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UK HYDROGRAPHIC DEPARTMENT PROGRESS WITH COMPUTER ASSISTED CARTOGRAPHIC TECHNIQUES

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INTRODUCTION

In an earlier contribution to this Review [1] in July 1976 the UK Hydrographic Department's experiences with digitising equipment were described. The procedures by which data were digitised on offline tables and then edited on a Ferranti interactive editing station were discussed.

A later paper by TOLSON [2] indicated, amongst other things, the use the UK Hydrographic Department were making of voice recognition equipment to help with the encoding of graphical sounding data on an offline digitiser table.

Details of the computer-assisted techniques being used at sea in some of the UK hydrographic surveying fleet have also appeared in an earlier issue of this Review [3] and elsewhere [4].

It is the intention of this paper to report the recent progress made by the UK Hydrographic Department in the area of computer assisted cartography.

PRESENT TECHNIQUES

Digitising and interactive editing

Digitisers

Three off-line incremental Ferranti digitising tables are currently being used, each comprising a 152 × 107 cm digitiser board, 7-track magnetic tape output and a 32 character alphanumeric display. Two of these tables are interfaced to EMI/ Threshold voice recognition systems with vocabularies of 16 words.

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Interactive Editing Systems

At present the tapes from three digitisers are edited and re-formatted on the Ferranti interactive editing station. This is similar to that described in reference [1], consisting of a 152 × 107 cm Bendix digitiser board, a Digital Equipment Corporation PDP 11/40 computer with 28K (16 bit) words of core store, Disc Operating System (DOS), 1.2M character disc pack, 7-track magnetic tape deck, Calcomp 563 30" drum plotter, paper tape reader and punch.

The system was originally supplied with a Tektronix 611 (28 cm) storage display unit which proved to be too small for easy editing of chart sized documents and this was subsequently replaced by a larger Tektronix 4014 (48 cm) storage screen when it became available.

The equipment has been in regular production use since 1975 and in that time has been employed in the preparation of a substantial number of nautical charts, as in Table 1.

TABLE 1

(1) Year	(2) Charts progressed via interactive editing equipment	(3) Column (2) expressed as a % of total annual new chart production
1975	1	1
1976	11	9.8
1977	17	14.9
1978	32	26.2
1979	41	38.0
1980 (lst half)	46	68.0

In this period many improvements have been made by Ferranti to the software which have not only increased the range of facilities available but also significantly reduced the "fragility" of the system to users with varying degrees of experience and skill. In this context the inability to recover from errors, particularly those made at the offline digitiser stage, has been especially irksome and has occasionally resulted in the loss of large files of data which have had to be recreated by re-digitising from the source document.

Many of the disadvantages of the system reflect the fact that it was designed and built over 7 years ago. In particular the limitations of the DOS operating system are being increasingly felt. Essentially DOS allows no more than one man to do one job at a time without unacceptable time penalties being incurred on the system. The relative slowness of the Calcomp 563 drum plotter and the limitations of a 1.2M character disc which has to hold not only the system software but also the files of chart data being worked on (files which are becoming increasingly larger in size) are further problems.

Problems with interactive system

Perhaps one of the most significant problems encountered in the use of the interactive system has been the difference in presentation between the display of some hydrographic features on the Tektronix screen and the final high-quality film plot. For instance, in the case of soundings, the position is indicated on the screen and calcomp plot to the right of a small "positioning" triangle. This dissimilarity with the final chart in terms of style (but not accuracy) of display prevents easy accomplishment of detailed editing of contours close to the soundings via use of the display screen and interactive facilities. It has indeed been necessary to perform these minor contour amendments manually at a later stage in the chart production process and thus far it has not proved worthwhile to make parallel amendments to the digital databank of the chart.

Although some of the disadvantages of the present interactive editing system have been highlighted it should be borne in mind that this system was one of the first in the world to be developed and used for hydrographic purposes. It is inevitable that elements of the hardware and software have now been superseded by later developments. Nevertheless this system has made an important contribution to the development of computer assisted cartography in the UK Hydrographic Department over the last 5 or so years and is still in daily production use.

Replacement interactive system

In 1979 steps were taken to procure a replacement system which would enable the continual development of the interactive editing of hydrographic data. Competitive tender action was initiated in which a comprehensive review of relevant systems being offered was undertaken, bearing in mind the requirements for such a system.

These requirements were divided into those which were considered mandatory, as in Table 2 (i.e. those which would enable us to perform the tasks undertaken on the present interactive system but in a more efficient manner) and those which were considered highly desirable, as in Table 3 (i.e. facilities that would enable us to develop new and important tasks).

The final choice from the equipments offered as a result of competitive tender action was particularly difficult because of the large number of highly advanced systems that are now available in various parts of the world.

The contract was eventually placed with Laser-Scan Ltd of Cambridge, UK. Laser-Scan Ltd are perhaps best known in the cartographic world for their development of a semi-automatic digitising system known as 'Fastrak'. However for the purposes of Hydrographic Department requirements they were able to offer a system based on the comprehensive and powerful software developed for 'Fastrak' but consisting essentially of equipment supplied by other manufacturers.

The system includes a Digital Equipment Corporation PDP 11/60 computer with 256 K bytes of store (16 bit words) and a 67 megabyte exchangeable disc store. The various peripherals to this computer will eventually include a 152 × 107 cm Ferranti Freescan absolute digitising table, 7 & 9-track magnetic

TABLE 2

Mandatory requirements for replacement of interactive editing system

(a) The new system must enable fast and efficient interactive editing of data generated on existing offline digitisers.
(b) To assist with the interactive editing the system will include a display of at least 48 cm as measured on the diagonal of the screen.
(c) If the system includes a digitising table this must have an active area of at least 152 cm by 107 cm.
(d) It is essential that the interactive system can accept directly the 7 track magnetic tape output of the existing offline digitiser tables.
(e) The system must enable rapid verification plots to be made at the same scales as those of the originals.
(f) The accuracy of the system must be commensurate with the existing offline digitiser tables, i.e. an overall accuracy of better than ± 0.127 mm with a resolution of 0.0254 mm.
(g) The display of features on the screen and check plot should agree as far as possible with the final high-quality plot in terms of position, style and size (or relative size where enlargement of the screen picture is involved).
(h) Output from the system must be suitable for input to the Department's ICL 1904 S mainframe computer.
(i) In the event of a power failure, hardware problems, software corruptions or operator errors as much of the data as possible must be preserved including any files being worked on at the time of the incident.
(j) It is essential that the source software for the system should be available. It should be possible for the Department's programmers to access and extend this source in a high-level language.
(k) The system must be capable of multi-task operation.

tape units, a Tektronix 4016 (63.5 cm) storage display, a Calcomp 1051 four-pen drum plotter and a DEC writer LA 120-DA.

The operating system (RSX-11M) will enable more than one task to be performed simultaneously and it is estimated that eventually up to four people will be able to use the system at the same time, all doing different tasks if required. To enable this to occur it will be necessary to purchase additional "seats". A seat will consist of either a suitable display screen and a full size (152 × 107 cm) digitiser table or, where the facilities provided by a large high accuracy table are not considered to be necessary, a display screen, a tablet and a hardcopy unit.

The tablet is essentially a small (28 × 28 cm) digitiser and information on the display screen is referenced to the tablet by means of the hardcopy unit. This produces an A4 size drawing of the information shown on the screen which can then be mounted on the tablet and referenced to the screen in the traditional manner. With regard to the additional seats it is planned to use one of these for interactive editing of data digitally logged at sea. These data will consist of information on position, depths, gravity, magnetics and other parameters, notably temperature, submitted to the Hydrographic Office both from our own survey ships and other sources as available.

TABLE 3

Desirable requirements for replacement of interactive editing system

(a) Where applicable, the use of a cursor should not be restricted by continuous contact with the digitiser table surface.
(b) It is desirable that the equipment be tolerant of a wide range of environmental conditions, especially temperature and humidity due to its intended location in a non-air conditioned room.
(c) Ideally the system computer should be capable of extension to a multi-user mode so that extra facilities could be added to the system that would enable more than one person to perform interactive editing tasks at the same time.
(d) It is desirable that output from the new system is in a format that is :
  (1) compatible with either the existing interactive system output format or the existing mainframe databank format;
  (2) suitable for input to one or more of the Department's present precision draughting systems;
  (3) suitable for subsequent processing by the Department's programmers using high level languages.
(e) It would be advantageous if the system were capable of being fitted with such device(s) as would assist the semi-automatic digitising of nautical chart information.
(f) It is desirable that the system should possess the ability to differentiate data on the display unit, so that information from two or more distinct sources could be superimposed on the display at the same time, while retaining the ability to identify its source. Editing of the amalgamated data should be possible in the normal way.
(g) It is desirable that the system offers databanking facilities with co-ordinate conversion, so that archived files could be stored in either cartesian or geographical co-ordinates on any one of a number of projections of which Mercator or Transverse Mercator would be the most important.

The hardware of the replacement interactive system includes a number of advantageous features new to the Department such as the large 63.5 cm display screen and a digitiser table from which the cursor may be lifted without the system losing its point of origin. The large amount of storage available on the exchangeable disc unit will help to overcome certain restrictions experienced in the past, particularly for tasks with above average amounts of data.

The Calcomp 1051 plotter is approximately eight times as fast as the intermediate quality plotter on the existing system as well as being able to draw different features (e.g. the various line thicknesses in up to 4 colours).

As far as possible there will be agreement between the styles in which features are displayed on the Tektronix screen, the Calcomp plotter and the final high-quality plot. This facility will overcome, for instance, the problem of positioning digitised detail very close to soundings.

When fully operational the system will be able to perform transformations from the raw data (in plain table digitiser co-ordinates) to geographicals.

Automated Draughting

For a number of years the Hydrographic Department has been using high precision flatbed plotters to produce high quality plots on film or scribecoat.

TABLE 4

Details of draughting systems

	Aristo/AEG 3001	Aristo/AEG 3012	Kongsberg 1825S
Table size (metres)	1.9 × 1.5	1.5 × 1.2	2.5 × 1.8
Input media	Paper tape or 9 track magnetic tape in each case		
Drawing	By pen, scribe or lighthead possible on each plotter		
Minimum programmable step	0.01 mm for each plotter		
Accuracy	± 0.04 mm	± 0.04 mm	± 0.075 mm
Speed	8 metres/min drawing	25 m/min drawing Mode 2: 40 m/min	Mode 1: 15 m/min Accn. 0.1 g Accn. 0.3 g
	12 m/min with pen up	28 m/min with pen up	
Lighthead	The AEG lightheads use discs which can have up to 100 symbols. The actual number of symbols depends on their size, which may be 2.5 × 10 mm, 5 × 10 mm or 10 × 10 mm		Includes a PS5 lighthead with 96 symbols, maximum size 6 × 6 mm and 3 magnifications. This will eventually be augmented to six magnifications.

Our original purchase in this area was a Kongsberg Kingmatic 1215 plotter. Driven by paper tape and without any lighthead facility this plotter has only recently been withdrawn from production use after 12 years' highly satisfactory service.

At present the Department's automated draughting equipments consist of:

(a) Aristo/AEG3001 draughting system purchased in 1975.

(b) Aristo/AEG3012 (1977).

(c) Kongsberg 1825S (1979).

Details of these plotters are given in Table 4.

Development of computer assisted cartographic techniques

For a number of years digital data has been processed from three principal sources.

1. *Data computed on the ICL 1904S mainframe computer* via applications programs which produce mathematically-generated information to enable the draughting systems to plot out chart borders and navigational lattices.

2. *Data obtained via the offline digitisers and the interactive edit station* using equipment described earlier in this paper.

For approximately five years manually prepared pen and ink compilation documents have been digitised on the offline digitiser tables. These compilations contain the information that will eventually appear on the printed new chart. The information digitised offline is subsequently edited and re-formatted on the interactive equipment. After further processing and databanking on the ICL mainframe computer a high quality film plot of the digitised document is made on one of the Department's draughting systems.

It would be possible to accomplish high-quality reproduction of the complete compilation document via this process. However so far for production purposes the Department has only attempted to process approximately 80 % of the content of a chart through the computer assisted techniques. The 20 % not yet automated is mainly comprised of those irregular line features such as low water rock, coral and cliffs as well as compass roses and names.

This is due to :

(a) An attempt to keep as close as possible to the accepted traditional styles of features used since the Admiralty chart metrication program was commenced in 1968.

(b) The introduction, as a matter of policy, of automation only to those aspects of a chart where there was a likelihood that it would be economical to do so.

For example, compass roses are still inserted on charts by photographic techniques to avoid the time penalty that would be incurred if these features were drawn via the high-quality plotters.

It is expected that developments in technology will reduce the outstanding 20 % even further. For instance, in an attempt to overcome the problems presented by the variations in text size and style used on Admiralty charts (and therefore the number of lighthead discs that would be required to cover all possibilities) a Barr and Stroud photographic lighthead with six symbol magnifications has recently been ordered. This will be fitted to the Kongsberg 1825S draughting system and when delivery of this has been completed it will be possible to put a full alphanumeric font on one of the 96 symbol discs and output this font in 6 of the most commonly used point sizes without resorting to a disc change.

3. *Digital data collected at sea*

The four ocean surveying ships are fitted with data-logging systems. These systems can record and process inputs from most of the currently available electronic position-fixing aids as well as data from the hydrographic sensors (i.e. gravity, magnetics and depth). All the data are presently recorded on to seven-track magnetic tape but this facility is currently being replaced by dual-cartridge recorders which it is hoped will exhibit greater reliability and robustness.

When submitted to the Office, digital survey data are processed via a number of applications programs on the mainframe computer. These validate and reformat the data into a form suitable for :

(a) manipulation on the interactive editing equipment;

(b) plotting of parameters on the automated draughting systems. This is especially important where retrospective reprocessing of the ships' raw data has been undertaken;

(c) long-term archiving.

The ships' ADL systems are suffering from being originally designed in the mid-1960s and they are now becoming obsolete. One of the largest problems with the existing systems is that it is not possible to edit the magnetic tape record on board the ship. Thus all data, whether it be of good or indifferent quality, has to be rendered to the office for further processing. It is intended that the facility to edit computer-recorded survey data on board ship will be provided for in the replacement system which is currently being specified.

FUTURE DEVELOPMENTS UNDER CONSIDERATION

Voice recognition systems

One of the problems with an otherwise very successful part of the digitiser system has been the speed with which the present voice recognition equipment can identify individual words in the vocabulary. To achieve a high rate of success on input it is necessary to separate each word by a slight but nevertheless distinct pause. The cumulative 'pause' becomes significant when dealing with a chart of, say, 1000 four-figure soundings.

Recent progress in this area has been the development of voice recognition systems which can accept speech input at normal speed without introducing unnatural pauses between words. It is hoped to use one such system, known as 'Quiktalk' and supplied by Threshold International Electronics of Hayes, Middlesex, UK, in the next few months. It is estimated that there will be an approximately 50 % time saving using the new voice recognition system to digitise the soundings on a chart.

Offline digitisers

Within the next few years it will be necessary for us to replace the 7-track magnetic tape units presently being used on the three offline digitiser tables. Although no final decision has been made it is currently thought that the magnetic tape units will not be directly replaced and that data digitised on these tables will be passed to a suitable mini-computer via cable and stored on an exchangeable disc unit. Such a solution would significantly decrease the cost of having to provide individual replacement magnetic tape units as well as making the data readily available for subsequent amendment and checking as appropriate.

Colour displays

There are hopes of incorporating a colour display facility into the interactive editing system in the near future. A colour facility would enable early differentiation of data on the display unit, so that information from two or more distinct sources could be superimposed on the display at the same time, while retaining the ability to identify its source.

Thus, for example, existing digital chart data could be displayed in one colour and at the same time new digital survey information could be superimposed on this in a different colour. This would facilitate the selection of new information which would be amalgamated with data from the existing chart file to produce a combined and updated chart file.

Automatic scanning

For a number of years progress with the development of automatic scanning devices has been monitored. Such a device could play an important part in the initial digitisation of hand-drawn compilation documents, perhaps replacing the traditional digitiser tables used at present. An automatic scanner could also be expected to be of importance in the establishment of a comprehensive database of hydrographic information based upon data on existing surveys and printed charts. Fully automatic scanning devices offer the possibility of document to digital conversion but at a cost both in terms of capital outlay and time that has to be spent subsequently identifying and feature coding the graphical elements.

It may well be that a semi-automatic scanning system offers the most effective solution in terms of providing the operator with a cheaper system and with the opportunity to feature code before initiating such procedures as line-following or point feature digitising. These are performed automatically by the system but under the control of the operator. The high proportion of short lines and the large number of discrete point features (e.g. soundings) which characterise hydrographic documents do not lend themselves so readily to automatic line-following as, for instance, maps with their (normally) much higher proportion of long continuous lines.

It may be possible in the near future to enhance the existing digitiser tables so that linework could be digitised at a greatly increased speed. This would be accomplished by a newly developed cursor which would include an 'active' area, of perhaps 1 cm × 1 cm, rather than just an 'active' centre point. Providing the line to be digitised fell within the active area of the cursor, information on its position would be transferred in digital form to the recording medium. Thus instead of having to place the centre point of the cursor precisely at intervals along each line digitising could be accomplished by scanning a line at fairly high speed.

Document comparator

One of the fundamental tasks in the Department occupying significant amounts of time and manpower is the comparison of various hydrographic documents. Such documents include new editions received from other hydrographic offices and internally generated proofs which represent intermediate stages in the chart production process. Both new editions and proofs require close inspection and comparison with earlier versions of the relevant documents to establish, in the case of the former, any significant insertions or deletions and, for the latter, any incorrect or unintentional insertions or omissions.

It is thought that it may be possible to assist the comparison of such documents by the development of suitable equipment. To this end negotiations are being undertaken with a number of firms, and while it may prove necessary to convert the document data to digital form before attempting a computer-based comparison, it is also thought that development of a comparator based around television technology could be of great potential.

Cathode ray tube lighthead plotting facility

It is probable that plotting systems using lighthead discs will always suffer from a certain degree of inflexibility because of the finite number of symbols it is possible to locate on any one disc. Therefore for a number of years attention has been paid to the progress of suitable alternative systems and in particular the developments concerning Cathode Ray Tube lightheads.

Instead of exposing individual symbols a CRT lighthead system composes a small square (approximately 7×7 cm) area (page) of information at computer speed before exposing the whole page on to film. The CRT lighthead is then sequentially repositioned, page by page, until the plot is completed.

It is estimated that such a facility will increase throughout by at least a factor of five. It will be possible to store all the relevant symbols, character fonts and line widths, etc. in the host computer to be summoned and plotted as required. With the successful resolution of such problems as the precise edge matching of pages of information it is thought that this facility will offer significant advantages not only in terms of increased flexibility but also speed and potential for development.

FUTURE TRENDS

Computer-assisted cartographic techniques are now firmly established in the UK Hydrographic Department. Significant progress has been made with those tasks which have most readily lent themselves to automation. Entry is now being made into a new phase of attempting the more difficult aspects of automated

cartography, such as the nautical chart compilation task, bearing in mind at all times the relative cost and effectiveness of the alternative solutions.

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A DIRECTOR GIVES HIS VIEWS ON OCEANOGRAPHIC RESEARCH

As the new incumbent in post of Director, I am taking this opportunity to state my views on the general policy of the Institute's programme of research. Oceanography is a vast subject, covering nearly all scientific disciplines as applied to the problems of understanding the oceans, those parts of the earth below and adjacent to them and the atmosphere immediately above. As a national institute, we have responsibility to provide advice and research expertise when there are national needs and so must maintain an awareness of the state of the science across a very broad front. At the same time, as a research institute, we must constantly move ahead at the frontiers of the subject in certain more limited areas where the individual research worker's interests and skills lie. Research planning can play only a part in determining which these areas are. Part must grow out of those intuitive feelings and occasional flashes of inspiration which come to the research scientist pondering his subject in his bath, feelings which owe their origins as much to the informal contacts with scientific colleagues from all over the world, as to the attendance at lectures or the reading of the literature. As Director, I see my principal task is to maintain the right balance between providing the facilities and ambiance in which frontier research can flourish and ensuring that the results of both this research and of oceanographic knowledge generally, can be used to benefit people.

Dr. A.S. LAUGHTON, newly appointed Director of the Institute of Oceanographic Sciences (U.K.) writing in his Annual Report for 1978.