Comparative Assessment of Travel Characteristics for Neotraditional Designs

MICHAEL G. MCNALLY AND SHERRY RYAN

The claim that transportation benefits can be derived from neotraditional neighborhood design is explored. Conventional transportation planning models are used as tools to evaluate the performance differences of two hypothetical street networks designed to replicate a neotraditional and a conventional suburban community. Relative transportation benefits are measured in terms of vehicle kilometers traveled, average trip lengths, and congestion on links and at intersections. This comparison provides an assessment of how well the two networks in question deal with trips generated by the activities that they serve. All aspects of the modeled communities are held constant except for the actual configuration of the networks. The results of this evaluation indicate that equivalent levels of activity (defined by the land uses within the community) can produce greater congestion with conventional network structures and that corresponding average trip lengths are generally longer. The ultimate goal is to determine if one network type, because of the nature of its design, can result in a more efficient transportation system. The results indicate that neotraditional designs can improve system performance.

The neotraditional design movement was largely originated by two urban designers, Peter Calthorpe and Andres Duany. Although their approaches are often described differently, that is, transit-oriented development and neotraditional neighborhood design, respectively, the content of the underlying concepts is very similar. This concept can be generalized as an attempt to reorient subdivision development toward patterns reminiscent of U.S. pre-World War II traditional communities. These patterns are based on mixed land uses, a highly interconnected street network (often in the form of a gridiron), and street design that accommodates the pedestrian and bicyclist equally as well as the automobile. Neotraditionalists are generally concerned with issues such as the degraded quality of life in the suburbs, a lack of conveniently assembled land uses, and the domination of automobile travel.

The term "conventional" is used in this paper to describe a fairly broad range of design practices whose beginnings can be traced back to the Garden City movement of the late 1920s. Current planning movements that fall under the category of conventional suburban design would be planned unit development (PUD) and cluster development, which became popular in the early 1960s. The original goal of these design practices was to provide a safe, peaceful environment removed from the overcrowding and automobile congestion of inner cities. Techniques used to achieve this goal include segregated land uses, hierarchical street networks, and extensive use of cul-de-sacs. One of the major purposes of conventional suburban design is to create an attractive living environment that is sustained by the convenience of automobile travel. The use of hierarchical traffic networks and cul-de-sacs is crucial in conventional design practices as a means of both providing accessibility to sometimes isolated developments and also removing potentially dangerous and unpleasant automobile traffic from the living environment.

Neotraditional planners generally claim that their design practices will result in reduced transportation impacts. The basic arguments are that neotraditional neighborhood design will reduce automobile dependence, increase public transit accessibility, and reduce travel distances and times (*1–3*). The arguments examined in this paper are the latter, namely, that this design concept will result in reduced vehicle kilometers and vehicle hours traveled.

Other more specific claims have been made in a paper presented by Kulash (*4*). He concludes that neotraditional street networks function more efficiently than conventional networks because (a) the large streets of a typically sparse conventional network operate under deficiency of scale, (b) turning movements are more efficient on the smaller streets associated with neotraditional networks, (c) the increased route choices offered by the typically dense neotraditional network make real-time route choice possible (drivers are not always forced onto a few large arterials), and (d) uninterrupted flow is more likely to occur in a dense network because smaller streets make it possible to have more unsignalized intersections.

In the following comparative assessment of alternative suburban designs, the neotraditional network will be referred to as the traditional neighborhood design (TND) network; the conventional network will be referred to as the PUD network.

HYPOTHETICAL NETWORKS

Description of Networks

The modeling exercise is based on two hypothetical networks developed to replicate a neotraditional and a conventional subdivision. The networks were developed with the guidance of several sources to ensure realistic networks and land uses (*5–10*). The hypothetical subdivisions are both approximately 1.3 km^2 (0.5 mi^2), and have approximately the same level of activity. Certain aspects of the two site designs, however, are not modeled here. For example, mixed land uses that would typically be found in neotraditional developments are not accounted for in this exercise. Also, the effect of certain design characteristics of the street environment such as street width, lane width, or landscaping cannot be directly modeled.

Institute of Transportation Studies, University of California, Irvine, Calif. 92717.

The characteristic of prime concern, therefore, is the shape of the networks.

Both networks are situated on intersecting collectors that break the developments into four equal quadrants. Each network is enclosed by arterials on the northern and eastern sides and by collectors on the southern and western sides (see Figures 1 and 2: unlabeled links are local streets). Both networks have approximately the same amount of land devoted to rights-of-way and housing. As seen in Table 1, approximately 30 percent of each network is devoted to rights-of-way, approximately 3 percent of the total land is made up of commercial areas, and approximately 60 percent of each network is devoted to housing.

Residential densities are also similar in both developments. Table 2 gives densities by quadrant in each network. Each development alternative has an identical number of residential units per quadrant. The amount of land devoted to rights-of-way varies slightly by quadrant; this contributes to the differences in the amount of land per dwelling unit. Most proposals for neotraditional development have been characterized by narrower rights-of-way, but with a denser grid. For this analysis, an equal trade-off is assumed. Further work is required to formally assess this trade-off and its potential impact on residential densities and trip rates. The networks were divided into 17 conventional traffic analysis zones. Table 3 summarizes zonal land use for each alternative network design. Figures 3 and 4 show the zoning system, including the location of external stations. The transportation facility types used in each network were identical in terms of right-of-way widths, lane miles, peak-hour capacities (*11*), and posted speeds. Table 4 illustrates the values assumed for creating the hypothetical networks.

Limitations of Networks

Efforts were made to create networks that would offer sufficiently general examples of both types of subdivision design. The intent here was to use generalized networks so that broad conclusions could be drawn rather than conclusions limited to specific networks. The fact that these networks are hypothetical, however, presents a certain randomness in the exercise. The street networks and arrangement of land uses could have assumed numerous different forms while still being described as neotraditional and conventional. To a certain extent, therefore, the results are restricted to these specific networks. It was not within the scope of this paper to compare a large number of networks from which truly generalized conclusions could be drawn. Rather, an attempt was made to begin with networks that would provide some reasonable basis

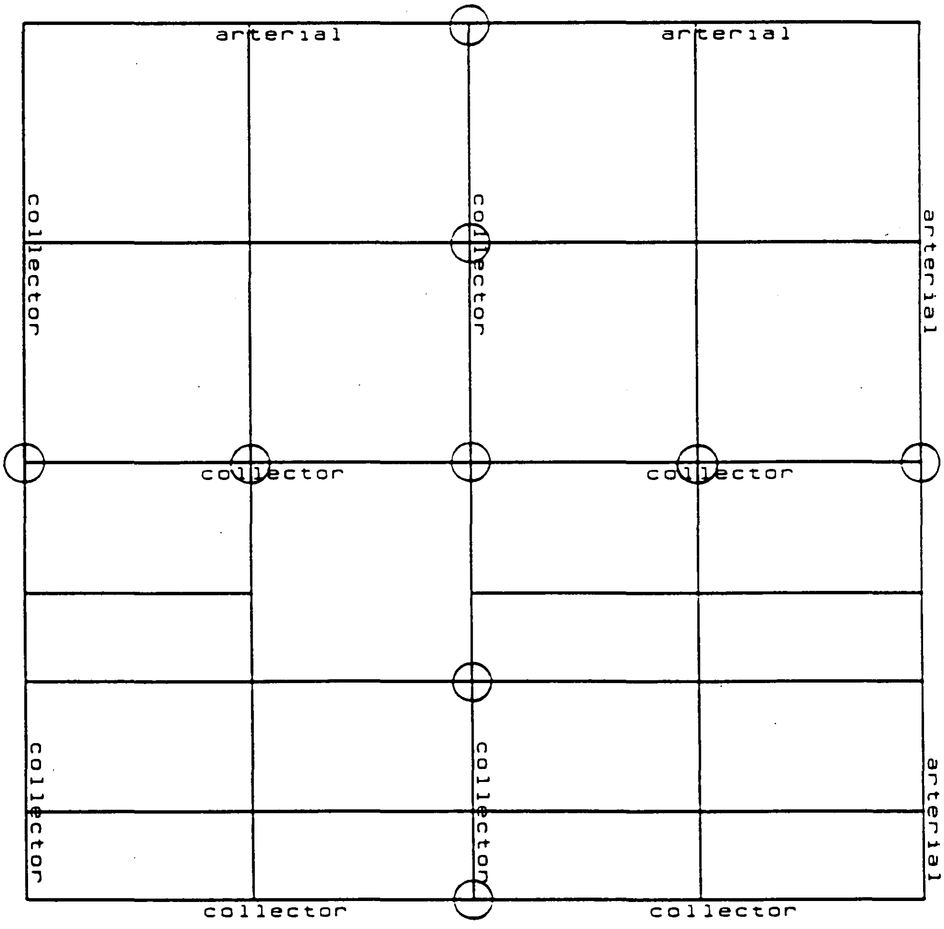

FIGURE 1 Neotraditional network design.

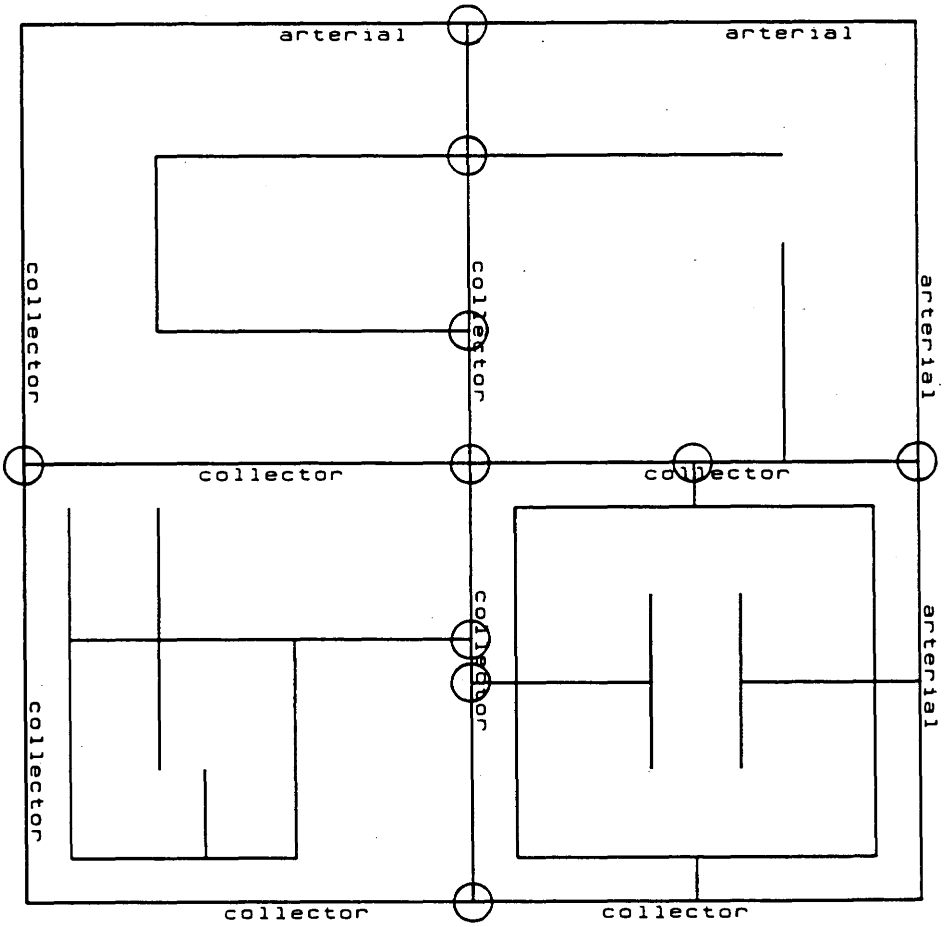

FIGURE 2 Conventional (PUD) network design.

for drawing general conclusions about the two design concepts in question.

COMPARATIVE ANALYSIS

Trip Generation

Trip generation for the study area was estimated on the basis of conventional land use trip rates, adapting rates developed by the city of Irvine, California (see Table 5). Other travel parameters assumed in this study were also based on those estimated for Irvine (*12*). Trip rates were applied to the land uses in the study area to produce estimates of total productions and attractions for the internal zones (1 through 17). These productions and attractions were categorized by the spatial orientation of the trip as (a) internal to internal (II), (b) internal to external (IE), and (c) external to internal (EI). To realistically simulate the distribution of trips in the study areas, it was assumed that a proportion of the trips would occur entirely within the area (II), and the remainder would have the production or the attraction outside the area (IE and EI). Eight external zones were created (see Figures 3 and 4). Because the external zone productions and attractions

TABLE 1 Summary of Land Use Percentages

LAND USE	TND[1]	PUDs[1]
Total Area of Development	439,649 m^2	439,649 m^2
Total Area devoted to R-O-W	131,784 m^2	128,439 m^2
Total Area devoted to Housing	261,152 m^2	264,498 m^2
Total Area devoted to R-O-W (%)	29.9	29.2
Total Area devoted to Housing (%)	59.4	60.2
Total Area devoted to Commercial(%)	3.4	3.4

1) 1 square meter = 10.76 square feet

TABLE 2 Land Areas and Residential Densities by Quadrant

QUADRANT	LAND USES	AREA (m^2)	DWELLINGS	DENSITY (m^2/DU)
Hypothetical Neotraditional Development Plan (TND)				
Southwest	School	11,617		
	Park	11,617		
	Housing	50,185	118 units	425
	R-O-W	19,516		
Southeast	Housing	70,631	144 units	490
	R-O-W	22,304		
Northwest	Housing	81,784	480 units	170
	R-O-W	11,152		
Northeast	Commercial	23,234		162
	Housing	58,550	360 units	
	R-O-W	11,152		
Hypothetical Conventional Development Plan (PUD)				
Southwest	School	11,617		
	Park	11,617		
	Housing	50,185	118 units	425
	R-O-W	19,516		
Southeast	Housing	68,401	144 units	475
	R-O-W	24,535		
Northwest	Housing	82,899	480 units	172
	R-O-W	11,288		
Northeast	Commercial	23,234		
	Housing	71,375	360 units	198
	R-O-W	6,691		

1 square meter = 10.76 square feet

TABLE 3 Land Uses by Zone

	TND		PUD	
Zone	Land Use	Quantity	Land Use	Quantity
1	Single family	36 SF units	Single family	34 SF units
2	Single family	38 SF units	Single family	28 SF units
3	Single family	36 SF units	Neigh. Park	1.2 km^2
4	Single family	36 SF units	Single family	36 SF units
5	Single family	44 SF units	Single family	36 SF units
6	Elem. School	600 students	Single family	56 SF units
7	Neigh. Park	1.2 km^2	Elem. School	600 students
8	Single family	36 SF units	Single family	36 SF units
9	Single family	36 SF units	Single family	36 SF units
10	Multi-family	120 MF units	Multi-family	90 MF units
11	Multi-family	120 MF units	Commercial	14,870 m^2
12	Commercial	14,870 m^2	Multi-family	90 MF units
13	Multi-family	120 MF units	Multi-family	180 MF units
14	Multi-family	120 MF units	Multi-family	60 MF units
15	Multi-family	120 MF units	Multi-family	120 MF units
16	Multi-family	120 MF units	Multi-family	120 MF units
17	Multi-family	120 MF units	Multi-family	120 MF units

1 square meter = 10.76 square feet

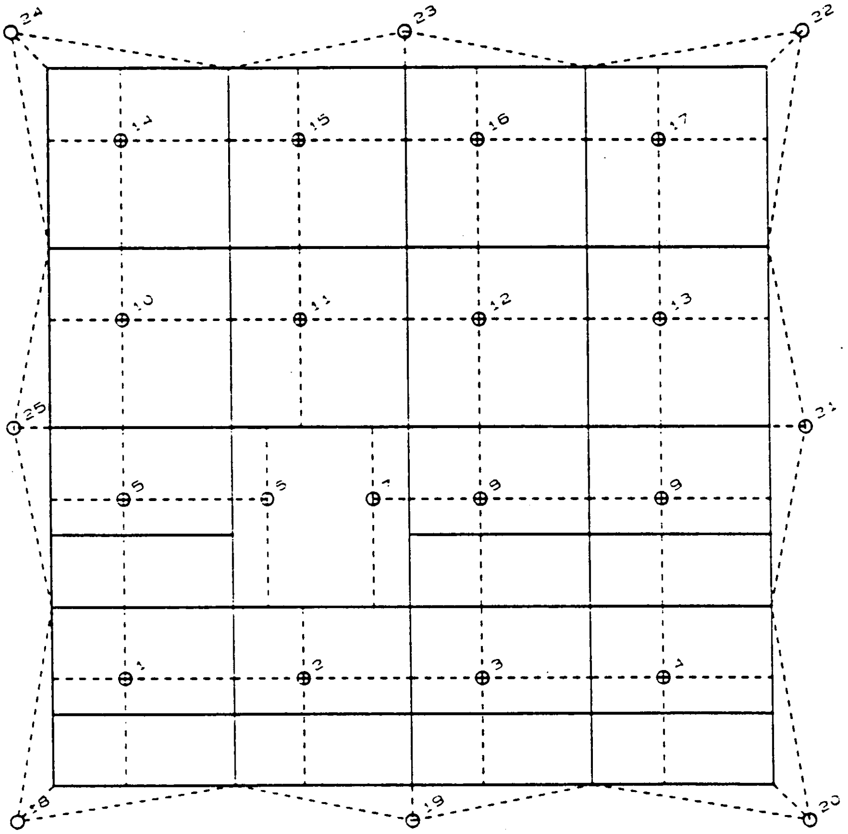

FIGURE 3 Neotraditional zone system.

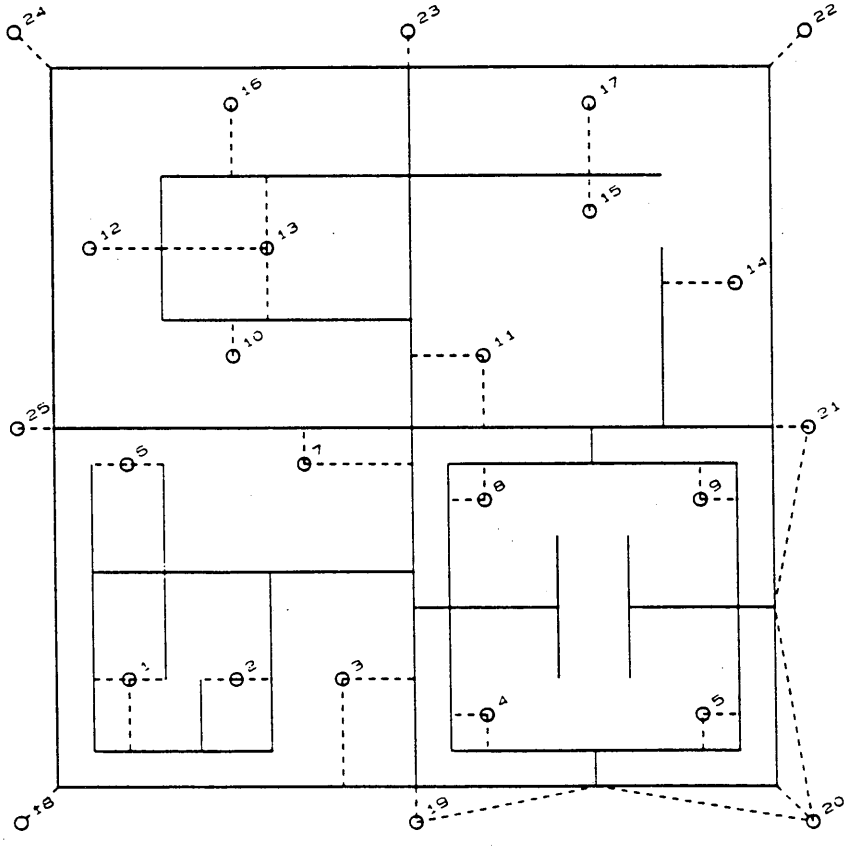

FIGURE 4 Conventional (PUD) zone system.

TABLE 4 Facility Characteristics (TND and PUD Networks)

Facility Type	1 Hour AM Peak Cap. (vph/lane)	R-O-W Width (m)	Number of Lanes	Speed (kph)
Arterial	800	33.5	2	64.4
Collector	600	24.39	2	48.3
Local	400	18.29	1	32.2

1 mile = 1.61 kilometers; 1 meter = 3.28 feet

could not be estimated as a function of nonspecified land uses (a shortcoming of modeling an isolated hypothetical subarea), they were estimated in proportion to the land uses within the study area. Specifically, an assumed percentage of the internal productions and attractions were generated outside the study area on the basis of assumptions of travel behavior and average travel times for each trip purpose. Trip length frequencies were adopted for each trip purpose (*12*) and used to determine the percentage of generated trips longer than 5 min that were assumed to cross the study area boundary (see Figure 5).

Because the study area is just less than 1.3 km^2 (0.5 mi^2), it was assumed that trips longer than 5 min would have to either begin or end outside the study area. A vehicle traveling at a constant 40.25 km/hr (25 mph) would traverse the study area in approximately 1 min; 5 min was used to account for delays or indirect routes. The area under the trip length frequency curve and to the left of the point on the x-axis depicting 5-min-long trips was assumed to represent the percentage of trips that would begin and end within the study area, corresponding to II trips. The remaining percentage was assumed to represent trips with one trip ending outside the study area or trips greater than 5 min, corresponding to IE and EI trips. Once these percentages were established for each trip purpose (see Table 6), they were applied to the original set of total productions (P's) and attractions (A's) by purpose. Zones 1 through 17 are internal zones; Zones 18 through 25 are external. Applying these splits to the total P's and A's resulted in estimates of P's and A's by trip type for each network.

Through trips were estimated with the intent of modeling realistic traffic volumes along the arterials and collectors found in the study area. Through trips were not distributed using the gravity model; rather, they were assigned to specific origin/destination (O/D) pairs and added directly to the origin/destination matrix. The method used to determine through trips was similar to that used for splitting P's and A's into II, IE, and EI trips. The trip length frequency curves seen in Figure 5 were used to determine that approximately 60 percent of home-based-work (HBW), home-based-other (HBO), and non-home-based (NHB) trips were longer than 20 min. By assuming that the study area is surrounded by similar types of areas, it could be assumed that 60 percent of the trips from each surrounding area would be longer than 20 min, a certain percentage of which would pass through the study area. It further was assumed that for each of the eight surrounding areas, one-fourth of the trips longer than 20 min would pass through the study area. The through trips added to the a.m. peak O/D matrixes were obtained by reducing the total through trips by a factor of 0.39 (*12*).

Because the neotraditional network provides greater accessibility than the conventional network (a 60 percent increase in connectivity measured in terms of the number of entrance and exit links), it was assumed that a greater number of through trips would be present with the TND design. At the site-specific level of analysis (as opposed to regional-level analysis), it is difficult to estimate the number of these trips. An increase in through trips for the TND design of 5 percent was assumed.

Trip Distribution and Assignment

Trip distribution was completed using a standard singly constrained gravity model routine. P's and A's for nine trip types were used:

1. Internal to internal (HBW, HBO, and NHB),
2. Internal to external (HBW, HBO, and NHB), and
3. External to internal (HBW, HBO, and NHB).

Friction factors from the city of Irvine were adopted for this study (see Figures 6–8). Using these factors could have introduced some error because they were developed for a study

TABLE 5 Trip Generation Rates (*12*)

LU Code	Land Use	Units[1]	Rate
12	Residential - Low Density	DU	10.00
15	Residential - High Density	DU	6.30
21	Community Commercial	1000 ft^2	70.00
72	Neighborhood Park	Acre	5.00
93	Elementary School	Student	0.75

1) 1000 ft^2 = 92.9 m^2; 1 acre = 3872.3 m^2

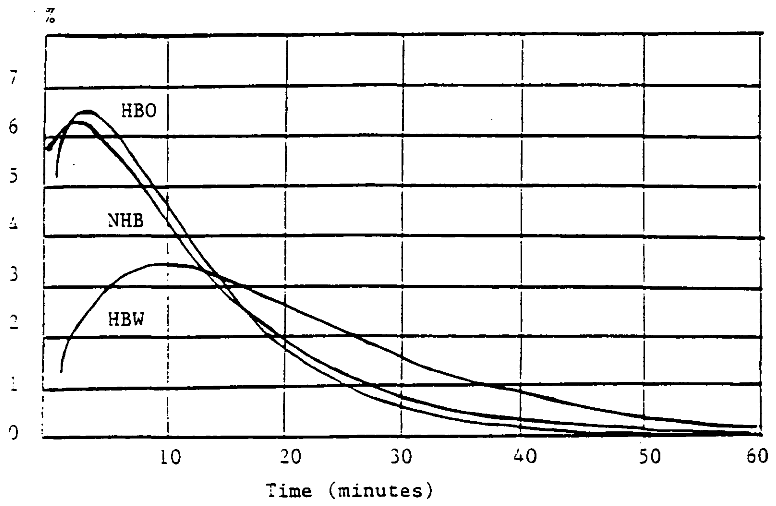

FIGURE 5 Trip frequency distributions (HBW, HBO, NHB).

TABLE 6 Percentage Splits for Total Productions and Attractions

	Internal-Internal			Internal-External			External-Internal		
	HBW	HBO	NHB	HBW	HBO	NHB	HBW	HBO	NHB
Internal Zones (1-17)									
P's	15	35	40	85	65	60	85	65	60
A's	15	35	40	85	65	60	85	65	60
External Zones (18-25)									
P's	0	0	0	0	0	0	85	65	60
A's	0	0	0	85	65	60	0	0	0

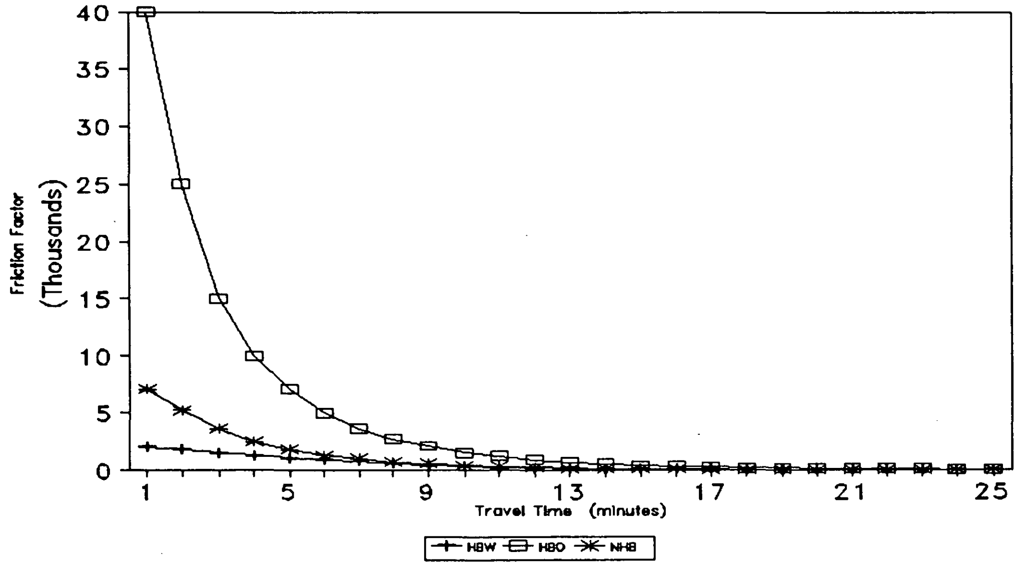

FIGURE 6 Friction factor distribution: internal-internal.

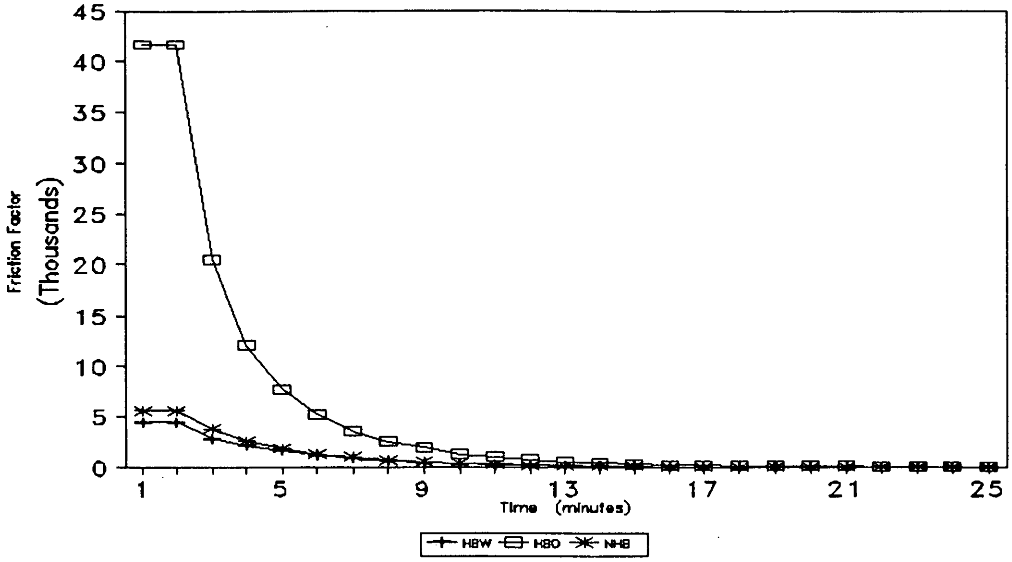

FIGURE 7 Friction factor distribution: internal-external.

area larger than that used in this exercise. Network loading was completed using a full user equilibrium assignment.

INTERSECTION ANALYSIS

Intersection analysis was conducted using a basic intersection capacity utilization (ICU) approach (*13*). This technique effectively compares volume-to-capacity ratios for each movement of an intersection. Input to the analysis program consists of the number of lanes per movement, the volume per movement, and the capacity per movement. Analysis is performed by identifying the highest conflicting volume-to-capacity (*V*/*C*) ratios for each direction and totaling these values into an ICU value that represents the percentage of the intersection capacity utilized by traffic demand. The ICU value is then used to reflect intersection level of service.

To compare the two networks in this exercise, nine intersections from the neotraditional network and ten intersections from the conventional network were chosen for ICU evaluation. These sample intersections included crossings of collectors with arterials, collectors with collectors, and collectors with local streets. The results of the intersection analysis are summarized in Table 7. These results indicate that there is not a great difference in the level of service provided by the intersections in the two networks. This is not fully consistent

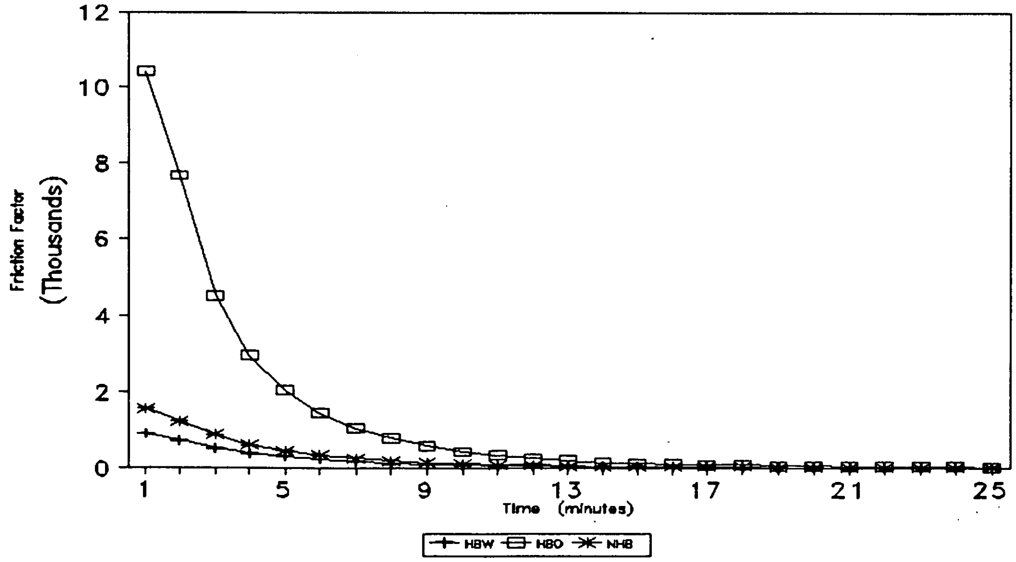

FIGURE 8 Friction factor distribution: external-internal.

TABLE 7 Summary of Measures of Effectiveness

Measure-of-Effectiveness	PUD	TND	Diff(%)[1]
1. Total Trips	14,019	14,733	+4.8
2. Vehicle-kilometers[2] (1000s)	290.13	259.36	-10.6
3. Total Vehicle-hours (1000s)	5.39	3.94	-26.8
4. Mean Speed (kph)[2]	53.85	65.75	+18.1
5. Mean Trip Length (km[2])	20.69	17.60	-15.5
6. Mean Trip Time (minutes)			
(a) Internal	1.74	1.50	-13.8
(b) Internal-External	14.79	9.87	-33.3
(c) External (thru)	14.64	10.76	-26.5
7. Intersection LOS			
(a) Arterial/Collector	0.78	0.79	1.9
(b) Collector/Collector	0.77	0.78	1.3
(c) Local/Collector	0.44	0.43	-2.7

1) Percent difference relative to PUD
2) 1 mile = 1.61 kilometers

with claims typically made by proponents of neotraditional design who suggest that a significant increase in intersection level of service (versus conventional networks) is achievable because of the dispersion of trips over the neotraditional grid. Examination of the selected intersections and the geometry of the alternative networks offers some explanation.

Figures 1 and 2 also present the selected intersections (unlabeled links are local streets). Five of the intersections are identical in each network; four of these are located on the periphery of the network and funnel external trips across the cordon. Although there are more entry/exit stations in the TND grid, there was also a higher proportion of through trips assumed. A systematic study of the tradeoff of network accessibility and increased travel, and the resultant congestion impacts, is necessary. It is also necessary to fully analyze resultant impacts of changes in intersection geometry that conventionally characterize TND plans.

Finally, intersections common to each network were compared to assess changes in level of service (LOS). For the central intersection (common to each network), the neotraditional network operates at an LOS that is 8 percent worse than that for the conventional network.

MEASURES OF EFFECTIVENESS

A variety of statistics were generated for postassignment evaluation. The following measures of effectiveness (MOEs) are based on a 1-hr a.m. peak trip assignment:

1. Vehicle kilometers traveled (VKT),
2. Average trip length,
3. Average trip length by trip type, and
4. *V/C* ratios.

Vehicle Kilometers Traveled

The VKT results show that the neotraditional network generates approximately 10.5 percent fewer kilometers of travel during the a.m. peak than does the conventional network. Total hours spent traveling during the a.m. peak in the neotraditional network is approximately 27 percent less than the hours spent traveling in the conventional network (see Table 7). Because the number of trips generated by each network is approximately the same, the difference in miles and hours traveled is very significant. The results imply that the neotraditional network operates more efficiently than the conventional network, most probably because of more direct routes and greater route choice. In addition, there is almost an identical amount of land devoted to right-of-way in each network, so that the increased efficiency cannot be discounted because of a greater supply of roadways. This factor is sometimes used as an argument to offset the apparent benefits of neotraditional design.

Mean Trip Length

The mean trip length in the neotraditional network is approximately 15.5 percent shorter than the trip length in the conventional network (see Table 7). These average trip length figures include trips that begin or end in the external zones. The length of each external zone connector varied, but in each network, the total length of the external connectors averaged 12.9 km. The neotraditional network has a definite advantage over the conventional network in that it has much greater accessibility from the external zones in terms of entrances to the study area. This factor could significantly affect route choice availability and, likewise, the resulting trip length.

TABLE 8 Vehicle Kilometers Traveled by *V/C* Ratio and Facility Type

VOLUME-CAPACITY RATIO	LOCAL		COLLECTOR		ARTERIAL	
	PUD	TND	PUD	TND	PUD	TND
0.2	128.8	20.9	0	0	0	6.4
0.4	22.5	0	1320.2	0	4033.0	2650.0
0.6	0	0	2509.9	6053.0	0	0
0.8	0	0	48.3	0	0	368.0
1.0	0	0	0	0	0	0
1.2	0	0	0	0	0	0
1.4	0	0	502.3	0	0	0

Note: V/C ratios for external connectors not included
1 mile = 1.61 kilometers

Average Trip Length by Trip Type

Results from average trip length by trip type show that, in effect, there is a greater difference between the trip lengths associated with external zones and the trip lengths strictly associated with internal zones. The II trip lengths in the neotraditional network are approximately 13.8 percent shorter than those for the conventional network, whereas the IE and the EI are approximately 33.3 and 26.5 percent shorter than those for the conventional network (see Table 7). As suggested in the previous section, the trip length by trip type results show that perhaps much of the trip length difference between the networks is caused by the increased accessibility of the neotraditional network to its external zones. Trip lengths associated with II trips are still significantly lower for the neotraditional network, a factor that directly reflects how the shape of the network itself is responsible for greater travel efficiency.

Volume-to-Capacity Ratios

The conventional network has 64 percent of its links operating at a *V/C* ratio of from 0.0 to 0.4, whereas the neotraditional network has 29 percent of its links operating at this level. About 30 percent of the conventional links operate at a *V/C* ratio between 0.6 and 1.0, whereas over 70 percent of the links in the neotraditional network operate at this level. All of these figures represent situations in which the networks are functioning within capacity. The conventional network, however, has 6 percent of its links operating above a *V/C* ratio of 1.0, which represents unacceptable levels of congestion. The neotraditional network has no links operating above a *V/C* ratio of 1.0 (see Table 8). These results suggest that the neotraditional design is better able to distribute trips throughout the network so that links do not become congested.

SUMMARY OF RESULTS

The performance measures obtained in this exercise indicate that in some senses the neotraditional network operates more effectively. The figures for kilometers traveled and average trip lengths point to the fact that less travel is required in the neotraditional network. In other words, drivers are able to choose more direct routes. Because no attempt was made to model the other elements of neotraditional neighborhoods that could have affected trip-making behavior (such as street design or mixed land uses), it must be assumed that the increased efficiency is entirely a result of more direct route choices. These results are consistent with earlier findings by Gordon and Peers (*3*), Kulash (*4*), and Stone and Johnson (*2*).

The congestion results obtained are less clear. Although the *V/C* link analysis indicates that the neotraditional network operates more efficiently, with no links showing volumes greater than capacity, the intersection analysis shows that the neotraditional network operates at approximately the same level as the conventional network. This result seems to contradict the neotraditionalists' claims that intersections should be less congested because there are more dispersed travel patterns.

The major limitation of the current results is the application to an isolated development. The transportation benefits of neotraditional design will most probably accrue on a regional basis. A comparative assessment of design benefits that reflects a regional mix of neotraditional and conventional developments is necessary. Such a development also will allow for the introduction of regional transit systems and a more accurate depiction of regional travel patterns.

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