it has been focused in increasing the coverage or on updating the available information.

The hydrographic survey information entered into a GIS, offers all the advantages of these systems for the analysis and handling of spatial information. Thus, when a requirement is made so that the Hydrographic Service executes a survey, previous information on hydrographic surveys in the area of interest can be displayed spatially. Also GIS have associated databases which can provide information about the surveyed areas, such as the order of the survey, date, hydrographic platform, equipment used, personal participant, etc., offering all the necessary information for planning and decision making.

All the information associated to the Nautical Cartographic Plan of Colombia was also digitized and entered into a GIS. This is a great advantage for the handling of the information, allowing its spatial display by layers according to the scales. The digitalization of the limits of the nautical charts is also provided in an associated database, in which information like the present edition of the chart, names, date and amount of published copies, scale, etc., can be found.

It was found necessary that Colombia, having maritime territories in more than one Regional Hydrographic Commission, reports the information of S-55, specifying its coverage pertaining to each one of them, which permits a greater knowledge of the real status of the hydrographic capacities at national and regional levels.

Finally, but perhaps the main advantage that was found when following the proposed methodology, was the possibility of using the database information of S-55 in the Geographic Information System as an extraordinary planning tool.

6.- Use of the Methodology as a Planning Tool.

As it was discussed concerning the S-55 analysis, this database is not by itself the final objective. Its true potentiality is found when used in diagnosing the status of the hydrographic capacities, to establish capacity building plans, hydrographic surveys missions or compilation and publication of nautical charts.

Considering that all the hydrographic information is in a GIS, it is possible to take advantage of all the potential that this software offers for the treatment of the spatial data, especially as regard to the spatial display of the information, handling of thematic layers to organize and to classify the data, as well as the associate data bases. This allows the user to have a " spatial diagnosis " of the status of its hydrographic capacities, which facilitates the analysis of the information. When considering all the hydrographic information in a GIS, it is possible to take advantage of all the advantages that is offered by this software for the treatment of the spatial data, especially the spatial unfolding of the information, the handling of thematic layers to organize and to classify the data, as well as the associate data bases. This allows the user to have a " space diagnosis " of the state of its hydrographic capacities, which facilitates the analysis of the information as well, allowing the detection of the strengths and weaknesses within the spatial scheme.

Through the use of the proposed methodology, Colombia managed to determine the weaknesses in hydrographic and cartographic coverage in its maritime territory in the Caribbean Sea and the Pacific Ocean. This diagnosis was the base on which a hydrographic medium term development plan was prepared, to allow the optimization of the limited resources in the solution of the highest priority needs.

For example in figure 5 a comparison of the information of surveys with the information of cartography on medium scale for the Colombian Caribbean is shown by means of a GIS. When comparing these images it can be observed that in the Peninsula of the Guajira there exists a cartographic deficiency as a consequence of the absence of surveys in shallow waters in the area. This would be very difficult to observe solely by a study of the S-55 percentages.

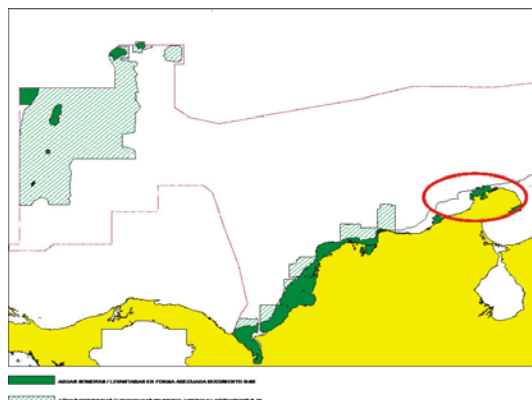


Figure 5. GIS use in planning. (Peninsula of the Guajira has been circled in red).

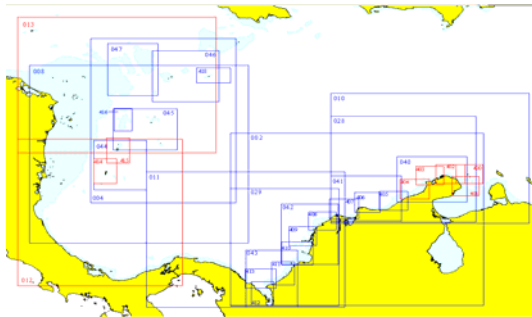


Figure 6. GIS use in charting planning.

Once the existing hydrographic requirements have been determined with the use of the GIS following the methodology discussed, prioritization of the needs can take place. For this, the volumes and characteristics of the maritime traffic of the main ports, as well as other maritime interests, physical changes in the areas caused by natural or anthropogenic causes, status of the navigational aids, etc. in consultation with the Port authorities. The maritime defence requirements were also evaluated.

When analyzing all this information and prioritizing the hydrographic needs, a plan that provides a solution to the needs in accordance with the human skills and material and financial resources available, can be structured,

Additionally, the possibilities of the proposed methodology can be exported with the purpose of analyzing the status of the hydrographic capacities within the Regional Hydrographic Commissions, allowing the detection of any weaknesses and to focus the efforts and resources towards concrete capacity building initiatives in its solution. To take advantage of this, it is necessary for all the countries in a region to feed a sub-database with information of their own surveyed areas and nautical cartography in a format appropriated for the use of GIS, sharing the same methodology. In this way it would be easy for the compiler country to merge all the information in the same GIS database, taking advantage of all the potential already discussed that allows a diagnosis of the status of the capacities of the Region.

In this way the Chairmen of the different RHCs may improve their participation in the IHO Capacity Building Committee, transmitting the prioritized regional needs for the allocation of resources.

Summary

The IHO publication S-55, 3rd edition has reached an important level of development, with the possibility of a permanent update by the Hydrographic Services through Internet. Its structure is ideal as it allows analyzing the status of the hydrography by means of the evaluating the development of its main capacities. All this contributes to recognize the immense importance it has in the diagnosis of the needs, thanks to the information contained in its database.

The fact that there is not at present a methodology to standardize the way to calculate the percentage of coverage, prevents an objective comparison of the information and makes it difficult to analyse the information by means of a simple evaluation of the displayed percentages.

Colombia, after finding it difficult to quantify the values required in the Publication S-55 due to the absence of a standardized methodology, developed a proposal that includes the use of GIS. With the application of this computer science tool, advantages in the form of displaying the status of the hydrographic capacities were found. This allows a spatial analysis of the data and improves the diagnosis of the hydrographic reality, facilitating the decision making and becoming an important tool for planning.

This methodology can also serve at a regional level to detect weaknesses in the hydrographic capacities of the countries of the area. Protocols for the exchange of data are due to be established, creating sub-databases integrated by the GIS. With the participation of the Regional Hydrographic Commissions, offering more detailed information on the regional needs, the decision making process of the IHO Capacity Building Committee can be optimised. Thus, progress will be achieved in the identification, support and prioritization of the cooperation needs, with the final purpose of improving safety of navigation and protection of the marine environment, the main objectives of the International Hydrographic Organization.

Bibliography

Publication S-55 " Status of Hydrographic Surveying and Nautical Charting worldwide" 3rd Edition. IHO (2004),

Publication M2 " National Marine Policies and the Hydrographic Services ".

Publication M4 " Regulations of the IHO for the International Charts & Specifications for IHO Charts. IHO OHI (2003).

Biography

Rafael Ricardo Torres Parra:

Lt.Cdr. Colombian National Navy.

He holds professional titles related to Naval Sciences and Physical Oceanography after studying at the Naval Academy " Almirante Padilla ".

Professor of the Hydrographic Cat "A" Program at the Naval Academy.

Graduated from the USN Oceanographic Office Cat "B" Hydrographic Program.

Since 2004 he is the Coordinator of the Hydrographic Area in General Maritime Directorate of the Republic of Colombia.