Computer Mapping for Publication

The Case for a Dual-System Approach

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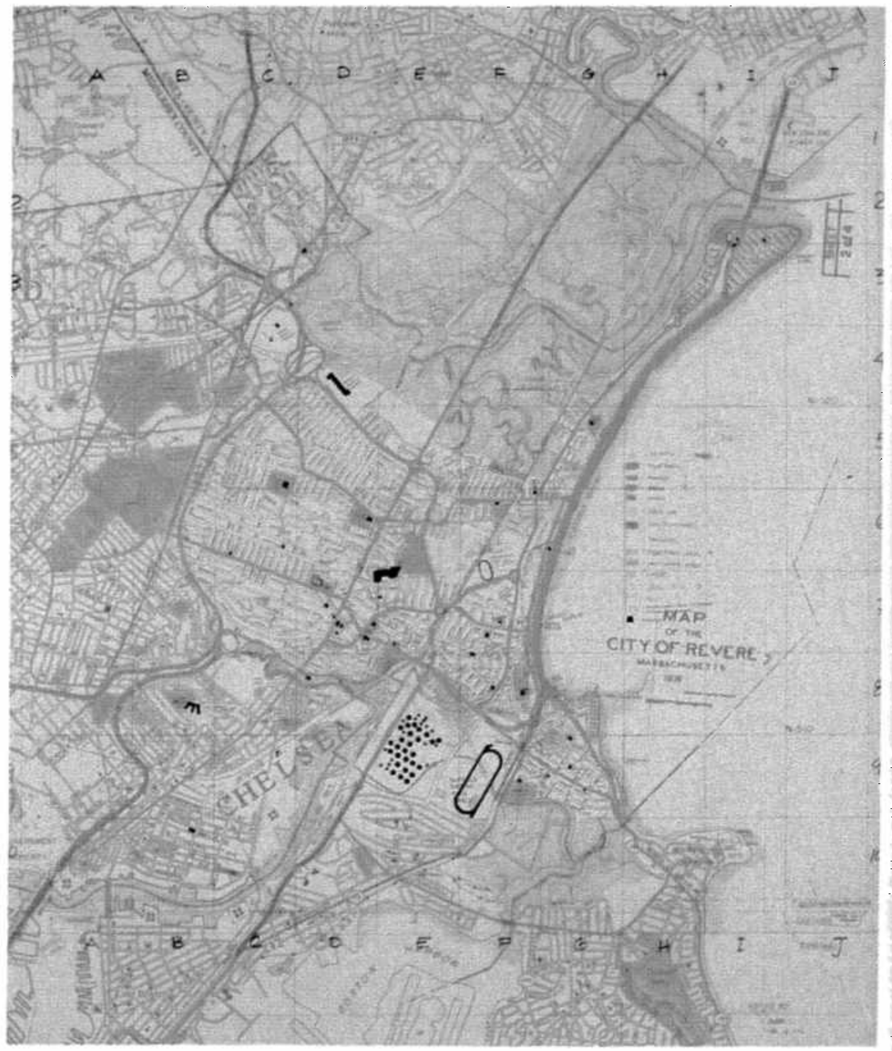

Figure 1a: First the manuscript is digitized.

Computer mapping for publication is not the same thing as computer mapping or computerized cartography. Such terms as grid cells, polygon segmentation, controls and contours are of secondary importance in the printing of maps. What is of primary concern in mapping for publication is the ability to combine lines, half-tone and continuous-tone areas, and text onto color-separated films ready for plate-making and printing. Further, this must be achieved using standard and well-tested cartographic symbolization for depicting natural, man-made and areal features. The result should be equal to that achieved by traditional cartographic techniques, as far as accuracy, integrity of design, and quality of reproduction are concerned. Additionally, the investment in equipment, personnel training, and transfer of map information to the computer must be cost-effective for the production of new maps and subsequent editions or adaptations of the data. Finally, computerization should provide a means to access the ever-increasing data from satellites, and eventually allow map data to be transmitted to an end user in a non-printed form.

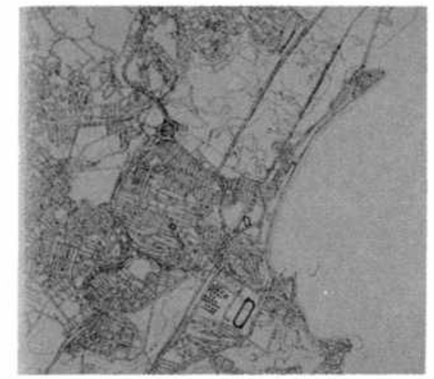

Figure 1b: Then its outlines are plotted.

Figure 1c: Masks are also plotted.

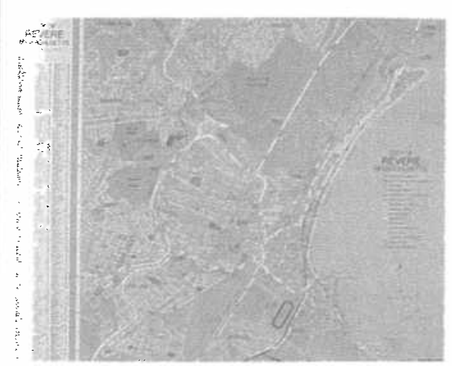

Figure 1d: A printed map is the final stage.

Figure 2a: Screened Scitex film containing all the yellow color for a four-color map.

The requirements are not substantially different from those faced by other publishing industries, but they represent a significant challenge for a computer graphics system. Almost since the inception of computer graphics, a fairly large number of governmental mapping agencies and a growing number of commercial map companies have attempted to take advantage of hardware and software advances in all areas of the industry. They have tried building their own systems using available hardware or combining custom-built hardware with special-purpose software, and they have tried adapting turnkey systems—with software patches—to increase cartographic intelligence. But no single system has solved the basic dilemma of computer mapping for publication. Input and editing of map information is most efficiently manipulated and stored in vector form, but the highest quality and the most direct means of producing separated films are achieved using raster-based data.

No single turnkey system has yet appeared to solve this problem because of a view widely held among suppliers: that the market is small and undercapitalized, and does not offer significant growth potential. Several manufacturers market turnkey mapping systems that are suitable for certain sub-tasks. Applicon, Summagraphics, Computervision, Kongsberg, and others offer mapping capability, but Scitex is presently the only producer of a completely raster-based cartographic system. The Intergraph system is vector-based, and has the most highly developed mapping capability for all types and scales of maps.

Figure 2b: Same printed map after being digitized, plotted, scanned and laser-plotted.

Vector-Based Systems

Vector-based systems offer a solution to data input for maps that contain a variety of complex features—where existing base material is not of high enough quality for scanning, or where it exists in different scales or graphics forms. Vector-based systems are also suitable when the resulting database must be used for a variety of map products. This is the most common situation faced by map publishers. Interactive digitizing is the fastest method available for getting data into digital form, while adding the necessary information concerning component specification and separation. Once completed in vector form, the map can be easily and quickly edited and revised. But the problem with these systems has been output. How do you turn a stick diagram—made up of digitized points and connecting lines—into smoothly curving contours, double-lined roads and screened films for color printing?

Early solutions to the vector output problem involved photoplotting map linework to the desired specifications. Photoplotters from such companies as Applicon, Kongsberg and Gerber, as well as the Image Graphics CRT plotters have proven acceptable, with plotted linework comparable to the best manual work. When the linework is photoplotted, the computer process ends, and the techniques used in traditional cartographic production are once again employed. The linework, in negative form, is photographically exposed over as many peel coats (also referred to as stripping masks) as required to obtain the desired number of open masks for final screening. Only one screen percentage per color is possible for a single mask.

Another solution is to photoplot the masks directly. For example, all the 100% cyan is plotted on one film, all the 50% yellow on another, and so on. The open masks—whether produced photomechanically and manually stripped, or through computer plotting—are then combined photographically, exposing the open areas through dot or line screens of the right percentage on to final plate-ready negatives. *Figures 1a, b, c and d* illustrate the steps from manuscript to printed map, using a vector system for input and output. After the manuscript is digitized, both outlines and masks are plotted. The individual masks are screened and combined to produce the final printing plates for each color. This map is printed in four PMS colors, plus black.

Raster-Based Systems

The primary problem with raster-based systems for printing maps is the difficulty of data input. Although is possible to digitize on some raster-based systems, and create a vector database, this does not usually compare either in speed or accuracy to vector system digitizing. For example, to digitize on the Scitex system you must scan the manuscript, display the manuscript on the color edit station, and digitize points with a pen cursor and a small digitizing tablet. This process works, and the result is a vector database, but the time taken does not compare favorably with digitizing di-

Figure 3: A vector database with each component type color-coded.

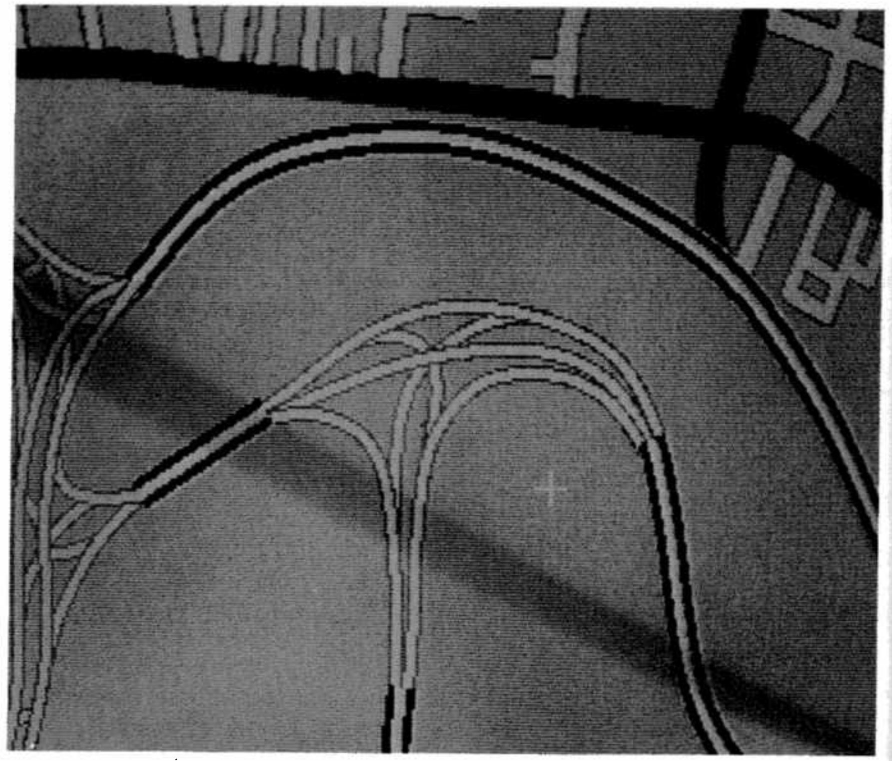

Figure 4: Smooth transition between different fonts is achieved through raster editing.

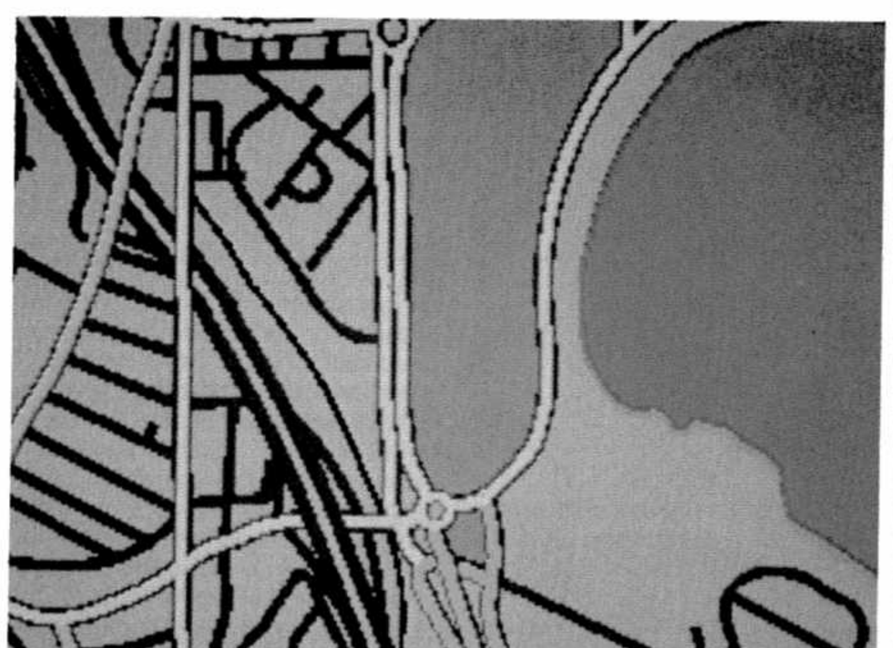

Figure 5: Example of application of intersection and overlap rules.

rectly from a manuscript. Scanning a manuscript and automatically vectorizing the line—a capability available with Scitex, Broomall, and Kongsberg (and in development with Intergraph and Optronics)—is a yet unproven technique in terms of cost efficiency, accuracy, data manipulation, and storage requirements. This situation may change as better raster-to-vector software becomes available.

Scanning high-quality linework and area filling, whether interactively or by scanning color fill dots, has proven to be a laborious process for all but the simplest maps or single contour features. The result is little different from traditional photographic techniques, and the database lacks the intelligence necessary to produce anything but scaled reductions or limited types of enlargements of the scanned data with color corrections. Furthermore, high-quality linework is essential, but not always available. Automatic line-following systems, such as LaserScan's Fastrack digitizer, are useful only for certain types of features (such as coastlines and height contours), and only for maps for which high-quality linework exists.

What the raster-based cartographic system lacks in input capability, however, it more than makes up for with its ability to turn skeleton data into high-quality artwork—automatically separating lines and areas into screened files, and then plotting the files on film using a laser plotter. *Figure 2a* is a screened Scitex film produced by scanning photoplotted films. This film contains all the yellow color for a four-color map.

Figure 2b represents the same printed map digitized and plotted on an Applicon system, and scanned and laser-plotted on a Scitex system.

A Dual Approach

Obviously the most desirable approach would be to input and edit the database on a vector system, and process and output using a raster system. The easiest way to communicate between the two technologies is through the scanning process, which has been tried with acceptable results. It is not a long-term solution, however, since the costs are too high, and the method does not permit the full use of the raster system's graphics abilities.

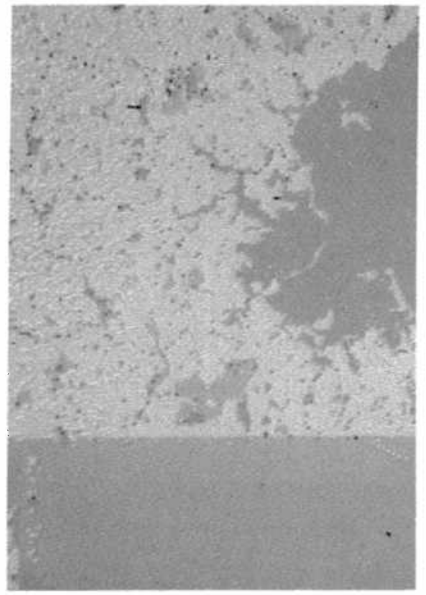

Figure 6: Completed map shown on raster display, prior to separation.

But it does eliminate the manual stripping and pre-press screening of masks, and allows color correcting and cosmetic editing (achievable only manually with plots produced on a photoplotter).

What is needed is a process for transferring data from a vector to a raster system—a stumbling block for most computer graphics users, who want to combine the benefits of two or more systems. Most manufacturers have made data conversion a difficult and tedious process by developing their own proprietary data format. When data conversion is achieved, it is usually accomplished through third-party software or through a common plotting format (e.g., converting Applicon files to Computervision format through each system's Gerber routines). But

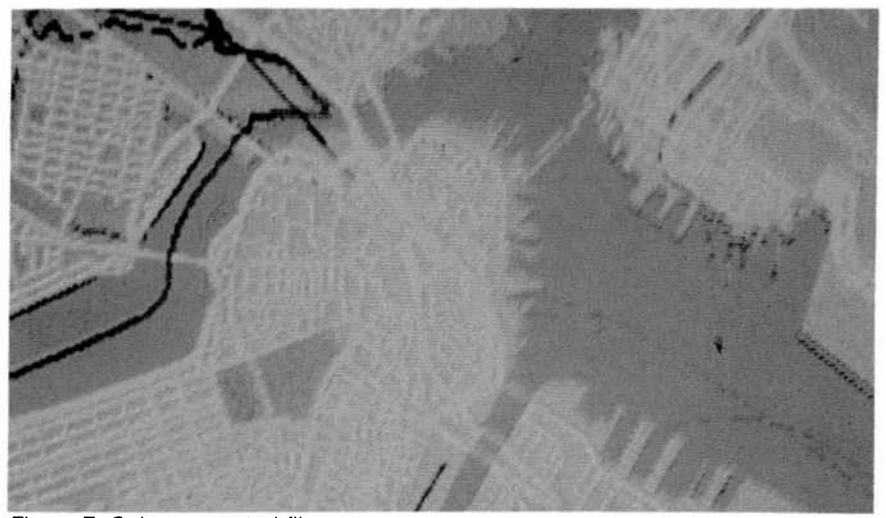

Figure 7: Color-separated files.

Figure 8: Laser-plotted film showing two sections clipped from a database.

most conversions, except for electrostatic plotters or raster displays, have been vector to vector. Converting a vector database to Scitex raster format is not straightforward, and, since it is not possible to obtain Scitex source code to assist in the writing of third-party conversion programs, cooperation between Scitex and vector system vendors has been essential.

Scitex has provided the means to convert Applicon and Intergraph vector databases to its data format, in a way that takes full advantage of the various systems' capabilities. Both Applicon and Intergraph have software to convert their system code into ASCII or ASCII/Binary format, which can then be transferred to magnetic tape. Scitex has written conversion programs to read these simplified formats directly from tape, arranging the data so that it can be accessed by all Scitex programs. The result is the same as if the data had been created by digitizing on the Scitex system, with information separated by map-component definition.

The Map Component

The concept of the map component is an important one in mapping for publication. Since a map is a two-dimensional, generalized depiction of information within a bounded area, presented at a given scale, a component is any feature that is judged to be significant at the chosen scale and that exists within the area. *Figure 3* shows a vector database, with each component type shown in a different color. Within each grouping, lines have been digitized as linear, parabolic and smooth. Graphically, components consist of lines, areas and points that represent map information. The key to reading and understanding the information is found in the legend, where each component is shown with a verbal description of its meaning.

Every component that is added to the map's database must eventually be given a proper graphic form. Therefore, when the map is digitized, all the subcategories must be known beforehand and, depending on the computer system used, component specifications must be assigned. The base material being digitized, referred to as a manuscript or compilation, must be prepared so that the person digitizing knows

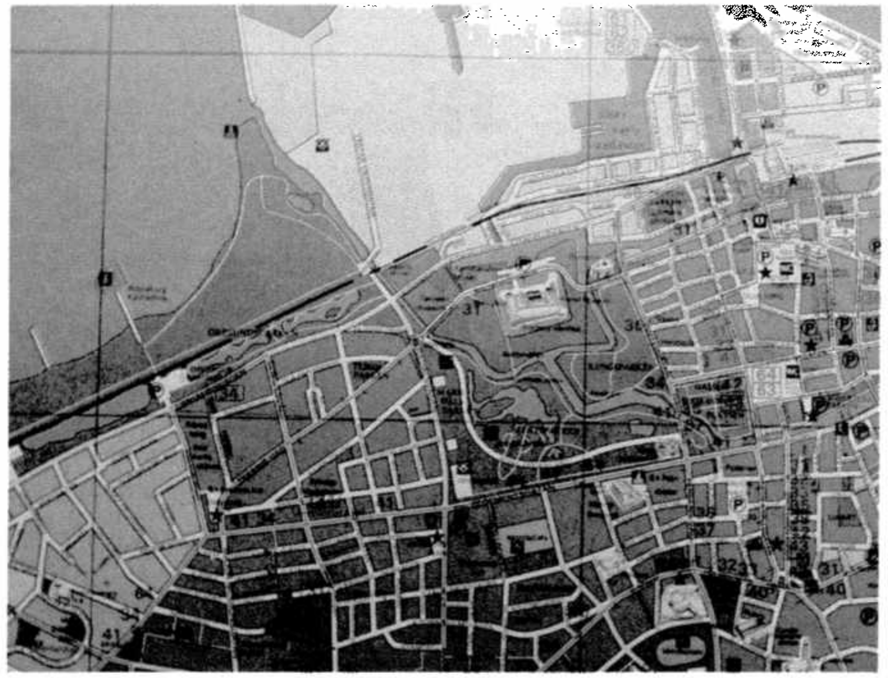

Figure 9: Detail of printed street map produced from same database as shown in Figure 8.

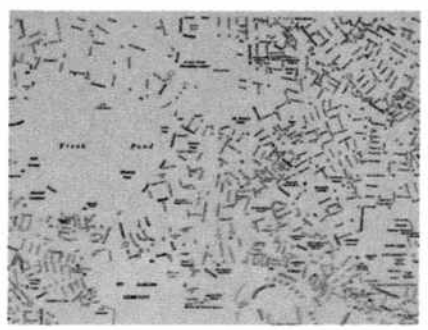

Figure 10: Phototypeset text overlay (manually positioned).

which component category each line, area or symbol belongs to.

In addition to knowing which component a line or area on the manuscript represents, it is also important to know how the component will be represented graphically on the final map. This is, perhaps, the key to achieving high quality in mapping for publication. Certain components, such as streets in a gridiron-patterned city, are meant to be shown as perfectly straight lines. Even small variations in straightness will detract from the informational content of the component. Other components, such as expressways, interchanges and railroad lines, must be shown as smoothly curving lines. Still others must be shown as randomly curving. There are great variations in the way a map's components must be shown if they are to be perceived correctly by the reader. To achieve the desired result on the final map, each component must be digitized with the proper number of points, with the correct spacing between points, and with a distinction made between straight, smoothly curving and randomly curving lines.

It is at the raster processing stage that graphic form is given to the components. Scitex has a font library, in which each component's line width, colors and symbolization are stored. When the vector database is brought into this raster system, each component is matched with its corresponding graphic description and converted into a raster form made up of pixels of a predetermined size. *Figure 4* illustrates how a map might appear on the raster display, and includes examples of different fonts. Also included in the conversion process and association of the vector data with the font library are specifications for line smoothing, line ends, area closing and rules for how each component interacts with other components. An example of which component has priority at intersections, and should block out the color of another when they overlap, is shown in *Figure 5*.

The raster edit phase of production takes place after the rasterization of the vector data, when the components are combined in raster form to produce a picture of the final map, but prior to the plotting of color-separated films. All elements, except for text, are now included in the data files. The colors are merely representative, but they approximate the final map closely enough to facilitate changes in color selection *(Figure 7)*. The amount of editing required depends on the care taken in digitizing and the level of quality required in the finished product. Few published maps require no editing at all. If the digitizing has been carefully executed and there are no mistakes in content, however, the editing is mostly cosmetic (such as smoothing transitions or highlighting special features). Other factors that determine the amount of editing required include the complexity of the map, output versus input scale, and size of the map. The improvement in visual quality derived from raster editing cannot be equalled by vector editing. Although it can be time-consuming, especially if the digitizing has not been done correctly, it is an essential step in the process of computer mapping for publication.

As a last step, the graphic elements of the raster picture of the map are separated into files containing all the elements to be printed in a single color. Just prior to plotting, each element is assigned its screen percentage. When the files are laser-plotted on film, each film that will be used to make a single printing plate will contain all the various screens required to produce the final map's color combinations. The number and types of colors used in printing depend on cost, type of map, market served, printing medium, or tradition. The laser-plotted film shown in *Figure 8* has two sections clipped from a database that will be printed as a three-color atlas. The same database was used to produce a street map printed in four PMS colors with different graphics. *Figure 9* shows this map, which was digitized on an Applicon vector system, and processed and plotted on a Scitex system.

There are few map publishers today using the dual system approach. Of those who have purchased computer graphics equipment, most are still in the testing stage and are concentrating on achieving results with either a vector or raster system. Thus far, the vector/raster combination has been put into production by only a small group of commercial companies. Esselte Map Service in Sweden is the only company producing maps for publication of the type described here. As with the other dual system users, Esselte began with a vector system. To date, four major products and several town plans have been digitized on an Applicon turnkey vector system, and edited and plotted on the Scitex system. An example is the street map shown in *Figure 10*. Comparisons with the earlier single-system approach show marked improvements in quality of linework. The dual system also allows a broader range of graphic elements and symbolization. Production time has also decreased, both for the initial maps and subsequent revised versions.

Text Overlapping

One major task has still not been adequately addressed by any computer system: the placing of names on a map. On most published maps of average to high quality, all map text is reproduced onto a clear film with an adhesive backing. Each name is cut out and positioned manually. The two primary requirements that govern proper text placement are that the text must be readable, and it must be associated with the feature it is meant to define. Very little of the text on a large-scale map, therefore, is perpendicular to the horizontal or vertical frames of the map's borders. *Figure 10* shows a text overlay produced with phototypeset text, positioned manually. On small-scale maps, text should follow along the curve of the nearest parallel of latitude, with the curvature depending on the map's projection.

Defining the location for a text string or label on a vector system is relatively simple and quick. Associating text with its location is also within the capabilities of most vector systems. However, while standard vector plotted fonts are satisfactory for most CAD applications, these fonts are not acceptable for a published map. Further, vector plotting or flashing (passing light through a negative aperture of a character) has never been seriously considered a viable alternative to hand placement for locating the thousands of names in the number of sizes and font styles required on a map.

The input of location by vector, and the output of desired text by raster, also seem to offer the best solution for this problem. The pixel-based laser plotter is technologically similar to the high-speed phototypesetters being used extensively in the publishing industry today. It is so similar, in fact, that several manufacturers of pre-press color processing systems that output on laser plotters have announced a typesetting capability. Such systems allow the combining of text and color images in the computer, and the plotting of the combined result on printer-ready plates.

Scitex, for instance, is attempting to adapt the advances made with horizontal line typesetting to the placing of high-quality text along predefined straight and curved lines. The best means found to date for inputting lines and text has been through vector systems.

Conclusion

If you recognize a need to employ computer graphics, but have been unable to find the right system, a dual or multiple system approach may be your answer. One word of caution, however. Computer equipment manufacturers are often more eager to sell you more of their own equipment than to help you link up with another manufacturer's hardware. Perhaps all industry members will eventually recognize the need for truly interchangeable databases.

In the meantime, a dual or multiple system approach may be the best solution. If you decide that your application will require two or more graphics systems—or else you will not be able to employ computer graphics at all—make the point clear to the vendors. Most of them will listen. ■

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