THE HYDROGRAPHIC DEPARTMENT AND THE REQUIREMENT FOR DIGITAL HYDROGRAPHIC DATA

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ABSTRACT

Recent events point to an emerging requirement for bathymetric data in a machine readable form, primarily to support the digital chart. The Hydrographic Department has developed expertise in the use of automated cartography as part of its paper chart production process. This paper details the current thinking on how these computer based methods must be modified in order to supply data to meet the new requirement. It also describes the experimental work undertaken at the Hydrographic Department, including the production and maintenance of a trial data set, and a method of data coding which automatically matches the level of generalisation of displayed detail to the selected scale. The paper reviews initial moves within the international hydrographic community to identify and find solutions to the problems which must be overcome before digital hydrographic data can be used for navigation at sea.

INTRODUCTION

It is almost impossible to read a nautical journal these days and not find some reference to the electronic or digital chart as a general concept, as a system under development, or as a first generation piece of equipment usually intended for a specialist market, eg fishing.

It is difficult to predict in detail the outcome of current technical activity and debate, and it is of interest that there is, as yet, little demand for the digital chart from navigators. It does, however, appear axiomatic that as we enter the 'information age' there will be a requirement for chart data to be made available in a digital form. Furthermore, we believe that it is incumbent upon hydrographic offices to start planning for this eventuality now, and in this paper we outline the United Kingdom Hydrographic Department's initial moves in this direction.

Before describing these activities, a word about nomenclature would appear to be in order. The term electronic chart is often used to describe a comprehensive electronic navigation and information display system, which will display a vessel's position against a background of chart data, possibly with radar information superimposed. Electronic chart is also used in a more limited sense to describe the chart data displayed by such equipment. To avoid the inevitable confusion which can arise from the dual use of the term electronic chart, we prefer the term digital chart to describe the chart data, ie for that element of the electronic navigation and information display system which will be provided by hydrographic offices.

CURRENT CAPABILITY

In considering the digital chart, the Department has been able to draw extensively on experience gained from the use of its existing 'digital flow-line' which plays a major role in the production of paper charts (Drinkwater 1985). A major element in the chart production process is the conversion of the detail appearing on hand drawn chart 'compilations' into the reproduction quality images which will appear on the printing plates. When performed using traditional manual methods, this activity is both time consuming and labour intensive.

Using the digital flow-line, compilation detail is converted into a machine-readable form using off-line digitising tables. A verification plot of the data is then produced and examined for errors, which are subsequently corrected using interactive editing equipment. An increasing amount of routine editing is now performed automatically by software (Drinkwater 1986). The contents of the edited data file are output to a flat-bed plotter equipped with light head, which produce reproduction quality images of the digitised data on film. These film positives provide the image for the printing plates.

INVESTIGATIVE ACTIVITY

Our first investigative activity was the production of six digital chart files, using as source a series of 1:150,000 scale paper charts covering the south coast of England. The purpose of the exercise was to identify the problems likely to be encountered when capturing, storing, updating and selectively extracting such data and, from the experience gained, establish reliable working methods. Fifty-eight types of charted detail were selected for inclusion in the data files. It should be stressed that this is merely a representative data set; it was not our intention at this stage to decide which charted detail should be included in the digital chart. Similarly the level of generalisation used when encoding linear features was a convenient compromise rather than our considered view on how such features should be stored in the digital chart. The data are arranged into twenty software layers, the rationale behind this being that the user will be able to select the combination of layers most suited to his particular needs. (Restricting the number of layers to 20 merely reflects the limitations of our current editing and display software).

Examples from this data set are illustrated by figures 1 and 2. Both figures cover the same sea area, bounded by a coastline to the north, and include 2 depth contours (20 and 30 metres) and navigational lights. This information was obtained by selecting layer 1 for coastline, layer 5 for 20m depth contour, layer 6 for 30m depth contour and layer 13 for lights. In addition, figure 1 includes detail from layer 10 (soundings), layer 12 (buoys), layer 14 (light sectors) and layer 15 (pilot station). In lieu of layers 10, 12, 14 and 15, figure 2 shows the position of all known wrecks (layer 11).

The production of the trial data files has revealed several areas where modifications to our existing methods were required. It soon became obvious that digital techniques developed for paper chart production do not always meet the data encoding requirements of digital charts. For example, all depth contours appear on the printed chart in the same line style, with the appropriate depth values indicated by contour labels. In the digital chart each contour value eg 10m, 20m, 30m etc must be allocated its own feature code to enable software to perform selective extraction and display. This, and other similar considerations,

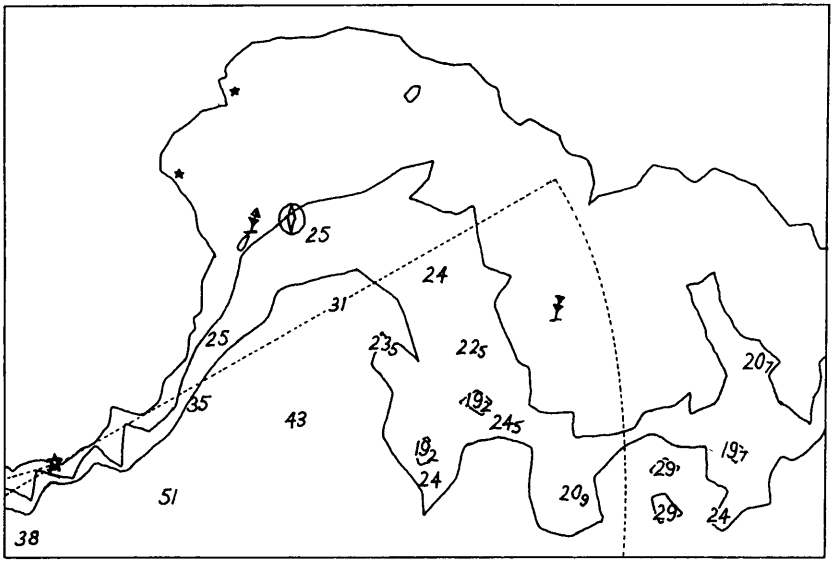

Figure 1

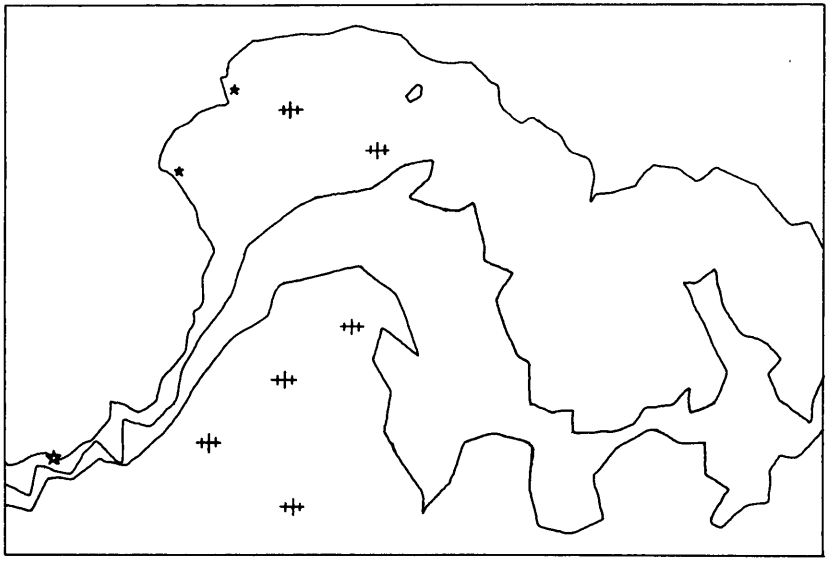

Figure 2

resulted in the creation of a new feature code menu specifically for the digital chart. Depth contours provide another good example of departure from 'conventional' charting practice. On the paper chart, cartograpic considerations often result in the localised omission of contours. In an area of steeply sloping seabed where contours lie very close together, it is often only possible to chart the shallowest and the deepest contours, intermediate ones being terminated on either side of the congested region. The digital chart will require all contours to be continuous - as we cannot predict in advance which ones the user may wish to select. Remaining with depth contours, it was necessary to establish a convention regarding the direction of digitising to enable software subsequently to determine on which side of the contour the deeper (or the shoaler) water lies.

Another indication of the difference between paper chart and digital chart digitising techniques is illustrated by the example of a lighthouse situated on an island. If the island is of very small extent, all that will appear on the chart is the symbol for a lighthouse without any encircling coastline. This is standard cartographic practice and does not confuse the mariner - he fully appreciates that the lighthouse must be standing on dry land and is not floating in the sea! Hence all that is encoded at that particular location in conventional chart production is the lighthouse symbol. For the digital chart, however, where the mariner may, for some reason, wish to omit the lighthouse from his display, it will be necessary to encode both a lighthouse and a symbol for a small island at the same location.

Requirements such as these illustrate the fact that the digital chart cannot be produced by simply digitising the paper chart of the relevant area, and that the preparation of the necessary source document - which could be an annotated version of the paper chart - will not be a trivial task. We must not lose sight of the fact that when reading a paper chart the mariner uses his interpretative skills to reach conclusions (as in the case of the non-floating lighthouse in the above paragraph), the spatial relationships between objects being an important input to this process. If he chooses to display a less than complete picture, then as many as possible of these relationships have to be built into the data set to enable software to emulate these human decision-making processes.

Not surprisingly, the study also revealed that the software associated with the production digitising flow-line did not satisfy all our new requirements, particularly in the areas of data update and data extraction. The ability to update is particularly critical for hydrographic data, being directly related to safety of navigation. The existing series of paper charts is updated each week, by the distribution of a free volume of so-called 'Notices to Mariners', describing the amendments to be made by the navigator to his charts. In the case of more complex changes the navigator is provided with a 'block correction' or chartlet, to be pasted over the affected area. Any professional digital chart series will require an analogous updating service. To this end we have established a method for updating our experimental data files for Notices to Mariners. Our initial data extraction capability was based solely on X, Y coordinates. We have now developed the ability to extract within specified geographical limits. The extraction routines operate on either selected feature codes or the contents of complete layers. Hitherto, each chart has been considered as an independent data file. The retrieval software is now being amended to access multiple chart files, so enabling the creation of new data files which cross chart file boundaries. The production of digital chart data sets brought with it the requirement to digitise textual information, something which had not been attempted hitherto. The

capability to handle text has now been developed and as an added benefit has been implemented in our production digitising flow-line (Drinkwater 1986).

We have also been looking at data selection and data generalisation. The proponents of the digital chart make much of the fact that the user will be able to vary the display scale to suit his changing requirements. In reality, such freedom will depend upon two major considerations:

a. The availability of data at suitable scales. Just as hydrographic offices would not contemplate publishing a chart at a scale of say, 1:10,000 based upon a hydrographic survey conducted at a scale 1:50,000, so must the electronic display system be prevented from displaying data at an inappropriately large scale.

b. The ability to control the degree of generalisation. If a data set is to be used to support a wide range of display scales, then the controlling software must ensure that the density of data displayed is commmensurate with the chosen scale, increasing automatically when the display scale is enlarged and decreasing when the display scale is reduced. The level of generalisation used to depict linear features, such as a coastline, must also be amended automatically as the scale is varied.

Without such generalisation there is a danger of the mariner being presented with a uselessly scant representation of his surroundings or, conversely, a confusingly detailed one. The selection made by the controlling software will have to be at all times conducive to safe navigation and moreover, produce a display which is cartographically acceptable. (It is appreciated that conventional attitudes towards what is and what is not acceptable may have to change as we move into the digital age). Certain features are scale dependent but others are not, and cannot be dispensed with if the display is to be of any use to the mariner, eg certain soundings must always be shown irrespective of scale, whilst others can be safely discarded below a certain scale. Similarly, the points required to satisfactorily depict a coastline are dependent upon the scale of display: major headlands are significant at any sensible scale, minor undulations are insignificant at the smaller scales.

In theory, what is required is software which will simulate the compiler's thought processes when he decides on the level of detail to include in a chart of a particular scale. As far as we are aware, no such software exists. We therefore considered the possibility of qualifying each element in the digital data set with a 'scale of display' indicator. This ensures that although the real time selection of display detail is performed by the software, the results of this process have been pre-determined when constructing the data set in the hydrographic office. One way of generating a correctly coded data set would be to prepare a set of source graphics, one for each scale range, and digitise from these, allocating to each point the appropriate scale range indicator. The drawback to this method is that many points will be common to several graphics and so must be digitised more than once. This would involve duplication of effort in both the production and the maintenance of the data sets.

An alternative method makes use of a single data set. Firstly the important points on the smallest scale graphic are identified. These points are then indicated on the next largest scale graphic, on which are also marked the additional points considered significant at that scale. This process is repeated at each successively

larger scale to produce, on the largest scale, a digitising guide indicating the scale of display appropriate for each feature. The advantage of this approach is that there is only one digitising source (the largest scale graphic for each area) and each point is digitised once irrespective of the range of scales over which it is suitable for display. Figures 3 and 4 are based on data derived from such a data set. Figure 3 shows a small scale depiction of the approaches to a harbour. Using the same data set, but specifying a larger display scale figure 4 is produced. Being at a larger scale this covers a smaller geographical area and it will be seen that the software has chosen a greater number of soundings, and that linear features such as coastline and depth contours are shown in greater detail than in the small scale example.

INTERNATIONAL APPROACH

Many outstanding items need to be resolved before the digital chart can be accepted as an effective replacement for the paper chart. These are the subject of debate by such bodies as the International Hydrographic Organization's (IHO) Committee on Exchange of Digital Data (CEDD), the North Sea Hydrographic Commission's (NSHC) Electronic Chart Display Systems (ECDIS) Working Group.

The primary question concerns the content of the digital chart. Should it contain all that is currently shown on the paper chart, less, or even more? The first generation of electronic chart systems operate on a very limited sub-set of chart information because of limited display resolution and data storage capacity. It is our view that this is not acceptable if the system is to be considered as a replacement for the paper chart. It is our contention that such a digital chart should contain all the detail shown on the equivalent paper chart, and this view is supported by others (Ligthart 1985). It is even conceivable that additional data may ultimately be included to support, for example, the real time tidal adjustment of depths and the generation of user-specified depth contours. It would also seem logical to consider including data from existing nautical publications which currently supplement chart detail.

There is common agreement that the digital data itself should be supplied by the national hydrographic offices in order to ensure the quality of the electronic chart data base. But system manufacturers will bear the responsibility for the integrity of the data if they subsequently process it, eg convert the format to that required by their particular equipments. The hydrographic offices will be responsible for obtaining and collating new information, and will update the electronic chart data base accordingly, but the means of supplying the update information to the user is still the subject of debate.

The selection of a suitable medium for supply of digital hydrographic data goes hand in hand with the development of a data format. It is clearly desirable that an internationally agreed format should be devised. CEDD has produced a proposal for an chain-node format, including a comprehensive feature/attribute coding scheme, for presentation to the XIIIth International Hydrographic Conference in Monaco in 1987.

The proposed format is intended for the exchange of large volumes of hydrographic data on magnetic tape between hydrographic offices. A simplified version of this format may be more suitable for use with electronic chart systems, but this cannot be produced until the requirements for such systems are more precisely defined.

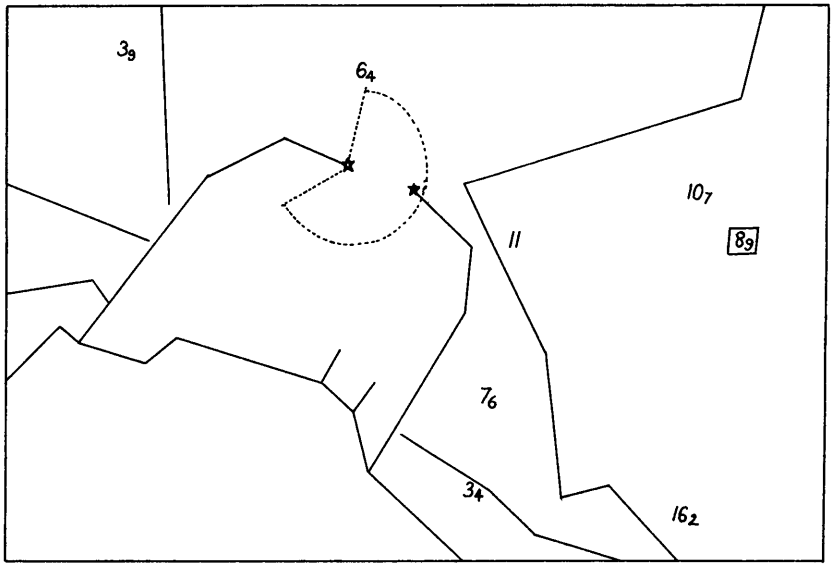

Figure 3

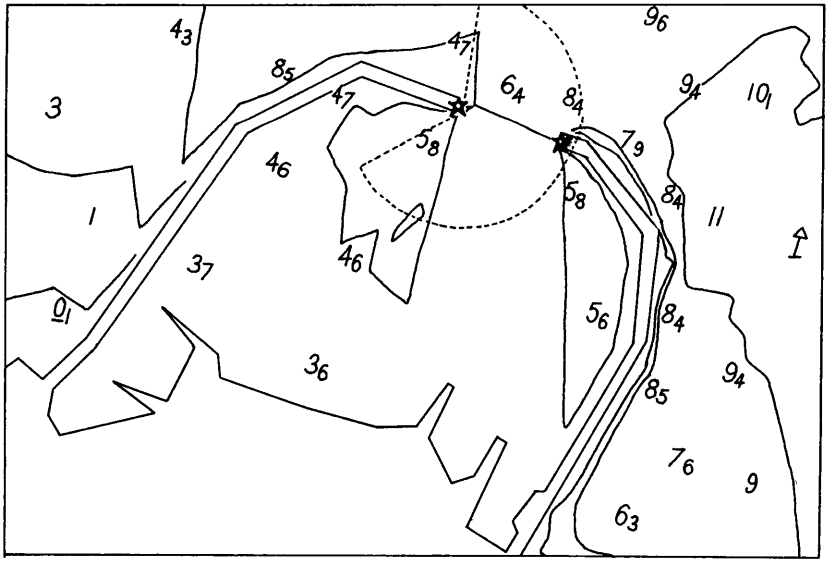

Figure 4

Consideration is also being given to the possibilities offered by telecommunications, particularly the supply of data to vessels at sea, and to this end a Canadian study is in hand to devise a format for this method of data transfer.

The other major area of discussion is that of the technical specification of the electronic chart systems. Systems of varying degrees of sophistication will emerge, each aimed at its own particular part of the market. There is a danger of some systems offering complex data manipulation capabilities which are not compatible with safe navigation. For example, care must be taken to ensure that the flexibility offered by a layering system of display is not abused by the navigator, who is not, after all, a cartographer. While the ability to select only those layers immediately relevant to his own vessel may produce a less cluttered display, the prudent navigator would also wish to display any information which may affect the navigation of other vessels in the vicinity.

Other aspects under consideration are: the standardisation of symbolism, the constraints which should be built in to prevent chart data being used at inappropriate scales; the means of recording a vessel's track and selection of data for accident investigation purposes.

From the above it should be clear that the problems of introducing a digital chart service are organisational, legal and financial, as well as technical. It is the aim of the Hydrographic Department to assist in finding answers to these questions, having as its overriding consideration the safety and convenience of the mariner.

The views expressed are those of the authors and do not necessarily represent the views of the Ministry of Defence, or of the Hydrographic Department.

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