Why TND Traffic Systems Work

Efficiency: Why "More Pavement" Isn't Faster Pavement

An FSCC golden classic from Walter Kulash, one of America's foremost traffic engineers.

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Posted 24 June 1998

Definition of Traditional Neighborhood Development (TND)

As participants in the Eleventh Annual Pedestrian Conference, this audience probably has a better feel for what TND means than any other group that could be assembled. Traditional neighborhood development, variously called “neotraditional” development or “urban villages” refers to a style of urban or suburban development, evolving since the 1970s, that revisits many of the features of urban neighborhoods of 50 to 100 years ago. If we had to give a single most distinguishing feature of TND, I would suggest that it is its continuous fabric of intimately blended land uses, arranged so that travel between them can be made by a variety of methods (walk, bicycle, transit, taxi) in addition to the usual privately-operated auto.

The land use in TND is mixed in an intimate blend, not, as in typical suburban development, in globules of single use parcels arranged in isolation from other uses.

The street design in TND is arranged to support this intimate blend of land uses. TND streets are small, and connected into dense networks. On these streets, there is an emphasis on non-motorized travel, and on the overall quality of travel for the automobile traveler. There is, at the same time, a de-emphasis of the narrowly defined performance standards (mainly travel capacity and speed) that are dictating what our streets and suburbs look like today.

The traffic engineering features of TND are attracting considerable attention and debate, because they seem to fly in the face of long-held principles of traffic engineering and subdivision planning:

Network of streets

The TND concept calls for a dense network of highly connected streets. In traffic terms, dense network means multiple available routes for a given trip. If the primary route for a trip is unacceptable because of traffic conditions, alternates are available. The dense network is in stark contrast to the sparse branched pattern of most suburban growth.

Street cross-section

The TND concept calls for street cross-sections that are typically no greater than two travel lanes plus on-street parking, which translates into a maximum pavement width of 40 feet. TND calls for a street right-of-way sufficient to contain this street cross-section, but not intended to accommodate a wider pavement at later stages. Typically, a right-of-way width of 70 feet can accommodate the TND street. Reduced or non-existent hierarchy of streets—the TND concept either eliminates or greatly reduces the 'hierarchy' of conventional functional classifications that are assigned to streets. In the conventional system, the base of the hierarchy is local streets, intended for immediate property access.

The next level is the collector, intended to gather traffic from local streets and feed it to the arterial system. The final level is the arterial street, intended for longer distance

mobility and not intended to serve as immediate access to properties (although this function is almost inevitable).

Lateral clearance

TND guidelines permit and even encourages the reduction in lateral clearance between street and the fixed objects (trees, street furniture) on the side of the street.

On-street parking

On-street parallel parking is basic to TND. This parking is designed to buffer pedestrians on the sidewalk from moving vehicles in the traveled lanes to provide street activity (drivers entering and leaving their vehicles), for the supply of parking itself, although this source of supply serves only a small part of the overall parking need in a business district, and to "enclose" the sidewalk space.

Short traffic signal cycles

Traffic signal lengths of no greater than 60 seconds are compatible with TND. Short traffic signals are pedestrianfriendly. They also create more frequent gaps in traffic for midblock pedestrian crossings.

Two-phase signals

These are signals that simply turn green for the entire approach, with no turn arrows. These are possible where there is a dense street network, because there is a much greater choice of locations for left-turn movements. The Conventional Suburban Development concept concentrates left-turn movements at a few major intersections, creating the need for multiphase signals. Two-phase signals convey a sense of small scale, to both drivers and pedestrians, that contrasts strongly to heavy-duty multiphase sequences. Two-phase operation permits a greatly reduced cycle time.

Curb radii

TND calls for a greatly reduced curb radii, typically 10 feet or less, at intersections to

reduce the speed of turning automobiles and to greatly reduce the in-street walking distance required for pedestrians crossing the street.

Alleys

The TND concept frequently includes alleys serving the rear of all properties. These alleys eliminate the need for curb cuts for driveways in the streets, and permit continuity of buildings along a block front, Curb continuity further increases the amount of on-street parking that can be obtained in the design. Alleys are also intended to provide a utility corridor, thereby removing utilities, particularly power lines, from the streetscape. Some other features, while not directly related to traffic, are highly characteristics of TNDs:

Architectural Themes

Most TNDs have vigorously pursued an architectural theme, generally following historical styles, further recreating the fueling of communities of 50- to 100-years old. Many of these TND street features are old ideas revisited. TND proponents hold that these are ideas whose time has come around again, in a new and innovative way, analogous to the return of the four-cylinder engine or all-natural fabrics. Critics hold that these are just old worn-out ideas. The debate is getting interesting.

Will the Traffic Work?

Much of the criticism and suspicion that has been directed at the TND concept stems from a belief that the vehicular traffic will not work. it is frequently pointed out that many of the TND elements--narrow streets, small blocks, closely abutting buildings--are urban design features that were found to be incompatible with good vehicular traffic flow many years ago. The last 40 or 50 years of traffic engineering and land development regulation have indeed been directed at securing diametrically opposed features in our new development. The debate about the traffic pros and cons of TND has been producing some interesting smoke and heat, but so far little light. Andres

Duany, who with his partner, Elizabeth Plater-Zyberk are easily the most widely known proponents of TND, has, by way of traffic analysis, asserted that traffic engineers are in the lower academic half of their graduating engineering classes. At first, I thought that this was a compliment, implying that half of us in fact graduated. Presumably this contribution to the understanding of the traffic issues of TND was provoked by some comparably relevant criticism of TND on the part of traffic engineers. The field of technical analysis of TND traffic is ripe for detailed traffic engineering analysis, and the results of precisely this type of analysis are what I will be addressing this afternoon. In order to answer this question of whether or not the traffic works, let's examine the three criteria that currently drive our traffic planning: vehicular capacity, travel speed (and therefore travel times) and safety. How about other considerations, such as Pedestrians, or how the streets look? Remember, we said we are looking the criteria used in traffic planning. Therefore, non-motorized travel and aesthetics cannot, by any stretch of the imagination, be considered as serious driving forces in street design. To settle the question of whether the traffic works, we will focus on only those three 'hard-nosed' engineering measures.

TND has superior traffic capacity

A network of small interconnected streets has more traffic capacity than the same street area arranged in a sparse hierarchy of large streets. This superior capacity is unrelated to the REDUCTION in travel demand or SHORTENING of travel distances that also results form the TND pattern. These decreases in total vehicular travel are also important advantage to TND, but we need to carefully isolate them in our analysis of TND traffic. The feature that we are focusing on is that for a given amount of traffic demand (i.e., same number of vehicular trips) the TND will simply out-perform the conventional street design.

Large Streets Have Deficiency of Scale

The fundamental reason why a dense network of small streets out-performs a sparse hierarchy of streets is that streets become less (not more) efficient as their size increases. So instead of an EFFICIENCY of scale as the street gets larger, we experience instead a DEFICIENCY of scale.

The reason is in the intersections. Intersections control the capacity of any network, dense or sparse. Think about it-- if it weren't for the intersections, every street would have essentially the capacity of a freeway lane, ideally 2,000 vehicles per hour (vph) and eroded, on surface streets, by various friction elements to 1,500 to 1,600 vph. But unfortunately, surface streets have to share the intersections with other surface streets. So their capacity is immediately cut in half. Then the streets have to further share with left turns. If the streets are big enough, left turns are in all directions, left turns need their own piece of the intersection signal time, still only 60 minutes per hour, regardless of how big the intersection is.

Let's take a somewhat abstract example of two different street patterns that illustrate this feature of traffic flow. In the first example, typical of the Conventional Suburban Development, we have a single large intersection of a four lane divided and six-lane divided arterial street: each having left-turn lanes and protected left-turn signals. In other words, a well-engineered major intersection.

Let's assume that this intersection is operating at close to peak-hour conditions, and that traffic service is beginning to be noticeably affected by the congestion. This corresponds to a level-of-service (LOS) 'D' at the intersection. This corresponds to traffic volumes of 3,000 vph on the six-lane street and 2,000 vph on the four-lane street, and turning movements of 300 and 200 vph, respectively, for the major left turn movements. The minor left turn movements are overshadowed, with respect to the signal time that they need by the major movements and are not significant in this analysis. The intersection described above is operating the limit of LOS ‘E.' No further

traffic can be added, in any of the major directions, without the LOS deteriorating to 'F,' or unacceptable. Now let's put the same amount of traffic on the same amount of pavement, but on a differently configured road system--a pair of two-lane streets intersecting three parallel two-lane streets. In a corridor sense, that is, in the east-west and in the north-south direction, the total number of lanes remains the same as in the Conventional Suburban Development example. Also notice that the total amount of pavement stays the same. The radical difference between the two plans is in the number of intersections in each system--the TND has six times as many as the Conventional Suburban Development. This large number of intersections reduces the turning movement load at any given intersection to a fraction (one-sixth in this example) of the turning movement load that exists in the Conventional Suburban Development pattern. Consequently, the entire system can carry greater traffic volumes at the same level of traffic service.

Turning Movements are More Efficient on Small Streets

The highly connected grid of streets that is built into the TND provides numerous, redundant opportunities to make a left turn. This contrasts to the pattern under Conventional Suburban Development, in which left turns are gathered up from multiple locations and focused at a single location. Many, perhaps most of these left turns in a TND network can be accomplished in gaps, and do not represent the loss of any green time to opposing through traffic. Obviously, left turns can proceed simultaneously at different intersections, in effect multiplying the turn movement capacity of the entire network. On the other hand, when left turns are all gathered and focused at intersections, EVERY left turn represents a loss in green time to the opposing through traffic.

Not only does TND offer many more places to make turns, but it also decreases the difficulty of a given turning movement. It is far easier to make a left turn across a given volume of traffic in a single lane than across twice that same volume of traffic in two

lanes, and so forth. So with multilane streets, you lose almost all of the capacity to make network left turns (street-to-street) and are left with only the ability to make turns into driveways. This finding is another one of those unexpected conclusions, and is worth illustrating with an example. When we make a left turn at an unsignalized location, we wait for an acceptable "gap" (around six seconds) to appear in the opposing traffic stream. Even with a fairly normal heavy traffic flow, reflective of a peak-hour, with 900 vph, you will get a large number of acceptable gaps. The statistics say you will wait an average of 14 second until you receive an acceptable gap. Now what happens as we simply double the traffic situation: twice the traffic and also twice the size of the road. Do we still have the same gaps? Do we still wait an average of 14 seconds? We would if the cars came paired perfectly. But, of course, they don't come paired. And in fact, three things start to go wrong with the left turn movement: the cars rearrange themselves, so that two-thirds of them are in the outside lane. We don't need to know why, we just know they do it. So, some of our gaps are gone. Then, the additional traffic, of course, does not pair perfectly with the existing traffic. The second lane is, in fact, also a separate distribution of gaps, totally independent from the first lane. Only when we get occasionally lucky do the gaps coincide. Now the speeds are different, and cars start to change lanes and present the left turner with a more uncertain picture of what's happening. Finally, the distance that we, as left-turners, have to clear has doubled, from one lane to two, and so we need a gap of not six seconds, but twice that or 12 seconds.

So all of these things working together mean not just a little more difficulty in making the turns, but a drastic drop in the ability to make them, to the point of impossibility.

What is our solution?

In the Conventional Suburban Development, there is only one solution: move every last one of those turning movements to a signalized location, whereas we now know, they rob capacity from all the other traffic movements.

Real-Time Route Decisions Occur on TND Networks

"Real-Time Route Decisions" is jargon for simply playing it by ear. In a TND environment, the driver can choose from the many routes available on the basis of what they see out on the street. In a TND, drivers make turns in advance or after their primary choice of turn location.

With the well-connected network in a TND, the driver can take alternative routes in the full confidence that the network is complete, and that they can find a reasonable route to their ultimate destination. Those of you that have lived in Phoenix with its highly connected network of streets know how this works. The importance of real-time decisions is that left turn movements stay out of the major intersections, and that minor streets pick up an important part of the turn movement load. Real-time route selection is most likely to happen in peak-hours, when congestion is present. This further explains the tendency of traffic volumes on local TND streets, to be more 'peaked' than traffic in general. Local streets are more likely to be pressed into service in peak-hours by drivers making work trips than in off-peak periods by drivers making mid-day trips.

Uninterrupted Traffic Flow is More Likely on TND

Uninterrupted flow conditions--meaning absence of traffic signals--are more likely to be obtained on TND systems than on sparse network. Freed from the sharing of right-of-way with other vehicles, the capacity of the street becomes essentially its free-flow capacity, ideally 2,000 vph and in reality, after considering side friction and other imperfections, around 1,500 to 1,600 vph.

Interrupted flow--as soon as a signal is installed--cuts the flow of the street to 800 to 900 vph, depending on the amount of time that is shared with the other movements at the intersection. So clearly, if we can stay beneath the threshold for signalization, we

can preserve uninterrupted flow on streets. At cross-streets, the need for signalization is reduced by greatly reducing the load on any given intersection, owing to a large number of intersections sharing the traffic load. The fine-grained land use along the TND street also works toward the containment of the need for traffic signals. Small commercial properties, each with their own access, do not individually warrant signals, particularly in light of the relatively low main street volumes and the two-lane cross-section of the TND streets on which they front. Also, the probable commercial site on TND streets is small scale, and may in fact turn out to be junior versions of our currently familiar suburban community and regional shopping destinations.

What the Book Says About Capacity

The definitive method for measuring traffic performance, the 1985 Highway Capacity Manual developed by the Transportation Research Board and evolving from earlier methodologies over a 30-year period, is the definitive statement of traffic performance in the US.

The procedures within the 1985 HCM clearly confirm the basic premise of TND traffic flow; namely that there is no advantage of scale in large unconnected streets, and that a well-connected network of small streets will out-perform the sparse unconnected network of larger streets in terms of capacity. For analyzing urban streets, the heart of the 1985 HCM methodology is the intersection analysis, since intersections, as we have seen, control the capacity of urban streets. in its planning method, (a short-cut approximation of the full HCM procedures) the 1985 HCM clearly states the diminishing returns on adding more traffic lanes.

Under the full detailed methodology, computationally complex, the deficiency of scale is not stated in simple rules, but is clearly visible when comparing capacity analysis results for identical traffic loadings applied to single, large intersections as opposed to a grid of smaller ones. The only way to really get at this, because of the inaccessibility

of the method, is to run identical traffic volumes through different types of intersections and compare them. A series of several such comparisons shows the thrust; the grid of small intersections consistently out-performs a sparse hierarchy, for the same amount of traffic and under the strict application of 1985 HCM methodology. In the view of many traffic engineers, the 1985 HCM method for unsignalized intersections is of marginal interest because unsignalized intersections are virtually designed out of conventional suburban design. However, the unsignalized intersection looms much larger in the analysis of TND, because of its ability to operate a large percentage of its intersections as unsignalized intersections. The unsignalized intersection methodology, more penetrable by manual analysis, very clearly shows the deficiency of scale of larger intersections.

These procedures, to put it simply, say that it is significantly more difficult for intersecting or turning traffic to cross a given volume of traffic in two lanes than to cross the same volume in a single lane of traffic. Consequently, the unsignalized intersection becomes less efficient as it gets larger.