A VERSATILE MAPPING SYSTEM FOR THE USGS 1:100,000 DLGs

David J. Cowen
and
Timothy R. White
University of South Carolina
Columbia, S.C. 29208

ABSTRACT

This paper describes a versatile mapping system for handling the USGS 1:100,000 digital line graphs. It was developed to automatically generate maps of any scale for any part of South Carolina. The system is based on a set of FORTRAN procedures that access and manipulate any number and combination of DLG files. Using a command language structure the procedures allow the user to select attributes, set windows, change scale, shade polygons, and assign line symbols and shading patterns. The system automatically combines the necessary files into panels for a study area and generates the legend and scale. The system is being used to generate a wide range of maps for a GIS that is designed to analyze state wide infrastructure needs and industrial site selection. For example, it has proven to be an excellent system for creating a diverse set of base maps that are used by local governments to compile additional coverages such as sewer and water lines.

INTRODUCTION

The 1:100,000 Digital Line Graphs

The creation of the 1:100,000 digital Line Graphs (DLG) represents a milestone in the development of a national digital cartographic database. As a result of the cooperative program between the United States Geological Survey (USGS) and the Bureau of the Census there now exists a digital representation of the transportation and hydrographic features of the United States (Callahan and Broome 1984). Throughout the United States organizations at every level are experimenting with the data for a wide range of applications.

For many users the 1:100,000 DLG data are somewhat of a mixed blessing. Although they provide an inexpensive existing digital cartographic base file they do not fulfill all of the user needs in terms of scale, accuracy, content or coverage. In practice, even though the data only meet accuracy standards at 1:100,000 the Bureau of the Census and numerous other organizations have "cheated" and enlarged them even beyond 1:24,000 for applications not requiring positional accuracy. Furthermore, even though the more than 200 DLG attribute codes represent a fairly complete set of the hydrographic, highway, railroad and miscellaneous transportation features found on standard USGS quadrangles they only include a few feature names. Additional problems arise when the files need to be converted into continuous data bases required for geographical information systems.

It should be noted that problems with the 1:100,000 DLG base are symptomatic of the current status of digital cartographic data and, more importantly, maps in general. Through the combined efforts of the USGS and the Bureau of the Census there now exists an extremely valuable topologically structured data base. These files provide a clear indication of the type of information that will be contained in the National Digital Cartographic Database. As such they provide an excellent basis for any organization to start to plan for future applications of digital cartography and GIS.

Importance to South Carolina

The DLG data provided a basis for the creation of a truly state-wide GIS that would help analyze the needs in South Carolina for infrastructure improvements and economic development decisions. Before the DLG base was created most research projects were forced to compromise with respect to either spatial extent or spatial resolution. The DLG data represent an excellent compromise for a state the size of South Carolina. It provides an unbiased and uniform coverage of transportation and hydrography throughout the state that will serve as a useful basemap until the higher resolution 1:24,000 scale data becomes available in the next decade.

The Need for a Mapping System

Once the DLG files arrived in the Fall of 1987 there was an urgent need to generate a series of output products. Initially, it was important to demonstrate that the data would be appropriate for state wide GIS applications. This "proof of concept" stage of the project required a versatile mapping system that could quickly generate high quality map products at a wide variety of scales with any combination of attributes for any section of the state. After considerable discussion and experimentation with the files it was evident that it would be desirable to have a mapping system that met the following criteria:

1. The user must be able to select any size rectangular window anywhere in state
2. It should be possible to specify the window in Latitude and longitude, UTM coordinates or with a center point and scale
3. The user must be able to select any combination of DLG attributes
4. The user must be able to generate maps at any scale
5. The user must be able to assign variable shading and line patterns to area and linear features
6. The program must automatically generate a legend that displays the attributes and related symbology
7. The user must be able to overlay grids in either latitude and longitude or UTM coordinates
8. It must be possible to export the selected data to other programs such as GIMMS, AUTOCAD, and SAS
9. The system should have a simple command language interface with a reasonable set of default settings

IMPLEMENTATION

Hardware Considerations

The first part of system implementation involved the selection of the hardware and software environments. Although Luman (1987) and others have developed personal computer based programs that merge and display the DLG files the volume of data for a state wide system prohibited such an approach. For example, even the small state of South Carolina consists of 575 7.5 minute quadrangles or 1150 individual data sets for the transportation and hydrography information. When combined with the 30 minute files for miscellaneous transportation the total data base consists of 1238 files that consume over 2 gigabytes of storage. It was obvious that the system should reside on the University main frame network where it could utilize disk rather than tape storage. It is also important to note that the system was designed to generate plots on a 24 inch electrostatic plotter with a resolution of 400 dots per inch and its own internal rasterization system. This type of output device is capable of quickly generating high quality output without operator intervention.

Software Considerations

It was also quickly determined that no existing software system would be able to meet the stated requirements. Since the program was designed only as a mapping system the individual 7.5 or 30 minute DLG data sets could be handled as needed without the need to construct continuous spatial databases required by polygon based mapping systems or GISs. For example, if a large water body extends over several quadrangles only the topology within each quadrangle is important for display purposes and the entire spatial entity such as a lake does not need to be created. Therefore, the system was designed to take advantage of the UTM coordinates and existing topology of the DLG optional format rather than incurring the extensive overhead required to create and store a fully integrated data base. Implementation within a CAD structure was dismissed for the same reasons plus the difficulty of handling multiple attributes in that environment. Therefore, the decision was made to create a special purpose mapping system that had limited functions but responded quickly to a variety of mapping needs.

The Driver Program

The final system consists of a driver program and plotting program. The driver program is the file management part of the system. It determines which data sets contain the DLG attributes for the window that has been selected. This part of the process involves converting the selected window into decimal degrees and searching a catalog of the data sets. The driver program automatically generates the required number of panels, proper job control data definition statements and submits the job. In fact, if the user is generating a series of the same type of maps for numerous windows throughout the state the driver program will automatically submit the proper number of jobs and calculate an estimated execution time. Furthermore, with this driver program it would be possible to map the entire state at any scale by simply specifying a bounding window. In practice this front end has facilitated the rapid generation of literally hundreds of maps with no operator intervention.

The Plotting System

Once the proper files have been defined by the driver program the plotting program utilizes the coordinates of the window and the scale to clip the data and determine the size of the resultant map. In practice, the system is typically used with 24 inch paper and scales are often adjusted to fit within that dimension. The actual plotting system consists of more than 60 FORTRAN subroutines than make extensive use of the CALCOMP plot library. The user interface to the system is based on a series of card images that contain parameters for the following set of commands:

ALLATT - SELECTS ALL ATTRIBUTES FOR PLOTTING AND / OR EXTRACTION. (Figs. 1 and 2)
ATTRIB - ATTRIBUTE CARDS.
CNTRPT - ALLOWS USER TO SELECT A CENTER POINT AND MAP DIMENSIONS IN INCHES TO DEFINE MAP WINDOW INSTEAD OF THE WINDOW
FILE - TURNS DATA FILE EXTRACTION FOR ARCS AND POLYGONS ON OR OFF.
FILES - SET FILES STARTING POSITION AND NUMBER OF FILES TO BE CONSIDERED FOR PROCESSING.
FREQ - GENERATE ATTRIBUTE FREQUENCY LIST.
GRID - TURN UTM GRID GENERATION ON OR OFF. (Fig. 3)
LABSCL - DRAW MAP SCALE LINE?
LEGEND - TURN LEGEND FOR PLOT ON OR OFF.
OTHERD - IMPORT AND PLOT ANOTHER FORMAT OF DATA?
PCOPY - SET NUMBER OF PLOTS TO BE GENERATED.
PLOT - PLOT GENERATION ON OR OFF.
PRZONE - UNIVERSAL TRANSVERSE MERCATOR MAP PROJECTION ZONE. USED BY THE GENERAL CARTOGRAPHIC TRANSFORMATION PACKAGE V1.0 TO CONVERT DECIMAL DEGREES TO METERS.
SCALE - SET PLOT SCALE.
TITLE - SET PLOT TITLES.
TITLBX - DEFINE A BOX FOR USER DEFINED TITLES.
VERBOS - SETS LEVEL OF PROGRAM MESSAGES.
WINDOW - DEFINE WINDOW OF DLG DATA TO BE EXTRACTED WITH LAT/LONGS OR UTM COORDINATES.

With the set of commands it is possible to generate an infinite set of maps such as the composite map of North Charleston (Fig. 4).

APPLICATIONS

During the course of the development of the system it was important to generate a series of base maps that clearly demonstrated the content of the DLG files and their applicability for state wide GIS applications. A map of the southeastern part of the state (Fig. 5) was one of the first maps generated. This one map was extremely instrumental in proving that the concept would work and helped establish the credibility of the research team. The system has been used to generate scores of such maps usually with only a couple of hours turnaround.

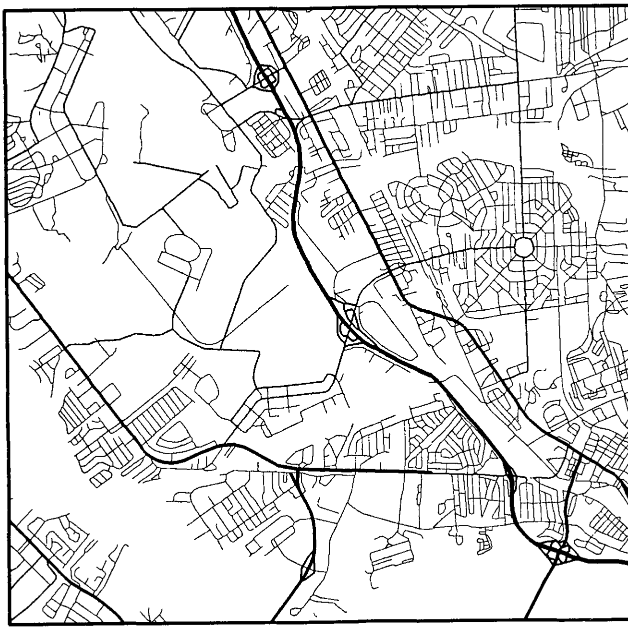

Fig. 1 Highway and Road Attributes - Charleston, S.C.
Scale 1:80,000

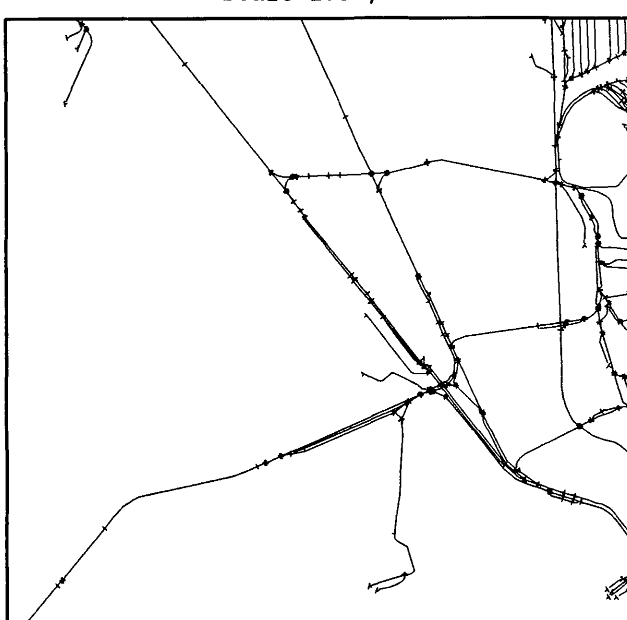

Fig. 2 Railroads, Sidings and Stations - Charleston, S.C.
Study Area

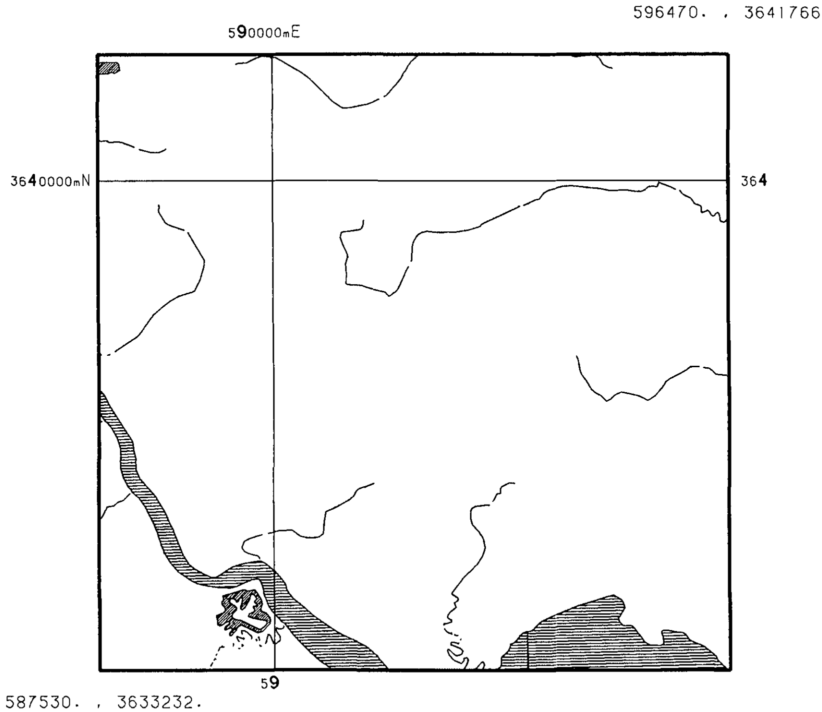

Fig. 3 Hydrographic Attributes With UTM Grid

GIS Applications

The second major use of the system has involved the creation of base maps of sewer and water districts. As a major part of the economic development project the ten regional planning councils in the state have been hired to create maps of the sewer and water lines that are relevant to economic development decisions. In order to assure that the maps can be registered to ARC/INFO transportation coverages it was important to provide the planners with maps that were derived from the DLG base. Using the mapping system it was possible to easily generate a base map of the existing transportation and hydrography for each of the 575 water districts throughout the state. Although the final maps were plotted at scales of 1:20,000 or 1:15,000 the system was also used to generate a series of 4 by 6 inch reference maps (Figs. 6 and 7). These proof maps were generated simply by specifying a center point for the water district and a scale. The planners are now transferring the water and sewer lines onto the full scale base maps and the data are subsequently being added to the statewide GIS simply by selecting the relevant arcs from the transportation layer within the GIS software.

EVALUATION

Within a few months the system has proven to be an important adjunct to the overall geographical data processing capabilities of the University of South Carolina. The system

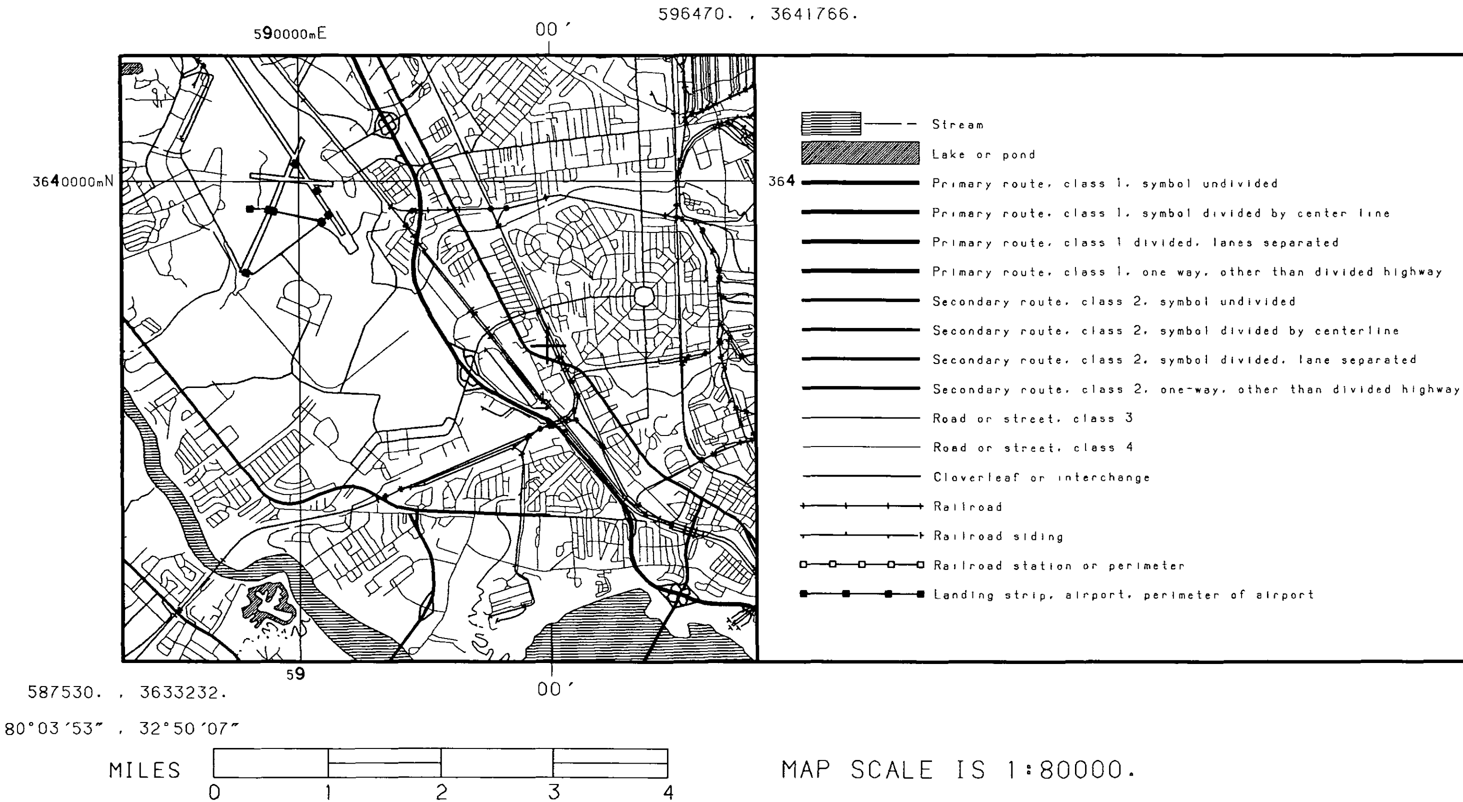

Fig. 4 Composite Map of Study Area - with Legend, Scale and Grids.

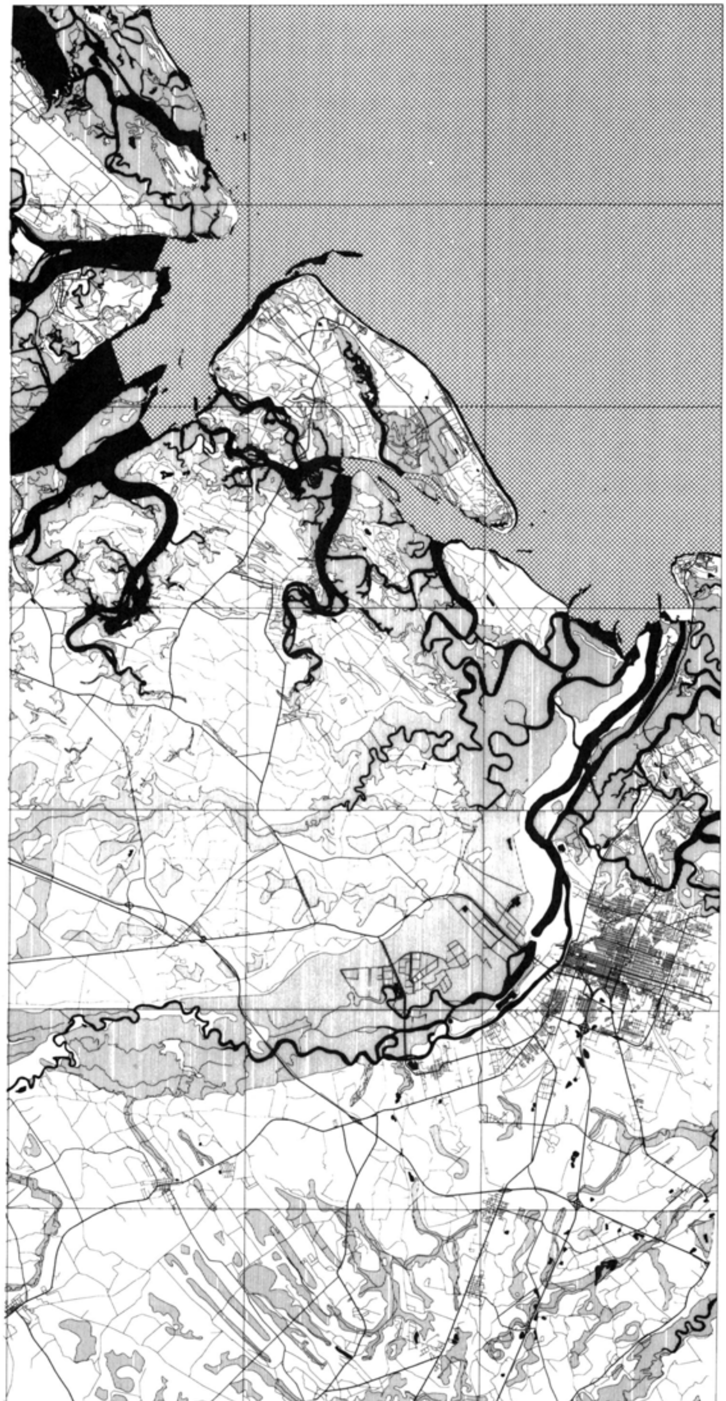

Fig. 5 Hilton Head Island and Savannah Georgia - Composite Panel consisting of 21 quadrangles.

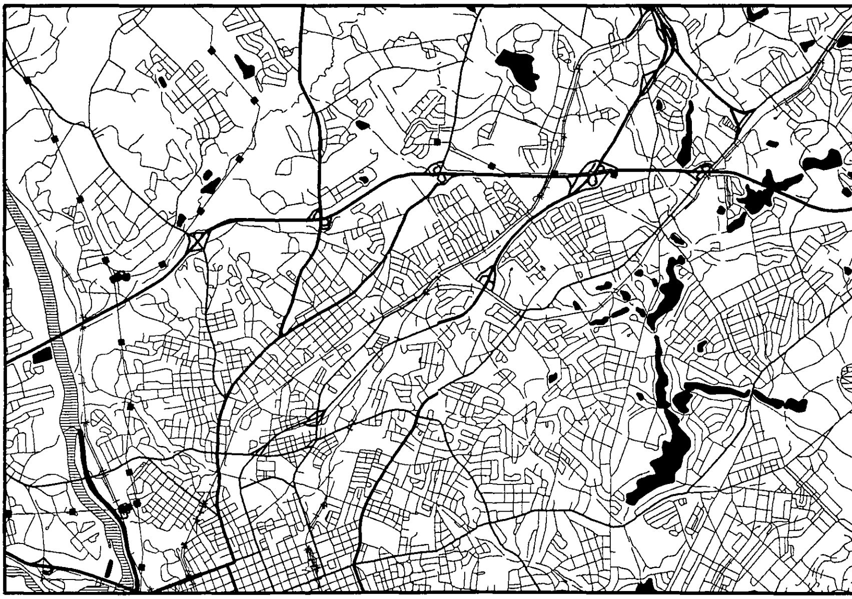

Fig. 6 1:100,000 Scale Section of Columbia, S.C.

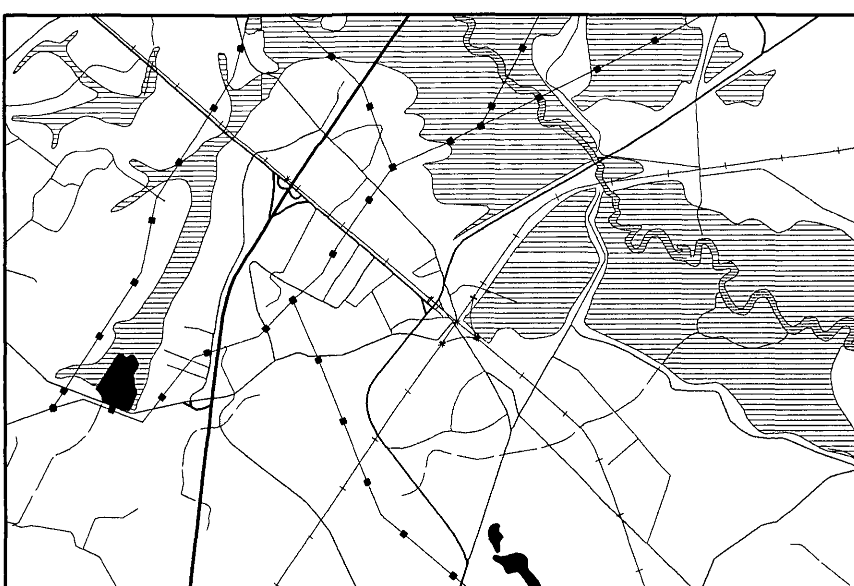

Fig. 7 1:75,000 Scale Map of Yemassee, S.C.

is sufficiently simple that it was successfully used by members of an introductory computer mapping class last semester after a single training session. The system has also been transferred to the Eastern Mapping Division of the USGS where it will be used to generate maps for error checking and other purposes. During the next few months the programs will be ported to the UNIX environment where they will run on a network of SUN work stations. The system has proven to be particularly efficient on raster output devices and probably would be impractical for anything but simple maps of limited spatial extent on vector plotters. The success of the system clearly demonstrates that even though general purpose mapping and GIS toolboxes have evolved tremendously in their functionality there still is a place for well designed special purpose programs, especially to manage large data sets such as the DLG.

REFERENCES

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