NEW YORK STATE'S DIGITAL COUNTY MAPPING PROGRAM

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ABSTRACT

This paper details the development, design and data used for producing a statewide series of digital county maps by the New York State Department of Transportation. Three counties have been completed with others in production. Each map in the series is produced by combining digital data from the U.S. Geological Survey's 1:100,000 scale Digital Line Graphs (DLG) with data digitized from the New York State Department of Transportation's 1:24,000 7.5' quadrangles and other data compiled from recent aerial photographs and other sources. All digital information is stored in the Department's Intergraph* interactive graphics computer system and is structured for a variety of uses. Using a laser plotter, and image compositing software, converted raster files are exposed to create color-separated, press-ready negatives. The County Base Map series is part of the Department's ongoing development of a statewide digital cartographic database to be used for multi-scale map publication and Geographic Information System applications.

BACKGROUND

The New York State Department of Transportation's (NYSDOT) Mapping Services Bureau is responsible for producing and maintaining the state's several base map series. The Statewide Base Mapping Program includes 1:24,000 scale planimetric and topographic maps which are based on the USGS's 1:24,000 scale maps; 1:9600 scale city and village maps; the 1:250,000 Four Sheet State Map; and the New York State Atlas. The County Base Map (CBM) Series, which has recently gone into production, provides the needed intermediate scale component of the Statewide Base Mapping Program. The various map series in the program are interrelated, e.g. use common grids and projection, data plotted at larger scales is used at smaller scales, etc.

The NYSDOT's multi-scale base mapping program was established over twenty years ago. Unfortunately, the production of the CBM Series was deferred for many years due to other priorities and lack of funds. However, with

*Mention of firms that manufacture computer hardware and/or software, or that supply commercial mapping services or data is for descriptive purposes only and does not constitute endorsement by the New York State Department of Transportation.

renewed interest in the series from within the NYSDOT and with support and funding from the Federal Highway Administration (FHWA), design and planning work was begun in 1986, followed by the publication of Monroe County, the first map, in mid-1988. (See figure 1)

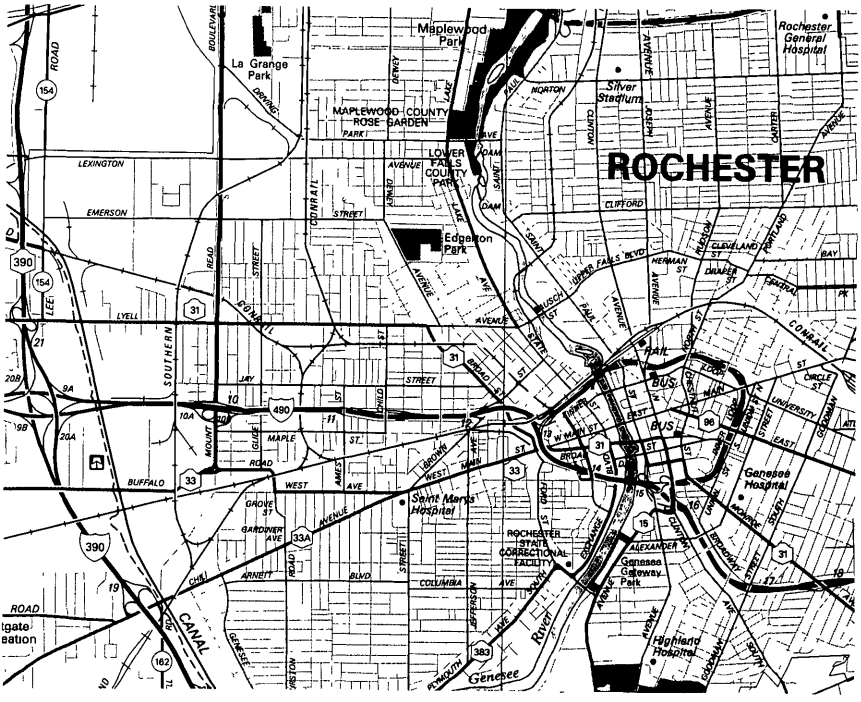

Figure 1. Black and white composite of a section of the four-color Monroe County Map at 1:75,000 scale.

The NYSDOT's purpose in producing the long-planned CBM Series was to have a county formatted map showing in detail the components of the state's transportation network and other important base features such as civil boundaries, hydrography, and public lands. While the CBM series was designed primarily to meet the needs and requirements of NYSDOT, assuring that the maps met the needs of other New York State agencies was an important consideration.

The Mapping Services Bureau is continuing the process of converting from traditional manual production of base maps to completely automated digital production. Up to the time that digital production was started on the CBM Series in early 1987, digital methods had been concentrated on the production of large-scale photogrammetric products and on a few small scale specialty maps. Since then, we have begun to convert the 1:24,000 scale quadrangle revision process to digital methods also. Laser plotting of all revision work in this series is now routine.

DESIGN

When the CBM Series design and production goals were outlined in 1986 we committed ourselves to accomplishing the following:

- The series would be produced digitally, from initial data input to final press-ready films for printing. With an Intergraph system available for digital production and a staff of experienced cartographers to operate the system, we felt we had the necessary resources for producing a high quality product.

- The digital database for the CBM series had to be compatible with NYSDOT's other statewide base map series, even though these series were not yet in digital format. Compatibility would assure future use for other multi-county or regional maps. To this end, we developed a Statewide Cartographic Database / Geographic Information System plan that outlined our concept of a multi-scale digital database to support production of the Statewide Base Mapping Program. (See figure 2)

- Utilize, to the maximum extent possible, existing digital databases to minimize the need for digitizing and other types of data entry.

- Maps in the series would be produced at one of three scales; 1:75,000 for urban counties, 1:100,000 for moderately developed counties, and 1:125,000 for the large rural counties in the Adirondack Region of New York State. Smaller adjacent counties would be published on one sheet wherever possible.

- Content categories would include the following: All public roads, railroads, airports, public transportation facilities, bike routes, power transmission and pipelines, civil boundaries, federal lands, state and local recreation lands, state and federal historic sites, hydrography, dams and locks, boat launch sites, and selected points of interest such as colleges, universities, hospitals and stadiums.

- All maps would be printed in four colors, with copies available both flat and folded. To produce color-separated copy for printing, laser plotter technology would be used, if possible, to produce press-ready films. Our objective was to eliminate all labor intensive manual production techniques including; hand scribing, type stick-up, cutting open window tint negatives, and final photo-mechanical compositing of film overlays. Methods were to be developed to perform these tasks with time and money saving automated techniques.

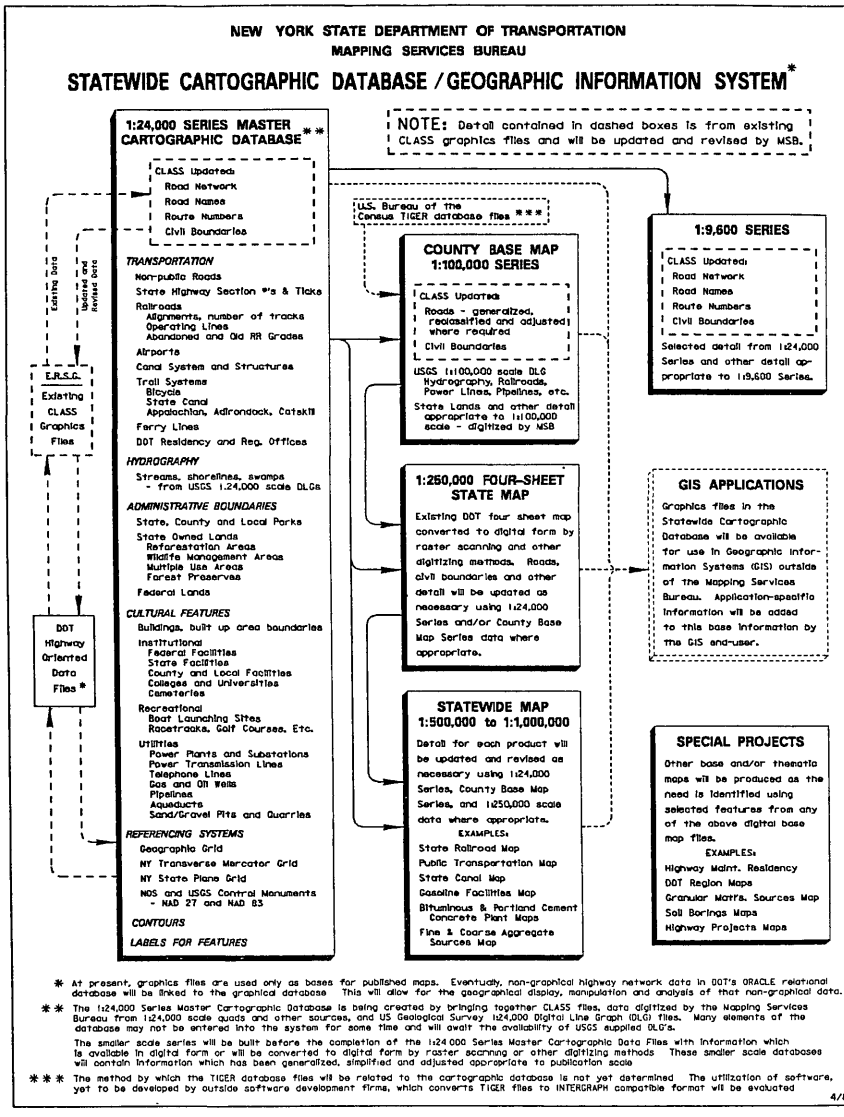

Figure 2. Statewide Cartographic Database / Geographic Information System Outline.

DIGITAL FILE CHARACTERISTICS

The CBM Series digital files are composed of six standard theme files for each county: Roads, Boundaries, Hydrography, Miscellaneous Transportation, Polygons, and Names/Design. All theme files use the same coordinate system so they register (overlay) precisely. All data is stored in Intergraph Corporation's design file format using Intergraph's Interactive Graphics Design Software (IGDS). Currently we are using IGDS version 8.8 on a

Digital Equipment Corporation (DEC) VAX 11-785.

Data in each of the six standard theme files is classified by graphic level. Additionally, several other graphic properties are used to differentiate map features, including color, line weight, line style, element class and graphic groups. Graphic definition of map features is being used as an interim approach while NYSDOT develops an agency-wide corporate attribute database.

Coordinates of all features in the files are expressed in New York Transverse Mercator (NYTM) values. NYTM is an east and west extension of Zone 18 of the Universal Transverse Mercator (UTM) projection/grid system that accommodates all of New York State in a single zone with a single origin. Coordinate values are metric.

DATA SOURCES

One of the principal activities in the planning and design of the CBM Series was evaluating and selecting existing digital databases. From a variety of databases considered, two were evaluated in detail, the 1:100,000 scale Digital Line Graph (DLG) database of the USGS, and the 1:24,000 scale Centralized Local Accident Surveillance System (CLASS) database of the NYSDOT. Ultimately, both of these data sources were chosen to form the foundation of the CBM Series digital files.

DLG Files

The DLG files are used for the Hydrography and Miscellaneous Transportation themes. DLG data has been converted to NYTM coordinates, edge matched, substantially updated, reclassified, and vertically integrated (matched) with data from other files.

CLASS Files

For the Roads and Boundaries themes, NYSDOT CLASS files were used. These files were originally table digitized from NYSDOT 1:24,000 scale quadrangles approximately 10 years ago.

For use in the CBM Series, CLASS files are updated using more recent NYSDOT quadrangles and aerial photographs, merged to form county files, reclassified to depict road jurisdiction and physical characteristics, and selectively generalized as appropriate for publication at county map scale. Civil boundaries, which are surprisingly dynamic in New York State, were updated from official sources.

All other features in the CBM files, such as state and federal lands and municipal parks, were compiled and digitized using NYSDOT 1:24,000 scale quadrangles.

All digitizing from NYSDOT 1:24,000 scale quadrangle maps was performed on high precision equipment using stable base film copies of the 7.5' quadrangles. Digitized maps were related to precise theoretical NYTM values of the

quadrangle corners for accurate digitizing control. In addition, stable base ink-on-film check plots are used to verify the accuracy of digitized alignments. All files are edge matched to form a seamless database.

Data File Evaluation

The choice of using the CLASS files over the DLG files for the Roads theme was the result of a careful comparison of the two data sets, and an estimate of the amount of work required to adapt either data set for the CBM Series. Our conclusion was that the DLG road files were suitable for the series, but would require a greater effort in sorting the roads to our classification scheme and associating them with their road names and route numbers. The CLASS files already contained these names and numbers, and we were able to programmatically convert the CLASS files to our road classification scheme based on this attribute data, a process we could not do based on attributes in the DLG road files. In addition, the CLASS files contained civil boundaries, and required no additional effort to vertically integrate roads and boundaries where they coincide.

Scale/Accuracy

The files have no expressed map scale, since all features in the files are stored in ground coordinates. However, the data sources for information in the files range from 1:24,000 to 1:100,000. Positional accuracy of features in the files is no better than the sources used for digitizing.

FEATURE TYPES

Four categories of map features are included in the CBM digital files: point, linear, area, and text/labels.

Point Features

Point features are represented at a single coordinate pair by either a cell or a symbol font. A cell consists of lines and other information which define a feature and are grouped together as a single element. A cell is stored in the file at a single point location. Cul-de-sacs at the ends of subdivision roads are represented by cells in the Roads theme file. A symbol font is a single character placed in the graphics file at a point location coordinate. The graphic representation of the character is stored in a separate font library and is displayed as the special symbol when the font library is attached to the graphics file. Symbols in open or outline form, such as route markers, use a unique font in the CBM font library, while color filled symbols, such as road rest areas, employ a different font. This allows selected symbols to be used as digital masks in a later image compositing process.

Linear Features

All linear features are represented by centerlines. Neither curve strings nor arcs have been used in the files. All linear features are stored as line strings with enough vertices to provide for reasonably smooth

bends.

Roads are stored in link/node format, with nodes (breaks) at intersections. Thus, long roads with many intersections are made of many short line strings. Some aspects of the road alignment for the published map are generalized from the original 1:24,000 CLASS files. Close alignments may be "pulled apart" so they do not touch or overlay at final published scale.

In the CBM Boundaries theme, all boundary information is kept at 1:24,000 scale accuracy specifications and is shown without generalization on the published map. Additionally, there are many instances where boundary lines coincide with other linear features, such as roads, hydrography, or other boundaries. Where boundaries coincide with another feature, such as a DLG stream alignment, we replaced the 1:100,000 scale DLG stream line with a 1:24,000 digitized line along the match zone. In this sense, we have selectively improved the DLG hydrography file to 1:24,000 scale accuracy.

In general, coincident features are stored separately with identical, but duplicate, line strings in each applicable theme file. For example, a boundary along a road is stored as a boundary in the Boundary theme file and also as a road line string in the Roads theme file. Coincident features within the same theme file are represented only once based on a hierarchy. For example, a state boundary is higher in the boundary hierarchy than a county boundary, and therefore, only the state boundary is represented along the match zone in the boundary file.

Area Features

All area feature polygons that are shown on the printed map with color fill are included in a separate Polygons theme file. The polygons are generated from line strings contained in the Hydrography and Boundaries theme files and thus duplicate the line strings from those files. Polygons are kept in a separate theme file so that the line strings can remain as simple linear elements in the original Boundaries and Hydrography theme files.

Since Intergraph polygons can only be coded for a single graphic level and do not share common edges with other polygons, cases of coincident linear features are handled through different element classes in the Polygons theme file. By this method coincident lines from different files can be built into one polygon, but can still retain the flexibility to selectively display the coincident alignments on the printed map.

Text and Labels

All text labels on the printed county map are stored in the Names/Design theme file. All text was produced digitally and was plotted with the high quality Intergraph "Bitstream" fonts. (See Figure 1) Type placement was, for the most part, performed interactively at the workstations. For populated place names Rand McNally's Randata file was used to automatically enter

names into the graphics file along with the type size codes scaled to population values. The coordinates in the Randata file define centroids of places, so final type position was adjusted interactively. Our approach has generally worked quite well for type placement. To accomplish all of this we have developed special commands to automatically set the names at the appropriate size, font, and distance from map features. Workstation operators make a final judgment on proper positioning.

We have not used the USGS Geographic Names Information System (GNIS) files to any significant extent. The GNIS file contains too little information about the size, category, and extent of features to allow for selection and classification of the names needed in the CBM series.

TOPOLOGY/ATTRIBUTES

The CBM files contain neither explicitly coded topological relationships of map features nor linkages to non-graphic attribute data. However, all files have been software checked to insure that end points of adjoining features match, and that breaks (nodes) occur properly at feature intersections. The files are clean and ready for conversion to a topologically structured database to support future applications for GIS use and analysis.

Graphic levels have been used extensively within files to permit "bulk loading" of attributes. In general, the graphics files use separate levels for each different type of feature so that all features on a level may be tagged simultaneously with attribute descriptors. We have on an experimental basis, converted the Monroe County Roads theme file to an ESRI ARC/INFO file, bypassing a SIF translation. This was accomplished by writing a Fortran program which reads the file and writes a macro to build the same graphics in ARC/INFO. Information attributes were created automatically from the data assigned to Intergraph levels. Work in this area is continuing.

FILE SIZE

Generally files for the CBM series are large. Of course, there is a wide variation in the volume of data depending on the size of the county. A single urban county may have 15 megabytes of data for all theme files combined. A range of 6-12 megabytes is expected for less urbanized counties, although we have not mapped any yet. For any county the Roads file will typically represent over half of the total county data.

LASER PLOTTING/PRINTING

For final publication all sheets in the county map series are offset printed in four colors: blue, yellow, red and dark brown. The composite film negatives used to make printing plates are created on a laser plotter which plots all information from the county files. For the Monroe County map the laser plotting was performed by

Hammond, Inc. of Maplewood, New Jersey.

Hammond uses an Intergraph system to drive an Optronics 4040 (40 inch by 40 inch) laser plotter. The plotter can operate at several different resolutions with 2000 lines per inch (12.5 microns) being the finest. Intergraph ILMS software creates the composite raster files to be output on the Optronics plotter. Through ILMS all design specifications for the printed copy, including line thickness, dashing, screening, masking, and color compositing can be accomplished. Within this environment, ILMS allows specified map features to have priority over other features. For example, route markers can be shown on a highway, with the line representing the highway broken under the marker only when plotted. In the graphics file the line remains unbroken. This masking technique is also used to show highway grade separations, and to create islands within polygon tints. Refer to Figure 1.

To achieve the highest image quality, the Monroe County map was plotted at 2000 lines per inch (12.5 microns) resolution. This yields the sharpest possible image, reducing any visible stair-stepping (aliasing) on lines and text to a minimum. For future maps we will plot at the 1000 lines per inch (25 microns) resolution for line and text, believing that this resolution will still give acceptable visual quality. In addition to the 1000 line per inch resolution, a process in the ILMS software called pixel replication can simultaneously allow plotting of polygon tints at 2000 lines per inch resolution, giving them a smoother and more even appearance than if done at 1000 lines per inch.

CONCLUSION

With the publication of the Monroe County Map in 1988 the goals we set for accomplishing the cost effective production of a fully automated and digitally stored county map have been achieved. In addition, we have built graphics files that are suitable for conversion to Geographic Information System use in the future. In fact, soon after the publication of the Monroe County Map, a Monroe County agency bought copies of all the digital files for use in developing an automated county-wide water and sewer planning and analysis system.