

COMPUTER GRAPHICS IN URBAN AND REGIONAL PLANNING:
SOME DEVELOPMENT PROJECTS IN SCANDANAVIA

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INTRODUCTION

The aim of the Inter-Scandinavian project, NIMS, is the development of a prototype for a computerized geographical information system for municipal planning purposes.

From the very beginning of the project a great deal of the efforts has been devoted to the development of systems for graphical display. A graphical display system adapted to Calcomp-compatible hardware equipment is now in operation. The experiences gained by using this system in practical planning applications have, however, initiated further development of a more general and flexible system for graphical presentation; this system is called GRIMAS (Graphical Information Management System). This paper will present the motives for the development of GRIMAS and to some extent describe the characteristics and technical features of the system.

To start with, however, I will describe a special device for plotting, the so-called color jet plotter, developed at Lund Institute of Technology in Sweden. This plotter, which can directly produce hard copy color pictures, is frequently being used for planning-oriented graphical presentation.

The access to the color jet plotter has been an important reason for the development of GRIMAS. Practical experiences have pointed out a need for a general graphical display system which would allow the use of several types of existing plotters and which is at the same time easily adaptable to future equipment.

THE COLOR JET PLOTTER

A unique feature of the color jet plotter is that it makes use of three fine ink jets in the colors red, yellow and blue; these jets act as the recording styli. They can be electrically controlled at frequencies as high as 100,000 dots per second by a new process developed at the Department of Electrical Measurements at the Lund Institute of Technology. Jets are created when small drops of ink pass under high pressure through three nozzles. Such a jet will draw a line when it hits the paper on a rotating cylinder. Between the nozzle and the paper the jet passes an electrical circuit, which can be on or off. When the circuit is on, the drops become

negative and repel each other. This changes the jet to a spray and the "line drawing" is interrupted. To prevent the spray from painting the paper, the drops

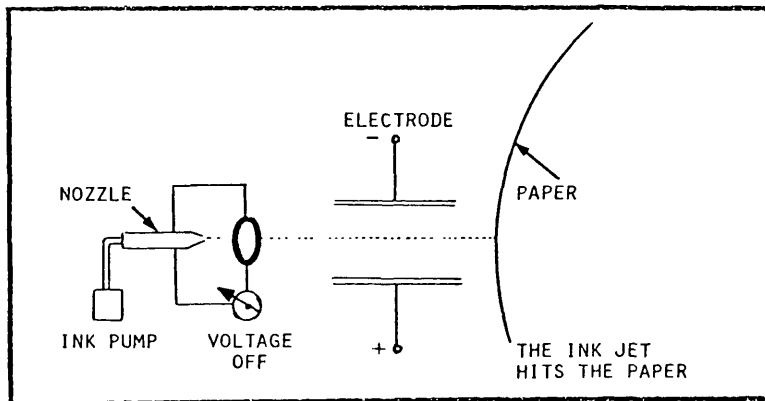


Figure 1

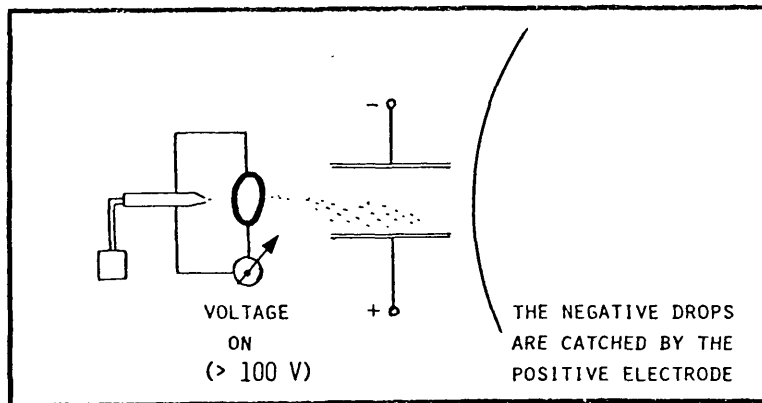


Figure 2

are absorbed by a positive electrode. Figures 1 and 2 explain the principle.

The color jet plotter consists of four parts: drawing unit, tape unit, buffer storage and control unit. The drawing unit consists of a drum which holds the recording paper and which is rotated at high speed by a motor (1,000 rpms). A screw drive moves the recording head carrying the three ink jet systems along the surface of the drum. Each jet draws five lines per mm and for the largest plot-

ter (map size = 65 cm x 60 cm) 3,500 lines are drawn for the total map. The plotting time is about 9 minutes for this map size, independent of the complexity of the picture.

Since ink jets are used in the plotter, no special demands are made on the record receiving surface. Thus, nearly all kinds of plain paper can be used and even films for overhead projectors can be prepared.

An overall view of the plotter is given in Figure 3.

The user of the color jet plotter controls the plotting by creating a magnetic tape containing only binary zeros and ones. The plotter will interpret a zero as "voltage off" and a one as "voltage on." This means that a color picture is represented by three binary matrixes on a magnetic tape.

One difference between an incremental plotter and the color jet plotter is that the total picture in the form of three matrixes must be accessible to the computer at every moment during the creation process. Due to the size of the matrixes, these

have to be stored on an external storage, which causes time consuming shuffling between core and external memory of matrix parts during the plotting process. The soft-

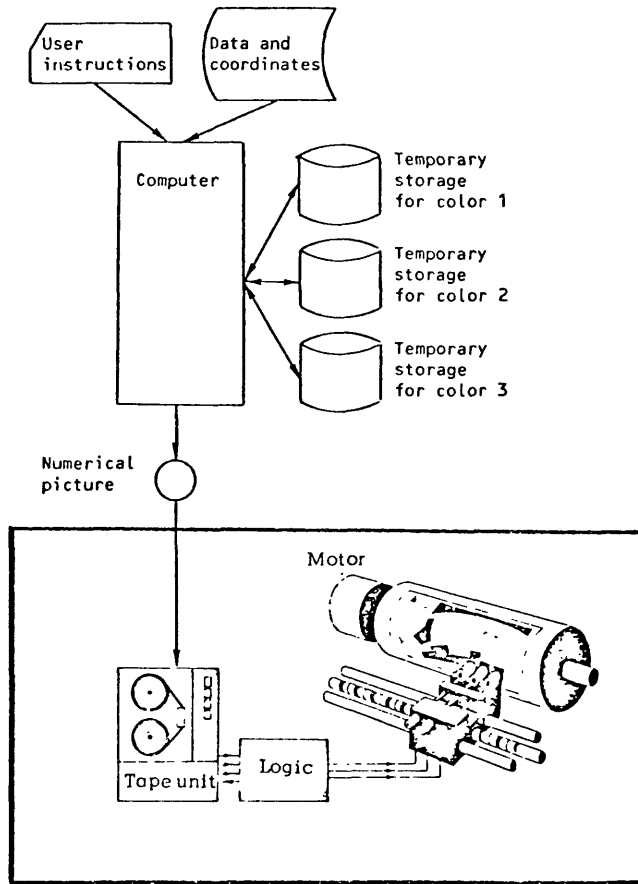


Figure 3

in ANSI Fortran and can be implemented on many different computer systems with only minor changes. It is presently running on UNIVAC, IBM and ICL computers.

ware developed for the color jet plotter uses a paging technique to minimize these shuffling times.

By using the color jet plotter the problem of hidden lines and surfaces in three-dimensional plotting is solved automatically. With access to the total picture at every moment, it is very easy for the user to erase parts of the picture where plotting already has been performed.

In order to generate a color picture with the color jet plotter, a rather complex software is needed. Therefore, a comprehensive program system, COLOR, has been developed. The system is coded

COLOR provides the following three general classifications of plotting software:

1. BASIC software consists of routines for plotting a line between two points in arbitrary color and width, a shaded surface in arbitrary color and shading pattern (there exist 15,625 different color/shading combinations), and plotting a text in arbitrary color and size.
2. FUNCTIONAL software consists of several routines for plotting figures and for special areas of application. For example, routines are included for plotting rectangles, circles, and previously prepared "background pictures" as well as scaling routines for handling coordinates in different scales. This part also includes a comprehensive graph and histogram system which can handle scaling and axis manipulation automatically.

3. APPLICATION software is the highest level of COLOR. It contains application routines which enable even users with little programming experience to plot complicated pictures. For example, routines are included for handling 3D information needed for grid maps, contour maps, perspectives, and 3D bar diagrams.

THE GRIMAS SYSTEM

As pointed out above, the main reason for the development of the GRIMAS system has been the need for a general and flexible graphical display system as independent as possible of the graphical equipment itself.

The system is an integrated part of a computerized information system for municipal planning. So far its main task has been to serve as a basis for further research in this field.

SOME DEFINITIONS

In order to facilitate the following discussion, it will be necessary to define some of the terminology which will be used.

OBJECTS are the smallest basic elements in the information system to which data are collected and assigned. The objects are divided into OBJECT CLASSES, i.e., individual streets, census tracts. For each object a unique IDENTITY is required.

In order to describe the characteristics of an object, DATA are collected. In a geographical information system the LOCATION of an object will often be recorded, either directly by the use of coordinates, or by relating the object to another already located immobile object, usually referred to as a SPATIAL REFERENCE OBJECT.

For the information system of which GRIMAS is a part, it is assumed that the location coordinates for an object form any of the geometrical configurations of a point, a segment or a polygon.

DATA BASE STRUCTURE AND DATA MANAGEMENT SYSTEM

GRIMAS requires a data base structure where data for object characteristics and coordinates are stored in separate files according to Figure 4.

As stated above, GRIMAS is part of an integrated geographical information system. The system components are shown in Figure 5.

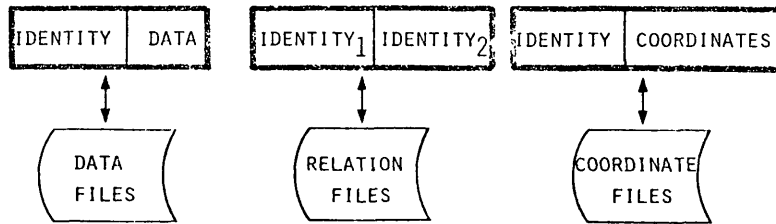


Figure 4

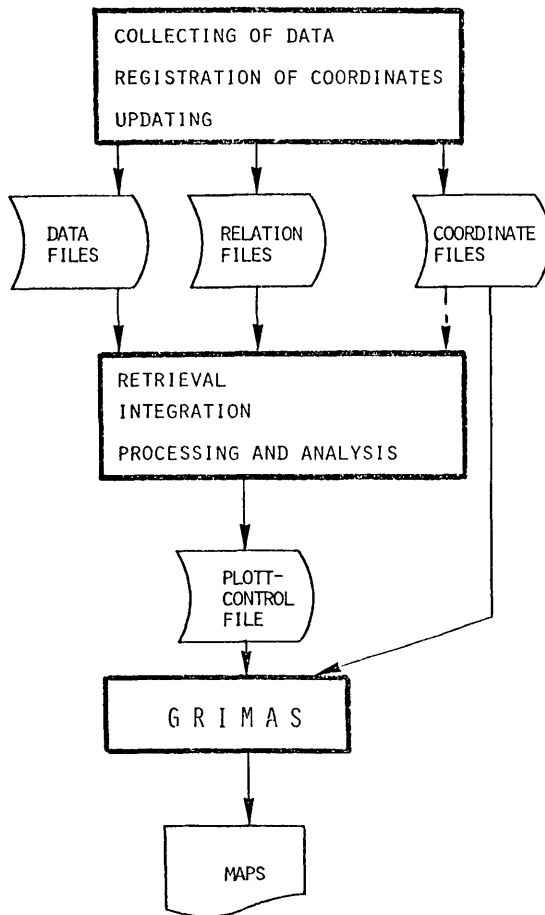


Figure 5

The following main requirements have been considered in the design phase of GRIMAS:

1. It should be possible to display graphically in one run of the system one or several optional regions selected from the total area included in the information system.
2. It should be possible to display simultaneously in optional and variable scales maps for various regions.
3. The system should be as simple as possible to adapt to different kinds of graphical hardware equipment.
4. It should be possible to display at the same map or on separate maps any combination of coordinate referenced object classes.
5. It should be possible to add in a simple way new plotting functions to the system. Such programming should be independent of the hardware equipment.
6. The display should be specified by a simple parameter language.

GRIMAS SYSTEM FLOW:

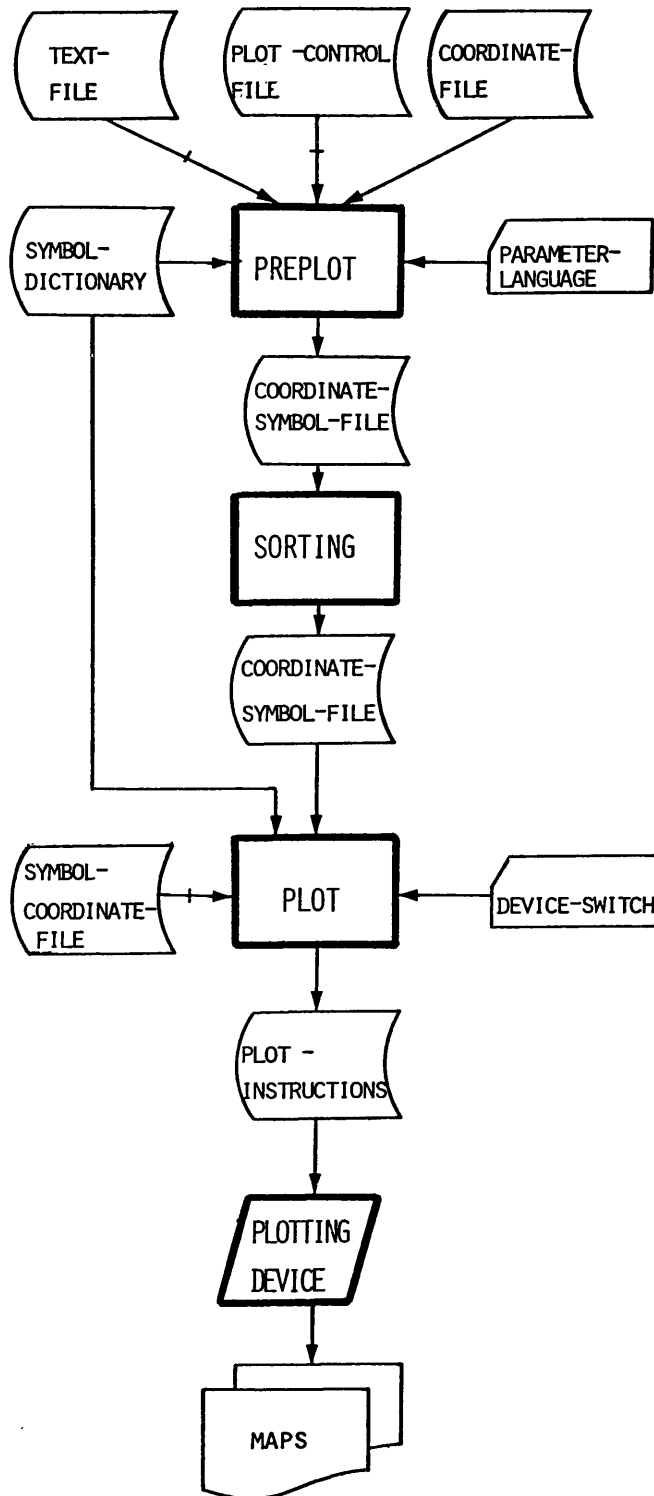


Figure 6.

THE TECHNICAL SYSTEM DESIGN

To fulfill the demand for hardware independence only very basic procedures for the actual display functions are used. These are:

- draw a point
- draw a line
- shade an area
- write a text string

It is assumed that all more or less complicated plotting symbols can be combined from the components above. This implies that the only requirement for using certain equipment for plotting a symbol is the existence of software for the basic plotting procedures of which the symbol is combined.

The process for map production with the GRIMAS system can be divided in three phases. These are shown in Figure 6 .

In the first phase each coordinate is labelled with a physical map-sheet identity. The number of sheets depends on the scale of the map and the size of the sheets. The coordinates are then transformed to a coordinate system corresponding to the size of the sheets. The information from the plot-control file (if existent) is transferred together with the sheet numbers and the transformed coordinates to an output file.

The second phase is the sorting of the coordinates in order to bring coordinates belonging to the same sheet together.

In the last phase the sheets are sequentially produced. As can be seen from Figure 7 below, input consists of a coordinate file, an optional plot-control file and a text file. The first two files have standardized record formats.

THE COORDINATE FILE:

OBJECT- CLASS	OBJECT- IDENTITY	GEOMETRIC FORM	POINT NUMBER	X- COORDINATE	Y- COORDINATE
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THE PLOT -CONTROL FILE:

OBJECT- CLASS	OBJECT- IDENTITY	SYMBOL CODE	PAR 1	PAR 2	PAR N
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Figure 7

The plot-control file has the following functions: The shape of an object graphically displayed is determined by symbol numbers and parameters in the plot-control file. The location of the display is determined by the coordinates in the coordinate file. Each symbol number refers to a specific sequence of instructions in the plotting module of the system. Such a sequence is mapping a set of coordinates (representing a point, a segment or a polygon) into one or several new sets of coordinates corresponding to the symbol to be plotted. The new set of coordinates thus in fact constitutes the plotting symbol by using components of points, segments and polygons. The reproduction procedure contains no actual plotting instructions. The programming of each symbol is entirely independent of the plotting equipment.

The actual plotting will then take place in a subsequent program step common to all previously programmed plotting symbols. The four basic hardware-dependent plotting procedures mentioned above will now be used to plot points, lines areas and text strings. It should be pointed out that this part of the plotting program is entirely independent of the program sequences performing the mathematical plotting of the symbols.

This will allow new drawing symbols to be easily included in the system by adding a new sequence of program instructions with no influence on the previous programming.

Furthermore, the already existing plotting symbols can be used when new symbols are designed. This will simplify the programming of new symbols.

AN EXAMPLE

The following example has been developed to clarify the design of the parameter language and is illustrated below.

A municipality has data for the following object classes: individuals (1), street segments (5), parks (6), railway lines (9), parking lots (10) and census tracts (15).

All object classes have locational references by coordinates stored in a common coordinate file. Processing and analysis have been performed and have resulted in a plot-control file for the object classes: street segments (5), parking lots (10) and census tracts (15).

- 1: PLOT THE OBJECT CLASSES 5,10 AND 15 ON ONE MAP IN THE SCALE 1:20000 FOR THE SUBREGION DEFINED BY X-MIN = 62000, Y-MIN = 2000, X-MAX = 72000, Y-MAX = 9000. THE PLOTTING SHALL BE CONTROLLED BY THE PLOT-CONTROL FILE.
- 2: IN THE SAME RUN PLOT THE OBJECT CLASSES 1,5,6,9 and 10 IN THE SCALE 1:5000 FOR THE SUBREGION DEFINED BY X-MIN = 63000, Y-MIN = 2100, X-MAX = 70000, Y-MAX = 8000. THE OBJECT CLASSES 1 AND 6 SHALL BE PLOTTED ON THE SAME MAP WHILE THE OBJECT CLASSES 5,9 AND 10 SHALL BE PLOTTED ON SEPARATE MAPS. THE IDENTITIES FOR 10 SHALL BE PLOTTED. NO PLOT-CONTROL FILE SHALL BE USED.

IN BOTH CASES THE COLOR JET PLOTTER SHOULD BE USED.

To specify the stated mapping problem to the GRIMAS system we have to write the following parameters:

```
*STD 4,,7,19,21
*REG 62000,2000,72000,9000
*SCL 1:20000
*SIZ 190x250 MM +
*TXT 'PARKING'
*COM 5,SYMB,NOTXT; 10,SYMBONLY,NOTXT;15,SYMB(7),NOTXT
*STD ,,17
*REG 63000,2100,70000,8000
*SCL 1:5000
*TXT ACCESS TO PARKS'
*COM 1,STAND,NOTXT; 6,STAND(2),NOTXT
*TXT
*NEW 5,STAND,NOTXT; 9,STAND(15),NOTXT; 10,STAND,STAND;
*END
```