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# Park-and-Ride Planning and Design Guidelines



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October 1997*

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## FOREWORD

Today's urban environment is changing ever more quickly, especially with regard to travel demands on the local highway and transit networks. Communities must increasingly rely on a variety of transportation modes to move people efficiently and cost-effectively between home, work, and play activities. For example, the United States Department of Transportation (USDOT) estimates that urban vehicle miles of travel (VMT) increased at an average rate of 4 percent per year between 1983 and 1993 (66). This increase represents an approximate 49 percent growth in travel over the 10-year period. At the same time, funding for highway related transportation improvements increased by 45 percent, and the total funding for transit related services increased by 58 percent (66). As demand for travel within U.S. urban areas continues to grow, reliance on the single occupancy vehicle (SOV) will often not provide a practical option, especially when many urban areas operate under environmental restrictions caused by concerns for air quality, noise and neighborhood impacts. Many of these urban areas lack adequate right-of-way to expand existing transportation systems while at the same time mitigating these concerns.

In addition to the growth in urban travel demand, many metropolitan communities throughout North America are seeing fundamental changes in their economies, especially those smaller sized urban areas that are openly embracing the high technology growth industries. In fact, within some smaller metropolitan areas, whole economies are diversifying from their historically rural base to the new professional services and technology based industries (i.e., San Jose, California; Spokane, Washington; Portland, Oregon; Salt Lake City, Utah; Wichita, Kansas; and Austin, Texas). The diversification is not only being sought by many of these communities, it is also being driven by new computer technologies that allow individuals to live in smaller sized urban and rural areas while still performing jobs once reserved for only the largest metropolitan areas. For example, Fidelity Investments, an investment and stock trading company is located in Salt Lake City, Utah, far from the major stock market trading houses in New York and Chicago.

Rapid growth and change in economic base experienced by these smaller urban cities, often coupled with a desire to preserve the character of the community, are forcing many decision makers to consider alternate methods for transporting people to and from their various activities. One option for providing alternate travel modes in low density auto-oriented developments is the park-and-ride lot. Park-and-ride facilities provide a means for encouraging transit ridership and carpool formation by providing a staging area to transfer from low occupancy or non-motorized modes (i.e., the single occupancy vehicle, bicycle, or pedestrian mode) to a higher occupancy means of travel (i.e., vanpool, carpool, transit). Thus, park-and-ride facilities perform the purpose of facilitating the intermodal transfer, aggregating patrons from the dispersed surrounding development into higher occupancy travel modes.

Little or no consolidated information is currently available to assist decision makers in planning sound park-and-ride systems or developing individual intermodal facilities. Many transportation agencies have developed guidelines to meet specific local conditions and needs, but these guidelines have generally not been widely published. A comprehensive collection of such information does not now exist, representing an unmet need within the transportation industry.

My personal interest in park-and-ride lots and similar intermodal transportation facilities has been growing for many years, not so much as for how they exist today but for their potential. My first recollection of a park-and-ride facility was that of a simple, semi-paved gravel lot within the right-of-way of a freeway near my childhood home. The lot was unfortunately never directly served by transit, and was seldom used by more than three or four vehicles at a time. In reality, I would now term this facility a park-and-pool lot, a facility that is intended to encourage spontaneous carpooling rather than serve as a major transit hub. Because of the low demand that I often observed, my perception at the time was of a wasted public investment, a perception likely held by others in the community.

The significance of this story is not merely that this park-and-ride (park-and-pool) lot demonstrated poor demand, but rather that the lasting public and agency perception (like mine) was that of an unwise investment. The consequence of this observation was the assumption that the park-and-ride approach to providing suburban transit and carpool access does not work. This perception of poor public investment represents a planning and engineering failure. Although not as drastic as the failure of a bridge or building, the perception of a wasted investment translates into public opposition to implementing future park-and-ride facilities elsewhere in the community, all based on limited experience with a poorly planned park-and-ride facility.

As a professional transportation engineer, I have had the opportunity to work with most of the transit agencies in the greater Puget Sound Region of Washington State including King County Department of Transportation (formerly Seattle Metro) and Pierce Transit, and have seen how a successful park-and-ride program can shape a transit system. At many park-and-ride locations in this region, transit agencies are faced not with the problem of insufficient demand, but rather with too much demand for their available parking capacity. This sharply contrasts with my previous experience and perception of park-and-ride facilities. I have thus seen both the successful and unsuccessful application of park-and-ride technology. Through my professional work and William Barclay Parsons Fellowship research, I am convinced that the overriding cause behind the hit-and-miss success in developing successful park-and-ride facilities is a result of the rather inadequate planning and design tools available to the implementing agencies. My belief is that insufficient information has been available to planning and design professionals, and consequently to the decision makers and transit users whom we serve. This has resulted in a trial-and-error approach to park-and-ride development, with some agencies having more success than others in implementing this technology. In an era of reduced government expenditures, we as design professionals must develop improved planning and design tools for park-and-ride facilities and share our knowledge, so that this unique intermodal facility may be used effectively and valued by the public as an asset to the community.

## Acknowledgments

Established by the Board of Directors of Parsons Brinckerhoff Quade & Douglas, Inc. "to perpetuate the ideals and achievements of [the company's] founder, William Barclay Parsons," the William Barclay Parsons Fellowship provides a unique opportunity for PB employees to develop their professional skills while providing meaningful research within the transportation industry. Unlike other company endeavors, the Fellowship program focuses on the individual, rather than on the design team. My experience, however, has shown that, although the responsibility for the Fellowship and associated honors are focused on the Fellow, the program is truly a team effort, supported by a host of fellow employees, friends, and family members who all make significant sacrifices so that the program can be successful. I owe a great deal of thanks to these people and to the entire Seattle area office for providing the support and assistance critical to meeting my Fellowship goals. I also feel fortunate to have worked with a number of outstanding individuals at the local King County Department of Metropolitan Services (Seattle Metro) and Puget Sound Regional Transit Authority (RTA), who are in large part responsible for introducing me to the need for this research effort.

I would like to extend a sincere thanks to my fellowship advisors, Dr. Youssef Dehghani and Mr. Kern Jacobson, for their help and assistance in pursuing my Fellowship goals. Youssef provided the day-to-day support and encouragement needed during each phase of the project, while Kern provided guidance and patience as the Seattle area manager, allowing me to work on my project during a hectic and difficult year. Ms. Cathy Strombom, my professional supervisor, also deserves thanks for encouraging me to apply and compete for the 1995 Fellowship, and for her unending support and friendship throughout my career.

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Lastly, I would like to thank my wonderfully understanding wife and partner, Lynn Layman-Spillar, whose unending belief in me and my work has held our family together through both the highs and lows of the Fellowship year. Her unending support and encouragement has enabled me to complete this work while enjoying an active, fun-filled life with her and our two children. I hope that I may someday have an opportunity to return this favor in kind.

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## 1.0 INTRODUCTION

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## 1.0 INTRODUCTION

### 1.1 Monograph Purpose

This monograph has been developed to provide planning and design guidelines for the development of park-and-ride facilities. The primary focus has been the assimilation of reliable methods for selecting optimum locations for park-and-ride facilities in terms of maximizing demand and promoting community integration. Design techniques utilized by a number of agencies with active park-and-ride programs have been synthesized, resulting in a collection of design concepts that will be useful to the planner, engineer, and policy maker in assuring that the resulting facility design is both efficient and aesthetically pleasing and integrated with the community fabric.

This monograph is intended to challenge the concept of the traditional park-and-ride facility as a mechanism for providing transit ridership, encouraging a more comprehensive planning approach to providing these intermodal facilities. It is this author's sincere belief that the park-and-ride facility can provide the mechanism for providing a community focal point within the suburban environment and that it can be used to encourage densification of surrounding land uses that results in more transit-friendly communities. It is hoped that this text provides a framework for an analysis of the park-and-ride facility as an integral component of the modern transit system—a system capable of supporting efficient urban development within and beyond the central urban core.

Information developed for this monograph has been largely developed based on research and observations of the park-and-ride systems in the Pacific Northwest (Seattle, Washington; Portland, Oregon; and Vancouver, British Columbia). However, numerous examples from other park-and-ride systems such as those found in suburban New Jersey; Denver, Colorado; Houston, Texas; and Northern California have been woven into the monograph. The transit agencies represented in the monograph provide both rail and bus-only service based systems. Literature research from around the world has also been incorporated within the study to broaden the perspective of the underlying findings and observations. Thus, this monograph represents a state-of-the-practice analysis, relevant to all types of park-and-ride facilities, regardless of location or transit technologies serving the facility.

## 1.2 Monograph Organization

The monograph is divided into six primary chapters. Each chapter is organized as a stand-alone treatise and deals with a unique element of the planning and design process. A description of each follows:

- **Chapter 2.0—Defining the Park-and-Ride System**  
In this chapter, a fundamental process for evaluating park-and-ride facilities is developed by defining the markets served by individual types of facilities. A park-and-ride nomenclature is developed which assists in the classification of facilities for planning purposes. Understanding the extended market of the park-and-ride facility, as well as the type of lot to be developed, can greatly assist the planning agency in developing policies towards implementing a successful park-and-ride program.
- **Chapter 3.0—Park-and-Ride Planning Process**  
A sound planning process is fundamental to the development of a successful park-and-ride program. A process for planning both a park-and-ride system as well as individual facility development is outlined in this chapter. The recommended planning approaches draw their reference from the major investment study concept developed jointly by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA). A robust public involvement process is a major feature of these planning approaches and is used to integrate the concerns and needs of the community with the planning and design of a successful program.
- **Chapter 4.0—Making the Facility Location Decision**  
Selecting the right location for the park-and-ride facility is perhaps one of the most important elements in assuring a successful lot. Based on industry experience, there are a number of rules of thumb that can be employed in choosing candidate locations for in-depth analysis and preliminary design. Many agencies have developed their own anecdotal indicators for selecting successful park-and-ride locations. In this chapter, the practices of a number of transit agencies have been synthesized into a comprehensive tool. This chapter will be especially helpful when seeking to implement park-and-ride facilities in areas with little or no previous experience with the park-and-ride concept.
- **Chapter 5.0—Suburban Park-and-Ride Demand Estimation Techniques**  
Suburban park-and-ride lots represent one of the largest and most important types of park-and-ride facilities. They are of interest to transit planners because they can provide opportunities to aggregate transit demand and support high frequency transit services in suburban environments. Likewise, they are of interest to urban planners because they can provide a mechanism for enhancing a sense of identity within the suburban community and encourage transit-friendly developments in the surrounding properties. Fundamental to the development of successful suburban park-and-ride facilities is the need to estimate accurately and reliably future parking demand for the facility. In this chapter, several methods are explored for estimating suburban park-and-ride demand. A site-level forecasting technique is developed, relating demand to specific site and service characteristics. Such a technique is useful in refining regional forecasts and in developing estimates of the number of spaces required for individual lot locations.

- Chapter 6.0—Design Requirements for Park-and-Ride Facilities  
A range of design options exist for individual park-and-ride facilities. The park-and-ride facility can be designed as a bare-bones parking lot with the intent of providing maximum efficiency only. On the other end of the spectrum, the park-and-ride facility can be designed as an integral part of the surrounding community, providing an integrated gathering place for a range of activities. A synthesis of design concepts and elements is provided in this chapter. Design requirements from a number of nationally recognized transit systems have been pooled into a single resource.
- Chapter 7.0—Architecture, Landscape, and Art: Integral Parts of the Park-and-Ride Facility  
It must be remembered that above all else, transit facilities and specifically park-and-ride lots are people places. By integrating art into the park-and-ride facility and by utilizing sound concepts of landscape and architectural design, the park-and-ride lot can become much more than just another parking facility. It can become a community focus point for the surrounding suburban community or neighborhood in which it is located. It can encourage a sense of permanence and ownership within the community, forging a positive community identity. Examples of integrating such aesthetic concerns with successful transit facilities are provided in this chapter, ranging from inexpensive community art programs to elaborate architecturally elegant transit centers. The purpose of this chapter is to provide decision makers and planning/design professionals with a concept library to excite their design imagination and promote unique architectural and artistic designs.

Information presented in this monograph is intended to provide a general knowledge of the park-and-ride planning and design process. Applicable local ordinances, design requirements, and building codes must be consulted for their affect on the planning and design process. Local data resources, development patterns, and transit networks may present unique opportunities for park-and-ride implementation, and should be explored with enthusiasm.

In the course of the development of this monograph, two previous monographs were of particular relevance. These monographs can provide useful additional references for specific issues related to park-and-ride development:

- Monograph 1, *Pedestrian Time-Space Concept, A New Approach to Planning and Design of Pedestrian Facilities*, Gregory P. Benz, R.A., A.I.C.P., Parsons Brinckerhoff Quade & Douglas, Inc., January 1986, Revised January 1992.
- Monograph 5, *High Occupancy Vehicle Facilities, Current Planning, Operational, and Design Practices*, Charles A. Fuhs, Parsons Brinckerhoff Quade & Douglas, Inc., 1989.

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## 2.0 DEFINING THE PARK-AND-RIDE FACILITY

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## 2.0 DEFINING THE PARK-AND-RIDE FACILITY

Park-and-ride facilities have existed in one form or another for over 25 years. Early public investment in park-and-ride lots in most American urban areas began in the early and mid 1970s, in response to increasing global oil prices and a renewed interest in mass transit. Thus the park-and-ride concept is not new to many areas of North America, and much has been learned within the industry over the past 25 years. As with other transit facilities and modes, the industry's current planning and design knowledge base has evolved from a combination of positive and negative experiences with the technology.

The purpose of this chapter is to provide a framework for a discussion of park-and-ride facilities. A number of labels have been developed to describe specific types of park-and-ride lots and it is helpful to understand the terminology when evaluating options for providing such services. In general, these terms can be applied regardless of the transit mode being served.

### 2.1 Classifying the Park-and-Ride Lot

Park-and-ride lots can be classified as intermodal transfer facilities. They provide a staging location for travelers to transfer between the auto mode and transit or between the single occupant vehicle (SOV) and other higher occupancy vehicle (HOV or carpools) modes. With planning and forethought, park-and-ride lots can serve a much wider array of intermodal transfers, thereby increasing the activity at the park-and-ride facility, and better integrating it with the surrounding community. Other modes potentially supported by a park-and-ride facility include: pedestrian, bicycle, paratransit, carpool and vanpool, intercity bus transit, airport service, intercity rail, and other modes, based on the location and opportunities available.

The United States federal government, through the Intermodal Surface Transportation Efficiency Act (ISTEA) and subsequent actions by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), has prioritized multimodal and intermodal projects over those that encourage the continued reliance on the private automobile in urban areas. Such a prioritization is also encouraged by the realities of limited infrastructure budgets at the local, state, and federal levels, which necessitate wise public investment.

The park-and-ride facility clearly fits the definition of a multimodal and intermodal facility. The park-and-ride lot, if carefully planned and integrated into a comprehensive transportation system, can encourage a shift from the single occupancy vehicle to higher occupancy modes, meeting the efficiency needs of future urban travel markets.

#### *The Park-and-Ride System as a Mode of Transportation*

As an intermodal staging location for transfers between numerous transport modes, park-and-ride facilities have traditionally been viewed as only a component of the larger transit or highway auto-oriented modes. If examined from a systems perspective, however, a park-and-ride network can be recognized as having unique modal characteristics, not shared by either the traditional transit or highway modes. These unique characteristics include demand patterns, service area concepts, patron attributes, transit operating concepts, and modes of access.

As a unique mode of transportation, the park-and-ride system provides increased opportunities over other modes of transit for private investment and private-public partnering. A healthy park-and-ride system can be used strategically to encourage urban development in lower density suburban environments. It can, however, also lead to continued sprawl, depending upon the location and design of the individual facilities within the system.

This monograph has been written largely from the perspective of the park-and-ride lot as a unique facility, as opposed to a modal system. However, keeping in mind the unique modal characteristics of the park-and-ride system will provide the transportation planner with valuable insights into the specific facility-related attributes explored herein.

### *The Park-and-Ride Lot as a Facility*

A number of previous researchers, implementing agencies, and transit operators have sought to categorize park-and-ride lots by the function they provide or by their distance from the destination market which they serve. As the principal function of the park-and-ride facility continues to evolve, and as urban areas continue to grow, it is likely that what is meant by “park-and-ride facility” will also continue to evolve. The definitions provided in this chapter represent those currently used within the industry, and are provided to develop a vocabulary for the transportation planner.

## 2.2 Park-and-Ride Facilities Defined by Function

A hierarchy of park-and-ride facilities can be developed based on the functional characteristics of the individual park-and-ride lot. Such a classification system can be beneficial when determining the intended use of a lot and the appropriateness of public investment in the planned facility. Six facility types—based on functional characteristics—can be identified, ranging from the informal park-and-ride lot to the design-intensive suburban park-and-ride lot.

### *Informal Park-and-Ride Lots*

The informal park-and-ride lot is often simply a transit stop to which motorists regularly drive their cars and leave them parked on-street or in an adjacent property. Such impromptu park-and-ride operations may indicate the need for a higher order facility providing a safer environment for patrons and a more identifiable presence for transit. Informal park-and-ride lots can also be locations where carpool or vanpool formation takes place. These non-transit operations are often more difficult to discern within the urban fabric than are those connected with a transit stop. Informal park-and-ride lots can be close to the primary service destination or at great distance from it. The key to their formation is convenient access. They are often found at the intersection of major arterials or upstream of recurring congestion points or other natural geographic barriers to travel. Public investment in informal park-and-ride facilities is typically non-existent. Private investment is possible, but unlikely.

## *Opportunistic or Joint Use Lots*

Opportunistic or joint use lots are characterized as sharing the facility with another activity such as a church, theater, shopping mall, or special events center. The park-and-ride activity can be either the secondary or primary use of the facility, depending upon the desired orientation and opportunity provided. Joint use lots can be constructed or procured at relatively low cost and developed fairly quickly if opportunities exist within the existing land use environment to encourage such facilities (e.g., available parking facilities which are unused during peak commuting hours). A primary concern when establishing a joint use lot is the arrangement of a long-term relationship between the implementing agency and the parking lot owner, usually requiring a 2- to 5-year commitment on both parts.

Opportunistic lots can also describe smaller lots built near a local bus stop or major roadway intersection, taking advantage of surplus highway right-of-way or vacant lands. In most cases, opportunistic or joint use lots tend to be smaller than other lots, ranging between 5 and 30 spaces, but are occasionally quite large. If directly served by transit, they may be linked to local or express transit. Alternatively, they may be intended to serve only as a place for carpool and vanpool staging and formation.

Public investment may be high or low, depending upon the enabling agreement and size of the lot. There is a great deal of potential for public-private joint venture in providing these facilities.

## *Park-and-Pool Lots*

Park-and-pool lots are typically smaller lots, intended exclusively for the use of carpool and vanpool formation. This type of lot is often developed as an opportunistic or joint use facility, and may be a part of a development mitigation plan whereby a developer dedicates a (small) number of spaces within a larger development for park-and-pool purposes. Similarly, some transportation agencies such as the Texas Department of Transportation (TxDOT) have made use of vacant right-of-way within highway interchanges or under overpasses to provide park-and-pool facilities.

## *Suburban Park-and-Ride Lots (As Defined by Use)*

Suburban park-and-ride lots, as the name suggests, are typically located at the outer edges of the urban landscape. The chief function of these lots is to collect potential transit patrons as close to their place of origin (their homes) as possible, and provide a transfer point to long-haul (often express) transit service. These facilities rely on the private automobile as the collection and distribution mode. They rely on trunk-line transit routes (bus or rail) to provide the long-haul aspect of the home-to-work trip.

Suburban park-and-ride lots are typically funded by public investment, but can in some cases sustain private ownership. Opportunities for joint development and multi-use facilities are high, depending upon the specific location of the facility and transit services supported.

## *Transit Centers (Intermodal Transit Center)*

A transit center is often thought of only as a place where interchange between local and express transit services occurs. The fact that such centers often serve as park-and-

ride facilities as well is often overlooked. As such, the transit center can play a vital role in both the transit and park-and-ride networks. Transit center park-and-ride lots have typically been built in higher demand locations than the typical suburban park-and-ride facility. They often offer the patron a much higher degree of travel services, route choices, and destination alternatives than is to be found at the latter. Although they typically require a greater investment on the part of the transit agency, they can portray a greater image of permanence on the part of the transit agency which, in turn, can generate opportunities for private investment in the center.

### *Satellite Parking Facilities*

Satellite parking lots (also known as remote parking lots) are placed at the edge of an activity center (i.e., sports complex, airport, or central business district) to provide relatively inexpensive alternatives to on-site parking within the activity center itself. Thus, the satellite parking facility is characterized by its proximity to the destination end, rather than the origin end, of the travel market being served. The ability of these facilities to provide the same benefits as other types of park-and-ride facilities is questionable. Optimally placed park-and-ride facilities, located closer to the origin than the destination end of their intended travel market, provide several distinct benefits which the satellite parking facility cannot provide. First, park-and-ride facilities which are located near the origin end of the travel market provide the opportunity to improve air quality within the urban air shed. Air quality is typically affected by the number of vehicle trips made, the distance of vehicle trips made, the speed of travel, and the characteristics of the vehicle making the trip. Park-and-ride facilities placed near the origin of the trip greatly reduce the length of the auto portion of the trip. Also, the emitting characteristics of the transit vehicle can be better controlled as compared to the private auto. Thus, minimizing the auto access distance and maximizing the transit travel distance provides a better chance of improving air quality. The satellite parking facility potentially maximizes the auto access distance and minimizes the transit vehicle travel distance. Park-and-ride facilities located close to residential trip generators can be designed to encourage walk access, reducing the total number of vehicle trips within the air shed, further improving air quality. The satellite parking facility does not provide this opportunity.

It can be argued that satellite parking facilities reduce congestion within an activity center and reduce demand for scarce parking resources. Some may say that such facilities even allow for the redevelopment of existing parking into higher and better uses. On the other hand, when using satellite parking facilities, congestion and parking demand is only shifted from the activity center to the edges of the activity center. Congestion on routes leading to the activity center will still exist, as private autos attempt to access the satellite parking facilities on the center's edge. In some cases, congestion may actually increase on approach roadways and within the activity center because some drivers may traverse the activity center to reach parking facilities moved to the opposite side of the center.

Satellite facilities operate more as private parking lots than as intermodal facilities. If space within an activity center is of sufficient demand to warrant the consideration of a remote parking facility, why not allow the free market to dictate the location and terms of that parking. In other words, by using public investment to build a free or low cost parking facility on the edge of an urban area, the implementing jurisdiction deprives the free market from providing the same facility. If provided by the free market, a price will likely be applied to the use of the remote facility while at the same time a higher price will be applied to the remaining parkway within the activity center. Conversion of properties within the activity

center to their highest and best use will naturally occur once the value of the land exceeds the utility of the current use.

## 2.3 Park-and-Ride Facilities Defined by Distance to Destination Market

In addition to their functional classification, park-and-ride facilities can be defined in terms of their distance from the primary destination market (typically the central business district or CBD) of the metropolitan area in which they are located. Lots can be defined as suburban lots, local urban lots, peripheral lots, or long-distance remote lots. Each provides a unique type of service, depending upon its location within the urban landscape.

### *Suburban Park-and-Ride Lots (As Defined by Location)*

Suburban lots are the traditional facilities thought of when planning and designing park-and-ride facilities. According to the American Association of State Highway and Transportation Officials (AASHTO), suburban park-and-ride lots are defined as lots that are typically between 6.4 and 48.3 kilometers (4 and 30 miles) from the CBD and that provide an intermodal or change-of-mode service. The predominant modal interchange is typically between the private automobile and transit mode, but may include modal changes between transit and bicycle, pedestrian, carpool, vanpool, or drop-and-ride modes, as well. Transit modes that may be offered at the facility include: express and local bus transit, rail (heavy, light, commuter, and intercity), ferries, and paratransit.

As indicated earlier, suburban park-and-ride lots tend to be publicly funded but can present significant opportunities for public-private joint ventures or outright privatization.

### *Remote Long-Distance Lots*

Remote long-distance lots, similar to suburban facilities, provide an intermodal platform for change-of-mode activities. However, these lots typically lie farther from their primary service destination and may exist within a secondary or bedroom urban area to the primary center being served. These lots are relatively new within the urban environment, and are a result of the rising costs of living in central metropolitan regions. They are typically seen where city pairs exist such as Dallas-Ft. Worth, Albuquerque-Santa Fe, Seattle-Tacoma, Denver-Boulder, and the communities of Northern New Jersey paired with New York City. Distances between the remote long-distance lot and the primary destination is typically 64.4 to 128.7 kilometers (40 to 80 miles) or more. Transit service between such distant locations and the central city has traditionally been the realm of the private intercity transit carrier (e.g., Trailways, Greyhound). However, as interurban travel demand increased between city pairs, and as suburban in-fill narrowed the distance gap between the city pairs, local and regional transit agencies have taken over the responsibility for these travel markets—providing basic services between the interrelated cities. From the user's perspective, avoidance of the drive commute becomes an important element in choosing to use such facilities due to the increase in personal costs of using a private automobile, resulting from increased congestion, slower average roadway speeds and overall deteriorating quality of the private auto commute.

Remote long-distance park-and-ride facilities will require varying degrees of public investment, depending upon the demand for travel existing between the paired urban areas. If demand for travel is high, opportunities for privatization may exist.

### *Local Urban Park-and-Ride Lots*

Local urban lots are those lots that fill the gap between the suburban market and CBD within the metropolitan area. They are typically between 1.6 and 6.4 kilometers (1 and 4 miles) from the CBD and are often informal, shared use, or opportunistic lots. They are often served by only local or local-express transit routes. Interchanges between non-motorized modes of access and the transit system are likely to play a more important role at these facilities than at the more remote suburban lots.

Local urban park-and-ride lots are often publicly funded, but also provide opportunities for private operation. Opportunities for small joint use facilities may exist and should be explored.

### *Peripheral Park-and-Ride Lots*

Peripheral park-and-ride lots include those facilities built at the edge or periphery of a business district to provide additional parking just beyond the business district core. One type of peripheral facility—the satellite park-and-ride lot—has already been described.

The chief purpose of the peripheral lot is to intercept travelers prior to downtown, storing their vehicles in locations where parking costs are relatively cheap and excess land is available. Parking patrons are then transported to downtown using local transit or a shuttle-type system. Urban areas typically resort to this type of facility when parking is limited in their downtown or when streets are extremely constrained or congested. A number of cities in Great Britain, including Bath, Cambridge, Oxford, and York, have successfully used peripheral and suburban park-and-ride lots to preserve the character of their town centers while providing additional parking within their municipalities (53).

Peripheral lots must be analyzed critically for their intended purpose. These lots are not well-suited to the task of reducing commute-oriented vehicle miles of travel and congestion on downtown-bound streets (see description of satellite parking facilities). It can also be argued that such peripheral lots, depending on their proximity to the primary activity center, do not provide for improved air quality or lessen the dependence on the private automobile. It is important for the implementing agency of such proposed facilities to consider the ability of the private sector to construct and operate such facilities on a for-profit basis. Peripheral parking lots often will naturally appear without public investment, if parking is constrained within the central business district or primary activity center. Thus, public investment in such lots should be carefully evaluated.

## 2.4 The Changing Role of the Park-and-Ride Facility

In the United States and Canada, park-and-ride lots have traditionally been designed for the purpose of primarily serving the work-oriented commute trip. Communities in Great Britain have turned to park-and-ride facilities as a means for reducing traffic within their historical town centers and providing convenient services to shoppers and tourists gaining access to their CBDs. The facility definitions provided in this chapter have been largely based on these traditional approaches to the park-and-ride mode. However, the role of the park-and-ride facility is rapidly changing. In congested urban areas, new interest in park-and-ride facilities is coming from both the private and public sectors. For example, in the Puget Sound region, one developer proposed to build parking structures at approximately 20 existing regional park-and-ride facilities, with the intent of charging for premium park-and-ride services. Another example of the new interest in park-and-ride facilities is an innovative study in San Jose, California, to link the development of new park-and-ride facilities with emerging intelligent transport technologies, creating a “smart lot.” This new public and privately generated interest is generating a host of innovative concepts and opportunities in park-and-ride planning and design.

One notable change on the horizon is the increasing move to package new park-and-ride facilities with urban developments and gain spin-off value from the investment. Some agencies are now even turning to the private sector to provide the needed parking capacity. Transit agencies with mature operating park-and-ride systems are looking towards their capital assets to find additional sources of revenue. Park-and-ride facilities, by their nature, represent capital-intensive assets that can be leveraged in the market place.

The changing role of the park-and-ride facility and the variety of environments in which they are built reaffirms the need to approach every planning or design project with an eye for innovation and optimization. In short, the park-and-ride facility can be whatever the community is willing to make of it, an integrated part of the urban fabric or a single use facility. As may be obvious from the perspective presented in this monograph, this researcher believes that the integrated approach is the preferred method for developing a successful facility.

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### 3.0 PARK-AND-RIDE PLANNING PROCESS

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## 3.0 PARK-AND-RIDE PLANNING PROCESS

Within the transportation industry, a park-and-ride planning process has evolved based on the experience of local, state, and regional agencies throughout North America. Unique solutions to planning issues have been developed by a number of agencies. These serve as a basis for current planning efforts. Many of these experiences are based on the planning of individual park-and-ride facilities.

It is typically more effective to plan park-and-ride facilities as part of a coordinated transportation system, than to plan individual facilities and try to tie these facilities together after the fact. Park-and-ride facilities cannot function on their own without direct linkages to the surrounding transit and highway infrastructure. It is important to develop a comprehensive system plan inclusive of park-and-ride facilities before developing the individual elements or facilities within that overall system plan. Success of the individual park-and-ride facility lies in its ability to connect with the regional transportation network and the selection of a site location within that network.

In an economy characterized by shrinking funds for capital projects, improved planning processes must be used in the development of park-and-ride and other multimodal facilities. Because park-and-ride facilities are often located in suburban areas with high visibility, individual lots that do not demonstrate successful demand characteristics engender a negative stereotype of transit; they suggest that transit is not efficient and therefore a waste of public funds. On the other hand, park-and-ride facilities that demonstrate strong demand characteristics raise the positive visibility of transit service, provide an efficient mechanism for collecting ridership, and set the stage for developing a stable transit market in surrounding neighborhoods. With the incorporation of effective architectural design and planning, suburban park-and-ride facilities can serve as major transit centers, becoming focal points for the communities they serve. Such facilities establish a transit presence that demonstrates a continuing commitment to the suburban market. As such, these public investments can encourage transit-friendly developments and land use densification within walking distance of the lot when accompanied by supporting land use policies.

### 3.1 System Planning Process

The system planning process is a critical step to ensuring successful park-and-ride operations throughout the metropolitan environment. Often, agencies within a single metropolitan area (e.g., local, state, and regional) may be interested in constructing such facilities. However, only the regional or local transit agency(s) may be responsible for providing service to a given facility. This situation requires the transit agency(s) to be a primary participant in the planning process. The transit agency must be able to provide service to each individual park-and-ride lot if the lot is to serve as a transfer point between auto and transit modes. Park-and-ride facilities planned without the participation and commitment of the local transit agency would be better defined as park-and-pool lots, because transit service may not be guaranteed to such sites.

The system planning process chosen by the transportation planner will often be unique to the urban area in which it is being implemented. Planners and engineers must be sensitive to the community they are serving, and every effort should be made to use customary planning processes tailored to fit the local planning environment. The role of the

planner and engineer during the system planning process is in large part one of facilitator and information gatherer. The participating agencies, community(s), and concerned citizens must be the primary decision makers to assure broad acceptance of the plan.

A schematic of a generalized park-and-ride system planning process is depicted in Exhibit 3.1. This approach highlights many of the important elements necessary for a successful planning process. Depending on how advanced a region is within its system planning process, as illustrated through either a coherent planning effort or through a history of ad-hoc planning and implementation, the order of individual system planning activities may differ. Individual elements of the process should be adapted to meet the needs of the local community, transit system operator, metropolitan planning organization (MPO), and expectations of the affected jurisdictions. The remainder of this chapter provides a brief discussion of each of the major elements of the system planning and implementation process.

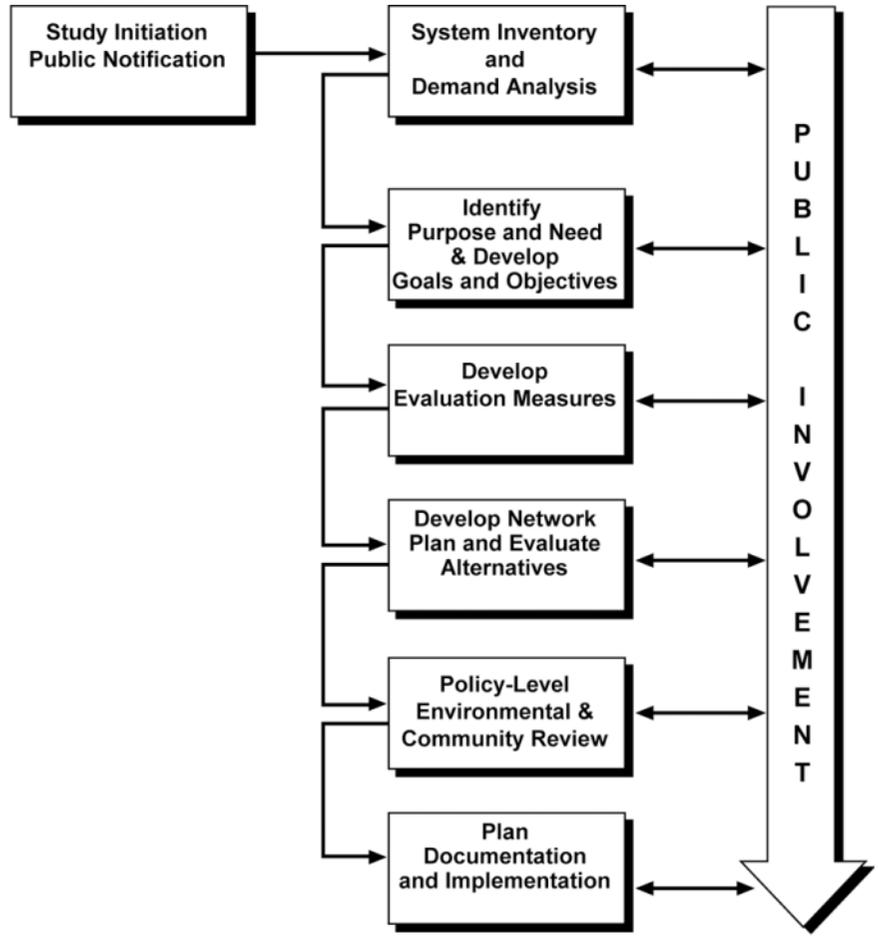
### *The System Study*

The purpose of the system study and resulting system plan is to identify a common regional approach to the provision of park-and-ride facilities. Broad policy issues including the goals and objectives of the system plan, system level measures of effectiveness, operational goals and responsibilities, and generalized location decisions, should be evaluated at the system plan level. It is important to remember that the system plan need not be a static guideline. On the contrary, it must reflect inevitable evolving conditions as well as new opportunities for park-and-ride developments over its lifetime. It must provide the participating agencies with a common platform from which to program further site-specific studies, investments, and construction projects.

Primary activities that should be completed as part of the system study and documented in a system plan include:

- Inventory of existing facilities
- Documentation of recognized purpose and need for a park-and-ride system, travel needs to be served, and the size and general character of such a system
- Determination of goals and objectives
- Establishment of an evaluation process framework (definition of a successful park-and-ride facility)
- Development of a systemwide service network, serving the existing and proposed park-and-ride system by connecting it to major employment destinations
- Development of intergovernmental agreements outlining general policies for facility acquisition, maintenance, and service
- Policy level environmental review screening for critical flaws, and investment analysis, if necessary
- A public involvement and review process (this is critical to positive public acceptance)

Exhibit 3.1  
Park-and-Ride System Planning Process



An important factor in the system planning process is realizing that considerable work may already have been completed within a region towards developing a regional park-and-ride system, either as part of an ongoing regional transportation plan or through the natural growth process of the local transit agency. In either case, this completed work should be inventoried and a definition of the existing state of the system be developed. At a minimum, the inventory should include:

- Identification of existing facilities
- Identification of site ownership by facility
- Listing of transit and non-transit services provided along with responsible agency
- Listing of capital amenities provided (e.g., shelters, schedule kiosks, benches, on-site retail vendors, security devices)
- Identification of access attributes of each facility with respect to high occupancy vehicle and/or freeway networks
- Inventory of spaces provided and utilization and turnover rate, including on-street parking related to on-site transit operations, types of spaces provided (long-term, short-term, drop-and-ride), costs, etc.

The system inventory should be keyed to a geographic information system or referenced to a map so that it can be used to develop a picture of the existing park-and-ride network. Existing and planned transit routes and services should be overlaid onto this graphical representation of the system plan to develop a context for placing new facilities or expanding those already in existence.

### *Purpose and Need*

Through definition of the existing system, the planning team will develop a working knowledge both of the region and of the strengths and weaknesses within the existing park-and-ride system (given that such a system exists). Local transit operators, transportation organizations, affected public agencies, and interested citizen groups should then forge a statement of purpose and need, of deficiencies within the existing park-and-ride system, and of the major regional goals and objectives for the system plan. Attention should be paid to developing a vision of the future system that is attainable and developing realistic goals and objectives. When developing these goals and objectives and in identifying the needs of the community, a planning team consisting of the implementing agency, the local transit provider, the agency responsible for highway and arterial streets, the local MPO, and major jurisdictions should be forged.

A statement of purpose and need should be included with supporting information on the existing park-and-ride system, regional deficiencies, and recognized opportunities. Goals and objectives developed at the regional level should be broad enough to apply to a number of specific locations. Goals and objectives that are overly focused on a single criterion or measure of success should be discouraged in favor of a more inclusive set of regional objectives.

## *Example Goals and Objectives*

Goals and objectives must be specifically relevant to the region in which the system planning effort is being conducted. Example goals and objectives that might be incorporated within a statement of purpose and need include the following:

- Maximize the demand potential and thus the projected transit ridership at individual park-and-ride facilities
- Provide a system of facilities that is well integrated into the surrounding urban development and that supports surrounding land uses and community plans
- Develop a system of park-and-ride facilities that promotes a conversion to a traditional pedestrian-access transit system and a reduced reliance on the private automobile as a transit access mode
- Develop a system that encourages transit-friendly development immediately adjacent to the individual elements of the system, and that develops a future transit market within the suburban environment
- Coordinate park-and-ride development with the provision of convenient and accessible transit system(s), providing for ease in route-to-route transfers and overall transit system optimization
- Develop a system that minimizes the cost to public agencies and promotes the use of joint use facilities, joint development, and privatization opportunities
- Develop a system that links individual communities to a regional transportation network, providing identity to the community and/or neighborhood in which individual elements and facilities are placed
- Incorporate a community art program and significant architectural elements into the design of individual facilities

It is important to note that a statement of goals and objectives will often contain a number of competing items. During the site-level alternatives evaluation process, which follows the system plan, the implementing agencies and community(s) will evaluate individual elements of the park-and-ride system and specific park-and-ride location opportunities for their ability to meet the various predefined goals and objectives. By incorporating a number of goals and objectives, tradeoffs among alternatives can be evaluated and a system that reflects the character and needs of the community can be better developed.

## *Evaluation Measures*

After the definition of regional goals and objectives, measures of effectiveness (i.e., evaluation criteria) must be developed that allow the implementing agencies and citizens to judge the usefulness of individual elements. The degree of detail incorporated into the measures of effectiveness should be in proportion to the issue that they are being used to evaluate. For example, at the system plan level, only rough estimates of potential park-and-ride demand based on general trip making characteristics of the underlying service populations will be adequate, whereas during the site selection process, more detailed and

reliable forecasting procedures should be utilized to define the scope of the needed design. Measures of effectiveness appropriate at the systems analysis level include:

- Regional or corridor demand for park-and-ride service based on socioeconomic, urban development, and trip interchange data
- Connectivity and mobility characteristics provided by the proposed park-and-ride system
- Community acceptance and support for individual elements of the system
- Availability of public funding, joint venture opportunities, and public-private investment alternatives
- Cost-effectiveness, based on competing and/or supportive community objectives
- Estimates of reduction in vehicle miles of travel and auto vehicle trips as a result of system implementation
- Emission reductions and pollutant reapportionment and/or reduction within the region resulting from system implementation

These measures of effectiveness are by no means comprehensive. Individual and unique measures should be developed that reflect the goals and objectives of the region for which the system plan is being developed.

### *Service Network*

Numerous studies have shown that one of the most important elements that affects park-and-ride demand is the frequency and character of the transit service provided at individual park-and-ride facilities (1, 23, 44). At the regional level, a network of transit services must be developed and implemented for individual park-and-ride facilities within the system to work effectively.

At a minimum, it is recommended that service corridors be identified throughout the region and that park-and-ride facility development be focused into these corridors, which will typically follow major travel corridors organized around the freeway or highway network or along existing rail transit systems. Minimum transit service standards should be identified, detailing what levels of peak and off-peak service will be provided by the participating transit agency to each (park-and-ride) facility within the regional corridors. Demand forecasting experience has shown that the most successful park-and-ride facilities, measured in terms of parking demand, are those provided with transit service characterized by a maximum of 10- to 15-minute intervals during the peak periods, and with the availability of regularly scheduled midday service between the primary activity center and suburban facility (23).

The importance of identifying transit service parameters which provide service levels necessary to support park-and-ride facilities within the system plan cannot be underestimated. Changing the transit service characteristics within any given corridor or for an individual park-and-ride facility can have significant cost-effectiveness impacts on the system.

## *Intergovernmental Agreements*

The system plan provides an opportunity to develop intergovernmental agreements or at least an intergovernmental understanding among the affected jurisdictions and participating agencies. Such agreements are most important when more than one transit operator (public or private) provides service within the metropolitan region or when several agencies are in the position to build and operate park-and-ride facilities. Such is the situation when a highway agency builds the facilities within excess roadway right-of-way space, and allows the local transit agency or a private operator to provide service to them.

Some of the more important issues to document in an intergovernmental agreement include:

- Development of a framework for intergovernmental participation and cooperation
- Coordination of transit service and identification of minimum design requirements
- Identification of transfer locations between neighboring transit operators and coordination of transfer policies
- Development of consistent policies on assignment of liability and definition of responsibilities.

The above issues are geared to developing a general approach to the interworkings and cooperation between government agencies with overlapping jurisdictions. At the project-specific level, additional refinements to specific intergovernmental agreements may be required to identify property ownership and usage, maintenance and service responsibilities, and the assignment of specific liabilities resulting from park-and-ride operations. Local legal counsel should be used to assure compliance with all applicable issues.

## *Policy-level Environmental/Investment Analysis*

Depending on the magnitude of the park-and-ride system plan and local requirements, a policy-level environmental analysis may be required. A primary concern at the system level will be the effects on air quality standards as a result of the park-and-ride plan. The National Environmental Policy Act (NEPA) requires that any time significant changes to local or regional traffic patterns occur that environmental considerations (i.e., air quality) be evaluated either at the planning level or through a hot spot analysis, depending on the type of planning effort being undertaken. For example, if the implementation of a specific facility is being considered, then a hot-spot analysis is required. If a new system of park-and-ride lots is being considered, impacts on the regional airshed may require analysis. In a federal non-attainment area, the metropolitan transportation plan (MTP) will likely require amending and conformity with established air quality goals. In such areas, the impacts of mobile emissions within the regional air shed must be considered. Likewise, local state environmental impact policy should be reviewed (if applicable) for the need to conduct a policy-level environmental impact analysis. If federal moneys are to be used, federal environmental analysis requirements should be reviewed (e.g., NEPA).

## *Public Involvement*

Public participation is also an important factor in the system planning process. Public participation can be used to determine minimum service standards for the proposed park-and-ride system, characteristics of lots, and corridor prioritization. Public participation at the system planning level can reduce opposition to future facilities by incorporating public concerns at the outset, rather than attempting to mitigate those concerns at the time of construction.

A public involvement program, consisting of a series of open houses and information gathering sessions, is strongly advisable at the system planning level. A citizen and technical advisory committee—consisting of transit patrons, community leaders, representatives of affected agencies, and community business—should be organized to provide input throughout the study and to build community support for the program. This same citizen and technical advisory committee can also serve as the advocacy group for the resulting system plan, interceding on behalf of the agency to the MPO and other elected jurisdictions.

## *Site-Level Location and Design Studies*

Once the regional system plan has been developed, planning and alternatives analysis for individual park-and-ride facilities can be conducted within the framework outlined during the broader system planning effort. Within the system plan, general locations for individual facilities will have been identified. During the alternatives analysis process, site-specific issues will be evaluated, often focusing on several specific locations/sites within the general location identified by the system planning process.

Choosing the optimum site within a generalized service area for a park-and-ride facility will depend on a number of competing interests and community goals. These factors are evaluated on a site-by-site basis. Individual site-specific locations are compared and evaluated to select a preferred park-and-ride location. The remainder of this monograph addresses many of these issues; in brief, a site-specific alternatives analysis process would include:

- Determination of site availability
- Site evaluation, ranking, and selection of a preferred site from a range of local alternatives
- Site-level demand forecasts (i.e., demand estimates for a specific location)
- Conceptual design, including allowances for public art and unique architectural elements to be incorporated into final design.
- Analysis of location-specific (site-specific) environmental impacts, including:
  - Traffic study/access analysis
  - Air and noise and vibration quality
  - Drainage analysis
  - Geotechnical/civil analysis
  - Hazardous waste mitigation plans (if necessary)
  - Historical/cultural resource impacts

- Developing and conducting a public involvement program centering around a specific site
- Pursuing and securing adequate funding resources
- Preliminary and final design and engineering

A successful site-level alternatives analysis process should eventually lead to a design report (supported by the necessary environmental documentation) and facility concept that is embraced by the community and by all the participating agencies. The time required to complete a site-level study will vary, depending on the complexity of the issues involved in the analysis, community support, and agency participation. Regardless of the time required, the resulting facility plan will be more inclusive if based on a community-oriented process. Community support built at the system-level and site-level planning stages will carry over into the construction, operation, and use of the facility.

A simplified site-level study process is identified in Exhibit 3.2, which illustrates the relationship of the site-level analysis with system planning efforts. As with the system planning process, a continuous public involvement process is identified throughout the duration of the project. The public involvement process incorporated at the site-specific level will be more focused than at the systems level, and will require greater interaction among the planning and design teams and the affected community.

### 3.2 Final (Detail) Design and Construction

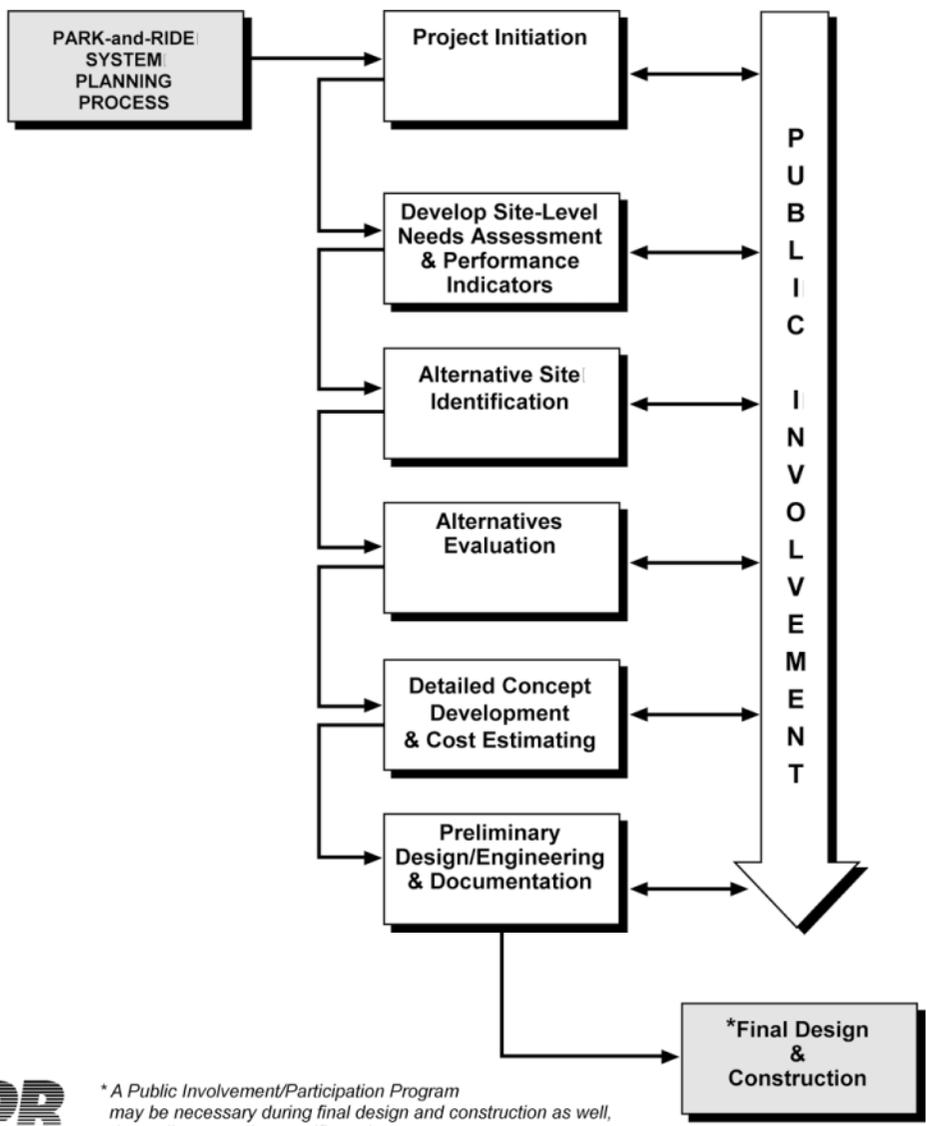
Final or detail design and construction may immediately follow the site-specific alternatives evaluation and preliminary/conceptual engineering design phase of the facility implementation process or be postponed until funding can be secured. Design options to traditional construction such as joint use parking facilities, facility leasing, and staged construction should be evaluated for potential advantages in expediting the implementation process. Leased and joint use lots, although not always in the best locations from the perspective of the park-and-ride system plan, can be used as test markets for expanded public investment in the form of a permanent park-and-ride facility<sup>1</sup>. Likewise, the staged construction of public lots can be used to minimize the financial exposure of the implementing agency, since construction of subsequent facility phases can be delayed if required.

Construction techniques should minimize the required public expenditure while at the same time provide for a long life cycle in terms of structures and materials used in the site development. This approach will reduce the operation and maintenance costs of the facility and prolong its usefulness.

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<sup>1</sup> Note: Some agencies prefer to organize the preliminary design/engineering and final design into a single phase called detail design. This single detailed design phase typically includes all phases of the design once a single site and concept have been selected. Adoption of this type of approach to detailed design may qualify more of the design phase for federal funding, thus shifting some of the financial burden off the local transit authority.

Exhibit 3.2  
Park-and-Ride Site-Level Study Process



*\* A Public Involvement/Participation Program may be necessary during final design and construction as well, depending upon the specific project.*

### 3.3 Operation/Performance Monitoring

Park-and-ride facility operation should be accompanied by a systematic evaluation process, analyzing the critical aspects of the transit service provided, the security attributes of the site and design, the maintenance costs and savings provided by the design, and the success of the site as reflected by parking demand, transit ridership, and other measures of effectiveness.

Construction of a proposed park-and-ride facility is the initial stage in an agency's involvement in providing regional park-and-ride service. As part of a regional plan, individual park-and-ride facility implementation should be viewed as an opportunity for continued refinement of the planning process within the region. Thus, implementation of a specific park-and-ride alternative should be used as a chance to gain new data to support future implementation(s) and to use as feedback into the regional planning process.

Community acceptance and attitudes towards the facility, both within the surrounding neighborhood and from the patron population, should be evaluated periodically using survey techniques so that changing needs can be identified. Such surveys should also extend to the non-users in the vicinity of the park-and-ride facility to identify service needs not being met by the constructed facility.

There should be a systematic process for injecting "lessons learned" from the ongoing analysis of park-and-ride facility performance into the existing facility management process as well as into the planning of future facilities. For example, if within a system an existing park-and-ride facility is found not to demonstrate adequate demand, it must be critically evaluated. Can it be made more attractive? If not, can it be surplussed and the resulting salvaged finances from the failed lot be reinvested in a more productive site. In this manner, the park-and-ride system can continuously be improved and optimized.

### 3.4 Summary

The park-and-ride system planning process is an important element in the development of a comprehensive park-and-ride service network. A strong, well-documented system planning process will provide significant advantages during the development of site-level designs. Major issues concerning connectivity of the system, location of major investments, and alignment of transit services can be resolved at an early stage, avoiding increased costs in the implementation process.

During the site-level planning phase of park-and-ride development, site-specific issues must be addressed and strong community support for individual facilities developed. Site-level evaluation will include several specific alternatives and will require detailed engineering and planning studies related to the proposed facility. This information will lay the foundation for the final/detail design and eventual construction of the proposed park-and-ride facilities.

This chapter was intended to provide a framework for the planning and design of suburban park-and-ride systems. It must always be remembered that the successful transportation planning approach will be one that is tailored to the urban area for which it is proposed. A community-based planning approach, based on the values and needs of the affected community, will receive the greatest acceptance and stand the greatest chance of success throughout its lifetime.

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## 4.0 MAKING THE FACILITY LOCATION DECISION

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## 4.0 MAKING THE FACILITY LOCATION DECISION

Park-and-ride facility location is an important factor in determining the demand characteristics for a proposed facility. Choosing the right location for a proposed park-and-ride facility, or even selecting the right set of location alternatives to evaluate, is often one of the more difficult elements in the park-and-ride planning process. Optimizing the location is often complicated because site options available to the implementing agency are typically limited because of existing land use developments, environmental constraints, lack of adequate available alternative sites, and location of transit lines in the case of fixed guideway transit systems.

Additionally, evaluation of site alternatives and the selection of the optimum site, is based on competing criteria developed for the park-and-ride system as a whole. When various sites are evaluated using multiple measures of effectiveness, tradeoffs among competing effectiveness measures must be accommodated. For instance, for specific locations it may not be possible to maximize demand while at the same time maximizing facility integration with surrounding land uses. Likewise, it may not be possible to eliminate or minimize adverse environmental impacts while at the same time minimizing the cost of construction. Thus the optimum park-and-ride location will be that site which best meets the greatest number of needs of the surrounding community (without any fatal flaws) while attaining ridership demand characteristics that provide acceptable cost-benefit performance ratios.

The purpose of this chapter is to provide a checklist consisting of site selection criteria that have been developed for and used in a number of park-and-ride facility studies. This checklist can be used to attain many different specific community goals. It must be remembered that it will be next to impossible for any one site to provide all the optimum characteristics included in the checklist. However, potential locations should be evaluated in terms of their ability to most effectively meet the greatest number of community needs. Tradeoffs among specific criteria must be weighed by the site selection team to determine the best suited location for the intended park-and-ride facility.

This site location checklist has been organized into three common community goal categories:

- Assuring strong patronage demand
- Providing for integration with the community
- Reducing the financial impact and risk to the implementing agency

A wide body of literature exists on location theory; however, it is not the intent of this monograph to provide a comprehensive review of this library of knowledge. It is the intent to provide a practical approach for sketch planning through an examination of industry rules of thumb that have been successfully applied in the development of operating systems. The rules of thumb presented in the checklist are not foolproof, but should serve as a guide for sketch planning studies and preliminary evaluations of candidate locations. The transportation planner must work with the affected agencies and community to develop a set of location criteria that best suits the specific study area. The checklist can assist in this

endeavor, but will most likely not provide the comprehensive evaluation approach that is to be gained through detailed evaluation of the options available.

## 4.1 Assuring Strong Patronage Demand

One of the primary concerns of an implementing agency—and indeed the community as a whole—is that a new park-and-ride facility demonstrate adequate demand to justify the public expenditure. Transit agencies in turn rely on demand estimates to schedule appropriate service levels, provide amenities, and program future growth. Although demand will not be the only factor in defining the optimum facility location, it must be considered an important criterion.

The following rules of thumb can be used to locate applicable site alternatives for evaluation. These rules have been compiled from the experiences of a number of transit agencies and planning studies. Although they do not guarantee high parking demand, they can significantly assist in the preliminary identification of promising opportunities:

- **Geographic Affinity to Activity Center Served.** Proposed facilities should be located in geographic areas that display strong origin-destination trip interchange characteristics with the primary activity center served (typically the metropolitan CBD). The geographic area immediately upstream of the lot should demonstrate sufficient suburban and urban residential densities to supply acceptable demand for the facility.
- **Minimize Auto Access Time.** Auto access to the park-and-ride facility should be made as convenient and as least time consuming to the user as possible. The transit portion of the trip should (in most cases) represent more than 50 percent of the total journey time from the patron's home to the final destination (43).
- **Maximize Regional Location.** Park-and-ride lots should generally be located no closer than approximately 6.4 to 8.0 kilometers (4 to 5 miles) and preferably 16 kilometers (10 miles) or more from the primary activity center being served. This will generate acceptable levels of reduction in vehicle miles traveled (VMT) and provide for congestion relief downstream. Park-and-pool lot demand is conducive at even further distances (in the range of 16 to 40.2 kilometers (10 to 25 miles)) from the primary activity center. Park-and-ride facilities at distances greater than 48.3 kilometers (30 miles) have typically not been found to be successful (1, 23, 43). However, special circumstances may exist, such as city pairs demonstrating strong historical intercity demand (e.g., Seattle - Tacoma, Dallas-Fort Worth, Denver-Boulder city pairs). The existence of city pairs can make park-and-ride facilities at greater distances from the primary activity center quite successful, where the underlying travel demand is high. Likewise, in some major metropolitan areas such as New York, New Jersey, and Los Angeles, park-and-ride lots at distances greater than 48.3 kilometers (30 miles) may be viable due to high residential costs in inner urban areas, which encourage longer commutes.

Park-and-ride facilities placed within the primary destination center they are intended to serve should be evaluated as to their purpose—for example, are they actually being used more as peripheral parking than as true park-and-ride lots? Such facilities will not generate reductions in vehicle emissions, VMT, or congestion, and can actually increase regional emission totals. Such facilities tend to operate more as periphery

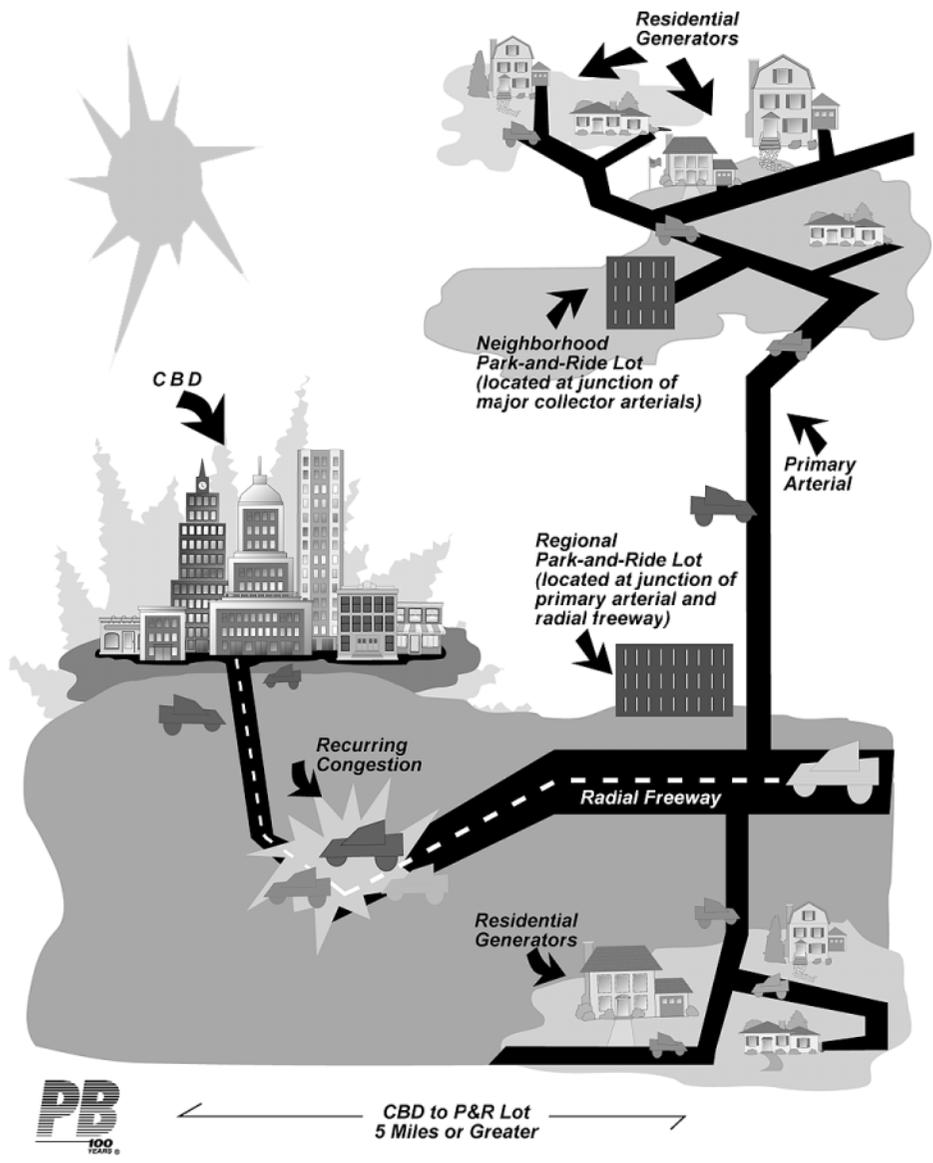
parking lots to the central activity center rather than as true park-and-ride facilities. This type of periphery lot provides an ideal opportunity for privatization on a for-pay and for-profit basis (see peripheral park-and-ride lots, Chapter 2.0).

- **Select Locations Upstream of Congestion.** Facilities immediately upstream of recurring congestion within the regional transportation system have been found to demonstrate higher demand characteristics than other facilities, resulting from commuters seeking to avoid traffic jams (see Exhibit 4.1). Demand is further enhanced if transit is supplied with a significant advantage over the private automobile (e.g., a transit HOV lane, queue bypass lane(s), or other transit priority features).

Likewise, the park-and-ride facility should be placed so as to intercept primary commuter paths prior to reaching the main radial travel corridor. The park-and-ride lot should therefore be placed between the primary commuter market area being served and the radial freeway connecting that area with the primary destination being served (see Exhibit 4.1).

- **Maximize Service Area Population.** Park-and-ride facilities should be placed so as to serve the greatest possible population base and population densities within 4 kilometers (2.5 miles) of the proposed facility. Research has shown that 50 percent of a park-and-ride facility's demand is typically generated within a 4-kilometer (2.5-mile) radius of the facility, and that an additional 35 percent (i.e., a total of 85 percent of total demand) will come from an area defined by a parabola extending 16.1 kilometers (10 miles) upstream of the lot and having a long cord of 16.1 to 19.3 kilometers (10 to 12 miles) (23).
- **Adjacent Transit Corridors.** New park-and-ride facilities should be located adjacent to existing major transit corridors, where peak transit service can be provided with headways on the order of 15 minutes or less (10 minutes or less is optimal) (23). Midday service can also be critical to generating high demand characteristics. Transit service should be oriented to the park-and-ride facility so as to minimize downstream transfers (i.e., the transit mode serving the park-and-ride facility should serve the primary activity center directly, without necessitating a transit-to-transit transfer). To achieve this goal, park-and-ride lots should be placed in proximity to the existing transit route structure within the given corridor (23).
- **Provide Frequent Express Service.** Experience has shown that frequent express service (between the park-and-ride facility and primary activity center being served) is one of the primary demand generating characteristics of successful park-and-ride facilities. Minimum service frequencies of 15 minutes are acceptable for major park-and-ride facilities. Experience in several regions has shown that once usage grows sufficiently to support 5- to 10-minute service headways, further demand will be drawn to the high frequency service provided at the lot, and demand growth accelerates rapidly (15).
- **Adjacent Regional Freeway or Arterial with Radial Orientation.** Locate park-and-ride facilities adjacent to, or within visible range of, major regional freeways or high speed arterials that provide radial access to the activity center being served. Such facilities can be defined as those with average daily traffic volumes per lane approaching 20,000 vehicles (54). By locating a park-and-ride facility within visible range of a radial freeway, the lot will be essentially self-advertising, and is more likely to

Exhibit 4.1  
Siting a Park-and-Ride Lot



develop demand quickly, drawing patrons from the adjacent (presumably congested) freeway. Access to the park-and-ride facility need not be directly from the freeway, and in fact the preferred access route is via a feeder arterial or secondary street. The main issue is that visibility from the primary travel corridor is critical (23, 45).

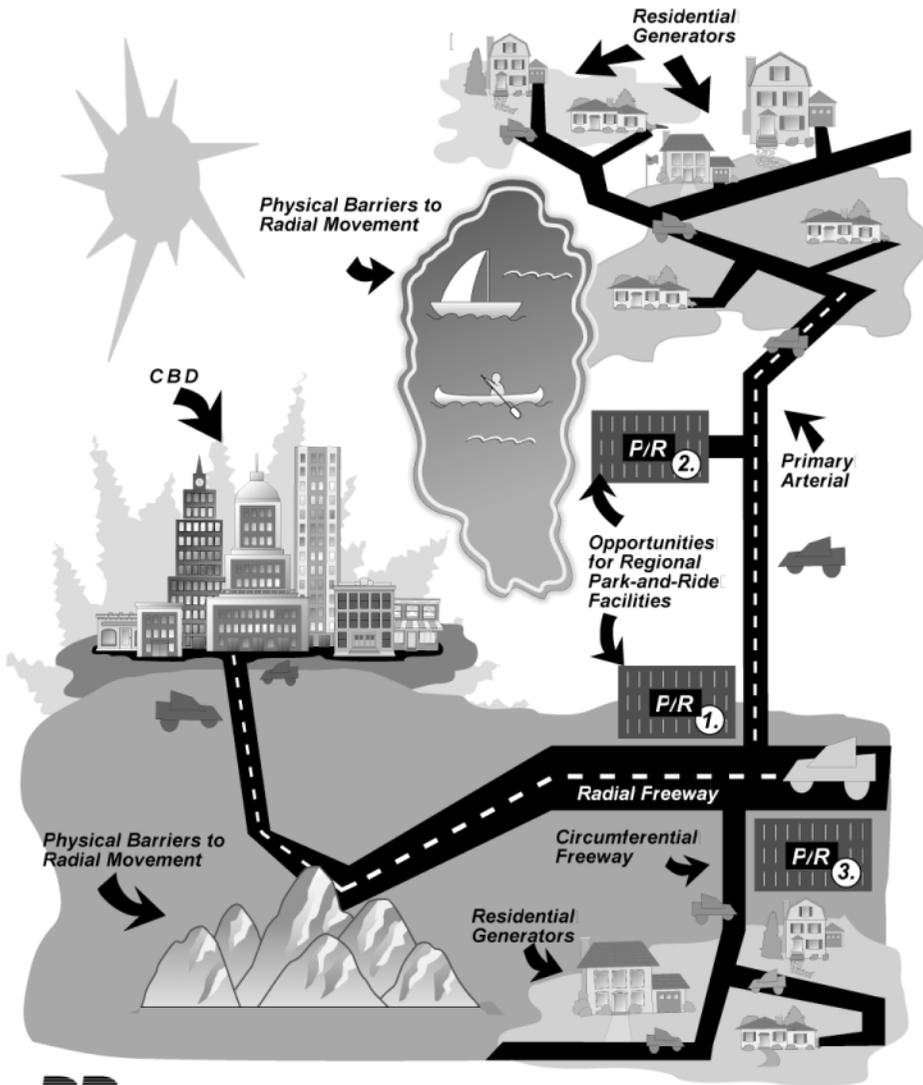
Within the freeway or arterial corridor, the park-and-ride facility should ideally be located at or near freeway interchanges to provide direct or semi-direct access to the freeway from the facility. This will maximize the ability of transit to compete with the private automobile, intercept the maximum number of potential users, and often coincide with existing transit route structures (42).

Location of park-and-ride facilities on circumferential beltways or other non-radial roadways will result in less productive facilities as compared to those located on the radial freeway network. Location of facilities at the intersection of a circumferential and radial freeway should be chosen so that the lot falls downstream of the interchange on the radial freeway, for maximum demand generating capabilities (see Chapter 5: Application of Demand Estimation Techniques to Denver, Colorado).

Geographic barriers to direct travel between the park-and-ride facility and the central activity center will affect the demand attributes of the park-and-ride facility. Barriers such as lakes, rivers, hills and mountains that block direct radial access between the origin and destination locations may induce park-and-ride demand on circumferential freeways, similar to that seen on radial networks (see Exhibit 4.2). The impact of geographical barriers should be analyzed for their effects on travel flow patterns. If radial movement requires a circumferential movement because of geographic barriers, these corridors may be good candidates for park-and-ride lots as well (see Exhibit 4.2).

- **Auto to Transit Cost Ratio.** To maximize the usage of the park-and-ride system, the ratio of regional auto operating costs to transit fare costs should be maximized from the user's perspective. The more expensive auto operating costs are relative to the transit fare, the higher the demand for remote parking or park-and-ride facilities. Parking costs are an important element in determining the cost of auto access. Increased parking costs in the central activity center being served, or increased difficulty in securing parking, will help to increase park-and-ride demand.
- **Lot Competition/Reinforcement.** When implementing a new park-and-ride facility, the influence of nearby park-and-ride lots should be evaluated. If transit demand is high and capacity at proximate lots is insufficient to handle the system demand, then additional supply can have synergistic effects on demand. On the other hand, if capacity exceeds demand, placement of adjacent lots may create competition for the same patron population. Park-and-ride lots placed closer than about 6.4 to 8 kilometers (4 to 5 miles) within the same corridor have strong potential for creating a (mutually negative) competitive situation, and should be evaluated carefully for their interrelated demand characteristics (23).
- **Transit Speed and HOV Facilities.** Provision of HOV facilities and transit priority treatments is highly beneficial to the development of a successful park-and-ride system. Increasing transit speeds has been found to increase the competitiveness of the park-and-ride facility with respect to the private automobile, thus increasing demand for park-and-ride usage.

Exhibit 4.2  
Combined Radial/Circumferential Commute Pattern



Note: When a Physical Barrier Does Not Exist (e.g., in the Case of a Beltway on a Flat Plane) the Preferred P&R Location is on the Radial Roadway Link (Location 1. Above)

- **A Safe and Secure Environment.** A safe and secure environment for patrons, parked vehicles, and transit operators is critical to the success of a park-and-ride facility. Safety and security is as much a perception as it is real. Frequent and consistent removal of graffiti, broken glass and trash, and overgrown landscaping is important when providing an environment that feels safe and secure to the user. An aggressive approach to security breaches and other concerns can support an operator's efforts to secure the park-and-ride facility. Security techniques should not be intrusive or create a feeling of imprisonment for the patrons. For example, security cameras, emergency telephones, and activity-generating joint uses are preferable to fences and on-site security. Techniques that facilitate integration with the surrounding community should be encouraged as a method for increasing the safety and security of the park-and-ride facility. Security measures should match the perceived need of the site, and should not inconvenience legitimate access to the park-and-ride facility. Architectural and design methods should be considered for discouraging vagrancy and for eliminating potentially unsafe conditions (see Exhibits 4.3 and 4.4).

Exhibit 4.3



River stone embedded in concrete beneath low overhang discourages vagrancyæBC-Transit, Vancouver, BC Canada

Exhibit 4.4



Open shelter design permits clear visibility of surrounding lot  
Howard Beach Park-and-Ride, New York City Transit

- **Design for Multimodal Connections.** The park-and-ride design should be developed as both a multimodal (providing access to a number of travel options) and an intermodal (providing convenient transfers between modes) facility. In addition to facilitating the traditional intermodal connection between the auto and transit modes, much attention should be given to planning and designing for bicycle, pedestrian, and handicap access. Similarly, carpool and vanpool formation should also be accommodated within the facility, and consideration should be given to defining specific locations for these other intermodal connections (i.e., between the SOV and HOV). Transit-to-transit connections should be optimized through the park-and-ride facility, giving the facility a dual purpose as both a transit center and park-and-ride facility. The increased activity will improve the connectivity of the lot with the surrounding community, and increase midday activity at the lot, thus improving the security attributes of the system.
- **Maximize the Facility's Visibility.** The optimum park-and-ride facility will be highly visible from the primary travel corridor. Every effort should be made so that the facility is not intrusive and fits appropriately within the surrounding environment, while still remaining visible. Increased visibility will reduce (although not eliminate) the need for extensive signage and advertising.

## 4.2 Providing For Community Integration

Choosing park-and-ride site alternatives that provide for improved integration of the facility with the surrounding community is desirable for numerous reasons. These include the enhanced perceived security of such locations, the economic benefit that the lot can bring to area businesses, and the ability of such facilities to develop a transit-oriented suburban market. A good community integration plan can also reduce impacts to the natural and built environment surrounding the proposed facility and therefore engender a greater sense of community ownership and popularity.

The following discussion provides insight into the placement of park-and-ride facilities so that they are better integrated into the surrounding community:

- **Locate in Areas With Compatible Land Uses.** Locating a new park-and-ride facility within an area of compatible land uses will increase the potential for joint usage and improve community integration opportunities. Compatible land uses will be defined by the community in which the facility is being located; possibilities range from a suburban business center to an industrial area to excess freeway right-of-way. The impacts on the built environment will likely be reduced by attention to compatible land use issues.
- **Locate in Accordance with Local Ordinances and Plans.** Locating new park-and-ride facilities within areas of compatible land uses, and in areas that do not require a zoning change or change in local land use plan, will minimize the cost of implementation and reduce delay in initiating operation. Long-range transportation plans should also be considered when selecting facility location or designing a park-and-ride system.
- **Minimize Environmental Impact.** By their nature, park-and-ride lots involve the introduction of significant amounts of new impervious surfaces into the natural and built environment. Operation of such facilities will also increase vehicle emissions in the vicinity of the facility, potentially increase local area traffic congestion, and introduce new visual and noise impacts into the environment. Sites should be selected and designs developed that seek to minimize these impacts.

Specifically, level sites should be chosen to minimize the need for grading. The sites should generally be free of hazardous wastes, drainage and soil problems, and otherwise fragile ecosystems. A preliminary investigation of all candidate sites (including, as appropriate, sample soil borings, wetlands delineation, and hazardous waste investigation) should be conducted early in the site selection process to avoid subsequent surprise costs or forced abandonment of a prospective site. Other specific investigations required by NEPA and local policies should be considered when selecting a range of alternate sites.

- **Minimize Impacts on Surrounding Local Traffic Circulation Patterns and Safety Characteristics.** Every effort should be made to minimize the impacts of the park-and-ride facility on local area traffic circulation patterns and congestion levels. Both the transit operations and the embarking and departing patron traffic should be analyzed for potential effects. PM peak traffic will typically define the critical time period for analysis, but AM peak operations should be evaluated at a fatal flaw level to determine if further evaluation is warranted. Joint development park-and-

ride lots will typically have more pronounced PM peak traffic impacts, resulting from the combined effects of traffic generated by transit activities and surrounding land uses.

Access and egress to the park-and-ride facility should be relatively easy and cause minimum delay. Whenever possible, the facility should be located on the right side of the roadway, in terms of the in-bound direction to the primary activity center. This should allow the arriving patron to make a right turn into the parking facility with minimum delay. Access to the facility from feeder arterials, rather than the primary one, is preferable.

- **Provide Adequate Space.** The size of the park-and-ride facility should be designed to minimize on-site pedestrian walking distance to about 122 to 152 meters (400 to 500 feet) 305 meters (1,000 feet maximum), while at the same time providing adequate space for expected demand. A lot will reach its effective capacity when about 85 percent of the total parking capacity is regularly filled. Beyond the 85 percent level, individual parking spaces often become more difficult to locate, and casual park-and-ride users will be dissuaded from using the facility.
- **Provide a Continuous Pedestrian Pathway.** To maximize the usability of the park-and-ride facility, provide a continuous sidewalk network and pedestrian circulation pathway throughout the park-and-ride facility. Provide direct unobstructed access between all parts of the lot, including the outer corners, and the transit intermodal facility (45).

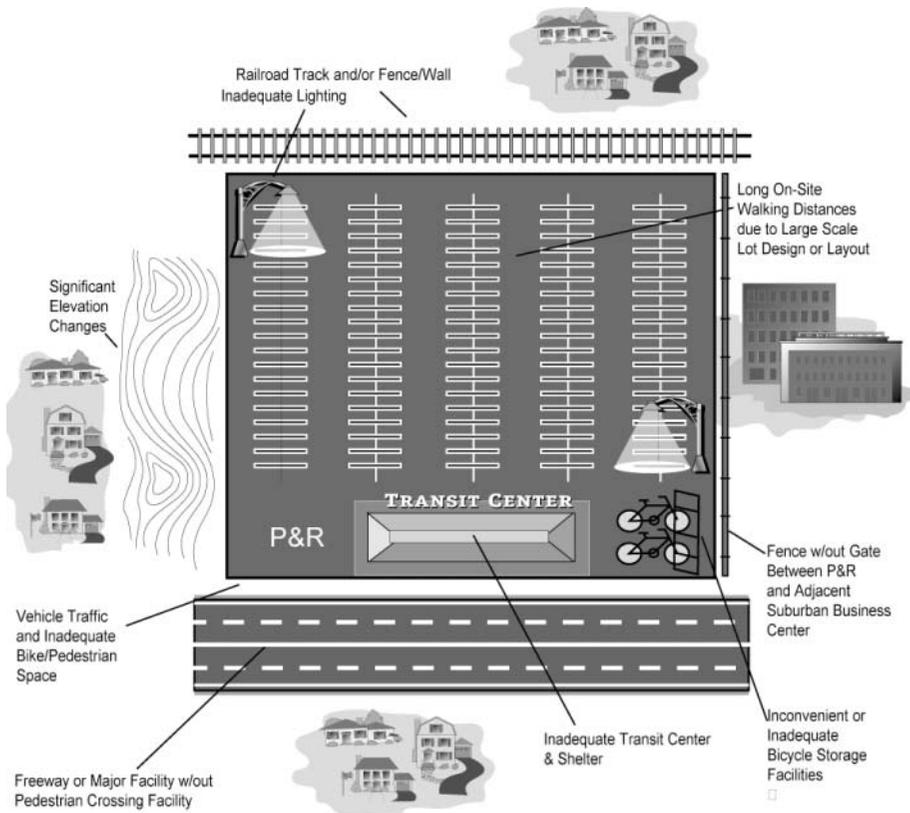
Barriers to pedestrian flow between the park-and-ride facility and adjacent residential or employment locations should be eliminated. Bicycle storage should be provided at the park-and-ride facility and allowances for taking a patron's bicycle onto the bus should be considered (see Exhibit 4.5).

### 4.3 Reducing Implementation Costs and Financial Risk

The third major category of community goals and objectives can be defined under the broad category of reducing cost impacts and financial risks of operation to the implementing agency. Maintaining high user demand, along with an active attempt to improve community integration of the proposed facility, will contribute significantly to a site's ability to provide minimal cost impacts and reduce the financial risk to the agency. Although no site can provide a fail-safe investment for the implementing agency, the transportation planner can reduce the threat of financial risk by planning a facility that is well served by transit, accepted and supported by the community, and one which relates well to the surrounding environment.

A number of guidelines are useful to consider in evaluating various site alternatives for park-and-ride opportunities. These concepts are based on various resources and are not intended to represent a comprehensive guide to successful risk management.

### Exhibit 4.5 Common Barriers to Pedestrians & Non-Motorized Access To Be Avoided or Mitigated



Close coordination with the implementing agency, the local jurisdiction in charge of land use regulations, and concerned citizenry is always advised:

- **Consider Joint Use or Temporary Lots.** Jurisdictions seeking to implement park-and-ride facilities within untried markets should first consider developing temporary test lots. This can be accomplished via a (temporary) joint use arrangement with a church, theater or other private business that has parking demand characteristics that do not compete with park-and-ride operations. If these test lots demonstrate satisfactory demand, a permanent presence can be negotiated with the property owner or permanent facility developed nearby.
- **Consider Enlarging Successful Lots.** Where possible, consider enlarging lots that demonstrate successful demand characteristics, rather than developing new facilities that could potentially compete with the existing lots to the detriment of both. Structured parking, re-striping, and remodeling of existing lots can often be effectively accomplished at or below the cost and risk of developing new facilities.

Unsuccessful facilities should be examined to determine if they can be rendered more successful by such techniques as adjusting transit operations at the facility, providing additional patron amenities, increased advertising, or improving security measures. Alternatively, facilities that truly do not present satisfactory conditions for attracting future demand should be evaluated for trade or sale so that more effective facilities can be developed. Empty or scarcely used transit facilities can have long-term negative impacts on an agency's ability to justify and fund future facilities, because of public criticism.

- **Encourage Positive or Negligible Economic Impacts.** Sites that require minimal relocation of productive viable business or residential properties should be chosen in preference to sites that would cause more extensive impacts. Relocation of productive businesses and residential properties is not only expensive, but can create ill will in the community towards the transit operator.
- **Select Sites That Minimize Capital and Operating Financial Commitments.** Sites that minimize financial costs to the implementing and operating agencies should be chosen. Tradeoffs between the expected lifetime operating costs and capital costs of site acquisition and construction should be evaluated using a net present value analysis. This will allow the implementing agency to determine the true costs associated with competing alternatives.

Donated or free sites should be evaluated carefully to determine their relative advantages with respect to the existing park-and-ride system and other competing site alternatives. It should be remembered that donated sites will still result in operating costs and may be less desirable than other site alternatives in the long run.

Sites that maximize the use of existing services or that can be accessed by only minor deviations of existing services should be evaluated in preference to those needing wholly new service routings. Geographic constraints en-route to the facility should be evaluated for their impacts on existing or proposed transit and patron access.

- **Allow for Potential Expansion/Joint Development.** Sites that can accommodate reasonable expansion and/or provide opportunities for joint development should be evaluated on the basis of this expanded potential. Expanding successful sites is often easier and more quickly implemented than construction of entirely new facilities. When developing new facilities, allowances for such potentials should be planned into the site location and design.
- **Design Park-and-Ride Service to Complement Local Service.** Park-and-ride facilities can, in some cases, compete with local service within the same area, especially when a cost differential exists between the two services (44). This situation should generally be avoided, either by local route modification or elimination.

Experience in the Puget Sound Region of Washington State indicates that park-and-ride services can be designed to complement local route networks rather than compete with them. The key to developing a complementing park-and-ride service (as opposed to a competitive one) is the provision of adequate, but not excessive, capacity at the park-and-ride facility. Research in the Seattle metropolitan area has shown that a commuter's decision to use a park-and-ride lot largely represents a choice between a transit and non-transit mode rather than between a local transit option and the park-and-ride transit option. However, as individual park-and-ride facilities grow in size and are accompanied by the supporting service frequencies necessary to sustain adequate demand, they become more attractive and the potential for competition arises (23).

Competition between the park-and-ride network and local route structure can be overcome using one of several options, one of which is to eliminate local service in favor of the park-and-ride system. This option may increase the auto vehicle miles of travel within the region and may not address the needs of the captive transit market. A second approach, which has been used in the Seattle metropolitan area, is to limit the size of the park-and-ride facility to around 400 to 800 spaces, and develop the park-and-ride lot into a combined transit center and park-and-ride facility (note that the Seattle Metro transit system is a bus-only system; the appropriate park-and-ride size to achieve a compatible local transit-park-and-ride service balance will be dependent on primary transit mode and other local factors). Local bus routes are designed to collect and distribute patrons from the surrounding community and then circulate through the joint park-and-ride/transit center. In many cases, these local routes then become the express service link between the park-and-ride lot and the primary activity center (e.g., the CBD) (23). Alternatively, local passengers have the opportunity (or requirement) to transfer to other routes via the transit center/park-and-ride. Limiting the capacity provided at the park-and-ride will encourage use of the local system in preference to the park-and-ride lot, while at the same time enabling commuters who would otherwise not use transit to do so via the parking facility.

- **Pursue Joint Development Opportunities.** Joint development of park-and-ride facilities with private businesses can lead to greater community integration and reduced operating costs. Several specific steps can be taken at the micro-scale level to promote joint development opportunities:
  - Develop a market-oriented approach to developing park-and-ride facilities. Evaluate what the transit organization can bring to the private development community in terms of access, allowances for higher building densities, parking requirement reductions, property exchange, etc.

- Explore opportunities for shared parking with businesses and community service organizations that demonstrate parking generation demands that are non-competitive to transit service (42).
- Provide direct connections between the park-and-ride facility and neighboring land uses for auto, transit, pedestrian, and other non-motorized modes (42).
- Develop facility designs that encourage the clustering of private buildings near the park-and-ride facility.
- Consider leasing space for transit administration offices and transit retail stores in joint developments, thereby providing an anchor or seed tenant for the joint development partner.
- Provide development coordination services when working with surrounding developments and businesses.

#### 4.4 Summary

Choosing the right location to place individual park-and-ride facilities is often a difficult decision for implementing agencies. A thorough alternatives analysis process should be conducted to identify the community's goals with respect to the specific proposed facility as well as the universe of potential sites available. Donated properties should be evaluated for their long-term operational attributes and impacts on the transit system rather than being automatically accepted as an inexpensive alternative to property acquisition.

A number of guidelines have been presented that can assist in the identification of site alternatives and can be used in a sketch planning process to refine the alternatives. Detailed site evaluation and engineering studies should be conducted before proceeding with site acquisition, final design, and construction efforts.

## 5.0 SUBURBAN PARK-AND-RIDE DEMAND ESTIMATION TECHNIQUES

**NOTE: The author is no longer employed with Parsons Brinckerhoff. This monograph is for reference/research purposes only and not for distribution.**

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## 5.0 SUBURBAN PARK-AND-RIDE DEMAND ESTIMATION TECHNIQUES

### 5.1 Overview and Background

Park-and-ride demand estimation has always been a difficult issue within the transportation planning field, largely because of the lack of research into this aspect of park-and-ride planning. Alternative approaches to demand estimation range from the traditional four-step process typically used in regions with robust regional modeling capabilities to site-specific demand estimation and sketch planning techniques such as demand observation and ridership surveys. A number of planning studies have developed site characteristic checklists to assist in the evaluation of potential park-and-ride demand without actually estimating facility demand.

This chapter evaluates a number of park-and-ride demand estimation techniques to provide a thorough knowledge of the options available when evaluating existing and future park-and-ride facilities. Both regional (i.e., systemwide) and site-specific techniques are examined.

As discussed previously, interest in the park-and-ride mode expanded rapidly during the oil crisis of the 1970s. Both state and regional transit agencies sought ways to make carpooling and transit usage more convenient for suburban and rural residents working in central cities and major employment centers. Initial approaches to park-and-ride facilities were largely based on practical knowledge of the proposed service area and often depended upon available building sites. This approach was largely driven by the concept that escalating oil and gas prices would force drivers to seek more economical forms of travel, such as organized carpooling and transit. However, as a percentage of household incomes, oil and gas prices have not continued to increase. Because of this relative stability in fuel prices, demand for some transit and carpool services has declined rather than increased as previously presumed. Many transit and transportation departments throughout the United States now realize that a more rigorous planning methodology for park-and-ride facilities and, in particular, a well-documented demand forecasting technique, is needed if implementation of future lots is to be successful (23).

Interest in park-and-ride demand estimation peaked in the late 1970s and early 1980s. A number of transportation agencies conducted extensive studies to evaluate the phenomenon of park-and-ride demand, including the Texas Department of Highways and Public Transportation (now the Texas Department of Transportation (TxDOT)), the Texas Transportation Institute at Texas A and M University, Houston METRO, Seattle Metro (now King County Department of Transportation), and the Tri-County Metropolitan Transportation District in Portland, Oregon (TriMet). Since the mid-1980s, few new techniques for estimating park-and-ride facility demand have been developed. Many agencies such as Houston METRO have now completed or nearly completed their planned systems of park-and-ride facilities. Other agencies have adopted incremental approaches to providing additional services: building a small test lot and then providing additional spaces as demand warrants (2). Most agencies choosing this latter method of park-and-ride provision still rely on practical knowledge of the proposed service area and are typically faced with relatively inexpensive land costs and the availability of multiple alternative sites (1, 2, 3, 4, 5).

Currently, a number of transportation agencies have again become interested in developing better demand estimates for their park-and-ride systems. This desire is largely driven by dwindling financial resources, both at the regional and federal levels. Two primary approaches for developing improved demand forecasts are evolving within the industry:

- Estimating individual park-and-ride demand based on regional modeling approaches
- Developing site-specific forecasting tools, tailored to the metropolitan region

Many smaller agencies, as well as larger ones interested in a more cursory analysis of potential site-specific demand, are utilizing basic rules of thumb to design individual facilities at a conceptual level. These rules of thumb can be used in sketch planning studies and for purposes of final design when better data are not available (see Chapter 4).

Each demand forecasting technique has strengths and weaknesses that the planner should be aware of when choosing one method over the other. It is critical to remember that forecasting, especially at the site-specific level, requires a great deal of common sense on the part of the planner. All of the approaches discussed in this document can generate erroneous forecast estimates if not applied with an extensive knowledge of the study area.

## 5.2 Reasons for Forecasting Demand

The remainder of this chapter provides information on a variety of park-and-ride demand estimation approaches. However, before exploring these techniques, an argument must be made as to why forecasting should be considered as an element of the planning and design process.

The underlying reason for the need to forecast demand is cost. In many western American cities, as well as along the East Coast, land values are fairly high in comparison to other costs encountered by the implementing transportation agency. Likewise, in many of these urban areas, available lands often contain environmental, community, or other constraints that limit the construction of park-and-ride facilities or significantly increase the cost to the transit agency. It is not uncommon for transit agencies and departments of transportation to display construction costs two or three times the average private sector cost for similar facilities. Hence, it is important to identify with some certainty the parcel size needed and the number of spaces required for construction. This, of course, requires demand estimation.

A second, and possibly more compelling reason for demand estimation is the effect that poor planning can have on the public image of the implementing agency. Here, however, cost must be measured by the long-term affect on the agency of constructing a facility seen by the public to be a wasted investment, or worse, a community blight. Over designed park-and-ride lots with excess capacity often become icons for public criticism. They are often difficult to remove or convert to other uses, and may impact the ability of the implementing agency to construct future transit-related facilities within the service area. Reliable demand forecasting is often the first step in assuring well-used facilities. Thus, the need to estimate demand for park-and-ride facilities is not an East Coast or West Coast phenomenon. Rather, it is a concern that all implementing agencies must share.

### 5.3 Regional Modeling Approach for Site-Specific Suburban Park-and-Ride Facilities

Use of regional modeling techniques to estimate park-and-ride demand at specific facilities has become more popular with recent advances in practical computing capabilities. Recent studies in Houston, Seattle, and California have focused on this methodology as a preferred means for estimating demand for park-and-ride facilities.

Use of a regional travel demand modeling approach for estimating park-and-ride demand must be viewed within the context of the overall transportation modeling technique. Determination of park-and-ride demand is heavily dependent on the modal choice model selected for use within the overall transportation modeling structure. As a consequence, techniques for estimating park-and-ride demand can only be as accurate as the theoretical modal split assumptions built into the model. Experience has shown that the potential for overestimation of park-and-ride demand is high when the travel characteristics incorporated within the systemwide model do not closely correspond to the site-specific conditions observed at the design and construction level when the lot is realized (15). This is especially true when the transportation model is not capacity constrained, and when the park-and-ride system being modeled is capacity limited.

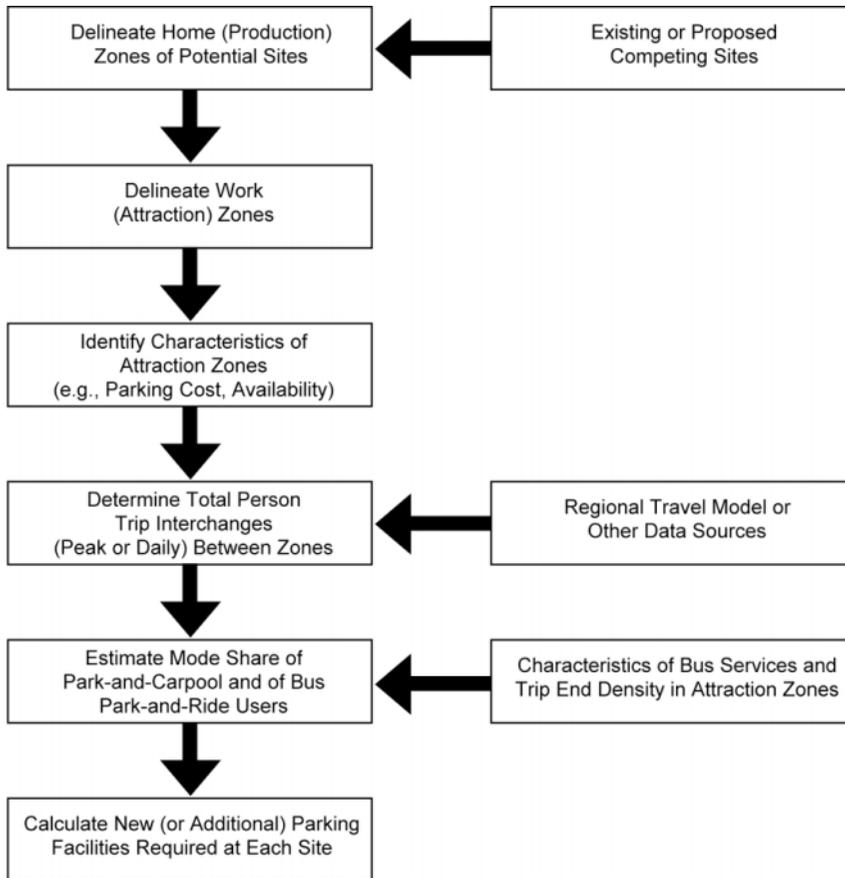
#### *Post-Modeling Techniques*

Post-modeling regional forecasting techniques for individual park-and-ride facilities closely follow the traditional transportation modeling methodology. Trip productions and attractions are first defined, followed by trip distribution and assignment and modal split calculations. Often, much of the assigning of trips to individual park-and-ride facilities is accomplished outside of a formal modeling procedure, using outputs from a regional model as the basis for trip estimation. An illustration of this approach is presented in Exhibit 5.1.

Estimating methods that use outputs from regional models as inputs to sketch planning estimation methods can loosely be categorized as post-modeling techniques, because demand forecasting at the site level is not performed internal to the transportation model. These techniques rely heavily on the knowledge and experience of the planning and design team with regard to local commuting patterns.

The first step in these post-modeling techniques revolves around identifying the production (home) and attraction (employment) ends of potential trips that might use a proposed park-and-ride facility. Studies conducted in California indicate that 98 percent of park-and-ride users access such facilities for home-to-work commute trips (26). The California study also indicated that the primary home influence area probably extends between 5 and 8 km (3 and 5 miles) from the individual park-and-ride facility, but is strongly influenced by such factors as the presence of competing lots, the distance to the primary destination activity center, and the existence of unique conditional characteristics such as downstream traffic congestion (23, 26).

Exhibit 5.1  
Overview of Park-and-Ride Demand Estimation Methodology



Source: W.E. Hurrell, et al. (26).

Based on the identification of the production and attraction zones, the trip interchange characteristics between the two influence areas can be determined using a regional travel

demand model. The destination center should be limited to those areas served directly by the facility (e.g., served by transit service between the lot and the activity center). However, it should be remembered that non-transit HOVs may also be using the park-and-ride lot as a formation or staging location. This necessitates that other large potential destination zones should not be ignored. However, for modeling and demand forecasting purposes, destination zones should be limited to two or three major centers for any given park-and-ride facility (26).

The third step in the post-modeling regional demand estimation process is actually estimating the proportion of each trip interchange between the production zones and the attraction zones, which might be made by either carpools forming at the park-and-ride lot or by patrons accessing transit operations. It is advantageous to use systemwide modal splits from the regional model that cover the study area to estimate the total carpool and drive-to-transit modal shares of total trips between origin and destination zones. If this can be achieved, the process of estimating specific facility demand becomes an exercise of demand distribution between the several facilities available to individual zones. On the other hand, if no such modal split estimates are available, then the process of determining site demand becomes much more complicated in that some form of user survey or similar mechanism is required to determine the underlying demand for transit and carpool usage of individual lots or the park-and-ride system as a whole. The latter situation is often the case, especially when the regional model in use does not provide a transit component.

Once modal splits are determined, the resulting park-and-ride demand shares can be applied to developed trip interchange tabulations and the number of parking spaces required for a site can be determined. Placement of individual park-and-ride spaces within a service area becomes a task best handled in a comprehensive system planning process (see Chapter 3).

### *Direct Regional Forecasting Techniques*

As indicated previously, modal split estimation is the key to using regional modeling procedures to estimate the demand for specific park-and-ride facilities. The above methodology, termed post-modeling regional forecasting techniques, leaves a large portion of the modal distribution effort to the experience of the local design team, and therefore can result in widely differing approaches to the actual determination of demand. A second regional forecasting approach is one in which the park-and-ride trip is actually modeled as a chained trip directly within the regional modeling process.

This direct approach tends to be somewhat more elegant than the post-modeling approach and can provide a higher level of standardization between estimates. It should be noted, however, that this approach requires a fairly high degree of modeling sophistication within the study region. A decision to utilize this methodology requires a commitment by either the local metropolitan planning organization (MPO) or the consulting team to supply the modeling capabilities necessary to undertake such a task (including the necessary socioeconomic data sets, modeling networks and modal split data).

The direct forecasting approach is best illustrated by example. The Puget Sound Regional Council (PSRC)—the MPO for much of western Washington State—supports such a planning tool. The PSRC uses a direct forecasting methodology based on an EMME/2 transportation modeling platform, and provides both highway and transit modeling capabilities for a four-county region. Within this region there are 162 park-and-ride lots with

a total of 24,000 spaces. Fifty of these lots can be termed major facilities, having in excess of 150 spaces each (27).

As with all transportation modeling endeavors, the Puget Sound region is divided into traffic analysis zones (850 in the PSRC model). Each zone is connected to the regional centers via a roadway network comprised of approximately 14,000 one-way roadway links (27).

Modal splits within the PSRC model are based on utility functions between the various modes available. Utility functions provide a measure of the usefulness or attractiveness of one mode relative to another. These utility functions are typically dependent on the travel time and cost characteristics of the competing modes, and are employed within a multinomial logit modeling format.

### *Multinomial Logit Model*

The theoretical underpinning of the logit model assumes that an individual trip maker would select a mode from a choice set which maximizes his/her utility. Utility of a trip maker,  $t$ , having to choose from  $J$  discrete modes is defined as a linear function of the level-of-service characteristics (travel times and costs) offered by each mode and socioeconomic attributes (e.g., annual income or availability of automobile) of individual trip makers. Transformation of this definition into a mathematical expression is as follows:

$$(1) \quad U_i^t = V_i^t + \epsilon_i$$

Where,

$U_i^t$  = is the utility of individual trip maker,  $t$ , for choosing mode  $i$  from the choice set  $J$  ( $j=1,2,3,\dots,i,\dots,J$ ).

$V_i^t$  = represents measurable level-of-service characteristics and socioeconomic attributes of individual trip maker,  $t$ , for choosing mode  $i$  from the choice set  $J$  ( $j=1,2,3,\dots,i,\dots,J$ ).

$\epsilon_i$  = is a random error variable in the utility function and represents those attributes which cannot be measured such as safety, comfort and service reliability.

Multinomial logit (MNL) models assume that alternatives in the choice set  $J$  are independent from one another. This property of the MNL model is referred to as Independence from Irrelevant Alternatives (IIA). Another assumption underlying the MNL model pertains to the type of random distribution used for the error variable. Variable  $\epsilon_i$  is assumed to have a Weibull distribution (63) which has the same general bell shape as the normal distribution. Combination of these two assumptions in conjunction with application of the utility maximization theory have produced the following equation which is referred to as the standard logit (or MNL) model.

$$(2) \quad S_i = \frac{\exp(b^k_i \times V_i + a_i)}{\hat{A}_{j=1}^J \exp(b^k_j \times V_j + a_j)}$$

Where,

$S_i$  = probability of choosing mode,  $i$ , from a choice set  $J$  ( $j=1,2,\dots,i,\dots,J$ ).

$V_i$  = represents measurable level-of-service characteristics such as travel time and costs for mode,  $i$ , and socioeconomic attributes of travel makers.

$b^k_i$  = represents coefficient for the  $k$ th variable (e.g., travel costs or annual income) in the utility function of mode,  $i$ . These coefficients need to be estimated using statistical methods such as maximum likelihood method.

$a_i$  = represents modal constant for mode,  $i$ . There are  $J-1$  modal constants in a logit model. They are normalized with respect to one mode. Constants are supposed to capture those attributes which are not measurable. Constants need to be initially estimated together with coefficients for other variables using statistical methods such as maximum likelihood method. Subsequently, modal constants need to be updated to reflect total aggregate shares of modes in the study region.

Thus, the basic theory behind a logit modeling approach is that travelers will choose the quickest and cheapest mode of travel between their origin and destination zone. Individuals will weigh the relationship between travel time savings and travel cost, and make the most efficient modal choice decision that fits their needs. In a perfect world, the automobile would typically be seen as superior to transit because of the value of the travel time savings afforded. Many travel costs associated with the auto mode are hidden from the driver and therefore not incorporated into the commuting decision. As the commuting environment moves away from the perfect world scenario and towards the reality of a congested urban commuting environment, alternate modes (to the private automobile) become more competitive. Thus as traffic congestion slows the private automobile commute relative to a transit alternative, and as travel costs increase (e.g., traveler paid parking costs (non-reimbursed), gasoline prices, VMT taxes, tolls, congestion pricing tolls), then transit, carpooling, and park-and-ride options become viable alternatives. It should be noted that the same modal choice made with respect to the private automobile versus alternative modes is also made between the alternative modes themselves. In other words, commuters would be expected to evaluate walk-to-transit versus park-and-ride in the same manner in which they evaluate the private auto versus alternative mode decision.

Based on this modal choice theory, once a commuter has decided to use park-and-ride as an alternative to the private auto mode, that commuter would be expected normally to drive as far as possible before changing to the transit mode at a park-and-ride facility (note that the park-and-ride mode *includes* a portion of the trip being made by private auto; for purposes of this discussion, however, a distinction is made). This would suggest that very large lots placed on the periphery of the primary destination activity center would be the optimal approach to generating park-and-ride demand. In reality, this is not the case. Just as with the decision to choose park-and-ride versus the private automobile, a choice is made by the commuter as to which park-and-ride lot within a commuting corridor to use. As

traffic congestion within a corridor increases and extends further up the corridor, drivers will be more likely to use a park-and-ride facility closer to their origin zone.

Thus, park-and-ride lots immediately upstream of anticipated traffic congestion tend to demonstrate high levels of demand, whereas lots further away from the anticipated congestion usually demonstrate less significant demand. Logit model coefficients for individual lots would be expected to differ by park-and-ride location because the transit service between each lot and the primary destination center will be different based on the relative transit service provided and the condition of downstream roadways, including the presence and condition of HOV lanes. Logit coefficients for individual lots can be determined using a trial and error approach, comparing estimates to observed occupancy and origin surveys until an acceptable level of accuracy is obtained. In the Puget Sound region, it was determined that, to estimate the characteristic of patrons correctly using park-and-ride lots in proximity to their place of origin, the competing drive commute was estimated to be three times more onerous as the park-and-ride transit commute (27).

The building of park-and-ride lots near the primary destination activity center is not recommended. As indicated in Section 2.2 and in the description of satellite lots, such facilities fail to generate the benefits provided by the park-and-ride lots placed close to the origin end of the typical trip. That is, they provide significantly reduced air quality benefits; their ability to reduce congestion on approach roadways to the activity center is often minimal; and they do not encourage walk access to transit services. They are more akin to off-street parking lots serving surrounding or nearby land uses and can be provided entirely by the private sector and the free market. Such private ventures can be encouraged by the public jurisdiction, if so desired, by making vacant and otherwise unusable parcels available for use by the private sector (e.g., space under overpasses and within unused portions of public rights-of-way).

## 5.4 Site-Level Forecasting Based on Site and Service Characteristics

As their name might suggest, site-specific forecasting methodologies attempt to estimate park-and-ride demand based on the attributes of the proposed park-and-ride location. These models are often based on the theory that a site's attributes and locational and service characteristics largely define the attractiveness of the site to potential users. To understand this theory, it is instructive to review the concepts of the more traditional patronage forecasting theory for transit usage, incorporated within most regional transportation models.

As indicated in the previous section, the generalized patronage forecasting approach typically assumes the following four-step process:

- Trip generation
- Trip distribution
- Modal split
- Trip assignment

This approach assumes that a modal split or preference for one mode over another can be implicitly determined either by measuring the differences in service attributes between competing modes or through travel surveys.

Using such an approach, it is a relatively straightforward process to develop regional estimates for park-and-ride usage via a standard transportation modeling package (e.g., EMME/2, TranPlan, MinuTP, Tmodel2, etc.). Site-specific demand is heavily influenced by a number of characteristics, including the location of the proposed lot, the facility's characteristics, the availability of adjacent or competing lots, and the perceived convenience of the proposed facility. To develop design-level forecasts for individual lots as an aid to site selection and sizing, these site-specific characteristics must be considered. This requires the planner to go beyond the regional modeling format and evaluate the site-specific characteristics using a more refined microlevel tool.

This discussion is not intended to discredit the regional modeling approach but rather suggests that it be used to develop planning-level regional or corridor estimates. Such models are invaluable when setting regional park-and-ride policies and when evaluating the effects of regional demand factors such as central employment area parking charges, increased auto operating costs, and changes in transit fares. However, at the site-specific level, planners must be aware of the limitations of the regional modeling approach. Just as one would not assume that an individual link in a transportation model represents a specific street, it should not be assumed that a specified zonal park-and-ride demand would be captured by a given lot. While regional models provide excellent tools for evaluating regional issues, site-specific tools are often more effective at providing accurate site-level design forecasts.

Site-specific forecasting methodologies generally revolve around defining a given service or market area for a number of individual park-and-ride facilities, and then developing explanatory equations through the use of a multivariate regression process. These equations are generally based on the characteristics of the market area population, as well as the design characteristics of the underlying facilities. Inherently assumed within these models is an underlying demand for transit. In other words, because these models are often developed on a region-by-region basis, the magnitude of demand for park-and-ride systems will differ by metropolitan area. Site-specific demand estimation models, like their regional counterparts, must therefore be calibrated for the specific metropolitan region in which they are being implemented. Although individual variables may be transferable from one metropolitan area to another, model coefficients will vary based on the sophistication of the transit system providing service, perceived congestion, and downtown parking prices.

### *Early Site-Specific Forecasting Tools*

Early approaches to evaluating site-specific park-and-ride lots focused on the attributes of the specific lot and the traffic on adjacent streets. Demand at park-and-ride lots was theorized to be proportionate to the traffic on adjacent arterials (1). This approach assumed that the patrons of a particular park-and-ride lot would be drawn from the pool of travelers already traveling within the same corridor along the exact same routes that transit would logically follow. These models provided some explanation of park-and-ride demand but failed to take into account various attributes of the regional transportation system, regional land uses, and other placement/location issues.

One notable exception to these early models was a study completed by Purdue University in 1972, which attempted to take a more comprehensive approach to park-and-

ride demand estimation (6). This study developed a multivariate regression model using data from a number of mid- to large-sized Midwest, East Coast, and Southeast cities. The primary variables affecting demand were those describing the size of the facility, its flexibility, reliability and parking costs, transit service type, and metropolitan area. Most importantly, it was found that up to two-thirds of the demand estimate could be explained by the design characteristics of the parking facility (e.g., size, location, amenities)(6). A critical flaw in this model, however, was the inclusion of a size variable as one of the explanatory variables in determining park-and-ride demand. Intuitively, lot size should not be used to determine demand if in fact the goal is to determine the appropriate size of lot to construct.

Later modeling attempts tended to follow the above example. Many of these efforts focused on facility attributes. Several investigations introduced the need to estimate park-and-ride demand within an entire corridor or region in aggregate first, followed by distribution of the demand among the various lots proposed to serve the study population (7, 8, 9, 14). This approach attempted to recognize the sensitivity of individual lots to the placement of complementary facilities within the same general service area. Modeling formats tended to be either a continued use of multivariate regression approaches or a reliance on regional transit/transportation models, based on a process of trip generation, distribution, modal split, and assignment.

A renewed interest in estimating park-and-ride demand has been expressed by some transit agencies such as Denver RTD, Portland TriMet, and Seattle King County Metro (11, 12). Many of the earlier efforts were constrained by both hardware and software limitations. The advent of newer, faster personal computers and more advanced modeling software is promoting this renewed interest, as is the need to be more sensitive to limited funding resources.

### *Defining the Market for Park-and-Ride*

A critical element of all site-specific demand estimation techniques based on facility and environmental attributes is the definition of a service area or market shed for the park-and-ride lot. Theory suggests that once a market area is defined for the park-and-ride lot, socioeconomic data can be collected regarding the people living within the market shed, which can then be used to predict demand for specific park-and-ride facilities.

A number of park-and-ride studies throughout North America have evaluated park-and-ride market sheds in an attempt to identify a single standardized market shape and size. Considerable evidence suggests, however, that market areas will differ in both size and shape, depending upon what type of lot is being analyzed (e.g., remote, rural, suburban, or peripheral). Not surprisingly, market sheds for each of these park-and-ride types have also been found to vary in size and dimension from one metropolitan area to the next, which is likely due to factors such as differences in central city parking costs, extent of the transit network, and perceived congestion within the region.

**Suburban Park-and-Ride Market Sheds:** For the suburban park-and-ride facility, a generalized service shape can be defined, based on a hydraulic analogy. That is, patrons using a specific park-and-ride facility will be expected to come from a catchment area, primarily upstream from the park-and-ride facility. Backtracking, the phenomenon of patrons who live between the park-and-ride lot and the employment destination driving upstream to gain access to a lot for a downstream location, would be limited.

A study completed in the Greater Seattle metropolitan area for the King County Department of Metropolitan Services (Metro), an all-bus transit network; evaluated the observed market areas for 31 large suburban park-and-ride lots (see Exhibit 5.2) (23). These park-and-ride facilities were examined for their existing demand characteristics and the draw area associated with the patrons accessing the lot. A 1993 vehicle license plate survey was used as the basis for geocoding the residential location of vehicles observed in each of the 31 lots. Addresses for each observed parked vehicle were generated via a license plate search with the Washington Department of Motor Vehicles. The coordinates of each vehicle accessing individual lots were compared to the coordinates of the lot being used and then plotted on a common scale. The resulting service area demand sheds for each lot were compared to generate a common service area shape.

Market area shapes incorporating 50 and 85 percent of the total observed users at each park-and-ride lot were evaluated. At the 85 percentile user level, a parabolic shape was found to most nearly represent a common draw area for each of the 31 lots. The dimensions of the resulting average draw area shape are shown in Exhibit 5.3. As will be noted, the maximum downstream point from which ridership would be expected to be generated, represented by the parabolic vertex, extends approximately 3.2 to 4 km (2 to 2.5 miles) towards the primary CBD downstream from the lot. Upstream demand extended approximately 16.1 km (10 miles), following the major freeway or major arterial closest to the lot. The maximum spread of the demand, represented by the long chord, was approximately 19.3 km (12 miles). The orientation of the draw area shapes generally followed a directional axis passing through the lot and the Seattle CBD. This is likely due to much of this region's roadway network being more or less radial to the Seattle CBD, and to the fact that most existing service routes are destined for the CBD. In locations within the Metro region where the roadway network is not radially oriented to downtown, the directional axis of the observed draw areas typically orients in the direction of the primary roadway network that would be used to access the Seattle CBD by private automobile.

At the 50 percentile demand level, the average service area was more closely described by a circular pattern with a radial diameter of 4 km (2.5 miles), measured from the park-and-ride lot. In other words, 50 percent of a park-and-ride lot's demand comes from within a 4-km (2.5-mile) radius of the lot. This is consistent with the findings at the 85 percentile level in that the 4-km (2.5-mile) radius falls within the nose of the 85 percentile service area (see Exhibit 5.3).

Studies conducted in several Texas metropolitan cities also suggest a similar service area as that found in the Seattle study (1). In fact, the Texas study examined two potential characteristic market area shapes, a parabolic model and an offset circular model.

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Exhibit 5.2  
Test Lots Used for Model Development

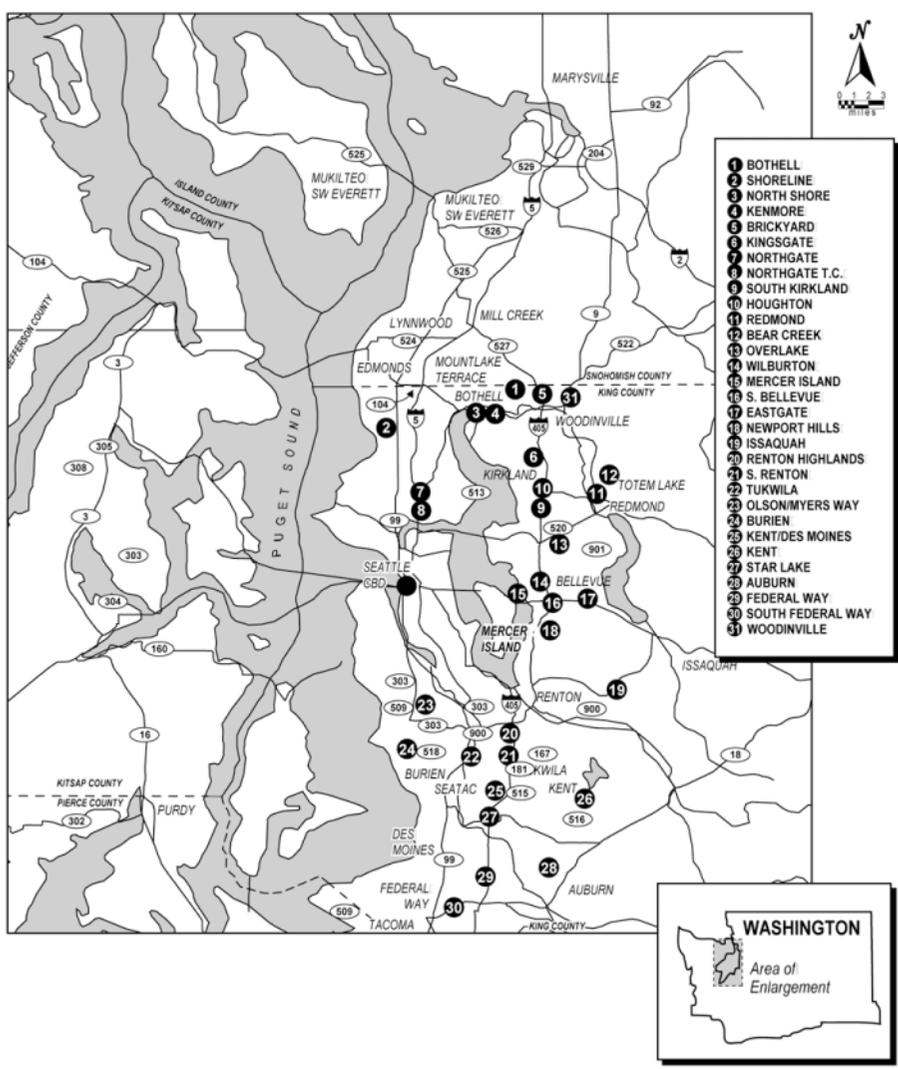
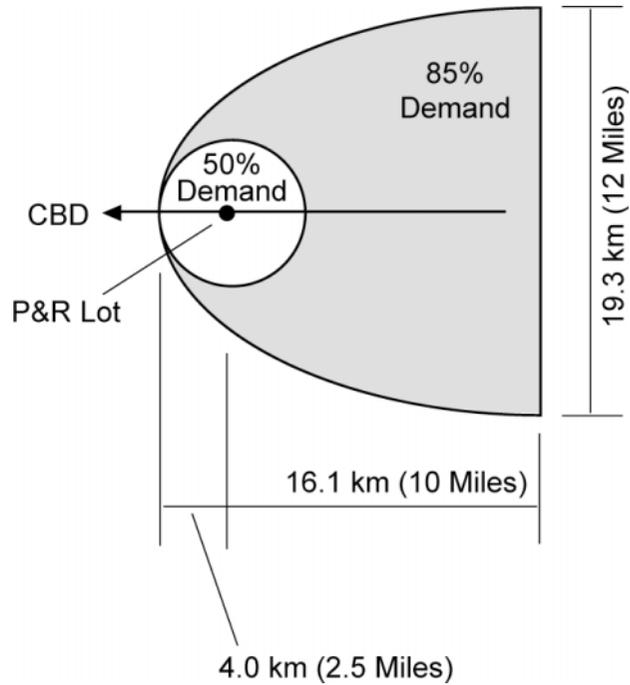
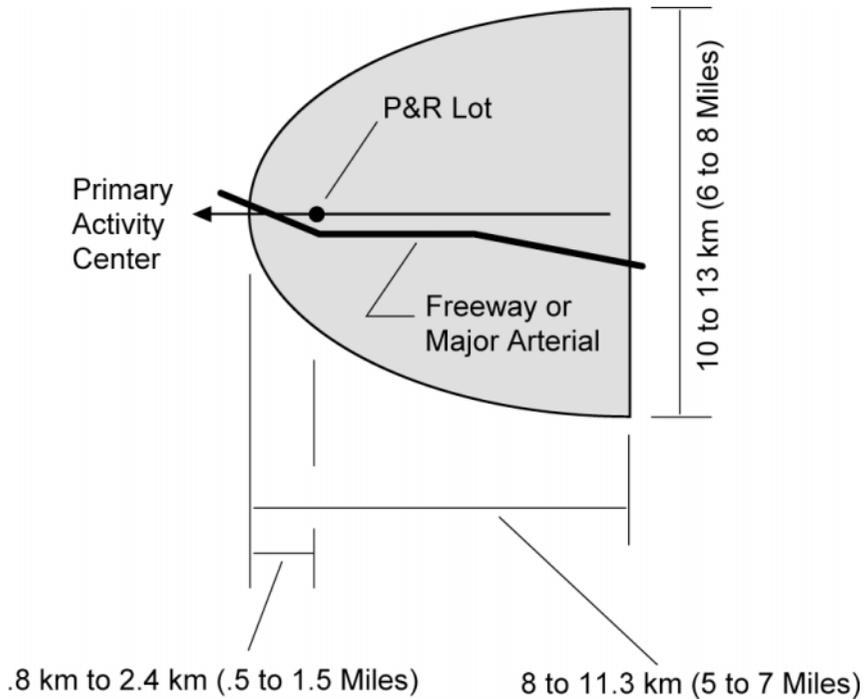


Exhibit 5.3  
Estimated Market Catchment Area  
(Seattle Metropolitan Area)



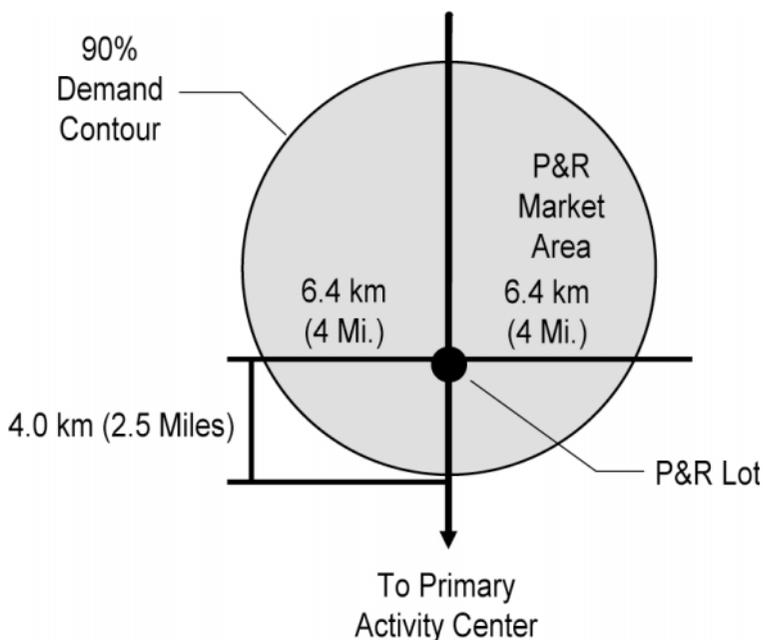
For the parabolic service area concept, dimensions similar to those seen in the Seattle metropolitan area study were identified (see Exhibit 5.4). The difference in measurements between the Texas and study models are likely due to a number of factors, including the fact that the Seattle study was conducted more than 10 years after the Texas study was completed. The Texas study also represents a composite analysis of several urban areas.

Exhibit 5.4  
Park-and-Ride Service Area—Texas Study



Data from the Texas study suggest that between 75 and 95 percent of the park-and-ride demand at a specific lot is typically generated within the defined market area represented by the parabolic model. This study also examined an alternative draw area concept that suggested that an offset circle could also be used to estimate the service area of a given park-and-ride facility. This concept, shown in Exhibit 5.5, was not pursued further. However, it is strikingly similar to the 50 percentile service area evaluated in the Seattle study.

Exhibit 5.5  
Alternative Service Area Concept  
Texas Study

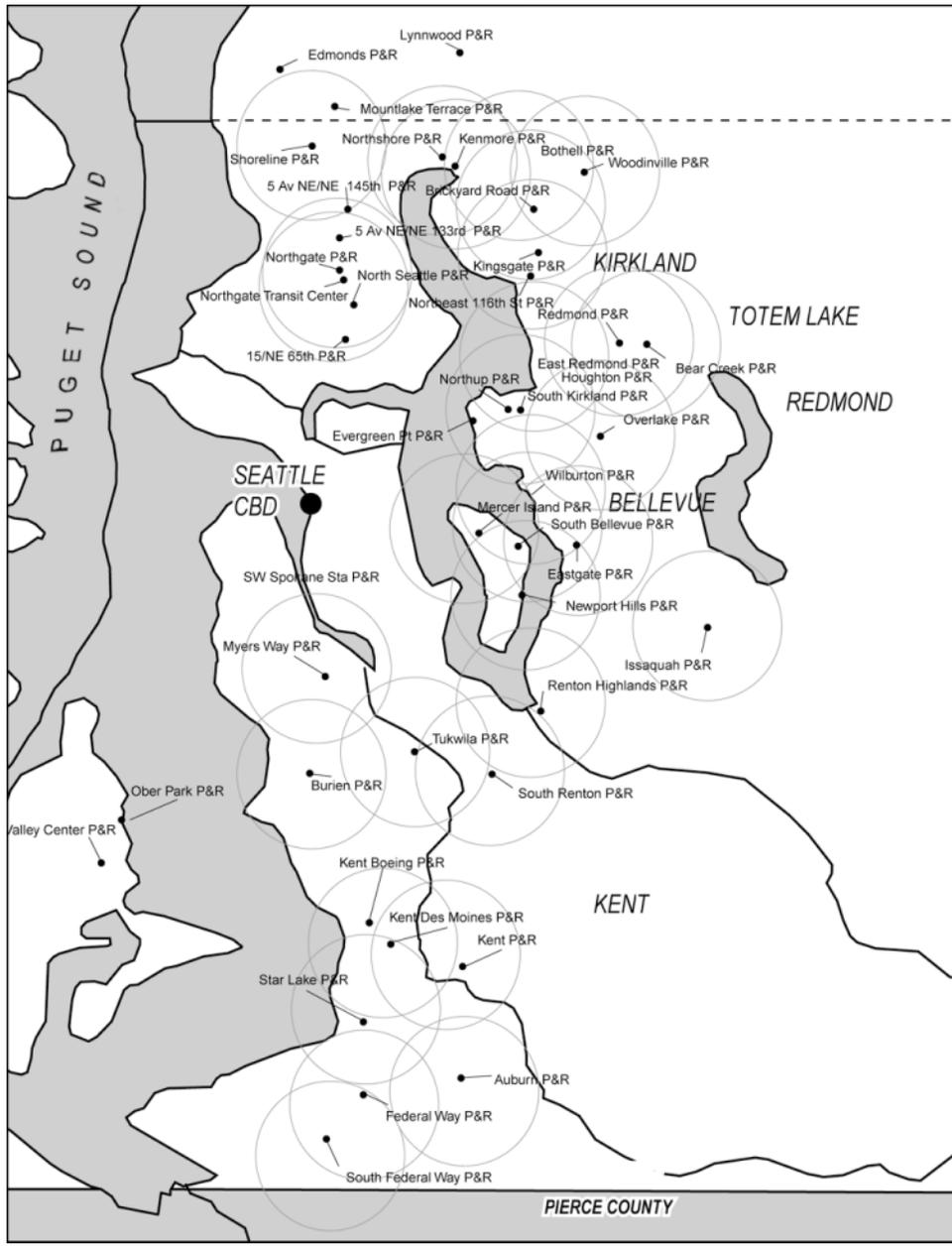


The parabolic draw areas (which can be as long as 16 km (10 miles)) can cover a considerable portion of the urban area (see Exhibit 5.3). For the Seattle study, the 50 percentile service area was chosen in preference to the 85 percentile market demand area to evaluate facility demand. As shown in Exhibit 5.3, the 85 percentile service area is roughly four times the size of the 50 percentile area. This implies that, to evaluate the additional park-and-ride lot users incorporated within the 85 percentile service area, one would have to evaluate three times the base area represented by the 50 percentile service area. Hence, the additional area represented by the difference between the 85 and 50 percentile draw areas is less productive and can be ignored for forecasting purposes. Later investigations in the Seattle study did indeed show that the 50 percentile service area definition provided significant statistical data for the purpose of estimating park-and-ride lot demand.

The resulting distribution of service areas for the Seattle park-and-ride system, assuming the 50 percentile service area definition, is shown in Exhibit 5.6 for all 31 test lots used in the study. From this exhibit, it can quickly be determined where existing park-and-ride facility services overlap, and where gaps in the regional system exist. It should be noted that unique geographical features of any study location may significantly affect the market area for any given park-and-ride lot. Individual market areas may therefore be significantly smaller than the standard market shed shape because of features such as lakes and mountains, which will also affect the backtracking phenomenon by reducing the likelihood of such travel.

**NOTE: The author is no longer employed with Parsons Brinckerhoff. This monograph is for reference/research purposes only and not for distribution.**

Exhibit 5.6  
Seattle Park-and-Ride Service Areas



## *Other Park-and-Ride Market Sheds*

Non-suburban park-and-ride lots include those that lie on the periphery of the primary business district served. Market area delineation can be used as one mechanism for identifying these non-suburban facilities within an existing park-and-ride system, especially the peripheral lot type.

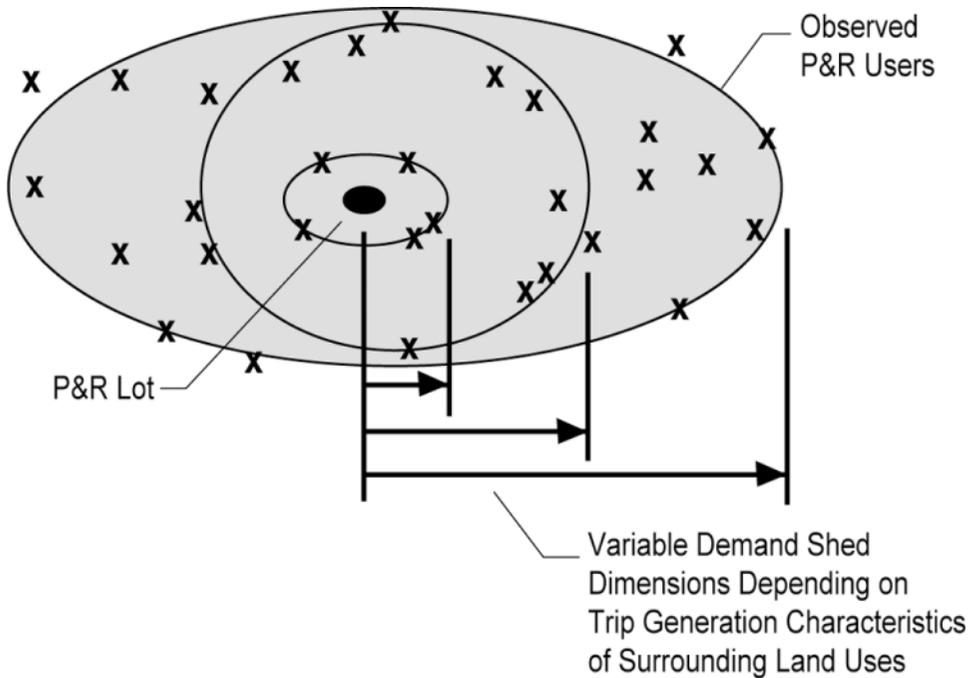
Within a built environment, there are often numerous primary and secondary destination work zones within the urban fabric. Placement of a park-and-ride lot in a traditional suburban neighborhood does not guarantee that it will operate as a suburban park-and-ride facility. If the lot is placed near a large suburban employment center, the lot may operate more like a peripheral parking lot to that suburban center rather than as a park-and-ride lot for a distant CBD. Corresponding to this condition will be a unique market shed identifiable as a peripheral park-and-ride market shed. A study conducted for the North Central Texas Council of Governments found that the average market shed for these lots is typically more dispersed than for the suburban park-and-ride type, and more closely described by concentric demand contours (see Exhibit 5.7) (14). These findings were confirmed in a similar study from the Puget Sound region, which examined two suburban lots that operate as peripheral park-and-ride facilities (23).

Knowing the average draw shapes for both suburban and peripheral park-and-ride facilities can assist the transit planner in evaluating the efficacy of individual operating lots within the system. Often, the experienced transit planner will suspect lots operating with high parking and low transit demands as being defacto peripheral lots. Comparing the market area shapes via a license plate survey can confirm the type of facility being operated.

**Generalized Application of Market Area Definitions to Metropolitan Areas:** Both the Texas and Seattle studies suggest that a standard market area or demand shed can be identified for individual park-and-ride facilities, depending on the service orientation of the lot (e.g., remote, rural, suburban, or peripheral). These standard market shed areas can be used to estimate the demand characteristics related to a proposed or existing park-and-ride lot. They can also be used on a regional basis to plan an integrated system of park-and-ride facilities by allowing the implementing agency to map the coverage zones for each proposed park-and-ride facility within its system and locating areas of service duplication and poor service.

Although standard service area shapes can be identified for various park-and-ride facility types, dimensions will differ somewhat from one metropolitan area to the next. This variance will largely be controlled by the characteristics of the transit system serving the lot, the perceived regional congestion, parking costs in the central activity center, community size, and natural geographic features of the region. However, it can generally be assumed that a market shed similar to the one evaluated in the King County Metro study is generally transferable to other urban areas. Thus, the 50 percentile service area for suburban park-and-ride facilities can be defined as a circular area with a radius of between 3.2 and 4 km (2 and 2.5 miles), centered on the park-and-ride lot itself. An 85 to 90 percentile service area can be roughly defined as a parabolic shape with a long axis of between 7.2 and 20 km (4.5 and 12.5 miles) and a long chord of between 9.7 and 19.3 km (6 and 12 miles). The planner should remember that such a market shed represents only a generalized relationship between the park-and-ride lot and the underlying service populations. They should be aware that individual lots may present dramatically different draw area characteristics, depending on the unique needs of the service populations and features of the area.

Exhibit 5.7  
Peripheral Park-and-Ride Market Demand Shed  
(Approximated)



**Site-Level Characteristics Affecting Park-and-Ride Demand:** A number of individual variables can be identified that affect the demand for specific park-and-ride facilities at the site level. Their influence will vary by metropolitan region. Site-level variables that can affect park-and-ride facility demand are provided in Exhibit 5.8. An intuitive explanation of the relational characteristic that these variables have with respect to facility demand is also provided. The list of influencing variables is by no means comprehensive. In any given case, unique planning and design characteristics may exist that can have dramatic effects on demand for individual park-and-ride facilities.

The list of variables provided in Exhibit 5.8 can be used as a sketch planning tool for evaluating various park-and-ride alternatives or opportunities. Some of the variables, as will be described later, can also be used to develop more robust site-level estimating tools. Furthermore, the list of variables was developed based on the experiences of a number of transit agencies, supporting both heavy and light rail systems as well as all bus systems. Hence, these rules of thumb are useful in either a bus or rail environment.

## Exhibit 5.8 Contributing Factors to Park-and-Ride Demand

Lot Attribute	Relational Characteristic
1. Number of AM peak-period express bus trips to CBD.	As the number of AM express trips to the primary CBD increases, so does demand. Some sources have recommended a minimum of 4 express buses per peak hour at park-and-ride lots, to be effective.
2. Number of AM peak-period express bus trips to major employment centers <i>other</i> than the CBD.	See Relational Characteristic 1.
3. Ratio of out-of-pocket auto costs to transit costs.	As auto costs increase relative to transit costs, transit demand tends to increase.
4. Distance between park-and-ride lot and primary business center or CBD (measured as either the straight-line or road mileage distance).	Within the Seattle Metro region, it has been observed that, as the distance between the park-and-ride lot and CBD increases, demand also tends to increase. However, there is likely a limiting factor with respect to this relationship.
5. Proximity to regional freeway system.	Lots immediately adjacent to a regional freeway have been found to demonstrate higher park-and-ride demand.
6. Availability of midday access between primary business center (CBD) and the lot.	Availability of midday access from the CBD to the park-and-ride lot increases potential demand.
7. Total population within the 50 percent service area of lot.	Population within a 4-kilometer (2.5-mile) radius of the lot has been found to supply approximately 50 percent of the total demand for the lot—the denser the population within the 4-kilometer (2.5-mile) radius, the larger the potential park-and-ride market.
8. Location within the region (for Puget Sound, the South Corridor demonstrated higher average demands)	Lots located within productive transit corridors will tend to generate higher park-and-ride demand.
9. Percent multifamily within the service area of the park-and-ride lot.	The higher the multifamily concentration within the service area of the park-and-ride lot, the higher the potential draw population.

Lot Attribute	Relational Characteristic
10. Percent of lower middle and lower income households within the service area of the park-and-ride lot.	Lower income populations tend to rely more frequently on transit; however, with park-and-ride lots this relationship may not be as strong as expected between income and general transit usage.
11. The average best schedule transit time between the park-and-ride lot and primary CBD.	Shorter schedule times with respect to increasing distances increase park-and-ride demand and provide a measure of service speed.
12. Travel time to secondary major destination (for Seattle Metropolitan region: University of Washington).	See Relational Characteristic 11.
13. Peak traffic on adjacent roadway facility.	Increasing traffic volumes on adjacent roadways may increase parking demand because such volumes may indicate higher downstream traffic congestion and potentially greater numbers of prospective park-and-ride users.
14. Peak traffic on adjacent prime facility.	See Relational Characteristic 13.
15. Number of home-based work trips between market area and specific destinations (e.g., the CBD).	Increased trip interchange characteristics between two locations increase the potential share of the modal split for the park-and-ride mode.
16. Employment or similar surrogate demand measure at activity center destination.	The larger the employment level at the primary business center served by the lot, the higher the potential demand. Likewise if multiple centers are aligned downstream of the lot, park-and-ride demand will generally be increased.
17. Relative measure of roadway congestion between subject lot and destination.	Increasing congestion between the lot and primary destination encourages park-and-ride demand because of the potential increased competitiveness of transit with the automobile. To achieve a transit advantage requires preferential treatment of transit (e.g., an HOV lane), otherwise no advantage will be realized.
18. Age of park-and-ride service/lot.	New lots require time to develop their demand characteristics. Older lots may demonstrate a reduction in demand if not adequately maintained and remodeled periodically.
19. Availability of priority treatments.	HOV lanes or transit-only policies increase the general competitiveness of transit with respect to the private auto.

Lot Attribute	Relational Characteristic
20. Surrounding density.	Increased surrounding densities represent increased populations, and hence a larger potential draw population.
21. Perceived safety characteristics of lot.	To the user, perception is reality when it comes to personal safety. Lots perceived to be more dangerous than others will generally experience lower demand.
22. Lot paving.	Paved lots are generally preferred to unpaved or gravel lots when an alternative is presented to the potential user.
23. Lot lighting.	Well-lit lots promote the perception of a safe environment (see Relational Characteristic 21).
24. Provision of passenger shelter.	Shelter and other amenities generally add to the perception of safety and permanence of the lot. This, in turn, will have a positive effect on demand.
25. Provision of passenger amenities.	See Relational Characteristic 24.
26. Transit information.	See Relational Characteristic 24.
27. Parking costs at primary destination.	Increased parking costs at the destination end of the commute trip will increase auto costs relative to transit, making transit more competitive in terms of cost.
28. Park-and-ride lot access attributes.	Lots that are difficult to access, even though they may be highly visible, may demonstrate reduced demand characteristics.

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### *Site-Level Demand Estimation and the Seattle Park-and-Ride Demand Model*

As discussed in the previous section, site-level data can be used to gain a better understanding of park-and-ride demand. Several variables have been used by researchers to define demand estimation models in an attempt to estimate the demand potentials for specific park-and-ride facilities more rigorously (1, 6, 24).

Methodologies for developing site-level estimates at individual park-and-ride facilities have varied in their sophistication and ability to reflect accurately the true demand characteristics of the lots for which they are used. A number of sources describe these alternative methods (1, 6, 13, 25).

The purpose of this section is to present a site-level estimating procedure developed for the King County Department of Transportation (formerly Seattle Metro) called the park-and-ride demand (PRD) model (23). A detailed statistical analysis of the PRD process is provided, as is a discussion of the transferability of the PRD estimation process to other metropolitan regions.

The PRD model was developed over a 12-month period as a joint effort between Parsons Brinckerhoff and staff from the King County Department of Transportation. In all, 31 active park-and-ride lots within the Metro service area were studied for their demand characteristics (see Exhibit 5.2). All lots were served by various levels of local, commuter, and express bus transit services. In addition, numerous data were collected detailing the site and service characteristics provided at the facilities. Population and economic data were also evaluated within the corresponding market areas determined for each park-and-ride facility.

In all, a set of five unique model equations were developed for estimating park-and-ride demand at individual facilities. These equations utilize a set of eight site-level descriptive variables in varying combinations to provide a range of demand estimating capabilities:

1. Service area population
2. Ratio of auto costs to transit costs
3. Distance from park-and-ride facility to major employment centers
4. Number of express buses during the morning (AM) peak
5. Best (*not* average) time between the park-and-ride facility and the CBD of the metropolitan area
6. Proximity to the regional freeway system
7. Presence of nearby park-and-ride facilities
8. Availability of midday service

Although a set of 31 observations (e.g., the park-and-ride lots used in the King County Metro study to develop the various PRD equations) is admittedly limited from a statistical perspective, the sample represents a fairly large set of facilities for a single metropolitan region. Other park-and-ride demand estimation modeling attempts have evaluated larger subsets of park-and-ride lots, but these facility observations were often collected from several different metropolitan regions and analyzed in a single regression analysis. The use of multiple regions in a single regression analysis automatically assumes that demand characteristics for park-and-ride facilities will not differ from one metropolitan region to the next. This assumption likely introduces some level of error into the estimation process, just as does the limited sample set used for the PRD model development.

## *Park-and-Ride Demand Model Format*

Previously published research gathered during the literature review process indicated that regression analysis using several explanatory variables with regard to park-and-ride demand would provide the most practical approach for the development of a planning model. An underlying multivariate format, as shown in the following equation, was chosen as the most reasonable regression approach.

$$\text{DEMAND} = N + aA^a + bB^b + cC^c \dots + zZ^z$$

Where:

N = some constant, theoretically incorporating a measure of the minimum lot size (derived by policy and by the sample of lots evaluated);

A, B, C, Z = independent variables;

a, b, c, z = model coefficients to be estimated using a *least squares* method, and;

a, b, g, z = variable exponents estimates using a *least squares* method.

Two primary issues controlled the number of variables incorporated in the regression analysis used to derive the King County Department of Transportation demand estimation model: the availability of data from past surveys and existing databases, and the potential ease of developing similar data for the evaluation of future lots.

## *Variables Used in the Seattle Park-and-Ride Demand Model*

Variables presented in the following definitions represent base variables evaluated for the Seattle area Park-and-Ride Demand (PRD) study. It should be noted that some base variables were combined during model derivation, forming new variables that seemed to have more explanatory capabilities. Base variables were chosen because of their theoretical relationship to the dependent variable (e.g., park-and-ride demand). The subsequent combined variables incorporated in several of the resulting demand equations were developed based on both their theoretical relationship to demand as well as by trial and error during the regression analysis. However, all variables incorporated in the final Seattle area demand estimation equations were evaluated for their logical cause and effect relationship to facility demand, and only those variables that could be intuitively explained with regards to demand were retained within the model.

**Demand:** Park-and-ride demand at each of the test lots was measured as the number of vehicles observed parked in and around the park-and-ride lot. Therefore, the measured vehicle demand represents both transit-oriented and non-transit-oriented (e.g., carpool) demand for park-and-ride spaces.

Lots demonstrating excess demand, as well as lots with excess capacity, were incorporated within the model regression. The use of lots demonstrating excess demand (i.e., lots for which observed demand exceeds the available capacity) was necessary to capture a representative sample of lots from within the Metro service district. However, it is evident that, for those lots, the true demand likely exceeds the observed demand, which is constrained by the limited capacity available.

**Service Area Population:** For the Seattle area, the standardized 50 percentile service area shape previously defined was used to identify traffic analysis zones (TAZs) for collection of demographic information about the populations served. The service areas were plotted over a map of the 1991 Puget Sound Regional Council's TAZ system. In cases where TAZs were split by the service area boundary, visual estimates were made of the percent of that TAZ included within the service area. It was assumed that the underlying TAZ populations were spread evenly throughout each TAZ; therefore estimates of the area included within the service area of each lot were assumed to represent the proportional populations from that TAZ included within the service area.

**Ratio of Auto Costs to Transit Costs:** User costs for transit and auto were calculated from the users' perspective for each of the 31 test lots used in the King County-Metro analysis. Because many lots are provided with express service to a number of destinations (e.g., the Seattle CBD, Bellevue CBD, Everett Boeing, Renton Boeing, and the University of Washington), costs were weighted based on the number of bus trips providing express service to each of the major centers.

For example, the average transit fare seen by transit patrons at each of the test park-and-ride lots was calculated by multiplying the peak fare from the lot to each of the five major activity centers within the region (i.e., Seattle CBD, Bellevue, University of Washington, Renton Boeing, Everett Boeing) by the number of bus trips serving that center. The sum of the weighted fares was then divided by the total number of peak bus trips, resulting in an average weighted transit cost seen by transit users. Auto costs were done similarly, by averaging weighted parking costs and driving costs across the five urban centers.

**Distance to Major Employment Centers:** The distance between each park-and-ride lot and the centroid of each of the five major employment centers (i.e., Seattle CBD, Bellevue, University of Washington, Renton Boeing, Everett Boeing) was measured using a straight-line method. Distance was combined with transit schedule times to produce a scheduled transit speed. Theoretically, the faster the transit service is, the more competitive that service would be with respect to the private auto; thus higher schedule speeds would be assumed to increase park-and-ride demand. It is implicitly assumed that the schedule speeds are representative of achievable speeds and that schedule times are realistic in that they incorporate recurring congestion delay.

**A.M. Express Service:** At King County Metro, service is structured such that, for many park-and-ride lots, there may be more than one route that operates between a lot and a given destination. Such routes may or may not have similar paths between a park-and-ride lot and their destination.

Because different routes may travel on different streets, the travel time of the two routes may also differ. For example, seven different routes operate between the Overlake park-and-ride lot in Bellevue and downtown Seattle during the AM peak period (defined as 5:00 to 10:00 AM for this model). Of these routes—which serve different intermediate markets between their respective origins and destinations—the fastest route takes 27 minutes to reach downtown Seattle, whereas the slowest takes 52 minutes.

Because the travel times of different routes may differ dramatically between a park-and-ride lot and a given destination, it was necessary to divide all such routes into those providing direct express service, and those providing less direct or slower service between the two areas. It was assumed that motorists traveling between a park-and-ride facility and

a given destination would be less willing to use the non-express service except perhaps during midday.

Data on AM passenger boardings at a number of park-and-ride lots reveal that boardings are highest on routes that offer the best travel time to a given destination. Riders also appear to be willing to board routes that offer slightly slower travel times to the same destination, but do not appear willing (i.e., boardings are low) to use routes that are 15 minutes slower than the quickest bus service offered to their destination.

Therefore, it was assumed that only those bus routes operating between a given park-and-ride lot and a primary destination that offered travel times within 15 minutes of the fastest route between those two points were express routes. Trips of less direct routes between the two points were not included because it was thought that people boarding those trips were probably not traveling to the ultimate destination of the route but to other places along the way.

**CBD Schedule Time:** Based on the selection of express routes as defined above, the CBD schedule time used for purposes of PRD model regression and derivation was the route with the fastest scheduled AM-peak travel time between the park-and-ride-lot and the Seattle CBD.

**Freeway Proximity:** Proximity to the regional freeway system was determined to be an important factor in determining the level of park-and-ride demand at individual lots within the Seattle metropolitan region. Proximity was defined as immediately adjacent to the freeway system or to a major regional arterial displaying characteristics similar to a freeway. Park-and-ride lots fitting this description were given a freeway proximity value of one, versus a value of zero for lots not adjacent to the freeway system.

**Adjacent Park-and-Ride Facilities:** Adjacent lots are defined to be lots within 4 kilometers (2.5 miles) of the lot being studied. In other words, it was assumed that a park-and-ride user would view another park-and-ride lot within the 50 percentile service area of a particular facility as a viable option, should the initial lot be full or the service at the competing lot be more convenient. The concept embodied by this variable is that lots with overlapping service areas either compete for a limited number of transit patrons (macroeconomic theory) or that they provide a higher level of service to the joint areas which they serve. In either scenario, it would be expected that an adjacent lot would provide some influence. The actual value of the variable for each individual lot is simply the total number of adjacent lots within the 50 percentile market shed of the subject lot.

**Midday Service:** The midday service variable is a measure of whether or not park-and-ride users in Downtown Seattle can return to their vehicles during the day (i.e., during midday off-peak hours) via transit. Values of one or zero are possible, with one indicating that direct midday transit service is available and a zero indicating that it is not. Midday service to other locations did not prove to be an important factor. This is likely due to the fact that a majority of the existing demand and service within the underlying King County Metro system is oriented to the Seattle CBD.

### *Variable Independence*

All base and composite variables used in the PRD regression process were evaluated for their dependence-independence characteristics. Mutual independence was evaluated by constructing a correlation coefficient matrix for all variables. Independent variables with a

maximum cross-correlation of 0.33 were chosen for use within a single model regression equation. A correlation matrix for the selected base variables is presented in Exhibit 5.9.

**Exhibit 5.9**  
**Cross-Correlation Matrix of Independent**  
**Park-and-Ride Demand Regression Variables**

	AMCBDBUS	FREEWAY	MIDDAY	ADJLOTS	TOTPOP	ATRANCOST	CBDDIST	TRANSPD
AMCBDBUS	1.000							
FREEWAY	0.238	1.000						
MIDDAY	0.525	-0.012	1.000					
ADJLOTS	0.156	0.254	-0.264	1.000				
TOTPOP	0.614	0.013	0.081	0.107	1.000			
ATRANCOST	0.115	-0.096	0.279	-0.211	-0.034	1.000		
CBDDIST	-0.142	-0.011	0.177	-0.309	-0.331	0.822	1.000	
TRANSPD	0.083	0.080	0.297	-0.160	-0.058	0.796	0.649	1.000

Shaded area indicates correlation coefficients of variables occurring in common regression equation

### *Park-and-Ride Demand Estimation Equations*

Five demand estimation equations were developed relating park-and-ride vehicle demand to the service, demographic, and locational variables presented herein. These equations utilized varying combinations of the base independent variables to estimate park-and-ride demand within the greater Seattle metropolitan area. Some of the equations were developed using only those lots for which demand was observed to be less than the capacity of the lot (e.g., 22 of the 31 King County Metro park-and-ride lots), while others were developed using all 31 test lots.

An illustration of each demand equation along with the adjusted R-squared value resulting from the equation, and the standard error generated by the equation, are presented in Exhibits 5.10 and 5.11. The adjusted R-squared value is a measure of the percentage of variability in the data explained by the model. Hence a 0.40 R-squared value indicates an equation explains approximately 40 percent of the variability observed within the underlying data set.

## Exhibit 5.10 Park-and-Ride Demand Estimation Equations

PRD Equation 1

$$\text{DEMAND} = -45.66 + 52.69 \times \frac{\text{AMCBDBUS}}{\text{CBDDIST}} + 0.60 \times \text{CBDDIST}^2 + 129.90 \times \text{FREEWAY}$$

PRD Equation 2

$$\text{DEMAND} = -129.49 + 118.47 \times \text{ATRANCOST} + 37.97 \times \frac{\text{AMCBDBUS}}{\text{CBDDIST}} + 152.68 \times \text{FREEWAY}$$

PRD Equation 3

$$\text{DEMAND} = -359.66 + 73.24 \times \frac{\text{AMCBDBUS}}{\text{CBDDIST}} + 13.22 \times \text{TRANSPD} + 145.39 \times \text{FREEWAY}$$

PRD Equation 4

$$\text{DEMAND} = (-16.98 + 43.28 \times \text{FREEWAY} + 40.94 \times \text{MIDDAY} + 2.51 \times \text{CBDDIST}) \times \frac{\text{TOTPOP}}{10,000}$$

PRD Equation 5

$$\text{DEMAND} = (-49.85 + 36.71 \times \text{FREEWAY} + 51.24 \times \text{MIDDAY} + 3.35 \times \text{CBDDIST} + 10.07 \times \text{NUMLOTS}) \times \frac{\text{TOTPOP}}{10,000}$$

Where:

- DEMAND = Vehicle demand for park-and-ride facility.
- AMCBDBUS = Number of AM peak buses destined to the (Seattle) CBD.
- CBDDIST = Straight-line distance between subject park-and-ride lot and (Seattle) CBD.
- FREEWAY = Boolean variable to incorporate proximity to freeway.
- ATRANCOST = Ratio of auto operating costs to transit costs.
- MIDDAY = Boolean variable to incorporate presence of midday service from and to the subject park-and-ride lot.
- TOTPOP = Total population within the 50 percentile market area served by the lot.
- NUMLOTS = Number of adjacent but independent lots observed within the 50 percentile market area that is served by the lot being examined.
- TRANSPD = Fastest transit schedule time between individual lot and the CBD, divided by the straight-line distance between the lot and CBD (CBDDIST).

Exhibit 5.11  
Statistical Characteristics  
for Park-and-Ride Demand Equations

<b>PRD Equation</b>	<b>Adjusted R-Squared</b>	<b>Number of Lots in Regression Sample</b>	<b>Standard Deviation (Spaces)</b>
PRD Equation 1	0.447	31	128
PRD Equation 2	0.403	31	133
PRD Equation 3	0.62	22	84
PRD Equation 4	0.573	22	20.9/10K pop
PRD Equation 5	0.683	22	17.9/10K pop

A range of five equations was developed because often not all data items needed for each equation would be available in future facility evaluations. If a data item in one of the PRD equations is not available for a particular application, the user may still be able to use the other four PRD equations to estimate demand.

Because the five PRD equations were developed specifically for the greater Seattle metropolitan area, care should be used in developing estimates using the PRD methodology outside the Puget Sound Region. It is recommended that results provided by the PRD model be evaluated against factual knowledge of the study area for reasonableness.

Regional transferability and calibration of the PRD equations must be considered by the user when choosing to use the PRD approach within any given region outside the Puget Sound Region. Two methods for regional calibration and/or validation are presented in the next chapter.

### *Transferability Analysis of Estimated PRD Models*

The PRD model was specifically developed for evaluating demand for park-and-ride facilities within the King County-Metro transit service area. As such, the individual demand estimation equations reflect the unique commuting and congestion characteristics of the Seattle metropolitan area, and cannot be transferred to other regions without estimation of a new model and/or validation of the Metro equations. It is reasonable, however, to assume that the underlying variables uncovered in the King County Metro study are reflective of demand for bus-based park-and-ride facilities in general, and are therefore fundamentally applicable to other metropolitan locations.

Two options are available to the transportation planner when attempting to transfer the PRD model to another location. The planner may estimate a new PRD model, estimating the coefficients for each of the variables used in the several PRD equations, or validate the Seattle PRD equations, developing a correction factor that compensates for the inherent differences between the region being studied and the Seattle metropolitan area.

The estimation approach is by far the most reliable of the two methods for transferring the Seattle PRD model to other regions. It is also the most demanding in terms of data requirements and effort required on behalf of the implementing agency.

An estimation approach requires the manual calibration or estimated coefficients for the PRD model based on local data within the region of interest. For purposes of statistical reliability, data for a minimum of 30 lots are required for such an endeavor. The task requires the transport planner to conduct a multivariate regression analysis, using the PRD equations as a guide for variable selection. A statistical software package such as Microsoft SYSTAT is required for this approach.

Although a calibration approach requires significant effort on the part of the implementing agency, it can provide the most reliable approach of the two transfer techniques. Likewise, in the process of calibrating new PRD equations, the implementing agency can test new variables, essentially developing its own unique PRD model.

### *Validation Analysis*

Although perhaps less reliable than the estimation and calibration technique, the validation technique for model transfer is much less demanding on data resources and requires somewhat less effort from the implementing agency. The validation technique can be an especially useful methodology for regions with too few existing lots to statistically calibrate the PRD model.

In estimation, an extensive number of existing park-and-ride lots are required for re-estimation of the variable coefficients (approximately 30 lots). In validation, fewer existing lots are required for transfer purposes (about 10 or 12). The validation process involves using the Seattle PRD model to estimate park-and-ride demand for a set of existing facilities within the new region, and then estimating by trial and error a correction factor to compensate for differences between the applicable region and the Seattle region by comparing the PRD estimates with observed demand rates found in the study region.

A validation technique was used, for example, to adapt the Seattle PRD model to the Denver metropolitan area served by the Denver Regional Transportation District (RTD), which maintains park-and-ride lots throughout its jurisdiction (see Exhibit 5.12).

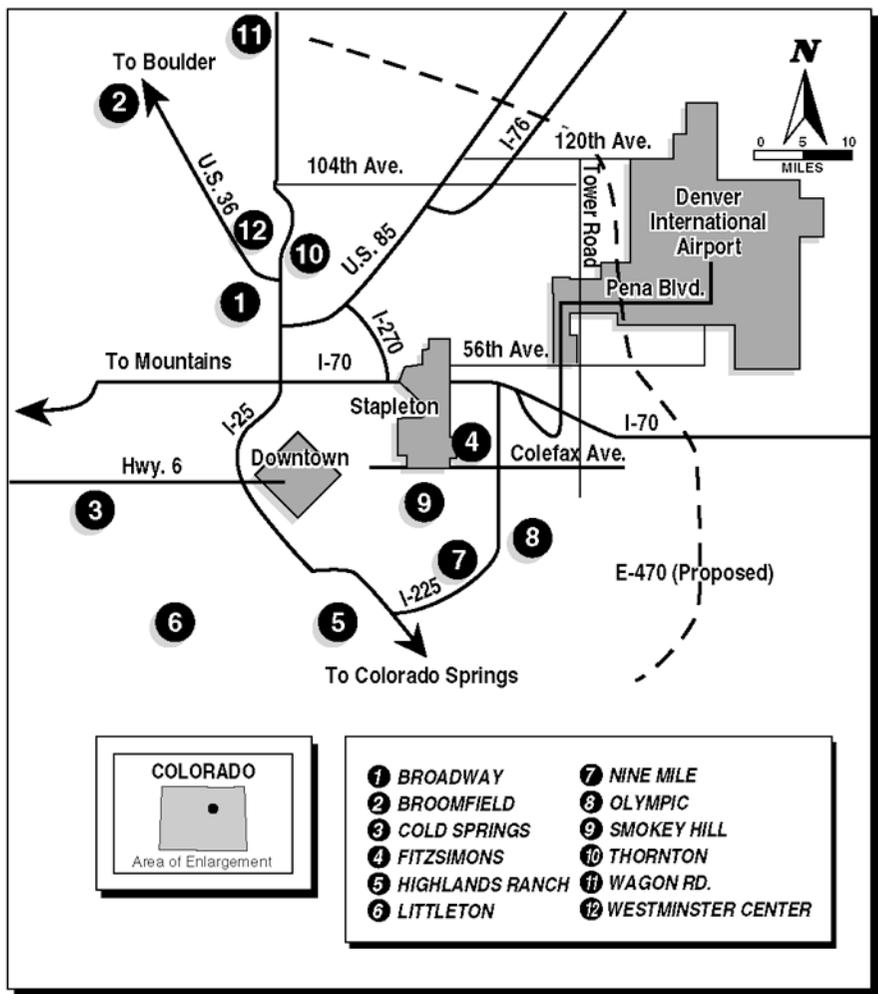
Twelve Denver area park-and-ride lots within the RTD service area were chosen and the required data needed to implement a PRD estimate were collected. Estimates of park-and-ride demand using the Seattle PRD equations were developed for the 12 Denver lots (see Exhibit 5.13). Correction multipliers were then estimated for each of the PRD equations to compensate for the differences between the Seattle and Denver park-and-ride markets. These multipliers were calculated by comparing the PRD estimates to the observed demands, and then estimating a correction factor for each equation that would provide the best fit on an equation-by-equation basis. Based on the Seattle equations, park-and-ride demand for Denver was generally observed to be between 35 and 60 percent of the demand estimated using the unadjusted Seattle PRD model. The lower demand seen in the Denver metropolitan area can likely be attributed to inherent differences between the two metropolitan areas, including:

- Geographical constraints
- Vehicle operating and parking costs
- Transit service characteristics
- Historical planning process for existing park-and-ride facilities

As in several of the Denver park-and-ride facilities used in Exhibit 5.13, the PRD equations significantly over- or underestimated the observed demand, even after a correction factor was applied to reduce the PRD estimates. This fact highlights the need to compare PRD forecasts against local knowledge of the urban area. There are probably fundamental differences between the Denver and Seattle metropolitan areas that cannot be accounted for using a simple validation technique. Local knowledge of the planning area could also suggest that improved definitions of individual variables is warranted for those lots not well represented by the PRD equations.

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Exhibit 5.12  
 Denver Regional Transportation District (RTD)  
 Service Area and Selected Park-and-Ride  
 Lots for Validation



**Exhibit 5.13**  
**Analysis of PRD Model Transferability**  
**to the Denver Metropolitan Area**

Park-and-Ride Facility	Spaces	1993	PRD Equation 1		PRD Equation 2	
	Currently Provided	Observed Demand	Corrected Estimate	Estimated Error	Corrected Estimate	Estimated Error
1 Broadway	353	105	163	58	80	-25
2 Broomfield	637	558	303	-255	318	-240
3 Cold Springs	418	239	114	-125	145	-94
4 Fitzsimons	164	41	86	45	59	18
5 Highlands Ranch	175	64	312	248	196	132
6 Littleton	256	162	195	33	1	-161
7 Nine Mile	364	220	199	-21	53	-167
8 Olympic	152	39	72	33	10	-29
9 Smokey Hill	218	63	-35	-98	69	6
10 Thornton	574	124	223	99	66	-58
11 Wagon Rd.	1,541	316	301	-15	80	-236
12 Westminster Ctr.	371	411	331	-80	151	-260

Park-and-Ride Facility	PRD Equation 3		PRD Equation 4		PRD Equation 5	
	Corrected Estimate	Estimated Error	Corrected Estimate	Estimated Error	Corrected Estimate	Estimated Error
1 Broadway	-131	-236	80	-25	220	115
2 Broomfield	358	-200	NA	NA	NA	NA
3 Cold Springs	24	-215	143	-96	221	-18
4 Fitzsimons	-55	-96	-5	-46	90	49
5 Highlands Ranch	878	814	198	134	312	248
6 Littleton	179	17	94	-68	225	63
7 Nine Mile	129	-91	388	168	524	304
8 Olympic	67	28	-127	-166	-32	-71
9 Smokey Hill	-176	-239	-314	-377	-373	-436
10 Thornton	494	370	490	366	617	493
11 Wagon Rd.	402	86	169	-147	299	-17
12 Westminster Ctr.	506	95	478	67	509	98

For instance, the variable "FREEWAY" is a Boolean variable with a value of "1" if the park-and-ride facility is adjacent to a freeway and a "0" if the lot is not adjacent to a freeway facility. A caveat that might be contributing to some of the differences between the estimated and observed demand for several of the Denver lots is that Denver has a circumferential as well as a radial freeway system. Incorporating a Boolean value of "1" for lots located on the circumferential freeway may be erroneous, and a value of "0" might be more reflective of the true relationship of such freeway segments to park-and-ride demand. However, further research was not conducted with regard to this particular example.

## 5.5 Summary

A salient conclusion resulting from the King County-Metro park-and-ride demand estimation study is that useful sketch planning models for park-and-ride demand can be developed based on site and service related characteristics. Furthermore, statistically identifiable market sheds for specific park-and-ride lots can be determined as a function of distance from the lot. That market area can be used to describe the demographic characteristics of the service populations. It is critical to understand that such sketch tools do not take the place of their more accurate regional modeling counterparts. On the contrary, site-level forecasting tools can be used to better define the demand estimates generated by such regional models, assisting in the distribution of park-and-ride demand to specific site locations. For smaller to midsize regions that do not support a regional transit model, site-specific sketch planning tools may provide the only practical technique for developing more rigorous estimates of potential park-and-ride demand.

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## 6.0 DESIGN REQUIREMENTS FOR PARK-AND-RIDE FACILITIES

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## 6.0 DESIGN REQUIREMENTS FOR PARK-AND-RIDE FACILITIES

A number of differing views regarding the design of park-and-ride facilities are held throughout the engineering and planning profession. At one extreme, there is the belief that the primary design goal should be to maximize the efficiency of the parking facility as an extension of the highway or transit network. At the other extreme is the belief that the primary goal should be to maximize the community integration characteristics of the individual facility, with a much lower consideration of regional freeway connectivity needs.

These differing design approaches have led to significantly different park-and-ride facilities and systems being constructed throughout North America. For example, when efficiency and connectivity with the regional freeway system have been the overriding concerns, the resulting facilities have often appeared more as wide spots in the freeway pavement than as well-connected with the surrounding land uses, serving relatively few modes other than the auto and transit modes of travel.

At the other end of the spectrum, when design approaches have placed a high degree of importance on community integration, the resulting facilities have demonstrated the ability to encourage several multimodal access and departure modes and a high level of community acceptability. Clearly, in an environment of dwindling financial resources and increased multimodal demands, the optimum design will attempt to blend these two very important approaches to provide an efficient park-and-ride design that is integrated into the community and can generate less-traditional access demands (i.e., pedestrian and bicycle).

When transit facilities such as park-and-ride lots are examined, experience will show that, to achieve a successful facility as measured by demand and operating expense, form must follow function in the pursuit of a design. Design professionals must take into consideration the various access and service modes associated with a park-and-ride facility, including on-site pedestrian movements, placing these concerns and design requirements at the top of the design priority list. Attention to these issues can produce an architecturally superior facility as well as a superior design, resulting in reduced maintenance requirements, lower operating costs, and manageable security risks. Throughout this chapter, a number of photos of successful rail-based and bus-based park-and-ride facilities are presented to highlight design concepts and to provide examples for future planning efforts. Other than for this notation, these photos are not specifically referenced.

### 6.1 Design Concepts

This chapter provides a discussion of a number of physical design components that should be considered in the development and design of a successful park-and-ride facility. These components fall into four categories:

- Designing a community integrated park-and-ride facility

- Providing for the design needs of pedestrians and bicyclists
- Providing for the design requirements of transit vehicles
  
- Providing for the design requirements of automobiles

In order for a park-and-ride design to be successful in the spirit of multimodal and intermodal planning, the design must address each of these four areas with equal competence. The level of community integration must be appropriate to the surrounding land uses. Because the pedestrian mode is a component of all commute trips accessing the park-and-ride facility, design considerations both within the park-and-ride facility and in the surrounding land uses must provide for and promote pedestrian flow. Likewise, transit access and accompanying facilities must provide for a smooth and seamless transfer between the private automobile and transit. The automobile must also be accommodated. Although a design hierarchy is appropriately and easily applied to these four concepts, each is important to the success of the proposed facility.

The information presented is in large part a compilation of design standards and concepts collected from a number of transit agencies with active park-and-ride development projects. As one might expect, when applying information from such a compendium, care should be exercised so that the general design criteria fit local conditions. The information presented is also intended to highlight only the minimum required information needed to design a successful park-and-ride facility. Often, individual jurisdictions and transit agencies will include substantially more in their design requirements. However, these requirements can, in some cases, lead to limitations in design creativity. Instead, the goal of these design parameters is to promote the greatest creative flexibility and therefore encourage solutions that fit local conditions. Furthermore, many of the design examples relate to the bus-oriented park-and-ride facility. However, many of the concepts are directly transferable to rail-oriented systems.

## 6.2 Community Integration

Park-and-ride facilities are often criticized for their inability to discourage travel by the private automobile, their adverse community and environmental impacts, and their perceived tendency to draw criminal activity into the heart of the suburban community. These commonly held animosities and vocal criticisms are often based on observations of existing park-and-ride facilities within the metropolitan study area, rather than on an understanding of the proposed project. This animosity is also often the result of an overemphasis on design efficiency and too little attention to community integration. A review of the historical development of park-and-ride programs may illuminate the reasons behind this observed phenomenon.

### *Park-and-Ride Design History*

Early park-and-ride facilities were often designed and built by the transit agencies operating service to the lot. They were often associated with fixed guideway transit modes or similar capital-intensive modes such as commuter train, interurban trolley, or intercity

ferry. As such, early park-and-ride facilities were often built as components of an intermodal station, located near the heart of the suburban or rural communities being served, and were well integrated into their surrounding environments.

In the late 1960s and early 1970s, a new era in park-and-ride development began, largely associated with bus transit and the expanding system of interstate highways being constructed at the time. This latter period of park-and-ride development more typically resulted in large featureless park-and-ride facilities, designed more for their efficiency characteristics than for their ability to integrate with the community. They were also typically designed to maximize only one intermodal transfer (i.e., between the private automobile and transit). This is in contrast to the earlier period of park-and-ride development, which produced lots serving multiple types of intermodal transfers and which even encouraged alternative modes to traditional auto access.



*Multimodal Approach to Park-and-Ride Lots (Bicycle Storage Rack)  
Northgate Transit Center, King County Department of Transportation,  
Seattle, Washington*



*Auto-Transit Park-and-Ride InterfaceæShoreline Park-and-Ride  
King County Department of Transportation, Shoreline, Washington*

The earlier period of community integrated park-and-ride facilities encouraged transit ridership by encouraging transit supportive developments surrounding the traditional park-and-ride facility and intermodal station. This feature of early park-and-ride development has largely been lost to the more recent emphasis on efficiency. Modern lots are often criticized for their potential to pull ridership from local feeder routes, thus increasing the number of vehicle trips within the study region rather than reducing them. This can be argued to be a direct result of a lack of attention to community integration.

In many locations, public opinion is increasingly more demanding of public works projects, including park-and-ride facilities. This is especially true in communities where vacant land is scarce and environmental concerns are high. Transit is increasingly being looked to as a means of solving traffic congestion problems as well as air pollution concerns. Park-and-ride facilities designed to serve only a transfer from the automobile to transit mode and that are not integrated with the surrounding community cannot provide the maximum benefit to be realized from a fully intermodal/multimodal park-and-ride facility.

A community integrated park-and-ride facility can increase transit ridership and, given the right situations, increase the potential revenue stream to the transit agency and tax base of the surrounding community by providing a higher degree of accessibility which, in turn, encourages a higher intensity in surrounding development. Integrated park-and-ride

facilities can also provide a suburban focal point, around which future urban developments can orient.

Developing an integrated park-and-ride facility cannot successfully occur within a vacuum. For successful integration, a coordinated effort is required, often spanning several jurisdictional agencies. It can be demonstrated that supportive zoning and/or deed restrictions that promote transit supportive land use development in the vicinity of the park-and-ride lot are extremely beneficial, if not absolutely necessary, for integration success. There must also be a market for the park-and-ride facility and accompanying transit services.

### *Land Use Coordination and Integrated Park-and-Ride Facilities*

Designing a park-and-ride facility to be an integral part of the surrounding community can be difficult, especially within a heavily auto-oriented travel market. However, there may be significant opportunities within the community to establish a park-and-ride facility such that it actually encourages transit friendly design in the surrounding neighborhood. When the surrounding community is oriented towards transit friendly design, then maximum use of the park-and-ride facility and intermodal transfer station can be accomplished.

Primary objectives and advantages of a community-compatible or integrated park-and-ride facility include:

- Adjacent residential, service-oriented, and commercial activities can provide transit patronage, services, and security to the transit agency operating the park-and-ride facility
- Multi-story buildings located near the site can provide visual surveillance of the park-and-ride facility, thereby increasing its perceived safety
- Attractive designs providing high visibility can engender a sense of community ownership and stewardship
- Adequate attention to pedestrian and bicycle facilities, both on-site and in the surrounding developments, encourage a multimodal use of the lot (40)
- Public investment in an integrated transit facility can serve as a focal point for suburban community development
- Increased massing of transit facilities and surrounding land uses increase the visibility of public transit and create a potential for future markets
- Centralizing transportation services increases accessibility to surrounding land uses and the community.



*Facilitating the PedestrianæA Brick Pathway Leading Between Area Businesses and Park-and-Ride Lot, South Orange Station Park-and-Ride Lot, NJ Transit, South Orange, New Jersey*

### *Organization of Surrounding Land Use*

Effective organization of land uses and land use mix in the vicinity of transit facilities can help to reduce the number of total trips within the area, and eliminate the need to make some trips by autos, thus reducing the need to provide parking and encouraging additional pedestrian activities.

Mixing of residential, commercial and retail services in the vicinity of the park-and-ride lot can encourage residents to link trips that might otherwise occur separately. When such land use mixing policies are coordinated with specific design techniques, a transit-supportive pedestrian-oriented environment can be developed. Park-and-ride facilities are similar to other intermodal facilities and, if designed with the community in mind, can become an integral part of the urban fabric while remaining efficient change-of-mode facilities.

A key to land use organization is the process of providing a focal point around which to organize various urban and suburban uses. Extensive research on this topic by New Jersey Transit (NJ Transit) suggests that three important concepts must be embodied in the design of a transit facility if it is to be used as a focal point for the surrounding community:

- Emphasize pedestrian and bicycle modes of access within the surrounding community and within the park-and-ride facility. The pedestrian linkages between the lot and the surrounding neighborhood, as well as the linkages internal to the park-and-ride lot, give the intermodal facility its character. Any transit-related trip includes some portion on foot. The pedestrian environment and the pedestrian activity generated by the amenities provided within the intermodal facility are typically identified as the elements that give a place its sense of community. It can therefore be argued that a pedestrian-oriented environment makes for a good transit friendly one, both at the neighborhood level and at the park-and-ride facility.
- Utilize traffic calming techniques to emphasize the pedestrian, and reduce the impacts of traffic circulation in and around the park-and-ride facility. By their nature, park-and-ride facilities require an interchange between the auto mode and transit. The auto's importance within this intermodal transfer must be accommodated, but the use of traffic calming techniques such as speed control devices within the lot can reduce or eliminate conflicts between the auto mode and pedestrian. This increases the opportunity for pedestrian linkages with surrounding land uses and encourages a more multimodal environment.
- Create a sense of place surrounding the park-and-ride facility and foster a sense of community stewardship. Often, transit is planned only as an afterthought and is located at the periphery of a community or suburban development. A bolder approach is to bring the park-and-ride facility and related transit service into the heart of the development so that it becomes a focal point for the surrounding land uses.

Careful planning of areas surrounding the intended park-and-ride lot can produce a sense of ownership for the park-and-ride lot within the surrounding community and provide a visible icon for the neighborhood. Architecturally unique pedestrian facilities, landscaping, and/or public art programs can add distinction to the park-and-ride facility, making it a focal point within the community. The design should not compromise the transit accessibility of the facility, but assure that an acceptable level of efficiency is provided.

## *Locate Supporting Land Uses in Proximity to the Park-and-Ride Facility*

An important element in obtaining a community integrated park-and-ride facility is understanding the general travel and time characteristics of traditional land use types, and then encouraging beneficial types to locate near the proposed park-and-ride facility(s).

In outlying suburban communities, park-and-ride facilities situated near larger suburban employers can provide a destination for “reverse” commuters, those traveling from the traditional CBD to the suburban employment center or between different suburban employment centers if transit service allows. Such a park-and-ride facility can also serve as a transit center or hub for a suburban distribution system or local shuttle service.

These activities will increase usage and pedestrian activity at the park-and-ride lot. A mix of complementary land uses in the surrounding neighborhood will create increased transit activity throughout the day. This increased transit and community activity can improve the safety characteristics of the park-and-ride facility and increase community acceptance of individual facilities.

Understanding the generic travel characteristics associated with various land use activities can also assist in the design of a community integrated park-and-ride facility. As the intensity and diversity of the surrounding land uses increase, so does the opportunity for increased off-peak travel. For example, low density residential and single-use oriented commercial office developments tend to primarily generate peak-period trips. Similarly, destination retail and entertainment uses would be expected to primarily generate off-peak travel demands. A combination of these land uses in conjunction with a park-and-ride development often results in a facility that demonstrates traditional commute demand during the peak periods, and non-commute demand during the off-peak periods. Other land use activities demonstrate both peak and off-peak demand generating capabilities such as high density residential, destination retail, and institutional-based activities (e.g., post office or other government office).

Encouraging land uses that generate healthy off-peak travel demands on the transit system can increase the efficiency of the park-and-ride facility and change its character from a parking lot to a transit center/community focal point. Elements important to reaching an increased level of all-day activity at a park-and-ride facility include:

- Creating a pattern of surrounding development that is supportive of transit service (e.g., in density, pedestrian orientation, and land use mix)
- Encouraging a pattern of development with a dense network of streets and pedestrian rights-of-way that enables pedestrian activity
- Improving pedestrian and bicycle connections to and from the park-and-ride facility
- Creating a visual focal point at the park-and-ride facility (e.g., a clock tower or similar unique elevated element)

- Utilizing open space to accentuate the park-and-ride facility, upgrading streetscapes to make them more interesting to the pedestrian via improved landscaping, paving techniques, public sculpture and art
- Making the intermodal transit facility within the park-and-ride lot a focal point for activity (e.g., provide the park-and-ride lot with a dual purpose, serving as both a transit center and a park-and-ride lot)
- Encouraging a land use intensity gradient, with the park-and-ride facility located near the center of the highest land use activity.



*The Park-and-Ride as a Focal Point for the CommunityæNorthgate Transit Center and Park-and-Ride, King County Department of Transportation, Seattle, Washington*



*On-Site Focal Point/IconæKaty/West Belt Park-and-Ride  
Houston METRO, Houston, Texas*

### *Identify Joint-Use Development Opportunities Related to Existing and Future Park-and-Ride Facilities*

In addition to encouraging transit supportive development in the surrounding community, a park-and-ride facility can be directly integrated into a larger development through the use of joint-use concepts. Such concepts suggest that a park-and-ride facility can be designed in conjunction with supporting land uses and activities directly attached to the transit-oriented facility.

Two types of joint-use park-and-ride facilities are the opportunistic joint-use lot and the planned joint-use lot. The opportunistic joint-use lot can be developed within existing public or private parking lots that demonstrate peak parking demands at times not typically associated with peak transit demand (e.g., movie theaters, churches, large shopping centers). By their name, these lots are opportunistic and difficult to plan on a consistent basis.

The planned lot involves a much more proactive approach that seeks out potential partners to develop prospective transit facilities. Such design processes demand a much higher level of planning and design attention. To maximize the opportunities for developing joint-use developments, the implementing agency should strive to:

- Identify opportunities to focus development at and around transit stations
- Review joint development options
- Consider redevelopment of existing facilities and privatization opportunities
- Utilize structured parking
- Encourage public communication

Land uses complementary to a park-and-ride facility can encourage pedestrian activity and be compatible with park-and-ride operations. Such land uses typically have minimal parking requirements, or their parking demand characteristics do not significantly conflict with the peaking characteristics of the park-and-ride operations. A partial list of some compatible land uses is provided in Exhibit 6.1. Once solicitation of individual land use types is begun, the implementing agency may well discover unique opportunities for additional integration. Particular design locations and various local conditions may also provide unique opportunities.

In seeking joint development opportunities, the basic design requirements for park-and-ride operation cannot be compromised. Basic design needs of the park-and-ride facility, as outlined later, must be maintained to provide efficient and effective transit access. Also, in selecting joint development candidates for inclusion in park-and-ride facilities, the planner should consider the primary market requirement for the candidate land use. Specifically, those businesses that rely primarily on convenience to generate market share will be more successful than those that rely primarily on other market factors. For example, all day child care facilities likely depend more on their reputation as a quality program than pure convenience in generating their market share. Since parents will typically have differing definitions of quality, such facilities may not add a substantial benefit to the park-and-ride facility. On the other hand, gas stations, shoe repair, and dry cleaning establishments are more dependent on convenience and accessibility and may more readily generate market share from the park-and-ride facility.

If allowed, market forces will determine the best joint use candidates for specific park-and-ride locations.

The planner can facilitate this natural market selection by simply allotting adequate space for joint development within the design of the proposed lot and by releasing requests

for proposals for joint development to the general business community. In this way, the business community will propose and define the best uses for incorporation into the proposed facility through a competitive process.



*Joint Use Park-and-Ride FacilityæHistoric Fire Station Located On-Site  
South Orange Rail Station Park-and-Ride, NJ Transit, South Orange, New Jersey*

## Exhibit 6.1 Compatible Land Use Activities

- Short-term day care or parent's-day-out facilities
- All-day, regular child care
- Convenience stores
- Video rental stores
- Pharmacies
- Dry cleaners
- Variety stores
- Small hardware stores
- Banks
- Photocopying
- Bakeries, small neighborhood grocery stores
- Shoe repair
- Post office
- Gas stations
- Auto repair facilities
- Restaurants, express food/delivery activities (e.g., take-out pizza kitchens)
- Public service offices (e.g., transit headquarters, utility offices, police and fire stations, community libraries, health and human resource offices, transit maintenance facilities)



*Joint Use Park-and-Ride FacilityæPolice Precinct in Transit Station  
South Orange Rail Station Park-and-Ride, NJ Transit, South Orange, New Jersey*



*Joint Use Park-and-Ride FacilityæEspresso Shop  
Northgate Transit Center and Park-and-Ride Facility*

### *Integrated Design Summary*

In describing potential joint development opportunities and community integration design concepts, it is hoped that an argument for community integration of park-and-ride facilities has been made. Community integration of transit facilities requires consideration of a number of criteria for “success” and an alternatives evaluation process that strives to maximize the benefits provided by the facility over all criteria, as opposed to focusing only on maximizing transit ridership as measured by parked vehicles. Thus, community integration of park-and-ride facilities requires the implementing agency to evaluate its goals in developing the park-and-ride facility as well as its opportunities within the development market.

## 6.3 Pedestrian and Passenger Facility Requirements

A park-and-ride facility consists of essentially three elements: facilities to accommodate the private automobile, passenger facilities, and pedestrian access space. For a park-and-ride facility to operate efficiently, all three elements must work in concert to provide a smooth intermodal transition from the private automobile to the transit system, via the pedestrian mode. In addition, other modes of access and egress must be accommodated within this three-part system.

Many factors must be considered when designing a successful park-and-ride facility. At the site-specific level, these include the general site layout, pedestrian circulation routes within the design, and the intermodal platform design. Each element is essential to providing a successful park-and-ride facility.

### *Park-and-Ride Facility Lot Layout Based on Pedestrian Access Needs*

The general layout characteristics of individual park-and-ride facilities will often be unique to the specific location for which they are being designed. However, two key concepts are paramount when developing a design to provide the maximum utility to its intended users:

1. Competing modes of access should be separated whenever possible, providing separate space for transit operations, private vehicle access, carpool formation, bicycle access and storage, pedestrian flow, and drop-and-ride activities
2. Pedestrian and transit modes should be elevated to be the primary design consideration in the layout and design of the facility

These two concepts should be the guiding principles in the design of pedestrian and transit interface facilities, as well as the overall layout of the park-and-ride lot.

### *Separation of Competing Modes*

Individual access and service modes should be organized within the park-and-ride facility to minimize conflicts and maximize the efficiency of the various operations. This can be achieved by providing separate access driveways for transit and non-transit modes and by providing separate access for short term drop-and-ride activities. A number of potential schematic layout concepts can be developed that provide these features. In selection of such design concepts, pedestrian access between the parking lot and the primary service mode (i.e., transit) should provide for convenient access with minimal walking distances (less than 152.4 meters (500 feet) is preferred). Acceptable walking distances for various applications are presented in Exhibits 6.2 and 6.3.

Exhibit 6.2  
Walking Distance Under Normal Conditions

Average High Capacity Transit Commuter	Average Commuter to Park-and-Ride Lot	Average Pedestrian	Mobility Impaired	Walking Distance	
				Under 300 m (750 ft.)	
				300 m (750 ft.) Average	
				152 to 305 m (500 to 1,000 ft.)	
				400 to 533 m (1,320 to 1,750 ft. or 1/4 to 1/3 mile)	

Source: Adapted from *A Guide to Land Use and Public Transportation*, Sno-Tran, December 1989

Exhibit 6.3  
Average Walking Distance in Meters (Feet)  
by Purpose and Population Size

Urbanized Area Population Size	Trip Purpose			
	Shopping	Personal Business	Work	Other
10,000 - 25,000	61 (200)	61 (200)	82 (270)	60 (190)
25,000 - 50,000	85 (280)	73 (240)	122 (400)	64 (210)
50,000 - 100,000	107 (350)	88 (290)	125 (410)	79 (260)
100,000 - 250,000	143 (470)	119 (390)	152 (500)	104 (340)
250,000 - 500,000	174 (570)	137 (450)	204 (670)	116 (380)
500,000 - 1,000,000	171 (560)	180 (590)	198 (650)	152 (500)

Source: Adapted from *Parking Principles*, National Research Council

Transit access for the site should be provided so that transit operations are maximized for efficiency. This may require a transit loop or drive-through area within the park-and-ride facility. It often requires allowance for a transit layover as well. Drop-and-ride activities (i.e., "kiss-and-ride") should not impede pedestrian paths or interfere with the visibility between the transit loading zone and the parking lot. Several prototype lot layouts are presented in Exhibit 6.4.

In an ideal design, pedestrian flow lines should not be blocked by landscaping or other impediments that would inhibit direct pedestrian access from the farthest point in the lot to the transit loading zone.

### *Pedestrian Pathways*

Pedestrian paths within the park-and-ride lot must be clearly distinguishable throughout the facility. Conflicts between pedestrians and automobiles and between pedestrians and transit vehicles should be minimized. Raised pedestrian paths and sidewalks are preferable to parking aisles, although raised paths are not always possible.

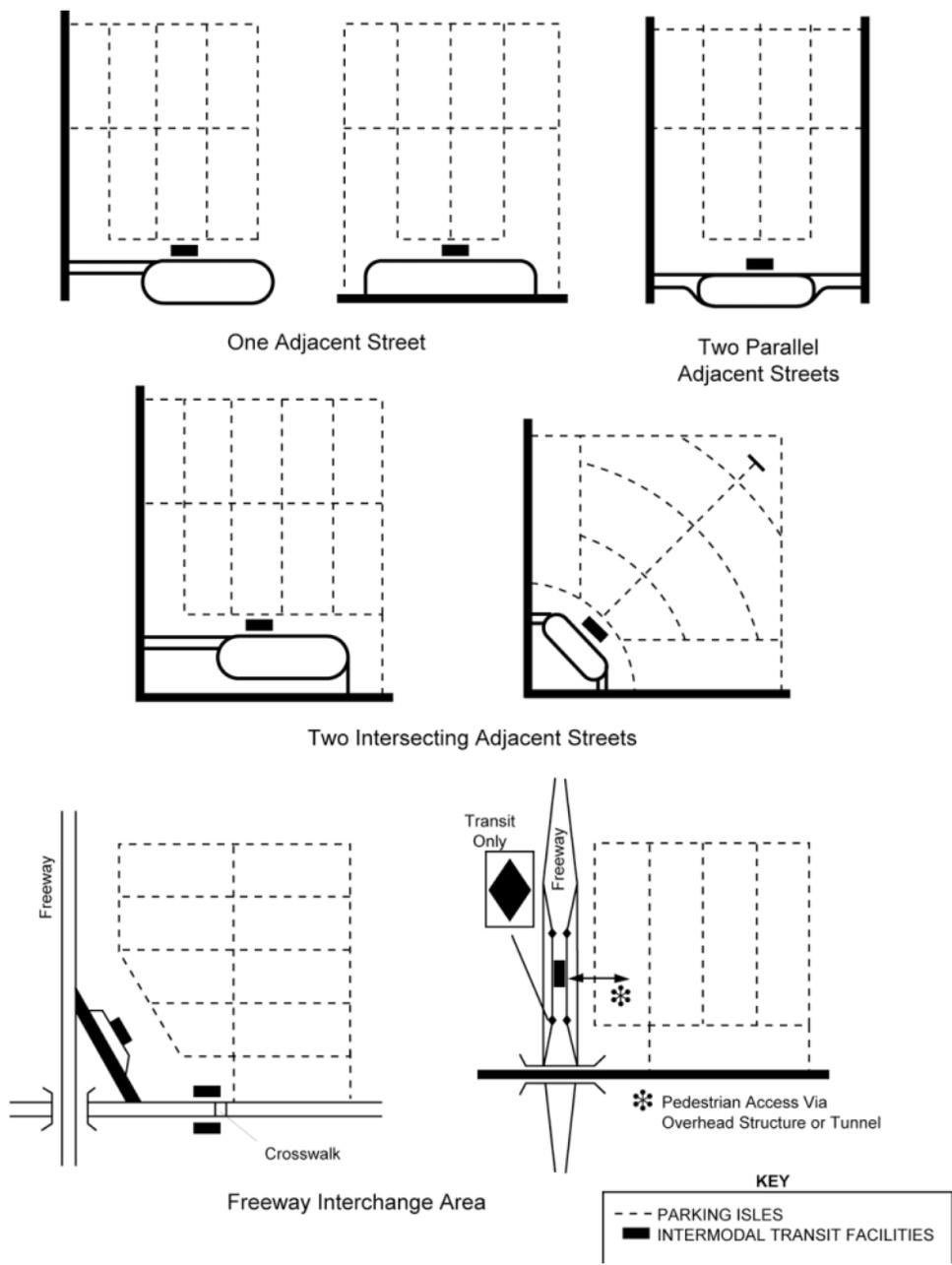
Pedestrian pathways should generally allow for direct travel between the point of entry into the park-and-ride lot and the transit loading area. In most cases, this can be achieved by orienting the parking stalls perpendicular to the transit boarding area. This allows pedestrians to use the aisles between parking stalls to walk directly to the boarding area. Alternatively, raised pedestrian pathways between facing stall rows can be provided for direct access to the boarding area. Parking stalls that radiate outward from the transit facility are even more preferable; however, this may prove difficult for parking patrons. For pedestrian paths crossing vehicle routes, the pedestrian pathways should provide maximum visibility. This can be done by either varying the pavement medium or by raising the pedestrian path above the driving surface. In the latter approach, the pedestrian path can be used as an enlarged traffic bump (or hump), raising the pedestrian above the paved surface and providing a traffic calming device as well (see Exhibit 6.5).

Pedestrian access between the transit loading zone and the farthest reaches (and specifically the outer street corners) of the park-and-ride lot should be examined. At these corners, pedestrian crosswalks are often provided for crossing adjacent streets, and patrons accessing the park-and-ride facility from these points will tend to walk directly from the corner to the transit facility, especially if their bus has just arrived. Every effort should be made to accommodate these movements. Elimination of barriers (such as landscaping) will minimize costly plant replacement due to pedestrians trampling shrubbery and will also increase pedestrian safety.

### *Pedestrian Waiting Areas*

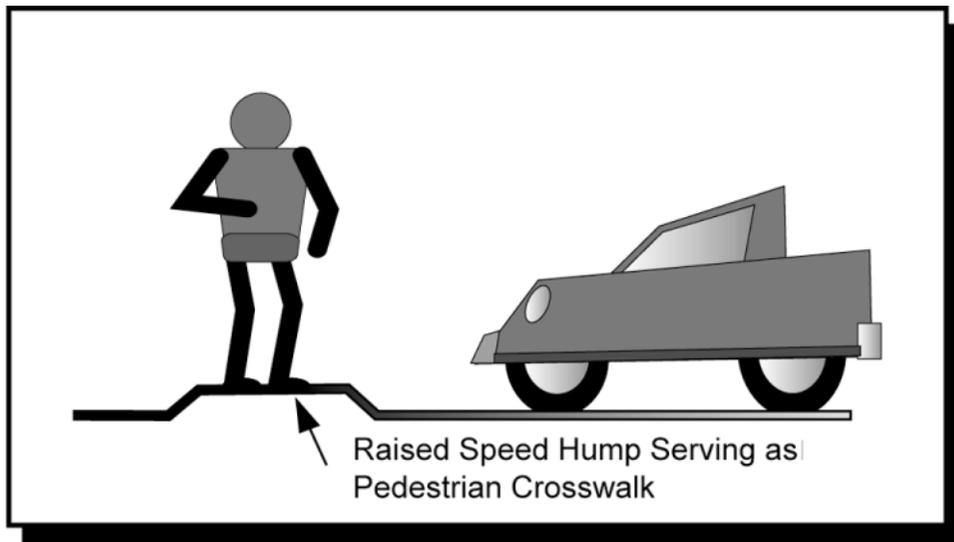
The intermodal transfer facility or boarding area also requires special attention within the park-and-ride facility. Curb spaces immediately adjacent to transit loading areas should be free of all barriers. Bus stop signs and street furniture, as well as other passenger amenities, should not interfere with transit loading, patron queuing, or pedestrian access.

### Exhibit 6.4 Prototype Park-and-Ride Facilities



Source: King County Department of Transportation and Various Parsons Brinckerhoff Design Studies

Exhibit 6.5  
Raised Pedestrian Pathway/Traffic Hump



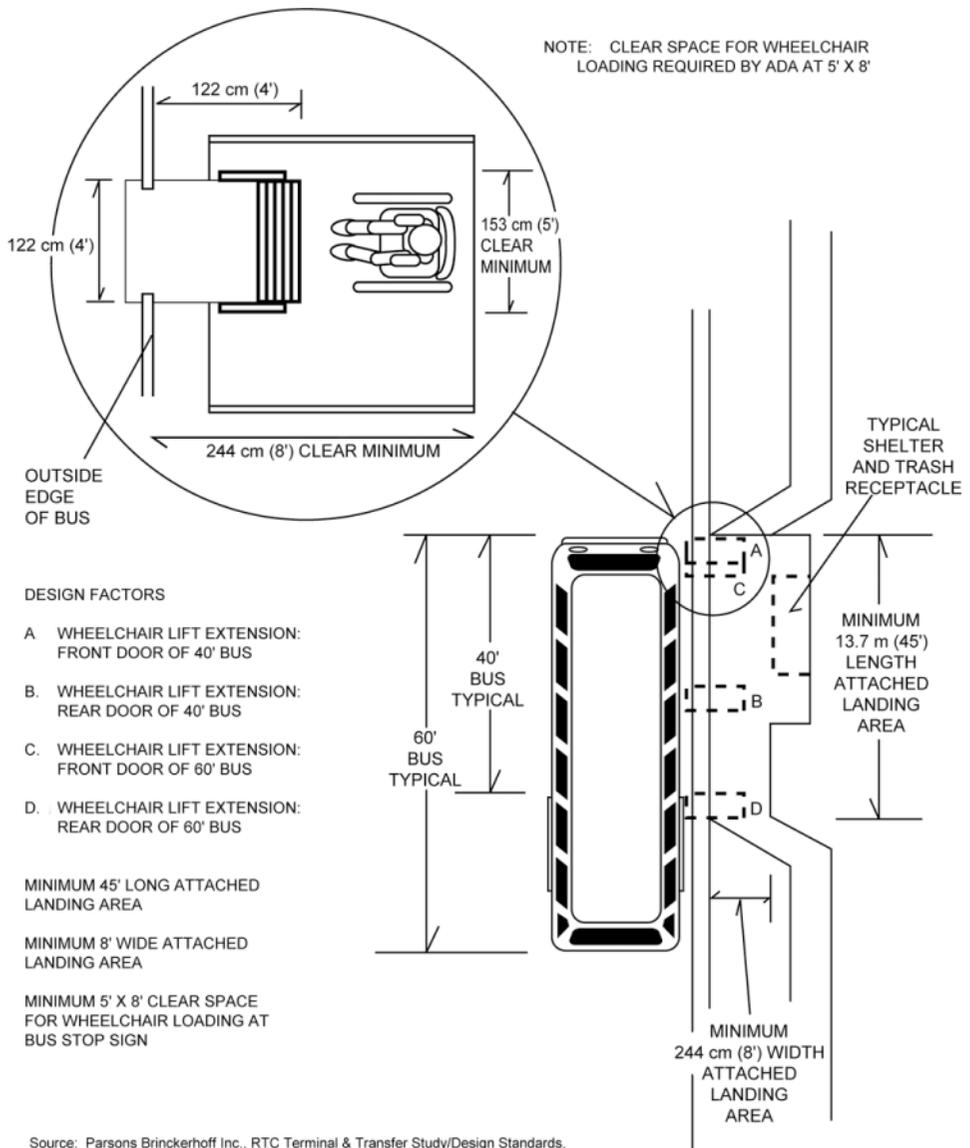
All pedestrian facilities must be designed to meet the requirements of the Americans with Disabilities Act. At a minimum, pedestrian spaces should be provided with wheelchair ramps and curb cuts, textured pavement surfaces, and a barrier-free path between handicap parking spaces and the transit terminal. Adequate space for full deployment and loading of vehicle lifts should be provided adjacent to each bus platform (see Exhibit 6.6). Additional amenities such as Braille signage and audible signals should be considered as aids to visually impaired patrons.

Passenger waiting and queuing areas should have a minimum of 1 square meter (10 square feet) per person, calculated for the peak pedestrian load expected, and based on the number and timing of transit vehicles serving the platform (42). Alternatively, if pedestrian demands are expected to be high, a pedestrian time-space approach can be used to analyze the space needed for the specific intermodal transfer operations occurring at the transit station (see *Pedestrian Time-Space Concept, A New Approach to the Planning and Design of Pedestrian Facilities, 1985 William Barclay Parsons Fellowship, Parsons Brinckerhoff Inc., Monograph 1*).

The minimum pedestrian space developed either through the minimum standard of 1 square meter (10 square feet) per person or through a time-space analysis should be in addition to space allotted for public amenities, information kiosks, newsstands, etc. Paving surfaces should provide good traction to reduce the risk of slipping and falling. Smooth, high polished surfaces should not be used in wet climates. Pavement textures, colors, and paving block shapes should be varied to provide a more interesting pedestrian environment and a unique identity to a station or park-and-ride location, and to delineate restricted areas.

Varied paving textures can also be used to organize the pedestrian waiting areas to encourage efficiency in pedestrian boarding operations.

### Exhibit 6.6 Wheelchair Loading/Lift Requirements

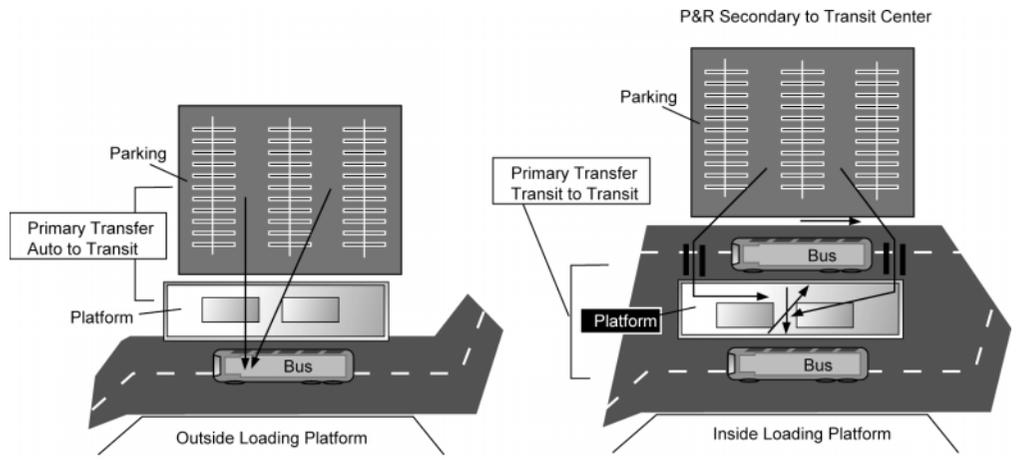


Source: Parsons Brinckerhoff Inc., RTC Terminal & Transfer Study/Design Standards, Regional Transportation Commission of Clark County, Washington, August 1994

The location of the passenger facilities should be determined by several factors, including: access constraints, the need for on-street or off-street location, and the transfer demand expected. For the typical park-and-ride facility, the pedestrian shelter or canopy should be placed between the parking lot and the transit access roadway. Transit vehicles should generally circulate counter clockwise so as to minimize the need for passengers to cross transit pathways. As transit-to-transit transfer demand increases (such as in the case of a transit center coupled with a supporting park-and-ride facility), a center island design concept should be considered to minimize the hazards to transferring passengers. In this latter case, the transit vehicles should circulate in a clockwise manner so that vehicle doors are presented to the inside platform. In choosing either an inside island or outside loading configuration, the goal is to reduce, as much as possible, the total likely number of pedestrian crossings of bus paths (see Exhibit 6.7).

As far as the design of the pedestrian shelter or canopy, consideration of the prevailing weather conditions and environmental surroundings should be included in the facility design. For example, in Houston, where temperatures are generally high and rain storms are often characterized by violent thunderstorms, large sheltering canopies are typically considered along with covered walkways in the design of major park-and-rides to provide for maximum protection from the elements. On the other hand, in locations where other environmental considerations such as snow/cold temperatures are a concern, more sheltering designs should be considered.

### Exhibit 6.7 Passenger Facility Location



\* Note: The structures shown on the loading platform may be either minimal transit structures or major architectural type facilities. They may consist of a single canopied/building structure or multiple individual shelter units.





*High Canopy Shelter Design to Allow for Air Flow in Hot Climate  
Gessner Park-and-Ride, Houston METRO, Houston, Texas*



*Enclosed Passenger Shelter to Protect Passengers in Colder Climate  
Olympia Transit Center, Olympia, Washington*

### *A Safe Environment*

Another important concept in providing for the pedestrian is to assure a safe and secure environment within the park-and-ride facility. Safety and security are essential if a park-and-ride facility is to be successful. Both safety for the passengers accessing the facility, and security for parked vehicles during the day, are crucial to success. Numerous techniques for assuring a level of real and perceived safety are available, ranging from design approaches to surveillance and control.

Providing a "defensible space" is a concept that encourages public areas to be designed in a manner that provides a sense of personal safety, while discouraging opportunities for criminal activity (45). A defensible space design can be achieved through specific design options, as well as through policy implementation, such as increasing police presence and community activity within the lot. Important concepts in developing a defensible space include:

#### *Design for a Defensible Space*

1. Provide a direct and unobstructed view of major destination points.
2. Encourage adjacent land uses and businesses to maintain large windows facing the park-and-ride facility, creating a perception of the lot being under visual inspection at all times.

3. Choose landscaping and street furniture that do not obstruct the view of the lot from the street.
4. Minimize the expanse of the lot, so that the entire lot can be seen from the transit interface location.
5. Locate or design the park-and-ride facility to be an integral part of the surrounding community so that it does not become isolated.
6. Provide adequate illumination on-site.
7. Locate on-site passenger amenities so that they maximize the comfort and accessibility for the patron while not obstructing sight lines from adjacent streets.
8. Provide adequate signage, both on-site and on surrounding streets, to identify the facility and the regulations protecting it.



*Designing a Defensible Space: Store Front Facing Park-and-Ride Facilityæ  
Shoreline Park-and-Ride, King County Department of Transportation, Shoreline,  
Washington*

### *Encourage a Police or Security Presence Within and Around the Park-and-Ride Facility*

1. Establish a policy of frequent police drive-throughs
2. Provide space for a police substation or police information and community outreach center within the design of the park-and-ride facility
3. Provide emergency and/or pay telephones within the facility, with clearly identified emergency procedures
4. Provide a continuous police presence in the form of a security guard, observation cameras, etc. (see subsequent items)
5. Encourage and support a community "Crime Stoppers" program in the vicinity of the park-and-ride facility, with the transit operator a participant in the program
6. Provide space for mobile vendors to access the site (e.g., book mobiles, rummage donation vehicles, etc.) to create a sense of on-site activity



*Designing a Defensible Space: Security Camera in Park-and-Ride Lotæ Northgate Transit Center & Park-and-Ride, King County Department of Transportation, Seattle, Washington*



*Designing a Defensible Space: Community "Crime Stoppers" Programæ Howard Beach Park-and-Ride, New York City Transit, Queens, New York*



*Designing a Defensible Space: On-Site Security Parking Attendant Officeæ  
Gessner Park-and-Ride, Houston METRO, Houston, Texas*



*Designing a Defensible Space: On-Site Security Toweræ  
Howard Beach Park-and-Ride, New York City Transit, Queens, New York*

### *Increase Activity Within the Facility*

1. Provide activity-generating services on-site
2. Concentrate activity into defined visible areas
3. Establish off-hour waiting areas
4. Provide windows to look onto pedestrian pathways
5. Encourage employees in surrounding businesses to maintain surveillance of the site

6. Schedule routine maintenance activities at the park-and-ride lot during off-peak periods (e.g., during the middle of the day and evenings)
7. Use the park-and-ride facility for midday layover and transfer operations
8. Encourage round-the-clock service
9. Encourage a community sense of ownership for the park-and-ride and transit facility



*Designing a Defensible Space: On-Site Bakery and ShopsæSouth Orange Station  
NJ Transit, South Orange, New Jersey*



*Designing a Defensible Space: On-Site Police PrecinctæSouth Orange Station  
NJ Transit, South Orange, New Jersey*

### *Consider Implementing Security Devices*

1. Consider providing surveillance cameras, protected from tampering and linked to a remote surveillance site
2. Consider providing voice activated, two-way communication between the main pedestrian and passenger loading areas and the security patrol, via security camera
3. Consider providing on-site security patrol during peak and off-peak periods
4. Assure that all pedestrian and driveway access to the park-and-ride lot can be controlled to minimize or eliminate unauthorized activity
5. Provide fencing and pathway bollards to control vehicle and pedestrian access
6. Provide warning signs advising patrons to remain cautious
7. Establish a strict enforcement policy of arresting and removing unauthorized users of the park-and-ride facility, based on local trespass laws (50)

### *Other Non-Motorized Modes of Access (Bicycles)*

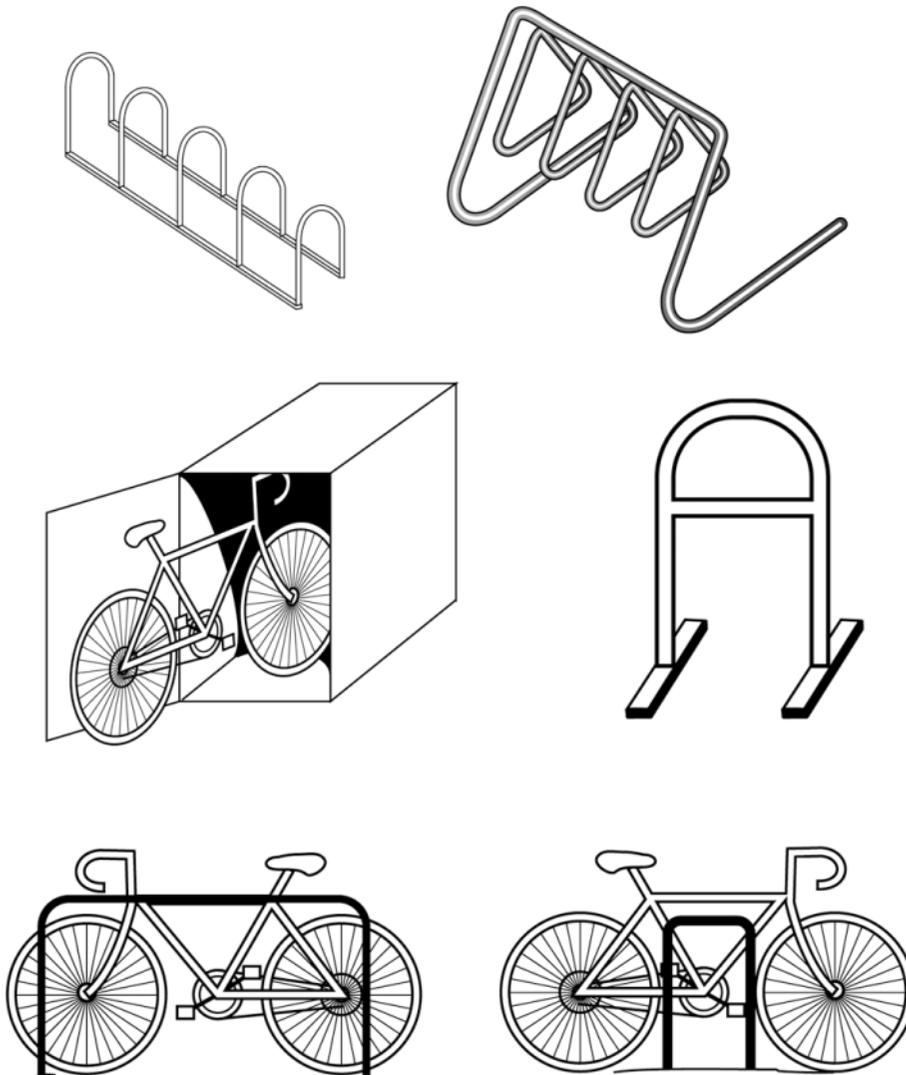
In addition to the traditional pedestrian mode of access, there is at least one other important non-motorized mode of access that should be actively planned for and incorporated within the design of the modern park-and-ride lot: bicycle access. The bicycle is becoming a more and more important element of the American transportation system. The bicycle fills the gap between pedestrian access and auto access, typically serving average commute trips of approximately 5.6 Km (3.5 mi.) or greater (57). Planning for proper storage and access of bicycles at the park-and-ride lot is important not only to support this mode of access, but to prevent damage to the transit facility by improperly stored bicycles. Lack of adequate bicycle storage and security devices can lead some bicyclists to chain their bikes to support posts, pedestrian hand rails, and trees, leading to significant damage and maintenance costs for the facility.

Example bicycle racks and storage facilities are presented in Exhibit 6.8. Devices chosen should:

- Support the frame of the bike
- Allow at least one wheel along with the frame to be locked to the rack
- Allow the cyclist the option of using either a U-lock or cable with padlock
- Be easy to understand without instruction

Bike lockers are typically preferred to bike racks as they provide maximum security and protection from the elements. Bike lockers can be leased or assigned to individual cyclists to control misuse of devices.

Exhibit 6.8



NOTE: These represent generic designs. Unique bicycle storage designs can be developed providing artistic/architectural qualities.

Source: Parsons Brinckerhoff Inc., RTC Terminal & Transfer Study/Design Standards, Regional Transportation Commission of Clark County, Washington, August 1994.

Bicycle racks and lockers should not block pedestrian or auto traffic. They should be situated so that they maximize the visibility of the storage area to deter criminal activity. If the park-and-ride lot provides on-site retail services or other type of activity generating use, bike storage facilities should be placed near these secondary uses to take advantage of the all-day surveillance opportunity provided by them. Bicycle racks also provide an ideal opportunity for use as artistic elements through a unique design (see Chapter 7).



*Bicycle Storage LockersæBC Transit  
Vancouver BC, Canada*

## *Pedestrian Design Summary*

Important topics to consider when designing for the pedestrian include:

- Separation of competing modes
- Provision of pedestrian pathways
- Provision of pedestrian waiting areas
- Provision of a safe environment
- Accommodation of other non-motorized modes.

Attention to pedestrian-related details will make the park-and-ride facility less of an intrusion on the surrounding community and help to develop a sense of community ownership in the facility. Attention to pedestrian details can also help to orient the facility towards a developing pedestrian market, rather than encouraging continued reliance on the private automobile.

## 6.4 Providing for the Transit Vehicle

Transit service provided to the park-and-ride lot will determine many of the design parameters of the facility. Transit service and access to the lot is of equal importance to pedestrian access. Specific transit design parameters for individual park-and-ride facilities will depend on the vehicles accessing and serving the park-and-ride lot and the on-site transit operations requirements.

### *The Transit Design Vehicle*

For roadway design, the local transit operating stock should be examined for critical design characteristics, as these will control the dimensions of the roadway and the vehicle envelope required to maintain a safe and efficient intermodal environment.

A survey of a number of North American transit agencies was conducted and design vehicle dimensions collected for a variety of bus types (see Exhibits 6.9, 6.10, and 6.11). It should be noted that the local transit agency must be consulted before choosing a specific design vehicle to assure that the transit vehicles expected to serve the proposed park-and-ride facility are properly represented.

Bus bay widths, bay configuration, and lane widths are all controlled by the lateral width and turning maneuverability of the transit coach. Transit vehicle widths also dictate the setback of patron amenities and structures. In evaluating transit vehicle widths and the need for patron amenity setbacks, it is important to consider the need to reserve platform space for deployment of on-board wheelchair lifts (see Exhibit 6.6).

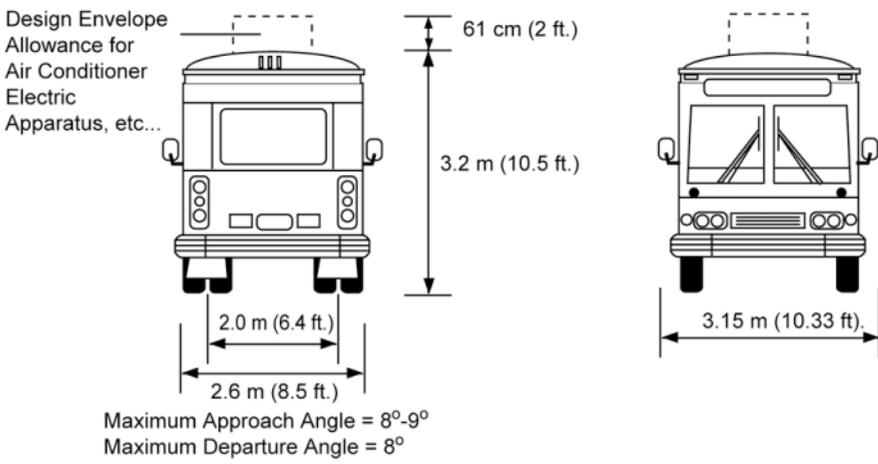
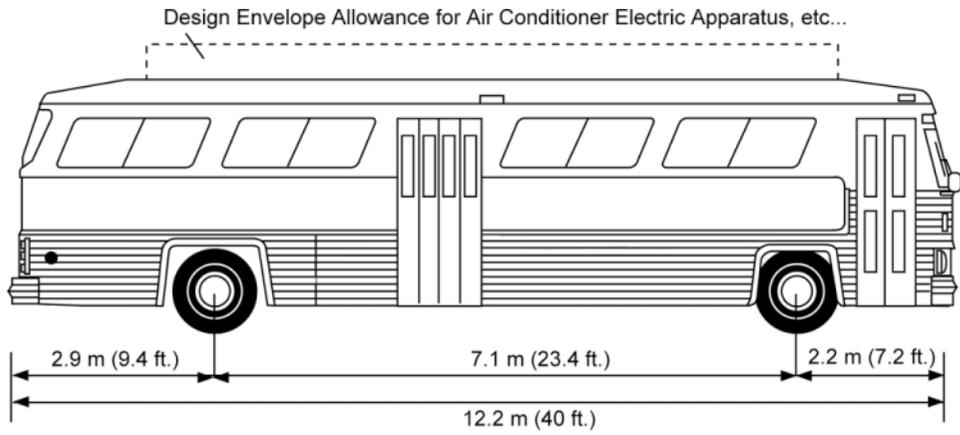
Bus heights are important in determining minimum clearances for vertical design elements. Pedestrian shelters, landscaping elements such as trees, and overhead walkways all must be designed with minimum bus clearances in mind. The critical design height will typically be the tallest transit vehicle to access the site. Approach and departure angles must be included in the calculation of critical height when considering clearances on sloped roadways.

### *Transit Vehicle Maneuverability and Access Requirements*

Transit vehicle maneuverability is an important element in the design of roadway and transit access elements of the park-and-ride facility. In designing for a park-and-ride lot, the access route between the primary travel corridor and the lot should be considered as a single system, along with the park-and-ride facility, for design and operations. Maneuverability issues include:

- Turning radii and the design of adequate curb returns
- Acceleration capabilities of transit vehicle and maximum negotiable grades
- Provision of adequate clear sight distances at intersections

Exhibit 6.9  
Typical Non-Articulated Transit Bus



Note: All dimensions are nominal and represent a composite of several vehicles. Specific vehicle dimensions for the expected design vehicle should be used for final design.



**Exhibit 6.10  
Typical Articulated Transit Bus**

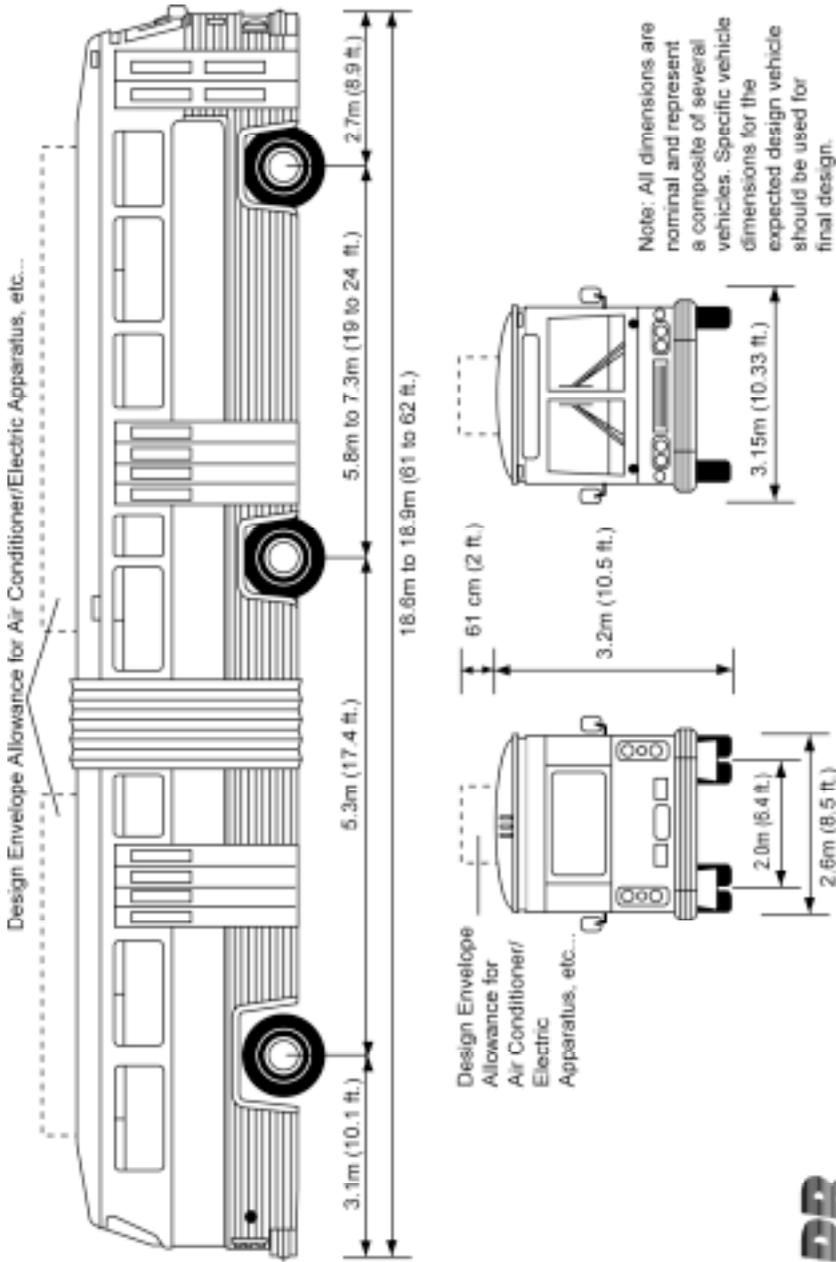
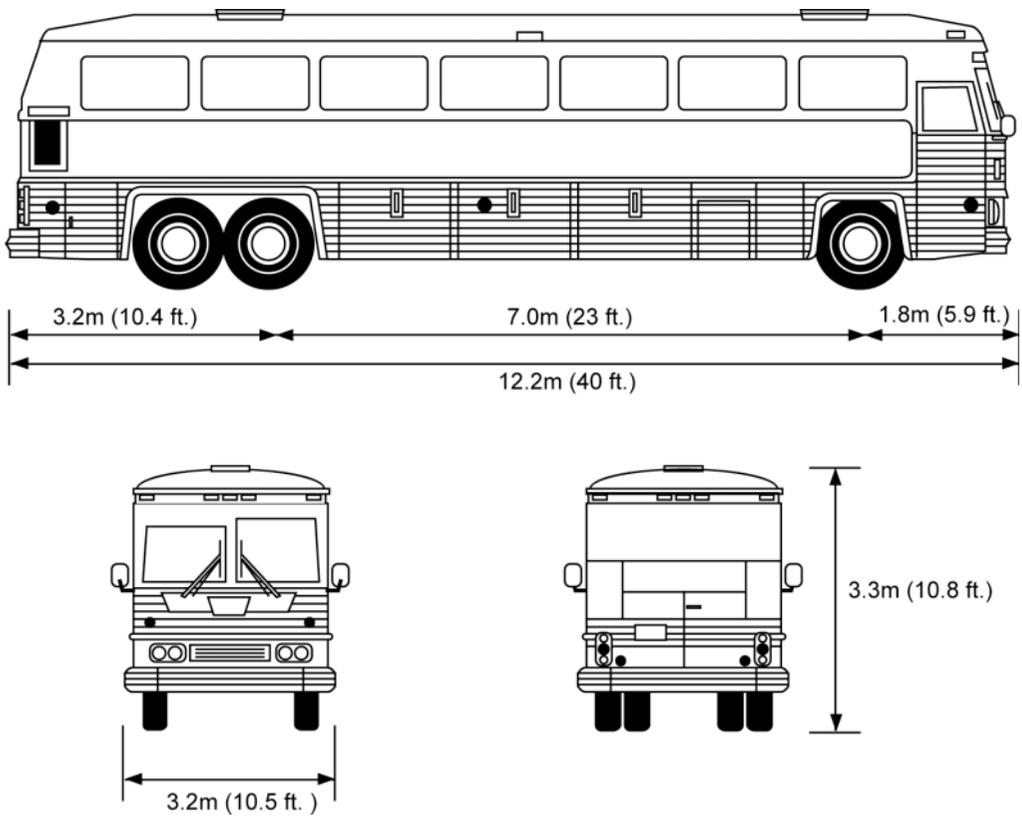


Exhibit 6.11  
Over-the-Road Coach



Source: Southwestern Michigan Transportation Authority

## *Turning Radii and Design of Curb Returns*

In considering the turning movements of transit vehicles within the park-and-ride facility and in designing curb return radii at entrances and exits, the designer must consider the more blocky design of modern transit buses. The increased front and rear overhangs will track considerably wider than the wheels. Likewise, the longer wheel base will necessitate wider turns.

Turning radii for average transit vehicles are presented in Exhibits 6.12, 6.13, 6.14, 6.15, and 6.16. Based on the turning maneuverability of the transit vehicle a minimum curb radius of 40 feet is recommended for streets and driveways with 3.7 meter (12-foot) lane widths. This will allow a standard bus (non-articulated or articulated: 35-, 40-, or 60-foot version to make a 90 degree turn with minimal encroachment on adjacent lanes at minimum vehicle speeds (i.e., creep speeds). This assumes that parking is not allowed on the adjacent arterial onto which the bus would be turning. If, on the other hand, parking is allowed on the street accessing the park-and-ride facility, the minimum curb return can be reduced to 10.7m (35 feet), taking advantage of the additional street width provided by the parking lane. In the second example, parking restriction within 9.2m (30 feet) of the driveway exit would be required to accommodate the transit movement.

Compound curve radii can also be used in the design of driveway exits and entrances. Common compound curve return radii to accommodate transit movements are presented in Exhibit 6.17.

## *Acceleration and Maximum Negotiable Grades*

Because of their increased mass, buses require greater distances to accelerate to required travel speeds, and likewise, greater distances to break and stop. The design of on-ramps to freeways and other arterials serving the park-and-ride lot should incorporate appropriate allowances for the reduced maneuverability of this vehicle.

Typically recommended maximum grades should not exceed 12 percent, with a preferred maximum design grade of about 8 percent. However, the length of grade and the horse power of the transit vehicle are also critical in the design consideration. Electric buses will tend to have greater hill climbing ability; however, they are not typically used in park-and-ride services because of their need for overhead electrification and inability to reach highway speeds.

Except for very short distances, grades of 5 percent or greater should generally not be allowed on roadways serving the park-and-ride facility without taking into account the impact on schedule and operating costs. Stops on either the up-hill or down-hill direction should generally not be allowed on grades of 5 percent or greater due to the added effort required to start and stop under such conditions.

Evaluations of grades should be considered both within the lot and on the streets providing direct access to the lot. If the lot is to be located on an arterial or minor street at some distance from the primary travel corridor, the entire route between the proposed park-and-ride facility and the primary travel corridor should be examined for grade considerations.

## Exhibit 6.12 Recommended Design Criteria for Turning Radii by Speed

Minimum Speed	Movement Operation	Typical Location	Applicable Template
5 MPH	Turning after stop or turning to stop	At bus stop or bus bay	Exhibit 6.13
7 MPH	Turning after slowing down from 10 MPH Turning during acceleration	At bus loop at park-and-ride or transit center	Exhibit 6.14
10 MPH	Turning after slowing down from 15 MPH Turning after acceleration	At bus loop at park-and-ride and transit center	Exhibit 6.15
15 MPH	Turning after slowing down from 30 MPH Turning after acceleration	Entering or exiting HOV or freeway ramp	Exhibit 6.16

Source: *Design Criteria for METRO Park-and-Ride and Transit Center Facilities*, Metropolitan Transit Authority of Harris County, Texas (Houston METRO), Houston, Texas, November 1992

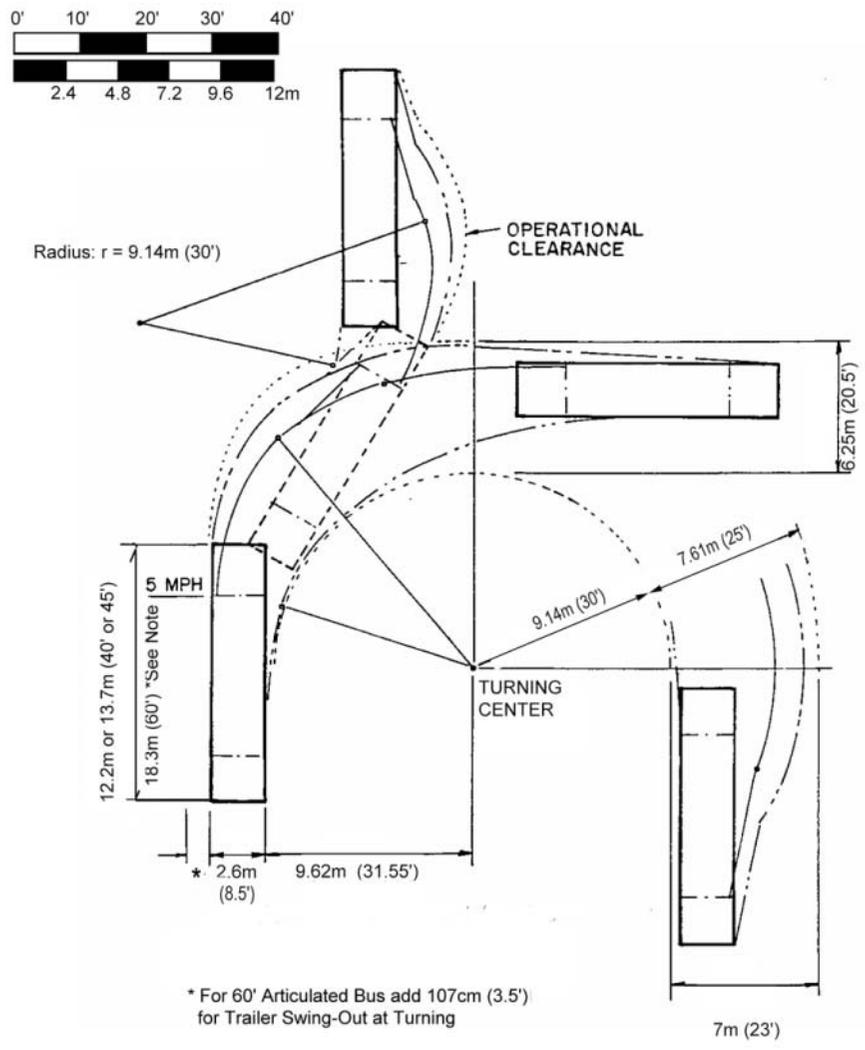
### *Adequate Clear Sight Distance*

The design of the park-and-ride facility, and especially the entrances and exits to the lot, should not allow for unnecessary obstruction to clear lines of sight. Landscaping and natural vegetation should be kept pruned and other physical barriers minimized or removed.

For each driveway exit, the required clear sight zone will be determined by the critical vehicle using the driveway and local street and roadway standards. For driveways used primarily by transit, the transit vehicle should be held as the critical design vehicle because of its slower acceleration capabilities. Minimum safe sight distances of approximately 61m (200 feet) should be maintained, assuming a 48 kmh (30 mph) average travel speed on the intersection arterial. At 48 kmh (30 mph), a 61m (200-foot) clear sight standard allows for a minimum vehicle gap acceptance of approximately 4.5 seconds.

On-street parking should be restricted within 9m (30 feet) of all street or driveway intersections surrounding the park-and-ride facility. This restriction should apply to both the internal park-and-ride roadway network and to the arterials serving the park-and-ride facility and connecting it to the primary travel corridor.

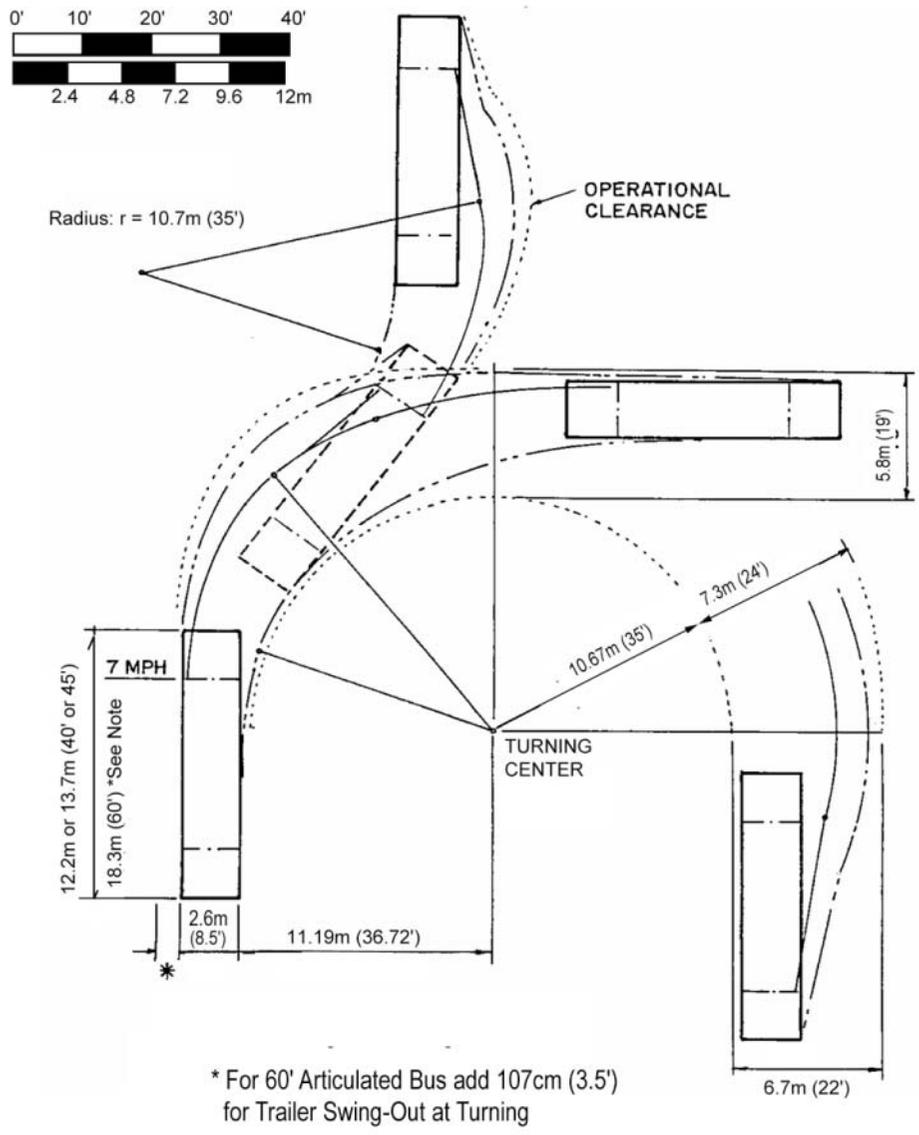
Exhibit 6.13  
Transit Turning Template  
5 mph



Source: Design Criteria for Metropolitan Transit Authority of Harris County, Texas (Houston METRO), Houston, Texas, November 1992.

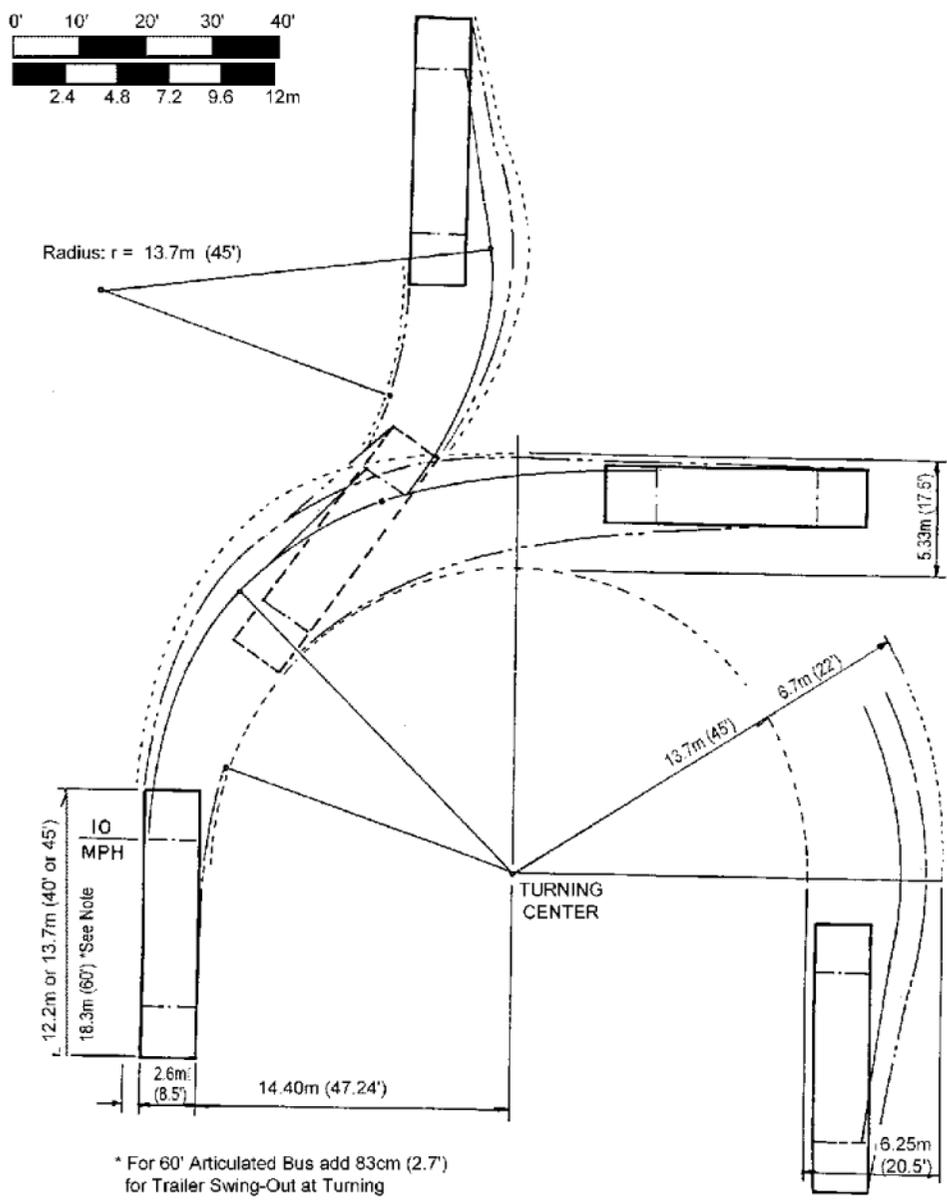
**NOTE: The author is not employed with Parsons Brinckerhoff. This monograph is for reference/research purposes only and not for distribution.**

### Exhibit 6.14 Transit Turning Template 7 mph



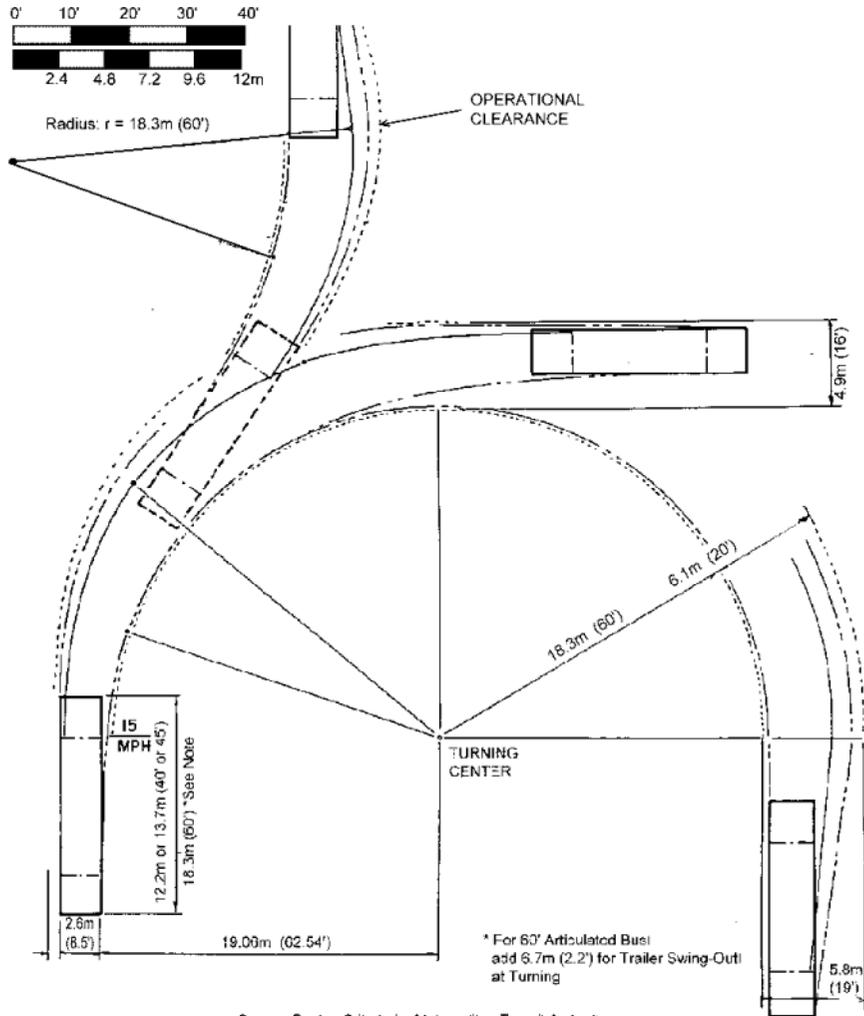
Source: Design Criteria for Metropolitan Transit Authority of Harris County, Texas (Houston METRO), Houston, Texas November 1992.

Exhibit 6.15  
 Transit Turning Template  
 10 mph



**NOTE: The author is not employed with Parsons Brinckerhoff. This monograph is for reference/research purposes only and not for distribution.**

### Exhibit 6.16 Transit Turning Template 15 mph



Source: Design Criteria for Metropolitan Transit Authority of Harris County, Texas (Houston METRO), Houston, Texas November 1992.

Exhibit 6.17A  
Compound Curve Radii Recommended for Turns at Intersections  
(Assuming no Encroachment on Adjacent Lanes)

Angle of Turn (Degrees)	Compound Curve Radii (meters)	Offset (meters)
75	36.6-13.7-36.6	1.2
90	36.6-12.2-36.6	1.2
105	30.5-10.7-30.5	1.2
120	30.5-9.1-30.5	1.5
135	30.5-9.1-30.5	1.5
150	30.5-9.1-30.5	1.5
180	39.6-7.6-39.6	2.4

Exhibit 6.17B  
Compound Curve Radii Recommended for Turns at Intersections  
(Assuming no Encroachment on Adjacent Lanes)

Angle of Turn (Degrees)	Compound Curve Radii (feet)	Offset (feet)
75	120-45-120	4.0
90	120-40-120	4.0
105	100-35-100	4.0
120	100-30-100	5.0
135	100-30-100	5.0
150	100-30-100	5.0
180	130-25-130	8.0

*Source: Alameda-Contra Costa Transit District*

### *Bus Access and Parking Requirements*

Bus access should be separated from general auto access to the park-and-ride facility. Sometimes this is not entirely possible for the entire access route. However, the bus loading area should always be separated from general purpose traffic when the transit terminal is off-street. Pulse scheduling of independent routes will generally require the greatest number of bus bays at an individual transit facility. Pulse scheduling requires several routes to come together at a single transit facility, dwell and then leave the facility all at once (i.e., pulsing).

Transit coach parking space requirements will be based on the maximum number of transit vehicles requiring independent pull-in and pull-out space at the facility. If all coaches

operate independently and access the transit facility simultaneously, curb space sufficient to park all vehicles must be provided. On the other hand, a reduction in costs can be achieved if bus arrival and departure can be staggered and individual bus bays shared. Care should be used to assure the reliability of each intersecting bus route if staggered through a single transit center, especially if transfers are expected between routes.

Several bus bay configurations are applicable within a park-and-ride setting, including:

- Linear bays with each successive transit vehicle lining up single file
- Saw-toothed bus bays providing individual bays for specific routes
- Circular bus loops

Example design considerations for each of these bus bay types is provided in Exhibits 6.18, 6.19, 6.20, 6.21, 6.22, and 6.23.

Flexibility can be provided with the saw-toothed bay design by casting the bay teeth as movable paving segments on top of a crushed rock base. Thus, if transit operating stock changes over time, the transit platform can be reconfigured at little cost and time to meet the changing need.

### *Pavement and Cross-Section Requirements*

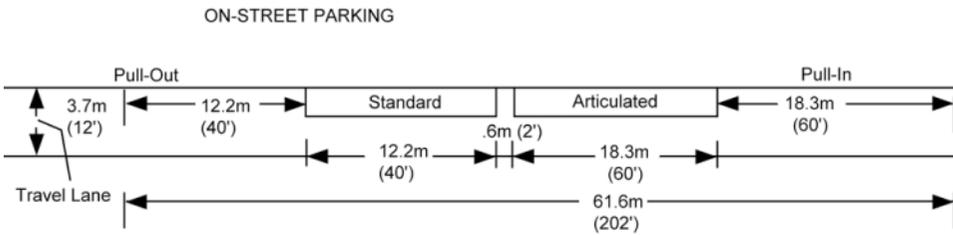
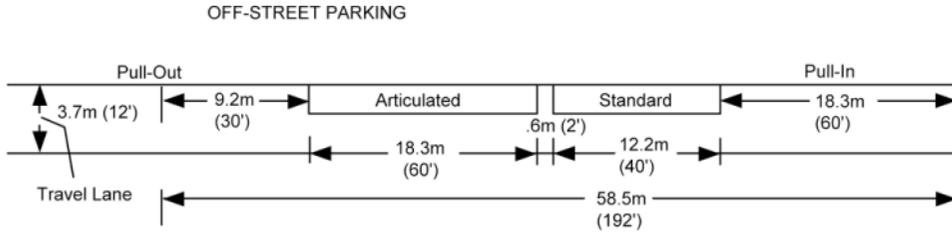
Cross-sectional design for bus related streets and on-site access roadways is important so as to reduce the hazard of water pounding and minimize discomfort and inconvenience to passengers. Adequate consideration of pavement design is required to minimize the long-term maintenance cost to the implementing transit authority and to minimize pavement surface degradation.

For both cross-sectional and pavement design, local standards should be referenced for specific conditional requirements and applicable codes. For cross-sectional design, a minimum of a percent cross-section slope is recommended, terminating in a curb and gutter design to allow for adequate drainage. In areas that typically receive substantial amounts of snow or frost, gutter and drainage system design should not create opportunities for icing in winter and subsequent drainage problems from melting snow. An example cross-section design is provided in Exhibit 6.24.

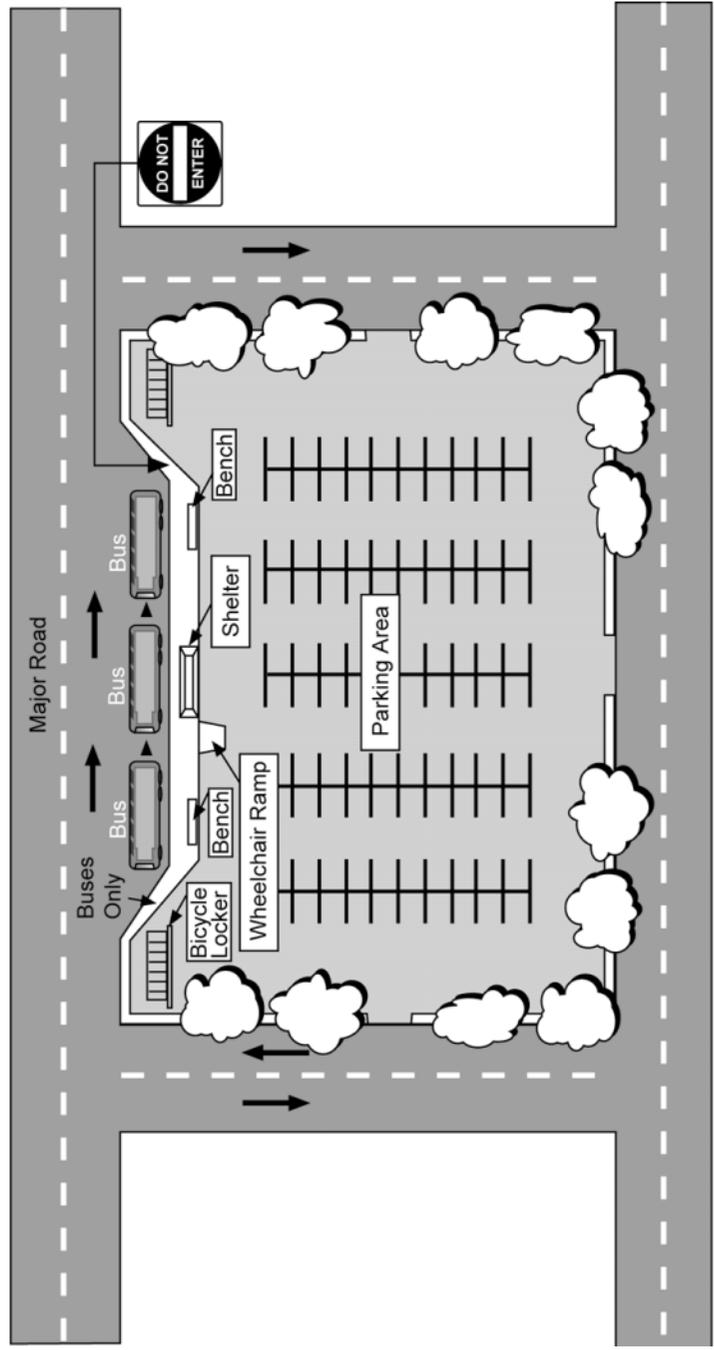
Pavement designs for bus facilities should account for the additional axial loads typically carried by transit vehicles (see Gross Vehicle Weights, Design Vehicle Section). At locations where transit vehicles are expected to stop and load passengers, a bus loading pad should be provided to accommodate the additional stresses exerted by the dynamic axial loads caused by stopping and starting.

**NOTE: The author is no longer employed with Parsons Brinckerhoff. This monograph is for reference/research purposes only and not for distribution.**

### Exhibit 6.18 Linear Bus Bay Design

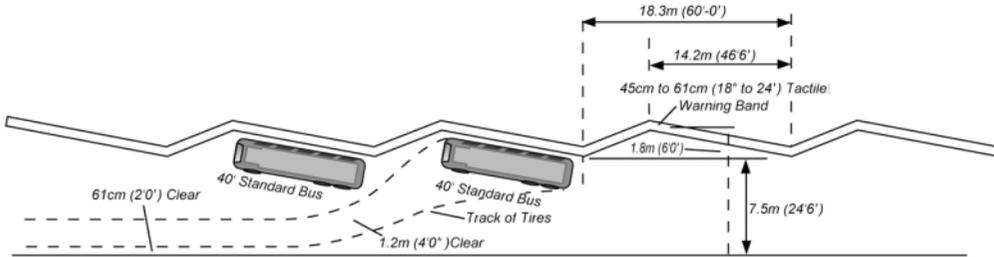


**Exhibit 6.19**  
**Linear Bus Bay Application**

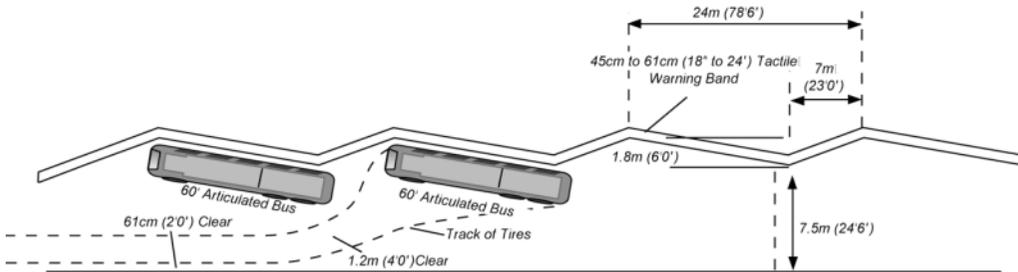


### Exhibit 6.20 Saw-Toothed Bus Bay Design

The best loading/unloading berth layout for buses is as follows:  
Saw-tooth berth for a 40' or 35' standard bus.



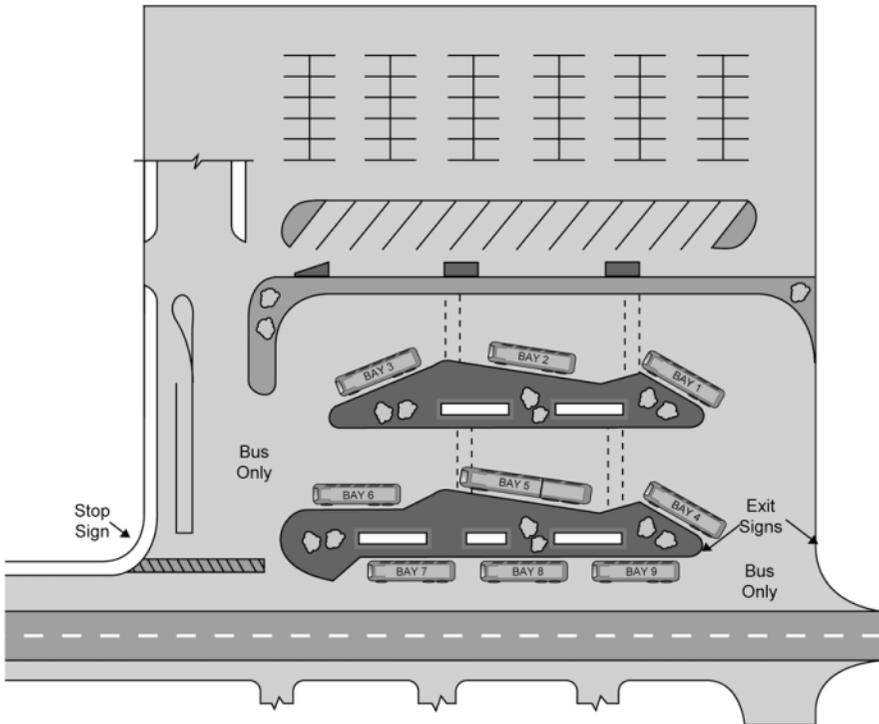
Saw-tooth berth for a 60' Articulated Bus



Saw-tooth berth design reduces passenger transfer distances and is preferred to a linear design.

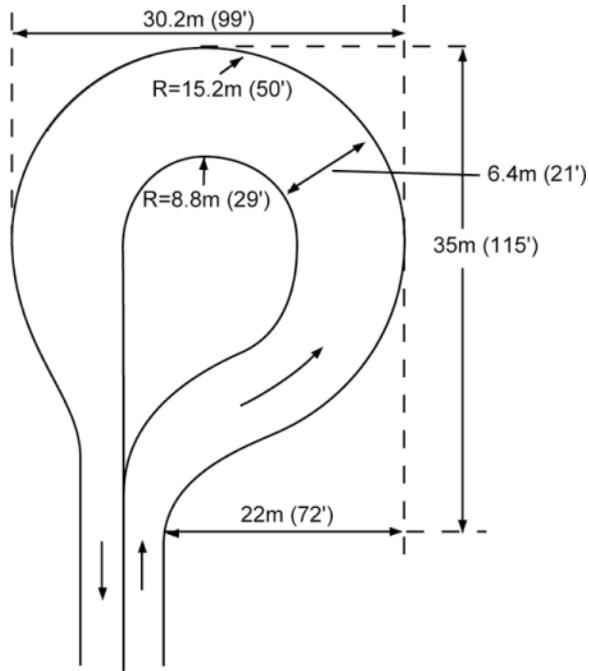
Source: Pierce Transit Design Criteria, Pierce Transit Centers Development Project,  
Parsons Brinckerhoff, Pierce Transit, Tacoma, WA.

Exhibit 6.21  
Saw-Toothed Bus Bay Application



Source: Metro Transportation Facility Design Guidelines,  
Municipality of Metropolitan Seattle, March 1991

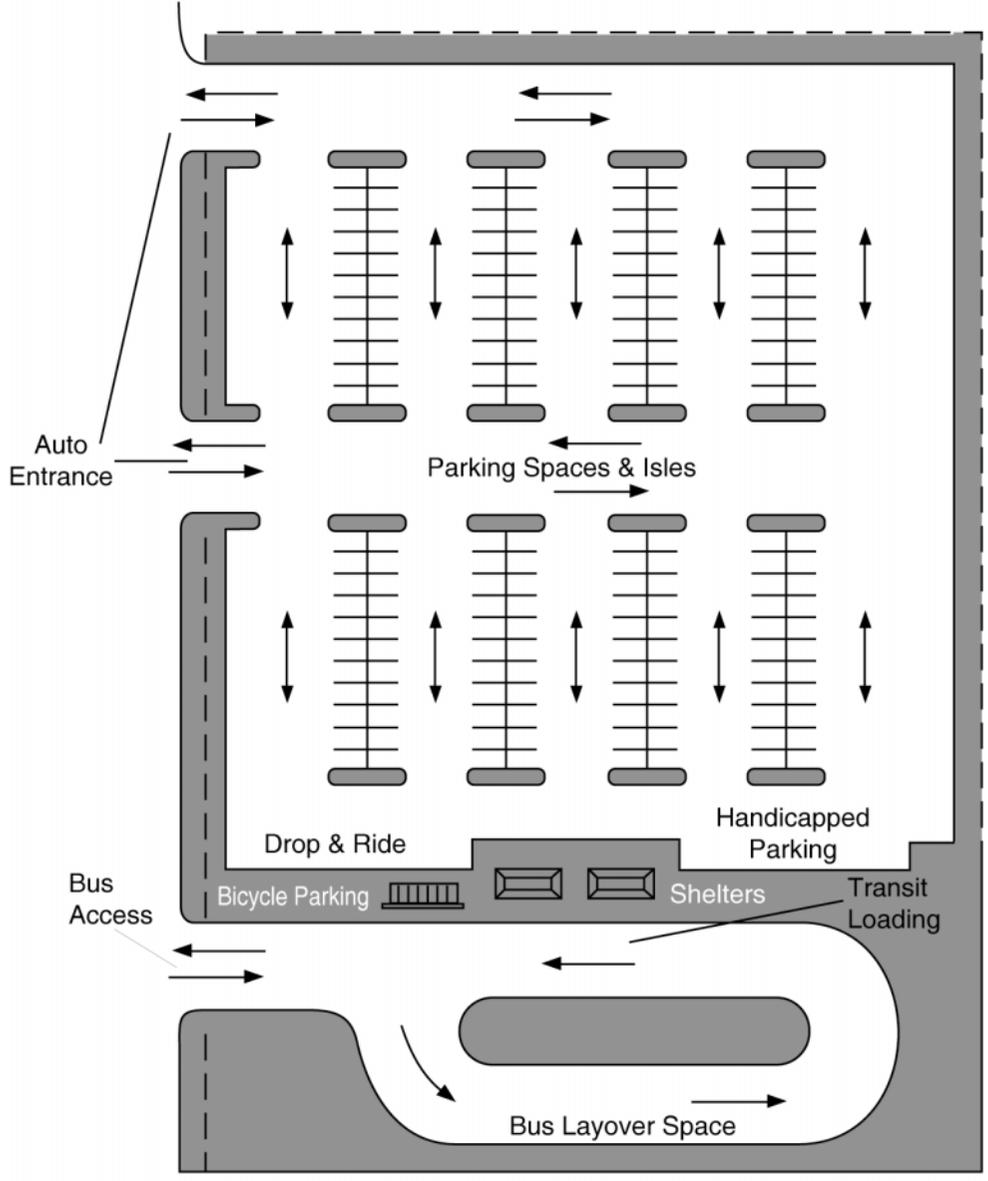
Exhibit 6.22  
Bus Loop Design



Source: Transit Facilities Standards Manual, Alameda-Contra Costa Transit District, Oakland, California, March 1983

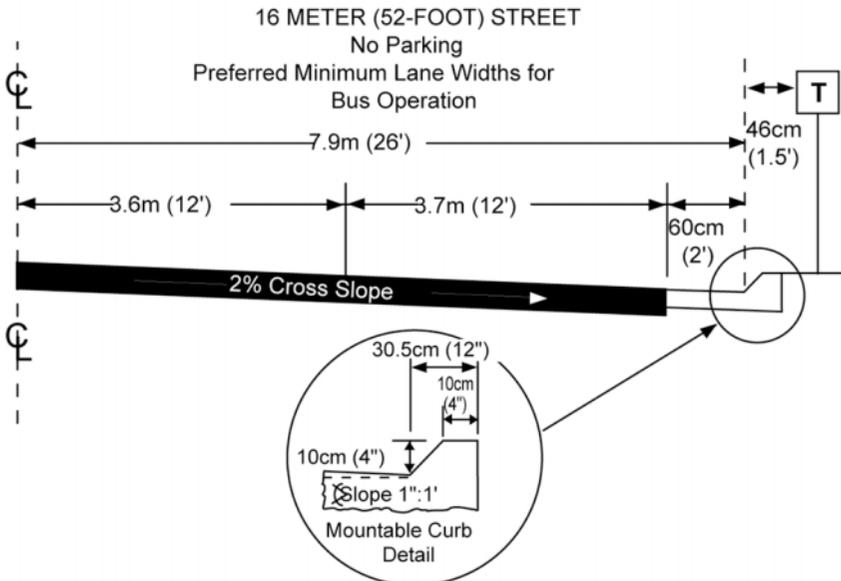
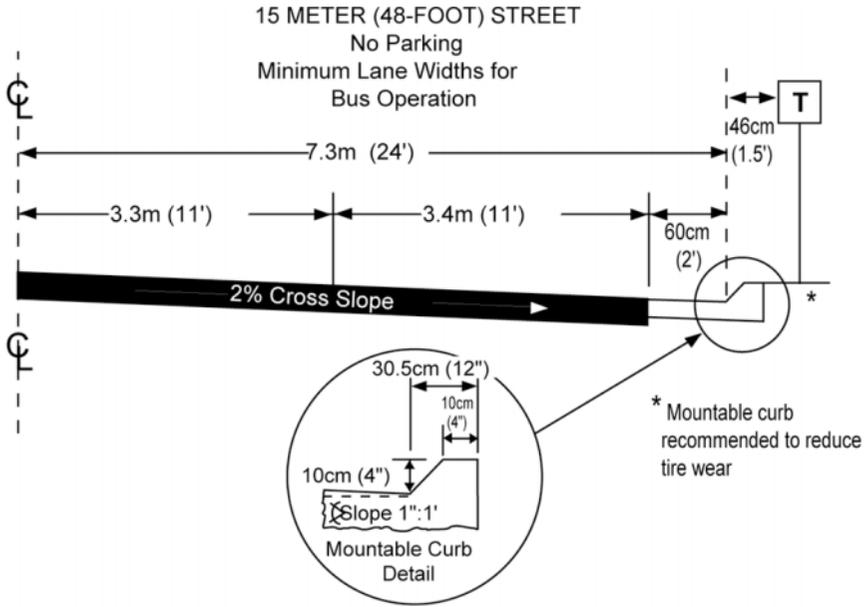
**NOTE: The author is no longer employed with Parsons Brinckerhoff. This monograph is for reference/research purposes only and not for distribution.**

Exhibit 6.23  
Bus Loop Application



*Adapted from: Metro Transportation Facility Design Guidelines,  
Municipality of Metropolitan Seattle, March 1991*

### Exhibit 6.24 Lane Widths for Bus Operations



Source: Transit Facilities Standards Manual, Alameda-Contra Costa Transit District, Oakland, California, March, 1983

Bus pads should be provided for layover spaces and transit boarding bays. A minimum of 20 to 23 cm (8 to 9 in.) of concrete on 5cm or more (2 or more inches) of crushed rock, depending upon base materials, or 5cm (2 inches) of asphalt on a 10.2cm (4-inch) asphalt treated base (ATB) and 4 inches of 1 1/4 inch crushed rock base, is recommended for all layover and stopping locations. The material actually used for bus pad construction (concrete or asphalt) should be consistent with materials used in other transit portions of the park-and-ride facility (42). Local design standards for bus pad facilities should be consulted, as well as consideration given to the specific transit vehicles accessing the proposed lot being evaluated, when considering design of a bus pad facility.

### *Other Operational Design Considerations*

Two other design considerations that should be incorporated within a park-and-ride facility are generated by the transit operations occurring on site. These include the need to provide layover space for scheduled down time and accompanying driver amenities. A layover is a scheduled time for which a transit vehicle dwells at a specific location for longer than is necessary to load passengers. Layovers can often be identified within a route schedule by location, as having both an arrival and a departure time listed.

**Layover Space:** Adequate space within the park-and-ride facility must be allowed for layovers, preferably a location separated from passenger loading bays. Buses using layover locations can reenter the internal transit stream and pick up passengers after the layover is complete. This will reduce passenger confusion and frustration with transit vehicles not leaving the park-and-ride transit stop promptly upon loading.

Dimensions for adequate layover space should be determined by the number of buses to be stored at the layover space and the physical dimensions of the critical design vehicle. The length of layover space required would also be determined by the scheduled overlap of layovers and by sight clearance requirements. Typical layover spacing requires:

- 12 to 18m (40- to 60-foot) layover length per dwelling transit vehicle
- 18m (60 feet) for pull in
- 12m (40 feet) for pull out (when buses are expected to merge with general traffic)
- 6m (20 feet) for pull out, 9m (30 feet) for articulated buses (when buses are able to enter a restricted lane (e.g., a bus-only lane at low speeds))
- 55m (180 feet) total for single bus layover
- 60cm (2-foot) clearance between buses
- 3.2m (12-foot) layover stall width (42)

**Comfort Stations:** Comfort stations for transit operators should be provided adjacent to the layover location and can be accommodated within a park-and-ride facility. It is generally preferable to provide separate facilities for transit operators for driver security and to limit schedule delays.

### *Designing for the Transit Vehicle: Concept Summary*

Design of adequate service roadways and facilities, both external and internal to the park-and-ride facility, are important to assure efficient transit access to the proposed facility and hence sufficient transit service. Important considerations include:

- Allowances for minimum horizontal and lateral bus clearances
- Allowances for minimum turning radii and curb returns
- Accommodation of acceleration needs and grade issues
- Provision of adequate clear sight distances
- Construction of adequate pavement bases
- Incorporation of appropriate roadway and driveway widths for transit operations

A summary of important design parameters is provided in Exhibit 6.25.

### Exhibit 6.25 Roadway Design Standards for Streets Associated with Park-and-Ride Facilities

Minimum Grade	0.5%
Maximum Grade	8.0%
Maximum Grade within 15.2 meters (50 feet) of Intersection	5.0%
Minimum Centerline Radius	91 meters (300 feet)
Minimum Tangent between Reverse Curves	46 meters (150 feet)
Minimum Curb Radii	12.8 meters (42 feet)
Minimum Pavement Width	8.5 meters (28 feet), no parking permitted; or 11 meters (36 feet), parking permitted on one side of street only; or 13.4 meters (44 feet), parking permitted on both sides of street

Source: (45)

## 6.5 Providing for the Private Automobile

It has previously been suggested that pedestrian and transit movements within the park-and-ride facility should be emphasized to assure successful community integration and efficient facility operations. The intent, however, has not been to suggest that the private automobile is an unimportant element to consider in the design of the park-and-ride facility. In fact, the private automobile, along with the transit element, is the primary mode for which the intermodal park-and-ride facility is being designed and often serves as a primary measure of effectiveness (MOE) for the facility (i.e., the number of vehicles using the facility is often a primary MOE for justification of the investment). Thus, in addition to providing a pleasing and safe environment for the pedestrian and efficient transit operations, the successful park-and-ride facility must provide adequate and secure parking facilities for the private auto.



*Park-and-Ride Lots and the AutomobileæHoward Beach Park-and-Ride Lot*

*New York City Transit, Queens, New York*

In terms of the private automobile, long-term or all-day commuter parking must be considered as well as short-term or drop-and-ride activities. Primary design considerations for these operations include:

- Provision of sufficient facility access
- Parking lot layout and stall design
- Vehicle security
- Illumination

### *Facility Type (Surface or Structured)*

In determining potential sites for park-and-ride facilities, consideration of a structured parking facility is critical. Accepting structured parking facilities as a potential design concept for a park-and-ride facility can provide a number of advantages to the implementing agency, including:

- A smaller parcel of land may be sufficient to provide required parking capacity
- Vehicle security issues can be better controlled by enforcing control of all entrances and exits
- Structured facilities provide a more permanent transit presence in the community
- Structured facilities can provide joint development opportunities for complementary land uses

Although construction and operation costs will vary by geographic location, construction of a parking garage generally cannot be justified if land costs are at or below \$15 per square foot. Garage construction will typically range between \$20 and \$30 per square foot (or between \$7,000 to \$12,000 per stall for aboveground structures) (33). However, these costs should be used only as a guide when considering various design options. They do not typically incorporate the full costs associated with constructing a park-and-ride lot in the public sector. Because public agencies constructing park-and-ride facilities are typically faced with limited opportunities to place a facility (and often these facilities have environmental limitations such as wetlands or limited access), the true cost of providing a surface lot may be comparable, if not more expensive, than a structured alternative. Also, opportunities for joint development, provided by occupying a smaller land area within a parcel, should be considered for their potential revenue contribution to subsequent parking and transit operations at the site as well as debt retirement. This is especially true if an existing park-and-ride facility can be increased in capacity by building a structured facility, resulting in land costs that are essentially zero.

In short, it is recommended that for a publicly funded park-and-ride sitting analysis in urban areas of greater than 50,000 population, a structured facility should be considered as an alternative, at least through the preliminary site selection and cost estimating

process. The structured alternative can always be dropped in favor of a surface lot design should the structured approach prove too costly.

### *Parking Layout and Stall Alignment*

Parking facilities within a park-and-ride lot should be designed in an easy-to-understand configuration that minimizes the time required to locate a parking space. The majority of parking spaces should be clearly visible from the major access points so that drivers can quickly identify if the lot is full or if space is available. If the lot is too large to allow visual identification of available spaces, a messaging system should be considered as an aid to the driver. Visibility from adjacent streets afforded by the design should be high. The design should be efficient in the way it relates to the parcel, providing opportunities for joint development, if appropriate, and the facility should complement the long-range community plan for the surrounding neighborhood.

In designing parking facilities for park-and-rides the goal is to provide a single continuous path for the commuter from the street to a parking space and to the transit platform with a minimum of conflicting barriers (see Exhibit 6.26). Maintaining this goal throughout the design process will provide a convenient and efficient parking facility.

### *Parking Stall Alignment*

Two primary components of parking stall design must be considered when determining the preferred design for a park-and-ride facility: parking angle and bay alignment.

Aligning the parking bay perpendicular to the intermodal transit platform allows pedestrian movement up the aisles to the transit boarding area, minimizing the need to cut between parked automobiles and the likelihood of access impediments such as landscaping. The consideration of parking stall angles will be a primary consideration in choosing a facility circulation pattern.

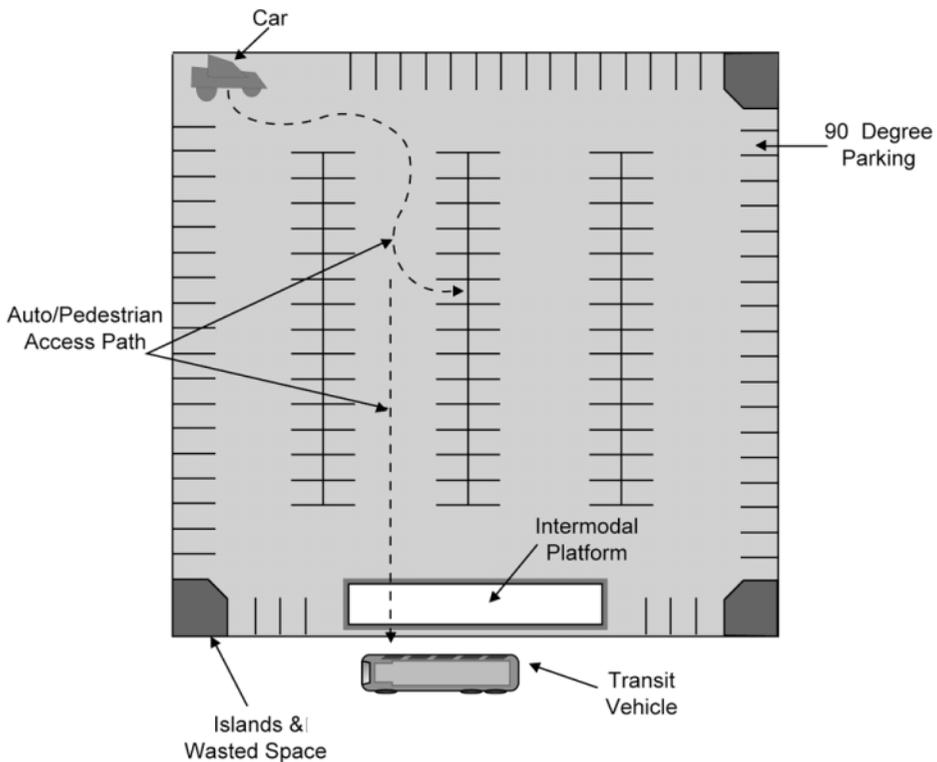
A number of options are available to the designer in terms of choosing parking angles. The most efficient parking configuration is the right angle or 90-degree parking configuration, as illustrated in Exhibit 6.27. A 90-degree configuration allows for two-way traffic flow between aisles for ease of access, and provides the least complicated pattern for drivers to recognize.

Although a 90-degree layout is clearly advantageous over angled alternatives, there may be specific cases in which angled or even parallel parking should be considered. For instance, if a site is larger than the space required for the projected demand, angled parking can be used, thus requiring more space within the lot and creating an appearance of higher use. When demand increases, the park-and-ride lot can be re-striped, adding additional stalls at a relatively low cost. Another example where angled parking might be advantageous is at the periphery of the lot, where space may be better utilized by an angled configuration.

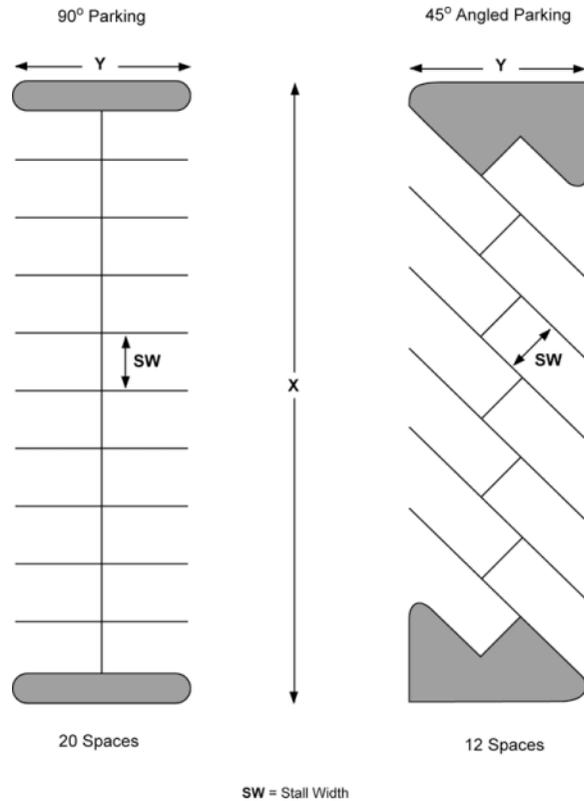
### *Access*

Access for automobile traffic should be separate from the transit entrance to reduce conflicts between the two modes. If a common access point must be used, a transit-only boarding area for transit patrons should still be provided, with automobile traffic directed to the lot via a separate internal lot entrance.

Exhibit 6.26  
Preferred Parking Stall Layout



### Exhibit 6.27 Angled Versus 90° Parking



Because inbound access to the park-and-ride lot is perceived by the user as more critical than outbound movement due to the tendency of patrons to arrive with few minutes to spare, inbound access efficiency should be maximized. However, it is typically in the evening peak that the facility demonstrates the greatest external impacts on the surrounding transportation network because of the large platoons of vehicles trying to leave the park-and-ride lot at the same time (e.g., shortly after a transit vehicle arrives at the lot).

Because of the desire to maximize the efficiency of inbound access movement, park-and-ride lots should be located on the right-hand side of two-way arterials for the directional movement towards the major destination. This allows most patrons accessing the facility to make a right turn into the facility.

Entrances and exits for park-and-ride facilities should be located to provide a minimum of 45.7 meters (150 feet) (preferably 106.7 meters (350 feet)) between successive entrances, and not be placed closer than 45.7 meters (150 feet) (preferably 106.7 meters (350 feet)) to any street intersection. A minimum of two combined entrances and exits should be provided for lots in excess of 300 spaces. When selecting the number of

entrances and exits the goal is to not exceed 300 vehicles per hour at any one entrance or exit. Lots in excess of 500 spaces should be evaluated for two-lane exits and the need for a dedicated traffic signal (29).

### *Circulation*

Vehicle circulation within the park-and-ride facility should generally encourage the inbound access movement, bringing inbound vehicles on-site quickly and conveniently to prevent on-street backups at key entrances. This will facilitate easier access in the morning peak period and will reduce on-street congestion. Entrances should allow the accessing driver to drive past as much of the lot as possible before entering, thus allowing visual inspection of the facility for available spaces.

Two-way circulation is generally preferred to one-way circulation within the lot. This will reduce confusion on the part of patrons and reduce the potential for drivers to circulate in the wrong direction in a one-way aisle. Two-way circulation is typically associated with 90-degree parking stalls, which provide a more flexible circulation and parking configuration but can also lead to increased parking conflicts between backing vehicles.

### *Handicapped Parking*

In July 1991, the United States Department of Justice published standards and guidelines for the provision of handicap parking spaces in general public parking facilities as stipulated in the Americans with Disabilities Act of 1990 (ADA). These standards dictate the minimum number of parking spaces to be provided for handicap parking within any park-and-ride facility, based on the number of general purpose stalls provided (see Exhibit 6.28).

In addition to providing an adequate number of handicapped stalls in the park-and-ride lot, facility design should promote safe and convenient access by all patrons. Design requirements for individual handicapped stall layouts can be found in several design manuals, including *The Parking Handbook for Small Communities*, published by the Institute of Transportation Engineers (33). Grade changes and barriers between the handicapped parking stalls and the transit loading area should be eliminated, and all facilities clearly signed for restricted use (see Exhibit 6.29).

Exhibit 6.28  
Accessibility Standards

Total Parking Spaces	Required Minimum Number of Accessible Spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1000	2% of total spaces
over 1000	20 plus 1 for each 100 over 1000

Source: *Uniform Federal Accessibility Standards*  
*Federal Register*, Vol. 56, No 173, Sept. 6, 1991

Exhibit 6.29  
Example Stall Layout—Handicapped Parking



*Gessner Park-and-Ride* Houston METRO  
Houston, Texas

In addition to the provision of handicapped stalls, consideration of the handicapped patron at the transit loading facility is required. This topic was discussed earlier in this chapter (see Exhibit 6.6, Wheelchair Lift Requirements).

### *Paving Requirements*

Pavement designs need not be uniform throughout a park-and-ride facility, but should be designed for vehicular traffic and weight distributions expected for the site. Three critical factors impact the selection of the proper pavement design:

- Expected traffic volume
- Vehicle weight and subgrade support
- The properties of the paving materials chosen (33)

In general, pavement designs should meet local code requirements. Common pavement materials include concrete, soil cement with an asphalt topping, or asphaltic concrete. Lots may also be unpaved, providing only a gravel surface for patrons. However, local weather conditions should be considered when selecting the appropriate material to provide for maximum patron comfort.

Example pavement designs for general parking areas can be found in various design manuals. Local soil conditions may dictate differing designs, and local code requirements should be consulted for specific design requirements.

Access streets and loading areas for transit vehicles will require additional design consideration to provide for the higher traffic volumes and bearing weights typically expected in these locations.

### *Illumination Requirements*

Sufficient lighting at park-and-ride facilities must be provided to create a safe environment for pedestrians and motorists as well as to provide security. Lighting designs must be developed within the context of the surrounding community so that undesirable light spillover into adjacent properties is minimal. The lighting design should avoid creating the perception for the patron of being on an island defined by the lighting at the transit platform. Transit patrons should be able to see into the park-and-ride lot from the platform so that they can observe potentially dangerous situations before entering the parking portion of the lot. Recommended lighting levels for park-and-ride facilities, developed by the American Association of State Highway and Transportation Officials (AASHTO), are presented in Exhibit 6.30.

Architectural lighting concepts are acceptable within a park-and-ride setting. However, depending upon the lighting design, the light distribution provided by the proposed luminary should primarily be evaluated for its dispersion and directional characteristics.

Exhibit 6.30  
Recommended Maintained Lighting Levels

	Footcandles	Lux	Uniformity Rate
<b>Roadways and General Parking Areas</b>			
Entrance and Exit Gores*	0.6	6	3:1 to 4:1
Interior Roadways	0.6	6	3:1 to 4:1
Parking Areas	1.0	11	3:1 to 4:1
<b>Activity Areas</b>			
Major	1.0	11	3:1 to 4:1
Minor	0.5	5	6:1

**At-Grade Pedestrian Platforms and Shelters**      **Footcandles**

Open Loading Platforms	5
Covered Loading Platforms	15
Ticketing Areas - Turnstiles	20
Passageways	20
Fare Collection Booth	100
<b>Concession/Vending</b>	
Machine Areas	30
Stairs and Escalators	20
Washrooms	30
Drop-and-Ride Areas	5

**Multi-Level Pedestrian Platforms and Shelters**      **Footcandles**

Entrances and Exits	50
Traffic Lanes	10
Parking Areas	1
Stairs and Escalators	20

\* For Transitional Lighting, See Freeway and Interchange Design Section, AASHTO, *An Informational Guide for Roadway Lighting*, current edition.

The above uniformity ratios are the maximum allowable. Lower numerical ratios produce better uniformity and are desirable.

Source: AASHTO, *Guide for the Design of Park-and-Ride Facilities*, 1992

## *Drop-and-Ride Activities*

Adequate space for drop-and-ride access is needed to maximize the efficiency of the park-and-ride facility. Demand for drop-and-ride activity will vary, depending on the type of transit service offered and the frequency of service. Higher order transit modes such as rail modes, ferry or marine modes, and high-capacity express bus services will tend to draw a greater number of drop-and-ride patrons than will local bus and lower capacity express bus operations.

For typical suburban park-and-ride facilities providing express service to the CBD a general rule of thumb is that as much as 10 percent of the total vehicles accessing the facility will be for drop-and-ride purposes (42). Demand for drop-and-ride will tend to be highest in the evening peak period, as opposed to midday and morning periods. Some of this demand can likely be accommodated within long-term parking spaces already vacated by daily users. Long-term daily parking spaces closest to the transit transfer location within a park-and-ride lot will tend to fill faster in the morning peak. These same spaces will tend to empty more quickly in the evening peak, making it possible for drop-and-ride patrons to use these spaces.

Average waiting periods for evening drop-and-ride vehicles is between 6 and 10 minutes. Approximately 1 to 1.5 percent of the total park-and-ride spaces within the facility should be reserved for drop-and-ride activity (42). This will accommodate short-term demand not provided for within the emptying long-term spaces.

## *Providing for the Private Auto: Conclusions*

Providing for the private automobile is, of course, a central issue in the design of park-and-ride facilities. Important elements to consider when designing for the auto include:

- Parking stall layout
- Use of surface or structured parking
- Access elements of the facility and on-site circulation
- Handicapped access and parking requirements
- Pavement designs
- Illumination needs

Allowances for both long-term (daily) and short-term (drop-and-ride) activities should be made to reduce conflict between parking vehicles and pedestrians.

Some in the transit industry will argue that the auto mode is the most important element of the park-and-ride facility, owing to the primary intermodal connection being provided at such facilities. However, overemphasis on the auto mode to the detriment of pedestrian and transit concerns will produce intermodal facilities that do little more than cater to the continued forces of suburban sprawl. A balanced approach, incorporating equal consideration of pedestrian, transit, and auto access is preferred. Such an approach will encourage community-oriented facilities and can support growing pedestrian-transit markets in and around the proposed park-and-ride lot.

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## 7.0 ARCHITECTURE, LANDSCAPE, AND ART: INTEGRAL PARTS OF THE PARK-AND-RIDE FACILITY

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## 7.0 ARCHITECTURE, LANDSCAPE, AND ART: INTEGRAL PARTS OF THE PARK-AND-RIDE FACILITY

Park-and-ride facilities are often looked to as the “poor cousins” of the transit industry, designed solely for efficient movement between the vehicle and transit modes. Over the past two decades, a number of facilities have been constructed with little or no attention paid to community integration or to their impact on the built and visual environment. The purpose of this chapter is not so much to provide guidelines for integrating architecture, landscape architecture, and art into park-and-ride facilities, as it is to make an argument for why such integration is necessary, to present a number of examples of facilities for which art and architecture have played a significant role in the design process, and to encourage the integration of these important elements into future park-and-ride facility developments. Furthermore, it is a goal to show that art and architectural treatments can be introduced at all levels of transit investment, whether it is a simple bus shelter, a major transit center or intermodal facility.

### 7.1 Art and Architecture

In 1995, the Federal Transit Administration published *FTA Circular 9400.1A*, establishing policies affirming the appropriateness of spending federal moneys on art and architecture in the design and construction of major transportation facilities. Perhaps the most eloquent statement of this policy is the wording chosen by the Federal Transit Administration itself:

*The visual quality of the nation's mass transit systems has a profound impact on transit patrons and the community at large. Mass transit systems should be positive symbols for cities, attracting local riders, tourists, and the attention of decision makers for national and international events. Good design and art can improve the appearance and safety of a facility, give vibrancy to its public spaces, and make patrons feel welcome. Good design and art will also contribute to the goal that transit facilities help to create livable communities.*

Source: Federal Transit Administration, Art, 1995

The importance of art and architecture must not be overlooked in the design of park-and-ride facilities. Such facilities represent major investments for the communities in which they are sited and often have long-term impacts on the host community. As indicated by the FTA policy, art and architecture—including landscape architecture—can be used to make the transit facility more appealing to the surrounding neighborhood as well as to potential users. Art and architecture can be used to soften the related and unavoidable impacts of transit facilities, and can be used to inspire community ownership of the facility.

Justification for the use of federal funding in the pursuit of artistic elements in the design of park-and-ride facilities is specifically documented in *FTA Circular 9400.1A* under the definition of major construction projects. Use of federal funding is allowed for both “new start” projects, as well as for “modernization” projects. It can be adapted to vehicle and related facility improvements, including simple bus shelters, and can be used for construction mitigation (67).

### *Justification for Art*

Art is a basic element of human civilization. If we look across time, many of the greatest artifacts of previous civilizations are the artwork that they leave behind. For example, the Mayan stonework of Central America and the beautifully adorned Aztec Calendar are two of the most well known icons of these largely unknown cultures. Likewise, the arches of the Roman Aqueduct and flying buttress of medieval Europe are icons of those civilizations as well. The reason for mentioning these specific historical examples is that they are all engineering structures or tools that are best known for their architectural or artistic contribution to history rather than their long forgotten practical uses. Try and imagine future generations exploring the artistic relics of the current world. Will those generations look at our most basic engineering structures and transportation facilities in wonder at the artistic beauty incorporated or in dismay at the complete lack of aesthetic attention. Herein lies one argument for why we should include art and architecture in the basic design of every public facility, including park-and-ride lots and other higher order transit facilities. Design professionals in the public service sector must strive to design structures and facilities that both inspire current populations as well as future ones through their artistic and architectural elements.

A second, and possibly more compelling reason to include artistic elements in transit and park-and-ride design, is that art can reduce vandalism. Inclusion of art in the transit facility will encourage a community to take ownership of the facility, increasing the public watchfulness over the investments placed at the park-and-ride lot. A 1992 before-and-after study conducted by King County Metro in Seattle concluded that the introduction of a community-based art program reduced window breakage by 20 percent for those shelters included in the program (58). Transit administrators involved with community arts programs indicate that maintenance costs due to removing graffiti and other vandalism is noticeably reduced by the inclusion of art and architecture in the design of transit shelters and park-and-ride lots. Additionally, increased community scrutiny brings a new level of awareness and appreciation for the transit system, often resulting in increased community support.

### *An Argument for Permanence*

The attention paid to art and architecture during the design of a park-and-ride facility can provide a statement of permanence within the community once the facility is constructed. Bus-oriented transit systems are often seen as less than permanent because of their non-fixed routing. For this reason, private businesses and developers are less likely to invest in transit-friendly projects because the transit system is seen as transitory over the long term. However, the construction of transit stations and intermodal facilities inclusive of artistic and aesthetic elements, in conjunction with park-and-ride facilities, can eliminate this misperception of impermanence. Incorporation of such elements makes a statement of commitment to the community and to system patrons.

## *When to Incorporate Art and Architecture*

Art and architecture can be added to the park-and-ride design process at almost any point during the design and implementation of the facility. However, the most effective and most influential approach is incorporation of artistic elements at the earliest possible opportunity, indeed even at the concept or preliminary design stage. In fact, the FTA indicates that artists should be incorporated during all aspects of the project, including the planning, design, and engineering phases. When developing a new park-and-ride facility, or any transit facility for that matter, the design team should, at a minimum, consist of representatives from the engineering, planning, public involvement, architecture, landscape architecture, and art professions.

## *Examples*

Parsons Brinckerhoff is world-renowned for its work in the field of transit architecture and the inclusion of significant artistic elements in the design process. Our engineers and technical specialists have learned the value of these “softer sides” of the design process and now the concept is largely an integral part of the design approach.

The remainder of this chapter provides examples of different ways in which art, architecture, and landscape architecture have been successfully integrated into the design process of park-and-ride facilities and related transit facilities. It is hoped that, through their display, these examples will encourage and promote the substantial use of art, architecture, and landscape architecture in the design of park-and-ride facilities.

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Exhibit 7.1



*Tulipsæ Seattle, Washington  
Photo Courtesy of King County Department of Transportation*

Exhibit 7.2



*Mt. Rainieræ Shoreline, Washington  
(NOTE: Painted by amateur artist as part of community eagle scout project)  
Photo Courtesy of King County Department of Transportation*

Exhibit 7.3



*Painted Trash ReceptacleæSeattle, Washington  
Photo Courtesy of King County Department of Transportation*

Exhibit 7.4



*Pearsæ Mercer Island, Washington  
Photo Courtesy of King County Department of Transportation*

Exhibit 7.5



*Bicycle Storage Rackæ Tempe, Arizona  
Photo Courtesy of City of Tempe*

Exhibit 7.6



*Bicycle Storage Rack, Tempe, Arizona  
Photo Courtesy of City of Tempe*

Exhibit 7.7



*Tile WorkæTohno Tadi Transit Center and Park-and-Ride, Tucson, Arizona  
Photo Courtesy of City of Tucson*

Exhibit 7.8



*Children's Playground Sculpture and Transit CenteræTohno Tadi Transit Center and Park-and-Ride, Tucson, Arizona  
Photo Courtesy of City of Tucson*

Exhibit 7.9



*Shelter Artæ Tempe, Arizona  
Photo Courtesy of City of Tempe*

Exhibit 7.10



*Desert Stream SculptureæTohno Tadi Transit Center and Park-and-Ride, Tucson, Arizona  
Photo Courtesy of City of Tucson*

Exhibit 7.11



*Architectural Focus PointæNorthgate Transit Center and Park-and-Ride, Seattle, Washington  
King County Department of Transportation*

Exhibit 7.12



*Transit ShelteræTempe, Arizona  
Photo Courtesy of City of Tempe*

Exhibit 7.13



*Bus SculptureæSunney Slope Transit Center, Phoenix, Arizona  
Photo Courtesy of Valley Transit and City of Phoenix*

Exhibit 7.14



*Olympia Transit Center*—Olympia, Washington

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## EPILOGUE

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## EPILOGUE

Information provided in this monograph represents only the first installment of a comprehensive planning and design handbook for park-and-ride facilities. In conducting the necessary research for this report, I have discovered that what at first appeared as a uniform, homogeneous topic (i.e., the planning and design of park-and-ride facilities) is really better represented as a number of intricate, intertwined issues, all deserving further attention and research from the industry.

I look forward to continuing my professional growth and experience in the planning and design of park-and-ride facilities, and invite all who would use this monograph to share their opinions and experiences with me. Please send your comments and thoughts on your own experience with park-and-ride facilities to:

Robert Spillar  
c/o Career Development Committee  
Parsons Brinckerhoff Quade & Douglas, Inc.  
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I can also be reached directly by Electronic Mail at:  
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## GLOSSARY OF TERMS AND ABBREVIATIONS

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## GLOSSARY OF TERMS AND ABBREVIATIONS

**Articulated Bus:** An extra-long, high-capacity segmented bus that has the rear portion flexible but permanently connected to the forward portion with no interior barrier to hamper movement between the two parts. The seated passenger capacity is 60 to 80 persons with space for many standees, and the length is from 18.3 to 21.3 meters (60 to 70 feet). The turning radius for an articulated bus is usually less than that of a standard urban or intercity bus.

**Attainment Area:** A geographic area in which levels of a criteria air pollutant meet the health-based primary standard (see NAAQS below) for that pollutant.

**Automatic Vehicle Identification (AVI):** Use of overhead or roadside detectors to read and identify vehicles equipped with a transponder or similar device. Used for electronic toll collection and traffic management.

**Average Vehicle Occupancy:** The number of persons divided by the number of vehicles traveling past a selected point over a predetermined time period, usually expressed to two or three significant figures (i.e., 1.2 or 1.26).

**Barrier-Separated Facility:** An HOV lane that is physically separated by guardrail or concrete median barriers from adjacent mixed-flow freeway lanes. The opposing directions within a barrier-separated facility may be separated by a barrier or buffer.

**Benefit-Cost Ratio:** The ratio of the dollars of discounted benefits achievable to a given outlay of discounted costs (TRB, Urban Public Transportation Glossary, 1989).

**Bi-Directional Facility:** A preferential facility in which two-way traffic flow is provided for during at least a portion of the day.

**Bus:** A self-propelled, rubber-tired road vehicle designed to carry a substantial number of passengers (i.e., 10 or more), commonly operated on streets and highways. A bus has enough head room to allow passengers to stand upright after entering (TRB, Urban Public Transportation Glossary, 1989).

**Bus and Carpool Lanes, Preferential Lanes, HOV Lanes:** A form of preferential treatment in which lanes on streets or highways are restricted for the exclusive use of high occupancy vehicles during at least a portion of the day.

**Bus Priority System:** A system of traffic controls in which buses are given a special advantage over other mixed-flow traffic (e.g., preemption of traffic signals or preferential lanes).

**Busway:** A preferential roadway designed for exclusive use by buses, constructed either at, below, or above grade, and located either in separate right-of-way or within freeway corridors (TRB, Urban Public Transportation Glossary, 1989).

**Capacity, Design (or roadway capacity):** The maximum number of vehicles (vehicular capacity) or persons (person capacity) that can pass over a given section of roadway in one or both directions during a given period of time under prevailing environmental, roadway, and roadway user conditions, usually expressed as vehicles per hour or persons per hour. (Operational capacity for an HOV lane should be less than this.)

**Carpool:** Any vehicle (usually a private automobile) or arrangement in which two or more occupants, including the driver, share the use, cost, or both traveling between fixed points on a regular basis.

**Change of Mode:** The transfer from one type of transportation vehicle to another (i.e., auto to bus or pedestrian to auto).

**Clean Air Act Amendments of 1990 (CAAA):** Federal legislation that establishes new requirements in metropolitan areas and states where NAAQS attainment could be a problem.

**Cold Start Emissions:** Air pollutants emitted in the first few minutes after a vehicle is started.

**Commuter Rail:** A passenger railroad service that operates within a metropolitan region on trackage that is usually part of the general railroad system. The service is intended for longer-distance passengers (usually commuters), and is usually operated at faster speeds, greater headways, and with greater distances between stops than is applied to intraurban fixed guideway systems.

**Corridor:** A broad geographical area that defines general directional flow of traffic. It may encompass a mix of streets, highways, and transit alignments.

**Cost-Benefit Analysis:** An analytical technique that compares the societal costs and benefits (measured in monetary terms) of proposed programs or policy actions. Identified losses and gains experienced by society are included, and the net benefits created by an action are calculated. Alternative actions are compared to allow selection of one or more that yield the greatest net benefits or benefit-cost ratio (TRB, Urban Public Transportation Glossary, 1989).

**Delay:** The increased travel time experienced by a person or vehicle due to circumstances that impede the desirable movement of traffic. It is measured as the time difference between actual travel time and free-flow travel time.

**Department of Transportation (DOT):** State agency responsible for administering federal and state highway funds.

**Drop-and-Ride:** (See Kiss-and-Ride)

**Emissions:** The release of pollutants into the air from a source.

**Express Bus Service:** Bus service with a limited number of stops, either from a collector area directly to a specific destination or in a particular corridor with stops enroute at major

transfer points or activity centers. Express bus service is usually routed along freeways or HOV facilities where they are available (TRB, Urban Public Transportation Glossary, 1989).

**Federal Highway Administration (FHWA):** Part of the U.S. Department of Transportation. FHWA is responsible for administering all federal-aid highway programs.

**Federal Transit Administration (FTA):** Formerly the Urban Mass Transportation Administration, part of the U.S. Department of Transportation. FTA is responsible for administering all federal-aid public transportation programs.

**Fixed Guideway:** Any urban transportation system composed of vehicles that can operate only on their own guideways, which are constructed for that purpose. Examples include rail rapid, light rail, monorail, etc.

**Headway:** The time interval between successive passing of vehicles (measured from bumper to bumper), moving along the same lane in the same direction on a roadway, expressed in seconds or minutes.

**High Occupancy Vehicle (HOV):** Motor vehicles carrying at least two or more persons, including the driver. An HOV could be a transit bus, vanpool, carpool or any other vehicle that meets the minimum occupancy requirements, usually expressed as either two or more, three or more, or four or more passengers per vehicle.

**In-Line Transit Stop:** A mode transfer facility located along an inside or outside oriented HOV lane. Mode transfers typically involve pedestrian or drop-off passenger to/from a bus.

**Informal Carpool:** A form of carpool in which the composition of traveling passengers varies from one day to another; there is no formalized arrangement for regular riders.

**Ingress/Egress:** The provision of access to/from an HOV or park-and-ride facility.

**Instant Carpool:** A form of carpool in which drivers pick up random passengers (usually commuters), often at predetermined locations along the route. The composition of the passengers typically varies from one day to another. Instant carpool passengers sometimes use this commute mode in one direction and take public transit in the other.

**Intergovernmental Agreement:** An agreement between two jurisdictions to meet the needs of common implementation of a park-and-ride lot or other cross-jurisdictional service. For example, a state department of transportation may form an *intergovernmental agreement* with a transit agency to provide right-of-way within a freeway corridor for use as a park-and-ride facility as long as the transit agency assumes the liability of operations and maintenance.

**Intermodal Surface Transportation Efficiency Act of 1991:** (ISTEA--say "ice tea"). Federal legislation that mandates the way transportation decisions are made and funded.

**Joint Development:** In terms of park-and-ride facilities, the development of a facility that provides the opportunity for private/public secondary uses of the facility. For example: a

park-and-ride lot that provides space in the transit shelter or on the periphery of the lot for small retail businesses; or the co-location of a public service facility (i.e., police precinct or fire station) on the same property as the P&R lot.

**Kiss-and-Ride (Drop-and-Ride):** An access mode to transit whereby passengers (usually commuters) are driven to a transit stop and left to board the vehicle, then met after their return trip.

**Lane:** A portion of a street or highway, usually indicated by pavement markings, that is intended for one line of vehicles.

**Level-of-Service (LOS):** A descriptive measure of the quality and quantity of transportation service provided the user that incorporates finite measures of quantifiable characteristics such as travel time, travel cost, number of transfers, etc. Operating characteristics of levels-of-service for motor vehicles are described in the Highway Capacity Manual (TRB, Highway Capacity Manual, 1985).

**Light Rail Transit:** See transit, light rail.

**Line-Haul:** That portion of a commute trip that is express (nonstop) between two points.

**Long Range Plan (LRP):** A 20-year outreach now required at the metropolitan and state levels that must consider a wide range of social, environmental (including air quality), and economic factors in determining overall regional transportation goals. (See MPO below.)

**Major Investment Study (MIS):** A detailed study and assessment of the various options available for the purpose of selecting one for implementation. Ideally, all feasible alternatives are investigated. A major investment study is required if federal funds in excess of the maximum allowable for MIS requirements are anticipated.

**Matching Funds:** ISTEA calls for a 20 percent match from state and local sources, with the federal share being 80 percent. This applies to the non-interstate portions of any NHS-funded projects, all projects funded under the STP and CMAQ programs, transit projects, and bicycle and pedestrian facilities.

**Metropolitan Planning Organization (MPO):** Agency designated by the governor to administer the federally required transportation planning process in a metropolitan area. In the Chicago metropolitan area, the responsible MPO is the Chicago Area Transportation Study (CATS). The MPO is responsible for the LRP and the TIP.

**Mitigation:** To lessen the impact of a proposed plan of action by developing a complementary plan.

**Mode:** A particular form of travel (i.e., walking, bicycling, traveling by bus, traveling by carpool, traveling by train).

**Mode Shift:** The shift of people from one mode to another (i.e., single occupancy vehicles to HOVs or vice versa).

Multimodal: Facilities serving more than one transportation mode.

National Ambient Air Quality Standards (NAAQS): Set by the USEPA, these standards measure the impacts of three criteria air pollutants: ozone, nitrogen oxides (NOx) and volatile organic chemicals (VOCs).

National Highway System (NHS): Interstate highways and roads designated as important for interstate travel, national defense, intermodal connections, and international commerce.

National Intermodal Transportation System (also known as National Transportation System): Integrated system connecting major transportation facilities.

Nonattainment Area: A geographic area in which the level of a criteria air pollutant is higher than the level allowed by the NAAQS.

NOx: A criteria air pollutant. Nitrogen oxides are produced from burning fuels, including gasoline and coal. NOx react with VOCs to form smog, and are also major components of acid rain.

Off-Line Station: A mode transfer facility located off of the HOV lane, either adjacent to the freeway or some distance away. Mode transfers could involve bus, rail, auto, or pedestrian modes.

Off-Peak Direction: The direction of lower demand during a peak commuting period. In a radial corridor, the off-peak direction has traditionally been away from the central business district in the morning and toward the central business district in the evening.

On-Line Station: A mode transfer facility located along the HOV lane. Mode transfers involve bus, auto and/or pedestrian modes.

Paratransit Vehicle: Any form of intraurban demand-responsive vehicle such as taxis, carpools, etc., that are available for hire to the public. They are distinct from conventional transit as they generally do not operate on a fixed schedule.

Park-and-Pool Lot: (See Park-and-Ride Lot, Park-and-Pool)

Park-and-Ride Lot: A parking facility where individuals access public transportation as a transfer of mode, usually from their private automobiles. Public transportation usually involves express bus from the lot to a central business district or major activity center:

- Informal P&R Lot: An unstructured modal transfer location, typically not served by transit but providing a location for carpool and vanpool formation. These lots differ from formal park-and-pool lots in that they are not usually funded or supported by the transit agency or other governmental jurisdiction.
- Opportunistic/Joint Use P&R Lot: A shared facility, where the park-and-ride lot is often the secondary use of the parking lot. Churches, government owned

parking lots and leftover land (e.g., under- and overpasses, unused portions of the median) provide opportunities for these lots. They may be served by transit.

- **Park-and-Pool Lot:** A parking facility where individuals rendezvous to use carpools and vanpools as a transfer of mode, usually from their private automobiles. The facility is not served by public transportation.
- **Peripheral P&R Lot:** A facility that provides additional parking for businesses and land uses primarily surrounding the lot or in proximity. These facilities may be unintentional consequences of poor facility location. They may be served by high levels of transit, but productivity measured by transit ridership from the lot may be low.
- **Remote Long-Distance P&R Lot:** Lots located at greater distances from the primary activity center than the traditional suburban P&R lot. These facilities will often be located at the center of a smaller activity center, but provide parking and transit service to the distant primary center.
- **Satellite Parking Facilities:** Park-and-ride lots placed on the perimeter of the primary activity center or central business center. These facilities are designed to provide relatively inexpensive parking for commuters accessing the activity center without having to travel into the center. These facilities may be served by transit.
- **Suburban P&R Lot:** Park-and-ride lot typically located in outer portions of the urban area, primarily serving commute-to-work travel between the suburbs and the central city or other major activity center. Transit services may be extensive, with routes provided to multiple locations. Alternatively, more restricted transit providing service only to the primary business center within the region may be offered.

**Peak Direction:** The direction of higher demand during a peak commuting period. In a radial corridor, the peak direction has traditionally been toward the central business district in the morning and away from the central business district in the evening.

**Peak Hour:** That hour during which the maximum demand occurs for a given transportation corridor or region, generally specified as the morning peak hour or the evening peak hour.

**Peak Period:** A portion of the day in which the heaviest demand occurs for a given transportation corridor or region, usually defined as a morning or evening period of two or more hours.

**Peripheral P&R Lot:** (See Park-and-Ride Lot, Peripheral)

**PRD Model:** Park-and-ride demand estimation model developed by Parsons Brinckerhoff. This multivariate model predicts P&R demand based on facility attributes, location characteristics, and service levels. The model was developed in the greater Puget Sound region for King County Department of Transportation (formerly Seattle Metro).

**Preferential Parking:** Parking lots or spaces that are reserved for HOVs as a means to encourage ridesharing.

**Preferential Treatment:** In transportation, giving special privileges to a specific mode or modes of transportation (i.e., bus lanes or signal preemption at intersections).

**Public Transit (or Transportation):** Passenger transportation service to the public on a regular basis using vehicles that transport more than one person for compensation, usually but not exclusively over a set route or routes from one fixed point to another. Routes or schedules of this service may be predetermined by the operator or may be determined through a cooperative arrangement.

**Queue:** A line of vehicles or persons.

**Queue Bypass (HOV/Transit):** An HOV/transit facility that provides a bypass around a queue of vehicles delayed at a ramp or main line traffic meter, toll plaza or other bottleneck location (i.e., bridges, tunnels, ferry landings).

**Rail Rapid Transit:** See transit, rail rapid.

**Ramp Meter Bypass:** A form of preferential treatment at a ramp meter in which one or more bypass lanes is provided for the exclusive use of high occupancy vehicles.

**Ramp Metering:** A system used to reduce congestion on a freeway facility by managing vehicle flow from local-access on-ramps. An on-ramp is equipped with a traffic signal that allows vehicles to enter the freeway.

**Remote Long-Distance P&R Lot:** (See Park-and-Ride Lot, Remote Long-Distance)

**Ridesharing:** The function of sharing a ride with other passengers in a common vehicle. The term is usually applied to carpools and vanpools.

**Satellite Parking Facilities:** (See Park-and-Ride Lot, Satellite)

**Single Occupant Vehicle (SOV):** Any vehicle carrying only the driver.

**Smart Park:** A park-and-ride or transit center integrated with the latest intelligent transportation systems (ITS), providing the user with travel data to allow an informed decision on commuting choices (Santa Clara Valley Transit Authority, 1997).

**Source:** Any place or object from which pollutants are released. Sources that stay in one place are referred to as stationary sources; sources that move around, such as cars, trucks, buses and planes, are mobile sources.

**State Implementation Program (SIP):** A periodic, ongoing plan for attainment of NAAQS. It is required by the Clean Air Act and regulated by the USEPA.

**Suburban P&R Lot:** (See Park-and-Ride Lot, Suburban)

**Transit:** See public transit.

**Transit Center (or transit station):** A mode transfer facility serving transit buses and other modes such as automobiles and pedestrians. In the context of this document, transit centers can provide premium park-and-ride services, allowing passengers to connect with a number of transit routes and other services.

**Transit, Bus Rapid:** An inexact term describing a bus operation that is generally characterized by operation on separate right-of-way that permits high speeds. This concept may include barrier-separated HOV facilities (TRB, Public Transportation Glossary, 1989).

**Transit, Light Rail (LRT):** An urban railway system characterized by its ability to operate single cars or short trains in streets or exclusive right-of-way, capable of discharging passengers at track or car floor level (TRB, Public Transportation Glossary, 1989).

**Transit, Rail Rapid (RRT):** An urban railway system characterized by high-speed trains operating exclusive right-of-way without grade crossings and served by platforms at stations (TRB, Public Transportation Glossary, 1989). Also called rapid rail transit.

**Transportation Control Measures:** A general term referring to transportation demand management (TDM), transportation systems management (TSM), and technology improvements that can be used to reduce regional emissions within a nonattainment area. Technology improvements can include more stringent vehicle emission testing requirements, old vehicle replacement programs, etc.

**Transportation Demand Management (TDM):** The operation and coordination of various transportation system programs to provide the most efficient and effective use of existing transportation services and facilities. TDM is one category of TSM actions.

**Transportation System Management (TSM):** Actions that improve the operation and coordination of transportation services and facilities to effect the most efficient use of the existing transportation system. Actions include operational improvements to the existing transportation system, new facilities, and demand management strategies.

**Vanpool:** A prearranged ridesharing function in which a number of people travel together on a regular basis in a van, usually designed to carry six or more persons.

*Reference: Definitions incorporated in this glossary were developed based on the Parsons Brinckerhoff HOV Glossary, Chuck Fuhs and HOV Practice Area Network, 1997.*

## ABBREVIATIONS

AASHTO:	American Association of State Highway and Transportation Officials
ASCE:	American Society of Civil Engineers
CBD:	Central business district
DOT:	Department of Transportation (State or Federal)
FHWA:	Federal Highway Administration
HCM:	Highway Capacity Manual (Transportation Research Board, Special Report 209, 3rd Edition, 1994)
HOV:	High occupancy vehicle
ISTEA:	Intermodal Surface Transportation Efficiency Act
ITE:	Institute of Transportation Engineers
ITS:	Intelligent Transportation Systems
LOS:	Level-of-service
LRT:	Light rail transit
MPH:	Miles per hour
MPO:	Metropolitan Planning Organization
MUTCD:	Manual on Uniform Traffic Control Devices (U.S. DOT, MUTCD, 1988)
P&P:	Park-and-pool
P&R:	Park-and-ride
PRD:	Park-and-ride demand estimation model
ROW:	Right-of-way (also ROW)
RRT:	Rail rapid transit
TCM:	Transportation control measure
TDM:	Transportation demand management

TRB: Transportation Research Board

TSM: Transportation systems management

VPH: Vehicles per hour

VPHPL: Vehicles per hour per lane

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