Comparing Transit-Oriented Development Sites by Walkability Indicators

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Transit-oriented development (TOD) represents an integrated approach to transportation and land use planning. An often unspoken but key component to TOD theory is pedestrian access between the transit stop and the immediately surrounding area. Understanding the opportunities for pedestrian movement should be a key component in understanding and evaluating TOD projects. The TOD–pedestrian link is addressed by using 12 geographic information system (GIS) based walkability measures, within two geographic scales, and across 11 TOD sites in Portland, Oregon, to visualize and quantify the pedestrian environments at each site. The main addition to the larger research on TOD and pedestrian access is the classification of the street network into pedestrian-friendly and pedestrian-hostile categories. Subsequent analysis based on this refined street data is conducted to identify the quantity of different street types, densities of "good" intersections and dead ends, and the catchment areas pedestrians are likely able to reach. The presence and location of pedestrian-hostile streets have a significant, negative influence on the pedestrian environment surrounding transit stops, often cutting off more-pedestrian-friendly environments from the transit stops. The three primary sections include a comparative TOD ranking, a detailed explanation (visual, quantitative, and textual) of the relationships between individual walkability measures and overall TOD rankings, and a presentation of possible refinements for future GIS-based walkability analysis.

Transit-oriented development (TOD) represents an integrated approach to transportation and land use planning. An often unspoken but key component to TOD theory is pedestrian access between the transit stop and the immediately surrounding area. That is, the success of TOD significantly rests on the capacity of pedestrians to navigate and access the range of land uses in close proximity to transit stations. Thus, it seems that understanding the opportunities for pedestrian movement should be a key component in understanding and evaluating TOD. In fact, it has been these kinds of fine-grained, spatially explicit types of analyses that have been lacking in TOD and smart growth efforts (*1*).

In most locations, the capacity to walk is based on the same infrastructure as the ability to drive: the street network. Although not all streets include sidewalks and not all walking paths are adjacent to streets, the street network provides a reasonably comprehensive proxy for the capacity to walk within a neighborhood. For this reason, understanding the pattern and form of the street network can provide critical insight into how consistent TOD designs are with walkability. Of course, more subtle differences in sidewalk or street circumstance—such as the ease of crossing streets, the quality of the sidewalk, and whether the sidewalk is offset from the street—are important components to the overall walking environment. Nevertheless, although the street network has some limitations for modeling walkability, it remains the most accessible proxy data for walking to any jurisdiction in the United States and thus can provide a reasonable planning and evaluation foundation for walkability studies. That is, until local jurisdictions have more comprehensive base data on the various elements of walkability, the street network can serve as a useful indicator of local pedestrian appropriateness.

This paper addresses the TOD–pedestrian link by using 12 geographic information system (GIS)–based walkability measures, within two geographic scales, and across 11 TOD sites in Portland, Oregon, to visualize and quantify the pedestrian environments at each site. It presents both an intra-urban analysis of these 11 TOD sites and an extended analysis of two specific sites (one positive and one negative example of walkability) to demonstrate the usability of the analysis techniques. The paper concludes with some possible refinements for further analysis.

BACKGROUND

Effective TOD depends on various factors, including higher-than-average density, land use mix, roadway connectivity and design, and building design (*2*, pp. xii and 387; *3–6*). A core component of TOD success also rests in the capacity of transit users to access the transit stop to begin with or to access key destinations after reaching their destinations. This access, within the theoretical conceptions of TOD, is often accomplished by foot or local transit connections. Clearly, those trips that are within the theoretical TOD zone of 0.25 or 0.5 mi are more oriented toward pedestrian travel. Thus, the pedestrian environment surrounding transit stops is a key element in understanding TOD because transit riders are pedestrians on at least one end of their transit trips (*7*). This paper focuses primarily on this one element: the connectivity of the walking environment. Although larger issues of the transportation–land use connection are important and relevant to the overall understanding of TOD (and of smart growth more generally), this particular paper does not focus on the dimensions of walkable environments related to density and land use mix.

In theory, TOD strives to create neighborhood-scale places where walking and transit become viable transportation options. Bernick and Cervero (*2*, pp. xii and 387) report that people who live in pedestrian-oriented environments are more likely to go to the market on foot. Handy (*8*, pp. 253–267) reports that residents who live in traditional neighborhoods have also been found to make two to four more walk or bicycle trips per week to neighborhood stores than those living in

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nearby, automobile-oriented environments. And Krizek (*9*) reports that people who live in areas with good neighborhood accessibility are more likely to walk and use transit than those who live in more traditional automobile-oriented environments. Thus, it appears that scholarly research has shown a positive relationship between walkable environments and the amount of walking. That is, the more walkable a neighborhood is, the more people are likely to walk at least part of the time.

Therefore, a good walkable urban form can be a key contributor to local mobility (*8*, pp. 253–267; *9, 10*) and walkable distances generally range somewhere between 0.25 and 0.5 mi (*2*, pp. xii and 387; *3*, p. 175). Because TOD represents both local and regional mobility, the streets and character of the immediate surroundings, the neighborhood linkage with the rail station, and the location of the neighborhood within the larger region may influence regional household travel behavior for neighborhood residents. Thus, the urban form at a neighborhood scale is an important variable that will allow residents to exercise nonautomotive transportation choices, if such options are available. In fact, these issues and the methods presented in this paper do not need to be restricted to accessing rail stations; they can be applied to various key local destinations where walkability is a significant interest, such as schools, health clinics, food markets, and neighborhood parks. As interests in obesity and in the linkage between urban form and physical health increase, so will interest increase in measuring the capacity to walk to some or all of one's daily destinations.

The existing street network often provides a key indicator of the walkability of TOD environments, especially in more urbanized areas, where off-street paths are less likely to exist. Streets form the foundation and framework on which cities are shaped, community interaction takes place, and neighborhood life exists (*11*). Southworth and Ben-Joseph argue that the significant contemporary urban issues of today—congestion, pollution, and community isolation—are inextricably linked to road patterns (*11*). Straight streets, small block lengths, and good street connectivity are some of the indicators that one can use to identify and quantify the street network–based urban form at a TOD scale (*3*, p. 175; *12*). Several GIS approaches have been used to measure walkability and connectivity, for example, block size (*13, 14*); intersection density (*13, 15*); route directness (*16*); land use barriers (*17*); and commercial density, intensity, and choice (*18*, pp. xii and 41). However, these measures do not segregate or classify the street network into segments that are more pedestrian friendly and less pedestrian friendly, thereby treating all road segments as equally attractive for walking.

Visualizing urban form is also an important component to understanding walkability, especially for public understanding and participation in the planning process. Lynch (*19*), one of the foundational observers of urban form, identified five basic components of urban form—paths, edges, districts, nodes, and landmarks—each of which can be conceived in terms of a walkable urban network. Paths can be thought of as minor roads; edges equate to freeways or other large roads (e.g., arterials) that impede pedestrian movement; districts can represent concentrated zones of walkable urban form; nodes represent street intersections; and landmarks represent key origins or destinations, such as a transit stop. Each of these elements can be measured spatially.

Jacobs characterizes the walkability of different urban environments by superimposing the streets as thick white lines on a black map background (*20*). This highly contrasting network pattern visually elevates the items of interest (streets) in the foreground, showing the importance of the street network in framing and supporting walkable urban forms. Using similar techniques, Southworth et al. extend Jacobs' work by analyzing intersection patterns and quantifying various elements of the street network (*21*). As a result, they develop a range of development patterns based solely on the pattern and form of the existing road network.

From a visual and sociodemographic point of view, Bossard focuses on identifying neighborhoods with TOD potential (*22*). Through the incorporation of several sets of data and with a set of different analysis schema, visual, spatial, and comparative sociodemographic analyses can be conducted.

Walkable environments are clearly important to transportation choices, and the spatial visualization of urban form can provide insight into the presence or absence of good, walkable urban form. Moreover, the road network can be used to provide key insight into these walkability domains. Quantitative analysis of walkable environments can provide another means by which to evaluate transit-supportive urban form. Thus, a combination of a visual, spatially based analysis along with a quantification of the underlying urban form in terms of walkability can help planners and policy makers understand the condition and performance of existing or potential TOD areas.

A series of visual and quantitative walkability indicators are presented later in comparing the environments around 11 TOD sites in Portland, Oregon. In 1990, voters gave Metro—Portland's regional managing agency—the authority to adopt a regional planning framework in accordance with the broad principles of smart growth and specific details of a TOD. This regional planning framework, called the Metro 2040 Growth Concept, focuses in part on creating compact communities around transit (*23*, p. 36). A specific feature of the regional planning effort is the Transit Station Area Planning (TSAP) program, which is a collaborative effort between TriMet (the regional transportation authority), Metro (the regional growth management body), the cities of Portland and Gresham, and Multnomah County (including affected cities contained within it). The goals of TSAP are to build support for TOD along the rail line and to promote opportunities for increasing the system's ridership. To date, the TSAP program has included market studies, coordination with other regional planning efforts, detailed station area plans, and design guidelines (*24*, p. 171). The transit stops chosen for this analysis are communities that have been designated as TOD communities; thus, their designation has been made by the planning agencies themselves (not the researcher). Therefore, the analysis that follows presents methods for evaluating what the local jurisdiction considers their TOD efforts.

METHODS OF RANKING TRANSIT-ORIENTED DEVELOPMENT

Three primary techniques were used to rank and compare the grain and connectivity of 11 TOD sites in Portland.

- Network classification. An evaluation and categorization of street type and purpose along the road network within the TOD sites provides insight into the basic quality of certain paths for walkability purposes and reflects the hierarchy of road types and the function of the road network (Figure 1). In Figure 1*a*, all the streets in a section of Portland are considered of equal type and are shown in white by lines of the same thickness. In Figure 1*b*, heavily automobile-dominated streets (e.g., major arterials and freeways) have been identified, classified as impedance arcs, and marked as thicker white lines. The identification of the impedance arcs is based on the GIS-based road classification system developed by the regional government. Figure 1*c* is the same neighborhood, but with the major automobile-

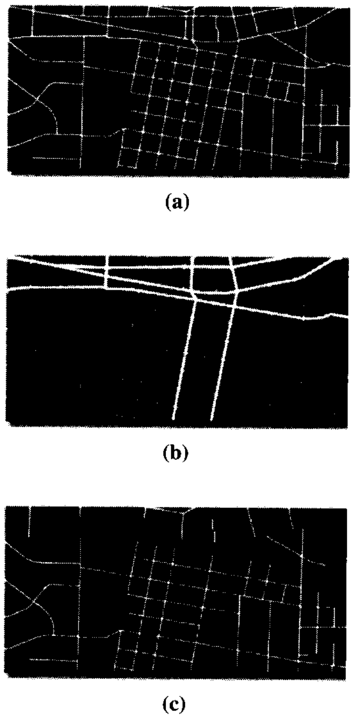

FIGURE 1 Network impedance roads: (*a*) unclassified network; (*b*) network classified, identifying impedance arcs; and (*c*) impacts of classification on pedestrian network.

oriented streets (impedance arcs) removed to visually show the pedestrian gap that emerges when automobile-dominant roads are removed from a pedestrian's set of potential walking routes.

• Pedestrian catchment areas (PCAs; also known as Ped-Sheds). Theoretical walkable zones can be mapped to show the actual area and network within a 5-min (0.25-mi) or 10-min (0.5-mi) walk from a rail station. The data are presented as a ratio between the Euclidean distance and the network distance from a given point (e.g., transit station), illustrated in Figure 2. Impedance pedestrian catchment areas (IPCAs) also have been calculated. The IPCA represents a recalculated PCA, but with the high-speed, high-volume roads removed. The result is a ratio that measures an area that a pedestrian is likely to actually travel.

• Impedance-based intersection intensities. In general, the intersection intensity analysis examines the concentration of intersections indicative of pedestrian choice (three way and four way) as well as the concentration of dead ends, which limit pedestrian access. In the impedance-based intersection intensity analysis, freeways and major arterial roads have been excluded from the overall data set, resulting in intersections derived only by neighborhood streets crossing each other. Additionally, dead ends now exist when a neighborhood street reaches a major arterial; with the arterial removed from the data set, the neighborhood road dangles in space. Intersections are not recorded for neighborhood roads that cross through a major arterial. Thus, intersections and dead ends are more consistent with how a pedestrian might view the walking environment rather than how a motorist would navigate the road network. The box at the top of Figure 3*b* highlights fewer intersections (open circles) than in Figure 3*a* and some new intersections (open triangles).

These analysis techniques yield two geographic scales (0.25 mi and 0.5 mi) and 12 separate measures (6 positive and negative):

- Quantity of accessible paths (high/low),
- Quantity of impedance paths (high/low),
- PCA ranking (good/poor),
- IPCA ranking (good/poor),
- Intersection density (high/low), and
- Density of dead ends (high/low).

COMPARING TRANSIT ENVIRONMENTS

Calculations for each of the 11 TOD sites were conducted. To simplify and focus the output, the three TOD sites that scored best and the three TOD sites that scored worst on each measure were extracted and grouped by TOD, resulting in 72 separate data points. (A total of 75 data points is presented in this paper because some of the sites received similar quantitative scores on some of the measures.) Figure 4 illustrates the final ranking of the 11 TOD sites; each time a TOD was ranked in the top three or bottom three for a given analysis method, it received a square on the chart.

Figure 4 is organized parallel to the main transit line in Portland, ranging from the terminal stop in the west to the terminal stop in the east. Transit stops within downtown Portland were not included in this analysis; rather, the focus of the selected sites was on green-fill and suburban retrofitting TOD sites, because those areas traditionally lack adequate transportation choice. TOD sites that have many squares to the left reflect environments with poor walkability, and sites with many squares to the right have more walkable environments. Although these measures include two geographic scales

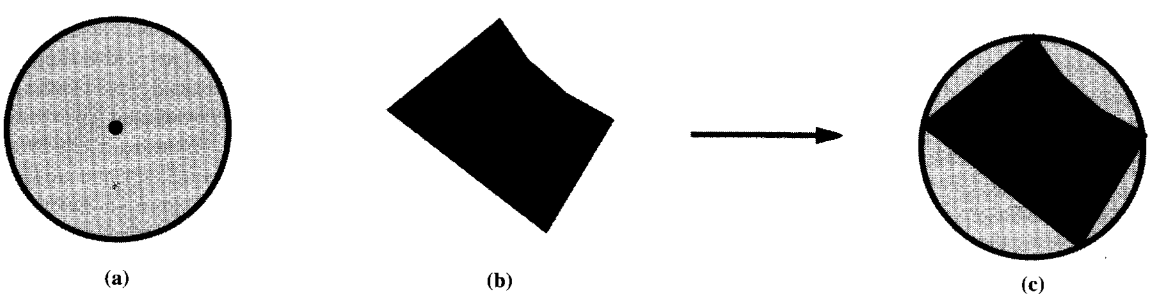

FIGURE 2 Pedestrian catchment areas: (*a*) theoretical pedestrian service area; (*b*) ped shed—network-defined pedestrian service area; and (*c*) ped shed ratio—ped shed acres/theoretical service area acres.

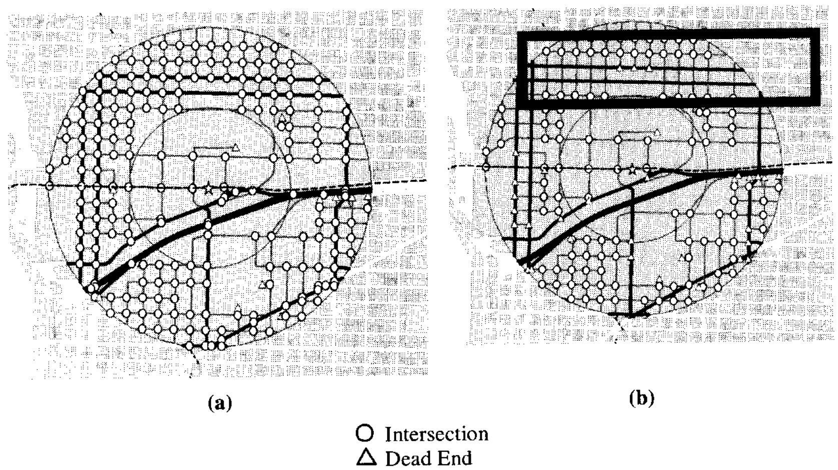

FIGURE 3 Intersection comparison: (*a*) all intersections and (*b*) impedance-based intersections.

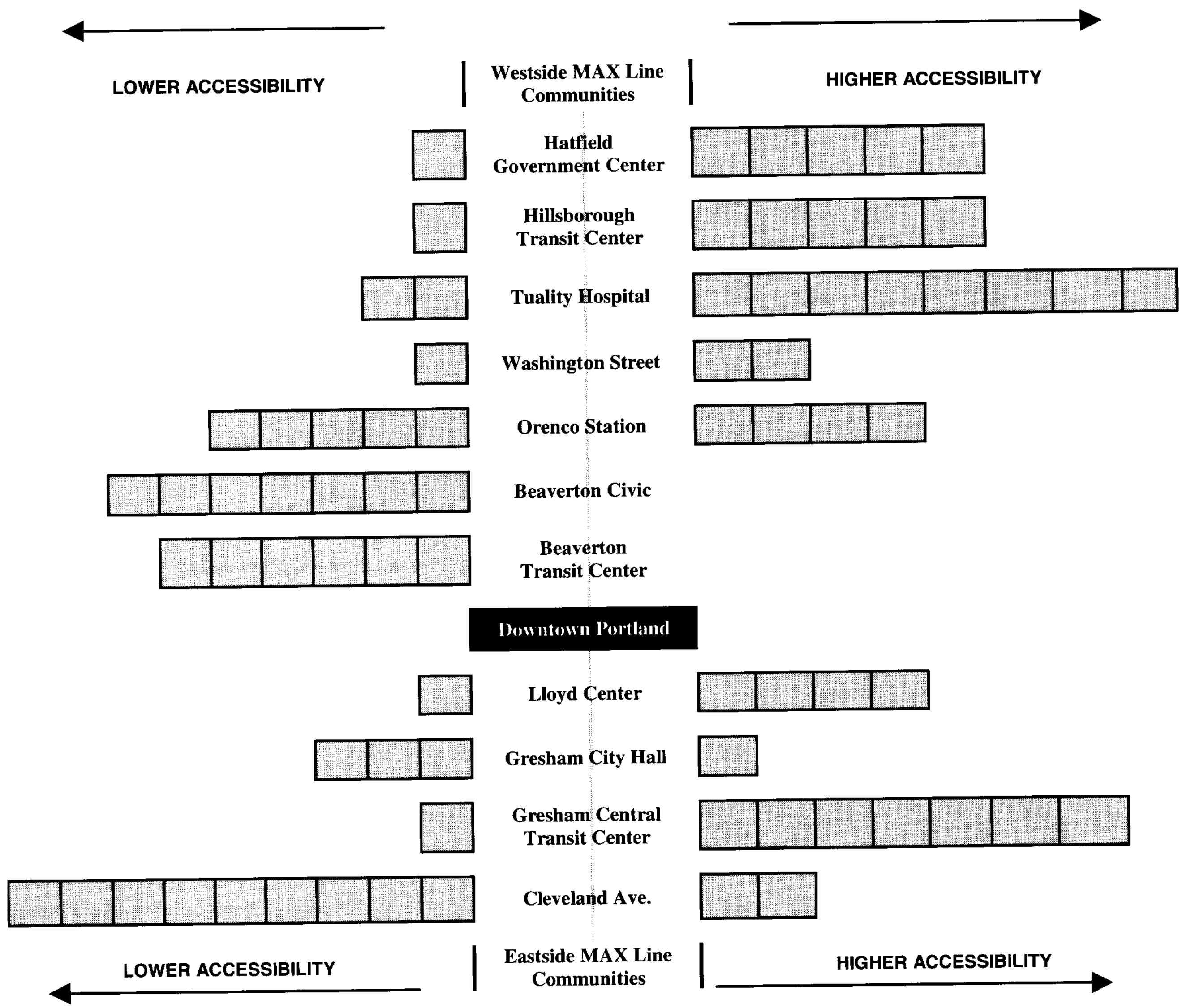

FIGURE 4 Walkability ranking of Portland TOD sites.

(0.25 mi and 0.5 mi), it is not the case that a TOD that scores well at 0.25 mi automatically scores well at 0.5 mi. In fact, many sites change dramatically between the two distances. Two transit stops rank highly in terms of walkability (Tuality Hospital and Gresham Central Transit Center), and three transit stops rank poorly (Beaverton Civic, Beaverton Transit Center, and Cleveland Avenue). Orenco Station is mixed, with several variables ranking highly in terms of walkability and several variables ranking low.

With the chart presented in Figure 4, it becomes possible to conduct an intra-urban analysis on a series of TOD sites within one metropolitan region. Portland has a positive reputation for its TOD system, but even within Portland, there clearly is a range of good and bad TOD examples. Or perhaps more appropriately, several TOD sites are consistent with TOD theory, and some TOD sites are significantly disconnected from TOD theory.

To provide some further insight into these rankings, a visual spatial analysis and a breakdown of the quantitative results for Gresham Central Transit Center (positive example of a walkable TOD) and Beaverton Transit Center (a negative example of TOD walkability) are illustrated in Figure 5. GIS-derived maps provide a visual analysis of

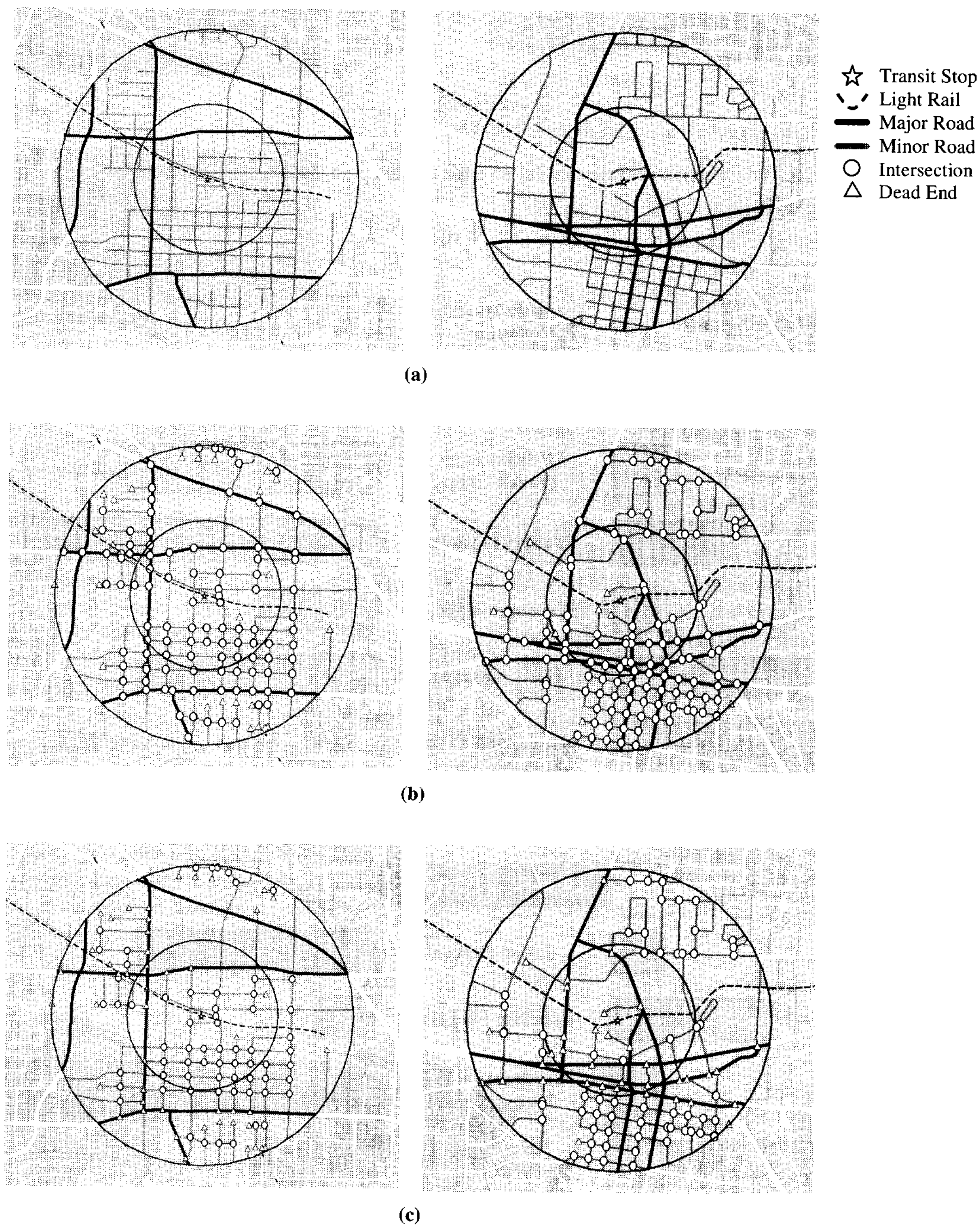

FIGURE 5 Visual comparison of TOD walkability for Gresham Central Transit Station (*left*) and Beaverton Transit Center (*right*): (*a*) street network classification; (*b*) intersection visualization; (*c*) impedance-based intersection visualization.

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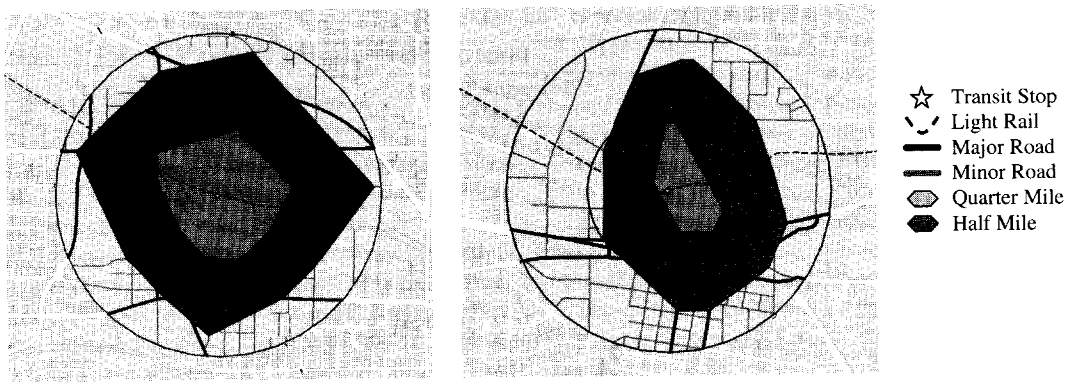
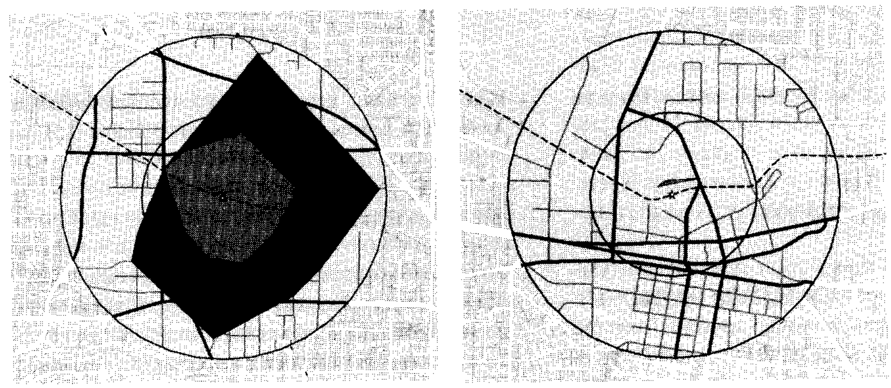


(d)



(e)

FIGURE 5 *(continued)* **Visual comparison of TOD walkability for Gresham Central Transit Station (*left*) and Beaverton Transit Center (*right*): (*d*) pedestrian catchment area visualization and (*e*) impeded pedestrian catchment area visualization.**

the environments' walkability and are grouped into five categories corresponding to the analysis methods described previously.

Street Network Classification

In comparing the two images in Figure 5*a* in terms of the types of roads that are proximate to the transit stops, two immediate observations emerge. First, in the aggregate, there seems to be a relatively similar quantity of street types between the two locations. In fact, within 0.5 mi of the transit stop, Gresham has 11.8 mi of minor roads and Beaverton has 11.3 mi; Gresham has 4.6 mi of arterial roads and Beaverton has 5.2 mi (Table 1). Each site has a similar quantity of minor roads (good for walkability) and a somewhat significant amount of arterial roads (potentially poor for walkability).

The second observation relates to the pattern of these arterials. In the Beaverton example, the arterials form a tight circle close to the transit stop, seemingly consuming and isolating the transit stop in an automobile-centric street system. In contrast, the arterials near the Gresham stop are less densely concentrated near the transit stop and are primarily found to the west and north of the stop, leaving a large southeast quadrant of space free from major automobile-oriented roads. Within 0.25 mi of the stops, then, the patterns are strikingly different. At the Gresham stop, there are 4.7 and 1.0 mi of minor and arterial roads, respectively. In contrast, Beaverton's 0.25-mi zone contains only 2.2 mi of minor roads and 2.5 mi of arterials, meaning that there are more automobile-centric roads than not within 0.25 mi of the transit stop. And judging from the visual analysis, these roads clearly form a noose around the transit stop, forcing would-be pedestrians to negotiate a potentially hostile environment.

These maps illustrate two key points. First, Beaverton's high concentration of arterials so close to the transit stop is counter to the theory of a walkable, urban form close to TOD stops. Second, the circular pattern of Beaverton's arterials cut off the areas beyond 0.25 mi by creating an automotive moat, making pedestrian travel difficult.

Intersection Analysis

Looking at the intensity of intersections and dead ends overall between the two sites in Figure 5*a*, patterns seem to be similar. Each has a section of a tight street grid with the resulting high concentrations of intersections, several dead ends throughout the zones, and sections that are absent of intersections or dead ends. In terms of numerical densities, the data are mixed. Beaverton has a relatively high density of intersections (around 150.0 per square mile) at both the 0.25- and 0.5-mi ranges; Gresham has a higher intersection intensity closer to the transit stop (188.4) and a lower intersection intensity in the 0.5-mi aggregate zone

TABLE 1 Quantitative Comparison of TOD Walkability

	Distance from Transit Stop (miles)			
	Beaverton Transit Center		Gresham Central Transit	
	0.00 - 0.25	0.00 - 0.50	0.00 - 0.25	0.00 - 0.50
Minor Roads (miles)	2.2	11.3	4.7	11.8
Major Roads (miles)	2.5	5.2	1.0	4.6
Intersection Density (per square mile)	147.6	150.2	188.4	133.6
Dead-End Density (per square mile)	20.4	11.5	10.2	31.8
Impedance-Based Intersection Density	20.4	78.9	137.4	82.7
Impedance-Based Dead-End Density	91.6	47.1	40.7	62.4
Pedestrian Catchment Area	0.2	0.4	0.6	0.6
Impeded Pedestrian Catchment Area	0.0	0.0	0.5	0.5

(133.6). In terms of dead ends, neither location suffers from an abundance of them.

Impedance-Based Intersection Analysis

Looking at the impedance-based intersection intensity analysis in Figure 5*c*, big differences are apparent between the two sites. Again, the impedance-based analysis removes arterials from the identification of intersections and dead ends and results in a decrease in pedestrian intersections (where minor roads cross arterials) and an increase in pedestrian dead ends (where minor roads terminate at an arterial).

The change in environment is striking, as represented by the spatial images. In this analysis, Beaverton "loses" many of its intersections due to the presence of multiple arterial roads, leaving a void of intersections—and thus pedestrian choice—within close proximity of the transit stop. In fact, within the 0.25-mi area, Beaverton's dead-end density exceeds its intersection density by more than four to one (91.6 vs. 20.4) and Beaverton's intersection density decreases by 86% within the quarter-mile distance. In contrast, the presence of arterials only reduces Gresham's intersection density by 27%—a significant amount, but not nearly as dramatic as in Beaverton. At the 0.5-mi aggregated zone, Beaverton and Gresham have similar intersection densities (78.9, 82.7), reflecting an increase in connectivity in Beaverton and a decrease in connectivity (due to the presence of arterials) in Gresham.

PCA Analysis

PCAs reflect the connectivity and grain of the network by comparing a theoretical, Euclidean distance to an actual, path-based walking distance in Figure 5*d*. Visually, the larger the walking zone (shaded areas within the large circle), then the better the coverage of the walkability network to the full theoretical 0.25- or 0.5-mi area of the TOD. In these two sites, the sizes of the PCAs are quite different, reflecting the different patterns of street networks between the sites. In Gresham, the PCA for both radii demonstrate relatively good coverage; in fact, both zones have a PCA score of 0.6, which is considered to reflect a walkable network (*25*, p. 2). However, Beaverton has a limited visual coverage, which is reflected in its lower PCA scores for the 0.25-mi (0.2) and 0.5-mi (0.4) zones.

IPCA Analysis

Similar to the impedance-based intersection analysis, the IPCA in Figure 5*e* is a refined measure of the zone of walkability by including the presence of automobile-centric roads into the visualization and calculation. Automobile-centric roads create barriers for pedestrians, reducing or eliminating a travel choice because automobile-oriented roads often create hostile and uncomfortably scaled environments from a pedestrian point of view.

The presence and location of impedance roads radically affect the two sites. In Gresham, where the arterials are located primarily west and north of the transit stop, the IPCA maintains relatively good coverage (0.5 at both distances). In severe contrast, the area surrounding the Beaverton stop becomes completely unreachable, with the IPCA at both distances scoring 0.0. At the Beaverton stop, there is no way to leave or access the transit stop without crossing and traveling along a major, automobile-oriented arterial. To the south and southeast of the stop, multiple barriers exist, severely separating the location of the transit stop and an area of high intersection density and a tight street grid (the old downtown).

The IPCA (or lack thereof) for Beaverton reflects the feeling that one has when accessing that transit stop. Although there is an intense development being built within feet of the stop (called the Round), access to any of the surrounding 0.25- or 0.5-mi area is nearly impossible by foot without traversing a series of large, high-volume, high-speed automobile-oriented roads.

REFLECTIONS

Access, connectivity, and choice are key elements in understanding the pedestrian environment, and all can be derived using various elements of the street network. Intersections, paths, and walkable zones (known in GISs as points, lines, and polygons) can all be derived from the basic urban skeleton of the street network to ascertain and evaluate the pedestrian compatibility of certain environments. In terms of TOD, the various methods described in this paper can be particularly useful for understanding the key link in the transit–land use connection that TOD helps to facilitate: the possibility of walking between the transit stop and key locations in close proximity to the transit stop.

Clearly, not all TOD sites are the same in terms of the pedestrian environment. Even within a single urban area (i.e., Portland), the pedestrian infrastructure can vary greatly. Using the analysis methods and a comparative framework can help policy makers, planners, and the public at large understand and evaluate how the network infrastructure relates to the location of the transit stop. Ideally, such analysis can be conducted before the placement of transit stops so that the locations can be selected based on an appropriate surrounding pedestrian environment. Alternatively, a postconstruction analysis of TOD locations can help planners and policy makers identify key connectivity barriers and opportunities so that TOD theories of walkability can be translated into practice.

FUTURE RESEARCH

The methods employed in this analysis are based on some assumptions that can be further refined. First, walkability as used in this paper assumes two things of the street network-based data: that all roads have sidewalks and that all roads of a given classification (minor, arterial) enjoy similar characteristics. Neither of these conditions wholly exists throughout an urban area, because sidewalks do not accompany all roads, especially in newly incorporated areas of a city, and sidewalks can come and go on the same street along its distance. Urban design of the streetscape also can affect how pedestrian friendly the environment is. Clearly, both pedestrian-friendly arterials and pedestrian-hostile minor roads exist, depending on various factors, including the volume of automobile activity, the presence of street trees, sidewalk setbacks and width, and the pedestrian-oriented amenities that exist along many roads.

The techniques and comparative analysis used here can be very easily replicated using easily accessible street networks and embedded road network classifications. And such analyses can be quite informative for both intra- and inter-urban analysis of TOD. However, three potential improvements can be made to the underlying data and analyses that may further refine the analysis of walkable environments.

- Sidewalk modeling. Developing accurate data sets of sidewalks would enhance the walkability analysis by using actual walking paths as a primary data set, rather than using the street network as a proxy. However, the development of such layers is not without difficulty. For example, sidewalk layers often do not cross streets, making it difficult to model distance traveled along the network. Also, classifying walking paths can be difficult. Do commonly used but informal paths across an empty lot count? Do paths that cut through major parking lots count?
- Intersection weighting. Not all intersections are the same, and refined classification can help in terms of modeling walking distances. For example, does an ill-designed 80-ft-wide road really feel more like 150 ft to a pedestrian? Does a nicely designed intersection actually feel more like 40 ft? Are intersections with crosswalks more conducive to longer walking trips than intersections without crosswalks? Weighting each intersection using various variables can help reflect actual walking behavior given a certain set of environments.
- Street reclassification. Streetscape design can have a significant impact on how pedestrian friendly one given route is compared to another. Our current hierarchical street classification is entirely automobile oriented, based on automobile volume. Reclassifying or developing an alternative classification based on a pedestrian scale could improve walkability analyses. Rather than classifying streets in terms of minor, feeder, collector, arterial, and so on, one could image a 1-to-10 ranking of walkability. A 10 would be a treescaped, separated sidewalk with various pedestrian amenities, from drinking fountains to benches to pedestrian-oriented shopping. In contrast, a 1 could represent a six-lane major automobile-oriented thoroughfare with an abundance of automobile-oriented commercial or industrial uses and no sidewalk.

The analysis of urban form at a fine-grain scale is an exciting development made possible by increasingly available data and the enhanced computing power of desktop GISs. Such analyses and their refinements will be particularly important in the upcoming decade as interest in various smart growth approaches continues to expand. Moreover, with the emergence of interest in connecting the built environment with physical activity, spatial analyses—both visual and quantitative—will be particularly relevant, especially in terms of walking and pedestrian access to local amenities.

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