

# Bursting the Bubble

## Determining the Transit-Oriented Development's Walkable Limits

Brian Canepa

**Transit-oriented developments (TODs) in the United States have been modeled almost exclusively with a half-mile radius as a reliable limit for pedestrian walkability from and to a light rail station. New research has emerged to challenge this standard, with data indicating that transit users may be apt to walk greater distances than previously estimated. Variables such as housing density, employment density, and urban design all significantly affect walking patterns. Those factors are analyzed as expanders or contractors of the TOD radius, and the implications that a fluctuating boundary might have on the future of urban growth are considered.**

Transit-oriented development (TOD) is a relatively recent phenomenon. Rising rates of urban sprawl, traffic, pollution, and community deterioration all have driven TOD. In the United States, the Congress for the New Urbanism (CNU) has been largely successful in codifying a plan by using pedestrian measures in conjunction with transit developments to help restore communities. The primary focus of TOD planning was placed on the pedestrian as a means to develop traditional town environments. Naturally, walkability plays a key role in transit development, and this study seeks to examine the scope of TODs, primarily in terms of the pedestrian.

Calthorpe's *The Next American Metropolis* (1) and the Western Australian Planning Commission's (WAPC's) 1997 Liveable Neighbourhoods Community Design Code set the tone for transit development. These studies established the appropriate walking distance from a TOD at roughly 0.5 mi (2, p. 38). It should be noted that TODs of this nature are based on rail nodes.

In addition to the half-mile measure, planners also use a quarter-mile radius to help denote the maximum distance that pedestrians will travel to reach a bus stop. This distance is based on an old transit industry standard and, as Ewing observes, is actually an accurate estimate of both walking distance and the area with the best potential for dense mixed-use development (3). Thus, both the quarter- and half-mile radii appear on TOD sketches to denote maximum walking distances to bus and rail stops, respectively.

From the time these standards were adopted, most rail-based transit developments in the United States have based the extent of development around a transit center on this half-mile distance. From Puget Sound, Washington, to Minneapolis, Minnesota, and the state of New Jersey, municipal- and state-level transportation agencies have

encouraged growth on this basis. However, recent studies have indicated that this distance may not be an ideal measure of the distance that pedestrians are prepared to travel.

Although the WAPC was at the forefront in establishing an educated estimate of the TOD boundary, it also has been one of the first to question its accuracy (as cited by Ker and Ginn [4]). In 2003, it released data that indicated a pedestrian's willingness to travel greater distances to reach transit hubs. The information also has been recently adapted to an American context. This analysis seeks to examine whether the established half-mile TOD radius is accurate. The walkable radius of a TOD is critical not only for its potential to affect sprawl and other negative externalities but also because of the large amount of land value at stake. As demonstrated in this paper, by expanding the TOD radius by 66% and subsequently allowing for greater density within that space, the amount of available land can be nearly tripled. This expansion could have significant impacts on investment; an area such as Arlington County, Virginia, could see its Metro corridor office space increase from 18.3 million ft<sup>2</sup> to roughly 50 million ft<sup>2</sup> and residential units increase from 22,500 to 62,500 (5).

This paper begins by examining the basis of the half-mile radius and then considering which traits (including controllable urban factors such as density and form) contribute to its potential size, along with their relative significance. From this information, one can determine why the half-mile boundary fluctuates in size, the implications for local and regional TOD planning, and the impact the half-mile boundary may have on transit use and urban growth.

### ACCURACY

The half-mile TOD radius has been an established standard for the past decade. Before WAPC released its design code, urban planner Peter Calthorpe had set guidelines to be used in setting development boundaries (1). His designs set the TOD boundary at 2,000 ft, which he equated to a 10-minute walk. However, Calthorpe also warned that TOD sites could be limited by topography and that large arterials that could dissect the proposed site. Thus, his average walking speed of 2.27 mph takes into account external variables such as hills, rivers, and roads that hinder pedestrian movement.

Although many planners have made use of the half-mile (or 2,000-ft) radius, they disagree as to the time required to travel that distance. After all, pedestrians are not as concerned with the total distance from their point of origin to destination as they are with their perceived total travel time. Estimates from 2002 use Calthorpe's 2,000 ft measure but gauge walking distance at a speedy 6- to 8-minute stroll (2.84 to 3.79 mph) (6); Australian measurements from 2003 list a 2,000-ft walk at 7.62 minutes (2.98 mph) (4). These discrepancies in walking speed may not appear significant initially, but they can seriously affect the sizes of transit developments. If it is assumed

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Nelson\Nygaard Consulting Associates, 785 Market Street, Suite 1300, San Francisco, CA 94103. bcanepa@nelsonnygaard.com.

*Transportation Research Record: Journal of the Transportation Research Board*, No. 1992, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 28–34.  
DOI: 10.3141/1992-04

that the longest trip a pedestrian is willing to make to a transit stop is 10 minutes—and this distance is by no means certain—then Calthorpe’s TOD boundary radius of 2,000 ft expands to 3,333 ft (using TCRP’s 3.79-mph speed), a nearly 67% increase. It leads to a 278% expansion in the potential area for development around the transit station, from 288 to 800 acres (Figure 1).

One of the major difficulties in establishing a firm TOD boundary is that although pedestrians are willing to walk more than 0.5 mi to a transit stop, most people realistically currently walk only a maximum of 2,000 ft. Ewing found that 80% of the cumulative total of pedestrians arriving at a transit station walk between 0 and 2,000 ft, and the number of pedestrians arriving from distances greater than 2,000 ft increases at a decreasing rate (3).

This logic has become policy in certain areas of the country. For example, in “Guiding Principles for Creating Transit Station Communities,” the Puget Sound Regional Council (PSRC) recommends focusing on small pedestrian shortcut improvements because “shortening a walk from 700 to 500 feet could benefit more people than reducing a 2,000-foot distance to 1,000 feet” (7). Several other cities—including Portland, Oregon, and San Diego, California—have codified TOD boundaries on the basis of this principle, thereby limiting dense, mixed-use development to a range between 0.25 and 0.5 mi.

As mentioned previously, data have emerged that could lead to the modification of these ordinances. A WAPC study released in 2003 examined walking patterns across five transit stations in the vicinity of Perth, Western Australia, Australia, a city of approximately 1.3 million. Statistics reveal that 55% of people walking to stations came from points originating more than 3,280 ft away (4). Figure 2 shows the large number of pedestrians apt to travel more than the traditional 2,000 ft. These numbers indicate that other factors influence the distance and travel costs that pedestrians are willing to incur to reach a transit station.

However, it is important to note potential differences between Australian and American travel behavior. Precisely how much farther, on average, foreigners will walk than Americans to transit hubs is difficult to gauge, but for this analysis, Americans residing in TODs are assumed to have walking distances similar to those of foreigners. This assumption is based on the types of people who reside in transit developments, which is discussed in detail below.

**DENSITY**

In attempting to explain the discrepancy between Calthorpe’s estimates and the data presented earlier in the previous section, one must observe factors that affect the radii of transit developments.

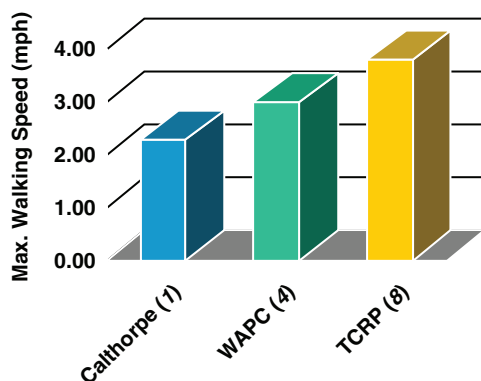


FIGURE 1 Maximum walking speeds (in mph).

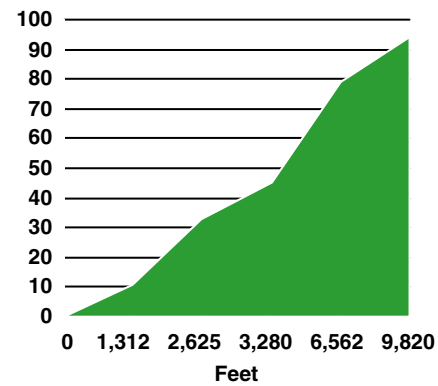


FIGURE 2 Capture rate at Perth light rail transit station: 10.5% came from within 1,312 ft (400 m), 22.5% from 1,312–2,625 ft (400–800 m), 12% from 2,625–3,280 ft (800–1,000 m), 34% from 3,280–6,562 ft (1–2 km), and 14.5% from 1.24–1.86 m (2–3 km) (4).

Perhaps the most important of these elements is density. One analysis of Portland’s transit demand revealed, “Of 40 land use and demographic variables studied, the most significant for determining transit demand are the overall housing density per acre and the overall employment density per acre. These two variables alone predict 93 percent of the variance in transit demand among different parts of the region” (8, p. 11). In real terms, PSRC discovered, “A 10 percent increase in household densities near light rail stations yields on average 5.9 percent more riders per station” (7, p. 26).

These increased densities are most often associated with apartment or condominium structures. A study of Metrorail stations in the Washington, D.C., area revealed that the transit capture rate exceeded 50% in several apartment buildings. Some of this is because of residential sorting, in which households choose apartments for the specific purpose of being near a transit stop (9, p. 279). This theory is supported by figures that indicate the dense neighborhoods around Metrorail stations experience far higher transit usage, regardless of housing type, than those areas outside the corridors. For example, transit ridership close to rail stations in Arlington, Virginia, is 235% higher than those locations outside the Metro corridors (10).

Before the impact of these figures on Ewing’s estimates is discussed, it is important to note that one of the potential positive consequences of increased transit usage is decreased vehicle use. It is, after all, one of the key assurances of the New Urbanist agenda. Data appear to be contradictory. An analysis of the Portland area by the 1000 Friends of Oregon indicated that several factors reduce the number of vehicle miles traveled (VMT): a quality pedestrian environment, an increase in household density, and an increase in the number of nearby jobs accessible by transit (11). However, more recent studies have provided results that do not corroborate the group’s findings.

Ewing and Cervero discovered that, in terms of VMT, a 10% increase in local density leads to only a 0.5% decline in vehicle trips (cited by Handy [12, p. 15]). In fact, neither of the two key traits (density and urban form) discussed in this analysis appears to lead to a significant reduction in VMT, with elasticities ranging from -0.03 to -0.05 (13). Planners continue to disagree over the nature of these findings. Many believe that it was not the built environment that caused individuals to drive less so much as their own personal desire to live in a non-vehicle-oriented neighborhood. This behavior is

often called self-selection. Thus, it is difficult to prove causality between VMT and density or other aspects of urban form.

How does this all affect Ewing's measures? Ewing's number of pedestrians traveling more than 2,000 ft represented only 20% of the total transit user population, whereas the Perth data indicate that at least 60% of transit user trips originate farther than 2,000 ft away. On the basis of data gathered from Portland and Chicago, Illinois, it is reasonable to assume that Ewing's data produced figures that were artificially low because of the differences in residential and employment density between the 2,000- and 3,000-ft radii. Or, as the WAPC report notes, "increased residential densities at least up to 2 km (1.24 mi) from stations would have a strong impact on walk-on patronage" (as cited by Ker and Ginn [4]). In much the same fashion that critics of widening highways state that new lanes will simply become filled with more cars, the same principle holds for constructing density farther than 2,000 ft from a transit stop: if you build it, prospective transit users will relocate there.

This theory seems to hold true in Australia, and although data indicate that Americans are willing to walk farther than 0.5 mi to a transit stop, present American development patterns do not allow for a fair comparison, because half-mile boundaries artificially limit construction. Calthorpe's TOD model was based on an average residential density of 18 dwelling units per acre (1, p. 58), and this number has since been used as a guideline for American developments. West Coast cities such as Portland and San Diego roughly adhere to Calthorpe's vision of density, and although the numbers give minimum density requirements within a half-mile radius, they do not make provisions for structures outside that area.

One factor in the effectiveness of transit developments vis-à-vis density is multimodal connectivity, which occurs when travelers must connect from one form of transit to another to complete their trip. Bus connectivity is critical in increasing rail usage. A great deal of effort is expended to promote parking at TODs, but data indicate, "A light rail station with parking has on average about 50 percent more boardings than a station without parking, while a station with feeder bus service has about 130 percent more riders than a station without bus service" (8, p. 14).

In addition, the availability of workplace parking can negatively affect transit usage. Employers that offer free parking decrease the likelihood that individuals will choose transit as a means of commuting. Furthermore, the introduction of flextime for workers has been the variable most strongly associated with transit commuting (0.462 correlation value) (14, p. 63). Figure 3 demonstrates the effect

of employer policies on transit in terms of flextime, parking, and shared transit or car costs. Public transportation patronage is thus a variable controlled not only by planners but also by employers that affect a worker's mode choice.

A positive example of transit connectivity is in Canada, where the Ottawa (Ontario) Official Plan took steps to accommodate those who preferred to live in low-density areas but still wished to use transit. Therefore, the city's planning staff approve of subdivision plans only if transit service is available within a 5-minute walk of each household (15, p. 153). Obviously, this goal cannot be accomplished through the use of light rail, so bus service is extensive and widely used. High residential densities are thus not required for sufficient TOD use, but in the absence of proper bus connectivity, as seen currently in the United States, it is almost essential.

In addition to residential densities, employment concentrations are crucial to walkability and, subsequently, TOD usage. A nonwork pedestrian travel survey in Portland found employment density to be a key contributor to promoting walkability and therefore "continue[s] to support the conclusion that New Urbanist practices promote walking behavior for nonwork travel" (16, p. 39). The survey also indicated that the density of retail employment within 1 mi of a home location was statistically significant in relation to employment density.

PSRC supports this claim by asserting, "Employment densities of 25 jobs per gross acre will support frequent, peak-period transit service"; this density results in approximately 15,000 jobs in a half-mile radius (7, p. 23). Put into a larger context, data indicate that downtown densities of 100 workers per gross acre translate into 300 boardings per day for suburban (20 mi from a downtown) light rail stations that are surrounded by low-density residences of five people per acre (6, p. 81). Again, this phenomenon is not limited to the Pacific Northwest. Data indicate that a 100% increase in station-area employment increased rail boardings in Chicago by 25% to 50% (8, p. 14). Furthermore, Frank and Pivo discovered that high employment densities or 75 employees per acre drastically increased transit use (17, p. 51). These examples support the notion that even residents in low-density areas can be drawn to transit developments if appropriate employment densities exist at their destinations.

### DESIGN

A key component to determining the operating scope of transit developments is the measure of connectivity and walkability as affected by the area's urban design. At first glance, it may appear to be obvi-

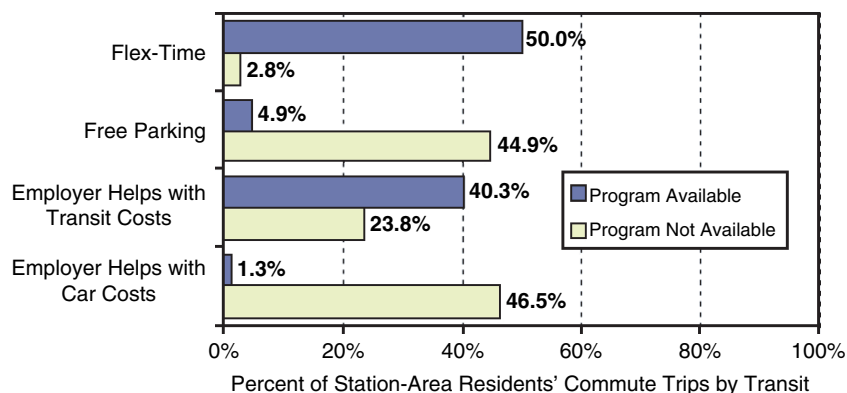


FIGURE 3 Influence of employer policies on transit commuting among surveyed station-area residents (14).

ous that heightened street connectivity and aesthetically pleasing walking environments would stimulate transit usage. However, with the rapid growth of gated communities, cul-de-sac construction, and segregation of uses, the United States has largely strayed from creating built environments conducive to mass transit travel.

Calthorpe determined that transit developments should have arterials and connectors similar to those seen today, but instead of creating dead ends and cul-de-sacs, those streets would form a cohesive network. Along these roads, pedestrian movement is encouraged through the construction of well-maintained sidewalks and visually pleasing frontages, such as ground-floor retail or townhome fronts. The practice of building front-loaded garages would be eliminated as it interferes with the streetscape by introducing more curb cuts and breaks in the continuous building façade.

Calthorpe asserted that his principles would lead to a stronger transit development. The examination of catchment areas or “ped sheds” has since proven him correct. According to the CNU, “Walkable catchments are the actual area within a five- or ten-minute walking distance as a percentage of the theoretical or ‘as the crow flies’ walking distance. A five-minute walking distance is typically one-quarter mile and a ten-minute walking distance is one-half mile. The higher the resulting percentage the better the walkability. A good target for a walkable catchment is to have 60% of the area within a five-minute walking distance, or within ten minutes in the case of major transit stops” (18).

The difference between actual and theoretical walking distances is important. When pedestrians are unable to travel from origin to destination in a perfectly straight line because of impediments such as buildings, travel time must be considered in terms of street connectivity. Fortunately, analyses of TOD connectivity provide a good deal of information on walkability.

In a geographic information system (GIS) study of Portland’s Gresham and Beaverton transit stations, Schlossberg and Brown evaluated the effects of road usage and placement through impedance-based intersection analysis (19, p. 40). One of the striking differences between the two sites lay in the abundance of arterials close to the Beaverton transit site compared with the network of minor roads surrounding the Gresham station. At a distance of up to 0.25 mi, Gresham contained only 1 mi of arterials, whereas Beaverton had 2.5 mi of major road. This difference may not appear to be major, but when the dead-end density was calculated to measure the level of potential pedestrian barriers, the researchers found that Beaverton possessed more than twice the amount of impedance as Gresham. Furthermore, Beaverton’s intersection density was 86% lower than that of Gresham. In total, Beaverton had 2.5 mi of major road and 2.2 mi of minor road compared with Gresham’s 1.0 mi and 4.7 mi, respectively. Essentially, even though Beaverton contained fewer road miles, the arterials slicing through Gresham station prevented pedestrians from accessing the transit stop. Figure 4 illustrates the level of walkability between the two sites at 0.25 and 0.5 mi.

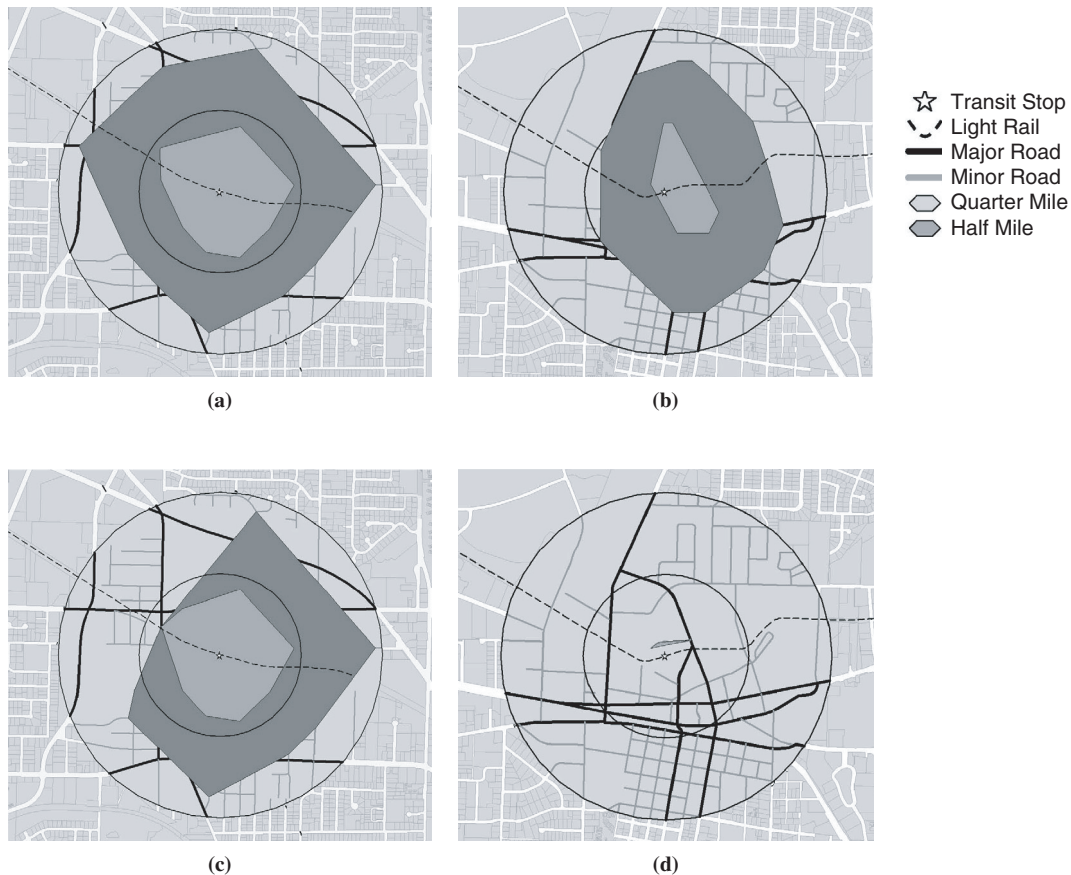


FIGURE 4 Visual comparison of TOD walkability for pedestrian catchment area visualization at (a) Gresham Central Transit Station and (b) Beaverton Transit Center and impeded pedestrian catchment area visualization at (c) Gresham Central Transit Station and (d) Beaverton Transit Center.

One of the main issues related to impedance-based walkability is the notion of pedestrian level of service (LOS). Historically, LOS considerations have been the exclusive domain of automobiles; however, pedestrian LOS made an appearance in the latest version of the *Highway Capacity Manual* (HCM), which bases its LOS standard on signal delay and pedestrian space requirements (20). Essentially, awareness is growing that traditional auto LOS standards may conflict with a walkable pedestrian environment. Some states have had appropriate measures in place for some time. California passed the Transit Village Development Planning Act more than 10 years ago, stipulating that the quarter-mile radius in transit village districts may ignore LOS standards. The HCM attempts to improve pedestrian LOS guidelines to give transit districts viable standards to implement. However, although the latest version of the HCM is an improvement over previous editions, critics argue that its criteria are still inadequate, and considerable disagreement exists over the nature of the correct measures.

Research conducted in Florida suggests that pedestrian LOS should be based on a user's perspective instead of a strict people-per-square-foot figure. It was found that pedestrians reacted favorably to the presence of sidewalks and an adequate barrier to traffic (i.e., parked vehicles) (21). The Florida Department of Transportation (FDOT) went so far as to implement many of these findings. In its 2002 *Quality/Level of Service Handbook*, FDOT based its LOS on the lateral separation of elements among vehicles and pedestrians, vehicle traffic volume, and vehicle speeds (cited in the 2003 handbook [22, p. 28]). Despite these measures, little consensus exists on the accuracy of these standards.

In a study of Sarasota, Florida, Petritsch et al. measured pedestrian perceptions against a range of variables from the impact of turning vehicles to vehicle volumes and signal delays (23, p. 60). Their results clash with those released by FDOT. Whereas right-turn-on-red and left-turn conflicts exhibited significant negative reactions among pedestrians, vehicular movement parallel to crosswalks did not, contradicting FDOT's basis that vehicle volume and speed adversely affect the pedestrian environment. Although the precise factors that influence pedestrian LOS are obviously ambiguous, this discussion highlights the negative impact of auto-based LOS on walkability and the resulting difficulties it creates for successful transit development.

In addition to the LOS standards mentioned above, an effectively connected street network is essential to creating an easily understood environment. That is to say, walkability increases if pedestrians have a better sense of direction. If streets are formed in convoluted patterns, then transit usage suffers because pedestrians may take circuitous routes when the quickest path is not readily apparent. Cervero echoed Calthorpe in stating that the grid is the simplest and most rudimentary street pattern (as cited in a TCRP study [6, p. 84]). If that network is without cul-de-sacs and other impedances, then pedestrians will be more willing to walk to transit stops.

Some cities have since codified this reasoning. PSRC not only discourages the construction of dead ends and indirect routes but also prescribes maximum block sizes (as cited by Lund et al. [14, p. 65]). Pedestrians are less willing and able to walk to transit stops if blocks appear too large, with elasticity levels of  $-0.127$  and  $-0.118$  for home-end and non-home-end block sizes, respectively, denoting how an increase in block size decreases the likelihood of a resident riding transit. Therefore, PSRC recommends average block perimeters of 1,200 ft with a range of 800 to 1,600 ft (7, p. 30), which lead to block lengths of 200 to 400 ft. These lengths are consistent with those of Ewing (300 ft) and of other American towns (e.g., Alexandria, Virginia, at 250 ft) (6, p. 85).

Although urban design can positively affect transit usage, a fair amount of disagreement remains as to the extent of its impact. Analysts have found that pedestrian traffic is higher around transit developments, but whether those people actually changed their mode of travel before their move to the site has yet to be ascertained.

In studying residential relocation patterns in the Puget Sound region, Krizek discovered that causality has not been determined between transit development construction and travel mode shift (24, p. 277). His regression analysis found that as the built environment became more urbanized, the number of trip chains (tours) increased; this finding is logical because a more urbanized atmosphere decreases the trip cost for individuals due to greater accessibility. However, Krizek also discovered that although the number of tours increased, the number of trips per tour decreased. He summarizes this result by stating, "When a household moves to a traditional neighborhood, its members are more likely to go to the corner store to buy a pint of milk. They do so more often and are less likely to link this trip for milk with a trip to the dry cleaner or the day care center." In essence, statistics show the decrease in trips per tour but not a mode shift from vehicles to transit. Krizek asserts that this finding undermines promises made by New Urbanists because it demonstrates that household travel preferences remain fixed: transit households use transit, and auto-using households continue to use vehicles.

Montgomery County, Maryland, compared mode share in six communities, three auto-oriented and three transit-oriented. It was found that the transit-oriented neighborhoods used transit 10 to 45% more than the auto-oriented ones (8, p. 22). A review by Cervero and Duncan in the San Francisco Bay area in California drew similar findings, but on a household level (25). This research indicated that as the number of automobiles increases to three per household, residents who live and work near transit are only 20% likely to use it. It also demonstrated that within 0.5 mi, 85% of households with no vehicles are willing to walk to transit stops, if they reside and work near a rail stop. These findings are significant because they help support Krizek's claim that auto-using households will continue to use their vehicles on the basis of personal preferences and because they help dispel the notion that pedestrians are unwilling to walk more than 0.5 mi.

Although a great deal of research has been devoted to vehicle trips from residential areas, considerable evidence indicates that urban design can positively affect transit use at work sites. In fact, data indicate that the greatest factor in increasing transit use was the presence of an aesthetic urban setting—defined as an environment that possesses abundant street trees and sidewalks and is free of graffiti (26)—generating a 4.1% increase in work site transit share. Furthermore, when land use impacts were examined independent of the existence of various demand management programs, no variable proved to be statistically significant except for aesthetic urban settings (8, p. 23).

WAPC claims that walking can be such a pleasurable activity that in areas with flat terrain, transit patrons may walk as far as nearly 2 mi to reach a stop that has frequent service (as cited by Ker and Ginn [4]). It is important to note that terrain plays a role in urban design. An incline on a path used for transit access will lead to a decrease in pedestrian users because it is a sort of physical barrier. PSRC acknowledges that steep slopes can actually shrink the half-mile operating radius of a transit development (7, p. 22). Therefore, developments intended to encourage pedestrian movement should avoid sharply differing topographical levels.

One final piece of urban design that affects pedestrian movement is lot coverage. Initially, the layperson may not recognize why cov-

erage affects transit usage if the total square footage of building space remains the same, but to the pedestrian—and the planner aiming for higher densities—coverage can make a notable difference. Calthorpe recommended that office buildings without structured parking have a minimum floor area ratio (FAR) of 0.35, thus guaranteeing a base density (*I*, p. 78). PSRC has gone even farther in promoting FARs of between 0.5 and 1.0, promoting these higher densities with greater frontage space for structures. It stands to reason that people do not feel comfortable walking in a wide open area and naturally are drawn to intimate, enclosed locations, which can be achieved by constructing buildings closer to sidewalks (*7*, p. 29). This philosophy is plausible, because retail along sidewalks almost always receives greater pedestrian activity than that in strip malls.

## REGIONAL CONNECTIVITY

In the early days of transit development research, Calthorpe noted the importance of regional development (*I*, pp. 62–70). From the distribution of TODs to transit connectivity and environmental constraints, he understood that a transit site is not a world in itself but is influenced by forces outside its borders. He therefore set guidelines for minimum 1-mi distances between developments, a regional transit network, and town boundaries that shifted due to topology and nonurban uses such as agriculture. The walkable community TOD was important as part of a greater regional network.

After an analysis of regional growth patterns in the Minneapolis–St. Paul area was completed, Swenson and Dock concluded, “The geographic area that is modeled as part of a transportation study should not be uniformly limited to the traditional  $\frac{1}{4}$ - to  $\frac{1}{2}$ -mile radius associated with TOD; rather, boundaries should be responsive to the development context surrounding the center” (*27*, p. 71). This statement came 11 years after Calthorpe’s work and essentially mirrors his claims. Swenson and Dock argue that a regional context is not only necessary for effective transportation but also beneficial to those within and without the transit development. It is accomplished when the nucleus of activity achieves a high enough density to support a transportation destination and the surrounding area balances the jobs-to-housing ratio, therefore expanding the tax base. The result is an area that offers the benefits of regional transportation, greater housing choice, and increased prosperity. The success of mixed-use centers is woven into that of surrounding areas, and collaboration between the two produces the best outcome.

Despite the work of Calthorpe and Swenson, many U.S. transit developments have been constructed with little thought to regional connectivity. Much of the difficulty in achieving a global view of development is inherent in the modern political structure. Competing jurisdictions govern land uses with policies that do not necessarily mesh well, and the result is a network of sites that do not maximize their potentials. Portland’s regional government, Metro, is one exception; it has been largely successful in coordinating land uses between its 25 cities. Swenson supports Metro’s position by asserting that “planning [should] precede local development proposals and guide infrastructure design, funding priorities, and resource allocation” (*27*, p. 78). The ultimate goal is to achieve a sort of regional political collaboration before implementing individual local plans that may eventually conflict with one another.

In determining the extent of transit development radii, it is necessary to view the boundary on two levels. First, one must take into account features within the site. Street connectivity, block lengths, sidewalk space, lot coverage, and residential and employment den-

sities all expand or contract the radius. Factors outside the planner’s control also come into play; physical topography, inclement weather, an elderly population, or a high crime rate can limit movement. All of these elements play a role in shaping the operating scope of the TOD, and municipal planning departments would be wise to create their own guidelines for gauging the radii of potential developments on the basis of these features.

To accommodate the effects of the variables mentioned above, it is important to note that external factors (e.g., the greater road–rail network and surrounding environment) are far more complex than those found on site. That is to say, it is easier to adjust for block lengths and sidewalk widths within a TOD than to restructure a larger transportation network. Swenson notes that one of the greatest challenges lay in the effect of TODs on trip type and length. The creation of dense, mixed-use development inevitably leads to shorter trips and an accompanying increase in pedestrian and transit mode share. These shorter trips increase volumes on collector and arterial roads and create greater subsequent need for street connectivity that is less frequently found in suburban environments (*27*, p. 78). Street connectivity impacts capacity broadly, affecting hundreds of lower-order streets rather than individual highways, necessitating a regional cooperative development pattern.

It could have a profound impact for areas such as Los Angeles, California. The emergence of TODs will place a greater burden on local streets and require transit to focus on point-to-point and express services. The region’s Metro Rapid ridership saw an increase of 27% over regular bus service 1 year after its opening in 2000 (*28*, p. 432). Both road and transit connectivity will rely on regional cooperation if individual jurisdictions are going to meet the coming needs of dense transit development.

## CONCLUSION

Is the half-mile radius a legitimate guide? Although it is used as a measure by almost every urban area in the country, this distance is tenuous at best because it depends on a set of variables that differs between locations. That is to say, the half-mile boundary is not necessarily static from city to city because factors such as street design may encourage or impede pedestrian flow. Furthermore, evidence from Australia and the United States demonstrates that pedestrians are prepared to travel more than 0.5 mi if an accommodating atmosphere prevails. If that is the case, then can a new radius be extracted from which development and urban growth can be gauged? The simple answer is no.

Although variables such as density and design have been determined to play a role in the success of transit developments, researchers have found, “It is difficult to untangle the effects of land use mix and urban design from the effects of density” (*8*, p. 23). This difficulty arises primarily because well-connected urban areas also tend to be of higher densities and more suitable to pedestrians. Efforts have been made to sort out findings between the variables, with some success, but questions still remain as to whether mode choice is an effective way to gauge the impact of the given variables. Despite the uncertainty of factors within transit sites, some planners have begun to find that the traditional stance of viewing developments as independent units may complicate the radius dilemma and that a regional context must be established to comprehend the impacts of communities on one another.

Furthermore, Minneapolis data indicate that no community is an island, and an individual TOD radius can be easily influenced by

regional developments. The impact of planning policies could well expand the range of TOD radii beyond the half-mile border and ensure a greater amount of mixed-use development. This expansion presents massive implications for communities as the amount of investment and density surrounding a transit development could increase nearly threefold. Furthermore, if radii expand to the 1-mi mark, the required number of regional transit developments may shrink as the distance between sites decreases, also reducing the number of necessary transit stops.

Despite all of the data collected on TOD radii, research remains largely inconclusive regarding certain key issues (e.g., their effect on externalities such as sprawl and VMT). Johnson was astute in asserting that a one-size-fits-all application of the TOD radius is counterproductive and that its underlying assumptions are unclear (29, p. 34). Future research of the variables discussed in this paper must be conducted if TOD potential is to be more accurately estimated. However, the current fixed measures of transit development radii may soon become a thing of the past.

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*The Public Transportation Planning and Development Committee sponsored publication of this paper.*