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# The Present Status of Automated Cartography

*by*

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The rapidly expanding frontiers of knowledge have made it apparent that conventional cartographic techniques are inadequate for the presentation of the complex and varied data of today. A demand for new cartographic forms with greater accuracy, efficiency and time-saving devices is therefore created. During the last quarter century another facet in cartography, that of automated cartography, has developed. The multitude of literature appearing in the professional journals indicate not only the enthusiasm of the Cartographers, but also, its growing importance. Fueschel comments:

> "Proposals for new basic concepts or systems are usually accompanied by slight exaggerations of the envisioned advantages. This is to be expected as the proponents must sell their enthusiasms to more conservative members of the community to win the support needed to pursue objectives. It appears that this critical stage in the endeavour to automate the cartographic procedures has now been passed, and we may safely proceed with realistic reporting of the problems that remain to be solved."[1]

The present status of automated cartography is, therefore, readily evident. It is no longer a reverie, but one which justifiably conveys a sense of promise. Such a promise in itself gives an incentive to the further development and employment of automated cartography.

A multitude of problems associated with automated mapping systems, such as the form of the data, the nature of the output map and hardware limitations have to be solved in attempting to set up a complete automated mapping system. Despite the unsolved problems and the limitations involved in automated cartography, it is used by many agencies and organizations with appreciable success, among which the United States Geological Survey, Weather Bureau and the Military Agencies are outstanding.

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1. Fueschel, Charles F., "Automation in Cartography", *Engineering Graphics*, April 1973, 6.

The advantages of automated cartography such as, reduction of costs, greater control of accuracy and the reduction of time far outweigh the limitations that accompany such a system.[2] Automated cartography is essentially linked to hardware, thus technical considerations place limitations of varying magnitude. However, a wide selection of advanced equipment, to suit the individual requirements of the user is available in the market. At present there is an increasing tendency among map making agencies to adopt automated mapping techniques and procedures. This augurs well for the future.

Historically, cartography received an impetus from the problems of navigation; this was especially true during the era of the great voyages of discovery and exploration. The information gathered from these voyages were incorpoarted in the new navigational charts. Following this came the era of air travel and with this, the emphasis on the charts shifted to stable land marks of the earth leading to the ultimate use of the computer. Linders discusses the role of the computer in the development of automated mapping systems in cartography.[3] Found suggests the use of the electric digitizer to avoid the time consuming procedures of determining map coordinates manually.[4]. In the electric coordinate digitizer, the coordianates are recorded automatically on computer cards, magnetic tapes and other such devices. Data is stored according to geographic location, which helps in the construction of data banks, a feature that helps in the preparation of data for computer mapping. This is especially true of the mapping systems which use the line printer, where the data had to be readable by the computer and accurate measurements for a very large number of map coordinates are needed as in the case of the SYMAP.

While research is underway in this field, there are a number of agencies that employ operational automated mapping systems. In order to comprehend the status of automated cartography, it is necessary to survey at least some of the mapping systems, that are in use today and weigh the relative advantages and the disadvantages of the different systems.

The Report Generator Program is one of the basic automated mapping systems in operation today. The purpose of this system is to spatially locate data,

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2. The reader is referred to the following for a further discussion of the advantages of an automated mapping system :
   Tobler, W. R., "Automation and Cartography", *Geographical Review*, XLIV, No. 4 Oct. 1959, 526–534 and Sherman, J. C., "New Horizons in Cartography, Functions, Automation and Presentation", *International Yearbook of Cartography*, 1961, Rand McNally, New York, 13 19.
3. Linders, J. G., "Computer Technology in Cartography", International Yearbook of Cartography, 1973, 69 80.
4. Found, W. C., The Electronic Map Coordinate Digitizer", *The Canadian Cartography*, VII, No. 2, Dec. 1970, 131 137.

thus a certain amount of data processing is involved in this system. The Report Generator System could be regarded as a means to an end, for it is only a subroutine to a computer program. This is a rigid system and demands long programming time. The resulting map is not suitable for publication as it is, and thus needs redrafting. The resulting map is normally used as a work map. In spite of the high expenditure and the various shortcomings, the Report Generator Program is used because it is easy to prepare.

The Package Program has a similar purpose as the Report Generator Program, as its main objective is also the spatial display of information. The outstanding examples of this system are the Card Mapping and the Tape Mapping Programs. The Card Mapping Program has again been developed for the spatial presentation of information. There is no computational ability built into the Program. It could, therefore, be used by those with only a limited knowledge of computer programming. These programs do not turn over maps suitable for publication, but could also be used as work maps. The inherent characteristics of flexibility gives this program an added advantage.

The Tape Mapping Program is more efficient and elaborate than the Card Mapping Program. Besides the spatial display of the processed information it has the capacity to do computational work. The possibility of processing a larger amount of data, over a much larger area, the capacity to make logical decisions and to work at greater speed may be cited as advantages of the Tape Mapping Program. On the whole it is more sophisticated than its counterpart, the Card Mapping Program. Its adaptability is, however, limited by the fact that it also turns out only work maps which cannot be published.

The Automatic Grid Contouring Program demands more specific mapping operations. Consequently, such a program becomes specialized and call for special equipment. The Automatic Grid Contouring Program that processes and displays geological/geophysical data needs an IBM 1620 system with a 20 k storage. This cannot be worked as a continuous operation but only in sections. Though this system carries a few distinctive advantages it is not entirely free of disadvantages. On the randomly distributed field observations a square grid system has to be superimposed. The size of this grid system is determined by the desired grid interval. Through the outermost data points a convex polygon has to be constructed, this forming the boundary of the work field. For each mesh point in the grid system a value has to be interpolated. The information in this program is recorded on punch cards. The value of the contour intervals and the plotting scale has to be specified. Once this information is ready isopleths will be interpreted and plotted.

The advantages of the Automatic Grid Contouring Program, has resulted in its widespread use. For instance, spatial analysis could be done as a part of the program. Interpolation of values for unknown points from a random sample of data points is possible. Discrete sample data could be transformed into a continuous system by way of isopleths. The areal distribution of phenomena over the data field is made possible by establishing contour intervals. The flexibility of the grid interval provides for a greater degree of freedom for graphic presentation.

The disadvantages of this system are relatively few. The hardware limitations are obvious and furthermore, the final product may or may not be of a publishable quality.

The Analysis and Automated Mapping System which was initially used in 1958 is now employed by the United States Weather Bureau. In the Analysis of data a few steps may be observed. First, the data, collected randomly in space and time, is converted into a rectangular grid array on a polar stereographic chart. If there are large loopholes in the data net, some logical decisions are made to fill them. As early as 1955, band contouring was used to depict geographically, the data prepared in this manner. With the passage of time improvements have been made in the degree of accuracy of the graphic presentation, for example, quadratic interpolation is used in place of linear interpolation. Greater strides have also been made in the speed of the entire operation, and today maps are produced at the rate of one per minute.

Plotting maps on the CRT printer is used by the United States Naval Weapons Laboratory. This prepares data tapes and subroutines for presenting maps on a Cathode Ray Point printer. These are used only for the analysis of coastline definitions. Since the printer draws only straight lines, it is necessary to locate all points which have to be connected.

The great speed with which the graphics are generated, the high degree of accuracy and the savings in labour in the preparation of the map are the main advantages of this system. Moreover, it produces a finished map suitable for publication. The most significant disadvantage in using the CRT printer is that tapes prepared for one type of CRT printer cannot directly be used on another.

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5. *Introductory Manual for Synographic Computer Mapping, SYMAP,* Version 4, I.ab. for Computer Mappings, Harvard Univ., 1967.
6. Monmonmier, M. S., "Computer Mapping with Digital Increment Plotter", *Professional Geographer,* XX, No. 6, Nov. 1968.

The United States Naval Oceanographic Office has established a number of Mapping Systems for the preparation of nautical charts. The necessity to maintain accuracy in their charts has made the emphasis to be focussed on plotters that would meet this requirement. Automation was employed in the preperation of the projection grid, the electronic navigational hyperbolic or circular curves and the plotting of adjusted 'survey strip' sounding tracts.[7]

The SYMAP program introduced by the laboratory for Computer Grapics at Harvard University in 1967, has the capability of producing three types of maps, namely contour, conformal and proximal.[8] Only a minimal knowledge of computer programming would enable one to successfully make use of the SYMAP program. This, therefore, is the main advantage of the SYMAP program. The preparatory work involved, before the program is fed to the computer for scanning and drafting of the data, is rather laborious and time-consuming. Once the study area has been selected the relative positions of the controlling points have to be established. The punch cards used in the program consists of a number of packages, each covering a specific category of information, such as, map outline, data points, the legend, and the point values. This stage involves a considerable amount of time and is rather time-consuming. These are thus the main limitations of the program. If the programmer is to construct a series of maps this limitation is overcome to a certain extent, since the same basic data could be used over and over again.

The preceding discussion is indicative of the present status of automated cartography. As Willberg observes:

> 'The establishment of any automated system poses numerous problems, many of which affect the basic design problems, It is in part evident that the preconceived idea of the outmap, the form of the input data, and the computer hardware which is available for use, will predetermine the nature of many of the problems to be confronted [9]

Many of these problems could, however, be overcome, especially when the conditions of the mapping system is known. The relevancy of automated

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7. For a detailed discussion of the various automated mapping systems available the reader is referred to De Meter, E. R., "Latest Advances in Automated Mapping", *Photogrammetric Engineering*, X IX, No. 6, Nov. 1963, 1027-1036, and Wilberg, Calvin G. "*Problems in Establishing an Automated Mapping System*", Unpub. Ph.D. Dissertation, Univ. of Washington, 1965, 11–35.
8. **Introductory Manual for Synographic Computer Mapping, SYMAP**, Version 4, Laboratory for Computer Graphics, Harvard University, 1967.
9. Wilberg, C. G., *loc. cit.*, 45.

mapping prodecures is increasingly perceived, and the techniques are being progressively refined. Accordingly, today we are in a stage in the development of a more sophisticated automated mapping system.

In 1961, Sherman posed the question: "Can you visualize the ability through a computer plotting device, to compile a base map on almost any desired projection, in an extremely short time, or to have data automatically plotted on a prepared base map?" The remarkable strides made in automated cartography since 1961 is an answer to this question. In recent years the computer has been used in the construction of different kinds of maps. For instance, the MAPIT program is being used to construct thematic maps.[10] Tobler further discusses the use of automation in thematic mapping.[11] Kirk, Diello and Callander present other uses of the computer in cartography.[12]

Geographers interested in Cartography and Cartographers interested in Geography are enthusiatic about automated mapping procedures. Since geographers rely heavily upon the recording of data in some spatial pattern, it is possible to successfully employ most of the operational mapping systems hitherto discussed. It is interesting to note that in recent years geographers are striving to develop an automated mapping system catering to their requirements. This is undoubtedly a result of the attempts to quantify the geographic method and to apply well defined mathematical procedures in geographic research. Though the awareness of the progress made in automated cartography provides an impetus to the geographer. he cannot hope to develop an "Unique geographic mapping system", nor is there any urgent necessity to make such an attempt.

Enormous strides have been made in the automation of cartography and it has become an established fact. Nevertheless, as pointed out by Thompson, in 1971, "the efforts to date represent only little more than a scratching of the surface of the subject."[13]

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10. Kern, R. and Rushton, G., "MAPIT: A Computer Program for the production of Flow Maps, Dot Maps and Graduated Symbol Maps." *Cartographic Journal*, VI, No. 2, Dec. 1969, 131–137.
11. Tobler, W. R., "Automation in Preparing Thematic Maps", *Cartographic Journal*, II, June, 1965, 10–23.
12. Diello, J., Kirk, K. and Callander J., "The Development of an Automated Cartographic System," *Cartographic Journal*, VI, No. 1, June, 1969, 9–17.
13. Thompson, M. M., Automation in Cartography, Report of Commission III, *International Yearbook of Cartography*, 1971, 51–59.