Multipurpose Traffic Assignment Using Volume Restraint and Link Restraint for Application in Small Urban Areas

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The development of a new traffic assignment model consisting of a set of procedures for an urbanized area with a population of 172,000 is described. Historical, social, and economic data were used as input to conventional trip generation and trip distribution models to produce a trip table for network assignment. This fixed table was divided into three trip types: external-external, external-internal, and internal-internal. The methodology used to develop the new traffic assignment model assigned each of the trip types by varying the diversion of trips from the minimum path. External-external trips were assigned on a minimum path routing and external-internal trips were assigned with a slight diversion from the minimum path. Internal-internal trips were assigned with more diversion than external-internal trips and were adjusted by using iterative volume restraint and incremental link restraint. An all-or-nothing traffic assignment model, Dial's multipath model, a volume restraint model, and a link restraint model were joined in five different combinations for a statistical analysis to analyze each procedure used in the new traffic assignment model. The results of the analysis indicated that assigning trips by trip type using trip diversion and volume and link restraint produces a significant improvement in the accuracy of the assigned traffic volumes.

In current professional practice in urban transportation planning, the all-or-nothing technique is commonly used in traffic assignment. This technique assigns trips on the minimum-time route from an origin to a destination. Unrealistic trip routes in the all-or-nothing technique often result in assigned volumes that are at variance with known street volumes. This lack of correspondence between known and assigned street volumes suggests the need for a new look at traffic assignment.

Present state-of-the-art urban transportation modeling involves four basic steps: trip generation, trip distribution, modal split, and traffic assignment. The final step, traffic assignment, is the allocation of zone-to-zone trips (determined from trip distribution) to the paths taken from each zone to all other zones. The output of traffic assignment consists of synthetic volumes on the links in the transportation system. Calibration consists of matching comprehensive 24-hr traffic counts to synthetic volumes from the models and is performed during the traffic assignment step.

The traffic assignment phase in the urban transportation planning process is based on user assumptions and model limitations in the calibration procedure. These assumptions and limitations result in errors in the existing or future assignment of trips to alternative transportation systems. The user assumptions made by the planner in the calibration procedure may be imposed by an abstraction of network travel behavior, whereas model limitations are due to restrictions inherent in the planning models themselves.

User assumptions may include the following:

1. The route selection criteria (speed, distance, cost, and diversion) are the same for all routes.
2. When speeds are used for route selection, only one set of speeds is used for all types of trips.
3. There is no distinction of trips by type for route selection.
4. For a majority of studies all trips are assumed to take the minimum-path route.

Model limitations may include the following:

1. Trips start and end at one point in a zone.
2. Intrazonal trips are not assigned to the network.
3. Because a limited street and highway system must be used, some streets are eliminated from consideration.
4. There is no link restraint option in existing assignment procedures that restricts overloaded links in the calibration process.

In addition to errors in the assignment phase, two other types of errors can contribute to error in calibration:

1. Sampling error in the collection of origin and destination data in the home interview surveys.
2. Errors in the ground counts used to calibrate the traffic assignment model.

These types of errors reduce the accuracy and credibility of the traffic assignment models, the output of which affects costly decisions on transportation projects and priorities. Because of the importance of allocating a given set of trips to a specific transportation system, it is imperative that more accuracy and credibility be established in the traffic assignment phase.

The objective of this study is to develop a traffic assignment procedure that assigns link volumes that provide greater accuracy and credibility of calibration in small urban areas. The new traffic assignment model will

1. Use a more efficient route selection process based on more than one set of values (speed, distance, cost, and diversion factor);
2. Use more than one set of speeds in the route selection process;
3. Use trip type to help determine route selection; and
4. Use volume restraint and link restraint in the calibration process.

If the previously mentioned traffic assignment model can be calibrated for one planning area, then

1. Calibration of a traffic assignment model will be systematic and provide more accurate results,
2. Turning movements for design can be given more credibility,
3. Construction priorities can be better determined,
4. Alternative systems can be tested with link restraint for overcapacity or overcount movements, and
5. New routes will have more reliable assignments.

REVIEW OF LITERATURE

Assigning a trip matrix by trip type and purpose has been suggested in the literature but relatively few articles are available. Edwards and Robinson (1) discuss the possible effects of assigning trip tables by purpose and time of day by using different weights for different impedances. Manheim (2) suggests that there are different traffic patterns for different trip purposes. Brand (3) also offers some support for these suggestions, referring to an ordering of travel decisions based on trip frequency, time of day, destination, mode, and path. Although these authors have made suggestions for traffic assignment by purpose, the literature shows little reported research. Some headway, however, has been made in reference to long or external-external trips.

Taylor (4) suggests that a coarse network could be adequate for assigning longer trips. Newell (5) also discusses trips as short, intermediate, and long in relation to trip length and type of road classification. Actual assigning of long trips has been done in the TRIMZONE computer program (6). In that procedure a minimum path is used to assign trips and capacity restraint can be applied after loading of a specific number of districts or zones. A procedure discussed by Low (7) assigns external-external trips separately and determines link volumes one link at a time.

These procedures are used for large and small urban areas but do not designate the size of the urban area to which the models are to be applied. In most transportation studies the size of urban area to which the traffic assignment models are to be applied is not specified. In assigning external-external traffic to a network, urbanized-area population could have an effect due to a decline in the percentage of through trips as population and network complexity increase (8).

The literature on volume restraint is sparse, but Poole (9) notes a disadvantage of the capacity restraint program in the FHWA battery of computer programs. Specifically, speed is overadjusted and this causes oscillation of assigned volumes. In addition, Bell, Benson, and Stover (10) use a traffic assignment method that can adjust impedances if the assigned volume does not equal the traffic counts. Beilner and Jacobs (11) found that traffic assignment should consider different behavior of drivers along with traffic volumes.

Traffic counts were used by Low (7) to help develop an internal volume forecasting model, and JHK and Associates (12) and R.H. Pratt Associates (13) have developed manual techniques to reallocate travel of future assignments by using average daily traffic and capacity of each link.

METHODOLOGY

The first three steps in urban transportation modeling, including trip generation, trip distribution, and modal split, are used to produce a single fixed origin-destination trip table of all trips in the planning area. This trip table is then used as input to the traffic assignment step. The principal output of the traffic assignment model includes link traffic volumes, which are compared with actual traffic volumes. This section describes the traffic assignment methodologies and analytic techniques used to pursue the objectives of the research.

Research Study Area

Winston-Salem, North Carolina, was used as the planning area for this study because it has a good balance of varying trip types and highway facility classifications. In addition, the planning area and network are large enough to support varying types of traffic assignment techniques by different trip types. Another reason for using Winston-Salem was the availability of a reliable data base of existing traffic volumes.

The Winston-Salem planning area has a population of about 172,000 people. The economic base is primarily a manufacturing economy with strong influences from banking and educational institutions. In the planning area there are 197 internal traffic generation zones and 39 stations at the cordon.

Screenlines

Two screenlines were developed within the area to test the completeness and reliability of the travel data. The location of each screenline was chosen to minimize the number of streets it crosses and to allow as little opportunity as possible for a vehicle to cross it more than once during a single trip. In the Winston-Salem urban area, screenline A is in a north-south direction and screenline B is in an east-west direction.

Data used to develop a 1975 fixed trip table as input to the new traffic assignment model were obtained from 1964 data from Wilbur Smith and Associates (14). A detailed analysis of the previously described procedure is outlined in technical reports (15,16) for the Winston-Salem Urban Area Transportation Study.

New Traffic Assignment Model

The primary objective of this research was to formulate a new traffic assignment model that would consist of a set of traffic assignment and trip diversion procedures and would more accurately duplicate actual ground counts. The procedure used to develop the new traffic assignment model assigned the trip table in three steps by varying the diversion of trips from the minimum path. External-external trips were assigned on a minimum-path routing, and external-internal trips were assigned with a slight diversion from the minimum path. Internal-internal trips were assigned with more diversion than external-internal trips and were adjusted by using iterative volume restraint and incremental link restraint. The results of the different traffic assignments were added together and compared with 1975 ground counts for the Winston-Salem urban area. The procedure used to develop the new traffic assignment model is shown in Figure 1. The computer programs UROAD and LOADVN were used to assign all trips. Speeds were adjusted by using a special written version of the HRMOD computer program.

External-External Assignment

External-external trips were assigned in all cases to the minimum path by using the all-or-nothing assignment concept. The all-or-nothing concept was used on the assumption that trips passing through the urban area were assumed to be better planned and that drivers will generally travel on the minimum path in order to save time. It was assumed that external-external trips would find the quickest route through the urban area. Out of a total of 636,407 trips in the Winston-Salem urban area in 1975, 19,548 were external-external trips.

External-Internal Assignment

External-internal trips were assigned by using Dial's multipath assignment technique (17). Dial's technique was used because it has the ability to assign trips to different paths. An advantage of the technique is that trips can be assigned to different paths by varying a user input parameter (θ)

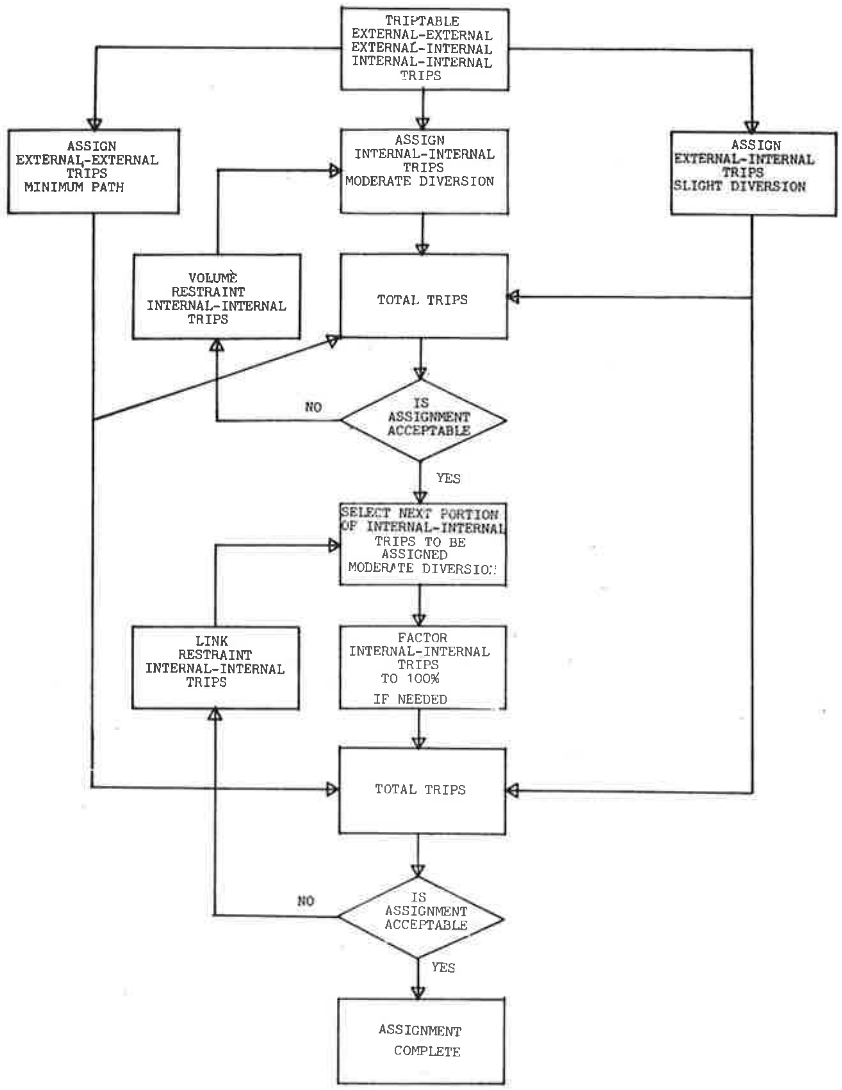


Figure 1. Procedure used to develop new traffic assignment model.

in the algorithm. As the value of θ increases--10 being the largest value and 0 the least value--the probability of trips being diverted from the minimum path decreases. Therefore, smaller values of θ tend to divert more trips from the minimum path than do larger values.

External-internal trips were diverted slightly from the minimum path by using Dial's technique. Guidance on the selection of θ, the diversion factor, was provided by Edwards and Robinson (1) and Morris (18). Morris (18) recommends a value of θ between 0 and 2, and Edwards and Robinson (1) recommend a value of 0.002. Because an exact value of θ for planning areas of different sizes has not been determined, the θ value was assumed to be a relative value and was specified to reflect a slight diversion for external-internal trips from the minimum path. A value of θ of 0.5 was chosen.

Guidance on the selection of cost of time and cost of distance was provided by Edwards and Robinson (1), who suggested that the traffic assignment model they were using responded more to changes in the impedance function than to changes in the value of θ. Edwards and Robinson (1) also found that when travel time alone is used in the impedance function the number of trips on the minimum paths increases with an increasing value of cost of time. This suggests that there is less possibility of overloading minimum-time paths on the street system if smaller values of cost of time are used in the impedance function. Therefore, a low value of cost of time of $0.50/hr was used to help obtain a slight diversion from the minimum path.

Trips originating inside the urban area and destined outside the urban area or vice versa (internal-external or external-internal trips) were assumed to be well selected. However, some alternative routes other than the minimum path will be chosen as a result of drivers accepting a longer route because the differences for alternative routes are not closely perceived or because drivers place different values on the number of stops and the quality of roads. In addition, external-internal trips are assumed not to be affected by existing street volumes. The number of external-internal trips in the Winston-Salem urban area in 1975 was 159,296.

Internal-Internal Assignment

Internal-internal trips were assigned by using Dial's multipath assignment technique (17). Dial's algorithm was used for this assignment for the same reason that it was used in the external-internal assignment--namely, the ability of the model to provide a better reflection of actual trip-making behavior. A moderate trip diversion factor of 0.05 for θ was used to reflect more diversion than external-internal trips. Cost of time and cost of distance factors were \$2.40/hr and \$0.08/mile, respectively. These values were used because research reported by Edwards and Robinson (1) indicated that increasing the relative weighting for distance over time has the effect of improving the loading on non-Interstate and arterial routes where internal-internal trips would constitute the majority of trips.

Volume Restraint

Volume restraint was applied to adjust the speeds on internal-internal trips. Volume restraint was used instead of capacity restraint for varying reasons. Volume restraint has certain advantages over capacity restraint because capacity restraint overadjusts speeds, which causes volumes to oscillate between assignments. In addition, in calibrating a network, the existing volume on the street represents actual base year flow whereas the capacity on the street represents the maximum number of vehicles that can be moved on that street. Because the purpose in calibration is to match the existing street volumes, volume restraint makes it possible to calibrate a network with more accurate volumes.

Links were adjusted by using a formula developed by Smock (19, p. 60) in 1962. Smock's original formula, $I_a = I_o e^{(V/C - 1)}$, was adjusted by using the reciprocal of I_a/I_o to obtain an adjusted speed instead of an adjusted time. The new formula is expressed as

$$I_a = I_o/e^{(V/C - 1)} \quad (1)$$

where

I_a = adjusted speed,
I_o = original speed,
V/C = volume-to-count ratio, and
e = base of Napierian logarithm.

To reduce oscillating effects of radial speed changes, the adjusted speed is weighted with the previous assignment speed by using the formula, $0.75(I_o) + 0.25(I_a)$ = new assignment speed.

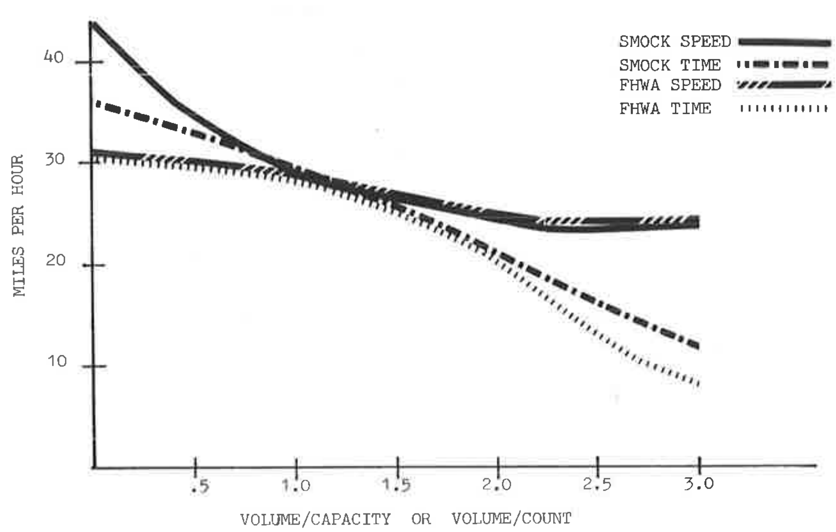
In Smock's formula speed is the impedance parameter. By using speed as the impedance parameter instead of time, speed changes are made to give an approximate balance in providing more or less attraction to underloaded and overloaded links. Smock's curve (19) was favored over the FHWA curve (20) because the FHWA curve provides more attraction away from heavily loaded links and practically no attraction to underloaded links. Smock's curve, on the other hand, provides more balanced adjustment because it uses speed as the impedance parameter. Figure 2 shows the relationship between Smock's curve and the FHWA curve by using speed and time as the impedance parameter for 30 mph. (Time curves are in miles per hour so that all four curves can be compared on the same scale. The distance for each time impedance section is assumed to be 1 mile.) The volume-restraint iterative assignment was applied to the network five times by using internal-internal trips.

Figure 2 indicates that adjusting speeds with the Smock impedance curve gives more balance in speed adjustments. On the other hand the FHWA curve (time) provides more attraction away from heavily loaded links and practically no attraction to links that are underloaded. Because the Smock curve using speed does offer a much larger adjustment for V/C less than 1.0, it can be seen that these speeds used for calibration are used as friction factors. This provides a greater and more rapid balancing effect in the network.

Link Restraint

After the preceding iterative assignment for volume restraint was completed, internal-internal trips were adjusted by using an incremental link-restraint assignment. This procedure was used to provide overloaded links with alternative route choices. Twenty percent increments of internal-internal trips were assigned and added to external-external and external-internal trips to check against ground counts after each incremental assignment. If the volume assigned to a link was larger than the actual ground count, the impedance was adjusted by doubling the travel time on that link. This is the formula of Bovy and Jansen (21) for finding an impedance at capacity. This phase of the new traffic assignment

Figure 2. Comparison of Smock and FHWA curves by speed and time for 30 mph.



model is beneficial because there is the possibility of using attractive alternative routes that were not used in the volume-restraint assignment.

RESULTS

The new traffic assignment model was evaluated for its capability to duplicate existing traffic counts on the street system of the Winston-Salem urban area. Screenline comparisons, traffic assignment procedure comparisons, and street volume comparisons were the three analytic techniques used for model validation and evaluation.

Screenline Comparison

In calibrating and validating traffic models, screenlines are one of the most effective means of determining whether the total amount of travel on the network is correct. In this study, two screenlines were used. The assigned volumes for the new traffic assignment model were compared with the comprehensive daily traffic counts on the two screenlines in the Winston-Salem urban area. The screenline totals in the new traffic assignment model, given in the following table, are the summation of the external-external, external-internal, and internal-internal assignments, where volume restraint and link restraint are used for adjustment (the critical value of χ^2 at 0.05 level of significance is 3.84):

Screenline	Actual Daily Traffic Count	Estimated New Traffic Assignment Model Daily Count	χ^2
A	226,572	226,282	0.372
B	130,590	130,916	0.812

The χ^2 test was used to check for variation in actual versus synthetic screenline crossings in the planning area. The χ^2 test is a goodness-of-fit measure: low values of χ^2 indicate a good fit and large values indicate a poor fit. A χ^2 value is found by using the following formula:

$$\chi^2 = \Sigma(O - E)^2/E \qquad (2)$$

where O is the observed value and E is the estimated value.

The χ^2 values in the preceding table compare the actual daily traffic counts with the daily synthesis counts of the new traffic assignment model for the two screenlines in the Winston-Salem urban area. The results at the 0.05 level of significance indicate no statistical difference between the two counts for either screenline.

Comparison of Traffic Assignment Procedures

To evaluate the procedures in the new traffic assignment model and to check for improvements over conventional assignment techniques, an all-or-nothing traffic assignment model, Dial's multipath model, a volume-restraint model, and a link-restraint model were joined in five different combinations (see Table 1) and used to assign external-external trips, external-internal trips, and internal-internal trips. To check for improvement over conventional traffic assignment techniques, assigned traffic volumes from each of the five models were compared on 1,050 street segments in Winston-Salem for their ability to duplicate actual ground counts. Then each of the four models involving traffic diversion, and in two cases link and volume restraint, were compared with the base all-or-nothing assignment of all trips.

Table 1. Model combinations.

Model	Definition
1	Base comparison model with all-or-nothing trip assignment
2	All-or-nothing assignment of internal-internal and external-external trips and slight diversion of external-internal trips
3	All-or-nothing assignment of external-external trips, slight diversion of external-internal trips, and moderate diversion of internal-internal trips
4	Same as model 3 but with five iterations of volume restraint on internal-internal trips
5	Same as model 4 but with five incremental assignments of link restraint on internal-internal trips

The Fisher F-test was next used to compare each of the traffic assignment procedures with the base traffic assignment method. This test was used to check the equality of variance in each of the traffic assignment methods. By using the Fisher F-test we are assuming that the difference between actual counts and synthetic counts by the various models is normally distributed. In addition, the quantity degrees of freedom (DOF) is assumed to be the linear difference between models. Both of these assumptions are not strictly true. However, because there are a large number of observations (1,050) and the observed differences are so large, the failure of the above two assumptions to be strictly true is of small consequence. The F-value is found by using the following formula:

$$F = [(N_1 \times VAR_1 - N_2 \times VAR_2)/DOF]/[(N_2 \times VAR_2)/N_2] \qquad (3)$$

where

- N_1 = number of street sections;
- N_2 = number of street sections minus DOF;
- VAR_1 = variance of the base traffic assignment model with which comparisons are made, developed from comparisons of actual ground counts versus synthetic volumes (the base traffic assignment method is an all-or-nothing assignment of all trips and is used in model 1);
- VAR_2 = variance of the traffic assignment model that is to be compared with the base traffic assignment model, developed from comparisons of actual ground counts versus synthetic volumes (models 2, 3, 4, and 5); and
- DOF = degrees of freedom related to changes in model parameters.

Table 2 gives the results of the statistical test.

By comparing each of the different traffic assignment models with the base all-or-nothing model, each procedural change in the new traffic assignment model can be analyzed by using the F-test. The row comparisons in Table 2 exhibit the variation in the F-value as each additional procedure is added to the new traffic assignment model. In each row comparison the results displayed at the 0.01 level of significance indicate that the four comparisons are statistically significant.

Street Volume Comparisons

Procedures used for traffic assignment are evaluated for their ability to duplicate actual ground counts on the network. The percentage root-mean-square error (RMSE) of estimated trips from actual trips is a suitable index for the accuracy of the new traffic assignment model. The expression for RMSE is

$$RMSE = \sqrt{[\Sigma_i^N (f_o - f_e)^2]/(N - 1)} \qquad (4)$$

Table 2. Comparison of traffic assignment procedures in new traffic assignment model.

Comparison	Models	N_1 and N_2	Sum of Squares	Variance	F-Value	Critical F-Value at 0.01 Significance Level
1	1	1050	1.811×10^{10}	17,255,424	42.1	6.63[a]
	2	1048	1.677×10^{10}	15,999,034		
2	1	1050	1.811×10^{10}	17,255,424	168.7	3.32[b]
	3	1045	1.002×10^{10}	9,591,211		
3	1	1050	1.811×10^{10}	17,255,424	280.4	2.41[c]
	4	1040	0.490×10^{10}	4,706,696		
4	1	1050	1.811×10^{10}	17,255,424	266.9	2.09[d]
	5	1035	0.372×10^{10}	3,594,816		

[a]DOF of (1,1049). [b]DOF of (4,1049). [c]DOF of (9,1049). [d]DOF of (14,1049).

Table 3. Comparison of street volumes in each traffic assignment procedure in new traffic assignment model.

	Total Trips[a]			
Model	Mean Base Volume[b]	Mean Test Volume of Estimated Trips	RMSE (%)	SD
1	8518	8552	48.8	4154
2	8518	8498	46.9	4000
3	8518	8408	36.4	3097
4	8518	8420	25.5	2169
5	8518	8544	22.3	1896

[a]Includes external-external, external-internal, and internal-internal trips.
[b]Actual ground counts.

where

f_o = actual ground counts,
f_e = estimated model counts, and
N = number of links for which comparisons are made.

The RMSE measures the deviation between the traffic volumes. The percentage RMSE is obtained by dividing RMSE by the average count of a group of traffic. Table 3 indicates how each traffic assignment procedure helped the street volume comparisons.

Possible Sources of Error

Additional sources of error in the traffic assignment phase may be inaccuracies in socioeconomic activity data or trip generation. Network representation of zone-to-zone access, major corridor movement that cannot be fully captured by the gravity form of trip distribution, and errors in ground counts are also possible sources of error.

FINDINGS

In this research a new procedure was developed for traffic assignment in a small urban area. The new traffic assignment model involved traffic assignment by trip type using the diversion of trips from the minimum path and assignment adjustment using volume and link restraint. A comparative analysis of the new traffic assignment model versus conventional assignment models indicates the following:

1. A screenline crossing check was used to compare known street volume crossings with the crossings resulting from the new traffic assignment model. There was no statistical difference between the two volumes.
2. A comparison of the all-or-nothing assignment of all trips with an all-or-nothing assignment of internal-internal and external-external trips and a slight diversion of external-internal trips provided a statistically significant improvement.
3. A comparison of the all-or-nothing assignment of all trips with a model consisting of an external-external all-or-nothing assignment, an external-internal slight diversion assignment, and internal-internal trips with a moderate diversion assignment showed that the diversion of external-internal and internal-internal trips produced a highly significant improvement.
4. An all-or-nothing assignment of all trips was compared with a model consisting of an external-external all-or-nothing assignment, an external-internal slight diversion assignment, and internal-internal trips with a moderate diversion with five iterations of volume restraint on internal-internal trips. The diversion of external-internal trips and internal-internal trips with volume restraint was found to provide a highly significant improvement.
5. The last comparison is an all-or-nothing assignment of all trips versus the completed new traffic assignment model. The new traffic assignment model consisted of an external-external all-or-nothing assignment, an external-internal slight diversion assignment, and an internal-internal moderate diversion assignment with five iterations of volume restraint and five incremental assignments of link restraint. The diversion of external-internal and internal-internal trips with volume and link restraint applied to internal-internal trips was found to provide a highly significant improvement.
6. Actual ground counts were compared with estimates from the new traffic assignment model for each procedure used. Each procedure was significant in helping to match actual ground counts.

CONCLUSIONS

This research has been concerned with the development of a traffic assignment model for an existing small urban network. The conclusions from this research are as follows:

1. The diversion of trips by type provides a significant improvement in the traffic assignment process.
2. Volume restraint significantly improves accuracy in the duplication of actual ground counts.
3. Link restraint is also significant in providing an additional refinement of model capacity to reproduce actual ground counts.

RECOMMENDATIONS

The new traffic assignment model involved the development of a traffic assignment model for the transportation network of a small urban area, but the modeling procedure may be adjusted for smaller or larger urban areas. An analyst familiar with a particular planning area could make assumptions as to varying types of traffic assignment by different trip types. As an urbanized area becomes larger in size more routes are available, driving patterns change, and more diversion for all types of trips may be appropriate. As an urban area becomes smaller, minimum paths may be the only reasonable routes to be considered and only the shortest route could be taken for all types of trips. By varying the size of the planning area and the amount of diversion of trips by trip type, one can hypothesize the different types of loading techniques.

Figure 3 shows some possible assignment procedures by planning-area population and diversion of trips from the minimum path. The curves in Figure 3 are based on engineering judgment from this current research effort and are not supported by actual research. An exact diversion value on the horizontal axis would depend on the route-choice behavior of the trip-making population and on the size of the transportation network and the urban-area population. The major emphasis of Figure 3 is that small urban areas of 10,000 and less would probably use a minimum path for all trips and very large urban areas of 750,000 or more would probably use a diversion from the minimum path for all trips.

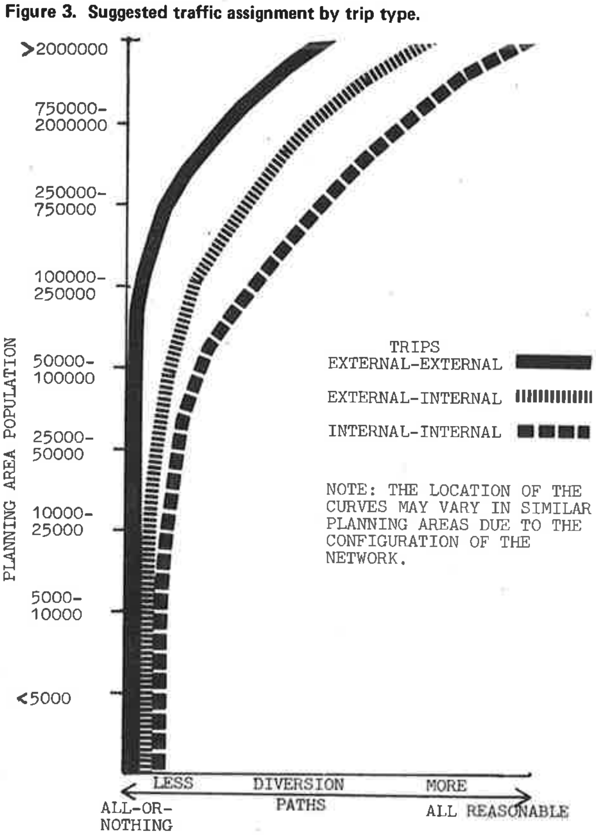
Recommendations for traffic assignments would be to load trips by type of trip to allow analysts to apply varying loading methods with the benefit of volume restraint and link restraint. In small urban areas this would help the analyst to develop a network traffic assignment model more efficiently and achieve more reliable results in turning movements, construction priorities, and alternative systems. Thus, the transportation analyst could respond to traffic assignment problems with more credibility. Transportation system management in urbanized areas could also benefit from the new traffic assignment model because it provides better estimates of traffic.

This research has been involved with the development of a traffic assignment model that has the capability to duplicate actual ground counts. The procedure for future assignment of trips would be the same as that of the new traffic assignment model. The only difference would be the substitution of capacities for counts.

The need for finding diversion values has been documented in this study. Further research should test different diversion values for variable planning-area populations for different trip types. Additional investigation should compare the effectiveness of volume restraint and capacity restraint in varying network size for different trip types in the calibration process.

Another research topic that needs additional investigation is applying link restraint to future networks within the forecast period--typically 20 years. Other investigation should include the advantages and disadvantages of applying the foregoing traffic assignment procedures to short-range transportation development of 5 years or less.

Figure 3. Suggested traffic assignment by trip type.



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Spatial Aggregation Effects in Equilibrium and All-or-Nothing Assignments

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The level of spatial aggregation (i.e., zone size and network detail) used in transportation analyses is commonly regarded as an important factor affecting the accuracy of the resulting estimates. However, the precise effects of the level of network detail are largely unknown. To investigate these effects empirically for the car traffic assignment module, an experiment was designed to study both the separate and combined effects of the level of detail and the type of assignment model. It involves the application of various assignment models at different levels of detail. Network models at three levels of detail—fine, medium, and coarse—were developed for the road network of Eindhoven, Netherlands (population 200,000). The results of equilibrium and all-or-nothing assignments are presented. This presentation is mainly confined to the sensitivity of link load estimates. For further clarification, effects on shortest route prediction are also discussed. The level of detail had a significant effect on load and route predictions with both assignment models. This effect proved to be consistent but diminishing: an increase in the level of detail always yields better results, but only marginal improvements can be obtained beyond a certain level. Compared with all-or-nothing assignments, equilibrium loads agree much better with traffic counts at all levels of spatial detail. Recommendations are given as to what combinations of level of detail and assignment model type should be applied in practice.

Transportation systems are usually quite complex. The analysis of such systems generally requires various simplifications because of time and money restrictions. Spatially, a transportation system is simplified into what is called a network model.

Many different network models of a particular transportation system can be constructed. An essential characteristic of a network model is its level of detail, which is mainly characterized by the numbers of zones and links included. It may be assumed that the level of detail greatly affects the time and costs involved in the analysis. Furthermore, the level of detail probably has a considerable effect on the results of the analyses (e.g., estimates of the plan's consequences).

An increase in the level of detail will presumably yield an improvement in the results at an additional cost. Therefore, the transportation analyst has to determine the appropriate level of detail by trading off the accuracy of the analysis and the analysis effort in the light of the specific planning problem to be solved. In practice, however, the optimal level of detail is hard to determine because knowledge of its effects on accuracy and costs is lacking.

In this paper results of empirical research into the effect of the level of spatial detail on car traffic assignment results are presented. The results of equilibrium and all-or-nothing assignments performed on network models with widely different levels of detail are presented and compared. The findings are also examined in relation to the accuracy of both assignment models as a function of the level of detail. They will assist the transportation analyst in selecting the optimal combination of network model and assignment technique, given accuracy requirements for the results. More detailed information on this research work and its results can be found elsewhere (1-4).

EXPERIMENTAL WORK

Experimental Design

The Dutch city of Eindhoven, with its nearly 200,000 inhabitants, was chosen for the case study. Various network models of the city were constructed at different levels of detail by systematically varying zone size and network detail. At each level of detail a number of complete assignments for peak-period car traffic were performed by using different assignment methods.

Three assignment models were applied at three network levels of the Eindhoven road system. Figure 1 shows the experimental design. It can be seen that the fineness of the zone system was adapted to the degree of network detail. Only assignment models used in current practice--all-or-nothing, equilibrium, and multiple-route assignment--were applied. The results presented, however, are confined to the load and route predictions of the equilibrium and all-or-nothing models.

Assignment Network Models

The road system was simplified by using the reduc-