COMPUTER ASSISTED CHART SYMBOLIZATION AT THE DEFENSE MAPPING AGENCY AEROSPACE CENTER

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ABSTRACT

Computer assisted cartographic techniques are being used at the Defense Mapping Agency Aerospace Center (DMAAC) for chart symbolization of digital data for prototype production of charts. These digital data are collected by employing different computerized collection systems, one system being the Automated Graphic Digitizing System (AGDS). Computer symbolization of the digital data is accomplished by the Graphic Line Symbolization System (GLSS). The GLSS software generates plotting instructions for drafting the symbology according to chart specifications and plots on film, paper, mylar or by the electrostatic plotter. By using GLSS software, 50 percent of the man-hours required by the negative engraver have been saved. The digital data from the previously mentioned systems can be archived for permanent storage and updated as needed to produce revised charts.

INTRODUCTION

The Defense Mapping Agency Aerospace Center (DMAAC) is producing prototype charts from digital data. The digital data for these charts are collected, edited, and color separated in-house by the Automated Graphic Digitizing System (AGDS). The cartographic features from the digital data are symbolized according to chart specifications and plotting instructions for them are generated by the Graphic Line Symbolization System (GLSS). The GLSS software saves 50% of the man-hours normally used by the negative engraver for building lithographic color separation plates. The symbolized data from GLSS is archived for later chart revisions.

AUTOMATED GRAPHIC DIGITIZING SYSTEM

The Automated Graphic Digitizing System (Broomall Industries, 1979) is a system designed for data collection, interactive editing, and color separation of compilation overlays (The referencing of Broomall Industries does not constitute endorsement by DMAAC). The three main subsystems of the AGDS system are: the scanner, the vectorizer, and the edit tag subsystem. (Figure 1).

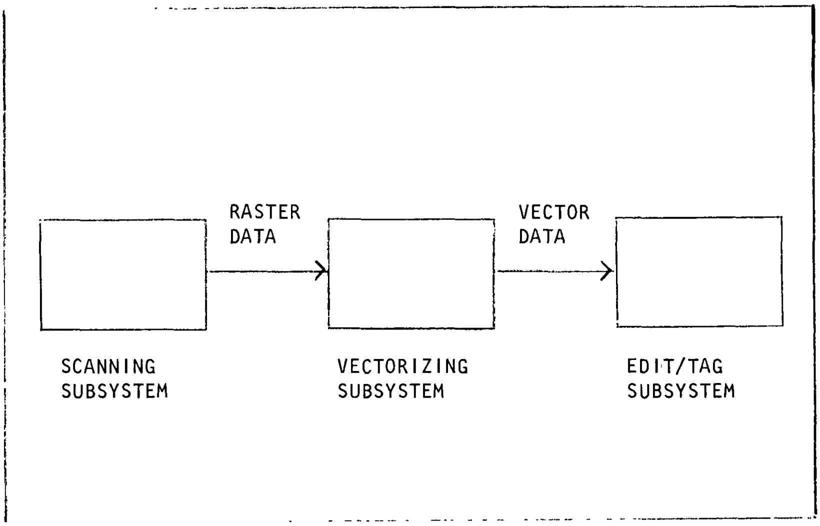

Figure 1. Automated Graphic Digitizing System (AGDS)

The laser scanning subsystem is used to scan compilation overlays outputting the data in raster format. The scanning subsystem has a resolution of 1 mil with an accuracy of 4 mils. The vectorizing subsystem converts the raster data to vector format. Once the scanned overlays are in vector format, the data are input to the edit/tag subsystem. The cartographer at the edit/tag subsystem has the capability to interactively edit the data, create sub files from the data, and to mathematically transform the separate overlays to the compilation projection base. Common points between the individual overlays and projection base are used for controlling the overlays to the projection. After the cartographer has transformed the overlays to the projection, he interactively separates and inserts unique feature identification codes (FIC) to features according to their unique color separation. For example, drainage would be displayed on the blue color separation whereas cultural features would be displayed on the black separation. The color separations correspond to the colors for the lithographic printing plate. The FIC, or tag number corresponds to a specific set of previously defined instructions for feature symbolization.

After the data has been separated at the edit/tag subsystem, an output tape is generated for off line chart symbolization by the GLSS Software.

GRAPHIC LINE SYMBOLOGY SYSTEM

The GLSS software is to provide the cartographer with a chart product that shows cartographic features, such that one feature can be easily distinguished from the other.

The GLSS software converts line centered data to a specific product format which depends upon the chart specifications being used for the final chart compilation. The product format is generated by a graphic film (photo) plotter.

GLSS was originally developed by the PRC Information Sciences Company (PRC, 1976) under contract to The Rome Air Development Center (RADC) (The referencing of PRC Information Sciences Company does not constitute endorsement by DMAAC). DMAAC has converted and modified the original source code to process in batch mode on the main frame computer system. DMAAC is currently in the process of converting the main frame program to process on a mini computer System.

The system design of GLSS depicted in figure 2 consists of: 1) symbol specification file, 2) job control data file, 3) line centered feature input file, 4) symbolization processing unit, 5) symbol generated output tape, and 6) a processing summary report.

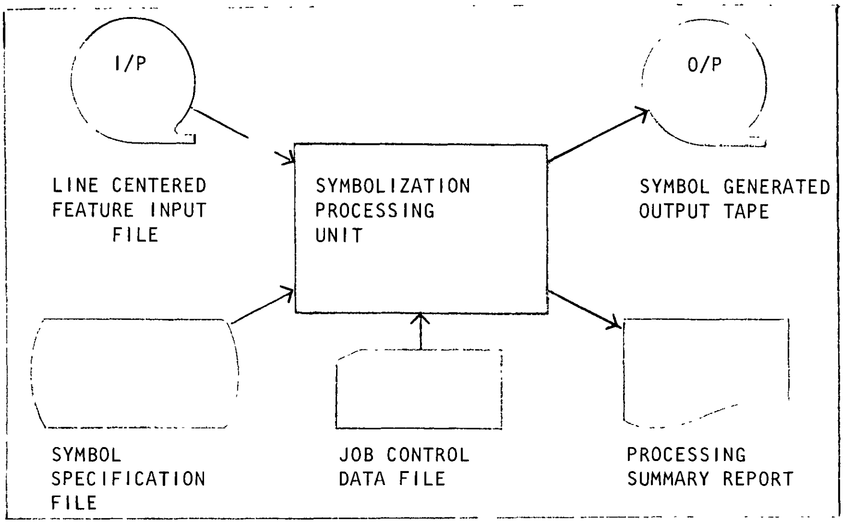

Figure 2. System Design of GLSS

The symbol specification file (SSF) from Table 1 consists of procedures and symbol pieces input to the symbol processing unit for generating chart symbology. There are procedures and symbol pieces defining each cartographic feature. The GLSS software was originally designed for processing symbology with a maximum of eight symbol pieces per feature. DMAAC has expanded this software restriction. The software can currently process 20 symbol pieces per feature. Table 1 is an example of the procedures and symbol pieces required to symbolize a perennial drain. Notice the file is organized by the headings: Feature Identification Code (FIC), Conformal or Non-Conformal, Type of Symbol, Lineal or Flashed Symbol, Symbol Size, and Symbol Line Weight. The FIC code is a unique number taken from the DMA Standard

Cartographic Feature Digital Identification Catalog. The Catalog contains a listing of possible chart symbology with its corresponding FIC number. A fifth digit is sometimes appended to the FIC number to relay instructions to the specialized ticking routine of the symbol processing unit. The conformal/non-conformal identifier instructs the symbolization routine to either draw point symbology parallel to slope of line (conformal) or parallel to plotter axis (non-conformal). The type of symbol identifies to the symbol processing unit which symbolization routine to use. All symbol pieces with an F are to be flashed by GLSS while those which are lineal or blank will be drawn in line mode. Symbol size and symbol line weight are parameters used by the symbolization routines. The actual symbolization process will be discussed under the symbolization processing unit.

Table 1. Symbol Specification File

Feature Identi- fication Code	Conformal Non- Conformal	Type of Symbol	Lineal (blank) Flash(F)	Symbol Size (inches)	Symbol Line Weight (inches)
4347	CON	DASH		.193	.007
	CON	SPACE		.029	.000
	CON	DOT	F	.007	.007
	CON	SPACE		.025	.000
	CON	DOT	F	.007	.007
	CON	SPACE		.025	.000
	CON	DOT	F	.007	.007
	CON	SPACE		.029	.000
EOSYMB					

The job control file in figure 2 provides the user with various options so that he can either create new symbol specification files, list the feature headers with descriptive information about the feature, or plot the line centered feature file according to chart specifications. New symbol specification files can be developed by employing different combinations of the specialized routines (Table 1). Flashed symbols can also be used to complement the specialized routines. By option, the symbolized features can be plotted on the Gerber film plotter, the Versatec electrostatic plotter, the Xynetics plotter, or the Gerber pen plotter. The Versatec, Xynetics and Gerber pen plotters are used for making proof plots. The function of the proof plot is to insure there are no symbolization errors due to improper tagging at the AGDS system. Upon acceptance of the proof plot, a final film plot is created which is used in the process of building a lithographic press plate.

The line centered feature input file from figure 2 contains digital cartographic features collected by the AGDS scanner. Each cartographic feature has an associated header record with a FIC code linking that feature to the symbol specification file. From GLSS, the symbol generated output tape contains all of the plotting instructions for actually drafting the chart symbology by a plotting device. At the termination of each GLSS processing program there is a processing summary report. This report includes such descriptive information as: the FIC numbers, the number of (x,y) points per feature, the sequence number for each feature, I/O processing actions, symbolization routines used for processing, and the number of points processed and deleted.

The symbolization processing unit of GLSS referenced in figure 2 is the heart of the program. In general, GLSS consists of a monitor or driving routine, data smoothing routines, data input routines, data output routines, and the symbolization processor. There are many specialized routines under the command of the symbolization processing unit which symbolize line centered cartographic feature data or cartographic point data. When using the Gerber photo plotter option, some point symbology is drawn by line drawing commands while other more complex symbols are flashed on the film at the desired (x,y) location. The point symbology drawn by the line drawing commands must have a unique subroutine for generating the plotting instructions. The more complex symbols requiring artistic flair and variable line weights are flashed. It is easier to flash them than develop subroutines which possess the artistic flair and capability to plot variable line weights. The most complex symbols, which are seldom used, are manually placed on the film positive by the cartographer.

Specialized routines including description for the symbolization processor are listed in Table 2.

Table 2. Specialized Routines

LINE -	Routine generates a line using line weight from SSF
DASH -	Routine generates a dashed line with line weight and dash length, coming from SSF
SPACE -	Routine to generate a space along a linestring with distances taken from SSF
TICK -	Routine which generates a tick along linestring; the tick is perpendicular to the linestring
HALFTICK -	Routine generates a tick perpendicular to linestring; however, doesn't intersect and the side of line to be ticked is determined by the 5th and most significant digit of the FIC code
ALTERNATING HALFTICK -	Routine generates alternating ticks on both sides of the linestring

DOT -	Routine drives plotter head to desired (x,y) location and flashes dot with diameter of dot taken from SSF
CIRCLE -	Routine generates a circle of specific size and line weight from a specific point
CROSS -	Routine generates a cross over specific point either conformal to slope of line or parallel to plotter bed
SQUARE -	Routine generates a square centered over a specific point
PYRAMID -	Routine generates a pyramid over a specific point
MINE SYMBOL -	Routine generates a mine symbol over a specific point

The processing scenario (Figure 3) for symbolizing a cartographic feature such as a perennial drain would be as follows. The GLSS driving routine would transfer control to the input routine. The input routine would read the feature header and pass the FIC code to the feature correlation routine. The feature correlation routine looks up the FIC code from the symbol specification file and, after positive correlation, program control is passed to the symbol routine which in turn invokes the specific specialized routine for performing the specialized functions indicated by the SSF file. For the perennial drain (Table 1), the plotting commands on the plotting output tape would be (dash, space, dot, space, dot, space, dot, space, dot . . .) until the entire linestring had been symbolized using this repetitive pattern. Program control would then pass to the input routine and the next cartographic feature would be read and symbolized with the process continuing until all features have been processed.

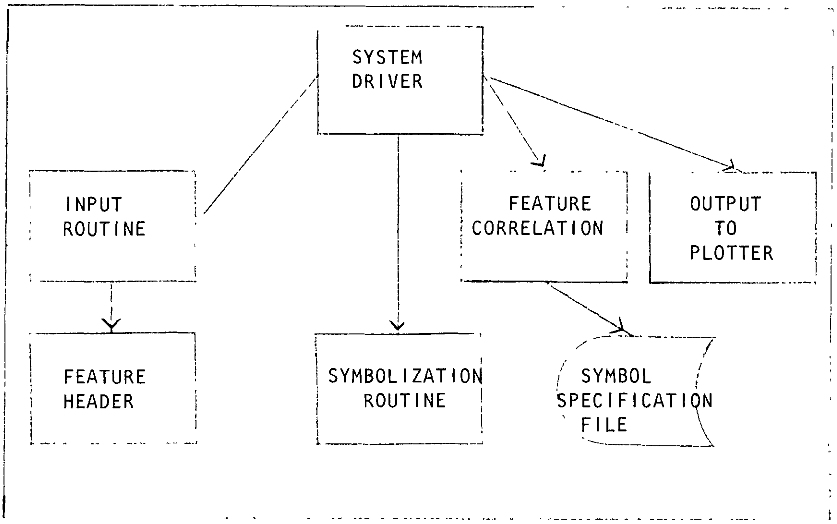

Figure 3. Processing Scenario for GLSS Symbolization

FILM POSITIVE PLOTS FROM GLSS

To this point, the collection and processing of digital cartographic data through AGDS and GLSS systems have been discussed. Now let's view some subplots taken from a full scale production chart. Figures 4 through 8 present symbolized plots for the following color separations: contours, drainage, roads, railroads, and radar significant analysis code (RSAC). Each subplot encompasses the same geographic area. The cartographic features for each subplot are plotted according to chart specifications. Figure 9 shows a composite registration of the film positives.

Figure 4. Contour Separation

Figure 5. Drainage Separation

Figure 6. Road Separation

Figure 7. Railroad Separation

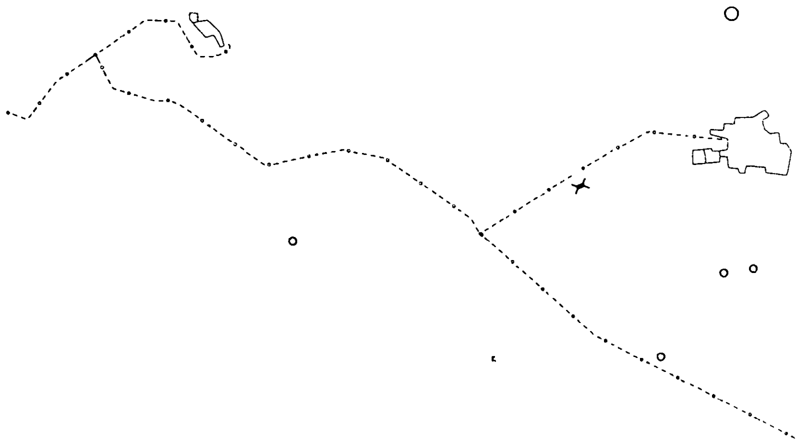

Figure 8. RSAC Separation

Figure 9. Composite of Separations
in Figures 4 through 8

The symbolized film positives from GLSS eliminate the need for the negative engraver to extensively hand engrave symbology on scribe cote. The engraved scribe cote is used for making photo negatives. The photo negatives are used for creating a lithographic press plate.

SAVINGS FOR THE NEGATIVE ENGRAVER

By eliminating the need to manually engrave most chart symbology, the negative engraver can save 50% of the manhours he would need to engrave the chart. For a particular prototype production chart, the engraver time required to scribe symbology and prepare the chart for printing was 430 manhours. To color separate the same prototype chart using digital data and GLSS software for symbolization required only 170 manhours from the negative engraver. Additional savings would be made for smaller scale, larger format charts.

ARCHIVAL OF DIGITAL DATA

The digital data for the prototype charts can be archived in a data base for later chart revision. A method for the archival of digital data would be to store the data in line centered linestring, or segment/node format. In this format, each cartographic feature would contain its attributes, including the FIC code in its descriptive header. For chart revisions, the simplification and classification or editing, tagging and merging of data sets could be done interactively on the AGDS edit/tag subsystem. After the data sets are edited and tagged, they must be merged according to their unique separations, then symbolized through GLSS again.

CONCLUSION

Computer assisted chart symbolization at the Defense Mapping Agency Aerospace Center is approaching production status. There are some restrictions which need to be further developed in GLSS. GLSS needs to process a larger set of point symbology. GLSS needs to have the capability of chart generalization, scale change, and data transformation from one projection to another. Interactive cartography through graphic work stations such as AGDS edit/tag subsystem are being exploited. In the future, chart production and revision will be supported from a digital cartographic data base. The data base will come from a variety of collection systems.

REFERENCES

1. Broomall Industries, Inc.; 1979; "Developer of the Automated Graphic Digitizing System," Broomall, Pennsylvania.

2. PRC Information Sciences Company; 1976; "Graphic Line Symbolization System," McLean, Virginia.