UNITED
NATIONS

E

Economic and Social Council

Distr.
LIMITED

E/CONF.90/L.8
11 April 1997

ENGLISH ONLY

SIXTH UNITED NATIONS REGIONAL
CARTOGRAPHIC CONFERENCE FOR
THE AMERICAS
New York, 2-6 June 1997
Item 5 (g) of the provisional agenda*

REVIEW OF THE LATEST TECHNOLOGY IN CARTOGRAPHIC DATA ACQUISITION, MANIPULATION, STORAGE AND PRESENTATION, WITH SPECIAL EMPHASIS ON POTENTIAL APPLICATIONS IN DEVELOPING COUNTRIES: HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING

The Digital Nautical Chart: a multi-use database

Paper submitted by the United States of America**

* E/CONF.90/1.

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97-09950 (E) 290497

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INTRODUCTION

The National Imagery and Mapping Agency (NIMA) is an agency of the Department of Defense(DoD), primarily charged to supply the accurate imagery, imagery intelligence, and global geospatial information required by the United States Army, Navy, Air Force, and Coast Guard. In addition, we are required by law to make available to the civil sector those of our products which enhance the safety of marine navigation. Our Defense mission has required us to provide products in a variety of paper and digital formats, often duplicating the information content to meet unique format requirements of the various systems being served. This situation is rapidly improving as we pursue the DoD goal of fully interoperable systems within and between the Services. We have standardized our raster and compressed raster data formats, and especially we have settled on a standard vector format for a wide variety of products.

That vector standard is called Vector Product Format, or VPF, and it is our implementation of the international Digest-C standard format adopted by NATO and some National Governments. Among our current or planned VPF outputs are a V-Map series of digital multipurpose data bases at scales from 1:1,000,000 to 1:15,000, littoral warfare data bases encompassing a region which could extend from 200 miles at sea to 60 miles inland, special submarine navigation products, and the navigational data bases which will replace paper nautical charts in the paperless ships of tomorrow's Navy. It is these navigational data bases which are the subject of this paper, for they hold the potential of serving coastal planning, environmental protection, transportation monitoring, and other civil efforts as well as safe navigation.

VPF is a relational data format, with data presented as topologically structured thematic layers. VPF and other formats in the DIGEST suite of standards rely on a Feature and Attribute Coding Catalog, the robust content of which supports nautical, aeronautical and topographic products alike. Because VPF is a relational data format, it is ideal for use in geographic information systems(GIS), where VPF data bases serve as versatile backdrops for the addition of purpose-specific information layers generated by the user. This can be illustrated by a discussion of our primary nautical chart product, the nautical navigational data base which we call the Digital Nautical Chart, or DNC.

The DNC is not only a comprehensive chart data base for ship navigation, it also is a component of other complex NIMA digital products such as the one for littoral warfare, and is designed to be integrated in combat systems with other VPF products. One way to do this integration, which avoids both translation loss and display confusion, is to have the combat system exploit the data directly in its VPF format. This approach is being taken by Navy and is expected to be implemented in some

civil GIS display equipments. This does not rule out translation into another format for data exploitation, since all VPF data bases should translate the same way, but it does give a useful option.

I am assuming that enough has been published on electronic charts in recent years to ensure that you all are familiar with the subject. I'll therefore keep the explanation of the DNC brief. With the exception of its format, the DNC has been developed to satisfy the standards set forth by the International Maritime Organization(IMO) and the International Hydrographic Organization (IHO) for the data bases to be used in their Electronic Chart Display and Information System(ECDIS) equipment. ECDIS is a very high-end replacement for the conventional paper chart to be used by the civil mariner. The IHO specifies a data format called S57 for delivery of data to an ECDIS. However, unlike VPF which is both a transfer and an operating format, S57 is a transfer format only--data cannot be held in it for direct exploitation within an ECDIS system. DNCs in VPF contain the same data content and functionality as their S57 counterparts. The data layers contained in the DNC as a seamless data base are shown in Figure 1. As can be seen from Figure 1, many of the themes layered are essential to those who plan or monitor coastal zone activities. Although such things as cultural landmarks, land cover, and relief may have sparse coverage in the DNC because only material relevant to safety of navigation is included, the coding catalog includes features and attributes to facilitate input of a broad range of user information under the categories, and standardized symbology for these additions exists for use on other NIMA products. The data basic to exploitation for coastal zone purposes, such as shoreline, islands, depths, bridges and so on are there, and are to the best accuracy available to us.

Our statutory commitment to the civil mariner is met through release for public sale of products for defense which enhance safety of navigation, and will be met by release of the DNC. This will make the DNC available not only to the mariner, of course, but also to those who require data bases of the geographic areas covered for other purposes.

Our production of DNCs is proceeding. We are dividing the world into 29 regions for CD-ROM purposes, as shown in Figure 2, and intend to digitize over 3700 charts to establish the full data base. Data bases are constructed by libraries which represent the scale ranges associated with general, coastal, approach and harbor charts, plus a browse library for orientation on DNC content. Tile size varies by library, as noted in Figure 1. Our NIMA production priorities place emphasis on U.S. ports and approaches, and Navy home ports overseas, in order to allow early practical training of Navy personnel as soon as their navigation display systems are installed aboard ship. We are also giving priority to support of special Navy projects as they arise. In addition,we are now in, or arranging, coproduction of VPF products with other nations, which will expedite the availability of the data bases. We should achieve worldwide DNC coverage by 1999. All DNC will be on WGS 84 datum, and show depths in meters.

We have a VPF updating method in an advanced state of development, and based on it will implement a DNC telecommunications based update service for Navy. Because of the lower data rates used in communications by much of the civil merchant marine, we still must consider what update service will be adequate for that sector. While updating is vital for navigation applications

of the DNC, it probably is a minor consideration for most GIS purposes. NIMA is also developing what we have termed Full Utility Navigation Demonstration, or FUND, software which we require to help familiarize our customers with the DNC, but which should actually exploit the DNC in operating systems to an estimated 95 percent or more of the capabilities for safe navigation, and be of use in GIS exploitation of the data base. The FUND software is currently UNIX based, but shortly will be available also in Windows NT for PC application.

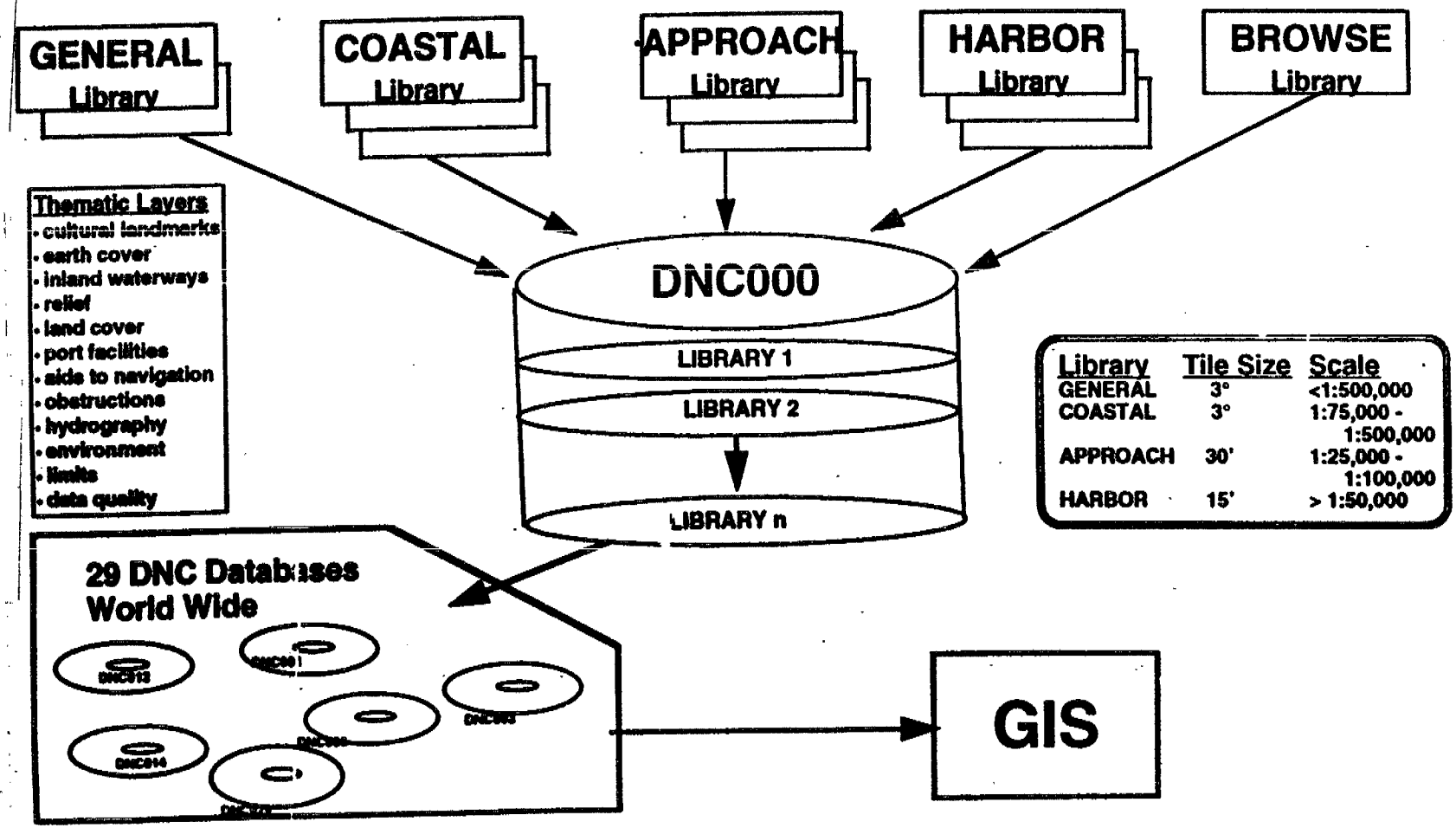
The DNC data base results from the digitization of charts from the NIMA portfolio. Many of these charts are based on data gleaned from foreign survey operations. The free use of foreign data in chartmaking has long been an established practice by many nations, as it was recognized that all benefited by increased availability of reliable charts. In recent years, however, the safety of navigation has taken a poor second place to the bottom line in the revenue ledger of several nations, and claims of copyright and intellectual property rights have been put forward in an attempt to obtain revenue for data used. While it has been the NIMA position that natural facts, whether the height of Mount Everest or the depth of the sea off Gibraltar, are not subject to copyright or intellectual property rights consideration, we do recognize that major resources and considerable personal effort go into the collection of chart data. We wish to avoid agreements which require administrative overhead which would probably far exceed the amount of royalty payments involved in the public sale of our charts based on foreign data, and we would not recognize any constraint on the use of NIMA products for U.S. Government purposes. But in the spirit of cooperation we would consider agreements to make available to the country whose survey data was used in our charts the VPF database which covered that country's national waters and coasts, and the international waters of its region, software to facilitate updating if the software rights are held by NIMA, and our FUND software to manipulate the data. The recipient country's Hydrographic Authority could repackage and sell the data for GIS purposes such as coastal or environmental planning or, if they implemented an updating service, for navigation. We believe that such an approach could relieve a number of small Hydrographic Offices from the necessity to spend the substantial resources required to produce a vector data set such as is now called for by the IHO, as well as result in a positive cash flow for them from the sale of the repackaged DNC products. We know from our own experience, as well as that of others, that many Hydrographic Authorities desiring compensation do not want that compensation in the form of royalties, since such royalties could go directly to their nation's treasury rather than to their operating fund. We expect many to prefer to receive the VPF data.

We do not expect to place our DNCs of foreign waters on public sale before we have discussed an appropriate quid pro quo with the affected nations. However, we have made our DNCs of United States waters available for GIS and navigational aid purposes, and those same DNCs will replace the paper chart for navigational use as soon as an adequate civil sector updating service can be developed. DNC use in lieu of the paper chart by the civil mariner requires that the U.S. Coast Guard authorize the use of the data base, with approved equipment, in US waters. A similar authorization by the appropriate maritime regulatory authority would be required for such civil maritime use of digital chart displays in the waters of other nations.

We know that our VPF DNC data base is the only feasible option for our Navy. We believe that our approach to making our DNC data base and related software available to other nations is not only in their best interests but also that it furthers the safety of navigation and facilitates national planning. We are proud to be able to contribute to the common good.

DNC Data Content

DNC DATABASE - Figure 1



DNC CD-ROM Footprint

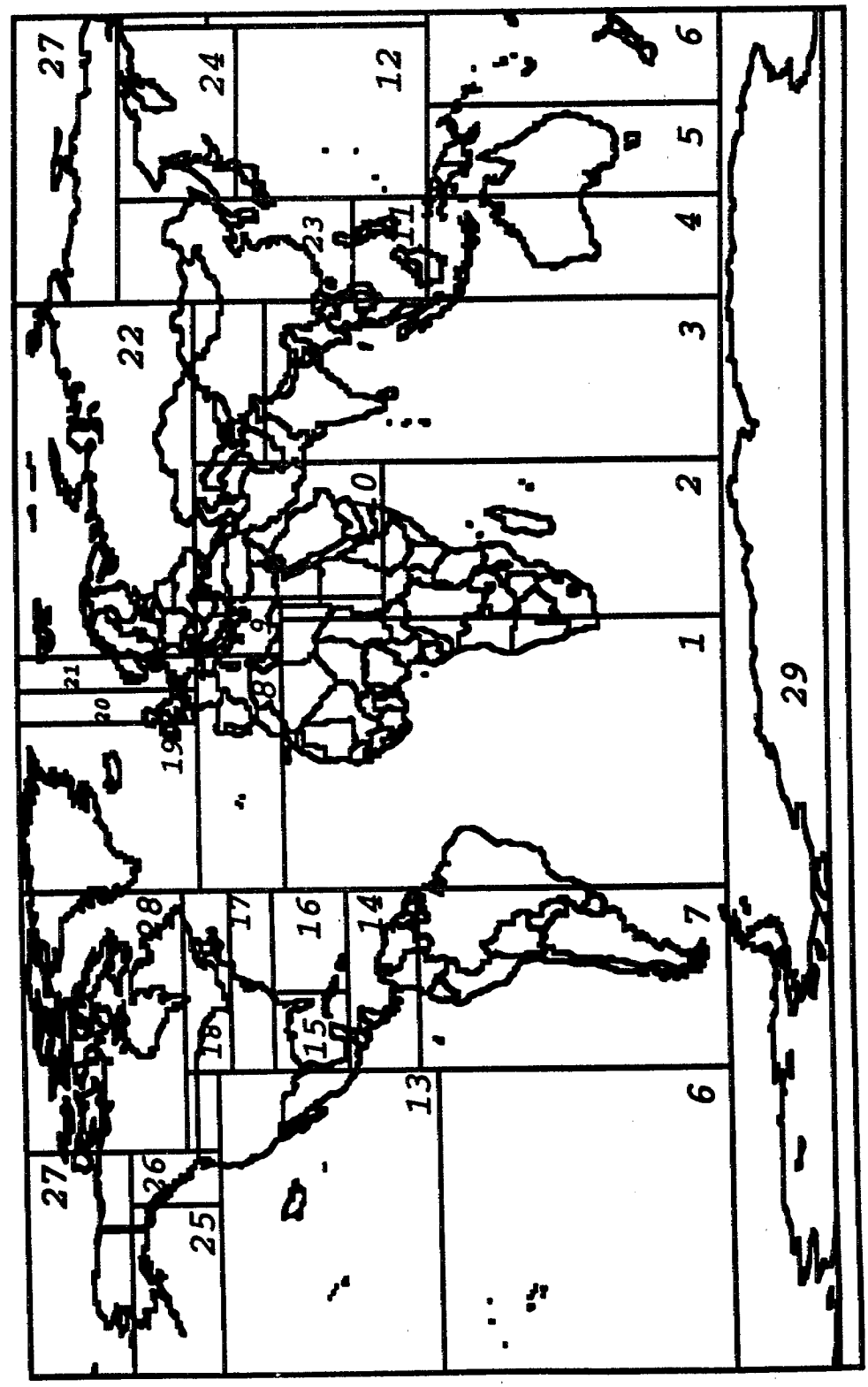


Figure 2
