AUTOMATED NAUTICAL CHARTING SYSTEM II

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ABSTRACT

The increasing demand for digital chart products combined with the need for increased productivity is the basis for a high-priority effort to modernize the nautical charting process within the Nautical Charting Division of NOAA's National Ocean Service. This paper is a description of the conceptual design of this modernization effort which, for the most part, is centered around the Automated Nautical Charting System. Major features include a product-independent data base, multiple high-performance graphic workstations, terminals for alphanumeric and medium-resolution graphic operations, a chart construction capability, and a network system to facilitate communications between major system components.

1.0 INTRODUCTION

The NOAA, National Ocean Service (NOS), under the Department of Commerce, has the responsibility for providing nautical charts, related marine publications, and information required for the safe and efficient transit of the Nation's coastal waters and inland waterways. NOS' nautical information products support marine transportation, offshore resource exploration and extraction operations, and government operations involved in the regulation and defense of the Nation's coastal areas.

The NOS has traditionally produced paper products in the form of charts, books, and special publications. The digital computer has, as most of us are aware, been the root cause of what we know to be the "information revolution." While paper products will assuredly remain a major form of information conveyance, the demand for digital products is increasing rapidly. Figure 1, although not supported by any hard data, illustrates the changing trends projected for nautical charting products by the turn of the century. We project that in the 1990's digital products will constitute over 50 percent of the total nautical charting products produced. NOS' program to modernize its nautical charting process is driven by trends in digital data demand as well as the internal need to enhance productivity regardless of the product form. The overall modernization program of the nautical charting functions of NOS revolves around three major technology projects: the first is the Shipboard Data System III (SDS III) which is an ongoing development to significantly advance the state of the art in hydrographic data acquisition, the second effort is the development of an Integrated Digital Photogrammetric Facility (IDPF), and the third effort is the Automated Nautical Charting System II (ANCS II).

Approximately one-third of the new revisions out of NOS' suite of 1,000 charts are presently produced through automation using the first generation Automated Nautical Charting System. Therefore, the need to use computer-assisted cartographic techniques to increase productivity is not new to NOS because it has had an active ongoing automation program since 1975. What is new to NOS and greatly affects the next generation of automated techniques is the demand for digital data.

This paper presents a conceptual framework for ANCS II. The design team at NOS' new NOAA Charting Research and Development Laboratory has spent the last 2 years developing this framework and is currently preparing for a competitive procurement of the entire system. Development will be phased over a 4-year period which will include a development and demonstration period, a pilot production, and finally full implementation.

2.0 CONCEPT

It is likely that the product forms of the near future will be as varied as the display hardware and software systems proliferating over the next few years; it is for that reason that a major design feature is a product-independent data base. The conceptual view of ANCS II, as shown in figure 2, recognizes the fact that the paper nautical chart, as we now
FORECAST OF NCD
PRODUCT DEMAND

Figure 1

MODERNIZE NAUTICAL CHARTING PROCESS

Figure 2

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know it, is only one of the many marine products that may be derived from a digital, chart-independent data base of marine information. The system is therefore designed to have a logical separation between the data management and chart production functions to lessen the impact of each function on one another. In figure 2 the three major functional areas to be addressed by ANCS II are data acquisition, data base servicing, and production and distribution.

2.1 Data Acquisition

The three major functions of data acquisition are Photogrammetry, Hydrography, and Marine. All these functions will employ either medium- or high-resolution workstations for editing and data entry. The Photogrammetry functions will use IDPF to provide shoreline data to the Nautical Information Data Base (NIDB) in digital form. The IDPF will employ multiple analytical stereoplotters, computer graphics, online aerotriangulation, and specialized data bases. The IDPF will also have the capability to operate as a workstation to review and edit the data before being entered into the NIDB. Shoreline data will be retrieved from NIDB and compared with new data to measure the extent of change.

The Hydrography function will access the NIDB to assist in survey planning as well as review newly acquired data prior to entry in the data base. Hydrographic data will be acquired from the SBS III which will have a high level processing capability. Thus, the shore-based hydrography function will only be required to edit and review for final quality assurance before entry into the NIDB. During the survey planning process, a composite source data set will be prepared using the NIDB to ensure that the survey has the benefit of prior survey data and any change data pertinent to the survey objectives.

The Marine function receives external source data from over 60 different sources including the U.S. Coast Guard, U.S. Army Corps of Engineers, and numerous other public and private organizations. These documents will be evaluated in an interactive mode using graphic workstations. Document evaluation is one of the major concerns being addressed in the design of ANCS II. The current ANCS does not provide interactive facilities to assist the cartographer during the registration, validation, and subsequent processing of new information. ANCS II has been designed as an interactive environment to assist the cartographer in a predefined evaluation process and to serve as a management tool for the tracking of documents, recording events during evaluation, data selection and reduction, and scheduling of resources. The workstations, with the ability to communicate with the NIDB and other source files, will enable the cartographer within the Marine function to interactively evaluate source documents, translate coordinates, and select change features to be entered into the NIDB.

2.2 Data Base Servicing

The NOS is responsible for charting approximately 2 million square miles of coastal area. This area contains more than 40 million features of interest to charting and navigation. Management of this vast amount of information to meet the growing demand for marine navigational products necessitates the use of modern data base design. The Data Base Servicing function is central to the ANCS II concept. It will service the NIDB which will be designed as a relational data base structure with two dedicated central processing units (CPU's). Information will flow from the Data Acquisition functions to the servicing function where data editing will take place in a workstation environment, to coordinate the data from the various sources before entry into the data base. However, no graphics data will reside in the NIDB. The NIDB will be a geographically oriented database consisting of geographic positions of the features entered and their associated attributes. As previously mentioned, the NIDB and the Charting Data Base (CDB) will be logically and perhaps physically separated. Table 1 indicates that the NIDB will have the capability to efficiently access a logical subgrouping of features, which is a difficult task with the present system. The Servicing function will, therefore, control the flow out of the NIDB to the Production and Distribution functions which will include paper charts as well as service request for digital data.

2.3 Production and Distribution

Information in the NIDB will be available to the chart production function for application to the nautical charts contained in a CDB. The CDB will be a digital database containing the information required to produce the published chart graphics for approximately 1,000 nautical charts. The data will consist of a link to the NIDB and instructions for producing the graphic attributes needed by the cartographer to make cartographic decisions during the compilation processes.
### TABLE 1
**PROPOSED NIDB FEATURE CLASSIFICATION**

| Classification Code | I. NAVIGATION | II. HYDROGRAPHIC | III. TOPOGRAPHIC | IV. CHART SPECIFIC |
|---------------------|---------------|------------------|-----------------|-------------------|
|                     | A. Aids       |                  |                 |                   |
|                     | 1. Lights     |                  |                 |                   |
|                     | 2. Buoys      |                  |                 |                   |
|                     | 3. Daybeacons/Markers |      |                 |                   |
|                     | 4. Radio Aids |                  |                 |                   |
|                     | 5. Fog Signals|                  |                 |                   |
|                     | B. Demarcation|                  |                 |                   |
|                     | 1. Boundaries |                  |                 |                   |
|                     | 2. Administered Limits |      |                 |                   |
|                     | 3. Anchorages |                  |                 |                   |
|                     | 4. Recommended Routes |      |                 |                   |
|                     | 5. Channels/Dredged Areas |    |                 |                   |
|                     | C. Marine Assistance |        |                 |                   |
|                     | 1. Stations/Other |         |                 |                   |
|                     | 2. Facilities  |                  |                 |                   |
|                     |                  |                  |                 |                   |
|                     | A. Bottom      |                  |                 |                   |
|                     | 1. Soundings  |                  |                 |                   |
|                     | 2. Depth Curves |                |                 |                   |
|                     | 3. Bottom Quality |           |                 |                   |
|                     | 4. Cleared Areas |              |                 |                   |
|                     | B. Features in Water |        |                 |                   |
|                     | 1. Manmade     |                  |                 |                   |
|                     | 2. Natural    |                  |                 |                   |
|                     |                  |                  |                 |                   |
|                     | A. Coastline   |                  |                 |                   |
|                     | 1. High Water Line (HWL) |    |                 |                   |
|                     | 2. HWL Associated|             |                 |                   |
|                     | B. Culture     |                  |                 |                   |
|                     | 1. Prominent Structures behind HWL | |                 |                   |
|                     | 2. Other Feature/Limits behind HWL | |                 |                   |
|                     | 3. Structures over Water |           |                 |                   |
|                     | C. Natural     |                  |                 |                   |
|                     | 1. Limits (Surface) |           |                 |                   |
|                     | 2. Drains (Non-Nav) |             |                 |                   |
|                     | D. Relief      |                  |                 |                   |
|                     | 1. Contours    |                  |                 |                   |
|                     | 2. Features    |                  |                 |                   |
|                     | 3. Spot & Trig Stations |        |                 |                   |
|                     |                  |                  |                 |                   |
|                     | A. Nomenclature |                |                 |                   |
|                     | 1. Legends    |                  |                 |                   |
|                     | 2. Blocked Text|                  |                 |                   |
|                     | B. Scales     |                  |                 |                   |
|                     | 1. Other Scales |                |                 |                   |
|                     | 2. Magnetic Variation |        |                 |                   |
|                     | C. Symbols/Annotation |        |                 |                   |
|                     | 1. Feature Enhancement |      |                 |                   |
|                     | 2. Chart Format |                |                 |                   |
|                     | 3. Generated Data |              |                 |                   |
An interactive retrieval of information from the NIDB will provide only new features entered since the last chart update or a specified date. Retrieval will be qualified by geographic limits, usually the limits of the largest scale chart associated with the area being compiled. Features retrieved are transformed into proper chart symbols based on coded information in the feature record. The largest scale parameters govern portrayal characteristics of data retrieval, scale, control, and screen orientation (for skewed charts). Additional processing performs line and symbol generalization and converts all NIDB depth values to the units of measurement on the chart (soundings). Initial application is rule based, but will allow the cartographer full latitude to apply the final portrayal of data.

A digital data distribution function will be created to accommodate the growing demand for digital data. Although tapes of shoreline data are now supplied to a limited set of users, we can envision that, as the electronic charting industry grows, there will be a high volume demand for data recorded on various recording media.

3.0 HARDWARE

The hardware concept as presently envisioned is shown in figures 3 and 4. Plans are to have up to 20 high-resolution and 20 medium-resolution graphics workstations distributed throughout Nautical Charting Division (NCD). These will be linked in a cluster-type arrangement to their respective CPU and the CPU's will be linked through a high bandwidth (HB) network. Dumb terminals will also be distributed throughout the NCD to provide ready access to the NIDB. An ethernet is also planned, in addition to the HB network, in order to facilitate peripheral connection to the CPU's and greater spatial separation. Six VAX 8500 or equivalent CPU's are presently envisioned with each having workstations arranged in a cluster configuration.

The physical management of the hardware is yet to be determined; therefore, the discussion that follows addresses more of a logical assignment of capabilities than physical. Two CPU's and their associated workstations will be used to support Data Base Servicing. A third graphics cluster will be used for evaluating external marine source information. The fourth and fifth cluster will support production and distribution while a sixth will be used for computation, analysis, and tailoring of products. Two raster plotters will be used in the production area.

4.0 SUMMARY

An attempt has been made to describe the present concept for the ANCS II with the caveat that there are still many unresolved issues that might cause substantial design changes. The key point is that NOAA's nautical chart modernization program is being directed toward a product-independent data base focused design. A major drive behind this direction is the growing demand for digital map products. A graphics-oriented paper production system similar in concept to the existing NOAA automated system will be employed as a logical extension of the data base. Completion of the system is planned for the early 1990's.
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