Microcomputer Applications in Traffic Engineering

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Microcomputers have proven to be an effective tool for the solution of traffic engineering problems. Even in the early stages of its development, the microcomputer was recognized for its utility in a wide range of traffic engineering tasks. The current use of microcomputers by traffic engineering agencies is reviewed. An overview is presented of the general categories in which microcomputers are applied. Specific examples of available programs are mentioned in each category. The applications include general desk-top computing for signal system design and analysis, data base management of accident records and inventories, and special graphics. Communication with other data processing devices is also discussed, including traffic data collection, intelligent terminals, and real-time signal system control.

Engineers in all fields are making use of the computer technology bonanza. The possibilities for microcomputer application in the traffic engineering field are endless, and many of these possibilities have already become realities.

The hardware systems within the scope of this discussion include general purpose microprocessor-based central processing units (CPUs) that have at least 64K of memory, at least one floppy disk drive, and a printer. A variety of peripheral and interface equipment might also be involved. The cost of this type of system is generally well within the budget of a traffic engineering agency. Equipment that is beyond the scope of this paper includes dedicated process control hardware (such as signal controllers) and larger-scale minicomputer and mainframe systems.

The purpose of this paper is to review the state of the art in the application of microcomputers to traffic engineering problems. Several available programs will be mentioned as examples of the current technology. Further detailed information on the capabilities and availability of the programs can be found in the references. Microcomputer Applications in Transportation Engineering (1) and Microcomputers in Transportation: Information Source Book (2) are valuable sources of information on traffic engineering. Microcomputer Applications in Traffic Engineering Agencies (3) offers guidelines for getting started in the microcomputer field. Together, these three references should provide the prospective user with a complete picture of the application of microcomputers in traffic engineering.

NUMBER CRUNCHER

Most of the available traffic engineering design programs involve traffic signal operation in some way. The following sections contain examples.

Capacity Calculations

Capacity calculation programs generally apply the TRB Circular 212 (4) methodology to determining critical lane volumes, intersection capacity, and level of service. Examples include CAPCALC (1), SIGCAP (1), and CMA (1).

Single Intersection Design and Evaluation

Several programs deal in some way with computing optimal cycle lengths and splits and evaluating the effect of a specified signal operation on such measures of effectiveness as stops, delay, fuel consumption, and air pollution. Examples include SOAP/M (1), SPLIT II (1), CYCLE-SPLIT-I (1), CYCLE (1), INTERANALY (1), POSIT (2), CAPSSI (2), and SIGNAL (2).

Arterial System Design and Evaluation

Several programs are available for the design and evaluation of arterial signal progression. Programs are available to achieve optimum coordination of cycle length, phasing, splits, and offsets, although not all programs seek optimum coordination of all of these variables. Examples include SPAN (1), PASSER II (1), SIGART (1), AAP/M (1), FORCAST (1), and NOSTOP (2).

Network System Design and Evaluation

The microcomputer has somewhat limited capability for network system design and evaluation because of constraints in memory size and execution time. The network program achieves optimum coordination of the same list of variables as the arterial programs, except that explicit optimization of phase sequence does not appear to be offered by any of these programs. Examples of network programs include EVALUATE (1), SIGRID (1), and TRANSYT (1).

The microcomputer system is used in three ways in these applications:

1. Traditional mainframe computer programs such as TRANSYT and PASSER II have been converted to use small microcomputers;
2. Special microcomputer programs have been written for capacity analysis, signal timing, and progression design; and
3. Other engineering calculations are performed routinely by small, often specially written, programs.

In all of these applications the microcomputer is simply used as a desk-top calculator. Numbers are fed in and results are generated. The advantages include accessibility and interactive data entry. The main disadvantage is the speed of computation, which is usually significantly (and sometimes painfully) slower than that of the larger systems.

DATA BASE MANAGER

Applications for data base management differ from simple number crunching applications in the permanent storage of data for nearly instant retrieval. Traffic engineering data bases fall generally into two categories.

1. General applications involving a commercial data base management system (DBMS) to store data and generate reports. Among the most popular are dBASE II (CP/M) and DBMASTER (APPLE); their data base management capabilities (search, sort, and merge) and their report generation capabilities are impressive.
2. Specialized applications with a DBMS written specifically for the purpose.

The popular trend among software developers is toward the first alternative (i.e., commercial DBMS). Some of the commercial systems such as dBASE II have attracted peripheral development in the form of utilities and statistical packages.

Although a signal system inventory for a medium-sized city can be stored onto a couple of floppy disks, serious data base applications will probably require a hard disk. The advantages of the hard disk include an increase in storage capacity (a 10-megabyte hard disk is equivalent to about 75 floppy disks) plus a significant increase in the data transfer rate.

Inventory Applications

The simplest data base application is the inventory or filing cabinet system. Data are stored, usually by intersection or location, for easy retrieval in response to interrogation commands. Limited capabilities for report generation are provided and only one data base may be used at a time. Several cities are using file management systems such as DBMASTER for physical inventories of signals, signs, and streets.

Accident Record Systems

The microcomputer, combined with a 10-megabyte hard disk, can provide an effective accident records system for a small- to medium-sized county. The disk can store 100,000 accidents with no difficulty, but with state-of-the-art DBMSs such as dBASE II files larger than 20,000 records, for example, may require excessive time to manipulate.

The main differences between simple inventory systems and state-of-the-art accident records systems include

1. The use of relational data base management systems (such as dBASE II) that work simultaneously with more than one data base; this permits cross reference between geographical information, traffic volumes, and roadway characteristics and the actual accident data;
2. Data analysis capabilities that extend beyond simple report generation to computation of accident rates based on exposure or hazard ratings; and
3. Collision diagram plotting capability included in the more comprehensive systems.

Examples of functional accident records systems on microcomputers include the ATEMS Traffic Accident Record System (1) and SCARS (5). Pfefer and Reischl (6), Kelsh (7), and Brown and Colson (8) discuss microcomputer-based accident records systems.

Network Data Bases

Most network data bases are used for transportation planning purposes and are therefore beyond the scope of this paper. A couple of applications are worth noting. An integrated traffic data base system (2) is available that includes physical inventory, traffic characteristics, and accident history. Another system is under development (2) that will provide automatic coding of input data for common traffic engineering models such as PASSER and TRANSYT from an areawide data base.

INTELLIGENT TERMINAL

The microcomputer has vastly expanded the capabilities for remote terminals that communicate with larger computers. Intelligent terminals, unlike their predecessors, offer the ability to transfer and store large blocks of data, to perform computations on these data, and to display the results in numerical or graphic form.

The most important applications of intelligent terminals to traffic signal systems include the following:

1. Monitoring the operation of a computerized system and generating status reports interactively (9);
2. Transmitting signal operating parameters to local or submaster controllers in the field (10);
3. Interactive data entry for mainframe signal optimization programs such as PASSER II and TRANSYT (11); and
4. Graphic displays of the results of these programs to enhance the traffic engineer's understanding of the system operation (12).

Graphic Displays

Graphic outputs are likely to become more common in the future because of the capabilities of microcomputer systems. Of particular interest is the compatibility of many systems with standard color television monitors. This creates the potential for public displays of areawide traffic conditions through commercial cable television channels. The large-screen projection television monitor is an excellent central signal system control room display because of this compatibility.

Two advanced developments in microcomputer graphics of particular interest to traffic engineers involve variations of the familiar time-space diagram for arterial signal progression. The first, part of the SPAN (1) program, displays a time-space representation that is corrected for travel time on the route to eliminate the need for proportional spacing of intersections. A 20-intersection system can be presented on a single video screen by using this technique, which is referred to as the time-location diagram (see Figure 1).

A second graphics development extends the concept of the time-space diagram beyond simple progression bandwidth to include a representation of the traffic density at all points in time and distance. This technique, which produces the platoon progression diagram (see Figure 2), uses a dot-matrix printer common to microcomputer systems. The platoon progression diagram combines the advantages of the time-space diagram produced by bandwidth optimization programs such as PASSER and the flow profile plots produced by TRANSYT. Two versions of TRANSYT have been modified to generate flow profile tables that are transferred to the microcomputer. The BITE (13) microcomputer program can then produce the graphics shown in Figure 2.

Real-Time Process Control

Can a small general purpose microcomputer system actually be used as the master controller for real-time control of a group of intersections? These systems have already been introduced into the market (14). If they are successful, substantial competition can be expected in this area, and a large variety of systems will be available.

Another process control area is in the signal maintenance shop. A system is currently under development that will perform a standardized series of tests in real time on a signal controller to determine how well the controller meets specified functional requirements (15). A separate system, in operation for 4 years, provides vehicle detection inputs to a controller and monitors the outputs. Displays of simulated traffic are displayed on a video screen (16).

TRAFFIC STUDY MACHINE

The microcomputer offers some relief from the tedious task of collecting, reducing, analyzing, and interpreting the vaious data used to support traffic

Figure 1. Time-space diagram compensated for travel time on each link to condense display onto video screen.

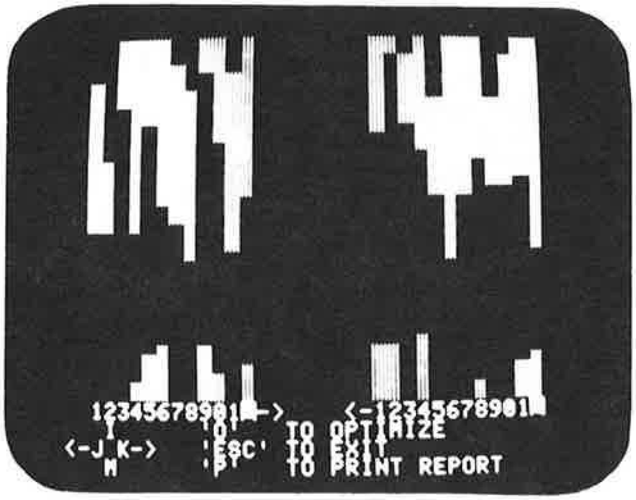
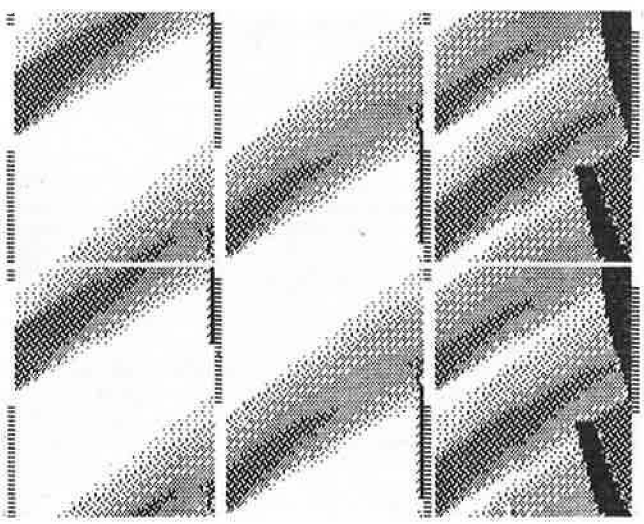


Figure 2. Time-space diagram with traffic densities superimposed to show propagation of platoons.



engineering decision making. Major areas of assistance are

1. Reading data automatically from field data collection devices to reduce labor costs and improve accuracy,
2. Processing the data to generate summaries that were previously developed manually,
3. Storing the data on disks instead of sheets of paper to facilitate future analysis by specialized programs, and
4. Transmitting the data automatically to other computer programs that perform design computations (e.g., signal timing).

The first three areas of assistance are well developed. The fourth area (the automatic link to the design process) offers excellent potential for advancing the state of the art.

Road Tube Counts

Most pneumatic tube counters generate some form of machine-readable output such as paper or magnetic tape. A variety of programs are available to read data into microcomputers. Examples of such programs include GATR (1), ATR COUNT (1), SCAN (1), and COUNTS PLUS][(1). Most of these programs have built-in processing capability. Another class of programs has the processing capability without the automatic reading capability. Examples include SPEED PLOT (1), SPEED (2), and TUBES (2).

Turning Movement Counts

Turning movement count data are still collected manually; however, a number of vendors now offer a turning movement counter that stores data for direct transfer onto a microcomputer. Several programs are also available to accept and analyze turning movement count data. Examples include TURNPLOT (1), TMC (1), and TURNING MOVEMENT COUNT (1). Another program, DELAY (1), uses a standard device for counting turning movements together with a study technique that redefines the meaning of the inputs to measure delay to traffic entering a major street from a minor street.

Travel Time Studies

Travel time is usually estimated by moving vehicle studies, either by stopwatch reading or by automatic recording equipment. Examples of programs that read or analyze these data include CRIT (1) and TRAVEL TIME (1).

Signal Warrants

One example of the direct use of road tube data is the numerical warrants for the installation of traffic signals. The COUNTS PLUS][(1) program generates a written report that compares traffic data with signal warrant criteria. The input data may be entered from the keyboard or read automatically from road tube counters.

MISCELLANEOUS APPLICATIONS

A few other traffic engineering applications that fall outside any of the previous categories are also worth mentioning. Many agencies are using spreadsheet programs such as VISICALC for a wide variety of administrative and technical applications. License plate techniques are also being used for special studies. For example, LMAT (1) performs license plate matching for traffic movement studies, and PKSUR2 (1) computes standard parking lot operational measures from license plate data. Accident reconstruction is another application. The program REC (1) performs a kinematic analysis of a two-vehicle accident by using conservation of momentum principles.

CONCLUSIONS

Microcomputers in traffic engineering are here to stay. As the technology advances so will the applications. The software base is now sufficient to justify the acquisition of a microcomputer system for traffic engineering purposes.

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Microcomputer Applications in Railroad Operations

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Railroad officials in North America are using microcomputers more frequently to complement the capabilities of their more formal computer systems. Applications range from simple word processing to complex modeling and real-time control. Within many railroads, however, serious debates address the need for microcomputers, the types of applications that are appropriate, the integrity of their data bases, and other important issues. Nevertheless, the rapid evolution of computer technology will provide a powerful impetus for railroads to install microcomputers or computer networks that give employees access to the kinds of flexible, powerful software that are now available for microcomputers.

Microcomputers and microcomputer applications are becoming more common within the U.S. rail industry. Applications range from simple word processing and filing to complex operations planning models. The power of the widely available software is a great attraction to managers and planners at all levels of the organizations. The impetus for acquiring microcomputers has generally come from mid-level managers and planners who see the microcomputer as a welcome alternative to the difficulties and frustrations of working with their railroad's management information systems (MIS) department. In a number of cases individuals acquired their own microcomputers, used them for company business, and eventually convinced the railroad to acquire additional microcomputers.

No consensus exists, however, concerning the value or appropriateness of microcomputers within the rail industry. Railroads, which have long been leading industrial users of computers, do not view microcomputers as providing an increase in computing power. Some MIS departments view microcomputers as a threat to the integrity of their company's information systems or a costly means of providing distributed computing capabilities.

In this paper various ways that railroads have used microcomputers are summarized and a number of issues that will determine the extent to which the use of microcomputers is likely to spread throughout the industry are identified. Because of the rapid rate of change in this field, the published literature alone cannot be used for a review of the state of the art. The information in this paper, therefore, is drawn from numerous informal conversations with railroad officials, most of whom shall remain anonymous. Although the debate over the role of microcomputers is still raging, identification of the issues is more important than identification of the protagonists.

Much of the information concerning applications has been obtained as a result of participation in various research projects sponsored by the freight car management program (FCMP) of the Association of American Railroads (AAR) (1,2). In particular, the Massachusetts Institute of Technology (MIT) rail group designed the MIT service planning model (SPM) to illustrate techniques of operations and service planning in cooperation with the Boston and Maine Corporation (3) and the Santa Fe System (4). To promote the use of this model by other railroads, FCMP provided support for MIT to (a) reprogram it for a microcomputer, (b) promote its transfer to individual railroads, and (c) provide support services to an SPM users' group. By the end of 1982 SPM had been acquired by six U.S. railroads [Boston and Maine; Burlington Northern; Consolidated Rail Corporation (Conrail); Illinois Central Gulf Railroad Corporation; Chicago, Milwaukee, St. Paul, and Pacific Railroad Company (Milwaukee Road); and Southern Pacific Transportation Company] plus the Spanish National Railroads (5). In addition many other railroads [including Delaware and Hudson Railway Company, Maine Central Railroad Company, Chessie System, Seaboard System Railroad (Family Lines), Chicago and Northwestern Transportation Company, Missouri Pacific Railroad Company, Santa Fe, Union Pacific Railroad, Soo Line Railroad Company, Grand Trunk Western Railroad Company, Elgin Joliet and Eastern Railway Company, and Canadian National Railways plus several foreign railroads] made inquiries concerning SPM, which inevitably led to discussions