CONCLUSIONS

This paper has discussed the application of several computer-based models for the design and evaluation of traffic control system timing. There are abundant resources for the traffic engineer in this area, and the development of these resources has managed to stay ahead of the implementation. Current and future developments in model improvement and program documentation, together with the user training efforts of FHWA, can be expected to increase the use of the technology. It is hoped that this, in turn, will produce some real benefits--both to the traffic engineer who faces many staffing problems and to the motorist who faces many red lights.

REFERENCES

1. Transportation Research Center. Signal Operations Analysis Package. Univ. of Florida, FHWA Implementation Package 78-9, Jan. 1978.
2. Arterial Analysis Package Test Analysis Report. Transportation Research Center, Univ. of Florida, Gainesville, 1981.
3. F.V. Webster and B.M. Cobbe. Traffic Signals. Road Research, Technical Paper No. 56, London, 1966.
4. C.J. Messer and others. A Report on the Users' Manual for Progressive Analysis and Signal System Evaluation Routine--PASSER II. Texas Transportation Institute, Texas A&M Univ., College Station, Aug. 1974.
5. D.I. Robertson. TRANSYT: A Network Study Tool. Road Research, Rept. LR253, 1969.
6. D.I. Robertson and P. Gower. User Guide to TRANSYT Version 6. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, Supplementary Rept. 255, 1977.
7. P.P. Jovanis and A.D. May. TRANSYT6C Model Workshop, Student Workbook. Institute of Transportation Studies, Univ. of California, Berkeley, July 1977.
8. P.B. Hunt and J.V. Kennedy. A Guide to TRANSYT/7. Transport and Road Research Laboratory, Note UN78/11, 1978.
9. C.E. Wallace and others. TRANSYT-7F User's Manual. Transportation Research Center, Univ. of Florida, Gainesville, 1981.
10. E.B. Lieberman and J.L. Woo. SIGOP II: Program to Calculate Optimal, Cycle-Based Traffic Signal Patterns. FHWA, 1974.
11. D.B. Fambro. A Report on the Users Manual for Diamond Interchange Signalization--PASSER III. Texas Transportation Institute Texas A&M Univ., College Station, Rept. ITT-2-18-76-178-1, Aug. 1977.
12. K.G. Courage and others. Arterial Analysis Package Users Manual. Transportation Research Center, Univ. of Florida, Gainesville, 1981.
13. PASSER II-80. Texas Department of Highways and Public Safety, Austin, Dec. 1980.
14. J.D.C. Little, M.D. Kelson, and N.H. Gartner. MAXBAND: A Versatile Program for Setting Signals on Arteries and Triangular Networks. TRB, Transportation Research Record, 1981 (in press).
15. R.A. Vincent, A.I. Mitchell, and D.I. Robertson. User Guide to TRANSYT Version 8. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, Rept. 888, 1980.

NETSIM: A User's Perspective

Bradley R. Hagerty and Thomas L. Maleck

INTRODUCTION

The Michigan Department of Transportation (MDOT) employs about 4400 people within seven bureaus: executive, administration, aeronautics, finance, highways, transportation planning, and urban and public transportation. The Bureau of Highways is the largest bureau, containing seven divisions, the smallest of which is the Traffic and Safety Division. The function of the Traffic and Safety Division includes the more traditional traffic engineering practices of signal and signing control devices and accident analysis. However, another major function is the preparation and evaluation of preliminary geometric designs. The division's traffic engineers participate in the planning, design, implementation, operation, and evaluation of all highway and some transit projects.

The practice of traffic engineering is often more of an art than a science. A good standard analytic methodology is needed to accurately predict the impacts of various geometric and traffic control alternatives on highway capacity and traffic flow. The 1965 Highway Capacity Manual, although a major improvement, often proves ineffective in weighing subtle alternatives to improve the intersection capacity and the traffic flow on arterial corridors and networks. Different conclusions are reached based on the unique assumptions of different engineers. Often, incomplete documentation leads to subsequent reanalysis. New measures of effectiveness are needed to reflect current conditions and policies. Fuel consumption and exhaust emissions have become important issues. The emphasis has also shifted from pure capacity to overall network and corridor performance.

NETSIM APPLICATION

Why use a simulation model? Why NETSIM? MDOT's implementation of NETSIM was happenstance. We were looking for a better automated means of doing capacity analyses and stumbled on the documentation of UTCS-1 (the forerunner of NETSIM). The logic of UTCS-1 resembled that of our manual headway analytic procedure. The model was implemented as a tool for analyzing geometric alternatives. At present, the model is used for a wide range of traffic engineering and transportation planning activities. Since its introduction in 1978, more than 15 000 runs have been made by using about 500 networks. The Traffic Network Study Tool (TRANSYT) is also heavily used. TRANSYT is used to optimize green time allocation and offsets, which are input into NETSIM runs to simulate the effects of the signal timing alterations.

This paper provides some insight into our experiences in implementing and using NETSIM. The following is a potpourri of experiences and comments obtained from the engineers and technicians who actually use the model.

The NETSIM model software was converted in-house to our Burroughs 7700 computer in less than two months. The source code was incompatible with our computer, since it was developed for IBM-type systems. The conversion was not labor intensive or complicated. After the conversion to the Burroughs system, the model was tested for inconsistencies. The major problem encountered while debugging the program was the outdated documentation, which was effectively solved on completion of the users guide and the supporting documentation. The development of a progressive series of published sample runs would simplify model debugging and assist in user introduction to network coding.

PROBLEMS AND LIMITATIONS

Through intensive use, problems and limitations with the use of NETSIM have surfaced. The model is expensive to operate. High computer costs are attributed to the large core memory requirements of the program. Though computer costs normally range from $30 to $50 per program execution, several have cost more than $150 and a few more than $500.

Difficulty is experienced when attempting to simulate high-volume arterials, since the model limits the input volumes on entry links at 999 vehicles per hour, allows a maximum of only five input lanes at intersections, and limits the storage in right-turn pockets to nine vehicles. The application of NETSIM does not allow for dual turns, it cannot simulate four-way stop conditions with moderate to high volumes, and right- and left-hand merges from lane drops are unrealistically simulated. The model does not adequately accommodate fully-actuated signal controllers nor correctly balance lanes of queued vehicles at signalized intersections.

Desirable enhancements would include more clearly defined input volume ranges for pedestrian traffic; allowances for railroad crossing simulation, especially for simulating the effects of a light rail transit system on traffic flow; the effective modeling of signal preemption at railroad grade crossings; updated exhaust emission and fuel consumption data; and the ability to specify vehicular speeds on input links to prevent slow loading of the network. It would be desirable to have the network name printed on the fuel consumption and emissions output page. The documentation could be improved to provide a better explanation of output parameters, and a condensed report documenting the model's logic could be prepared for use in public hearings. Also, provisions for subsystem outputs would allow for the quick analysis of specific corridors and individual intersections.

In order for NETSIM to be operationalized, potential users had to be trained to ensure proper use of the model. Both engineers and technicians were trained. Initially, the first users of the model were self-educated by using the NETSIM Users Guide. This method of training is not cost-effective on a departmentwide basis. Thus, we conducted an in-house class on network coding and model execution. Other individuals were taught in a formal training session. At MDOT, an introductory training manual was developed. It includes a small example network used to expose the trainee to NETSIM. Less than 4 h of training are now needed when using this method.

More extensive training is needed for a user to grasp the full realm of NETSIM's capability. It is important to have users who understand the theoretical methodologies of the model. The users must grasp the significance of the output parameters so that coding or model inequities can be identified and program results interpreted correctly.

Several research studies required making multiple program runs on relatively small networks. This caused problems with our computer system operation because of the large core memory requirements of NETSIM. Greater efficiency was provided when we developed a new version of NETSIM with substantially reduced core memory requirements. The program arrays for link data, vehicle information, and the number of nodes was reduced to 20 nodes, 30 links, and 600 vehicles.

On the other hand, many large networks exceeded the maximum of 1600 vehicles per link during one time step. The network would reach the saturation level and abort the execution. Therefore, we expanded the capability of the program to simultaneously track and maintain statistics on 3200 vehicles.

As a result, we now maintain three separate versions of NETSIM for small, medium, and large runs. This increases program maintenance and user confusion. In order to overcome this, the program should be revised to internally adjust the array of sizes to fit the requirements of various networks as specified by the user.

The simulation use of NETSIM and TRANSYT requires two different networks to be coded. By using our automated drafting equipment we combined both networks into one. The computerized graphic contains NETSIM node numbers and link configuration, TRANSYT link numbers, and three hourly intersection volumes and the saturation rate for each node. Figure 1 is an example of a section network used for analysis

DATA ENTRY

At MDOT, more than 2000 potential computer system users share 180 CRT terminals and two card-punch machines. Instead of using punch cards, we input data on-line through CRT terminals into disk files containing card images. This method of data entry is more efficient than punching cards, but it is time-consuming and error prone. Due to the large size of many data files, errors of omission are generated.

In response to data entry problems, a forms display program was developed. It provides the user with a structured format with instructions to enter data in properly-sized data fields. The program automatically transfers the data into the proper order on disk data files. The program initially displays a menu in which the user specifies the appropriate form by depressing a function button. Below is a list of the forms and the data card types they generate.

1. Network Information Form
   - 99 Execution
   - 00 Title
   - 01 Network Name
   - 03 Network Priming
   - 60 Simulation Control
2. Link Information
   - 02 Link Name
   - 04 Link Geometry
   - 05 Link Operation
   - 07 Link Turning Movements
   - 08 Auxiliary Topology
   - 20 Volumes

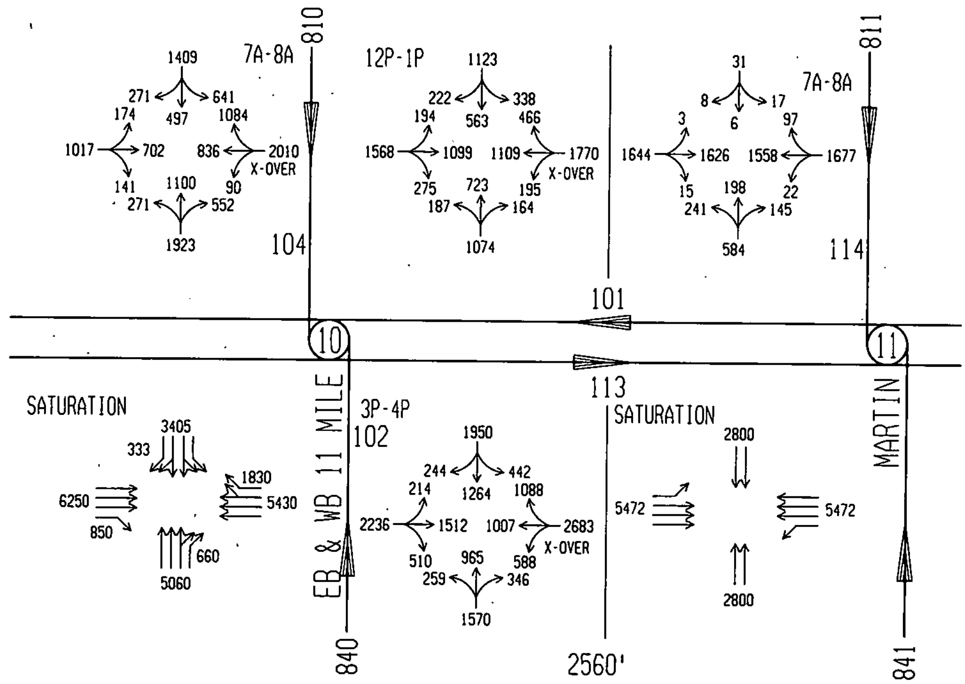

Figure 1. Example of combined NETSIM and TRANSYT computerized graphic.

3. Fixed-Time Signal Information Form
   10,11 Fixed-Time Signal Control
4. Actuated Controller Form
   15 Actuated Controller
5. Phase Information Form
   16A Actuated Phase
6. Phase Operation Form
   17 Actuated Phase Operations
7. Surveillance Information Form
   25 Surveillance Systems

The forms display program virtually eliminates the possibility of data being input into improper fields. The consolidation of many card types on one form reduces errors of omission significantly. The forms are limited to include only the most widely used card types. We are planning to expand the forms to include all card types and to allow a preprocessor program to edit the data before executing the model. The use of forms display has reduced our data entry time by 75 percent. In the long range, we hope to have the capability to interface a common data base to automatically create a coded network. This would greatly improve the data entry process.

CONCLUSION

The time for model simulation as a serious analytic tool has arrived. The growth and acceptance of NETSIM have exceeded all expectations. NETSIM was initially used as a supplement to reinforce traditional analytical methods. Today, the results from NETSIM analyses stand on their own merit.

Application of NETSIM Computer Simulation Model to Traffic Control Problems

WILLARD D. LABRUM

Utah's experience with the NETSIM (then UTCS-1) model began in 1973 with a need to determine whether to use traffic-actuated intersection control or a fixed-time progressive arterial control in a small city near Salt Lake. Application was made to the National Highway Traffic Safety Administration (NHTSA) for a project to investigate the use of models to study traffic flow problems.

On receipt of project approval, the UTCS-1 (NETSIM) model was obtained from FHWA and modified for use on the University of Utah's 1108 UNIVAC computer. A network consisting of two intersecting arterials and adjoining streets in the Salt Lake suburban area was selected to test the model. All available personnel from our office simultaneously counted vehicles traveling in and out of the network through the morning and afternoon traffic peaks. The results were then compared with simulated results to determine if the model could be applied to obtain simulated results that reasonably compared with the observed traffic. A link node diagram of the network is shown in Figure 1. Statistical comparisons of vehicle volumes were made (t-test),