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A COMPARATIVE ASSESSMENT OF TRAVEL CHARACTERISTICS FOR NEOTRADITIONAL DEVELOPMENTS

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ABSTRACT

The primary intent of this paper is to explore the claim that transportation benefits can be derived from neotraditional neighborhood design. 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-miles 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 which 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.

1. INTRODUCTION

1.1 Review of Neotraditional and Conventional Suburban Design

The neotraditional design movement was largely originated by two urban designers, Peter Calthorpe and Andres Duany. Although their approaches are often described with different language, "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 the United States' 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 as equally well as the automobile. Neotraditionalists are generally concerned with issues like 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 1920's. Current planning movements that fall under the category of conventional suburban design would be Planned-Unit-Developments and Cluster Developments, which became popular in the early 1960's. The original goals of these design practices was to provide a safe, peaceful environment removed from the overcrowding and auto 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 which 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 automotive traffic from the living environment.

1.2. Claims Made by Neotraditionalists

Neotraditional planners generally claim that their design practices will result in reduced transportation impacts. The basic arguments made are that neotraditional neighborhood design will reduce automobile dependence, increase public transit accessibility, and reduce travel distances and times (**5, 8, 14**). The arguments examined in this report are the latter, namely that this design concept will result in reduced vehicle-miles traveled and vehicle-hours traveled.

Other more specific claims have been made in a paper presented by Kulash (**10**). He concludes that neotraditional street networks function more efficiently than conventional networks because of the following reasons: (1) the large streets of a typically sparse conventional network operate under deficiency of scale, (2) turning movements are more efficient on the smaller streets associated with neotraditional networks, (3) 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 (4) 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 alternate suburban designs, the neotraditional network will be referred to as the 'TND' (for Traditional Neighborhood Design) network; the conventional network will be referred to as the 'PUD' (for Planned Unit Development) network.

2. HYPOTHETICAL NETWORKS

2.1 Description of Networks

The modeling exercise is based on two hypothetical networks developed to replicate a neotraditional and conventional subdivision. The networks were developed with the guidance of several sources to insure that realistic networks and land uses were used (**1, 3, 6, 7, 9, 11, 12, 15**). The hypothetical subdivisions are both approximately one hundred and eight acres, 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 which 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 can not be directly modeled. The characteristic of prime concern, therefore, is the shape of the networks.

Both networks are situated on intersecting collectors which 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: unlabelled 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 thirty percent of each network is devoted to rights-of-way, commercial areas comprise approximately three percent of the total land, and approximately sixty percent of each network is devoted to housing.

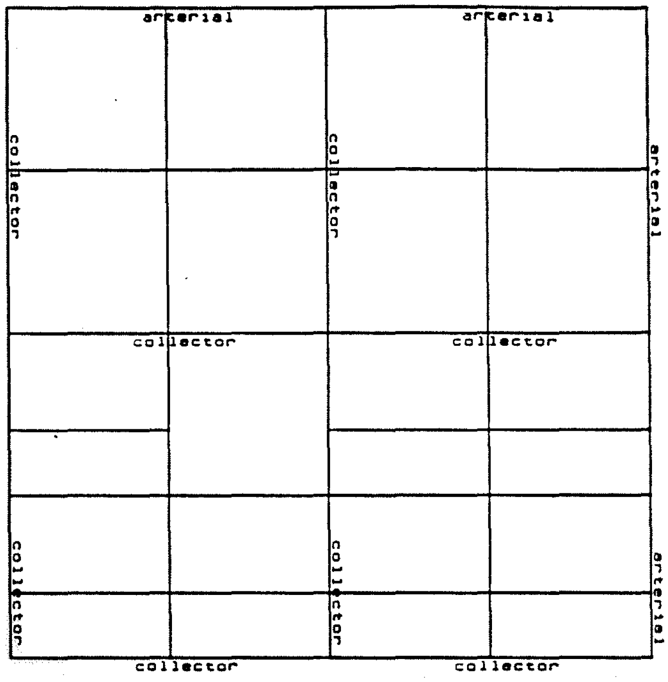

Figure 1. Neotraditional Network Design

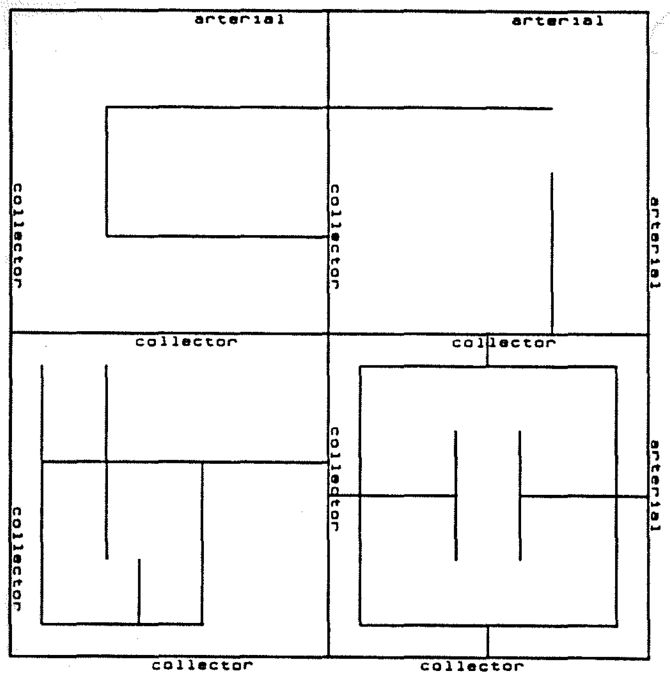

Figure 2. Conventional (PUD) Network Design

TABLE 1. Summary of Land Use Percentages

LAND USE	TND	PUD
Total Area of Development (2175 ft x 2175 ft)	4,730,625 sf 108.6 acres	4,730,625 sf 108.6 acres
Total Area devoted to R-O-W	1,418,000 sf 32.6 acres	1,382,000 sf 31.7 acres
Total Area devoted to Housing	2,810,000 sf 64.5 acres	2,846,000 sf 65.3 acres
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

Residential densities are also similar in both developments. Tables 2 and 3 depict 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 tradeoff is assumed. Further work is required to formally assess this tradeoff and its potential impact on residential densities and trip rates. The networks were divided into seventeen conventional Traffic Analysis Zones (TAZs). Table 4 summarizes zonal land use for each alternative network design.

TABLE 2. Neotraditional Areas and Residential Densities by Quadrant

QUADRANT	LAND USES	AREA (ft^2)	DWELLINGS	DENSITY (ft^2/DU)
Southwest	School Park Housing R-O-W	125,000 125,000 540,000 210,000	118 units	4576 sf/du
Southeast	Housing R-O-W	760,000 240,000	144 units	5278 sf/du
Northwest	Housing R-O-W	880,000 120,000	480 units	1833 sf/du
Northeast	Commercial Housing R-O-W	250,000 630,000 120,000	360 units	1750 sf/du

TABLE 3. Conventional Areas and Residential Densities by Quadrant

QUADRANT	LAND USES	AREA (ft^2)	DWELLINGS	DENSITY (ft^2/DU)
Southwest	School Park Housing R-O-W	125,000 125,000 540,000 210,000	118 units	4576 sf/du
Southeast	Housing R-O-W	736,000 264,000	144 units	5111 sf/du
Northwest	Housing R-O-W	892,000 108,000	480 units	1858 sf/du
Northeast	Commercial Housing R-O-W	250,000 678,000 72,000	360 units	1883 sf/du

TABLE 4. 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	3 acres
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	3 acres	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	160,000 sqft
12	Commercial	160,000 sqft	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

Figures 3 and 4 depict 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 (4), and posted speeds. Table 5 illustrates the values assumed for creating the hypothetical networks.

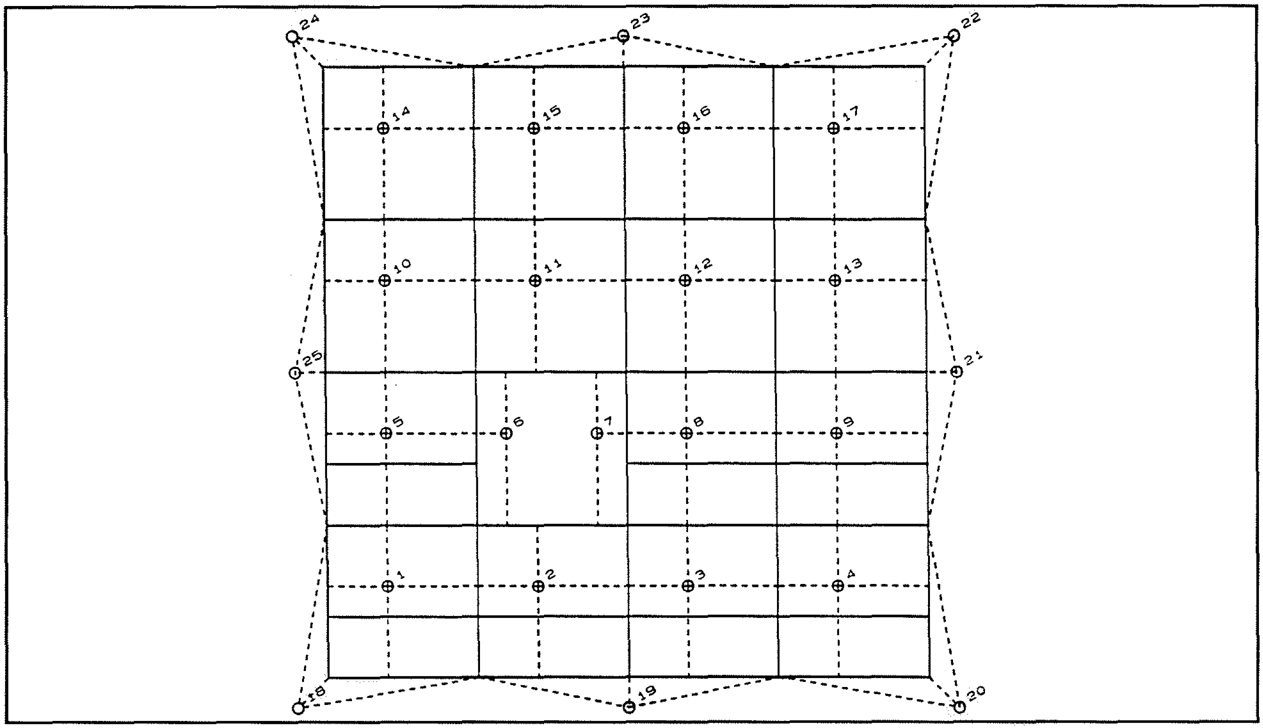

Figure 3. Neotraditional Zone System

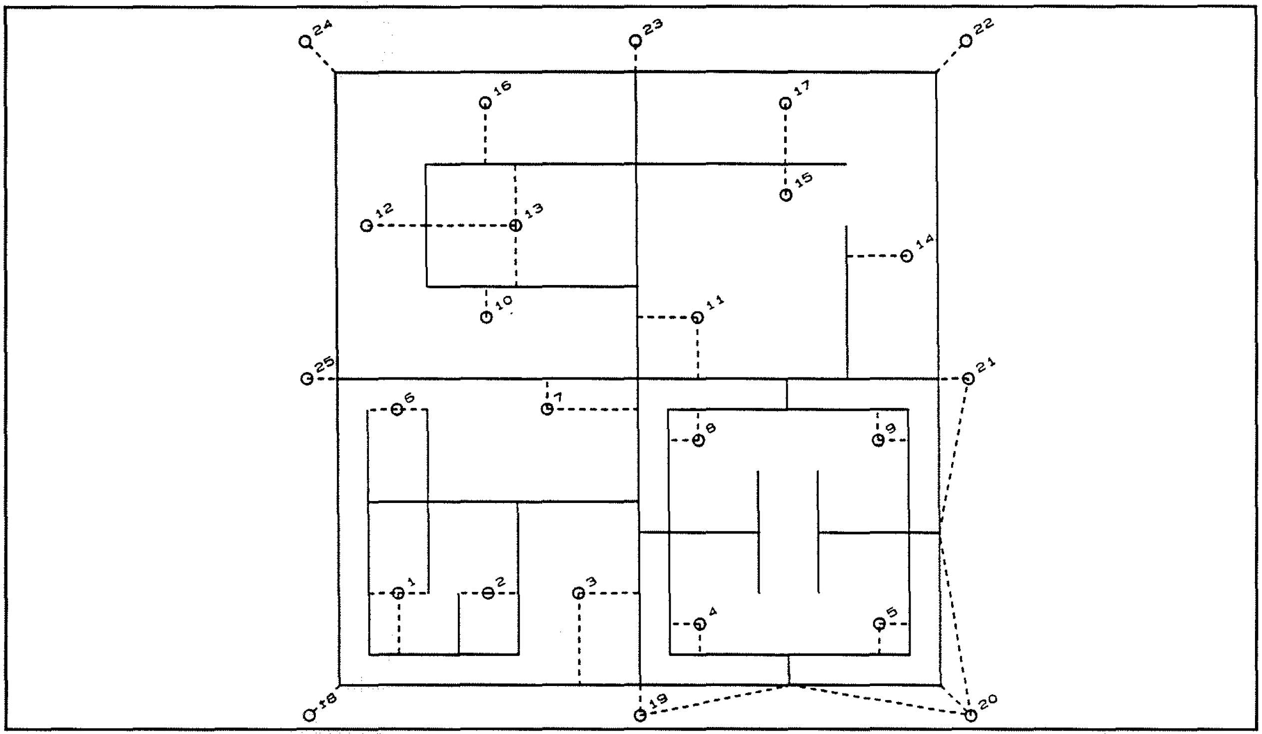

Figure 4. Conventional (PUD) Zoning System

TABLE 5. Facility Types and Capacities (TND and PUD Networks)

Facility Type	1 Hour AM Peak Cap. (vph/lane)	R-O-W Width (ft)	Number of Lanes	Speed (mph)
Arterial	800	110	2	40
Collector	600	80	2	30
Local	400	60	1	20

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

3. COMPARATIVE ANALYSIS

3.1. Trip Generation

Trip generation for the study area was estimated based on conventional land use trip rates, adapting rates developed by the City of Irvine, CA (see Table 6).

TABLE 6. Trip Rates (City of Irvine)

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

Travel parameters assumed in this study were adopted from those estimated for the City of Irvine (**2**). Trip rates were applied to the land uses in the study area to produce estimates of total productions and attractions for the internal zones (1-17). 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 (internal-to-internal), and the remainder would have the production or the attraction outside of the area (internal-to-external and external-to-internal). Eight external zones were created (see Figures 3 and 4). Because the external zone productions and attractions could not be estimated as a function of non-specified 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 based on assumptions of travel behavior and average travel times for each trip purpose. Trip length frequencies were adopted for each trip purpose (**2**) and used to determine the percentage of generated trips greater than 5 minutes in length which were assumed to cross the study area boundary (see Figure 5).

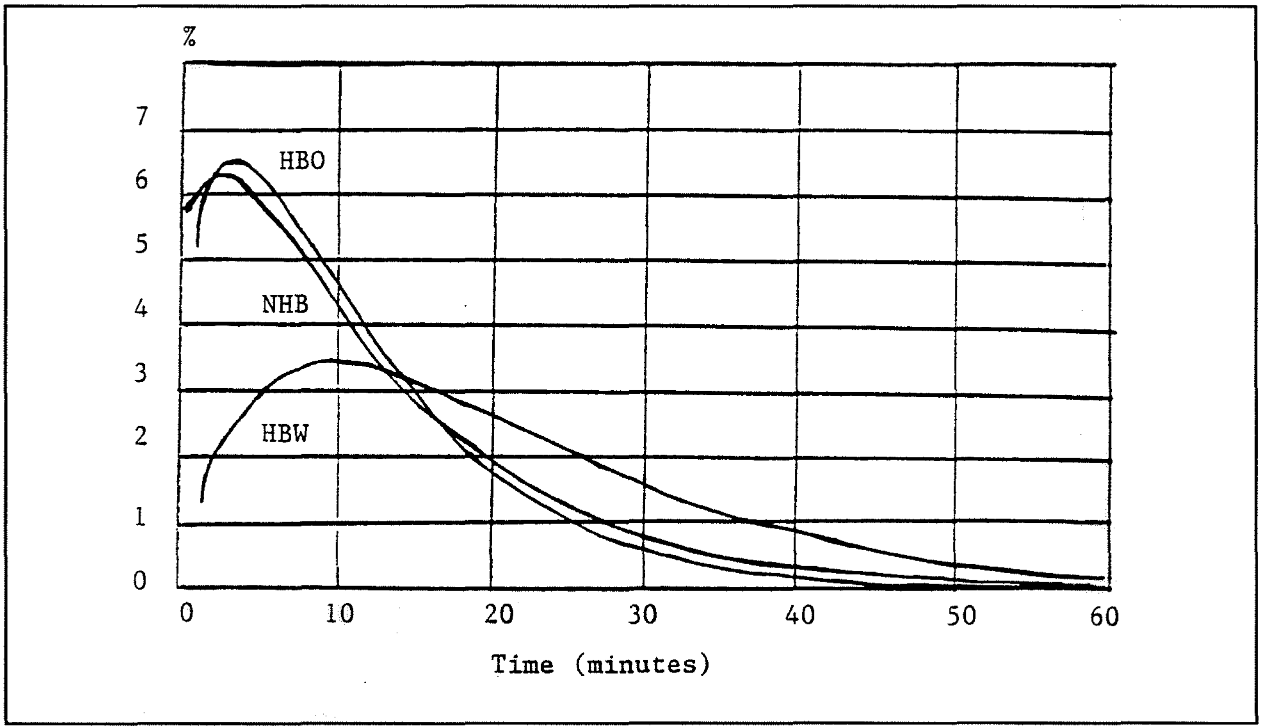

Figure 5. Trip Frequency Distributions (HBW,HBO,and NHB)

Since the study area is just less than a half mile square, it was assumed that trips over five minutes would either have to begin or end outside of the study area. A vehicle traveling at a constant 25 mph would traverse the study area in approximately one minute; five minutes 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 five minute long trips was assumed to represent the percentage of trips that would begin and end within the study area, corresponding to internal-internal trips. The remaining percentage was assumed to represent trips with one trip end outside of the study area, or trips greater than five minutes, corresponding to internal-external and external-internal trips. Once these percentages were established for each trip purpose (see Table 7), they were applied to the original set of total P's and A's by purpose. Zones 1-17 are internal zones; zones 18-25 are external. Applying these splits to the total P's and A's resulted in estimates of productions and attractions by trip type for each network.

TABLE 7. 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

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 pairs and added directly to the origin/destination matrix. The method used to determine through trips was similar to that used for splitting productions and attractions into II, IE and EI trips. The trip length frequency curves seen in Figure 5 were used to determine that approximately 60 percent of HBW, HBO, and NHB trips were longer than twenty minutes. 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 have trips longer than twenty minutes, a certain percentage of which would pass through the study area. It further was assumed that, for each of the eight surrounding areas, one quarter of the trips longer than twenty minutes would pass through the study area. The through trips added to the AM Peak O/D matrices were obtained by reducing the total through trips by a factor of 0.39 (**2**).

Because the neotraditional network provides greater accessibility than the conventional network (a 60 percent increase in connectivity measured in terms of number of entrance/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 (versus regional-level analysis), it is difficult to estimate the number of these trips. An increase in through trips for the TND design of five percent was assumed.

3.2 Trip Distribution and Assignment

Trip distribution was completed using a standard singly-constrained gravity model routine. Productions and attractions for nine trip types were used:

(a) Internal-to-Internal (HBW, HBO, and NHB),
(b) Internal-to-External (HBW, HBO, and NHB), and
(c) External-to-Internal (HBW, HBO, and NHB).

Friction factors from the City of Irvine were adpted for this study (see Figure 6a, 6b, and 6c). Using these factors could have introduced some error since they were developed for a study area larger than that used in this exercise. Network loading was completed using a full user equilibrium assignment.

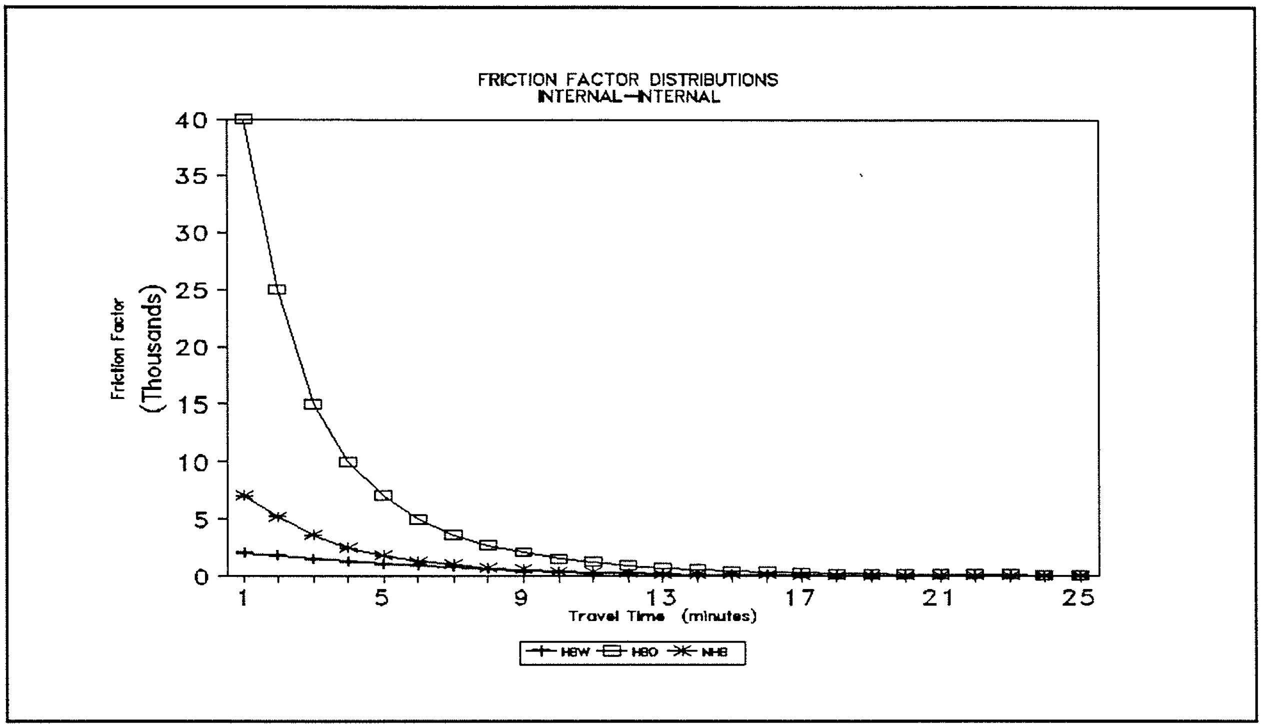

Figure 6a. Internal-to-Internal Distribution Functions

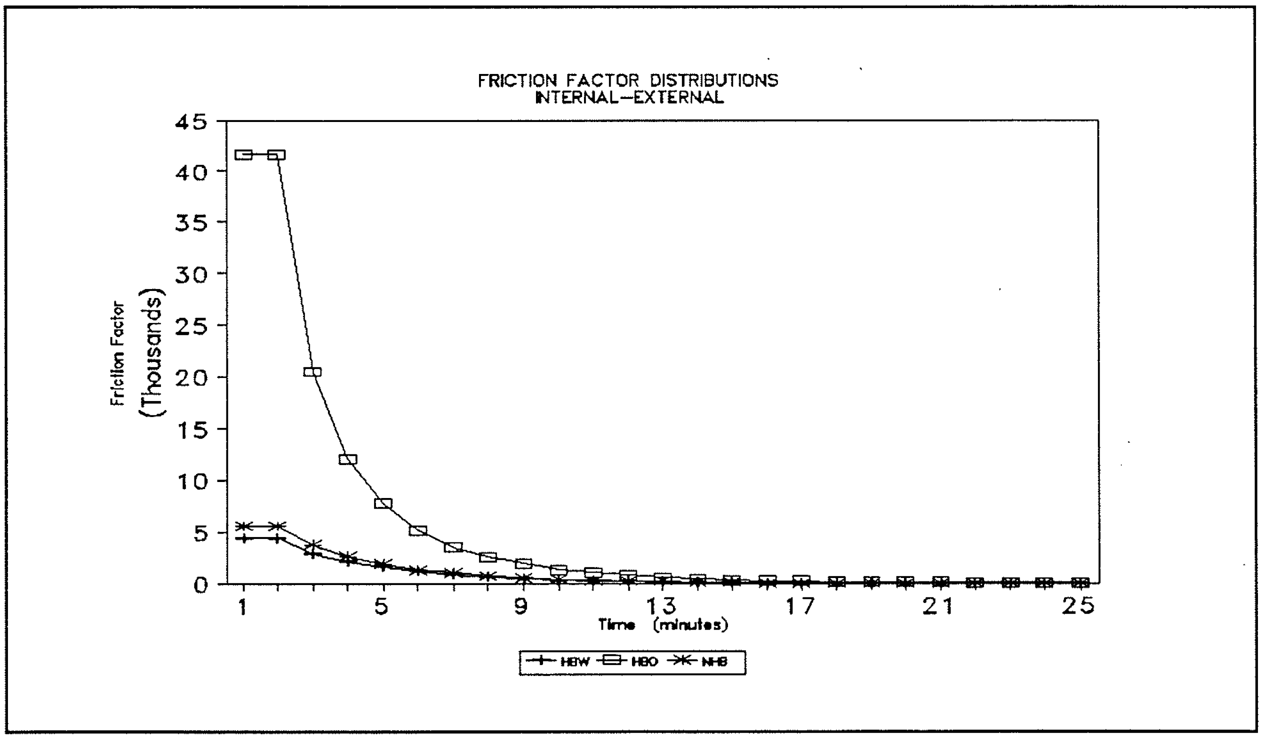

Figure 6b. Internal-to-External Distribution Functions

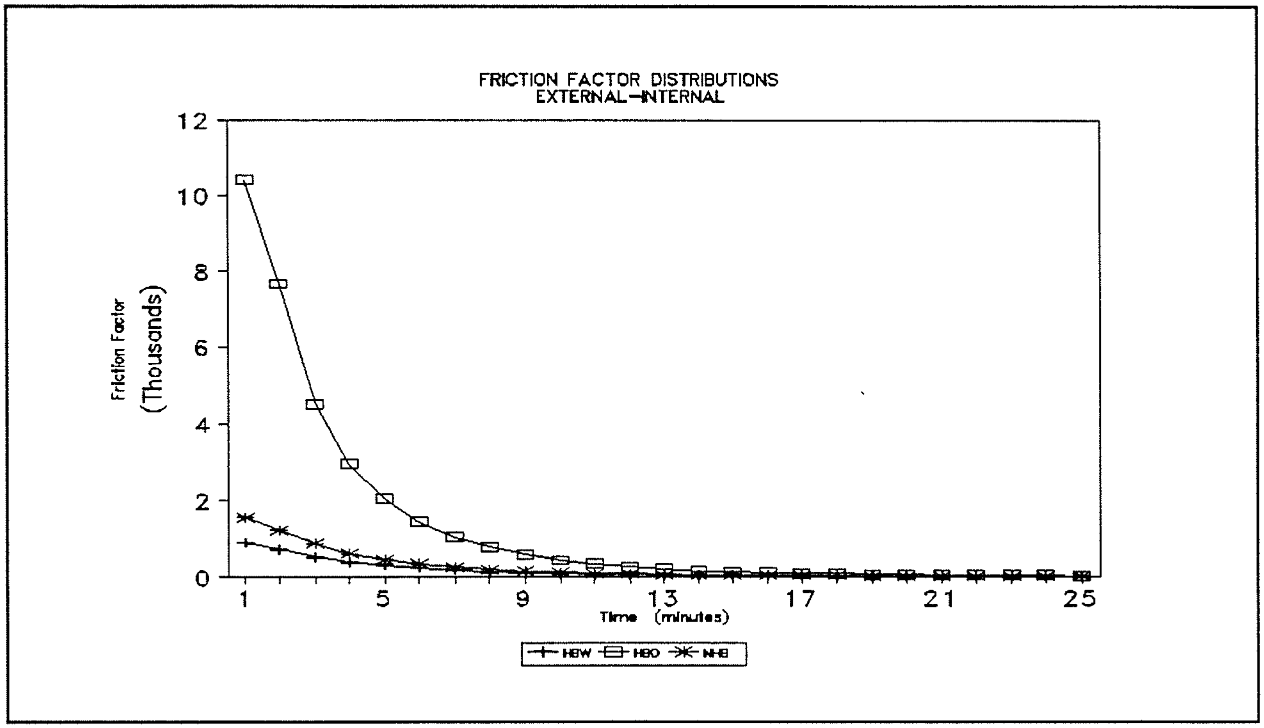

Figure 6c. External-to-Internal Distribution Function

4. 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 v/c ratios for each direction, and totaling these values into an ICU value which 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 8. 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 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 due to the dispersion of trips over the neotradtional grid. Examination of the selected intersections and the geometry of the alternative networks offers some explanation.

TABLE 8. Summary of Intersection Level of Service

Intersection Type	Average Intersection Level-of-Service		
	PUD	TND	Diff.(%)[1]
Arterial/Collector	0.78	0.79	1.9
Collector/Collector	0.77	0.78	1.3
Local/Collector	0.44	0.43	-2.7

[1] Percent difference relative to PUD

Figures 7 and 8 present the selected intersections (unlabelled 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 which conventionally characterize TND plans.

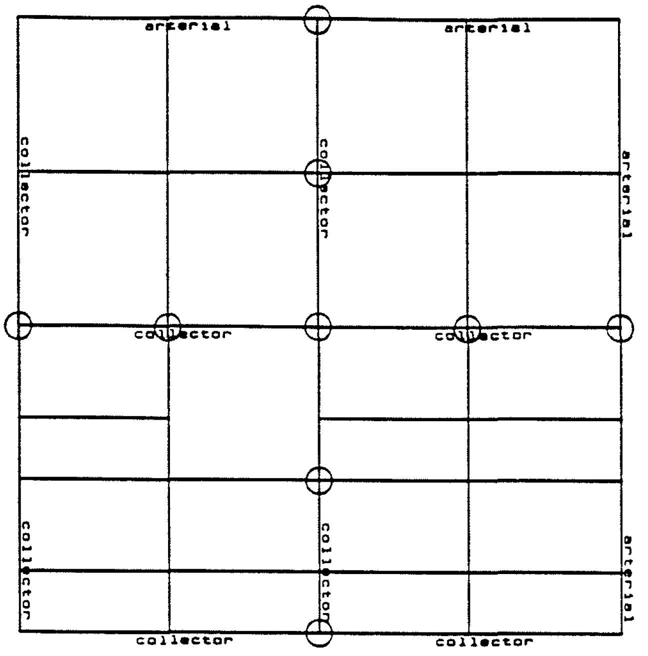

Figure 7. TND Selected Intersections

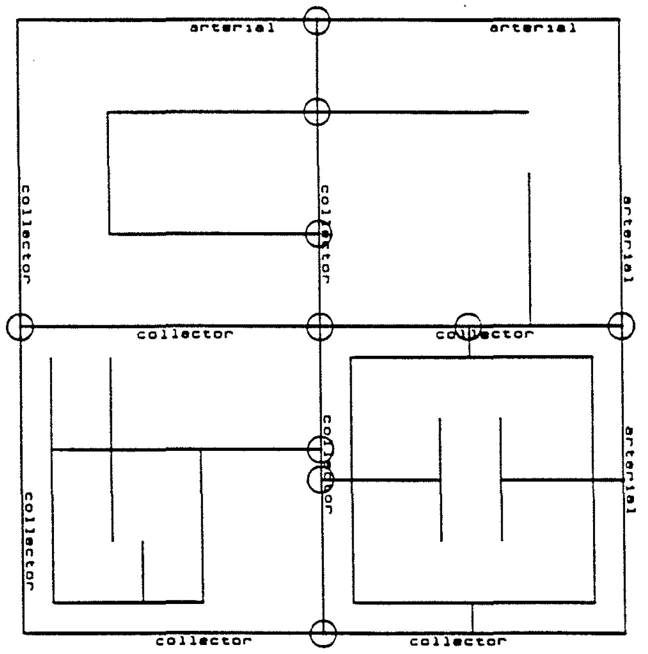

Figure 8. PUD Selected Intersections

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

5. MEASURES OF EFFECTIVENESS

A variety of statistics were generated for post-assignment evaluation. The following Measures of Effectiveness (MOEs) are based on a one hour AM peak trip assignment:

1. Vehicle-Miles-Traveled (VMT)
2. Average Trip Length
3. Average Trip Length by Trip Type
4. Volume/Capacity Ratios

5.1 Vehicle-Miles-Traveled

The VMT results show that the neotraditional network generates approximately ten and a half percent fewer miles of travel during the AM peak than the conventional network. Total hours spent traveling during the AM peak in the neotraditional network is approximately twenty-seven percent less than the hours spent traveling in the conventional network (see Table 9). Since 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 due to more direct routes and greater route choice. It should also be emphasized that there is almost an identical amount of land devoted to right-of-way in each network, so that the increased efficiency can not be discounted due to a greater supply of roadways. This factor is sometimes used as an argument to offset the apparent benefits of neotraditional design.

TABLE 9. Total Vehicle-Miles (VMT) and Vehicle-Hours (VHT)

VARIABLE	PUD	TND	Diff.(%) [1]
Total VMT	180,205	161,093	-10.6
Total VHT	5388	3944	-26.8
Mean Equil Speed	33.45 mph	40.84 mph	+18.1

[1] Percent difference relative to PUD

5.2 Mean Trip Length

The mean trip length in the neotraditional network is approximately fifteen and a half percent shorter than the trip length in the conventional network (see Table 10). These average trip length figures include trips that begin or end in the external zones. The length of the external zone connectors were varied but in each network, the total distance of the external connectors averaged eight miles. 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 effect route choice availability, and likewise, the resulting trip length.

TABLE 10. Mean Trip Length (miles)

VARIABLE	PUD	TND	Diff.(%) [1]
Total VMT	180,205	161,093	-10.6
Total Trips	14,019	14,733	+4.8
Mean Trip Length	12.9	10.9	-15.5

[1] Percent difference relative to PUD

5.3 Average Trip Length by Trip Type

These results 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 internal to internal (II) trip lengths in the neotraditional network are approximately 13.8 percent shorter than those for the conventional network, while the internal to external (IE) and external to internal (EI) are approximately 33.3 and 26.5 percent shorter than those for the conventional network (see Table 11). 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 due to the increased accessibility of the neotraditional network to its external zones. Trip lengths associated with internal to internal (II) trips are still significantly lower for the neotraditional network, a factor which directly reflects how the shape of the network itself is responsible for greater travel efficiency.

TABLE 11. Average Trip Length by Trip Types

MEAN TRIP LENGTH (minutes)	PUD	TND	Diff.(%) [1]
Internal-to-Internal	1.74	1.50	-13.8
Internal-to-External	14.79	9.87	-33.3
External-to-Internal	14.64	10.76	-26.5

[1] Percent difference relative to PUD

5.4 Volume/Capacity Ratios

The conventional network has sixty-four percent of its links operating at a V/C ratio of from 0.0 to 0.4, while the neotraditional network has twenty-nine percent of its links operating at this level. Thirty percent of the conventional links operate at a V/C ratio between 0.6 and 1.0, while seventy-one percent of the links in the neotraditional network operate at this level. All of these figures represent situations where the networks are functioning within capacity. The conventional network, however, has six 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 12). These results suggest that the neotraditional design is better able to distribute trips throughout the network so that links do not become congested.

TABLE 12. VMT by V/C Ratio and Facility Type[1]

VOLUME CAPACITY RATIO	LOCAL		COLLECTOR		ARTERIAL	
	PUD	TND	PUD	TND	PUD	TND
0.2	80	13	0	0	0	4
0.4	14	0	820	0	2505	1646
0.6	0	0	1559	3760	0	0
0.8	0	0	30	0	0	229
1.0	0	0	0	0	0	0
1.2	0	0	0	0	0	0
1.4	0	0	112	0	0	0

[1] Note: V/C ratios for external connectors not included.

6. SUMMARY OF RESULTS

The performance measures obtained in this exercise indicate that in some senses the neotraditional network operates more effectively. The figures for vehicle-miles-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. Since no attempt was made to model the other elements of neotraditional neighborhoods which could have effected trip making behavior (such as street design or mixed land uses), it must be assumed that the increased efficiency is entirely due to more direct route choices. These results are consistent with earlier findings by Gordon and Peers (**5**), Kulash (**10**), and Stone and Johnson (**14**).

The congestion results obtained are less clear. While the volume/capacity 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 due 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 which reflects a regional mix of neotraditional and conventional developments is necessary. Such a development will also allow for the introduction of regional transit systems and a more accurate depiction of regional travel patterns.

ACKNOWLEDGEMENT

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