International Hydrographic Review, Monaco, LXVI(2), July 1989

USE OF THE CARIS INTERACTIVE CARTOGRAPHIC SYSTEM FOR CHART PRODUCTION AT DHI

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1. INTRODUCTION

The Deutsches Hydrographisches Institut (DHI), as the national Authority of the Federal Republic of Germany, among other things is responsible for the production and maintenance of nautical charts and nautical publications (List of Lights, List of Radio Signals, Sailing Directions, Notices to Mariners, etc.).

Approximately 1,000 charts are produced to cover the areas of the seas and oceans which are of main interest to the Federal German merchant fleet. The DHI conducts hydrographic surveys of the continental shelf of the Federal Republic of Germany in the North Sea and the Baltic Sea.

Especially in the shallow home waters of the North Sea, charts are subject to frequent new editions due to the high instability of the sea bottom topography; therefore, these charts are very exacting with regard to chart maintenance.

In view of the intensive time pressure in production and updating of the chart originals, attempts have been made for a long time at DHI to introduce new advanced methods to the production process. The first major step was made in 1971 when an automatic, high-precision drawing table was installed. No interactive methods, however, were known at that early stage.

When, in the mid-seventies, the first interactive digitizing systems appeared on the market, the DHI purchased its first own system in 1977, an ARISTO GRID CD 400 from the German manufacturer ARISTO. Although this system could be used successfully for a number of steps of chart production — such as compilation of line features and depth soundings — its technology and capacity did not yet permit its full integration into the routine chart production process.

After a long period of re-examining the needs and requirements for computer assisted cartography, in November 1987, a new digitizing system was purchased by the DHI. The system is driven by the software package CARIS (Computer Aided Resource Information System) developed and marketed by the Canadian company Universal Systems Ltd. The same software package is

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installed at the Canadian Hydrographic Service offices and the Hydrographic Service of the Netherlands, which led to a close co-operation between these Hydrographic Services. Other Hydrographic Offices have shown interest in this software package. The system is designed for use with compiling, editing, and updating of data bases containing digital chart information, and to prepare drawing files for chart originals. The hardware, as configured at DHI, also provides capacity for other tasks, e.g. compilation of data bases for the production of nautical publications. The capacity of the present configuration is expected to cover at least production and maintenance of the nautical charts for home waters, and derived products — such as yachting charts.

2. SYSTEM CONFIGURATION (See Fig. 1)

The CARIS software package runs on off-the-shelf hardware which can be purchased independently of the software. At the DHI, the CARIS system is based upon a VAX/VMS compatible node computer Tektronix 4130G6. This computer, which is used for interactive processing, is connected to two graphic workstations. A CARIS workstation consists of the colour raster graphics terminal Tektronix 4125, an ALTEK digitizing table, and an IBM compatible PC Tandon PCA as digital controller.

The Tektronix 4125 serves as a dialogue station between operator and node computer. Thus there is the ability to download graphic information to the terminal and then process this information locally. A controller is placed in the workstation configuration to relieve the node computer of several processing functions, such as analog to digital conversion, transformation of digital co-ordinates to geographic co-ordinates, filtering of stream-digitized lines, data compaction, controlling digitizing functions for the digitizer.

Via Ethernet, the node computer with the workstations is connected to the local host computer CDC Cyber 930-11 operating under NOS/VE. This computer is used for batch processing, data storage, and creation of drawing files for the drawing table ARISTO MAT 308, which is also connected to the network via Ethernet.

The drawing table plots chart originals by photo-head or by pen. The configuration also allows the transmission of drawing files to the drawing table which are computed independently of the digitizing system on the local host computer or another CDC mainframe within the DHI network.

The disc capacity with the workstations amounts to 300 Mbyte. The local host computer caters for 800 Mbyte disc storage capacity for banking and maintaining the digitized charts and related data banks. Much more disc space is available on the other CDC mainframes within the DHI network.

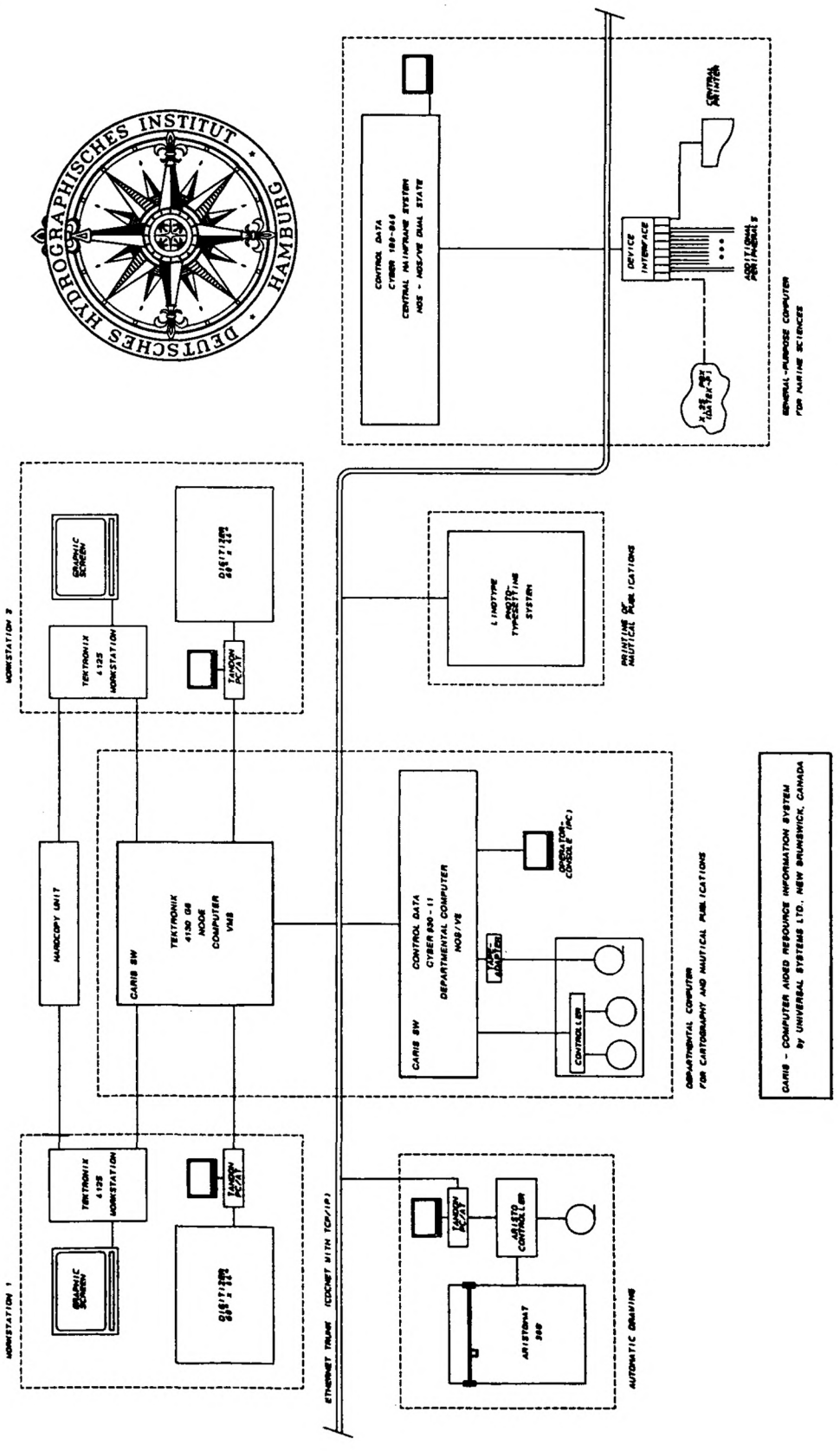

FIG. 1.— Overview of the components of the data processing system used for cartography and nautical publications at the Deutsches Hydrographisches Institut, Hamburg.

3. CARIS SOFTWARE OVERVIEW

The Computer Aided Resource Information System (CARIS) is a geographic information system, which specializes in management of geographically referenced data bases, interactive compilation of maps/charts from data bases, and map/chart production. Thus CARIS encompasses the capabilities necessary for performing the entire data base compilation and management process, from the digitization of data to the querying of attribute data associated with mapping/charting information.

Each component software module performs a specific task within the cartographic and geographic information structure of CARIS. Most of these modules, described below, are installed at the DHI. For a full overview on the CARIS package, see [1].

The main function of the Primary Graphics modules is to provide the user with the necessary software to create and maintain digital files. With the introduction of additional CARIS software modules, these files can form the foundation for a topological data base. The modules are used for registration, digitization, interactive editing, symbolization, plotting, data exchange (for transferring CARIS data to and from other data formats; for example, DHI format), file transformation (for example, change of map projections), etc.

The objective of the Extended Graphics module is to increase the sophistication of CARIS files to prepare the data for the creation of topology as well as the creation of textual information which may be attached to the graphic data. The objective of the Topology Creation modules is to formulate networks and polygons.

The Data Base Analysis module provides the user with the ability to carry out inquiries and generate reports from a CARIS data base. The CARIS data base consists of a graphic subsystem and a textual subsystem. The CARIS data base manager is generally used for queries about the graphic data base and to spawn queries to the textual data base. The textual data base is managed by a proprietary relational data base management system; in this case, INGRES.

The objective of the Continuous Data Base Management is to provide the user with the ability to treat disconnected files as a single unified data base. The result is a data base that may be displayed without concern for file boundaries.

The CARIS Digital Elevation Modelling (DEM) package permits the creation and manipulation of 3D data. This software module is currently installed for testing only.

The peculiarity of the system configuration using two different computer systems makes it necessary to store some CARIS modules on both systems. This required a conversion of these modules from the standard VMS-version to NOS/VE for operating on the CDC host.

4. SHORT TERM OBJECTIVES OF COMPUTER-ASSISTED CARTOGRAPHY AT DHI

Introduction of computer-assisted methods to chart production is considered to be the first step towards a more comprehensive long term development of information management for charts and nautical publications.

The capacity of the present system is designed to achieve, first of all, only modest short term objectives, with the possibility of being able to design future extensions based upon the experiences gained to that time.

These objectives are:

— to provide a capacity for storage and maintenance of the circa 50 nautical charts of that part of the Federal Republic of Germany's continental shelf in the North Sea and Baltic Sea;

— to develop methods for digitizing *all* contents of the charts, including all symbols, lettering, and textual information; the developing requirements of the 'Electronic Chart', currently being in its definition phase, shall be taken into account;

— to develop efficient methods for updating the chart data base;

— to substitute the conventional chart compilation and production process for charts of the Federal German territorial waters by computer-aided procedures, and to optimize these procedures;

— to develop and optimize methods for deriving charts from the data base of digitized charts — such as yachting charts — to study the possibilities of creating new charts from charts of different scales.

5. EXPERIENCE WITH THE DIGITIZING SYSTEM DURING THE FIRST YEAR

5.1 Development work needed

From the very beginning, it was clear that CARIS, although tailored more to the needs of nautical cartography than other systems available on the market, was still not completely covering all the requirements of the DHI.

For example, only the symbols used by the Canadian Hydrographic Service were available. As the DHI had decided to adopt the INT1 symbology, an order was placed with the vendor of CARIS — USL — to develop the respective symbology in co-operation with the DHI. This task, unfortunately, is not yet completed.

The font available with CARIS upon delivery did not correspond to the font

used at DHI, the 'Akzidenz Grotesk'. Thus, it was necessary to develop our own font, including the variants needed (Roman, bold, oblique and bold oblique). This work is now nearly completed. However, a modification to CARIS allowing the selection of the appropriate font is not yet available.

5.2 Problems encountered

Apart from the deficiencies known in advance, some unexpected problems did occur.

First of all, it was found that the accuracy of the digitizing tables, a standard product of a well-known manufacturer, was not satisfactory for application in nautical cartography, although it was in agreement with the guaranteed limits. With the kind agreement of the vendor, it was possible to replace the tables with devices of the American manufacturer ALTEK. Unfortunately, the new tables could not be delivered before September 1988. They proved able to maintain the required accuracy of 0.1 mm. However, the exchange necessary caused a major delay in the digitization work, because most of the chart contents previously digitized had to be corrected.

Another problem occurred with line digitizing. Initially, the so-called 'stream mode' provided by CARIS was used for the digitization of depth contours and coastlines, a mode with automatic registration of co-ordinates. However, test drawings showed a somewhat shaky line shape which was not acceptable. In spite of considerable efforts to find better parameter settings for the 'stream mode', this problem remains unresolved as yet. Therefore, at present, the much more time-consuming 'single point mode' has to be used for line digitization.

5.3 Work carried out with CARIS

In 1988, the following charts were digitized using the CARIS system:

a) Chart No. 91, the River Ems from Dukegat to Pogun, scale 1:25 000, including plans of the harbours of Emden, scale 1:12 500 and Dollart, scale 1:50 000.

This was the first chart digitized with CARIS. 'Spaghetti digitizing' was employed, which was found to be inappropriate for creating topology. As the chart was digitized using the low-accuracy tables, most of the chart content has to be digitized again.

b) Chart No. 44, Estuary of River Elbe, scale 1:50 000, including plan of Cuxhaven, scale 1:12 500 (see Fig. 2-4).

Parts of this chart were digitized for use with the COE 'North Sea Electronic Chart Project 1987/88'. By systematic digitization work (required for building up a topological data structure), it was possible to form closed polygons for displaying colour-filled areas on the display and for obtaining information about the relationships between different features. The buoy data were transferred from an existing digital file to the CARIS system. This chart was also digitized with the old low-accuracy tables, so that the chart content had to be corrected later on.

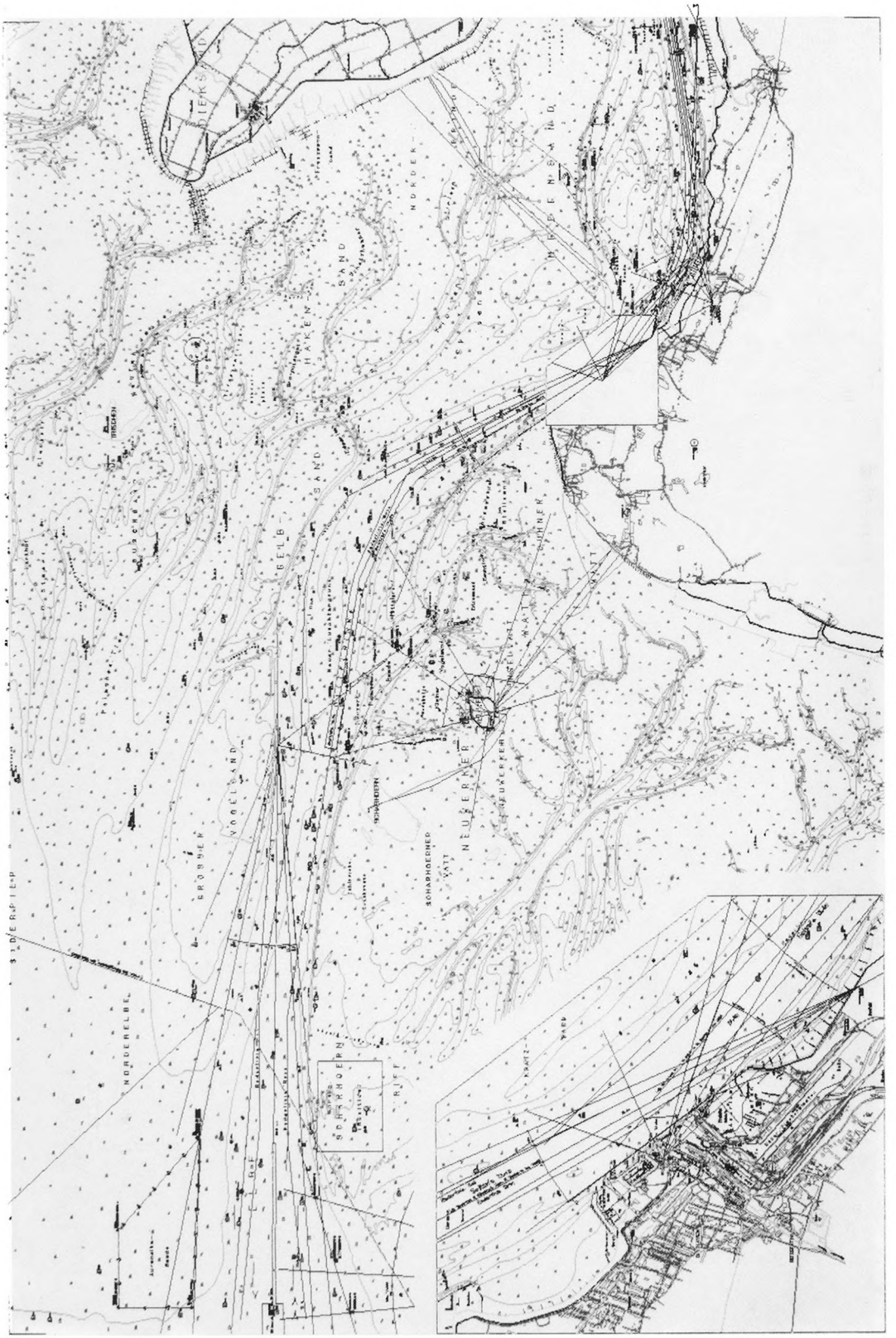

FIG. 2.— Digital chart No. 44, including plan of Cuxhaven.

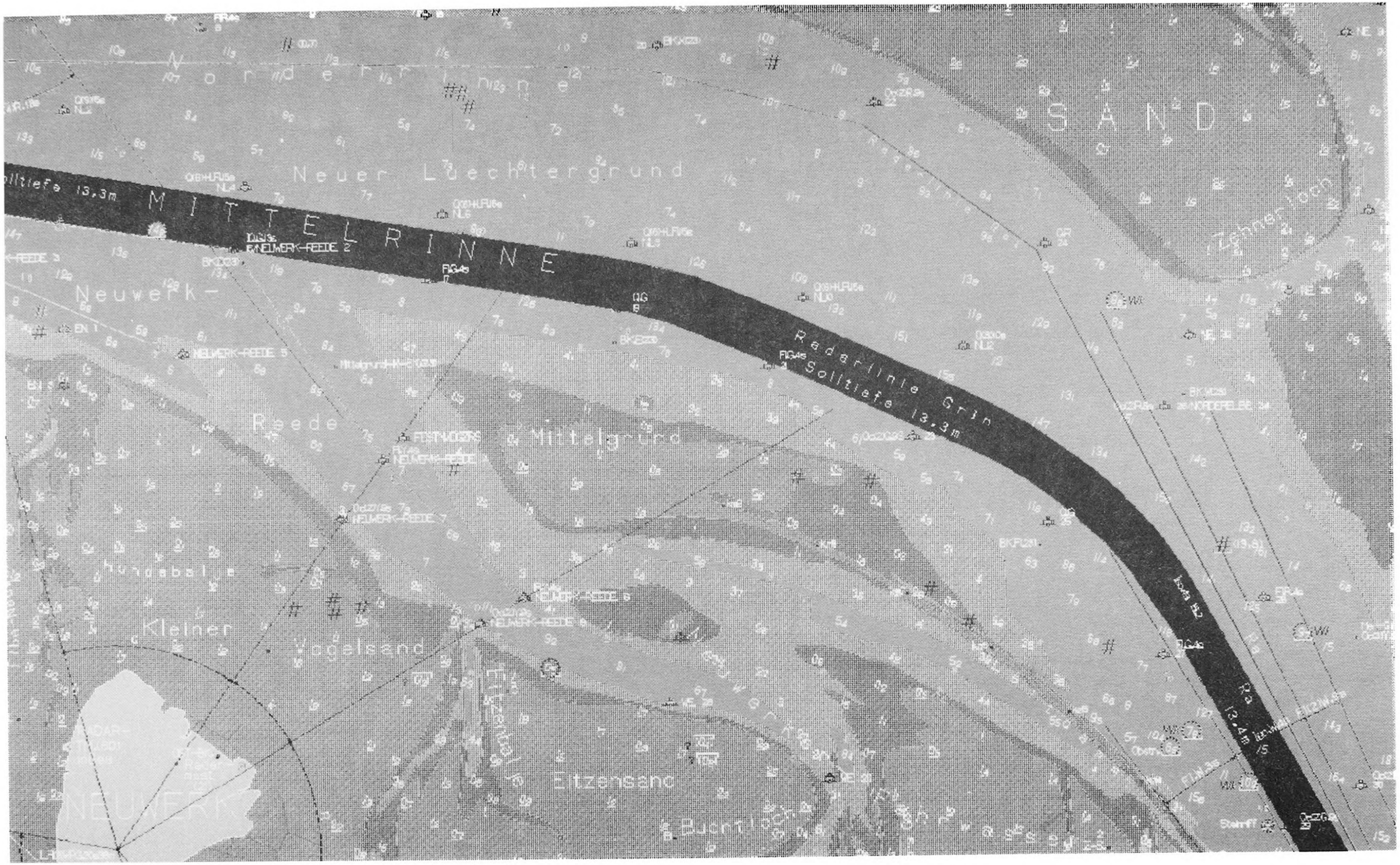

FIG. 3.— Extract of digital chart No. 44 (colour filled).

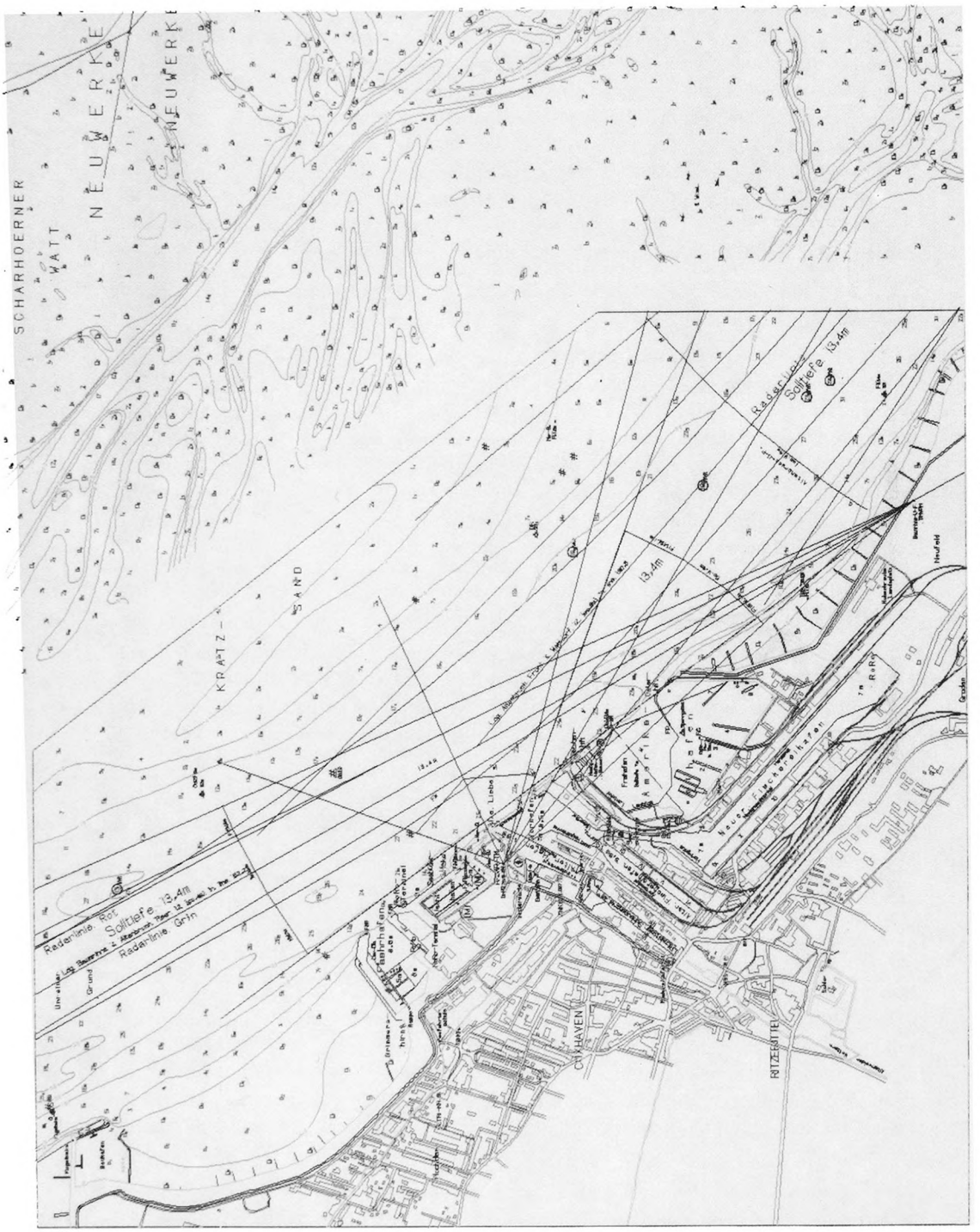

FIG. 4.— Digital chart No. 44, plan of Cuxhaven.

The digitization of chart No. 44 has been completed subsequently, so that the complete chart, including the plan of Cuxhaven, now exists in digital form. Depth contour lines were digitized again in 'single point mode', the points were joined by spline curves, because 'stream mode' digitization did not work properly. The land area was digitized anew by means of the ALTEK tables supplied in September 1988. A second digitization of the sea information with better accuracy is currently being carried out — step by step — when data from new sea surveys are available, because the sea area represented in this chart is very variable. Symbology has been digitized as well, based upon the Canadian symbology, except for some 20% where appropriate feature codes are lacking.

c) Chart No. 7, The Jade, inner part, scale 1:35 000, including plan of Wilhelmshaven, scale 1:15 000.

This chart was chosen as the first true production exercise. The digitization of this chart started in November 1988. The work was carried out in two phases. As the INT1 symbology was still missing, first of all the line features and soundings were digitized, such as coastlines, depth contour lines, roads, buildings and groynes. The missing symbology is being added in the traditional manner (patching and scribing). Parallel to this manual work, the omitted symbol information is being digitized — using the Canadian symbols — in order to complete the chart information data base.

d) Chart No. 2, Estuary of Jade and Weser, scale 1:50 000, including plan of Dove Harle, scale 1:25 000.

During the digitization of chart No. 7, the digitization of chart No. 2 started at the second workstation. This chart overlaps chart No. 44 and chart No. 7, thus in those areas the chart has not to be digitized again. The experiences gained in the composition of this chart will be employed for finding a solution to realize a data base of chart information.

Upon completion of the digitization of charts No. 2, No. 7, and No. 44, digital data of a continuous area will be available. These data will be a good basis for the development of a chart data base because of their complexity (different scales, overlapping areas, high updating rate).

5.4 Training

Thorough training of the staff is of prime importance for successfully integrating the new technique into the production process. Our experience has shown that theoretical training alone does not yet provide a ready concept for production. Rather, sufficient time has to be allowed for a learning phase from which the organizational basis can be developed. The following training phases were allowed for:

- Initial introductory training courses conducted by the vendor of the software, USL; this has been accomplished in close co-operation with the Hydrographic Service of the Netherlands through joint courses.
- On-the-job training by digitizing some selected charts parallel to conventional chart production. Three cartographers were allocated part-time, one cartogra-

pher even full-time to this phase, in order to gather sufficient skills and experiences for setting-up the final organizational scheme. More cartographers will be trained in future. Close monitoring by the chief cartographer is needed. One of the first results of this phase was the realization that clear and rigid digitizing rules are needed in order to ensure the possibility of maintaining the digitized charts as well as the proper inclusion of topology. These digitizing rules needed some refinement in the course of this phase.

- A trial phase with production work concludes the training, which is envisaged to pave the way for later transition to routine production. In view of some components of the system still being missing, such as INT1 symbology and corresponding feature codes, this phase is anticipated to last for some time to come and some overlap exists with continued on-the-job training. In addition, maintenance procedures have yet to be developed and tested.

5.5 Preliminary assessment of the experiences

The learning phase with on-the-job training has already proved the power of the CARIS system and its suitability for the production of nautical charts, in spite of some deficiencies still in existence. With regard to both gaining operational experience and the utilization of the digitized charts for the 'Electronic Chart', the participation in the North Sea Project was found to be extremely useful.

Experience also shows that it would be premature to expect any quick financial gains from introducing digital interactive methods to cartography. However, it is very clear that, in the medium and long term scale, the system will prove highly profitable.

6. OUTLOOK TOWARDS FUTURE INFORMATION MANAGEMENT

Some prospects and requirements of future management of hydrographic information are already set out in the contribution by K. BURROWS [2]. Whilst he examines in detail the requirements of a hydrographic survey data management, he also gives a long term scheme indicating the relationship of charts to other publications and their contents. Indeed, the nautical chart is only displaying graphical information needed for navigation, which could be extracted from a number of more comprehensive data bases, which may be used for production of publications as well, such as List of Lights, List of Radio Signals, and Sailing Directions. Likewise, the task of keeping these data bases up-to-date also involves the production of Notices to Mariners, blocks (patches) and/or tracings, etc. Thus, the introduction of digital methods to cartography would remain 'patchwork' without taking into account all the information sources of charts and nautical publications by integrating them within a comprehensive concept of digital information management. The divisions and subdivisions of the INT1 [3] may serve as a guideline as to which types of information are involved in charting.

It may be noted that this set of source data bases is referred to, in the

terminology adopted by IHO for the 'Electronic Chart', as the 'Electronic Chart Data Base' (ECDB or HO-ECDB) [4]. This illustrates that the formation of these digital source data bases is in fact a prerequisite for the production of the 'Electronic Chart'.

The benefits from an integrated digital information management are manifold:

— Each piece of information (new information as well as update to existing information) appearing in charts and publications would have to be entered once only, thus eliminating potential sources of errors and ambiguity.

— Minimization of the manual digitizing work by using digital data entry directly from the source data base; mainly editorial work for cleaning up the chart image would be left.

— Speed up of the whole process of chart production.

— Production of nautical publications, including Notices to Mariners, directly from the respective data base with minimum manual work involved.

As a first small step to study the implications of integrated information management, the DHI has started a pilot project to set up a data base for the List of Lights (North Sea). It is intended to study how a single data base can be used for producing both the List of Lights publication and keeping up-to-date, with regard to lights, the digitized charts concerned. Recommendations are to be developed on how to proceed with other information data bases, and how to produce Notices to Mariners from these data bases.

References

[1] Universal Systems Ltd.: CARIS Product Description, Document No. USL-88-05-13, 1988.

[2] BURROWS, K.G.: Information management in the modern hydrographic office — A challenge for the 21st century, *Int. Hydrogr. Rev.*, Vol. LXV(1), 1988, pp.93-105.

[3] Deutsches Hydrographisches Institut: INT1 — Symbols, abbreviations, terms used on charts, 1987.

[4] International Hydrographic Bureau: Draft Specification (third) for Electronic Chart Display and Information Systems (ECDIS), (Appendix: Updating the Electronic Chart), Special Publication 52, 1988.