COMPUTER AIDED MAP COMPILATIONS

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In the process of map and chart making, automatic drawing systems have now reached an advanced state of the art and can give very high quality results. However, the methods of control and decision-making are still embrionic, and it is only when these also have advanced, that automatic cartography will be completely viable.

In cooperation with the Canadian Hydrographic Service, the Electrical Engineering Department of the University of Saskatchewan has been examining the feasibility of various systems and methods and the first of such decision-making operations is now starting to take form. The work involves both hardware and software development, as well as a detailed study of the cartographer's requirements, and considerations of design from the psychological and ergonomic points of view.

The work is specifically concerned with detailed high accuracy mapping and this limitation creates both advantages and disadvantages compared with the general problem of Computer Aided Design (CAD). We have chosen to call our own work Computer Aided Compilation (CAC).

In cartography of this type there is little need for on-line computation or for dynamic image generation. Thus, considerable simplicity and economy can be achieved by the off-line preparation of a display tape in a large computer followed by the interactive decision-making being carried out on a small computer fitted with a low-cost disc store.

While the amount of detailed data required on the screen is large, cartographic decisions are essentially slow operations so that a few seconds delay in image generation or erasure is unimportant. The storage display therefore appears to be an obvious choice; this also means that the small computer has only occasional demands made on it, allowing it to be used with a number of display stations on a time sharing basis. This is a most important consideration from the economic aspect of applying these techniques to cartographic production where many compilation operations must be going on at the same time.

For fully interactive decision-making, the display must be fitted with both a simple keyboard and some type of 'pointer'. With a storage display the easiest method is to move a 'non-stored' spot over the screen by means of a joystick, rolling ball, 'mouse' or input tablet. For cartographic display this turns out to be not only easier, but also more efficient than 'light pens', which result in an appreciable part of the image being covered by the pen and the operator's hand.

A storage display such as the Tektronix 611 is very adaptable. The required amount of line and alphanumeric detail can be presented, and held, with clarity. Addition of data is simple and merely requires a short interruption of the computer. Erasure of data is equally satis-

factory provided that a disc is available; one part of the disc store always carries a digital image of the data on the display. The process of a small item erasure is therefore a complete image erasure, modification to the data on the disc and regeneration; a total time lapse of less than one second is involved.

Interactive manipulation by the 'pointer' includes erasure or addition of features, or modification of the symbolization of a feature. A feature may be a position or a line. Addition of line data requires an extra process of display feed-back to produce the effect of drawing with ink.

The Canadian Hydrographic Service system is based on a grid module of 0.004". Good display of line data is obtained on the Tektronix 611 by placing 0.008" diameter dots at intervals of 0.008", i.e. by leaving out alternate data points. The line is cartographically clear and pleasing to the eye. The absence of any flicker is an important consideration, the amount of data usually required in a cartographic display is so large that 'refresh' type displays would exhibit appreciable flicker unless a very long persistance tube or a video disc were used as intermediate image storage.

In the present storage display experiments, data input is on IBM-compatible tape and the data therein is divided into a number of groups. The most important data - in our work that is specifically hydrographic data, consisting of coastlines, soundings, water contours and navigational aids - is put into the first group and this is used for any preliminary display operations for an area; in order to provide maximum speed of access the data from this group is transferred to disc as soon as operations commence. While disc storage capacities are now appreciable, there is still not sufficient space for all cartographic data, so that all topographic and background data are retained only in tape form. The access time for such data could sometimes be of the order of one or two minutes.

When initial examination commences it is entirely from data on the first group on disc. It is equally simple to examine data for the whole chart area as for one section; if it is for the whole chart area the scale is reduced in a ratio of 8:1. Unless otherwise specified by the operator a standard selection of the data available in this first group is presented.

At the time of the off-line generation of the IBM-compatible tape, the desired projection and scale will have been stated by the requester and all calculations will have been carried out by the time the display operation commences. The present procedure is for the display operator or compiler to press button D (Diminish) which presents all the data at a reduced scale of 1:8. Superimposed on the image is a set of rectangles, each rectangle representing a numbered image area when normal display scale is used. A particular rectangle is selected, for example 00: on pressing buttons 00C (C indicating 'Continue') the selected area will immediately appear on the screen. An alternative method is to use the 'pointer' and press button S (Shift). The normal scale image centered on the pointed position will now appear. It should be noted that certain

reductions in symbology have to be made in the diminished image to avoid clutter: for example, soundings appear only as small dots.

When background data is to be examined it is normally necessary to go to a magnified scale. This is accomplished by using the pointer to specify the desired centre and key a request for magnification and shift (eg M4S). Binary multiples of x2, x4, x8, x16, x32 are available. Lines will widen in the same selected ratio as also will symbols enlarge.

If the compiler now wishes to add topographic data to the image, this can be called by a simple keying operation, and within a relatively short time the data will have been found in the tape and added to the image.

At the same time as the image increases in complexity so does the data in the parallel digital image on the disc. This disc area is called 'present image'.

Trial and error is used frequently in interactive display operations and to facilitate this it has been found convenient to retain another disc area for 'last image'. Thus at any time a complete re-start of an image build-up can be made.

A further disc area is concerned with listing all items which have been erased, modified or added. A single coordinate-pair is associated with a description for position work, two coordinate pairs for a line erasure and a stream of incremental coordinates for added lines. When work on any area has been completed, an IBM-compatible output tape is generated containing the modification data as well as the original data. This is returned to the off-line computer and the modifications are incorporated. It may or may not require further display checking and modification before finally being approved.

In this type of system all the necessary interactive display manipulations can be carried out in a small computer such as a PDP-8: all of the more difficult calculations will have been carried out previously in a larger unit.

For detailed hard-copy drawing operations all symbolization will be produced in the off-line computer, but in other cases a sufficient approximation can be made in the PDP-8 for display discrimination. Lines can be changed in width and in density (by changing positioning of dots) and dot and dash formats can be generated. It is normal to increase line width and symbol dimensions as magnification increases. If symbolization has been done off-line then this can be shown if the operator desires to do so. On the other hand if the operator wishes to change the symbolization or make it non-standard it is within his power to do it. For example, at a magnified scale he may wish to increase size without line width for certain specific symbols. One particularly important usage of non-standard symbolization is to enhance certain aspects which particularly need operator attention, eg. lines that do not join or unreasonable sounding values. The possible facilities are impressive but the best and easiest utilization of these is at present in course of experiment and

study.

As each part of the map is considered and decisions are made, it is advisable to take a hard copy for record purposes. While a number of methods are now available, the one used at the University of Saskatchewan is to have an automatic film advance 35mm camera attached to the display above the operator's head. It is also useful to have within the camera field of view a row of numerical indicators to provide reference data such as date, operator, work, etc. The data is not put onto the screen itself to avoid taking up useful work area. The image quality of the photographs can be seen from the attached copies.

It is hoped that eventually somewhat larger screen areas than the $6\frac{1}{4}$" x $8\frac{1}{4}$" of the Tektronix 611 will become available. To this end hardware experiments are being made at the University of Saskatchewan using dark trace tubes in projection systems. Two years ago, at this same conference, I mentioned the Skiatron as a possible valuable device for cartographic display. Since that time, technical improvements have enhanced the possibilities considerably, although our own work in this area has been slow due to limitations in financial support.

The specific advantage of this device is that storage time can be very long indeed, without any deterioration in image quality, resolution is only limited by electron beam spot size in this application and the image is uniquely capable of being optically projected to full chart or map size from a 7" diameter tube. Moreover the image can be of considerable brilliance and contrast ratios greater than 5:1 appear feasible.

Cartography makes some special demands on display equipment in the amount of data and resolution, but at the same time affords easement in other directions. While a large screen image is most useful, it is normally only to be viewed by a single operator, and the longer erasure time of the dark trace tube of several seconds is not a particular worry.

The principle of the dark trace tube is to use a screen material which exhibits tenebrescence instead of fluorescence when impinged upon by an electron beam. Materials such as potassium chloride or sodalite possess this property, the electron beam changing the colour centres from pure white to dark magenta. The process is called cathodochromism. Some tenebrescent materials are erased by light of certain wavelengths, and others by heat, but the latter are more convenient for cartographic applications.

In parallel with our own experiments on potassium chloride screens, I have been examining the developments under way by manufacturers and trying to persuade them that there is a real future in projected dark trace images for cartography. As the screen is essentially a passive plate carrying hard-copy magenta lines and symbols on a white background, a separate powerful light projection system, using either transmitted or reflected light, is relatively simply applied. Until now most manufacturers in the area have been content with direct view images.

The most advanced device I have so far seen is at RCA using

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sodalite:Br as the screen material. I was able to carry out some pro-
jection experiments with them and the results seemed most hopeful. Rea-
sonable illumination, contrast and resolution were obtained even at a
magnification of sixty times although eight is the required level for us.
Other manufacturers such as National Union Electric at Bloomington, Ill.,
Thomas at New York and Ferranti in the UK are also doing interesting work.

A number of interesting engineering approaches are also being
considered for the videodisc colour display system mentioned previously.
Map or chart data is essentially in line or position form, whereas a tele-
vision set and videodisc normally work in raster format. Should a trans-
lation in format be made, or should the television set and videodisc be
used in a different and abnormal manner? In cartographic work it must be
appreciated that the main purpose of colour is to aid decision making
processes by distinguishing between one feature and another, and not
necessarily anything to do with the colour presentation to be used finally
on the map. Any colour control should therefore be under the direct hand
of the operator and should mainly consist of a series of different propor-
tional current balances between the guns.

If the television display and videodisc are maintained in raster
format, each dot must be colour labelled as against only the beginning of
line sequences when in line form. In the first case any change in colour
presentation requires a completely new loading of the videodisc image from
the computer and this can take appreciable time. However the videodisc is
actually only a very high frequency analog recorder and can record data in
many different analog methods. Also a standard television CRT can be made
to work on input line data under positional control instead of with a
raster. Thus it is feasible to maintain data in line and position form
throughout the display process, still using the videodisc as a rapid image
refresh device. With this method the operator can change the colour diff-
erentiation at will, to suit any line label.

Experiments are now proceeding to examine which of the above is
the preferable method, or, in fact, whether any hybrid method might not be
superior. In the not too distant future it should be possible to use
colour displays in one or other of these ways and in an interactive mode.
Of course, the compromise is that colour will be obtained at the expense
of resolution so that it must only be used in decision making where colour
outways the disadvantage.

The attached photograph shows the experimental system at the
University of Saskatchewan. The operator's right hand holds the 'mouse'.

The present status of work is that the Tektronix 611 display
system is now becoming operational and addition, erasure and modification
for symbols and lines is undergoing test. A simple but fully comprehen-
sive computer aided compilation program can be expected by the end of
1971. One year ago, at the Annual Hydrographic Conference, I gave a paper
on my expectations using simulated display images. These ideas are now
well on the way to being realised and our main considerations are now
making it as sensible and simple as possible to use - the cartographic
compiler must like to use it, otherwise we have failed.

The work described here is part of a team operation at the University of Saskatchewan and the author would like to express his appreciation to all those students and programmers who have been involved in the development, particularly to the present team of W. Wilkie, J. Goldie and Mrs. A. Marusinec.
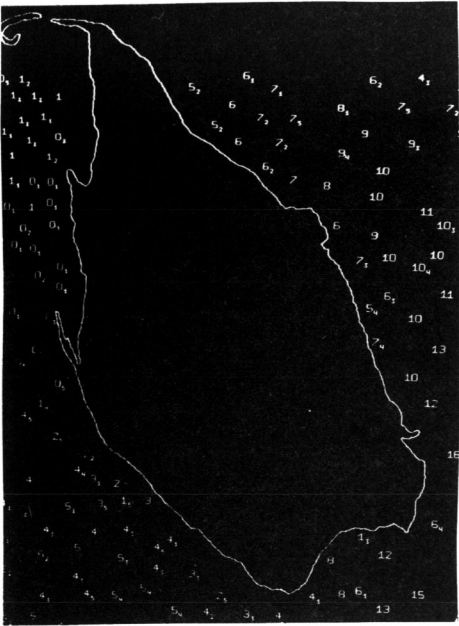
Actual photograph of early
Tektronix 611 chart image
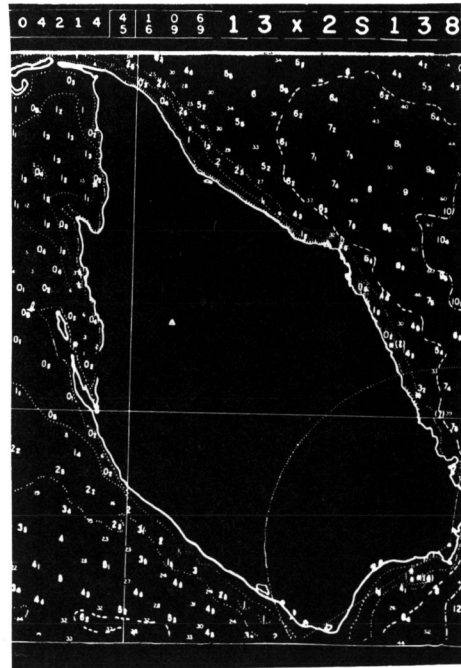
Simulation of chart image
now being programmed
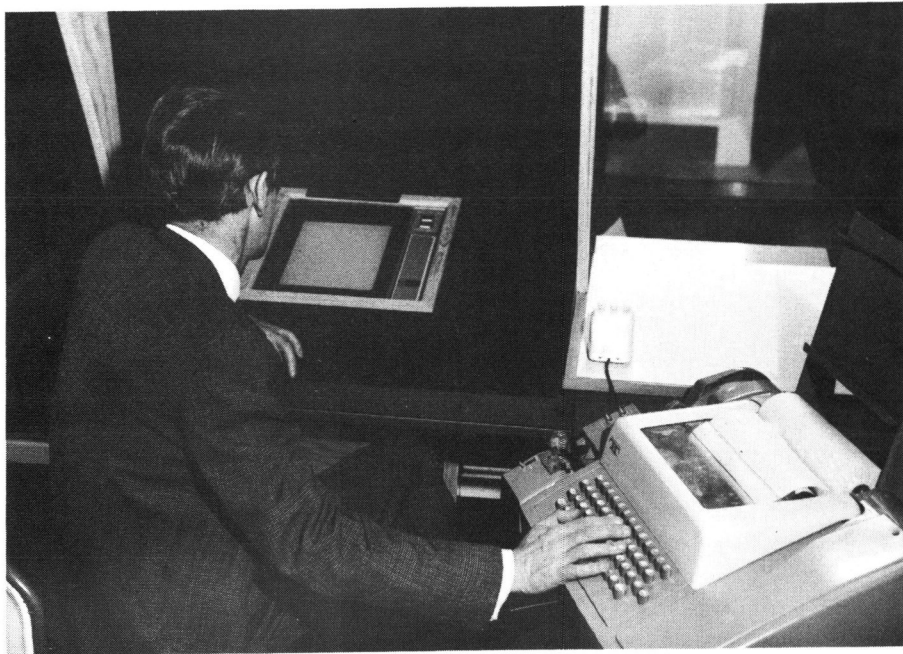
Tektronix 611 display system with interactive 'mouse'.