International Hydrographic Review, Monaco, LIII (2), July 1976

U. K. HYDROGRAPHIC DEPARTMENT EXPERIENCE IN THE USE OF DIGITISERS

by G. E. MURT and J. M. ADAMS
U. K. Hydrographic Department, Taunton

INTRODUCTION

Automated cartography was introduced into the U.K. Hydrographic Department about eight years ago when we installed a digitiser table and an automatic draughting system for office use, and automatic data logging and plotting systems on the three largest survey ships. Initially the emphasis within the office was on the mechanisation of the drawing of chart borders and navigation lattices. These are applications which require little data input but considerable computation, and most of the operation is therefore carried out by the machines.

The application of automation to the drawing of irregular lines and scattered points involves the handling of very large amounts of data, and under present conditions most of these data are derived from documents. The equipment normally used for data input is the free cursor digitiser. This is a table on which the position of a cursor is sensed electrically and can be recorded onto paper or magnetic tape. The operator places the cursor on a point or traces it along a line, recording co-ordinates as required. Other information can be entered into the record by a keyboard. This manual data input is slow and prone to error, and the benefits of automation in this field are less clear-cut than in the production of computed linework such as borders and lattices.

INITIAL EXPERIENCE

We obtained our first digitiser table, a D-Mac (now CETEC) line follower, early in 1967. It functions by a coil on a gantry within the table, being electromagnetically linked to another in the cursor. Movements of the gantry are translated into x and y co-ordinates. On our machine the output was paper tape only. In practice we found this machine to be somewhat unreliable and the digitising accuracies achieved were not sufficient to progress chart data banking beyond the experimental stage. It was also too small to accommodate our standard size charts. It was, however, used for production digitising of depth contour lines on survey graphics to provide data for volumetric analysis calculations in connection with sand-bank movement studies and assessing dredging workloads. This digitiser has now been stood down.

PRESENT EQUIPMENT

Our second digitiser was delivered in 1973 and another in 1975. By this time D-Mac line followers of high accuracy and proven reliability were available. But we decided that the solid state Ferranti Freescan digitising system (figure 1) was more suited to our work. In this, the signal from the cursor coil is picked up by an array of electrical conductors embedded in the surface of the table. Voltages induced in the array are converted by the control unit to cartesian co-ordinates for X and Y axes. We use a cursor with cross wires and a central spot. Control buttons on the cursor allow the operator to set origin, commence a new feature and output co-ordinates, and there is a separate digital display showing the co-ordinate position. The resolution of the system is 0.025 mm with a maximum overall error of 0.1 mm. Stream digitising can be carried out at up to 10 points per second. This type of digitiser has a very fast response to cursor movement, and the embedded conductors give an inherently constant accuracy.

A major problem with digitised data is making alterations, either to correct errors or to update a chart that was digitised previously. It is possible to run editing programs on a mainframe computer, but the delays inevitable with batch operation make the repetition of alteration and checking a lengthy process. We have therefore converted one of our digitisers into an interactive work station by the addition of a computer, a graphic display terminal and a drum plotter. The computer is a PDP 11/40 with 28 K words of core store, a 1.2 M word disk to carry the system and data, and a magnetic tape unit. The display is a Tektronix 611 storage cathode ray tube. The current position of the cursor on the table is shown by a flashing cross on the display. Facilities available include windowing, scaling and element detection to enable the operator to indicate a line or point on the drawing and then apply his editing commands to the feature containing this element. A pen plot of a completed file can be produced on the Calcomp drum plotter, which operates simultaneously with, but independent of, the digitiser operation.

Most of the functions of the work station, including the selection of symbols for plotting point data, are operated through a "menu". This is a plastic sheet with squares labelled as instructions or symbols, which can be placed anywhere on the digitiser table (fig. 3). A record of a position in any of the squares is decoded by the computer as the appropriate function or symbol. Operation of the system using the menu is quick and appears to lead to fewer errors than use of a keyboard. The fast response of the solid state type digitiser is essential for menu operation, as the cursor is frequently moved between the job and the menu.

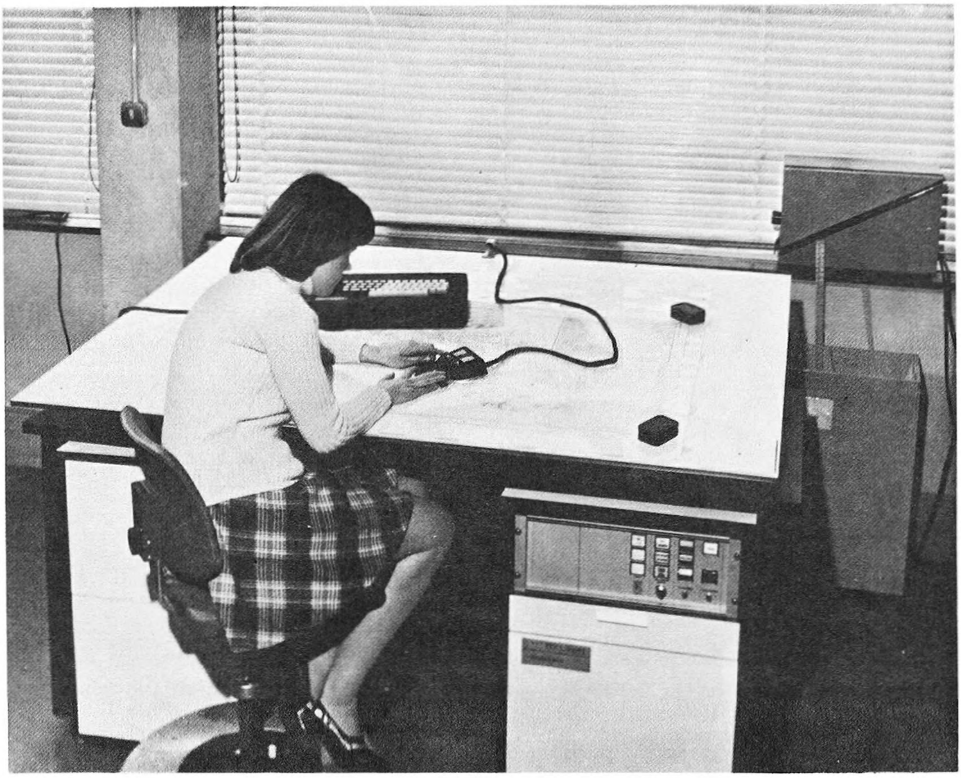

FIG. 1. — Ferranti Freescan digitiser.

A digitiser work station with editing facilities is expensive, and we plan to use off-line digitisers for most of our data input. The magnetic tapes produced on these digitisers will be read into the work station for editing. Our second Ferranti digitiser is designed to be operated in this way.

Both our digitisers can be used off-line to produce paper-tape. The provision of paper tape output was originally seen as an interim measure, to be used only until software to handle magnetic tape was available. In practice the simplicity of paper tape handling has meant that a considerable proportion of our work still uses paper tape, and short or special jobs are likely to continue to be done in this way for some time.

We have experimented with different types of original to find one which is visually easy to use. Our source documents are usually black on white translucent plastic, but we normally work from negatives with clear lines on a brown background, produced by developing a film in the usual way and then reducing it with a ferricyanide solution. These are less tiring for the operators than the higher contrast black and white negatives, and also allow instructions to be written on with pencil or in black/coloured ink.

We have also experimented with the use of grooved film. Source originals are photo-etched onto a film with a coating about 0.1 mm thick and the line work is then represented by grooves with widths corresponding to the original line weights. Digitising is carried out in the normal way but

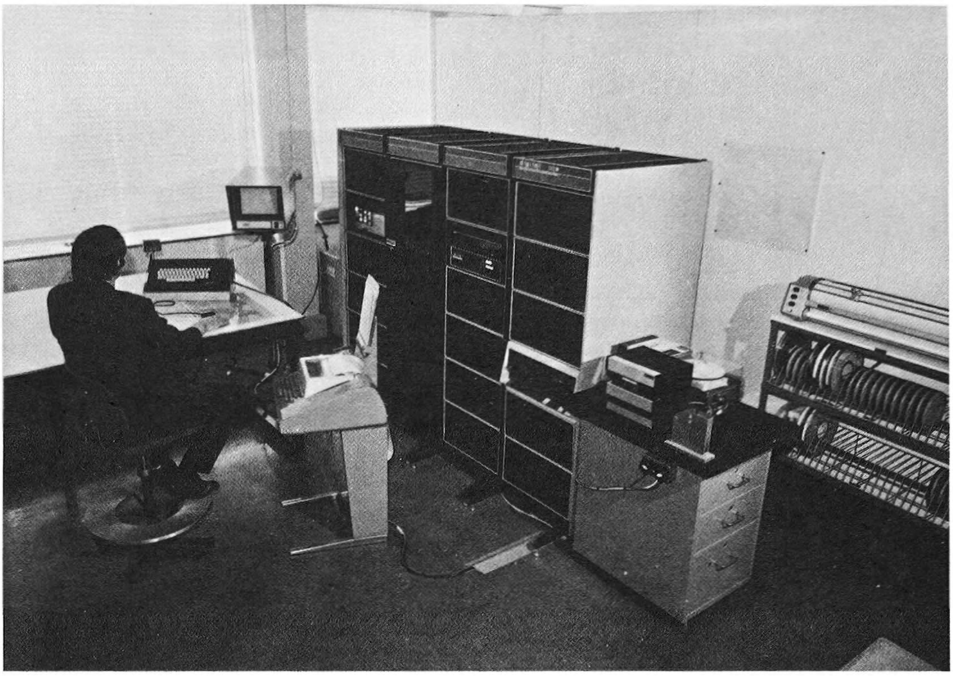

FIG. 2. — General view of interactive work station, showing the digitiser table and keyboard with the cathode ray tube display beyond. The console teletype is in the foreground with the computer, disk and tape units to the right. The drum plotter is on the extreme right.

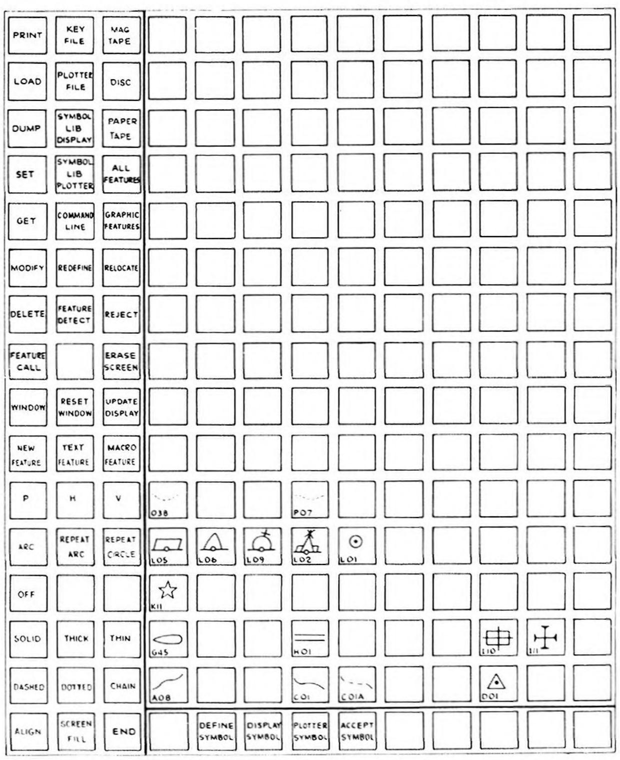

FIG. 3. — "Menu" for interactive operation.

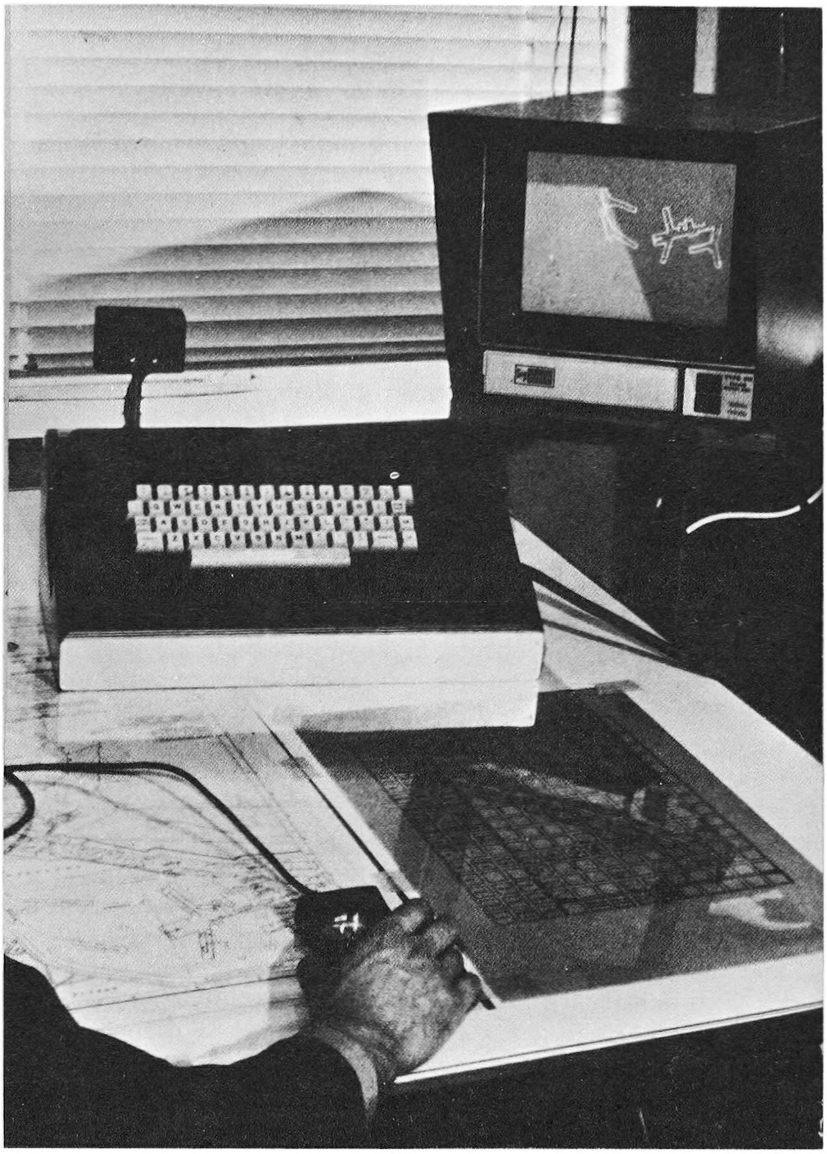

Fig. 4. — Operator's view of interactive working. The menu is to the right of the chart being digitised, and the lines that have been recorded are displayed on the cathode ray tube screen.

with a scribing cursor with a blunt point corresponding to the line weight being digitised. Both digitising accuracy and speed are increased in optimum circumstances, but unfortunately pen compilation drawings are not usually of sufficient line quality for the reproduction of consistent line weights on the groove film. Thus we can only use the technique for a limited proportion of our work.

WORK IN HAND

The largest task carried out is the digitising of temperature/depth profiles produced by expendable bathythermograph traces. The graphs, together with header information input via the keyboard, are digitised at the rate of 30 per hour, each graph being digitised twice to facilitate subsequent quality control. Digitising using stream mode at 8 points per second results in about 300 points per graph, and this number is reduced to about 15 per graph by an off-line computer program. After quality control and validation, which rejects about 20 % of the records, the data are put into a data bank where they are merged with data from manually digitised bathythermograph and other sources. Retrieval of information from the data bank is in terms of location and/or date. The main use of the data bank is statistical analysis in connection with oceanographic forecasting. Plots are made of multiple traces for individual geographical areas for several periods of the year.

The Ferranti equipment is now being used to digitise the fair drawing of chart compilations. Initially we are only digitising the line work, and can then produce a negative on our high accuracy plotter with this information reproduced in its correct line widths and styles within a computed chart border. We also produce the land tint and shallow water blue masks using cut and peel techniques. Digitising this work is quicker than hand scribing to high quality, and the training for digitiser operation is shorter than for scribing. The main benefits of holding the data in digital form are expected to be evident when re-plotting with major corrections is required for a future edition of the chart.

Digitising contours for volume predictions is still a production routine, and the digitisers have also been applied to a range of small jobs, mainly to gain experience in their use and in the handling of the data. These jobs include the computation of areas within fishery limits, and digitising of coastlines for special charts. A recent requirement has been for coastlines and contours defined by a very small number of points for display on refreshed cathode ray tube displays. On this type of display the picture is re-generated on the face of the tube several times per second, so the quantity of data that can be handled is limited.

A possible project would be the creation of a world data bank of coastline on a sufficiently large scale to be used as the source of the coastline on a chart of any required scale or projection. It would be an immense task and we are not convinced it would be worthwhile except in key areas. We have not yet developed generalisation software to cope with extraction at scales far removed from source scales. Our preliminary experiments indicate that we can get visually acceptable results from 5 times below to 5 times above the digitised scale. At larger scales we find it necessary to apply curve smoothing to get adequate visual quality, but accuracy is not increased from that at the digitising scale.

We have also carried out tests on using the digitiser to assist with the replacement of charts on worn and distorted copper bases, some well over

100 years old. Apart from their poor printing quality, correction problems are caused by the land and foreshore stippling being engraved on the copper. Land and foreshore tints will be inserted on the redrawn charts by masking as with newly drawn charts. Distortion can be corrected by a computer program which compares the digitised co-ordinates of grid intersections on the original with their known true positions, and calculates the shift required to plot all the digitised points relative to the true grid. The tests have given promising results, but the procedure has not yet been adopted for production work.

Wherever possible, systems development connected with the digitisers has been to give an immediate useful product, and extensive development for purely long-term projects has been kept to a minimum. This not only gives a quick return on our investment in the equipment, but also experience in using the equipment and handling the data under production conditions.

ORGANISATION OF WORK

Although the digitisers are housed in the automated cartography branch of the Department, the jobs requiring their use are handled by whichever branch is responsible for the output. The digitiser operators are draughtsmen, normally of basic grade, from the branch handling the job. A large job, such as the fair drawing of a chart, is carried out by a small team headed by a higher grade draughtsman. This means that digitising is likely to be a part of any draughtsman's work and also that he will be responsible for other aspects of a job. It gives variety in work and also the satisfaction of being involved in a major part of a job. Most jobs are organised so that an operator uses a digitiser for up to two hours at a time.

All chart information is divided into features for digitising, with feature codes giving a unique description to each feature. Off-line processing is by feature, but it is possible on the work station to specify any pair of points on a line and to delete or modify the length of line between them.

Irregular lines, including most coastlines, are digitised with closely spaced points which are joined by straight lines in the subsequent drawing. The draughtsman makes his own decision whether he uses the digitiser in point or stream mode. Curves are digitised in point mode with widely spaced points and a plotting program in the central processing computer draws a smooth curve through the points.

The operation of an off-line digitiser is a simple extension of a trained draughtsman's skills, and the only specialised training given is a two hour lecture-demonstration. We have trained nearly two hundred staff as operators in the two and a half years we have had the Ferranti digitisers. It is possible that some of these staff will never be on work requiring digitising, but such a course is a simple practical introduction to the handling of digital data. We consider it important that this should be regarded as a normal part of the work of staff in the Department, rather than the province of specialists.

FUTURE PROJECTS

A major project is the digitising of soundings. We are beginning to receive digital sounding data from some of our survey ships and would like to use this to help make chart compilation less labour intensive, for example by producing plots of selected soundings and automatically drawn depth contour lines at the scale and projection of the required chart. To justify the large software effort needed we would need also to obtain digitised soundings from the graphic fair sheets received from other sources. The experiments we have carried out indicate that using a keyboard to record depths gives a large number of errors.

We are therefore planning to interface an EMI/Threshold voice recognition equipment to our off-line table. The Threshold system recognises spoken words and converts them to digital signals which can be used to enter data directly into a computer. It is necessary, initially, for each operator to train the equipment to recognise the sound of his voice and this takes 15-20 seconds per word using about 10 repetitions. When a sequence of words, in our case a sounding value such as twelve point five metres spoken as ONE TWO FIVE, is successfully recognised, it is displayed. In use, the operator will move the cursor over the survey original to position the sounding in the usual way and then read the sounding value aloud. When he is satisfied that the correct value has been comprehended he will say "go" or "next" and this will result in the sounding value and the corresponding x, y position co-ordinates being recorded on magnetic tape.

Progress in the more distant future is likely to be towards automatic line following, which should give quicker and more accurate data conversion. The most promising developments at present appear to be equipment derived from line followers used in nuclear physics research to analyse records of tracks of sub-atomic particles, but these work from originals on small-format film. This leads to problems with accuracy and also introduces extra photographic steps into the production process. An alternative approach is the raster scanner, but this requires complex software to reconstruct lines and allocate feature codes.

In the longer term also is the prospect of using an interactive digitiser for chart compilation. This involves bringing together data from a number of source documents with different scales and projections, and procedures for this will have to be worked out. Operation of the equipment when doing work of this complexity is not easy, and the high hourly cost means that the work must be done quickly if it is to be cost-effective.

CONCLUSION

During the short period that we have had digitisers in the Department they have become accepted as useful tools for a variety of tasks. The main limitation on their application at present is a lack of supporting software, and when this is provided we expect to make more extensive and more economical use of our digitisers.