COMPUTER GRAPHICS WORLD

MAPPING

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Advances in computer-aided map publishing drive new industry

By Michael L. Sena

With the growing availability and declining costs of digital geographic databases—and the emergence of new hardware and software—computer graphics technology is fundamentally changing the traditional printed map.

Map scientists (geographers) throughout history have searched for mathematical solutions to the problem of reshaping the Earth's surface from a spherical to a planar one. Map makers (cartographers), have labored to invent graphical solutions to the problem of representing natural and manmade features, as well as invisible (areal) features, such as political boundaries, in a way that map readers might comprehend the facts being presented for a particular purpose and process those facts into useful information.

Within the private, map-publishing sector, a small number of organizations dominate the road atlas and travel-map markets in their respective countries. The public-sector agencies publish the largest number of maps. The U.S. Geological Survey and the land surveys of many other countries, especially Great Britain, Sweden, and Norway, have become major distributors of maps for all types of uses. The public section has traditionally been the primary source of geographic information in paper form. In recent years, national, state, and municipal agencies have become the primary sources of geographic data in digital form.

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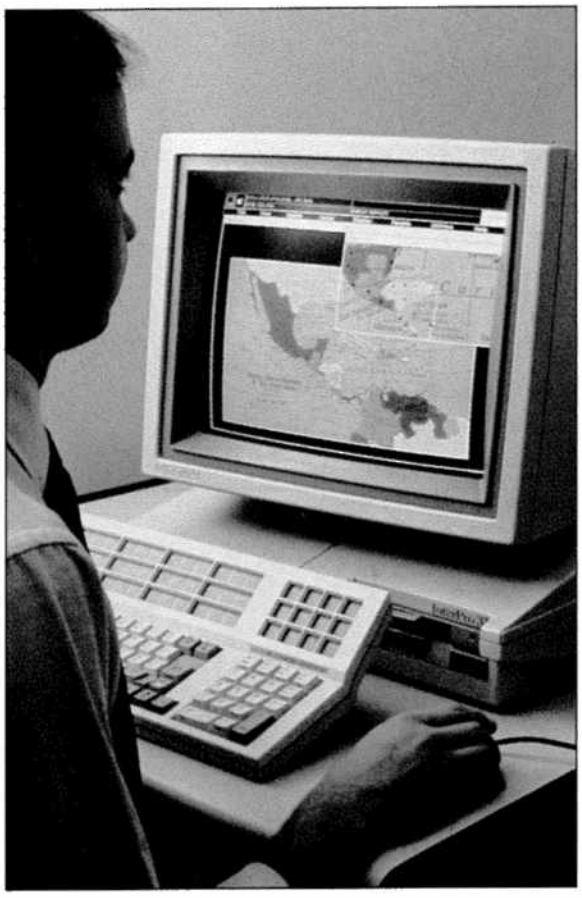
The mapping industry has traditionally been divided into two groups—those who collect the data to be mapped and produce the official version of what is extant, and those who use this geographic data as a base to produce new maps. These secondary producers collect and add more facts to the base maps to redistribute new maps. The map publisher makes multiple copies for redistribution using lithographic or offset printing.

Options Available

Many publishers today are at a crossroads. Should they continue to maintain and reproduce their film libraries—using traditional, manual, and photographic techniques? Should they invest in converting these libraries to digital cartographic databases? Or should they abandon their own sources and use available public domain digital geographic databases?

The ideal computer-aided map publishing system contains features found in geographic information systems, CADD, electronic publishing, image processing, prepress, and phototypesetting systems. With such a system, map publishers collect, store, edit, and reproduce geographic data in a form that can be printed by conventional printing presses.

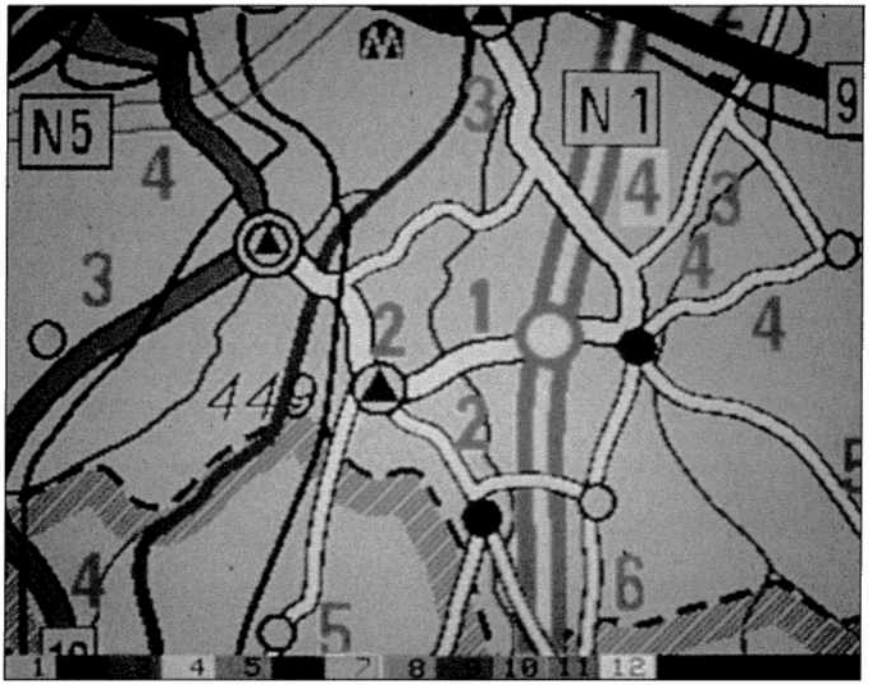
The following is a list of what a computer-aided map publishing



This map is being prepared for plotting on an Intergraph InterPro 32C workstation and Map Publisher software. The map will be prepared on an Intergraph/Optronics plotter.

system should accomplish:

- Combine lines, halftones, and continuous-tone lines with areas and type on color-separated film ready for plate making and printing. The result should equal traditional cartographic techniques in accuracy, design integrity, and quality of reproduction.
- Plot large-format (minimum of one meter square) sheet maps and atlas pages in a signature format.
- Produce a variety of different maps from the same geographic database by altering the design specifications for lines, symbols, and type.
- Place type in a variety of fonts and point sizes at any angle of rotation.
- Provide capabilities for combining data from sources including scanners, digitizers, satellite mapping systems, and from public domain geographic databases such as USGS Digital Line Graph files, U.S. Census DIME files, and others.
- Enable map products to be edited and updated easily and cost-effectively.



This completed map displaying text and graphics was done on Scitex's Response 280 cartographic system.

Using computers in map publishing is very different from applying computer-aided design and drafting systems in other mapping application areas where a printed map is not the end product (see "Computer Mapping for Publication," July 1983, p. 68). In 1983, facilities mapping and GIS systems were not sufficient for solving the map publishing problem. The one system that was used for the editing and film production side of map publishing was the Scitex Response 280 Cartographic System from Scitex Corporation Bedford, MA).

Five years ago, computer-aided map publishing was not widely accepted or employed among private map publishers. There were no real competitive pressures or threats forcing the move to digital geographic databases.

But as we survey the field of available systems today, we find a growing number of new players entering the market. The climate for automation—because of competitive pressures coming from outside the traditional map publishing industry—has definitely improved.

Intergraph Corporation (Huntsville, AL) has maintained a strong lead in facilities mapping database systems since the early '70s. Many map publishers who are currently using automated techniques rely on Intergraph systems for creating their map databases. These include Jeppesen Sanderson (Denver, CO) and SAS (Stockholm, Sweden)—both produce aeronautical charts—Esselte Map Service and Liber Kartor (Stockholm), AAA (Falls Church, VA), and the Dutch Travel Club (with TeleAtlas, den Bosch, The Netherlands).

Intergraph's primary strength has been its integrated graphic and attribute database on Digital Equipment computers running an unmodified DEC operating system. The integrated database is essential for most mapping applications since it allows users to maintain separate attribute files and vector representation files of map data. The two files are linked together with pointers so that a change in an attribute can be reflected in graphics, and an alteration of a graphic feature can automatically update the feature's attribute.

Trends Change Market

Several recent trends have affected Intergraph's dominance of the mapping market and caused the company to make strategic alterations to its hardware and software. One trend has been a move of many vendors away from proprietary hardware and bundled software to off-the-shelf hardware and special-purpose software. Intergraph purchases DEC processors from Digital and then adds its own proprietary graphics and file processors to enhance system performance.

Intergraph software runs only on Intergraph computers, although standard VMS programs can also be run on their machines. Products such as SysScan's (Hauppauge, NY) KartoScan, Synercom's (Sugar Land, TX) Infomat, GeoVision's (Ottawa, Ontario) GIS Software, and IBM's (Armonk, NY) GFIS are major competitors to Intergraph in facilities mapping. These companies have begun to win contracts because organizations can purchase their software and operate it on their own DEC or IBM computers. SysScan has had an added edge because its input device is a sophisticated scanner with automatic vectorization software.

Mapping software has also evolved from a CADD base, which is Intergraph's strength, to a topo-

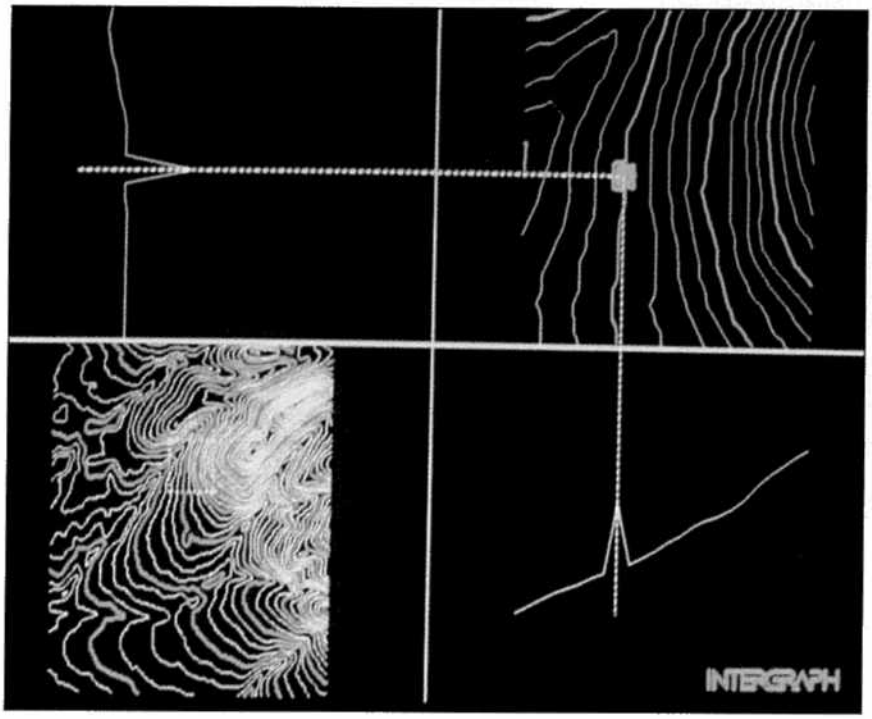
logical structure, which is the base for geographical information systems (GIS). The topologically structured GIS network of nodes, links, and closed shapes is especially useful in resource management and market area analysis, but it is used in all areas of mapping since the database provides geographic accuracy and network connectivity.

Environmental Systems Research Institute (ESRI, Redlands, CA), with its ARC/INFO system running on Prime and DEC computers, and GeoVision have given Intergraph very heavy competition during the past few years in both the public and private sectors. Among the map publishers that have recently acquired ARC/INFO are Bartholemew (Edinburgh, Scotland), Thomas Brothers Map Co. (Los Angeles), and the National Geographic Society. The USGS cartographic laboratory in Minnesota is also using ARC/INFO for its national atlas project.

The personal computer phenomenon has also affected the mapping market. PC-based systems for digitizing map input, vector editing, and database construction began to appear in force in 1986. In addition to mapping overlays for popular PC-CADD and database programs, special mapping packages for PCs are now hitting the market.

Intergraph has attempted to meet these challenges from open systems, GIS software, personal computers, and systems with scanning input through a strategy involving acquisitions and alliances, new hardware platforms, and a completely new approach to its software.

A series of stand-alone workstations built around the Intergraph Advanced Processor (formerly National Semiconductor) Clipper processor is the core of Intergraph's future systems. For these workstations, Intergraph has developed a new interactive graphics environment software base to replace IGDS and DMRS when the workstation is disconnected from the host. The company has been working on a product called Tigris, which creates a topologically structured database for GIS network applications.



Divided into sections, the Intergraph screen shows several layers of a map at one time.

Merging Systems

Rather than developing its own high-precision scanner/plotter, Intergraph purchased Optronics Corp. (Wilmington, MA), a leading manufacturer of laser scanning and large-format plotting devices. The Optronics 4040 has been combined with Intergraph's hardware and equipped with software for capturing scanned data and performing raster-to-vector conversion and optical character recognition.

For a foothold in the PC market, Intergraph purchased controlling shares in both Bentley Systems and CNR Research, two companies that had emulated Intergraph software on PCs. Both systems can be used as inexpensive input and editing devices for mapping database creation. CAD Partner (Stockholm, Sweden), which was founded in 1986 by former employees of Intergraph Scandinavia, has developed GIS, digitizing, and editing applications for these systems.

Older System is Reliable

Scitex has had an exclusive place in the automated cartographic and map publishing market since 1978. In that year, Scitex introduced its Cartographic System with unique capabilities for map production. The system allows the user to view and edit the final map and produce screened films for each printing color, eliminating the time-consuming peel coat, masking, and photographic stripping process common in traditional map production. The Scitex high-resolution ELP/Laser Plotter, with up to 2000 lines per inch, provides typeset-quality output and extremely high-quality line definition and screen values.

One key ingredient of the Scitex system is its ability to process both vector and raster data. Vector data can be imported from any mapping database system that can produce Standard Interchange Format (SIF), Gerber, or Scitex Digit format files. Scitex can also scan color maps using its Super Scanner or black-and-white separations with the ELP/Laser (the same device used for plotting) to convert raster scanned images into vector format. The system accepts preprocessed Landsat and SPOT satellite imagery and can combine these images with digitized or scanned data.

Oil and gas exploration, printed circuit board production, and, most of all, technical documentation and publishing applications have spawned many new products that

can be used in map publishing. Oil and gas exploration systems require both vector and raster technologies for base-map acquisition, attribute data management, subsurface map database creation, well log, as well as seismic data interpretation.

Techniques Will Change

Digital color systems for prepress and technical markets, along with input and output peripheral devices being developed to support these systems, will eventually have a major impact on map-publishing techniques. The effects of what the *Seybold Report on Publishing Systems* (Dec. '87, Vol.17, No.6) describes as a "volcano of change" in such systems have still not been fully felt in map publishing. All of the requirements of a map production system are present in technical documentation and publishing: vector conversion, raster editing, and WYSIWYG symbolization.

One of the most important new developments reported by Seybold is the prospect of generating color halftones on a typesetter instead of an expensive laser plotter. At Graph Expo '87 in Chicago, Howtek Systems presented Colorscan, which, according to Seybold, is the first commercially available system for creating color halftones from a typesetting device. At about the same time that Graph Expo was taking place, ESRI programmers were assisting the USGS in producing color separations on a Linotronic 300 typesetter by transferring data via PostScript format to the typesetter.

A few companies have been actively working on developing turnkey map-publishing systems that would combine vector database capabilities with raster editing and plotting. The acquisition of Optronics has given Intergraph a scanning and plotting device that matches the Scitex ELP/Laser in format size and resolution. The Optronics system is capable of producing high-quality halftone and continuous-tone films.

Intergraph's work on functional software for seismic analysis and technical publishing has given the company a strong base for its map-publishing system, which now offers an extensive library of Bitstream type fonts that can be placed, rotated, and plotted. Hammond Map Co. (Maplewood, NJ) has been working with an Intergraph/Optronics system for producing small-scale country atlas maps.

At this time, Intergraph's offering does not have the sophisticated batch processing and interactive editing software available from Scitex. Such functions as complex intersection definition, asymmetrical line symbolization, and edge contour generation are also not yet available.

More Systems Available

Hell Graphic Systems, the West German manufacturer of color prepress systems, has also been working on a cartographic system. Like Scitex, it has scanning, raster editing, and film production capabilities. As far as we know, this system is still under development.

As the situation stands today, public-sector mapping agencies—the primary producers of geographic data—have automated their database production processes and are creating a strong demand for high-quality editing and film output. Geographic data integrators have appeared during the past three years with digital map products to complete with printed maps and the traditional map publishers (see "Digital Mapping Creates New Market Opportunities," p. 7).

Automation is the Key

Map publishers are beginning to automate in greater numbers and are searching for systems that can quickly convert their cartographic film libraries into geographically accurate databases, produce high-quality film for printing, and provide a means to use their digital cartographic databases in electronic systems of the future.

Some might argue that developing new map-publishing systems that can produce printable output is an academic exercise, since the future direction for map distribution points toward digital, not paper, reproduction. But the demise of the printed map is not imminent. There are still many advantages to having a disposable, folded map and/or atlas for easy reference.

Experience in other fields of automation, most notably electronic magazine, newspaper, and technical document publishing, has shown that computer aids do not reduce the desire or need for publishable material. What automation has done in these industries is to eliminate many of the tedious and costly manual steps required to create the end product.

Furthermore, even when (and if) digital transmission of maps and geographic data becomes the primary method of communication between map creator and map reader, the cartographic quality requirements necessary for printed map publication will be just as essential. Typeset-quality text in different fonts, sizes, and colors is used in printed maps because it is more legible than hand lettering or simple stick fonts produced on a pen plotter.

Better Quality Offered

The text conveys valuable information instantly to the map reader. Intricate line and point symbols are not just pretty, artistic devices invented by cartographers—they enhance readability and improve the ability of the map reader to interpret the information correctly. These and other features of cartographic-quality printed maps, are not abstract notions but are the result of several centuries of research in both academic and practical settings.

If digital maps are to be used, they will have to match the paper map in cartographic quality. Perhaps at some point in the future it won't make any difference to the map user whether a map is printed on paper or transmitted to a portable monitor. **CGW**

Digital Mapping Creates New Market Opportunities

The availability of digital geographic databases from public mapping agencies has spawned dozens of new companies and promises new distribution channels for maps in digital form. Dedicated to reproducing and repackaging geographic data, these geographic data integrators (GDIs) are expanding the market by applying automation to problems that have been difficult to solve with paper maps.

Leading this group are GDIs with their geographic decision software such as Strategic Locations Planning's (San Jose, CA) Atlas, Mapping Information Systems' (Troy, NY) Midas, Geovision's (Norcross, GA) CD-ROM mapping software, Geosoft's (Vernon, CT) Map Builder, and Geographic Data Technology's (Lyme, NH) Zone Ranger. These vendors, among others, provide transportation, political, and ZIP code boundary files acquired from public domain sources such as the USGS Digital Line Graph files. Vendors package such data with GIS and presentation graphics software to allow users to create their own maps.

In-vehicle navigation systems for cars and trucks represent the most ambitious application of digital geographic data. Major car manufacturers and a number of electronics firms are developing products that will put a map, written descriptions, or verbal instructions from voice synthesizers into cars and trucks within the next few years.

For instance, ETAK Inc. (Menlo Park, CA) is converting detailed street networks of major metropolitan areas into digital form. The company uses a proprietary method to transfer U.S. Census Bureau DIME files with street names and intersections to a format that can be used with its ETAK Navigator, which displays roads on a small screen mounted on a vehicle's dashboard. The vehicle's position is shown by an arrow, and as the vehicle moves, the map moves, always keeping the vehicle pointed upward on the screen. The Navigator will be distributed by Delco, a subsidiary of General Motors, and by Blaupunkt in Europe.

Routing Technology Software (Bethesda, MD) has been working on a routing system that uses laser disks and scanned map images that are calibrated to precise geographic reference maps. Philips is developing a CD-ROM-based, in-vehicle navigation system called CARIN, which has a color monitor and voice synthesizer saying such things as, "Turn right. Turn left. You have arrived." Philips will use TeleAtlas's (Hertogenbosch, The Netherlands) data in its CARIN system. TeleAtlas is completing a large-scale (1:10,000) road database of The Netherlands and smaller scale maps of other parts of Europe. All of these digital maps are produced to a high degree of geographic accuracy. The Dutch Auto Club, ANWB, which owns 40 percent of TeleAtlas, will use this same data for producing printed maps.

In Scandinavia, the Swedish Post Office has completed a local street database of 50 of the largest cities in Sweden and a network of all major roads in Europe. The database will be used to automate dispatching and routing of package delivery trucks.

There are many firms in the U.S. and in Europe that are either using public-domain digital maps or digitizing available source to create vehicle routing, decision support, and travel-planning products.

The changes now occurring in map production and distribution will have a number of profound effects on the entire mapping industry:

- Publishers of printed maps will face shrinking markets as alternative mapping methods—such as digital mapping systems for personal computers, videotex with travel information and maps delivered directly to the home or office, and vehicle navigation systems—first supplement and then replace paper maps. Such systems threaten to make the printed map obsolete.
- Primary cartographic data producers, including governmental agencies and private-sector surveying firms, will shift from manual techniques to completely automated methods and will increasingly use their own digital data for map-publishing activities.
- Geographic data integrators who digitize and/or repackage primary data for specific end-user applications will become the dominant factor in the mapping industry.
- End users of maps will rely on computer-based mapping programs, especially those designed for personal computers, to analyze and present geographic data in ways we are just beginning to imagine.
- Vendors of automated cartographic and geographic systems will be challenged to determine which of a myriad of potential market niche opportunities should be the focus of their development efforts and marketing resources.
- Suppliers of traditional photo and graphic arts equipment for map producers will confront shifting markets and will need to evolve new products to meet the demands of automated map-publishing technologies.

Traditional map publishers will either become geographic data integrators or will form alliances with groups who already have the know-how to produce geographic databases. GDIs will form alliances with map publishers who can help ensure the long-term accuracy of geographic data and add value to digital data in the form of increased cartographic quality and multiple levels of information. At the same time, vendors of computer-aided mapping systems will develop products for vertical markets ranging from primary input through editing and value-added software development to end-user applications.—*MLS*