Using TRANSYT for Evaluation

Sam Yagar and E.R. Case

A companion paper in this report summarizes the operational aspects of the UTCS-1/NETSIM models in terms of user-interface and evaluative characteristics (see preceding paper in this section). In the same study in which UTCS-1 was evaluated (1) the TRANSYT model by Robertson (2,3) was considered as an alternative evaluation model to UTCS-1.

Since TRANSYT was developed as an optimization procedure, it has to be able to evaluate various schemes in order to find an optimal one. This paper looks at the evaluative capability of TRANSYT and the effects of varying certain parameters when applying TRANSYT. While comparing the evaluative capabilities of TRANSYT and UTCS-1/NETSIM, this paper does not advocate TRANSYT as a replacement for NETSIM. It is noted that TRANSYT can only be considered as an alternative to NETSIM for certain types of applications. For example, TRANSYT cannot treat networks with more than one cycle length in a simple application. This is discussed in this paper along with other TRANSYT shortcomings and potential pitfalls that the TRANSYT user should avoid. Also discussed is the question of TRANSYT's sensitivity to time-aggregation of flow volumes and to the user's preestimate of link speeds (an input data requirement of TRANSYT).

DESCRIPTION OF TRANSYT FLOW MODEL

Unlike UTCS-1, which attempts to simulate the details of individual vehicle dynamics, TRANSYT is based on platoon dispersion. It considers the distribution of traffic over time at each single location of interest in the TRANSYT network. Examples of time-distributions of traffic are illustrated in Figure 1a. Figure 1 represents a typical cycle of the distribution of traffic over time just downstream of a traffic signal. In general, the peak level at the beginning represents queue service at the saturation flow rate, the second distinct level represents arrivals during the green phase after the queue has been served, and the lowest level represents turning movements onto the street during the red phase. TRANSYT applies a platoon-dispersion algorithm to the distribution in Figure 1a in estimating the behavior of these vehicles farther downstream. The effect is that the distinct pattern is lost and a dispersed distribution such as that illustrated in Figure 1b is obtained. To obtain the distribution of traffic entering an intersection, TRANSYT basically superimposes the distributions from any upstream locations whose dispersed platoons converge at that intersection. This combination procedure preserves the relative offsets of the platoons being superimposed. When the combined dispersed distribution is filtered through another traffic signal, it again attains a structure such as that in Figure 1a.

The above procedure represents an abstract type of simulation model, one that attempts to emulate rather than to simulate the traffic flows in a network. TRANSYT is easier to work with than NETSIM, as it requires less-detailed data and employs a simpler form of data input. Its performance evaluation procedure also requires much less computer time than NETSIM's. TRANSYT needs a quick evaluative procedure because it employs an iterative "optimization" model that has to perform many evaluations in optimizing the aggregated operation of the traffic signals in a network. Therefore, it has to be selective in choosing the aspects of a traffic network that it will model. The level of its success in this regard can be seen in the studies reported in Yagar (1,4).

COMPARISON OF TRANSYT AND UTCS-1 PREDICTIONS

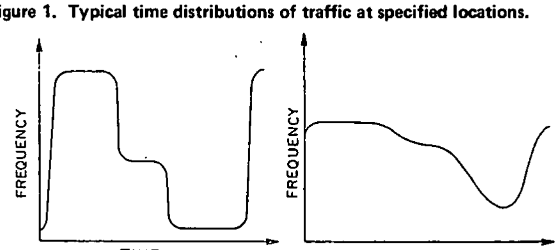
In a study conducted on Bloor Street in Toronto, speeds were predicted by the TRANSYT model as well as the UTCS-1 model. The simulation results were than compared with speeds obtained by floating-vehicle studies. The experimental results are illustrated in Figure 2. There is no discernible difference in quality of prediction relative to the standard of comparison, which was based on 10 floating-vehicle runs. Since it was not practically feasible to conduct the number of floating-vehicle runs required to ultimately find the better model, there was no discernible difference between the models. In fact, the models predicted an average performance, based on average data, while the floating-vehicle results were based on a number of realizations that reflect the varied measures of performance various users will encounter. In view of the results in Figure 2, the question is raised whether a practically sized sample of traffic data has a sufficiently small statistical variance to provide a better test of traffic control strategies than a carefully derived model and, in fact, whether the test of a model based on manually obtained data is even appropriate.

SENSITIVITY OF TRANSYT TO TIME-AGGREGATION OF FLOW VOLUMES

The effort required to simulate a sequence of short individual time slices is considerably greater than that required to simulate one longer period with aggregated demands from the viewpoints of data collection, data reduction, and computer processing (1). A study was therefore conducted on Toronto's Bloor Street network to determine TRANSYT's sensitivity to the time variation in the input flow demands as simulated by the use of short time slices. This was done by comparing the individual TRANSYT speed predictions for each of three sequential 20-min time slices to the speeds that would be predicted if these sequential flow levels were aggregated into a longer period.

The speeds predicted for the links of the Bloor Street network by using the aggregated peak-hour volumes are plotted in Figure 3. For comparative purposes the speeds predicted for the individual

Figure 1. Typical time distributions of traffic at specified locations.



(a) Just Downstream of a Traffic Signal (b) Some Distance Downstream of a Traffic Signal

Figure 2. Comparison of UTCS-1 and TRANSYT with floating-vehicle confidence intervals (shaded background).

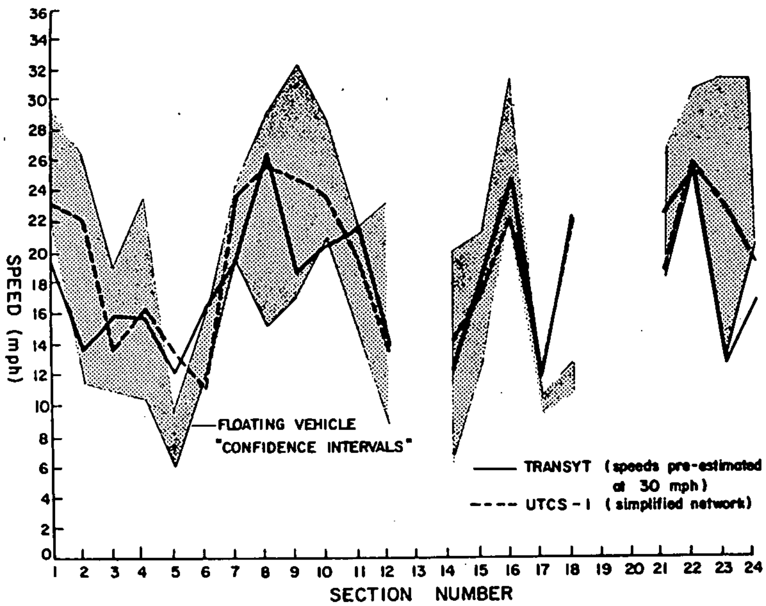
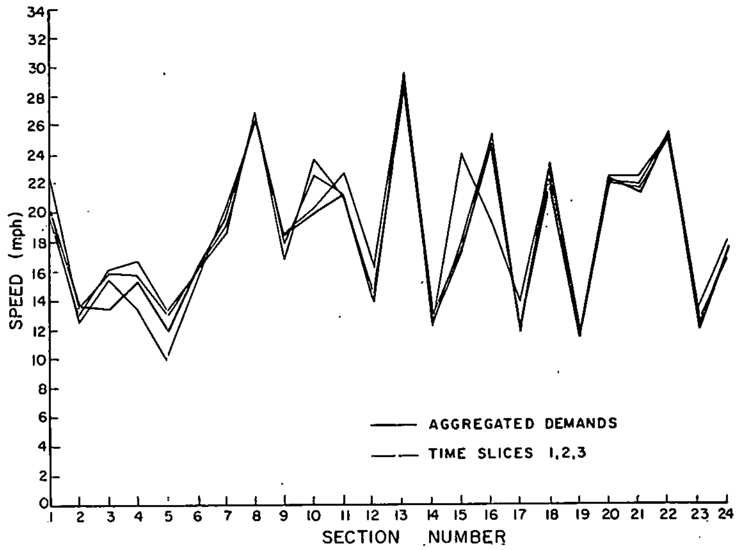


Figure 3. Comparison of TRANSYT results for individual time slices and aggregated demands.



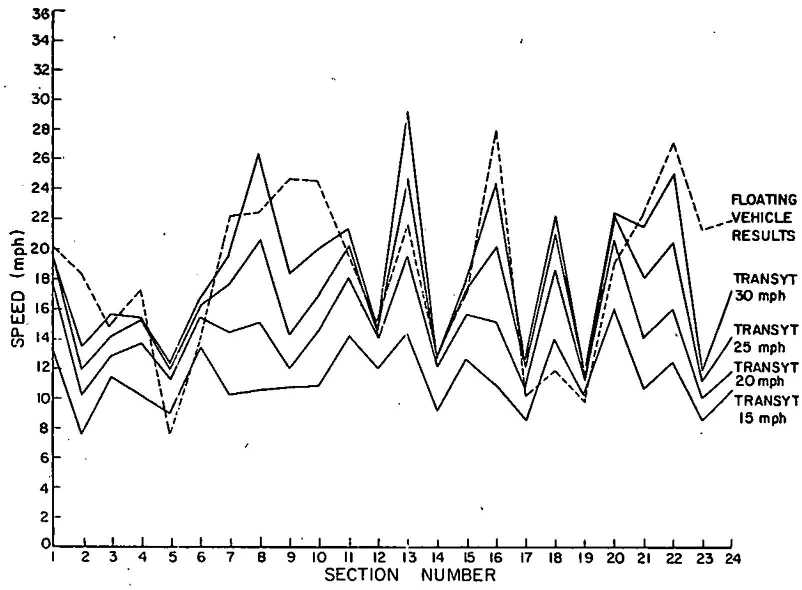
time slices are shown in the background. As with the UTCS-1 simulation (1), there are some inconsistencies where the results from using the aggregated demands are extreme, notably for links 3, 10, 21, and 23. However, these inconsistencies are less pronounced than with the UTCS-1 experience described in our other paper in this report. Also, it is conceivable that some travel time has been transferred to or from adjacent links in that case. It appears that TRANSYT, like UTCS-1, is not very sensitive to a reasonable level of time aggregation of flow volumes. This result is supported by more recent results obtained by using TRANSYT 7 in a network in Waterloo (5). It would therefore seem reasonable to use peak-hour volumes rather than shorter time slices in applying TRANSYT.

SENSITIVITY OF TRANSYT TO PREESTIMATION OF LINK SPEED

The definition of the term average link speed in the documentations (2,3) of the TRANSYT model is rather unclear. Rather than attempting to arbitrarily interpret this definition, a study was performed on the sensitivity of TRANSYT results to various interpretations of this term. This was done by assuming that the average link speeds on all links were the same unknown value and treating this value as a parameter. The intention of the substudy in this section was to observe the sensitivity of the results to the variation in this parameter and to calibrate the parameter for the Bloor Street network. This calibrated value could then also serve as a rule-of-thumb estimate of average link speed for other similar networks.

The operation of the Bloor Street network was simulated by using a common value of average link speed for all links in the network. Simulations were performed by using values of 15, 20, 25, and 30 mph for this parameter. The section speeds predicted by TRANSYT are plotted in Figure 4 for each of the values assumed for the average link speed parameter. The average floating-vehicle value is also plotted for each section. It is seen that TRANSYT is very sensitive to the estimated speed values. Therefore, the user should be quite careful in estimating them. Since the TRANSYT documentation

Figure 4. Calibration of average link speed parameter for TRANSYT with respect to floating-vehicle studies.



(2,3) does not seem to be specific enough for this purpose, we have adopted that value for average link speed (30 mph) that gives the best results relative to the floating-vehicle speeds. This is, in a sense, a calibration of our Bloor Street TRANSYT model to floating-vehicle results.

It is noted that only the evaluative capabilities of TRANSYT were considered in this study. Before using TRANSYT as a signal optimization tool, one should ensure that the preestimated speeds (or travel times) correspond to the values that the model requires, as TRANSYT's evaluations have been found to be sensitive to these preestimates. Its optimizations rely on its evaluations and would, therefore, be at least as sensitive. Since the optimization procedure determines optimal offsets, it would find them for the link speeds (or travel times) that it perceived. Incorrect preestimates would cause the TRANSYT optimization procedure to suggest incorrect offsets and therefore non-optimal solutions.

SOME POTENTIAL PITFALLS FOR TRANSYT USERS

Some minor problems were encountered in using TRANSYT 5. These potential pitfalls are described for the benefit of prospective TRANSYT users. [Some of these problems have been alleviated in more recent versions of TRANSYT.]

1. The program did not accept any negative offsets or any offsets greater than half the cycle length when specified on the type 88 cards. These were therefore specified on the type 12 cards along with the red-green splits.
2. Volumes entering a link from given upstream links as specified in columns 30, 45, 60, and 75 of the type 32 cards must be ≥10. This is stated in the manual, but no reason is given for it.
3. For both evaluative and optimization purposes, TRANSYT requires that a common cycle length be specified for all of the traffic signals. This can be overcome partially by partitioning the network so that all of the traffic signals of each subnetwork have a common cycle length. Problems of boundary interface between subnetworks still remain, however.
4. In treating closed loops, TRANSYT must have a sequence in which it is to treat the links in the loop. It must know the flow on a link before it can treat that link. However, the flow on each link in the loop will depend on the flow on another link in the same loop. In order to have a starting point, a dummy link must be defined, parallel to one of the links in the loop and with a link number that is the negative of its parallel link. [In TRANSYT 7, loops are generated internally--the user no longer inputs a link list.]
5. TRANSYT requires an estimate of average journey time or speed for each link (specified on card type 32, columns 31-35). There is difficulty in interpreting the definition of this link speed. This paper has attempted to provide some guidance in this regard.

CONCLUSIONS AND RECOMMENDATIONS

Although TRANSYT has been developed as an optimization model, its evaluative capabilities were found to be commensurate with those of UTCS-1, at least relative to the floating-vehicle standards to which they were compared. Since TRANSYT's data and computer requirements are less than those of UTCS-1, it is recommended that TRANSYT be seriously considered for any evaluative purposes to which it is applicable.

It would be desirable to have a TRANSYT type of model developed that could simulate the effects of queuing delays and spillbacks that occur due to limited queue storage capacities of the links. This would increase the scope for TRANSYT's applications.

TRANSYT's estimates of link speeds were found to be quite insensitive to aggregation of time slices, but very sensitive to the preestimation of link speed that the user must specify in the data input. For the Bloor Street network, a preestimate of 25 to 30 mph was required.

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Interactive Computer-Graphics User Interface for Traffic Simulation Models

Shih-Miao Chin

The sustained dependence on automobiles and decreasing availability of urban land has intensified the urban traffic problem. The practicing traffic engineer has long needed a problem-solving aid to deal with the increasingly sophisticated and complex urban traffic flow problem. In order to understand the behavior of an urban street system and to evaluate various corrective strategies implemented on such a system, one has to construct a model that best represents the internal relationship among components and accurately predicts the system performances. Due to the size of the urban street network and the random nature among vehicles and drivers, it is impossible to use an analytical approach to model such a system. On the other hand, a simulation model becomes appealing in modeling the large urban network. Furthermore, with the aid of modern digital computer technology, it is economical and practical to apply digital computer simulation modeling in solving vehicular movement problems on a large urban street network. Subsequently, many computer traffic simulation models have been developed in order to help the traffic engineer to deal with complex urban traffic flow problems. Among these, NETSIM, TRAFLO, INTRANS, and FREQ6PE are the most widely known.

ISSUES WITHIN TRAFFIC SIMULATION MODEL

Although computer traffic simulation models are useful in predicting the performance of urban networks, certain deficiencies quickly become apparent. A simulation model is only a simplification of an actual system. The results obtained from such a model are only as good as its capacity to reflect, in this case, a real-world urban street network. The vehicular flow within an urban network is a very complex phenomenon. In order to fully describe and/or accurately predict such a system, the traffic simulation model must be relatively complex. Consequently, computer traffic simulations require extensive input data bases.

One study (1) shows that 85 percent of the total cost of an initial NETSIM model run consists of information coding costs. For succeeding runs, approximately 65 percent of the total cost is in input data modifications. There are several probable reasons for such high input data preparation costs. Conceptually, most traffic simulations are modeled on a simplified link-node network. A node represents the intersection, and a link represents the street segment between intersections. Some microscopic models even require more detailed representation of traffic lane configuration within the link. Unfortunately, the digital computer cannot process such a link-node network. Every necessary piece of information must be digitized. A clerical service is required to "translate" the link-node network into rows and columns of machine-acceptable digital data. The intuitive physical meaning of the geometry and signal information is oftentimes lost during the translation process. The coder is consequently faced with the problem of constantly referring to the network diagram and user's manual. This is time-consuming and confusing. In addition, much of the required input data does not always follow a logical order. As a result, some input information is duplicated. This interrelated information requires the coder to recall prior input data, a situation which in many cases leads to inconsistencies. Finally, options have to be provided within the input field in order to accommodate a variety of situations. Such option spaces are often scattered throughout the input data field and may not follow any apparent pattern from the user's point of view. Consequently, many errors may result in the input data file. The traffic simulation model has the capability of detecting errors and prints out error messages. However, the error message is often in numerical format and does not clearly indicate the mistake made by the coder. More decoding and encoding clerical work is required between the network diagram and the alphanumerical input data listing.

On the other hand, the traffic simulation model also requires many different and sometimes conflicting measures of effectiveness (MOEs) to describe the overall performance of the network. The number of MOEs is frequently further complicated by the size of the network. As a result, voluminous outputs are generated by the computer. Although they are presented in an appealing format, they are sometimes difficult to interpret. While the outputs are useful in defining the existence of potential problems, it may be difficult for the user to understand how such problems have evolved during the simulation. It is difficult for such a large amount of information to be conveyed to and assimilated by the user within a short period of time.

INTERACTIVE COMPUTER-GRAPHICS USER INTERFACE

With regard to the problems associated with the use of computer traffic simulation models, interactive computer-graphics user interface, in conjunction with existing simulation packages, can aid in reducing or even eliminating many of the deficiencies. Since pictures convey more information than do tables and in a more easily assimilated manner,