

COMPUTER ASSISTED NAUTICAL CHART UPDATING

A CHILEAN NAVY HYDROGRAPHIC AND OCEANOGRAPHIC SERVICE PROJECT.

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SUMMARY

The purpose of this paper is to share with the international hydrographic community, in particular with the Hydrographic Services of the International Hydrographic Organization (IHO), how the Chilean Navy Hydrographic and Oceanographic Service (SHOA) has developed a solution, -applying computer and graphics technology- to the old and continuing problem of updating the nautical charts stored in the chart depot. Before putting into service the present project, the updating was done by manually applying the corrections published every fifteen days in the Bulletin of Notices to Mariners.

I. INTRODUCTION

In 1874 -that is 122 years ago- the present Chilean Navy Hydrographic and Oceanographic Service (SHOA) was established. The issue of Notices to Mariners was established the same year through the Bulletin of 'Hydrographic Notices'.

During the following years, the Hydrographic Service, concerned with providing the navigator with the best available information needed for safe navigation, gradually incorporated all this information to produce updated charts and nautical publications. At present, SHOA provides the navy, merchant and fishing vessels and recreational crafts, whether national or foreign, all charts and nautical publications updated to the latest Notice to Mariners. After that, the owners and

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users of these publications are responsible for applying the updating information that may be needed after distribution, information which is disseminated nowadays by SHOA, through the Notices to Mariners Bulletin. This Bulletin which is issued every fifteen days- contains all information and hydrographic news that occurred in the period, being used for updating the affected charts and nautical publications on board the ships. This is most important to the safety of navigation, since those charts and nautical publications were delivered updated, but many changes may occur later, such as: buoys out of position, lights out of service, inaugurated or discontinued radio navigation aids, new soundings, changes in the features of harbours, etc., which are essential information that the mariner should know.

The Chilean export and coasting-trade, of which 94% is carried by sea, results in the yearly arrival of nearly 11,000 ships with flags from about 60 countries, which in turn means that the Hydrographic Service must maintain more than 300 nautical charts with a total stock in the chart depot of more than 115,000 units. In the last ten years, the tonnage moved showed an increase of 114.9%. Since a similar increasing rate is expected in the future -given the economic expansion of the country- the SHOA decided to develop a programme to expedite **the delivery of updated nautical cartography to its users.**

Being aware of the substantial increase in the demand for nautical charts, and having analysed this requirement, the SHOA decided to improve the quality of its service to the user by delivering charts updated to the last Notice to Mariners. However, such a goal could not be met with manual methods of updating, and it was decided to incorporate available computer technology. The procedures are described in this paper.

II. THE BACKGROUND OF THE PROJECT

1. Description of the problem

The "Chart Updating" Section, within the Department of Nautical Information of the Hydrographic Office of the Chilean Navy is tasked to provide the users with the updates for the nautical charts produced by the H.O. This Section ensures that charts are duly corrected and updated in accordance with the "Notices to Mariners", which are published every two weeks.

For the 335 charts of the Chilean portfolio, 197 of them have an annual average of 12 corrections. With respect to the sale of charts, this figure means that about 12,000 corrections must be made annually by the six staff members carrying out this task, using manual procedures, such as erasing, applying patches, handwriting notes etc.. SHOA was not aware of any automated system which enables carrying out the above mentioned repetitive procedures on a large number of charts.

The following drawbacks of the manual updating are listed below :

- It does not permit the establishment of any standardization with respect to the quality of the correction work carried out manually, as the results obtained are variable, according to the experience and qualification of each corrector.
- Being a manual procedure, it is slow and this results in low productivity. Besides, the checking procedure is complex and also slow, to the detriment of the reliability of the corrections made.
- It is necessary to have a permanent reserve of personnel in order to handle the request for charts exceeding the usual stock, with the efficiency and speed required.
- The master chart that has been thoroughly corrected, used as a model to carry out the corrections on other charts, eventually gets spoiled. This means that a new master must be periodically prepared and that during the procedure of duplication some accuracy and information may be lost.

2. General Objective

The general objective is to provide the user with a better service, through an increase of the productivity and quality of the nautical charts correction procedures carried out by the "Chart Updating" Section of the Department of Nautical Information. This is achieved with the use of computer and graphic technology.

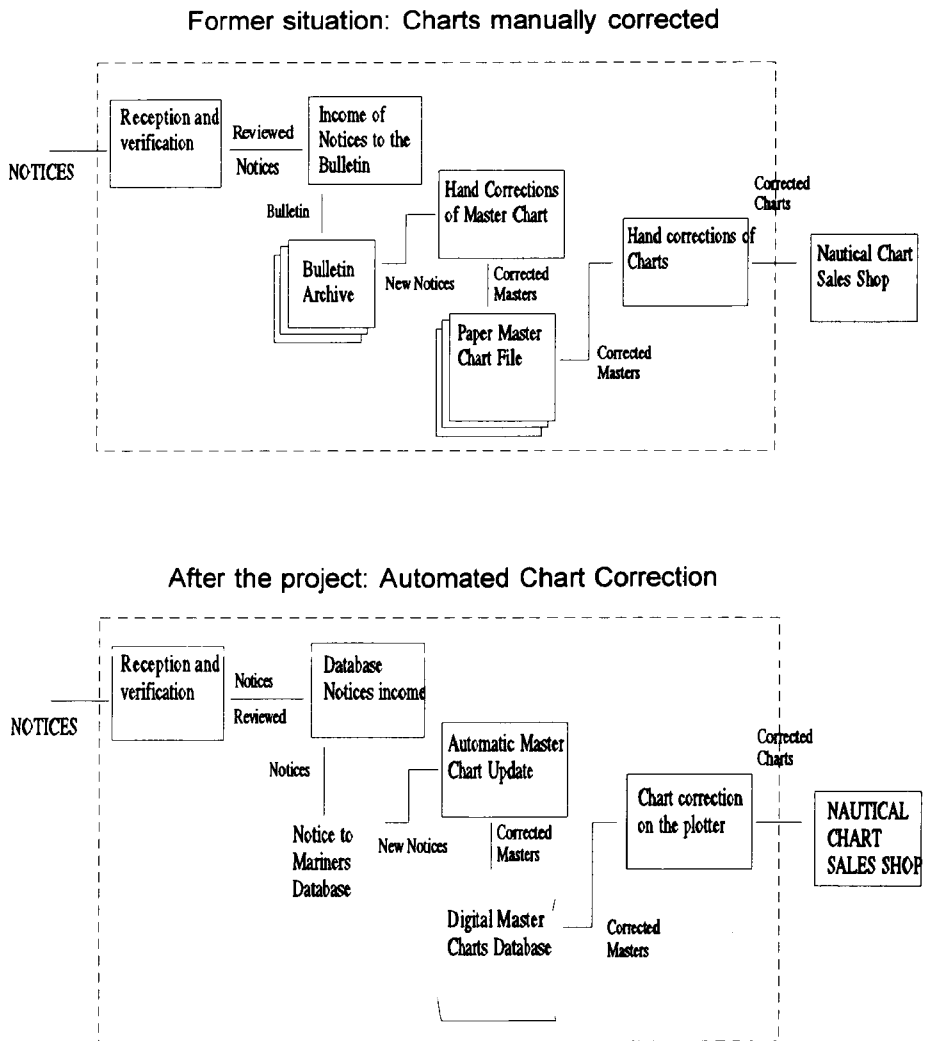
3. Specific Objectives

- To develop a Nautical Chart Updating System using computer and graphic technology.
- To create a Nautical Chart Correction Data Base, including an historical record of each chart.
- To implement a Computer Storage System of the master corrections, to eliminate the natural damage suffered by the nautical chart masters.

III. PROJECT LAYOUT

To achieve the objective of this project, the present procedure of updating nautical charts was analyzed and perused and the phases which should be changed to implement it were identified. The general idea was to automate the procedure as far as possible in all steps, including the creation of the "Notices to Mariners Bulletin", the preparation of the master chart and the quick, accurate and automated

updating of the current charts, at a rate of one or more copies at the same time. (Fig. 1).



To achieve this, a layout is drafted, based on the creation of a data base which could include all the warnings listed in the Notices to Mariners Bulletins. This data base replaced the old archive of Bulletins and was named "Notices to Mariners Data Base". Another data base, including the master charts and their respective notices was created in replacement of the portfolio of paper master charts, under the name of "Digital Master Charts Data Base" (Fig. 1).

The project had a final draft that was more ambitious than the establishment of two independent data bases. The target was to link all elements of the system, so that the mere input of a Notice in a pre-established format and in accordance with the most frequent one, would originate automatically the "Bulletin of Notices to Mariners" itself, and, in turn, would generate the action to be taken on the corresponding master charts, as it should be noted that a Notice normally affects various charts.

After establishing a relationship between both data bases, it was necessary to create them with all the options usually inherent in a data base and implementing all the functions needed to provide a friendly interface to users. This included scrolling menus and in the special case of the "Digital Master Charts Data Base", a Windows environment based on objects and attributes. So, two modules, "Notices to Mariners Data Base Module" and "Digital Master Charts Data Base Module", were developed.

Finally, it was considered to use two PC based workstations; one to handle the Notices to Mariners Data Base Module" and the "Digital Master Charts Data Base Module", including a PC computer, printer, plotter and digitizer, and the other to handle the updating of charts, including a PC computer and a plotter. The transfer of information between computers was initially made by means of magnetic media and later through a network.

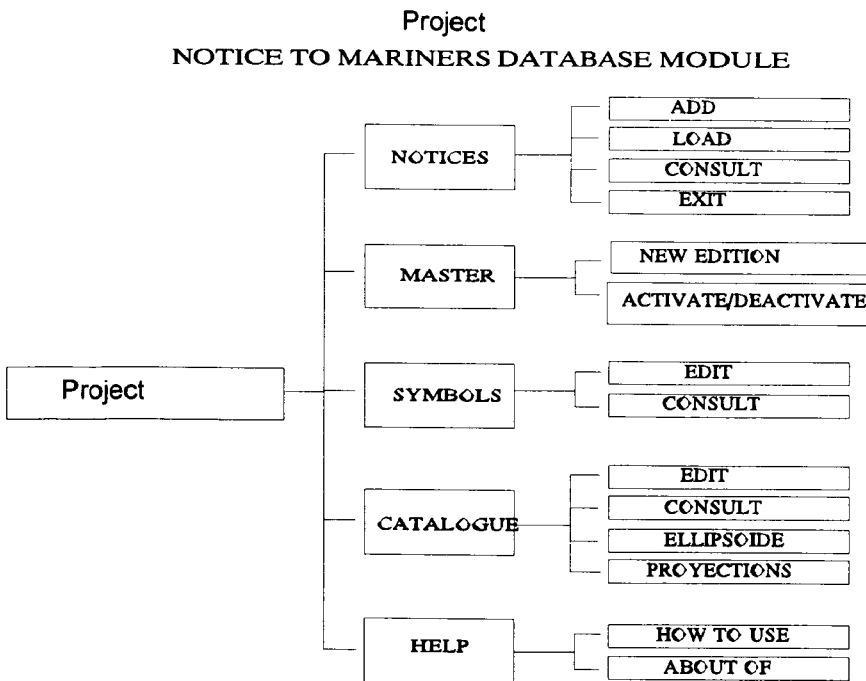


FIG. 2.- Notices to Mariners Database Module.

This module has the following five options:

1. Notices: This is the basic option for 'Add, Load or Consult' the information contained in a Bulletin or Notice (Fig. 3). In the Notices several pre-established cases or formats are defined, in accordance with a combination of 'Actions' (None, Insert, Update or Delete) that are to be performed in the nautical chart, and the 'Type' (Symbol, Feature, Visibility Sector, Labels, Soundings, or others) of the element affected by this action. The combination 'Action - Type', 'None - Others' was created to permit the input of those Notices that are not in the defined formats. Of special interest is the option '**Load**', designed to permit the inclusion of certain Notices to a specific chart, and '**Consult**', action that can be performed through several search combinations (Fig. 4).

Editar Avisos

Año Aviso: 1996 Número de Aviso: 7

Boletín N°: [] Fecha Boletín: 15/01/96

Título Aviso: Bahía Valparaíso - Punta Osas - Enfilación

Acción: Insertar Tipo: Símbolo Acción-Tipo 1 de 3

Símbolo: [] Código: J-19 ASTA DE BANDERA

Posición en:

Latitud: 32 ° 59 ' 8,00 " Sur

Longitud: 71 ° 32 ' 34,70 " Weste

Texto: Insertar el símbolo de "Asta de bandera" (J-19)

Anterior Siguiente Eliminar

Cartas y Publicaciones Afectadas: 00511 BAHIA Y PUERTO DE VALPARAISO

Fuente: []

Salir Grabar Deshacer Borrar

FIG. 3.- Notice of information.

2. Master: Option that permits to 'Create' a new edition of a chart and 'Activate or De-activate' a certain notice. In the first case, it de-activates all Notices affecting a certain chart as a 'New Edition' of it must include them. However, if this is not the case, all or some of them can be activated again, because all the data are permanently in the data base, even if they are no longer valid.

Consulta de Avisos

Parámetros de la Consulta Ordenada por **Boletín** ▾

Nº Carta	desde	<input type="text" value="00511"/>	hasta	<input type="text"/>
Año	desde	<input type="text" value="1990"/>	hasta	<input type="text" value="1996"/>
Nº Aviso	desde	<input type="text"/>	hasta	<input type="text"/>
Boletín	desde	<input type="text"/>	hasta	<input type="text"/>
Fecha	desde	<input type="text"/>	hasta	<input type="text"/>
Latitud más al Norte	desde	<input type="text"/>	◀	<input type="text"/>
				◀ <input type="text" value="Sur"/> ▾
Latitud más al Sur	hasta	<input type="text"/>	▶	<input type="text"/>
				▶ <input type="text" value="Sur"/> ▾
Longitud más al Este	hasta	<input type="text"/>	▶	<input type="text"/>
				▶ <input type="text" value="Weste"/> ▾
Longitud más al Weste	desde	<input type="text"/>	▶	<input type="text"/>
				▶ <input type="text" value="Weste"/> ▾
Acción	<input type="text" value="Todas"/> ▾			
Tipo	<input type="text" value="Todos"/> ▾			
Activos	<input type="text" value="Sí"/> ▾			

Subtítulo








FIG. 4.- Notice of consultation.

3. Symbols: It permits to 'Edit and Consult' the library of symbols existing in the system (FIG. 5).



FIG. 5.-Symbol.

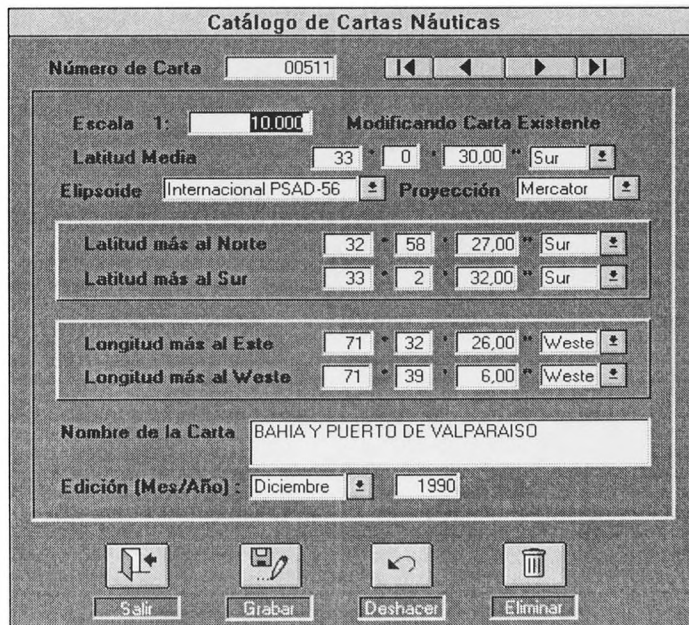


FIG. 6.- Catalogue.

4. **Catalogue:** It corresponds to the functions of 'Edit' and 'Consult' of the Nautical Chart Catalogue and to the input and editing of the 'Ellipsoids' and 'Cartographic Projections' (Fig. 6 and 7).

5. **Help:** The systems offers help on line if the user requires it, under two options 'How to Use' and 'About Of'.

Carta	Escala	Nombre	Edic. Mes/Año	Latitud Media	Latitud		Longitud		Avisos	Elip.	Proy.
					Norte	Sur	Este	Weste			
00205A	20000	RADA PAPOSO	/1945	25°01'36,00"S	25°00'24,00"S	25°02'54,00"S	070°27'29,00"W	070°29'31,00"W	1	Sudamer	Mercat
00205B	15000	CALETA COLORADA	/1945	24°38'25,00"S	24°37'45,00"S	24°38'56,00"S	070°32'52,00"W	070°34'45,00"W	0	Sudamer	Mercat
00205C	10000	CALETA COLOSO	/1945	23°44'36,00"S	23°44'05,00"S	23°45'07,00"S	070°27'12,00"W	070°28'59,00"W	5	Sudamer	Mercat
00205D	30000	RADA BLANCO ENCA	/1945	24°21'06,00"S	24°19'39,00"S	24°22'33,00"S	070°30'55,00"W	070°33'55,00"W	1	Sudamer	Mercat
00206	40000	BAHIA LAVATA	/1961	25°37'25,00"S	25°35'36,00"S	25°39'15,00"S	070°37'12,00"W	070°41'38,00"W	0	Sudamer	Mercat
00206A	20000	CALETA AGUA DULC	/1961	24°07'29,00"S	24°06'57,00"S	24°08'03,00"S	070°28'35,00"W	070°30'20,00"W	0	Sudamer	Mercat
00206B	40000	CALETA FLAMENCO	/1961	26°34'54,00"S	26°33'01,00"S	26°36'39,00"S	070°41'05,00"W	070°45'29,00"W	0	Sudamer	Mercat
00206C	20000	CALETA EL COBRE	/1961	24°14'15,00"S	24°13'06,00"S	24°15'26,00"S	070°28'42,00"W	070°31'54,00"W	0	Sudamer	Mercat

FIG. 7.- Cartographic projections.

This module has the following five options:

1.- **Master:** It permits to 'Open', 'Save' or 'Delete' the respective digital master chart. When a digital master chart (Fig. 9 and 10) is opened, it is updated with all the current notices in the Notices to Mariners Database, displaying them with their relevant geographic position.

2.- **Edition:** It has the options 'Confirm/Unconfirm', 'Light/Unlight', 'Content Consult', 'Rotate', 'Move', 'Delete', 'Lines', 'Circles' and 'Text', all them fundamental to refine the Notice coming from the Notice to Mariners Data Base. The System Manager takes here the necessary action to define the best position in the chart of the Notice, confirming it afterwards, or creating it graphically when handling any special action not considered in a standard notice (i.e., the creation of a pier, etc.) When new Notices are input, they are displayed with a different colour until revised and confirmed by the System Manager. The 'Light'/'Unlight' option permits, without deleting a Notice in the digital master chart, to avoid its plotting. As an example, when a Notice indicates 'Delete Sounding', instead of marking the sounding on the paper chart, it is deleted using an eraser. The option 'Consult Contents' enables the Manager to see on the display screen the text, together with the action that originated it graphically.

PROJECT DIGITAL MASTER CHART DATABASE

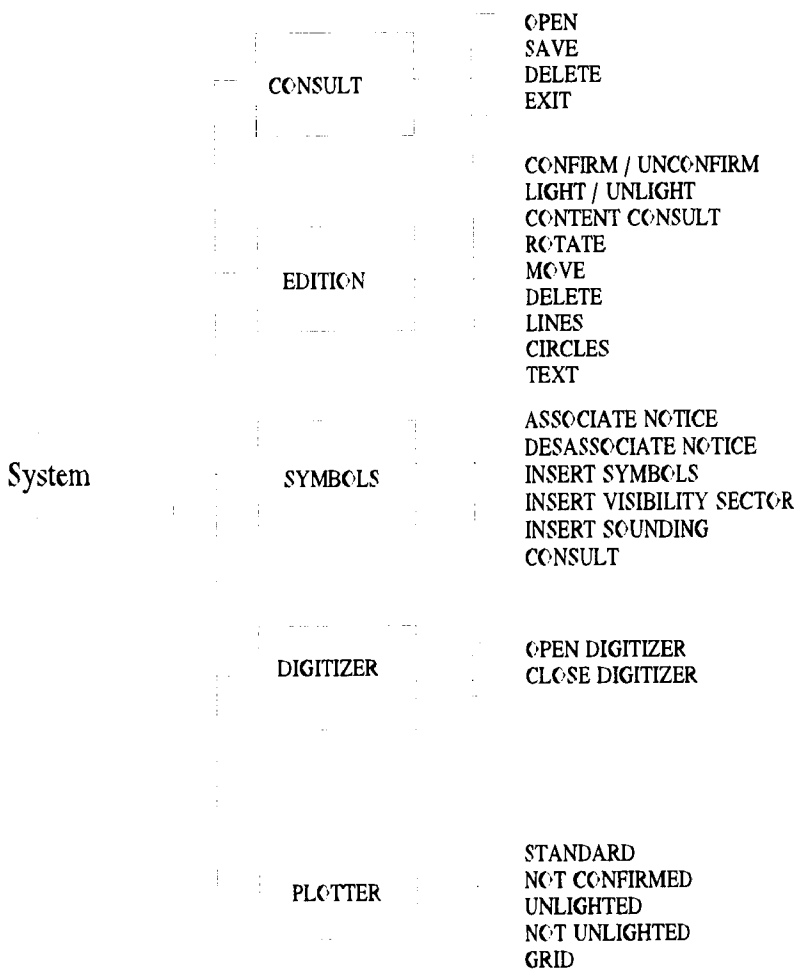


FIG. 8.- Digital Master Charts Database.

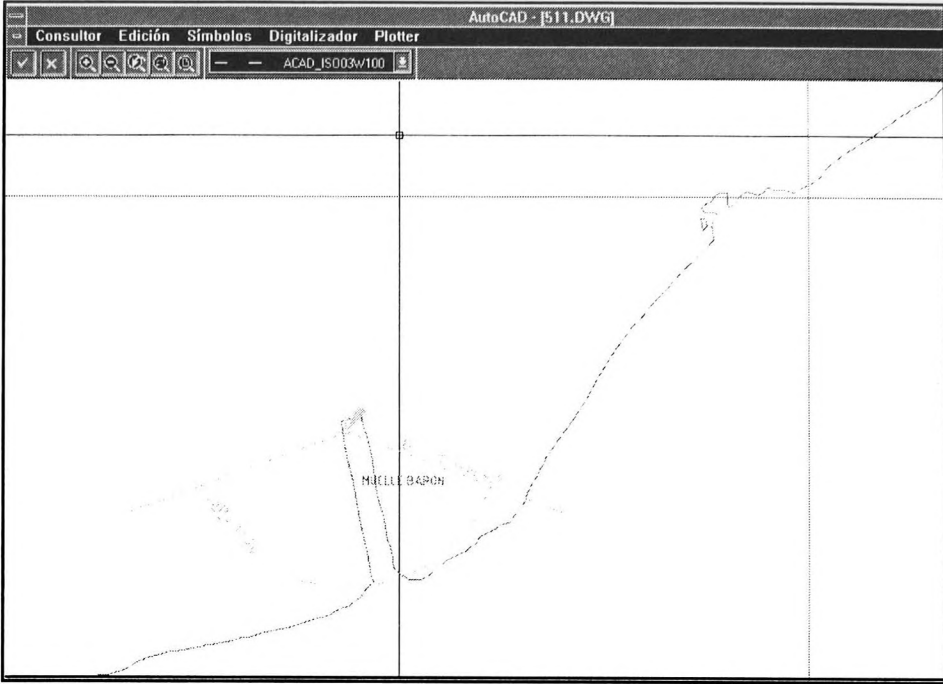


FIG. 9.- Digital Master Chart.

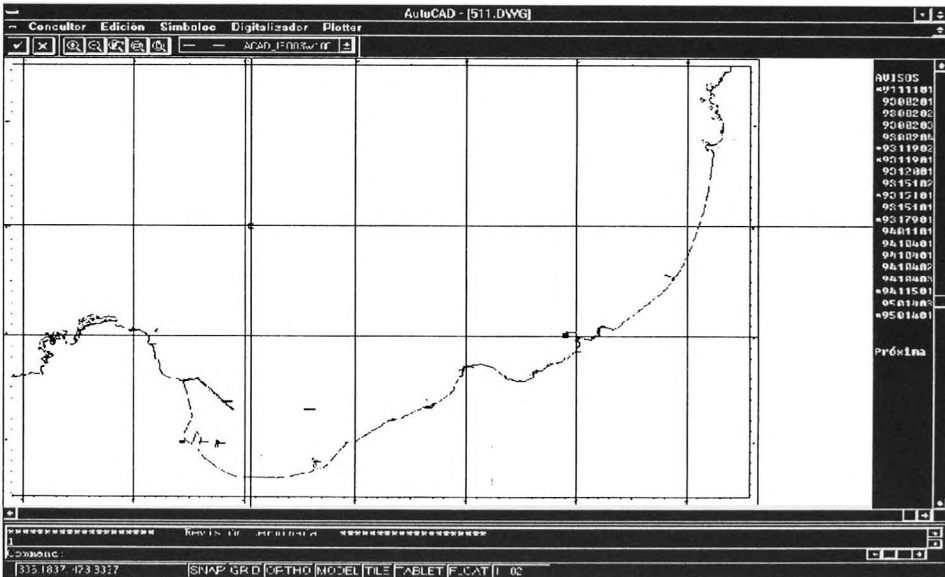


FIG. 10.- Digital Master Chart.

3. Symbols: Option that permits the System Manager to associate or dissociate a compound symbol, and also to input symbol sectors of visibility and/or soundings in the library of symbols of the system.

4.- Digitizer: It opens or closes the digitizer. Its use is essential for revising and confirming Notices, and also for creating those Notices that are not in a standard format, such as the insertion of a pier.

5.- Plotter: Through the options '**Standard**', '**Not Confirmed**', '**Unlighted**', '**Not Unlighted**' and '**Grid**', the plotting of the correction is carried out on the selected paper nautical chart placed on the plotter, thus correcting one or several copies of that chart (FIG. 11 and 12).

IV. HARDWARE AND SOFTWARE INVOLVED

The need to keep the overall cost of the project at a level in accordance with the intended objective led to the decision of implementing the system using the hardware and software available in the market. Any special development based on a specific programme language, as well as the construction of specific electronic or electromechanic equipment, were reduced to a minimum.

1. Hardware

A study based on statistics from the last 10 years at the Nautical Charts Updating Section, determined the computer and graphics equipment necessary to the project :

Two personal computers, each one equipped with:

- 66 Mhz CPU.
- 16 MB RAM.
- Local Bus.
- 1 345 MB HD.
- 1 1.2 MB FD.
- 1 1.44 MB FD.
- 1 17" colour monitor (1280 x 1024).
- 1 SVGA graphics controller.
- 1 3-button mouse.
- 1 Spanish keyboard, 101 keys.

Two flatbed plotters, with the following features:

- Usable bed surface: 1229 x 924 mm.
- 8 pens, software selectable.
- Maximum drawing speed: 919 mm/sec.
- Mechanical resolution: 0.003125 mm.
- Software resolution: 0.025 mm by steps.
- Repeating positioning: 0.05 mm or less.
- Buffer size: 1 MB.
- RS-232C serial port.

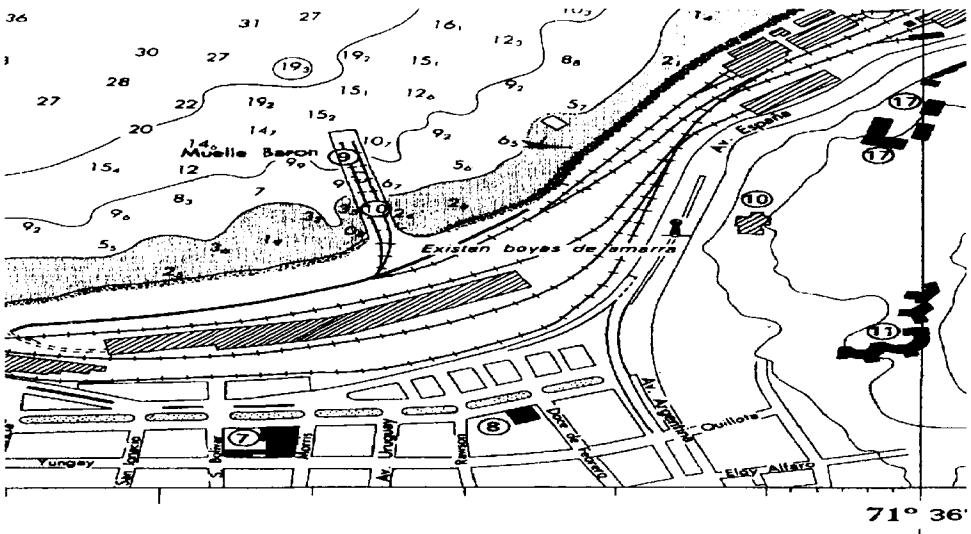


FIG. 11.- Uncorrected Nautical Chart.

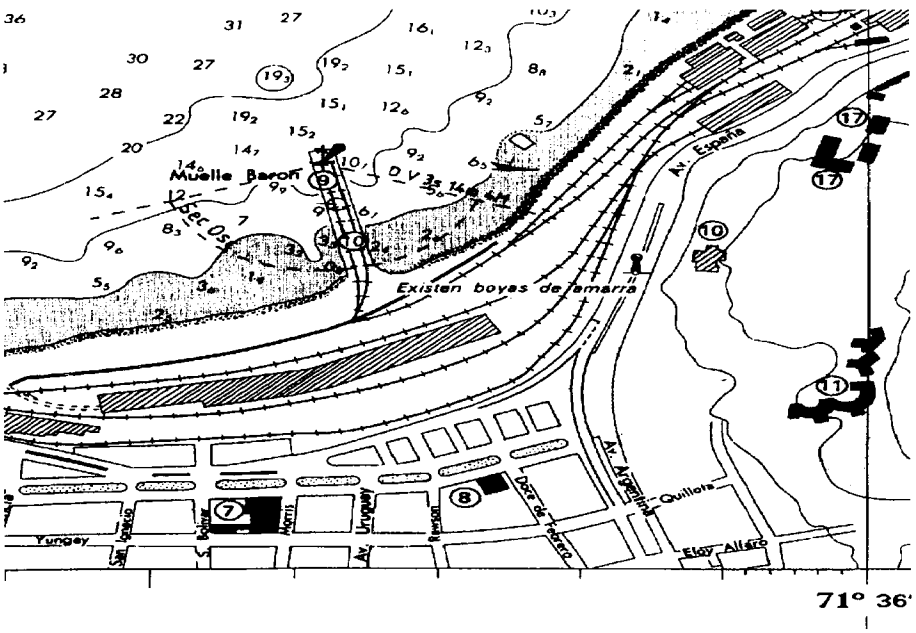


FIG. 12.-Corrected Nautical Chart Using The System's Plotter.

One digitizer, with the following features:

- Usable bed surface: 914.4 x 609.6 mm.
- Translucent surface, with transmitted lighting.
- 16 buttons cursor, with magnifying glass.
- Standard resolution: 0.127 mm.
- Maximum resolution: 0.0762 mm.
- Motorized supporting table.

Figure 13 shows the physical layout of the above mentioned equipment.

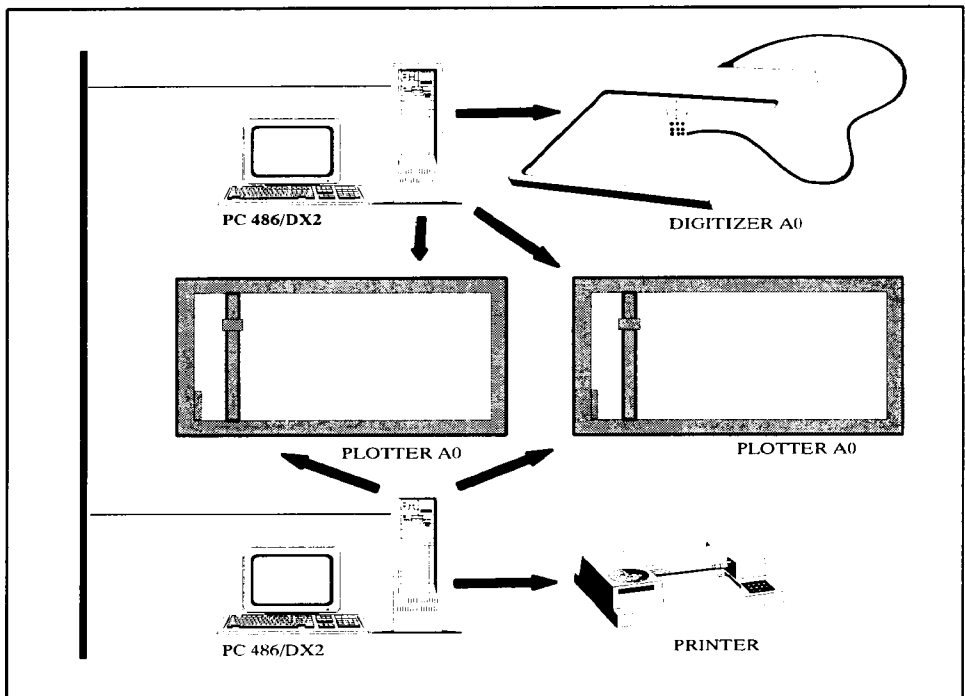


FIG. 13.- Layout of the equipment.

2. Software

The Operation System identified was MS-DOS Version 6.0, combined with MS-WINDOWS Version 3.11.

AUTOCAD Version 13 for Windows was selected for the digitization and drawing of graphical corrections. Further application development was made using AUTOLIST language.

For the storage and consultation of the correction files, "ACCESS", a relational data base management system (RDBMS) of Microsoft was chosen.

The total cost of the system development was:

HARDWARE:	US. \$51.000.-
SOFTWARE:	US. \$26.938.-
OTHER MATERIAL	US. \$ 5.000.-

TOTAL:	US. \$82.938.-

V. DEVELOPMENT AND IMPLEMENTATION OF THE PROJECT

During the phase of development and implementation of the project, a series of tests were performed, based on technical specifications and initial requirements of the design. Details on this phase are given below :

1.- Programming the "Notices to Mariners Database Managing Subsystem" (60 days).

This phase included the development of data input, edition and report of Notices to Mariners, Charts and Nautical Publications Catalogue Management Programmes and programs for data input and edition of the cartographic symbols contained in "Chart N° 1 Conventional Symbols and Abbreviations".

2.- Programming the "Graphics Edition, Digitization and Plotting of Master Charts Subsystem" (80 days).

This second phase included the interface for the "Notices to Mariners Database Manager" with the graphics edition system for each digital master chart. It also included the programming of all tools required for the edition of graphics (lines, circles, symbols, labels, sectors of visibility, zoom, panning, etc.) which were needed for the creation of Notices. Furthermore, the options for the digitization of notices and their final plotting on the nautical chart were also developed.

3.- Loading of the Data Base (5 days).

Once the programming of the project was completed and in order to permit a consistent operation of the programs, the Catalog of Charts and Nautical Publications data tables were loaded with all the information related to each nautical chart published by the SHOA. The same operation was carried out to fill the Cartographic Symbols tables with the codes and descriptions issued from "Chart No. 1 Conventional Symbols and Abbreviations".

4.- Cartographic Symbol Creation (10 days).

After having loaded the tables of the data base, which is an essential operation to initiate the functioning of the project, all cartographic symbols were converted into AUTOCAD format. To achieve this task, a program was developed to translate the cartographic symbols of the AUTOCARTA System (see International Hydrographic Review, Monaco Vol. LXX (2), September 1993), from the format IBM-

GPG to the format DXF, and therefore be imported by AUTOCAD. A procedure to create new symbols not defined in the AUTOCARTA System, was also implemented.

5.- Creation of Reference Grids for Nautical Charts (15 days).

In order to facilitate the task of updating the Digital Master Charts, a grid frame in DXF format was developed for all nautical charts of the SHOA portfolio. These grids are to be used as a reference for the positioning of the notices, in accordance with the Digital Master for each chart. This task was made by developing a re-formatting program for the output generated by the Grid Programs available at SHOA.

6.- Preliminary Test of the Project (5 days).

After having developed the project, a first operational test was performed. All Notices affecting SHOA chart No. 511 (Bahia de Valparaiso) were input in the data base, where they were automatically recorded in the digital master chart No. 511.

- Notices to Mariners Database Manager.

The input of Notices in the "Notices to Mariners Data Base", in addition to the automatic transfer of the notices to each Digital Master Chart, also permitted to obtain a series of products such as:

- A list of the Bulletin of Notices to Mariners.
 - A list of notices affecting a certain chart.
 - A list of notices within certain geographic coordinates limits, etc.
- Graphical Edition of the Digital Master Chart.

The process of graphical edition of master chart No. 511 permitted to display and consult on the screen the text and preliminary geographic position of the notices in the nautical chart. Once reviewed, the Notices that did not require positional changes were confirmed, and those needing changes were moved or rotated. The adjustments were made in the chart No. 511 using the digitizer and the mouse for a better accuracy.

- Use of Digitizer.

In general, operations with a digitizer did not present any problem and its use was essential to obtain a fine adjustment of the position and the angular direction of notices in the digital master chart.

- Test of Drawing on plotter

Once all the information of Notices was downloaded, reviewed and confirmed, an HPGL-2 format plotting file was generated. Using a magnetic recording of this file, the operator or draftsman placed a paper copy of nautical chart No. 511 on the plotter surface, to eventually draw all the Notices related.

A series of tests were performed in order to determine the best procedure to position the nautical chart on the plotter, as this operation requires a high degree of accuracy of the origin of coordinates and the orthogonality. These tests resulted in:

- The digitization of the origin of coordinates and the alignment by plotter commands.
- The adjustment of a carefully cut paper guide on the plotter to place the chart on the plotter table.

Although both procedures permitted a perfect placement of the chart, the second operation was quicker.

7.- Starting the Operational Phase of the Project.

To start the operational phase of the project, all Bulletins of Notices to Mariners from 1 January 1996 were processed, as well as the active Notices to Mariners affecting all nautical charts of the SHOA portfolio. The priority of the data input was based on the request for each chart from the users.

VI. EXPERIENCE AND SUGGESTIONS

A "USER'S MANUAL" has been prepared to provide guidelines about the operation of the system. It is a working guide with all details of the procedures involved in the updating of nautical charts. The manual is divided into two sections. The first -'Basic Concepts'- includes the principles of "Windows" that must be mastered to use the system: performing a Windows application, selecting options from the menu, answering to the 'dialog boxes', entering data in a dialog box, use of mouse and special keys. The second section is -'Operation of the Programme'- and lists the procedures to use the system. After having a quick look to the action to be carried out, it provides detailed information about how to carry out a corrective action, describing steps to be followed in order to execute that action and indicating possible errors of the user.

The system has been designed to operate with charts with a known Datum. For charts referred to a local datums, it is required to first perform a traditional (manual) correction on the master chart and from it, to obtain, using the digitizer, the exact position for the updating system.

To fill the data base of the system, all active Notices to Mariners affecting the nautical charts must be input. The traditional way to prepare the Bulletin of Notices to Mariners has been modified, so that the data base may be instantly updated.

Although the system has only been put into operation recently, the conclusion is that the process is highly productive, as very favourable correction times have been obtained during the implementation phase. As an example, a chart

affected by 13 Notices to Mariners was updated by the system in only 3 minutes, while using the traditional method, the procedure required 15 minutes.

VII. CONCLUSION

The implementation of this project is the result of the action of SHOA in the accomplishment of its mission to provide users of its nautical cartography with a high level of safety in navigation within the Chilean waters. The incorporation at a reasonable cost of the technology available in the national and international market to optimize the traditional methods for updating charts has resulted in an improvement of the efficiency of SHOA to face the increasing demand of navigation, fishing and recreation charts.

This experience is then now available to the world hydrographic community in accordance with the objectives of the International Hydrographic Organization (IHO), of which Chile was a Founding Member in 1921.