Operating Systems Panel

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Diello: Almost everything that the people on this panel have to say has been said before, and in most cases it has been published. However, I have asked each person to briefly describe his system in order to refresh your memory and perhaps enable you to challenge their present endeavors.

Gottschalk: We spent more time getting the money for our system than getting the system assembled. In November 1974 we got our system, which is now located at the Institute for Applied Geodesy in Frankfurt. The hardware consists of: the center processor, a PDP-1145 computer with 80-k 16-bit word memory; 4 disk packages of 76-million-bit storage capacity; 2 9-track and 800 BPI magnetic tapes; a paper tape reader capable of 300 characters/sec; a paper tape punch capable of 75 characters/sec; a card reader capable of 300 cards/min; a Contraves Coragraph drawing machine with light-spot drawing and scribing and tangential control; a Bendix interactive digitizer called Cordimat; an interactive graphic display; a Tektronix 4014 or 4015 with a hard-copy unit and a graphic tablet; an 80-characters/line printer; and a teletype console. The system can be connected to a large-scale computer for precise teleprocessing. The cartographic software runs under the operating system RSXIID for the PDP-1145, which allows multiprograming and real time processing. Most of the programs are written in FORTRAN IV, but some are written in PL/1 assembler.

A cartographic system performs three major functions: digitizing, editing, and drawing. Batch processing of other programs is done in the background. The heart of the system is the cartographic data bank which allows storage and retrieval of cartographic data.

For digitizing, there are two possibilities, on-line and off-line. With on-line digitizing, the data and the digitizing progress are displayed on the storage tube and make it possible to edit the data. With off-line digitizing, the data are directly stored sequentially on magnetic tape.

The following procedures are performed on-line: The points (up to 25) where the graphic information is registered and the digitized data are transformed into a geodetic system, for example the UTM. We always use a plane-coordinate system, not a geographic one. Using a menu and a keyboard, we digitize the lines with a cursor. There are facilities for point digitizing and stream digitizing, and we have the capability of storing about 450 points on the disk in one session. We can input up to 4 headers per subject, and we can define for one session about 63 different headers when we are digitizing. The digitized subjects are displayed during the digitizing process for easy monitoring. Editing at this stage includes deletion of digitized subjects, insertion of new subjects, probability checks, rejection of erroneous data, and output of data in three different formats. For off-line digitizing, the digitized data are output directly on magnetic tape. (Only a few error codes are possible in off-line digitizing.) The data are then processed with a batch program.

Numerous editing functions are contained in the system. For output and data searches, the functions are windowing and identifying points, line elements, and sections of line elements. For manipulation of data, headers may be checked and points, lines, and parts of lines may be deleted, moved, connected, or replaced. Manipulated data are stored by means of additional statements.

For drawing, data are extracted from the data bank and filtered because the drawing machine uses high-order interpolation. Symbolization is automatically selected from a table in accordance with a scale and the kind of map. We make tables for several scales processed on the system--1:50,000, 1:200,000, 1:250,000, and 1:500,000--which are correlated with the disks where the symbols are on the photohead. There are two different tables for photoscribing and for scribing coated foils.

The data bank consists mainly of three sets of data. The data bank description gives the necessary information about the data to be stored and the structure of the data. An edge-description data set contains descriptions of line elements and points stored in the bank, that is, mainly headers. The stream data set contains coordinate strings of the elements. Edge descriptions and strings are connected by pointers. In addition there are two inverted files, a location index and a header index, which allow retrieval of the data. With this system we have compromised between storing data in a chain structure or a grid structure.

All the tasks--digitizing, editing, and drawing--are performed simultaneously. Other tasks with less priority are run in the background. This system will be used by persons and institutions in the Federal Republic of Germany interested in producing maps at scales of 1:5,000 to 1:1,000,000. Our goal is to discover methods for accelerating mapmaking in Germany. We designed this system mainly as a tool for research.

Porter: The Department of Energy, Mines, and Resources in Ottawa, Canada, has an on-line system for collecting, manipulating, storing, retrieving, and presenting cartographic data. This system consists of: 2 computers--a PDP-11 concerned with cartographic peripherals which is on-line to a PDP-10; 5 digitizing stations on-line to a PDP-11; a flatbed plotter also on-line to this PDP-11; and a remote station interfaced to the PDP-11 with a digitizer and a PDP-11 at this remote station.

In 1970 we began acquiring this equipment and developing an automated cartographic facility. We had to write software for the computers, build some equipment interfaces in-house, and develop procedures for using this tool. The system was first used in the production of 1:50,000-scale topographic maps with the idea that once satisfactorily operable, extensions of this system could produce small-scale maps, aeronautical charts, geologic maps, and other products. We also planned to have stereoplotters on-line to the system to enable direct capture of topographic data.

In the data collection, points or lines are digitized with a resolution of about 0.001 in. The operator first types a feature code and then tracks with the cursor to the end of the feature. The source material is usually a deep etch of the lines which allows the operator to track effectively using a cursor with a stylus that sits inside the edge; tracking is more accurate and 4 times faster than without this edge. A sign-on procedure enables the user to relate the cartographic table coordinates to a particular grid (usually UTM). The operator identifies the current position of the manuscript on the digitizer with respect to the grid, and the data are transformed by rotation and translation to a line with previous data.

Because digitizing is on-line, the operator carries on a dialog with the computer and can edit as he digitizes. The operator sets a scan rate, usually 50 scans/sec. The PDP-11 scans the output from that digitizing station, but sends the data to the PDP-10 only when there has been a change from the last scan. The PDP-10 standardizes the data and poses a 0.0001-in separation on successive points on continuous lines. Thus, on-line digitizing has two features--immediate computer response to the user and some data reduction and filtering as data are collected. The data are finally sorted and then archived either on disks or on tape.

We have a 48-in by 60-in flatbed plotter which also has a resolution of 0.001 in. We use it with a ball-point pen to get a preliminary plot of the digitized work. This plot is used for subsequent editing. Once map editing is completed, the plotter is used with scribing and cutting tools to prepare the various color plates for printing and the open-window negatives, such as blue water or green forest. Feature codes allow the computer to select the relevant features for each plate. Plotting routines have been written for symbolization appropriate to topographic mapping--dashed lines, houses, or railways.

This system was developed in-house; a small group wrote the software for digitizing, organizing, and plotting the data and for the PDP-11 operating system. This group is now writing the next level of operating software, which will be better than the present level and should give more flexibility.

Since we have been in production for about 2 yr, we are experienced with this system. The digitizer and plotter operators are cartographic draftsmen who were trained to use this equipment; in fact, they have helped develop procedures to make this system a good one. Two outside consultants have also contributed to the development. In 2 yr we have digitized about 140 1:50,000-scale topographic maps, some experimental maps of different scales and projections, and some geologic maps. In 1974 we finished 75 topographic maps, and we have another 40 as well as 3 geologic maps in production. We hope to increase productivity after the current phase of development because we are still only in a one-shift phase. We have to use the remaining time to develop the next level of software and to give people a chance to work with the system. After this current phase of development, we hope to provide cartographers with a more flexible and more powerful cartographic facility.

Sinclair: I am standing in for Dan Dixon to tell you about production use of the Lineal Input System (LIS) previously described by Moritz and Dixon. First, I will refresh you on the LIS configuration. LIS, which is part of a larger Advanced Cartographic System (fig. 1), is a device for acquiring data from analog sources in order to form a data bank. The data derived from the bank will be used to produce compilations or digital products. Until we have a data bank and a digital compilation device, we are using application programs specially written for these purposes. The primary purpose of LIS is to produce error-free digital data for the bank (fig. 2).

LIS consists of three hardware subsystems and a comprehensive software system that integrates the subsystems into one functional unit (fig. 3). The system is controlled by the master processor, a PDP-15 which supplies the work stations with program modules for execution on the minicomputer or on the display. In figure 4 the master processor is next to the operator, and the mass storage is behind him. The control is a PDP-15 with two 262-k-word fixed disks, two 10.2-megaword disk pack drives, magnetic tapes, and the normal peripherals. The proof plotter is a Xynetics plotter with a Hewlett-Packard minicomputer used for producing proofs of data files generated by the system. The main part of LIS is the work station, which consists of a Gradicon digitizing table, an Imlac PDS-1 minicomputer, and the appropriate display and keyboards. The whole operation centers around getting the necessary programs to the work station and filing the data produced. Figure 5 is a schematic of the work station, and figure 6 shows what that work station looks like in operation. All display, data entry, digitization, and editing routines are transmitted from the master processor to the work station and stored there. Conducting all cartographic operations from the work station eliminates delays incurred by time-sharing the master processor and allows parallel processing.

This tree (fig. 7) indicates the type of software used by the system. An executive monitor, derived from the RSX supplied by DEC, ties everything together. Terminal support software is necessary to use the work station on-line. The data management package sorts the data generated by the digitizers into proper files for later retrieval and use. The batch programs, subdivided into input and output processsing, allow many operations to be conducted against the working file. The system programs module is very important to the personnel responsible for maintaining the system software.

The operation of LIS is based on a man-machine dialog whereby all of the necessary cartographic functions--digitizing, editing, and drawing--can be accomplished. The cartographer is presented with a series of operations which, if he takes them sequentially, will result in a complete data file ready for chart production. Using the batch software he can create a data file for later use, which is nothing more than a bookkeeping stage. A least-squares adjustment procedure built into the system allows him to register source material to the table and to the real world. The cartographer is then ready for on-line digitization. He can identify features with a rather complex data hierarchy set up to uniquely identify each feature on the entire source. He can record in the trace, point-point, or point-feature mode, and he can do a type-one edit with a digital eraser which allows him to correct the last 2 cm of his work.

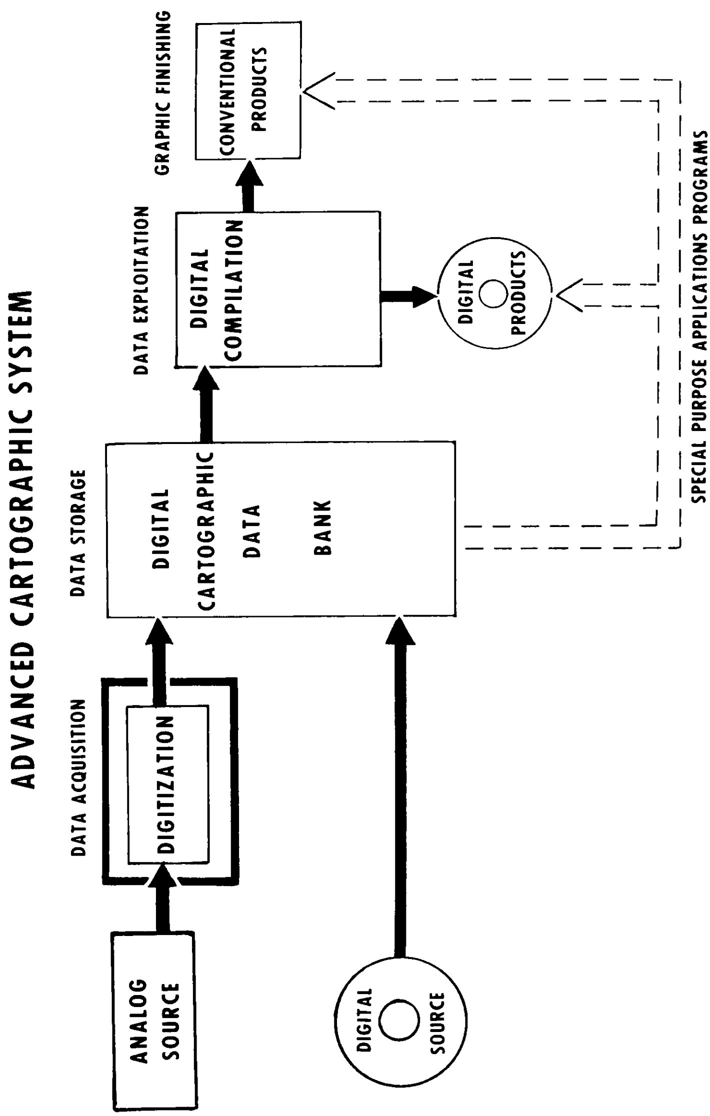
ADVANCED CARTOGRAPHIC SYSTEM
DATA ACQUISITION
DATA STORAGE
DATA EXPLOITATION
GRAPHIC FINISHING
ANALOG SOURCE
DIGITIZATION
DIGITAL SOURCE
DIGITAL CARTOGRAPHIC DATA BANK
DIGITAL COMPILATION
CONVENTIONAL PRODUCTS
DIGITAL PRODUCTS
SPECIAL PURPOSE APPLICATIONS PROGRAMS

Figure 1

LINEAL INPUT DIGITIZING SYSTEM

PRIMARY PURPOSE: BUILD DATACELLS

THIS REQUIRES TAKING DATA FROM SEVERAL GRAPHICS EACH OF WHICH CAN BE AT A DIFFERENT SCALE, DATUM, AND MAP PROJECTION AND TRANSFORMING ALL THE DATA TO A COMMON FORM AND REFERENCE DATUM.

Figure 2

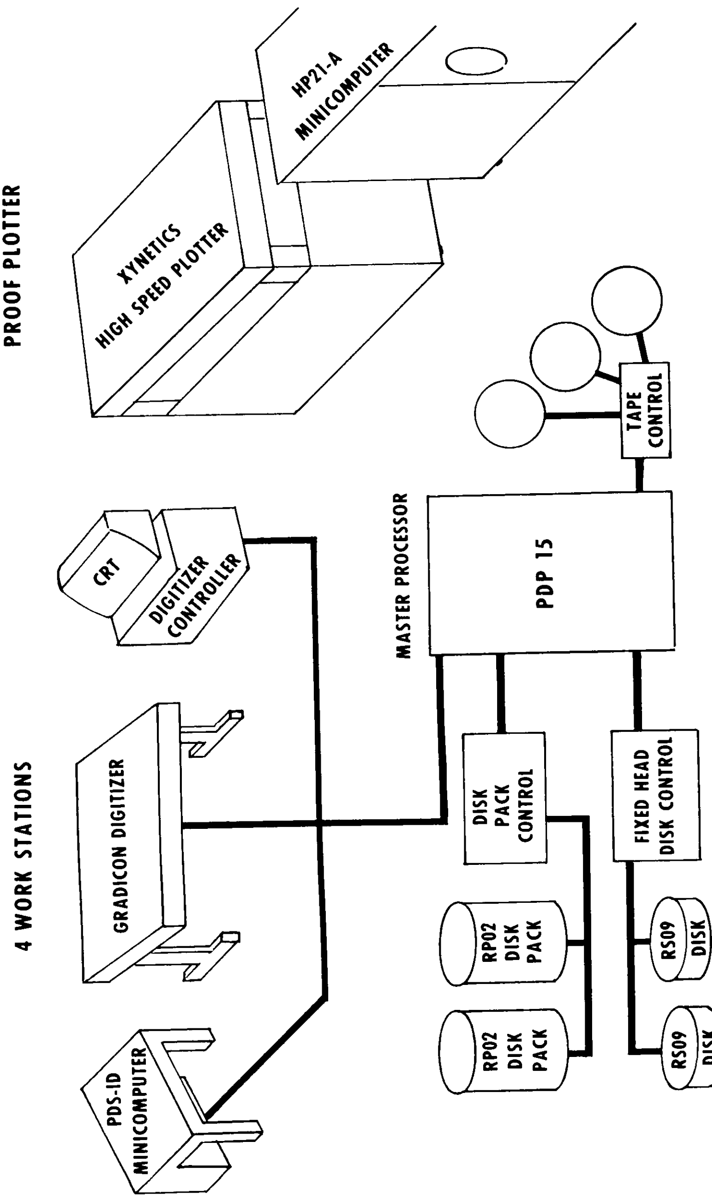
4 WORK STATIONS
PROOF PLOTTER
PDS-ID
MINICOMPUTER
GRADICON DIGITIZER
CRT
DIGITIZER
CONTROLLER
XYNETICS
HIGH SPEED PLOTTER
HP21-A
MINICOMPUTER
MASTER PROCESSOR
PDP 15
TAPE
CONTROL
DISK
PACK
CONTROL
FIXED HEAD
DISK CONTROL
RP02
DISK
PACK
RP02
DISK
PACK
RS09
DISK
RS09
DISK

Figure 3

Figure 4

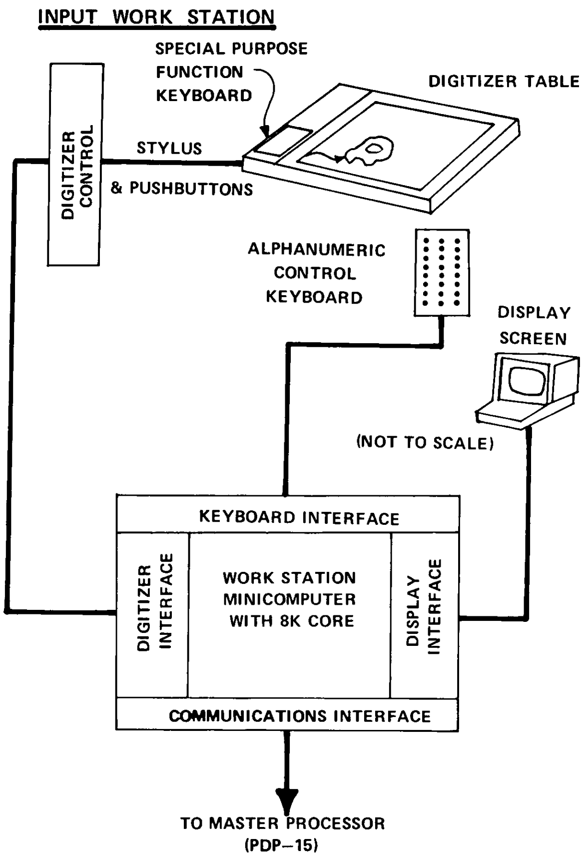
INPUT WORK STATION
SPECIAL PURPOSE FUNCTION KEYBOARD
DIGITIZER TABLE
DIGITIZER CONTROL
STYLUS
& PUSHBUTTONS
ALPHANUMERIC CONTROL KEYBOARD
DISPLAY SCREEN
(NOT TO SCALE)
KEYBOARD INTERFACE
DIGITIZER INTERFACE
WORK STATION MINICOMPUTER WITH 8K CORE
DISPLAY INTERFACE
COMMUNICATIONS INTERFACE
TO MASTER PROCESSOR (PDP–15)

Figure 5

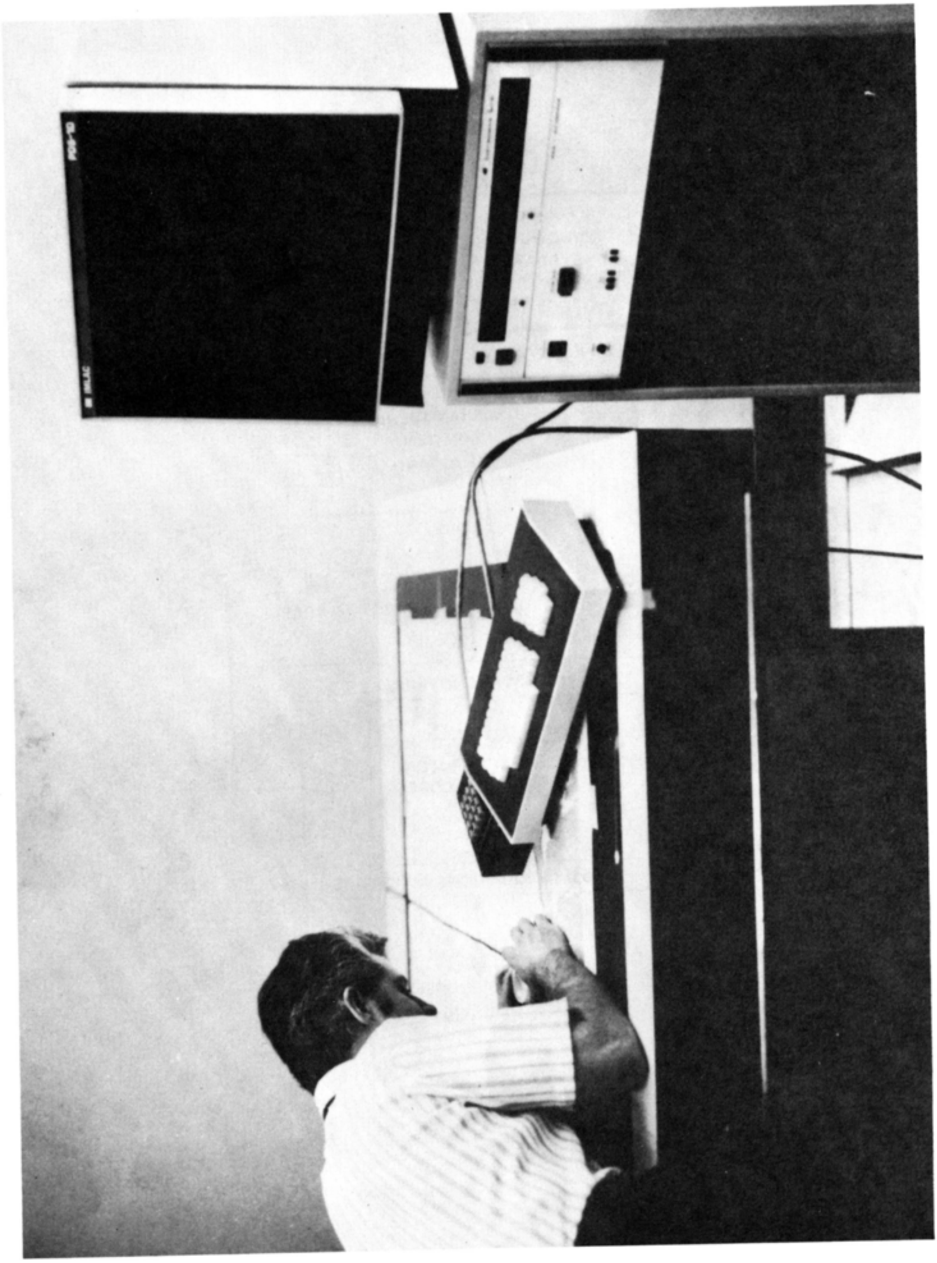

Figure 6

LINEAL INPUT SYSTEM SOFTWARE

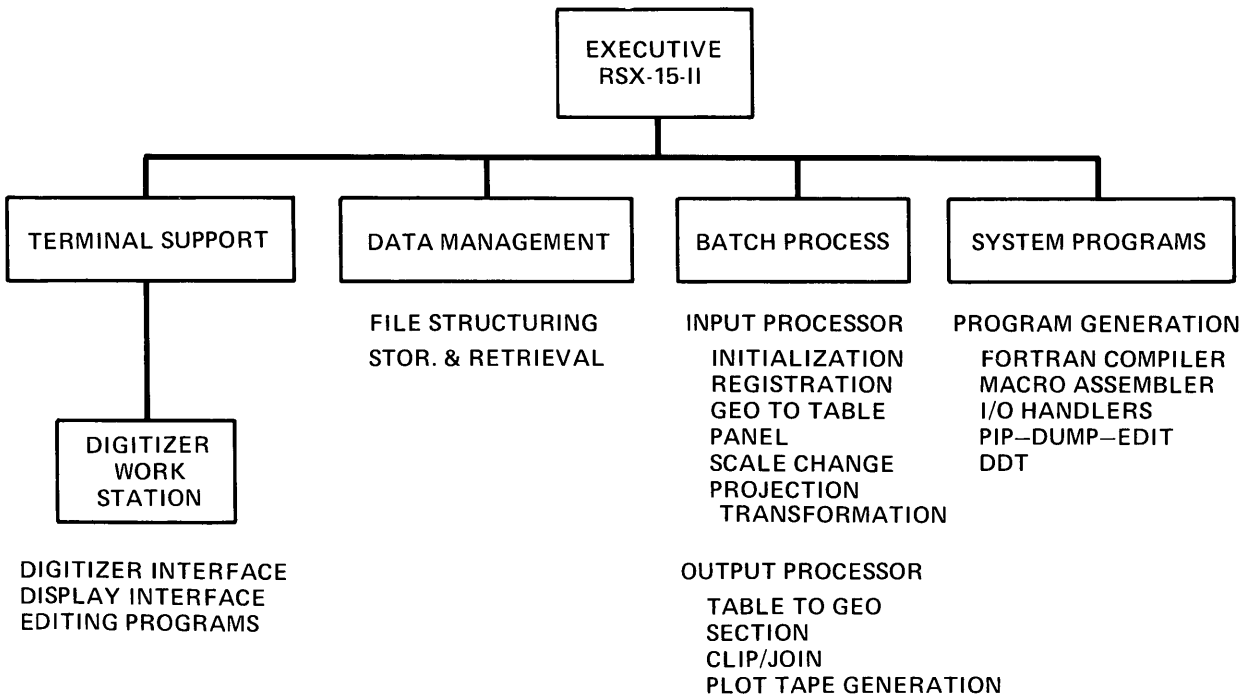

Figure 7

If this edit is not sufficient, LIS has a complete editing capability independent of the digitization process. The feature to be edited can be found with a "find feature." The feature may be called from the data file merely by placing the stylus over the feature and pushing a button on the cursor. The system will respond by displaying a header. If this header is correct, the cartographer accepts the feature, and a picture of the last 10 cm will be displayed on the Imlac screen. If he wants to modify the feature, he can modify the mid-segment or the end segment. He can join two features, delete features, or modify their headers.

Once a data file is complete and ready for further processing, additional batch programs are called from the work station. These processes allow the entire feature file to be converted to geographic coordinates instead of table coordinates, to be sectioned (sort of digital scissors), and to be paneled with other files to create one large file. The operator can also make scale and projection changes from the work station. At any time during production the cartographer may call for a proof plot. He may then edit, continue digitization, or call batch modes. The final product is a data file that may be used as a finished product or converted to an analog product at a new scale or projection.

Cook: The Semi-Automated Cartographic System at the Defense Mapping Agency Topographic Center (DMATC) has been in production since April 1974. At first glance, the system (fig. 1) may seem complex, but it is really not difficult to follow. Across the top of the figure are the collection devices, and in the center are the software support systems. DMATC data collection systems include the Digital Topographic Data Collection System (DTDCS), Universal Automatic Map Compilation Equipment System (UNAMACE), Symbols, Names, and Placement System (SNAPS), and cartographic and names digitizer systems.

Figure 2 shows our oldest system, DTDCS, which has a resolution of 10 mil. It has 5 digitizing stations on-line with the CDC-1700 computer. In the background is a disk storage and on-line plotter, for digitizing line vectors (specifically contour information) so that surface matrices can be extracted. UNAMACE (fig. 3) generates the orthophotograph, which is taken to the graphic digitizers, and the surface matrix.

Both DTDCS and UNAMACE generate a surface matrix (fig. 4); if a grid is laid across the surface of the Earth, there is an elevation at each grid intersection. Once the data are in this form, several products can be generated. For example, a three-dimensional hard copy (fig. 5) can be made by using a milling machine and high-density urethane to represent the topology; this is an old technique of DMATC for producing plastic relief maps. The elevation matrix can be input into the contour program to generate contours (fig. 6). The area outlined is an adverse area, where the stereocompilation equipment loses correlation and generates erroneous elevation data. This particular set of line vectors is taken back to the digitizers, the adverse area boundaries are defined, and the adverse data are suppressed by software. The surface matrix can be used to generate a slope map (fig. 7) for highway planning.

Figure 8 shows DMATC's present digital coverage--most of the U.S. This information, stored on about 1,600 tapes, has been compiled at 1:250,000 scale. Any questions or requests for these data should be addressed to the U.S. Geological Survey. (If you find anomalies in these data, please notify DMATC.)

With SNAPS (fig. 9), the lithographic copy is placed on drum locators,

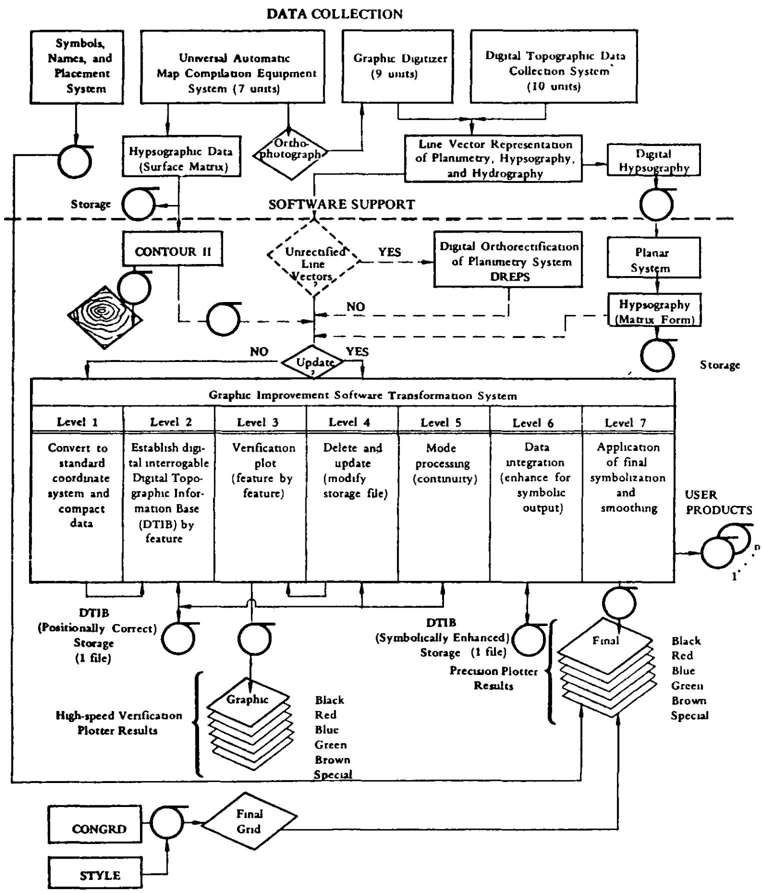

Figure 1.--Semi-Automated Cartographic System (SACARTS).

Figure 2.--Digital Topographic Data Collection System (DTDCS).

Figure 3.--Universal Automatic Map Compilation Equipment (UNAMACE).

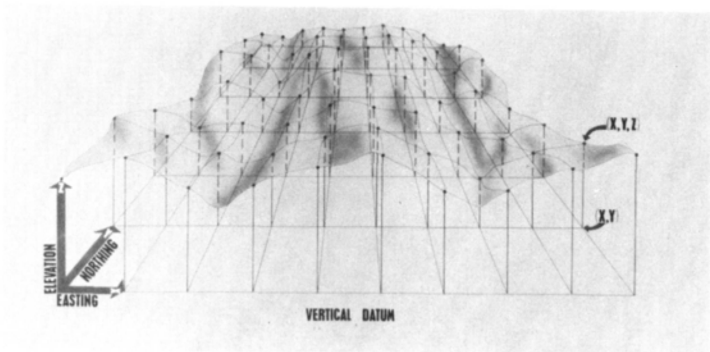

Figure 4.--Surface matrix (digital terrain elevation data).

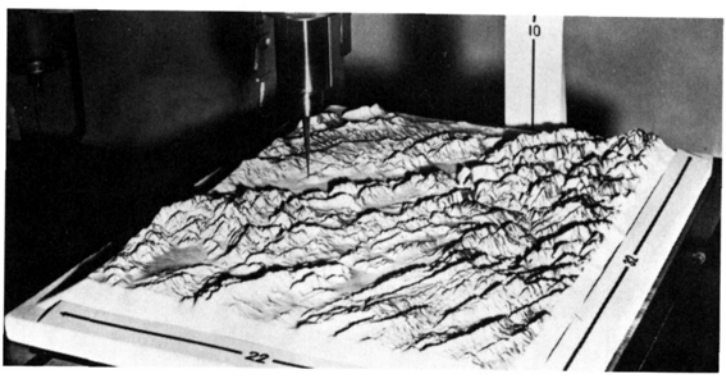

Figure 5.--3D portrayal.

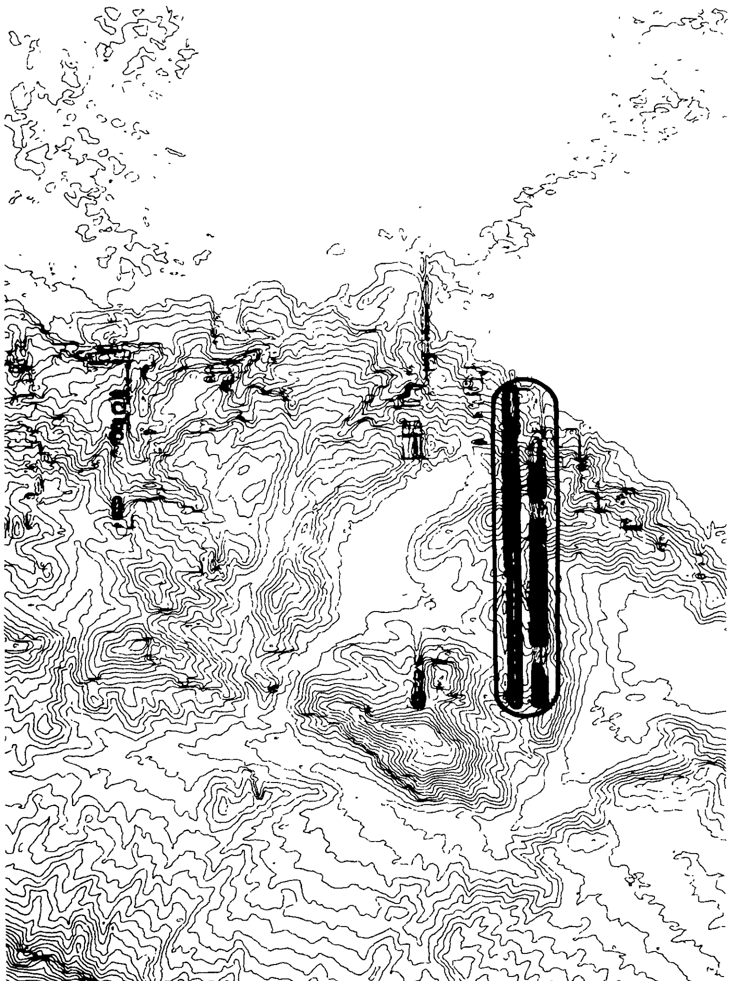

Figure 6.--Unedited computer-generated contours.

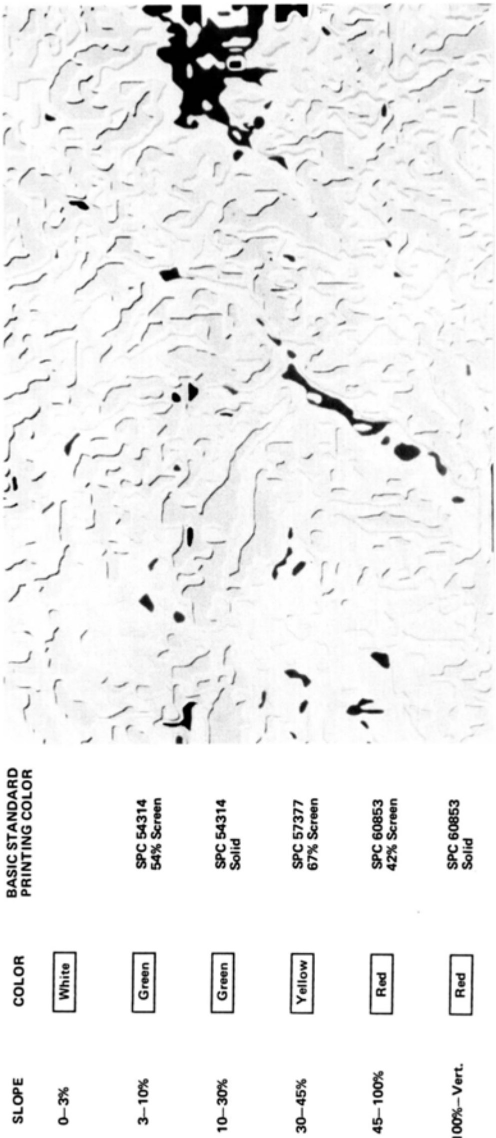

Figure 7.--Computer-generated slope map.

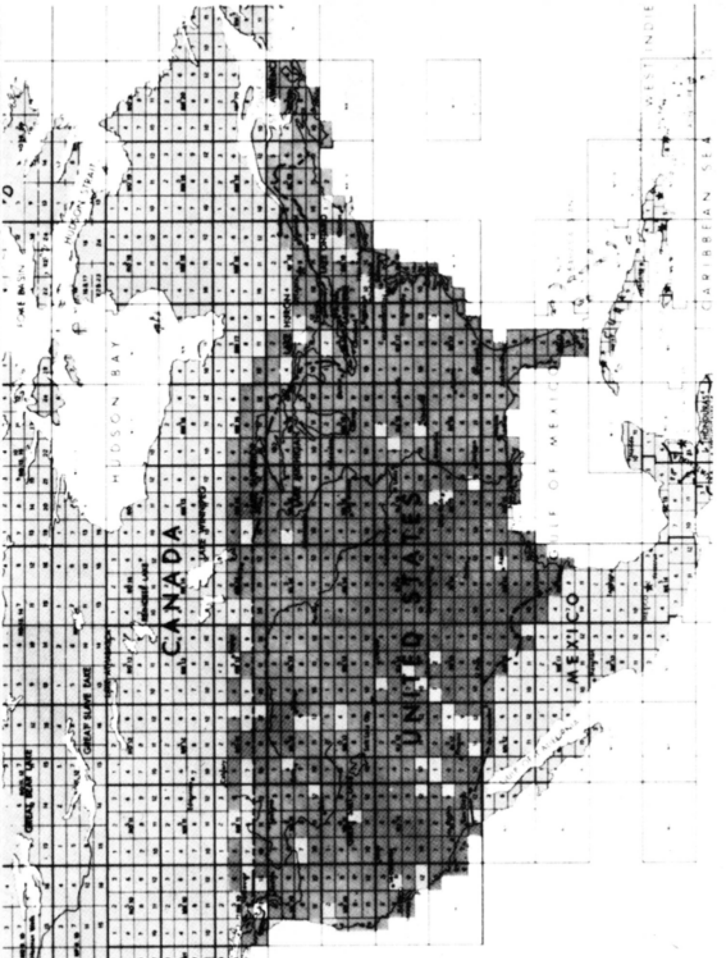

Figure 8.--Index of digital elevation coverage of the conterminous U.S.

and the operator digitizes the position and orientation of the names. The names are entered on the keyboard, and their coordinates are entered on the drum locator. This information, recorded by the computer, is then taken to the Photon system where the names are output onto 70-mm film. In conjunction with our high-precision plotter, the names are placed in their respective orientation to produce the finished names product.

Figure 10 shows newer graphic digitizers, familiar to most people. DMATC has several versions, but they basically consist of minicomputers, teletypes, and digitizing tables with 1-mil resolution. Operators may work either from compilations or orthophotographs. All of DMATC's systems are off-line in the sense that they are not tied to a large general-purpose computer.

DMATC's newest compilation equipment, the Digital Planimetric Compiler (fig. 11), was designed by the U.S. Army Engineer Topographic Laboratories. Five systems are on-line with the minicomputer.

The primary data manipulation system at DMATC is the Graphic Improvement Software Transformation System (GISTS). Other systems are the Planar Interpretation System, the Digital Orthorectification of Planimetry System, and the Automated Contouring System. The GISTS package (fig. 12) is the glue that holds the information together. The off-line digitizers generate generate magnetic tapes, which are then moved to the UNIVAC-1108 where the master files are built. These files are the data bases in interrogatable form (Levels 1 and 2). Once the interrogatable data base is built, information can be swept out using the general plot package (Level 3) that gives center-line information which can be ported out to the high-speed plotters for verification. Then, using light-tables, the operator notes the ambiguities or the areas of information that have not been put into the data bank and returns to the digitizer to generate the updates.

The add and delete function (Level 4) is performed in conjunction with the digitizer where an update tape is generated and returned to the U-1108. After Level 4, all processing is automatic. "Dirty" data do not have cartographic quality. Mode processing (Level 5) moves through each feature, trims, makes connections, and notes the intersections. This file is retained because it gives correct information.

Data are then moved into Level 6 for data integration. Considering each feature on a single plane, the processor inspects these planes for any conflicting data. If there are problems, the processor goes to its hierarchy tables and begins moving or displaying information for symbolic purposes only. This operation is accomplished for graphic output, and a graphically enhanced file is generated.

Once that operation is completed the symbolic output (Level 7) is applied to the Level 6 retention file. Level 7 maintains all references for each feature in the file and asks certain fundamental questions: "What is the symbolic requirement for this feature: Is it a dash line or a solid line of a particular width? What is the best plotter technology that the data can be ported out to?"

The GISTS philosophy is "fail-soft" (fig. 13)--the system is designed so that no single change in technology will affect the system. It is input independent--it can be given any digitizer desired. A translation module can be written so that the digitizer can be interfaced to the software. It is also output independent. DMATC can redefine the symbolic directories of Level 7 to accommodate the latest technology in high-speed

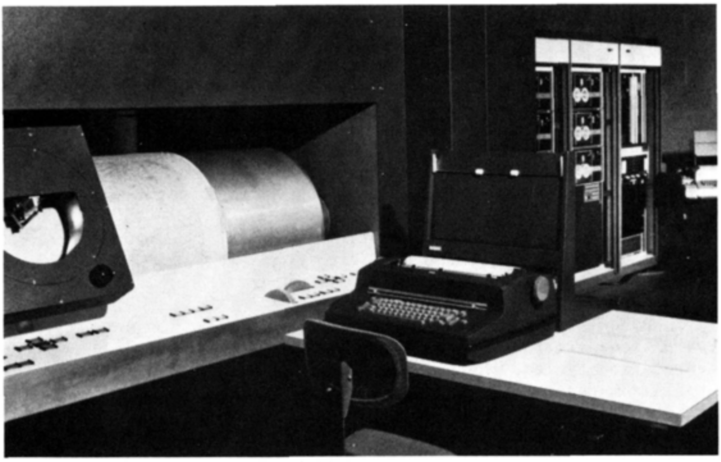

Figure 9.--Symbols, Names, and Placement System (SNAPS).

Figure 10.--Graphic digitizer and closeup of digitizer position.

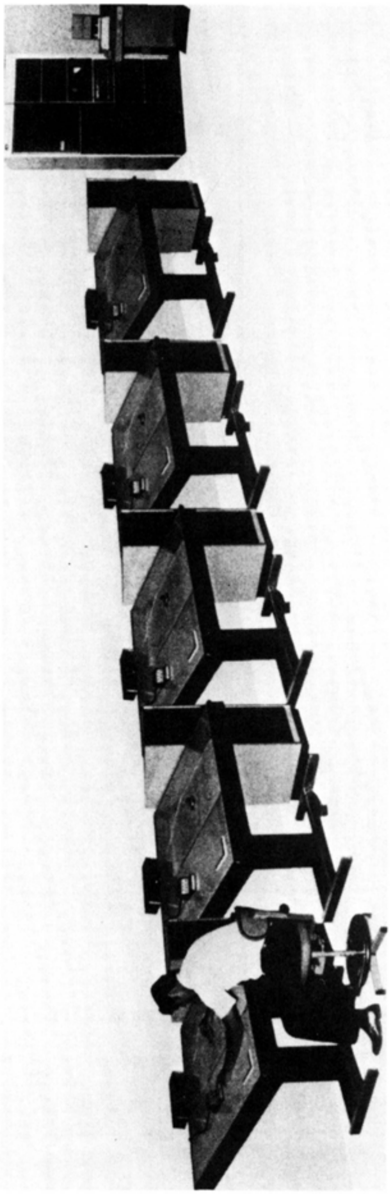

Figure 11.--Digital planimetric compiler.

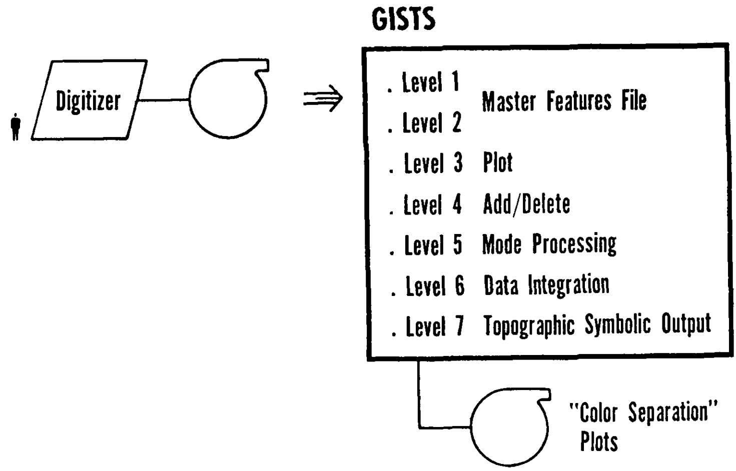

Figure 12.--Conceptual overview of GISTS.

- Input Independent
- Output Independent
- System Modular in Architecture, Redefinable Under Parameter Control
- "Universally Accepted Programming Language". . . FORTRAN IV
- Computer Independent (Redundancies in Data Structure)

Figure 13.--System philosophy--fail soft.

Figure 14.--Xynetics plotter.

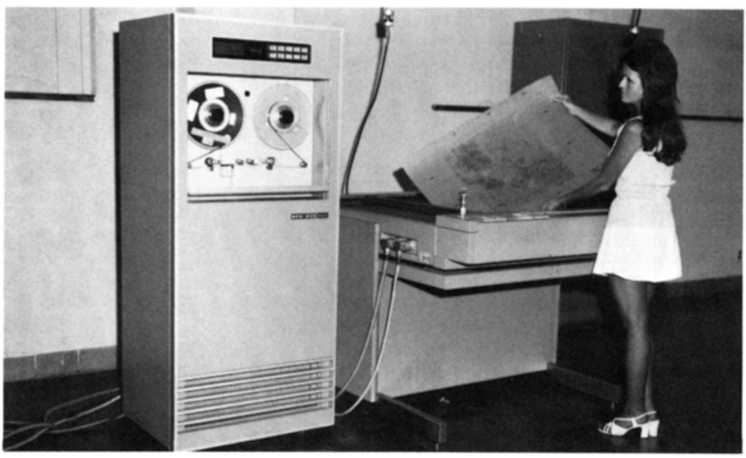

Figure 15.--CalComp plotter.

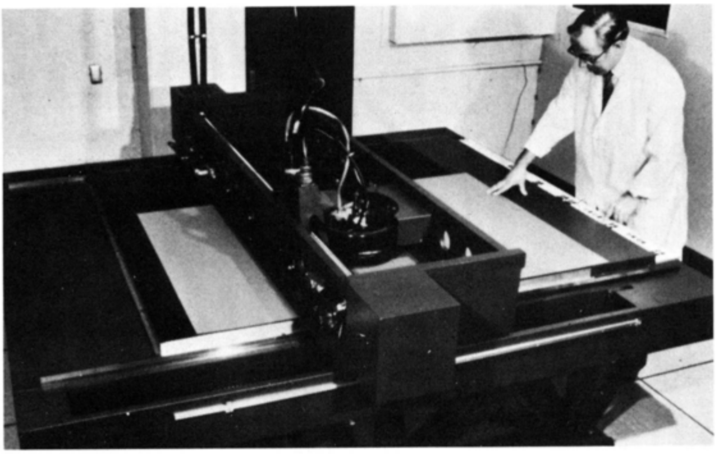

Figure 16.--Concord plotter.

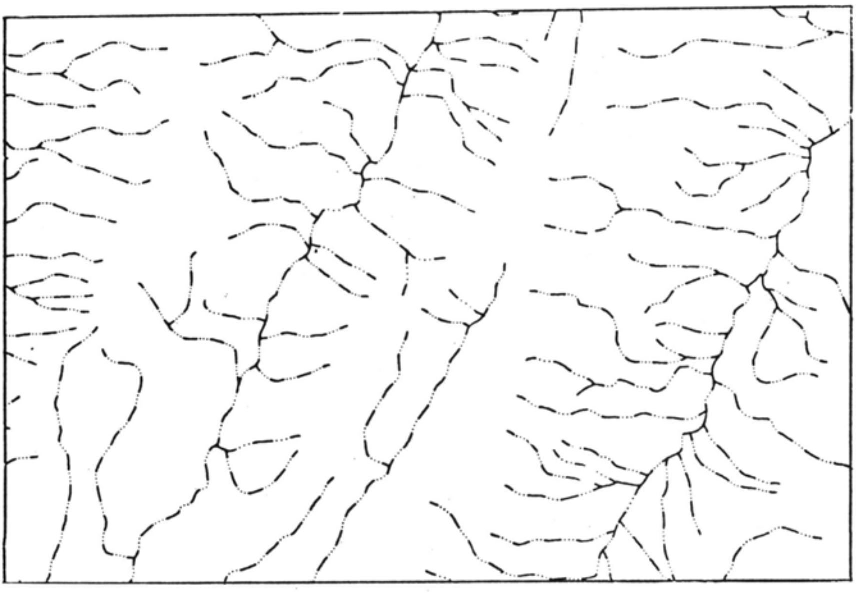

Figure 17.--Reproduction quality plots from GISTS.

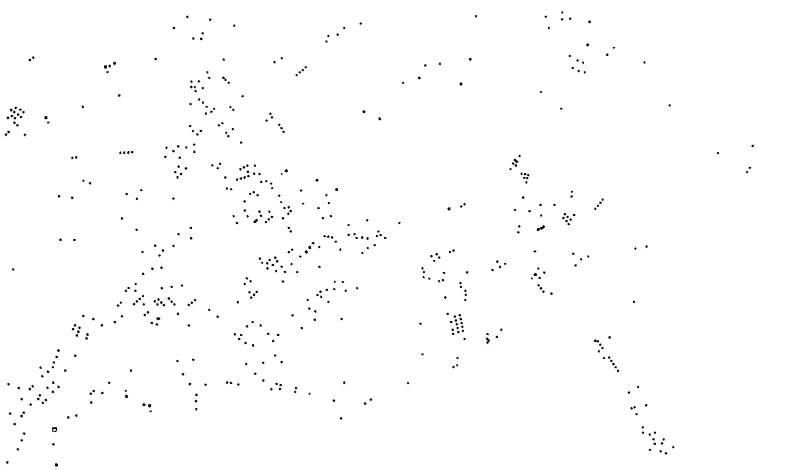

Figure 18.--Sample plot of black point symbolization.

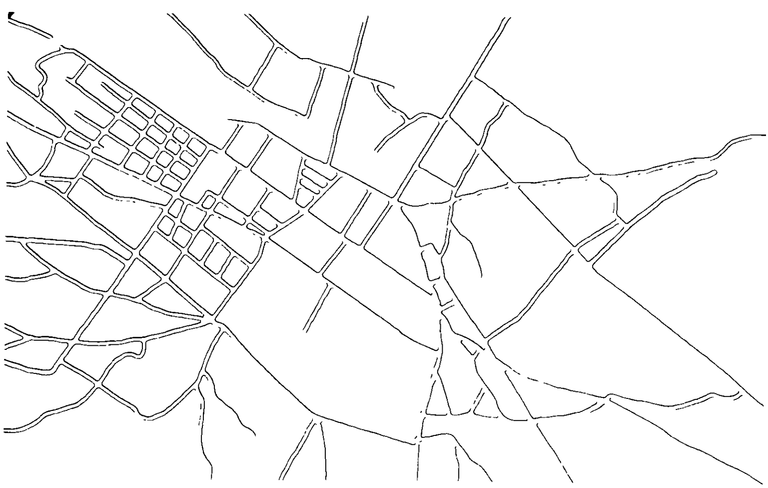

Figure 19.--Road casings generated by the photographic process.

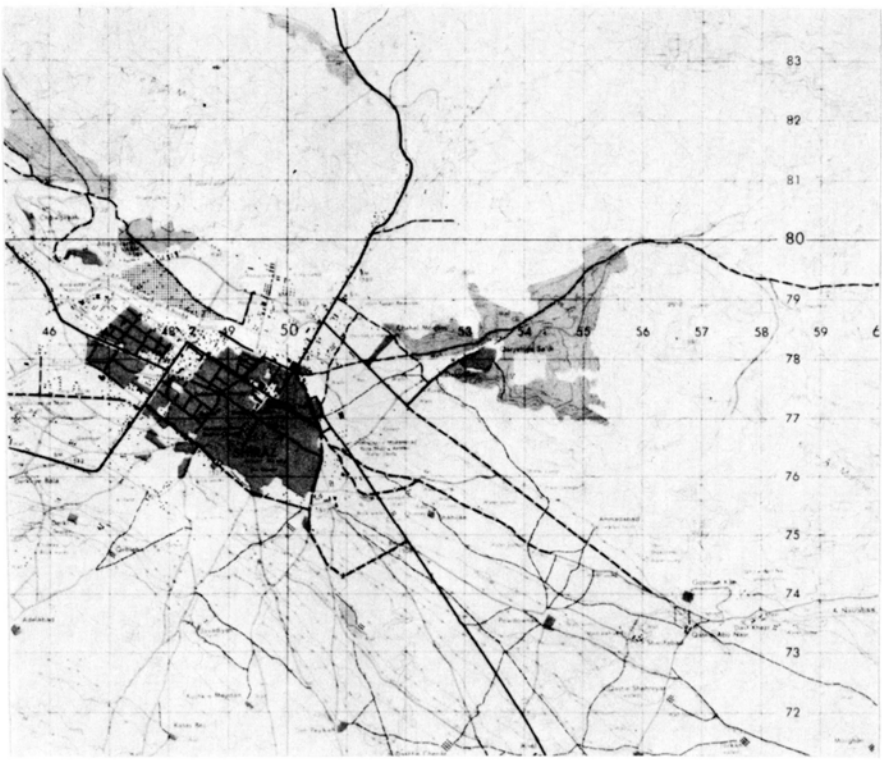

Figure 20.--Digital map (Shiraz).

plotters. The system is modular and redefinable under parameter control. The mesh interval is 2 mil, but it can be redefined as DMATC's mission requires. The program is written in FORTRAN IV in an attempt to be as universal as possible. These data have been made as independent as possible. Redundancies have been programed in the data structures so that we can move from a UNIVAC, a 36-bit word machine, to an IBM, a 32-bit word machine, without adverse effect on the data files.

The Xynetics plotter (fig. 14) is the high-speed plotter that DMATC has just put into production. Figure 15 shows the old CalComp plotter which is slow in comparison to the Xynetics; DMATC does not have one of the newer CalComp plotters. The precision plotter (fig. 16), which can either scribe or photoscribe, has a 60- by 60-in bed surface.

The following items can be produced from Level 7. Figure 17 shows a drainage network in which each of the intersections start and terminate in solid lines. Level 7 takes care of all of these peculiarities in the data nets. They are symbolized exactly to specifications. At Level 6 if a building is on top of a road, the processor will displace it and orient it in the direction of the road. Since the buildings are square (fig. 18), they have a definite angle. Figure 19 shows a road network prepared completely by software or semiautomatic processing. The network is drawn twice at varying lineweights, and one is used for a photographic mask.

Figure 20 shows the Shiraz sheet that was distributed here this week. All of the information shown was produced automatically: the grid numbers, the grid itself, and the contours. The mathematical generators are the Control Graticule and Grid System and the Automatic Grid and Projections System; the latter was used to generate the grid. The system used for the open windows (area fills) is semiautomatic: the area is outlined, then the precision plotters are used to plot the boundary of that area on Peelcoat, and finally a photographic screen is used for the area fill.

Sharp: With this conference the professions are beginning to communicate. Not only are the surveyors talking to the cartographers, but three automated processing professions are also participating. Two of these professions are well-developed--automated photographic processing and automated lithographic processing. The third, automated data processing, is new. We used to send our work to the photolab or the lithographic department and complain that it didn't get out for weeks. Now we send it to the data processing department and complain when we don't get it the next day.

Conflicts within and among the professions can only retard our progress. The system presented by Cook, for example, was produced with the cooperation of people of varied capabilities. Communication helps economics as well as technology. We aren't really professionals unless we're concerned with economics. This concern involves defining the type of points, lines, areas, names, and symbols for our product; collectively treating point data bases, line data bases, and area, names, and symbol data bases and examining products for content, addressable points, reproducibility, accuracy, readability, and credibility--we've been calling it topo license.

We use equipment costing from $3 to $300/hr, materials costing up to $25/item, and people costing from $5 to $15/hr. Quantity also affects cost. National Geographic may make about 6 maps/yr, but they deliver them to 6 million people, whereas USGS makes about 2,000 maps and 5,000 copies/map. Both quantities are large, but they involve different problems and different economics. Both high- and low-cost equipment is used. The small user can buy low-cost equipment, but he must share high-cost equipment to be economical.

Don't get caught in one school of thought. You an produce interactive or off-line graphics, you can perform forward or on-line editing, and you can put 1 to 4 tables on-line with one computer. Give the production people the tools, and let them decide what is more economical. I think that we are becoming economically and professionally responsible.

Thorpe (Natural Environmental Research Council, U.K.): Could members of the panel comment on their efforts and achievements in automatic name placement? Also, have you used or investigated any of the CODASYL data management languages for cartographic data handling?

Porter: We have done neither. Names are still placed manually because it is more cost-effective. We are now building a file management system which we hope is more suitable to cartographic data than the one proposed by the CODASYL committee.

Stine (Chairman, ICA Commission III): Throughout the week I have heard the hue and cry that no one is taking care of systems for the small man. Then Wickham said that private industry and local governments are working with systems. If they are, and I know that they are, it is one of the best kept secrets in automated cartography. Commission III of ICA has repeatedly asked for papers about the small systems, but I cannot find anything in writing about them. I gave the chairman of this conference the name of someone who is operating a very elaborate system, and he wrote to this man, but he was too busy to come to the conference. Commission III, which is supposed to report developments in automation, really needs to communicate with these people.

Sharp: Private industries and local governments have been busy staying solvent and really working, while most of us have been involved in devel-lopment. I want to show a picture of a system that scanned and digitized about 15,000 sheets. This system hasn't had much publicity recently. Tomlinson, would you comment on this system?

Tomlinson (Chairman, IGU Commission on Geographical Data Sensing and Processing): I must speak unofficially about this system which is in the Department of the Environment in Canada. I helped develop this drum scanner in 1962, but I have not had anything to do with it in 4 yr. Soil maps, agricultural land charts, or any type of polygon data are put on the drum. The drum revolves and the data are scanned in 2 to 15 min. The tapes are processed separately and go into a storage bank of maps. The file structure covers all of the populated area of Canada, about 1 million mi^2. There are 11 different types of data in the system now, and it has been fully operational for about 3 yr.

There is a great tragedy here. The Department of Energy, Mines, and Resources has an excellent system that digitizes maps and puts all the data in one file format. Another government department has another system that digitizes maps in an entirely different file structure. At some point the systems will have to be compared, and somone will have to change. All the maps in one file format will have to be converted into another format, a process that may be impossible without redigitizing the maps. I suspect that this situation is happening in the U.S. and elsewhere. Conferences such as this one should more thoroughly consider the question of compatible file structures.

Ward (Central Intelligence Agency): Cook or Sharp, are you finding it cost-effective to use your system for automatic name placement?

Cook: Yes, we are, mainly because of the speed with which we can lay the name down.

Ward: What is the factor of improvement over the manual system?

Sharp: At least 5-percent improvement.

(Unidentified speaker): It takes half a minute with vector technology and vector digitizers. With the development of raster digitizers automatic placement of names should be more rapid and more economical.