APPENDIX A

TRANSIT SUPPORTIVE BEST PRACTICES

Table of Contents

Table of Figures

Appendix A.

Best Practices Report Overview

The following review of best transit supportive and alternative transportation development practices compiles bits and pieces of an overarching transit policy framework for the City of Redmond. Although not providing a detailed description or 'road map' to develop a fully fledged program for the long term, the document provides a comprehensive review of policies and strategies that could potentially be applied to address the mobility needs of Redmond's communities. The review is organized in two major chapters: Chapter 1 – Transit Service Development Strategies, and Chapter 2 – Mobility and Transit Supportive Strategies.

- **Chapter 1. Transit Service Development Strategies**: provides a discussion of transit market characteristics, service strategies to address specific market needs, and urban planning and traffic management strategies to improve service quality and performance.
- **Chapter 2. Mobility and Transit Supportive Strategies**: provides a discussion of transportation demand management strategies, including parking supply management, and promotion of ridesharing, bicycle and on-foot travel. It also discusses land use densification and effective urban design strategies to disincentive SOV travel.

Understanding of the Problem

In relation to the Local Transit Study, the focus of discussion in Redmond revolves around balancing the classic dilemma of coverage versus productivity, which is typically summarized as spreading the geographic coverage of the service network versus concentrating resources to increase service frequency in a smaller number of high-demand corridors.

Most activity centers and corridors in Redmond get service coverage. Coverage, however, has not only a geographic dimension (the transit network footprint) but also a temporal dimension (the span of service – peak, midday, evening/night, and weekend service). Transit service in Redmond is markedly peak oriented with reduced connections and frequency in the midday and minimal service on weekends.

The analysis of market characteristics in Redmond shows that there is a strong demand for commute trips at the regional level and strong demand for midday and off-peak trips that are sub-regional and local in nature. To increase productivity, a performance monitoring system shall be established that focuses on increasing the quantity of service (e.g. frequency and hours of service span), the quality of service (e.g. reliability, overcrowding, and speed), and the performance of service (e.g. ridership, passengers per hour, and/or passengers per mile).

Of all these variables, the elements that Redmond has no direct control over are the levels of service (i.e. service frequency and span of service hours). Every other aspect of the transit system operation is under direct or indirect control of the city. For example:

- Accessibility to service is strengthened by extending the reach and connectivity of sidewalks throughout the city area, as well as by investing in bus stops, bicycle parking and bicycle travel infrastructure
- Accessibility and demand for service is also strengthened by encouraging mixed-use and land use densification (commercial, industrial, and residential), and more compact urban

form development to bring residents, employees, and visitors more closer to the points of access to the transit network

- More density and diversity of uses generates more trips and increases the market base for transit, which in turn justifies investments in service frequency and service hours
- At the same time, fixing the street network to improve its functionality and grid connectivity (as Redmond is actually doing) increases the accessibility to transit on-foot or bike, and its market reach
- Managing parking supply via elimination or reduction of minimum requirements and management of on-street parking helps improving traffic circulation and reducing congestion, and ultimately improving transit operating speeds
- Service reliability (i.e. punctuality or on-time performance) and operating speeds are improved by optimizations in vehicle traffic, traffic signals and street design along key corridors and intersections
- Establishing a street hierarchy and identifying a network of multimodal corridors as Redmond has done in the TMP helps prioritization of transportation infrastructure investments into priority corridors that integrate and provide for multimodal trips which benefit transit demand and accessibility
- Furthermore investments in key corridors to optimize traffic signal progression and/or synchronization and transit signal priority protocols, result in significant improvements to transit operating speed and reductions in operating cost, and significant improvements to the reliability of service.

In summary, there are a number of strategies and policies that the City of Redmond can pursue (and is currently pursuing) to encourage and guide regional transit service investments in priority corridors that can help in better balancing the coverage versus productivity dilemma in the city. Identifying a network of multimodal corridors and, moreover, prioritizing investments in a subset of multimodal corridors to, for example, improve and protect transit operating speeds would go a long way in nudging regional transit providers to move from a destination based service (regional focus) to a corridor based service focus that concentrates service frequency in a set of key travel corridors that can sustain local, sub-regional, and regional travel demands.

Shifting the focus to corridor-based (higher-frequency) service would help addressing the growing need for local shorter trips that are characteristic of the ‘home-based other’ market (i.e. midday and off-peak period), which is forecasted to be the biggest and fastest growing market in the future.

1. Transit Service Development Strategies

1.1 Transit Market Characteristics

Transit markets and ridership decisions are typically influenced by three main factors – user characteristics, trip characteristics, and service quality.

User Characteristics

The mass transit market includes two broad categories of riders – choice riders and captive or transit dependent riders. Understanding the needs and preferences of these groups can help transit agencies tailor service provision and amenities to attract ridership from their desired market segment.

- **Choice Riders**: will use transit if the service it provides is competitive with other transportation alternatives (primarily the automobile) in terms of comfort and speed. Choice riders are most likely to use transit for work trips during the AM and PM peak periods. In most areas, these riders comprise the majority of the commuter market.
- **Transit-Dependent Riders**: typically fall within the segment of the population that is either too young, too old or has a physical limitation that prevents them from driving, or is too poor and does not own a vehicle. Like choice riders, transit-dependent riders will use transit for work trips, but also rely on the service for other utilitarian trips and social trips. Due to limited alternatives, transit dependent riders are more likely to use transit for less convenient trip purposes (e.g. shopping, medical, and/or recreational trips) and during off-peak hours, even with reduced service frequency.

Trip Characteristics

Travel characteristics such as trip purpose and trip length have important implications for transit ridership and service needs. Transit becomes more attractive and viable under high frequency service conditions where users can minimize wait time and plan trips regardless of published transit schedules. Transit agencies are typically more successful attracting commuter trips because more frequent service is provided during rush hours towards major activity centers. They are also successful in attracting local trips, during off-peak hours, along dense mixed-use (commercial and residential) urban corridors with high travel demand and service frequency. The local transit market can comprise a large percentage of total trips in areas where overall transit ridership is high, such as in university towns, dense urban centers, and major urban corridors.

- **Commuter Service**: has the advantage of serving regular trips. Because work trips are typically taken to the same location at approximately the same time each day, system users become familiar with the service and can plan to arrive at the stop or station to minimize wait time. For this reason, commuter service can operate on longer headways and still attract choice riders. Commuter service typically runs at a higher frequency in the AM and PM peak periods, with reduced or no service during the day. Commuter service is most competitive in terms of travel time when the route is as close to "express" as possible, and stops are limited to major activity centers. With its focus on regular peak period trips between major activity centers, commuter service can be quite efficient.

- **Local Service**: due to the nature of most local trips, local service must operate at a higher frequency to attract choice riders. Out-of-vehicle wait time (i.e. service headway) is especially important for local trips, as this time becomes an increasingly significant portion of overall travel time when making shorter trips. Local service users are also less able to plan both ends of trips to minimize wait time. For example, while a rider using transit to run errands can probably coordinate their departure with the transit schedule to minimize wait time; their return trip will be less predictable. High frequency local transit service (e.g. every 10 minutes) is a much more attractive alternative, giving users greater flexibility and reducing overall wait time.

Service Quality

The most important aspects of service quality are travel time, service frequency, and reliability (punctuality). These service quality factors tend to have a greater impact on ridership than price. In most cases transit is more affordable than using a private automobile (for choice riders), and although captive riders are burdened by fare increases, their alternatives are limited. Service quality is also discussed under Service Performance Monitoring.

- **Travel Time**: total door-to-door travel time has three components: travel time to reach the transit stop, out-of-vehicle wait time, and in-vehicle travel time. There are often tradeoffs between these components. For example, in-vehicle travel time is significantly influenced by the distance between transit stops and dwell time at each stop. Although greater spacing between stops increases average speed and reduces in-vehicle travel time, it also increases passenger travel time to and from stations and therefore may increase total door-to-door travel time.
- **Service Frequency**: combined with *Service Reliability* influences passenger wait time. Because passengers' out-of-vehicle wait time is perceived as longer[1] and more onerous[2] than actual travel time, service frequency and reliability are especially important components of total travel time and service quality. Providing real-time information (using NextBus, MyBus, SmarTraveler or similar services) reduces uncertainty and allows passengers to make more efficient use of wait time or switch to a similar route with a shorter wait time.

[1] Rabi G. Mishalani, Mark M. McCord and John Wirtz. "Passenger Wait Time Perceptions at Bus Stops: Empirical Results and Impact on Evaluating Real-Time Bus Arrival Information." *Journal of Public Transportation*, Vol. 9, No. 2, 2006.
[2] Ben-Akiva, M., and, S.R. Lerman, 1985. *Discrete Choice Analysis*. MIT Press.

1.2 Local Market Strategies

A variety of services and strategies are utilized to serve local transit markets, these include Feeder Services and Community Circulators, Downtown Shuttles, and Community Transit Networks.

Feeder Services and Community Circulators

Feeder and circulator services provide transit connections to major transit-oriented areas, urban activity centers, or major transit facilities. Feeder and circulator networks are usually based at a transit center or hub such as a rail/BRT station or a major CBD, providing a focal point or node where services can locate and take advantage of high daily pedestrian volumes and a diverse land use market base. The following practices are recommended to maximize the advantages of feeder services.

- **Service Connectivity**: effective feeder/circulator service must connect single-use areas (residential or industrial) to transit-oriented mixed-use areas where people want to go (e.g. a downtown or commercial corridor or district). Feeder and circulation services are an integral part of the regional transit infrastructure providing both a first mile/last mile connection, as well as a secondary network of transit services that complement the regional transit corridors.
- **Service Coordination**: effective feeder/circulator networks include scheduled transfers between feeder routes, and between feeder routes and major transit service modes (such as commuter rail, subway. light rail, BRT or other), to allow sufficient time for travelers to connect between modes without having to run. Peak period service is usually frequent enough so missing a connection does not require a long wait. However, off-peak service usually includes timed transfers between services to allow connections.
- **Service Information Exchange**: the key to modal connectivity is providing information that draws from all transit services, so riders can use whichever service will take them where they want to go. In this way, riders can perceive all transit as one linked system. Comprehensive information should be provided at transfer points and should include schedules, maps, service bulletins, and real-time information, about all services that are accessed from that stop/station.

Case Studies

Bay Area Rapid Transit – San Francisco Bay Area, CA

Bay Area Rapid Transit coordinates schedules at many rail stations with connecting feeder transit services. One example is at the Pittsburg/Bay Point Station, 38 BART trains in each direction on each weekday are met by Tri-Delta Transit’s Route 300. Transfer times range from 2 minutes (during early morning hours when travelers tend to stop less and few stores are open) to 13 minutes during the afternoon when travelers are more willing to stop and patronize stores.

Los Angeles, CA - Community DASH Shuttle Program

The Los Angeles Department of Transportation (LADOT) runs a family of shuttles in 27 neighborhoods in the City of Los Angeles that provide community circulation to local destinations such as schools, medical centers, and shopping centers/districts as well as feeder connections to the regional transit network and service to major destinations in the city. Community DASH shuttles use "neighborhood friendly" vehicles that are small (30-foot long), low floor, and alternative fuel (propane powered). DASH routes run every 15 minutes, are short and circuitous, and usually are anchored at a rail station, major transit corridor, or major destination where riders can access the regional transit infrastructure. DASH routes are designed to fill in gaps in the regional transit network and provide service to communities with an unmet need that otherwise have no accessibility to transit service. DASH service is provided Monday to Friday, from 7:00 am to 7:00 pm, with a few routes running also on Saturdays. The system is used for very short trips of about 1 or 2 miles long on average; service performance is high at over 20 passengers per hour on average. The success of the system has generated enormous local pressure for developing new routes in other city neighborhoods that have no connections to the regional transit network.

Downtown Shuttles

A dedicated shuttle route or system that focuses on circulation within a downtown area or regional center can further improve circulation and serve as an incentive for new downtown residents, employees, and/or visitors to reduce their dependence on auto travel for local and regional trips. A downtown circulator also reinforces the "park once" concept where visitors drive to downtown, park at a central location and walk or ride shuttles to multiple destinations in downtown. Furthermore, downtown shuttles that are designed for flexibility can be initiated within existing local resources and expanded over time to create a unique, frequent, and free or low-cost shuttle that will attract new riders to transit in general.

Case Studies

Denver, CO – Mall Ride

In Denver, the 16th Street Shuttle "Mall Ride" links Denver's Union Station with regional rail service to shopping, entertainment and business locations downtown. The shuttle is operated with both conventional and hybrid electric equipment, making frequent stops along the one mile route. The downtown business core in Denver is just beyond comfortable walking distance from regional rail service, requiring a shuttle to make a regional rail commute reasonable for employees coming to downtown Denver. The Denver Mall Ride carries over 60,000 people on a typical weekday, running very frequent service over a very long service span.

Santa Barbara, CA – State Street Shuttles

Santa Barbara runs two very successful shuttles with electric vehicles, along State Street downtown, and along their waterfront. These shuttles operate every 15 minutes, cost $0.25 per ride (compared with $1.25 for other transit routes), and carry local riders and visitors. The availability of the shuttles has enabled the Tourism Bureau and other organizations to advertise "Car Free in Santa Barbara" itineraries for visitors, stressing Santa Barbara's commitment to the environment. The downtown parking authority publishes maps of parking garages that show shuttle routes, encouraging "park once" combined with shuttle or walking travel through the downtown. Current technology allows these vehicles to be in service for about 8 hours between charges, operating about 75 miles on a single charge. To operate over a 12 to 15 hour service day, twice as many vehicles would need to be procured as required for peak service demand. At $400,000 per vehicle, the capital costs of an all electric fleet may be prohibitive. However, new technology in alternative fuel vehicles may make other types of clean and quiet buses a reality for other cities.

Los Angeles, CA – Downtown Area Short Hop (DASH)

The Downtown Los Angeles DASH system, operated by the Los Angeles Department of Transportation (LADOT) is a major success story, turning less productive “big bus” trunk routes operated by the MTA into local shuttles serving downtown LA districts and destinations and operated at less cost. The DASH system now includes over six routes with a concept similar to a community transit network providing – frequent, direct, and low-cost service in a small alternative fuel vehicle that is identifiable as distinct from the regional service.

Community Transit Networks

A Community Transit Network (CTN) is a policy framework to develop a network of top-quality transit services that connect key destinations within a city or community with the region, with service that meets basic needs critical to transit passengers in the community. If the operating and capital resources to implement a CTN are not present, its purpose is to act as a policy framework that ensures quality transit will be available when operating and capital resources become available, and when land use and street design standards in priority investment corridors have adopted transit-oriented forms. In summary, the CTN policy says:

- If development along a corridor achieves the minimum density required to support “high quality network” service, and
- If street design and management permits the operation of transit service at a given minimum speed and reliability, and maximizes the pedestrian access to each transit stop on the corridor, and
- If funding sources for high-ridership transit grow at an adequate rate to permit transit growth,
- Then the corridor will be permanently upgraded to high-quality network service levels, along with a corresponding higher priority for passenger amenities, fleet improvements, and other elements of transit quality.

The CTN is designed to guide transit service priorities, transit preferences in street design and signalization, transit passenger facilities, land use planning and development, and the siting of future transit-oriented and mixed-use developments.

Case Study

Boulder, CO Community Transit Network

The major example of a successful CTN is provided by Boulder’s Community Transit Network, which in collaboration with the Denver RTD developed a grid of local bus routes that operate with “neighborhood friendly” vehicles (low-floor, alternative fuels, smaller vehicles, memorable route names) at high-frequency (10 minutes or less at peak) along routes designed to be simple and interconnected. Routes are especially designed and branded for local service within Boulder, affording them high visibility and recognition from the community. CTN route services include the HOP, Skip, LEAP, Bound, Jump (Short Jump and Long Jump), among a growing list of services.

1.3 Transit Priority & Customer Information

Protecting Speed and Reliability

Most transit systems in growing communities are experiencing gradually slowing down of service. Many agencies lose one percent or more per year in average operating speed, due to a combination of increased traffic congestion and rising patronage, which increases dwell times at stops and time wasted in traffic at major street intersections.

Traditionally, transit agencies have set aside a portion of their expansion resources for “headway maintenance,” which means adding time to schedules so that buses have more time to complete their cycle (complete a round trip), longer cycle times overtime require adding more buses to the line to maintain service frequency or headways. This may be the only solution to a running time problem in the short term, but it does nothing to arrest the downward slide in operating speeds. Instead, the transit agency simply pays more drivers to endure ever-increasing delays, and tolerates the gradual deterioration in the speed of the service.

Transit operating speed is a crucial consideration for two reasons. First, time is money; the longer it takes to complete the cycle of a line, the more it will cost to operate at a given frequency. Second, the discretionary transit rider is very sensitive to speed. Because transit must stop to pick up passengers, it will usually be slower than cars driving on the same street. If it is too much slower, it will lose passengers to the automobile.

For these reasons, every major transit agency needs a comprehensive speed-protection strategy. The goal of such a strategy should be to set and maintain an average service speed policy on every line even as congestion, ridership, and other factors increase. The policy speed, of course, would vary with the line, but the slowest services – urban arterials – are also the most crowded, so even the loss of one mile-per-hour in speed can have cost and ridership impacts. Ultimately, the policy can be included in a city’s street classification system (i.e., as an overlay), so that a deficiency in transit speed becomes visible as a problem just as deteriorations in traffic level of service do. Ultimately, the city and the transit agency may want to encourage all jurisdictions in the transit district to adopt similar standards.

Protecting a policy operating speed requires joint action between the transit agency and the local jurisdiction that manages the roadway in question. Improvement may be best accomplished via a city lead or multi-jurisdictional effort that improves a full corridor. Virtually all speed protection measures require close cooperation and partnership between the city and transit agency. Most operating speed enhancements are capital development projects; these include signal technology enhancements and right-of-way improvements such as bypass lanes or queue jumps at intersections. However, a seemingly mundane element of service design, stop spacing and placement at intersections, is an extremely important consideration in keeping transit moving.

Providing Curb Access for Efficient Station Spacing

Spacing and location of transit stops strikes many people as so mundane that it is often treated as a detail to be left to the operational department that installs bus stops. Yet, stop location and spacing requires a carefully thought-out policy that is then implemented consistently throughout the system. Running-time savings due to efficient spacing and location of stops could be substantial on the busiest routes in the system where operating speed issues are likely to be most costly.

Ideal stop spacing is close enough that everyone in the surrounding area can walk to a bus stop, but no closer. Two blocks, typically about 600 feet (or 0.1 mile), is a common spacing standard in the industry for dense urban areas; the maximum tolerable spacing for local lines is usually in the range of 900-1,200 feet (around 0.20 to 0.25 mile), or about three to four blocks. One-quarter mile spacing is most typical of less dense urban areas, many times coinciding with first-rung suburban neighborhoods.

Protections from Traffic Delay

A wide variety of tools are available to protect transit from traffic delay. The following tools are the most common, listed in order from lowest cost and benefit to highest cost and benefit. Cost in this case is not necessarily money; often, the cost takes the form of a negative impact on single-occupant traffic that must be tolerated to optimize transit speed.

- **Merging delay from stops:** Transit often loses significant time yielding to traffic as it exits bus zones. For this reason, many agencies discourage bus pullouts, preferring bulbs that extend the sidewalk out to the traffic lane. This permits transit to stop in the traffic lane, and eliminates the need to merge out of the stop. Many states, including Washington, also have traffic laws requiring traffic to yield to a bus exiting a zone. Buses have prominent flashing yield signs on the left-rear to alert drivers of this requirement.
- **Traffic Signal Priority (TSP):** Many of the signals along major arterials are not linked to the signal progressions of intersecting streets. These minor signals typically occur at intersections with minor collectors and pedestrian-activated crosswalks. While these signals are important to local mobility, the green-time offered to the intersecting street is typically a policy minimum, and there are few side effects from delaying it to prevent minor signals from delaying a bus.

  The purpose of TSP is simply to pre-empt the green-time of the intersecting street or crosswalk just long enough for the bus to get through. The result does not disrupt the signal progression of the main arterial, because it simply extends the green time of a minor signal; the minor signal would still be red for the arterial only when the progression dictates. The pre-emption does not need to interrupt pedestrian-activated crosswalks once the pedestrian has been given a WALK signal, but it can delay the WALK signal until the next logical point in the arterial's signal progression. While this may sometimes cause running passengers to miss a bus, this tool is for use only on high-frequency lines where the next bus will be coming soon. It can also be de-activated in the evenings when frequencies are poorer and rapid pedestrian access is a higher priority relative to operating speed.
- **Queue Bypass at Major Signals:** It is often not practical for transit to preempt signals at the intersection of two arterials, because the intersecting arterial may have its own signal progression that cannot be disrupted without unacceptable traffic impacts. At these intersections, a common tool is the queue bypass. In this arrangement, the right lane approaching the intersection is reserved for buses and right-turning traffic. A special brief signal phase gives a green light to this right lane only, while also giving a red light to the crosswalk to which right-turning traffic would otherwise yield. This permits the right lane to clear out and for the bus to cross the intersection prior to the parallel traffic on the arterial. Queue bypasses require careful study, but are often an effective solution to moving transit through major intersections where queue delays can otherwise be severe.

- **Bus-Only Lanes and HOV Lanes:** The highest-benefit and highest-impact solution to bus operating speed problems is the bus-only lane. Freeway HOV lanes are an excellent example of this tool in an express mode, but there are also urban arterial applications. Los Angeles has been experimenting with a bus-only lane segment along Wilshire Boulevard (in West Los Angeles close to the I-405 freeway) that has been successful in reducing bus delays with low impacts to fronting businesses on-street parking.
- **Peak-Hour Parking Restrictions:** Many cities eliminate parking during high-demand hours to create a bus/HOV lane, though not all of these are properly enforced. Full bus/HOV lanes on arterials can be appropriate especially in very high-frequency corridors. Of course, these lanes dramatically impact the capacity of the street for traffic and parking, and typically require a well-established sense of urgency about the transit speed. Santa Monica implemented this policy in sections of Lincoln Boulevard to improve operating speed of its Rapid Blue service which was losing the benefits from traffic signal priority due to notorious traffic back-ups along Lincoln Boulevard.

Again, most of these treatments require leadership from the jurisdiction that controls the roadway. For this reason, policy operating speed standards, as discussed above, are especially relevant for identifying the need for these protections.

Case Studies

It is notable that a number of recent rapid bus projects in Washington and around the United States have shown that signal improvements focused on transit priority have succeeded in improving or at least maintaining general traffic levels of service, while reducing overall corridor delay. More importantly, higher transit speeds lead to mode shift which can dramatically increase the capacity of the facility (arterial) to move people at peak times and reduce delay measured on a per person, rather than per vehicle, basis.

Los Angeles, CA – Metro Rapid Bus Program

A prime example of this is the Metro Rapid Bus program in Los Angeles, which started as a pilot project on Wilshire and Ventura Boulevard in June 2001. Transit priority policies and dynamic signal priority at all intersections (that extends green times and shortens red times only when necessary and only for the time needed for the bus to clear the intersection) helped improve overall traffic in the corridor with negligible impact (less than one second) average delay to crossing streets. Faster bus travel times (30%) have consistently attracted new riders to the system; one-third of them have been former solo drivers and new to transit. Today the system is comprised of a network of Rapid Bus lines operating on more than 20 different corridors carrying more than 200,000 passengers every day.

Passenger Communication

There are several different types of passenger and transit operator forms of communication available for use at transit stations and shelters and on buses. Transit agencies throughout the country use automatic vehicle location and computer aided dispatch (AVL/CAD) technologies to track vehicle location and progress. AVL/CAD systems include an onboard computer equipped with global positioning system receivers that provide real time updates on bus locations. Other AVL/CAD systems include sign-post transmitters, schedule adherence monitoring, onboard mobile data terminals, managed voice communications, text messaging, next stop announcements, and automatic passenger counting. Vehicle location is then made available via the worldwide web, mobile and wireless devices, shelter signs and public displays, and on pole signs. Benefits associated with AVL technologies include:[3]

- AVL/CAD software enhances voice communications management for dispatchers
- Text messaging improves dispatch efficiency and informs passengers of bus arrival times
- Real time arrival and departure predictions increase efficiency, productivity, and ridership
- Automatic passenger counting equipment benefits passengers, drivers, and dispatchers by increasing efficiency and improving safety
- Historical data collected via AVL/CAD technology allow transit agencies to better analyze existing and future trends and conditions (schedule, headway adjustments, etc.)
- Onboard navigation helps keep operators on schedule and on route

[3] TCRP Synthesis 73: AVL Systems for Bus Transit Update

1.4 Park-and-Ride/Transit Centers

Park-and-ride facilities are an integral part of most medium and large transit systems. They are primarily designed to serve commuters, allowing individuals to change from an automobile to a carpool, vanpool, bus or a rail transit system when traveling to/from work. Park-and-ride facilities support bus and rail services by focusing demand, especially in low-density suburban communities where many potential riders are not within reasonable walking distance of transit services. The results can include both reductions in highway traffic volumes and the lessening of parking demands adjacent to major employment zones.[4]

Research has shown that most park-and-ride users have a choice about whether to utilize a private car for their entire commute. Accordingly, they tend to be highly influenced by potential cost savings, frequency of service, competitiveness of travel times, and parking limitations/cost at the destination. Successful park-and-ride facilities tend to address each of these interest areas and are conveniently located, provide pleasant facilities, and are safe and secure places to leave an unattended vehicle.

The "market shed" is the area around the park-and-ride facility from which most users are drawn. Industry research suggests that most users are unwilling to backtrack, and that a parabolic shape most nearly represents the draw area. A Seattle-area study, which incorporated 31 large suburban park-and-ride lots, found that 50 percent of lots' users came from a location within two and one-half miles of the lot. Furthermore, 85 percent came from a larger area that began two and one-half miles downstream (i.e. towards Downtown Seattle) from the park-and-ride lot and extended about 10 miles in the opposite direction.[5]

Most successful park-and-ride facilities are located near suburban population centers. As a result, issues of traffic, access, and encroachment into adjacent businesses' parking facilities are common, especially when a park-and-ride lot is located near a central business district. Two local examples provide case studies about how other Puget Sound communities integrate combined transit center/park-and-ride facilities into their broader downtown vision.

Case Studies

Tacoma, WA – Tacoma Dome Area Plan

The Tacoma Dome Area Plan is being used to transform the area around the Tacoma Dome, an industrial, manufacturing and commercial area in the heart of an urban center, into a mixed-use urban neighborhood. The plan was originally developed as a partnership between Pierce Transit and the City of Tacoma and its centerpiece remains the Tacoma Dome Station. It provides dedicated parking access for area businesses while serving as a transportation hub, bringing Amtrak, commuter rail, light rail, and regional express bus service together for easy user access. The area is connected with other major public investments such as the University of Washington branch campus by the Tacoma Link light rail line and an extensive pedestrian system. Meanwhile, the city is using this facility to springboard development within the project area, working towards a mix of transit-oriented residential and business activities.

[4] TRCP Report 95, "Park-and-Ride/Pool – Traveler Response to System Changes," 2004.
[5] Spillar, R. J., "Park-and-Ride Planning and Design Guidelines," 1997.

Lynnwood, WA – Lynnwood Transit Center and City Center Project

Community Transit operates a major transit facility at the edge of Lynnwood's emerging downtown district. Over the years it has become a focus of transit activity, where patrons can transfer from local bus services to regional routes operated by Sound Transit and Community Transit. Additionally, the center provides 1,200 park-and-ride spaces, making it the largest park-and-ride lot in Snohomish County. To keep up with demand, Community Transit and Sound Transit have steadily upgraded the transit center's facilities, adding direct access ramps to/from Interstate 5, providing additional parking spaces, and upgrading passenger waiting facilities. In the future, the Lynnwood Transit Center will become the northern terminus of Sound Transit's Link Light Rail, which was approved by voters in November 2008.

Because the Transit Center is located inside the boundary for Lynnwood's City Center Project, the city has paid careful attention to how this transit facility will relate to the rest of the emerging downtown area. Lynnwood's City Center Plan promotes a mix of retail shops and services, entertainment, public spaces, and cultural attractions while breaking up superblocks and emphasizing pedestrian access throughout the downtown, along with a possible 'super stop' at a central downtown location. Over time, downtown-area surface parking is expected to decline and the city has expressed interest in promoting residential development within the air rights over the transit center.

Auburn, WA – Lakeland Hills Commuter Rail Feeder Service

The City of Auburn is employing a different strategy. The park-and-ride facility at the Auburn Sounder Station is routinely filled to capacity, with parking spilling out onto adjacent city streets. As a short-term alternative to adding more capacity, the city has partnered with King County Metro, Pierce Transit, and Sound Transit to operate a rail feeder service from the Lakeland Hills Neighborhood to the Sounder Station. Lakeland Hills is a primarily residential neighborhood, located within Auburn's city limits. The neighborhood is split between King and Pierce counties but, prior to initiation of the rail feeder service, was not served by either Pierce Transit or King County Metro.

Auburn initially proposed this service as part of Metro's Transit Partnership program. Pierce Transit and Sound Transit joined as of means of sharing the cost of needed services. The route began operation in February 2009. Six morning and six evening trips are designed to coordinate with train schedules. If the train runs late, the bus waits, thus providing highly reliable transfer connections. While still a new service, ridership has exceeded projections.

This service represents an alternative to the expansion of park-and-ride capacity to meet demand. Figure A-1, below compares the operating costs associated with the Lakeland Hills service with the costs of recent structured park-and-ride facilities.[6] It suggests that, prorated over the 20-year life of a structured parking facility, each space would cost about $1,700 per year. Meanwhile, operation of a feeder route similar to the Lakeland Hills service would cost about $1,700 per year per passenger at full capacity. While these calculations include the direct costs associated with construction and operation of park-and-ride facilities and feeder bus service, they exclude many indirect costs and possible revenues. For example, both the purchase of

[6] Numbers are rounded. Park-and-Ride costs are based upon the costs associated with construction of the Mountlake Terrace Park-and-Ride Lot, which opened in March 2009. Costs for transit facilities have been excluded. Annualized construction costs assume a 6% implied interest rate. Feeder service costs reflect the costs assumed in the inter-local agreement between project partners for the Lakeland Hills Rail Feeder Route.

equipment and construction of facilities may be eligible for federal capital assistance, which could reduce the construction costs to local governments. Similarly, because fewer vehicles would be traveling through adjacent neighborhoods, feeder bus services might reduce roadway costs compared to street costs associated with a park-and-ride. Finally, land that would otherwise be locked up in park-and-ride facilities could be used for other purposes if feeder bus services operate instead. All these factors suggest that local conditions and levels of demand need to be carefully evaluated before choosing between the expansion of park-and-ride facilities and initiation of feeder bus services.

Figure A-1: Comparison of Feeder Service and Park-and-Ride Unit Costs

Item	Cost per Unit
Cost of Structured Parking	
Total Construction Cost	$30,000,000
Annualized Construction Cost	$1,500,000
Annual Operating Cost	$200,000
Number of Parking Spaces	1,000
Annual O&M Cost per Space	$1,700
Cost of Feeder Service	
Annual Operating Cost	$300,000
Annual Capital Cost	40,000
Capacity of Service (daily riders)	200
Annual Cost per Rider	$1,700

Transit Centers

Transit centers are sheltered waiting areas located where several bus routes converge. They are a common feature of many bus transit systems around the country, especially in suburban communities that lack a well-established central business district and in large urban areas with numerous activity nodes. Transit centers serve as ‘hubs,’ allowing riders from various locations to take advantage of express trips or other route-to-route transfers. In each case, the goal is to offer a range of convenient transfer opportunities that accommodate a variety of trip patterns. Transit centers also tend to provide a permanent identifiable presence in a community, increasing the transit system’s visibility.

Transit centers vary greatly in design and operation. A rural transit center may be little more than an intersection between two routes marked by bus stop signs and a waiting area. In contrast, large urban transit centers may consist of major off-street facilities where twenty or more bus routes converge.

Timed transfer, the practice of coordinating schedules so that buses arrive and depart within a common ‘window’ is a common, but not universal, practice at transit centers. Because buses are scheduled to arrive and depart at the same time, transferring between routes is made more convenient when timed transfer operations are employed. Normally, a timed transfer can only be designed at one point along a bus route. Timed transfer operations may also make it impossible to meet class or shift times at other points along the route and may not be a viable strategy when traffic conditions vary widely from day to day.

Transit Centers are generally an effective service strategy when the following conditions exist:

- More than one transit route operates in a community
- Densities are relatively low and transit service generally operate less frequently than every 15 minutes
- Travel patterns are dispersed with no single origin/destination pattern dominating trip making
- There is widespread transfer activity within the transit system
- Transit routes can be modified to serve the transit center location without significantly increasing travel times for patrons riding through the transit center
- While not absolutely essential for success, transit centers normally prove much more effective when they are located within convenient walking distance of a major trip destination, such as a shopping center, rail station, or school.

Conditions that tend to make transit centers less desirable include:

- A preponderance of radial trip making where people travel from their home to a central business district and not to other locations within the community
- Trips tend to be long, if higher speed regional express services (express bus or rail) are not provided
- Transit services cannot be redesigned to serve the transit center location without creating significant delay for through riders
- The absence of a pedestrian-friendly environment in neighborhoods surrounding the transit center may reduce its market success

1.5 Service Performance Monitoring

Transit service performance measures are used by transit agencies to assess the performance of their transit systems and to ensure that customer and community concerns and issues are properly addressed. In addition to being required by the National Transit Database, performance monitoring is also needed to inform those outside the agency of system performance.

Performance measures provide transit agency management with a means of objectively assessing past and current trends, existing concerns and issues, challenges, and unmet needs. More specifically, performance measures are used by agency management to monitor service, evaluate economic performance, develop service design standards, and to communicate accomplishments.

Service Quality Standards

Service quality can significantly affect customer perceptions and influence ridership. In general, transit agencies have partial control over whether or not someone decides to use transit. If service is available a potential customer may utilize transit if it is convenient, comfortable, and competitive with other modes both in terms of cost and time. Things that transit agencies have control over that affect the decisions of those considering riding transit are service delivery, travel time, safety and security, and maintenance.

- **Service Delivery**: It is important that service delivery meets and/or exceeds customer expectations. Factors that affect service delivery are the reliability and quality of service, the customer’s physical comfort with using transit, and the ability of the transit agency to achieve promised service goals.
- **Travel Time**: Travel time must be competitive with other travel modes in order to encourage and sustain ridership. Travel time can be measured by person minutes of delay, or time can be converted to a monetary value.
- **Safety and Security**: Passenger perception and realities of risk and injury also greatly affect quality standards and potential ridership.
- **Maintenance**: Service quality and customer perception is affected by agency maintenance programs. Maintenance and the reliability of transit vehicles in part greatly affect overall customer confidence as do the cleanliness of vehicles, stops, shelter, and other facilities. In addition, an agency’s ratio of primary to spare vehicles is important in ensuring that all trips are made.

Service Coverage and Accessibility Standards

Strategic coverage and accessibility to stops and shelters contributes to overall customer satisfaction and potential ridership. The availability and accessibility of transit service can both greatly affect potential ridership. Thus transit service must be provided to locations with high demand at times that are most convenient for passengers. Many of the characteristics associated with accessibility and availability are under the control of the transit agencies. These characteristics include headway (frequency), hours of service provided daily, potential passenger awareness, and constraints. Performance measures that are often used to assess availability and accessibility are service coverage, frequency, hours of service, stop and shelter accessibility, and route coverage, among others.

Cost-Benefit Standards

Cost benefits indicators are commonly used as a means of measuring, monitoring, analyzing, and reporting operational efficiency. Efficiency standards and measures are used to evaluate a transit system's ability to perform its primary duties effectively. Commonly used operational performance measures include:

- Passengers per revenue hour
- Passengers per revenue mile
- Farebox recovery ratio (total revenue over operating costs)
- Operating cost (subsidy) per passenger
- Operating cost (subsidy) per passenger mile

These measures indicate productivity and efficiency, or how much of the agency's costs are covered by passenger fares, and therefore how much subsidization is required.

Performance/Productivity Standards

Performance standards should be established for each measure, especially when linked to transit agency goals. Standards should be realistic and useful to ensure that performance measure programs are achievable, but should also set challenging goals. From a cost-benefit perspective, ideally the benefit obtained should greatly outweigh the cost of increased performance. Performance monitoring should be conducted annually.

Outlined below are re six commonly used methods transit agencies employ when developing standards for performance measure tracking.

- Comparison of performance to annual average (route performance, ridership, etc.)
- Comparison to baseline data (first year the performance measure was implemented)
- Trend analysis (performance improvement when compared to previous annual data)
- Agency identified standards (use current performance, professional judgment, and agency goals)
- Performance comparison to other transit agency standards and measures
- Performance comparison to similar transit systems (size, purpose, ridership, etc.)

Case Studies

Seattle, WA – UVTN Performance Monitoring and Implementation

The purpose of the UVTN Performance Monitoring and Implementation Project is to report the performance of the Urban Village Transit Network (UVTN), or "Seattle Transit Connections." The UVTN is Seattle's vision for a network of high quality, reliable transit corridors that support and connect Seattle's urban villages, as set forth in the Seattle Comprehensive Plan. The UVTN represents the backbone of transit service in Seattle with a goal for service at least every 15 minutes (in both directions), 18 hours a day, seven days a week.

Annual reports are issued that measure the performance of the UVTN and make recommendations for improvements that ensure the network is meeting established standards. The performance of the UVTN is monitored using five independent Quality of Service (QOS) measures. These measures describe the key quantifiable features of service quality from the passenger perspective: frequency, span of service, overcrowding, reliability, and travel speed.

Frequency

Frequency is described by the duration of the maximum scheduled gap between consecutive buses on the route. When all service is on schedule, this gap, called the “headway,” is the maximum waiting time a customer will experience. Frequency can never be described in terms of averages, only in terms of worst case. If four buses are scheduled to come at the same time each hour, this could be construed as an “average 15-minute frequency” or “hourly service”. The passing threshold for the Frequency measure, as described in the Seattle Transit Plan, is 15 minutes. UVTN segments with headways higher than 15 minutes are considered below the passing threshold and remedial actions or strategies are necessary.

Span of Service

Span of service describes the number of hours in the day that a service runs at UVTN frequencies (every 15 minutes or better). The passing threshold for the Span of Service measure is at least 16 hours for services with frequencies every 15 minutes or better. UVTN segments with a service span less than 16 hours are considered below the passing threshold and remedial actions or strategies are necessary.

Passenger Loading (Overcrowding)

This is an important measure that provides insight into a range of issues affecting transit, including:

- Passenger comfort, both in terms of finding a seat and crowding levels on the vehicle.
- The need from the transit operator’s perspective to increase service frequency or vehicle size to improve passenger comfort.
- The risk of “pass-ups,” where a transit vehicle bypasses waiting passengers because it is too full.

Many agencies measure loading in terms of a “load factor,” defined as the ratio between the number of passengers and the number of seats. Historically, when bus designs were uniform, a load factor in the range of 150 percent (one passenger standing for every two seated) described a crush-loaded vehicle. However, as transit vehicles have become more diverse, standard load factors have become less useful. Low-floor buses, for example, typically have fewer seats than standard buses of the same size, but the same amount of standing space, so they can tolerate a higher load factor. For this reason, a measure of percentage of vehicle capacity (% capacity) was chosen as a way to provide a more level means of comparison between different vehicles serving different needs. The capacity of a transit vehicle describes the number of passengers (seated and standing) that can safely and comfortably travel on the vehicle. It generally also reflects the operational needs of the vehicle such as passenger circulation (within the vehicle and boarding and alighting). Since the vehicle capacity includes the passengers who can stand safely, the passing threshold is less than 100 percent of this capacity. If loads in a UVTN corridor are greater than 100 percent of vehicle capacity, this is considered deficient in the Overcrowding measure.

Reliability

Whereas the Frequency measure describes the scheduled elapsed time between transit vehicles, Reliability describes the degree to which the schedule is achieved. The minimum passing thresholds for the Reliability measure is that greater than 60 percent of all services are less than one (1) minute late, 90 percent of all services are less than three (3) minutes late, and less than three percent of all services are over five (5) minutes late. If more than three percent of services are more than five minutes late, then that UVTN segment is considered deficient.

Travel Speed

Speed is average speed, not top speed. It describes how long the service takes to traverse each mile, including all sources of delay.

As discussed in the Seattle Transit Plan, transit service in Seattle continues to be slow. On key downtown Seattle streets, average operating speeds never top 10 miles per hour (mph). On some streets during the PM peak period (3:30 p.m. - 6:00 p.m.), speeds fall below 5 miles per hour. This is not unique to the Puget Sound region – many agencies across the country are losing one percent (1%) or more per year in average operating speed.

The system of measurement proposed in the Seattle Transit Plan is the travel speed as a proportion of posted speed limit, or the Percentage of Posted Speed Limit (%PSL). The measurement of travel speed needs to include all aspects of the trip, including dwell time at stops and traffic signals, and delays caused by traffic congestion and mechanical faults. The minimum passing thresholds for the Speed measure is that all services operate at 30 percent of PSL, at least 70 percent of services operate at 50 percent of PSL, and at least 5 percent of all services operate at 70 percent of PSL. If, for example, more than 70 percent of services are operating at 50 percent of PSL, and more than 5 percent of services are operating less than 30 percent of PSL, then that UVTN segment is considered deficient.

2. Other Mobility Strategies

2.1 Transportation Demand Management (TDM) Programs

The City of Redmond has one of the strongest TDM programs in the country and most of the strategies included in this section have been implemented in the city with great success. Still a state-of-the-art review of TDM programs is included below for context and benchmarking purposes. Transportation demand management initiatives can be divided into three groups: destination-oriented, origination-oriented, and universal TDM, as described herein:

- **Destination-Oriented TDM:** focuses on supporting non-auto access at trip-generator locations (i.e. a shopping center or a place of employment)
- **Origination-Oriented TDM:** focuses on supporting non-auto trips at places of residence (i.e. homes)
- **Universal TDM:** measures that promote community-wide support for and awareness of alternatives to single-occupancy auto travel (i.e. citywide programs and infrastructure)

Destination-Oriented TDM Strategies

Destination-oriented strategies are employer-based TDM strategies. In general, they tend to be the most effective means of reducing rush hour auto trips and promoting transit use. For many urban centers and corridors, the focus of these strategies is on the large employers drawing most commute trips and generating traffic congestion. Typical employer-based TDM initiatives include the following:

- Central bulletin board, display case, or use of internal e-mail systems or websites, to distribute information on commute options and transportation modes
- Reserved parking spaces for carpools and vanpools at prime locations
- Formal telecommute program or informally supporting telecommute through labor policies
- Flextime or compressed work week schedule options
- Tax-free transit benefits program, either employer-sponsored or through pre-tax payroll deduction
- Incentive program for those who carpool, bicycle, or walk to work
- Installing bicycle and/or shower facilities to encourage bicycle and walking trips
- Providing employee/customer shuttles to local transit stations or other service areas
- “Guaranteed Ride Home” program where non-driving employees who work past normal shift hours, or have a personal emergency during the day, are offered paid cab service to go back home
- Charging fees to solo drivers for parking at work (for employers who previously offered free parking)
- Implementing a parking cash-out program, where a cash payment is offered to employees who opt out of employer-provided free parking

- Offering free or reduced-price parking for carpools and vanpools (where a fee previously existed)
- Starting employer sponsored or subsidized vanpools
- Implementing an Air Quality Action days or Commute Fair days program where TDM initiatives are heavily promoted to employees
- Conducting regular employee transportation surveys to determine travel patterns and measure the effectiveness of the TDM programs

Origination-Oriented TDM Strategies

Compared to standard residential developments, transit-oriented development (TOD) tends to attract residents who own fewer cars and make more transit trips. Thus, local transit access tends to figure prominently in the choice of TOD housing. Home-based TDM measures can strengthen non-SOV mode use at TODs and widen support for transit and alternative modes at standard residential developments, and further reduce auto demand. In general, common home-based TDM measures include the following:

- Social marketing programs (like King County's In Motion) to inform the community on alternative commute modes and healthier choices for every day travel
- High-bandwidth Internet connections that support telecommuting
- Pedestrian-friendly and neighborhood-based design that encourages interaction and socialization between neighbors, and within the immediate community
- Secure and adequate storage for bicycles, including guest bikes
- Allowing developers to pay a fee *in-lieu* of meeting parking requirements, reducing parking requirements, or implementing maximum on-site parking limits
- Requiring developers to "un-bundle" parking costs from housing prices, charging for actual use rather than passing the cost onto all residents. This makes the cost of vehicle ownership more transparent, and offers savings to those who do not need parking

Universal TDM Initiatives

Other TDM initiatives can be implemented to promote a community-wide multi-modal transportation culture. Such measures include the following:

- Commuter Assistance Kiosks providing alternative transportation information and space to post ride-sharing requests and offers
- Free meter-parking for car-share vehicles
- Providing and maintaining convenient and secure bicycle storage

Case Studies

Cycling Incentives at Children's Hospital in Seattle, WA

This is a Destination-Oriented TDM case study. Ranked as one of the best children's hospitals in the country, Seattle Children's serves as the pediatric referral center for Washington, Alaska, Montana, and Idaho. The hospital is planning to double the size of its main campus in the Laurelhurst neighborhood and in turn is reinforcing its already successful TDM program which has reduced solo driving to a 38 percent mode split. Children's bicycle programs are among the most innovative TDM strategies used by the hospital to reduce SOV traffic. These programs include:

- *Bike to Work* – this is a low cost program in which employees form teams and compete to log the greatest number of commute bike miles. Winning team members earn a $25 REI gift card. During May 2008, Children's *Bike to Work* month teams rode over 30,800 miles to and from work, preventing 30,800 pounds of carbon release. Out of all 627 competing organizations, Children's registered the most riders, most new riders, and most teams. By comparison, Microsoft formed fewer teams, but has around 10 times more employees. An exciting program for those involved, *Bike to Work* boosts employee morale and incites friendly interdepartmental competition.
- *Commute Bonus* – this is a mid cost incentive in which employees are paid to use alternative transportation modes during their commute. With this program, employees can earn $65 per month for riding their bike to work. *Commute Bonus* works on the honor system whereby employees keep a log calendar. In the future, the hospital plans to move to *real time* format in which monitors cross-check log calendars against key card swipe data gathered at parking facilities, on shuttles, or at shower facilities. Just as employees are paid not to drive – employees pay to drive. The cost for driving is incurred when parking.
- *Company Bike* – this is another mid cost program in which employees who pledge to bike to work at least two days each week get a *Company Bike* free of charge, theirs to use as long as they continue to commute by bike. The program includes training classes and bicycle maintenance. Over 100 employees have signed up since the program's launch in July 2008. The bikes come with fenders, a rack, lights, and a helmet.
- *Bikesharing at Building One* – this is another mid cost program in which the 200 employees in Children's Building One can check-out any of 10 dedicated bikes overnight or for midday errands.
- *Flexbikes* – this is a high cost program option in process of implementation. The program will use automated kiosks where employees will be able to check-out electric-assist bicycles for midday trips. The partnership was proposed with the University of Washington to get more people onto bikes and out of cars, especially new riders concerned about cycling up hills. The program is high cost because the bikes' electric motors require expensive docking systems for charging. Children's did not win the first grant they applied for to fund the program, so the program is still in the funding phase.
- *Biking Classes and Tune Ups* – In addition, Children's offers bike commuting courses and on-site tune-ups. The classes run in fall and spring via a partnership with two local bike advocacy non-profits; the tune-ups are coordinated through a private contractor.
- *Mode Combination* – When cycling for the full commute is not possible, Children's still encourages combining biking with another mode such as the bus, a shuttle, or walking.
- *Shower and Lockers* – To support cyclists and these programs, Children's offers showers, changing facilities, towel service, secure lockers, outdoor lockers, racks on Shuttles, outdoor bike parking racks, and easy access to the Burke Gillman Trail.

San Francisco Carpool and Vanpool Parking Program

This is a Universal TDM case Study. The San Francisco Department of Parking and Traffic operates a Carpool and Vanpool Parking Program that provides preferential on-street parking to certified carpools and vanpools within designated parking areas. The Carpool Program allows certified carpool vehicles to park in designated carpool permit parking areas near participating workplaces. The annual fee for a carpool parking permit is $21, and permit holders may park in designated on-street spaces without charge for the entire workday. Carpools must have three or more riders, and permits are transferrable among vehicles registered in the carpool. The City currently has three designated carpool parking permit areas with a total of 100 reserved spaces.

The Vanpool Permit Parking Program has six designated vanpool parking areas on the fringes of downtown. Permitted vanpool vehicle may park in designated spaces all day without charge or time limit (these spaces are typically $1.00/hour with a 1 hour time limit). Vanpools must have at least five riders. There are currently 107 certified vanpool vehicles, removing an estimated 400 vehicles from the roadway during the AM and PM peak periods.

Both the carpool and vanpool programs are popular and considered successful. Similar programs are offered in Los Angeles, CA, Nashville, TN and Phoenix, AZ.

2.2 Parking Management

Parking management is essential for managing urban mobility, traffic congestion and maximizing the benefits of transit. There are three important goals to parking management:

- Minimize on-site parking
- Manage on-street utilization and turnover
- Prevent spillover

Minimize On-Site Parking

Parking policy should begin by emphasizing provisions of on-site parking that reflect the fact that mixed-use development generates less parking demand than separate free-standing developments of similar size and character.[7] Furthermore, urban environments that are high-density and transit-supportive, and have pedestrian-focused urban design, offer potential for decreased vehicle use and ownership. Mixed-use districts' benefits to urban development, community development, and the environment justify seeking strategies for aggressively minimizing the use of developable land for vehicle parking. Three of the most effective means for this are the following:

- Reducing or eliminating parking requirements
- Allowing developers to pay a fee *in-lieu* of meeting parking requirements
- Requiring or encouraging shared parking

Reduce or Eliminate Parking Requirements

The reduction or elimination of minimum parking requirements for all land uses should be strongly considered. Minimum parking requirements increase off-street parking supplies and site development costs; they also reduce sites' potential uses and building design options. In turn, off-street parking increases curb-cuts and pedestrian-auto conflict points on the sidewalk. This makes it considerably more difficult to achieve dense, walkable, and pedestrian-friendly development patterns, thus providing more incentives for driving. Zoning options for reducing parking include the following:

- Reduction of minimum parking requirements for residential and commercial developments
- Elimination of parking requirements
- Establishing maximum parking limits for all developments
- Including on-street parking as part of a development's parking supply for purposes of satisfying zoning requirements
- Reducing minimum requirements when a development incorporates TDM practices such as shared parking arrangements or transit-pass programs

In-Lieu Fees

Allowing developers to pay a fee "in-lieu" of meeting the standard requirements can be a highly effective means of minimizing on-site parking, especially in space-constrained older urban areas.

---

[7] Urban Land Institute, "Shared Parking", 1983.

A fixed base fee, typically set well below the construction cost of one parking space, can be collected for each zoning-mandated space left unbuilt. This provides a financial incentive to eliminate, or minimize, on-site parking for development projects.

Collected fees can be pooled to construct parking as necessary. This parking is by default shared-parking, as it is tied to no specific land use and is controlled publicly. This policy works especially well where a local civic association is available to administer the collected funds and return them to local benefit. Providing an In-Lieu Fee option can reduce the impact of parking and traffic in several ways:

- Increasing off-street efficiency by matching supply to demand on a district-wide, rather than a site by site, basis
- Providing fees to support TDM policies and programs
- Increasing control over parking facility design and location
- Supporting infill development in older urban corridors, where meeting standard on-site parking requirements is often infeasible

Shared Parking

Shared parking is defined as "parking space that can be used to serve two or more individual land uses without conflict or encroachment."[8] Shared parking supplies are fundamentally more efficient than single use spaces, because each space can be occupied for more hours throughout the day, week, and year. Sharing parking also allows for reduced pedestrian-auto conflict points, by reducing parking access points, allowing for better pedestrian levels of service and increased development densities. Shared parking opportunities are created by two basic conditions:

- Offsetting demand peaks among neighboring land uses
- Complementary land uses that generate multiple-destination visits to a single area

Park & Ride lots, for example, can be shared with churches, nearby movie theaters and/or restaurants. Transit riders use the parking on weekdays, while others use it on evenings and weekends. Another example is a space that may be used by patrons that dine out at a local restaurant before attending a nearby play.

Shared parking can be supported by centralizing parking supplies. Privately controlled on-site supplies can be shared as well through agreements arranged informally among local businesses, or brokered by a local parking authority or civic association.

These three parking best practices are mutually supportive and maximize each other's benefits. For example, where In-Lieu fees are used to construct central supplies of shareable parking, reduced parking minimums work all the more effectively by reducing demand for on-site supply.

Manage On-Street Utilization & Turnover

Ideal utilization of on-street parking leaves about 15 percent of curb space vacant at all times[9]. This is generally enough vacancy for parking to "feel" available and not discourage the short-term

[8] Urban Land Institute, “Shared Parking”, 1983.
[9] Shoup, Donald. The High Cost of Free Parking

trips upon which many businesses depend. The traditional approach to encouraging effective turnover is to impose time limits for high-demand spaces. This however has proven difficult or expensive to enforce, especially where meter rates compare favorably with long-term off-street prices.

Pricing is a tool that has been gaining a lot of attention lately for its potential to manage occupancy and turnover for on-street parking. Technology, most notably computerized multiple-space meters, has added important flexibility to this option, by allowing meters to charge "market" rates that track demand levels throughout the day and week. This technology also improves customer convenience, for example through accepting credit cards or refunding charges for unused time.

Flexible and effective pricing of on-street parking is especially beneficial to local businesses that depend on high turnover rates to maintain front-door access for their customers. If cities charge the right price for curb parking, they can do away with time limits. Prices alone can maintain curb vacancies and create turnover. Prices can vary frequently enough to avoid chronic overcrowding or underuse. These prices can be reviewed periodically to examine whether they are producing the target occupancy rate. Prices will typically vary by time of day (e.g. lower evening rates) and location (i.e. lower rates on side streets or less intense commercial frontages).

Effective pricing can preserve curb space availability even during peak hours, and fill spaces that would otherwise be vacant during off-peak times. It can maintain optimal turnover at spaces that provide front-door access to local shops and services. It also can reduce "search" traffic generated by over-occupied free-to-cheap on-street supplies.

Prevent Spillover

Effective parking management does not mean adjacent neighborhoods will be affected by spillover parking demand. These problems can be addressed through thoughtful implementation of Residential Permit Parking or Parking Benefit District programs. This is true regardless of whether parking demand is generated by rail stations or commercial centers.

Residential Permit Parking

Residential Permit Parking (RPP) programs are becoming an increasingly standard practice in urban areas, as cities move away from traditional separation of uses, and residents are moved ever closer to visitor-parking generators. These programs preserve on-street spaces for permit-holders to allow residents better opportunity of finding on-street parking near their homes. Such programs have generally been very effective in meeting this goal.

While RPP programs have proven a highly effective tool in protecting against parking demand spilling over into residential neighborhoods, they have often overreached in this direction, leaving on-street spaces idle while visitors circle commercial blocks in search of spaces. One solution that is emerging as an effective remedy to this is the creation of Parking Benefit Districts.

Parking Benefit Districts

A Parking Benefit District differs from traditional RPP in two important ways. First, while residents continue to use permits to park free of meter charges on RPP-designated streets, non-residents may access the same spaces by purchasing daytime-only permits or paying at meters. Second, all on-street parking revenues collected in the district are used to fund local public services and improvements. Meter fees can be adjusted, using computerized multi-space meters, to maintain ideal occupancy rates throughout the district, and to free up RPP-designated spaces during resident demand peaks.

Advantages of Parking Benefit Districts over traditional Residential Permit Parking include the following:

- Expanded parking opportunities for non-residents
- More efficient use of on-street supply
- Funding for local improvements and services
- Simplified/expanded visitor parking options for residential guests and resident users of car rentals and car sharing

Case Studies

Marlborough, MA Parking Strategies[10]

To accommodate its workforce and residential parking needs, Marlborough, MA has enacted three zoning measures that promote a smart parking approach. The city has taken steps to decrease the oversupply of parking using three principal strategies:

- Provisions for shared parking
- Compact car spaces
- Temporary reserve parking

Marlborough's **shared parking** provision has been used mainly within the mixed-use center, taking advantage of the differing parking needs among residential and commercial uses. In response to growing parking needs in a constrained environment, Marlborough enacted a provision for shared parking to relieve the pressure on developers to account for 100 percent of their parking requirements.

Although the City of Marlborough has experienced some difficulties with its shared parking regulation, it has been effective in balancing the needs of new development and existing businesses. The end result has been largely positive in that it supports a functional, accessible mixed-used city center with a more efficient use of downtown parking facilities.

Marlborough's **compact car regulation** allows up to 33 percent of a site's required parking spaces to be reduced by 1 foot in width and 2 feet in length, reducing the footprint required to hold the same number of cars. Developers have taken advantage of this regulation to maximize use of buildable land.

Marlborough's **temporary reserve parking regulation** is mainly used within industrial parks where the daily demand for parking falls well below the required number of spaces (the additional spaces are required to accommodate increased parking demand on select occasions). This regulation allows developers to leave the reserve parking supply unpaved, which helps reduce

[10] Massachusetts Smart Growth / Smart Energy Toolkit

total impervious surface area and improve on-site storm water retention and surface water quality.

Cambridge, MA Parking Strategies and TDM[11]

Cambridge, MA has implemented two main strategies designed to manage parking in high-density, urban settings – a Parking and Transportation Demand Management (PTDM) Ordinance, and regulations for underground parking.

Cambridge's **PTDM Ordinance** was enacted to help reduce parking demand by encouraging the use of alternative transportation and shared car arrangements. The Ordinance requires new developments to implement Transportation Demand Management (TDM) programs ranging in scope from three measures (for smaller developments) to an entire PTDM Plan with specific single occupancy vehicle use commitments (for larger developments). The range of potential TDM measures includes:

- Carpool and vanpool parking
- Pre-tax deduction of transit and vanpool fares
- Transit and vanpool subsidies
- Onsite car sharing vehicle
- Employee shuttles
- Emergency Ride Home (ERH) program
- Bicycle parking
- Shower and locker facilities for bicyclists and walkers
- Flexible or alternative work hours
- Telecommuting opportunities

The PTDM Ordinance has been very effective in reducing parking demand by encouraging the use of alternative modes. Developers have appreciated that the Ordinance is both consistent and flexible.

Cambridge has also enacted an underground parking regulation that exempts underground facilities from typical parking requirements based on Gross Floor Area (GFA) calculations. This exemption creates an incentive for constructing underground facilities instead of surface lots, which is extremely beneficial in a dense, urban environment like Cambridge. The roof of underground parking facilities may not be more than four feet above ground to avoid detracting from streetscape aesthetics and ground floor land uses.

[11] ibid

2.3 Bicycle Network & Infrastructure

Integrating bicycles with transit service coverage is beneficial as bicycles extend the travel range in a low-cost and low-impact manner. There are three fundamental components to bicycles in supporting transit:

- Connecting the transit facilities to the cycling network
- Including safe and secure bicycle parking at facilities
- Ensuring that bicycles can be brought on board transit so that they may be used at both ends of a journey

Connecting Transit to Bikes

Transit facilities should be integrated with the existing bicycle network, including off-street paths, on-street lanes, and other streets frequented by cyclists. Dedicated bicycle facilities should bypass the transit facilities proper so as not to conflict with pedestrian movements. Signage at stations should direct cyclists to bike parking, local points of interest and distant destinations; in much the same way that wayfinding is provided for pedestrians and drivers.

Maps and information kiosks are useful at disseminating information. The transit map should contain information about bicycle facilities (including parking, storage, and paths); in turn the local bicycle map should show where the transit stops and lines are. The goal is to provide one map per journey, not one map per mode.

In the case of transit stations such as subway, light rail, and/or BRT, providing elevators, ramps, or rails, at station stairways is an effective means of maximizing bike accessibility if stations are not at grade.

Bike Parking

The lack of a secure parking space keeps many people from using their bikes for basic transportation. Leaving a bicycle unattended, even momentarily, is not an option for most urban bicyclists. Finding a bike rack that doesn't work or isn't conveniently located can discourage future bike use. The design and placement of appropriate bicycle parking should be incorporated into planning, as well as at transit stations. This can include special zoning requirements for the provision of bike storage for new developments, including locker and shower facilities at large centers of employment.

In any case, bike racks, lockers, and/or automated parking structures such as the Bike Tree umbrella[12] (shown here at left) should be as close as possible to the transit stop for security and convenience.

[12] www.biketree.com

Case Studies

Intermodal Transportation Planning and Development – Tucson, AZ[13]

Tucson's regional transit system, Sun Tran, has grown significantly since its establishment in 1973, with impressive ridership gains in recent years (ridership increased 31 percent between 2002 and 2007, and an additional 15 percent between 2007 and 2008). Tucson has made a number of improvements to Sun Tran in an effort to improve intermodal connections, including bicycle racks on buses, park-and-ride amenities, sidewalk connections, and bikeways, among others.

As part of the **Bikes-On-Bus program**, all Sun Tran buses have bicycle racks to accommodate two bicycles. Sun Tran reports an average of 27,000 bicycle boardings per month, and both racks are often full on the buses.

Sun Tran serves 22 park-and-ride facilities. The four city-owned facilities each have between 50 and 100 vehicle parking spaces, and include both bicycle racks and lockers the public can rent for $2 per month. The six new regional park-and-ride facilities being built as part of the 20-year RTA plan will include similar amenities.

Tucson is installing sidewalks and ramps along major roadway corridors in response to a regional sidewalk study conducted in 2003 (and a follow-up in 2008) identifying gaps in the pedestrian system. Corridors with high transit use, dense commercial and residential development, and connections to major medical centers are given priority. Pedestrian travel has increased noticeably along the improved corridors.

Although the regional mode split for bicycling is low, a larger proportion of citizens in central Tucson commute by bicycle, especially near the University of Arizona (14 percent of the campus population, and 23 percent of those living within 5 miles of campus, commute by bike). Factors contributing to the success of the bikeway network include:

- The Tucson DOT requires that all roadway improvement projects include on-street bicycle lanes
- The region has a network of shared-use paths connected via overpasses and underpasses
- About half of all bikeways are on major transit routes or provide direct access to park-and-rides and transit centers where bicycle parking is available

Boulder's Multimodal System – Boulder, CO

Boulder has been taking steps to reduce reliance on automobile travel since the late 1980s. Boulder has built on natural advantages (e.g. the presence of a major university and a significant growth boundary in the form of 43,000 acres of dedicated open space) with proactive and progressive planning and a significant financial commitment. In 2007 and 2008, the city dedicated 49 percent of its transportation budget to pedestrian, bicycle, transit and transportation demand management projects.

[13] Pedestrian and Bicycle Information Center Case Study Compendium (PBIC, 2009)

The combination of the city's compact size (25 square miles), a strong transit system, and an extensive multiuse path network facilitates the use of non-motorized, multimodal and non-automobile trips.

Boulder's **Community Transit Network** is a grid of local bus routes that operate with "neighborhood friendly" vehicles (low-floor, alternative fuels, smaller vehicles, memorable route names) at high-frequency (10 minutes or less at peak) along routes designed to be simple and interconnected. Routes include the HOP, Skip, LEAP, Bound, Jump (Short Jump and Long Jump), among a growing list of services.

Boulder has been building its **multiuse path system** since 1989, and now has over 100 miles of pathways with 74 underpasses. The city has an additional 200 miles of dedicated on-street facilities including bicycle lanes, signed routes and shoulders. Bicycle paths and lanes are given equal priority with the city's major street system for maintenance and snow plowing. Today Boulder's bicycle mode share is 8.8 percent compared to a national average of 0.5 percent.

2.4 Pedestrian Network & Infrastructure

Pedestrian access is essential to maintaining the urban vitality needed to support the dense mixed-use character and transportation objectives of successful pedestrian environments. Successful pedestrian networks offer high levels of pedestrian service in four key measures:

- Safety
- Convenience
- Comfort
- Attractiveness

Safety

Many areas with good transit service are inherently urban and characterized by shared spaces and conflicts therein. Unlike other areas where the preference may be to separate modes (freeways or pedestrian zones), a successful transit area embraces the energy of the street while minimizing the conflicts. There are four fundamental aspects to maintaining pedestrian safety for transit users:

- **Vehicle speed**. Vehicle speed is a significant determinant of crash severity and often dictates the nature of a street including the pedestrian facilities and access to a transit station. As vehicle speed increases, so does risk to drivers and pedestrians; increased speeds must be accompanied by additional physical separations or impact protections. As speed decreases, the range of design options expands and so do options for pedestrians.
- **Pedestrian 'exposure' risk**. This is the time that pedestrians are exposed to the dangers of traffic and has both a temporal and spatial component. Crossing distances and crossing times at signalized intersections are key indicators of exposure risk, as are vehicle speeds and volumes. To reduce the exposure risk is to increase safety.
- **Driver predictability**. Drivers are constantly making decisions, and if other street users - drivers, cyclists, or pedestrians - can better predict those decisions, then the street will be safer. Reducing the number of turning options for drivers at key junctures is the simplest way to improve driver predictability.
- **Vehicle volumes**. A street with zero cars will see zero auto-related incidents. Every additional vehicle in the street increases the possibility of incident with pedestrians, until there are so many vehicles that people are banned, like on an expressway. Therefore, reducing vehicle volumes is one technique used to reduce vehicle-car conflicts.

Design elements such as shorter blocks, narrower rights of way, curb extensions at intersections, raised crosswalks, infrequent curb-cuts, and driveways that give visual emphasis to the continuation of the sidewalk are a few basic design elements that can minimize pedestrian risk exposure and help in bringing down average travel speeds for cars.

Convenience

As with bicycles and transit, pedestrian networks should be designed to maximize *walk + ride* trips. A well-designed pedestrian access plan will provide a natural flow of walking customers from the surrounding area to activity centers and transit facilities such as stops or stations.

Pedestrian walkways should be well maintained, safe, and well-lit. They should be sufficiently broad to comfortably handle the expected pedestrian traffic peaks. Signage should be adequate to lead individuals (especially those unfamiliar with the area) to the stations. Pedestrian levels of service along connecting routes between major origins and destinations should be emphasized.

Mapping pedestrian movements provides the baseline data that will help shape the optimum design of the supporting pedestrian infrastructure.

Comfort

Sidewalks should be wide enough for two pedestrians to walk abreast. The minimum width for two people to walk comfortably side by side is about 5 feet. For strolling pairs to be able to pass each other in stride, a minimum of 10 feet of sidewalk width is necessary. In places defined by high pedestrian volumes and buildings that directly face sidewalks, widths up to 20 feet are commonly recommended, though a more modest width of 10-15 feet can add a sense of vitality. Places to sit and to wait are also a key component of a pedestrian friendly environment.

Attractiveness

Successful public spaces attract people by offering a combination of three basic qualities: utility, beauty, and company. Uses should provide the local community with daily needs, minimizing regular out-of-area trips for goods and services. Uses should be mixed to maximize trip-chaining opportunities, and encourage longer area visits. Uses should also be strategically placed to maximize pedestrian-trip efficiency, such as placing dry cleaners and day care facilities near transit nodes.

Aesthetics play an important role in supporting these uses. Sidewalks and plazas should be visually appealing and physically inviting. Appealing streetscape design can be an effective means of announcing the uniqueness of the environs and encourage initial visits to the area. When combined with quality land uses, such aesthetics can play an important role in drawing and maintaining the crowded urban vitality that marks successful transit-oriented areas.

Case Studies[14]

Monterey, CA – Pedestrian Countdown Signals

This is a Pedestrian Safety case study. Countdown signals show pedestrians how many seconds of crossing time remain. The City of Monterey has a downtown area that experiences a high volume of pedestrian activity. Some of the intersections in the city are also rather large and create large distances for pedestrians to cross. Accidents had not been an abundant concern, but confusion and conflicts between pedestrians and motorists were a common problem during periods of high pedestrian traffic.

The City of Monterey decided to take advantage of an experimental program by the Federal Highway Administration to test pedestrian countdown signals at selected intersections. The new experimental device was designed to enhance the effectiveness of pedestrian signals to clear the crosswalk before the signals changed.

[14] http://www.walkinginfo.org/pedsafe/case_studies.cfm

Initially, two intersections were chosen for the experimental pedestrian signal countdown. The first two signal countdowns were installed in early 1999. Since then, seven more intersections were equipped with the devices. A study of the pedestrian and motorist responses to the signal countdown was performed. Previous studies had indicated that a large number of pedestrians began crossing during the flashing "don't walk" phase and become caught in the crosswalk when the solid "don't walk" indication lights up. After observing pedestrians using the crosswalk locations with the new signal countdown, most pedestrians that arrived at the intersection with less than 10 seconds showing on the countdown at the first intersection and less than 7 seconds at the second did not initiate crossing and decided to wait for the next phase to come up. Of these pedestrians, the majority were seniors (13%) and adults (83%).

Most people misinterpret the meaning of the flashing hand of the signal. According to previous studies, most people think that it means to hurry up or to turn back to the sidewalk, instead of not to initiate crossing if not already in the crosswalk. Of those interviewed, 87% said that having the pedestrian countdown device helped in understanding the pedestrian signals. The results of the study indicate that pedestrian countdown signals are successful in discouraging some pedestrians from crossing with few seconds left. The countdown feature also demonstrated benefits in encouraging pedestrians to wait on the median refuge for the next phase or accelerate their pace when time was running out, preventing them from being stranded in the middle of the crosswalk.

Corvallis, OR – Curb Bulbouts with Bicycle Parking

This is a pedestrian safety and convenience case study. In 1995, Corvallis had a total of six pedestrian crashes, the majority of which took place within the downtown area. In 1996, the number of pedestrian crashes rose unexpectedly to 22, again with the majority in the downtown area. The City needed to devise a plan to increase the safety of the downtown area for pedestrians as well as address the needs of the numerous cyclists who live there.

The Bicycle/Pedestrian Advisory Commission determined that curb extensions furnished with covered bicycle racks would help both pedestrians and cyclists while slowing down traffic. The City decided to install three curb extension bulb-outs on Monroe Street, the main commercial strip next to the Oregon State University campus, to maximize the impact in an area with heavy bicycle and pedestrian traffic.

The total cost of the three intersection bulbs and covered bike racks was $140,000. The Oregon Department of

Transportation funded $100,000 of the project and the City of Corvallis funded the remaining $40,000.

The bike rack coverings were designed specifically to blend in with the area's architectural style. The Bike lanes already in existence along Monroe Street prior to this project were not changed. The new bulb-outs were the beginning of an attempt to focus on pedestrian safety within the downtown area. As such, the City has been pleased with the curb extensions, and is already considering funding for three more.

Ultimately, the bulb-outs helped direct pedestrians to crosswalks, instead of crossing at more dangerous mid-block locations. Two of the bike racks are consistently full and one is regularly half full. Locating the bike racks on bulb-out corners also encouraged users to cross at the crosswalk adjacent to the bike racks. In addition, the covered areas for bike parking have been used regularly by transit patrons, some of whom thought the shelters were designed as transit stops.

Thus far, the project has been a success in contributing to pedestrian safety in downtown Corvallis.

2.5 Land Use & Urban Design Strategies

Planners often talk about "transit-supportive density" or "transportation-efficient land uses." So how exactly should transit service respond to land-use density measures? How does population and employment density help to determine the level and type of service that should be provided on a street or in a specific corridor?

It is known that there is a strong positive correlation between land use density (mostly residential and employment density) and transit demand. However, this relationship is not linear and transit demand tends to increase most dramatically at more than 10 households per residential acre (or beyond 25-30 persons per acre on average). Density in many urban neighborhoods outside downtowns is below this range today, but areas designated for transit-supportive growth could reach this threshold quickly with new infill development. In fact, this illustrates that efforts to promote infill development, even at modest densities, could have exponential impact in increasing transit and non-motorized travel (i.e. walking and biking), and reducing vehicle miles traveled.

However, land use density is only one determinant of transit quality and the likely demand for service in a given environment. Urban design, network accessibility and multimodal system integration is a major factor as well. The following graphic illustrates how land use types, intensity of use, built environment and service quality all interact to support environmental, community and economic goals.

Figure A-2: Community Benefits from Transit Access, System Integration and Land Use

There is a mutually supportive relationship between land use, access and system integration, and service quality from which community benefits from transit are derived.

Elements of Transit Demand

Clearly, population and employment density alone do not determine transit service level and quality. The level of service depends on several market factors, including: *density, size, regional location, community design, and street design.*

- **Density** is described by persons and employees/jobs per acre.
- **Size** must be considered together with density to determine the overall market that has been organized in a transit-oriented way, which in turn will determine the level of service that can be supported. An isolated, 50-unit apartment building surrounded by surface parking and/or open space could have a very high-density rating, but this alone would not mean it deserves the same level of service as a university, for example, because it is a much smaller market. A particular level of service will require a minimum density over a minimum market area.
- **Regional Location** also affects travel demand as well as transit's efficiency. Travel demand between two points tends to be inversely related to the distance between them. The longest the distance between an origin and destination the least demand (this is valid for all modes of travel). Also, if transit-oriented developments are close to major service corridors, it is more likely that transit will be an attractive mode to residents or employees. In addition, regional location determines whether a proposed line will have strong anchors to sustain ridership at both ends of the line (trip origins and destinations at both ends). Regional location is addressed by ensuring that future transit corridors have major activity centers at their endpoints.
- **Community Design** is another crucial, but often overlooked, element of transit demand. Community design is especially important as it relates to pedestrian access and safety. Even at high densities, people will not use transit if it is difficult or dangerous to access a bus stop (i.e., no direct pathways, no sidewalks, hilly terrain or absence of lighting and poor visibility). Also, many of today's auto-oriented suburban apartment complexes, while very dense, have extremely poor access to bus stops in major arterials or to viable transit carrying streets.
- **Street Design** is also an important component of transit access and operational viability. Neighborhoods where all roads are designed to connect to arterials or collector streets allow transit customers to reach bus stops without walking out of direction and provide more efficient routing options that can support high-frequency service. In contrast, many suburban neighborhoods are designed on cul-de-sac street networks with limited vehicle accessibility and out-of-direction or no pedestrian connections from main arterials.

While cities may not have control on how transit service investment is allocated, it does control most of the elements that make transit successful. *In other words, cities have some control over the development patterns that will drive future service allocation and the demand for service*.

Zoning

To ensure transit will be successful, cities can include transit-supportive zoning and design elements into their comprehensive plans, such as those that encourage infill, mixed-use development, transit oriented development (TOD), and transit strategy corridors.

Transit Strategy Corridors

Zoning in these corridors should require transit supportive densities, which in turn improve market feasibility for dense, mixed-use development. Cities can focus land use planning and zoning changes along the corridors where future transit service capacity and quality is guaranteed. Land use coordination with neighboring jurisdictions that control land use on corridors that extend beyond city boundaries is also critical. It also provides assurance to transit agencies that cities will manage street rights-of-way to maintain minimum levels of operating speed and reliability. This means new transit resources can be spent to improve service, rather than simply maintain. To make this more feasible, cities can consider the following:

- Zoning changes and density incentives for land in and around corridors
- Reallocating regional growth to transit supportive corridors, particularly those close to job centers.
- Adopt zoning requirements in centers and corridors that encourage minimum densities of 5-6 households and or 8-10 jobs per acre.
- Adopt a transit overlay or multi-modal overlay to the city street classification system. This would act much like a zoning overlay for a special use and would serve as assurance that any street design or changes would allow transit to continue to meet basic transit performance criteria.
- Avoid creating new transit demand away from corridors. Like the transit network as a whole, transit quality will always be inversely related to its size, so it is important to have the minimum necessary network mileage, but no more.
- Locate transit-friendly land uses on corridors. Transit-dependent uses should locate on the corridor, or in other areas with established service. Sometimes, an agency will locate a transit-dependent function (such as a social service office, a disabled workshop, etc.) in a place with no transit, and then demand that transit go there. The best way to ensure quality transit service must be to locate on the corridor. The next best way is to locate on another existing transit route.
- Avoid locating transit-friendly land uses off corridors. New transit-oriented development, and high-density development in general, will not reach its potential if it is not on the corridor. If the market needs more such development than the corridor can support, then plans should be made to expand the corridor into new areas, but with the commitment to developing a corridor.

Other Capital Elements

There are a number of other capital elements that are important in developing a top-quality transit system.

- **Bus stop amenities:** The comfort of transit passenger access and waiting environment is a critical element of the overall user experience and one that cities have a key role in improving. While transit agencies are primarily responsible for providing shelters, benches and amenities at stops, cities can provide further improvements by adding better lighting, landscaping, and art work to improve public spaces around transit facilities.
- **Improved bicycle parking:** Most transit vehicles accommodate up to two bikes on a front-end bicycle rack. Many transit agencies are interested in moving to three bike racks,

but short turn radii on certain intersections don't allow this. Since transit agencies are not able to accommodate a large number of bicycles on bus racks, providing bicycle parking at transit stops becomes a critical aspect to increasing bike and transit use.

- **Pedestrian access improvements:** Most transit trips start or end with a walking trip. Improving and connecting sidewalks, ensuring curbs and stops are ADA accessible, and enhancing the walking environment along key transit streets improves the attractiveness of transit. Quality pedestrian accessibility typically includes the following characteristics:
  - Continuous and connected network of sidewalks
  - Barrier free routes, crosswalks, and ramps
  - Good lighting
  - Seating and shelter from wind and rain at stops
  - Interesting visual environment and good line of sight (studies have shown that people are willing to walk farther on streets that have active street facing buildings and vital street life)
- **Pavement overlay:** A number of cities budget for broader pavement depth along streets that are subject to higher transit traffic volumes. This tends to reduce maintenance costs and required frequency of repaving over the long term.
- **Transit centers:** Upgrading transit center facilities based on existing and projected ridership patterns is a good method for determining needed shelters expansion, route and schedule information, lighting enhancements, and place-making elements.

Case Studies

Portland (OR) Metropolitan Area – TriMet High Frequency Service Criteria

TriMet, the transit provider in the Portland metropolitan area, has a number of criteria it uses to determine whether a corridor merits "High Frequency" service, which means route service operates at 15 minutes or better all day and seven days per week. Two of the land use density criteria applied by TriMet in prioritizing frequent service corridors are shown in Figure A-3, below. There are a total of seven major criteria of which "Corridor Ridership" is the most important[15]. The two most fundamental variables explaining Corridor Ridership are Residents per Acre and Employees per Acre.

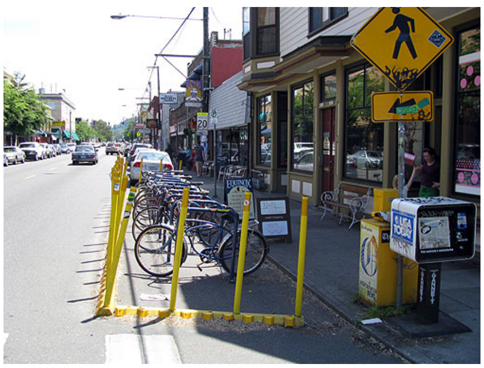
Figure A-3: Tri-Met Frequent Transit Service Criteria

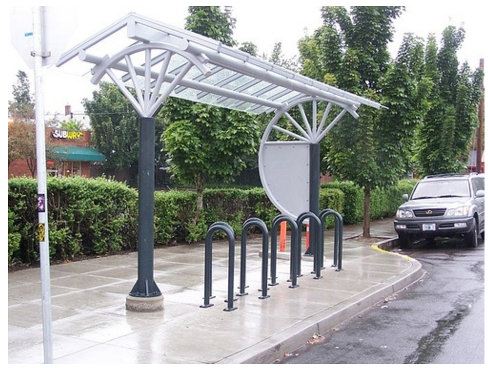
Criterion	Rating	Residents Per Acre	Dwelling Units Per Acre (@ 2.5 persons per unit)
Number of Residents Per Acre within ¼ Mile of Frequent Service	10 (Highest)	15+	6+
	8	12-14	4.8-5.6
	6	9-11	3.6-4.4
	4	6-8	2.4-3.2
	2	3-5	1.2-2
	0 (Lowest)	<3	<1.2

15 http://trimet.org/pdfs/tip/tip.pdf (Page 97, Frequent Service Criteria)

Criterion	Rating	Employees Per Acre
Number of Employees Per Acre within ¼ Mile of Frequent Service	10 (Highest)	15+
	8	12-14
	6	9-11
	4	6-8
	2	3-5
	0 (Lowest)	<3

Rating scores on each criterion are then combined at the corridor and segment level to identify investment priorities by corridor and guide service frequency improvements in the system. In addition, Portland has begun to remove on-street parking at strategic locations along high-frequency priority corridors to provide higher-capacity bicycle parking opportunities that provide good access to both transit and local businesses. The photos below are located in high-demand bus stops in high-frequency corridors.





Charlotte's South Corridor – Pedestrian Access to Transit

The City of Charlotte adopted the Transit Station Area Planning Principles in 2001 to ensure proper design and connections to the new South Corridor Light Rail. The principles emphasized pedestrian needs, including:

- Increasing development density within one-half mile of the 15 transit stations
- Providing parking at the rear or sides of buildings
- Constructing buildings at the sidewalk line
- Orienting building access for pedestrian use
- Promoting higher density residential development with first floor commercial uses

In a collaborative charrette process, the city also developed a Pedestrian Quality of Service Methodology to evaluate the walkability of adjacent neighborhoods and surrounding land uses. Using this methodology, they created a detailed vision for the corridor, including wide sidewalks, shade trees, pedestrian-scale lighting and midblock crosswalks. Significant pedestrian facilities have been built at a majority of the transit stops, spurring economic investment and increasing property values along the corridor.

2.6 Transit-Oriented Development

Transit-oriented development (TOD) refers to the integration of transportation and land use so that they are mutually reinforcing. Denser and more diverse land use is critical for supporting high quality transit service. Transit-oriented development promotes communities with mixed land uses, compact built environments, multi-modal streets and pedestrian-friendly environments. Dense, pedestrian accessible land uses have several benefits to transit:

- High quality service to a relatively large number of points and destinations can be offered
- The cost per rider of operating transit is reduced when transit is more fully utilized. Reaching density levels of an average of 8 or more dwelling units per acre (20 persons per acre) in full corridors (or comparable job density) will allow for a new level of investment in transit quality
- More frequent service can be provided. Again, industry studies show that average densities comparable to 10 to 15 units per gross acre are required to support all-day 15 minute service

It is important to note the critical role of providing developers confidence to invest in transit-oriented development forms. While rail tends to be more effective in this regard due to perceived permanence, rubber-tired transit can have the same effect.

An effective way for municipalities to promote transit-supportive land use is to update the zoning code and existing municipal plans and design guidelines. This can be done by designating areas where there will be minimum average densities, mixed-use buildings and land use, and property tax exemptions for new transit supportive residential or mixed use.

- **Minimum average densities:** Minimum average densities should be highest around transit nodes and corridors. This promotes higher transit ridership and allows for convenient pedestrian access.
- **Mixed-use buildings:** Mixed-use buildings contain a mix of uses within one building, including residential, retail, office, etc. Office and residential uses should be located on the ground level, with retail on the ground floor. These buildings tend to be significant generators of pedestrian activity.
- **Mixed land use:** Mixed land uses create urban districts or corridors with a more diverse origin-destination travel base which attracts a more diverse user base and generates higher transit usage and pedestrian activity.

TOD Strategies

- **Revise zoning to increase density along transit corridors**. Residential densities should be at least 10 units per acre as a minimum threshold for high performing transit.
- **Expand High Density Corridors.** Expand corridors where there is expected growth, need for transit, and compatibility with the Comprehensive Plan.
- **Encourage mixed-use** within buildings and within land use zones by updating and clarifying the city code.
- **Provide incentives to local developers** to build high density mixed-use buildings within convenient walking distance to transit emphasis corridors or multi-modal corridors.

Case Studies

Portland, OR

In Portland, Oregon, a property tax exemption for new transit-supportive residential or mixed-use development was incorporated into its city code. The purpose of the property tax exemption is to encourage the development of high density housing and mixed-use projects affordable to a broad range of the general public on vacant or underutilized sites within walking distance to transit service.

Seattle Metropolitan Area, WA

In the Puget Sound, development patterns over the last decade suggest a strong relationship between frequent bus service and medium density mixed-use development patterns. For example, mixed-use development and multi-family housing characterize development surrounding the Renton Transit Center in South King County. In the City of Seattle, significant new residential and commercial development has sprung up in key trolleybus corridors in south Lake Union, Eastlake, the University District, Uptown Queen Anne, First Hill and Capitol Hill. It is clear that the bus network is related to the concentration of development along these lines.

Olympia, WA

Olympia, Washington's Comprehensive Plan supports high density development, infill development, especially in areas where development will facilitate efficient, effective mass transit service. For example, Policy LU 3.1 states "Establish High Density Corridors with sufficient residential and employment density to support frequent transit service, encourage pedestrian traffic between businesses, provide a larger customer base for corridor transit services and businesses, and diminish the reliance upon automobiles for local trips". Olympia's zoning code identifies High Density Corridors (centered along Martin Way) and a downtown designation where increased densities are encouraged.

References

- Transportation Mobility Strategy for the City of Olympia. Nelson/Nygaard Consulting Associates 2009
- TCRP Report 88: A Guidebook for Developing a Transit-Performance Measurement System
- A Summary of TCRP Report 88: A Guidebook for Developing a Transit-Performance Measurement System
- NCHRP Report 551: Performance Measures and Targets for Transportation Asset Management

Washington DOT Performance Measurement Library:
http://www.wsdot.wa.gov/Accountability/Publications/Library.htm