It weak points are

- Poor documentation,
- Limited capacity, and
- Poor data handling routines.

VisiCalc to Run on Apple IIe

The strong points of VisiCalc are

- Ease of use,
- Flexibility,
- Efficient use of memory (96K available for the model), and
- Logic and editing functions.

Its weak point is its poor display capabilities (no commas in numbers).

Advanced VisiCalc

The strong points of Advanced VisiCalc are

- Ease of use;
- Powerful financial routines (e.g., time, IRR); and
- Powerful display capabilities (e.g., commas, negative numbers in parentheses).

The weak points of Advanced VisiCalc are that it uses a lot of memory (only 70K available for the model) and is slower than VisiCalc.

Apple Writer IIe

The strong points of Apple Writer IIe are that it is easy to learn and relatively powerful.

Its weak points are that it does not handle very large documents without splitting them into separate chapters and requires memorizing control codes.

VisiPlot/VisiTrend

The strong points of VisiPlot/VisiTrend are

- Ease of use,
- Excellent documentation,
- Adequate statistical functions,
- Outstanding data manipulation capabilities, and
- Powerful graphics capabilities.

The weak points are that it operates relatively slowly and is not a full statistics package.

Publication of this paper sponsored by Committee on Computer Graphics and Interactive Computing.

Applications of Computer Graphics to Chicago Area Transportation Planning and Programming

ELIZABETH A. HARPER and DONALD P. KOPEC

ABSTRACT

In the last few years computer graphics has become an important analytic tool. This tool exceeds the individual capabilities of both rapid computing and graphic illustrations in providing insightful perspectives and understanding of planning data. While the field of computer graphics has been rapidly developing as a general business aid, transportation professionals have been developing interactive computer graphic programs designed for specialized modeling functions. The use of existing software packages to supplement transportation planning and programming has lagged. Instances in which current planning and programming techniques can be enhanced by integrating existing software graphics packages with transportation models and functions are described. The tailoring of existing software packages for use by transportation planners who are inexperienced in system analysis is also discussed.

That graphics is an important tool for understanding and communicating information is not new. There are many instances in which a visual image of a phenomenon raises new questions or produces insight into the meaning of the data being displayed. There also is no doubt that the speed and flexibility of computers have vastly expanded and enhanced the potential scope of any analysis. Planners now have access to a vast amount of information from which to infer relationships and project future effects of various alternatives.

Computer graphics, a combination of these two important techniques, is a tool for analysis that goes beyond either graphics or rapid calculations. The speed and accuracy with which a computer can manipulate, modify, and visually represent data make computer graphics a valuable new tool for both analysis and presentation.

In the past, planners spent long hours studying numbers to determine relationships. Then those numbers were sent to graphics departments for visual representation. Anywhere from 2 days to 2 weeks later visual aids were returned to be used for pre-

sentation or publication. Now planners can use the computer to quickly produce graphics, which often illustrate relationships or anomalies worthy of study or attention. When analysis has been completed to the planner's satisfaction, the graphics generated are of good enough quality for presentation or publication.

In the last decade the importance of computer graphics has been evolving and numerous people have been experimenting with its applications. Spearheading the movement in the transportation field was Jerry Schneider of the University of Washington who in 1973 organized and reported on a seminar on "Interactive Graphics in Transportation Systems Planning and Design" (1). The seminar explored capabilities of interactive computer graphics and brainstormed potential applications. Since then computer graphics in transportation planning has received attention and support from numerous individuals and organizations, including the U.S. Department of Transportation, the Transportation Research Board, the Transportation Systems Center (Warren, Michigan), and the University of Washington Department of Civil Engineering (2).

Efforts so far have emphasized interactive applications especially developed for operations planning, and many practical uses of computer graphics in the transportation planning field have been left unexplored. There are two reasons why there is a need for developments in this area:

1. Interactive computing usually requires programming expertise, which is beyond the majority of planners (3). Attempts at producing interactive graphics by an inexperienced programmer will be more frustrating than productive.
2. Large amounts of planning data are not operations related. This wealth of information, including socioeconomic data, time series data, and capital programming data, is still pertinent to transportation planning and policy decisions and should be subjected to computer graphic analysis techniques in order to make the best use of all available resources.

Although interactive computing enhances all computer-aided tasks, including graphics, the assets of computer graphics are not dependent on being interactive. Interactive packages are usually designed for narrow, specific, operations analysis tasks and do not allow for applications to, and use of, the numerous other planning functions and existing data bases.

Through use of the Statistical Analysis System Graphics (SAS) (4) and the IBM Graphic Data Display Manager (GDDM) (5) at the Chicago Area Transportation Study (CATS), it has become apparent that existing, commercially available graphics software packages can be applied to almost any of the numerous existing data bases to greatly enhance the many-faceted transportation planning functions. Because computer graphics packages are general in scope, they can be easily adapted to standard computer-aided analyses and projects, including capital development, system management, demand modeling, socioeconomic data-base maintenance, and operations planning. Examples of such applications follow.

POSSIBLE APPLICATIONS

In every case the graphic presentation provides a different perspective on the information produced than was previously available. Also, in each case, the graphic output could be easily incorporated into jobs that are already run as standard procedure in a transportation planning function. It is hoped that these examples will lead to further application of computer graphics, both batch and interactive, to planning functions.

Preliminary Data Analysis

In many cases graphics can indicate characteristics of data that are critical to the initial study design. The following two examples show (a) a way in which planners can use graphics to check for accuracy and completeness of a network and (b) a way in which planners can understand trends in initial socioeconomic data before applying travel demand models.

A standard, traditional network data set contains various characteristics of links, including the nodes they connect and their capabilities, in a tedious list format. Before beginning a regional or subregional analysis the planner may want to focus on the configurations of a particular area of concern to look for errors in coding and for consequential characteristics of the particular area.

The series of network maps shown in Figures 1-5 represents a portion of the Du Page County, Illinois, highway network. When the network of Du Page County (Figure 1) was first processed, it was obvious that a particular link had been miscoded. This link was corrected and the county map rerun. The corrected network is shown in Figure 2. It was then decided to take a closer look at a 36-square-mile township in the center of the county. Figure 3 shows this enlargement. Following a detailed examination of the network, concern was expressed about the capacity of some links in a particular area of the township. The links of the township were factored by the capacity found in the network data base and displayed (Figure 4). An alternative representation of the link capacity is shown in Figure 5.

These graphics were produced in an interactive session, and could have displayed any characteristic of the link such as volume or speed. Although the interactive aspects of this particular application greatly add to its usefulness, the same information could be gleaned from a few iterations of batch jobs

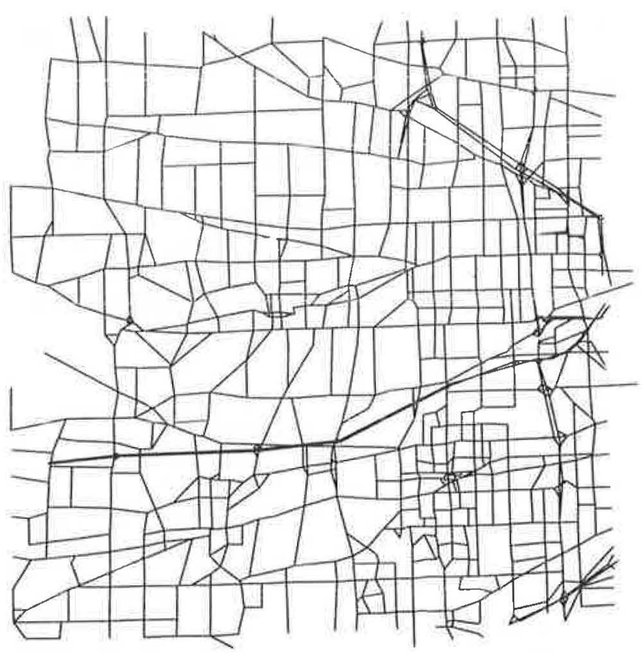

FIGURE 1 Highway network of Du Page County, Illinois.

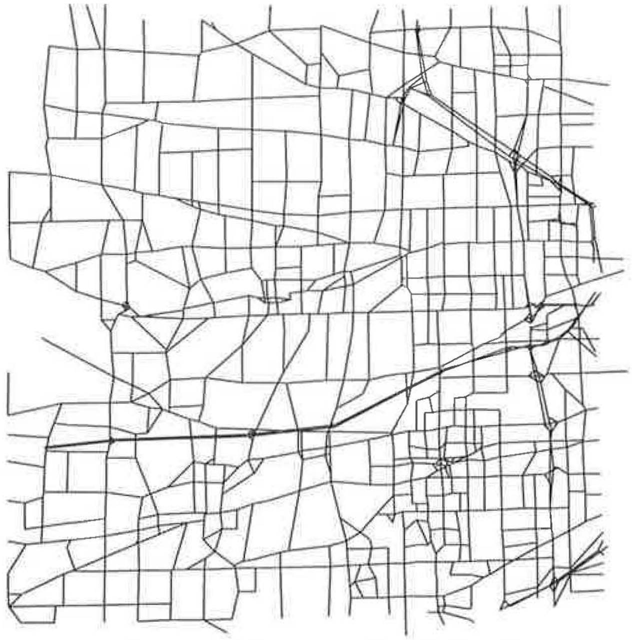

FIGURE 2 Corrected highway network of Du Page County, Illinois.

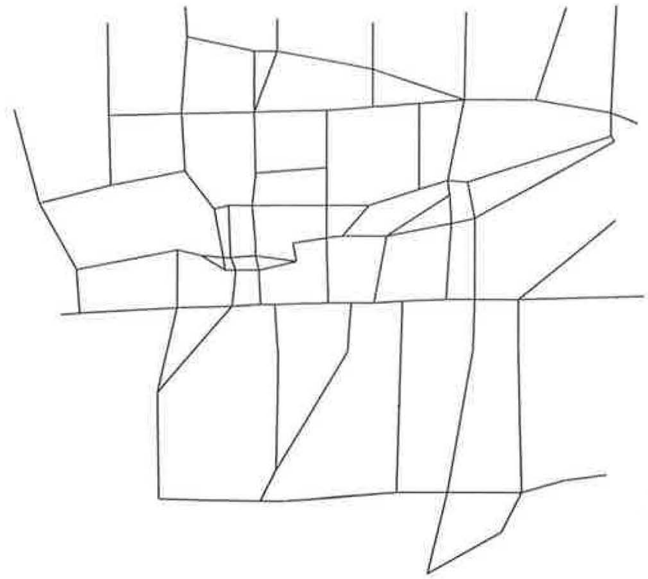

FIGURE 3 Highway network of Milton Township, Du Page County, Illinois.

designed to zero in on areas of concern. The planner inexperienced in programming merely needs to select for input the zones to be examined.

Before beginning the regional analysis the planner may be interested in attributes of the data such as changes in socioeconomic characteristics. Listings are usually provided of all relevant data available such as changes in population. Figure 6 shows decreases in population that occurred in southern Cook County. This graphic, produced as part of the usual processing of socioeconomic data, facilitates analysis of trends in the region. Subsections of this information could also be enlarged by specifying the townships of special interest.

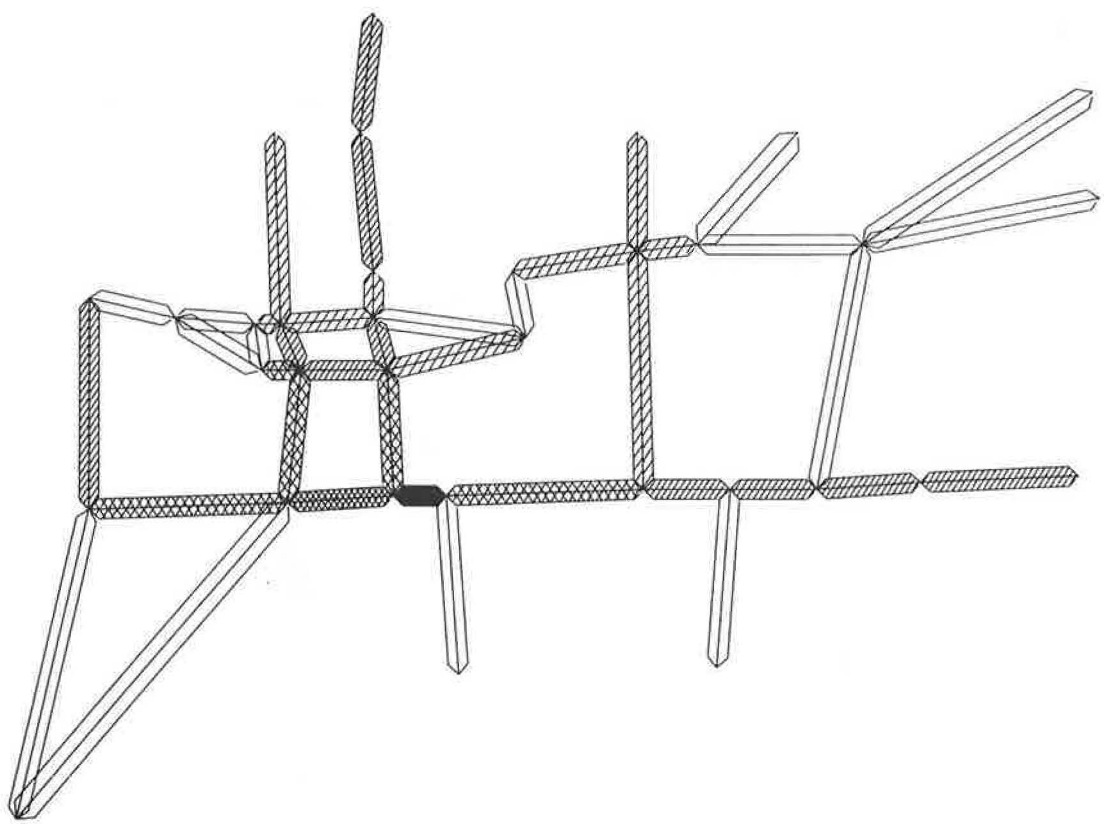

FIGURE 4 Link capacity of highway network of city of Wheaton, Milton Township, Du Page County, Illinois.

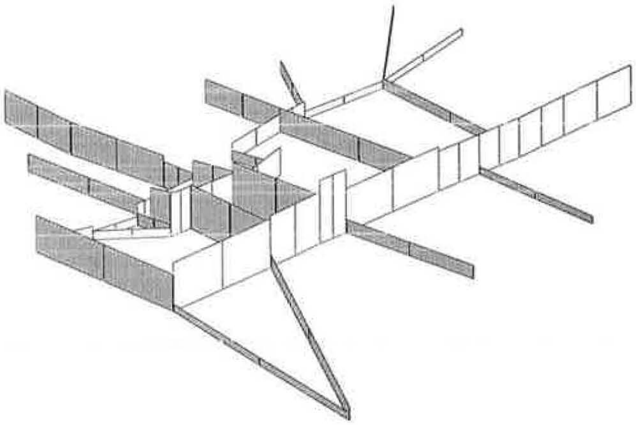

FIGURE 5 Alternative representation of link capacity of highway network of city of Wheaton, Milton Township, Du Page County, Illinois.

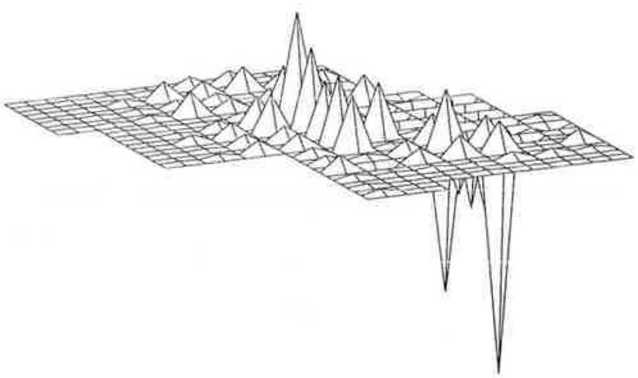

FIGURE 6 Changes in population in southern Cook County, Illinois.

Implementation

Implementation is an area where comprehensive analysis has been lacking in the past. As more efficient means of maintaining information, monitoring programs, and forecasting fiscal needs are being developed, the uses of computer graphics in understanding and communicating developing trends to policy makers are becoming apparent. In the past policy makers had endless lists of capital projects as their main input to the comprehensive decision-making process. Figures 7 and 8 show an easier way to comprehend CATS' 5-year capital program. The bar charts show, at a glance, the relative magnitude of investments in geographic, investment, and temporal categories. These charts could be modified in numerous ways to show most aspects of the program that are of interest to policy makers. These graphics can be produced by the same jobs that provide listings and summary tables. Therefore, when developing the new transportation improvement plan (TIP), alternative investment scenarios could be quickly and easily developed, illustrated, and compared.

Computer graphics can also supplement the implementation process by helping in the analysis of programming issues and trends. Figure 9 shows one way of examining information about the progress of the TIP in implementing transportation system development (TSD). Charts like the one in Figure 8 can be produced at any time during the TSD or TIP effective period and could, with a series of options, be factored for changing inflation rates, project awards, and funding scenarios.

An important factor in plan implementation is the impact of awards on the profile of the programmed investment. Although lists of numbers and percentages can be used to illustrate the impact of awards on the program's investment characteristics, the magnitude of the impact of varying award rates can be more clearly shown graphically (Figures 10 and 11). These charts and similar charts showing numerous other issues affected by awards could be produced as a standard procedure when the summary of awards is generated.

Long-Range Plan

Long-range planning techniques are easily adapted to computer graphic analyses because of the wealth of data available to, and generated by, the travel demand models. An integral part of the process is the estimation of the demand for travel on any link compared to the capacity of the existing system. Various reports are produced by an evaluation routine as part of the standard planning models. The planner is to examine this output for information that would be useful in developing alternatives for evaluation and to gain an understanding of the general characteristics of the system. Figure 12 shows volume on links with a volume-to-capacity ratio greater than one.

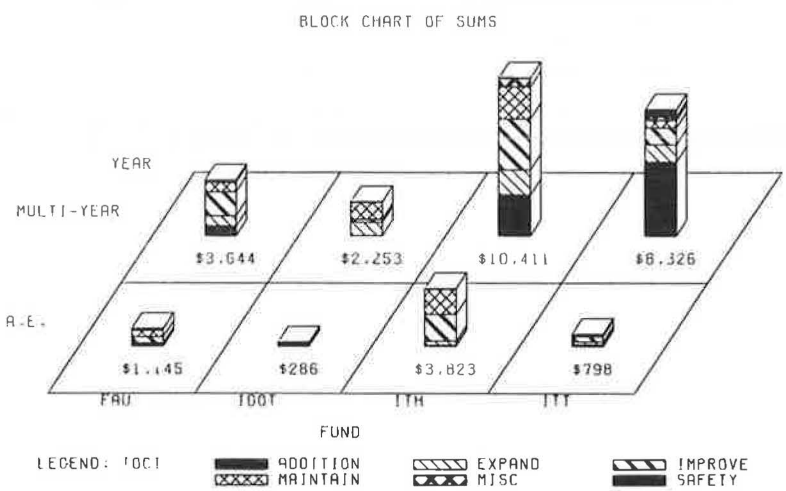

FIGURE 7 FY 1983-1987 TIP investment by year and fund category ($000,000).

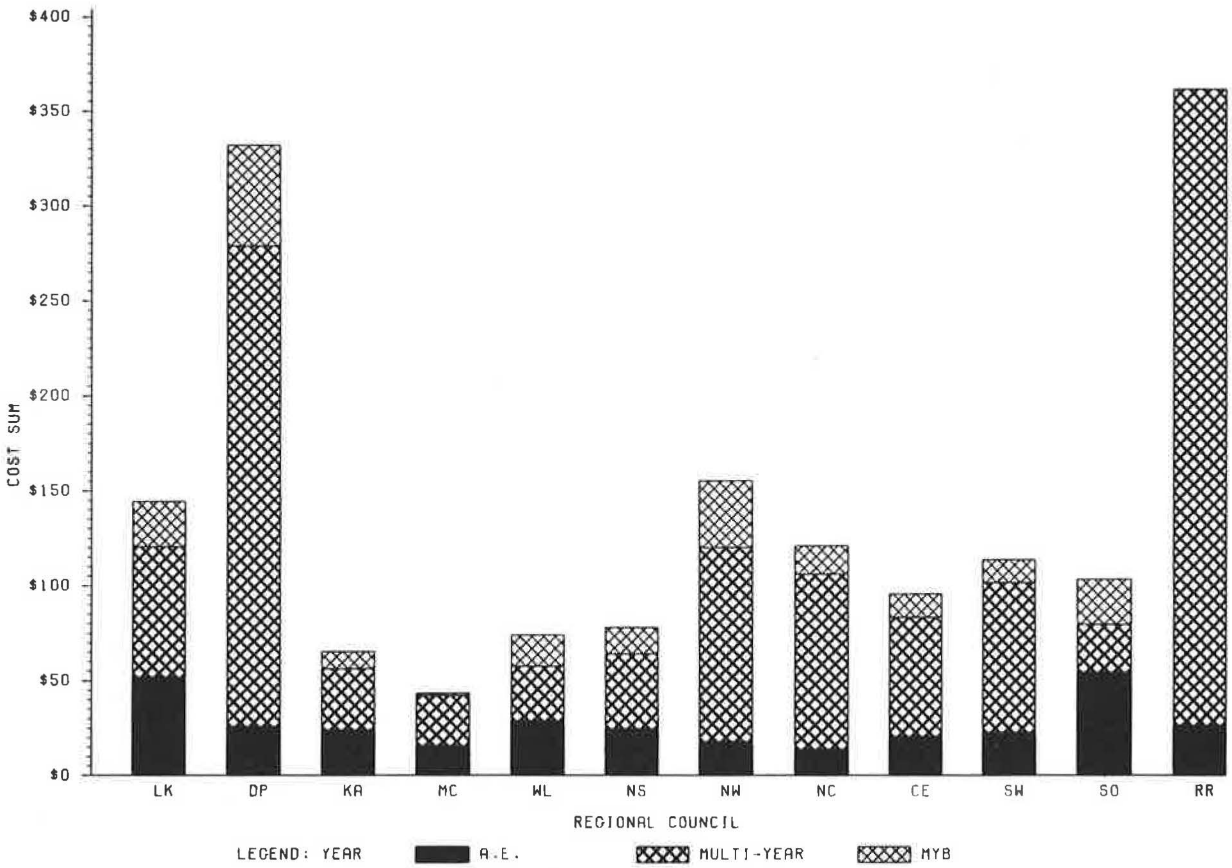

FIGURE 8 TIP investment by regional council and year ($000,000).

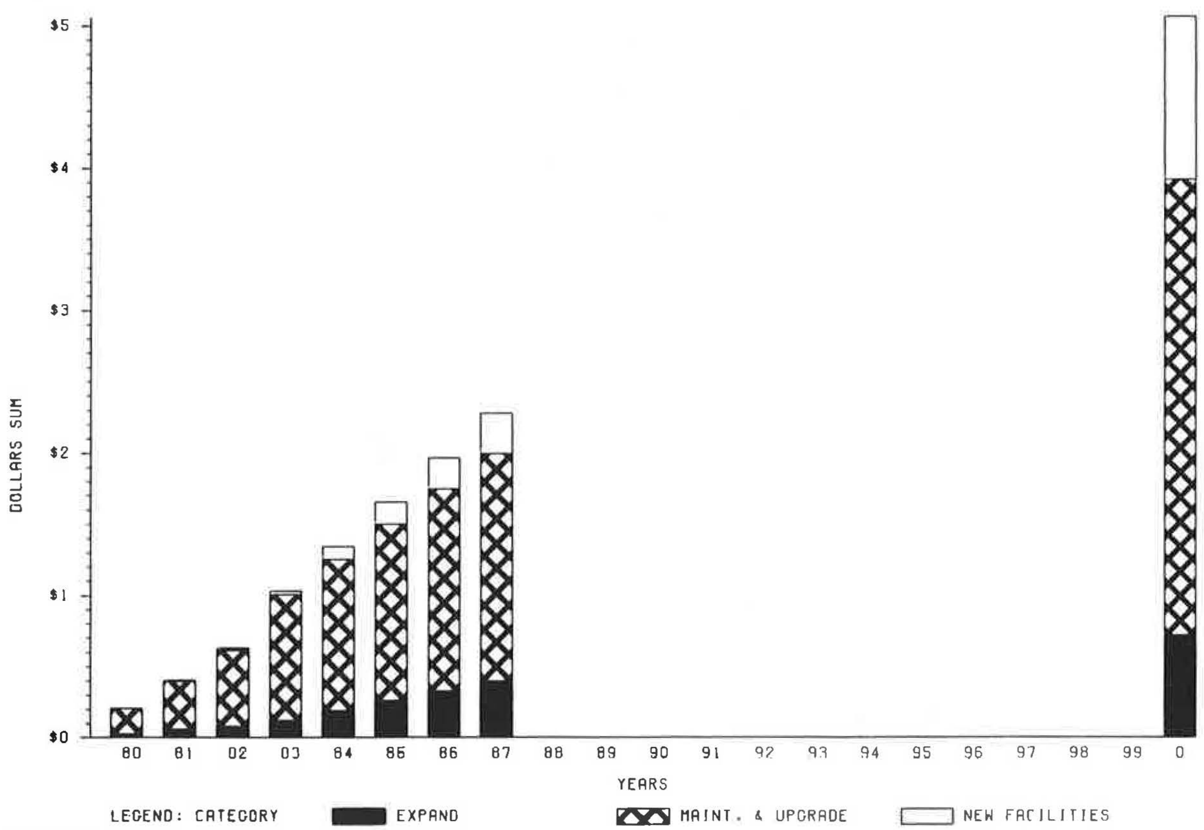

FIGURE 9 Cumulative TSD implementation progress ($000,000,000).

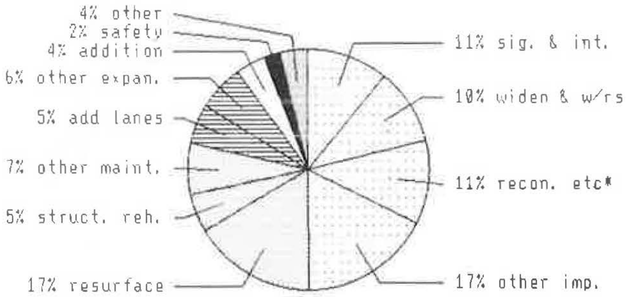

FIGURE 10 Original investment by category.

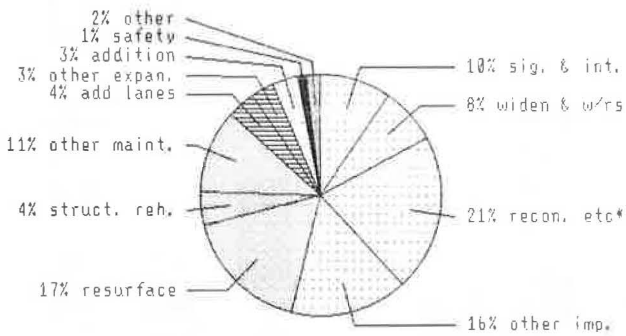

FIGURE 11 Awarded investment by category.

This map can be applied to any of the variables available in the evaluation routine, or to any other available data that can be aggregated to townships, zones, or links. (When standard levels and scope of analysis are known, simple software can be included in the evaluation program to produce similar maps along with the batch run.)

One of the steps in the CATS travel demand estimation process is to distribute trips by zone. The result of this step is a table of trips into and out of each zone. The output of this program is not one of the standard reports, but selected parts of it can be printed, compressed, or generated onto an active computer file for examination by a batch or interactive compilation of charts. The graph in Figure 13 shows, by the height of each block, the number of

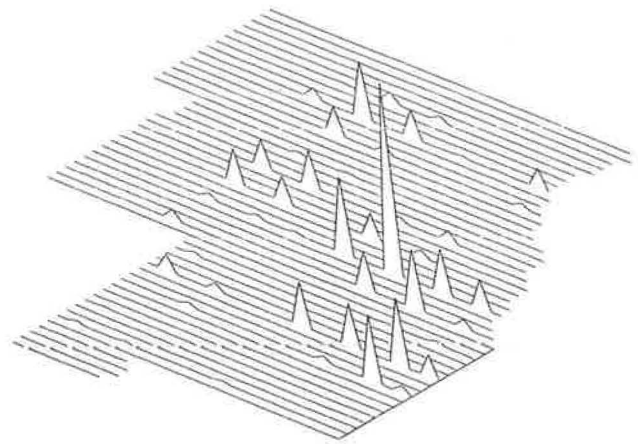

FIGURE 12 Excess volumes by township.

home-to-work trips between each possible pair of counties in the region.

Another step in the CATS travel demand estimation system is to make an estimation of the split of trips between transit and automobile. The result of this program is a printout of percentages of trips that are estimated to occur between zones by automobile and transit.

In this example, trends in the data, which are not easily seen in the numbers generated by the standard report, are observed in the computer graphic illustrations shown in Figures 14 and 15. For example, notice that work trips to the central business district (CBD) are predominantly on transit in the zones that are 30 or more miles from the CBD (Figure 14). Also notice that zones that are 5-10 miles from the CBD are almost exclusively in the 60 percent transit bracket. A very low percentage of work trips to the CBD from 1 to 3 miles away are on transit. But in zones that are 10-50 miles from the CBD the mode of transportation to work in the CBD is seemingly unrelated to distance.

For non-CBD-bound work trips there is a natural break point beyond which the principal mode of travel to work is not transit but automobile (Figure 15). This break point, 15 miles, is approximately the market area of the Chicago Transit Authority.

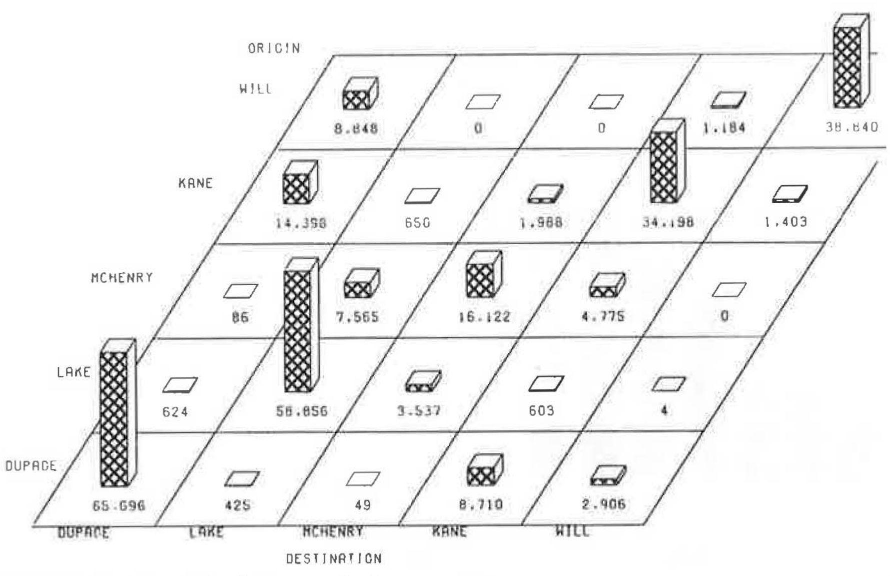

FIGURE 13 Work trips between suburban counties.

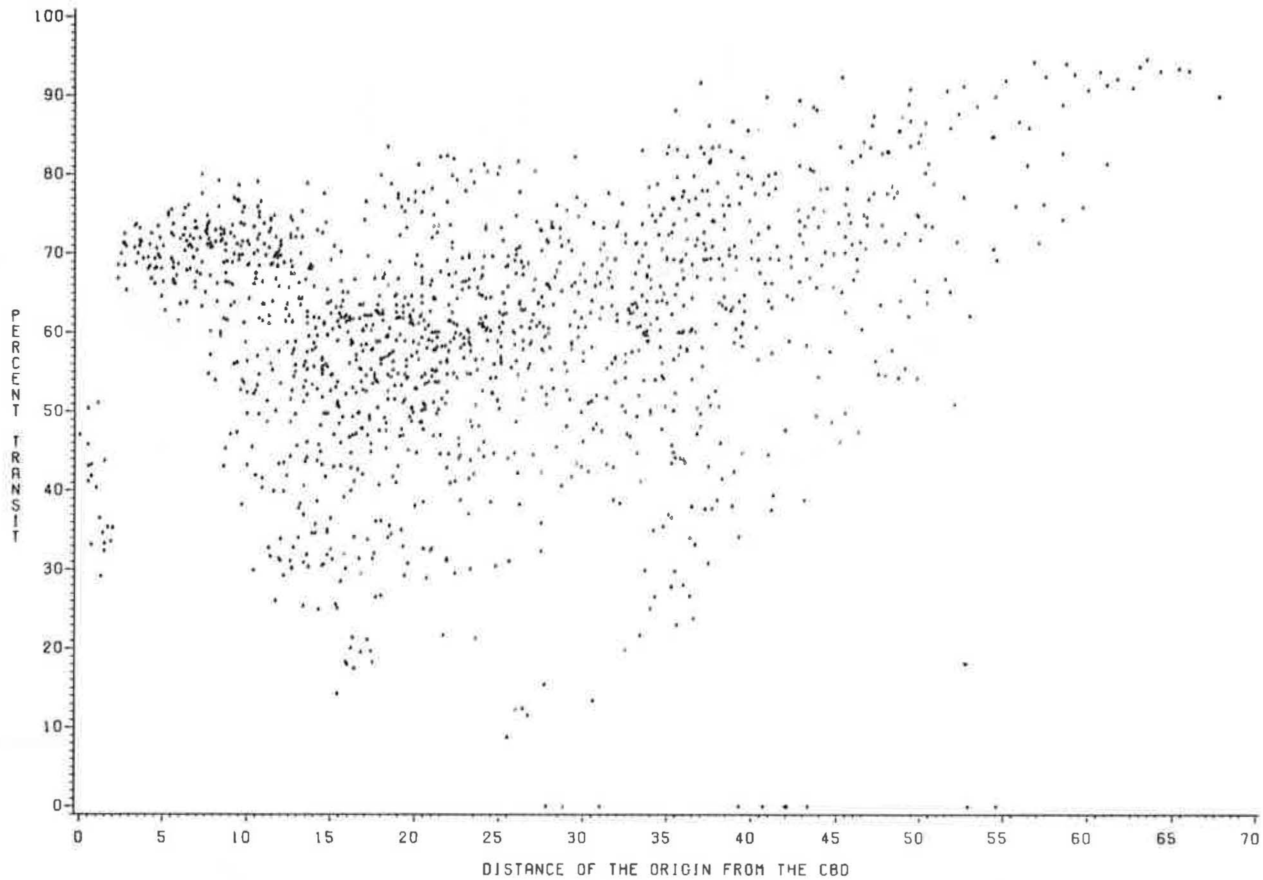

FIGURE 14 Mode split of CBD-bound work trips.

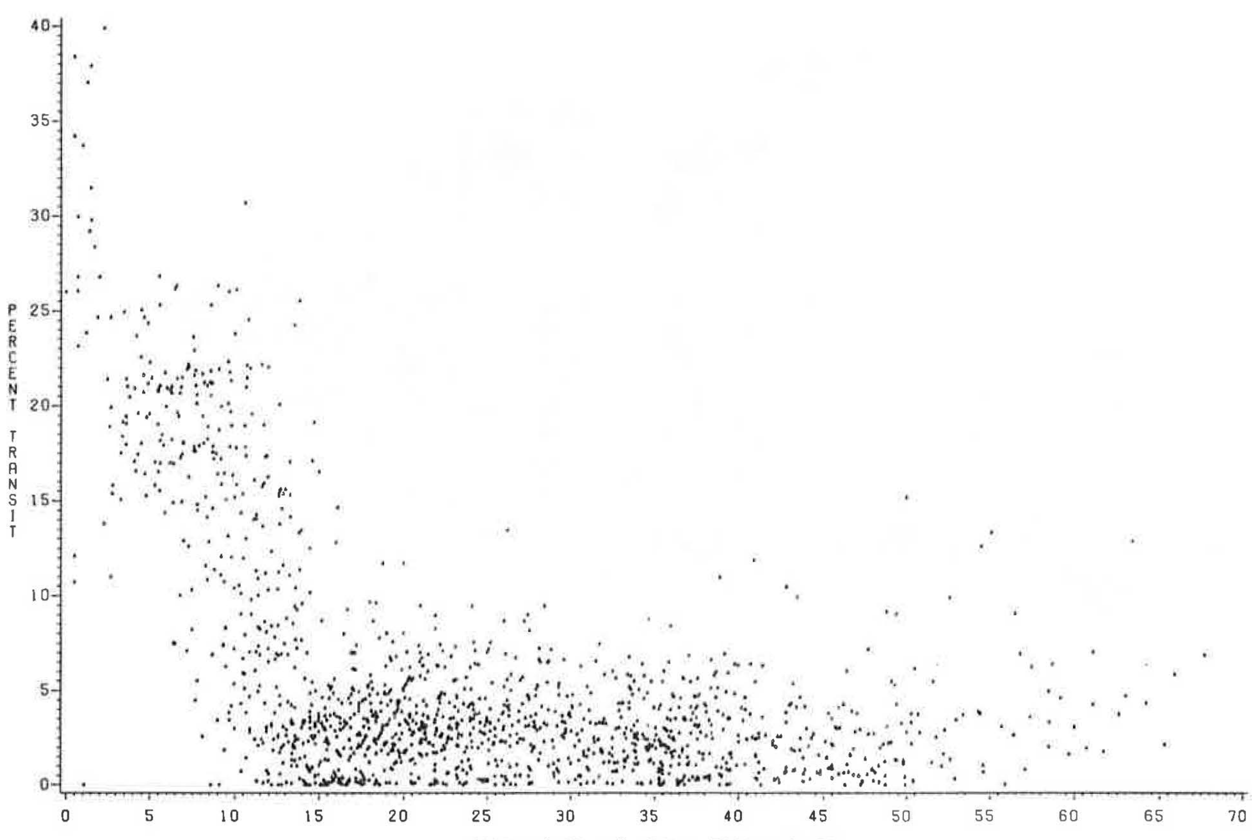

FIGURE 15 Mode split of non-CBD-bound work trips.

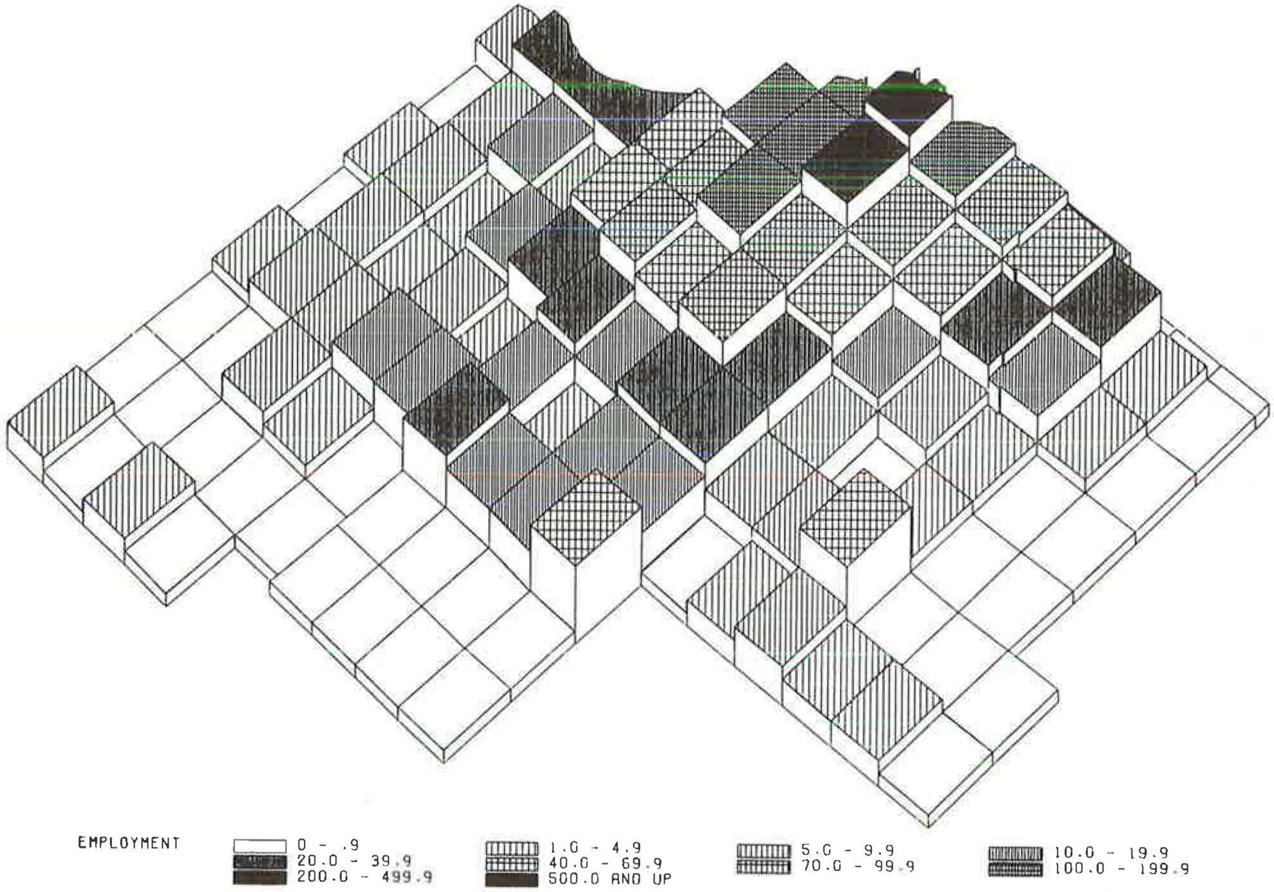

FIGURE 16 1980 employment by township.

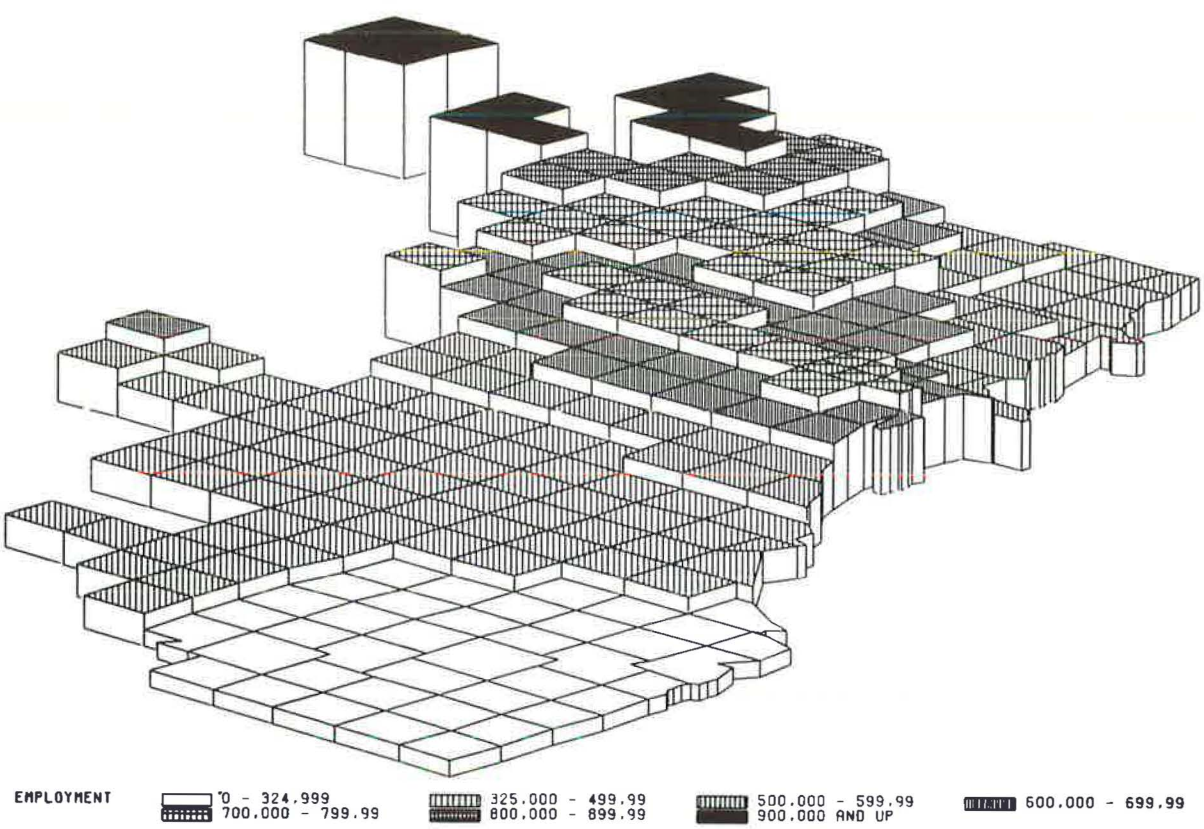

FIGURE 17 Suburban employment within 45 min. of each Chicago analysis zone using the highway system.

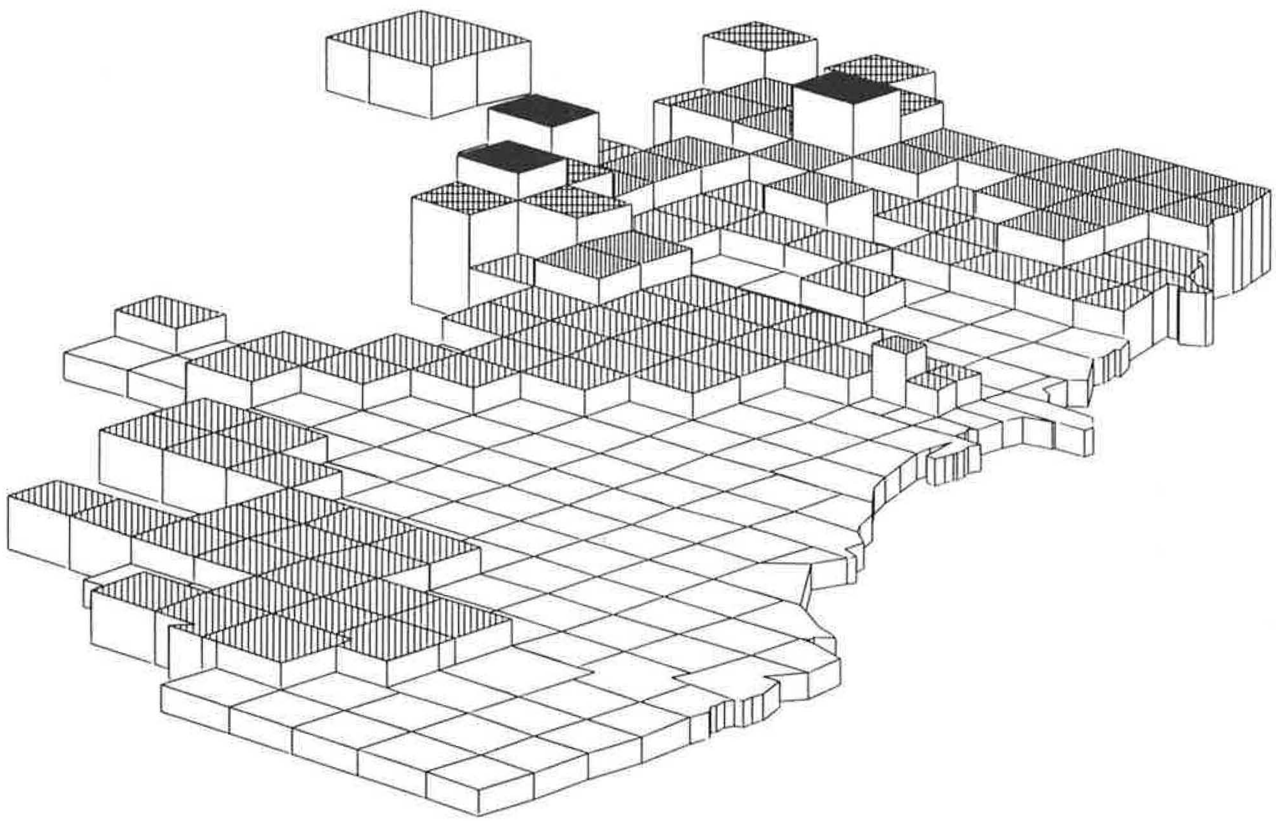

FIGURE 18 Suburban employment within 45 min. of each Chicago analysis zone using the transit system.

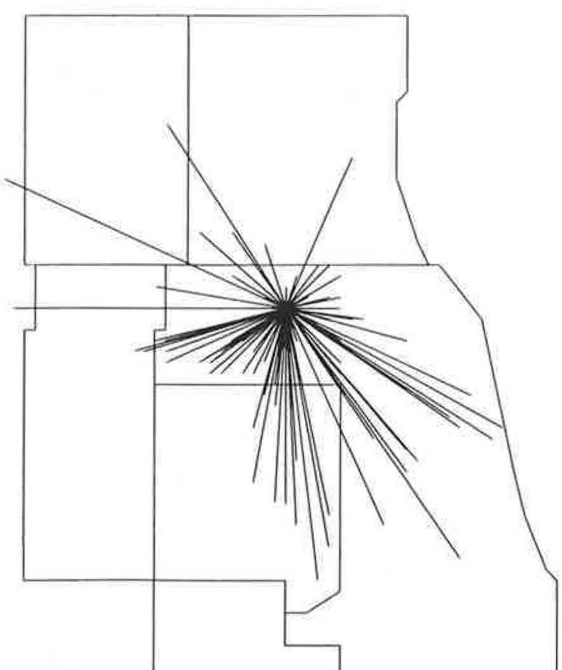

FIGURE 19 Carpool participants for a Schaumburg, Illinois, employer.

In addition to supplementing the products already produced by the planning functions, computer graphics can aid in evaluating results in new ways. For example, a project recently completed at CATS required the evaluation of Chicago residents' accessibility to suburban employment. Figure 16 shows the employment in the region by township. The three-dimensional maps shown in Figures 17 and 18 illustrate the amount of suburban employment (number of jobs in the suburbs) that is within 45 minutes of each Chicago analysis zone on the highway and transit networks, respectively. Other such analyses might include per capita expenditures on maintenance, travel time to the CBD under various proposed alternatives, or many other combinations of pertinent data.

Transportation System Management

The best example of using computer graphic analysis in transportation system management is in the ridesharing program. An important part of the CATS ridesharing program is the determination of desire lines; that is, where the demand for a ridesharing program might exist. The match program produces a listing of information about employees, their home and work grid coordinates, start and work times, and ridesharing or driving preference. Some minimal additional software could produce graphic displays of these desire lines as a result of a run of this program (Figure 19). This graph shows one line for each trip to work at a suburban employer. Corridors for potential carpools are evident.

CONCLUSIONS

A variety of applications of computer graphics to the field of transportation planning has been presented. The benefits realized through the work illustrated here include the ability to have traditional transportation planning programs produce graphics for analytic purposes; the capability for non-computer-oriented planners to select from a menu list and generate graphics for varied and specialized purposes; the potential for the experienced system analyst to interactively manipulate and analyze information in a manner not addressed by the standard models; and, finally, the production of graphics that are used for analysis and that may also be used in presentations and publications.

Even though there is a definite need for the development of specialized interactive graphics tools, especially for operations analysis, it is thought that low-cost, commercially available graphics packages can be effectively used to enhance the knowledge of transportation planners and their audience. The planning field is characterized by the complexity of its data sources and structures. The professional should make use of all tools available in order to realize the full potential of personnel, data, and models.

In conclusion, it is recommended that every effort be made to explore potential applications of existing software packages. In addition, efforts should be made to train transportation professionals in basic uses of computer graphics, both batch and interactive, in order to take the best advantage of the enormous potential.

REFERENCES

1. J.B. Schneider. Interactive Graphics in Transportation Systems Planning. Final report DOT-TST-74-10. U.S. Department of Transportation, 1974.
2. J.B. Schneider. Bibliography of Applications of Computer Graphics to Transportation Planning and Engineering Problems. Vance Bibliographies, Public Administration Series. Vance Publishing Corp., New York, 1981, 681 pp.
3. Y. Gur. Interactive Graphics as a Tool in Plan Evaluation. In Transportation Research Record 491, TRB, National Research Council, Washington, D.C., 1974, pp. 60-79.
4. SAS User's Guide: Basics, 1982 edition. SAS Institute, Inc., Cary, North Carolina, 1982.
5. Graphical Data Display Manager Presentation Feature Interactive Chart Utility User's Guide. IBM Corporation, White Plains, New York, June 1983.

Publication of this paper sponsored by Committee on Computer Graphics and Interactive Computing.

Design of a Single-Route Ridership Forecasting Model

ALAN J. HOROWITZ

ABSTRACT

The transit ridership forecasting model (TRFM) has been designed to overcome many of the serious obstacles to implementation presented by previous methods of forecasting ridership on a single route. TRFM simplifies, optimizes, and repackages conventional ridership forecasting techniques to make the job of the planner as easy as possible. The model exploits the advantages of a popular, modest-sized microcomputer (e.g., animated color graphics), but it also deals effectively with inherent limitations of microcomputers (e.g., small memory and slow calculation speed).

Travel demand estimation is considered an integral part of transportation planning. However, despite two decades of model development, few transit planning agencies use the best available methods for ridership estimation. Transit planners instead often substitute rules-of-thumb or intuition in determining the impacts of service changes. There are many reasons for this gap between theory and practice, but one major reason is that virtually all available computer packages for ridership estimation require more data, more computer expertise, more equipment, and more time than planners generally possess.

The transit ridership forecasting model (TRFM) attempts to put sophisticated forecasting methodology into the hands of transit planners. TRFM greatly simplifies ridership estimation from the planner's viewpoint and attempts to retain the accuracy of mainframe models. In TRFM, simplification takes three forms: (a) eliminating mathematical procedures that are unnecessary to its sole objective of single-route ridership estimation; (b) designing the input procedures to remove, as much as possible, the burden of data preparation; and (c) organizing the program so that planners may easily customize the model to their needs.

TRFM is a fully interactive, color graphics program that just estimates ridership on a single route. The design of TRFM retains the salient parts of mainframe models such as the urban transportation planning system (UTPS) but exploits the advantages of microcomputers, specifically the Apple II+/IIe.